Keynote

Multiphase Oxidation Chemistry: Impacts on East Asian Haze, Brown Carbon, Indoor Contaminants

Jonathan Abbatt
University of Toronto, Canada

Abstract

Through phenomena such as the Ozone Hole and acid rain, we know that aerosol particles and cloud droplets facilitate important oxidation processes that do not readily occur in the gas phase. The complexity of this chemistry requires detailed laboratory studies conducted in a manner that informs us about the nature of this chemistry in the real atmosphere. This talk will present three vignettes of multiphase oxidation chemistry with relevance to: i) air quality, ii) climate, and iii) chemical contaminants. Specifically, the nature of aerosol oxidation reactions that drive fast formation of particulate sulfate under polluted haze conditions will be described. From a climate perspective, it will be illustrated how the ability of colored organic aerosol – brown carbon – to absorb light can be modified by multiphase chemistry. Lastly, although we obtain most of our chemical exposure indoors, the manner by which contaminants are transformed in our living and work spaces is poorly characterized; recent progress in this area will be presented. An overarching goal of the talk is to illustrate the need for fundamental chemistry studies to assess the impacts that we have on our environment.

Early Career Scientist

NO, I am not an early career scientist.
Keynote

The future of indoor air: on the crossroads between science, technology and politics

Prof Lidia Morawska
Queensland University of Technology, Australia

Abstract

We take indoor air for granted, not realising how complex interior atmospheres can be. We waste energy prodigiously, to maintain mediocre indoor atmospheric quality, inadequate for many occupants; and we cannot detect pathogens to prevent us from inhaling them. Building systems do not respond to outdoor- and indoor-generated air pollution, to prevent ingress of pollutants from outside or efficient removal inside. We don’t have indoor air quality standards, and even if we had we could not enforce them because routine monitoring of air quality in every interior is still not feasible. We need a profound change how we apply science, building engineering technologies and public health policies to create healthy indoor atmosphere. The presentation will explore how to make this vision a reality.

Early Career Scientist

NO, I am not an early career scientist.
Atmospheric chemistry and climate are intricately linked with changes in one influencing the other. Short-lived climate forcers (SLCFs), including methane, ozone and aerosols, and their precursors, are key players connecting atmospheric chemistry and climate. They influence climate by perturbing the Earth’s radiation balance and their abundances are influenced by climate via meteorology induced alterations in chemical, physical and transport processes. Globally, emissions of SLCFs have undergone major changes over the past few decades driven by policies to address air pollution and climate change and are expected to continue to change in the coming decades in response to societal and economic transformations. What will be the implications of changing SLCF emissions for atmospheric chemistry and climate interactions? How will climate respond to spatially varying projections of SLCFs emissions that have opposing climate effects? How will air quality change in response to changing SLCF emissions and climate? In this keynote, I will address some of these questions highlighting leading-edge results from comprehensive Earth System Models participating in AerChemMIP and ScenarioMIP as part of Phase 6 of the Couple Model Intercomparison Project (CMIP6). I will also discuss process-level uncertainties that impede our ability to predict what the future holds for atmospheric chemistry-climate interactions.
Ozonolysis of α-pinene, Δ3-carene and their mixtures.

Professor Merete Bilde
1. Department of Chemistry, Aarhus University, Denmark, Denmark

Author list (excluding presenting author)

Lotte Dyrholm Thomsen (1), Emil Mark Iversen (1), Þuriður Nótt Björgvinsdottir (1), Sofie Falk Vinther (1), Jane Tygesen Skønager (1), Thorsten Hoffmann (2), Jonas Elm (2), Marianne Glasius (1)

Abstract

Biogenic volatile organic compounds (BVOCs) are precursors for secondary organic aerosol formation. Two abundant BVOCs in boreal forests are the bicyclic monoterpenes α-pinene and Δ3-carene. With respect to chemical structure the main difference between the two is a four membered secondary ring in α-pinene and a three membered secondary ring in Δ3-carene.

Few studies have investigated aerosol formation from these BVOCs at temperatures below 20°C and most studies have investigated oxidation of a single VOC at a time.

This work describes and compares formation and properties of secondary organic aerosols formed in the dark ozonolysis of α-pinene and Δ3-carene at temperatures in the range 0-20°C. In addition, aerosols formed from a mixture of the two monoterpenes are investigated at 20°C.

Experiments were performed in the AURA atmospheric simulation chamber at Aarhus University under dark conditions. Aerosols were characterized using a variety of instruments including Scanning Mobility Particle Sizer (SMPS), a high-resolution time of flight aerosol mass spectrometer, and offline chemical analysis of aerosol particles using ultra-high performance liquid chromatograph with both quadrupole time-of-flight mass spectrometry and orbitrap mass spectrometry. Experimental data were complemented by quantum chemical calculations.

Key results from the experiments will be presented: the evolution of particle mass and number concentrations with time in the different experiments differ depending on the precursor BVOC and temperature. The particle chemical composition as identified from the off-line analysis is different depending on the BVOC precursor with α-pinene SOA displaying a much more complex product distribution than SOA formed from the oxidation of Δ3-carene. In the experiments with mixed monoterpenes we observe indications of chemical interaction between oxidation products.

Early Career Scientist

NO, I am not an early career scientist.
Session 1 Oral

Lessons from 22 years of MOPITT

Dr. Helen M Worden
NCAR/ACOM, USA

Author list (excluding presenting author)

Jim Drummond (2); Rebecca Buchholz (1), Merritt Deeter (1), David Edwards (1), Louisa Emmons (1), Gene Francis (1), Benjamin Gaubert (1), John Gille (1), Debbie Mao (1), Sara Martínez-Alonso (1), Gabriele Pfister (1), Wenfu Tang (1), Dan Ziskin (1)

Abstract

Measurements Of Pollution In The Troposphere (MOPITT) on the NASA Terra spacecraft has been measuring the global atmospheric abundance of carbon monoxide (CO) since March 2000. Direct emissions of CO are mainly produced by incomplete combustion from both natural fires and anthropogenic activity. CO is also produced chemically from methane (CH4) and volatile organic compounds (VOCs). Although CO makes a negligible contribution to greenhouse gas absorption, it does play an important role in atmospheric chemistry and climate because it is a dominant sink for the hydroxyl radical (OH) and thus affects the abundance of methane and ozone (O3). Because of these interactions, CO is considered a short-lived climate forcer and anthropogenic emissions of CO have played a role in warming the climate. The MOPITT record is long enough to allow the detection of significant trends in atmospheric pollution and assess changes in emissions due to regulations, agricultural burning, technological improvements to combustion efficiency, and increasing wildfires due to a warming climate. We will present an overview of the MOPITT data record, describe how our algorithms have adapted to instrument changes on-orbit, and discuss the continuation of the MOPITT record with recent and planned satellite CO observations.

Early Career Scientist

NO, I am not an early career scientist.
Session 1 Oral

Diurnal variations in N and O isotopes of atmospheric nitrogen dioxide and nitrate: implications for tracing NOx oxidation pathways and emission sources.

Sarah Albertin
LATMOS/IPSL, Sorbonne Université, UVSQ, CNRS, 75005 Paris, France. IGE, Univ. Grenoble Alpes, CNRS, IRD, Grenoble INP, 38000 Grenoble, France

Author list (excluding presenting author)

Joël Savarino (1); Slimane Bekki (2); Roberto Grilli (1); Quentin Fournier (3); Irène Ventrillard (3); Nicolas Caillon (1); Kathy Law (2)

Abstract

The use of stable isotopes over the past decades has demonstrated its ability to provide information relevant for tracing emission sources, individual chemical processes and atmospheric trace gases budgets. Atmospheric nitrate (NO$_3^-$) is the end product of nitrogen oxides (NO$_x$ = NO + NO$_2$) oxidation and an emblematic compound of this isotopic approach. Of particular interest is the propagation of the ozone (O$_3$) distinctive oxygen-17 anomaly ($\Delta^{17}$O) into the reactive nitrogen cycle which has led to a better understanding of nitrate formation pathways in various environments. A very powerful approach is to combine isotopic measurements of different atoms in linked molecules, for instance O and N in NO$_2$ and NO$_3^-$. Here we report for the first time on measurements and analysis of $\Delta^{17}$O and $\delta^{15}$N in NO$_2$ and NO$_3^-$ collected in Chamonix, France, at high temporal resolution in order to interpret more quantitatively the fate of reactive nitrogen.

The $\delta^{15}$N values of NO$_2$ and NO$_3^-$ show strong variability (-10.6 to 19.7 ‰ and -4.2 to 14.9 ‰, respectively), suggesting important N fractionation during NO$_x$ to nitrate conversion. We find a large diurnal variation in $\Delta^{17}$O for both NO$_2$ and NO$_3^-$, with maximum values during the day (40.8 ‰ and 28.1‰, respectively) and minimum values at night (19.6 ‰ and 18.3 ‰, respectively). There is also a substantial variability in $\Delta^{17}$O(NO$_2$) and $\Delta^{17}$O(NO$_3^-$) during the day itself, certainly driven by changes in the O$_3$ to peroxyl radical ratio. By collating atmospheric observations (NO, NO$_2$, O$_3$ and PM concentrations) and $\Delta^{17}$O/$\delta^{15}$N data, we investigate nitrate formation pathways, N fractionation effects, and the relative contribution of NO$_x$ emission sources influencing our measurement site. The results demonstrate that the combined study of the NO$_2$ and NO$_3^-$ multi-isotopic composition allow to interpret better NO$_3^-$ isotopic composition records and provide more stringent and quantitative constraints on the atmospheric reactive nitrogen cycle.

Early Career Scientist

YES, I am an early career scientist.
Nitrogen Dioxide Uptake Coefficients Derived from in situ Measurements at a Forested Site in Southern Indiana: Method Validation and Empirical Parametrization

Mr Adrien Gandolfo
Paul H. O’Neill School of Public and Environmental Affairs, Indiana University, USA. School of Chemistry, University College Cork, Ireland

Author list (excluding presenting author)
Zachary C. Payne (1); Jonathan D. Raff (1,2)

Abstract

Chemical interactions of reactive nitrogen compounds at the land-atmosphere interface play a crucial role in the biogeochemical N-cycle and atmospheric chemistry. The formation of nitrous acid (HONO) from nitrogen dioxide (NO2) deposition followed by its heterogeneous reduction is of particular interest. This process represents a major source of HONO in the troposphere, where it photolyzes to form hydroxyl radical (OH) and nitric oxide (NO). Thus, the accurate representation of NO2 uptake chemistry in models is essential for predicting air quality and climate.

Explicit representation of NO2 to HONO conversion on surfaces is lacking due to ambiguities in the chemical mechanism and its potentially complex dependence on soil properties and environmental variables. Surface HONO production is typically parametrized using bulk parameters such as the NO2 reactive uptake (γ), the NO2 ambient mixing ratio, and the NO2 to HONO reaction yield. NO2 concentrations can be monitored at ground level so that γ (constrained by laboratory experiments and environmental parameters) can be adjusted to match observed HONO concentrations. The unknown HONO reaction yield is generally set to 0.5 and 1 for dark and photoenhanced reactions, respectively. Direct measurement of the NO2 uptake would reduce uncertainties in parameterizing HONO formation and help us understand the factors driving its formation.

This study presents in situ measurements of NO2 coefficients at a forest clearing during summer 2017 in southern Indiana. The method is based on flux measurements of NO2 using automated dynamic flux chambers and a resistance model for gas deposition. The calculated uptake coefficients are on the order of 10^-5, in agreement with previous laboratory and modeled data. In addition, a clear diurnal pattern is observed with minimums at night and maximums at ~5×10^-5 during the afternoon. Finally, the derived uptake coefficients and the environmental parameters are used to propose an empirical parametrization.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

CATCH: the Cryosphere and Atmospheric Chemistry
Multiphase Chemistry in cold parts of the atmosphere

Dr. Thorsten Bartels-Rausch
Paul Scherrer Institute (PSI), Switzerland

Author list (excluding presenting author)

Jacinta Edebeli (1); Xiangrui Kong (1), Fabrizio Orlando (1), Astrid Waldner (1), Thomas Huthwelker (1), Markus Ammann (1)

Abstract

Snow may hold impurity deposits, such as sea salt aerosol, which show vivid reactions. Snow’s porosity guarantees efficient gas exchange of reaction products with the overlaying air. Here, we investigate the freezing point and reaction rates of reactants embedded in this ideal natural reactor in the temperature range of 259 K to 240 K, most typical for springtime Arctic, where chemistry in coastal snow is most active.

The strategy of the experiments reported here was to probe the phase of sodium chloride – water samples at various positions in the phase diagram. Phase changes were observed in-situ by Partial Auger-Meitner electron-yield NEXAFS spectroscopy (NEXAFS) at the Cl K-edge. We find that sodium chloride at the interface of frozen solutions remains as supercooled liquid down to 240 K. Below this temperature, hydrohalite precipitates for which we present the first NEXAFS spectrum. Taken together, this study reveals no differences in the phase changes of sodium chloride at the interface as compared to the bulk.

As temperature approaches the freezing point of such brines, thermodynamics dictate that concentrations of reactants in these aqueous patches increase ("freeze concentration effect"). Here we show how this does not always lead to increased reaction rates: We present results from a kinetic laboratory study on the oxidation of bromide in mimics of sea-salt aerosol embedded in snow. Our finding indicates that changes to diffusivity of reactants and in the solubility of ozone in the aerosol counteracts the freeze concentration effect leading to an overall slower reaction rate.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

CATCH: the Cryosphere and Atmospheric Chemistry, PACES: Air Pollution in the Arctic: Climate, Environment, and Societies
COALA-2020: Are SO2 and NOx driving factors for new particle formation over rural areas in South-east Australia?

Jhonathan Ramirez-Gamboa
University of Wollongong, Australia

Author list (excluding presenting author)

Clare Paton-Walsh (1)
Jack Simmons (1)
Melita Keywood (2)
Ruhi Humphries (2)
Asher Mouat (3)
Jennifer Kaiser (3)
Gunaratnam Gunashanhar (4)

Abstract

Aerosols play an important role in atmospheric processes influencing cloud formation, scattering and absorbing solar radiation, and as a part of the chemical reactions affecting the abundance of trace gases in the atmosphere. Ultimately aerosols affect the radiative balance of the earth modifying climate. A large fraction of aerosols is formed through chemical reactions following “gas to particulate” processes in the atmosphere: nucleation, condensation and growth. Biogenic Secondary Organic Aerosols (BSOA) are formed when plant produced volatile organic compounds (VOCs) react in the atmosphere through heterogeneous reactions. South-east Australia is one of the locations with the highest emissions of biogenic VOCs in the world, due to the high density of Eucalyptus species which are high emitters of VOCs. The COALA-2020 (Characterizing Organics and Aerosol Loading over Australia) campaign worked towards a better understanding of biogenic VOCs in quasi pristine conditions in the atmosphere.

During the COALA-2020 campaign, fourteen clear new particle formation (NPF) events were identified from 5th Feb to 15th March. Using the particle size distribution, along with the gas-phase and meteorology measurements we identified how sulphur dioxide (SO2) and nitrogen oxides (NOx) act as particle formation and grow drivers during daytime NPF events. Applying cross correlation techniques to the SO2 and NOx and the modelled geometrical diameter during the NPF events showed how the time series correlation improves with time lags between thirty minutes to two hours. The best correlation at a lag time was attributed to a combination of SO2, NOX, VOCs availability and relative humidity in the atmosphere, enhancing particle formation and growth rate. This presentation provides a summary of the NPF characterization results and insight on how the aerosol mass composition changes under different atmospheric conditions.
Early Career Scientist

YES, I am an early career scientist.

IGAC Regional Working Groups

Southern Hemisphere Working Group
Session 1 Oral

Formation of Secondary Brown Carbon in Biomass Burning Aerosol Proxies through NO3 Radical Reactions

Professor Yinon Rudich
Weizmann Institute, Israel

Author list (excluding presenting author)

Abstract

Atmospheric brown carbon (BrC) is an important contributor to the radiative forcing of climate by organic aerosols. Because of the molecular complexity of BrC compounds and their dynamic transformations, it is challenging to predictively understand BrC optical properties. Photochemical reactions (photolysis, OH radical and O3 reactions) tend to diminish light absorption and hence lower the warming effects of biomass burning BrC. Night-time aging and the resulting the optical properties of BrC aerosols are less known. In this talk we will present laboratory studies on night-time NO3 radical reactions with tar aerosols from wood pyrolysis. The study shows that the optical properties of BrC change because of transformations driven by reactions with the NO3 radical that form new absorbing species and lead to significant absorption enhancement over the ultraviolet–visible (UV-vis) range. The overnight aging increases the mass absorption coefficients of the BrC by a factor of 1.3–3.2 between 380 nm and 650 nm. Night-time aging of BrC aerosols represents an important source of secondary BrC. Nitrated organic compounds, particularly nitroaromatics, were identified as the main products that contribute to the enhanced light absorption in the secondary BrC.

Early Career Scientist

NO, I am not an early career scientist.
Photochemical reaction of vanillin under pressure: Proof of pressure significance inside atmospheric aerosols

PhD Student Clement Dubois
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Author list (excluding presenting author)

Sébastien Perrier (1); Candice Cart (1); Christian George (1); Matthieu Riva (1)

Abstract

Secondary organic aerosols (SOA) are key players in the atmosphere, formed either by nucleation of low volatile (organic or inorganic) compounds or by heterogeneous reactions occurring on pre-existing aerosols.

A better understanding of the formation and aging of atmospheric aerosols is the objective of intense research. Therefore, we focused our interest on one fundamental physical property that is not considered in atmospheric science hitherto: the pressure inside nanoparticles. It is well known in organic chemistry and has shown its efficiency in impacting (e.g., accelerating) selective chemical processes.

According to the Young-Laplace law, the pressure inside nanometric aerosols (i.e., < 100 nm in diameter) can reach thousands or hundreds of bar. This pressure can affect chemical reactions, during which the product molar volume differs from the reactants. When the reaction mechanisms are favoured at high pressure it could allow the formation of compounds. Consequently, these reactions could aid in the formation and the growth of nanometric particles.

To study this, we developed an experimental system, allowing in-situ characterization of chemical compounds at various pressures (i.e., 1 to 600 bar). Experiments can be performed with or without irradiation. We used vanillin, which is a well-known photosensitizer, can create radicals under irradiation and further form dimers by Norrish reaction (Vione et al., 2019). The dimer formation is suspected to be accelerated under pressure. Therefore, we decided to use aqueous vanillin samples that we tested under different pressures over time. Chemical composition of samples was retrieved using high-resolution mass spectrometry (UHPLC-ESI-Orbitrap-MS). The results show a modification of the rate constant (= +25%) at 600bar, typical to atmospheric nanoparticles.

Overall, these results provide a new understanding of the growth of nanoparticles in the atmosphere and could help to predict their formation.

This work is funded by the European Research Council (ERC-StG MAARvEL, grant nr 852161).

Early Career Scientist

YES, I am an early career scientist.
Session 1 Oral

Surface spectroscopic analysis of aqueous phase iodine oxides: Electron binding energy and surface propensity

Dr Antoine Roose
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Author list (excluding presenting author)

R. Opoku (2); A. Boucly (1); H. Yang (1,3); L. Iezzi (1,3); C. Toubin (2); V. Vallet (2); L. Halbert (2); A. S. P. Gomes (2); M. Ammann (1); L. Artiglia (1)

Abstract

Iodine chemistry is implicated in atmospheric chemistry and can form several oxides such as HOI, I₂, IO, OIO, and finally I₂O₅ or HIO₃, which may nucleate as nanoparticles relevant for cloud formation in remote environments. These oxides can be formed through reaction with oxidants or other halogen compounds in the gas phase or the particle phase. Most of the iodide oxidation processes have been suggested to be enhanced at interfaces, similar to other halogen species, either due to the surface propensity of intermediates or the iodine species itself. However, no data are available about the surface concentration of iodine species other than iodide. After two decades of research into the surface propensity of iodide and bromide, the picture emerges that their surface propensity is not as extreme as initially thought.

Liquid jet X-ray photoelectron spectroscopy (XPS) experiments have been carried out at the SIM beamline at the Swiss Light Source. Acquisition of kinetic energy dependent (thus at different probing depth) I3d, I4d core level and valence level spectra has been done for iodide, iodate and iodic acid. This allows to retrieve the surface propensity of these iodine species at the aqueous solution – air interface. Theoretical computations were performed to calculate the spectra using the so-called Frozen Embedding Method where DFT SAOP is coupled with CVS-EOM-IP-CCSD/d-aug-dy-all.ac2vz via a molecular mean-field X2C including the Gaunt interaction. The computation of the iodide core binding energies in the aqueous have been determined and compared to experimental measurements.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

CATCH: the Cryosphere and Atmospheric Chemistry
Session 1 Oral

Fundamental Oxidation Processes in the Remote Marine Atmosphere Investigated Using the NO-NO₂-O₃ Photostationary State

Simone T. Andersen
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Author list (excluding presenting author)

Beth S. Nelson (1); Katie A. Read (1,2); Shalini Punjabi (1,2); Luis Neves (3); Matthew J. Rowlinson (1); James Hopkins (1,2); Tomás Sherwen (1,2); Lisa K. Whalley (2,4); James D. Lee (1,2); Lucy J. Carpenter (1)

Abstract

The photostationary state (PSS) equilibrium between NO and NO₂ is reached within minutes in the atmosphere and can be described by the PSS parameter, φ. Deviations from expected values of φ have previously been used to infer missing oxidants in diverse locations, from highly polluted regions to the extremely clean conditions observed in the remote marine boundary layer (MBL), and have been attributed to missing understanding of fundamental photochemistry. Here, contrary to these previous observations, we observe good agreement between PSS-derived NO₂ calculated from photochemical model predictions of peroxy radicals (RO₂ and HO₂) and measured NO, O₃, and jNO₂, and observed NO₂ in extremely clean air containing low levels of CO (< 90 ppbV) and VOCs. However, in clean air containing small amounts of aged pollution (CO > 100 ppbV), we observed higher levels of NO₂ than inferred from the PSS, implying missing RO₂ radicals. Potential NO₂ measurement artefacts have to be carefully considered when comparing PSS-derived NO₂ to observed NO₂, but we show that the NO₂ artefact required to explain the deviation would have to be ~ 4 times greater than the maximum calculated from known interferences. If the missing RO₂ radicals have an ozone production efficiency equivalent to that of methyl peroxy radicals (CH₃O₂), then the calculated net ozone production including these additional oxidants is similar to that observed, within estimated uncertainties, once halogen oxide chemistry is accounted for. This implies that peroxy radicals cannot be excluded as the missing oxidant in clean marine air containing aged pollution, and that measured and modelled RO₂ could both be significantly underestimated under these conditions.

Early Career Scientist

YES, I am an early career scientist.
Probing the Multiphase Chemistry of Atmospheric Peroxy and Alkoxy Radicals

Dr. Victoria P Barber
Massachusetts Institute of Technology, USA

Author list (excluding presenting author)

Lexy Lemar (1); Yaowei Li (2); Frank Keutsch (2); Jesse Kroll (1)

Abstract

The atmosphere is a multiphase environment, encompassing not only gases but also condensed-phase environments, such as aerosol particles and cloud droplets. The oxidation of organic compounds plays a critical role in the chemistry and composition of Earth’s atmosphere, and can take place in any of these phases, as well as at the interfaces between them. In each phase, organic radicals, especially alkoxy (RO) and peroxy (RO$_2$) radicals, are key intermediates in oxidation chemistry. Most laboratory studies of organic radical reactions are carried out in the gas phase; the chemistry that governs the evolution of these radicals in the atmospheric condensed phase is comparatively poorly understood. The condensed phase represents a more complex environment than the gas phase, because locally high concentrations may facilitate additional reactions between organic species, and solvent effects may alter relevant potential energy surfaces. Here, we investigate the chemistry of photolytically generated RO and RO$_2$ radicals across a variety of phase environments, including the gas phase, bulk organic and aqueous solution phases, and in aerosol particles. The photolytic generation of RO and RO$_2$ radicals allows for the selection of specific radical isomers as starting points, greatly simplifying the subsequent chemistry as compared to oxidation via traditional (oxidant-initiated) routes. Products are probed in each case using a chemical ionization mass spectrometer, which provides real-time chemical kinetic information as well as molecular-formula-level identification of products. Initial experiments focus on chemistry in bulk solution, which is observed to be substantially different than in the gas phase. In particular, high yields of alkyl nitrates are observed in the condensed phase, representing a possible unexplored atmospheric NOx sink or reservoir and a potential source of particulate nitrate. This approach is then extended to probe the chemistry of RO and RO$_2$ radicals within suspended submicron particles.

Early Career Scientist

YES, I am an early career scientist.
Observations of NO\textsubscript{y}, O\textsubscript{3} and CO in the Arctic Summertime During the SEANA Cruise Campaign

Ms Anna B Callaghan
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Author list (excluding presenting author)

James Lee (1);
Lucy Carpenter (1);
Will Drysdale (1)

Abstract

The rate of warming seen in the Arctic is thought to be at least twice that observed globally. One of the consequences of this is a dramatic decrease in sea ice in the Arctic, with recent studies suggesting that by the middle of the 21\textsuperscript{st} century it will be possible to use the Northwest passage as a shipping route during the Arctic summer. In order to understand how the consequent increase in shipping emissions will affect the Arctic atmosphere, it is necessary to have measurements representing the current background Arctic atmosphere. The number of atmospheric measurements in the Arctic is, however, quite limited, due to its remoteness and harsh environments. As a result, our understanding of the atmospheric chemistry in this region is not complete.

The SEANA (Shipping Emissions in the Arctic and North Atlantic Atmosphere) cruise (19\textsuperscript{th} May to 27\textsuperscript{th} June) sailed from Reykjavik, past the south of Greenland and north into Baffin Bay. Concurrent measurements of atmospheric gases and aerosols were performed in order to improve our understanding of the Arctic atmosphere and our ability to predict the effects of an increase in shipping emissions in the region. This poster will present NO\textsubscript{y}, O\textsubscript{3} and CO data collected during the cruise and will examine their relationships and features based on factors such as air mass origin and local meteorology, in the context of existing knowledge of the photochemical state of the background Arctic atmosphere.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities
A highly sensitive laser-induced fluorescence system for the detection of trace level sulfur dioxide

Miss Loren G Temple
University of York, United Kingdom

Author list (excluding presenting author)

Pete Edwards (1);
James Lee (1);
Stuart Young (1);
Jake Vallow (1);
Andrew Rollins (2)

Abstract

Sulfur dioxide (SO$_2$) plays a pivotal role in the chemistry of the troposphere, ultimately affecting the Earth’s radiation balance and climate. Emissions are dominated by primary sources, including both natural (e.g. volcanoes, biomass burning) and anthropogenic (e.g. fossil fuel combustion), whilst secondary emissions mainly result from biogenic dimethyl sulfide (DMS) oxidation. Within the atmosphere, SO$_2$ is oxidised by gas- and aqueous-phase chemistry to sulfate. Not only is this a major human and ecosystem health concern but sulfate aerosols contribute to the offset of greenhouse gas-induced warming. Both the direct radiative forcing from aerosols and the indirect forcing from aerosol-cloud interactions are poorly understood and produce large uncertainties in climate models. Therefore, it is of interest to precisely quantify the concentration of atmospheric SO$_2$ if we are to predict the effects of changing emission rates on both climate and air quality.

Current commercial SO$_2$ detection techniques, for example pulsed fluorescence, are no longer sensitive enough to detect trace levels of SO$_2$ such as those found in remote marine environments. Therefore, we report the development of a novel laser-induced fluorescence instrument for in situ SO$_2$ measurements using a custom-built, tunable fiber-amplified laser system. Based on the system initially developed by Rollins et al. (2016), the University of York LIF-SO$_2$ system has a detection limit of 50 ppt for 30 seconds and its relatively small size, weight and power requirements makes this instrument suitable for a variety of field campaigns.

Here we present the University of York LIF-SO$_2$ instrument and data from recent aircraft and ship-based field campaigns, investigating remote ocean sources of SO$_2$.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities
Session 1 Poster

OH/HO₂ uptake coefficient onto various polydisperse aerosols determined by combining laser-pump and laser-induced fluorescence

Dr Jiaru Li
Kyoto University, Japan. National Institute for Environmental Studies, Japan

Author list (excluding presenting author)

Yosuke Sakamoto (1, 2); Kei Sato (2); Yoshizumi Kajii (1, 2)

Abstract

The uptake of hydroxyl (OH) and hydroperoxy (HO₂) radicals onto aerosols potentially affect VOC oxidation, ozone formation, and SOA generation under atmospherically relevant conditions. However, such a multiphase reaction pathway has not been well understood yet. This study reports the experimental result of uptake coefficients of OH and HO₂ radicals onto a series of artificial aerosols. The results could be advantageous for studying the heterogeneous processes and evaluating the oxidative potential of particulate matter.

We jointly applied the laser-pump and laser-induced fluorescence (LP-LIF) technique with an atomizer/bag-based chamber to measure the loss rate of OH/HO₂ radicals due to aerosol uptake. Polydisperse salt aerosols were produced from

- NaCl
- (NH₄)₂SO₄
- Na₂SO₄
- Seawater
- (NH₄)₂SO₄ + Anthropogenic SOA

using a commercial constant output atomizer. The 0.03% w/v reagent alone or contained with 0.0015% w/v transition metal ions (either Cu²⁺ or Fe²⁺) were dissolved in ultrapure water to produce polydisperse aerosols. A bag-based chamber was used to coat (NH₄)₂SO₄ aerosols with products from toluene ozonolysis. The effective uptake coefficient, γ, can be extrapolated from γ=4k'/ωS, which depends on the radical loss rate (k') measured by LP-LIF, the mean molar velocity, ω, and the surface area of aerosols (S) measured by scanning mobility particle sensor (TSI, model 3938). The determined γ of reactive oxygen species (OH or HO₂) onto aqueous aerosols made by different components were compared with known reported corresponding values and showed good agreement with them. For the first time, γ measured from Na₂SO₄, seawater, and ASOA-coated (NH₄)₂SO₄ aerosols are reported in this study.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon

IGAC Regional Working Groups
Japan National Committee
**Session 1 Poster**

**Molecular-level characterization of Brown Carbon chromophores in atmospherically-relevant samples and their gas-particle distribution**

Mr. Chong Xing  
China University of Geosciences, Wuhan, China

**Author list (excluding presenting author)**

Yibei Wan(1), Huan Yu(2)

**Abstract**

Brown carbon (BrC) affects atmospheric chemical processes and global climate by absorbing solar radiation. It is crucial to accurately identify the structures of BrC chromophores in atmospherically-relevant samples, in order to understand their source, sink and light absorption. In addition, few researches have investigate the gas-particle distribution and diurnal variation characteristics of BrC chromophores in the atmosphere. In this study, we collected 7 types of atmospherically-relevant samples including vehicle tunnel aerosols, biomass burning aerosols, chamber SOA, size-resolved ambient aerosols and rain water. The techniques of chromatographic separation, photodiode array detector, and high-resolution tandem mass spectrometry were used to explore the identity of BrC chromophores in these samples. Possible contributions of chromophores from different sources to local atmosphere were discussed. A time-of-flight chemical ionization mass spectrometer (TOF-CIMS) was used to obtain the gas-particle distribution and the diurnal variation information of these chromophores in the atmosphere.

**Early Career Scientist**

YES, I am an early career scientist.

**IGAC Regional Working Groups**

China Working Group
New Particle Formation Events at a Unique “Dragon Eye “Marine Lake Area in Rogoznica, Croatia

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Author list (excluding presenting author)

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Abstract

Atmospheric new particle formation (NPF) is the dominant source of atmospheric particles in the global atmosphere. [1] In such a way, newly-formed particles can act as cloud condensation nuclei (CCN). [2] The size at which the formed particles become climatically relevant depends on the nuclei growth rate and the scavenging of nuclei by various removal processes. In this regard, particles of sub-20 nm occupy special attention since they are most susceptible to coagulation scavenging by larger pre-existing particles. The growth of newly formed particles has been observed worldwide in different typological areas: urban, rural, remot, coastal, marine coastal, arctic areas, and Antarctica.

Of particular interest are the marine and coastal NPF events. NPF via the secondary gas-to-particle conversion processes over the oceans is one of the primary mechanisms controlling the global aerosol number population; however, this phenomenon has not been well quantified yet. This work aims to characterize, classify, and determine the main components of the NPF events at the Dragon Eye lake area in Rogoznica. For this purpose, a combination of online (SMPS and Aethalometer) and offline (Berner impactor and PM2.5) instruments are used. The preliminary results show high NPF occurrence frequency. Regional nucleation events were observed even if the particle total number concentration was relatively low (3000 cm$^{-3}$). In accordance with this, the condensation and evaporation growth rates were dominant compared to the coagulation. It is important to note that all NPF events were connected with the trajectories coming from the sea. Because the growing population reaches only 30 nm, special attention will be given to the organic compounds with surface-active properties, which can participate and possibly control the growing particle population.


Early Career Scientist

YES, I am an early career scientist.
Identification of Different Generation Oxidation Products: Secondary Organic Aerosol Formation from Aromatic Precursors (Toluene and m-Xylene)

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Author list (excluding presenting author)
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Abstract
Secondary organic aerosol (SOA) formed via the atmospheric oxidation of volatile/semi-volatile organic compounds (SVOCs) is well-known to comprise a significant fraction of fine particulate matter in urban areas. The identification of the oxidation products of biogenic precursors under different atmospheric condition such as high-/low-NOx, have been reported in number of studies. However, work on aromatic SOA precursors is very limited. In urban environments, aromatic hydrocarbons (e.g., benzene, toluene, xylene) contribute up to 30% of VOC emissions. These aromatic VOCs have been shown to account for significant fraction of SOA formed which can be substantially higher than biogenic SOA. Therefore, identification of significant SOA tracers and quantification of their ‘oxidation products’ from anthropogenic precursors could improve our knowledge on SOA formation processes as well as their key role in climate change and air quality. A potential aerosol mass (PAM) chamber was used to investigate the oxidised products from the photo oxidation of m-xylene and toluene. The experiments were carried out with OH radical as oxidant in the presence of high-/low-NOx and resultant aerosol samples were collected using quartz filters and analysed after a multi-step derivatisation approach (BSTFA+1%TMCS, PFBHA; derivatising agent) by GC×GC-TOFMS. Results show the oxidation products derived from both precursors included ring-retaining and -opening compounds while high number of ring-opening compounds were observed from toluene oxidation. SOA yields were higher for both precursors under high -NOx (toluene: 0.111; m-xylene: 0.124) than those observed for low-NOx (toluene: 0.089; m-xylene: 0.052), possibly linked to high OH concentrations during low-NOx experiments which may lead to high degree of oxygenation. DHOPA (dihydroxy oxopentanoic acid), a known SOA tracer for mono aromatic compounds, was also observed in both oxidation systems. In addition, the mass fraction of DHOPA in SOA from toluene oxidation was comparable to the value reported previously.

Early Career Scientist
NO, I am not an early career scientist.

IGAC Activities
ACAM: Atmospheric Chemistry and the Asian Monsoon

IGAC Regional Working Groups
MANGO: Monsoon Asia and Oceania Networking Group
Highly oxygenated organic molecules formation in the oxidation of limonene by OH radical: significant contribution of hydrogen abstraction pathway

Dr Hao Luo
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Author list (excluding presenting author)

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Abstract

Highly oxygenated organic molecules (HOM) play a pivotal role in the formation and growth of secondary organic aerosol particle. Their distribution, formation mechanism, and yields in the oxidation of common atmospheric VOC are fundamental to understand their contributions to SOA particle formation and growth. As an important biogenic monoterpene with the fourth largest emission rate and a common component in volatile chemical products, limonene and its oxidation derived HOM have potentially important role in SOA formation in both forested and urban regions. In this study, we report HOM formation in the oxidation of limonene by OH radical in the SAPHIR chamber (Simulation of Atmospheric PHotochemistry In a large Reaction chamber) measured by a high-resolution time-of-flight chemical ionization mass spectrometer with nitrate reagent ion (NO$_3^-$-CIMS). We performed analysis of complex mass spectra acquired and identified the distribution of HOM, including major monomers (C9-10) and dimers (C17-20), to classify them into various series. Numerous HOM, both closed-shell products and open-shell peroxy radicals (RO$_2$), were identified in low and high NO condition (0.06-0.2 ppb, 17 ppb). C10 monomers are the most abundant HOM products which account for over 80% of total HOM. The HOM formation pathways were proposed on the basis of observed RO$_2$ and known mechanisms. Particularly, the role of hydrogen abstraction by OH is highlighted, which is compared with the role of the OH addition pathway quantitatively. The molar yields of HOM were estimated at low and high NO conditions, respectively.

Early Career Scientist

YES, I am an early career scientist.

IGAC Regional Working Groups

China Working Group
Session 1 Poster

NO3 radical suppresses new particle formation from biogenic precursor gases

Ph.D Candidate DANDAN LI
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Abstract

More than half of cloud condensation nuclei (CCN) are formed through gas-to-particle conversion of oxidation products, a process called new particle formation (NPF). It is well established that highly oxygenated organic molecules (HOMs) play an important role both in nucleation itself and in particle growth, either alone or by stabilizing sulfuric acid clusters. HOMs are formed from the gas-phase oxidation of biogenic and anthropogenic volatile organic compounds (VOCs) through multiple autoxidation reactions of peroxy radicals (RO2). The resulting aerosol particles, called secondary organic aerosol (SOA), are the largest source of organic aerosol which accounts for up to 90% of the total aerosol load. While HOM production occurs all day long, NPF involving organic species during nighttime is not commonly observed. The mechanism suppressing NPF at night remains unknown, although it is suspected that NO3 chemistry may play a role.

Here, we examined the reactivity of monoterpenes with NO3 radicals and the influence of these reactions on NPF through laboratory experiments and field observation. An Orbitrap mass spectrometer with ammonium chemical ionization (NH4+) was used to determine the chemical composition of neutral gas-phase oxygenated VOCs (OVOCs).

We observed that nitrate radical (NO3) chemistry inhibits NPF during the oxidation of monoterpenes, and thus NPF at night. Nitrooxy peroxy radicals formed from NO3 chemistry suppress the production of ultra-low volatility organic compounds (ULVOCs) responsible for NPF, i.e., the dimeric compounds formed from the RO2 bimolecular reaction. Ambient observations further confirm that when NO3 chemistry is involved, NPF is completely turned off. Overall, these findings explain the frequent suppression of nocturnal NPF in monolipene-dominated environments.

Early Career Scientist

NO, I am not an early career scientist.
Session 1 Poster

Cl-CRM - Determining chlorine reactivity in the troposphere

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Abstract

Atomic chlorine radicals (Cl), generated by the tropospheric cycling of inorganic reservoir species such as HCl and ClNO$_2$, are efficient oxidants of both organic and inorganic species thought to play a potentially significant role in a number of tropospheric processes including, but not limited to, the control of ozone and nitrogen oxides budgets and the determination of greenhouse gas lifetimes such as methane. Compared to our knowledge of other oxidants however, our current understanding of the tropospheric Cl budget is poor with estimated global concentrations spanning several orders of magnitude. Rigorous observational constraints are therefore required to better ascertain the impact of Cl in the aforementioned processes. Due to the high reactivity of Cl, its tropospheric concentrations are too low to be measurable using existing techniques. Instead, our understanding of Cl sources and sinks must be used to estimate its steady-state concentration. Here, we present the development of an instrument to directly measure the atmospheric loss rate of Cl, or Cl reactivity, utilising the comparative reactivity method (CRM). Such measurement will directly test our understanding of Cl reaction pathways and provide a key constraint on our current understanding of tropospheric Cl chemistry.

Early Career Scientist

YES, I am an early career scientist.
Applying known chemical kinetics data to model atmospheres of extrasolar planets

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Author list (excluding presenting author)
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Abstract

Chemical kinetics data are used in many fields of science. In air quality, these data are used to describe the transformation of primary pollutants into secondary pollutants, while in combustion, some of the same data are used to describe the degradation of fuels. When chemical kinetics data are obtained, they are usually obtained with a specific application in mind. However, new applications could be found, and here we present two such applications in the field of astrophysics, specifically the study of extrasolar planets (exoplanets). We show (1) how combustion chemical kinetics data are used to study the atmospheric composition of so called hot Jupiters (Jupiter-size exoplanets orbiting very close to their host star), and (2) how Earth's air quality chemical kinetics data are used to model the atmospheres of rocky exoplanets.

We share results from the 3D coupled hydrodynamics-radiation-chemistry model, the Met Office Unified Model, adapted to simulate exoplanetary atmospheres. First, we discuss the simulated distribution of major chemical species in the atmosphere of hot Jupiter HD 189733b in the context to existing telescope observations. Second, we present a scenario, where rocky exoplanet Proxima Centauri b (that orbits the star closest to our Sun) has a N₂-O₂-dominated atmosphere, and predict what ozone and NO₂ distribution might look like in such a scenario. By showing these examples, we hope to spark interest in an interdisciplinary collaboration between atmospheric chemists and astronomers.

Early Career Scientist

YES, I am an early career scientist.
Session 1 Poster

Relationships between supermicrometer particle concentrations and cloud water sea salt and dust concentrations: Analysis of MONARC and ACTIVATE data

Dr. Marisa E Gonzalez
University of Pretoria, South Africa. University of Arizona, USA

Author list (excluding presenting author)

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Abstract

This study uses airborne field data from MONterey Aerosol Research Campaign (MONARC: northeast Pacific - summer 2019) and Aerosol Cloud meTeorology Interactions oVer the western ATlantic Experiment (ACTIVATE: northwest Atlantic – winter and summer 2020) to examine relationships between giant cloud condensation nuclei (GCCN) and cloud composition to advance knowledge of poorly characterized GCCN-cloud interactions. The analysis compares cloud water composition data to particle concentration data with different minimum dry diameters between 1 and 10 µm (hereafter referred to as GCCN) collected below and above clouds adjacent to where cloud water samples were collected. The northeast Pacific exhibited higher GCCN number concentrations above 1 µm, but with a sharper decline to negligible values at higher minimum diameters (5-10 µm) as compared to the northwest Atlantic. Vertical profiles of GCCN data revealed the larger influence of sea salt with major reductions above typical boundary layer heights for both regions. Interrelationships between GCCN and cloud water composition revealed the following major conclusions: (i) sub-cloud GCCN data are better related to cloud water species concentrations in contrast to above-cloud GCCN data owing to overwhelming influence of sea salt relative to dust; (ii) GCCN number concentrations at the lowest (highest) minimum dry diameters were best related to cloud water sea salt concentrations for the northeast Pacific (northwest Atlantic) in part due to hardly any GCCN above 5 µm for the northeast Pacific; (iii) the northwest Atlantic exhibited stronger near-surface winds and turbulence linked to the enhanced levels of larger GCCN and the stronger relationship with cloud water sea salt levels; and (iv) linear regression models have marginal success in predicting cloud water sea salt levels. This study demonstrates feasibility in relating cloud water chemical data with supermicrometer particle data to provide insights about GCCN-cloud interactions, with results relevant to designing future lab, modeling, and field studies.

Early Career Scientist

YES, I am an early career scientist.

IGAC Regional Working Groups

ANGA: African Group on Atmospheric Sciences
Studies for Atmospheric Mercury Using Stable Isotope Ratio Measurement

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National Institute for Minamata Disease, Japan

Abstract

Atmospheric mercury is a mixture of gaseous mercury from variety of sources. Thus, concentration measurements alone have limitation to understand its source identification and processing information. Measurements of naturally occurring stable isotopic compositions of mercury potentially allow us to gain more detailed information into mixing states. At the National Institute for Minamata Disease, we are conducting stable isotope researches of mercury using a multicollector-ICP-MS. In this presentation we introduce the brief overview of our progress on atmospheric mercury research; development of sampling and analytical techniques, the source studies for biomass burning and man-made mercury-contained products, and laboratory studies for mercury oxidation in the gas-phase.

Measurements of total gaseous mercury from open grass field burning in the Aso region, Kumamoto, Japan showed the elevation of atmospheric total gaseous mercury concentrations by factor or three or more. The stable isotope ratios showed lighter compositions in D199Hg and d200Hg than 0 ‰, and the observations approximately coincided to the isotope ratios of mercury in plants reported to date.

Measurement results of stable isotope ratios of mercury in thermometers were very similar isotopic compositions to those of mercury reported for cinnabar ores and elemental mercury, and the differences were insignificant. Meanwhile, the stable isotope ratios of gaseous and adsorbed mercury in fluorescent tubes showed very unique values, indicating their potential for the fingerprinting use.

Preliminary results from the laboratory studies for isotope fractionation during the reaction of gaseous elemental mercury with OH radical exhibited very unique mass independent isotope fractionation; odd mass and the mass 204 isotope ratios of the remaining gaseous elemental mercury were enriched with heavy isotopes, while the mass 200 isotope ratio was significantly depleted with heavy isotopes.

Even though the studies are limited currently, the results still demonstrate the usefulness of mercury isotope ratios in the mercury cycle research.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities
Session 1 Poster

Influence of NO\textsubscript{x} and NO\textsubscript{3} radicals on cloud condensation nuclei activity of monoterpenes secondary organic aerosols

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Abstract

Nitrogen oxides emitted by anthropogenic sources can potentially affect the cloud condensation nuclei (CCN) activity of biogenic secondary organic aerosols (BSOA), but the specific impact is still unclear. Moreover, the CCN activity of atmospheric relevant organic nitrates, important components of SOA formed in the presence of NO\textsubscript{x} and NO\textsubscript{3}, is largely unknown. In this study, we investigated the CCN activity of BSOA formed from photo-oxidation of two monoterpenes (α-pinene and limonene) at different NO\textsubscript{x} levels (NO: <0.20 to 20 ppb), as well as BSOA generated in the dark by reaction of limonene and NO\textsubscript{3}. And We use the hygroscopicity parameter κ to characterize the CCN activity of aerosols.

Under photo-oxidation conditions, we derived the κ value of total organic aerosol and organic nitrates in the low and high NO\textsubscript{x} condition for both α-pinene and limonene systems. We found that NO\textsubscript{x} has negligible effects on the CCN activity of BSOA via photo-oxidation. We also measured the κ value of BSOA formed in the reaction of limonene with NO\textsubscript{3} under dark conditions. The κ values of organic nitrates formed in the photo-oxidation agree within experimental uncertainties, the κ values of BSOA were significantly lower compared to photo-oxidation conditions. This indicates that NO\textsubscript{3} oxidation at night and subsequent BSOA formation can reduce the CCN activity of BSOA compared with BSOA produced via photo-oxidation.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon

IGAC Regional Working Groups

China Working Group
A modified prewhitening method for long-term trend analysis of atmospheric aerosols at a remote high-altitude site in the Indian central Himalaya.

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U.C. Dumka (1); R.K. Hooda (2)

Abstract
In combination with Sen's slope, the non-parametric Mann–Kendall (MK) test is one of the most often used statistical techniques for determining a time series' trends. A serially uncorrelated time series is required for the MK test since the autocorrelation in the dataset seriously affects the type 1 and type 2 errors and reduces the performance of the MK test in detecting the statically significant trend. To mitigate this problem, numerous prewhitening techniques have been developed that effectively reduce lag-1 autocorrelation. In this work, the advantages and disadvantages of several prewhitening approaches are analyzed using Monte-Carlo simulation, and a novel method is devised with low sensitivity to type-1 error, high test power, and an unbiased slope estimate for a statistically significant trend. Additionally, we reported long-term trend analyses of temperature and total aerosol particle number concentration as well as black carbon (BC), PM$_{2.5}$, and PM$_{10}$ mass concentration measurements at a high-altitude site in the Indian central Himalaya.

Early Career Scientist
YES, I am an early career scientist.

IGAC Activities
Iron carboxylate photochemistry as a particle phase radical source and feedbacks to gas phase nitrogen oxides and iodine

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Abstract

Dissolved iron is ubiquitously present in atmospheric particles. It results from both anthropogenic sources and natural mineral dust emissions after processing by acidic species. A considerable fraction of soluble iron(III) is present as iron-carboxylate complexes, which can absorb light in the UV-A or visible range. Ligand to metal charge transfer leads to iron(II) and oxidation of the ligand, setting off a radical oxidation sequence and Fenton chemistry that affects the life-time of organic species in the aerosol phase but also feeds back to gas phase composition. We use a range of laboratory experiments spanning from scanning transmission X-ray microscopy to coated wall and aerosol flow tubes to study the photochemistry of iron(III)-citrate (Fe-cit), its impacts on the evolution of the organic matter, and on the links with nitrogen oxides and iodine chemistry. We show that Fe-cit photochemistry leads to substantial reduction of nitrogen dioxide (NO$_2$) to HONO, which we suspect to occur via the reaction of NO$_2$ with hydroperoxy radical (HO$_2$) and decomposition of peroxynitrate. On the other hand, Fe-cit photochemistry leads to a reduction of iodate, demonstrated by the formation of I$_2$, which we suspect to be initiated by the reaction of H$_2$O$_2$ with iodate. This could represent one of the missing iodine recycling processes in the atmosphere. A kinetic process model is used to discern effects of mass transport and chemical reaction in the flow tube experiments. We use the explicit aqueous-phase chemistry model CAPRAM to assess the atmospheric implications.

Early Career Scientist

NO, I am not an early career scientist.
Tropospheric and Stratospheric Photolysis CF₃CHO: When is CF₃CHO a Source of HFC-23?

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Author list (excluding presenting author)

Ole John Nielsen (1)

Abstract

Trifluoro acetaldehyde, CF₃CHO, is an atmospheric degradation product of several chlorofluorocarbon (CFC) alternatives, e.g., CF₃CH₂CF₂H (HFC-365mfc) (~100% yield), and E-CF₃CH=CHF (HFO-1234ze) (100% yield). Atmospheric photolysis of CF₃CHO is thought to proceed through three principal pathways:

(1) CF₃CHO + hν → CF₃ + HCO
(2) CF₃CHO + hν → CF₃H (HFC-23) + CO
(3) CF₃CHO + hν → CF₃ + CO + H

There is conflicting information on the CF₃CHO photolysis in the literature. E.g., Campbell et al. (DOI 10.21203/rs.3.rs-199769/v1) recently announced that they have observed a 308 nm - quantum yield of Φ₂ = 0.010 ± 0.005, meaning that actinic photolysis of CF₃CHO would be a source of CF₃H. CF₃H (HFC-23) has a large global warming potential of GWP₁₀₀ =12,960. It is important to establish the yield of CF₃H in the tropospheric photolysis of CF₃CHO. Photochemical production of HFC-23 would in effect present a significant additional secondary contribution to the radiative forcing of climate from the parent CFC alternatives.

We have conducted chamber studies, investigating the photolysis kinetics and products of CF₃CHO under separate photolysis conditions using either broadband actinic [2] or 254 nm UV-C radiation. Actinic photolysis produces CF₃ radicals in a yield of unity, which under atmospheric conditions gives dominantly COF₂. No formation of CF₃H was observed using actinic radiation in contradiction to results published most recently. Photolysis using 254 nm radiation yields CF₃H in detectable amounts, in addition to CF₃ radicals. The photochemical lifetime of CF₃CHO and the CF₃H yields is evaluated for surface to lower stratosphere atmospheric conditions and discussed in context of the environmental impact of CFC substitutes.

References


Early Career Scientist

NO, I am not an early career scientist.
O:C ratios from pyrolytic aerosol: What do we know about the continuum from emission to aged aerosol?

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Author list (excluding presenting author)

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Abstract

Trace constituents of the atmosphere that originate with the combustion of solid biomass undergo disparate processes. These include pyrolysis or degradation of the solid matrix; release of pyrolytic material; gas-phase reactions between oxidizers and the pyrolytic material at elevated temperature near the flame; and reactions between oxidizers and pyrolytic material during atmospheric transport. Gases and particles that undergo these processes constitute a large fraction of reactive organic carbon in the atmosphere, yet little is known about oxidative transformation during the initial segments of their journey. We summarize what is known about O:C ratios measured in pyrolysis, in plumes near sources, and in aged aerosol with a combination of literature review and unpublished measurements. We address whether O:C ratios can be explained throughout this continuum, or whether there are as of yet unidentified transformations.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Regional Working Groups

Americas Working Group
Session 1 Poster

Tropospheric Bimolecular Sinks of Criegee intermediates Derived from Hydrofluoroolefins

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Author list (excluding presenting author)

Dr Joseph Beames (1)

Abstract

This computational study investigates the chemistry of a range of Criegee intermediates that emerge from the reaction between ozone and hydrofluoroolefins (HFOs), a now widely available group of halogenated alkene refrigerant, designed to replace the existing HFC and HCFC range of coolants. HFOs are now widely available and in circulation as refrigerants and insulation foam, and, in areas of commercial production and significant use, HFOs have been found to have a sizeable tropospheric abundance. The >C=C< bond makes HFOs most susceptible to these chemical loss mechanisms, including ozonolysis, and the increase HFO emissions in recent years, often in ozone-rich urban areas, it is likely to increase the atmospheric population of hydrofluoroolefin-derived stabilised Criegee intermediates (HFO-sCIs).

The main role of this study is to show the substantial change in sCI bimolecular chemistry caused by the introduction of haloalkyl or halogen sCI substituent groups. sCIs are widely studied in the atmospheric chemistry literature because these short-lived intermediates can react with a large variety of other atmospheric species, as well as fragment to produce OH radicals. To show the effect of this halogenation on sCI chemistry, the reaction of various atmospheric species with syn- & anti-CF₃CHOO and syn- & anti-CF₃CFOO (derived from prominent HFOs: CF₃CF=CH₂, E-CF₃CH=CHCl & E-CF₃CH=CHF). This tropospheric co-reactants studied here include other HFO secondary products (e.g. CH₂O and TFA), molecules with a large atmospheric abundance (water), and tropospheric species known to significantly deplete sCIs (HNO₃ & HCl).

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities
Session 1 Poster

Mathematically Representing Spatial Representation Errors in Satellite Retrievals

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Abstract

A critical error in the satellite-based observations or model-based fields is from unresolved spatial variability in trace gas concentrations within a satellite pixel or a model grid (Souri et al., 2022). The amount of spatial variability which is unresolved, or the representation error, can in principle be modeled if we base our reference on a distribution map made from a high spatial resolution dataset. We developed a method based on modeling isotropic semivariogram to quantify the amount of spatial information lost for different ground pixel sizes and length scales. Our method is compelling to understand and easy to apply to other products and different atmospheric environments. We developed an open-source package called SpaTial Representation Error EstimaTor (STREET) (https://github.com/ahsouri/STREET) based on this approach for everyone to use.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

AMIGO: Analysis of eMissions using Observations
Session 1 Poster

Elucidation of the Structures and Formation Mechanism of Dimer Esters in α-Pinene and β-Pinene Secondary Organic Aerosol

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Abstract

Multifunctional dimer esters have been identified using advanced mass spectrometric techniques as significant components of secondary organic aerosol (SOA) formed from oxidation of α-pinene and β-pinene, and have been implicated as key players in new particle formation and growth, particle viscosity, and cloud condensation nuclei (CCN) activity. Particle-phase reactions of closed-shell monomers (e.g., esterification and peroxyhemiacetal/diacyl peroxide decomposition) and gas-phase reactions involving early-stage oxidation products and/or reactive intermediates [e.g., stabilized Criegee intermediates (SCIs), carboxylic acids, and organic peroxy radicals (RO₂)] have been advanced as possible dimer ester formation pathways. Due to a lack of authentic standards, however, structures of the dimer esters are inferred from accurate mass/fragmentation data and, therefore, mechanistic understanding of their formation remains unconstrained. Here, informed by detailed structural analyses (MS and MS/MS, ¹³C and ¹⁸O isotopic labeling, and H/D exchange) from current and past work (Kenseth et al., PNAS, 2018), we synthesize the first authentic standards of several major dimer esters identified in SOA from ozonolysis of α-pinene and β-pinene and elucidate their formation mechanism from a series of targeted environmental chamber experiments using chemical ionization mass spectrometry (CIMS) and liquid chromatography/electrospray ionization mass spectrometry (LC/ESI-MS) for respective analysis of gas- and particle-phase molecular composition. Identification of the chemistry underlying dimer ester production provides a missing link tying the atmospheric degradation of α-pinene and β-pinene to the observed formation of low-volatility compounds capable of driving particle formation and growth.

Early Career Scientist

YES, I am an early career scientist.

IGAC Regional Working Groups

Americas Working Group
Morphology and hygroscopicity of nanoplastics in sea spray determined by humidified tandem differential mobility analysis coupled to high-resolution time-of-flight aerosol mass spectrometry

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Author list (excluding presenting author)

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Freja Hasager (1);
Andreas Massling (2);
Marianne Glasius (1);
Merete Bilde (1)

Abstract

The environmental detection, fate, and transport of micro- and nanoplastics is becoming a topic of great interest in environmental chemistry, atmospheric chemistry, and public health. The presence of microplastics (diameter < 5 mm) in living tissue suggests a strong potential for numerous adverse health effects. Plastic particles accumulate in the ocean and recent works suggest that they can be transferred to the air with sea spray through wave-breaking action. The role of airborne nanoparticles (diameter < 1000 nm) in atmospheric chemistry and public health is largely controlled by particle size, morphology, and surface composition and coatings. Size-resolved aerosol mass spectrometry provides real-time characterization of submicron atmospheric particles. However, the analysis of nanoplastics in complex aerosol mixtures such as sea spray is severely limited by challenges associated with the detection limit of the instrument as well as the high background signal of the aerosol matrix. In this work we characterize the internal and external mixing state of sea spray aerosols spiked with nanoplastics. A humidified tandem differential mobility analyzer is used as a size and hygroscopicity filter, separating the nanoplastics from the sea spray, and an inline high-resolution time-of-flight aerosol mass spectrometer is used to characterize particle composition and internal mixing state. Aerosol from both synthetic and near-shore samples was internally and externally mixed. Aerosol enrichment and coating have a profound impact on aerosol hygroscopic water uptake and humidified size distributions, impacting aerosol efficiency in nucleating cloud drops and the oxidative aging of the particles. This work broadly contributes to the growing understanding of the detection, morphology, and hygroscopicity of micro- and nanoplastics in the lower atmosphere and their impact on the environment and the earth system.

Early Career Scientist

NO, I am not an early career scientist.
Session 1 Poster

Effects of photochemical aging on biomass burning aerosol properties: from field and laboratory observations

Dr. Huihui Wu
University of Manchester, United Kingdom

Author list (excluding presenting author)

Huihui Wu1, Jonathan W Taylor1, Justin M Langridge2, Kate Szpek2, Chenjie Yu1,†, Aristeidis Voliotis1, James D Allan1,3, Michael I Cotterell‡,§, Paul I Williams1,3, Michael Flynn1, Jim Haywood2,4 and Hugh Coe1

Abstract

Biomass burning (BB) is a globally significant source of trace gases and carbonaceous particles in the atmosphere, which have important climate impacts but are poorly constrained. This study will combine in-situ airborne measurements conducted in African wildfire regions and BB simulation experiments conducted in the Manchester Aerosol Chamber, to investigate the emissions and evolution of BB aerosols, regarding their chemical, physical and optical properties.

Some main findings include: The evolution of some aerosol optical properties with photochemical aging (e.g., the absorption angstrom exponent (AAE) and the mass absorption coefficient (MAC_{BC})) is dependent on fire conditions and initial aerosol properties. The observations of more flaming-controlled burning indicate an initial enhancement stage of AAE and BrC absorptivity, followed by a decrease with longer aging times, while more smoldering fires are suggested to have higher AAE and BrC absorptivity at emission and BrC net loss upon aging. The observed evolution of BrC absorptivity is due to a combination of secondary organic aerosol (SOA) production, oxidation of primary OA mass, and photobleaching loss. These results suggest different treatments of aerosol properties from different types of fires and their downwind evolution should be considered when modelling regional radiative forcing. We will also present the analysis of BC microphysical properties (BC sizes and coating thickness) and the link between chemical and optical properties.

Early Career Scientist

YES, I am an early career scientist.
Session 1: Poster

Insights into the organic complexation of Fe in like-Fenton reactions and implications on atmospheric oxidation cycles

Daniele Scheres Firak
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Author list (excluding presenting author)

Thomas Schaefer (1); Hartmut Herrmann (1)

Abstract

In the atmospheric clouds and aerosols, short-lived radicals are formed in photo-mediated processes and like-Fenton reactions, the latter consisting in the Fe-catalyzed decomposition of H$_2$O$_2$ into hydroxyl radical (HO$^\cdot$). Iron does not occur free in the atmospheric aqueous phase due to the presence of organic ligands, such as (poly)carboxylic acids and humic substances. Organic complexation enhances the solubility of Fe in aerosols and affects its reactivity towards H$_2$O$_2$. The mechanisms that lead to the formation of reactive species during like-Fenton processes in the presence of Fe ligands are still debatable and involve the formation of HO$^\cdot$ and higher valence Fe states. Spin-trapping is a technique used to monitor the formation of short-lived radicals through the reaction between these species and an organic compound, forming a stable adduct with activity in electron paramagnetic resonance (EPR). This investigation uses EPR in an effort to provide insights into the like-Fenton process, a key reaction taking part in atmospheric oxidation cycles. In this work, 5,5-Dimethyl-1-pyrroline N-oxide (DMPO) was used as the spin-trapping agent, and reactions were investigated in a Fe: H$_2$O$_2$ ratio of 1:10 in the presence of oxalate (OXL), citrate (CIT), malonate (MAL), and tartrate (TAR). Since the total production of HO$^\cdot$ was limited by the Fe concentration, control experiments in the absence of organic ligands were optimized to produce HO$^\cdot$ concentrations close to the initial Fe concentration. Upon addition of increasing concentrations of organic ligands, decreasing rate constants for the formation of the DMPO-OH adduct were observed, although not always accompanied by a decrease in the yields of HO$^\cdot$. The decrease in HO$^\cdot$ yields followed the stability constants for the formation of Fe(II) complexes, CIT > OXL > TAR ≈ MAL. These results can be associated with the inhibition or modification of the H$_2$O$_2$ degradation mechanism.

Early Career Scientist

YES, I am an early career scientist.
The Tropospheric Ozone Assessment Report (TOAR): Exploiting modern IT concepts, from web services to machine learning, for the integration and exploration of global ozone observations

Dr. Owen R Cooper
Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder, USA. NOAA Chemical Sciences Laboratory, Boulder, Colorado, USA

Abstract

The Tropospheric Ozone Assessment Report (TOAR) is a highly successful IGAC Activity with a mission to provide the research community with an up-to-date scientific assessment of tropospheric ozone’s global distribution and trends from the surface to the tropopause. The first phase of TOAR (2014-2019) produced an open-access database with easily accessible web services to evaluate ozone metrics at all available monitoring sites worldwide, affording scientists the first observation-based view of the global surface ozone distribution. TOAR-I also included the first comprehensive multi-annual evaluation of different satellite retrievals of tropospheric ozone. A team of scientists in the USA has recently merged the TOAR surface ozone observations with output from an ensemble of global atmospheric chemistry models to generate ozone exposure maps spanning 1990-2017. This product was used by Global Burden of Disease to improve their estimates of human mortality due to long-term ozone exposure. TOAR is now at the midpoint of its second phase (TOAR-II, 2020-2024), with active participation from over 150 scientists from 31 nations. Through the formation of 14 working groups, TOAR-II will produce an updated assessment of tropospheric ozone’s global distribution and trends, and also aims to quantify the impacts of ozone on climate, human health and vegetation. New developments at Forschungszentrum Jülich, where the TOAR database is hosted, include the design of a novel web service architecture to link atmospheric measurements with geographical and numerical weather model data, and the exploration of state-of-the-art machine learning concepts for gap filling and predictions of surface air quality levels. Through the enhanced data storage and analysis capabilities we aspire to become a showcase for FAIR (Findable, Accessible, Interoperable, and Reusable) and open data and science in the global atmospheric chemistry domain.

Early Career Scientist

NO, I am not an early career scientist.
Session 2 Invited

Prediction of Secondary Air Pollutants: Progresses and Perspectives

Professor Xuemei Wang
Institute for Environmental and Climate Research, Jinan University, China

Author list (excluding presenting author)
Zhenhao Lin (1); Liqing Wu (1); Fenghua Yan (2); Weihua Chen (2); Bin Yuan (2); Min Shao (2)

Abstract

As the critical secondary air pollutants, ozone (O₃) and secondary organic aerosol (SOA) are key factors influencing the air quality in China. However, accurate prediction of O₃ and SOA is still challenging. In recent years, large varieties of improvements have been performed for the prediction of O₃ and SOA. The improvements of O₃ prediction mainly included the development and adoption of 1) more accurate emission inventories of anthropogenic and biogenic volatile organic compounds (VOCs), as well as nitrogen oxides (NOx), 2) up-to-date land use data, 3) the influence of fine particulate matter (PM₂.₅) on photolysis rates of related pollutants and the uptakes of NOx and HO₂, 4) synergistic mechanism of biogenic VOCs (BVOCs) and soil nitrogen, and 5) the production of Cl species and their reaction with VOCs. On the other hand, in addition to accurate VOC emissions, particularly aromatic emissions, the prediction of SOA was greatly improved through 1) the updated SOA yields of VOCs with the consideration of the wall loss of SOA in chambers, 2) emissions and chemical degradation for other missing key precursors, such as semi-volatile and intermediate volatility organic compounds (S/IVOCs), 3) other oxidation pathways of precursors like NOₓ, O₃ and Cl involving reactions, 4) aqueous-phase mechanism of some intermediate products including glyoxal and methylglyoxal. However, further efforts are still needed for the better prediction of O₃ and SOA as emissions of precursors and parameters for O₃ and SOA formation are still highly uncertain and some mechanisms that are probably important still need exploration. For example, parameters within the SOA prediction module such as aqueous-uptake coefficient and the yield of SOA, and parameters within O₃ prediction module such as the branching ratio of cresol and bicyclic peroxy radical pathways as well as the total reactivity of VOCs are still far from accurate.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities


IGAC Regional Working Groups

China Working Group
Session 2 Oral

New fire and lightning schemes in the Canadian atmospheric global climate model (CanAM)

Dr Cynthia Whaley
ECCC, Canada

Author list (excluding presenting author)

Courtney Schumacher (2); David Plummer (1); Vivek Arora (1); Joe Melton (3); Ayodeji Akingunola (1); Jack Chen (4); Paul A. Makar (4); Kerry Anderson (4); Knut von Salzen (1); Jason Cole (1); Montana Etten-Bohm (2)

Abstract

Wild fires are a complex but important process to include in earth system models (ESMs). They have significant impacts on climate via emission of short-lived climate forcers (SLCFs); changes to weather and clouds; deposition of particulate matter on ice and snow, lowering albedo; and changes to vegetation biomass and distribution. In turn, climate and climate change impact wildfires to a large degree by creating fire conditions via lightning ignition; increased temperatures, and sometimes drier conditions; northward migration of vegetation; and changes to wind patterns. Lightning itself is an indirect source of SLCFs given that it produces NOx – a tropospheric ozone precursor – in the atmosphere, and it is responsible for igniting a significant portion of wildfires as mentioned above. Lightning is also expected to increase with climate change in several regions, including the northern mid-latitudes.

The interactive feedbacks between lightning, fire, climate, and atmospheric composition require processed-based interactive modelling between the land surface and the atmosphere in order to answer the questions “How will wildfire emissions change in future climates?” and “How will changes in future fires regimes impact air quality and climate?”

In this study, we integrated new components of the Canadian Forest Fire Emission Prediction System and a logistic regression lightning parameterization into Canada’s Atmospheric Model, CanAM5.1. Prior to this work, the fire simulations in CanAM were only partially interactive with the atmosphere. For example, lightning came from a climatological input file instead of the atmospheric model, and plume height in the atmospheric model was determined from a climatology as well. For wild fires, this set up did not allow for interactions between atmosphere and land, nor was it predictive of changes into the future. This presentation will explain the upgrading of the lightning and fire schemes in CanAM5.1 and show the results of its first interactive runs.

Early Career Scientist

NO, I am not an early career scientist.
Session 2 Oral

Obtaining a high-resolution OMI-NO₂ product over South America using Generative Adversarial Networks

Santiago Parraguez
Laboratory for Modelling and Observation of the Earth System (LAMOS), Institute of Environmental Physics (IUP), University of Bremen, Bremen, Germany. Center for Climate and Resilience Research (CR2), Santiago, Chile. Departamento de Ingeniería Mecánica, Facultad de Ciencias Físicas y Matemáticas, Universidad de Chile, Santiago, Chile

Author list (excluding presenting author)
Laura Gallardo (2, 4); Axel Osses (2, 5, 6); Viviana Meruane (3)

Abstract

Nitrogen oxides are heterogeneously distributed in both space and time due to their short atmospheric turn-over time and the variable distribution of their sources and sinks. Further, nitrogen dioxide (NO₂) has a chemistry-mediated climate impact through nitrate aerosols, ozone, and thus, methane. Therefore, it is fundamental to monitor this trace gas concentration in high resolution. Since 2004, the Ozone Monitoring Instrument (OMI) onboard Aura has provided global daily measurements of NO₂, with a spatial resolution of 12x24 km². Additionally, since 2017, the Tropospheric Monitoring Instrument (TROPOMI) onboard the Copernicus Sentinel-5 Precursor (S5P) has extended the observations with a resolution of 7x3.5 km².

In this work, we use a Deep Learning approach to improve the spatial resolution of OMI NO₂ fields over South America, based on supervised adversarial learning carried out over a Residual Network. The model successfully improves low-resolution data (OMI, 25x25 km²) into a high-resolution product (6.25x6.25 km²) after being trained using the latent information assimilated from TROPOMI data. A stochastic approach is proposed, training the model to infer parameters of a Gaussian distribution for each pixel maximizing the likelihood of finding the desired value. Our model outperforms a bicubic interpolation according to several error metrics while allowing to estimate the uncertainty of the prediction. In the first evaluations over central and southern Chile, the proposed approach obtained robust noise sensitivity results, maintaining its metrics almost constant for noises up to 10%, always better than the base case. Since the methodology has been proven to be adequate, our work considers the application to reconstruct the OMI NO₂ v3 product for South America for the period 2005-2021.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

AMIGO: Analysis of eMissions using Observations

IGAC Regional Working Groups

Americas Working Group, Southern Hemisphere Working Group
Impact of climate warming on atmospheric composition over the tropical Indian subcontinent: A key role of enhanced biogenic emissions

Meghna Soni
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Author list (excluding presenting author)
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Abstract

A rise in temperature can accelerate the rate of chemical reactions enhancing the production of tropospheric ozone ($O_3$) and secondary aerosols. The tropical Indian region is among the most populated regions of the world and a hotspot of anthropogenic emissions. In recent years, this region has been experiencing frequent heatwaves on top of its already warm and humid climate. Nevertheless, the impact of climate warming on atmospheric composition and chemistry remains uncertain over the tropical Indian subcontinent. In this regard, we have combined state-of-the-art measurements from the Proton Transfer Reaction-Time of Flight-Mass Spectrometer (PTR-TOF-MS) and other online analysers with a detailed photochemical model (Master Mechanism). In response to a change in temperature from 10 to 40 °C, the model revealed large enhancements (by 20–35 ppbv) in the noontime $O_3$ due to faster reactions. An additional 8-12 ppbv of $O_3$ enhancement was simulated when an isoprene-temperature response factor was incorporated into the model. The impacts of temperature on $O_3$ varied and were stronger in the NOx-rich urban environments. To extend the analyses across the Indian subcontinent, the satellite-retrieved leaf area index is being updated in a regional model - Weather Research and Forecasting coupled with Chemistry (WRF-Chem). The study provides quantitative assessments on the roles of enhanced biogenic emissions on $O_3$ also via the land-cover change, besides faster chemistry in a warming climate. The findings of this study highlight the need to consider the effects of climate warming for planning strategies for cleaner air, particularly on the reductions of secondary pollutants in urban regions of India.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Session 2 Oral


Dr Melita Keywood
CSIRO, Australia

Abstract

Marine aerosol is globally one of the most important natural aerosol systems, contributing to the Earth’s radiative budget, biogeochemical cycling, impacts on ecosystems and regional air quality. In turn the Southern Ocean as one of the cleanest regions of the globe is often referred to as a proxy for the pre-industrial atmosphere. It is also a region where Earth System models show a strong bias in radiative forcing, attributed to the inability of these models to accurately simulate cloud frequency and phase over the Southern Ocean (Fiddes et al., 2022). While the past five years have seen an increase in the number of observation campaigns that will contribute data needed to resolve these biases (e.g. Humphries et al., 2021), observations of aerosol properties at the Kennaook/Cape Grim Baseline Air Pollution Monitoring Station (KCGBAPS) have been ongoing since the late 1970s, resulting in invaluable long term data sets of aerosol properties that provide temporal context for the recent shorter term campaign data and provide information to assess changes to Southern Ocean aerosol properties over time.

The KCGBAPS is located in the northwest of Tasmania Australia and for approximately 30% of the year samples air masses that have only passed over the Southern Ocean (known as baseline air). A preliminary assessment of the long-term (1978-2020) trend in the ultrafine particle number (CN3) concentrations indicates a slight, but significant increase in baseline CN3 concentrations (1.1% per year). The greatest rates of change occur during the Southern Hemisphere spring and summer seasons, with no increase observed over the 48 years during the winter months. In this presentation these insights into changes in the background marine boundary layer particle number concentration will be discussed in the context of trends observed at other background and regional locations.

Humphries 2021 https://doi.org/10.5194/acp-21-12757-2021
Fiddes 2022 https://doi.org/10.5194/acp-2022-259

Early Career Scientist

NO, I am not an early career scientist.

IGAC Regional Working Groups

Southern Hemisphere Working Group
Session 2 Oral

A Global Perspective Comparing Urban NMVOCs Measurements with Representation in Emission Inventories

Dr. Erika von Schneidemesser
IASS, Germany

Author list (excluding presenting author)

Brian C. McDonald (2), Hugo Denier van der Gon (3), Monica Crippa (4), Diego Guizzardi (4), Agnes Borbon (5), Pamela Dominutti (6), Ganlin Huang (7), Greet Jansens-Maenhout (4), Meng Li (8), Chang-Feng Ou-Yang (9), Jia-Lin Wang (10)

Abstract

Emissions inventories are a crucial part of air quality and climate modelling. Non-methane volatile organic compounds (NMVOCs) are key precursor compounds in ozone formation and secondary organic aerosol formation. Accurately representing NMVOCs in emission inventories is crucial to be able to reproduce air quality conditions in models, for understanding atmospheric chemistry, the impact of policy measures, and for climate projections. The challenge of improving NMVOCs in emission inventories and understanding how accurately these inventories represent real-world conditions is compounded by the lack of (long-term) measurements of NMVOCs, limited efforts on updating emission factors, and the variable reactivity of various NMVOCs which makes validation of the emission inventories and the assessment of the capacity of models to capture NMVOCs and accurately represent them difficult. Here we focus on evaluating the representation of urban NMVOC speciation in emission inventories at the global level. This study is an effort of the Global Emissions Initiative (GEIA) Working Group on NMVOCs and evaluates available measurements of NMVOCs from urban areas and their representation in the global emission inventory EDGARv4.3.2 (Huang et al., 2017). To facilitate a comparison, the ratios of individual NMVOCs to acetylene are used. Owing to limitations in measurement data and grouping of NMVOCs in emission inventories, the comparisons are limited to alkanes, alkenes, and aromatics. Results demonstrate poor agreement between the observations and emission inventories which could be related to incorrect speciation profiles and/or spatial allocation of NMVOC emissions to urban areas. By comparison, regional emission inventories show some agreement among the ratios. Further investigation into the dominant source sectors of the NMVOCs evaluated, as well as a comparison to regional inventories, provides some insights into why this might be the case.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

GEIA: Global Emissions Initiative
Session 2 Oral

Climate Responses to NOx Emission Reductions From Aviation During COVID-19 Lockdowns

Ms. Qi Ran
School of Atmospheric Sciences, Key Laboratory of Tropical Atmosphere-Ocean System, Ministry of Education, Sun Yat-sen University, Zhuhai, China., China. Department of Civil and Environmental Engineering, National University of Singapore, 1 Engineering Drive 2, 117576, Singapore, Singapore

Author list (excluding presenting author)

Shao-Yi Lee (1); Liya E.Yu (2,3); Wenjie Dong (1,4)

Abstract

Global tight restrictions of the movement have severely affected civil aviation during COVID-19 lockdowns, resulting in noticeable reductions in aviation-related NOx emissions worldwide. NOx is one of the most important emitted non-CO2 species from aircrafts, contributing to climate change via affecting the formation of ozone (O3) and destruction of methane (CH4). Climate responses to increases in NOx emission have been discussed extensively, while the explorations in abrupt decreases in NOx emission due to pandemic-induced global quarantine are still lacking. In this work, we quantify the location- and time-resolved emission reductions of aviation-related NOx due to the COVID-19 lockdowns based on open-access air traffic activity data. Then the Single Column Atmospheric Model Version 6 (SCAM6) with the tropospheric and stratospheric chemistry is used, to simulate the responses of atmospheric compositions and regional climate to the abrupt changes in both surface and elevated NOx emissions from aviation between 2019 and 2021. The simulations are conducted for three research locations at different latitudes (Singapore, Shanghai, China and Oslo, Norway), to consider the possible effects of geographical positions. We expect the large emission reductions of NOx from aircrafts can induce detectable changes in atmospheric CH4 and O3 concentrations, especially in the upper troposphere and lower stratosphere. Since CH4 and O3 have different lifetimes and opposite contributions to climate change during the NOx-CH4-O3 interaction, we expect time-dependent climate responses to their concentration changes caused by NOx emission declines.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

CCMi: Chemistry Climate Model Initiative

COVID-19 related abstracts

yes
Joint evaluation of European anthropogenic trace gas and aerosol emissions in 2016 using EURAD-IMs 4D-var data assimilation method

Dr. Philipp Franke
Forschungszentrum Jülich, Germany

Author list (excluding presenting author)

Anne Caroline Lange (1)

Abstract

Anthropogenic emissions are one of the key drivers of air quality. Yet, they are estimated with static temporal and spatial distribution functions. In a changing world, e.g. with flexible power generation due to the use of renewable energy and transitions in the mobility sector, these static emission data are not representative of true emissions anymore. Thus, in order to investigate air pollution the use of realistic emissions is inevitable. We present results of a comprehensive analysis of European anthropogenic emissions of trace gases and aerosols using the four dimensional variational data assimilation technique within the EURAD-IM chemistry transport model. The analysis was performed for the full year 2016 on 15 km x 15 km horizontal resolution. It shows a systematic underestimation of CO and NOx emissions in large parts of Europe. Emission corrections reduce the RMSE of CO- and NO2-concentrations of up to 60 % and 50 %, respectively. The ability to estimate emissions of unobserved species as NH3 and NMVOC is evaluated using satellite and ground based observations that are not used in the assimilation. Further, the analysis allows for identifying species and regions with limited observability, which leads to a reduced performance of the assimilation in these areas.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

AMIGO: Analysis of eMissions using Observations
Do current Earth System Models capture observed climate driven variation in secondary organic aerosol?

Dr Cat Scott  
University of Leeds, United Kingdom

Author list (excluding presenting author)


Abstract

Biogenic secondary organic aerosol (SOA) is formed as a result of the atmospheric oxidation of gas-phase biogenic volatile organic compounds (BVOCs). Here, we evaluate the ability of five European Earth System Models (CNRM-ESM2-1, EC-Earth3, IPSL-CM6, NorESM1.2, UKESM1) to capture the amount, and behaviour, of biogenic SOA in the atmosphere.

The ESMs cover a range of complexity in terms of their representation of the sources and processing of biogenic SOA (i.e., from a fixed climatology of SOA amount without interannual variation, to an interactive BVOC emission scheme followed by atmospheric processing).

We combine station measurements of BVOC emission and atmospheric BVOC concentrations with remotely sensed isoprene emission estimates to evaluate the models’ representation of the sources of biogenic SOA. We use organic aerosol mass and particle number concentration measurements from a number of forested sites to evaluate the ability of the models to capture the seasonal cycle in the amount of biogenic SOA present, as well as its impact on the aerosol size distribution. Whilst the models appear to capture the seasonal cycle in organic aerosol well for a boreal forest site, the ESMs consistently over-predict the amount of organic aerosol present at a tropical forest location.

Finally, we explore the ability of these models to capture the observed relationships between organic aerosol mass and temperature. We find that the ESMs equipped with vegetation models that generate BVOC emissions interactively are able to capture well the strength of the observed relationship between temperature and organic aerosol mass. This lends confidence to the ability of these ESMs to accurately represent changes in atmospheric composition driven by climate.

Early Career Scientist

NO, I am not an early career scientist.
Session 2 Oral

The IntelliAQ project - combining machine learning and air quality

Felix Kleinert
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Author list (excluding presenting author)
Clara Betancourt (1); Lukas H. Leufen (1); Cathy Li (1,2); Ankit Patnala (1); Scarlet Stadler (1) and Martin G. Schultz (1)

Abstract

Pollutants in the ambient air impact human health, agriculture and natural ecosystems. Within the IntelliAQ project, we develop and apply advanced machine learning tools for interpolation, prediction, and quality control of air quality information with special focus on ozone pollution. We fuel our machine learning methods with measured air quality data from the Tropospheric Ozone Assessment Report (TOAR) database. TOAR has collected near-surface ozone measurements, high-resolution geodata and numerical weather data at over 13,000 stations around the world and constitutes one of the world’s leading infrastructures for long-term air quality data. Within IntelliAQ, we work towards the following two objectives:
Firstly, we develop novel spatial and temporal interpolation methods to expand the coverage of historic and recent data and allow for more robust assessments of air pollution impacts. Secondly, we develop innovative air quality forecasting concepts; both based on machine learning algorithms.
Within this contribution, we present the achievements made during the first three years of IntelliAQ. One highlight is the first published ready to use air quality related benchmark dataset AQBench in conjunction with explainable machine learning for spatial high-resolution near-surface ozone mapping. A second focus so far has been on time-series prediction methods and tools, namely the scientific software framework MLAir (Machine Learning on Air data) that is now also being exploited by the AQ-WATCH (Air Quality: Worldwide Analysis and Forecasting of Atmospheric Composition for Health) consortium.
IntelliAQ combines cutting-edge knowledge on machine learning with in-depth expertise in atmospheric chemistry and meteorology. This unique set-up enables us to push the limits of what is possible with respect to air quality data analysis and forecasting.

Early Career Scientist
YES, I am an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report
Session 2 Oral

**Vertical Transport of Trace Gases and Aerosols: Contrasting WRF-Chem, CAM-chem, and MUSICAv0 Results with Field Campaign Observations**

Mary C Barth  
National Center for Atmospheric Research, USA  

**Author list (excluding presenting author)**  
Simone Tilmes (1)  
Gustavo Cuchiara (2)  
Megan Bela (3, 4)  
Genevieve Lorenzo (5)  

**Abstract**

The upper troposphere (UT) is a critical region for Earth’s climate because water vapor, ozone, cirrus clouds and aerosols in this region strongly contribute to radiative forcing of the climate system. Deep convective clouds provide an important and efficient mechanism for transporting boundary layer trace gases and aerosols to the UT. However, for soluble trace gases and aerosols, vertical transport can be offset by wet scavenging, an important process that removes constituents. Wet scavenging is affected by cloud physics processes, which is complicated by the presence of different types of cloud particles. As a result there are many uncertainties in representing wet scavenging in chemistry transport models (CTMs), which can lead to a poor representation of the vertical distribution of trace gases and aerosols in the troposphere.

Here, we investigate the capabilities of cloud-scale, regional-scale, and global-scale CTMs in representing vertical transport and scavenging of trace gases and aerosols for two aircraft field campaigns that occurred over the United States. We compare results from CTMs at different horizontal grid spacings: WRF-Chem at ~1 km, WRF-Chem at 12 km, CAM-chem at ~1 degree, and MUSICAv0, which is configured with ~14 km over the contiguous United States and 1 degree horizontal grid spacing outside this region with observations from the DC3 and SEAC4RS field experiments. Precipitation at the surface is evaluated to contrast each model’s ability to represent observed storms and vertical profiles of trace gases and aerosols in clear-air regions and convectively-influenced regions are examined. Preliminary analysis shows that cloud-scale simulations produce the best representation of precipitation for specific storm cases. However, when averaged over a region where convective activity takes place, the vertical profiles of CO, H$_2$O$_2$, and sulfate aerosol are fairly similar among models.

**Early Career Scientist**

NO, I am not an early career scientist.
Session 2 Oral

A first look at the diurnal variation of pollutant distributions over Asia using observations from the Geostationary Environment Monitoring Spectrometer (GEMS)

David Edwards
National Center for Atmospheric Research (NCAR), USA

Author list (excluding presenting author)

Sara Martinez-Alonso (1); Duseong Jo (1); Ivan Ortega (1); Louisa Emmons (1); Helen Worden (1); Jhoon Kim (2); the GEMS Team

Abstract

Over the last 20 years, low-Earth orbit (LEO) atmospheric composition observations have provided amazing satellite measurements of atmospheric pollutants, mainly at continental-to-global, weekly-to-seasonal scales. The new-generation geostationary (GEO) satellite perspective, with high spatial resolution and hourly measurements, represents a major step forward in capability for understanding how air quality processes change diurnally at the local scale. South Korea’s Geostationary Environment Monitoring Spectrometer (GEMS) was launched in February 2020 over Asia and is the first member of the GEO constellation that will eventually include the Tropospheric Emissions: Monitoring Pollution (TEMPO) mission over North America, and Sentinel-4 over Europe. The measurement hourly time resolution is truly the new perspective that the GEO platform provides, and in this presentation, we use a combination of satellite observations from GEMS and chemical transport model simulations to investigate the diurnal variation of pollution over several Asian regions. When considering the GEMS whole-Asia field-of-regard, the most striking impression of the NO2 diurnal variation is of how large it is in magnitude as well as how much the spatial distribution changes hour-by-hour. This questions our understanding of the distributions of reactive species based on the representativeness of once-a-day LEO observations. To help understand daily differences in diurnal patterns at regional and local scales, we use the Multi-Scale Infrastructure for Chemistry and Aerosols (MUSIC-V0). This uses a global modeling framework with regional grid refinement to resolve chemistry at emission and exposure relevant scales. The model shows reasonable agreement with the GEMS data and captures the different diurnal patterns at the different spatial scales and the degree of day-to-day variability. The model also allows the drivers of variability due to emissions, meteorology, and photochemistry to be considered separately. We further analyze the related chemical cycles between different nitrogen species and begin to compare these with the GEMS HCHO data.

Early Career Scientist

NO, I am not an early career scientist.
Session 2 Oral

Closing the VOC flux budget for a coniferous ecosystem

Dylan B. Millet
University of Minnesota, USA

Author list (excluding presenting author)

Michael P. Vermeuel (1); Delphine K. Farmer (2); Lauren A. Garofolo (2); Michael F. Link (2); Matson A. Pothier (2); Mj Riches (2); Sara Williams (2)

Abstract

Terrestrial ecosystems are the largest source and a major sink of reactive carbon for the global atmosphere, and these two-way fluxes are a key lever controlling tropospheric ozone, OH, reactive nitrogen, and aerosol budgets. Recent studies have reported active ecosystem-atmosphere fluxes for hundreds of organic species—far more than are included in current models. However, the impacts of such “missing” VOCs is not clear. Here, we present simultaneous ecosystem-atmosphere flux measurements over a Colorado pine forest using dual high-resolution mass spectrometers. The instruments employ H$_3$O$^+$ (PTR-TOF-MS) and I$^+$ (I-CIMS) chemical ionization, which together have been shown to capture the large majority of organic carbon loading and reactivity. We apply this unified dataset to characterize the VOC flux budget across the mass spectrum of both instruments, test how well that two-way exchange is captured in current models, and assess the importance of unrepresented VOCs. Compounds detected by PTR-TOF-MS account for most (>90%) of the net and upward ecosystem fluxes but only half of the deposition fluxes, which are 10-fold smaller than the upward fluxes. Upward carbon and OH reactivity fluxes are dominated by MBO and monoterpenes, and are well-represented by GEOS-Chem/MEGAN. Far more species are needed to account for the downward fluxes, which are strongly underestimated in the model. Sesquiterpenes account for nearly all of the ozone reactivity flux. We discuss implications of our results for current understanding and modeling of reactive biosphere-atmosphere exchange.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

AMIGO: Analysis of eMissions using Observations, GEIA: Global Emissions Initiative
**Session 2 Oral**

**Linking the composition of carbonaceous aerosols and trace gases: Insight from the EMeRGe aircraft campaigns in Europe and East-Asia**

Dr Adrien Deroubaix  
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**Author list (excluding presenting author)**

John Burrows (1)

**Abstract**

The processes that lead to the formation of carbonaceous aerosols, organic carbon and black carbon, in the atmosphere are related to trace gases. We focus here on the statistical links between organic and black carbon with trace gases that can be estimated using remote-sensed measurements (CO, NO2, O3, HCHO and SO2).

To analyze both the composition of aerosols and trace gases, measurements obtained in a research aircraft provide the best platform because both are available on board, whereas this is not the case for most ground stations of measurement. Moreover, the EMeRGe campaign has created a unique dataset, with flight plans dedicated to the study of major population centers in two regions of Europe (2017) and East Asia (2018).

After analyzing the composition of gases and aerosols in different environments ranging from oceanic to highly urbanized using aircraft observations, we compare with the modeling results. A model ensemble is constituted which aims to represent the state of the art of atmospheric modeling, including global models, ECMWF-CAMS (forecast and reanalysis) and NCAR-CAMchem, as well as WRFchem simulations using two meteorological inputs (GFS and ERA5). The model ensemble is evaluated against the proportion of carbonaceous aerosols and trace gases in various environments traversed by the HALO research aircraft. The focus is on flight legs that correspond to urban pollution plumes, and that are localized using passive tracers in the WRFchem simulations released from the major population centers.

This analysis of the statistical links between carbonaceous aerosols and trace gases aims to understand what information on the amount of carbonaceous aerosols in the lowest troposphere can be retrieved by satellite.

**Early Career Scientist**

NO, I am not an early career scientist.

**IGAC Activities**

AMIGO: Analysis of eMIssions using Observations

**IGAC Regional Working Groups**

ANGA: African Group on Atmospheric Sciences
Session 2 Oral

Sleuthing errors in reactive nitrogen in the global upper troposphere using recent and historical research aircraft campaigns and GEOS-Chem

Miss Nana Wei
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Author list (excluding presenting author)

Eloise A. Marais (1); John F. Roberts (2); Robert G. Ryan (3); Gongda Lu (4)

Abstract

Reactive nitrogen (NO\textsubscript{y}) in the upper troposphere (UT; 8-12km) impacts climate, air quality, and atmospheric oxidants. Despite this, large uncertainties in NO\textsubscript{y} in the UT persist, evidenced by discrepancies between models and observations. We use observations from research (NASA DC8) aircraft and the GEOS-Chem model to identify and quantify these errors after assessing whether DC8 observations offer representative sampling of the atmosphere by comparison to routine observations of total NO\textsubscript{y} from commercial (MOZAIC, IAGOS) aircraft campaigns and new data products of NO\textsubscript{2} from cloud-slicing satellite observations (TROPOMI). Most total UT NO\textsubscript{y}, according to DC8, is from a few individual components, namely nitrogen oxides (NO\textsubscript{x}; 9-52\% of total NO\textsubscript{y}) peroxycetyl nitrate (PAN) and other PAN-like compounds (collectively PANs; 23-63\%), nitric acid (HNO\textsubscript{3}; 4-27\%), peroxynitric acid (HNO\textsubscript{4}; 3-11\%), and organic nitrates (3-14\%). Discrepancies between annual mean total NO\textsubscript{y} from comparison of DC8 and MOZAIC (DC8 17\% less), DC8 and IAGOS (DC8 41\% less), and IAGOS and MOZAIC (IAGOS 10\% more) can be explained by sharp linear increase in NO\textsubscript{y} with altitude above 300 hPa and higher sampling altitudes of IAGOS (average 233.55 hPa) than MOZAIC (247.43 hPa) than DC8 (326.39-328.63 hPa). Comparison of UT NO\textsubscript{2} from DC8 and cloud-slicing TROPOMI is ongoing. We find that GEOS-Chem compared to DC8 underestimates total NO\textsubscript{y} by 60-112 pptv largely because of a low bias in NO (of 5-15 ppt) and NO\textsubscript{2} (of 11-24 ppt). The underestimate in NO is due to misrepresentation of maritime lightning NO\textsubscript{x} emissions. At least half the low bias in NO\textsubscript{2} can be explained by the model locking up ~10 ppt NO\textsubscript{2} as the PAN-like NO\textsubscript{x} reservoir compound peroxypropionyl nitrate (PPN) that is overestimated in the model due to missing PPN loss processes.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

CCMi: Chemistry Climate Model Initiative

IGAC Regional Working Groups

Americas Working Group
Session 2 Oral

Deconstructing tropospheric chemical reactivities, feedbacks and loss frequencies, parcel by parcel: the ATom data

Michael Prather Prather
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Author list (excluding presenting author)

the ATom Science Team (1)

Abstract

The NASA Atmospheric Tomography (ATom) mission built a photochemical climatology of air parcels based on in situ measurements with the NASA DC-8 aircraft along objectively planned profiling transects through the middle of the Pacific and Atlantic Oceans for four seasons. The 4 ATom deployments provided a continuous data stream from which one can calculate the 24-hour chemical tendencies. Curtain plots show a rich and highly heterogeneous mix of reactivity on scales that should be resolved by modern global models. In general, global models produce similar probability densities (PD) and these PDs provide a new statistical metric for the models. Given the chemical composition of an air parcel, we can calculate the sensitivity to the initial values of the species and thus identify the key species controlling the budgets of O3 and CH4 (i.e., O3, CO, H2O, ...). Further, we can look at the correctly linearized loss rate for an O3 perturbation, d(P-L)/dO3, and the first order CH4 feedback factor, dOH/dCH4, parcel by parcel. Defining tropospheric chemistry at the inherent scales of variability provides a deep understanding of tropospheric chemistry.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report, CCMi: Chemistry Climate Model Initiative
Ammonia variability and trends from urban and remote ground-based FTIR measurements

Beatriz Herrera
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Abstract

Ammonia (NH₃) is the most abundant alkaline compound in the atmosphere. NH₃ neutralizes acids and contributes to the formation of aerosols and particulate matter, with potential consequences to the environment, human health, and radiative forcing. NH₃ is primarily emitted by agricultural sources; however, it is also present in urban environments. NH₃ has a short lifetime on the order of hours to a few days. NH₃ emissions and deposition depend strongly on environmental conditions; temperature and moisture play a crucial role in determining NH₃ concentrations on diurnal to annual scales. Several studies have used satellite measurements to assess the global variability of NH₃; however, the interannual variability does not reveal clear trends and is not possible to determine the diurnal variability as a consequence of the limited satellite observations per day. The objective of this study is to determine and compare the temporal variability and trends of NH₃ in urban and remote areas around the world. This work uses NH₃ total columns retrieved from solar absorption measurements by sixteen ground-based Fourier transform infrared (FTIR) spectrometers. These are located at seven urban and nine remote stations globally dispersed in both hemispheres from 80.05°N to 45.04°S, most of them part of the Network for Detection of Atmospheric Composition Change (NDACC). In addition, modelled NH₃ from the GEOS-Chem chemical transport model and from the preliminary Tropospheric Chemistry Reanalysis (TCR-2) are used to complement the measurements and provide additional insight into the diurnal and seasonal variability as well as NH₃ trends in urban and remote environments.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

AMIGO: Analysis of eMissions usinG Observations

IGAC Regional Working Groups

Americas Working Group
Session 2 Poster

Quantifying vehicle road dust emission factors in South African low-income residential areas using field-based empirical measurements.

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Abstract

On-road vehicle particulate matter (PM) emissions in South African low-income residential areas contribute between 4-16% towards ambient and 9-55% towards indoor particulate matter concentration. The lack of field derived vehicle road PM emission factors limits the knowledge required to model and understand on-road traffic source contribution towards the PM exceedances in low-income residential areas. The study aim quantify the vehicle road dust emissions per vehicle type on paved and unpaved roads and determine the impact of meteorological factors on the emissions. The objectives to characterise roads within the residential areas using GIS, to classify vehicles and describe diurnal traffic cycles using a traffic counter, to quantify vehicle PM emission factors from paved and unpaved roads using 14 real-world field experiments monitored with a DustTrak sensor during the summer season. The measured PM concentration and meteorological data were then used as input parameters on the Box and US EPA-42 Model to quantify the emission factors. The results showed about 85% of the roads in low-income residential areas are unpaved. Vehicle traffic composition profiles vary with medium duty and motor vehicles dominating unpaved roads whilst medium and heavy-duty vehicles dominate paved roads. Traffic diurnal patterns show traffic peak hours between 06h00-08h00, 12h00-15h00 and 16h00-20h00. The US EPA-42 model unpaved road daily PM10 emissions ranged between 926.96 kg - 2385.40 kg, while box model unpaved road daily PM10 emissions were 542.8 g - 1789.92 g. The US EPA-42 model paved road daily PM10 emissions ranged between 2643 g - 2682 g while box model unpaved road daily PM10 emissions were 368.2 g - 3156 g. The field-based emissions will reduce uncertainties associated with inconsistencies between modelled and measured PM concentrations in residential areas.

Early Career Scientist

YES, I am an early career scientist.
COVID-19 related abstracts

yes
Modelling and measuring VOCs concentrations in East Asia

Dr Adedayo R Adedeji
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Abstract

Tackling the challenge of rapid growth in ozone concentrations in East Asia requires improving our knowledge of the chemical processes involved in its formation, especially from non-methane VOCs. Unfortunately, long term measurements of VOCs are scarce, and the few observation sites available do not measure higher molecular weight VOCs due to the complexity and limited technological capability.

From June 2021, measurements of VOCs and OVOCs were taken from Hateruma Island, the southernmost inhabited island of Japan, using a novel TD-GC-MS system developed between the University of York in the UK and National Institute for Environmental Studies in Japan. The VOCs measurements include hydrocarbons such as alkanes, alkenes and aromatic hydrocarbons including their isomers, with carbon numbers between C2 and C11. We are also measuring OVOCs such as methanol, ethanol, acetaldehyde, acetone, propanal, methacrolein and methylvinylketone at the Island. The GEOS-Chem chemical transport model has been used to assess the likely sources of these VOCs. Simulations suggest Asian C2H6 and C3H8 emissions are significantly underestimated (factor of 2-3), but this only results in a small increase in O3 over highly polluted regions such as Beijing. We extend this analysis to the faster reacting VOCs and find mixed results of model over and underestimates. These observations highlight the need for long term monitoring of the concentrations of VOCs and OVOCs to assess emission inventories and how these might change over the long term.

Early Career Scientist

YES, I am an early career scientist.
Session 2 Poster

Regional emissions of nitrous oxide (N₂O) estimated by inverse modelling of atmospheric observations

Dr. Prabir K Patra
Earth Surface System Research Center (ESS), Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan. Center for Environmental Remote Sensing, Chiba University, Japan

Abstract

Nitrous oxide (N₂O) contributes to strongly global warming (GWP=273) and most significantly to stratospheric ozone depletion in the recent years. Reduction of uncertainty in estimates of emissions from different source types and regions is important for climate policy. Using the JAMSTEC’s MIROC4-based atmospheric chemistry-transport model (ACTM) in situ measurements of N₂O are analysed for the period 1978-2020, and we estimated N₂O lifetime as 127.6±4.0 yr in the control ACTM simulation. Then, five combinations of known (a priori) N₂O emissions due to natural soil, agricultural land, other human activities and sea-air exchange are used for inverse modelling purpose. Regional N₂O emissions are optimised for 84 partitions of the globe at monthly intervals in a Bayesian inverse modelling framework, using measurements at 42 sites around the world covering 1997-2019. The best estimate global land and ocean emissions are 12.99±0.22 and 2.74±0.27 TgN yr⁻¹, respectively, for 2000-2009, and 14.30±0.20 and 2.91±0.27 TgN yr⁻¹, respectively, for 2010-2019. Both the land and ocean totals show increase in emissions between the two period. On regional scales, lower emissions in the Southern Ocean regions, fits better with that predicted by the inversions. Marginally higher (lower) emissions than the inventory/model for the tropical (extra-tropical) land regions is estimated and validated using independent aircraft observations. Global land and ocean emission variabilities show statistically significant correlation with El Niño Southern Oscillation (ENSO). Analysis of regional land emissions shows increases over the Americas, Central Africa, and Asia. Our analysis suggests that the terrestrial ecosystem models simulate the annual total emissions well, but the lag-time scales of N₂O emissions from nitrogen fertiliser application may need to be revised. Urgent policies are needed for reduction of N₂O emissions from the agricultural sector, in particular.

Details are available in Patra et al., 2022. https://doi.org/10.2151/jmsj.2022-018

Early Career Scientist

NO, I am not an early career scientist.
Session 2 Poster

Modelling the Impact of HO\textsubscript{2} Uptake onto Aerosols During Summertime in Beijing using the Master Chemical Mechanism

Dr Joanna E. Dyson
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Abstract

Following multiple policy changes in response to increasingly poor air quality in China, a decrease in NO\textsubscript{x} and PM\textsubscript{2.5} emissions has been reported, along with an increase in O\textsubscript{3}. Li et al., (2018) proposed that the increase in O\textsubscript{3} across China could be attributed to the decrease in PM\textsubscript{2.5} which led to a decrease in the loss of HO\textsubscript{2} via aerosol uptake resulting in an increase in HO\textsubscript{2} concentration. This could then lead to a proportional increase in the loss of HO\textsubscript{2} via NO, a decrease in the titration of O\textsubscript{3} by NO and an eventual increase in O\textsubscript{3} overall. However, analysis of the measured radical budget from observations during a field campaign in the North China Plain (NCP) in Summer 2014 showed no evidence for a significant impact of HO\textsubscript{2} uptake on radical concentrations, concluding that reduced HO\textsubscript{2} uptake was unlikely to be the cause of increasing O3 levels in the NCP (Tan et al., (2020)).

To investigate the impact of HO\textsubscript{2} uptake onto aerosol surfaces on the radical budget in Beijing during the AIRPRO campaign in Summer 2017, a novel parameterisation, developed by Song et al., (2020) in the framework of the resistor model, was used to calculate $\gamma$(HO\textsubscript{2}) for the Beijing Summer campaign as a function of aerosol soluble copper concentration, aerosol liquid water content and particulate matter concentration. We will present the results of modelling the concentrations of OH, HO\textsubscript{2} and RO\textsubscript{2} using the Master Chemical Mechanism (v3.3.1) with and without the calculated $\gamma$(HO\textsubscript{2}) value for the Summer AIRPRO campaign. The effect of HO\textsubscript{2} uptake on the O\textsubscript{3} regime will also be presented.


Early Career Scientist

YES, I am an early career scientist.
Session 2 Poster

Interannual variability of aerosols in the UTLS and its connection to the pollution sources and Asian summer monsoon variability – Results from AeroCom models and observations

Dr. Mian Chin
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Author list (excluding presenting author)

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Abstract

We present results from a suite of AeroCom model experiments on the two-decadal variations of UTLS aerosols and factors controlling such variability. The model simulations from 8 AeroCom models are compared to four satellite products of aerosol extinction profiles, including OSIRIS, CALIOP, SCIAMACHY, and OMPS LP, during 2002-2018 in the upper troposphere, near the tropopause, and in the lower stratosphere. We attribute the change of UTLS aerosols to emissions from anthropogenic, volcanic, and biomass burning sources using model experiments tagging different emission sources. Further, investigate the connections of UTLS aerosol interannual variability to the variability of Asian summer monsoon strength and other climate indicators through a common transport tracer implemented in the models.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon
Session 2 Poster

Using a coupled chemistry-climate-vegetation modeling system to evaluate BVOC emission changes in the Earth system

Ryan Vella
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Author list (excluding presenting author)

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Abstract

To investigate the complex interactions in the Earth system, we need Earth System models which combine sophisticated representations of the atmosphere, the biosphere and the ocean. A good description of the global isoprene and monoterpene emissions from terrestrial vegetation, which are the most significant sources of VOCs in the Earth system, is a prerequisite for modeling the impact of biogenic organic compounds on the chemical composition of the atmosphere. The Modular Earth System Model (MESSy) framework includes advanced representations of chemical and physical processes in the atmosphere, the ocean and the land surface, and is therefore a sophisticated tool for examining atmospheric chemistry interactions and feedbacks in the climate system. The EMAC (ECHAM MESSy Atmospheric Chemistry) model has recently been augmented to include biosphere processes described by the global dynamic vegetation model LPJ-GUESS. In this study, we present the evaluation of the model as well as the total emissions of different components in its actual implementation. We also assess changes in fluxes driven by climatic and vegetation states (e.g. CO₂ variation, ENSO variability).

Early Career Scientist

YES, I am an early career scientist.
Session 2 Poster

Potential of machine learning to simulate atmospheric trace gases

Dr Imran A. Girach
Space Application Centre, ISRO, Ahmedabad-380015, India. Space Physics Laboratory, Vikram Sarabhai Space Centre, ISRO, Thiruvananthapuram-695022, India

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Abstract

Atmospheric trace gases play pivotal role in atmospheric chemistry, climate, and air quality. While greenhouse gases (e.g., carbon dioxide) influence the earth’s radiative forcing, others (e.g., tropospheric ozone) are crucial in atmospheric chemistry and air quality. Thus, understanding the detailed underlying mechanisms and their variability is very important. In recent times, Artificial intelligence (AI) and Machine learning (ML) have proven to be powerful tools to deal with complex problems including those in atmospheric science. Here, we explore the potential of ML to simulate variability of atmospheric trace gases, for instance, carbon dioxide (CO$_2$) and surface ozone (O$_3$). We have used long-term data to train the ML model and simulated CO$_2$ and O$_3$ over background sites of Mauna Loa and foothills of Himalaya, respectively. Model trained with past variation of CO$_2$ residue (i.e., detrended deseasonalised CO$_2$) and various input parameters, reproduced 72% of observed variability in CO$_2$ residue with root mean square error of 0.45 ppmv over Mauna Loa. The cumulative temperature anomaly is found to play a key role in the simulation of CO$_2$ residue, highlighting that the signature of minute variation in CO$_2$ lies in the cumulative temperature anomaly. However, the model shows limitation in capturing spikes resulting from strong local/regional emissions. Similarly, the model successfully simulated surface O$_3$ capturing ~70% of variability based on either meteorology or major precursors (CO and NO$_x$) over foothills of Himalaya. Better performance ($r^2=0.86$) is achieved when both precursors and meteorology were included. Our study demonstrates the potential of ML modeling for the simulations of trace gases to complement the computationally expensive global and regional chemistry-transport models.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon, TOAR: Tropospheric Ozone Assessment Report

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Source attribution of aerosol impacts to snow cover over High Mountain Asia

Mr. Chayan Roychoudhury
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Author list (excluding presenting author)

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Rajesh Kumar (2);

John M. McKinnon (3);

Avelino F. Arellano Jr. (4)

Abstract

As one of the important hydrological sources over Asia, glaciers in High Mountain Asia (HMA) undergo rapid snowmelt through the deposition of light-absorbing particles (LAPs viz. black carbon (BC) and dust) and its consequent feedback on the climate. In this study, we assimilate two decades of Moderate Resolution Imaging Spectroradiometer (MODIS) aerosol optical depth (AOD) and MOPITT carbon monoxide (CO) into the Weather Research and Forecasting coupled with chemistry (WRF-Chem) model over HMA to simulate the deposition of absorbing aerosols onto snow and use these assimilated products to (a) estimate the relative importance of modeled aerosol and hydro-meteorological variables on observed MODIS snow cover fraction (SCF) and (b) identify the sources of these importances by tagging aerosols from different source regions and tracking them until they are deposited over the glaciers in HMA. A tagged based approach over 10 Asian regions is used for source attribution of their relative contributions. Based on a previous analysis using ERA5/CAMS Reanalysis, we see significant interactions between aerosols and meteorology during late snowmelt season (around June) for low snow-covered glaciers over HMA. Among these interactions, carbonaceous aerosols and dynamic circulation variables contribute most to snow cover variability. Our results also show that BC modeled surface abundance for glaciers in the Himalayas is largely attributed to India, Nepal and Pakistan while for India and China for glaciers in the Tibetan Plateau. Anthropogenic BC largely dominates more than fire BC across all months. These results are a step towards unraveling the complex interactions between aerosols and meteorology in modulating HMA snow cover and highlight the need for more observations and modeling constraints for improved predictions of snow hydrology and snow dynamics in HMA.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

CATCH: the Cryosphere and Atmospheric Chemistry, AMIGO: Analysis of eMIssions using Observations

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Development of a system for optimised air quality forecast by Model Output Statistics

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Author list (excluding presenting author)

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Abstract

In order to be able to caution and protect the population in a timely manner about the occurrence of poor air quality, a forecast as precise as possible is required. However, the spatial resolution of current state-of-the-art numerical air quality models is too low for this.

Because of this, in the LQ-WARN project we are developing a system for improving the air quality prediction in Germany. Using observations of pollutant concentrations, model results of the numerical European air quality forecast of CAMS (Copernicus Atmospheric Monitoring Service) and meteorological parameters from the ECMWF numerical weather prediction model, we apply model output statistics (MOS) as an approach of statistical post-processing. This is how we calculate the point forecast for the concentrations of NO₂, O₃, PM₁₀ and PM₂.₅ for several hundred German locations covering lead times up to 96 hours.

Forecast approach and evaluation of forecasts against observations will be explained. The improvement is demonstrated by a significant reduction of the RMSE (Root Mean Square Error) in comparison to the numerical CAMS forecast, especially for NO₂ concentrations at traffic related sites. Additionally, the skill of prediction can be improved by probability forecasts with regard to exceeding threshold values of hazardous pollutant concentrations.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality
Session 2 Poster

Isoprene-consuming production and loss pathways of tropospheric ozone

Dr. Ralph Lehmann
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Author list (excluding presenting author)
Idir Bouarar (1); John Orlando (2); Guy Brasseur (1)

Abstract

Production and loss pathways of tropospheric ozone and their rates were identified by an algorithm for the automatic determination of reaction pathways in complex chemical systems. For this purpose, reaction rates were provided by the chemical transport model IFS(MOZART) (ECMWF Integrated Forecasting System with the Model for Ozone and Related Chemical Tracers). A detailed analysis was carried for the ozone formation from isoprene in Beijing (August, noon). The pathways determined show in detail all steps of the isoprene degradation, including the interaction with NOx and HOx species. Different pathways compete for the intermediate species formed. An oxidation pathway of one isoprene molecule may lead to the loss of up to 14 ozone molecules or the formation of up to 22 ozone molecules, resulting in an average net formation of 6.8 ozone molecules per isoprene molecule consumed (under the conditions analysed).

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report
Session 2 Poster

An update on tropospheric ozone trends above western North America

Dr Kai-Lan Chang
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Abstract

Tropospheric ozone is a greenhouse gas and pollutant detrimental to human health and crop productivity. The latest IPCC AR6 report concluded with high confidence that observed free tropospheric ozone has increased at northern mid-latitudes since the mid-1990s. However, a very recent study has shown that the positive trend since the mid-1990s above western North America was weakened during the COVID-19 lockdown period in 2020 due to the decrease of ozone precursor emissions. This presentation will give an update on the latest ozone mean and percentile trends above western North America, using a data fusion approach that incorporates all available observations from ozonesonde, lidar and airborne data sets. Particular focus will be placed on observations collected during 2021 to determine if free tropospheric ozone is rebounding as the COVID-19 pandemic recedes.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report

COVID-19 related abstracts

yes
Session 2 Poster

Arctic tropospheric ozone: assessment of model performance

Dr Cynthia Whaley
ECCC, Canada

Author list (excluding presenting author)

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Abstract

As the third most important greenhouse gas after CO₂ and methane, tropospheric ozone (O₃) is also an air pollutant causing damage to human health and ecosystems. This study brings together recent research on observations and modeling of tropospheric O₃ in the Arctic, a rapidly warming and sensitive environment. At different locations in the Arctic, the observed surface O₃ seasonal cycles are quite different. Coastal Arctic locations, for example, have a minimum in the springtime due to O₃ depletion events resulting from surface bromine chemistry. In contrast, other Arctic locations have a maximum in the spring. The 12 state-of-the-art models used in this study lack the surface halogen chemistry needed to simulate coastal Arctic surface O₃ depletion in the springtime, however, the multi-model median (MMM) has accurate seasonal cycles at non-coastal Arctic locations. The vertical distribution of tropospheric O₃ is evaluated using recent ozonesonde measurements. The models are highly variable, simulating free-tropospheric O₃ within a range of +/- 50% depending on the model and the altitude. The MMM performs best, within +/- 8% at most locations and seasons. However, nearly all models overestimate O₃ near the tropopause (~300 hPa or ~8 km), due to the inability of the models to simulated the tropopause height and the stratosphere-troposphere exchange accurately. Observed and simulated O₃ precursors (CO, NOₓ and reservoir PAN) are evaluated throughout the troposphere. Models underestimate wintertime CO everywhere. Throughout the vertical profile (compared to aircraft measurements), the MMM underestimates both CO and NOₓ but overestimates PAN. Perhaps as a result of competing deficiencies, the MMM O₃ matches the observed O₃ reasonably well. Our findings suggest that despite model updates over the last decade, model results are as highly variable as ever, and need additional improvements in order to accurately simulate Arctic tropospheric O₃. The 1990-2019 trends are also reported on.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

PACES: Air Pollution in the Arctic: Climate, Environment, and Societies
Probing the cause of air pollution episodes in Taichung Metropolitan area, Taiwan by air quality modeling

Dr Ming-Tung - Chuang
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Author list (excluding presenting author)

Charles C.-K. Chou (1), Ja-Huai Lee (2), Wei-Che Lin (3)

Abstract

In order to deeply analyze the physical and chemical mechanisms that affect the ozone (O3) and fine particulate (PM2.5) concentrations and to clarify the key factors affecting air quality in urban area in Taiwan, a series of Intensive Observation Periods (IOPs) campaigns were hold in the second largest city in Taiwan, the Taichung city. This study chose the IOP of November 2021 for conducting the WRF/CMAQ air quality modeling. After checking the performance evaluation of simulation results is fine and accepted, the discussion of temporal variations of simulated and observed PM2.5, O3, and their precursors was presented. Then a PM2.5 and O3 joint event occurring on 3-6 November was selected for detailed analysis, which is a perfect case because this event was caused by calm win and local sources. The wind field and near surface and cross section distributions of PM2.5 and O3, obviously, show that the land/sea breeze circulation and boundary layer evolution dominated the transport. The formation mechanisms of nitrate and sulfate were analyzed through process analysis and sulfur tracking. In this event, nitrate concentration was the highest among resolved species. It is found the heterogeneous reaction of N2O5 during nighttime contributed the most of nitrate, followed by the daytime of NO2 and OH oxidation reaction. On the other hand, the aqueous-phase H2O2 oxidation reaction were the major contribution of sulfate.

Keywords: PM2.5, O3, Taichung, WRF/CMAQ

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

China Working Group

COVID-19 related abstracts
yes
Session 2 Poster

Using a Machine Learning Method to Make Projections of Tropospheric Ozone Along Different Shared Socioeconomic Pathways from 2020 to 2050 in China

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Author list (excluding presenting author)

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Abstract

Tropospheric ozone has become one of the primary air pollutions in major urban clusters, which has an adverse effect on public health and crop production. Although China has implemented a series of intensive air pollution control policies since 2013, tropospheric ozone, however, showed a continuously increasing trend. Anthropogenic emission variations and climate change complicate the long-term ozone control policymaking. China is committed to achieving zero carbon emission by 2060 and is going to implement a series of more ambitious climate policies to reduce anthropogenic emissions. Therefore, climate change and future anthropogenic emissions controls bring uncertainties about long-term tropospheric ozone levels.

The new generation of global scenarios, Shared Socioeconomic Pathways (SSPs), associated with a range of climate forcing levels described by Representative Concentration Pathways (RCP) reflect plausible future emissions and climate conditions. In this study, we explore the use of a machine learning method to make computationally inexpensive projections of tropospheric ozone from 2020 to 2050 under five SSPs (SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP4-60, and SSP5-8.5) over China. Training data includes historical reanalyzed meteorological variables, ozone observation data over 1022 air pollution monitoring sites, and historical emission inventory variables from 2013 to 2017. The predicting performance of the machine learning model on the test data shows a higher variability, with an average R2 of 0.87. We use future climate variables from Coupled-Model Intercomparison Project Phase 6 (CMIP6) and China-focused SSPs emission inventories to predict monthly ozone concentration from 2020 to 2050. Mean surface ozone concentrations in 2050 are projected to change by -8%–6% under different SSPs compared to those in 2020. This study also predictively quantifies the meteorology-induced and emission-induced surface ozone changes under five SSPs. The results will be compared with ozone levels as predicted by numerical simulations made using more computationally climate/atmospheric intensive models.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report

IGAC Regional Working Groups
China Working Group
Sources and Photochemical Behaviour of Atmospheric Nitrophenols

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Abstract

Nitrate phenols (NPs) are compounds that comprise hydroxyl- and nitro- functional groups attached to the benzene rings. Primary sources of NPs include vehicle exhaust, waste incineration plants, biomass burning emissions, and secondary NPs and their derivatives (e.g. methyl NPs) can be formed by the gas-phase reaction of OH or NO$_3$ radicals in presence of NO$_2$ with various aromatic precursors. During the Study of Houston Atmospheric Radical Precursors (SHARP) campaign NPs including 2,4-DNP, 4-NP, 2-NP, and 2-Me-4-NP and comprehensive atmospheric chemistry data set were measured hourly at the Moody Tower (MT) site (29.7172$^\circ$ N, 95.3416$^\circ$ W), Houston, Texas from May 15 to June 30, 2009. The SHARP NP data for Houston shows maximum concentrations for 4-NP, followed by 2-Me-4-NP, 2-NP, and 2,4-DNP which might indicate rapid photochemistry. NPs concentrations in Houston were found to be higher compared to other studies conducted in summer and comparable with studies conducted in winter. Source apportionment of NPs and other atmospheric pollutants (i.e., volatile organic compounds, SO$_2$, CO) is conducted based on Positive Matrix Factorization (PMF) which yielded nine factors: secondary formation (21.9%), nitrophenols source (4.1%), petrochemical industries/oil refineries (10.4%), monoterpenes (5.4%), traffic (14.3%), biogenic (4.3%), phenol source (2.3%), naphthalene source (2.3%), and natural gas/crude oil (24.9%). Bivariate polar plots suggest that the Houston Ship Channel and oil refineries are the primary emission source for petrochemical industries/oil refineries, monoterpenes, phenol, naphthalene, and natural gas/crude oil sources. The Nitrophenols source showed a diverse pattern that needs to be investigated further. Future research will focus on the understanding of the formation of secondary NPs, their impact on HONO formation, and OH production using AtChem2 Master Chemical Mechanism (MCM) v3.2 box model in an urban area with complex emission sources, here in Houston.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon, CCMi: Chemistry Climate Model Initiative, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

Americas Working Group, MANGO: Monsoon Asia and Oceania Networking Group
Session 2 Poster

TOAR-II Chemical Reanalysis Focus Working Group

Kazuyuki Miyazaki
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Author list (excluding presenting author)

Dylan Jones (1); Helen Worden (2); Zhen Qu (3); Emanuele Emili (4)

Abstract

Chemical reanalysis is a systematic approach to create a long-term data record of atmospheric composition, consistent with model processes and observations, using data assimilation. Similar to meteorological reanalyses that have extensively been used to study weather and climate variability, chemical reanalysis has the great potential to provide comprehensive information on atmospheric composition variability for broad atmospheric chemistry studies. Chemical reanalyses have made considerable progress in recent years and offer a unique global coverage of decadal ozone trends during the satellite data records. By utilizing the most recent chemical reanalyses, the IGAC TOAR-2 Chemical Reanalysis focus WG aims to support IGAC TOAR-II objectives to investigate the impacts of tropospheric ozone on climate, human health, and vegetation, working together with other TOAR-II WGs that include HEGIFTOM, OPT, TOP, Satellite Ozone, and Statistics Focus WGs, as follows.

- Evaluation of chemical reanalyses with TOAR-II observations and other data will assess the potential of using chemical reanalysis for studying spatial gradients at both regional and global scales and trends in areas with sparse in-situ observations. The chemical reanalysis long-term record will also assist in determining the contribution of precursor emissions and changing meteorology to observed ozone trends and surface ozone exceedances.
- Sensitivity analyses of the impacts of satellite and in-situ observations of ozone both at the surface and in the free troposphere and precursors will assess the relative importance of individual observations to improve surface ozone analyses and help to design observing systems that better capture the distribution and regional trends in tropospheric ozone.
- Well-validated chemical reanalysis ozone fields will provide an opportunity to improve the TOAR-II observation quality control processes and representativeness by providing first guess information.

In this presentation, we will discuss the current progress and future directions of the TOAR-2 Chemical Reanalysis Focus WG.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report
Organic aerosols at Fukue Island before, during and after large scale lockdown in China due to COVID-19

Dr Chunmao Zhu
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Author list (excluding presenting author)

Takuma Miyakawa (1); Fumikazu Takekani (1); Bhagawati Kunwar (2); Dhananjay Kumar Deshmukh (2); Kimitaka Kawamura (2); Yugo Kanaya (1)

Abstract

Carbonaceous aerosols are one of the most important components affecting the Earth’s radiative forcing. Although it is quite clear that black carbon is a prominent climate forcer, the role of organic carbon is controversial. It had been considered to cool the Earth’s surface until the light-absorbing fraction, brown carbon, was found to cause warming. The emission of black carbon in China increased before 2010 and decreased after that. However, the temporal trend of organic carbon is ambiguous due to its diverse sources, such as fossil fuel combustion, biomass burning, direct emissions from biogenic sources, and secondary formation by the oxidation of volatile organic compounds. To better understand the characteristics of carbonaceous aerosols and their effects on climate, we have collected aerosol samples and analyzed carbonaceous components since late 2019 at Fukue Island, western Japan. Due to the spread of COVID-19, China implemented a large-scale lockdown in major cities from late January to early April in 2020. As a result, economic activities are largely restricted, where emissions of carbonaceous aerosols would possibly change. In this work, we found that during the lockdown period, carbonaceous aerosols decreased in February and rebounded in April at Fukue. The sources of organic carbon and PM2.5 were evaluated using the organic tracer method and positive matrix factorization method, respectively. Organic carbon and PM2.5 from oxidation of aromatic hydrocarbons in the lockdown period decreased by 34% and 19% than the previous month, respectively, indicating decreased anthropogenic activities from transport and industry sectors. Meanwhile, organic carbon and PM2.5 from biomass burning increased by 39% and 6% in the lockdown period, respectively, indicating the continuous effects of biomass burning from domestic sector. Our findings provide information to better understand the dynamics and emission controls of carbonaceous aerosols in East Asia.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

PACES: Air Pollution in the Arctic: Climate, Environment, and Societies

IGAC Regional Working Groups

Japan National Committee

COVID-19 related abstracts

yes
Session 2 Poster

Development of air quality products for societal applications based on a high-resolution chemical reanalysis

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National Center for Atmospheric Research, USA

Author list (excluding presenting author)

Cenlin He (1), Piyush Bhardwaj (1), Stefano Alessandrini (1), Forrest Lacey (1), Cassandra R. O’Lenick (1), Olga Wilhelmi (1), Gabriele G. Pfister (1), and Priyanka (2)

Abstract

The assimilation of satellite observations of atmospheric composition can partially reduce errors in air quality simulations. Here, we present a high-resolution (12 x 12 km$^2$) air quality reanalysis over the contiguous US (CONUS) from 2005-2018. This reanalysis is generated using a newly developed chemical data assimilation system that simultaneously assimilates aerosol optical depth (AOD) retrievals from the Moderate Resolution Imaging Spectroradiometer (MODIS), and carbon monoxide (CO) retrievals from the Measurement of Pollution in the Troposphere (MOPITT) in the Community Multiscale Air Quality (CMAQ) model. The Weather Research and Forecasting (WRF) model provides meteorological input for CMAQ simulations over the CONUS at 12 x 12 km$^2$. The evaluation of WRF against the ground-based and satellite observations showed that the model captured the seasonal, interannual, and regional variability of key meteorological parameters very well. The evaluation of CMAQ simulations shows good performance in capturing the seasonal cycles and trends of ozone and fine particulate matter at state- and region-level in the CONUS. This dataset is being used to develop a suite of air quality products relevant for societal applications namely (1) products and metrics for assessing the long-term impact of air pollution on public health, agriculture, and economy; (2) estimating the number of excess deaths attributable to PM2.5 and ozone during 2005-2018; and (3) quantifying air quality changes in unmonitored areas and benefits of emission control policies. A website has also been developed to disseminate these products to the society. The air quality reanalysis and different products will be discussed in detail during the presentation.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

Americas Working Group
Session 2 Poster

Hydrogen: the Fuel of the Future? Modelling its Environmental Impacts

Miss Hannah Bryant
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Author list (excluding presenting author)

Professor David Stevenson (1), Professor Mathew Heal (1), Maria Sand (2)

Abstract

A shift in our energy production is crucial to the control of global warming. This will occur as fossil fuels are phased out, following legislation created to reach the targets set out in the Paris Agreement. One of the possible sources for a low carbon energy landscape is hydrogen. Whilst hydrogen represents a potential energy source, it carries the risk of leakage from the system. This leakage causes an associated increase in atmospheric hydrogen concentrations. Changes in $\text{H}_2$ have both chemical and radiative impacts; here we use a model to investigate potential environmental effects of a $\text{H}_2$ economy.

I am using the Met Office Unified Model coupled to the United Kingdom Chemistry and Aerosol model (UM-UKCA) to define the current atmospheric budget of hydrogen, including the primary chemical reactions and the soil sink. The $\text{H}_2$ Global Warming Potential will also be updated to allow quantification of the indirect radiative effects. These occur due to the interaction between hydrogen and the radiatively active gases methane, ozone, and water vapour. Without suitable quantification of these effects, the consequences of a hydrogen economy remain uncertain.

Estimates of hydrogen through modelling studies disagree with observational measurements due to limited representations of hydrogen within chemistry climate models and some budget terms remain highly uncertain. To address this, I am developing an emissions-based version of UKCA for hydrogen using the CEDS emissions database. This will improve the representation of hydrogen deposition and emission within the model and lead to a more detailed understanding of the hydrogen budget. Future work will involve investigation into the benefits associated with the switch from fossil fuels to hydrogen.

This work is part of a wider model inter-comparison project, HYDROGEN, with CICERO, the Centre for International Climate Research, and is funded by the Research Council of Norway.

Early Career Scientist

YES, I am an early career scientist.
Hydrogen peroxide plays a key role in the oxidative chemistry of the atmosphere. It forms an important reservoir for peroxy radicals (HO$_2$), which are controlling the self-cleaning processes of the troposphere. This study focuses on the distribution of hydrogen peroxide in the tropical upper troposphere between 8 and 14 km altitude based on airborne in situ observations during the Chemistry of the Atmosphere: Field Experiment in Africa (CAFE-Africa) campaign performed in August - September 2018 over the Atlantic Ocean. The objectives of the campaign were investigations of trace gas and aerosol distributions in the free troposphere and their relation to natural and anthropogenic emissions, long-distance pollution transport and atmospheric oxidation processes. The base of operation on Cape Verde established a unique opportunity for analysis of the role of the ITCZ in processes impacting global trace gas distribution.

Upper tropospheric average hydrogen peroxide (H$_2$O$_2$) levels of 0.14 ± 0.11, 0.20 ± 0.12 and 0.15 ± 0.12 ppbv were measured in the North, ITCZ and South, respectively. Elevated mixing ratios close to the ITCZ are partly due to transport from the boundary layer into the upper troposphere.

The observations are supplemented by photostationary steady state calculations and global 3D model simulations by the global circulation model EMAC. Results from numerical simulations performed by EMAC overestimate the measured H$_2$O$_2$ in the southern hemisphere, most likely due to underestimation of the H$_2$O$_2$ precursor budget and photolysis rates. In contrast, photostationary steady state calculations fall short by up to a factor of 2 relative to the observations, most prominently in the northern hemisphere. Excess hydrogen peroxide levels give evidence that convection and the subsequent redistribution towards the subtropics have a global impact on the spatial distribution of the species.
Session 2 Poster

Regional-scale modeling in a global model with MUSICAv0: MUlti-Scale Infrastructure for Chemistry and Aerosols

Louisa K Emmons
National Center for Atmospheric Research, USA

Author list (excluding presenting author)

Mary C. Barth (1), Gabriele G. Pfister (1), Simone Tilmes (1), Wenfu Tang (1), Duseong S. Jo (1)

Abstract

The first implementation of the MUlti-Scale Infrastructure for Chemistry and Aerosols (MUSICA), a model called MUSICAv0, is being used to explore fine-scale atmospheric composition distributions within a global model. The MUSICA goals of developing the capability of unifying various spatio-temporal scales, coupling to other Earth System components and process-level modularization will allow advances on topics ranging from fundamental research to air quality to climate and is also envisioned to become a platform that addresses the needs of policymakers and stakeholders. The community is invited to participate in MUSICA development and the opportunities for collaboration will be described.

MUSICAv0 is a configuration of the Community Atmosphere Model with chemistry, using the Spectral Element dynamical core on a cubed sphere grid (CAM-chem-SE), a component of the Community Earth System Model (CESM), with a regionally refined grid over the area of interest. A number of studies have used the publicly available CONUS grid, with 14-km horizontal resolution over the coterminous United States, focused on biogenic compounds in the Southeast U.S. and fire plumes in the Pacific Northwest. Other grids have been created to study air quality in S. Korea (7-km grid) and the Asian Summer Monsoon (25-km grid over East Asia). Comparisons between MUSICAv0 with the CONUS grid and WRF-chem with 20-km resolution over the U.S. illustrate that MUSICAv0 can provide comparable results to WRF-Chem while eliminating the need for lateral boundary conditions and more accurately representing influences from outside the WRF-Chem domain and the stratosphere.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality
Application of the Multi-Scale Infrastructure for Chemistry and Aerosols (MUSICA) over Africa

Wenfu Tang
Atmospheric Chemistry Observations & Modeling (ACOM) Lab, National Center for Atmospheric Research, USA

Author list (excluding presenting author)
Louisa Emmons¹, Helen Worden¹, Sara-Eva Martinez-Alonso¹, Rajesh Kumar², Cenlin He², and Pieternel Levelt¹,³,⁴

Abstract

The Multi-Scale Infrastructure for Chemistry and Aerosols (MUSICA) is a new community modeling infrastructure developed by the Atmospheric Chemistry Observations and Modeling (ACOM) Laboratory at NCAR together with the atmospheric chemistry community. MUSICA enables the study of atmospheric composition and chemistry across all relevant scales. Africa is one of the most rapidly changing regions in the world and air pollution is a growing issue at multiple scales over the continent. We have developed a MUSICA grid specifically for atmospheric chemistry research over Africa. The model configuration has a refined resolution over Africa (~28 km) while still containing a global domain (~1-degree resolution). The model configuration also includes carbon monoxide (CO) tracers to indicate the source regions (West Africa, South Africa, North Africa, East Africa, Central Africa, and inflow from outside the continent) and source types (anthropogenic, fire, and waste burning) to the air pollution over Africa. We have run the model for the whole year of 2017 and compared our MUSICA results with a Weather Research and Forecasting (WRF) model coupled with Chemistry (WRF-Chem) simulation over Africa (~20 km resolution). The preliminary results show that the performance of MUSICA is comparable to WRF-Chem when compared to in situ observations of CO. In addition, as the in situ observations over Africa are limited, we also evaluate the MUSICA model results using satellite products. Specifically, we compare the model results to CO from the Measurement of Pollution in the Troposphere (MOPITT), nitrogen dioxide (NO₂) and ozone (O₃) from the Ozone Monitoring Instrument.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

ANGA: African Group on Atmospheric Sciences
Session 2 Poster

**Automated machine learning to evaluate the information content of tropospheric trace gas columns for fine particle estimates over India: a modeling testbed**

Zhonghua Zheng  
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**Author list (excluding presenting author)**

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**Abstract**

India is largely devoid of high-quality and reliable on-the-ground measurements of fine particulate matter (PM$_{2.5}$). Ground-level PM$_{2.5}$ concentrations are estimated from publicly available satellite Aerosol Optical Depth (AOD) products combined with other information. Prior research has largely overlooked the possibility of gaining additional accuracy and insights into the sources of PM using satellite retrievals of tropospheric trace gas columns. We first evaluate the information content of tropospheric trace gas columns for PM$_{2.5}$ estimates over India within a modeling testbed using an Automated Machine Learning (AutoML) approach, which selects from a menu of different machine learning tools based on the dataset. We then quantify the relative information content of tropospheric trace gas columns, AOD, meteorological fields, and emissions for estimating PM$_{2.5}$ over four Indian sub-regions on daily and monthly time scales. Our findings suggest that, regardless of the specific model assumptions, incorporating trace gas modeled columns improves PM$_{2.5}$ estimates. We use the ranking scores produced from the AutoML algorithm and Spearman's rank correlation to infer the relative dominance of primary versus secondary sources of PM$_{2.5}$ as a first step towards estimating particle composition. Our comparison of AutoML-derived models to selected baseline machine learning models demonstrates that AutoML is at least as good as model selection and hyperparameter tuning prior to training. The idealized pseudo-observations used in this work lay the groundwork for applying satellite retrievals of tropospheric trace gases to estimate fine particle concentrations in India and serve to illustrate the promise of AutoML applications in atmospheric and environmental research.

**Early Career Scientist**

YES, I am an early career scientist.

**IGAC Activities**

CCMi: Chemistry Climate Model Initiative, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality
Climate impacts of a historical shift in aerosol precursor emissions

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Author list (excluding presenting author)

Paul T. Griffiths (1, 2)
Alexander T. Archibald (1, 2)

Abstract

Aerosols affect the Earth’s energy budget, both directly via scattering/absorption and indirectly via their effect on important terms in the energy budget by enhancing cloud formation and by modulating cloud properties.

Sulfur dioxide ($SO_2$) is an important aerosol precursor with the largest sources coming from anthropogenic activity. Unlike well-mixed greenhouse gases, anthropogenic aerosols are heterogeneously distributed because of localised emission and the short atmospheric residence time. Global anthropogenic $SO_2$ emissions increased from 1850 to 2005, with different trends across regions. The emissions in North America and Europe have declined over 1980-2015. In Asia, there is a strong increase from China up to around 2005, while over India, the emissions are increasing steadily. It could therefore be argued that the emission of aerosol precursors shifted eastwards and equatorward away from the Western European region since 1980.

This work investigates the modelled response of sulfate aerosol burden to emissions increases and the effect of emission location change on the climate over the period 1850-2014. We use the UKESM1 model to examine the role of sulfur in the Earth system. From an analysis of the CMIP6’s and AerChemMIP’s experiments, we show that there have been significant changes in the atmospheric oxidation processes of $SO_2$ over this period. $SO_2$ reacts with hydroxyl radical in the gas phase or with either ozone or hydrogen peroxide in the aqueous phase. We found that the gas-phase reaction dominates the oxidation pathways in most regions. For the aqueous-phase reaction, the oxidation rates have shifted from reaction with ozone in the Western Europe region in 1980 towards greater oxidation with hydrogen peroxide in the Eastern Asia in 2014. We will present an analysis of the effects of these changes to sulfur oxidation on surface air temperature and aerosol radiative forcing.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

CCMi: Chemistry Climate Model Initiative
CO emission optimization using TROPOMI

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Author list (excluding presenting author)

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Abstract

Carbon monoxide (CO) in the atmosphere adversely affects air quality and climate, making knowledge about its sources crucial. However, current global bottom-up emission estimates retain significant uncertainties. We attempted to reduce these uncertainties by optimizing the emission estimates through a top-down inverse modeling approach. Specifically, we introduced observations from the TROPOspheric Monitoring Instrument (TROPOMI) into the TM5-4DVAR model. The employed TROPOMI CO retrieval features high spatial resolution and daily global coverage paired with a high sensitivity to the whole atmosphere, including the boundary layer.

In our study, we investigated global CO emissions in the latter half of 2018, with a specific focus on the northern hemisphere. To constrain the emissions, we used NOAA surface flask measurements in conjunction with the TROPOMI satellite observations. Compared to the bottom-up inventories, our model found strong, broad-scale emission reductions in China and India. In part, these reductions can be attributed to policy changes in China. However, the OH climatology we used to simulate chemical loss appears to be underestimated in that region, which skews the inversion towards lower emissions as well. Conversely, we found very strong local emission increments over Europe and the Sahara. These are likely artifacts caused by the model’s limited capabilities to capture the surface flask measurements at these specific stations and could not be confirmed by the satellite observations.

Additionally, the mixing ratios calculated using optimized emissions from an inversion driven solely by the satellite observations agreed surprisingly well with the flask measurements. While this holds true only south of 55° N, due to model limitations, it could potentially allow for near real-time and purely satellite-based inversions. These would then be validated against and adjusted to the surface flasks as soon as they are available.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

AMIGO: Analysis of eMIssions usinG Observations
Future atmospheric composition in a widescale but plausible tree planting scenario and implications for climate in UKESM1 and CESM2.

Dr James Weber
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Author list (excluding presenting author)

James A. King (1); N. Luke Abraham (2); Peter J. Lawrence (3); Maria Val Martin (4)

Abstract

Afforestation and reforestation (AR) proposals to sequester CO$_2$ from the atmosphere are one of the most popular climate change mitigation strategies. However, changes to emissions of biogenic volatile organic compounds (BVOCs) and the resulting impacts on atmospheric composition are often overlooked when the efficacy of tree planting strategies is evaluated. BVOCs affect climate via the formation of secondary organic aerosols (SOA) and their influence on cloud properties, and via atmospheric oxidation changes influencing the greenhouse gases ozone and methane, and sulphate aerosol.

Using the Earth System models UKESM1 and CESM2 we have designed a series of modelling experiments to examine the effects of different tree cover pathways on atmospheric composition and the associated radiative forcing at 2050 and 2095. We consider two future scenarios, both with SSP3-7.0 climate and anthropogenic emissions but different land use and land cover (LULC): a deforestation scenario that follows SSP3-7.0 land use in which global tree cover decreases (“baseline”) and a tree planting scenario that features the maximum plausible increase in tree cover where trees are added only where they will thrive and encroachment on cropland is avoided (“AR”).

We also isolate the influence of changing temperatures, LULC and atmospheric composition on BVOC emission changes and assess the role the background atmospheric composition plays. We compare results from UKESM1 and CESM2 to take into account the variations between models in parameterisations of key processes.

Isoprene emissions are ~20% higher at 2050 in the AR scenario than the baseline, rising to ~40% at 2095, leading to changes in SOA, O$_3$, OH and other important species. We will discuss these results in the context of large-scale atmospheric composition changes and their implications for climate.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

CCMi: Chemistry Climate Model Initiative

COVID-19 related abstracts
no
The importance of using emission pre-processors in CTMs: TM5-MP meets HERMES

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Author list (excluding presenting author)
Nikos Daskalakis (1); Mihalis Vrekoussis (1,2,3)

Abstract

Regional atmospheric composition is largely influenced by emissions of trace gases emanating from local and more distant sources. Chemical Transport Models (CTMs), such as the TM5-MP are commonly used to investigate and study the regional and global impacts of global natural and anthropogenic emission sources on air quality, climate, and human health. Emissions sources in TM5-MP come from emission datasets, such as the Coupled Model Intercomparison Project, which is now in its 6th phase (CMIP6). While the TM5 model supports several emission datasets, the full treatment of these datasets happens in the model's source code. This approach results in a lack of flexibility in the modification of emissions (i.e. when creating various scenarios), their update, or including even more datasets.

In this study and towards accounting for this problem, TM5-MP was combined with the “High-Elective Resolution Modelling Emission System version 3” (HERMESv3). HERMESv3 is a framework used to select specific emissions from different emission inventories and create input files for the target model. To achieve this, HERMES had to be modified to produce files that include all necessary species needed in TM5-MP. As a first step, HERMES-output files, which are used as TM5-MP-input files, were created based on emission datasets already used in TM5-MP in its current form. Following this, TM5-MP was adapted to read HERMES-produced files. The model is then validated to ensure the consistency of the new workflow.

The above novel system can be used in various applications, including policy-making decisions. Herewith, and as a proof of concept, it is used to assess the impact of large vessel shipping emissions on the global atmospheric composition. This is achieved by comparing the atmosphere simulated with and without shipping emissions.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

GEIA: Global Emissions Initiative
Session 2 Poster

Anomalies of tropospheric gases obtained with multiple ground-based FTIR & modeling evaluation during the 2020 COVID19 lockdown

Ivan Ortega
Atmospheric Chemistry Observations & Modeling, National Center for Atmospheric Research, Boulder, Colorado, USA

Author list (excluding presenting author)

James W. Hannigan (1); Benjamin Gaubert (1), Guy Brasseur (1)

Abstract

Efforts to study the impact of COVID-19 lock-downs on atmospheric composition are largely weighted towards the use of surface in-situ and satellite platforms and for a small number of atmospheric species, e.g., NO2. Here, we quantify the change of several tropospheric species (ozone, CO, C2H2, H2CO, and C2H6) retrieved with ground-based Fourier-Transform InfraRed spectrometers (FTIR) during the stringent lockdowns in 2020 from a wide range of sites (urban & remote). In order to minimize the impact of long-term trends and meteorological effects we applied an exponential smoothing approach to the long-term data sets (10 years) to produce “business as usual” values in the 2020 lockdowns, which then are compared with actual observations. The Community Atmosphere Model with chemistry (CAM-chem) within the Community Earth System Model (CESM) framework is used to simulate the same gases for all sites using adjusted COVID-19 emissions and “business as usual”. We estimate that the tropospheric ozone column declined in April-May for most sites with a mean value of 7.9%. Simulations reproduced well the decline of ozone and reductions in emissions due to COVID-19 explain about a third of the decrease. For most urban sites, tropospheric CO was reduced between 1-7% with the largest decrease near the surface while remote sites show a moderate increase between 2-5% predominantly in the free troposphere. CO simulations pointed out that the increase would have been larger without COVID-19 perturbations. The anthropogenic tracer C2H2 shows a drop of 10% in urban northern hemisphere sites related to reductions in combustion emissions. We capture a decrease in C2H6 on sites with anthropogenic urban influence, although the variability is large and sometimes non-significant the simulations with COVID-19 emissions also capture the decrease. H2CO declined during the stringent 2020 lockdown in all urban sites explained by COVID-19 reductions in emissions of precursors.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

AMIGO: Analysis of eMissions usinG Observations

IGAC Regional Working Groups

Americas Working Group
COVID-19 related abstracts

yes
Session 2 Poster

Modelled impact of large-scale circulation on daily PM$_{2.5}$ concentrations and PM$_{2.5}$ sensitivity in China during winter

Zixuan Jia
School of GeoSciences, University of Edinburgh, Edinburgh, United Kingdom

Author list (excluding presenting author)

Zixuan Jia (1); Ruth M. Doherty (1); Oliver Wild (2); Steven T. Turnock (3,5); Carlos Ordóñez (4); Fiona M. O’Connor (3)

Abstract

Haze pollution in winter is a major concern in China due to high levels of suspended particulate matter (PM$_{2.5}$) caused by pollutant emissions, meteorological conditions and regional transport. We mainly examine the influence of the large-scale circulation on daily PM$_{2.5}$ concentrations and on the sensitivity of PM$_{2.5}$ to local and regional emissions in the Yangtze River Delta (YRD) region of China over the period 1999–2018 using an Earth system model, UKESM1. Weak cold, dry northerly winds over northern China associated with a weakened Siberian High are found to suppress southward transport of aerosols from YRD and may suppress southward transport of aerosols into YRD from the north. Furthermore, weak oceanic winds and precipitation deficits over southern China associated with a weakened Maritime Continent Low are conducive to air pollution over YRD. This provides favourable conditions for the accumulation of local emissions and may contribute to the transport of air pollutants into YRD from the south. Based on the dominant large-scale circulation, we construct a new index using the north-south pressure gradient to project PM$_{2.5}$ concentrations over the region. We show that this index can effectively distinguish different levels of pollution over YRD and explain changes in PM$_{2.5}$ sensitivity to emissions from local and surrounding regions. We then project future changes in daily PM$_{2.5}$ concentrations using this index and find an increase in PM$_{2.5}$ concentrations over YRD due to climate change that is likely to partially offset the effect of emission control measures.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality, ACAM: Atmospheric Chemistry and the Asian Monsoon
Session 2 Poster

Consequences of insufficient production of temporary NO\textsubscript{x} reservoirs on ozone production in models during KORUS-AQ

Katherine Travis
NASA LaRC, USA

Author list (excluding presenting author)

James. H. Crawford (1), Benjamin A. Nault (2)

Abstract

The advent of geostationary satellites, starting with GEMS over South Korea, offer the potential for additional insight into urban air quality. In preparation for these satellites, the joint NIER-NASA KORUS-AQ field campaign in 2016 obtained a large dataset for understanding local air quality and the contribution of local emissions to ozone and PM2.5 pollution. Models continue to be challenged in their ability to reproduce the rate of ozone production in the region and simulate NO\textsubscript{x} reservoirs (organic nitrates) that can contribute to ozone production downwind. During the KORUS-AQ campaign, models partitioned NO\textsubscript{x} primarily into inorganic nitrate (HNO\textsubscript{3} + nitrate aerosol) while observations suggest that acyl peroxy nitrates (PNs) should be an important sink. Models also tended to produce ozone too efficiently, which may be due to insufficient alkyl/multifunctional nitrate (ANs) production. As a result, models are unable to simulate the transport of NO\textsubscript{x} away from the urban center and its impact on ozone production downwind. We implement additional ANs/PNs nitrate production in the WRF-GC model at high resolution (~4km) to improve simulations of ozone and NO\textsubscript{x} reservoirs during KORUS-AQ.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
The impact of vertical wind on the daily variation of surface ozone concentration

Prof. Ying Li
Southern University of Science and Technology, China

Author list (excluding presenting author)

Xiangjun Zhao(1); Xuejiao Zheng(2)

Abstract

It is widely reported that the surface wind impact on variation of the ozone pollution levels. However, the process how the vertical wind impact on the daily ozone pollution levels have not been clearly studies, which is crucial for better prediction of the daily surface ozone variation. In this study, the analysis of ground observation, wind profile data, and model simulation are integrated to investigating the wind and ozone interactions in typhoon circulations over the Pearl River Delta of China. By analyzing the wind profile radar observations, we found a weak winds deepening (WWD; vertical depth of the weak winds increased), which is more correlated to the ground-level ozone variation than surface weak wind. Long-term statistical analyses show that the WWD is a common weather phenomenon that occurs in the peripheral subsidence region of typhoons and was generally accompanied by ozone pollution episodes. WRF-Chem with process analysis simulation show the clear sky and warmer air under the peripheral circulation of typhoons are conducive for the ozone photolysis formation above the ground in planetary boundary layer (PBL) and compensate for the surface ozone through the vertical mixing effects. The WWD induced by the peripheral circulation of typhoon system result in ozone enhancements throughout the whole PBL due to a weakened horizontal advection, which play an important role in determining the daily daytime ozone variation. That why the daytime peak ozone level could continue to increase when the daytime photochemical reactions begin to decrease at the end of sustained typhoon-induced ozone episodes. These results indicate the important role of the WWD in the lower troposphere due to the peripheral circulation of the typhoon controls the daily ADV impact on both the daytime and nighttime ozone levels, which helps to better predict the daily changes of peak ozone levels.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

China Working Group
The interaction of weather and air pollution extremes in warmer climate

Tamara Emmerichs
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Author list (excluding presenting author)
Domenico Taraborrelli (1)

Abstract

Understanding the multiple interactions between weather and pollution extremes becomes more and more compelling in the current times of climate warming as the frequency and intensity of meteorological extremes are projected to increase. Meteorological extremes as well as high air pollution events represent a remarkable threat for human life which have been reported in the past decades. Heat waves, air stagnation and temperature inversion are known to affect air quality and air chemistry. Among many trace gases, the fate of tropospheric ozone is highly dependent on meteorological conditions.

By developing descriptive storylines of past extreme events in present and future climate we examine the drivers, chemical and physical, of air pollution extremes during heat waves and drought. Separating the dynamical (large scale circulation patterns, high uncertainty) from the thermodynamic effects via spectral nudging of only wind and vorticity allows to reproduce the dynamical conditions of the extreme events while thermodynamic aspects can be studied in detail. This approach aims to make climate change and its impact more tangible by studying the intensity rather than the likelihood of an event.

In this study, we employ the global atmospheric chemistry model ECHAM5/MESSy with an advanced and comprehensive chemical mechanism. To ensure that important processes respond realistically to the changed climate conditions the model has recently been equipped with additional features concerning important coupling processes between the land and atmosphere. Plant transpiration and dry deposition are now based on the net CO₂ assimilation of plants ($A_{\text{net}}$-g approach). Different from other models, the plant response to soil moisture is, fully considered for the transpiration, dry deposition and emissions of volatile organic compounds. Here, we assess the multiple impacts of weather extremes on pollution extremes in changing climate and finally provide a range of ozone extremes for the present and a +2K climate world.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report
Session 2 Poster

The AMIGO (Analysis of eMIssions using Observations) project of IGAC

Dr. Claire Granier
Laboratoire d’Aerologie, Toulouse, France. NOAA/CSL - CIRES/University of Colorado, Boulder, CO, USA

Author list (excluding presenting author)

1. Avelino Arellano

2 Jenny Stavrakou

3. Daven Henze

4. Dylan Jones

5. Jennifer Kaiser

6. Kazuyuki Miyazaki

Abstract

The overarching goal of AMIGO (https://amigo.aeronomie.be) is to organize scientific discussions for defining syntheses of research using observations to better quantify emissions for a variety of trace gases at different spatial and temporal scales.

AMIGO is a new project within IGAC, which started around 2018, in order to address the need for a more coordinated use of observations, and for discussions on the ability of different analysis techniques to provide consistent quantification of the emissions of multiple species, as of their uncertainties.

AMIGO is a community effort which stands at the crossroads of several IGAC activities involving emissions, atmospheric modeling and analysis on observations. It is also of high relevance for policy makers and society.

Since 2018, AMIGO organized workshops, including a workshop organized together with the MAP-AQ (Monitoring, Analysis and Prediction of Air Quality) of IGAC, where common activities were discussed. A workshop was organized in November 2020 on the changes in atmospheric composition during the Covid-19 lockdowns. The presentations given at these workshops are available through the AMIGO website, as well as a very long list of publications (400+) on the impact of Covid-19 lockdowns on emissions and atmospheric composition.

AMIGO is currently organizing its first working group called CRANES (Working Group on Chemical Reanalysis And flux iNvErsionS), with aims to promote the use and access to chemical reanalysis products to a wide audience, including stakeholders, international scientific community, and students.

During the IGAC conference, we will elaborate with the IGAC community plans for the next two years, with focus on the implementation of a new AMIGO working group with the MAP-AQ IGAC activity on global and regional atlases and on a series of seminars on satellite data available for air quality analysis. Inputs from the IGAC community are warmly welcome.
Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

AMIGO: Analysis of eMIssions usinG Observations
Rapid reduction in black carbon emissions from China and the dominance of the residential sector: evidence from 2009-2022 observations on Fukue Island, Japan

Dr. Yugo Kanaya
Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan

Abstract

Black carbon (BC) emissions cause health impacts and contribute to global warming. Although China has been regarded as a major global emitter, a robust quantification of BC emission rates and trends have not been achieved from atmospheric observations, partly because its loss rate due to wet deposition was too uncertain and variable. Based on the long-term (2009-2022) observations of atmospheric BC mass concentrations using COSMOS and MAAP instruments at Fukue Island, western Japan, located downwind of China, we assessed for the first time that the total emission rate was around 1.1 Tg yr\(^{-1}\) in 2018, i.e., near the lower bound of the wide range (1-2 Tg yr\(^{-1}\)) of emission estimates, and was associated with a rapid decrease (-4.6 % yr\(^{-1}\)). This evaluation includes correction for the interannual meteorological variability by using the regional atmospheric chemistry model (WRF/CMAQ) simulations with the constant emissions. This resolved the fundamental disagreements about the sign of the BC emissions trend from China over the past decade and led to an update of the Community Emissions Data System (CEDS) used for IPCC model comparison studies. The pace of reduction, as fast as those of SSP1 scenarios for 2015-2030, was likely driven by the stringent PM\(_{2.5}\) mitigation policy in China and efforts to increase access to clean fuels for residential cooking and heating. We also identified the dominance of the residential sector in recent Chinese BC emissions, as the estimated emission rate declined only by 18% during the COVID-19 lockdown period. This was in a clear contrast to carbon monoxide (CO), for which a relatively large emission reduction (36%) was estimated, likely due to major emission share from industry/transport sectors. We provide strong scientific evidence supporting mitigation policies targeting reduction of residential BC emissions from China by demonstrating the economic feasibility using marginal abatement cost curves.
Impacts of Aromatic Chemistry on the Global Atmosphere

Mr Stephen MacFarlane
University of Wollongong, Australia

Abstract

Aromatics are an important subset of volatile organic compounds (VOCs), emitted mostly by anthropogenic sources such as vehicle exhaust, industry, and solvent usage. These sources make them particularly important in urban environments, accounting for up to 60% of total VOCs in urban and semi-urban areas. Aromatic species can undergo atmospheric oxidation resulting in significant contributions to both ozone and secondary organic aerosol (SOA) production, making it important for air quality to understand aromatic chemistry. The impacts of aromatic chemistry can be examined using Chemical Transport Models (CTMs) that simulate atmospheric processes. However, CTMs are only useful if they can be trusted to provide an accurate description of the real atmosphere.

Here, we evaluate a new aromatic chemistry mechanism recently implemented in GEOS-Chem, a global CTM. The new aromatic mechanism includes new reactions, species, and products. However, it has not yet been evaluated using atmospheric observations. To evaluate the new aromatic mechanism, we compare GEOS-Chem model simulations to measurements from the Korea-United States Air Quality (KORUS-AQ) aircraft campaign, during which a variety of aromatic species and their oxidation products were measured around the Korean Peninsula from May to June 2016. In this presentation, we will provide a preliminary analysis of model ability to reproduce observed aromatic concentrations and variability during the campaign. We will also discuss implications for atmospheric composition in aromatic-influenced regions and plans for future model development.

Early Career Scientist

YES, I am an early career scientist.
Session 2 Poster

The global COVID-19 lockdown impacts on secondary inorganic aerosols

Dr. Takashi Sekiya
Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan

Author list (excluding presenting author)

Kazuyuki Miyazaki (2); Henk Eskes (3); Kengo Sudo (4,1); Masayuki Takigawa (1); Yugo Kanaya (1)

Abstract

The world-wide lockdown measures to prevent spreading the 2019 Novel Coronavirus (COVID-19) led to substantial reductions in anthropogenic air pollutants’ emissions. The unprecedent global emission reductions allow us to investigate how atmospheric composition respond to reduced human activity. Global COVID-19 lockdown impacts on fine particles have been evaluated (e.g., Hammer et al. 2021). However, changes in secondary aerosols on regional to global scales remain unclear. Integration of observational information on aerosol precursor gases from space allows us to investigate how secondary aerosols respond to reduced anthropogenic emissions on the global scale. We quantify the response of secondary inorganic aerosols to COVID-19-related NOx and SO2 emission reductions using a multi-constituent chemical data assimilation of the TROPOMI for tropospheric NO2 column and total SO2 column, the MLS for O3 and HNO3 profiles.

Compared to the baseline “business-as-usual” emissions, anthropogenic NOx and SO2 emissions in April 2020 were reduced by 19–25% and 14–20%, respectively, over major polluted regions. These regional emission reductions led to decreases in sulfate and nitrate aerosol column amounts by 11% and 21%, respectively, over the eastern United States, by 8% and 11% over Europe, and by 12% and 14% over eastern China in April 2020, which resulted from complex and non-linear responses of chemistry and aerosol thermodynamic system to the emission reductions and seasonal cycles in meteorology. The decreases in secondary aerosols over these three regions corresponded to more than 43% of the aerosol optical depth changes between April 2020 and previous years derived from Suomi NPP/VIIRS and Terra and Aqua/MODIS. The global aerosol decreases led to effective radiative forcing of 0.14 Wm^{-2} during April-June 2020. These results provide a test case of NOx and SO2 emission controls for aerosols and their climate forcing.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Regional Working Groups

Japan National Committee

COVID-19 related abstracts

yes
Introducing new lightning schemes into the CHASER (MIROC) chemistry climate model

PhD student Yanfeng He
Nagoya University, Japan

Author list (excluding presenting author)

Kengo Sudo (1)(2); H.M.S. Hoque (1)

Abstract

The formation of nitrogen oxides (NO\textsubscript{x}) associated with lightning activities (hereinafter designated as LNO\textsubscript{x}) is a major source of NO\textsubscript{x}. Therefore, improving the prediction accuracy of lightning and LNO\textsubscript{x} in chemical climate models is crucially important. The authors implemented three new lightning schemes with the CHASER (MIROC) global chemical transport/climate model. The first lightning scheme is based on upward cloud ice flux (ICEFLUX scheme). The second one is the original ECMWF scheme which was also adopted in the ECMWF forecasting system. For the original ECMWF scheme, by tuning the equations and adjustment factors for land and ocean, a new lightning scheme named ECMWF-McCAUL scheme was also tested in CHASER. In the original version of CHASER, lightning is initially parameterized with the widely used cloud top height scheme (CTH scheme). Model evaluations with lightning observations (LIS/OTD) indicate that the newly implemented lightning schemes simulate the spatial distribution of lightning more accurately on a global scale than the CTH scheme does. The ECMWF-McCAUL scheme showed the highest prediction accuracy for the global distribution of lightning. Evaluation by atmospheric tomography (ATom) aircraft observations (NO) and tropospheric monitoring instrument (TROPOMI) satellite observations (NO\textsubscript{2}) shows that the newly implemented lightning schemes partially facilitated the reduction of model biases typically within the regions where LNO\textsubscript{x} is the major source of NO\textsubscript{x} when compared using the CTH scheme. Although the newly implemented lightning schemes have a minor effect on the tropospheric mean oxidation capacity compared to the CTH scheme, they led to marked change of oxidation capacity in different regions of the troposphere. Finally, we quantitatively estimated the LNO\textsubscript{x} emission effects on tropospheric NO\textsubscript{x} and O\textsubscript{3} column trends during 2001–2020. Results showed that a marked trend of annual global LNO\textsubscript{x} emissions significantly affects the trend of global mean tropospheric NO\textsubscript{x} and O\textsubscript{3} columns.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

CCMi: Chemistry Climate Model Initiative

IGAC Regional Working Groups
**Session 2 Poster**

**Photosynthetic stomatal conductance models are better suited for modelling the pollution uptake of vegetation and reveal nocturnal pollution uptake contributes significantly to the total uptake.**

Mrs. Savita Datta  
1Department of Earth and Environmental Sciences, Indian Institute of Science Education and Research Mohali, Sector 81, S.A.S Nagar, Punjab 140306, India

**Author list (excluding presenting author)**

Anita Sharma (1); Baerbel Sinha (1)

**Abstract**

DO3SE (Deposition of Ozone for Stomatal Exchange), is a dry deposition model, designed to assess tropospheric ozone risk to vegetation, and is based on two algorithms: multiplicative and photosynthetic. The multiplicative model has been argued to perform better for leaf-level and regional level applications. In this study, we demonstrate that the photosynthetic model is superior to the multiplicative model even for leaf-level studies using measurements performed on *Mangifera indica*. We find that the multiplicative model overestimates the daytime stomatal conductance, when compared with measured stomatal conductance and prescribes zero conductance at night while measurements show an average conductance of 100 mmol m$^{-2}$ s$^{-1}$ between 9 PM and 4 AM. The daytime overestimation of the multiplicative model can be significantly reduced when the model is modified to include a response function for ozone induced stomatal closure. However, nighttime pollution uptake fluxes can only be accurately assessed with the photosynthetic model which includes the stomatal opening at night during respiration and is capable of reproducing the measured night time stomatal conductance. At our site, the nocturnal flux contributes 60%, 36%, 42%, and 83% of the total for NO$_2$ uptake in winter, summer, monsoon, and post-monsoon respectively. For SO$_2$ nocturnal uptake amounts to 35%, 28%, 28%, and 44% in winter, summer, monsoon, and post-monsoon respectively while for ozone the nighttime uptake contributes 30%, 17%, 18%, and 29% of the total stomatal uptake in winter, summer, monsoon, and post-monsoon respectively.

**Early Career Scientist**

NO, I am not an early career scientist.

**IGAC Activities**


**IGAC Regional Working Groups**

MANGO: Monsoon Asia and Oceania Networking Group
Comparative analyses of fleet replacement strategies for road-transport air pollution reduction over India by 2030

Dr. Haseeb Hakkim
Indian Institute of Science Education and Research Mohali, India

Author list (excluding presenting author)
Ashish Kumar (1); Baerbel Sinha (1); Vinayak Sinha (1)

Abstract

Traffic emissions are a major source of air pollution and associated damage to human health in India. Many of the Indian metro cities urgently require cleaner transportation technologies to ensure cleaner air. Here, using a new spatially disaggregated, gridded, high-resolution (0.1° x 0.1°) road transport emission inventory for India (RTEII) compiled using measured emission factors for varied fuels and vehicle technologies extant across India, we have compared the changes in annual emissions of 74 speciated VOCs, CO, SO\(_2\), NO\(_x\), NH\(_3\), CH\(_4\), CO\(_2\), BC, OC and PM\(_{2.5}\) under three “what-if” intervention scenarios with respect to emissions that would occur under business-as-usual development under the projected transport demand for the SSP5 fossil fuel-based economic growth for the same year, 2030. The results show that significant reductions in direct emission of pollutants (Non-Methane VOCs, -91%; CO, -80%; PM\(_{2.5}\), 44%) including toxic VOCs (e.g., isocyanic acid, -76%; BTEX, -93%; as well as individual VOC classes (e.g., sum of OVOCs, -61% and sum of alkenes, -80%) can likely be achieved in 2030 by shifting from highly polluting Internal Combustion Engine (ICE) based 2 and 3-wheeled vehicles to Electric Vehicles (EVs) under scenario 1. The amount of secondary pollutants such as SOA and O\(_3\) that can potentially be formed from traffic also showed a significant reduction of 94% and 84%, respectively, under scenario 1. Conversion of diesel-fueled vehicles to CNG under scenario 2 can lead to a larger reduction in BC emissions (-50%). Scenario 3, in which the benefits of scenarios 1 and 2 are combined, represents the best long-term strategy moving forward, which can result in massive emission reductions of pollutants through existing technologies of greener transport fleets over India. Large scale conversion of the vehicle fleets as explored here can lead to a substantial reduction in air pollution and fewer lives lost.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities


IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Evaluating biomass burning organic aerosol markers in ToF-ACSM data using a capture vapouriser: Case study from the COALA-2020 campaign

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School of Geography, Earth & Atmospheric Sciences, University of Melbourne, Australia. Climate Science Centre, CSIRO, Australia

Author list (excluding presenting author)

Melita Keywood (1), Clare Paton-Walsh (2), Jack Simmons (2), Quang Dang (2), Michihiro Moshida (3), Sho Ohata (3), Sonia Afsana (3), Bhagawati Kunwar (4), Kimitaka Kawamura (4), Ruhi Humphries (1), Kathryn Emmerson (1), Caleb Mynard (1), Robyn Schofield (5), Peter Rayner (5)

Abstract

A feature of the Time-of-Flight Aerosol Chemical Speciation Monitor (ToF-ACSM) is its vapouriser, which converts incoming aerosols into the gas phase. The standard vapouriser is a major source of uncertainty as particles can bounce away at the vapouriser, thereby contributing over 30% of the uncertainties for both organic and inorganic aerosol mass. One solution which has been implemented in recent instruments is the capture vapouriser (CV). The CV has negligible loss of particles due to differences in its size, structure, and construction, but has also been shown to alter the established fragmentation patterns of known organic marker species, including that of the biomass burning OA (BBOA) marker levoglucosan. Hence, the profile of molecular fragments produced from BBOA by the CVs requires investigation.

This study characterises BBOA markers from data collected using a ToF-ACSM with a CV as part of the Characterising the Organics and Aerosol Loading over Australia 2020 (COALA-2020) campaign, which took place in southeastern Australia in January-March 2020, overlapping with the Black Summer bushfires. Calibrations of a ToF-ACSM with a CV using levoglucosan standards yielded similar molecular fragments as those proposed by the ToF-AMS analysis in Hu et al. (2018) (r=0.96), which also used a CV. Positive Matrix Factorisation analysis of the COALA-2020 ToF-ACSM data resulted in factors that contained high proportions of BBOA marker species. Analysis of the BBOA factors will include comparing their mass spectra with that of the levoglucosan standard, as well as co-located measurements of levoglucosan and acetonitrile concentrations.

Reference:


Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality
IGAC Regional Working Groups

Southern Hemisphere Working Group
Session 2 Poster

An interactive model AMmonia-CLIMate (AMCLIM) for quantifying climate-dependent ammonia emissions from agriculture

Mr Jize Jiang
University of Edinburgh, United Kingdom

Author list (excluding presenting author)

David Stevenson (1)
Mark Sutton (2)

Abstract

Ammonia is the primary form of reactive N, which has significant impacts on the environment and resource distribution. Ammonia originates mainly from agriculture, including livestock housing, manure storage and application, and fertiliser use, which accounts for over 85% of all atmospheric releases in Western Countries. Ammonia emissions from agriculture are highly dependent on climate. However, current estimates were mostly calculated by applying emission factor methods, which only considered climatic impacts to a limited extent and might introduce large uncertainty because NH$_3$ volatilisation is strongly influenced by climate through temperature and water interactions. We developed an interactive model, AMCLIM, to investigate the effects of meteorological factors on NH$_3$ volatilisation and to quantify how climatic interactions and local management affect NH$_3$ emissions based on understandings at process-level. We found strong variations in both geographical distributions and seasonal trends of NH$_3$ emissions, which is a combined effect of the climatic conditions and local practices. A critical finding was that the volatilisation rates (per cent of N volatilised as NH$_3$) differed significantly across the globe, with the value being up to 5 times in some hot regions compared to cold places. More importantly, local management affected the emission fraction to a large extent. Over 60 per cent of applied N can be lost through NH$_3$ emissions if using improper techniques, so such techniques should be avoided or improved in particular regions to reduce NH$_3$ emissions. Preliminary results suggested the NH$_3$ emissions are likely to increase in a warming climate, and it is of great importance to find out adequate ways of sustaining the N in the agricultural sector and improving the use efficiencies.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

GEIA: Global Emissions Initiative
Session 2 Poster

Studying the chemistry-climate interaction and impact of dust on the Indian Summer Monsoon Rainfall

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Author list (excluding presenting author)

Gaurav Govardhan (1,2), Rajesh Kumar (3), Mary Barth (3), Gabriel Pfister (3), Subodh Kumar Saha (1), Anupam Hazra (1), Samir Pokhrel (1), Sachin Ghude (1)

Abstract

The impact of chemistry-climate interaction on the Indian Summer Monsoon Rainfall (ISMR) is examined in this study. Considering the present scenario of changing climate, where aerosols are thought to have a significant effect on modulating the monsoon rainfall, it is imperative to include the explicit representation of atmospheric chemistry in the numerical simulation of the ISMR. We have carried out two sets of 122-days simulations (JJAS) for a period of 10 years (2010-2019) using the WRF-Chem model (v3.9.1): (1) a control experiment without embedding chemistry and (2) a sensitivity experiment with embedding fully coupled MOZART-MOSAIC chemistry, at a spatial resolution of 45 km covering the CORDEX South Asia domain followed by dynamical downscaling to 15 km spatial resolution over the Indian subcontinent. Results have shown that the inclusion of interactive chemistry in the model alters the spatial distribution of mean rainfall, modulating the spatial distribution of both the convective and non-convective rainfall and year to year variability. The inclusion of chemistry also impacts the simulation of sub-seasonal modes of monsoon intra-seasonal variability, thus modulating the seasonal mean rainfall.

Additionally, many recent studies have highlighted a decreasing trend in the pre-monsoon dust loading over the Indian subcontinent, which has motivated us to investigate and quantify the effect of reduced dust emissions on the ISMR. Our analyses show that reducing dust emissions significantly alters the spatial distribution of seasonal mean monsoon rainfall. The low aerosol loading conditions strengthen the Somali jet over the Arabian Sea and cyclonic circulations over the Bay of Bengal (BoB), thus intensifying convective activity over the BoB region. As a result, the 10-20 days sub-seasonal mode of the ISMR strengthens, facilitating enhanced westward propagation of rain-bearing systems formed over northern BoB, which consequently provides substantial rainfall over vast regions of the Indian subcontinent.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Session 2 Poster

Extreme PM and ozone pollution over central Europe: interactions of the urban canopy meteorological forcing and radiative effects of urban emissions

Alvaro Patricio Prieto Perez
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Author list (excluding presenting author)

Peter Huszár (1); Jan Karlický (2)

Abstract

Extreme air pollution in European cities still persists today, being a large health burden on their inhabitants. Understanding the processes that control or modulate such events over urban areas is therefore crucial. In this study, based on two air pollution events in August 2015 (elevated ozone levels during a dry sunny summer period) and January 2017 (high winter PM concentrations and stagnant conditions), we examine the mutual role of urban emissions (and the secondary pollutants formed from them) and the urban canopy meteorological forcing (UCMF) over central Europe. We performed a series of WRF-Chem simulations with/without urban land-surface and with/without urban emissions, while eight large cities from Central Europe were considered. Impact on the meteorological conditions and chemical species is examined.

As for the impact on meteorological conditions, we showed that the direct effect of UCMF is much larger than the secondary effects of the radiative impacts of urban emissions. We also showed that these radiative impacts depend whether UCMF is included or not. The impact on the chemical concentrations is driven especially by UCMF causing decrease of PM and increase of ozone while the indirect effects of urban emissions induced meteorological changes are substantially smaller.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities
Session 2 Poster

Measurements and modelling of OH, HO₂, RO₂ and OH reactivity on the Tibetan Plateau

Dr Dwayne E. Heard
University of Leeds, United Kingdom

Author list (excluding presenting author)

Eloise Slater (1); Joanna Dyson (1,2); Chunxiang Ye (3); Yaru Wang (3); Jianshu Wang (3); Yingjie Zhang (3); Weixiong Zhao (3); Jiacheng Zhou (3); Robert Woodward-Massey (1); Oliver Marsh (1); Dwayne Heard (1)

Abstract

With an area of 2.5 million km² and an average altitude of about 4 km above sea level, the Tibetan Plateau is the largest and highest plateau in the mid-latitudes of the Northern Hemisphere. The high altitude, low latitude, and large snow coverage leads to strong solar radiation at the surface and, as such, a high production potential for OH. Given the large area of the Plateau, understanding the chemistry controlling OH concentrations in this region is important to accurately predict the global lifetime of the greenhouse gas, methane.

As part of the @Tibet campaign, observations of OH, HO₂, RO₂ and OH reactivity using laser-induced fluorescence were made in April 2019 at Namco research station, which is located on the Tibetan plateau.

Previous photostationary steady state (PSS) calculations of the OH concentrations in this region, which consider O₃ photolysis and subsequent reaction of O¹D with H₂O as the primary source of OH and CO and methane as the OH sinks, range from 3.7 to 11 x 10⁶ cm⁻³ in January and from 1.4 to 3.0 x 10⁷ cm⁻³ in July. (Lin et al., JGR, doi:10.1029/2007JD008831, 2008) suggesting an extremely photo-active environment.

The mean peak OH concentrations observed during @Tibet were ~3 x 10⁶ cm⁻³, which are at the lower end of the previously reported PSS predictions. The mean peak HO₂ and total RO₂ concentrations observed were ~3 x 10⁶ cm⁻³ and ~7 x 10⁸ cm⁻³ respectively. OH reactivity displayed a weak diurnal profile, peaking before sunrise at ~2.5 s⁻¹. By comparing the observed radical concentrations and OH reactivity with a radical budget analysis and detailed modelled predictions, we find that the OH reactivity in this region can be up to four times greater than calculated if only methane and CO are considered and this can significantly alter the predicted OH.

Early Career Scientist

NO, I am not an early career scientist.
Session 2 Poster

Unprecedented surface ozone decreases in China under net-zero policies: chemistry-climate model projections corrected with deep learning

Mr. Zhenze Liu
School of GeoSciences, The University of Edinburgh, Edinburgh, United Kingdom. Lancaster Environment Centre, Lancaster University, Lancaster, United Kingdom

Author list (excluding presenting author)

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Abstract

Surface ozone is damaging to human health and ecosystems, but is difficult to simulate well with current atmospheric chemistry-climate models. There are large uncertainties and limitations in the representation of physical and chemical processes in models, leading to errors in current and future projections of surface ozone. We develop a deep learning model to correct biases in surface ozone and successfully demonstrate its application in simulating daily mean surface ozone in China in the present day and under future net-zero policies. We find that summertime surface ozone in industrial regions of China decreases in the future, but has larger reductions after bias correction, reflecting the greater benefits of emission controls. Wintertime ozone increases due to reduced titration with nitric oxide, but has higher levels after bias correction, leading to the smaller seasonal variation of ozone in the future. Our study successfully demonstrates the value of applying deep learning to refine the results of process-based atmospheric chemistry-climate models and to provide more reliable assessment of how surface ozone will respond to changing emissions and climate in the future.

Early Career Scientist

YES, I am an early career scientist.
Session 2 Poster

Evaluating the first year of volatile organic compound (VOC) measurements at the subtropical remote site of Hateruma in East Asia

Dr Takuya Saito
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Author list (excluding presenting author)

Stephen J Andrews (2); Adedayo Adedeji (2); Mathew Evans (2); Alastair Lewis (2)

Abstract

A collaborative project between NCAS/University of York and the National Institute for Environmental Studies (NIES), Japan, has installed a new instrument on Hateruma Island for the autonomous measurement of wide range of volatile organic compounds (VOCs) in East Asia, key precursors to the surface air pollutant ozone.

Measurements are made from the NIES observatory on Hateruma Island (HAT), the southernmost island of the Japanese archipelago, around 200 km from the east coast of Taiwan. HAT is a very valuable site for long-term monitoring. The 12 km$^2$ island is almost completely flat, has very few inhabitants and is composed of coral with very little macroalgae around the coast. The air inlet is 46.5 m amsl, on the east coast of the island with a steep insular shelf. This allows measurement of very clean air from the South Pacific Ocean as the ITCZ pushes north during the summer months with very low ozone concentrations measured (<10 ppb). During winter, HAT sees the outflow of pollution from China with air masses from along the Chinese coast and influence from Beijing, Shanghai and China’s industrial East coast. We aim to quantify NMHC, biogenic VOC and oxygenated species, plus the shorter-lived, higher molecular weight VOC and aromatics.

We present an evaluation of measurements from the 1st year of operation; the air masses arriving at the station, the range of species identified and their probable sources. We explore the diurnal and seasonal variability of the VOC measurements and compare with a limited range of VOC measurements from an existing, co-located halocarbon GC-MS instrument, complementing useful anthropogenic tracers.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities


IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Max-DOAS observations of formaldehyde and nitrogen dioxide at three sites in Asia and comparison with the global chemistry transport model CHASER

Mr Hossain Mohammed Syedul Hoque
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Author list (excluding presenting author)

Kengo Sudo (1,2); Hitoshi Irie (3); Alessandro Damiani (3); Manish Naja (4); Al Mashroor Fatmi

Abstract

Formaldehyde (HCHO) and nitrogen dioxide (NO₂) concentrations and profiles were retrieved from ground-based multi-axis differential optical absorption spectroscopy (MAX-DOAS) observations from January 2017 through December 2018 at three sites in Asia: (1) Phimai (15.18°N, 102.5°E), Thailand; (2) Pantnagar (29°N, 78.90°E) in the Indo Gangetic plain (IGP), India; and (3) Chiba (35.62°N, 140.10°E), Japan. The retrievals were performed using the Japanese MAX-DOAS profile retrieval algorithm, version 2 (JM2). The observations were used to evaluate the NO₂ and HCHO partial columns and profiles (0-4 km) simulated using the global chemistry transport model (CTM) CHASER. The NO₂ and HCHO concentrations at all three sites showed consistent seasonal variations throughout the investigated period. Biomass burning affected the HCHO and NO₂ variation in Phimai during the dry season and Pantnagar during spring (March-May) and post-monsoon (September-November). The results on the HCHO to NO₂ ratio (R_{HN}), an indicator of high ozone sensitivity, show that the transition region (i.e., 1< R_{HN} <2) changes regionally, echoing the recent finding on the effectiveness of R_{HN}. Moreover, reasonable estimates of transition regions can be derived by accounting for the NO₂-HCHO chemical feedback. CHASER demonstrated good performances reproducing the HCHO and NO₂ abundances at Phimai, mainly above 500 m from the surface. Model results agree with the measured variations, ranging within the one sigma standard deviation of the observations. Simulations at higher resolution improved the modeled NO₂ estimates in Chiba, reducing the mean bias error (MBE) in the 0-2 km height by 35%. However, resolution-based improvements were limited to the surface layers. Sensitivity studies showed pyrogenic emissions in Phimai contribute to the HCHO and NO₂ concentrations up to ~50 and ~35%, respectively.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Session 2 Poster

Evaluating the GEOS-Chem High Performance (GCHP) model with observations of radical species at a UK monitoring supersite

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Author list (excluding presenting author)

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Abstract

Chemistry transport models are often used to assess strategies for reducing population exposure to air pollution. Although these models are often evaluated against air quality pollutants they are less regularly evaluated against the concentration of the photochemical radicals which underpin atmospheric chemistry. The summer 2021 OSCA measurement campaign at the Manchester Air Quality Supersite made observations of hydroxyl radicals (OH), hydrogen peroxyl radicals (HO2), hydrogen peroxide (H2O2) and the OH reactivity together the measurements of VOC, NOx, and other parameters. We use these observations to evaluate the performance of the GEOS-Chem model of atmospheric composition in a stretched grid configuration (C120/S6) which gives the model a ~10 km resolution for Manchester. Over Europe we implement the European Monitoring and Evaluation Programme (~11 km) emissions whilst over the UK we use the National Atmospheric Emissions Inventory (~1 km). We find that the model underestimates OH reactivity, resulting in an overestimate of OH concentrations and an underestimate of HO2. NOx concentrations are also underestimated resulting in a general underproduction of O3 production rates. We explore possible explanations for this and the impact on the model prediction of pollutants.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality
Session 2 Poster

Land cover change impacts on tropospheric composition: from the satellite record to modelling.

Emma G Sands
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Author list (excluding presenting author)
Ruth Doherty (1); Richard Pope (2, 3); Fiona O’Connor (4); Chris Wilson (2,3); Hugh Pumphrey (1)

Abstract

Forest cover change can impact regional climate through biogeophysical and biogeochemical mechanisms. Biogeophysical effects, such as shifts in surface albedo, are generally well understood, but certain biogeochemical processes require detailed quantification like the emission of biogenic volatile organic compounds (BVOCs) and their direct/indirect impacts on the Earth system. BVOCs are precursors to ozone and secondary organic aerosols and can affect methane lifetimes. Consequently, changes in land cover can modify regional air quality and climate through biogeochemical effects with implications for human health and climate adaptation/mitigation strategies.

This research investigates the links between land cover and atmospheric composition over regions of major forest cover change such as the Amazon. The work initially focuses on the remote sensing data (from 2001 to 2019) of land cover and atmospheric composition species including formaldehyde, carbon monoxide (CO) and aerosol optical depth (AOD). Comparisons of these records show strong responses in atmospheric composition to land use change, e.g., high CO and AOD values during the substantial biomass burning years (e.g., in 2010 and 2015), as well as long-term trends in concentrations, such as an overall decrease in AOD over the Cerrado, potentially driven by forest cover change.

The relative importance of the different processes can be investigated in Earth System Models such as the UKESM1 model, developed by the UK Met Office and partners. We determine if UKESM1, using the current BVOC representation, can simulate the observational relationships between land cover and atmospheric composition species with the aim to quantify the key processes driving changes in atmospheric composition. Future work will build on these results to investigate the climate and air quality impacts of land use changes and simulate potential future scenarios.

Early Career Scientist

YES, I am an early career scientist.
Session 2 Poster

Understanding the impact of future land-use change on climate through emissions of biogenic volatile organic compounds

Eleanor S Smith
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Author list (excluding presenting author)

C. E. Scott (1)

Abstract

The overall impact of land-use change (LUC) on the climate results from a combination of several factors. Of these, the alteration to atmospheric composition from the emission of biogenic volatile organic compounds (BVOCs) from plants has only recently been considered alongside the others, and its importance understood. BVOC emissions impact short-lived climate forcers (SLCFs) by chemically reacting in the troposphere and different plant functional types (PFTs) vary in their rates of emission.

CMIP6 has provided suitable experiments and generates the outputs required to assess the impacts of LUC and the emissions of BVOCs on the future climate. Here, we analyse CMIP6 outputs generated by the UKESM model to evaluate two scenarios (SSP1-2.6 and SSP3-7.0). The projections analysed are the ssp370 and ssp126 experiments from ScenarioMIP along with the ssp370SST and ssp370SST-ssp126Lu experiments from AerChemMIP.

Focussing on the period 2090-2100, we identify differences in the projected land-use between the two scenarios by determining global and regional coverage of different PFTs. We make use of the AerChemMIP outputs to quantify how BVOC emissions and concentrations of isoprene, ozone and aerosol vary as a result of the difference in land use between SSP3-7.0 and SSP1-2.6. We compare these variations to the changes in land use to identify relationships between the type of LUC and the direction of change of BVOC emissions and atmospheric concentrations. Finally, we explore whether the changes to the atmospheric chemistry as a result of the LUC contribute to discrepancies in future warming in the two scenarios, through analysis of the radiative forcing.

The results provide an improved understanding of the impact of LUC on BVOC emissions, how this impacts concentrations of SLCFs and what this means for the climate.

Early Career Scientist

YES, I am an early career scientist.
Satellite observation of wildfires in the Northern Hemisphere and their impact on CO and aerosol long-range transport: variability over 2008-2022

Antoine Ehret
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Solène Turquety (1); Maya George (1); Cathy Clerbaux (1)(2)

Abstract

Wildfires are responsible for significant emissions of greenhouse gases, pollutants and aerosols. In addition to being a large source of carbon monoxide (CO) and carbon dioxide (CO2), they alone account for more than half of black carbon emissions and the majority of primary organic aerosol emissions.

Despite proactive fire suppression policies in the Northern Hemisphere (NH), allowing a decrease in fires, especially in Europe, an increase in the number of extreme fires can be noted in recent years. In the NH, this increase is mainly in Western America and boreal regions. The pollution plumes produced during extreme fires can be transported over thousands of kilometers, impacting background pollutant levels on a hemispheric scale. Thus, variability in fire intensity may explain a large part of the spatial and temporal variability of many atmospheric pollutants. For longer lived pollutants, wildfires may significantly increase background levels.

In this study, the link between extreme fire weather (high temperature), large fires and background pollution in the Northern Hemisphere is analyzed based on satellite observations. The impact of large wildfires on background levels of CO and aerosols above Europe is studied more specifically.

We present the variability of fire frequency in the NH, their intensity and the related emissions using 19 years (2003-2021) of MODIS fire observations analyzed with the APIFLAME model. The link between large events and fire weather is studied using the ERA5 reanalyses and the Canadian Fire Weather Index (FWI). The related impact on the variability of total CO and AOD in the NH is analyzed using 14 years (2008-2021) of satellite observations from IASI/Metop and MODIS/Terra and Aqua, respectively. Finally, the year 2018 is studied more specifically in order to evaluate the constraints provided by satellite observations bring on the emissions calculated by APIFLAME.

Early Career Scientist

YES, I am an early career scientist.
Session 2 Poster

Sources and processes influencing black carbon over Alaska during wintertime

Eleftherios Ioannidis
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Author list (excluding presenting author)

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Abstract

Anthropogenic emissions from mid-latitudes transported to the Arctic during winter and early spring lead to enhanced concentrations of aerosols including black carbon (BC), the so-called Arctic Haze. There are also local sources within the Arctic, contributing to BC during wintertime. Fossil fuel combustion and gas flaring over Russia influence BC at Utqiaġvik, northern Alaska. Petroleum extraction on the North Alaskan Slope (NSA), residential and power plant combustion also contribute to Alaskan BC but the sensitivity of modelled BC to these sources and removal processes is uncertain. In addition, very cold winter temperatures coupled with stable conditions lead to higher emissions and elevated pollution, including BC, for example in Fairbanks, central Alaska.

This study contributes to the Air Pollution in the Arctic: Climate, Environment, and Societies - Alaskan Layered Pollution And Chemical Analysis (PACES-ALPACA) initiative. The Weather Research Forecast model, coupled with chemistry (WRF-Chem), is run on quasi-hemispheric and regional scales.

The sensitivity of modelled BC to removal treatments is investigated first focusing on northern Alaska. Results suggest that wet removal, occurring during transport to Alaska, and regionally over Alaska, plays a larger role than dry removal in controlling modelled BC at Utqiaġvik. However, dry removal of regional sources is also important. The contribution of regional and local anthropogenic emissions, relative to non-Alaskan sources, is also examined. Results suggest that up to 30% of BC at Utqiaġvik is from the NSA oilfield emissions, while local sources are missing from global inventories.

The sensitivity of modelled BC to regional and local anthropogenic emissions is also examined during the winter 2019 ALPACA pre-campaign in Fairbanks. Biases in the model results compared to observations, in Fairbanks and at background sites, are used to estimate biases in regional BC emissions. The sensitivity of modelled BC to processes, such as removal treatments, is also investigated.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

PACES: Air Pollution in the Arctic: Climate, Environment, and Societies
IGAC Regional Working Groups

Americas Working Group
Identifying sources of local air pollution in Fairbanks, Alaska using FLEXPART-WRF simulations and observational data from the Alaskan Layered Pollution and Chemical Analysis (ALPACA) 2022 campaign.

Ms Natalie L Brett
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Abstract

There have been many developments in the understanding of long-range transport of pollution to the Arctic from mid-latitudes. More recently, local air pollution sources have been acknowledged as important in high latitude cities. Fairbanks in central Alaska, is a prime example of an Arctic city affected by poor air quality, in particular during winter months. The topography of Fairbanks (situated in a valley), coupled with strong surface-based temperature inversions, contribute to stable meteorological conditions that hinder the dispersion of pollutants. Stable meteorological regimes are frequently interspersed with less stable episodes, resulting in vertical mixing between surface and elevated inversion layers. In addition, coal and oil power stations in the city, along with domestic heating sources (oil, wood, gas) and heavy transportation use, are the main pollutant sources, and the harsh winter conditions (temperatures can reach -40 °C) lead to enhanced activity levels. However, there are many uncertainties in the understanding of pollution sources and secondary aerosol formation under cold, dark winter conditions, where photochemistry is limited.

These issues were addressed through the collection of comprehensive datasets on atmospheric composition and meteorology during the international ALPACA (Alaskan Layered Pollution and Chemical Analysis) field campaign in January and February 2022. Data were collected at the surface and on masts, and vertical profiles were collected using a tethered balloon (helikite). Here, the origins of observed pollution plumes and surface pollution episodes are investigated using FLEXPART-WRF simulations and emission inventories. Available meteorological observations are used to provide information on boundary layer structure including the presence of surface or elevated inversions and indications of turbulence (vertical mixing). This study also investigates the transport and dispersion of elevated power plant emissions and the extent to which they are contributing to regional pollutant levels, or possibly surface pollution during, for example, the disruption of stable meteorological conditions.

Early Career Scientist

YES, I am an early career scientist.
IGAC Activities

PACES: Air Pollution in the Arctic: Climate, Environment, and Societies
Session 2 Poster

Global datasets of natural emissions for the Copernicus Atmosphere Monitoring Service (CAMS) including emissions from vegetation, soils, oceans and volcanoes

Marina Liaskoni
Charles University, Czech Republic

Author list (excluding presenting author)

Alvaro Patricio Prieto Perez
Santiago Allerano
Michael Gauss
David Simpson
Katerina Sindelarova

Abstract

Copernicus Atmosphere Monitoring Service (CAMS) is part of the European Union’s Earth observation programme Copernicus and focuses on the Earth’s atmosphere. CAMS aims to provide consistent and quality-controlled data for air quality and health, solar energy, greenhouse gases, and climate forcing. CAMS core activities include global and regional air quality modelling as well as in-situ and satellite observations of the Earth’s atmosphere. An important part of CAMS is the development and evaluation of the emission data prepared for the CAMS global and regional models. The emission data are open and fully accessible also for users outside CAMS.

This paper describes the development and accessibility of global inventories of emissions from natural sources, i.e. vegetation, soils, oceans, and volcanoes. The dataset CAMS-GLOB-BIO contains gridded emissions of 25 biogenic VOC species/chemical groups available with 0.25x.25 deg. resolution for the period of 2000-2020. The data were calculated by the MEGANv2.1 emission model driven by ERA5 meteorological reanalysis. CAMS-GLOB-SOIL includes emissions of NO from soils and non-frozen surfaces on a global grid with 0.5x0.5 deg. resolution available for the period of 2000-2018. The dataset with emissions from oceans is called CAMS-GLOB-OCE and includes global gridded emissions of DMS (dimethylsulfide) and halogenated species in a resolution of 0.5x0.5 deg. for the period of 2000-2019. It also includes emissions of OCS (carbonyl sulfide) with a resolution of 1x1 deg. Representative of the 2002-2014 period.

CAMS-GLOB-VOLC contains volcanic emissions of SO2 presented on a 1x1 deg. grid for the period of 2005-2019. The data are based on gas emissions collected via the NOVAC network (Network of Observation of Volcanic and Atmospheric Change) that continuously monitors 36 volcanoes around the world.

We will present the methodology used to develop each emission inventory together with examples of emissions' spatial and temporal distribution.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities
Air quality is one of the most relevant environmental problems in the world, being the particulate matter (PM) exposure of paramount concern. A widely used indicator of PM is Aerosol Optical Depth (AOD), an integrated measurement of light extinction in different wavelengths over the atmospheric column due to absorption and scattering from suspended particles. The golden standard of aerosol optical properties measurements is the AERONET network (AErosol RObotic NETwork). Solar photometers of AERONET made continuous observations of AOD at different wavelengths which can be used to derive other products, such as the Ångstrom coefficient. This parameter is sensitive to particles size and it is commonly used for aerosol classification, but the extinction of light measurement uncertainty impact is rarely considered. As in terms of relative error the effect is greater when the absolute value of AOD is lower, this could hinder the characterization of pollution sources in places with a lower aerosol load. This work aims to study and characterize the propagation of uncertainties on typical aerosol classification schemes using as a study case six different cities in Central and South America. It was possible to determine that the Ångstrom coefficient has a mean relative uncertainty of around 18% in Buenos Aires (Argentina) and La Paz (Bolivia), 11% in Medellín (Colombia), 9% in San Pablo (Brazil) and Santiago (Chile), and 5% in Mexico City (Mexico). As the main outcome, the impacts on the aerosol classification schemes follow the same trend as those percentages. The worst-case scenario indicates a possible misclassification from 50% for Mexico City to more than 90% for La Paz. Given the nature of the propagated error, the less polluted the city the biggest is the error impact in aerosol classification, and major precautions must be taken regarding results interpretation.
Americas Working Group, Southern Hemisphere Working Group
Abstract

The design of Artificial Neural Networks (ANN) is usually complex given the number of hyper-parameters and predictors to be determined with crossed sensitivities. In the case of air quality (AQ), several antecedents seek to predict concentrations of pollutants, but generally, it is done with default ANN parameters and predictors selected with expert knowledge, which biases the results. Moreover, design details such as architecture, hyper-parameters, and predictors selection, are normally ignored in the literature. In regions with scarce AQ measurements, this problem is even more complex. This is the case for Argentina, where there is not much information regarding AQ since the availability and quality of data are compromised due to the presence of few and scattered surface monitoring stations with several issues in their measurements. This study aims to explore and present a novel methodology for the design of a Multilayer Perceptron-type ANN for particulate matter prediction in Buenos Aires, Argentina. Non-linear machine learning hybrid methods are implemented for the selection of predictors using a testing bench Perceptron and Self-Organizing Maps. Different hyper-parameters, architectures, and methods for the choice of predictors are explored. Finally, a model designed with expert knowledge (ENET) is compared with the novel one (FNET). Results indicated that the FNET model overcome the ENET model performance, with a correlation coefficient of 0.88 and root mean squared error of 1.8µgm-3. This work proposed a series of steps for the design that does not pretend to occupy a universal place but has proven to be effective for the problem studied, and can be adapted for other regions and in other fields of study.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

Americas Working Group, Southern Hemisphere Working Group
Session 2 Poster

Seasonal and regional characteristics of carbon monoxide anomalies as seen by IAGOS between 2002 and 2019:

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Author list (excluding presenting author)
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Abstract

IAGOS (www.iagos.org) is a European research infrastructure using commercial aircraft to measure atmospheric composition. In particular, IAGOS provides regular carbon monoxide (CO) data since December 2001. In this study we use eighteen years of available data (from 2002 to 2019) to investigate CO anomalies throughout the entire flight i.e. vertical profiles over airports and upper troposphere at cruise altitude.

IAGOS flight track is divided into three distinctive vertical groups: boundary layer, middle troposphere and upper troposphere. The entire IAGOS data set has been split in 18 regions according to the geographical variability (e.g. continents over northern mid-latitudes, tropics, etc ...) and the different seasonal cycles of CO. CO anomalies are defined as air masses with CO mixing ratios above the 95th/99th percentile of the regional/seasonal/vertical distribution. This unique data set allows us to look at the variety of CO anomalies between regions and seasons.

SOFT-IO module which couples emission inventories and Lagrangian modeling along IAGOS flight track is used to quantify in which proportion those anomalies are linked to biomass burning and anthropogenic emissions.

The origin of those events presents high seasonal discrepancies (drought season and cold season) but also inter-annual variabilities. Anomalies coming from anthropogenic sources hit the most heavily on the lower part of the atmosphere of densely populated areas. However, none of the regions, whatever the altitude range, are spared by anthropogenic pollution. Anomalies coming from biomass burning present large regional variability caused by weather conditions and biomass differences. We quantified these local and temporal variabilities to better understand processes affecting CO anomalies in the troposphere.

Early Career Scientist

YES, I am an early career scientist.
Session 2 Poster

Air pollution simulation in South America using the Multi-Scale Infrastructure for Chemistry and Aerosols (MUSICA) model

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CIRES, University of Colorado-Boulder, USA. Global Monitoring Laboratory, NOAA, USA

Author list (excluding presenting author)

Louisa Emmons (3); Pablo Lichtig (3); Guy Brasseur (3)

Abstract

The South American atmosphere is influenced by multi-scale meteorological patterns. One of the most important is the Intertropical Convergence Zone (ITCZ) which provides humidity to most of the continent. Also, the South Atlantic Convergence Zone (ZCAS) provides intense precipitation north of South America including Brazil, Paraguay, Uruguay, and Argentina. This area is also heavily impacted by biomass burning which is transported across the continent. One of these extreme episodes, happened in 2019, when most part of southeast Brazil was covered by black rain. The Multi-Scale Infrastructure for Chemistry and Aerosols (MUSICA) is model that allows for solving air pollutant concentrations across the scales. Then the objective of this study is to simulate the impact of biomass burning on air quality during the 2019 black rain episode. The air pollutant concentrations will be evaluated local surface stations and TROPOMI.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

Southern Hemisphere Working Group
Session 2 Poster

Contrasting background ozone patterns along the Andes

Prof. Laura Gallardo
Center for Climate and Resilience Research, Chile. Dept. Geophysics, Faculty for Mathematical and Physical Sciences, University of Chile, Chile

Author list (excluding presenting author)

María Cazorla (2), Camilo Menares (1), Isabel Moreno (3), Edgar Herrera (2), Carmen Vega (4) and Marcos Andrade (3)

Abstract

Background tropospheric ozone measurements have been carried out along the Andes in western South America. Data coverage spans over 26 years in Chile, 10 years in Bolivia, and 8 years in Ecuador. In Chile and Bolivia measurements are carried out at the surface level, while in Ecuador ozone in the free troposphere has been measured through ozone soundings. Hereby we provide a joint analysis including Tololo (30° 17′ S, 70° 84′ W, 2154 m a.s.l.), Chacaltaya (16°21′ S, 68º08′W, 5240 m a.s.l.), and Quito (0.19° S, 78.4° W, 2414 m a.s.l). We propose explanatory factors by means of Generalized Additive Models (GAMs), i.e. we perform a local meteorology normalization. For Tololo we estimate a decadal trend (+0.9 ppbv/decade) using various statistical approaches, and show that it is dominated by changes in methane and stratosphere-troposphere exchange (STE). The impact of biomass burning is determinant in Chacaltaya, as derived from previous work. Potential effects of both long-range transport and changes in meteorological conditions are explored for Quito.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report

IGAC Regional Working Groups

Americas Working Group, Southern Hemisphere Working Group
**Session 2 Poster**

**Diagnosing the stratospheric proportion in tropospheric ozone using triple oxygen isotopes as tracers**

PhD. Hao Xu  
National Institute for Environmental Studies, Japan. Graduate School of Environmental Studies, Nagoya University, Japan

**Abstract**

Tropospheric ozone (O$_3$) plays an important role in environmental problems, including global climate change. Because the stratosphere is a large reservoir of O$_3$, stratosphere-troposphere transport (STT) is one of the most important factors controlling tropospheric O$_3$. Therefore, to better understand the factors controlling the levels of tropospheric O$_3$, we must clarify the origin and behavior of O$_3$ in the troposphere, especially the temporal changes in STT.

The triple oxygen isotopic composition ($\Delta^{17}$O) of tropospheric O$_3$ can be a useful tracer to identify the sources and variations, particularly in the mixing of stratospheric O$_3$. Using a multistep nitrite-coated filter-pack system for sampling, we determined the seasonal variations in the $\Delta^{17}$O of tropospheric O$_3$ in the terminal positions ($\Delta^{17}$O$_{\text{term}}$(O$_3$)) in the urban areas of Nagoya and Niigata (Japan) in the eastern Asia region to quantify the mixing ratio of stratospheric O$_3$ within the total tropospheric O$_3$ supplied by STT.

By using the relationship between the reciprocal of concentrations and $\Delta^{17}$O$_{\text{term}}$(O$_3$), we estimated the $\Delta^{17}$O of stratospheric O$_3$ supplied through the STT ($\Delta^{17}$O$_{\text{STT}}$), together with that produced through photochemical reactions at surface altitude ($\Delta^{17}$O$_{\text{sur}}$). Moreover, using $\Delta^{17}$O$_{\text{STT}}$ and $\Delta^{17}$O$_{\text{sur}}$, we estimated the mixing ratios of stratospheric O$_3$ in each tropospheric O$_3$ ($f_{\text{STT}}$), as well as the absolute concentrations of stratospheric O$_3$ supplied through STT in the troposphere ($C_{\text{STT}}$(O$_3$)). The $C_{\text{STT}}$(O$_3$) exhibited (5.3 ± 1.0) ppb in summer (minimum) and (15.9 ± 2.1) ppb in late winter to spring (maximum). Although the $f_{\text{STT}}$ values ((35.3 ± 9.5) % in spring and (15.6 ± 6.1) % in spring) were higher than those estimated using the chemistry-climate models from past studies, the trends of the seasonal variations were consistent with them. We concluded that $\Delta^{17}$O successfully provided observational constraints on the STT of O$_3$.

**Early Career Scientist**

YES, I am an early career scientist.

**IGAC Activities**

TOAR: Tropospheric Ozone Assessment Report, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

**IGAC Regional Working Groups**

Japan National Committee
Session 2 Poster

**Constraining the accuracy of satellite derived XCO₂ and XCH₄ trends and variations over oceans - two approaches using commercial ship and aircrafts**

Astrid Müller  
National Institute for Environmental Studies, Japan

**Author list (excluding presenting author)**

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**Abstract**

Changes in the trends and variability of the two major greenhouse gases (GHG) CO₂ and CH₄ can be monitored by satellite observations of the column-averaged mixing ratios of CO₂ (XCO₂) and CH₄ (XCH₄). Over oceans, the accuracy of these satellite observations remains difficult to access, which hinders reliable conclusions about changes in the trends of atmospheric GHG concentrations.

We present two complementary approaches to evaluate the accuracy of satellite derived XCO₂ and XCH₄ over oceans by taking advantage of regular observations by the private sector. In the first approach, we obtained an “observation-based column-averaged CO₂” (obs. XCO₂) dataset by integrating cargo-ship (Ship Of Opportunity, SOOP) and commercial aircraft (Comprehensive Observation Network for Trace gases by Airliner, CONTRAIL) observations with the aid of state-of-the-art atmospheric chemistry-transport model calculations. In the initial study, we accurately captured seasonal and interannual variations of CO₂ and successfully evaluated the improvements in the satellite retrievals of GOSAT (Greenhouse gases observing satellite) and OCO-2 (Orbiting Carbon Observatory) between 2014 and 2017 over the Western Pacific. In the follow-up study, we made a temporal extension of the obs. XCO₂ dataset. The same methodology was applied to CH₄ to obtain obs. XCH₄.

In the second approach, XCO₂ and XCH₄ is derived from observations by a customized Fourier Transform infrared spectrometer. The setup, developed by the Heidelberg University, was initially deployed on two research cruises in spring 2021 and winter 2021/2022. In June, the setup will be deployed on a cargo ship between Tokyo and Fukuoka, Japan, for the first time. The aim is to cross-check the observation-based datasets, and as complement, to validate satellite and model derived data over oceans. These new approaches will contribute to a better understanding of changes in sources and sinks of GHG.

**Early Career Scientist**

NO, I am not an early career scientist.

**IGAC Activities**

AMIGO: Analysis of eMissions using Observations

**IGAC Regional Working Groups**

Japan National Committee
Shipborne observations of black carbon aerosols in the Arctic Ocean during summer and autumn 2016–2020: Episode analysis and model comparison

Dr. Yange Deng
National Institute for Environmental Studies, Japan

Author list (excluding presenting author)
Hiroshi Tanimoto (1); Kohei Ikeda (1); Sohiko Kameyama (2); Yuko Omori (3); Jinyoung Jung (4); Young Jun Yoon (4); Eun Jin Yang (4); and Sung-Ho Kang (4)

Abstract
Black carbon aerosol (BC) is considered an important contributor to the fast climate warming and snow and sea ice melting in the Arctic. East Asia is known to be a main source region of anthropogenic BC and biomass burning BC emissions from the region are also substantial. We made shipborne observations of BC mass concentration in the Arctic Ocean as well as western North Pacific in July to October in the years of 2016 to 2020. The observations were conducted on board the icebreaker R/V Araon operated by the Korea Polar Research Institute (KOPRI), South Korea. A continuous soot monitoring system (COSMOS, model 3130, KANOMAX) and a BC monitor of KOPRI were used in the cruises in 2016–2019 and in 2020, respectively. The background BC concentration in the Arctic was estimated to be 1–10 ng m⁻³. The 5-min BC mass concentration that was greater than 30 ng m⁻³ was observed in the Arctic in all cruises. The observations were compared with BC tagged-tracer simulations using a global chemistry transport model (GEOS-Chem). The horizontal resolution of GEOS-chem was 2° × 2.5° with 47 vertical layers from the surface to 0.01 hPa. In the tagged tracer simulations, BC tracers in the global domain were distinguished by 16 anthropogenic emission regions and 27 biomass burning emission regions. The HTAP v2.2 developed for the experiments of HTAP Phase 2 (Janssens-Maenhout et al., 2015) and the Global Fire Emissions Database v3.1 with 0.5° × 0.5° of spatial resolution and daily temporal resolution (van der Werf et al., 2010) were adopted as anthropogenic and biomass burning emissions, respectively. The analyses enabled the interpretation of transport episodes of BC from Asia to the Arctic and the identification of possible BC sources and transport pathways.

Early Career Scientist
NO, I am not an early career scientist.

IGAC Activities
PACES: Air Pollution in the Arctic: Climate, Environment, and Societies

IGAC Regional Working Groups
Japan National Committee
Air quality deterioration episode associated with typhoon over the complex topographic environment in central Taiwan

Dr. Chuan-Yao Lin
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Author list (excluding presenting author)
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Abstract

Air pollution is typically at its lowest in Taiwan during summer. The mean concentrations of PM10, PM2.5, and daytime ozone (08:00–17:00 LST) during summer (June–August) over central Taiwan are 35–40 µg/m3, 18–22 µg/m3, and 30–42 ppb, respectively, between 2004 and 2019. Sampling analysis revealed that the contribution of organic carbon (OC) in PM2.5 could exceed 30% in urban and inland mountain sites during July in 2017 and 2018. We explored an episode of air quality deterioration that was associated with a typhoon between 15 and 17 July 2018, using the Weather Research Forecasting with Chemistry (WRF-Chem) model. The results indicated that the continual formation of low-pressure systems or typhoons in the area between Taiwan and Luzon island in the Philippines provided a strong easterly ambient flow between 15 and 17 July. The interaction between the easterly flow and Taiwan’s Central Mountain Range (CMR) resulted in stable weather conditions and weak wind speed in western Taiwan during the study period. Numerical modeling also indicated that a lee side vortex easily formation and the wind direction could be changed from southwesterly to northwesterly over central Taiwan because of the interaction between the typhoon circulation and the CMR. The dynamic process for the wind direction changed given a reasonable explanation why the observed SO42- became the major contributor to PM2.5 during the episode. SO42- contribution proportions (%) to PM2.5 at the coastal, urban, and mountain sites were 9.4 µg/m3 (30.5%), 12.1 µg/m3 (29.9%), and 11.6 µg/m3 (29.7%), respectively. Moreover, the variation of the boundary layer height had a strong effect on the concentration level of both PM2.5 and ozone. The combination of the lee vortex and land-sea breeze, as well as the boundary layer development, were the key mechanisms in air pollutants accumulation and transport.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality
A numerical study of impacts of marine-emitted halogens on atmospheric OH radicals in East Asia

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Author list (excluding presenting author)

Ying Li (1,2,3)

Abstract

The hydroxyl (OH) radical is the most important daytime oxidant in the troposphere. In the marine atmosphere, OH levels could be significantly affected by the halogen species emitted from the ocean. However, due to the complicated interactions of halogens with OH through different pathways, it is not well understood how halogens influence OH and even what the sign of the net effect is. In this study, we aim to quantify the impact of marine-emitted halogens on OH by using the WRF-CMAQ model with process analysis. The modeled BrO and IO concentrations are validated using data reported in literature, and based on the validation, detailed analysis is conducted on the model results. The OH production rate ($P_{OH}$) responds complicatedly to marine halogen emissions, generally negatively in the ocean but positively in many nearshore areas. This complicated distribution $\Delta P_{OH}$ is controlled by the competition of three main pathways (OH from $O_3$ photolysis, OH from HO$_2$ conversion, and OH from HOX, X=Cl, Br, I) through different halogen species. Sea spray aerosol (SSA) and inorganic iodine gases are the major species influencing the strengths of these three pathways. Both of these two types of species decrease $P_{OH}$ through physical processes (SSA extinction and oceanic-iodine-induced $O_3$ deposition), while generally increasing $P_{OH}$ through chemical processes (Cl and I chemistry). Iodine chemistry is more complicated than Cl chemistry as it can also decrease $P_{OH}$; the increase generally occurs in the areas near $O_3$ sources and the decrease occurs when $O_3$ experiences longer transport over the ocean. Over the continent, the SSA extinction effect leads to the negative $\Delta P_{OH}$ in southern China. The identified impacts of main halogen species and related processes and pathways can help us understand the halogen-induced OH changes and further implications for important species such as CH$_4$ and $O_3$ in other circumstances.

Early Career Scientist

YES, I am an early career scientist.

IGAC Regional Working Groups
Characteristics of atmospheric black carbon and other aerosol particles over the Arctic Ocean in early autumn 2016: Influence from biomass burning as assessed with observed microphysical properties and model simulations

Fumikazu Taketani
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Author list (excluding presenting author)
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Abstract
We conducted ship-based measurements of marine aerosol particles (number concentration, size distribution, black carbon (BC), autofluorescence property, and PM2.5 composition) and trace gases (ozone (O$_3$) and carbon monoxide (CO)) during a cruise of the R/V Mirai (23 August to 4 October 2016) over the Arctic Ocean, Northwest Pacific Ocean, and Bering Sea. Over the Arctic Ocean at latitudes >70°N, the averaged BC mass concentration was 0.8 ± 2.1 ng/m$^3$, confirming the validity of our previously-reported observations (~1 ng/m$^3$) over the same region during September 2014 and September 2015. The observed levels over the Arctic Ocean need to be used as a benchmark when testing the atmospheric transport models over the ocean, while they are substantially lower than those reported at Barrow (Utqiaġvik), a nearby ground-based station. We identified events with elevated BC mass concentrations and CO mixing ratios over the Arctic Ocean and Bering Sea as influenced by biomass burnings, with evidences from elevated levoglucosan levels, mixing states of BC particles, and particle size distributions. With WRF-Chem model simulations, we confirmed Siberian Forest fire plumes traveled over thousands of kilometers and produced exceptionally high BC and CO levels over the Bering Sea. The DBC/DCO ratios during these periods were estimated as ~1 ng/m$^3$/ppbv, which are lower than those values reported, indicating that the results might have been affected by the wet removal process during transportation and/or by emission in smoldering conditions.

Early Career Scientist
NO, I am not an early career scientist.

IGAC Activities

PACES: Air Pollution in the Arctic: Climate, Environment, and Societies

IGAC Regional Working Groups

Japan National Committee
Halogenated Greenhouse Gas Emissions from the Netherlands determined from Regional Atmospheric Measurements

Dominique Rust
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Author list (excluding presenting author)
Ioannis Katharopoulos (1,2); Martin K. Vollmer (1); Stephan Henne (1); Arnoud Frumau (3); Pim van den Bulk (3); Arjan Hensen (3); Simon O’Doherty (4); Dickon Young (4); Angelina Wenger (4); Lukas Emmenegger (1); Renato Zenobi (2); Stefan Reimann (1)

Abstract

Halocarbons are very strong greenhouse gases, and, in addition, chlorinated or brominated halocarbons cause stratospheric ozone depletion. Global to national halocarbon emissions can be derived by so-called "top-down" inverse modeling methods, which rely on atmospheric concentration observations that are sensitive to the targeted emissions.

Here, we quantify industrial and consumption-related halocarbon emissions and localize pollution sources from the Netherlands. Our top-down emission estimations are based on 8 months (December 2021 to July 2022) of continuous, high-frequency, high-precision halocarbon measurements from the Cabauw tall tower in the province of Utrecht. The site is sensitive to the most populated and industrialized centres of the Netherlands. To refine the top-down modelling, our observations at Cabauw are complemented with measurements from other European sites that are fully intercalibrated within the Advanced Global Atmospheric Gases Experiment (AGAGE) and thus with our measurements.

For chemical analysis, hourly two-liter air samples are pre-concentrated at low temperatures (-165 oC), before the analytes are separated by gas chromatography and detected by quadrupole mass spectrometry (GC-MS). Our measurements cover more than 60 halocarbons, ranging from globally banned chlorofluorocarbons (CFCs) to the youngest generation substitute products, the hydrofluoroolefins (HFOs). We find strong and distinct pollution events for a suite of halogenated compounds, hinting at specific point sources, whereas for other compounds pollution events indicate more dispersive emission sources. As a top-down modelling method, we use Bayesian inversion based on regional atmospheric transport modeling. This allows us to quantify Dutch emissions and to better understand the sources of halocarbon emissions in the Netherlands.

Early Career Scientist

YES, I am an early career scientist.
Session 2 Poster

A new emission inventory for NOx and BC based on OMI observations with a simple top-down mass-conserving model method

Mr Jian Liu
SYSU, China

Author list (excluding presenting author)

Jason Blake Cohen(1)

Abstract

Rapid urban development, industrial growth, and the broad use of biomass burning in South, Southeast, and East Asia, have been leading to ever increasing and rapidly changing emissions inventories. This in turn has led to many missing or mis-represented sources in terms of geospatial location. This is especially true for extreme events. A lack of ground stations outside of China, Korea, Japan, Singapore, and Thailand, combined with a general lack of coverage in remote areas within these countries, means that satellites are required to provide a consistent dataset. The goal of this top-down approach is to identify missing regions and improve upon existing data from bottom-up estimates. This work uses remotely sensed measurements of OMI NO2 and OMI UVI to estimate a daily emissions database of both NOx and BC, taking advantage of the wide spatial-coverage, high time frequency, and the fact that both NO2 and BC are by-products of temperature of and the amount of material combusted. A mass-conserving relationship between emissions, day-to-day changes in measured concentration, chemical/physical loss, and dynamical transport of NOx/BC are jointly considered. Existing a priori emissions from FINN, and EDGAR-HTAPv2.2 are used to constrain the coefficients of the simple model’s chemical, physical, and dynamical terms for the extreme events of one year using a technique based on Cohen (2014) and further extended by Lin et al. (2020). It is demonstrated that there are significant underestimations in rural areas in Myanmar, Northern Thailand, Laos, and Northeast India, as well as in urban areas in the Pearl River Delta, Wuhan, Nanchang, Changsha, and Dhaka. On the other hand, it is found that some highly developed urban areas are overestimated, including Shanghai, Singapore, and Taibe, among others. These new findings help understand the changing features of NOx and BC emissions under extremes events.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon

IGAC Regional Working Groups

China Working Group
Session 2 Poster

Seasonal and diurnal characteristics of wind in urban boundary layer

Dr. Yung-Chang Chen
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Author list (excluding presenting author)

Wei-Nai Chen (1); Charles, C.-K. Chou(1)

Abstract

Atmospheric boundary layer influences significantly the air pollutant dispersion in urban areas, where about 50 % of the residence on the entire world live. However, the lack of long-term observation in a fine-temporal resolution results in inappropriate and insufficient understanding of the characteristics of the urban boundary layer. The naturally thermal wind circulation could be involved by the anthropogenically thermal circulation which is generated by the heat island effect. The interactions of anthropogenically and naturally thermal wind circulation involve in the dispersion of the air pollutants emitted out from urban regions. Applying campaigns during intensive observation period and data regularly operational radio sounding by WMO could not give sufficient and appropriate data to describe the properties of urban boundary layer. In order to investigate the above mentioned issue, a wind-profile Lidar has been installed in the Taichung metropolitan to carry out the wind characteristics in urban region. Because of the specifically topographic feature in middle Taiwan, the naturally thermal wind circulation is caused here by both sea-land and hill-valley breeze interactions. Combination with the anthropogenic urban-rural breeze, the local urban boundary layer thereby is expected as a complicated thermal wind system. This thermal wind system does not only effects horizontal air flows, but also gives a complex vertical stratification of the sublayers in the urban boundary layer. Using the Wind Lidar data in 2018 in Taichung, we will propose an airflow data in seasonal and diurnal variance to study the involvement of the urban-rural thermal breeze in the naturally thermal breeze in urban regions.

Early Career Scientist

NO, I am not an early career scientist.
Session 2 Poster

An Arctic cyclone-induced bromine explosion event in Ny-Ålesund, Svalbard

Dr Xin Yang
British Antarctic Survey, UKRI, United Kingdom

Author list (excluding presenting author)

Douxing Chen(1,2), Yuhan Luo(1), Ke Dou(1), Haijin Zhou(1), Yuanyuan Qian(1,2), Chunqiao Hu(1,2), Fuqi Si(1), Jianguo Liu(1), Wenqing Liu(1)

Abstract

Bromine explosion events (BEEs) are important processes that influence the atmospheric oxidation capacity, especially in the polar troposphere during springtime. Although sea ice surface is thought to be a significant bromine source, bromine release mechanisms remain unclear. High-resolution ground-based observations of reactive bromine, such as BrO, are important for assessing the potential impacts on tropospheric ozone and evaluating chemical models. However, previous model studies paid little attention to Svalbard, which is surrounded by both open ocean and sea ice. In this paper, we present continuous BrO vertical column densities and volume mixing ratios derived by Multi-Axis Differential Optical Absorption Spectroscopy deployed at Ny-Ålesund (78.92°N, 11.93°E) in March 2017. We focused on one BEE in mid-March, during which BrO vertical column densities surged from 9.1×10^{13} molec cm^{-2} to the peak at 1.23×10^{15} molec cm^{-2} on March 17, surface ozone depleted from a background level of 46.25 parts per billion by volume (ppbv) to 13.9 ppbv. This case study demonstrates that the BEE was strongly associated with a cyclone that approached Svalbard from March 14 to 18. By taking into consideration meteorological conditions, sea ice coverage, and air-mass trajectory history, we demonstrate that sea salt aerosols (SSAs) from blowing snow on sea ice, rather than from open ocean, are attributed to the occurrence of this BEE. Model results from a parallelized-tropospheric offline model of chemistry and transport (p-TOMCAT) indicate that this BEE was mainly triggered by a blowing snow event associated with a low-pressure cyclone system. The concentration of blowing-snow-sourced sea salt aerosols surged to peak when the airmass pass across the sea-ice-covered area in high wind speed, which is a critical factor in the process of bromine explosion observed in Ny-Ålesund.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

CATCH: the Cryosphere and Atmospheric Chemistry
Session 2 Poster

Seasonal comparison of summer and wintertime hydrogen chloride at an inland urban site

John W Halfacre
Wolfson Atmospheric Chemistry Laboratories, Dept of Chemistry, University of York, United Kingdom

Author list (excluding presenting author)

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Abstract

Atomic chlorine radicals are known to affect boundary layer oxidation and pollutant lifetimes, but are challenging to detect due to their low atmospheric concentrations. Hydrogen chloride (HCl) is the most abundant and long-lived inorganic tropospheric chlorine reservoir species, yet sampling challenges have prevented high frequency field observations until recently. In this work, we report HCl field observations using a Tunable Infrared Laser Direct Absorption Spectrometer (TILDAS), deployed in Manchester, United Kingdom, during the 2021-2022 Integrated Research Observation System for Clean Air campaign. Observations obtained during June and July 2021 yielded limits of detection (3σ) of 21-24 pptv at 1Hz data collection, and tended to exhibit a diurnal profile on clear days. Conversely, observations from February 2022 displayed no similar diurnal profile, staying near instrument limits of detection for much of the observation period. Data will be further interpreted using gas phase box modelling and the partitioning model, ISORROPIA-II, to determine the relative impacts of gas phase chlorine cycling and particulate matter partitioning on the diurnal structure and seasonal differences in HCl. HCl data will also be compared with predictions from the chemical transport model, GEOSChem, to further determine the implications on atmospheric oxidation chemistry.

Early Career Scientist

NO, I am not an early career scientist.
Vertical profiles of global tropospheric nitrogen dioxide (NO\textsubscript{2}) obtained via cloud-slicing TROPOMI partial columns.

Miss Bex Horner
Department of Geography, University College London, United Kingdom

Author list (excluding presenting author)
Eloise A Marais (1); Nana Wei (2)

Abstract
Nitrogen oxides (NO\textsubscript{x} ≡ NO + NO\textsubscript{2}), are produced both naturally by lightning and via anthropogenic combustion. In the troposphere, NO\textsubscript{x} are long-lived and have a substantial impact on the oxidising capacity of the troposphere and on the formation of ozone in the mostly NO\textsubscript{x}-limited troposphere, but routine observations of NO\textsubscript{x} are lacking. Here we derive vertical profiles of NO\textsubscript{2} from satellite observations by applying the cloud-slicing method to partial columns of NO\textsubscript{2} from the TROPOMI instrument. The resultant data are seasonal means of NO\textsubscript{2} volume mixing ratios at a resolution of 1° x 1° for multiple years (May 2018 to November 2021) on a global scale in the upper troposphere (180-320 hPa and 320-450 hPa), the middle troposphere (450-600 hPa and 600-800 hPa) and the boundary layer (800 hPa to the Earth’s surface). We validate our product using NASA DC-8 aircraft measurements from campaigns over the Arctic (ARCTAS), North America (SEAC\textsuperscript{4}RS, INTEX-NA) and the Atlantic and Pacific Oceans (ATom). In the middle troposphere, cloud-sliced NO\textsubscript{2} is on average 20-40 pptv and deviates by less than 5 pptv from the aircraft observations due to high sampling frequency and ideal conditions for cloud-slicing (NO\textsubscript{2} constant with altitude). Differences with aircraft observations are larger (10 pptv) in the upper troposphere where aircraft observations may be susceptible to interference from NO\textsubscript{x} reservoir compounds. In the boundary layer, retrievals consistent with the aircraft observations are only possible over the marine environment, as our approach does not currently account for steep gradients in NO\textsubscript{2} typical of the terrestrial boundary layer. Tropospheric vertical profiles from cloud-slicing satellite observations offer a unique opportunity to determine the environmental factors that impact tropospheric NO\textsubscript{x} on a global scale by comparison to the GEOS-Chem chemical transport model.

Early Career Scientist
YES, I am an early career scientist.

IGAC Activities
AMIGO: Analysis of eMIssions usinG Observations
The Spectroscopic Determination of ClNO$_2$ via TILDAS

John W Halfacre
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Author list (excluding presenting author)

Pete. M. Edwards (1); Scott. C. Herndon (2); Joseph. R. Roscioli (2); Christoph Dyroff (2); Tara I. Yacovitch (2); Emily Matthews (3); Aristeidis Voliotis (3); Thomas Bannan (3); Hugh Coe (3); Katie Read (1,4); Patrick R. Veres (5); Steven S. Brown (5)

Abstract

Nitryl chloride (ClNO$_2$) is a reservoir species of chlorine atoms and nitrogen oxides, both of which are highly reactive atmospheric compounds. However, virtually all ambient ClNO$_2$ observations to date have been made by chemical ionization mass spectrometry (CIMS). In this study, ClNO$_2$ was quantified by interfacing a furnace with a commercially available Hydrogen Chloride Tunable Infrared Laser Differential Absorption Spectrometer (HCl-TILDAS). Briefly, ClNO$_2$ is thermally dissociated into Cl and NO$_2$ within the furnace, and the Cl subsequently reacts with ambient hydrocarbons (i.e., methane) to produce HCl that can be detected via TILDAS. Signal resulting solely from ambient HCl (obtained via an unheated sample flow path) can be subtracted from the signal produced from the heated flow path to produce a quantitative measurement for ClNO$_2$. Figures of merit derived from field testing include limits of detection of 90 pptv ($\sigma$) and a 1 Hz precision of 30 pptv. Potential interferences formed in the inlet were investigated in a temperature varying 0-D model. In addition, this technique was field tested during the 2021-2022 Integrated Research Observation System for Clean Air campaign in Manchester, England, and results were compared with a co-located CIMS. This technique provides an alternative analytical approach to CIMS that may complement future datasets.

Early Career Scientist

NO, I am not an early career scientist.
There is a natural partitioning of scientific interest amongst three specialties of aerosol research: modeling, in situ measurements, and remote sensing. The community sees enhanced measurement capabilities when these groups interact, and this strengthens the overall scientific impact on climate and air quality. The Models, In situ, and Remote sensing of Aerosols (MIRA) working group connects members of the different aerosol communities through collaborative projects.

What is MIRA? MIRA is forum that fosters international collaborations amongst the aerosol specialties. MIRA is also a collection of interdisciplinary projects with clear goals that are pursued by small working groups. Finally, MIRA projects are generally characterized by requests for additional scientific data (both observational and modeled).

Why? The purpose of MIRA is to contextualize both observations and model results through the encouragement of holistic projects and collaborations.

How does MIRA differ from other projects? MIRA focuses on interdisciplinarity to improve measurements and their utility, so MIRA complements the activities of other groups. For example, ensemble model runs of AeroCom could be used in a MIRA project with greater robustness than a similar effort that uses single-model analyses.

We first present a description of MIRA and how your project can become a part of the MIRA community. This is followed by brief descriptions of some of the current MIRA projects, which include the Mapping of Aerosol lidar ratios for CALIPSO (MAC), the Tables of Aerosol Optics (TAO), and the Harmonization of aerosol Assimilation Models and Retrievals (HAMR). Finally, we discuss the immediate science goals and organization of MIRA.
Session 2 Poster

Single particle chemical and physical composition of freshly emitted Saharan dust.

Agnesh Panta
Institute of Applied Geosciences, Technical University of Darmstadt, Germany

Author list (excluding presenting author)

Konrad Kandler (1), Andres Alastuey (2), Cristina González-Flórez (3), Adolfo González-Romero (2,3), Martina Klose (4), Marco Pandolfi (2), Xavier Querol (2), Cristina Reche (2), Jesús Yus-Díez (2,5), and Carlos Pérez García-Pando (3,6)

Abstract

Mineral dust is one of the most abundant aerosol types by mass in the atmosphere, and its particle size distribution, mineralogical composition, particle shape, and mixing state determine its impacts on the Earth’s climate. The FRontiers in dust minerAloGical coMposition and its Effects upoN climate (FRAGMENT) is dedicated to understanding, constraining and calculating the global mineralogical composition of dust along with its effects on climate. During the FRAGMENT 2019 field campaign near M’hamid El Ghizlane in Morocco, the chemical, physical, and mineralogical properties of freshly emitted desert aerosol were measured.

Samples were collected with an impactor system, a passive dry deposition sampler, and a free-wing impactor. All aerosol samples were collected on pure carbon adhesive substrates mounted to standard aluminum stubs. Here we present the size-resolved particle aspect ratio distribution and the chemical composition determined by scanning electron microscopy and energy-dispersive X-ray microanalysis of single particles. Overall, our size-resolved measurements of mineral content from one of the major dust source regions would help evaluate Earth system models for a better understanding of the roles mineral dust plays in atmospheric chemistry and climate processes.

Early Career Scientist

YES, I am an early career scientist.
Session 2 Poster

Assessing the tropospheric ozone budget in the tropics - UKCA contribution to the TOAR-II OPT project

Dr Paul T Griffiths
National Centre for Atmospheric Science, Cambridge University, United Kingdom

Author list (excluding presenting author)

James Keeble (1); Fiona M. O’Connor (2); N. Luke Abraham (1); Audrey Gaudel (3); Bastien Sauvage (4); Alexander Archibald (1)

Abstract

A grand challenge in the field of chemistry-climate modelling is to understand the connection between anthropogenic emissions, atmospheric composition and the radiative forcing of trace gases and aerosols. Phase 2 of the Tropospheric Ozone Assessment Report (TOAR-II) includes a Working Group focused on Ozone and Precursors in the Tropics (OPT).

We present the results of simulations in support of the aims of this WG. Targeted attribution studies are presented looking at key drivers of ozone production, with a focus on quantifying the effect of NOx and other ozone precursors. We include simulations designed to look at the effect of global and regional emissions changes, with a focus on quantifying changes to the ozone budget over the recent historical period, 1995-2014.

Observational data provide important constraints on ozone and its precursors. Data are available from a variety of platforms, spanning a range of spatial and temporal scales covering the past 40 years. Recent work has highlighted the discrepancy in model and observations concerning surface ozone at key stations and the trend in tropospheric ozone levels over the past 50 years. We will present a comparison between modelled ozone, its budget and appropriate recent observational products, to examine how such data may be used to assess and to validate chemistry-climate models such as UKCA.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report
Session 2 Poster

Using low-cost sensors to measure NO\textsubscript{2} and O\textsubscript{3} pollution in urban street canyons

Seán Schmitz
Institute for Advanced Sustainability Studies e.V. (IASS), Germany

Author list (excluding presenting author)

Guillermo Villena (1)(2); Alexandre Caseiro (1); Fred Meier (3); Andreas Kerschbaumer (4); Erika von Schneidemesser (1)

Abstract

Despite improvements in air quality over the last several decades, air pollution will continue to be a leading cause of harmful health effects in European cities as urban populations continue to grow. In recent years, the technology of low-cost sensors (LCS) has been adapted for use in expanding air pollution measurements at higher spatial resolution in cities across the globe. In this study, we deploy metal oxide (MOS) and electrochemical (EC) low-cost sensors housed in EarthSense Zephyr sensor systems to measure NO\textsubscript{2} and O\textsubscript{3} concentrations in three different urban environments in Berlin in winter, spring, and summer from 2017-2020. Two of these environments are typical urban street canyons, whereas the third is a much wider main thoroughfare. After calibration with reference instrumentation using the seven-step methodology outlined by Schmitz et al. (2021), we compare the measured concentrations with urban background and reference concentrations, as well as local meteorological and emissions data. We find that, following proper calibration, LCS capture expected patterns of urban pollution in association with diurnal chemistry and meteorology well and on a consistent basis. Furthermore, we measure concentrations of NO\textsubscript{2} and O\textsubscript{3} in street canyons that match those of modelling studies, indicating that high spatial resolution deployment of LCS can successfully yield valuable new insights in urban microenvironments. While LCS have a wider range of uncertainty than reference instruments, these results suggest that they can be reliably used for a variety of new applications, including to better understand distribution of air pollution in unique urban environments, to validate urban street canyon models, or to measure changes in air pollution in connection with changes in urban infrastructure.

Early Career Scientist

YES, I am an early career scientist.
Calibrating a global chemistry transport model for tropospheric ozone

Prof Oliver Wild
Lancaster University, United Kingdom

Author list (excluding presenting author)

Edmund Ryan (1,2)

Abstract

The major physical, chemical and dynamical processes governing the abundance of atmospheric oxidants such as ozone are now largely understood, but obtaining a quantitative understanding of the importance of key processes and the interactions between them remains challenging. Weaknesses in representing these processes in atmospheric chemistry transport models introduces substantial uncertainty, and model intercomparisons show considerable diversity even when representing current conditions. In this study we perform a global uncertainty analysis on a chemistry transport model to identify the processes contributing most to uncertainty in tropospheric ozone at local, regional and global scales. We then demonstrate the use of atmospheric measurements to calibrate the model and to provide critical new insight into weaknesses in process representation and current understanding. We show that the calibrated model reproduces independent observations substantially better than the standard model, and provides clear guidance on which processes need refinement. Calibration with surface ozone measurements alone is shown to be insufficient to constrain the model, and we demonstrate the importance of using a range of different observations and metrics to provide tighter constraint. While this study is exploratory in nature, focussing on a limited number of parameters and metrics, we clearly demonstrate the value of rigorous calibration for providing important new constraints on key processes in atmospheric models.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report
Session 2 Poster

Assimilation of Aerosol Observations from the Future Spaceborne Lidar Onboard the AOS Mission into the MOCAGE Chemistry-Transport Model

Mr Flavien CORNUT
CNRM, Université de Toulouse, Météo-France, CNRS, France

Author list (excluding presenting author)

EL AMRAOUI Laaziz(1), CUESTA Juan(2), SCHMISSER Roseline (3), BLANC Jérôme(3), JOSSE Béatrice(1)

Abstract

CALIOP lidar observations for more than ten years have improved the estimation of radiative forcing of aerosols and cloud feedbacks, two of the main uncertainties for climate prediction. However, the estimations of aerosol extinction profiles from backscatter lidars such as CALIOP rely on hypothesis of their optical properties (e.g. Lidar Ratio) and can therefore present large uncertainties. The international Atmosphere Observing System (AOS) mission, a collaborative program from NASA, CNES, JAXA and CSA aims to carry a new generation spaceborne lidar for better characterizing clouds and aerosols. The AOS design offers a High Spectral Resolution Lidar (HSRL) at 532nm, thus avoiding the ambiguities in the estimations of aerosol extinction profiles by separating the particular and molecular signal.

In the current presentation, we analyze the contribution of these new spaceborne measurements implementing an Observations System Simulation Experiment (OSSE) based on the MOCAGE chemistry transport model: (1) A realistic atmosphere is simulated and considered as the most perfect state of the atmosphere, called the Nature Run (NR). (2) From this atmosphere, we sample Synthetic Observations (SO) using a lidar signal simulator called ‘BLISS’ following typical satellite trajectories. (3) These observations are then assimilated into another version of the model called the Control Run (CR) to obtain analyses called the Assimilation Runs (AR).

The Nature Run extends over a two-weeks period in March 2018, centered on an intense Saharan episode reaching Greece. Two simulations are computed, one with a standard “Klett” inversion (CALIOP-like), and a AOS Lidar with HSR at 532nm. Comparisons between both configurations allows to evaluate the added value of the HSR lidar.

First results concerning the benefits of the AOS configuration for observing aerosols and constraining MOCAGE are presented. We consider the AOD structure and the vertical distribution in term of backscatter and concentration of desert dust for diagnostics.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality
Session 2 Poster

Going beyond "shut-up and calculate" performance metrics: a low-cost story on pollution sensors

Dr Sebastian Diez
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Author list (excluding presenting author)

Stuart Lacy (1); Pete Edwards (1)

Abstract

Air pollution and climate change are fully entangled and a large proportion of the world’s population is unaware of the planet’s greatest environmental threats. In order to tackle them, we need to know in as much detail what and how much is emitted, what secondary pollution formation mechanisms are dominant, as well as the spatial distribution of pollutants. Low-cost sensors (LCS) could help in this challenge by offering information on spatial and temporal scales never seen before.

When a potential user is given the task of finding an instrument capable of answering questions such as “Are people in this area exposed to safe levels of X?”; “What is the maximum concentration in site Y?”; “Did intervention "Z" work?), they often find themselves with many available alternatives and a flood of information that will not always be as transparent as we’d like it to be. In an ideal world each instrument would have been thoroughly assessed in a relevant environment, and typical performance metrics -R², RMSE, MAE- would be available to describe which instrument would fit our purpose. However, LCS suffer from hardware and software related issues, but also single metrics have limited validity as they synthesise lots of information into one single number. In this study, we evaluate the performance of 13 different commercial LCS devices in UK roadside and urban background locations (in London, Manchester & York), under a range of conditions (4 seasons, ~3 years), using visual methods such as Bland-Altman and Relative Expanded Uncertainty plots, for a more complete panorama of the LCS capabilities in real life applications. The tools generated for the analysis are open-source (R and Python code, via GitHub), hoping to contribute to the information interpretation by interested parties, beyond what a dimensionless numerical index can offer.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

Americas Working Group
Deep Semi-supervised Learning for Early Warnings of Dust Events: Evidences from The Middle East

Dr Ron Sarafian
Weizmann Institute of Science, Israel

Author list (excluding presenting author)
Ron Sarafian (1), Dori Nissenbaum (1), Shira Raveh-Rubin (1), Yinon Rudich (1)

Abstract

Dust storms are extreme meteorological phenomena occurring increasingly frequently in the Middle East region. Dust storms have significant impacts on both the physical and human environments due to the dust particles’ properties. Early forecasting systems are a critical part of mitigating dust event’s damage, and can save human lives.

Modeling and predicting local dust levels is a long standing challenge, due to the multi-scale nature of the governing meteorological dynamics, and the complex coupling between the atmospheric particles and the underlying flow patterns. Predictions are thus highly model-dependent and generally suffer from low skill.

Accumulated studies suggest that a range of meteorological conditions are associated with dust emission over the Sahara, and its subsequent long-range transport to the Middle East. While detailed physics-based numerical modeling is often being used, we developed a novel AI approach for dust storms forecasting in the region.

In this study, we combined spatio-temporal data of sea-level pressure, winds, potential vorticity, satellite aerosol-optical-depth, and other variables taken from the Copernicus database, along with ground dust loading measurements over the last 20 years, to train a deep network to forecast hourly PM10 levels in the Negev Desert. To overcome statistical learning challenges such as frequency bias of rare dust events, or strong correlation among input samples, we suggest a semi-supervised approach, where during training we both forecast sample’s PM10 level, and learn a compressed representation that keeps the features of PM10’s macro-scale dynamics.

Our network can forecast more than 80% of the events. Analysis shows that local-dynamics driven events are the main source of the misclassification. Further, we demonstrate the spatio-temporal importance the network attributes for the explanatory variables, and reveal the dynamics of the processes that govern dust storms in the region.

Early Career Scientist

YES, I am an early career scientist.
Session 2 Poster

Tropospheric ozone variability over the Mediterranean basin using SCIAMACHY and OMPS/NPP Limb-Nadir matching datasets.

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Author list (excluding presenting author)

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Abstract

Around 10% of the total amount of ozone resides in the troposphere, which acts as a potent greenhouse gas. Anthropogenic emissions and biomass burning are the main sources of ozone in the troposphere. Overexposure to this pollutant causes health problems and damage to vegetation.

A combination of space-borne limb and nadir measurements in UV-visible spectral range (so-called limb-nadir matching) provides valuable information on tropospheric ozone columns. This study uses the data from the SCanning Imaging Absorption spectroMeter for Atmospheric CartograpHY (SCIAMACHY) (2002-2012) and the Ozone Mapping and Profiler Suite on board of Suomi National Polar-Orbiting Partnership (OMPS/NPP, since 2012). Both instruments observe the atmosphere in both limb and nadir geometry.

Tropospheric ozone columns are retrieved globally by subtracting the stratospheric ozone column calculated from limb observations from the total ozone column, derived from the nadir measurements, previously done for SCIAMACHY and now implemented in OMPS/NPP. Using these datasets, we analyse the variability and distribution of tropospheric ozone over the Mediterranean basin from 2002 to 2018, comparing and evaluating our results with previous studies in the region.

Early Career Scientist

YES, I am an early career scientist.
NO\textsubscript{x} and CO\textsubscript{2} emission estimation from high-resolution satellite pseudo-observations over the Kanto region of Japan using WRF model

Masahiro Yamaguchi
Japan Agency for Marine-Earth Science and Technology, Japan

Author list (excluding presenting author)

Jagat S. H. Bisht (1); Masayuki Takigawa (1); Prabir K. Patra (1); Yugo Kanaya (1); Hiroshi Tanimoto (2)

Abstract

Emission controls of carbon dioxide (CO\textsubscript{2}) and other greenhouse gases are urgently needed to mitigate global warming. It would be ideal if high-resolution emission maps are produced from global and continuous satellite observations resolving point-sources to track the mitigation efforts or reveal unidentified emission hotspots. However, this task is challenging, as the signals of CO\textsubscript{2} concentration gradients due to human emissions are often interfere with fluxes from natural vegetations and poor signal-to-noise ratio of satellite instruments. To overcome the difficulties, recently planned satellite missions (CO\textsubscript{2}M and GOSAT-GW) will include simultaneous observations of NO\textsubscript{2}, serving as a combustion emission marker, to help constraining the emission estimations. Here we report progresses with our methodology development to estimate NO\textsubscript{x} and CO\textsubscript{2} emissions from large sources, possibly applicable to the upcoming satellite missions.

We first developed a high-resolution (1 km) atmospheric chemistry and transport modeling system, to simulate column-average CO\textsubscript{2} (XCO\textsubscript{2}) and tropospheric NO\textsubscript{2} column (TropNO\textsubscript{2}VCD), based on the Weather Research and Forecasting model, (1) coupled with Chemistry (WRF-Chem) for simulation of NO\textsubscript{x} and (2) coupled with Vegetation, Photosynthesis, and Respiration (WRF-VPRM) for simulation of CO\textsubscript{2}. The innermost (4\textsuperscript{th}) domain at 1x1 km horizontal resolution is centered over the Kanto region of Japan using two-way nested setting. A good model performance was confirmed against surface observations during May 2018, suggesting strong covariation of NO\textsubscript{x} and CO\textsubscript{2}. Then, we regarded the modeled fields of XCO\textsubscript{2} and TropNO\textsubscript{2}VCD as pseudo satellite observations and applied a divergence-based method to estimate emissions. We found that known CO\textsubscript{2} and NO\textsubscript{x} emissions from selected large point sources were reasonably estimated but also learned that case selections satisfying air mass balance, regarding the wind flow patterns surrounding the paths of integration, are critical. Results of the same method application to the TROPOMI NO\textsubscript{2} observations are also to be presented.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Regional Working Groups

Japan National Committee
Session 2 Poster

Introduction to the AQ-WATCH project and its multi-model air quality forecast system

Dr. Cathy W. Y. Li
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Author list (excluding presenting author)

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Abstract

AQ-WATCH (Air Quality: Worldwide Analysis and Forecasting of Atmospheric Composition for Health) is an international consortium, which co-develops and co-produces tailored products and services derived from space and in situ observational data for improving air quality forecasts and attribution. For this purpose, AQ-WATCH develops a service chain leading to innovative downstream products and air quality information systems at improving public health and optimizing service provided by the energy sector in different regions of the world. These prototypes are based on existing space and in situ observations of air quality and tailored to the identified needs of international users. The AQ-WATCH products and services are organized into 5 modules allowing users to access historical and air pollution data as well as air quality forecasts at a global and regional scale: (1) Global and regional air quality atlas, (2) Air quality attribution & mitigation, (3) Dust and fire forecasting system, (4) Fracking analysis, and (5) Air quality forecast.

In this presentation, apart from an overview of the AQ-WATCH project and its products, extra focus will be put on the Air quality forecast module. Air quality forecast models provided by the AQ-WATCH consortium have been set up for the focus regions in Asia and the Americas, based on the templates of Copernicus and MarcoPolo-Panda ensembles, but with much higher resolution and reliance on regional emission and observational information. The models are established over the focus regions using the meteorological and emission data taken from Copernicus repositories and other national archives and refined with local information wherever available. Each forecast model is then evaluated using local observational datasets and with the needs of the stakeholders. The machine learning workflow MLAir (Machine Learning on Air data) is being incorporated into the forecast system to deliver an improved forecast ensemble based on bias correction from observations.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups
Session 2 Poster

Weekly-based Top-Down Biogenic VOC fluxes over Europe Constrained by TROPOMI HCHO Column Densities

Dr Glenn-Michael Oomen
Royal Belgian Institute for Space Aeronomy, Belgium

Author list (excluding presenting author)

Jean-François Müller (1); Trissevgeni Stavrakou (1); François Hendrick (1); Martina Friedrich (1); Corinne Vigouroux (1); Isabelle De Smedt (1); Andreas Richter (2); Tim Bösch (2); Ankie Piter (3); Thomas Wagner (4); Julia Remmers (4); Sebastian Donner (4); Udo Frieß (5); Thomas Blumenstock (6); Rigel Kivi (7); Maria Makarova (8); Mathias Palm (2); Amelie Röhling (6); Yao Té (9)

Abstract

Biogenic emissions of volatile organic compounds (BVOCs) have a profound impact on air quality due to their important role as precursors of ozone and secondary organic aerosols. Many non-methane VOCs (NMVOCs) are emitted by vegetation and fire events, from which a large fraction oxidizes to formaldehyde (HCHO). Due to the short timescales of those chemical processes, HCHO forms an excellent proxy tracer for those emissions. Here, we employ the high spatiotemporal resolution HCHO product from the Sentinel-5p TROPOMI mission in order to improve biogenic emission estimates over Europe using inverse modelling.

The inversion strategy relies on the MAGRITTev1.1 chemical transport model, which includes a detailed chemical representation of isoprene oxidation. The inversion scheme minimizes the overall difference between observed and modeled HCHO columns by varying the VOC fluxes from different emission categories, namely anthropogenic, biogenic, and biomass burning emissions. The a priori NMVOC emissions are provided by MEGAN-MOHYCAN for biogenic compounds, QFED for fire emissions, and CAMS-GLOB-ANT for anthropogenic emissions. The TROPOMI HCHO columns are corrected for systematic biases on the basis of comparisons with MAX-DOAS and FTIR measurements at European sites.

The high TROPOMI data quality allows the use of weekly-averaged data as top-down constraints for the first time, instead of monthly averages used in previous studies. This constitutes a great improvement in the top-down emission estimation, given the strong meteorology-induced variability of isoprene emissions. The satellite data suggest a large increase in biogenic emissions in Europe; the optimized isoprene emissions are approximately doubled with respect to their a priori values. Anthropogenic VOC and biomass burning emissions are only mildly changed by the inversion with respect to their bottom-up inventories, however. This work is performed in the context of the European Commission H2020 SEEDS (Sentinel EO-based Emission and Deposition Service) project.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

GEIA: Global Emissions Initiative
Session 2 Poster

A comparison of greenhouse gas emissions during COVID-19 lock downs in Manchester, UK

Mr Han Yong
University of Manchester, United Kingdom

Author list (excluding presenting author)

Grant Allen1, Jacob Shaw1, Michael Flynn1, Patrick Barker1

Abstract

Urban greenhouse gas emissions are an important source and remain a particular challenge to measurement-led quantification science. In this study, we will present an analysis of simultaneously-sampled in-situ measurements of methane and co2 concentrations (along with other air quality trace gases), aerosols and meteorological conditions made from an air quality supersite in an urban area to the South of Manchester, UK. We will present a statistical and climatological assessment of observation at the monitoring site and discuss their potential utility in understanding the nature of urban sources. We also present a comparison of observations during COVID-19 lockdown and non-lockdown periods, which show clear emission changes in response to lockdown policies and human activity changes. We also discuss the use of machine learning, which was also applied to the dataset to derive a weather-normalised baseline, which could be used to highlight emission “events”, and assess emission deviations associated with future Net Zero policies in the UK and beyond.

Early Career Scientist

YES, I am an early career scientist.

COVID-19 related abstracts

yes
Is the 2020-2021 surge in global methane related to COVID-19 lockdown emission reductions?

David S. Stevenson
The University of Edinburgh, United Kingdom

Author list (excluding presenting author)
Dick Derwent (1); Oliver Wild (2); Bill Collins (3)

Abstract
Measurements show a surge in atmospheric methane growth rate from under 10 ppb/yr in 2015-2019 to over 15 ppb/yr in 2020 and 2021 (https://gml.noaa.gov/ccgg/trends_ch4/). The main sink for atmospheric methane is reaction with the hydroxyl radical (OH). Several studies, summarised in IPCC-AR6, demonstrate that historical changes in anthropogenic emissions of nitrogen oxides (NOx), carbon monoxide (CO) and non-methane volatile organic compounds (NMVOC) have modulated global OH and significantly influenced methane’s pre-industrial to present-day radiative forcing. Increases in NOx emissions generate more OH, whilst increases in CO and NMVOC emissions reduce OH. Global multi-model experiments, performed as part of the Hemispheric Transport of Air Pollution programme, quantified how regional changes in NOx, CO and NMVOC emissions affect global OH, and hence methane. Gridded estimates of how emissions changed during the COVID-19 lockdowns have been produced, based on activity data, including reductions in emissions from surface transport and aviation. By combining these regional OH sensitivities to emissions with estimates of regional emission changes, we calculate that about half of the observed surge in methane can be attributed to lockdown emission reductions. These results are subject to quite large uncertainties in both the OH sensitivities and the lockdown emissions changes, and there are likely to have been several other potentially important influences on methane (and maybe OH) over the last two years. Nevertheless, these simple calculations, based on our current understanding, suggests that a large fraction of the recent surge in methane is related to lockdown emissions changes. Better understanding of the sensitivity of methane growth rate to non-methane emissions is crucial for constraining future projections of methane and climate change, and further more detailed studies of the response methane over the lockdown period are urgently needed.

Early Career Scientist

NO, I am not an early career scientist.

COVID-19 related abstracts

yes
Evaluation of Modeled PM$_{2.5}$ and NO$_2$ with Ground-based and Satellite Measurements in the Eastern Africa Cities

Mr. Ezekiel Waiguru Nyaga
Laboratoire Interuniversitaire des Systèmes Atmosphériques (LISA), UMR CNRS 7583, Université Paris Est Créteil et Université de Paris, Institut Pierre Simon Laplace, Créteil, France. France. Université Paris Cité, France

Author list (excluding presenting author)
Mike Giordano (1),(2),(3),(8); Savannah Ward (4); Daniel Westervelt (4); Michael J. Gatari (5); Moses Njeru (5); John Mungai (6); Godwin Opinde (7); Tedy Mwendwa (7); Albert Presto (8); Emilia Tjernstrom (9); V. Faye McNeill (10); Matthias Beekmann (1),(2); R. Subramanian (1),(2),(3),(8)

Abstract
The Eastern Africa cities of Nairobi, Kampala, and Kigali are experiencing high population growth rates, rapid urbanization, and an increase in economic activities. This has caused unprecedented levels of air pollution, putting the majority and highly vulnerable urban poor at great risk of exposure. Nairobi ground-based measurements are available (Jan 2020-Jan 2022) at an urban background site (the IPA offices in Wetlands neighborhood) and (May-December 2021) at urban roadside sites (Kenyatta University, University of Nairobi), a residential site (Ngong), a mixed residential/industrial site (Buru Buru) and a residential roadside site (Marurui). The calibrated PM$_{2.5}$ mean concentration ranged between 20.6 µg/m$^3$, and 31.8 µg/m$^3$ at the IPA office and Kenyatta University respectively but the NO$_2$ measurement were not calibrated due to lack of sufficient collocation data. We will use a high resolution (2.5 km x 2.5 km) CHIMERE Chemistry Transport Model covering the Eastern Africa domain and will show a first evaluation with ground-based (PM$_{2.5}$, NO$_2$) and satellite measurements (AOD, NO$_2$). CHIMERE will be driven by assimilated metrological data (WRF), time-varying global anthropogenic emissions CAMS, fire emission fluxes (CAMS-GFAS), and CAMS boundary conditions. Analysis of anthropogenic emissions has been conducted and the transport and residential emission sectors in CAMS emissions replaced by DICE-Africa which is more representative in terms of regional sources and their emission factors. The modeled observations will improve our understanding of the contribution of local sources to ambient air pollution, daily and seasonal variabilities, and regional transport of biomass burning, as well as our ability to predict future changes in air pollution under different emission scenarios.

Early Career Scientist
YES, I am an early career scientist.

IGAC Activities
MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups
ANGA: African Group on Atmospheric Sciences
Tropical soil NO emissions: the view from TROPOMI NO\textsubscript{2} column data

Dr. Jenny Stavrakou
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Author list (excluding presenting author)

Beata Opacka (1); Jean-François Müller (1)

Abstract

Nitrogen oxides play a major role in tropospheric chemistry through their impact on ozone and OH distributions, and therefore on the oxidizing capacity of the atmosphere. Whereas anthropogenic NO\textsubscript{x} emissions are dominant globally, natural sources are responsible for ca. 30% of the total emissions into the atmosphere. These sources include soil emissions and lightning. Chemistry-transport models (CTMs) rely on bottom-up (BU) inventories, the uncertainty of which is acknowledged, especially for natural sources. Current global BU estimates range from 4 to 15 Tg N yr\textsuperscript{-1} with nearly 70% occurring in the tropics. Satellite retrievals of tropospheric NO\textsubscript{2} columns are used as top-down (TD) constraints in CTMs to derive NO\textsubscript{x} emissions from various sources (anthropogenic, biomass burning, soil, lightning), cf. Martin et al. (2003), Jaeglé et al. (2005), Stavrakou et al. (2013), Vinken et al. (2014). This is realized through inverse modelling, that is, the iterative optimization of emissions in a CTM in order to minimize the discrepancy between observed and simulated NO\textsubscript{2} columns.

Here, we present top-down monthly soil NO emissions for 2019 (a) at 0.5° ×0.5° over Africa and South America and (b) at a global scale at 2°×2.5°. Top-down NO\textsubscript{x} fluxes are inferred from TROPOMI tropospheric NO\textsubscript{2} columns (version 2.2, van Geffen et al., 2022), the global MAGRITTEv1.1 CTM and its adjoint (Müller et al., 2019). Two inventories are used as a priori: (1) YL-MAG, based on the Yienger and Levy parameterization (1995), and (2) HEMCO (Weng et al., 2020) based on Hudman et al. (2012). The a priori and optimized soil NO fluxes are subsequently assessed against a large array of in situ measurements in the Tropics.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

GEIA: Global Emissions Initiative, AMIGO: Analysis of eMissions usinG Observations
Impact of Chlorine from Very Short-Lived Substances on Stratospheric Ozone

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School of Earth and Environment, University of Leeds, Leeds, United Kingdom. Department of Ocean Sciences and Engineering, Southern University of Science and Technology, Shenzhen, China

Author list (excluding presenting author)

Wuhu Feng (1, 2), Chris Wilson (1, 3), Ryan Hossaini (4), and Martyn Chipperfield (1, 3)

Abstract

Although the Montreal Protocol has been successful in reducing the emissions of long-lived ozone-depleting substances (ODSs), some chlorinated very short-lived substances (VSLS, lifetimes < 6 months), which have not been regulated by the Protocol, are believed to be having an increasing impact on stratospheric ozone depletion. Emissions of VSLS have been reported to be increasing both from bottom-up estimates and observations. For example, stratospheric chlorine source gas injection of VSLS was estimated to increase by around 70% from 2000 to 2007. We have used the TOMCAT/SLIMCAT 3-D offline chemical transport model (CTM) to investigate the impact of these increasing VSLS emissions.

TOMCAT/SLIMCAT contains a detailed description of stratospheric chemistry and is driven by meteorology from the European Centre for Medium-Range Weather Forecasts (ECMWF). We use surface mixing ratios of VSLS given by recent WMO Ozone Assessment Reports, including CH2Cl2, CHCl3, CH2ClCH2Cl, and C2Cl4. We present results from two sensitivity experiments from 1994 to 2020 (years before 2001 as spin-up) with and without the impacts of the above VSLS.

The results show that if these main VSLS are removed from the atmosphere, the monthly averaged Antarctic ozone column could be up to 8 Dobson Unit (4.5%) larger, and the impacts become more significant with time as the VSLS mixing ratios increase. We also find that the patterns of the additional depletion remain similar regardless of the meteorological conditions throughout different years, showing how the VSLS chlorine enhances the standard halogen ozone loss processes. We show that although the extra depletion of stratospheric ozone by VSLS is currently small, it can be considered an increasing threat to the recovery of the ozone layer.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities
AMIGO: Analysis of eMIssions usinG Observations, ACAM: Atmospheric Chemistry and the Asian Monsoon, GEIA: Global Emissions Initiative

IGAC Regional Working Groups
Session 2 Poster

Continuous monitoring of biogenic VOC fluxes over South America by inversion of TROPOMI HCHO columns, 2018-2021

Dr. Jenny Stavrakou
Royal Belgian Institute for Space Aeronomy, Belgium

Author list (excluding presenting author)

Jean-François Müller (1), Beata Opacka (1), Glenn-Michael Oomen (1), Corinne Vigouroux (1)

Abstract

South America is a continent of special importance, as it hosts the Amazon forest, which is the single largest emission source of biogenic volatile organic compounds (BVOCs) into the atmosphere; it is also a region where extremely violent and extensive wildfires are occurring. Thanks to the TROPOMI instrument onboard the Sentinel-5p mission, observations of formaldehyde (HCHO) columns are retrieved at an unprecedented spatial resolution and signal-to-noise ratio. In combination with atmospheric composition models enhanced with inverse modelling capabilities, these observations allow to infer improved, space-based estimates of BVOC emissions. Here we present top-down monthly BVOC emissions over South America at 0.5°×0.5°, constrained by TROPOMI HCHO data over the first 4 years of the TROPOMI mission, 2018-2021. The TROPOMI data are corrected for biases against ground-based FTIR data determined by Vigouroux et al. (2020). Only data with low cloud fraction (< 20%) are retrained for the inversion and a filtering based on TROPOMI NO₂ data is applied to eliminate scenes heavily affected by fires. The regional MAGRITTEv1.1 model and its adjoint (Müller et al., 2019) are used to infer top-down fluxes. The model uses a priori biogenic emissions from the MEGAN-MOHYCAN model (Opacka et al., 2021), fire emissions from the QFED database (Koster et al., 2015), anthropogenic emissions from the CAMS-GLOB-ANT inventory, and soil NO emissions obtained from an optimization based on TROPOMI NO2 column data. The optimized isoprene columns are evaluated against direct isoprene retrievals from the CrIS instrument (Wells et al., 2022), as well as FTIR HCHO data at Porto Velho in Rondônia, Brazil. The seasonal variation and interannual variability of the top-down fluxes will be investigated and discussed.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

AMIGO: Analysis of eMissions using Observations, GEIA: Global Emissions Initiative

IGAC Regional Working Groups

Southern Hemisphere Working Group, Americas Working Group
Insights from long-term measurements of biogenic volatile organic compounds using novel autonomous instrumentation

Dr Valerio Ferracci
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Author list (excluding presenting author)

Fred Otu-Larbi (2); Thomas King (2); Kirsti Ashworth (2); Julia Schmale (3); Neil R.P. Harris (1)

Abstract

A better understanding of the emissions and global distribution of biogenic volatile organic compounds (BVOCs) is crucial for an accurate characterisation of the composition and oxidising capacity of the atmosphere, especially as global change in the near future is expected to profoundly affect the drivers of BVOC emissions.

Currently BVOC monitoring relies on instrumentation that is both power and resource intensive, resulting in limited coverage of available measurements, both spatially and temporally. This in turn limits our understanding of BVOC emissions in a variety of key regions and environmental conditions, including extreme weather scenarios, such as heatwaves and droughts, which are predicted to become more frequent in the coming decades.

To overcome the limitations of current BVOC instruments, we developed a portable gas chromatograph with photoionisation detection, the iDirac. It has been designed to operate autonomously with low power and gas requirements, to be robust to operate away from more traditional measurement sites, with installation and maintenance performed by non-specialists.

We report on some of the highlights from iDirac deployments in recent years. Notably, the measurements of isoprene in a UK woodland (Wytham Woods, Oxfordshire) for five consecutive summers revealed the importance of soil moisture on isoprene emissions, with moderate drought driving a sharp increase in emissions. This effect is currently overlooked in emission models.

In addition, measurements from the Antarctic Circumnavigation Expedition provided data on isoprene abundances across under-sampled Southern latitudes. Data showed isoprene hotspots in the Southern Ocean and provided strong indications of a marine source of isoprene during daytime as well as higher concentrations linked to phytoplankton blooms in the marginal ice zone (both currently unaccounted for in models).

These results highlight how applying robust, novel technologies to atmospheric monitoring can advance our understanding of atmospheric composition and elucidate the drivers of atmospheric change.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

AMIGO: Analysis of eMissions using Observations
IGAC Regional Working Groups

Southern Hemisphere Working Group
Assessment of emission corrections for the German national emission inventory by applying spatio-temporal inversion

Dr Anne Caroline Lange
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Author list (excluding presenting author)

Hendrik Elbern (2)
Philipp Franke (1)

Abstract

Emission inventories, which are an important data source for decision making with respect to air pollution mitigation strategies as well as a crucial input for chemistry transport models, depend on rough estimates from bottom-up and top-down strategies. Further, the temporal and spatial distribution functions of national emissions, for example for air quality forecasting and analyses, include high uncertainties, as in times of renewable energies and decreasing work commuting, emissions are much less steady. Within a full year reanalysis of 2016, we assess emission correction factors for the German anthropogenic emission inventory applying the 4D-var data assimilation system of EURAD-IM. Assimilating ground-based, airborne, and satellite observations within successive 24 hours assimilation windows, we jointly assess initial value optimisations and emission correction factors for anthropogenic emissions of nitrogen oxides (NO\textsubscript{x}), carbon monoxide (CO), particulate matter (PM), sulphur oxides (SO\textsubscript{x}), ammonia (NH\textsubscript{3}), and non-methane volatile organic compounds (NMVOCs), achieving consistency with observations. Special focus is placed on the spatial distribution of emission corrections on a high horizontal resolution. We obtain consistency in the national emission sums of the national inventory, while the spatial distribution reveals heterogeneous patterns for emission corrections. For densely populated regions, as for example the industrially characterized Rhine-Ruhr area in North-Rhine-Westphalia, we find significant corrections towards reduced emissions of CO and SO\textsubscript{x}, while NO\textsubscript{x} emissions are corrected towards higher emissions. The high-resolution analysis allows for the assignment of certain emission corrections to individual polluter groups, such as road transport or industrial point sources.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

AMIGO: Analysis of eMIssions usinG Observations, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality
Free tropospheric ozone trends observed by IASI and simulated by LMDZ-OR-INCA between 2008 and 2020 over Central East China, Europe and North America and COVID impact in spring 2020

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Author list (excluding presenting author)

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Abstract

Free tropospheric ozone is investigated using the IASI observations and the state-of-the-art global model LMDZ-OR-INCA. We focus on the large urbanized regions of the Northern Hemisphere: Central East China, Europe and North America. We study the recent ozone trends from 2008 to 2020, including a specific analysis of the COVID lockdown period in spring 2020. Both model simulations and IASI observations show negative trends over the three regions, which are rather consistent. The trends derived from IASI range from -0.7%/yr to -0.5%/yr, and those derived from the model from -0.8%/yr to -0.5%/yr. Normalizing the seasonal cycle of 2020 by the 2008-2019 mean cycle shows that the model and the observations are in good agreement in the upper free troposphere, with a decrease of ozone accentuated during the lockdown period. In the lower free troposphere, the model tends to overestimate the ozone reduction during the lockdown period compared to IASI.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report

COVID-19 related abstracts

yes
Session 2 Poster

Assessment of tropospheric NO$_2$ over South and East Asia in global climate-composition model and Satellite data

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Author list (excluding presenting author)
David Stevenson (2), Alcide Zhao (2), Richard Pope (1), Krishan Kumar (3)

Abstract

We analyse NASA’s Aura satellite Ozone Monitoring Instrument (OMI) troposphere column nitrogen dioxide (NO$_2$) data and compared it with the global climate composition model – United Kingdom Chemistry and Aerosol (UKCA) tropospheric column NO$_2$ over South and East Asia. UKCA model is an aerosol-chemistry model coupled to the UK Met Office Hadley Centre HadGEM family of climate models and the atmospheric composition component of the UK Earth system model. UKCA was run with nudged meteorology, producing hourly output over South and East Asia from 2005 to 2015. To allow consistent model-data comparison OMI averaging kernels have been applied to the model hourly data sampled at Aura’s local overpass time of 1345±15 minutes. OMI and UKCA data have been analysed spatially and temporally. Background model and satellite tropospheric column NO$_2$ usually range between 0 – 2 × 10$^{15}$ molecules/cm$^2$. The model captures the seasonality right but overestimates tropospheric column NO$_2$, particularly during the winter season.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

CCMi: Chemistry Climate Model Initiative, ACAM: Atmospheric Chemistry and the Asian Monsoon

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
**Ground-based Lidar Ratio Retrievals for Improvement in Extinction Products in Version 5 of CALIOP**

Jayanta Kar  
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**Author list (excluding presenting author)**

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**Abstract**

The spaceborne elastic lidar CALIOP onboard the CALIPSO spacecraft has been providing vertically resolved profiles of aerosol extinction globally since June 2006. These extinction retrievals depend critically on the aerosol lidar ratio; i.e., the ratio of the aerosol extinction coefficient to the aerosol backscatter coefficient. Up until the current CALIPSO data version (V4.20), the lidar ratios for different aerosol subtypes have been assumed constant both spatially and temporally. This has been generally successful in retrieving extinction coefficient profiles and optical depths of tropospheric aerosols globally. However, it has been clear from ground based and airborne measurements over the last few decades that the lidar ratios of individual aerosol species can vary significantly regionally, seasonally, diurnally, vertically, as well as a function of age, mixtures of aerosol composition, and relative humidity. In future versions of the data products, the CALIPSO team plans to implement spatially/temporally variable aerosol lidar ratios. This scheme will use CALIOP profile measurements together with collocated aerosol optical depth (AOD) retrievals from MODIS and the Synergized Optical Depths of Aerosols (SODA) satellite datasets to derive global climatologies of constrained lidar ratios for each of the CALIOP aerosol subtypes. These climatologies will be validated using lidar ratios retrieved by ground based lidars. Model data will be used where constrained retrievals are unavailable. In this paper, we will present the current state of information on these lidar ratios and their variability as available from the published results. We will also discuss the availability of lidar ratio retrievals from the various ground-based lidar networks which will be leveraged for the new scheme either using Raman or high spectral resolution lidars or using elastic backscatter lidars constrained by AOD from collocated photometers.

**Early Career Scientist**

NO, I am not an early career scientist.
Session 2 Poster

CALIPSO-SODA lidar ratio maps for CALIPSO aerosol types

David Painemal
SSAI /NASA Langley Research Center, USA

Author list (excluding presenting author)

Zhujun Li(1)
Gregory Schuster (2)
Marian Clayton (1)

Abstract

CALIPSO Version 4.2 (V4) aerosol types are characterized in terms of their lidar ratios using a retrieved columnar lidar ratio estimated by combining CALIPSO attenuated backscatter and aerosol optical depth (AOD) retrievals from the Synergized Optical Depth of Aerosols (SODA) algorithm (CALIPSO-SODA). For samples detected at 5-km or 20-km spatial resolutions and having AOD > 0.05, the CALIPSO-SODA lidar ratios are significantly different between different aerosol types, and are consistent with the type-specific values assigned in V4 to within 10 sr. We find remarkable daytime/nighttime regional agreement for clean marine aerosol over the open ocean (CALIPSO-SODA = 20-25 sr, V4=23 sr), elevated smoke over the southeast Atlantic (CALIPSO-SODA = 65-75 sr, V4=70 sr), and dust over the subtropical Atlantic adjacent to the African continent (CALIPSO-SODA = 40-50 sr, V4=44 sr). In contrast, daytime polluted continental/smoke lidar ratio is more than 20 sr smaller than the constant V4 value for that type, attributed in part to the challenge of classifying tenuous aerosol with low signal-to-noise ratio. Dust over the Atlantic Ocean features CALIPSO-SODA lidar ratios less than 40 sr, possibly suggesting the presence of dust mixed with marine aerosols or lidar ratio values that depend on source and evolution of the aerosol plume. The dusty marine type features similar magnitudes and spatial distribution as its clean marine counterpart with lidar ratio differences of less than 3 sr, and nearly identical values over the open ocean.

Our goal is to produce reliable regional lidar ratio that can be used in aerosol remote sensing applications and in the future version of CALIPSO products. This work is also part of the Models, In situ, and Remote sensing of Aerosols (MIRA) Working Group; thus, we seek lidar ratio measurements for verification as well as model and in situ measurements of aerosol type for contextualization.

Early Career Scientist

NO, I am not an early career scientist.
Investigating the importance of aqueous-phase chemistry in deliquescent aerosols using the global atmospheric chemistry model EMAC

Dr Simon Rosanka
Institute of Energy and Climate Research: Troposphere (IEK-8), Forschungszentrum Jülich GmbH, Jülich, Germany, Germany

Author list (excluding presenting author)

Domenico Taraborrelli (1)

Abstract

Understanding how multiphase processes impact the atmospheric composition is key to properly predict air quality and climate. Overall, aqueous-phase processes in cloud droplets and deliquescent aerosols are known to alter the abundance of oxygenated volatile organic compounds (OVOCs), important oxidants like ozone, and contribute to the formation of secondary organic aerosols. A proper representation of these processes is thus important but missing in most atmospheric chemistry and climate models. The global atmospheric model ECHAM/MESSy (EMAC) however is capable to represent explicit aqueous-phase chemical kinetics in cloud droplets as well as deliquescent aerosols by integrating the corresponding ordinary differential equation systems using a Rosenbrock solver. Recently, EMAC was already used to represent the uptake and oxidation of OVOCs in clouds by using the Jülich Aqueous-phase Mechanism of Organic Chemistry (JAMOC). It focuses on the phase transfer of species containing up to 10 carbon atoms and the oxidation of a selection of species containing up to 4 carbon atoms. In this study, we use JAMOC to additionally represent aqueous-phase kinetics in aerosol water for the first time and evaluate the impact of this process on the atmospheric composition focusing on key oxidants, organic acids, and OVOCs in general.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report, ACAM: Atmospheric Chemistry and the Asian Monsoon
Session 2 Poster

Regional and Local Mineral Dust Activity over South America assessed through high-resolution satellite products

Dr Nicolas Huneeus
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Author list (excluding presenting author)


Abstract

Most of the dust related studies have historically been focused on the largest desert dust regions in North Africa, the Middle East and China. Comparatively, South America has received scarce attention, especially on the characterisation of sources at regional and sub-regional scale.

A satellite-based analysis is conducted to characterise mineral dust sources at both regional and sub-regional scales. The regional analysis is based on MODIS Deep Blue products (MOD04L2-MYD04L2) of Aerosol Optical Depth (AOD) and Angstrom Exponent (α) between 2015 and 2019 at 10 km horizontal resolution. The sub-regional scale characterisation is carried out using the MODIS MAIAC AOD product (MCD19A2) at 1 km horizontal resolution. High values of AOD along with low values of α are associated with coarse mineral dust particles and consequently mineral dust sources. The above approach is complemented with geological evidence and also contrasted with the computation of the Dust Optical Depth (DOD), as formulated by Anderson et al. (2005).

Large mineral dust sources are identified in the Atacama Desert (Northern Chile), the Sechura Desert (Northern Peru), West-Central Argentina and the Argentinian Patagonia. In both the Atacama and the Sechura Deserts, mineral dust sources are primarily associated with coastal dunes and wind erosion features. In West-Central Argentina, mineral dust sources are dominated by partially dried lakes and dunes developed on distal alluvial fans, whereas, in the Argentinean Patagonia, these are mostly associated with dried lakes.

In connection, time series analysis reveals different seasonal patterns across regions. These differences are driven by soil type, vegetation cover and wind patterns, showing how heterogeneous dust activity is across South America.

Implications of these findings for solar energy production, air quality, and modelling validation applications will be discussed.

Reference:


Early Career Scientist
NO, I am not an early career scientist.

**IGAC Activities**

GEIA: Global Emissions Initiative

**IGAC Regional Working Groups**

Americas Working Group
The retrieval of atmospheric trace gases using passive solar remote sensing from satellite and aircraft platforms: progress and challenges

Professor John P. Burrows FRS
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Author list (excluding presenting author)
Andreas Richter (1); Kezia Lange (1); Heinrich Bovensmann (1); Konstantin Gerilowski(1) ; Sven Krautwurst (1); Jakob Borchardt (1); Mark Weber (1); Michael Buchwitz (1); Stefan Noel (1); Oliver Schneising (1); Max Reuter (1).

Abstract
GOME (ESA ERS-2 (1995-2011)) and SCIAMACHY (ESA Envisat (2002-2012)) began a new age of nadir viewing passive remote sensing instruments from space, aiming to deliver globally trace gas amounts and distributions. Follow-ons with progressively improving spatial resolution and signal to noise have resulted: the most recent being TROPOMI, on the Copernicus Sentinel-5 Precursor, EU-ESA-S5P (2017 to present). In addition, the Geostationary Environment Monitoring Spectrometer, GEMS, on the Korean Aerospace Research Institute GEO-KOMPSAT-2B satellite launched in 2020 into a Geostationary orbit, GEO. This evolution of passive remote sensing stimulated the development of aircraft-borne instruments at the University of Bremen e.g. the AIRMAP and the MAMAP family of instruments.

The spectral resolution of the above instruments is sufficient to identify the electronic-vibrational-rotational-absorptions in the ultraviolet, visible, and near-infrared spectral regions of the upwelling radiance. Using differential optical absorption spectroscopy, DOAS, total column amounts of key trace gases (e.g. ozone, O3, nitrogen dioxide, NO2, bromine monoxide, BrO, chlorine dioxide OCIO, iodine oxide, IO, formaldehyde, HCHO, glyoxal, CHO.CH0, and water vapour H2O) are retrieved. In addition, SCIAMACHY and TROPOMI observe in the shortwave-infrared. CO columns and the dry columns of methane, XCH4, and carbon dioxide, XCO2, are retrieved from SCIAMACHY measurements, and the inversion of TROPOMI radiances delivers CO columns and XCH4 at a much higher spatial resolution. The AIRMAP and MAMAP family of instruments have been developed to target absorptions respectively in the ultraviolet/visible and the near-infrared/shortwave-infrared.

This presentation focuses on recent results addressing: i) the validation of TROPOMI and the estimation of urban emissions of NO2; ii) ozone measurements; iii) the validation of the GEMS data products; iii) the emissions of CH4 from TROPOMI and CH4 and CO2 from the new MAMAP 2D Light instrument. These developments will be put in the context of the evolving global observing system.

Early Career Scientist

NO, I am not an early career scientist.
IGAC Activities

TOAR: Tropospheric Ozone Assessment Report, CATCH: the Cryosphere and Atmospheric Chemistry, GEIA: Global Emissions Initiative

IGAC Regional Working Groups

Southern Hemisphere Working Group, China Working Group, Japan National Committee
Performing ICON-ART simulations for atmospheric long-range transport of PFAS

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Author list (excluding presenting author)

Johannes Bieser
Martin Ramacher
Volker Matthias

Abstract

Persistent Organic Pollutants (POPs) from local and regional sources are often transported over long distances and will constitute a severe environmental problem for decades to come. The increase of industrial production of synthetic chemical compounds for manufacturing and daily use products has raised the environmental burden and human exposure to these pollutants, which often have toxic, carcinogenic, or endocrine disrupting properties. Therefore, it is necessary to identify major sources, pathways and sinks of POPs in order to estimate their negative effect on human health. In this study, a next generation atmospheric circulation model is used, the ICOsahedral Non-hydrostatic model (ICON) and its chemistry transport submodule, Aerosols and Reactive Trace gasses (ART) to investigate the long-range atmospheric transport and fate of POPs. ICON-ART is a global unstructured grid model complemented by a chemistry submodule capable of representing the emission, transport, gas phase chemistry and aerosol dynamics. Two Per- and poly-fluoroalkyl substances, Perfluorooctanoic acid (PFOA) and Perfluorooctanesulfonic acid (PFOS) have been included as a first step towards a wider range of POPs. The gridded PFAS emission sources for our simulations are taken from a newly developed global Persistent Organic Pollutants Emission model for different compartments (POPE).

To investigate atmospheric PFAS transport, we performed a series of experiments including deposition and degradation processes. We use a global high resolution domain to evaluate the role of large-scale phenomena (e.g. Rosby waves) on PFAS transport and identify the patterns related to major climate teleconnections over different zones around the world.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities
Session 2 Poster

On the identification of an emerging anthropogenic combustion source of Carbon Monoxide at continental scales

Benjamin Gaubert
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Author list (excluding presenting author)

Helen M. Worden (1)
Louisa K. Emmons (1)
Rebecca Buchholz (1)
Kavitha Mottungan (2)
Avelino F. Arellano (3)
Claire Granier (4,5)
Guy P. Brasseur (1,6)
Gabrielle Pétron (7)

Abstract

Emissions of gases and particles from the combustion of fossil fuels and biofuels in the fastest growing economies are expected to increase significantly. In the context of a decline of CO emissions and in the atmospheric background trend, with a large inter annual variability in fire emissions, it is difficult to disentangle a potential CO signal from emerging anthropogenic combustion. The focus of this study is to evaluate CO variations at a slow temporal frequency, from months to years, at continental to hemispheric scales for the 2001 to 2021 period. We analyze the satellite total CO columns observations from the Measurement Of Pollution in The Troposphere (MOPITT) and surface in situ measurements from the NOAA Global Monitoring Laboratory network of sampling sites. We first decompose the CO time series from observations and simulations into a long-term trend component, a time varying seasonal cycle and the remainder inter-annual variability. After removing the large-scale zonal averaged background, we identify rising anthropogenic CO trends over West Africa and over the Indo Gangetic plain. We also perform global model simulations with the Community Atmosphere Model with chemistry (CAM-chem), driven by the anthropogenic emissions (version 5.1) provided by the Copernicus Atmosphere Monitoring Service. Emissions for 2020 are adjusted for lockdowns using the CONFORM (COvid-19 adjustmeNt Factors fOR eMissions) dataset. We contrast different simulations to attribute the drivers of the observed signal. We also compare our results with MOPITT data assimilation experiments, reanalyses product and other posterior emission estimates.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities
AMIGO: Analysis of eMIssions usinG Observations

IGAC Regional Working Groups

ANGA: African Group on Atmospheric Sciences

COVID-19 related abstracts

yes
Session 2 Poster

Tropical tropospheric ozone distribution and trends

Audrey Gaudel
CIRES, University of Colorado, Boulder, USA, USA. NOAA Chemical Sciences Laboratory, Boulder, USA, USA

Author list (excluding presenting author)

Meng Li (1,2), Ilann Bourgeois (1,2), Owen Cooper (1,2), Kai-Lan Chang (1,2), Bastien Sauvage (3), Jerry Ziemke (4,5), Anne Thompson (6), Ryan Stauffer (6), Nadia Smith (7)

Abstract

Tropospheric ozone is the third most important greenhouse gas, is detrimental to human health and crop and ecosystem productivity, and controls the oxidizing capacity of the troposphere. Tropospheric ozone in the tropics has been shown to be quickly increasing especially in Southeast Asia compared to regions in the Northern mid-latitudes, and based on model simulations the global ozone increases have been mostly explained by the shift of emissions toward the equator. Current and future geostationary satellite missions are designed to monitor air composition for air quality and climate purposes. Unfortunately, the tropics are not always covered. In this context, the present study presents the analysis of in situ data to assess the tropical tropospheric ozone distribution and trends, and evaluates current polar orbiting satellite products.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report

IGAC Regional Working Groups

ANGA: African Group on Atmospheric Sciences, Southern Hemisphere Working Group, Americas Working Group
Observations of the AOD–PM Relationship and its Variation on Urban Spatial Scales

Milan Y Patel
University of California Berkeley, USA

Author list (excluding presenting author)

Pietro Vannucci (1); Yishu Zhu (2); Anna Winter (3); Naomi Asimow (4); Paul J. Wooldridge (5); Catherine Newman (6); Ronald C. Cohen (7)

Abstract

Particulate matter (PM) is a leading cause of premature mortality and contributes to a variety of acute and chronic diseases. Geostationary satellite observations provide comprehensive spatial maps of aerosol optical depth (AOD) with updates as often as 5 minutes and a resolution as fine as 2 km. AOD is a column property, with reflected scattering occurring at multiple levels in the atmosphere and possibly from aerosols of different composition. Evaluation of variation in the retrieved AOD and its comparison to surface measurements of aerosol mass or scattering on a pixel to pixel basis has not been previously described. We use the Berkeley Environmental Air-quality and CO2 Network (BEACO2N), with observations in the Bay Area of California to examine pixel to pixel variations in AOD at approximately 2 km spatial resolution.

Early Career Scientist

YES, I am an early career scientist.
Overview of the SPARC Reanalysis Intercomparison Project (S-RIP) and Phase 2 Plans

Jonathon S Wright
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Author list (excluding presenting author)
Masatomo Fujiwara (1); Gloria L. Manney (2,3); Lesley J. Gray (4); and the SPARC Reanalysis Intercomparison Project team

Abstract

The SPARC Reanalysis Intercomparison Project (S-RIP, https://s-rip.github.io/) is a coordinated activity initiated in 2013 to: (1) compare atmospheric reanalysis products for key diagnostics in the stratosphere, upper troposphere, and lower mesosphere; (2) understand the causes of differences among reanalyses; (3) provide guidance on the appropriate usage of various reanalysis products in scientific studies; and (4) connect such activities with future improvements in the reanalysis products by establishing collaborative links between the reanalysis centers and the SPARC community. In January 2022, the S-RIP published its Final Report with 12 chapters (https://www.sparc-climate.org/sparc-report-no-10/). This presentation provides an overview of the S-RIP Final Report and key outcomes relevant to the iCACGP-IGAC community, along with preliminary plans for phase 2 of the activity. Feedback and suggestions for further analysis are welcome.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

CCMi: Chemistry Climate Model Initiative

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Assessing data quality in long-term Canadian ozone sounding records

David W Tarasick
Environment and Climate Change Canada, Canada

Author list (excluding presenting author)

Ryan M. Stauffer (2); Herman G.J. Smit (3); Anne M. Thompson (2); Jonathan Davies (1); Roeland Van Malderen (4); Bryan J. Johnson (5); Holger Vömel (6)

Abstract

Ozonesondes have made inexpensive, accurate measurements of ozone from the ground to 30 km for more than 50 years. The data are used extensively for trend analyses and for evaluation of satellite and model data products, and are also part of climatologies that are used as a priori data for satellite retrievals. They are essential as a transfer standard when merging shorter satellite-derived time series, and are the most important source of trend-quality long-term records below about 18 km.

The importance of long-term ozonesonde records as a stable reference has led to increased attention to quantifying uncertainties and changes in ozonesonde data. The recent Assessment of Standard Operating Procedures for Ozone Sondes (ASOPOS 2.0; WMO/GAW Report #268) recommended that homogeneity and long-term stability in ozone sounding network time series be regularly evaluated by comparison with satellite sensors, as well as ground-based photometers.

Although the long Canadian network time series appear quite stable, detailed analysis of station data shows modest but quantifiable shifts in bias with respect to other measurements, at several points in individual station records. Not all can be explained and corrected. An attempt is made to treat these as an additional uncertainty and to evaluate their potential impact on long-term trend analyses.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report

Jeffrey A Geddes
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Author list (excluding presenting author)
Bo Wang (1)
Taylor Adams (1)
Elena Spinei (2)

Abstract

Sea breezes can bring welcome relief to coastal communities during warm summers, but they can also recirculate air pollution near the surface which may exacerbate air quality-related health risks in coastal urban environments. Unfortunately, these meteorological features also represent major challenges to both routine surface and satellite-derived monitoring of air quality due to their spatial heterogeneity, temporal dynamics, and the role of local geography. Here, we present new insights into the nature and importance of sea breeze dynamics on air pollution in a representative coastal urban environment with low-lying topography. We integrate three years of ground-based remote sensing measurements of total column NO\(_2\) across the Boston basin with surface concentration observations and satellite-based retrievals, vertically resolved meteorological observations, and high-resolution (3 x 3 km) WRF-Chem chemical transport model simulations. Like in many coastal urban environments, we find the sea breeze tends to exacerbate local air pollution primarily by enhancing the accumulation of local primary emissions in the morning and recirculating secondary air pollutants inland in the afternoon. The sea breeze drives large spatial heterogeneity in surface concentrations of O\(_3\) and NO\(_2\) that are not well captured by the current monitoring network in Boston. While satellite remote sensing offers some opportunity to inform surface concentration mapping, we find operational satellite retrievals of NO\(_2\) are systematically poorer compared to reference observations during sea breeze conditions specifically, which we speculate results from misrepresentation of the geophysical retrieval inputs during sea breeze days compared to more synoptic westerly conditions. We discuss recommendations for better quantifying the local air pollution impacts in coastal urban environments.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities
Multi-scale Modeling Over Australia for the 2019/2020 Extreme Wildfire Season

Dr Rebecca R Buchholz
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Author list (excluding presenting author)
W. Tang (1); L. K. Emmons (1); S. Tilmes (1); H. M. Worden (1)

Abstract

The Australian wildfire events of 2019/2020 saw large local emissions of pollution with wide-scale impacts across the southeast of the continent, where smoke and haze degraded air quality for many days for millions of people. Hemispheric transport of pollution at low and lofted altitudes also occurred, creating an atmospheric signature over New Zealand and South America, and had a direct influence on climate. These multiple-scale impacts from wildfire in the Australian region make it ideal for testing the new capability of multi-scale modeling. Modeling atmospheric chemistry across scales with the Multi-Scale Infrastructure for Chemistry and Aerosols (MUSICA) leverages a new regional refinement capability within the NCAR Community Earth System Model (CESM). This framework allows for simultaneous simulation at human-relevant and policy-relevant scales at the same time as hemispheric and global-scales. Here, we present a regional refined grid over the Australian region and assess initial simulations for the 2019/2020 wildfire season.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

Southern Hemisphere Working Group
Airborne eddy covariance measurements of Volatile Organic Compounds and NOx in Los Angeles for emission inventory validation

Dr. Eva Y. Pfannerstill
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Abstract

Los Angeles is a major hotspot of ozone and particulate matter air pollution in the United States. Air quality in this region has been stagnant for the last decade, despite a reduction in vehicular emissions of their precursors, NOx and volatile organic compounds (VOCs). Recent estimates suggest non-vehicular VOC sources are now dominant. This leads to the need to investigate other emergent emission sources of precursors to these air pollutants. We used a Vocus-PTR-ToF-MS, a Laser Induced Fluorescence instrument and a wind radome probe on a Twin Otter aircraft to map the emission and deposition fluxes of VOCs and NOx in Los Angeles with a ~3 km spatial resolution. VOCs measured include tracers for a wide range of source categories such as traffic, vegetation, volatile chemical products, or water treatment, as well as oxidation products. We derived fluxes using airborne eddy covariance with a wavelet analysis approach. Flights were conducted in June 2021 as part of the RECAP-CA (Re-Evaluating the Chemistry of Air Pollutants in California) campaign, with ~9000 km of flight paths at 300-400 m altitude over the Los Angeles basin covering both industrial and residential neighborhoods.

The fluxes derived were compared spatially and temporally to commonly used emission inventories: the California Air Resources Board Inventory, and the BEIS and FIVE inventories which serve as the basis for WRF-Chem. The comparison revealed some under- and some overestimated VOC emissions and points at potentially underestimated sources. Notably, measured monoterpene emissions were higher than in the inventories, while isoprene was lower. This finding has impacts for ozone and particle formation.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

GEIA: Global Emissions Initiative, AMIGO: Analysis of eMissions using Observations
Session 2 Poster

A significance of regional transports on urban air quality indicated by PM$_{2.5}$ and O$_3$ measurements at a 630m mountain top site in Seoul

CHANGDONG YUN
Korea University, Korea, Republic of

Author list (excluding presenting author)

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Abstract

Lately, boundary layer processes are highlighted due to its role in vertically mixing local emissions with those transported aloft. In this study, the variations of PM$_{2.5}$ and O$_3$ concentrations observed at the top of Mt. Gwanak (MG, 630m altitude) located in the southwest of Seoul, were analyzed and compared with surface measurements at the National Institute of Environmental Research site (NIER) during 2019~2021.

The 10th-90th percentile and mean concentrations were 3-37 and 18.36ug/m$^3$ of PM$_{2.5}$, and 8-61 and 34.17ppb of O$_3$ at MG. Also, those concentrations of PM$_{2.5}$ and O$_3$ at NIER were 7-46 and 23.61ug/m$^3$, and 5-54 and 28.23ppb, respectively. In average diurnal variations for 3 years, the PM$_{2.5}$ maximum concentration was observed at 10h at the surface (26.0ug/m$^3$) but at 22h at MG (21.3ug/m$^3$). For O$_3$, the highest mixing ratio was found at 16h at the surface (45.4ppb), but at 17h at MG (40.6ppb). Accordingly, the chemical regime of the air masses of the two sites contrasted sharply. While the urban signature was stronger at night than the daytime for surface air masses, it was opposite for those aloft.

In this regard, the measurements were separated into the two, based on PBLH (planetary boundary layer height) measured at surface using Ceilometer: daytime from 11h to 18h and nighttime from 22h to 05h. When PM$_{2.5}$ concentrations were higher than 75ug/m$^3$ at MG, the surface PM$_{2.5}$ reached the highest concentrations of 179ug/m$^3$, most of which were observed in severe haze pollution days. These high PM$_{2.5}$ events were concurrent with elevated CO concentrations corresponding to CO/NO$_2$ and O3/NO$_2$ ratios at both MG and NIER, indicating that the air masses were influenced by continental outflows.

Therefore, this study suggests that the mountain-top site at urban areas can provide long-term baseline measurements useful to diagnose the urban air quality.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Long-term Variations of Climate Pollutants Observed in the Yellow Sea during 2015~2021

Mr. DOYOUNG KIM
KOREA UNIVERSITY, Korea, Republic of

Author list (excluding presenting author)
Saehee Lim (1); Meehye Lee (1); Jongmin Jeong (2); Jinyong Jeong (2)

Abstract

Northeast Asia is characterized by high population density, along with rapid industrialization, resulting in high concentration levels of short-lived climate pollutants (SLCPs) including O$_3$, PM$_{2.5}$ and BC (black carbon) as well as long-lived greenhouse gases. The Socheongcho Ocean Research Station (S-ORS) has been established on the Yellow Sea (37°25'N, 124°44'E) by Korea Institute of Ocean Science and Technology (KIOST). The chief aim of observes atmospheric constituents including PM$_{2.5}$, eBC, O$_3$, CO, CO$_2$, CH$_4$, and H$_2$O as well as oceanographic parameters.

In this study, climate pollutants have been measured at S-ORS since 2015, for which temporal variabilities were intensively analyzed. PM$_{2.5}$, and eBC concentrations have noticeably decreased after 2016 and remained nearly constant until 2021 (p<0.01), while CO$_2$ and CH$_4$ mixing ratios have increased. These species showed a typical seasonal pattern observed in the study region, with higher concentrations in winter and spring than in summer and fall. Especially, the monthly averaged PM$_{2.5}$ concentration was the highest in March, which was, decreased significant in 2020. It reflects the effects of reduced mobility due to lockdown in China. In contrast, H$_2$O was slightly increased in recent years, which is thought to be related decreased PM$_{2.5}$ concentrations through the scavenging of BC and PM$_{2.5}$. Accordingly, the increased in CH$_4$ and CO$_2$ mixing ratios are likely to reflect climate variability.

The long-term variability in climate pollutants observed at S-ORS highlight the reduced emissions of SLCPs in the study region and emphasize the importance of baseline measurements in a regional background site for a long period.
yes
Interactive ammonia emissions from feed and food production within the IPSL coupled model: evaluation using satellite observations

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Author list (excluding presenting author)
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Abstract

Ammonia (NH₃) is a key species in the atmosphere, playing a crucial role in air quality and climate through the formation of sulfate and nitrate particles. About 85% of NH₃ global anthropogenic emissions are related to food and feed production. Even though the estimate of the emissions from livestock can reach 36 Tg N/yr, they are generally not represented explicitly in global land surface models. Most global chemistry transport models rely on bottom-up emission inventories subject to large uncertainties. Our objective consists of replacing these external emissions data with dynamical emissions computed by ORCHIDEE, a terrestrial ecosystem model including the carbon and the nitrogen cycles. This new version of the ORCHIDEE model includes a detailed integrated scheme for livestock management.

Ultimately, our work aims at developing an interactive representation of the nitrogen cycle in a coupled climate-chemistry-vegetation model in order to investigate the impact of NH₃ emissions from livestock on atmospheric chemistry and climate, and the associated feedbacks.

In this study, we describe and present global NH₃ emissions from livestock calculated with our new ORCHIDEE version.

Then, using the global atmospheric chemistry transport model LMDZ-OR-INCA, we investigate the impact of these new simulated NH₃ emissions on atmospheric chemistry, either when considered as a monthly emission forcing (“offline mode”) or calculated and transmitted interactively within the model (“online mode”).

The resulting simulated NH₃ atmospheric columns are evaluated by global and regional comparisons with the spaceborne IASI instrument measurements. The products used are monthly gridded NH₃ distributions using observations of IASI-(Metop)A and (Metop)B for the 2011-2017 period. In addition, we compare our results with ammonia atmospheric columns simulated based on reference bottom-up emission inventories (CEDS). Finally, we investigate the impact of NH₃ emissions on key atmospheric species concentrations in the scope of different scenarios.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities
GEIA: Global Emissions Initiative, CCMi: Chemistry Climate Model Initiative
Impacts of improved sea-spray and biogenic aerosol representation on simulated aerosol, cloud and radiation biases over the Southern Ocean.

Ms Imogen Wadlow
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Author list (excluding presenting author)
A/Prof Robyn Schofield (1)
Dr. Matt Woodhouse (2)

Abstract

Global Climate Models (GCMs) poorly represent clouds and aerosols over the Southern Ocean (SO), leading to systematic shortwave radiation biases. In this work, we identify how key aerosol metric (e.g: Aerosol Optical Depth (AOD) and Cloud Condensation Nuclei (CCN)) biases could be reduced by improving the representation of sea-salt and biogenics which dominate SO aerosol populations.

Using the atmosphere-only version of Australian Community and Earth-System Simulator Coupled Model (ACCESS-CM2), we ran hourly-resolution simulations from 2016-2018. ACCESS-CM2 employs the Gong (2003) sea-salt parameterisation that has been widely regarded by the SO modelling community as problematic; it has been shown to overestimate sea-spray aerosol (SSA) production (Revell, et.al. 2019). ACCESS-CM2 lacks an important component of SO aerosol populations through an absence of Primary Marine Organic Aerosol (PMOA) representation. We implement an empirically-derived modification of the SSA source function (Hartery, et.al. 2020), and introduce PMOA as an organic-mass-fraction of the SSA scheme.

Aerosol, cloud, and radiation parameters were found to be sensitive to modifications in the SSA and PMOA schemes. Resulting changes to aerosol size distributions saw contrasting changes in bias for each scheme. The SSA scheme substantially improved the AOD bias but worsened the CCN bias, whereas the PMOA scheme worsened the AOD bias but improved the CCN bias with a high spatial dependency on the [chl-a]-based parameterisation. This research highlighted the limitations of tuning with the introduction of Southern Hemisphere observationally-based parameterisations, and the need for further improvements in representing these key physical/chemical aerosol processes in GCMs.

Early Career Scientist
YES, I am an early career scientist.

IGAC Activities
CATCH: the Cryosphere and Atmospheric Chemistry

IGAC Regional Working Groups
Southern Hemisphere Working Group
Land use change and meteorology effect on atmospheric ammonia (NH$_3$) as seen by IASI

Rimal Abeed
LATMOS/IPSL, Sorbonne Université, UVSQ, CNRS, France

Author list (excluding presenting author)
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Abstract

Agriculture contributes to air pollution and is affected by meteorology and climate change. One of the gases emitted from agricultural practices is ammonia (NH$_3$). Ammonia emissions contribute to the formation of fine particulate matter (PM$_{2.5}$), causing deleterious effects on air quality. Many studies proved the capability of the Infrared Atmospheric Sounding Interferometer (IASI) instrument aboard the Metop satellites in measuring ammonia from space. The series of instruments provide a continuous view of the global atmosphere since end of 2007, allowing us to study NH$_3$ and many other pollutants relevant to air quality. In this presentation, we explore the interaction between atmospheric ammonia on the one hand, and land and meteorological conditions on the other hand.

First, we look at the spatio-temporal variability of ammonia, focusing on different regions around the globe. We show that the NH$_3$ variability is mainly driven by agricultural practices and affected by meteorology, and interestingly, we can detect the fertilizers application period by looking at the NH$_3$ – temperature relationship. We study this relationship in two test regions: an agricultural region in Syria that was subject to land use change during the war, and agricultural regions in which the political situation is stable. In Syria we show that the detected changes in NH$_3$ concentrations are driven by land use change rather than meteorology.

Then, the emission potential of NH$_3$ from the soil is investigated. The computation of NH$_3$ soil emission potential depends mainly on (i) soil temperature, (ii) NH$_3$ concentration in the atmosphere, (iii) the rate of exchange between the soil and the atmosphere, and (iv) the lifetime of NH$_3$. IASI NH$_3$ total columns and ERA5 temperatures are used to estimate the NH$_3$ emission potential from the soil. The results are used to validate the emission potential of NH$_3$ as derived from the chemistry transport model Geos-Chem.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon, CCMi: Chemistry Climate Model Initiative
Modified stacked hourglass network is used to capture the height of convective boundary layer (CBLH) from radial wind speed and aerosol backscatter measured by a Doppler wind lidar. We collected a year’s lidar data and generated over 30,000 maps for training. The results show that the dataset of 4 directional wind speeds and aerosol backscatters (without vertical component), the Mean Absolute Error (MAE) of the CBLH estimated by the proposed deep learning methods is about 60 m. If only aerosol backscatter is used to train the model, the MAE of CBLH are about 91 m and 86 m for day-time and night-time measurements, respectively. The minimum required data size for the training is examined. This work shows the advantage of proposed deep learning method in better estimation of CBLH. Our results also indicate that it is possible to derive CBLH from backscatter profiles measured by Mie lidars.

**Early Career Scientist**

NO, I am not an early career scientist.

**IGAC Activities**

ACAM: Atmospheric Chemistry and the Asian Monsoon, TOAR: Tropospheric Ozone Assessment Report
Session 2 Poster

Formation of HONO and its implication for nitrogen oxides chemistry in Urban Seoul

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Author list (excluding presenting author)
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Abstract

There are increasing number of studies reporting the considerable level of HONO and its involvement in \( \text{O}_3 \) and secondary aerosol formation in high \( \text{NO}_x \) conditions. Once produced, HONO serves as an additional source of \( \text{OH} \) radical, initiating the photochemical cycle in early morning. However, its formation mechanism is still in debate. We have measured HONO in urban Seoul using several different methods such as MARGA (Monitor for AeRosol and Gases in Ambient air) and QC-TILDAS (Quantum Cascade – Tunable Infrared Laser Differential Absorption Spectrometer) during May ~ June from 2016 to 2021 and October ~ November in 2021. HONO started to increase after sunset, reached the maximum of 1~3 ppbv at midnight, and remained the considerable level till sunrise. During the entire experiment period, the highest concentration of HONO was 8.9 ppbv and observed with the high \( \text{NO}_2 \) of 70 ppbv in the end of November 2021. The HONO level was lowest during July ~ August when \( \text{NO}_x \) was at the minimum. There was no significant correlation between HONO mixing ratios and measured boundary layer heights. Instead, HONO concentration was found to be closely related with the distribution of condensation (200~300 nm) and droplet mode (600~700 nm) particles. These observations demonstrate that HONO was formed through heterogeneous conversion of \( \text{NO}_x \) on the aerosol surface. It was supported by calculation using artificial neural network model. It was also found that HONO and particulate nitrate were reasonably correlated at night when \( \text{PM}_{2.5} \) mass increased moderately under condition between haze and mist (visibility 1 ~ 10 km & RH ~ 75 %), implying that the production of HONO is coupled with \( \text{HNO}_3 \) formation, possibly increasing nitrate concentration on particulate phase on a local scale.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report
Session 2 Poster

National scale inversion of NOx emissions in France constrained by TROPOMI NO2 tropospheric columns

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Abstract

Since 2018, TROPOMI onboard Sentinel-5P brings images of NO2 tropospheric columns at an unprecedented high spatial resolution. We attempt at exploiting the potential of this high resolution information to estimate NOx emissions at national to regional scales based on atmospheric inversion approaches. The study focuses on France and on the period 2019-2020.

Our analysis is based on the variational mode of the recently developed Community Inversion Framework (CIF), coupled with Europe and France's configurations of the CHIMERE regional chemistry transport model (CTM) and its adjoint code. Both CHIMERE and its adjoint code include the MELCHIOR-2 chemical scheme with more than 100 reactions (24 for inorganic chemistry). This variational framework allows to solve high dimensional inversion problems and thus investigate fine-scale patterns in the concentration and emission fields. It also allows to properly account for the non-linearities associated with the chemistry.

We present the results from standard inversions of the NOx emissions at 50 to 10 km and 1-day resolution. Further analysis of the comparisons between the 50 to 10 km resolution CHIMERE simulations, the TROPOMI NO2 observations and the coarser resolution OMI NO2 QA4ECV retrievals are used to infer the contribution from the high resolution information and the ability to exploit it. In particular, the analysis reveals the need for novel inversion approaches to overcome the misfits between the patterns in the modeled and observed NO2 images due to the chemistry-transport model errors.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

AMIGO: Analysis of eMIssions using Observations

COVID-19 related abstracts

yes
Session 2 Poster

Investigating the impact of atmospheric biomass burning aerosols of the 2019 and 2020 burning seasons on the Metropolitan Area of São Paulo, Brazil with the EURAD-IM model on high-resolution and local measurements

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Abstract

Vegetation fires and droughts in the Pantanal wetlands and Amazon Forest associated with climate change and deforestation expose not only local communities but also remote regions such as the Metropolitan Area of São Paulo (MASP) to hazardous air quality. We present a high-resolution air quality study over São Paulo, Brazil, using the EUROpean Air Pollution Dispersion — Inverse Model (EURAD-IM) simulating aerosols. Biomass burning emissions estimated with the Global Fire Assimilation System (GFASv1.2) from Copernicus Atmosphere Monitoring Service (CAMS) are used in the model for case studies during August/September 2019 and September 2020. We investigate mega-fire events with distinct meteorological conditions and pollution patterns showing transport to the MASP from (i) Bolivia and central-western South America associated to unprecedented fires in Pantanal in addition to the standard burning in the central continent, (ii) rural regions of the state of São Paulo. Differing transport patterns that agree well with those observed by satellite-derived Aerosol Optical Depth, -fire spots and burnt areas, Lidar measurements in São Paulo, as well as with in-situ observations allow a detailed insight into air pollution pathways and the complex interactions between local and long-range transported pollution. EURAD-IM simulations show PM10 and PM2.5 plumes with concentrations over more than 100 µg/m³ and CO concentration higher than 1,000 ppbv, built up and transported on August 17-19th over MASP contributing to increased pollution at ground level. EURAD-IM simulated well the behavior of observed PM2.5, PM10 and CO concentrations at the surface, with Pearson's correlation coefficients of, rPM2.5 > 0.5, rPM10 > 0.4 and rCO > 0.5, respectively, also reproducing an expected day-to-day variability. These events further elucidate the role of long-range pollution transport on deterioration of air quality in MASP, generating Black-rain phenomena, and impacting human health.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

Southern Hemisphere Working Group
Evaluation of different Aerosol Optical Depth products over the Northeastern region of Brazil based on land use characteristics

MSc Gabriel Bonow Munchow
Federal University of Rio Grande do Sul, Brazil. Federal University of Rio Grande do Norte, Brazil

Author list (excluding presenting author)

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Ediclê Duarte (2)
Daniel C. F. dos S. Oliveira (3)
Nilton É. Do Rosário (4)
Judith J. Hoelzemann (5)

Abstract

The atmosphere over the Northeastern region of Brazil (NEB) contains a variety of aerosol types: marine, soil, biomass burning and urban aerosols and mixed species. However, few reliable information is available for the region. Satellite data provide spatial and temporal coverage in places without observational networks, with Aerosol Optical Depth (AOD) as most important measure of the atmospheric aerosol load. To investigate how AOD products from satellites behave over the NEB region we compared AOD from MODIS TERRA/AQUA satellites retrievals, and ground-based AOD from the Aerosol Robotic Network (AERONET) site at Petrolina-PE from January 2015 to October 2018. We based our initial analysis on the following products: Dark Target (DT), Deep Blue (DB), the combined product (DB_DT), MAIAC and the 3 km resolution product (MxD3k), all based on MODIS retrievals. The AERONET AOD was averaged using an interval of 1h, centered at the time of the satellite overpass. MODIS AOD data was spatially averaged in a sample window of 30x30 km, centered over the AERONET site (9.069S, 40.320W). Additionally, we used AOD from MERRA-2 reanalysis for an additional comparison that may provide insight on which products perform best over the region. We used a Taylor Diagram to gain an overview on all relevant parameters at a glance and the percentage of the data falling within the expected error (EE) of a ±(0.05+0.15τ) envelope. The results show that DB from Terra and Aqua yield the best results, with correlations of 0.74 and 0.56, a RMSE of 0.03 and 0.04 and a percentage of the data sample falling within EE of 94.4% and 90.9%, respectively. MAIAC and the MxD3k products yield a much lower performance with correlations of 0.44 and 0.36. A further investigation analyzing the behavior of these products over time and their relation with land use will be presented.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

CCMi: Chemistry Climate Model Initiative, GEIA: Global Emissions Initiative, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality
IGAC Regional Working Groups

Americas Working Group, Southern Hemisphere Working Group
Session 2 Poster

Machine Learning Modelling for Studying the Impact of the COVID-19 Lockdown on Air Pollution Levels in Air Quality Measurement Sites in Manchester, UK and Its Characteristics: Analysis of Meteorological Factors, Traffic Factors, and Historical Data

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Author list (excluding presenting author)

Hugh Coe (1)

Abstract

Since the outbreak of the COVID-19 pandemic in 2020, the UK experienced strict restrictions on anthropogenic activities and traffic behaviors, which led to significant reduction in air pollution levels. The impacts of lockdown on air pollution have been quantified in numerous previous studies using various data processing techniques or models, whereas these changes are masked by multiple factors apart from effects of lockdown. For obtaining accurate and long-term effects of lockdown on NO, NO2, O3, and PMs in Manchester air quality sites (Firs, Piccadilly Garden, and Sharston) in 2020 through machine learning modelling, this study analyses individual meteorological and traffic factors and compares historical data and events (e.g. changes in policy and law regarding traffic and vehicles).

The study period in 2020 was from 04/02/2020 to 27/06/2020 and split to pre-, during-, and post-lockdown, then expanding study period from 2016 to mid-2022 and data were collected from site measurement. By building meteorological-normalization models and gradient-boosting-regression models, the de-weather data, business-as-usual data and the independent-influenced data of meteorological, temporal, and traffic factors were developed, and their relative influences can be analyzed, respectively. Historical data was used to compare the similarity and uniqueness of the lockdown with previous events that affected changes in air pollution levels, data after lockdown allowed to analyze and forecast long-term impacts on air pollution.

This study illustrated the significant impact that lockdown brought to the air pollution in Manchester in 2020, with long-term effects until mid-2022. Meteorology played an important role in changes in air pollution by dominating the changes of PMs and concentrations of NOx were highly related to changes in emissions. Unlike historical events that permanently changed the air pollution level, the impact of lockdown decreased over time and air pollution "recovered" to normal by the analyses of machine learning modelling.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups
China Working Group

COVID-19 related abstracts

yes
Session 2 Poster

Multi-sensor estimates of global and regional Ozone generated with the Tropospheric Ozone and its Precursors from Earth System Sounding (TROPESS) framework

Dr Edward Malina
NASA/JPL/Caltech, USA

Author list (excluding presenting author)

Vijay Natraj (1), James McDuffie (1), Matthew Thill (1), Le Kuai (1), Thomas P. Kurosu (1), Kevin W. Bowman (1), Gregory Osterman (1), Kazuyuki Miyazaki (1)

Abstract

The distribution of ozone in the atmosphere plays a vital role in climate change, air pollution, and human health. Remote sensing of ozone is typically performed in the Ultra-Violet (UV) or Thermal Infrared (TIR). UV is most sensitive to the stratosphere, while TIR measurements have maximum sensitivity in the troposphere. The current and future generations of Earth Observation (EO) satellites enable observations from the UV to the TIR satellite sensors. This availability of ozone sensitive instrument measurements offers an opportunity to improve knowledge of the vertical distribution of ozone in the atmosphere.

Optimal utilization of these measurements requires a framework for simultaneous retrievals. We describe the MUltiSpEctra, MUlti-SpEcies, MUlti-SEnsors (MUSES) retrieval algorithm being developed for the TRopospheric Ozone and its Precursors from Earth System Sounding (TROPESS) framework. This algorithm has a flexible and generic Radiative Transfer model that covers the entire wavelength range from the UV to the TIR and a nonlinear optimal estimation retrieval algorithm.

Using MUSES/TROPESS, we show examples of multi-sensor retrievals of ozone from Suomi NPP CrIS and Sentinel 5P (SSP)/TROPOMI. The CrIS retrieval operates in a series of micro-windows in the 950-1317.50 cm⁻¹ range, while the TROPOMI retrieval uses the window 325-335 nm. Suomi NPP orbits in formation with SSP, meaning both satellites view the same scene within minutes of each other allowing for co-location and therefore joint retrievals. The joint retrieval of CrIS and TROPOMI provides additional information content over and above that of each instrument individually.

We provide statistics characterising the retrievals from each instrument independently, as well as the joint retrievals over a range of global conditions, and make comparisons with independent measurements including MUSES-produced OMI and ozonesondes. We evaluate differences with other satellites using the JPL MOMO-Chem chemical data assimilation system.

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Early Career Scientist

NO, I am not an early career scientist.
IGAC Activities

TOAR: Tropospheric Ozone Assessment Report

IGAC Regional Working Groups

Americas Working Group
Session 2 Poster

First vertical profile measurements of NO₂, formaldehyde and aerosols over Central London

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Author list (excluding presenting author)

Eloise A. Marais (1); Jan-Peter Muller (2); Neil Humpage (3); Hartmut Boesch (3,4); Robbie Ramsay (5); Jan-Lukas Tirpitz (6); Udo Friess (7)

Abstract

The passive solar multi-axis differential optical absorption spectroscopy (MAX-DOAS) technique provides a robust method for retrieving lower-tropospheric vertical trace gas and aerosol profiles; crucial for improving model and satellite air quality estimates. Air quality has been extensively studied in London using models, surface in-situ and satellite observations, but validation of satellite-derived tropospheric columns and long-term monitoring of vertical pollutant gradients is lacking. Here we address this gap by deploying a long-term MAX-DOAS instrument installed on the rooftop of an 11-story building on the University College London (UCL) campus in Central London. Retrieval of vertical profiles and tropospheric columns of nitrogen dioxide (NO₂), nitrous acid (HONO), formaldehyde (HCHO) and aerosol extinction have been carried out using a near-realtime retrieval algorithm. These parameters are key to understanding nitrogen oxides (NOx), volatile organic compounds (VOCs) and particulate matter pollution. We demonstrate consistency of the measurements by intercomparison with a neighbouring MAX-DOAS on short-term deployment at UCL, and reliability of the technique by comparison to three nearby surface air quality monitoring sites. We also conduct the first assessment of tropospheric NO₂ and HCHO columns from the TROPOMI satellite instrument in the UK and demonstrate near-realtime detection of smoke plume evolution associated with fires during the record-breaking July 2022 heatwave. These results will provide useful vertically resolved information to constrain NOx and VOC sources and chemistry in London.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality, CCMi: Chemistry Climate Model Initiative

IGAC Regional Working Groups
Session 3 Invited

Air quality and perspectives learned during the COVID-19.

Prof Maria de Fatima Andrade
University of Sao Paulo, Brazil

Abstract

During the last years it has been observed an improvement in air quality in many high-income countries of the world. But still the levels are above the air quality guidelines recommended by WHO. How restricted levels of air contaminants can be achieved with actual local regulations for controlling the emissions and energy production? This question involves many different aspects, from political desire to scientific knowledge, and at the end the integration between them.

The diagnosis of the actual conditions a region faces in terms of the concentration of regulated pollutants is the first step, but the costs of air quality networks has made the community use and develop low-cost sensors. The second important aspect is the knowledge of the emissions sources, this information is essential when there is the desire to reduce the concentrations in ambient air. What has been observed is the difficult in controlling secondary pollutants, such as ozone and fine particles. The fine particles have in the composition organic and inorganic secondary compounds. For the inorganic fraction, it has been discussed the role of the NH3, which had been neglected as an important precursor of aerosol. During the lockdowns due to the pandemic improvements were achieved in many countries, including in South America, however Ozone and Fine Particles have not shown a consistent behavior in different cities. The lockdown was a great opportunity for the study of atmospheric chemistry and verification of the Chemical Transport Models representation of the process in different places. Although many learnings were achieved with the pandemic, the need for economic recovery of the countries are putting in the second plane the importance of reducing emissions, which bring uncertainties related to the implementation of the SDG in the desirable pace.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Regional Working Groups

Americas Working Group

COVID-19 related abstracts

yes
Session 3 Invited

Aerosols and air quality over South Asia from Long term observations and Modelling

Dr SURESH BABU S
SPACE PHYSICS LABORATORY, VIKRAM SARABHAI SPACE CENTRE, ISRO, THIRUVANANTHAPURAM, India

Abstract

South Asia is considered as one of the major hot spots of aerosols and is a topic of scientific interest due to its impact on regional climate and air quality. There have been several focussed scientific programs in the recent past to address this important scientific issue which includes the long-term observations on aerosols from a network of aerosol observatories (ARFINET, SKYNET and AERONET), dedicated field experiments (ICARB, RAWEX and SWAAMI) employing aircrafts, research ships and high-altitude balloons besides extensive utilizations of satellite observations. It is found that, though the columnar content of aerosols over South Asia is increasing, the near surface concentration of anthropogenic aerosol species such as black carbon (BC) is decreasing pointing towards a vertical heterogeneity in the long-term trends in aerosols over this region. Vertically resolved observations of aerosols over the region using aircrafts, balloons and LIDARS (both ground based and spaceborne) showed the presence of enhanced loading of aerosols at elevated altitudes, especially during spring season. While the elevated layers of aerosols mainly composed of sulphates and transported mineral dust, the aerosols within the boundary layer is mainly consist of carbonaceous aerosols. The details of the observations and the possible implications will be presented.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Session 3 Oral

Impact of indigenous fire management on the annual cycle of carbon monoxide over Northern Australia

Miss Shyno Susan John
University of Wollongong, Australia

Author list (excluding presenting author)

Nicholas Deutscher (1); Clare Paton-Walsh(1); David Griffith (1)

Abstract

The 2019-20 bushfires in south-eastern Australia were unprecedented in their extent and intensity. Human activities can regulate fire behaviour effectively through good fire management practices. In Northern Australia, indigenous fire managers use prescribed burns during the early dry season to prevent large late dry season fires, which shifts the overall temporal distribution of fire activity earlier during the primary biomass burning season. This increasing trend of prescribed burns has helped to significantly reduce the size and extent of the intense late dry season fires, indicating that such fire management practices can be effective at managing wildfires in savannas.

This study examines whether the earlier fire season in Northern Australia impacts seasonal variability of carbon monoxide (CO) measured at Darwin. Column CO data from the ground-based Total Carbon Column Observing Network site in Darwin is used together with surface measurements and observations from the satellite-based sensor MOPITT.

Observed trends from TCCON and MOPITT column data over Darwin indicate that CO increases during the early dry season and decreases in the late dry season, which could be attributed to the prevalence of prescribed burning practices. In addition, the observed CO trends shown by different global biomass burning inventories match with those of the TCCON and MOPITT column CO. The shift to earlier burning results in fires that burn at cooler temperatures, reducing the amount of biomass burned (or CO$_2$ emitted), but increasing the proportion of fire emissions from incomplete combustion. We see a seasonal pattern in CH$_4$ : CO emissions from the fires, indicating that reductions in CO$_2$ might be offset by increased emissions of CH$_4$. The GEOS-Chem CO tagged tracer modelling capability will be used in order to disentangle the CO emitted from the study region from that measured from remote emissions coupled with long-range transport.

Early Career Scientist

YES, I am an early career scientist.
Session 3 Oral

Declining anthropogenic emissions and improving air quality over China

Ziqiong Wang
University of Edinburgh, United Kingdom

Author list (excluding presenting author)

David S. Stevenson (1); Mathew R. Heal (2); Yao Ge (2)(3); and Massimo Vieno (3)

Abstract

In China, emissions estimates and measured concentrations of atmospheric pollutants, including SO$_2$, NO$_2$, PM$_{2.5}$ and CO, have generally declined from 2015 to 2020. Simulated pollutant concentrations from a weather model (WRF) coupled to a chemistry-transport model (EMEP MSC-W), driven by emissions, are compared with air quality data from over 1000 measurements sites. This allows quantification of the influence of emissions and weather on concentration changes, and evaluation of the model performance. Moreover, the strict COVID-19 lockdown period at the beginning of 2020 is another focus for understanding and quantifying the relationship between changes of emissions and concentrations over China.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities


IGAC Regional Working Groups

China Working Group

COVID-19 related abstracts

yes
Session 3 Oral

Simulating the impacts of present-day and future agricultural emissions on air pollution

Dr Ailish Graham
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Author list (excluding presenting author)

Martyn Chipperfield (1); Lisa Emberson (2); Connie O’Neill (3); Sam Bland (4); Chris Malley (5); Eleanor Jew (6); Kevin Hicks (7); Martin Wooster (8); Zixia Liu (9); Catherine Oliver (10); Pritha Panda (11); Nathan Booth (12)

Abstract

Globally, agriculture is a key source of both CO2 and non-CO2 greenhouse gas (GHG) emissions. In China 41% of total GHG emissions (~3.5% of global GHG emissions) and 50% of non-CO2 GHG emissions are from agriculture. The large contribution of agriculture to overall emissions in China stems from the introduction of the 1987 Reform and Opening policy. The policy encouraged farm labourers to move to cities for better paid jobs. As a result agriculture became more reliant on fertiliser and machinery use, increasing agricultural emissions. Production and consumption, which are closely linked to emissions, are predicted to continue to increase according to the 10-year outlook. However, China has pledged to reach peak emissions by 2030.

We simulate the impact of recent-past and future agricultural emissions on air pollutant concentrations using the WRF-Chem model. The Stockholm Environment Institute demand based agricultural emissions model, driven by 10 year outlook data, is used to provide Chinese agricultural emissions for 2017 and 2030. Three future scenarios are explored for 2030: 1) baseline, 2) baseline + on-farm measures 3) baseline + on-farm + demand side measures. We quantify the contribution of China’s current targets to 2030 air pollutant concentrations under the outlook projections (baseline). We also explore the additional pollutant reductions that could be achieved from on-farm (animal feed composition, rice water regimes, agricultural burning, proportion of synthetic fertiliser application etc.) and demand-based (population diet, food waste etc.) emissions reductions. Stakeholder engagement and a digital survey are used to inform on-farm emission reduction options and possible barriers to adoption.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

China Working Group
Global Premature Mortality by Dust and Pollution PM2.5 Estimated from the MERRA-2 Aerosol Reanalysis

Dr. Hongbin Yu
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Author list (excluding presenting author)
Alexander Yang (1, 2); Qian Tan (3, 4); Chamara Rajapakshe (1,5), Mian Chin (1)

Abstract

This study quantifies global premature deaths attributable to long-term exposure of ambient PM2.5, or PM2.5-attributable mortality, by dust and pollution sources. We used NASA’s Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2) aerosol reanalysis product for PM2.5 and the cause-specific relative risk (RR) from the integrated exposure-response (IER) model to estimate global PM2.5-attributable mortality for five causes of deaths. The estimated yearly global PM2.5-attributable mortality in 2019 amounts to 2.89 (1.38 ~ 4.48) millions (the numbers in parentheses represent the estimated mortality range due corresponding to RR spread at the 95% confidence interval). The mortality counts vary with geopolitical regions substantially, with the highest number of deaths occurring in Asia. In particular, China and India account for 40% and 23% of the global PM2.5-attributable deaths, respectively. In terms of sources of PM2.5, about 22% of the global all-cause PM2.5-attributable deaths are caused by desert dust. The relative contributions of dust and pollution sources vary with the causes of deaths and geographical regions. Enforcing air pollution regulations to transfer areas from PM2.5 nonattainment to PM2.5 attainment can have great health benefits. Being attainable with the U.S. air quality standard (AQS) of 15 μg/m3 globally would have avoided nearly 40% or 1.2 million of premature deaths. The most recent update of PM2.5 guideline from 10 to 5 μg/m3 by the World Health Organization (WHO) would potentially save additional one million lives. Our study highlights the importance of distinguishing aerodynamic size from geometric size in accurately assessing the global health burden of PM2.5 and in particular dust. A use of geometric size in diagnosing dust PM2.5 from the model simulation overestimates the PM2.5 level in the dust belt by 40-170%, leading to an overestimate of global all-cause mortality by 32%.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities


IGAC Regional Working Groups

Americas Working Group
Spatial and temporal variation of aerosol optical depths and aerosol climatology characterization over Bangladesh using ground-based and remotely sensed satellite measurements

Mr Shahid Uz Zaman  
University of Dhaka, Bangladesh, Bangladesh

Author list (excluding presenting author)  
Md Riad Sarkar Pavel, Farah Jeba, Md. Safiqul Islam, and Abdus Salam

Abstract

Atmospheric aerosols affect human health, alter cloud optical properties, influence the climate and radiative balance and contribute to the cooling/warming of the atmosphere. Aerosol Optical Depth (AOD) is a crucial parameter for assessing aerosol content and determining the level of air pollution. In this study, we represent almost seven years’ aerosol optical behavioral patterns of six major cities in Bangladesh with emphasis on trends, seasonal variations, sources characterization, comparison between ground (AERONET) and satellite (MODIS Terra and Aqua) measurements, and relation with particulate matter (PM). In addition, aerosol climatology based on AERONET over Bangladesh was conducted for eight years (2012–2019), focusing on two characterization schemes. Four aerosol parameters, such as extinction Angstrom exponent (EAE), absorption AE (AAE), single scattering albedo (SSA), and real refractive index (RRI), were exclusively discussed to determine the types of aerosol. The light absorption properties of aerosol were inspected tagging the association between size parameters similar to fine mode fraction (FMF), AE, and absorption parameters (SSA and AAE). High AOD values (>0.70) were obtained in most of the western parts of the country in all seasons. Decreasing patterns were observed from northwest to southeast. Both PM2.5 and PM10 were well correlated with all AODs but weakly correlated with AE. AODs, AE, and PM were negatively associated with meteorological variables such as rainfall, relative humidity, wind speed, and temperature. Two types of aerosols were potentially identified, e.g., biomass-burning and urban/industrial types over Bangladesh with insignificant contribution from the dust aerosol. Black carbon (BC) was the prominent absorbing aerosol (45.9%–89.1%) in all seasons with negligible contributions from mixed BC and/or dust and dust alone. The results of aerosol parameters will have substantial impacts on the aerosol radiative forcing, climate modeling as well as air quality management in Southeast Asia’s heavily polluted region.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Urban biogenic VOC emissions and air quality

Alex Guenther
UC Irvine, USA

Author list (excluding presenting author)
Hui Wang (1), Jesus Campos (1), Saewung Kim (1), and Louisa Emmons (2)

Abstract

Biogenic volatile organic compound (BVOC) studies have primarily focused on emissions from rural areas and investigated impacts on regional to global scales. The widespread reductions in urban anthropogenic VOC emissions in recent decades have increased the relative contribution of BVOC emissions to the total VOC emissions within many urban areas. Estimating BVOC emissions in urban landscapes is more challenging than other areas due to the spatial heterogeneity, rapid changes, and the lack of urban observations. We present an approach for quantifying BVOC emissions from urban landscapes using the Model of Emission of Gases and Aerosols from Nature (MEGAN version 3.2). The approach utilizes ultra high-resolution imagery and virtual surveys to characterize tree cover fraction and species composition and a multi-modal emission survey technique. In addition, air quality impacts and implications for air pollution mitigation strategies are investigated by coupling MEGAN with the MUSICA model at high spatial resolution suitable for urban landscapes. Urban BVOC responses to climate and landcover change and potential for emission mitigation activities will be discussed and remaining gaps and priorities for future progress identified.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

GEIA: Global Emissions Initiative
Session 3 Oral

Agricultural emissions of ammonia most effective lever for UK to meet the World Health Organization guideline for fine particles

Dr Eloise A Marais
University College London, United Kingdom

Author list (excluding presenting author)

Jamie M Kelly (1), Karn Vohra (1), Zbigniew Klimont (2), Jordan White (3), Roland Leigh (3)

Abstract

Air pollution mitigation measures in the UK have historically targeted large point sources dominated by sulfur dioxide (SO$_2$) emissions forming sulfate aerosol. More recently, the focus is on vehicles that emit nitrogen oxides (NO$_x$) forming nitrate aerosol. Due to limited regulation targeting agriculture, ammonia (NH$_3$) emissions forming ammonium aerosol is the largest contributor to fine particulate matter pollution (PM$_{2.5}$) in UK rural and urban environments. Here we use the GEOS-Chem chemical transport model, nested over the UK at 25-31 km resolution, to assess the efficacy of legislation and technically achievable measures to address air pollution. We implement in GEOS-Chem predicted 2030 air pollutant precursor emissions from the GAINS model under current legislation and if technically feasible measures are adopted. This follows validation of the ability of GEOS-Chem to reproduce reference monitor and low-cost sensor measurements of the current spatial distribution of total PM$_{2.5}$, individual components of PM$_{2.5}$, and the relative contribution of local and non-local sources to PM$_{2.5}$ in UK cities. 75% of the UK exceeds the recently updated WHO guideline for PM$_{2.5}$ of 5 ug/m$^3$. Under currently legislated measures, still mostly targeting SO$_2$ and NO$_x$ sources, the decline in PM$_{2.5}$ is marginal (<1 ug/m$^3$). If all technically feasible measures are adopted, NH$_3$ emissions would decrease by 20% leading to decline in PM$_{2.5}$ to 5 ug/m$^3$ in almost all months of the year. There is also a shift in PM$_{2.5}$ seasonality from peak concentrations in cold-season months when pollution transported from Europe mixes with persistent UK NH$_3$ emissions to summer when agricultural activity and warm temperatures promote NH$_3$ emissions. Ongoing work is to use GEOS-Chem to quantify the potential benefits to health from avoided premature deaths and to ecosystems from decline in nitrogen deposition to motivate adoption of more ambitious measures to address air pollution.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

ANGA: African Group on Atmospheric Sciences
Refractive index of black carbon (BC) and brown carbon (BrC) particles using aerodynamic aerosol classification

Dr James D Allan
University of Manchester, United Kingdom. National Centre for Atmospheric Science, United Kingdom

Abstract

The refractive indexes (RI) of black carbon (BC) and brown carbon (BrC) are important in determining their radiative forcing in the atmosphere. Previous studies have used differential mobility analyzers (DMAs) to select mono-disperse BC/BrC particles to derive their RI, but these suffer from issues caused by multiple charging. Here we couple the Aerodynamic Aerosol Classifier (AAC) with the EXSCALABAR (Extinction, Scattering and Absorption of Light for Airborne Aerosol Research) system, achieving optical extinction and absorption measurements of an aerosol classified according to a single physical size, which improves the subsequent RI derivation using a Mie model. The RI of pure BC from different sources such as wood burning, a light-duty automotive diesel engine and an inverted propane flame were derived in this study. Organic matter from wood burning and both absorbing and non-absorbing chamber-generated secondary organic aerosol (SOA) were also studied. The chamber was also used to coat BC particles to critically test different models of the optical properties of mixed particles for use in the HadGEM climate model. Models used included external mixing, core-shell, homogenous mixing and effective medium. This work will improve the prediction of the radiative forcing of BC and BrC in the atmosphere.

Early Career Scientist

NO, I am not an early career scientist.
Rapid rise in premature mortality in fast-growing tropical cities due to anthropogenic air pollution

Dr Karn Vohra
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Abstract

Tropical cities are experiencing rapid population growth but lack routine air pollution monitoring to develop prescient air quality policies. This has the potential to drastically increase exposure to air pollutants detrimental to health. Here we conduct targeted sampling of recent (2000s-2010s) observations of air pollutants from space-based instruments over 46 fast-growing tropical cities. We use satellite observations to estimate trends in nitrogen dioxide (NO$_2$), ammonia, volatile organic compounds (VOCs), fine particles (PM$_{2.5}$), and ozone formation dependence on precursor emissions. We quantify significant increases in NO$_2$ (1-14 % a$^{-1}$), ammonia (2-12 % a$^{-1}$) and reactive VOCs (1-11 % a$^{-1}$) in most cities, driven almost exclusively by emerging anthropogenic sources rather than traditional biomass burning. In tropical cities in Asia and Southern Africa increases in urban air pollutants are 2-3 times steeper than reported regional trends, and opposite in Northern Africa to the reported decline in regional air pollution attributed to recedence in biomass burning. Steep, significant increases in NO$_2$ also pose a challenge for mitigating already severe ozone pollution, as ozone formation in some cities should transition from strongly NO$_x$-sensitive to the difficult to regulate VOC-sensitive regime as early as 2025. We estimate increases in urban population exposure to air pollutants of 1-18 % a$^{-1}$ for PM$_{2.5}$ and 2-23 % a$^{-1}$ for NO$_2$ from 2005 to 2018 and attribute 180,000 (95 % confidence interval: -230,000 to 590,000) additional premature deaths in 2018 (62 % increase relative to 2005) to this increase in exposure. These cities are forecast to reach populations of up to 80 million people by 2100, so regulatory action targeting emerging anthropogenic sources is urgently needed.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities


IGAC Regional Working Groups

ANGA: African Group on Atmospheric Sciences, Americas Working Group, MANGO: Monsoon Asia and Oceania Networking Group, Southern Hemisphere Working Group
High resolution reactive nitrogen and ozone spatial distributions and emission factors in two southwestern U.S. cities

Dr. Kristen Zuraski
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Author list (excluding presenting author)
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Abstract

Nitrogen oxides (NO$_x$ = NO$_2$ + NO) and ozone (O$_3$) play crucial roles in the Earth’s atmospheric composition, oxidative capacity, regional air quality and climate and are inexorably linked through their complex photochemistry. Total reactive nitrogen (NO$_y$), which includes NO$_x$ and all its reservoirs and sinks, also provides important information on photochemical age, ozone production efficiency, and competition of important chemical processes. In urban environments, anthropogenic emissions of NO$_x$ primarily come from fossil fuel burning. Photolysis of NO$_2$ ultimately provides the dominate source of tropospheric O$_3$, which alongside NO$_2$, exacerbates air pollution though chemical reactions that lead to the formation of urban haze, secondary organic aerosols, nitric acid, and longer lived peroxyacylnitrate species (PANs). The negative impacts of O$_3$ and NO$_2$ on vegetation, human health, and climate have led to a worldwide science initiative to monitor these species through a combination of satellite measurements, flight campaigns, and ground-based and balloon-sonde networks.

We contributed to this initiative by taking high resolution on-road measurements of NO$_2$, NO, NO$_y$, and O$_3$ via cavity ringdown spectroscopy (CRDS) during the summer of 2021 as part of the SUNVEx campaign. These data were collected alongside speciated volatile organic compounds (VOCs) measured via proton transfer reaction chemical ionization spectrometry as well as CO, CO$_2$, and water vapor, measured via CRDS, in two southwestern U.S. cities, Las Vegas, NV, and Los Angeles, CA. Here, we use the enhancement ratios of NO$_x$ relative to CO and CO$_2$ to infer catalytic converter efficiencies and emissions relative to total fuel consumption. Spatial correlations between NO$_x$ and VOCs were also explored and linked to emission sources. These results are used to assess current emission inventories, ascertain correlations between urban air pollution and human demographic parameters, and determine trends in air pollution over time through comparisons with previous campaign mobile laboratory measurements.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities
Session 3 Oral

High Time Resolution Online Quantification of Oxidative Particle Properties Indicate Photochemical Processes as Dominant Sources for this Novel Particle Toxicity Proxy

Professor Markus Kalberer
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Author list (excluding presenting author)
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Abstract

Despite decades of compelling epidemiological evidence, large uncertainty remains regarding the toxicity mechanisms of inhaled particles, that lead to observed adverse health outcomes. Oxidative potential (OP), referring to the catalytic production of reactive oxygen species (ROS) by particle components with subsequent depletion of anti-oxidants on the lung surface, is widely suggested as a measure of potential PM toxicity. The accurate quantification of OP and ROS in the ambient atmosphere is challenging due to the short lifetime of these components. A reliable quantification is urgently needed to assess if ROS or OP are potentially better aerosol toxicity proxies than total particle mass, which is the conventional metric in air pollution legislation.

We developed in recent years the first online field instruments to quantify OP and ROS with an unprecedented high time resolution of about 5 min. The instruments utilise reactions systems of 2,7-dichlorofluorescin (DCFH) to quantify ROS and ascorbic acid to quantify OP, respectively. Besides the high time resolution, which allows to follow fast-changing concentrations of OP and ROS in the atmosphere, we established that OP and ROS, especially in organic aerosols, have a lifetime of only a few hours and that after a day 90% or more OP and ROS decayed in aerosol particles collected and stored on filters. Thus, for a meaningful quantification of OP and ROS, online instruments are essential.

The two instruments were deployed in a series of laboratory flow tube and chamber experiments as well as field campaigns in cities in Europe and China during winter and summer time. Ambient measurements clearly point to photochemical processes as a dominant source for ROS formation. In laboratory experiments the importance of photochemistry could be confirmed and we assessed synergistic effects of internally mixed metal-organic particles on ROS and OP.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality
Session 3 Oral

The ozone–climate penalty over South America and Africa by 2100

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Author list (excluding presenting author)

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Lina M. Mercado (3,12)
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Kostas Tsigaridis (4,5)
Hans Verbeeck (6)

Abstract

Climate change has the potential to increase surface ozone (O3) concentrations, known as the ‘ozone–climate penalty’, through changes to atmospheric chemistry, transport and dry deposition. In the tropics, the response of surface O3 to changing climate is relatively understudied, but has important consequences for air pollution, human and ecosystem health. In this study, we evaluate the change in surface O3 due to climate change over South America and Africa using 3 state-of-the-art Earth system models for the years 2090–2100. To quantify the changes
driven by climate change alone, we evaluate the difference between end of the century predictions for simulations which include climate change and simulations with the same emissions scenario but with a fixed present-day climate. We find that by 2100, models predict an ozone–climate penalty of 15 ppb (model range 12 to 18 ppb) in areas where O3 is already predicted to be high due to the impacts of precursor emissions, namely urban and biomass burning areas, although on average models predict a decrease in surface O3 due to climate change. The ozone–climate penalty in polluted areas is shown to be driven by an increased rate of O3 chemical production, which is strongly influenced by NOx concentrations and is therefore specific to the NOx emissions pathway chosen. However, models disagree on the role of climate change in remote, low-NOx regions, partly because of significant differences in NOx concentrations produced by each model. We conclude that if the climate were to change according to the emissions scenario used here, models predict that forested areas in biomass burning locations and urban populations will be at increasing risk of high O3 exposure.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report

IGAC Regional Working Groups

ANGA: African Group on Atmospheric Sciences, Southern Hemisphere Working Group
Session 3 Oral

Improving spatial disaggregation of vehicular emission

Bianca Meotti
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Author list (excluding presenting author)

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Abstract

Controlling vehicular emissions requires robust and spatiotemporal detailed emissions inventories. However, when existent in developing and low-income countries, emissions inventories are aggregated by municipalities and do not fulfill the input requirements of air quality models, which are essential tools to control air pollution. In this article, we present a method to improve the spatial disaggregation of vehicular emission from municipality aggregated inventories. We have used data from high-resolution bottom-up emission inventory as reference and data from the Brazilian Vehicular Emission Inventory Software - BRAVES to represent the aggregated emission inventories. Our method uses weighting factors to disaggregate the vehicular emissions, which account for the road type and vehicle type dominance over the pollutant emission. Comparing to the traditional road density approach, our method has reached better agreement with the reference high-resolution inventory. We have reduced the bias and increased the number of cells within the acceptability criteria (factor of two) in a domain of 1x1 km of resolution. These results would contribute to improve the disaggregation of national and regional emissions inventories, providing data to run air quality models and for air quality management systems.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality
COVID lockdown unveils the aerosol masking effect on global warming

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Author list (excluding presenting author)

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Abstract

Anthropogenic aerosols mask (scatter and absorb) a part of the solar radiation reaching the earth’s surface and cause a cooling effect on climate. Climate change mitigation policies targeting greenhouse gas emissions, also decrease co-emitted aerosols, which leads to warming, inadvertently countering the intended impact. However, it is challenging to constrain the strength of this demasking effect, given the little direct observational evidence available. The sudden reduction in emissions during the COVID-19 societal slow-down provided a unique opportunity to observationally quantify the effect of aerosol masking over South Asia. Here we used the surface aerosol measurements complemented with remote sensing observations and modeling analysis to delineate the impacts of aerosol demasking. The aerosol optical depth, averaged over the entire South Asian region, decreased by as much as ~20% during the COVID-19 shutdown period compared to the non-COVID-19 period of 2018 and 2019. This decrease in aerosol loadings was concomitant with an increase of ~7% (20 ± 12.6 Wm-2) in the clear sky surface-reaching incoming short-wave solar radiation observed over the Northern Indian Ocean. The aerosol surface forcing decreased by ~40% (14.1 ± 12 W m-2), subsequently leading to a drop in the atmospheric columnar heating rate by ~0.4 K d-1. The changes were more conspicuous over South Asia on a regional scale owing to the large spatial variability. Taken together we present empirical evidence of direct effects of climate warming demasking due to reduction of aerosol emissions, with implications for both understanding this climate process and for guiding climate change mitigation policy.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

GEIA: Global Emissions Initiative, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group

COVID-19 related abstracts

yes
Session 3 Oral

The influence of long-range smoke transport from the Pantanal 2020 megafires on air quality in the state of São Paulo.

Ediclê Duarte
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Author list (excluding presenting author)

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Abstract

In 2020, one-quarter of the Pantanal, Brazil, burned, during the most catastrophic fire season ever recorded. These unprecedented mega-fire events have several local effects on the ecosystem, population and economy. The impacts were also felt thousands of kilometres away: During the peak of the 2020 fire crisis in the Pantanal (P20F), smoke was observed in southeastern and south Brazil, where episodes of dark sky and black rain were reported by the media. Using different and independent datasets, we provide multiple lines of evidence for the potential influence of long-range smoke transport from the P20F on air quality in the state of São Paulo (SP). Results from in-situ PM2.5 measurements at several stations and visibility information from the main airports in SP state, jointly with satellite-derived data, a regional 3D atmospheric chemistry model (EURAD-IM) and a trajectory model (HYSPLIT) indicate that the fire emissions from the Pantanal during two separate episodes in September 2020, were transported to SP. The enhancement of PM2.5 daily concentrations in SP was up to 214% a few days after the fire peaks in the Pantanal, crossing the acceptable health thresholds for consecutive days. The event reduced the visibility by 60%, closing one airport for approximately 10 hours. Diurnal cycles of traffic-related pollutants do not present any anomalous peaks simultaneously with morning rush hours, allowing us to discard the association of main peaks of concentrations with local vehicular emissions during the analyzed period. These results highlight that the economic costs from the P20F may be underestimated because they do not yet take into account the potentially impact of air pollution on human health, not only within the Pantanal but also in remote locations.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

Americas Working Group, Southern Hemisphere Working Group
The mutual interactions among ozone, fine particulate matter, and carbon dioxide on summer monsoon climate in East Asia

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Author list (excluding presenting author)
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Abstract
O3 and PM2.5 are the main air pollutants, CO2 is the key greenhouse gas in East Asia. They are furthermore radiative active species. Most importantly, both O3 and PM2.5 can interact with CO2 through the terrestrial ecosystem, thus having effects on the regional climate. Here, the mutual interactions among O3, PM2.5, and CO2 on the East Asia summer monsoon climate were investigated using the coupling regional climate-chemistry-ecology model, RegCM-Chem-YIBs. Two numerical experiments were performed with and without considering the interactions among the three species in the summer monsoon period. The difference between the experiments shows, due to O3 and PM2.5 interactions with CO2, in northern China, surface PM2.5 was reduced by 2~6 μg/m3, O3 was increased by 4~6 μg/m3 and CO2 was enhanced by 3~5 ppm. In southern China, surface PM2.5 was enhanced by 2~4 μg/m3, O3 was increased by 1~2 μg/m3 and CO2 was reduced by 2~4 ppm. Surface downward shortwave radiation flux and longwave radiation flux were increased by 8~12 W/m2 and 2~4 W/m2 in northern China, whereas decreased by 12~20 W/m2 and 2~4 W/m2 in southern China. The lower atmosphere was warmed in northern China by 1~2 K, enlarging the air temperature gradient between land and sea, easterly and southerly winds at 850hpa became stronger, which all indicated that the interactions among the three species have a significant impact on regional climate. We argue that the interactions should be considered in future simulations to better predict changes in air pollution and climate in this region. The results of this study could aid us in better understanding the climate effects of the mutual interactions among the three species, and provide a scientific reference for developing collaborative governance of regional climate and air pollution strategies over East Asia.

Early Career Scientist
YES, I am an early career scientist.

IGAC Activities
ACAM: Atmospheric Chemistry and the Asian Monsoon, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups
China Working Group

COVID-19 related abstracts
no
Black carbon emissions from traffic contribute substantially to air pollution in Nairobi, Kenya

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Author list (excluding presenting author)
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Abstract

Rapid urbanization in sub-Saharan Africa is linked with increased air pollution, with severe implications for human health. However, the pollutant characteristics and sources are poorly constrained, hindering informed mitigation measures and policies. In this study, year-round PM$_{2.5}$ aerosol filter samples were collected at an urban background location in Nairobi City. The PM$_{2.5}$ concentrations exceed the World Health Organisation’s recommended safe limit throughout the year, with little seasonal variability in particle concentration or composition. Similar to major sub-Saharan African cities, and unlike large cities on other continents, the black carbon fraction (a particularly toxic PM$_{2.5}$ component) is high (15 ± 4%), suggesting black carbon is a prominent air pollutant in Nairobi City. Radiocarbon-based source quantification indicates that fossil fuel combustion emissions are a dominant source of black carbon throughout the year (85 ± 3%), while fuel consumption statistics point towards traffic. Taken together, this indicates that black carbon emissions from traffic are a key stressor for air quality in Nairobi.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

ANGA: African Group on Atmospheric Sciences
Modelling aerosol-boundary layer interactions over Northern India- Case study of 2016 haze episode using WRF-Chem

Ms Prerita Agarwal
University Of Edinburgh, United Kingdom

Abstract

Black Carbon (BC) particles released from incomplete combustion are a strongly light-absorbing component of PM$_{2.5}$ (particulate matter having an aerodynamic diameter < 2.5 microns). BC emissions from India are some of the highest globally and are thought to significantly impact regional climate and human health. In October-November 2016 northern India experienced a severe haze episode lasting for nearly a week, with observed mean PM$_{2.5}$ concentrations reaching over 500 μg/m$^3$ over Delhi. Aerosol-planetary boundary layer (PBL) feedbacks are thought to significantly impact the vertical temperature profile (stabilizing it) and consequently increase surface pollutant concentrations during haze episodes. Such feedbacks have previously been found to induce heating in the upper PBL and enhance near-surface haze pollution over China. This study uses the WRF-Chem v4.2 model at 12 km horizontal resolution to examine aerosol-radiation feedbacks during the 2016 haze episode over northern India. We perform sensitivity simulations to isolate the feedbacks associated with 1) all aerosols; and 2) only BC aerosols, on meteorology. Modelled spatiotemporal distributions of pollutants and meteorology are evaluated against several openly available datasets. WRF-Chem simulates the spatial variation of pollutants reasonably well. However, it underestimates both surface-level PM$_{2.5}$ and BC compared to measured data. Aerosols impact the vertical temperature profile over Delhi by inducing a net cooling near the surface and net warming in the upper layers above 300m. The inclusion of the aerosol feedback on meteorology suppresses the PBL height, more so during the evening when the differences reach up to ~2km. In the presence of aerosol interactions, PM$_{2.5}$ and BC concentrations can dramatically increase (almost double) near the surface. We follow this by further model experiments isolating the effects of just the BC aerosol on the PBL, radiation and surface heat fluxes. Our results highlight the importance of mitigating BC emissions to improve air quality over Northern India.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Session 3 Poster

Aerosol remote sensing uncertainty estimation in Latin American cities

Josefina Urquiza  
Facultad Regional Córdoba, Universidad Tecnologica Nacional, Argentina. Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina

Author list (excluding presenting author)

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Abstract

Satellite aerosol remote sensing is a complex task to carry out due to the fact that surface and atmospheric conditions are in general diverse and consequently, the error depends on multiple factors. The Multi-Angle Implementation of Atmospheric Correction (MAIAC) algorithm has been developed to quantify the Aerosol Optical Depth (AOD) with the high spatial resolution advantage (1km²), necessary for air quality studies in urban areas. The spatial scale has led to an intensive use, e.g., for modeling surface level particulate matter. In Latin America, where air quality monitoring stations are limited, this product has become of particular interest. However, ignoring the uncertainties associated with $\text{AOD}_{\text{MAIAC}}$ may lead to inappropriate conclusions and results. The aim of this paper was to estimate the uncertainties associated with $\text{AOD}_{\text{MAIAC}}$ using Latin American cities as case studies: São Paulo, Santiago, Buenos Aires, Medellín, La Paz and Mexico, for the period 2015-2020. An analysis of the error characteristics and impacts in this algorithm was performed using typical single-valued metrics and another more detailed which focuses on evaluating the relative error structure locally called the Relative Expanded Uncertainty (REU). For these sites, both the AOD and its variability are relatively low showing an intermediate correlation with AERONET (the reference surface measurements) (R < 0.6). Within these cities there are two groups according to AOD levels: Buenos Aires, La Paz and Medellín with low values (<0.2), and Santiago, São Paulo and Mexico with medium and high values (0.2-0.4, mainly Mexico). For $\text{AOD}_{\text{MAIAC}}$ low levels (0.05 - 0.15, ~65.3%), the REU was always greater than 30%. When AOD values are close to the detection limit, the REU becomes exponential, while, at higher values, the REU becomes asymptotic, with similar patterns for all sites. These observed errors could be caused by the background aerosol model used by MAIAC in Latin America.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities
Monitoring of hygroscopicity of PM2.5 using low-cost sensors at Chandigarh in North India: Effect of crop residue burning

Dr. Tomoki Nakayama
Nagasaki University, Japan

Author list (excluding presenting author)

Hideya Kinjo (1), Yutaka Matsumi (2), Harshita Pawar (3), Baerbel Sinha (3), Vinayak Sinha (3), Sachiko Hayashida (4,5)

Abstract

Severe air pollution events are often observed from post-monsoon to winter seasons in North India. Agricultural residue burning activities especially on October and November in Punjab and Haryana regions were reported to contribute to enhancement of PM2.5 in downwind area including Delhi. However, real time monitoring of variation of aerosol type is not easy because of limited infrastructures to measure aerosol chemical properties in real time. Low-cost sensors will give promising opportunities to monitor PM2.5 in rural area. Typically, optical PM sensors measure light scattering from aerosol particles without drying, and therefore, potentially detect both a fraction of water and other chemical compositions in PM. In this study, Panasonic optical PM2.5 sensors [Nakayama et al., Aerosol Sci. Technol. (2018)] were operated under different relative humidity (RH) conditions from 30th October 2019 to 8th January 2020 at IISER Mohali (30.667°N, 76.729°E) near Chandigarh in North India. By comparing the PM2.5 mass concentration obtained by one PM2.5 sensor under ambient RH conditions with those under lower RH conditions by another PM2.5 sensor and beta attenuation monitors (BAMs), parameters related to hygroscopicity of particles were estimated. As results, lower hygroscopicity was observed before the middle of December compared to those after that, likely due to significant contributions of emissions of primary organic aerosols and elementary carbons emitted from agricultural residue burning and/or local sources such as traffic. After the middle of December, secondary formation of inorganics and/or oxygenated organic aerosols would contribute to higher hygroscopicity. This study demonstrates the potential of low-cost optical PM2.5 sensors to monitor variations of properties of aerosol particles, especially in rural area.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

IGAC Regional Working Groups
Assessing Black Carbon and Particulate Matter from mobile measurements in Quintero, Chile

Zoe L Fleming
Universidad del Desarrollo, Chile. Center for Climate and Resilience Research (CR2), Chile

Author list (excluding presenting author)

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Nicolas Fierro (1)
Carolina Concha (1)
Camilo Rodríguez (1)

Abstract

To the west of Santiago de Chile on the industrialized Pacific coast, the town of Quintero has been sandwiched between the industrial zones of Ventanas and Concón for the past few decades, on the receiving end of air and water quality episodes. These so-called Sacrifice Zones are getting more and more attention, with stricter air quality plans and more monitoring stations. Chile is heading towards closing down a third of its coal and gas power stations by 2025, the rest by 2040 in order to reach its goal of carbon neutrality by 2050, so assessing the extent of the pollution in these zones at the present moment from a local exposure point of view, is of real interest.

A month-long monitoring campaign in January 2022 and a follow up campaign in August 2022 were carried out by a few university research groups, along with the help of the Quintero Municipality and the local arm of the Ministry for the Environment. Parallel to the permanent measurements, four Aethelometers that measure Black Carbon and a GRIMM 11-D dust de-coder that measures a variety of Particulate Matter including TSP, PM10, PM2.5 and PM1 were carried around by researchers and volunteers that walked along 4 different set routes in the Quintero Peninsula. Several days of morning and evening walking experiments allowed a characterisation of the black carbon levels and its relationship to Particulate Matter and allowed us to map the spatial variation in these parameters during hour long periods.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report

IGAC Regional Working Groups
Americas Working Group
Session 3 Poster

Inhalable Particulate PAHs: Variability, Sources and Associated Health Risks in Delhi, India

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Author list (excluding presenting author)

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Abstract

Polycyclic aromatic hydrocarbons (PAHs) generally form an integral component of air pollutants in the ambient atmosphere. This study focuses on how proximity to roadways affects the ambient concentration of PAHs. Spatial and seasonal distribution of sixteen PAHs, and collectively represented as $\Sigma_{16}$ PAHs were determined in the ambient atmosphere of Delhi, the National Capital Region (NCR) of India. The results showed that the average mass concentration of $\Sigma_{16}$ PAHs near roadway (67.8 ± 40.2 ng m$^{-3}$) is significantly higher as compared to urban background site (56 ± 30 ng m$^{-3}$). Moreover, source apportionment study indicated that major PAH-emission sources in Delhi NCR are traffic and coal combustion. Health risks associated with inhalation of particulate PAHs were assessed using benzo(a)pyrene equivalent concentration (BaPeq) and incremental lifetime cancer risk (ILCR) approach. ILCR values at both the sites fall in the range of $10^{-2}$ to $10^{-4}$ that correspond to the priority risk level ($10^{-3}$) and not the acceptable risk level ($10^{-6}$). Thus, the present study concludes that the concentration of ambient PAHs is significantly higher at the site with busy traffic than an urban background site, thereby indicating a significantly higher health risk to the population of Delhi.

Early Career Scientist

YES, I am an early career scientist.
Session 3 Poster

Investigating the impacts of cooking on indoor air quality

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Abstract

People in developed countries spend approximately 90% of their time indoors, mostly at home. As a result, exposure to airborne pollutants mostly occurs indoors, whether those pollutants originate indoors or outdoors. As energy efficiency measures are adopted and homes become increasingly airtight, indoor pollutant sources have the potential to become increasingly important to indoor air quality, and therefore to personal exposure and health impacts. Cooking and cleaning are both activities that occur in most homes, and are known to produce a wide variety of pollutants including volatile organic compounds (VOCs) and particulate matter. These are the focus of the EPSRC-funded IMPacts of Cooking and Cleaning on indoor Air quality: towards healthy BuiLdings for the future (IMPeCCABLE) project, which aims to measure and model primary emissions and secondary chemistry from cooking and cleaning on a range of spatial scales, from the process level to the UK housing stock.

As part of IMPeCCABLE, this study investigates VOC and particle emissions during scripted cooking activities in a room scale environment. A suite of online and offline instrumentation was used to identify and quantify VOCs, particulate matter and trace gases. Real time concentrations of over 40 targeted VOCs were measured using selected-ion flow tube mass spectrometry (SIFT-MS) at a time resolution of <10s. Particle number size distributions were measured using an electrical low-pressure impactor (ELPI). Short cooking experiments were followed by a study of the evolution of reactants and products over several hours. Real time SIFT-MS and ELPI data were cross referenced with stages in the cooking process, to identify links between emissions of individual species and corresponding cooking processes and ingredients. The secondary chemistry will then be interrogated further using an indoor chemistry model.

Early Career Scientist

NO, I am not an early career scientist.
Probing wintertime air pollution sources in the Indo-Gangetic Plain through 52 hydrocarbons measured rarely at Delhi & Mohali

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Abstract
The Indo-Gangetic Plain experiences significant air pollution during the winter, affecting hundreds of millions of people. During the WiFEX (Winter Fog Experiment) campaign in the winter of 2016-2017, we conducted unprecedented measurements and source studies of 52 NMHCs (25 alkanes, 16 aromatics, 10 alkenes, and one alkyne) in the cities of Delhi and Mohali (300 km north of Delhi). A thermal desorption gas chromatograph with flame ionisation detectors measured the NMHCs, with data traceable to WMO standards. Propane, n-butane, acetylene, ethane, toluene, i-butane, ethene, i-pentane, benzene, and propene were the 10 most abundant NMHCs observed in both Delhi and Mohali, accounting for more than half of the total measured NMHC mass concentration (137.0 ± 5.8 µgm⁻³ in Mohali and 239.0 ± 7.7 µgm⁻³ NMHCs in Delhi). The measured ambient abundances of NMHCs and calculated hydroxyl radical reactivity were nearly twice in Delhi as compared to Mohali, and 2-12 times higher as compared to other megacities of the world. Using the chemical source signature of emission sources, vehicular emissions were identified as the most dominating source over both sites, with additional minor contributions of garbage burning in Mohali, and biomass burning and evaporative fuel emissions in Delhi. The analysis and comparison of the NMHC/CO and NMHC/C₂H₂ ratios suggested the dominance of petrol-fuelled vehicular emissions at both sites, most of them with older emission control technologies. It was further found that reactive NMHCs like propene, ethene and trimethylbenzenes were poorly represented in the EDGARv4.3.2 emission inventory over Mohali and Delhi. This study adds to our understanding of the sources of reactive NMHCs (lifetime a few days) that contribute to regional wintertime pollution through direct effects and secondary pollution generation and highlights the need for systematic and comprehensive measurements in future to better constrain the sources and emission inventories.

Early Career Scientist
YES, I am an early career scientist.

IGAC Activities
MAP-AQ: Monitoring, Analysis and Prediction of Air Quality, ACAM: Atmospheric Chemistry and the Asian Monsoon

IGAC Regional Working Groups
MANGO: Monsoon Asia and Oceania Networking Group
Characterization of intense winter air pollution from residential wood burning at an urban location: VOCs and aerosols.

Dr Maximilien J Desservettaz
The Cyprus Institute, Cyprus

Abstract

Biomass burning is a significant global source of gaseous and particulate matter emissions to the troposphere. Combustion of biomass releases a complex variety of Volatile Organic Compounds (VOC) that can significantly affect local and regional air quality, human health, and atmospheric chemical processes. Here, we present wintertime, high temporal resolution observations made with a Proton Transfer Reaction - Time of Flight - Mass Spectrometer (PTR-ToF-MS), and complementary instrumentation, at Ioannina, a medium-size mountainous city in the NW Greece, during December/January 2022.

The city of Ioannina is characterized by intense residential wood burning in the cold winter period, that in combination with its topography results in a magnified accumulation of gaseous and particulate pollutants. We report high concentrations for a vast range of VOCs (oxygenated VOCs, aromatics, acids, terpenes, etc) that are comparable with the ambient concentrations measured in highly polluted megacities globally. By studying the VOC emission source patterns together with other air quality variables monitored in this study, we characterize the different pollution sources and evaluate their significance in atmospheric chemistry.

This work was supported by the National Council for Aerosol Research under grant JB/005, the European Union’s Horizon 2020 research and innovation program under grant agreement No. 856612 and the Cyprus Government, and the PANhellenic infrastructure for Atmospheric Composition and climate change (PANACEA), MIS 5021516.

Early Career Scientist

YES, I am an early career scientist.
Abstract

Most developing cities struggle with deteriorating air quality challenges and Nairobi is such a city. This paper explores the state of air quality in Nairobi city drawing from the outcomes of the Nairobi Urban profile and the Vulnerability scoping studies conducted under the A system Approach to air pollution in East Africa project. Using these studies’ outcomes, the paper aims to provide insights on the state of air pollution, the vulnerability scope of the residents and users, and give appropriate recommendations. The outcomes indicate that both indoor and ambient air pollution levels in the city regularly exceed WHO guideline amounts with the PM2.5 concentrations indoors measuring an averagely of 43 ± 19 µg m3 and peaking at 47 ± 14 µg m3 most of the time in the city center. The outdoor concentration levels of PM2.5 recorded larger concentrations, averaging 54 ± 22 and peaking at 61 ± 21, which is consistently at an unhealthy level. The air pollution levels are too high exceeding the WHO guidelines in the city’s largest Dandora dumpsite affecting more than 3.5 million city residents living within a radius of 10 Kilometers. The site recorded PM2.5 concentrations of about 47.4 ± 9.5 µg/m3 and a peak concentration of 94.5 ± 32.6 µg/m3 most of the days. Despite this evidence, the city has no continuous and robust air quality monitoring system and thus a data gap to conclusively ascertain the overall air quality and its impacts on human and environmental health. The study, therefore, recommends a quick establishment of a robust and reliable air quality monitoring and management system in the city besides the policy, strategic infrastructural expansion, city decongestion, proper waste management, and strategic traffic management by the Nairobi city-county government working with its strategic partners and stakeholder towards a holistic air quality improvement in the city.
Air pollution has profound societal, economic, and environmental impacts. The airborne particles or aerosols, particularly nanoparticles, are identified as the cause of ~ 7 million people worldwide every year (WHO, 2021). Aerosols are also significant in climate change and Earth’s energy processes. In this presentation, we will discuss the comparison of cold-climate and mild-climate air quality and the impact of ice and snow on the lifetime of air pollutants, focusing on aerosols. We further discuss real-time and in-situ observation and physicochemical processes involving nanoparticles and nano-size particles. We present data on emerging contaminants during the COVID-19 lockdown. We explore physicochemical characteristics of nano and micro-plastics and black carbon using novel technologies. Finally, we discuss using fundamental science to design zero-net energy and recyclable technology using natural particles to remove pollutants in air/water/snow.
Session 3 Poster

Sensitivity of simulated Ice Nuclei Particle concentrations to soil mineralogy

Mr. Marios E. Chatziparaschos
Environmental Chemical Processes Laboratory (EPCL), Department of Chemistry, University of Crete, Greece. Center for the Study of Air Quality and Climate Change (C-STACC), Institute of Chemical Engineering Sciences (ICE-HT), Foundation for Research and Technology, Hellas (FORTH), Patras, Greece

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Abstract

Aerosol-cloud interactions are among the most important sources of uncertainty in climate projections. Atmospheric particles that enable heterogeneous ice formation are known as Ice Nucleating Particles (INP) and affect clouds’ lifetime, electrification and radiative properties as well as precipitation rates. Mineral dust and more specifically its K-rich feldspar and quartz content, is thought to be globally the most important type of INP in mixed-phase clouds. Chemistry-transport and Earth System models can simulate INP based on dust mineralogy and experimentally-derived immersion freezing parameterizations. Dust mineralogy depends upon regional variations in the mineralogy of dust sources. Challenges for models include the uncertainty in current soil mineralogy datasets and accounting for the differences in size-resolved mineralogy between the emitted dust and the parent soil.

In the present study, we further develop the global 3-D chemistry transport model TM4-ECPL to account for INP concentrations from K-rich feldspar and quartz particles using two different soil mineralogy atlases. The mineral fractions emitted in the accumulation and coarse insoluble modes of TM4-ECPL are estimated from the soil mineralogy atlases of Claquin et al. (1999; doi.org/10.1029/1999JD900416) and Journet et al (2014; doi.org:10.5194/acp-14-3801-2014) based on brittle fragmentation theory (Kok, 2011; doi.org/10.5194/acp-11-10149-2011, 2011). We compare the model results with available INP measurements from BACCHUS database from different campaigns worldwide and in the Arctic (Wex et al., 2019; doi.org/10.5194/acp-19-5293-2019). The analysis highlights how different soil mineral composition datasets impact the ice initiation and to what extent a better quantification of dust mineralogy may improve ice nucleation representation in modeling.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

CCMi: Chemistry Climate Model Initiative

IGAC Regional Working Groups

COVID-19 related abstracts

no
In situ qualitative and quantitative characterization of Biogenic Volatile Organic Compounds emissions under urban conditions

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Author list (excluding presenting author)

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Abstract

Urban vegetation is beneficial for the environment, the human health, and the well-being, making it a priority topic for many cities like Paris. However, vegetation is a source of Biogenic Volatile Organic Compounds (BVOC), key compounds in the urban photochemical pollution. As part of the sTREEt project, the present work aims to: i) qualify and quantify the BVOC emissions (at branch level) in response to diurnal and seasonal variations of climatic parameters and water status fluctuations from plane trees (Platanus x hispanica), a common urban tree grown in a dense urban area (Vitry-sur-Seine near Paris), ii) characterize the BVOC emission from various species in an urban garden located in the city center of Paris and its impacts on the chemical composition of the surrounding atmosphere.

Three campaigns were carried out during July 2020, May and July 2021, where the BVOC emissions from young potted plane trees, grown under semi-controlled environmental conditions, were followed, and compared to in natura adult trees. Experiments were performed at the branch scale using dynamic chambers coupled to a Proton Transfer Mass Spectrometer (PTR-MS). The BVOC emissions were dominated by isoprene (50-95%) followed by oxygenated compounds (mainly methanol and acetone). Significant seasonal variability was observed during the 2021 campaigns, where the isoprene emission factors (EF_{iso}) during the summer were an order of magnitude higher than those in the spring for certain branches. In addition, the high variability in the EF_{iso} dominated the effect of a mild drought.

Besides, another campaign is planned in June-July 2022 in a garden, in the city center of Paris, a site under significant BVOC influence and important anthropogenic contribution (traffic). This campaign will assess the variability of BVOC emissions from various species (Buxus sempervirens, Fagus sylvatica...), and characterize the chemical composition (gas and particles) of the surrounding urban atmosphere.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities
Establishment of Conceptual Schemas of Surface Synoptic Meteorological Situations Affecting Fine Particulate Pollution Across Eastern China in the Winter

Dr. Xuewei Hou
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Bin Zhu(1), Kanike Raghavendra Kumar(2), Gerrit de Leeuw(3), Wen Lu(1), Qian Huang(1), and Xiaoxin Zhu(1)

Abstract

In the present study, the characteristics of weather conditions and local meteorological variables over the Beijing-Tianjin-Hebei (BTH) and the Yangtze River Delta (YRD) regions in the winter are analyzed using the principal component analysis (PCA) method and daily PM2.5 accumulation rate. Typical synoptic weather patterns over China in the winter can be classified into four types. During the Type 1 synoptic weather pattern, China is under the influence of the Siberian High, and northerly winds prevail; this situation is beneficial to the transport of pollutants from north to south. However, when the Siberian High is weak, southerly winds prevail which may result in the transport of pollutants from south to north. The Type 2 weather pattern refers to a weak high pressure located in the BTH resulting in the accumulation of pollutants. During the Type 3 weather pattern, an intense cold Siberian High moves to the south and affects the northern areas of China. The associated front brings heavy precipitation in the YRD resulting in the wet deposition of pollution. During the Type 4 weather condition, the weak Siberian High is blocked by the northeast cold vortex and moves towards the south, causing the accumulation of pollution in the YRD. The PCA model shows that there are two transport pathways for pollutants to the BTH (YRD) area: one from the YRD (BTH) and Shandong during Types 1 and 2 (Types 1 and 3) situations and the other one from the central provinces during Type 4 (Types 1 and 4)

Early Career Scientist

NO, I am not an early career scientist.
Session 3 Poster

DEVELOPMENT OF ATMOSPHERIC EMISSIONS INVENTORY FOR BRAZIL'S REFINERY SECTOR WITH A BOTTOM-UP APPROACH

Camila A. Ibagué
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Author list (excluding presenting author)

Sergio Ibarra Espinosa (1); Leila Droprinchinski Martins (2)

Abstract

Oil refinement represents 40% of the environmental impacts on the industry's value chain. The air pollutants emitted in greater proportion are Total Suspended Particulate (TSP), sulfur oxides (SOx), and Non-Methane Volatile Organic Compounds (NMVOCs), resulting from catalytic cracking and recovery of steam and burning. In the world ranking of 2020, Brazil occupied the 9th position in refining capacity, being the country's main activity with the highest production and sales. Data from the national inventory of Greenhouse Gases (GHG) showed that this industry contributed significantly to CO2 emissions equivalent in the last ten years. There is no official atmospheric emissions inventory for criteria pollutants in the country that allows identifying their impact on air quality. Atmospheric emission inventories are a valuable tool for analyzing the impacts of climate control policies, climate change, and the protection of human health. This work estimates the atmospheric emissions of criteria pollutants of the 17 refineries in Brazil looking for the Bottom-up approach. The quantification of atmospheric emissions follows the guidelines defined by the United States Environmental Protection Agency (EPA) and the European Environment Agency (EEA), published in the AP-42 and EMEP/EEA 2019 guides. In general, the trend of atmospheric emissions between 1990 and 2021 of criteria pollutants was growth and it was not observed influence by the COVID-19 health emergency. The highest emission rates were due to the increase in the nominal capacity of nine refineries. In 2021, the total emission of TSP was 201,757 t/year, SOx of 156,271 t/year, and NMVOCs of 92,896 t/year. The emissions using the upper EEA emissions factors showed rates above twice those estimated with the EPA upper range factors. This inventory favors the direction of efforts to meet local and national air quality objectives.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

GEIA: Global Emissions Initiative, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality, CCMi: Chemistry Climate Model Initiative

IGAC Regional Working Groups

Americas Working Group, Southern Hemisphere Working Group
Session 3 Poster

Relationship between extreme rainfall and drought events and particulate matter concentration

Miss Rafaela S Ramos
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Author list (excluding presenting author)

Flavia N. D. Ribeiro

Abstract

Climate forecasts for southeastern Brazil predict an increase in extreme rainfall events, but its impact on air quality is not yet clear. This work aims to quantify the relationship between rainfall patterns and particulate matter (PM) concentration in the Metropolitan Region of São Paulo (MRSP), considering extreme rainfall events and droughts. We used data recorded from 2011 to 2020 by two meteorological stations, one in the North and the other in the South of the MRSP. Extreme rainfall was defined as daily accumulated precipitation above the 95th percentile for the corresponding month. Droughts were defined as a period of five consecutive days without rain during the rainy season and 10 consecutive days during the dry season. We found 57 extreme rainfall and 48 drought events in one station and 59 extreme rainfall and 89 drought events in the other. We obtained coarse (PM10) and fine (PM2.5) PM hourly average concentrations recorded by two monitoring stations, each located within 8 km from the correspondent meteorological station. We noticed rainfall events substantially higher than the 95th percentile, especially in the dry season. Both stations presented higher PM10 and PM2.5 concentrations during droughts in the dry season (30.1-78%), followed by concentrations during droughts in the wet season (2.1-19.9%) than the whole period average. Additionally, the average concentration during extreme rainfall events was lower (5.6-15.8%) than for the whole period average. We concluded that when the weather is dryer for 5 or more consecutive days there is an accumulation of PM and, when there are higher volumes of rain, the air is less polluted. However, years with more extreme rainfall events do not necessarily have the lowest annual concentrations and years with more drought events do not present the highest concentrations, indicating the influence of other factors.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality, GEIA: Global Emissions Initiative

IGAC Regional Working Groups

Southern Hemisphere Working Group
Session 3 Poster

Fluorescent characteristics of historical African dust event: The Godzilla dust plume in June 2020

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Author list (excluding presenting author)

D. Baumgardner (1); Benjamin Bolaños-Rosero (2); O. L. Mayol-Bracero (3)

Abstract

Every summer, African dust influences the air quality, atmospheric chemical composition, and human health in the Caribbean region. The year 2020 has historical importance in terms of African dust events. The mega “Godzilla” dust plume that arrived in June 2020 was the largest ever African dust event in the Caribbean in the last 21 years, based on satellite information and ground-based measurements. In this study, using a Wideband Integrated Bioaerosol Spectrometer (WIBS) we have identified the fluorescent characteristics of particles in this mega dust event based on measurements at the Cape San Juan atmospheric observatory, located in a remote coastal location in Puerto Rico. The preliminary findings suggest that the “Godzilla” dust plume was carrying bioaerosols that were picked up at the dust source or during transport. The measurements showed fluorescent particle concentrations increased during the peak of the mega dust event (June 23) that lasted from 21-30 June. The highest diameter measured during the peak event was around 4 µm. The higher particle asphericities measured during the peak event shows the particles were nonsymmetric in shape. The fluorescence particles identified were characterized in seven different groups. The variability in fluorescent intensities, number concentrations, diameter, and asphericity during the event duration will be discussed. These findings are important as dust associated with bioaerosol particles could influence regional air quality and pose additive health threat to the human population in the region.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

Americas Working Group
Understanding Atmospheric Properties of Pesticides Using Mass Spectrometry

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University of Manchester, United Kingdom

Author list (excluding presenting author)
Aristeidis Voliotis (1) Thomas Bannan (1) Dave Johnson (2) Hugh Coe (1)

Abstract

Pesticides have been used on fields since the 1950s to promote crop yield by reducing crop losses due to diseases and/or pests. Once the pesticide is in the atmosphere it may undergo re-partitioning between the particle and gas phases as an aerosol and be transported away from the source, polluting the environment, and potentially affecting the health of the nearby population.

Current reported physiochemical properties of pesticides e.g.: vapour pressure, often come with large uncertainties and discrepancies between sources (M. Leistra, 2011). Vapour pressure of low volatility compounds (like most atmospherically relevant species) are difficult to measure, historically being measured at high temperature leading to extrapolation for ambient results. An added layer of complexity is present in pesticides as sources often lead to confidential industrial reports making it hard to know exact how the data has been determined.

Previous pesticide measurements have been carried out both in the lab (T. Murschell and D. K. Farmer., 2017 and T. Murschell, S. Fulgham, D. K. Farmer., 2017) and field (T. Murschell, 2019). In the lab, gas phase iodide-CIMS (Chemical Ionization Mass Spectrometry) was used. Whilst in the field, gas phase acetate-CIMS was successfully used to monitor the spraying of two pesticides.

To carry out calibration measurements several techniques can be used. These may include FIGAERO-TOF-CIMS (Filter Inlet for Gases and AEROsols – Time of Flight – Chemical ionisation Mass Spectrometer), as described by F.D. Lopez-Hilfiker et al., (2016) and Knudsen Effusion Mass Spectrometry (KEMS) (A. Booth et al., 2009). Both techniques have previously been used to measure low volatility atmospherically relevant compounds however this is the first time these techniques have been used to measure pesticides.

Early Career Scientist

YES, I am an early career scientist.
PM chemical characterization in a semi-arid region in central Mexico

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Author list (excluding presenting author)
Sara Erika Oliva-Salazar(1)

Abstract

Although several urban areas in Mexico struggle with relatively high concentration of airborne pollutants, Mexico City is almost the only metropolitan area whose atmosphere is well studied. On the other hand, the metropolitan area of Querétaro (MAQ) is situated on the southeastern border of the Bajio region, in Central Mexico, recognized for its largescale industrial and agricultural activities, with approximately 20 million inhabitants. Located 200 km north of Mexico City, MAQ is one of the fastest growing urban areas in the country, with a population of approximately 1.5 million inhabitants. In addition to local industry and traffic, airborne pollutants sources include the industrial corridor Leon-Irapuato-Salamanca, where an important refinery is located, as well as other industries such as textiles, metal processing, and food. However, little is known about the interactions between local and regional emissions and air quality. In this presentation, we will describe the chemical composition of PM$_{10}$ and PM$_{2.5}$ in the MAQ. We will present, combine, and compare different data sets to gain more insight into the major emission sources and processes involved in the formation of particles in this region.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Regional Working Groups

Americas Working Group
Session 3 Poster

African anthropogenic emission inventories for main GHGs and air pollutants from 2010 to 2018

Dr Sekou KEITA
Université Peleforo GON COULIBALY, Côte d'Ivoire. Laboratoire d'Aerologie de Toulouse, CNRS, France

Author list (excluding presenting author)
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Abstract
There is a lack of emissions data and regional inventories in Africa while Africa is expected to become an emerging giant in the next future in terms of anthropogenic emissions if no regulation occurs (Lioussse et al., 2014). Currently, there is one African regional inventory (DACCIWA inventory version 1 (Keita el al. 2021)), which provides anthropogenic combustion emission inventories from 1990 to 2015 for air pollutants. The Copernicus CO2 project (coco2-project.eu) has allowed the extension of this inventory to the main GHGs and to non-combustion sources such as fugitives, agricultural soils and waste dumps and the update to the most recent years.

Briefly, for the sources existing in DACCIWA version 1, fuel consumption data updated over the period 2010-2018 were associated to emission factors measured in Africa for BC, OC, CO and fossil fuel and biofuel CO2 and from the literature for CH4, NOx, NMVOCs and SO2, to develop annual grid maps of emissions by sector at 0.1°x0.1° spatial resolution. For the sources not studied in DACCIWA version 1, results were obtained from a mosaic of global emission inventories including Africa (CAMS-GLOB-ANT inventory).

In our presentation, this DACCIWA version 2 inventory will be presented and compared to other global inventories in order to highlight the main uncertainties and to encourage the modelling community to evaluate the emission inventories in Africa.

We will also present the Africa emissions working group of the GEIA/IGAC project, which is led by Sekou Keita, Mogesh Naidoo and Cathy Lioussse. The DACCIWA version 2 inventory will serve as a baseline in the activities of this working group.

Early Career Scientist
YES, I am an early career scientist.

IGAC Activities
GEIA: Global Emissions Initiative

IGAC Regional Working Groups
ANGA: African Group on Atmospheric Sciences
Controls over the intraurban variability in nitrogen dioxide pollution in Dakar, Senegal

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Author list (excluding presenting author)

Mary Angelique G. Demetillo (1); Tahi, P. Wiggins (1); Kathrine K. Knowles (1); Dallas Tatman(2); Mamadou S. Drame (3,4); Demba Ndao Niang (3), Jeanine Braithwaite (5), Kamwoo Lee (6), and Sally E. Pusede (1)

Abstract

Nitrogen dioxide (NO$_2$) is highly variable within cities, with important consequences for secondary pollutant formation and public health. Few observations capture this variability in large cities, as routine monitoring networks are too spatially sparse, especially in West Africa. Here, we describe vehicle-based measurements of the intraurban variability in NO$_2$ across Dakar, Senegal in February–March 2020. We show that NO$_2$ mixing ratios are the highest downtown, at congested major intersections, and near the Port of Dakar. We use these observations to create a land-use regression model, representing the first regression model for NO$_2$ trained using locally collected measurements for a major West African city. We find predictions based on local measurements yield substantially different NO$_2$ distributions than global models based largely on datasets collected in cities in the Northern Hemisphere. We use our model to explore the relative importance of various predictors for NO$_2$ spatial variability and discuss implications for which emissions sources drive variability throughout the city.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

AMIGO: Analysis of eMissions using Observations, CCMi: Chemistry Climate Model Initiative, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

ANGA: African Group on Atmospheric Sciences

COVID-19 related abstracts

yes
Identifying Wildfire Influence on Air Pollutant Levels in Rural and Urban Canada

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Author list (excluding presenting author)
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Abstract

Wildfires are sporadic, large sources of commonly monitored pollutants, including PM2.5, NO2, CO and O3. Currently, retroactively identifying wildfire periods which have influenced local measurements of air quality remains a challenge, due to the uncertain amount of pollutant concentrations from wildfires compared to the local background concentrations. We have developed an automated, straightforward approach called the trajectory-fire interception method (TFIM) to identify time periods where wildfires have influenced local air quality. The TFIM compares the location of HYSPLIT back-trajectories originating from air quality stations to MODIS satellite imagery of wildfire ‘hot-spots’. For this method, we define a wildfire period as a 6-hour measurement average which contains ≥ 20 interceptions between the satellite detected wildfires and the 72-hour HYSPLIT back-trajectories. To establish the method, we investigate the instances of wildfire-influence on the concentrations of CO, NO2 and O3 from 2001-2019 using TFIM. Initially, our results show that wildfire-influenced time periods have elevated concentrations of CO and NO2, but not O3, in Western Canadian cities. However, O3 is a secondary pollutant, whose formation depends on other factors, such as NOx (NO + NO2) concentration, sunlight and plume age. We use a statistical modelling approach to better understand the influence of wildfires on O3 in Western Canada from the TFIM. With this approach, we compare the impact of wildfires on air quality in rural and urban areas to explore the impact of urban pollutants on the wildfire plume as it is transported long distances.

Early Career Scientist

YES, I am an early career scientist.
Wildfires CO pathways in the global atmosphere – a climatological study

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Author list (excluding presenting author)

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Abstract

Carbon monoxide (CO) is one of the main trace gas pollutants in the global atmosphere. CO can be emitted by several anthropogenic and natural sources. Its main anthropogenic source is the incomplete combustion of fossil fuels. CO can also be produced as an intermediate species in the oxidation of other compounds. CO is chemically removed from the atmosphere through its reaction with the hydroxyl radical (OH) and by forming ozone in sufficient amounts of nitrogen oxide. Thus, it affects the oxidative capacity of the atmosphere and, subsequently, the lifetime of the greenhouse gas methane (CH4). As a result, CO influences the atmospheric composition and, indirectly, climate.

One of the main, reoccurring, non-anthropogenic sources of CO is wildfires. Wildfires are responsible for about 25% of global CO emissions. Through atmospheric transport of the emitted pollutants, they can affect atmospheric composition far away from their sources. Massive quantities of pollutants are emitted by wildfires in different altitudes depending on the fire activity. Therefore, wildfire emissions are transported to long distances following various pathways in the middle and upper troposphere and reaching remote regions.

In this work, we use the well-documented and extensively evaluated TM4-ECPL global chemistry and transport model to assess the climatological transport pathways of wildfire CO emissions in the global atmosphere. We introduced thirteen marked CO tracers in the model, each originating from one of the (land) source regions defined by the Hemispheric Transport of Air Pollution (HTAP) project. We then run the model for a period of 20 years (1994-2015) to achieve climatological conditions and be able to assess the global, reoccurring pathways of pollution. Distinction for the El Niño years is made in this analysis. The results are shown with respect to the relative impact of wildfires on the global ocean-atmospheric composition.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

GEIA: Global Emissions Initiative, TOAR: Tropospheric Ozone Assessment Report
Session 3 Poster

Influences of Fireworks on Chemical Characterization and Optical Properties of Water-soluble Organic Aerosols in a Coastal City, China

Dr. Caiqing Yan
Shandong University, China

Author list (excluding presenting author)

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Abstract

Fireworks (FW) emission has significant negative influences on air quality and human health. However, FW events still occur during various festivals like New Year’s Eve all around the world. To investigate the effects of a huge display of FW on chemical characterization and optical properties of water-soluble organic aerosols, fine particulate matter (PM$_{2.5}$) samples were collected during the Chinese Spring Festival in Qingdao, a coastal city in China. In this study, organic carbon (OC), elemental carbon (EC), water-soluble species (e.g., water-soluble organic carbon (WSOC), water-soluble ions, and saccharides), and molecular characteristics of WSOC, as well as UV-Visible and fluorescence spectra by WSOC were measured with a combination of several state-of-the-art techniques for the same batch of samples. Our results showed that water-soluble species in PM$_{2.5}$ like K$^+$, Mg$^{2+}$, Ca$^{2+}$, Cl$^-$, SO$_4^{2-}$, levoglucosan, mannosan, and WSOC dramatically increased by a factor of 67, 39, 17, 16, 8, 3.4, 4, and 2 during the FW events, respectively. Correspondingly, the number and fractional contributions of the subgroups of CHOS and CHONS compounds identified by ultrahigh-resolution Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR-MS) both increased. The modified van Krevelen diagrams suggested that the increased CHOS compounds were with higher aromaticity and mainly composed of highly aromatic molecules, highly unsaturated molecules and unsaturated aliphatic molecules. Besides, our results indicated that FW emissions may be a source of water-soluble brown carbon with enhanced light absorption coefficients, which could also be evidenced by the enhanced fluorescence intensities of WSOC especially by less-oxygenated humic-like substances and protein-like substances, based on the fluorescence excitation-emission matrices (EEMs) and parallel factor (PARAFAC) analysis. In addition, the relationships of water-soluble organic molecules with light-absorbing properties and the intensities of PARAFAC components will be further discussed and presented.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

IGAC Regional Working Groups

China Working Group
Rapid Changes of Meteorology and Emission Increased the Contribution of Cross-regional Transport to the Ambient PM2.5 in the Pearl River Delta Region during the Polluted Seasons of 2015-2017

Dr. Kun Qu
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Abstract

PM2.5 pollution in the Pearl River Delta (PRD) region, South China, is notably influenced by cross-regional transport. Despite its importance, systematic studies focusing on the changes of transport contributions to PM2.5 over multiple years and their driving factors are limited. During the polluted seasons (Oct.-Jan.) of 2015-2017, both meteorological conditions and anthropogenic emissions in eastern China encountered rapid changes: Interannual climate variability, especially the transition from El Niño to La Niña, resulted in increasingly favorable conditions for PM2.5 transport to the PRD; while simultaneously, pollution control measures notably reduced pollutant emissions in both the PRD and its upwind regions. These changes provide a unique opportunity to explore the variations of transport contribution to PM2.5 and its secondary inorganic components (sulfate, nitrate, ammonium; SNA) in the PRD and their driving factors.

For this purpose, factor separation method was applied based on WRF-CMAQ simulations for the three years. Transport contributions, defined as the contributions from emissions outside the PRD, are split into direct transport (in the form of PM2.5 or SNA), indirect transport (in the form of the precursors of secondary PM2.5 components), and background (sources outside the modeling domain) contributions.

Results show that during three polluted seasons from 2015 to 2017, the overall transport contributions accounted for 70%, 74% and 78%, respectively, of the PM2.5 levels in the PRD. Direct transport is not only the main contributor to PM2.5 (~50%), but also the driver of yearly increases in transport contribution. Besides, over 80% of the SNA in the PRD were contributed by cross-regional transport, and its contributions also showed increases during three polluted seasons. Based on sensitivity simulations and budget analyses, the influence of meteorological and emission changes on various sources and processes of PM2.5 and SNA were further quantified to reveal the detailed reason behind their increasing transport contributions.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups
Lagrangian inversion of long-lived VCP tracers and forward chemical modeling in the southwestern United States

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Author list (excluding presenting author)
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Abstract

Non-traditional anthropogenic volatile organic compound (VOC) emissions are a significant source of uncertainty in current emission inventories and affect model predictions of air quality. McDonald et al. (2018) identified volatile chemical products (VCPs, e.g. personal care products, insecticides, coatings, and adhesives) as an emerging source of anthropogenic VOCs in urban regions. They reported that VCP emissions in the U.S. were underestimated by a factor of 2—3. In the Los Angeles basin, half of the VOC reactivity of petrochemical sources were attributed to VCP emissions. In this work we will link a Lagrangian back-trajectory model (FLEXPART-WRF) with a forward Eulerian chemical transport model (WRF-Chem) to improve bottom-up emission inventories for non-traditional anthropogenic VOCs. We will focus on measurements collected during the SUNVEx 2021 campaign, which took place in Las Vegas, NV and Los Angeles, CA (https://csl.noaa.gov/projects/sunvex/). The suite of instruments deployed during SUNVEx 2021 included, among others, mobile and stationary mobile Doppler lidars, and a Proton Transfer Reaction-Time of Flight-Mass Spectrometry instrument (PTR-ToF-MS). The mobile lidar was strategically driven through the Los Angeles basin to probe different dynamical features (e.g., sea breeze and upslope transport) and its data has been used, together with the stationary lidar measurements, to optimize the WRF dynamics setup. The PTR-ToF-MS measured chemically longer-lived VOCs linked to use of personal care products (D5-siloxane), adhesives (D4-siloxane), coatings (PCBTF) and insecticides (p-dichlorobenzene). We will perform Lagrangian inversions on these VCP tracers to obtain sub-sector emission adjustments for personal care product, adhesive, coating, and insecticide VOC emissions, which will then be input in a forward WRF-Chem simulation to assess how secondary chemistry is impacted, including for ozone, PM2.5, and formaldehyde. To the author’s knowledge, this is the first time that a Lagrangian inversion is being employed to evaluate emissions linked to the use of VCPs.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

AMIGO: Analysis of eMIssions usinG Observations
Session 3 Poster

Long-term Variations of Tropospheric Ozone and Precursor gases over the Himalayan and Foothill Region: Observations from Ozonesonde, MAX-DOAS, and Satellite

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Author list (excluding presenting author)

Manish Naja (1), H. Irie (2), R. Kumar (3), S. N. Tiwari (4)

Abstract

Regional air pollution has become one of the utmost environmental concerns over south Asia, especially in Northern India. Additionally, the adjacent Himalayas provide conducive conditions to confine these pollutants and transport them to the greater horizontal and vertical extents. However, our understanding of air pollution in this region is limited owing to the sparsity of in-situ observations and the lack of comprehensive validation of data retrievals from space-borne sensors. To address this issue, we performed observations from ozonesonde and MAX-DOAS and analyzed satellite data. Ozonesonde and AIRS satellite observation over the subtropical Himalayas detected frequent tropopause folding during the winter and spring leading to a 5 - 25% increase in ozone over the troposphere. Whereas ozone increased by 10 - 20% during biomass burning periods over the lower troposphere. The estimated ozone UV radiative forcing over the Himalayas is increasing and matches well between ozonesonde (4.86 mW/m²) and OMI (4.04 mW/m²), while significant underestimation is seen in AIRS (2.96 mW/m²) RF calculations due to large uncertainties in the total ozone observations. Additionally, NO₂, SO₂, HCHO, and CHOCHO vertical column densities (VCDs) observations are performed using MAX-DOAS over a Himalayan foothill site. The MAX-DOAS and satellite observations (TROPOMI and GOME-2) captured systematic seasonal variations. MAX-DOAS comparison with the satellite observation shows underestimation up to 30% for satellite NO₂ VCDs, while SO₂, HCHO, and CHOCHO VCDs agree well. The diurnal variation of NO₂ and HCHO is of typical urban type with morning and evening peaks. However, the CHOCHO diurnal variation is typical of forest areas with a noon peak. VOCs sensitivity calculation (R₀) shows prominent biogenic sources of VOCs during noon hours. R₀ calculation mostly shows NO₂ limited ozone production regime. This study highlights factors governing trace gas’s diurnal and seasonal variations and discusses their possible sources over the Himalayan and foothill region.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities


IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Session 3 Poster

A Street-level assessment of Greenhouse Gas emissions associated with Traffic Congestion in the City of Nairobi, Kenya

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Author list (excluding presenting author)

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Leah Oyake (2)
Aderiana Mbandi (3)

Abstract

Traffic congestion significantly contributes to climate change due to the emissions of Greenhouse Gases (GHGs) such as Carbon Dioxide (CO2), Nitrous Oxide (N2O), and Ozone (O3). Rapid urbanization and poor planning coupled with increased motorization and fragmented public transport system in cities such as Nairobi have led to increased vehicular emissions, especially during heavy traffic along the various roads and within the Central Business District (CBD). To reduce GHG emissions in the urban transport sector, institutional coordination and relevant policy tools must be considered. This study aimed at estimating CO2 emissions from different vehicle categories during traffic congestion, using Uhuru Highway as a case study. The relationship between traffic congestion and CO2 emissions were analyzed using qualitative and quantitative methods, through a bottom-up approach. 120 Questionnaires were administered to vehicle owners, passengers, and pedestrians to get individual vehicle characteristics and opinions on the best actions for reduction of CO2 emissions along Uhuru Highway in Nairobi. The Average Annual Daily Traffic (AADT) for different vehicles from 2014 to 2019 was used to estimate the CO2 emissions. Results showed that private cars predominate over other vehicle types, contributing to 73% of the total CO2 emissions in Nairobi (CBD). Private cars are the highest contributor to CO2 emissions with a total of 25.3 million Carbon dioxide equivalent (gCO2e), between 2014 and 2019. In comparison, Public Service Vehicles, commonly referred to as Matatus, emitted 6.89 million gCO2e, Light Commercial Vehicles (1.82 million gCO2e), Heavy Goods Vehicles (251,683 gCO2e), and motorcycles (181,054 gCO2e). To minimize CO2 emissions, the study recommended enforcement of strong mobility policies to control the high motorization rate. One of these policies is prioritization of the development of mass public transport system to achieve the potential health, economic and environmental gains within the CBD.

Keywords: GHG emissions, traffic congestion, CO2 emissions, policy

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality
IGAC Regional Working Groups

ANGA: African Group on Atmospheric Sciences
Abstract

Air pollution is one of the world’s leading causes of premature death. It is therefore important to understand how future changes in emissions could impact air-pollution related mortality. Futures with more ambitious climate change mitigation could have air quality co-benefits compared to less sustainable futures due to common sources of greenhouse gases and air pollutants. Different futures can be represented with the Shared Socioeconomic Pathways (SSPs), which provide narratives describing different futures and projected socioeconomic and emissions data and supersede the Representative Concentration Pathways, used by a lot of previous research into future air pollution. Current modelling of air quality following the SSPs often use low-resolution global scale models or reduced complexity models that give regional averages of air pollution related mortality, which may poorly represent changes in mortality on a smaller scale.

Using emissions projections from three SSPs representing very different approaches to climate change mitigation (SSP1-2.6, SSP2-4.5 and SSP3-7.0) and a detailed, high-resolution atmospheric chemistry model (WRF-Chemv4.2) with chemical initial and boundary conditions from WACCM simulations of the same scenarios, we simulate 2050 PM2.5 and O3 in Western Europe. This allows for an estimation of the future air pollution-related health burden at a more regionally-refined scale than previous research.

Early Career Scientist

YES, I am an early career scientist.
Development of an interactive atlas for air quality and impact applications using chemical reanalysis products

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Author list (excluding presenting author)
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Abstract
Reanalysis products combine observational data and prior estimates from numerical models to produce gridded and physically consistent data that describe the recent history of the atmosphere, land, and ocean. As part of the AQ-WATCH (Air Quality – Worldwide Analysis and Forecasting of Atmospheric Composition for Health) European project and the CRANES (Chemical Reanalysis And flux iNvErsionS) working group in the AMIGO (Analysis of eMissions usingG Observations) IGAC activity, an interactive atlas of air quality was developed. This atlas is primarily based on the reanalysis of the global atmospheric composition performed by the European Centre for Medium-Range Weather Forecasts (ECMWF) within the CAMS (Copernicus Atmosphere Monitoring Service) project and the regional chemical reanalysis from the coupled Weather Research Forecast and Community Multiscale Air Quality (WRF-CMAQ) model. The atlas includes climatological distributions of the major particulate matters and gases, as well as associated health indices, and provides spatial and temporal analyses of atmospheric composition change. This online tool can be used to assess the impact of policy decisions on air quality, identify air pollution hotspots, and compare concentration levels across countries, states, provinces, and cities.

Early Career Scientist
NO, I am not an early career scientist.

IGAC Activities

IGAC Regional Working Groups
ANGA: African Group on Atmospheric Sciences
Session 3 Poster

Sensitive of spaceborne NO\textsubscript{2} observations to coal mining and production over the Kuznetsk Basin

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Author list (excluding presenting author)
Lev D. Labzovskii(1); Alessandro Damiani(2)

Abstract
Coal use emits greenhouse gas and degrades air quality, two major environmental problems. The effects of industries in the Kuznetsk Basin (Kuzbass) located in Siberia, among the world’s largest exploited coal basins, on atmospheric pollution are unknown. This study reports observation of Kuzbass using space-borne measurements of night lights and NO\textsubscript{2}, which reveal a long-term (2005–2018) regional tropospheric NO\textsubscript{2} anomaly. The spatial coincidence of NO\textsubscript{2} and night lights indicates that the anomaly is attributable to an agglomeration of coal quarries and the cities in Kuzbass with economies that are heavily reliant on coal. A positive relationship between the trends in NO\textsubscript{2} and coal production suggests that the NO\textsubscript{2} anomaly was driven by activities related to coal, where a ~1.0% increase in annual coal production raised NO\textsubscript{2} by ~0.5%–0.6%. Specifically, as coal production accelerated from 2010 onward, NO\textsubscript{2} levels over Kuzbass increased correspondingly in 2010–2014 (7%) and 2015–2019 (15%), compared with 2005–2009. Conversely, Siberian cities lacking a coal industry followed the global trend of reducing NO\textsubscript{2} for the same periods (~5% and ~14%, respectively), driven by improvements in fuel combustion. Our results demonstrate that coal mining and production can induce tropospheric NO\textsubscript{2} anomalies that can be detected from space.

Early Career Scientist

NO, I am not an early career scientist.
Session 3 Poster

Hydrochloric acid emission dominates inorganic aerosol formation from ammonia in the Indo-Gangetic Plain during winter

Miss Pooja V Pawar
Indian Institute of Tropical Meteorology (IITM), Pune, India. Kalinga Institute of Industrial Technology (KIIT), Bhubaneshwar, India

Author list (excluding presenting author)
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Abstract
The Winter Fog Experiment (WiFEX) was an intensive field campaign conducted at Indira Gandhi International Airport (IGIA) Delhi, India, in the Indo-Gangetic Plain during the winter of 2017-2018. Here, we report the first comparison in South Asia of the high temporal resolution measurements of ammonia (NH₃) along with water-soluble inorganic ions in PM₂.₅ and corresponding precursor gases made at the WiFEX research site, using the Monitor for AeRosols and Gases in Ambient Air (MARGA) and high-resolution simulations with Weather Research and Forecasting model coupled with chemistry (WRF-Chem). The hourly measurements were used to investigate how well the model captures the temporal variation of gaseous and particulate water-soluble species and gas-to-particle partitioning of NH₃, using the Model for Simulating Aerosol Interactions and Chemistry (MOSAIC) aerosol scheme. The model frequently simulated higher NH₃ and lower NH₄⁺ concentrations than the observations, while total NH₃ variability agreed well with the observations. Under the winter conditions of Delhi, high concentrations of hydrochloric acid (HCl) in the ambient air are found to dominate the gas-to-particle partitioning, as NH₃ is usually in excess. The default model set-up of WRF-Chem excludes anthropogenic HCl emissions, so sulfuric acid dominates the gas-to-particle partitioning with NH₃ during the simulation period. The sensitivity experiments, including HCl emissions in the model, showed that the inclusion of HCl emissions improves the simulated gas-to-particle conversion rate of ammonia by 24% while reducing the bias in gas phase NH₃ by 10%. Nevertheless, even with waste burning HCl emissions included, we find that WRF-Chem still overestimates sulfur dioxide and nitrate formation and underestimates sulfate, nitrous acid, nitric acid, and HCl concentration in which it interacts, thus limit the gas-to-particle conversion of NH₃ to NH₄⁺ in the model. This indicates that modeling of ammonia requires a correct chemistry mechanism with accurate emission inventories for the industrial HCl emissions.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Session 3 Poster

Impact of Covid-19 lockdown on air quality of Dhaka city: an in-depth investigation

Professor Dr Biswas K Farhana
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Author list (excluding presenting author)
Raisa Binthe Ahmed (1); Md Firoz Khan (1); Saiful Momen (1); Syedul Hoque (2)

Abstract
During Covid-19 pandemic, countries worldwide faced a mandatory lockdown, which led to a reduction in anthropogenic activities. In addition, numerous studies have demonstrated that lower emissions caused improved air quality globally due to fewer emission sources. While this scenario holds for developed and developing nations, the monthly Air Quality Index (AQI) remained unhealthy in Dhaka city, despite the halt in anthropogenic processes. This research aims to properly quantify the impact of the lockdown on the air quality in Dhaka city (PM$_{2.5}$, PM$_{10}$ and tropospheric NO$_2$) compared to business-as-usual utilizing ground monitoring stations and satellite observations; separated into pre-lockdown, lockdown, and post-lockdown. Data were collected from AirNow (2018 to 2020) using Clean Air Monitoring Stations (CAMS) maintained by the USEPA at the US Embassy Dhaka, and from the CAMS maintained by the Department of Environment (DoE) at Bangladesh Agricultural Research Council (BARC) and Darussalam (2015, 2018 to 2020). Also, satellite data for tropospheric NO$_2$ was collected from TROPOMI onboard the Copernicus Sentinel-5 Precursor (2019 to 2020). Levels of PM$_{2.5}$, PM$_{10}$, and NO$_2$ were found to reduce during the lockdown compared to the pre- and post-lockdown period in 2020. However, similar pattern was observed historically. Tropospheric NO$_2$ columns showed an insignificant fall of 1.10e+14 molecules cm$^{-2}$ during lockdown compared to 2019. For Darussalam, the absolute mean difference is 1.61e+15 molecules cm$^{-2}$, and for the US Embassy, it is 2.10e+15 molecules cm$^{-2}$. While a significant 60 to 80% decline in PM$_{2.5}$ abundance was noted for 2020, but, in 2019 a similar decline (30-60%) had been observed; thereby the absolute difference was only 16µg m$^{-3}$. Hence the pollutant reduction is not statistically significant compared to historical data. Results of our research indicates the existence of hidden emission sources of air pollutants in Dhaka city that remained operational even during the lockdown.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group

COVID-19 related abstracts
yes
Chemical characteristics of atmospheric particulates collected in low-income urban settlements in South Africa

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Chemical Resource Beneficiation, North-West University, Potchefstroom, South Africa

Author list (excluding presenting author)


Abstract

An important source of atmospheric particulate matter (PM) in South Africa is household combustion for space heating and cooking, which predominantly occurs in low-income urban settlements. The aim of this study was to conduct a detailed size-resolved assessment of chemical characteristics of aerosols associated with household combustion through the collection of particulates in low-income urban settlements in South Africa in order to quantify the extent of the impacts of atmospheric pollution. Outdoor and indoor aerosols in different size fractions were collected during winter and summer in four low-income urban settlements located in the north-eastern interior of South Africa. The highest concentrations of particulates were measured indoors with the highest mass concentration determined in the indoor PM2.5-10 (coarse) size fraction. However, the highest mass concentrations were determined in PM1 in all outdoor aerosol samples collected during winter and summer. Significantly higher concentrations were determined for SO4^2- in outdoor and indoor particulates compared to other ionic species, while SO4^2- occurred primarily in the PM1 size fraction. The combined concentrations of trace elements were higher for indoor particulates compared to outdoor aerosols, while the total trace element concentrations in PM1 were substantially higher than levels thereof in the two larger size fractions. PM1 collected during all sampling campaigns had the highest organic- and elemental carbon (OC and EC) concentrations. The highest concentrations were recorded during winter for most chemical species, which can be attributed to changes in meteorological patterns and increased household combustion during winter. It was estimated that dust is the major constituent in all size ranges of particulates, while trace elements were the second most abundant. Mass concentrations and chemical concentrations determined for aerosols collected in low-income settlements reflect the regional impacts of anthropogenic sources in the north-eastern interior of South Africa, as well as the influence of local sources.
Achieving continuous measurement of Asian VOC emissions, including oxygenates, on Hateruma Island

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Author list (excluding presenting author)
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Abstract

Volatile organic compounds (VOCs) are key precursors of climate-relevant constituents, such as tropospheric ozone and secondary organic aerosol, and regulate atmospheric oxidative capacity. Long-term and high-frequency monitoring of VOCs is crucial for understanding their sources/sinks, but such measurements are generally limited to some non-polar compounds (e.g., light-weight non-methane hydrocarbons (NMHCs)) and are very few for polar compounds (e.g., alcohols, aldehydes and ketones) due to limitations in measurement techniques, difficulty maintaining sample integrity and the instability of calibration standards. In this study, we developed a new instrumentation for comprehensive VOC measurement using a new, bespoke thermal desorption unit (Uni-goat) combined with a multidimensional gas chromatograph (GC) with multiple detectors (mass selective detector (MSD) and two flame ionization detectors (FIDs)). The Uni-goat GC/MSD/FIDs system was deployed in June 2021 at Hateruma monitoring station (HAT) on Hateruma Island, located over 1000 km southwest of Japan mainland. All the operations including de-humidification and calibration were automated.

With its remote location and a climate classified as a tropical rainforest climate, HAT is clearly a difficult location for long-term, unattended measurements. Measurements of this range of VOC are globally sparse, and HAT presents a significant analytical challenge. Here we describe our approach and innovations for measurement and calibration, which have allowed for the installation of an instrument more comprehensive even than any UK measurement site, during a time of severely restricted international travel.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities


IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Session 3 Poster

Sources of pollutant emissions affecting air quality in rural and urban areas in northern Africa.

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Abstract

Aerosol particles play an essential role in the atmosphere because of their impact on air quality, human health, and climate-related processes. However, the characterization and the identification of natural and anthropogenic atmospheric particles can be challenging due to the complex mixture occurring during atmospheric transport. Some studies reporting measurement at background remote sites have been reported mostly in central Europe, Asia, and North America. However, few studies exist in African regions despite their diversity in natural and anthropogenic emissions. In this study, filter samples were collected during an intensive campaign at the three sites in Middle Atlas region in Morocco simultaneously: Atlas Mohammed V (AMV) observatory, a newly established research station located at high altitude (2100 m.a.s.l) in the Atlas Mountains, and two suburban sites located at Fez-city. Particulate matter (PM10) was collected in September-October 2019 using a high-volume (HV) collector with a PM10 inlet 12h sampling. The chemical composition of the samples was analyzed for particulate mass, trace metals, inorganic ions, organic and elemental carbon, and a wide range of organic species. The results show that urban pollution in Fez contributes to an increase in PM10 concentration by up to 55% compared to AMV during the sampling period. The chemical composition of PM10 is dominated by inorganic species such as mineral dust (48-65%) and organic matter (10-24%). Fez's urban site was characterized by anthropogenic tracers (up 62%) such as Zn, Pb, Ni, levoglucosan and 4-nitrophenol, anthracene and indicating biomass burning, typical for industrial emission, waste incineration, and other combustion processes. Moreover, biogenic organics contributed up to 40% of the identified organic matter with high contributions of terpene SOA tracers such as pinic and pinonic acid, resulting from plant wax abrasion in the surrounding forests.

Early Career Scientist

YES, I am an early career scientist.
Session 3 Poster

Global and European inventories of anthropogenic emissions of greenhouse gases and air pollutants for the Copernicus atmosphere monitoring service (CAMS)

Antonin Soulie
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Author list (excluding presenting author)
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Abstract

During the past few years, Europe has developed a program called Copernicus dedicated to the forecast and monitoring of land, oceans and the atmosphere. As part of Copernicus, the Copernicus Atmosphere Monitoring Service (CAMS) provides consistent and quality-checked data of air quality, solar energy, greenhouse gases and climate forcing all over the globe.

The models used in CAMS simulate the distribution of greenhouse gases and air pollutants to provide air-quality forecasts and historical reanalyses. To do so, these models need air pollutants and greenhouse gases emissions data as input. In order to drive the CAMS models, several emissions inventories have been developed. A global anthropogenic emissions dataset has been developed for the major atmospheric pollutants (including 25 speciated VOCs), for the 2000-2022 period, for several sectors. The emissions are provided at a 0.1x0.1 degrees resolution on a monthly basis. A regional inventory of European emissions has also been developed for the 2000-2018 period at a spatial resolution of 0.1x0.05 degree for fifteen sectors. Both global and European temporal profiles of emissions are also provided, taking in account the impact of meteorological conditions on emissions as well as human activities variations. In addition of these inventories, emissions from ships based on ship automatic identification systems are now available both at the regional and global scales, on a daily basis and at a 0.1x0.1 degree spatial resolution. Adjustment factors to account for the lockdowns in different countries during the Covid-19 pandemic have been developed at the global and regional scales. All these datasets will be described, together with an evaluation of the emissions datasets and their consistency at the global, regional and country scales. The access to these datasets and the tools for visualization and download using the ECCAD (Emissions of atmospheric Compounds and Compilation of Ancillary Data) database will be described.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

GEIA: Global Emissions Initiative

COVID-19 related abstracts

yes
Session 3 Poster

Towards an integrated anthropogenic emission inventory for China

Phd candidate Yijuan Zhang
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Author list (excluding presenting author)
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Abstract

Despite pollution mitigation strategies in China, ground-level ozone increased in recent years. At the same time, persistent growth in anthropogenic NMVOCs (non-methane volatile organic compounds) emissions occurred. Changes in air quality levels calculated by chemistry transport models are driven substantially by the adopted emission inventory. In this study, we compare ozone precursors' emissions, e.g., nitrogen oxide (NOx), carbon monoxide (CO), and NMVOCs in three bottom-up anthropogenic emission inventories. A regional inventory, the Multi-resolution Emission Inventory for China version 1.3 (MEICv1.3), is adopted for long-term local mitigation estimates for China. Two global inventories, the Copernicus Atmosphere Monitoring Service emissions version 5.3 (CAMSv5.3) and the Community Emissions Data System (CEDS), are adopted for various sectoral emissions.

Temporal emission trends based on the MEIC inventory are -2.4%/yr for NOx, -3.8%/yr for CO, and +1.3%/yr for NMVOCs between 2008 and 2020. Differences in the annual total emissions over China in the three inventories are estimated to vary from -9.2% to -4.2% for NOx, -10.5% to 3.9% for CO, and -0.3% to 2.4% for NMVOCs. The differences between inventories and the derived emission trends under consideration are of the same magnitude, therefore the uncertainties need to be identified and further reduced.

Our aim is to develop an integrated anthropogenic emission inventory for China, with policy-relevant trends and background emissions based on global datasets. We define activity sectors based on the IPCC sectors and aggregate them when appropriate. NMVOCs were speciated according to the MOZART mechanism for ozone simulation. The Weather Research and Forecasting/Chemistry model (WRF-Chem) was applied to evaluate the performance (indicated by ozone, NO2, and CO concentrations) of the three candidate inventories toward developing an improved integrated inventory. The integrated inventory will facilitate the simulation of long-term ozone trends in China and avoid modeled discrepancies associated with uncertainties in emission inventories.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report, GEIA: Global Emissions Initiative, CCMi: Chemistry Climate Model Initiative
IGAC Regional Working Groups

China Working Group
Session 3 Poster

Speciated VOC emissions from road transport

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Author list (excluding presenting author)

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Abstract

The UK’s National Atmospheric Emissions Inventory (NAEI) is used for understanding compliance with legally binding emissions targets and in aiding the identification of policy to achieve them. The accuracy of emissions inventories is generally assessed through real-world measurements. In the case of non-methane volatile organic compounds (NMVOCs), there is a distinct lack of verification for the road transport sector. Seasonal, fleet average emission factors of speciated NMVOCs for road transport were calculated via a roadside increment-type analysis in Manchester, UK, using the new, University of York mobile measurement platform. Ethanol had a significantly higher emission factor than typical vehicle-use tracer aromatic species which was in major disagreement with the NAEI. This highlighted the outdated speciation methodology for NMVOCs in the inventory and suggested a large underestimation of evaporative emissions from road transport. This was attributed to the reduced effectiveness of the carbon canister emissions control technology in trapping evaporated NMVOCs due to the recent introduction of bioethanol into petroleum blends. The resulting exceedance of NMVOC emissions standards will have had implications on atmospheric chemistry and air quality. Considerable improvements in emissions testing and emissions control technology are recommended in light of these findings.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality, AMIGO: Analysis of eMissions usinG Observations
Volatile Organic Compound (VOCs) in ambient air and its effect to the environment and human health

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Author list (excluding presenting author)

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Abstract

Volatile organic compounds (VOCs) has been recognised as one of the major air pollutants in ambient air that participate in atmospheric photochemical processes. This study focuses on determining the variation of VOCs in Malaysia. This study also aims to investigate the correlation of VOCs with other pollutants, identify the potential emission sources of VOCs, and evaluate the human health effects due to VOC exposure. The concentration of 29 selected VOCs in the ambient air is obtained from 10 continuous air quality monitoring stations belonging to the Malaysian Department of Environment (DOE). The Positive Matrix Factorization (PMF) model is applied to identify the potential VOC emission sources in the ambient air. The data obtained from continuous monitoring is also used to quantify the Ozone Formation Potential (OFP). The health risk assessment (HRA) method is used to calculate the hazard quotient (HQ) for non-carcinogenic and the life-time cancer risk (LTCR) of BTEX. The expected result of this study is that the concentration of VOCs recorded the highest concentration in urban areas, with motor vehicles and industrial activities being the major sources of VOCs. Several types of VOCs are predicted to influence the formation of ambient ozone and secondary organic aerosols. The concentration of BTEX as the major component of VOCs is expected to contribute to the acute and carcinogenic effect on human health.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group

COVID-19 related abstracts

no
Assessment of Reductions in Emission-driven Air Pollution during three largest Mega-events and Wuhan COVID-19 Lockdown of China

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Author list (excluding presenting author)
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Abstract

Quantifying and comparing the effectiveness of different emission control strategies can provide insights for policy design and air quality management. In our previous work, we developed a wind-pollution decomposition (WPD) method that provides a robust tool to quantify meteorology-driven and emission-driven impacts on air quality changes. In this study, we applied this method to quantify emission-driven impacts on the observed air quality changes during the three largest international socioeconomic mega-events in China, namely, Shanghai World Expo in 2010, Beijing Olympic Games in 2008, and Guangzhou Asian Games in 2010. We also applied the method to the air quality variation during the lockdown period in Wuhan due to COVID-19 and compared the emission-driven impacts on air quality among these events. The results quantitatively show that the emission-driven factor generally played a much stronger role (>86%); the meteorology-driven factor promoted pollution mitigation during Wuhan, Beijing and Guangzhou events but worsened the air quality during Shanghai event. The emission-driven pollution reduction was largest in the Wuhan COVID-19 lockdown (64% NO2, 54% PM2.5 reductions), followed by Beijing Olympics (42% PM2.5, 31% NO2 reductions). The Wuhan COVID-19 impact on air quality improvement is not as effective as expected especially for O3, which implies the difficulty of air quality attainment under normal, non-lockdown days. Comparison of these events show that shutdown or emission control measures applied to industries and power plants were generally benefit for PM2.5, SO2 and NO2 reduction, while those applied to on-road traffic control are less-effective for reducing NO2 and not works for the mean O3 reduction. The results imply that advanced control measures for vehicle exhaust and control strategies considering the interaction between O3 and NOx/VOC/PM are necessary. In addition, the ongoing supervision of control strategies implementation is one of the key issues for future air quality management in China.

Early Career Scientist
YES, I am an early career scientist.

IGAC Regional Working Groups
China Working Group

COVID-19 related abstracts
yes
Session 3 Poster

Using multi-year datasets of daily scale satellite and in-situ flux observations to estimate NOx emissions on a provincial scale in energy rich northern China

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Author list (excluding presenting author)

Jason B. Cohen(2), Qin Kai(2), Hong Geng(1)

Abstract

Nitrogen oxides are strong makers of anthropogenic combustion-related pollution. They contribute to ozone, secondary aerosol production, and acid rain. NOx Emission inventories provide crucial information for atmospheric environmental protection policy makers and are a necessary input for air quality models. We present a new model-free mass-conserving inverse method specifically designed to use daily Tropospheric Monitoring Instrument (TROPOMI) observations of NO2 column concentrations and fluxes from the continuous emissions monitoring systems (CEMS) to rapidly invert emissions of NOx on a spatial scale of (0.05° × 0.05°) over Shanxi, a major energy producing province in Northern China. The top-down inversion method quantifies horizontal advective transport at 0.7±0.3 km/d and first order chemical loss of 13.1±0.8 hours, consistent with a non insignifiant amount of NOx emissions advected into the free troposphere, where it is colder and the lifetime tends to be longer. The inversion method is applied daily from 2019 through 2021, yielding an emissions of 0.58±0.17 µg/m²•s, 0.53±0.24 µg/m²•s, 0.46±0.13 µg/m²•s for each year respectively. Our emissions are found to compare well with multiple a prior inventories. In specific, we find that the Taiyuan Basin has a high average NOx emissions, spread roughly uniformly in space over a larger area than given by the a priori datasets. In general, there is a large increase found in cleaner regions, residential regions, and regions thought to be emissions-free, overcompensating a decrease at well-controlled steel, coke and power plants. Using satellite observations for emission estimates has important advantages for spatially consistent, high temporal resolution, and enable updates quickly follow the satellite and CEMS data. Finally, multiple special events are observed in the inverted emissions datasets that occur at the daily to weekly scale, which will also be discussed.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

CCMi: Chemistry Climate Model Initiative

IGAC Regional Working Groups

China Working Group
Estimation and evaluation of biogenic volatile organic compound emissions from urban green space in China

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Author list (excluding presenting author)

Yang Gao (1)

Abstract

Biogenic volatile organic compounds (BVOCs), the largest source of VOCs emissions globally, play vital roles in modulating atmospheric chemistry and the formation of ozone and secondary organic aerosol (SOA). A large number of previous studies have quantified BVOC emissions. However, the source of BVOC emissions in the urban areas, urban green space BVOC (U-BVOC) emissions, is largely neglected due to relatively coarse landcover type data. In this study, the first U-BVOC emission inventory in China was developed based on ultra-fine landcover dataset at a spatial resolution of 10-m. This U-BVOC emission inventory has a spatial resolution of 27 km, while a high resolution of 1 km is applied in areas with dense U-BVOC emissions, such as the North China Plain (NCP), the Yangtze River Delta (YRD) and the Pearl River Delta (PRD)). Our results show that nationwide U-BVOC emissions account for only 0.1% of natural BVOC emissions, but they are mainly distributed in developed regions with high ozone pollution. In particular, the interannual variability in developed regions such as NCP fits well with recent ozone trend changes, emphasizing its potential key role in driving ozone formation.

Early Career Scientist

YES, I am an early career scientist.

IGAC Regional Working Groups

China Working Group
The impact of extreme weather events and emissions on ozone in urban and rural areas under a warming climate

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Author list (excluding presenting author)

Mingchen Ma (1); Feifan Yan (1); Xinran Zeng (2); Junxi Zhang (3)

Abstract

Ozone pollution has been a major air pollution issue in China, and the ozone pollution has become more severe recently despite of emission reductions. Previous studies on ozone pollution primarily focus on the characterization of ozone on regional scales, however, to what extent the emissions may exert different influences on ozone over urban and suburban-rural areas is not clear. In this study, based on a series of numerical simulations, we first identify the synergic effect of anthropogenic emissions and biogenic emissions, under the modulation of extreme weather events, on ozone concentrations in typical ozone pollution prone regions. Following that, we examine the mean ozone concentrations over the suburban-rural and urban areas due to changes in emissions under the Shared Socioeconomic Pathways (SSPs). The strongest response to emission changes is found in SSP1-2.6, in which anthropogenic emission reduction leads to lower MDA8 ozone concentrations in the suburban-rural than urban areas, reversing the present state of higher ozone concentrations in the suburban-rural areas. The findings indicate different responses of ozone in urban and suburban-rural areas to changes in emissions.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Regional Working Groups

China Working Group
Replacing the greater evil: can legalizing decentralized waste burning in improved devices reduce waste burning emissions for improved air quality?

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Author list (excluding presenting author)
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Abstract
Open waste burning emissions constitute a significant source of air pollution affecting human health in India. In regions where cleaner fuels have displaced solid biofuel usage, open waste burning is rapidly becoming one of the largest sources of airborne human class I carcinogens and particulate matter. As the establishment of waste management infrastructure in rural India is likely to take years, we explore whether health-relevant emissions can be reduced by legalizing the burning of dry non-biodegradable waste in improved devices. We measure emission factors of 76 VOCs, CH4, CO, and CO2 from different types of waste burned in two different improved devices, a burn basket and a local water heater. Based on our experiments, we create four “what-if” intervention scenarios to assess the improvement of air quality due to the emission reductions that can be accomplished by four management strategies. We find that substituting the traditional, more polluting water heating fuels with dry plastic waste across rural India can reduce primary emissions (e.g., \(-29 \text{ Ggy}^{-1}\) for benzene) and ozone formation potential (\(-3420 \text{ Ggy}^{-1}\)) from open waste burning. When dry waste is used in lieu of more polluting fuels, and it’s burning serves a purpose, the net class-I carcinogen benzene emissions would be halved compared to the present, while emissions for class-I carcinogen 1,3 butadiene would become net negative. This happens because of the emission avoided, when part of the solid biofuel currently used in rural India is replaced by plastic waste, exceed the waste burning emissions of this compound by so much, that residential sector emission reductions offset all waste burning emissions including those of landfill fires. Our study demonstrates that India’s air quality can be improved by permitting and promoting the use of dry packaging waste in lieu of traditional biofuels and by promoting improved burning devices.

Early Career Scientist
YES, I am an early career scientist.

IGAC Activities

AMIGO: Analysis of eMIssions usinG Observations, GEIA: Global Emissions Initiative

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Session 3 Poster

Influence of COVID-19 Conditions on Ozone Chemistry of Delhi

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Author list (excluding presenting author)

Chhemendra Sharma 1,2

Abstract

Climate change is the hottest topic in the present world. The world uses every possible move to cut emissions to address it. The COVID-19 pandemic is also a scorching topic in the present world due to its severe health impact, which shattered millions of human lives. COVID-19 negatively impacted human health and wealth but predominantly positively on the environment. Many most polluted regions of the world experienced a clear sky during the pandemic period due to reductions in anthropogenic emissions. Several studies related to pollutant level alteration during the pandemic period have been conducted, which pointed out the quantitative change in the ambient pollutant levels. The present study focuses on changes in ozone chemistry during the pandemic lockdown period (April to June 2020). For the analysis, Central Pollution Control Board, Shadipur Station data was used, along with the meteorological parameters from March 2020 to June 2020 period.

The study showed that the mean surface ozone concentration during the lockdown period over the city decreased by 18% during the daytime, while an increase of 38% was recorded in the background or nighttime ozone level. Previous studies reported that both NOx and NMHCs concentrations influence the ozone production over Delhi, but majorly it is controlled by NOx. During the lockdown period, the calculated NMHC to NOx ratio was substantially lower than pre-lockdown, which indicated a shift in ozone sensitivity regimes. But still, the calculated ratio suggested that NOx is the primary regulator of ozone production over Delhi. The calculated photo-stationary state (Φ) values for the pre-lockdown period showed a positive deviation from unity, while during the lockdown period, the Φ values showed proximity to unity. Which suggested that the ozone formation during the lockdown period is majorly controlled by the NOx.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities


IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group

COVID-19 related abstracts

yes
Source identification and health risk assessment of PM$_{2.5}$-bound heavy metals in residential environment of Dhaka, Bangladesh

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Department of Chemistry, University of Dhaka, Bangladesh

Author list (excluding presenting author)
Farah Jeba (1); Tasrina Rabia Choudhury (2); Bilkis Ara Begum (2); Abdus Salam (1)

Abstract

This study aims to develop a better understanding of indoor exposure of PM$_{2.5}$-bound heavy metals and the associated health risk in residential environment of Dhaka, Bangladesh. Indoor PM$_{2.5}$ samples were collected for 24 hours from six locations across Dhaka city using SIBATA mini volume sampler (Model: MP-$\Sigma$500 NII, Japan) to quantify six metals (Pb, Cr, Zn, Fe, Cu, and Mn) by Atomic Absorption Spectroscopy (AAS). The 24-hour average PM$_{2.5}$ concentration was 100± 19.4 µgm$^{-3}$, with a range of 77.1 µgm$^{-3}$ to 123 µgm$^{-3}$. The mean concentration of heavy metals followed the order: Zn (2201± 967 ngm$^{-3}$) > Fe (1489± 955 ngm$^{-3}$) > Pb (288± 137 ngm$^{-3}$) > Mn (182± 365 ngm$^{-3}$) > Cu (109± 92.7 ngm$^{-3}$) > Cr (73.1± 49.8 ngm$^{-3}$), where Zn and Fe jointly contributed 85% to the total detected heavy metals in indoor PM$_{2.5}$. Enrichment factor analysis showed that, Pb, Cr, Zn, and Cu had anthropogenic origin, whereas Fe and Mn originated from crustal sources. Positive Matrix Factorization (PMF) model resolved four sources of PM$_{2.5}$-bound heavy metals, namely vehicular emission (4.8%), crustal sources (17.6%), Zn source (44.6%), and mixed source (32.9%). Health risk assessment of heavy metals revealed that, children were at 2.18 times greater non-carcinogenic risk than adults, the hazard index (HI) for children and adults being 8.28 and 3.79, respectively. Mn had the highest hazard quotient (HQ) contribution (85%) among the measured heavy metals. The carcinogenic risk was 5.18× 10$^{-4}$, which was higher than the acceptable limit (1× 10$^{-6}$) and indicated that, 1 in 1930 individuals had a possibility of developing cancer in his lifetime. The total cancer risk was almost entirely (99%) contributed by Cr. The average hazard ratio (HR) for indoor PM$_{2.5}$ was 6.68 (>1), which implied severely deteriorated indoor air quality in residential homes of Dhaka, Bangladesh.
Session 3 Poster

NO$_2$ variation during the COVID-19 lockdown over Poland from TROPOMI and OMI - a comparison of the major Polish cities.

Emeka Ugboma
Institute of Geophysics, Faculty of Physics, University of Warsaw, Pasteura 5, 02-093, Warsaw, Poland

Author list (excluding presenting author)

Iwona S. Stachlewska (1); Philipp Schneider (2); Kerstin Stebel (2).

Abstract

In recent years, increased public and global interest in addressing air quality issues has resulted from COVID-19 restrictions on social interaction and the global economy. One of the major air pollutants that absorbs visible sunlight and impairs visibility is NO$_2$. Retrievals from the Sentinel-5P/TROPOMI vertical column were utilised in this study to investigate NO$_2$ pollution in Poland between March 16 and June 30, 2020, when COVID-19 restrictions were imposed. Based on long-term year-to-year variability derived from OMI vertical column NO$_2$ (2010-2020), we assess a negligible effect resulting from COVID-19 restrictions. The relative change of 2020 vs the average of 2010–2019 for selected Polish cities revealed a significant drop in NO$_2$ concentration during the lockdown. In June, Warsaw reported an 85% drop; 77% in Bialystok; 73% in Katowice; 59% in Lodz; 45% in Krakow; and a 37% drop in Wroclaw. Our seasonal assessment shows that NO$_2$ pollution levels are clearly higher in the autumn months than in the summer months in these years. Furthermore, when compared to the NO$_2$ pollution levels seen throughout the autumnal seasons of 2018, 2019, and 2020, the summer months reveal a distinct pattern of NO$_2$ levels, as observed by the satellites. These improvements present an interesting potential for Poland’s air quality monitoring.

Early Career Scientist

YES, I am an early career scientist.

COVID-19 related abstracts

yes
Roles of regional transport and boundary layer mixing in aerosol pollution observed above Shanghai urban canopy over the COVID-19 lockdown period

Zhen Song
Fudan University, Shanghai, China

Author list (excluding presenting author)

Wei Gao (2); Yali Jin (1); Hongru Shen (1); Chenqi Zhang (1); Hao Luo (1); Liang Pan (2); Bo Yao (1); Minde An (5); Yijun Zhang (1, 6); Juntao Huo (3); Yele Sun (4); Jianmin Chen(1); Yusen Duan (3); Defeng Zhao (1); Jianming Xu (2)

Abstract

Covid-19 lockdowns led to a significant decrease in local emissions all over the world. However, several pollution episodes from late Jan. to early Feb. 2020 still occurred in Shanghai, China. This work investigated the source of aerosols in Shanghai during the Covid-19 lockdown period based on the observation of aerosol chemical composition at a site of Shanghai Tower (609 m above ground level) and a nearby ground site (3.2 km away). The site of Shanghai Tower is proved to represent a regional characteristic. By correlation analysis between the two sites and diurnal variations of vertical ratios for aerosol species, it was found that the regional transport (air masses mostly originated from northern areas and East China Sea) provided the most aerosol species (sulfate, nitrate, ammonium, and organic aerosol), and the subsequent vertical mixing process within planetary boundary layer contributed significantly to aerosol pollution in Shanghai. We highlight the importance of measurements at high altitudes and the demand for regional joint prevention and control of pollutant emissions in the future.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

China Working Group

COVID-19 related abstracts

yes
Aerosol layer height retrieval using Advanced Himawari Imager (AHI), and analysis of aerosol-related variables to improve the accuracy of tropospheric NO2 vertical column density from GOSAT-GW

Hyunkwang Lim
National Institute for Environmental Studies (NIES), Japan

Author list (excluding presenting author)
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Abstract

In order to retrieve aerosol layer height (ALH) from the satellite, the absorptions in the O2-O2 and O2-A/B bands or multi-angle observation are generally used. Since the geostationary earth orbit satellites are advantageous in understanding the diurnal changes in ALH, we have developed a new method to retrieve ALH using Advanced Himawari Imager (AHI), a single passive imager onboard on Himawari-8 and 9. Before retrieving the ALH, aerosol optical properties (AOPs) are retrieved using the green to near-infrared bands, which are relatively insensitive to ALH. The retrieved AOPs are used as an input to the radiative transfer calculation to compute the top-of-atmosphere (TOA) reflectance of the highly sensitive band. Then, the ALH is retrieved using the observed and calculated TOA reflectances. Since the retrieval accuracy of aerosol optical depth over the ocean is better, the retrieval is performed only over the ocean during the KORUS-AQ period. The retrieved ALH is validated using the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) and the High Spectral Resolution Lidar (HSRL).

The AOPs including ALH, significantly affect the accuracy of tropospheric air mass factor (AMF), hence can have substantial impacts on the satellite-derived tropospheric NO2 vertical column density (VCD). Therefore, our aim further extends to better estimation of the tropospheric AMF by using the aerosol-related variables of the GOSAT-GW to be launched in 2024. As proxy data, we use the TROPOMI dataset and calculated the AMF considering aerosol-related variables by using a linearized pseudo-spherical vector discrete ordinate radiative transfer code (VLIDORT) version 2.7. Finally, our AMF and tropospheric NO2 VCD were evaluated with the TROPOMI operational products and the ground-based MAX-DOAS observations.

Early Career Scientist

YES, I am an early career scientist.
Algorithm to estimate aerosol concentration with image analysis techniques: SNAP-CII

Dr. Tomohiro O Sato
National Institute of Information and Communications Technology, Japan

Author list (excluding presenting author)
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Abstract

Aerosols play an important role for the radiative forcing, such as scattering and absorption of sunlight and cloud condensation, and they, especially PM$_{2.5}$, are also suggested to increase morbidity and mortality. In this study, we develop an algorithm, named SNAP-CII, to estimate aerosol concentration from sky image data. The SNAP-CII algorithm enables us to measure aerosol concentration with commonly used cameras even in places where it is difficult to install specialized equipment such as sky radiometer.

A machine learning model was developed to classify aerosol concentration into three classes using the sky image data. The reflectance and pixel value ratio were calculated to extract the difference in scattering by aerosols depending on wavelength. The reflectance was derived by dividing the luminance by the illuminance. The illuminance was derived by applying a bilateral filter to the reference image data that was given in sunny and low aerosol concentration condition.

The aerosol concentration was given by the suspended particle matter (SPM) data measured by the Atmospheric Environmental Regional Observation System (AEROS). We used the data with global solar irradiance (GSI) and diffuse solar irradiance (DSI) observed by Himawari-8 satellite to select sunny condition with criteria of GSI > 550 W/m$^2$ and DSI/GSI < 0.15.

We developed random forest model to classify three classes of aerosol concentration from sky image data. The image data obtained at 10 sites in Japan were applied to our model. The sample data in one year were divided into training and test data with a ratio 6:4. The accuracies for the 10 sites were 56%~68%. To validate our model for measurement of the same area with different directions, we installed three cameras at Kitakyushu city. The repeatability, defined as ratio of number of samples those give the same classification result and number of total samples, was 78%.

Early Career Scientist

NO, I am not an early career scientist.
Session 3 Poster

**Analysis of the COVID-19 influence on an air quality in urban cities in Japan with multiple satellite and ground-based measurements**

Dr. Tamaki Fujinawa  
National Institute for Environmental Studies, Japan

**Author list (excluding presenting author)**  
Satoshi Inomata (1); Takafumi Sugita (1); Kohei Ikeda (1); Hiroshi Tanimoto (1)

**Abstract**

Nitrogen dioxide (NO$_2$) is one of the major air pollutants and is harmful to human health. It is mainly emitted from anthropogenic sources and play a key role in the photochemical reaction of tropospheric ozone. Therefore, ambient NO$_2$ concentrations are monitored by a variety of instruments at ground-based, airborne, and satellite platforms. The COVID-19-driven lockdowns were implemented in many countries at the beginning of 2020, resulting in dramatic (26-67%) decline in the tropospheric NO$_2$ level. (Gkatzelis et al., 2021). For Japan several previous papers suggested the NO$_2$ decline up to about 50% based on in-situ and satellite observations (Ghahremanloo et al., 2020; Ma and Kang, 2020; Fu et al., 2020; Itahashi, 2022), though the lockdown was not strictly implemented as in the other countries (i.e., non-legal movement restriction). In this study, we examined multiple in-situ and satellite observations with the great focus on Japan’s urban cities and found that the decline of NO$_2$ and related species due to the COVID-19-driven movement restriction in the ‘Kanto’ region including the Tokyo metropolitan area. The comparison of the tropospheric NO$_2$ vertical column densities (VCD) in March and April between 2019 and 2020 shows a 30-40% decline in the TROPOMI NO$_2$ VCD. The OMI NO$_2$ data shows a similar declining trend of NO$_2$, though a bias of about $0.4 \times 10^{16}$ molec. cm$^{-2}$ can be seen against the TROPOMI data. Given the instrumental bias of $0.31 \times 10^{16}$ molec. cm$^{-2}$ between OMI and TROPOMI (Wang et al., 2020), the bias derived from our analysis is in reasonable agreement with the previous work, and thus, the decline of the NO$_2$ VCD in March and April in 2020 is not caused by the year-to-year factors but by the reduced emissions driven by the movement restriction.

**Early Career Scientist**

NO, I am not an early career scientist.

**IGAC Activities**

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

**IGAC Regional Working Groups**

Japan National Committee

**COVID-19 related abstracts**

yes
Session 3 Poster

Demystifying carbonaceous aerosols and CO over the Central Himalayas: Synergising about two decades of ground observations

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Author list (excluding presenting author)

Manish Naja (1); T.R. Seshadri (2); Rajesh Sharma (3); Piyush Bhardwaj (3); Hema Joshi (4); Mukunda M Gogoi (5); S. Suresh Babu (5)

Abstract

Long-term ground-based observations of BC, OC, EC and CO are synergistically analysed along with satellite data and model simulations over a high-altitude location in the Central Himalayas (ARIES, Nainital, 29.4°N, 79.5°E, 1958 a.m.s.l.). The derived multispectral site-specific and time-dependent Mass Absorption Cross-section (MAC) values reveal that the site-specific MAC is three times lower than that used in Aethalometer. This in turn implies BC levels to be higher by a factor of 1.5 to 3.5. The long-term (2004-2021) MAC-corrected BC shows a statistically significant decline of ~20 ng m⁻³ year⁻¹. This decline is in stark contrast with positive trends in both surface and columnar BC from MERRA-2, CAMS, emissions inventories (REAS/EDGAR) and Aerosol Optical Depth (CALIPSO/MODIS/OMI). The estimated BC fraction from fossil fuel is found to decline faster than that from biomass burning. Continuous observations of OC and EC made for the first time over this region showed unimodal diurnal variation that induces 70% higher afternoon radiative forcing than forenoon. The primary and secondary OC are estimated from ambient OC and it is shown that annually POC dominates (64%) over the region while SOC has higher springtime concentrations. These aerosol concentrations are shown to rise with higher boundary layer heights and enhanced springtime fire events over the Northern Indian region. A multiple-regression based framework is applied to constraint CO sources and the results are found to perform better than CO from MOPITT and WRF-Chem tracer runs. Vertically, long term observations from CALIPSO and POLDER reveal an elevated aerosol layer at about 2-4 km a.m.s.l. around the region. These observations thus provide a unique long-term characterization of aerosols with implications for radiative forcing in an otherwise sparsely studied complex terrain of the Central Himalayas. This can help constraint models, form mitigation policies and perform epidemiological studies.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities


IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Connecting aerosol composition to health effects

Professor Yinon Rudich
Weizmann Institute, Israel

Author list (excluding presenting author)

Abstract

Secondary organic aerosols (SOAs) formed from anthropogenic or biogenic emissions substantially contribute to the ambient PM2.5 burden, which is associated with adverse human health effects globally. However, there is only limited evidence on their differential toxicological impact. In this study, we tried to discriminate the toxicological effects of secondary organic components from biogenic (β-pinene) or anthropogenic (naphthalene) precursors that condensed on fresh soot particles (SP) using two different lung cell models exposed at the air-liquid interface (ALI). To reach the goal, mono- or co-cultures of lung epithelial cells (A549) and endothelial cells (EA.hy926) were exposed at the ALI for 4h to different concentrations of a photochemically-aged mixture of primary combustion SP coated by β-pinene (SOAβPIN-SP) or naphthalene (SOANAP-SP). The soot/SOA particles were comprehensively characterized to decipher their physical and chemical properties. We conducted toxicity tests to determine cytotoxicity, intracellular oxidative stress, primary- and secondary genotoxicity as well as inflammatory and angiogenic effects. Both investigated SOA types caused significant toxic effects, while the nano-sized soot cores alone showed only minor effects. The toxicological assays indicate greater adverse effects of the SOANAP-SP compared to SOAβPIN-SP in both cell models. We will detail the results of the biological assays and the connection to the chemical composition. Overall, our study shows that SOA compounds increase the toxicity of primary soot particles. Aromatic naphthalene precursors cause the formation of more oxidized, more aromatic SOAs with higher oxidative potential and toxicity than aliphatic β-pinene precursors. Thus, the influence of atmospheric chemistry on the chemical PM composition plays a crucial role in the adverse health outcome of emissions.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report
Spatio-temporal of surface ozone (O$_3$) variations at urban and suburban sites in Sarawak region of Malaysia

Mdm HARTINI MAHIDIN
Department of Earth Sciences and Environment, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, Malaysia

Author list (excluding presenting author)
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Abstract
The Sarawak Region of Malaysia is currently experiencing a high demand for capital needs such as conversion of forest to plantations, new infrastructure, economic development, and improving transportation systems. Those land cover changes will increase primary pollutant emissions and trigger surface O$_3$ formation. Surface O$_3$ is a secondary pollutant and a significant greenhouse gas, contributing to climate change and declining air quality. Variations in surface O$_3$ concentrations at urban and suburban sites in Sarawak were explored in this study using data from the Malaysian Department of Environment spanning a five-year cycle (2015-2019). The primary goal of this study is to ascertain the variation of surface O$_3$ concentrations reported at four monitoring stations in Sarawak, namely Kuching (SQ1) (Urban), Sibu (SQ2) (Suburban), Bintulu (SQ3) (Suburban), and Miri (SQ4) (Suburban). The study also analysed the relationship between O$_3$ distribution and nitrogen oxides (NO and NO$_2$). The findings showed that O$_3$ concentrations observed in Sarawak during the study period were lower than the maximum Malaysian Air Quality Standard of 100 ppbv, except for SQ3, which had an hourly average and daily maximum O$_3$ concentration 12.4 and 110 ppbv, respectively. Further analysis on O$_3$ precursors expected to reveal higher NO$_2$/NO ratios for sampling sites near local petrochemical industrial operations, such as SQ3 and SQ4. The characteristics of nitrogen oxides, notably NO titration, influenced the surface O$_3$ concentration. This research will assist the relevant agency in forecast, monitor, and mitigate the level of O$_3$ in the ambient environment, especially in the Sarawak Region.

Early Career Scientist
YES, I am an early career scientist.

IGAC Activities
TOAR: Tropospheric Ozone Assessment Report

IGAC Regional Working Groups
MANGO: Monsoon Asia and Oceania Networking Group
Session 3 Poster

The impact of environmentally friendly fireworks on the urban air quality and population exposure

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Author list (excluding presenting author)

Ying Li (1,2); Chanfang Liu (3)

Abstract

Fireworks are widely used around the world and the related emissions can cause severe air pollution over a short period of time. Environmentally friendly fireworks have been made world widely to reduce the level of firework-generated air pollution. Research has suggested that the use of environmentally friendly charges in fireworks can reduce emissions, but their impact on ambient air quality has not been quantified. In this study, based on a detailed estimation of emissions from fireworks and dense observations available for simulation validation, we successfully forecast the air quality with a scheduled fireworks display, and assess the benefits of environmentally friendly fireworks in reducing ambient PM$_{2.5}$. Model validation results show that the plume track, peak and lasting time are well predicted. Our results also show that environmentally friendly fireworks can reduce ambient PM$_{2.5}$ by ~50% (in the range of 15–65% with a “central” value 35% considering uncertainties) compared with traditional fireworks. The influencing areas and duration of PM$_{2.5}$ pollution are also reduced. However, due to the large number of fireworks used, the air quality still significantly deteriorated, and the effect of using twice the amount of environmentally friendly fireworks on air quality would be comparable to the use of traditional fireworks. With reduced emission, the impact area of the plume from the fireworks display is about 26 km$^2$ and a total of approximately 0.47 million people were exposed to the fireworks smoke-polluted air in this case. Our results indicate that environmentally friendly fireworks are not actually “green”. To make them green, the total number of fireworks used at one time must be strictly restricted.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

China Working Group

COVID-19 related abstracts

no
Session 3 Poster

Long-term observation of PM$_{10}$, PM$_{2.5}$, and black carbon aerosols at a high-altitude background station in the western North Pacific

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Author list (excluding presenting author)

Neng-Huei Lin

Abstract

Aerosols play an important role in the radiation balance of the earth-atmosphere system. Black carbon (BC), a prominent particle-phase light absorber, is exclusively produced by the incomplete combustions of fossil fuel, biofuel, and biomass. BC-related research has received significant global focus due to its notable impact on regional-to-global climate change. However, the knowledge about long-term changes in PM$_{10}$, PM$_{2.5}$, and BC aerosols in the western North Pacific is very limited. Lulin Atmospheric Background Station (LABS; 23.47°N, 120.87°E; 2862 m above sea level) on the summit of Lulin Mountain in central Taiwan is the only high-altitude background station in the western Pacific region and still operational since the spring of 2006 to study the impact of various air pollutants through long-range transport. Continuous real-time measurements of PM$_{10}$ (2006-2016)/PM$_{2.5}$ (2013-2020) and BC (2008-2020) at LABS were carried out by using the tapered element oscillating microbalances (TEOM 1405; Thermo Fisher Scientific, USA) and an aethalometer (AE-31, Magee Scientific, USA), respectively, in order to investigate their temporal variations, characteristics, and the important factors controlling long-term trend. The influence of meteorological parameters on their monthly/seasonal burden was extensively studied through correlation analysis. Multi-year annual mean mass concentrations of PM$_{10}$, PM$_{2.5}$, and BC were 9.2, 7.2, and 0.4 µg m$^{-3}$, respectively. Based on concentration weighted trajectory analyses, important contributory long-distant source regions for all aerosols at LABS were northern peninsular Southeast Asia and mainland China, particularly during spring (March-May) and northeast-monsoon (October-November), respectively. A slightly downward trend in PM$_{10}$ (-0.35% year$^{-1}$), PM$_{2.5}$ (-0.24% year$^{-1}$), and BC (-0.63% year$^{-1}$) mass concentrations was observed at LABS. This might be due to the decline in the contribution of biomass-burning smoke emissions from peninsular Southeast Asia to the western North Pacific, recent energy policy change in China, and also changes in regional atmospheric boundary layer dynamics.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon
Session 3 Poster

Quantifying NO$_x$ source contributions to aerosol nitrate across the South African air pollution priority areas using nitrogen stable isotopes

Dr Katye E Altieri
University of Cape Town, South Africa

Author list (excluding presenting author)

Jessica Burger (1), Brigitte Language (2), Stuart Piketh (2)

Abstract

In South Africa, the Highveld region and the Johannesburg-Pretoria megacity are known as global NO$_x$ (NO$_x$ = NO + NO$_2$) “hotspots” identified by satellite-based instruments. The ultimate sink for atmospheric NO$_x$ is conversion to aerosol nitrate. However, measurements of aerosol nitrate concentrations do not provide information on which NO$_x$ sources served as nitrate precursors at that location. This complicates efforts to reduce concentrations of particulate matter (PM) in these air quality priority areas. Here, we measured the nitrogen stable isotopic composition of nitrate from daily total PM collections at three air quality monitoring stations located in the Vaal Triangle Air-Shed Priority Area (VTAPA). The overall aim of this study was to evaluate the use of the distinct stable isotopic signatures of various NO$_x$ sources to identify their relative contribution to aerosol nitrate across the Highveld. We will present results of the spatial and seasonal variability in the nitrogen isotopic ratios of aerosol. The stable isotope results, along with a combination of air mass back trajectory and isotope mixing models will be used to quantify the relative contributions of NO$_x$ from coal-burning, biomass burning, vehicles, and soil emissions.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Regional Working Groups

Southern Hemisphere Working Group
Trends in surface ozone and its precursors in Saxony, Germany

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Author list (excluding presenting author)
Dominik van Pinxteren; Hartmut Herrmann

Abstract
Tropospheric surface ozone (O$_3$), has significant impacts on air quality, human health, vegetation, and even climate. Given the importance of surface O$_3$, the long-term trends of O$_3$ concentrations in the federal state of Saxony, Germany, are presented, based on the measurements from 16 stations with long-term O$_3$ data (>10 years). Traffic sites and most urban background stations showed clearly increasing trends over periods of typically recent 15-20 years, ranging from 0.18 - 0.65 µg m$^{-3}$ year$^{-1}$, p<0.05, in deseasoned monthly mean O$_3$ data based on the robust Theil-Sen trend estimator. In contrast, rural background and elevated mountain stations display mixed patterns with partially decreasing, stagnant or increasing trends. Faster growth or slower reduction rates of O$_3$ across all sites were seen during recent 10 years (2011-2020) than those obtained for longer periods (e.g., 1997-2020). Next to O$_3$, the relative trends of meteorological parameters and anthropogenic precursors of O$_3$ are also discussed, which provide insight into the potential causes of the observed trend of surface O$_3$. Decreasing NO$_x$ accompanied by rising temperature would promote further O$_3$ increase, at least in urban areas. Besides, it is shown that stagnant or downward trends in the O$_3$ 90th, 95th, 99th, and maximum of O$_3$ in most of urban and rural stations and all mountain stations had occurred, while the lower percentiles (minimum, 1th, 5th and 10th), O$_3$ concentrations across almost stations seemly continued to increase (with a trend ranging from 0.05 - 0.54µg m$^{-3}$ year$^{-1}$, p<0.05). The trends of high percentiles (75th to Maximum) of O$_3$ coincided with more significant decreasing trends of BTX (Benzene Toluene Xylene) and NO$_x$. Overall, our findings not only provide evidence that Germany is facing increased O$_3$ in recent 10 years, but also indicate the complex effects of reduced ozone precursor emissions on driving O$_3$ trends.

Early Career Scientist
YES, I am an early career scientist.

IGAC Activities
TOAR: Tropospheric Ozone Assessment Report
Session 3 Poster

Sources and processes of water-soluble and water-insoluble organic aerosol in cold season in Beijing, China

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Author list (excluding presenting author)

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Abstract

Water-soluble and water-insoluble organic aerosol (WSOA and WIOA) constitute a large fraction of fine particles in winter in northern China, yet our understanding of their sources and processes are still limited. Here we have a comprehensive characterization of WSOA in cold season in Beijing. Particularly, we present the first mass spectral characterization of WIOA by integrating online and offline organic aerosol measurements from high-resolution aerosol mass spectrometer. Our results showed that WSOA on average accounted for 59% of the total OA and comprised dominantly secondary OA (SOA, 69%). The WSOA composition showed significant changes during the transition season from autumn to winter. While the photochemical-related SOA dominated WSOA (51%) in early November, the oxidized SOA from biomass burning increased substantially from 8% to 29% during the heating season. Comparatively, local primary OA dominantly from cooking aerosol contributed the major fraction of WSOA during clean periods. WIOA showed largely different spectral patterns from WSOA which were characterized by prominent hydrocarbon ions series and low oxygen-to-carbon (O/C = 0.19) and organic mass-to-organic carbon ratio (OM/OC = 1.39). The nighttime WIOA showed less oxidized properties (O/C = 0.16 vs. 0.24) with more pronounced polycyclic aromatic hydrocarbons (PAHs) signals than daytime, indicating the impacts of enhanced coal combustion emissions on WIOA. The evolution process of WSOA and WIOA was further demonstrated by the triangle plot of $f_{44}$ (fraction of $m/z$ 44 in OA) vs. $f_{33}, f_{44}$ vs. $f_{60}$, and the Van Krevelen diagram (H/C vs. O/C). We also found more oxidized WSOA and an increased contribution of SOA in WSOA compared with previous winter studies in Beijing, indicating that the changes in OA composition due to clean air action have affected the sources and properties of WSOA.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities


IGAC Regional Working Groups
China Working Group
Identification and quantification of volatile organic compounds at a regionally representative background site in South Africa

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Author list (excluding presenting author)

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Abstract

Measurements of anthropogenic (aromatic) and biogenic volatile organic compounds (VOCs) were conducted for more than two years at the Welgegund measurement station (South Africa), which is in a savannah-grassland region for which very few atmospheric VOC measurements exists. The monthly median aromatic hydrocarbon concentrations ranged between 0.01 and 3.1 ppbv with toluene being the most abundant compound. No statistically significant temporal variances were observed for these species, while air mass back trajectory analysis indicated that the absence of seasonal cycles could be attributed to different source regions influencing the levels of aromatic VOCs measured at Welgegund. The highest contribution of aromatic hydrocarbon concentrations to ozone formation potential was observed in plumes passing over anthropogenically impacted regions. The highest concentrations of isoprene, 2-methyl-3-butene-2-ol, monoterpenes and sesquiterpenes were 14, 6, 102 and 6 pptv, respectively, with α-pinene being the most abundant species. The highest concentrations were observed during the wet season. Statistical analysis indicated that soil moisture had the greatest impact on 2-methyl-3-butene-2-ol, monoterpenes and sesquiterpenes concentrations, whereas temperature had the highest influence on isoprene. α-Pinene and limonene had the highest reaction rates with ozone, whereas isoprene exhibited relatively small contributions to ozone depletion. Limonene, α-pinene and terpinolene had the largest contributions to the OH• reactivity. Positive matrix factorization analysis revealed ten factors with five factors being associated with biogenic emissions, while five other factors corresponded to anthropogenic sources.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Regional Working Groups

Southern Hemisphere Working Group, ANGA: African Group on Atmospheric Sciences
Variabilities in surface ozone at different sites in the Central Himalayas: Assessing the role of NMHCs

Mr. Mahendar Rajwar
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Author list (excluding presenting author)
Manish Naja (1); Vikrant Tomar (2); Yogesh Kant (3); Rakesh K.Tiwari (4)

Abstract
Northern India is one of the most diverse regions as it is home to one of the most polluted regions i.e. IGP and also to a pristine Himalayan range. Despite that, ground-based observations of trace species are highly limited in this region. In view of this, observations of surface ozone have been made at high altitude mountain site (Nainital, 29.37°N,79.45°E,1958 m amsl), low altitude semi-urban sites (Pantnagar, 29.02°N, 79.49°E, 231 m amsl); Haldwani, 29.22°N, 79.51°E, 424 m a.m.s.l.) and an urban site (Dehradun (30.34°N, 78.04°E, 700 m a.m.s.l.). We observed diurnal variations in ozone with higher values (above 50 ppbv) during daytime and lower values (below 25 ppbv) during nighttime like a polluted atmosphere at semi-urban and urban sites throughout the year except during the monsoon. The nighttime ozone levels at Dehradun are found to be about 10 ppbv higher than other polluted sites. As expected, the high altitude site does not show the daytime photochemical build-up of ozone. We observed a symmetric diurnal pattern of the rate of change of ozone (6.5 ppbv hr$^{-1}$) at Dehradun, whereas an asymmetric diurnal pattern at Pantnagar with a morning time high (8.5 ppbv hr$^{-1}$) and evening time lower rate (5.6 ppbv hr$^{-1}$). The monthly variation of ozone shows springtime maximum (~40 ppbv) and monsoon time minimum (~10 ppbv) at all four sites. The spring maximum is found to be mainly due to biomass burning. The CAMS model shows agreement in the ozone seasonal variations, nevertheless, model values are found to be significantly higher in monsoon. The NACR-MM box model analysis showed the highest ozone production potential (8.5 ppbv hr$^{-1}$) by aromatics and followed by alkenes (6.5 ppbv hr$^{-1}$) and alkyne (3.5 ppbv hr$^{-1}$). More details will be presented during the conference.

Early Career Scientist
YES, I am an early career scientist.

IGAC Activities

IGAC Regional Working Groups
MANGO: Monsoon Asia and Oceania Networking Group

COVID-19 related abstracts
no
Session 3 Poster

Emissions of particulate associated - major and trace elements from residential biofuels burning in rural regions of Western India

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Author list (excluding presenting author)
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Abstract

In developing countries like India, emissions from residential biofuels burning for cooking and heating in rural areas are major contributors to atmospheric emissions. In this study, the emissions of particulate associated major and trace elements (Al, S, Cl, K, Ca, Fe, Na, Mg, P, Pd, Ag, Cu, Cr, Zn, Mn, Co) were determined from biofuel samples used in the three states (Gujarat, Maharashtra, and Rajasthan) of Western India. A total of 321 residential (rural) biofuel samples were analyzed which include fuelwood (176), dung cake (62), and crop residue (83) collected by laboratory combustion experiment. The average emission factor (EF) of dominant elements (Al, Cl, K, Ca, Fe, S and Na) was determined as : Fuelwood (Al: 12.5±13.4 mg/kg > S: 6.1±8.4 mg/kg > Cl: 2.5±0.7 mg/kg > K: 1.7±0.5 mg/kg); Dung cake (Cl: 13.0±23.8 mg/kg > K: 8.2±5.4 mg/kg > Al: 4.7±13.2 mg/kg > Fe: 3.4±3.5 mg/kg > Ca: 3.2±0.4 mg/kg) and Crop residue (Fe: 16.0±7.7 mg/kg > Na: 6.2±2.2 mg/kg > Cl: 4.2±4.5 mg/kg > K: 3.2±2.0 mg/kg > Ca: 2.1±0.6 mg/kg). The obtained results indicated that the properties of different biofuels possess a strong influence on the emission of particulate-associated major and trace elements. The total emissions of elements from FW, DC, and CR have been estimated using laboratory-generated EFs over the rural sector in the Western region of India.

Keywords: Biofuels burning, Elements, Emission factor, Western India

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

AMIGO: Analysis of eMIssions usinG Observations
Session 3 Poster

Speciated Fingerprints of Plastics: Applications and Implications on Urban Air Quality

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Author list (excluding presenting author)

Liya E. Yu (1)

Abstract

Broad applications of plastic products have rendered ubiquitous plastic emissions in ambient environments both indoors and outdoors. This study examines how plastic emissions affect >250 bulk daily PM$_{2.5}$ samples collected during 2018–2020 by speciating nine plastic tracers including phthalic acid esters (PAEs), tris(2,4-di-tert-butylphenyl)phosphate (I168O), terephthalic acid (TPA) and 1,3,5-triphenylbenzene (135TPB) in Singapore. Source apportionment involving 33 input elements shows that plastic tracers are associated with plastic burning, vehicular, industrial, and cooking emissions along with transported sources. More than 40% of di-iso-butyl phthalate (DiBP) and di-n-butyl phthalate (DnBP), and di(2-ethylhexyl) phthalate (DEHP) concentrations are associated with traffic and road dust, with a concentration ratio of ([DiBP]+[DnBP])/[DEHP] (~3.5) higher than stationary combustion (0.45) and industrial emissions (0.01). This demonstrates the potential of employing plastic tracer ratios to differentiate traffic emissions from other anthropogenic sources, which at times can be challenging. Long-range transported emissions associated with biomass burning smoke contribute to >90% diethyl phthalate (DEP) and ~50% of dimethyl phthalate (DMP), demonstrating a dominant contribution from transported sources such as industrial emissions, enhanced emissions of burning plastics (e.g., open burning of plastic waste), and/or pesticides used in agricultural lands carried by air masses along with biomass burning smoke. Emissions of plastic burning are ascertained by the dominant presence of I168O (90%), TPA (90%), and 135TPB (~35%), accounting for on average 5% (1.17 µg/m$^3$) of total PM$_{2.5}$ in Singapore during 2018–2020. Relative to 2018 and 2019, PM$_{2.5}$ associated with plastic burning in 2020 increases by respective >150% and >60%, suggesting treatment of a larger volume of plastic wastes in 2020. This demonstrates that air quality can timely reflect substantial changes in social-economic activities in a densely populated urban environment.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group

COVID-19 related abstracts

yes
Session 3 Poster

Measurements of HCHO, OH, HO\textsubscript{2}, and OH reactivity at a UK urban site

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Author list (excluding presenting author)

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Abstract

Formaldehyde (HCHO) plays an important role in the HO\textsubscript{x} cycle, the cycling between the hydroxyl radical (OH), the hydroperoxy radical (HO\textsubscript{2}), and peroxyl radicals. HCHO is formed by OH-oxidation of volatile organic compounds (VOCs), whilst other sources of HCHO include direct emissions from both natural and anthropogenic sources, as well as ozonolysis reactions and the photolysis of oxygenated VOCs. The main sinks for HCHO are photolysis and reaction with OH, which forms HO\textsubscript{2}. OH is the dominant daytime oxidant, the oxidising capacity of the troposphere is governed by the OH concentration which is controlled by the HO\textsubscript{x} cycle.

Ground-based measurements of HCHO, OH, HO\textsubscript{2}, and OH reactivity were taken during the NERC-funded Integrated Research Observation System for Clean Air (OSCA) intensive operating period (IOP) at a UK urban location. The measurements were taken at the Manchester Air Quality Supersite, approximately 3 miles south of the city centre. OH and HO\textsubscript{2} radicals were measured using the fluorescence assay by gas expansion (FAGE) technique, OH reactivity was measured using laser flash photolysis coupled with laser-induced fluorescence (LFP-LIF), and HCHO was measured using LIF.

Peak HCHO concentrations were consistent for most of the measurement period and did not seem to be affected by direct local emissions of HCHO. The HCHO concentrations increased towards the end of the campaign, from mean peak concentrations of ≈3 ppb to ≈5 ppb corresponding to warmer weather. During this period of elevated HCHO, OH and OH reactivity were also elevated, suggesting that the increase in HCHO was due to an increase in secondary production of HCHO from radical chemistry. HCHO production rates were calculated using the OH and OH reactivity data and used to calculate the fraction of OH + VOC reactions that contributed to HCHO production.

Early Career Scientist

YES, I am an early career scientist.
Session 3 Poster

Assessment of PM$_{2.5}$ characteristics in old Delhi region, India: Carbonaceous species, FTIR profiling, morphological and elemental analysis

Ms. Shobhna Shankar
IGDTEUW, India

Author list (excluding presenting author)

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Abstract

Fine particles were collected at traffic-influenced site in old Delhi region from January -June 2021 (January-March: with regular activities; April-June: partially restricted months due to second wave of pandemic) to assess noteworthy effect on carbonaceous content [organic carbon (OC), elemental carbon (EC), their sub-fractions], morphological, elemental and infrared (IR) spectral features. Daily PM$_{2.5}$ levels, OC, EC and total carbon (TC) ranged between 19.8-283.0 µg/m$^3$, 5.8-87.1 µg/m$^3$, 2.0-38.7 µg/m$^3$ and 9.8-125.8 µg/m$^3$, respectively. OC and EC accounted for 17.1-37.4% and 5.0-14.4% of daily average PM$_{2.5}$ mass, whereas 73.3±4.4 % of TC was attributed to OC. Out of all the sub-fractions of OC and EC, EC1 (37.4%) was found to contribute maximally to TC. Monthly variation in OC/EC: 2.6-3.7, EC/TC: ~0.3 and OM/OC: 0.8-4.0 revealed the probable emission sources (gasoline, nearby biomass burning, LPG exhaust). The daily-average of 5.5±3.3 µg/m$^3$: soot-EC and 0.5±0.1 µg/m$^3$: char-EC indicated for diesel emissions and local biomass burning emission, respectively. Varying morphologies and elemental composition were revealed using SEM-EDX. Collectively, the major and trace elements were aluminium, cadmium, calcium, chlorine, chromium, copper, fluorine, iron, magnesium, manganese, nickel, nitrogen, phosphorus, potassium, sodium, sulphur, titanium, terbium and zinc; but most of the particles were dominated by chlorine (3.3%), aluminium (2.7%), sulphur (2.6%), potassium (1.6%), calcium (1.6%) and traces of iron (0.8%), zinc (0.7%), sodium (0.5%) and magnesium (0.5%) which was in accordance with results obtained from ICP-MS. Absorbance peaks for structural and functional groups for previously identified compounds associated with vehicular/combustion/biogenic emissions at the site were notable. Intensive peaks for C=C, C-H, O-H and NH$_4$NO$_3$ obtained for certain sampling days pointed towards enhanced emission of the related compounds. Lesser intensive peaks were observed for March and first half of April probably due to transitioning meteorological variables and imposed pandemic restrictions.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

AMIGO: Analysis of eMissions usinG Observations, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality
Session 3 Poster

Global Emissions InitiATive (GEIA) – IGAC Activity

Dr Cathy Liousse
CNRS, France

Author list (excluding presenting author)

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Abstract

Quantification of emissions of GHGs and pollutants into the air is a key step in explaining observed variability and trends in atmospheric composition and in attributing these observed changes to their causes on local to global scales. Accurate emissions data are necessary to identify feasible controls that reduce adverse impacts associated with air quality, human health and climate, to track the success of implemented policies, and to estimate future impacts.

The Global Emissions InitiATive (GEIA) is a community effort dedicated to emissions information exchange and competence building, bridging science, society and policy. GEIA was created in 1990 under the International Geosphere-Biosphere Programme (IGBP) and is now an IGAC activity. GEIA is led by an international steering committee bringing together emissions experts covering most source types and all world regions, and working on GEIA planning efforts to develop and implement outreach strategies.

Main GEIA core plans are to (1) strengthen the community of emissions stakeholder groups which are more than 2000 real-time GEIA users, (2) build the scientific basis for emissions characterizations by enhancing analysis of emissions processes, and (3) promote broad and consistent access to emissions information. GEIA’s efforts are advanced by working groups on specific topics (COVID-19, VOC emissions, Urban emissions) and on regional activities (China, Africa and Latin America/Carribbean), by overarching activities, and through collaborations with other initiatives, science teams, and agencies. ECCAD, GEIA’s emissions data portal, provides consistent access to inventories and ancillary data with easy-to-use tools for analysis and visualization, to serve scientific research & assessment efforts. GEIA communicates with the emissions community through in-person meetings organized every two years and through online resources within the NASA-sponsored GEIA Web Site. The GEIA web site is the initiative’s virtual communications center, building emissions data access and platforms for information sharing on working group and other activities.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

GEIA: Global Emissions Initiative
Long-term trends of Total Number Count and Black Carbon at Rural, Urban Background, and Urban Traffic Sites in the UK

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Author list (excluding presenting author)
Roy M Harrison (1,2); Francis D. Pope (1)

Abstract

Total number concentration, derived from a condensation particle counter (CPC), and black carbon (BC) data from rural background (Chilbolton and Harwell), urban background (London North Kensington, LNK), and urban traffic (London Marylebone Road, LMR) sites in the UK were analysed. Data covered the period 2008 to 2022, but availability differed between sites. The Theil-Sen slope shows a downward trend of TNC and BC concentration, apart from TNC at Chilbolton, which showed no clear trend. Over a similar timeframe (2010-2018), the decrease of BC and TNC at LMR is slightly greater (8.8%/year; 7.5%/year, respectively) than that at LNK (5.6%/year; 6%/year, respectively). CPC/BC ratios show that the ratio at LMR was the lowest of all sites until the middle of the period. A higher ratio was observed at LMR and LNK from 2018 onwards due to the significant decrease of BC concentrations at those sites at the end of the period. The increased penetration of the vehicle fleet from 2011 onward by Euro 5 and 6 vehicles fitted with Diesel Particle Filters was the main cause of significant BC reduction, particularly at LMR. A seasonal analysis of CPC/BC shows a peak in the very early morning at LNK and LMR in all seasons, apart from LNK in the summer, which may be due to home heating emissions from gas boilers at a time when traffic emissions of BC are low. A reduced ratio occurred during morning and evening rush hours. Another peak in the afternoon, apart from in winter, may be the result of new particle formation from regional nucleation. TNC and BC shows a strong correlation at LMR, with an annual coefficient ranging from 0.76-0.93 during 2010-2019, indicating road vehicles as a major contributor. A much weaker correlation was observed at a rural site (0.21-0.61), suggesting a different dominant source of particles.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality, AMIGO: Analysis of eMIssions usinG Observations

COVID-19 related abstracts

no
Session 3 Poster

VOCs changes under COVID-19 lockdowns in Europe

Alexandre Caseiro
Institute for Advanced Sustainability Studies, Germany

Author list (excluding presenting author)

Seán Schmitz (1)
Pedro Salvador (2)
Erika von Schneidemesser (1)

Abstract

With the goal to reduce contact between people, governments throughout Europe established lockdowns in spring 2020. These measures resulted in decreased anthropogenic, e.g. vehicular, emissions. Particularly, nitrogen dioxide, strongly dependent on vehicular traffic in cities, has been extensively studied and reported in the literature. Despite disparate methodologies (e.g. if and how natural variation induced by the meteorology is taken into consideration) and heterogeneous ranges, the case for reduced ambient nitrogen dioxide concentrations is evident.

The effect of lockdown policies on tropospheric ozone levels, a pollutant very harmful to human health, however less extensively studied than nitrogen dioxide, is not as clear. Some studies point towards a decrease while others have reported an increase. Such is due to its complex secondary nature, whose production depends non-linearly on meteorology, nitrogen oxides and volatile organic compounds (VOCs).

VOCs, both biogenic and anthropogenic in origin, interact with nitrogen oxides and are determinant for the atmospheric production of ozone. In contrast to nitrogen oxides and ozone, the fate of VOCs during covid-19 lockdowns remains under-studied and under-reported. However, such information is necessary in order for policy-makers to use the lockdowns as large-scale, real-life experiments to support the design of air pollution abatement policies.

In the present work, the change in VOCs concentrations measured in-situ during lockdowns throughout Europe is studied. The effect of meteorology is filtered by clustering the sample into 8 different synoptic meteorological patterns. The effect of human activity is filtered by discriminating between weekdays and weekends. The double subsetting strategy allows to isolate the effect of the lockdown and assess the impact of reduced vehicular emissions in the ambient concentration of VOCs.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

COVID-19 related abstracts

yes
Session 3 Poster

APExpose: an european air pollution exposure dataset based on modelling, satellite and in-situ measurements and its application to COVID-19 hospitalizations

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Author list (excluding presenting author)

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Susanne Koch (2)
Christina Hoffmann (2)
Marie Ledebur (2)
Mario Menk (2)
Erika von Schneidemesser (1)

Abstract

The APExpose dataset is a long-term (starting 2003) dataset providing ambient air pollution metrics at yearly time resolution for NO2, NO, O3, PM10 and PM2.5 at the NUTS-3 or LAU-1 spatial resolution level (corresponding to e.g. the Landkreis/Kreisfreie Stadt in Germany for the NUTS-3 level). The sources used for the production of the dataset were Airbase, from the European Environmental Agency, and the Copernicus Atmospheric Monitoring Service (CAMS) global reanalysis EAC4. Each in-situ measurement station of the type "Background" was geo-located within, and each computed yearly value associated to, a NUTS-3/LAU-1 unit. Within each unit and for each metric, the yearly values per station were averaged in three ways, giving preference to different station sitings, each representing a different scenario: average, urban, remote. In order to complete the dataset for the NUTS-3/LAU-1 units where no monitoring data for a given pollutant is available, the CAMS EAC4 reanalysis was used. The yearly-averaged rasters from CAMS were vectorized and scaled to available monitoring data to obtain values for each NUTS-3/LAU-1 units. As a final step, the Airbase and CAMS derived data were combined to produce the APExpose dataset. The dataset is intended to be used as an input to studies investigating the association between long-term exposure to air pollution and other outcomes. APExpose was used to investigate the possible relationships between the long-term exposure to air pollution and the severity of the covid-19 disease in Germany. After adjustment for risk factors in the tri-pollutant model (NO2, O3, PM2.5) an increase of 1µg/m3 NO2 was associated with an increase of the need for intensive care by 4.2%, and mechanical ventilation by 4.6%.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality
COVID-19 related abstracts

yes
Session 3 Poster

Investigation of major emission sources of non-methane hydrocarbons and their role in ozone formation in New Delhi, India

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Author list (excluding presenting author)

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Abstract

Non-methane hydrocarbons (NMHCs) play a critical role in the atmospheric chemistry and air quality in urban regions. They are major precursors of ozone, secondary organic aerosols but studies in South Asia are still lacking. New Delhi is one of the most polluted cities in the world where sources of ambient NMHCs are poorly characterized. Estimation of the contributions of different sources of NMHCs in New Delhi is important for effective to control levels of ozone and other secondary pollutants. Mixing ratios of some NMHCs can be used as a marker for a particular emission source such as vehicular exhaust, solvent usage, and vegetation. A comprehensive suite of measurements of NMHCs and oxygenated-VOCs were performed at an urban site in New Delhi during winter and summer seasons using C2-C6 VOC analyzer and proton transfer reaction-time of flight-mass spectrometer (PTR-TOF-MS). The daily mean mixing ratios of ethane and propane were 24±12 and 34±23 ppbv during winter and 18±10 and 23±12 ppbv during summer, respectively. Such higher levels of NMHCs were mainly due to strong local sources and favorable meteorological conditions. Significantly higher levels of isoprene (~4 ppbv) in daytime during summer and poor correlation with ethane and acetylene (r²<0.1) suggest strong biogenic contributions of isoprene in Delhi. The ratios of two NMHC species were used to characterize major sources of NMHCs. During winter, emission ratios of toluene/benzene (2.07 ppb ppb⁻¹) and i-pentane/n-pentane (2.95 ppb ppb⁻¹) suggest NMHCs are mainly emitted from vehicular exhaust. While higher emissions ratios of toluene/benzene (2.35 ppb ppb⁻¹) and i-pentane/n-pentane (3.27 ppb ppb⁻¹) suggest combined effect of vehicular exhaust and gasoline evaporation (due to higher temperature) during summer. Findings of this study suggest the emissions from both light- and heavy-duty vehicles are main local sources of gas-phase urban air pollution.

Early Career Scientist

YES, I am an early career scientist.
Session 3 Poster

**Stable isotope constraints on atmospheric nitrate sources and formation pathways in an urban polar area: preliminary results of the winter 2022 CASPA/ALPACA campaign**

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Abstract

Urban polar areas can be subject to severe air pollution in winter, exacerbat...d and physical measurements, gaseous (NO$_2$), particulate, and snow samples were collected and subject to multiple isotopic analyses in order to identify the sources of nitrogen oxides (NO$_x$) emissions and understand how NO$_x$ are oxidized to atmospheric nitrate (NO$_3^-$).

Here, we present the preliminary results of the multi-isotope composition ($\Delta^{17}O/\delta^{15}N$) of NO$_3^-$ collected on glass filters from high-volume particulate samplers. We discuss the sources and fate of NO$_3^-$ during winter in Fairbanks by collating atmospheric observations and isotopic records.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

PACES: Air Pollution in the Arctic: Climate, Environment, and Societies
Health impacts of the Saddleworth Moor fire 2018: the importance of model resolution

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Author list (excluding presenting author)
Ailish Graham (1)

Abstract

The Saddleworth Moor fire in 2018 was a high impact wildfire event that led to a considerable deterioration in air quality for nearby urban areas, particularly Manchester. Numerical modelling of wildfire smoke plumes is critical for emergency response during the event, for estimating impacts in the aftermath of the event, and for scientific research to inform policy that can reduce the impacts of wildfires in the future. I will present a case study that explores the importance of model spatial resolution for predictions of pollutant concentrations from wildfires, with a focus on air quality health impacts, using the Saddleworth Moor fire. We have performed modelling experiments with different horizontal resolutions to quantify the impact of model resolution on the predicted surface concentrations of pollutants downwind of the fire. We find that using a finer horizontal resolution gives a narrower smoke plume with higher peak concentrations of pollutants within the plume. Finally, we perform a health impact assessment to quantify the impact of model resolution on the estimated excess mortality due to exposure to wildfire sourced PM2.5. The narrower plume given by the finer resolution model means that fewer people overall are expected to be exposed to elevated PM2.5 concentrations, reducing the estimated excess mortality due to the fire. However, as concentrations within the plume are higher, the fewer people that are exposed are exposed to higher PM2.5 concentrations. The outcomes of this project could inform development of tools and procedures for emergency response to future wildfire events, as well as informing policy to reduce the long-term of risks of exposure to wildfire smoke.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality
Session 3 Poster

Variability of aerosol sources and atmospheric deposition processes to the area of Brijuni National Park, Croatia

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Author list (excluding presenting author)

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Abstract

Anthropogenic climate change is altering ecological and human systems globally, including national parks that conserve unique but vulnerable ecosystems and biodiversity. Yet the magnitude and spatial patterns of climate change across national parks are generally unknown. The National Park (NP) Brijuni in Croatia encompasses 14 islands and islets covering an area of 33.9 km$^2$ in the northern Adriatic Sea, representing a unique microenvironment with a specific biodiversity, natural, cultural and historical features. Due to its location, NP Brijuni is in direct threat of potentially strong air pollution from regional and long-range sources from continental Europe. However, the atmospheric pollution impacts to the area of the NP Brijuni have been unknown.

This work presents the first insight into the air pollution sources, its seasonal variabilities as well as atmospheric deposition impacts to the area of NP Brijuni. The sampling campaign at NP Brijuni was conducted from June to November 2020 and included on-line measurements of black carbon (BC) concentrations and collection of particulate matter (PM$_{10}$), wet and total deposition samples. The results of BC concentrations and its source apportionment and dataset comprising dominant ions (NO$_3^-$, SO$_4^{2-}$, Cl$^-$, Na$^+$, K$^+$, Ca$^{2+}$, Mg$^{2+}$, NH$_4^+$) and organic matter (organic carbon and water soluble organic carbon) in PM$_{10}$ and deposition samples were statistically analysed and discussed considering different seasons, meteorological conditions and specific air-mass inputs in order to better understand the extent of the changing environment as a main prerequisites for air quality management, planning and implementation of appropriate environmental protection measures in the NP Brijuni.

Acknowledgment: This work has been supported by National Park Brijuni under the „Insight into the variability and composition of atmospheric deposition in the area of Brijuni National Park“ project, and by and Croatian Science Foundation under the IP-2018-01-3105 BiREADI project.

Early Career Scientist

YES, I am an early career scientist.
Abstract

Global, regional and local air quality is the result of balances between many chemical compounds in the atmosphere. A large part of the volatile organic compounds present in the atmosphere comes from vegetation emissions, in particular isoprene, emitted by trees during sunny periods. Within the framework of research on climate change and its limitation to +2°C, many studies have been carried out taking into account prospective scenarios of reduction of emissions due to human activities. However, the impact of climate change on vegetation and thus on natural emissions has been little studied. Improving future air quality in regions where urbanized and natural areas coexist requires a detailed understanding of climate/vegetation/natural emissions interactions. This step is essential in the study of the integrated earth system.

The CNRM develops and implements SURFEX and MOCAGE models. SURFEX model allows numerical simulation of soil/atmosphere interactions, as well as the response of vegetation to meteorological forcing (e.g., the evolution of the leaf area index). The chemistry-transport model MOCAGE model simulates the chemical composition of the troposphere and the lower stratosphere.

In this context, the objective of this study will be to study, with the SURFEX model, the impact of a global temperature increase of 2°C on vegetation and on natural emissions. Then, the MOCAGE model will be used to model the impact of these new biogenic emissions on future air quality, as well as the response to the combined action of reducing human emissions and new natural emissions.
Monitoring the atmospheric composition and air quality impacts of the Cumbre Vieja volcanic eruption in 2021

Dr Mark Parrington
ECMWF, Germany

Author list (excluding presenting author)

Antje Inness (1); Johannes Flemming (1); Sebastien Garrigues (1); Zak Kipling (1); Melanie Ades (1); Nicolas Bousserez (1); Richard Engelen (1); Vincent-Henri Peuch (1); Samuel Remy (2); Vincent Huijnen (3); Olga Mayol-Bracero (4)

Abstract

The Cumbre Vieja volcano in the Canary Islands erupted on 19 September 2021 causing widespread devastation on the island. A prominent impact on the atmosphere was almost continuous observed daily emissions of sulphur dioxide (SO2) for several weeks following the initial eruption. The relatively high levels of SO2 and subsequent sulphate aerosol formation were observed across northern Africa, Europe, generally in the free troposphere, and across the Atlantic Ocean, where a mixture of sulphate and desert dust aerosols led to episodes of degraded air quality in Puerto Rico and other Caribbean countries. Analyses and forecasts from the Copernicus Atmosphere Monitoring Service (CAMS), implemented by the European Centre for Medium-Range Weather Forecasts (ECMWF) with funding from the European Union, are based on the assimilation of total column SO2 observations from the TROPOMI and GOME-2 satellite instruments. In the current operational CAMS system an initial injection height of SO2 in an atmospheric layer at 500 hPa is assumed for volcanic eruptions and the assimilated SO2 can influence sulphate aerosol through interactions between the gas-phase and aerosol chemistry schemes used in the model. Observed SO2 layer heights derived from TROPOMI were between 700 and 500 hPa, i.e. slightly below the height assumed in the CAMS system but, in general, the long-range transport patterns of CAMS total column SO2 forecasts were well matched with independent observations. Assimilation of TROPOMI SO2 layer height information is being implemented in CAMS and is anticipated to lead to improved monitoring of the atmospheric impacts of volcanic eruptions in future. We present an overview of the performance of the CAMS SO2 and sulphate aerosol analyses and forecasts in relation to the Cumbre Vieja eruption, focussing on long-range transport across Europe and the Atlantic Ocean and initial evaluation of the CAMS forecasts against independent ground-based and in situ measurements.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

GEIA: Global Emissions Initiative, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

Americas Working Group
Session 3 Poster

Investigating air quality impacts from unconventional oil and gas development in surrounding communities

Ph.D. Student I-Ting Ku
Colorado State University, USA

Author list (excluding presenting author)

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Abstract

Improved fossil fuel extraction techniques, including horizontal drilling and hydraulic fracturing, have allowed rapid growth in U.S. production of oil and natural gas (ONG). Expanded ONG development happens not only in rural regions, but also in urban and suburban zones where people work, attend school, and live. Despite rising concerns about ONG impacts on the environment (e.g., noise, water, and air quality) and human health, direct measurements of key air toxics in adjacent communities are limited.

In this study we report long-term monitoring of ambient concentrations of air toxics and other volatile organic compound (VOC) around large, multi-well oil and gas pads in suburban Broomfield, Colorado, USA. Records of well-pad development allow periods of increased emission to be associated with specific activities during ONG well development. A spatial network of weekly integrated air samples revealed elevated VOC mixing ratios near well-pads during various preproduction activities, including drilling, coil and production tubing operations, and flowback. A PTR-MS providing fast BTEX measurements and several online PID sensors with triggered canister systems helped continuously monitor ambient VOC levels and document episodic emission plumes, their composition, and acute exposure potential in nearby neighborhoods. A mobile plume tracker, equipped with onboard instruments for real-time methane, acetylene, and BTEX measurements and VOC grab canisters, helped further characterize targeted plumes and their sources.

A combination of complementary measurement techniques and measurement time resolutions allow the Broomfield ONG monitoring program to identify both longer (weeks) and shorter (minutes) impacts on local air quality. The collected data also provide new insight into well development activities producing larger emissions that represent future opportunities for reducing community air quality impacts through improved emission control practices.

Early Career Scientist

YES, I am an early career scientist.

IGAC Regional Working Groups

Americas Working Group

COVID-19 related abstracts

no
Session 3 Poster

Seasonal variations and compositions of size-fractioned urban atmospheric particulate matter in Kuala Lumpur, Malaysia

Prof Mohd Talib Latif
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Author list (excluding presenting author)

Anas Ahmad Jamhari (1); Mohd Talib Latif (1); Murnira Othman (1); Muhammad Ikram Abdul Wahab (1); Haris Hafizal Abd Hamid (1); Perapong Tekasakul (2); Worradorn Phairuang (3); Mitsuhiko Hata (3); Masami Furuchi (3); Nor Fadilah Rajab (1)

Abstract

This study was conducted to determine the inorganic and carbonaceous components; and polycyclic aromatic hydrocarbons (PAHs) of size-fractioned urban atmospheric particulate matter in Kuala Lumpur, Malaysia. Different fractions of particulate matter (PM) were measured using a nanosampler. The water-soluble inorganic ions (WSIs) and carbonaceous components of PM were analysed using ion chromatography and carbon analyser thermal/optical reflectance, respectively. Extractions of PAHs were performed using dichloromethane:n-hexane (1:1) and analysed by gas chromatography-mass spectrometry. The health risks of PAHs were estimated based on the toxic equivalency factors (TEFs) and incremental lifetime cancer risks (ILCRs). The results show the total PM concentration was recorded at the highest concentration during the southwest (SW) monsoon (70.9 ± 6.04 µg/m^3). PMs with the greatest accumulation were PM_{0.5-1.0} (22%–30%, 9.55 ± 1.03 µg/m^3) and PM_{2.5-10} (22%–25%, 10.3 ± 0.81 µg/m^3). SO_4^{2-}, NO_3^- and NH_4^+ were the major contributors to WSIs, particularly in the SW monsoon (80.5% of total ions). The average contribution of carbonaceous species (OC+EC) to total carbonaceous concentrations was higher in fine particle and coarse sizes; PM_{0.5-1.0} (35.2%) and PM_{2.5-10} (26.6%). The total average of ∑_{16}PAHs concentration for the size-fractionated particulates was highest during the SW monsoon (15.7 ng/m^3). Approximately 71.7% to 80.7% of indeno[1,2,3-cd]pyrene, dibenzo[a,h]anthracene, and benzo[g,h,i]perylene were concentrated as fine particulate matter (PM_{0.1-0.5}, PM_{0.5-1.0}, and PM_{1.0-2.5}). The total percentage of benzo[a]pyrene equivalent (BaP_{eq}) concentration in the ultrafine particulate matter (PM_{<0.1}) was found to contribute to more than 50% of the potential health risk. Further health risk assessment showed that the estimated ILCRs due to airborne BaP_{eq} exposure are negligible.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Simulations of Air Quality in South America: effects of boundary conditions and model intercomparison.

Pablo Lichtig
National Commission of Atomic Energy (CNEA), Argentina. National Council of Science en Technology (CONICET), Argentina

Author list (excluding presenting author)

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Abstract

(The current abstract presents work in progress.)

Simulations of Air Quality (AQ) are being performed in South America (SA), using the regional Weather Research and Forecasting Model coupled Chemistry (WRF-Chem) and the global Multi-Scale Infrastructure for Chemistry and Aerosols (MUSICA) model, with grid refinement in the South American Continent. Both models are being used in the same regions, during the same period, and using the same emission inventories (CAMS 5.3), and run with a resolution in the area of interest of ~28 km. WRF-Chem is run using MOZART chemistry and the bin-based MOSAIC 4 aerosols, while MUSICA uses MOZART-TS1 chemistry and the modal MAM4 aerosols, since the different implementations of both models make it impossible to use the exact same chemical mechanisms. Both models are being evaluated using satellite images and local AQ data.

As periods of interest, we selected 3 periods: May 2019, as a period with relatively few regional events, July 2019, during the Amazon Fire season, and December 2019, when the effects of the Australian bushfire season were observed in South America. During that period, work in our research group characterising regional events in the region of Buenos Aires, Argentina, has been performed. These will be used to partially evaluate the representation of regional events by the models.

Although the chemical mechanisms implemented in both models differ, the effects having a global model instead of a regional one are evaluated, especially when far away fires are involved. In those situations, we expect to see significant differences, as regional models only include those through boundary conditions. This work is part of the project Prediction of Air Pollution in Latin America and the Caribbean [1], which aims to create a regional AQ forecasting model ensemble in the LAC region.


Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

**IGAC Regional Working Groups**

Americas Working Group, Southern Hemisphere Working Group
Retrieving CALIOP-based particulate matter concentrations for the Models, In situ, and Remote sensing of Aerosols (MIRA) Project

Dr. Travis D. Toth
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Author list (excluding presenting author)

Jianglong Zhang (2); Mark A. Vaughan (1); Jeffrey S. Reid (3); James R. Campbell (3); Greg L. Schuster (1)

Abstract

Past studies of PM2.5 (particulate matter with diameters smaller than 2.5 µm) pollution using space-based remote sensors have primarily focused on the development of PM2.5 proxies using aerosol optical thickness (AOT) retrievals from passive remote sensors. While this AOT approach is limited by a column-integrated perspective of aerosol loading, lidars provide near-surface aerosol optical property information that can be employed for PM2.5 applications. In this study, the mean state and trends of PM2.5 concentrations over the contiguous United States (CONUS) are derived from a bulk-mass method using twelve years (2007-2018) of near-surface aerosol extinction coefficients (532 nm) from NASA’s Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) instrument. Compared against ground-based U.S. Environmental Protection Agency (EPA) in situ PM2.5 measurements, an encouraging relationship between CALIOP-derived PM2.5 and EPA-observed PM2.5 is found (R² = 0.36; Deming slope = 0.89; RMSE=3.42 µg/m³; mean bias=-1.00 µg/m³). A PM2.5 trend analysis reveals that air quality is generally improving over the eastern CONUS but is worsening during the more active wildfire season in the western CONUS. This research may help characterize air quality in areas of the CONUS with few surface stations and motivates further exploration of aerosol extinction derived PM2.5 concentrations in anticipation of the next generation of spaceborne lidars.

The Models, In situ, and Remote sensing of Aerosols (MIRA) Working Group was created to promote the collaboration of researchers from these aerosol research disciplines to advance the scientific understanding of air quality and climate. As part of MIRA, the Particulate Matter from Lidars in Space (PMLS) project focuses on the development of robust PM2.5 retrievals from global lidar measurements for use in air quality research and applications. For this study, as part of the MIRA/PMLS Project, we seek international ground-based in situ PM2.5 datasets in order to validate the lidar-derived PM2.5 concentration estimates.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality
Session 3 Poster

Improving representation of population exposure to urban air pollution by the addition of microenvironmental low-costs sensors to existing fixed site monitoring network

Tilman Leo Hohenberger
Hong Kong University of Science and Technology, Hong Kong

Author list (excluding presenting author)

Alexis K.H. Lau (1)

Abstract

Ambient air pollution is a major environmental health risk in many cities, leading to millions of premature deaths per year globally. In many cities, fixed site monitoring station (FSM) networks provide high-class data for regulatory purposes and academic research. Here, because high spatial pollutant variability in urban areas like Hong Kong cannot be adequately represented by a small number of stations, FSM networks are more and more supplemented with low-cost sensors. Moreover, existing research on pollution exposure highlights large exposure differences between various microenvironments such as home, traffic or outdoors. As a large proportion of daily activity is performed indoors, outdoor sensors often overestimate population exposure to air pollution. In this field, we propose a mixed-sensor network based on adequately representing indoor – and outdoor exposure to air pollution. Based on one year of high-resolution modelling data in our study area (Hong Kong) and experimentally derived infiltration factors, we apply a pseudo-sensor approach to model the ability of the 1) baseline FSM network, 2) FSM and ambient smart sensor network and 3) FSM and ambient + indoors smart sensor network to adequately represent population exposure to urban air pollution. In our study area, results show that significant improvements can be achieved with a small number of additional low-cost sensors representing indoor pollution concentrations when choosing adequate pathways to communicate measured concentrations to the affected populations.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups
Influence of airborne PM2.5 on the respiratory disease incidence in Mendoza, Argentina

PhD Maria F Tames
Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina. Grupo de Estudios de la Atmósfera y el Ambiente (UTN-FRM), Argentina

Author list (excluding presenting author)
Josefina Urquiza (1); S. Enrique Puliafito (2)

Abstract
PM$_{2.5}$ have an impact on the respiratory tract and can reach the vascular system directly through the pulmonary alveoli, causing effects on the entire organism. Their severity will depend mainly on the environmental concentration of pollutants, the time of exposure, and population and individual vulnerabilities. Georeferenced epidemiology data combined with pollutant dispersion models and demographic data can be used to predict the number of probable cases in a population potentially exposed to air pollution. In addition, existing data on exposure-response relationships can be used to estimate the number of expected cases at each exposure concentration. The objective of this research was to analyze the relationship between respiratory diseases and PM$_{2.5}$ concentrations from different origins in the Metropolitan Area of Mendoza, Argentina. For this purpose, daily data on admissions to public hospitals for respiratory diseases according to the ICD-10 classification were considered. In addition, PM$_{2.5}$ concentration modeling through WRF-CALPUFF were used. We found a direct relationship between population density, PM$_{2.5}$ concentration and the rate of respiratory illnesses. The most common diseases are pneumonia (J18, with an incidence rate of 30.4%) and acute bronchiolitis (J21, with an incidence rate of 14%).

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

IGAC Regional Working Groups

Southern Hemisphere Working Group
A Global Gridded Emission Inventory for PFOA and PFOS, 1950 to 2020

Pascal Simon
Helmholtz-Zentrum Hereon, Germany

Author list (excluding presenting author)

Johannes Bieser (1); Corinna Schrum (1)(2)

Abstract

Per- and Polyfluoroalkyl Substances (PFASs) present themselves as a large self-imposed risk to human health and the environment as a whole. This risk is amplified by their high persistence and long-range transport in the atmosphere and ocean. For the assessment of this risk, transport modeling plays a major role. Essential as an input for any modeling of PFAS is the spatial distribution of emissions. Therefore this study considers the emissions of the most widely used PFASs; perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), to water and air, and develops a global, spatially resolved emission inventory. It covers the whole time span since the first industrial-scale production around 1950, up until 2020, annually.

The three main sectors considered are the production of fluoropolymers, the diffuse emission by the use and disposal of consumer products, and the emissions by firefighting exercises in airports using Aqueous Film Forming Foams.

It makes use of already well-researched global total inventories and local measurements around relevant sites. Furthermore, it relates measured concentrations of major emission pathways to the diffuse emissions sources.

A mixed top-down and bottom-up approach is used, redistributing known totals based on socioeconomic proxies as well as estimating the emissions of single known point sources for multiple years by inter-and extrapolating production volumes, usage quotas, and recapturing efficiency of PFOA and PFOS.

The resulting distribution shows the major contributors over the relevant time periods and the modern production shift from Europe and the United States to China. It is observable that even with a theoretical total global fadeout of PFOA and PFOS, significant legacy pollution is still to be expected. It emphasizes the role of PFAS as a global persisting problem and the important role of global multi-compartment transport modeling to understand the danger that PFASs will pose in the future.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities
Session 3 Poster

Health burden of air pollution from the oil and gas lifecycle in Texas

Dr Karn Vohra
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Author list (excluding presenting author)
Ploy Achakulwisut (1), Eloise A. Marais (2), Jamie Kelly (2), Colby Francoeur (3,4), Colin Harkins (3,4), Brian McDonald (4)

Abstract

Texas is the largest US producer of oil and gas. Recent (mid-2010s) increases in production and lack of enforcement of regulations targeting activities such as flaring contribute to ambient air pollution with adverse effects on health. Here we quantify the impact of individual steps in the lifecycle on local and distant air quality and health. Steps include upstream (exploration and production including flaring), midstream (storage, transmission, and distribution), downstream (oil refining and petrochemical manufacturing), and end-use (marketing and consumption) activities. We use the GEOS-Chem model to simulate contemporary concentrations of health-hazardous air pollutants. Specifically, fine particles (PM$_{2.5}$), nitrogen dioxide (NO$_2$) and ozone after updating the model with air pollutant precursor emissions for each lifecycle stage from the US EPA National Emissions Inventory for 2017. The model is simulated at high resolution (25-31 km) nested over Texas to estimate local air pollution and globally at coarser scales (200-250 km) to assess influence of Texas on neighboring states and countries. We find that oil and gas activities in Texas contribute to 0.59 ug m$^{-3}$ (9%) of local PM$_{2.5}$, mostly (0.42 ug m$^{-3}$) from end use and 1.41 ppbv (62%) of local NO$_2$, mostly from combined upstream and midstream (0.37 ppbv) activities and from end use (0.99 ppbv). We use a health risk assessment model to estimate premature mortality from long-term exposure to PM$_{2.5}$ from all activities totaling 3,410 adult premature deaths dominated by end use (81%). This far exceeds small health benefits from decline in urban ozone pollution due to decline in its titration by NO$_x$. PM$_{2.5}$ from Texas oil and gas emissions may be responsible for 2,000 premature deaths in other US states, 160 in Mexico and 50 as far north as Canada. Our results underscore the need to mitigate air pollutant emissions from the whole oil and gas lifecycle.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups
Characteristics and Sources of Delhi aerosol—an overview based on filter-based observations

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Author list (excluding presenting author)
Mohammed S. Alam (1), Daniel J. Rooney (1), Sachin Dhawan (2), Mukesh Khare (2), Roy M. Harrison (1, 3), Zongbo Shi (1) and William J. Bloss (1)

Abstract

New Delhi is one of the most polluted cities in the world, where concentrations of particulate matter (PM) with diameters less than 2.5 µm (PM2.5) can exceed 600 µg m⁻³. The city experiences severe haze events during the post monsoon and winter period due to the combination of several factors, such as open burning of agricultural waste, wood burning, coal combustion and roadside trash burning. Therefore, it is important to understand the variability of PM composition, sources, and formation processes when developing tailored cost-effective mitigation air quality management policies. Here, we have investigated the PM composition over the course of a year using filter-based measurements at two urban sites within Delhi. Results suggest that the PM2.5 concentrations at both sites were above 150 µg m⁻³ for all seasons, more than the national standard limit (60 µg m⁻³), reaching up to >500 µg m⁻³ during winter. High chloride concentrations (> 90 µg m⁻³) were observed at both sites during winter. However, chloride concentrations were low (summer, max: 36 µg m⁻³; autumn, max: 30 µg m⁻³) during other seasons, suggesting different sources and chemical processes dominate during these seasons. In addition, high relative humidity and low temperature seem to facilitate aqueous phase reactions, resulting in high sulphate formation during the winter, whereas these reactions are less pronounced during the drier summer and autumn seasons. PM composition is greatly affected by regional air masses in the autumn due to the burning of the rice crop residue in the neighbouring states of Punjab and Haryana, while the formation of organic aerosol in summer seems to be dependent on the temperature. Overall, this study delivers an insight into the day/night and seasonal PM composition variability, sources (local vs. regional) and chemical processes that could be helpful for policy makers when delivering air quality management strategies.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Session 3 Poster

Changes in Global Urban Air Quality due to Large Scale Disruptions of Activity

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Author list (excluding presenting author)

Charlotte Stapleton (1)
James D. Lee (1,2)

Abstract

Since 2020, countries around the world have implemented various interventions in response to a global public health crisis. The interventions included restrictions on mobility, promotion of working from home and the limiting of local and international travel. These, along with other behavioural changes from people in response to the crisis affected various sources of air pollution, not least the transport sector. Whilst the method through which these changes were implemented is not something to be repeated, understanding the effects of the changes will help direct policy for further improving air quality.

We analysed NOx, O3 and PM2.5 data from many 100s of air quality monitoring sites in urban areas around the world, and examined 2020 in relation to the previous 5 years. The data were examined alongside mobility metrics to contextualise the magnitude of changes and were viewed through the lens of World Health Organisation guidelines as a metric to link air quality changes with human health. Interestingly, reductions in polluting activities did not lead to wholesale improvements in air quality by all metrics due to the more complex processes involved with tropospheric O3 production.

Early Career Scientist

YES, I am an early career scientist.

COVID-19 related abstracts

yes
Session 3 Poster

Atmospheric organic pollutants detected with high temporal resolution during 2020 (COVID-19 period)

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Author list (excluding presenting author)

Martínez-Domínguez Y. Margarita (1), Amador-Muñoz Omar(2)

Abstract

Polycyclic aromatic hydrocarbons (PAHs) and oxy-PAHs are toxic to humans (Mastandrea et al. 2005; Iwamoto et al. 2007). In this study, their presence in airborne particles ≤2.5 μm (PM$_{2.5}$) were determined using a Thermal Desorption Aerosol Gas Chromatograph /Mass Spectrometer (TAG-GC-MS). Measurements were made on an hourly frequency in May 2020 at Southwest of Mexico City, which is considered a receptor site for air pollutants. PAHs and oxy-PAHs concentrations were compared with those performed in May 2019. 27 of 33 PAHs analyzed and 5 of 7 oxy-PAHs analyzed were consistently detected. The concentration (median) of PAHs ranged from 1 (perylene) to 356 pg m$^{-3}$ (phenanthrene). The sum of 5 carcinogenic PAHs were 154 pg m$^{-3}$. The highest medians sum of carcinogenic PAHs were observed from 8:00 am to 10:00 am and from 8:00 pm to 9:00 pm (p<0.001), matching with the frequency of vehicle traffic. The concentration (median) of oxy-PAHs ranged from 18 pg m$^{-3}$ (7H-Benzo[de]anthracen-7-one) to 195 pg m$^{-3}$ (9,10-dihydroanthracen-9,10-dione). The median value of the sum of 5 oxy-PAHs was 402 pg m$^{-3}$. The results suggested that 1H-Fenalen-1-one and 7H-Benzo[de]anthracen-7-one were emitted from the fossil fuel combustion emitted by vehicles. While results indicate to fluoren-9-one is formed in the atmosphere, 9,10-dihydroanthracen-9,10-dione is likely to have both primary and secondary origin.

Due to mobility restrictions caused by the COVID-19 pandemic during 2020, the air quality improved. Concentrations of PAH and oxy-PAHs in May 2020 with respect to May 2019 reduced between 44 and 93% (68±17% in average) for PAHs, while for oxy-PAHs, decreased between 52 and 99% (77±20%, in average).

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

AMIGO: Analysis of eMIssions usinG Observations

IGAC Regional Working Groups

Americas Working Group

COVID-19 related abstracts
yes
Session 3 Poster

Organic molecular markers hourly measured in PM$_{2.5}$ at Southwest of Mexico City

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Abstract

The concentration of particle matter in the air ≤ 2.5 µm (PM$_{2.5}$) in the Metropolitan Zone of the Valley of Mexico (MZMV) has persisted for the last years and even increased in recent years despite different government policies implemented$^{[1]}$. The increase in PM$_{2.5}$ mass concentration by 10 µg m$^{-3}$ has been associated with an 8 % increase in mortality$^{[2]}$. Part of this mass is constituted by organic matter (20 % – 90 %). It is essential to elucidate the chemical composition of this fraction in order to identify the emission sources and understand the secondary formation processes of PM$_{2.5}$. This knowledge will lead to recommending actions to decrease particle mass and toxicity, which has been less considered in public policies.

For these reasons, a study was performed at Southwest of MZMV during May-June of 2019. Hourly determination of the PM$_{2.5}$ chemical composition was performed using a thermal-desorption aerosol gas chromatograph-mass spectrometer (TAG/GC-MS)$^{[3]}$. Positive Matrix Factorization (PMF)$^{[4]}$ was applied to identify the emission sources and formation processes. A constrained, converged PMF model with four factors explained 72 % of the variation of the PM$_{2.5}$. Specific organic markers were associated with Biomass Burning (levoglucosan, retene), Local Traffic (PAHs, hopanes), Petrogenic-Evaporative (pristane, light n-alkanes), and Secondary Organic Aerosol (SOA) (oxy-PAHs, esters). Biomass Burning factor represented 63 % due to a significant fire event in this period in the South of the country. Mass contributions to the PM$_{2.5}$ were SOA (22 %), Local Traffic (9 %), and Petrogenic-Evaporative (7 %).


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Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality
Seasonal Variation Analysis of PM2.5 over Accra, Ghana

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Author list (excluding presenting author)

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Abstract

Meteorology is a major driving force to poor urban air quality. This is due to its ability to influence the emissions, transport, formation, and deposition of air pollutants. In this study, the relationship between meteorological parameters including temperature, relative humidity, wind speed and direction and ambient air pollutants concentrations such as PM2.5 in the capital city of Ghana was carried out for a continuous period of 12 months from March 2020 to February 2021. Clear seasonality was observed for PM2.5, meteorological parameters and the air quality index. Maximum concentrations of PM2.5 were recorded in winter leading to poor air quality. Wind speed and relative humidity reversely correlated with the air pollutant while temperature showed a positive correlation with PM2.5. North-easterly winds led to highest concentrations during the winter season while south-westerly winds prevail over Accra in summer. The results from air quality index (AQI) indicated that severely poor air prevails during the winter period. These results justify the crucial role of meteorological parameters in air pollution formation with large variations in different seasons. These findings can be employed to enhance the understanding of processes that lead to air pollution and improve the accuracy of air quality forecast under different meteorological conditions.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

ANGA: African Group on Atmospheric Sciences
Session 3 Poster

Targeting double disproportionality in industrial air emissions in Canada: A strategy to reduce environmental inequities?

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University of British Columbia, Canada

Author list (excluding presenting author)

Shuoqi Ren (1); David Boyd (1); Amanda Giang (1)

Abstract

Marginalized groups are often exposed to disproportionate amounts of air pollution in Canada and around the world. Additionally, many emissions categories exhibit disproportionalities in air pollution releases. When these high emitters affect disadvantaged communities, double disproportionalities arise and in extreme cases, create sacrifice zones. This pattern in relation to industrial emission has been observed in the United States but has not yet been studied in Canada. The existence of double disproportionalities may cause emissions reductions, as enacted by many environmental and climate policies, not to reduce differences in exposure for vulnerable groups.

Our study assesses strategies to target the highest emitting industries and facilities to reduce emissions and air pollution exposure to improve environmental justice. We focus on emissions of PM$_{2.5}$ and PM$_{2.5}$ precursors from a subset of industries to identify double disproportionalities and how potential changes in emissions would affect exposure for vulnerable populations. Our results show that emissions from Canadian industrial facilities are unequally distributed. Super-emitting facilities frequently make up more than half of the total emissions from an industry. A buffer analysis suggests that in some cases, the highest emitting facilities within an industry are disproportionately located in vulnerable communities. Indigenous and low-income populations are the most frequently affected, which is in line with previous environmental justice research in Canada. We compare the results of the buffer analysis with modeled health impacts to differentiate between the effects of proximity and pollution dispersion. For modeling concentrations and health impacts we use Global InMAP, a reduced complexity chemical transport model. We will also present results on using Global InMAP to determine the effects of reducing or eliminating emissions from selected industries and their highest emitters. These results highlight potential strategies for effectively and efficiently reducing injustices due to industrial air pollution exposure.

Early Career Scientist

YES, I am an early career scientist.

IGAC Regional Working Groups

Americas Working Group
Session 3 Poster

A high spatial resolution (~2km) map of NOx emissions in the Bay Area

Yishu Zhu
University of California, Berkeley, USA

Author list (excluding presenting author)

Jinsol Kim (1); Anna Winter (2); Pietro Vannucci (2); Milan Patel (2); Naomi Asimow (2); Paul Wooldridge (2); Catherine Newman (2); Ronald C. Cohen (2)

Abstract

Nitrogen oxides (NOx), the sum of nitric oxide (NO) and nitrogen dioxide (NO2), are air pollutants critical to atmospheric chemistry, air quality, and climate. They are emitted into the atmosphere by both natural processes and human activities. Fossil-fuel combustion from transportation (passenger vehicles, heavy duty trucks, shipping by sea and air) and industrial emitters represent the bulk of anthropogenic NOx emissions. In the San Francisco Bay Area, we established a ~2-km spaced multipollutant low-cost sensor network (the Berkeley Environmental Air Quality and CO2 Observation Network, BEACO2N) which provides measurements of CO2, CO, NO2, NO, O3, and aerosol particles at ~40 locations. Here we first describe our approach to calibration of the NOx sensors and then present a map of NOx concentrations. Comparison of that map to a high spatial resolution map of emissions will be described.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

AMIGO: Analysis of eMissions usinG Observations, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality
Abstract

Tropospheric ozone causes numerous negative respiratory and cardiovascular effects, as well as billions of dollars in agricultural loss annually. The formation of this air pollutant is a complex non-linear process involving precursors of nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the presence of sunlight. In urban areas, emissions of NOx and VOCs as well as their impact on ozone levels can vary in time and space. Meteorological influences and varying topography further the complexity of understanding ozone spatial variability in urban areas. In the United States, the Environmental Protection Agency continuously monitors ozone, NOx, and other pollutants through standard regulatory air quality monitoring stations. These measurements are high-quality; however, the data lacks the spatial resolution needed to characterize neighborhood scale variations in urban air quality and the associated differential impact on population groups. The Berkeley Environmental Air-quality and CO2 Network (BEACO2N), a network of low-cost gas and aerosol sensors with 70 nodes in the Bay Area, is recording detailed ~2km pointwise maps of O3. Here, we utilize BEACO2N data to investigate drivers of spatial variability in tropospheric ozone at neighborhood scales.
Organic acids can be emitted directly into the air from vehicle emissions, biomass burning, food cooking, and other combustion processes; as well as formed in the atmosphere by oxidation reactions. Hourly measurements of polar organic compounds in particulate matter ≤2.5 μm (PM$_{2.5}$) were carried out from May to June 2019, at southwest of Mexico City. A Thermal Desorption Aerosol Gas Chromatograph-Mass Spectrometer (TAG-GC-MS) was used.

The campaign was characterized by a biomass-burning episode from May 10-16. Concentrations of PM$_{2.5}$, organic acids, retene and levoglucosan (biomass burning markers) during the biomass-burning episode were 4-, 3-, 9- and 4-times higher with respect to the period without biomass-burning, respectively (Mann Whitney, MW, p<0.001). Six organic acids were analyzed; palmitic acid was the most abundant, followed by stearic acid. The strong correlation of behenic and cerotic acids with retene and levoglucosan (Spearman, R>0.5, p<0.001) suggests biomass burning as their main source. In contrast, capric, myristic, palmitic, and stearic acids showed no correlation with levoglucosan or retene. They have been associated with cooking of meat. In addition, three dicarboxylic acids were identified: glutaric, suberic, and azelaic acid. A 1.5-fold increase in the concentrations of glutaric and azelaic acids was observed in the biomass-burning period with respect to non-biomass burning (MW, p<0.05). Suberic acid showed a similar concentration in both episodes. The presence of biomass-burning is an important source of polar organic compounds that contribute to the PM$_{2.5}$ mass.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

PACES: Air Pollution in the Arctic: Climate, Environment, and Societies

IGAC Regional Working Groups

Americas Working Group
Session 3 Poster

Flaring combustion efficiencies and NOx emission ratios from oil and gas facilities in the North Sea

Dr Jacob T Shaw
The University of Manchester, United Kingdom

Author list (excluding presenting author)

Amy Foulds (1); Shona Wilde (2); Han Yong (1); Patrick Barker (1); Freya Squires (2); James Lee (2); Ruth Purvis (2);
Stefan Schwietzke (3); Grant Allen (1)

Abstract

The oil and gas industry is a substantial source of methane (CH4), with emissions from intentional venting, leakage, and flaring. Gas flaring is widely used to combust natural gas into carbon dioxide (CO2). Inefficient combustion leads to emissions of unburnt natural gas (including CH4), as well as combustion by-products such as carbon monoxide (CO) and nitrogen oxides (NOx). Flaring is typically assumed to be highly efficient, with many inventories assuming 98% efficiency. However, very few studies have been performed on operational flares, particularly those operating offshore. Large uncertainties in flaring combustion efficiencies leads to significant uncertainties in greenhouse gas emissions from flaring.

We measured CH4, CO2, NOx, and ethane (C2H6) in 58 flare plumes observed and sampled during two aircraft campaigns in the North Sea. We report combustion efficiencies for these flares, destruction removal efficiencies of natural gas components, and emission ratios for NOx and C2H6. These measurements were made as part of a United Nations Climate and Clean Air Coalition (UN CCAC) project, the Methane Observations and Yearly Assessments (MOYA) project, and the NERC Assessing Atmospheric Emissions from the Oil and Gas Industry (AEOG) project.

We will also present updates on our work using unmanned aerial vehicles (UAVs) to measure and quantify emissions of CH4 from oil and gas production, landfill and wastewater treatment, and agriculture.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

AMIGO: Analysis of eMIssions usinG Observations
**Session 3 Poster**

**Future PM2.5-related premature mortality**

Dr Ulas Im  
Aarhus University, Department of Environmental Science/Interdisciplinary Centre for Climate Change (iClimate), Roskilde, Denmark

**Author list (excluding presenting author)**

Susanne E. Bauer (2), Lise M. Frohn (1), Camilla Geels (1), Kostas Tsigaridis (2,3), Jørgen Brandt (1)

**Abstract**

EVAv6.0 system has been used to estimate the present (2015) and future (2015-2050) global PM$_{2.5}$ and O$_3$-related premature mortalities, using simulated surface concentrations from the GISS-E2.1-G Earth system model. The PM$_{2.5}$-related global premature mortality is estimated to be 4.4 million, where ischemic diseases are the leading cause of PM$_{2.5}$-related premature deaths, contributing by 35% globally. Bias correcting the simulated PM$_{2.5}$ concentrations in 2015 leads to an increase of up to 73% (7.7 million) in the global PM$_{2.5}$-related premature mortality. The global burden of premature deaths is mainly driven by the Asian region, which in 2015 contributes by 75% of the total global premature deaths. PM$_{2.5}$-related premature mortality in 2050 decreases by up to 57%, due to emission reductions alone. However, the projected increase and aging of the population leads to increases of premature mortality by up to a factor of 2, globally, showing that the population exposed to air pollution can be more important than the level of air pollutants.

**Early Career Scientist**

NO, I am not an early career scientist.

**IGAC Activities**

CCMi: Chemistry Climate Model Initiative, PACES: Air Pollution in the Arctic: Climate, Environment, and Societies, TOAR: Tropospheric Ozone Assessment Report
Variations of Chemical Composition and Sources of PM2.5 in Beijing Based on Hourly Continuous Online Measurements from 2016 to 2019

Mei Zheng
College of Environmental Sciences and Engineering, Peking University, China

Author list (excluding presenting author)
Xiaomeng Liu(1)
Yue Liu(1)
Tianle Zhang(1)
Junyi Liu(1)

Abstract

PM2.5 concentration has shown a decreasing trend in China in recent years, especially in Beijing. This study aims to answer what sources and components of PM2.5 have shown the most dramatic changes and contributed to air quality improvement in the past few years. As most evaluations of effectiveness of control policies were based on emission inventory, it is very important to assess it based on ambient measurements. In our study, 1-h resolution measurements of various components of PM2.5 including ions, metals, elemental carbon, organic carbon, and black carbon (BC) were conducted continuously from 2016 to 2019 in Beijing. Sources of PM2.5 were identified based on receptor model (Positive Matrix Factorization).

Our results showed PM2.5 and BC concentration exhibited significant decrease from 2016 to 2019 (by 9.7 μg/m³ and 0.6 μg/m³, respectively). Both concentration and relative percentage of SO4²⁻ showed a decreasing trend, while the relative contribution of NO3⁻ has increased from 24% in 2016 to 30% in 2019, indicating the relative importance of vehicular emission increased. The contribution of coal combustion to both PM2.5 and BC decreased significantly especially in winter, by 3.5% yr⁻¹ for PM2.5 and 8.9% yr⁻¹ for BC. Secondary PM2.5 increased in both concentration and relative contribution. Therefore, in the future, for primary sources, traffic emission would become one of the main targets and secondary aerosol will play a more important role in PM2.5 in Beijing.

The receptor model results of sources of PM2.5 and BC were compared with the emission inventory for China (MEIC). A better correlation was found in the residential sector with correlation coefficient of 0.58 for PM2.5 and 0.78 for BC. This study is an example to show a combination of emission inventory and ambient measurements would provide a more complete picture of changes in sources of PM2.5 and effectiveness of control policies.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Regional Working Groups
China Working Group
**Session 3 Poster**

**Physico-chemical Characterization of Atmospheric Particles During Dust Storm in the Vicinity of Thar Desert**

Ms. Mamta Devi  
CSIR National Physical Laboratory, Dr. K.S. Krishnan Marg, New Delhi-110012, India. Academy of Scientific and Innovative Research (AcSIR), Ghaziabad - 201002, Uttar Pradesh, India

**Author list (excluding presenting author)**

Sumit Kumar Mishra (1,2); Supreet Kaur (1,2)

**Abstract**

Mineral particles present in dust impact the Earth’s radiation budget by absorbing and scattering the solar radiation and influencing cloud micro-physics. For the present study, atmospheric particles were collected during the dust storm in the pre-monsoon season i.e. May 2022 (on 4th and 6th May 2022) over the Jhunjhunu region (26.91ºN; 75.81ºE), Rajasthan, India. An offline characterization technique Scanning Electron Microscope coupled with Energy Dispersive X-Ray Spectroscopy (SEM-EDS) was used to study the individual particle morphology and composition.

Morphological analysis reveals the predominance of Angular, Layered, Quadrangular, Flattened, and Aggregate particles. The morphological parameter, AR (Aspect Ratio) of the particles exhibit exhibits the extent of particle non-sphericity (AR= 1, Spherical; >1, Non-Spherical). The frequency distribution of AR of 956 particles shows bimodal distribution having peaks at >1.2 - ≤1.4, >1.4 - ≤1.6, showing that ~90% of the particles were non-spherical and irregular in nature. The frequency distribution of another morphological parameter, circulatory factor (CIR) shows peaks at >0.6≤0.7 and >0.7≤0.8 respectively, confirming the result obtained from AR. EDS analysis shows that the C, Ca, Mg, Si, Al, and Fe were found to be abundant in the majority of particles. Na, K, S, and Cl were also present in a few particles. The probable mineral dust sampled in this study is consistent with previous studies indicating the presence of quartz (Si rich), hematite (Fe rich) and carbonates Ca rich minerals. Backward trajectory analysis confirmed the air parcel movement from the North West region i.e. from the Thar desert. The present work will be discussed in detail during the presentation.

**Early Career Scientist**

YES, I am an early career scientist.

**IGAC Activities**

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

**IGAC Regional Working Groups**

MANGO: Monsoon Asia and Oceania Networking Group
COVID-19 related abstracts

no
Session 3 Poster

Particulate Matter Removal Efficiency of Potted *Epipremnum aureum*: A Study in Indoor Environment

Miss Supreet Kaur
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Author list (excluding presenting author)

Sumit Kumar Mishra (1, 2); Chhemendra Sharma (1,2); Vikas Goel (3); Mayank Kumar (3); Rishabh Singh (1,2)

Abstract

The present study elucidates the effects of indoor plants, on the particulate matter reduction of various sizes. To access the exposure in the indoor microenvironment, indoor air quality was evaluated in the presence of 8 *Epipremnum aureum* potted plant species placed in a room (16 ft × 10 ft × 6 ft) for 7 consecutive days during which the temperature and relative humidity (RH) parameters were measured along with the PM mass concentrations. The control experiment (without plants) was conducted with the same conditions in the empty room. The indoor PM concentration was simulated by regular incense smoldering in a series of 3 days.

A strong correlation (0.8) was observed in the indoor and outdoor RH in control conditions, whereas in the presence of plants, it reduced to 0.59. However, there was no correlation found between the indoor and outdoor temperatures. Although indoor to outdoor PM ratio for PM$_{2.5}$ and PM$_{10}$ were found to be declining in the presence of potted plants. The evapotranspiration process in plants increased the RH in the room up to 60% which affects the PM deposition rates. Moreover, the PM depositions rates increased for the ultra-fine particle size range in the case of incense smoldering as compared to the real environment conditions where no effects were observed. Though a difference in concentration for 1µm and 2.5µm sized particles was found to be 16µg/m$^3$ and 6µg/m$^3$ respectively in the presence of plants during the incense burning. The type of particles seems to affect the removal efficiencies due to changes in particle hygroscopic and wetting properties in response to RH. The strong humidification capacity of *Epipremnum sps.* looks to play a crucial role in PM reduction and its rough leaf surface with grooves provides strong dust retention ability. Alongside, WD-XRF results also confirm reduction in some metal concentrations.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities


IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Temporal Variation of Elemental Composition of PM Fine Mode Fraction over Delhi NCR

Ms. Kartika Pandey
CSIR-National Physical Laboratory, Dr.K.S.Krishnan Marg, New Delhi, Delhi-110012, India. Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002, Uttar Pradesh, India

Author list (excluding presenting author)
Sumit Kumar Mishra (1,2); Chhemendra Sharma (1,2); Mukesh Khare (3)

Abstract

Ambient aerosol is a complex mixture comprising of mineral dust, sea salts, metals, and carbonaceous components (OC and EC). Out of these constituents, metals are considered to be a serious concern due to its active role in biological effects like the carcinogenic effects on human health in trace quantities. With the objective to better understand the levels and sources of ambient particles, PM$_{2.5}$ samples were collected at the seven sites in Delhi-NCR viz., IIT Delhi, Manesar, Noida, Faridabad, Bahadurgarh, Sonepat and Mullana. Approximately 700 samples were collected seasonally (Winter, Summer, Post Monsson, Spring and Intensive) so as to capture seasonal variation along with day-night temporal variations.

To determine the variation of elemental composition, Energy Dispersive X-ray Fluorescence (ED-XRF) technique has been employed. In total 33 elements have been found in varied concentration at different sites and in different seasons of which major elements include Na, Cl, S, Si, Cr, Mn, Ni, Pb, Cu, Co, As, Rb, Zn, Sn, Fe. The average concentration of some of the elements recorded for IIT Delhi during Winter are, Cl (20.01 ± 19.61 µg/m$^3$), in Summer (1.23 ± 2.68 µg/m$^3$), in Spring (4.52 µg/m$^3$ 4.52 µg/m$^3$), and in Post Monsson (3.85 ± 5.97 µg/m$^3$). In winters, high concentration of Cl has been found at IIT Delhi supersite in comparison to other seasons which may be attributed to waste burning/biomass burning. In Bahadurgarh, concentration of Cu has been observed in Winter (0.09 ± 0.10 µg/m$^3$), Summer (0.13 ± 0.20 µg/m$^3$), Post Monsson (0.14 ± 0.19 µg/m$^3$), which may be associated with industrial emissions. In Manesar, Pb observed in Winter (0.40 ± 0.67 µg/m$^3$), Summer (0.11 ± 0.24 µg/m$^3$), Spring (0.26 ± 0.42 µg/m$^3$), which may be due to metal processing industries.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon, AMIGO: Analysis of eMIssions usinG Observations, GEIA: Global Emissions Initiative

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Session 3 Poster

Effects of ambient air pollution exposure on IVF (in vitro fertilization) outcomes.

Mr Haoze Song
University of Edinburgh, United Kingdom

Author list (excluding presenting author)

Tom Clement (1), Ruth Doherty(2).

Abstract

Air pollution has received much attention in recent years, due to its deleterious health effects, which largely influence people’s life quality. However, little attention has been paid to the influence of air quality on in vitro fertilization (IVF) outcomes (biochemical pregnancy, clinical pregnancy, pregnancy loss, and live birth). We searched PubMed database for related articles written in English. At least one of the IVF outcomes needs to be included and the statistical associations need to be reported. Predefined tables were used to demonstrate extracted data from these studies. A total of 70 results were found from the databases, of which 11 studies were included in this systematic review. The selected studies are mainly conducted in China (7), US (3) and South Korean (1). NO2, O3, PM2.5, and PM10 are the most common air pollutants reported, which could decrease the chance of live birth, biochemical pregnancy, and clinical pregnancy following IVF. In Chineses cities, CO had a significant negative impact on the chance of clinical and biochemical pregnancy following IVF. However, results from the selected studies also reported that air pollutants (NO2, O3, PM2.5, and PM10) had no statistically significant relationship with IVF outcomes, and it happened in China, US and South Korean studies.

The inconsistency in the classification of IVF exposure windows and the different types of air quality data (simulated and measured) make the results of the selected studies unsatisfactory to make conclusive conclusions based on preliminary studies. In addition, the conflicting results of the selected studies, for example regarding the effect of ozone on live births, suggest the need for further research on the relationship between air pollution exposure and IVF.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups
Mitigating COVID transmission in place of worship: Characterizing CO2 concentration in California churches

Ms. Paloma Ledesma
Anthropocene Institute, USA

Author list (excluding presenting author)
Michelle Mendoza(1), Richard Lee(1), Frank Ling(1), and Ajith Kadowela(2)

Abstract

We have installed several sensors in two disadvantaged churches in northern California to gather CO2 data to assess air movements in those facilities. The prevailing scientific wisdom is that the enhanced movement of outside air through indoor environments would reduce the COVID reinfection rates indoors. Here we assume that CO2 concentrations are a good proxy for the cleanliness and movement of air. That is, a lower CO2 concentration (800-1000 ppm) would suggest that the indoor air would be less stagnant with reduced accumulation of pollutants such as organics and viruses. (We do not monitor organic or particle pollution.)

Our data analyses indicate that using the Heating Ventilation and Air Conditioning (HVAC) system more often would reduce the indoor CO2 concentrations, but it is an expensive remedy. Holding sermons remotely would cut down reinfection rates dramatically, but that would deprive church goers of an opportunity to worship in a more traditional setting during these trying times. Thus, filtering indoor air appears to be a better solution.

While continuing to monitor CO2, we will discuss the additional monitoring for particle pollution and filtering of indoor air using fan/filter combinations to reduce COVID reinfection rates indoors.

Explaining the implications of our measurements to church officials and encouraging them to take additional steps to curb COVID reinfection rates indoors has been a challenge. We will also discuss our attempts to engage social scientists to carry out this task.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups
Americas Working Group

COVID-19 related abstracts

yes
**Session 3 Poster**

**Sources of Carbonaceous Aerosols in Douala City, Cameroon**

Dr. Samuel Mwaniki Gaita  
Stockholm University, Sweden

**Author list (excluding presenting author)**

Robert Mbiake (2); August Andersson (1); Leonard Kirago (1); Örjan Gustafsson (1)

**Abstract**

The ability to combat air pollution in sub-Saharan African cities is limited due to the poor understanding of both local and regional pollution sources such as biomass burning emissions. For instance, carbonaceous aerosol emissions from fires in Africa accounts for about 50% of the global biomass burning emission, (Werf et al., 2010). In addition, rapid urbanization in sub-Saharan Africa, has led to increased pollution sources such as biomass-based fuels and vehicular emissions, (Kirago et al., 2022).

As such, an air pollution pilot study was done in Douala, Cameroon, whereby airborne particulate matter less than 2.5 µm (PM$_{2.5}$) samples were collected on quartz filters using a high-volume sampler operating at 30 m$^3$ h$^{-1}$. Samples were collected at the rooftop level (12 m a.g.l.) at the University of Douala, Cameroon between 6th July and 9th August 2021.

The average PM$_{2.5}$ species’ concentrations in µg m$^{-3}$ were; 7.4±2.2 (organic carbon, OC), 1.9±0.5 (elemental carbon, EC) and 2.9±0.5 (water soluble organic carbon, WSOC). The OC/EC ratio was about 4 indicating possible contribution from biomass burning, (Zhang et al., 2020). The WSOC/OC ratio was 0.4 indicating not-so aged OA, indication possible local sources. The mass absorption cross-section for WSOC at 365 nm was 0.9±0.2 m$^2$ g$^{-1}$ and the absorption Ångström exponent was 6.2±1.0. These optical values were in line with results from regions in Asia that are affected by carbonaceous aerosols from within and without the polluted big cities (Desari et al., 2019).

To gain a better understanding the specific contribution of these local and regional OA sources, radiocarbon composition analysis is recommended.

**Early Career Scientist**

NO, I am not an early career scientist.

**IGAC Activities**

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

**IGAC Regional Working Groups**

ANGA: African Group on Atmospheric Sciences
Session 3 Poster

Estimating changes in ozone levels due to COVID-19 lockdown measures based on a business-as-usual prediction scenario using a machine learning approach.

Mrs Melisa C. Diaz Resquin
Comisión Nacional de Energía Atómica, Argentina. Universidad de Buenos Aires, Argentina

Author list (excluding presenting author)

Pablo Lichtig (1,2); Diego Alessandrello (1); Marcelo De Oto (1); Dario Gomez (1); Cristina Rössler (1,3); Laura Dawidowski (1,3)

Abstract

The lockdown imposed during COVID-19 pandemic provided a unique opportunity to evaluate how $\text{O}_3$ concentrations respond to a sudden and deep decline in emissions of the primary pollutants. Argentina, in general, and the Metropolitan Area of Buenos Aires (MABA), in particular, were under strict control measures from March to May 2020. During this period private vehicle restrictions were intense, and primary pollutant concentrations decreased substantially. To quantify the changes in tropospheric $\text{O}_3$ concentrations, observations during the different lockdown phases were compared with modeled concentrations that would have occurred under a business-as-usual (BAU) scenario under no restrictions. We employed a Random Forest (RF) algorithm with and without meteorological normalization to estimate the BAU concentration levels. This approach exhibited a high predictive performance based on only a handful of available indicators (meteorological variables, air quality concentrations and emission temporal variations) at a low computational cost. The results during the testing period showed that the model captured the observed daily mean variation of $\text{O}_3$ with a normalized mean bias (NMB) of 7% and its diurnal cycle with a Person correlation coefficient of 0.8 ($r_{dc}$). Based on the Random Forest results, higher $\text{O}_3$ concentrations were also observed, which is consistent with the response in a VOC-limited chemical regime to the decline in NOx emissions. Also the variable importance (permutation difference) was evaluated pointing out the need of accounting not only for the differences in emissions, but also in meteorological variables to evaluate the lockdown effects on air quality. The findings of this study may be valuable for formulating emission control strategies that do not disregard their implication on secondary pollutants.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

AMIGO: Analysis of eMIssions usinG Observations, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

Americas Working Group

COVID-19 related abstracts
yes
Characterization of submicron aerosol composition and size near ship plumes, within a Sulphur Emission Control Area (SECA), and in international waters.

Dr Navaneeth Meena Thamban
Postdoctoral Research Associate, United Kingdom

Abstract

Ship emission has become a significant contributor to anthropogenic air pollution in recent decades. Submicron aerosols from ship emissions affect the radiative forcing by altering the cloud properties. One such contributor is Sulphate aerosol, which causes a net negative radiative forcing. Additionally, other non-refractory species, Black Carbon (BC) and Organic Carbon (OC) emitted from the ships, may also affect the radiative forcing by increasing the uncertainty in radiative forcing estimation. Hence, it is important to understand the composition and size of submicron aerosols in various ship emission environments.

We have measured the size and composition of submicron aerosols in three-ship emission environments that includes the shipping lanes of the Bay of Biscay, the English Channel Sulphur Emission Control Area (SECA), and the Celtic Sea to understand the difference in emissions in these different regions. The measurements were made between 29th September and 12th October 2021 using the Facility for Airborne Atmospheric Measurements (FAAM) research aircraft as a part of Atmospheric Composition and Radiative forcing changes due to UN International Ship Emissions regulations (ACRUISE)Project.

This study discusses results from various onboard measurements. Submicron aerosol composition and size are derived from Aerodyne Compact Time-of-Flight Aerosol Mass Spectrometer (c-ToF-AMS; Aerodyne) and Single Particle Soot Photometer (SP2; DMT). Other instruments such as cloud droplet probe (CDP; DMT) and Scanning Mobility Particle Sizer (SMPS) were further used to measure the size-resolved particle number concentrations and to investigate the relationship between ship emissions and cloud properties. The key ship plumes were from container ships, bulk carriers, LNG tankers, crude oil tankers, and ferries.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group, ANGA: African Group on Atmospheric Sciences, Americas Working Group
Session 3 Poster

City and site-type variations of two PM2.5 oxidative potential measures in five Colombian cities

Dr Nestor Y Rojas
Universidad Nacional de Colombia, Colombia

Author list (excluding presenting author)

Dayana M. Agudelo (1), Diana M. Marin (2), Juan G. Piñeros (3), Laura A. Rodriguez (4)

Abstract

Ambient fine particles (PM2.5) have been shown to cause oxidative stress, which has negative health consequences. The oxidative potential (OP) caused by PM 2.5 was assessed in five Colombian cities using the synthetic respiratory tract lining fluid (RTFL) assay that tracks the depletion of glutathione (GSH) and ascorbic acid (AA). For this, a set of 91 integrated 2-week ambient PM2.5 samples were collected using Ultrasonic Personal Aerosol Samplers (UPAS) at background, traffic, industrial and residential sites. PM2.5 mass concentration was 20.20 ± 9.36 μg m−3. The OPGSH and OPAA burdens were 2.67 ± 1.27 and 2.93 ± 1.22 % Depletion m-3, respectively. OPGSH and OPAA differences among cities neither followed the same pattern nor reflected PM2.5 mass concentration differences. Overall, industrial sites showed higher PM2.5 mass concentrations and OPAA. In contrast, OPGSH did not show significant differences among industrial, traffic, and residential sites, but was lower for background sites. These site patterns, however, varied among cities.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Regional Working Groups

Americas Working Group
Identifying sources of fine mode aerosols during the pre-monsoon period in Brahmaputra Valley

Mr. Adnan Qadri
IIT Kanpur, India

Author list (excluding presenting author)
Tarun Gupta (1)

Abstract

24-hour time-integrated ambient aerosol samples were collected using a multi-channel speciation air sampling system. Sampling was carried out at a regional station in the Brahmaputra valley at Jorhat during the pre-monsoon period (March-May). The samples were analyzed for gravimetric mass as well as thermal fractions of carbon water-soluble inorganic ions, and trace and crustal metals. Clustering of air mass trajectories along with Potential Source Contribution Function (PSCF) modeling indicated the influence of regional as well as remote aerosols. A prominent seasonal characteristic is the influence of remote aerosols from the Indo Gangetic Plains region. The mean concentration of PM2.5 was observed to be 41 ± 21 µg m⁻³. The region is dominated by ammonium-rich conditions with an average neutralization ratio of 1.5. Source apportionment of PM2.5 indicated the presence of biomass burning aerosols, secondary aerosols, and dust. The mineral dust characterized by the high presence of silica and iron sources was apportioned to contribute about 27% to the aerosol mass concentration followed by the secondary inorganic aerosol rich source (26%). The SIA source shows the neutralization of nitrate, sulfate, and chloride by ammonium. A biomass burning factor with potassium and thermal fractions of carbon was identified with higher mean values in the month of March and April. The presence of considerably high fire activity during the two months was identified using MODIS. The Brahmaputra Valley region in the South Asia mainland witnesses high fires during the pre-monsoon period on account of shifting agriculture and forest fires resulting in the high contribution of biomass burning to the fine aerosols.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon, AMIGO: Analysis of eMIssions usinG Observations

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Session 3 Poster

Sea breeze role on air quality in the Red Sea coastline cities: Jeddah as a case study

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Author list (excluding presenting author)

James Allen (1)
Hugh Coe (1)

Abstract

Local wind flow is a vital factor in controlling pollution levels in cities. The change to the flow system could lead to considerable improvement or distortion of air quality in the near-surface troposphere layer. Coastal cities near the shoreline are more vulnerable to these changes due to the frequently occurring sea breeze. The Red Sea has been considered to experience the strongest sea breeze in the world, with wind speed exceeding 8 m/s.

Therefore, we expect that there will be such a great influence on air quality in these cities, resulted from the change in the thermodynamic flow of land-sea breeze. We selected Jeddah to be a case study due to its favourable coast of sea breeze flow, large population, various industrial and transportation activities as it is considered to be the economic and tourism capital of Saudi Arabia.

In this paper, we use surface meteorological parameters and vertical profiles of sounding data to track sea breeze presence. Also, we utilise the HYSPLIT model to understand the influence on local flow from the synoptic force and the sea breeze. These findings will be supported by previous work on sea breeze studies within the same region.

The findings of this work are going to enhance our understanding of how sea breeze systems affect coastal city air quality at different conditions, at weak and strong breezes. Another objective is to quantify that influence on coarse and fine particulate matter concentrations and how it is related to the air pollution background level.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality
Session 3 Poster

Assessment of particle pollution events in a large megacity in the Southern Hemisphere

Dr. Guilherme Martins Pereira
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Author list (excluding presenting author)
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Abstract

São Paulo Metropolitan Area is among the largest in the Southern Hemisphere and its air quality standards are less restrictive than the ones adopted by EU countries, leading to high air pollution levels, especially in the dry season. Particulate matter was sampled in a dry period (99 samples) with high-volume samplers (24 hours of sampling); fine particulate matter (PM$_{2.5}$) was collected in quartz fiber filters. Then, different chemical species were determined in PM$_{2.5}$ (trace elements, anhydrosugars, sugar alcohols, organic and elemental carbon). PM$_{2.5}$ concentrations varied largely, ranging from 7 to 62 µg m$^{-3}$, surpassing the WHO daily recommendations on 75% of the sampling days. The most abundant elements were K > Al > Cu > Fe; K was associated with soil resuspension and biomass burning, Al with soil resuspension, and Fe and Cu with vehicular sources in this site. The biomass burning tracer levoglucosan levels (mean: 406 ng m$^{-3}$) presented a reduction compared to a previous sampling campaign performed in a dry period five years earlier (mean over 500 ng m$^{-3}$); control policies on sugarcane crop burning have been applied since then. During high pollution events, Lev/Man ratios were increased, suggesting the influence of the burning of different types of biomass. Levoglucosan presented strong Pearson correlations with traffic-related species such as V, Zn, and La (above 0.7), suggesting an increase in the levels of pollutants from different sources when meteorological conditions are unfavorable for pollutant dispersion. OC1 is the most volatile fraction of organic carbon and was strongly correlated with metals (Bi, U, La, Zn, Co, and V) from different sources (including vehicular) and levoglucosan (biomass burning). It was possible to identify high pollution events in the studied period and observe the influence of biomass burning on these events, added to the local vehicular source.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

GEIA: Global Emissions Initiative

IGAC Regional Working Groups

Americas Working Group, Southern Hemisphere Working Group
Session 3 Poster

**Improving NMVOCs control strategies based on emission source characteristics and chemical reactivity in Spain**

Kevin Oliveira  
Earth Sciences Department, Barcelona Supercomputing Center, Barcelona, Spain

**Author list (excluding presenting author)**

Marc Guevara (1), Santiago Enciso (1), Oriol Jorba (1), Carlos Pérez García-Pando (1,2)

**Abstract**

Tropospheric ozone (O\(_3\)) is an adverse environmental and health problem in Spain, where the target value for health protection set up by the European Air Quality Directive 2008/CE/50 is systematically exceeded.

During the last decade, the two main O\(_3\) emission precursors have evolved in different ways: while NOx emissions have been reduced by -28% and are expected to continuously decrease during the next years, NMVOCs have had a smaller reduction (-16%) and are expected to remain quite constant or even increase according to official future projections.

To support the design of the Spanish national O\(_3\) plan, which is being prepared by the Spanish Ministry of Environment, we developed an anthropogenic NMVOC speciated emission inventory and used a reactivity-based approach by calculating the Ozone Formation Potential (OFP) to identify the main emission sources influencing O\(_3\) levels in Spain.

Official annual emission inventories reported by the Ministry were temporally disaggregated to the monthly scale and combined with source-specific speciation profiles based on state-of-the-art literature. Multiple chemical speciation profiles, which are used to split total NMVOC into individual components, were collected and compared to assess the uncertainty related to the speciation process.

By focusing on the main O\(_3\) season (between June and August) we identified the solvent sector as the main contributor to the total OFP, with variable weight per autonomous community. This work showed that, when addressing local emissions, each autonomous community has specific challenges. Mainly in the south and more rural areas of Spain, the focus should be on the agricultural waste burning sector. While in major urban areas, e.g. Madrid, the domestic use of solvents can contribute to OFP by up to 75%.

**Early Career Scientist**

YES, I am an early career scientist.

**IGAC Activities**

GEIA: Global Emissions Initiative
Abstract

Chemistry in snowpacks and at ice surfaces can dramatically affect atmospheric composition and the fate of atmospheric pollutants. Including snow and ice as reaction media in coupled chemistry-atmospheric models is challenging because we generally do not understand how reactions occur there. There is not a lot of research in this area, and existing results are often conflicting. We combine measurements of reaction kinetics in laboratory-prepared snow and ice with microspectroscopic investigations of the physicochemical properties of ice surfaces in the presence of environmentally-relevant solutes to link reactivity to physicochemical properties of the local environment. This work shows that reaction environments can be very different at ice surfaces compared to in liquid aqueous solution, and provides mechanistic and kinetic insight that may help improve model parameterization.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

CATCH: the Cryosphere and Atmospheric Chemistry

IGAC Regional Working Groups

Americas Working Group
Session 4 Invited

Connecting the physicochemical with the biological: Viruses and bacteria in atmospheric aerosol

Prof. Jonathan P. Reid
University of Bristol, United Kingdom

Author list (excluding presenting author)

Henry P. Oswin (1), Allen E. Haddrell (1), Mara Otero-Fernandez (1), Robert Alexander (2), Jamie F.S. Mann (3), Tristan A. Cogan (3), Thomas G. Hilditch (1), Jianghan Tian (1), Daniel A. Hardy (1), Darryl J. Hill (2), Adam Finn (2), Andrew D. Davidson (2)

Abstract

The COVID-19 pathogen has led to a growing recognition of the importance of aerosol in transmitting respiratory pathogens. Indeed, aerosols provide a unique microenvironment for micro-organisms. Aerosol particle compositions often access supersaturated solute concentrations that exceed anything achieved in bulk phases. Particles are dynamic, adapting on short timescales to changes in the local ambient environment, leading to rapid changes in water content, temperature, pH and phase. The high surface-to-volume ratio leads to facile interaction of biological components with gas phase pollutants and reactants.

We recently reported a novel combination of techniques to study both the physicochemical transformation of single aerosol particles on timescales from <1 s to hours and to measure changes in the viability of bacteria or infectivity of viruses in the aerosol phase. Studies of physicochemical transformations include the rate of change of moisture content and particle size, the evolving pH, and the phase behaviour of drying surrogates of respiratory fluid aerosol. For example, we have shown that the dramatic change in gas phase carbon dioxide concentration from within the lungs to the ambient environment leads to a significant increase in pH to strongly alkaline conditions. In parallel, we have made measurements of the airborne survival of the Mouse Hepatitis Virus, the Severe Acute Respiratory Syndrome Coronavirus 2, Escherichia coli and Group A Streptococcus with varying relative humidity and temperature.

In this talk, we will compare our developing understanding of the environmental factors that drive changes in the physicochemical properties of aerosols and how they influence the survival of bacteria and viruses in atmospheric particles.

Early Career Scientist

NO, I am not an early career scientist.

COVID-19 related abstracts

yes
Session 4 Oral

Influence of a new 'aerosol inhibited' photochemical ozone regime.

Prof Mathew J Evans
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Author list (excluding presenting author)

Peter Ivatt (1,2); Ally Lewis (1,2)

Abstract

The chemical chain reactions where volatile organic compounds (VOCs), carbon monoxide, and methane are oxidised in the presence of oxides of nitrogen (NOx) lead to the production of the pollutant O₃. For decades regions have been separated into either ‘NOx limited’ (peroxyl radical self-reactions dominate) or ‘VOC limited’ (OH+NO₂ reaction dominates) regimes. This controlling regime would then decide policies for emission reductions and so how to reduce O₃ concentrations. We show that a third ‘aerosol inhibited’ regime can exist, where reactive uptake of HO₂ radicals onto aerosol particles dominates. Using a chemistry transport model we show that in 1970, 2% of the Northern Hemisphere population lived in this aerosol-inhibited regime, but by 2014 this had increased to 21%. This is significantly (60%) more than those who lived in a VOC-limited regime. O₃ concentrations in North America and Europe in the 1970s were reduced due to the aerosol-inhibited chemistry and it is currently reducing O₃ concentrations over Asia. The potential existence of this third photochemical regime thus leads efforts to reduce aerosol loads in some parts of the world, to increase surface O₃ concentrations. Future work to better assess modelled aerosol surface area densities, and the processes controlling the value of the HO₂ uptake coefficient (ϒHO₂) are needed to better understand the significance of this regime.

Early Career Scientist

NO, I am not an early career scientist.
Session 4 Oral

A potential feedback mechanism of springtime Arctic snow/ice algae, iodic acid aerosols and Arctic clouds

Dr. Yongxiang Hu
NASA Langley Research Center, USA

Abstract

Water cloud droplet number density ($N_d$) can be accurately estimated from CALIPSO lidar measurements (Hu et al., 2021, https://www.frontiersin.org/articles/10.3389/frsen.2021.724615/full ). One interesting findings from the new droplet number density statistics is the huge cloud droplet number density ($N_d$) of boundary layer clouds in the springtime Arctic. Comparing $N_d$ with chlorophyll biomass of snow/ice algae calculated from high resolution Arctic models, we found excellent spatial/temporal correlations between the two. In this talk, I will introduce the lidar measurements of water cloud microphysical properties, the correlation between cloud droplet number density and ice algal biomass, as well as a hypothesis of a positive feedback mechanism of springtime Arctic snow/ice algae, iodic acid aerosols and Arctic clouds. I will also introduce the ongoing ICESat-2 data analysis of snow properties (Hu et al., 2022, https://www.frontiersin.org/articles/10.3389/frsen.2022.855159/full ) that helps modeling of ice algal biomass and evaluating the feedback mechanisms.

Early Career Scientist

NO, I am not an early career scientist.
A seasonal analysis of aerosol NO$_3^-$ sources and NO$_x$ oxidation pathways in the Southern Ocean marine boundary layer

Miss Jessica M Burger
Department of Oceanography, University of Cape Town, South Africa

Author list (excluding presenting author)

Emily Joyce (1)
Meredith G. Hastings (1)
Kurt A. M. Spence (2)
Katye E. Altieri (2)

Abstract

Nitrogen oxides, collectively referred to as NO$_x$ (NO + NO$_2$), are an important component of atmospheric chemistry involved in the production and destruction of various oxidants that contribute to the oxidative capacity of the troposphere. The primary sink for NO$_x$ is atmospheric nitrate which has an influence on air quality, climate, and the biogeochemical cycling of reactive nitrogen. Despite its importance, NO$_x$ cycling remains poorly constrained particularly over the Southern Ocean (SO). This is due to a lack of observational data owed to the logistical challenges of sampling in remote regions, especially during winter. This study presents seasonally resolved measurements of the isotopic composition ($\delta^{15}$N, $\delta^{18}$O and $\Delta^{17}$O) of atmospheric nitrate in coarse mode aerosols (> 1 μm), collected between South Africa and the sea ice edge in summer, winter and spring. Similar latitudinal trends in $\delta^{15}$N-NO$_3^-$ were observed in summer and spring, suggesting similar NO$_x$ sources. Based on the isotopic composition of aerosol nitrate, the main NO$_x$ sources were lightning, oceanic alkyl nitrates and snow pack emissions at the low, mid and high latitudes respectively. A combination of natural NO$_x$ sources, likely transported from the lower latitude Atlantic characterises the winter, with the potential for a stratospheric NO$_x$ source evidenced by one sample of Antarctic origin. Low summertime $\delta^{18}$O-NO$_3^-$ (< ~70‰) suggests daytime processes involving oxidation by OH dominates nitrate formation, while higher winter and springtime $\delta^{18}$O-NO$_3^-$ (> ~60‰) suggests an increased influence of O$_3$ oxidation (i.e., N$_2$O$_5$, DMS, BrO). Significant linear relationships between $\delta^{18}$O and $\Delta^{17}$O suggest isotopic mixing between OH/H$_2$O(v) and O$_3$ in winter, and atmospheric O$_2$ and O$_3$ in spring. These results confirm the importance of the surface ocean and sea ice to NO$_x$ sources and nitrate formation pathways outside of the more regularly sampled summertime.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

CATCH: the Cryosphere and Atmospheric Chemistry

IGAC Regional Working Groups
The Relative Contribution of Ozonolysis and Photolysis of the Sea Surface Microlayer as a Source of Volatile Organic Compounds in the Canadian Arctic

Stephanie R. Schneider
University of Toronto, Canada

Author list (excluding presenting author)

Douglas B. Collins (1), Jonathan P. D. Abbatt (2)

Abstract

Photolysis and ozonolysis of the sea surface microlayer (SSML) have been shown to be a source of volatile organic compounds (VOCs) to the atmosphere. This abiotic source of marine VOCs is important to consider for particle growth/formation in the remote marine troposphere, since this process can potentially lead to new particle formation and growth, with climate impacts. While both reaction pathways have been shown to occur in the laboratory setting, there is uncertainty about the relative importance of each pathway. Here, we use Thalassiosira pseudonana cultures to form a reproducible SSML to investigate the yield of VOCs from both ozonolysis and photolysis. We show that the VOC yield from ozonolysis is initially higher, however it is a finite source of VOCs due to the specificity of the ozonolysis reaction to unsaturated compounds. Photolysis yields are initially lower and are sensitive to the presence of a surface film and underlying photosensitizers. We also compare the VOC yield from both mechanisms for real SSML samples collected from the Canadian Arctic during the NETCARE campaign. Previous results from the campaign concluded that oxygenated-VOCs correlated with the presence of enriched organics in the ocean water (Mungall et al., 2016), and we aim to identify the mechanism by which the oxygenated-VOCs were released.

Early Career Scientist

YES, I am an early career scientist.
Session 4 Oral

Iodine monoxide (IO) variations in the global marine boundary layer

Hisahiro Takashima
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Author list (excluding presenting author)

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Abstract

Iodine compounds destroy ozone (O₃) in the troposphere and form new aerosols, thereby affecting the global radiative balance. However, few reports have described the latitudinal distribution of atmospheric iodine compounds. This work reports iodine monoxide (IO) variations observed by ship-borne multi-axis differential optical absorption spectroscopy (MAX–DOAS) on RV Mirai from 2014 to 2021, over unprecedented sampling areas from the Arctic to the Southern Hemisphere and spanning a large range of sea surface temperatures (SSTs). The highest IO concentrations (up to ~1 pptv) were observed over the Western Pacific warm pool, where O₃ minima were also measured. There, a negative correlation was found between O₃ and IO mixing ratios at extremely low O₃ concentrations. This anti-correlation is not explained readily by the O₃-dependent oceanic fluxes of photolabile inorganic iodine compounds, which is the dominant source in recent global-scale chemistry transport models representing iodine chemistry.


Early Career Scientist

NO, I am not an early career scientist.
Session 4 Oral

Oceanic Transfer and Atmospheric Transformation of Marine Carbohydrates in the Arctic and the Southern Ocean west of the Antarctic Peninsula

Sebastian Zeppenfeld
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Author list (excluding presenting author)

Manuela van Pinxteren (1); Manuel Dall’Osto (2); Hartmut Herrmann (1)

Abstract

Marine carbohydrates are released by microbes at the surface of the oceans and contribute significantly to dissolved and particulate organic carbon. They enter the atmosphere as part of sea spray aerosol (SSA) through wind-driven processes. However, the emission processes of marine carbohydrates, their atmospheric aging and their microphysical role in cloud formation processes are not well understood. To this end, the primary transfer of carbohydrates from the ocean via the sea surface microlayer (SML) to the atmosphere and their secondary atmospheric modifications were studied in the pristine Arctic (PASCAL/SiPCA cruise, May-July 2017) and Southern Ocean west of the Antarctic Peninsula (PI-ICE campaign, January-March 2019).

Here, we present marine carbohydrates found in bulk seawater (at 1 m depth), the SML, size-resolved aerosol particles and fog water and their contribution to organic carbon. Air back-trajectories and strong correlations between the aerosolized carbohydrates, sodium and the wind speed suggest local and regional wave breaking and bubble bursting processes as the driving emission processes for the atmospheric carbohydrates.

The carbohydrate to sodium ratios in seawater, aerosol particles and fog water showed a chemo-selective transfer of carbohydrates towards sodium during the sea-air transfer. A direct comparison of enrichment factors in the SML and the aerosol particles in the two polar regions revealed, however, a more complex marine environment in the sea-ice covered Arctic than the ice-free Antarctic Peninsula in the summer period, most likely due to the presence of different sea-ice related habitats, such as the marginal ice zone and melt ponds.

Finally, the monosaccharide composition of the carbohydrates detected in the aerosol and water samples gave strong evidence for bacterial modifications, rather than abiotic reactions or processes, of the aerosolized carbohydrates in the atmosphere after their oceanic emission.

Early Career Scientist

YES, I am an early career scientist.

COVID-19 related abstracts

no
Session 4 Oral

Thermodynamical roadmap to effectively mitigate high aerosol loading during winter over the Indo-Gangetic Plain (IGP)

Prodip Acharja
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Abstract
Researchers have a long-standing conundrum for the apparent disconnection between immense aerosol loading and adopted mitigation policies in different climatological regions like the USA, Europe, China, and India. Ammonium chloride and ammonium nitrate are the major inorganic fractions of fine aerosols in the Indo-Gangetic Plain (IGP) during winter, and here, we investigate the sensitivity of aerosol loading to precursor gases like hydrochloric acid (HCl), nitrogen oxides (NO\textsubscript{x}), and ammonia (NH\textsubscript{3}). A new mechanistic insight into the secondary aerosol formation is proposed by integrating ISORROPIA-II thermodynamical model with high-resolution simultaneous measurements of precursor gases and aerosols, simultaneously monitored for the first time in India using the MARGA-2S instrument. Results show aerosol acidity (pH) and aerosol liquid water content (ALWC) to be the main parameters that modulate the mass loading and volume growth factor (VGF) of aerosols. VGF of PM\textsubscript{1} and PM\textsubscript{2.5} increases exponentially with RH, attributing to the water uptake by hygroscopic constituents and enhanced multiphase reactions in high humid conditions. Using pH and ALWC as co-ordinates, we defined six sensitivity regimes, (a) "HNO\textsubscript{3} sensitive", (b) "HCl and HNO\textsubscript{3} sensitive", (c) "HCl, NH\textsubscript{3} and HNO\textsubscript{3} sensitive", (d) "HNO\textsubscript{3} and NH\textsubscript{3} sensitive", (e) "NH\textsubscript{3} sensitive", and (f) "insensitive" where aerosols are sensitive to HCl, HNO\textsubscript{3}, and/or NH\textsubscript{3}. We found the PM\textsubscript{1} and PM\textsubscript{2.5} aerosols to fall in the "HCl and HNO\textsubscript{3} sensitive regime", emphasizing that HCl and HNO\textsubscript{3} reductions would be the most effective pathway to reduce aerosols in ammonia-rich IGP. This is in disparity with the existing mitigation strategies, which prioritize NH\textsubscript{3} abatement and are less effective. Thus, our study provides "actionable intelligence" to the policymakers to consider pH and ALWC as policy-relevant parameters and abate precursors not at "random" but in a thermodynamically consistent way to alleviate aerosols optimally over a region.

Early Career Scientist
YES, I am an early career scientist.

IGAC Activities
MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups
MANGO: Monsoon Asia and Oceania Networking Group
Session 4 Oral

Marine aerosol feedback on biogeochemical cycles and climate in the Pacific Ocean

Dr. Akinori Ito
JAMSTEC, Japan

Author list (excluding presenting author)

Yuzo Miyazaki (2); Fumikazu Taketani (1); Yoko Iwamoto (3); Yugo Kanaya (1); Jun Nishioka (2)

Abstract

Human activities have profoundly altered the air quality and climate on a global scale in the Anthropocene. It is our task to quantitatively evaluate the impact of human activities on marine ecosystems and climate through various feedbacks in global biogeochemical cycles. To what extent do aerosols and their precursor gases change the cloud properties under the influence of marine biogeochemical activities, and thereby affect the climate? At the same time, to what extent does the supply of nutrients from the atmosphere to the ocean change biogeochemical cycles under the influence of human activities, and thereby affect marine ecosystems? We summarize the progresses in research on organic aerosols, iron and nitrogen in the marine atmosphere, focusing on the Pacific Ocean. Future perspectives include the integration of field observational, laboratory experimental, and numerical modeling studies.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Regional Working Groups

Japan National Committee
Phase state in secondary organic aerosols over China simulated by WRF-Chem

Zhiqiang Zhang
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Author list (excluding presenting author)
Haiyan Ran1,2; Wei Zhou1; Yele Sun1,2; Junling An1,2; Ying Li1,2

Abstract

Secondary organic aerosol (SOA) can exist in liquid, semi-solid or solid states, depending on chemical composition and ambient atmospheric conditions. SOA is often assumed to be homogeneous and well-mixed liquids in chemical transport models, with its formation modelled assuming rapid establishment of gas–particle equilibrium. Recent studies, however, have demonstrated that an amorphous solid or semi-solid phase state can result in kinetic limitations in gas-particle partitioning. Phase states of SOA were simulated in several previous studies, with a focus on the globe or locations in U.S. or the Amazon rainforest. Here we simulate the glass transition temperature ($T_g$) and phase state of SOA over China based on volatility distributions (Li et al., 2020) in summer and winter of 2018 using the Weather Research and Forecasting model coupled to Chemistry (WRF-Chem). The simulated $T_g$ is mostly in a range of 285 ~ 300 K, with the spatial distribution negatively correlated with volatility distributions. The simulated $T_g$ at the Beijing site is 290 K, consistent with the value predicted using ambient observations of volatility. Considering the water uptake by SOA, the simulated viscosity shows a prominent geospatial gradient, and the spatial pattern is consistent with our previous global simulations (Shiraiwa et al., 2017). Sensitivity simulations show that assuming that SOA particles are internally mixed with inorganic species in one phase, the water associated with inorganic compounds could lower the viscosity by several orders of magnitude in southern China, while the particles in northern China could remain semi-solid, indicating that thermodynamic gas-particle partitioning should be more thoroughly evaluated in these locations.

Reference:


Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

of Air Quality, PACES: Air Pollution in the Arctic: Climate, Environment, and Societies, TOAR: Tropospheric Ozone Assessment Report, ACAM: Atmospheric Chemistry and the Asian Monsoon

IGAC Regional Working Groups

China Working Group
Session 4 Oral

Constraints on the role of Laplace pressure in multiphase reactions and viscosity of organic aerosols

Sarah Petters
Aarhus University, Denmark. University of North Carolina, USA

Author list (excluding presenting author)

Abstract

Organic aerosols in the atmosphere impact climate and public health. Heterogeneous reactions occurring in or on particles can alter their key properties such as volatility, light absorption, toxicity, and hygroscopicity. These reactions are difficult to characterize due to the difficulty of detecting interfacial phenomena and molecules in nanoparticles, and the role of interfaces in condensed-phase reactions remains poorly understood. In this work I use aerosol nucleation physics and transition state theory to model the size-dependence of aerosol reaction rates and viscosity (Petters 2022, Geophys. Res. Lett., doi: 10.1029/2022GL098959). I derive a liquid-drop formalism to account for surface tension in these reactions. Insights from organic synthesis studies suggest that accretion and cyclization reactions are accelerated in particles smaller than 10 nm. Reactions of peroxide, epoxide, furanoid, aldol, and carbonyl functional groups are accelerated by up to tenfold. Effective rate enhancements are ranked as: cycloadditions >> aldol reactions > epoxide reactions > Baeyer-Villiger oxidation. Multi-step reactions are inhibited in sub-10-nm particles. This work is also the first to present a model for size-dependent aerosol viscosity changes induced by Laplace pressure, e.g., the energy added to the droplet by surface tension. In sharp contrast to models for the viscosity of organic liquids, atmospheric aerosols are predicted to liquefy at small sizes due to changes in their microstructure. Results suggest that internal pressure is an important consideration in studies of the physics and chemical evolution of nanoparticles. Incorporation of these insights into atmospheric chemistry changes the way we interpret phase, activity, and reactions in the aerosol phase.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Regional Working Groups

Americas Working Group
Session 4 Poster

Comparing the impacts of isoprene and iodine emissions on tropospheric photochemistry

Dr Ryan J Pound
University of York, United Kingdom

Author list (excluding presenting author)

Mat Evans (1,2)
Lucy Carpenter (1)

Abstract

The impact of anthropogenic emissions is modulated by the natural world. A great deal of research attention has been given to better characterise the emissions and chemistry of isoprene, as it has a significant impact on tropospheric ozone, oxidation and aerosols. Comparatively less attention has been given to other processes by which natural emissions impact tropospheric composition. Here we compare the impact of oceanic iodide on atmospheric composition to the impact of isoprene emissions using a global chemistry transport model (GEOS-Chem). Oceanic iodide influences both the rate of ozone deposition to the ocean and the rate of iodine emissions from the ocean, which subsequently catalytically destroy ozone. We show that the influences on global tropospheric ozone burdens are comparable between oceanic iodide and isoprene emissions but opposite in sign. Isoprene has a substantial impact on tropospheric OH, but ocean iodide shows much less impact due to compensating chemical effects. Overall, oceanic iodide has a substantial impact on atmospheric composition and we suggest it should be considered analogously to isoprene emissions, as a natural control on atmospheric composition.

Early Career Scientist

YES, I am an early career scientist.
Session 4 Poster

Ozone precursors And Boundary Layer Meteorology Before and During a Severe Ozone Episode in Mexico City

Tanzina Akther
University of Houston, USA

Author list (excluding presenting author)

(1) Tanzina Akther
(2) Bernhard Rappenglueck,
(3) Olabosipo Osibanjo
(4) Armando Retama
(5) Olivia Rivera-Hernández

Abstract

Volatile organic compounds (VOCs) data in conjunction with other inorganic pollutants, surface meteorological data and continuous measurement of the Planetary Boundary Layer height (PBLH) at an urban site in Mexico City were performed from 6 to 18 March 2016. Positive Matrix Factorization (PMF) identified four emission source factors: (1) secondary aerosol, (2) evaporation and non-LPG fuel combustion (3) geogenic source and (4) vehicle exhaust. Propylene Equivalent and Maximum Incremental Reactivity (MIR) methods identified isoprene and ethylene as the highest oxidation and O3 forming species. Pollutant data normalized to the variation of the planetary boundary layer height (PBLH) revealed continued emissions of O3 precursors in the afternoon beyond the typical morning rush hour. In particular this could be observed during the second part of the measurement period (12-15 March) when a strong O3 episode occurred under weak wind and lower PBLH conditions compared to the preceding period (6-11 March) when well mixed conditions due to elevated daytime PBLH and strong advection led to overall reduced pollutant mixing ratios in the afternoon hours.

Early Career Scientist

YES, I am an early career scientist.
Session 4 Poster

Anthropogenic and biological Nano-and micro-particles ice nuclei: Impact on interfacial processes

Professor Parisa A. Ariya
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Author list (excluding presenting author)

Ariya et al., (Dev Pal, Zi Wang, Gorjana Barudzija, Mattie Hibbs, Rodrigo Rangel, Mainak Ganguly, Roya Mortazavi, Mailine Cheung, etc.)

Abstract

Nano, micro, and macro-particles are ubiquitous on Earth, including at atmospheric interfaces. Particles are chemically, physically, and biologically diverse and are naturally produced or increasingly through numerous anthropogenic activities, namely medicine-health, chemical industries, materials, construction, transport, communication, aerospace, agriculture, and energy sectors. Aerosols play a role in processes such as radiation, ice nucleation and precipitation events (IPCC, 2018). Aerosols are a joint knowledge gap shared by the IPCC and the World Health Organization (WHO). It becomes clear that they are related to the physicochemical characteristics of particles. In this presentation, we strive to narrow this gap in technologies. Air and water can move so are the particles in them. It is thus crucial to observe the physicochemical transformation in both dynamic and stationary modes. We discuss this lab’s innovation allowing 4D (3 dimensions + time) tracking of environmental particles in air and water. Particle tracking involves size (from nanometer to millimetre), phase, intensity, morphology, and in-situ, thus allowing a fast response. This prototype is nearly automated to observe both aerosols and water droplets simultaneously as a single particle AND ensemble of particles, designed for interfacial processes, in a millisecond timescale. We present novel ice nucleation insights on anthropogenic nanoparticles in air and water and bioaerosols, including viruses at atmospheric interfaces.

Early Career Scientist

NO, I am not an early career scientist.
Session 4 Poster

A day in the life of a Scribbly Gum Tree - COALA-2020 campaign

Professor Clare Murphy (Paton-Walsh)
University of Wollongong, Australia

Author list (excluding presenting author)

Ian E. Galbally (1,2), Jhonathan R. Gamboa (1), Jack Simmons (1), Malcolm Possell (3), Alex Guenther (4), Asher Mouat (5), Yuyang Peng (5) and Jennifer Kaiser (5,6)

Abstract

Despite the importance of biogenic volatile organic compounds (BVOCs) to atmospheric chemistry in the relatively clean Southern Hemisphere, only a few Australian studies have measured emissions from native tree species. The Characterising Organics and Aerosol Loading in Australia 2020 (COALA-2020) campaign took place from January 17 to March 23 2020 within Cataract Scout Park (34°14’44”S, 150°49’26” E) in a dry sclerophyll forest dominated by Eucalyptus trees, including Eucalyptus haemastoma (commonly known as Scribbly Gum trees). We present the results of an experiment measuring emissions from a mature Scribbly Gum tree using a proton-transfer-reaction-time-of-flight-mass spectrometer (PTR-TOF-MS). The experiment ran for 3 days and measured the emissions from three separate branches of the Scribbly Gum tree, each contained in a dynamic branch enclosure for one day and night of the experiment. The PTR-TOF-MS was configured to draw sample via a bypass pump at 1 litre per minute on rotation from three separate lines:

1. 10 minutes sampling ambient air from a 10 m mast
2. 10 minutes from the enclosure containing the branch of the Scribbly Gum (with a separate pump running 12 litres/minute through the enclosure)
3. 10 minutes sampling from open line in midst of scribbly gum branches

with concentrations of BVOCs determined from 30 second averages of the mass spectra.

We present these BVOC emissions as a function of temperature and photosynthetic active radiation, We compare the mixture of BVOCs measured in the open leaves with that measured in the chamber to assess the extent that this experiment may have induced emissions of BVOCs through a stress reaction in the Scribbly Gum. Finally, we compare these results with other available BVOC emission measurements in Australia and discuss what is necessary to reduce the uncertainty of the estimates of BVOC emissions from Continental Australia.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

GEIA: Global Emissions Initiative

IGAC Regional Working Groups

Southern Hemisphere Working Group
Session 4 Poster

Impacts of changes in land-use, climate, and emissions on global air quality by 2050

Mr Hemraj Bhattarai
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Author list (excluding presenting author)

Amos P. K. Tai1, Maria Val Martin2, David H. Y. Yung1

Abstract

Surface ozone (O3) and PM2.5 concentrations are the major air pollutants, which are adversely influenced by changes in land use, climate, and emissions, and are associated with serious health and environmental effects. However, the influence of future land use and land cover change (LULCC), climate, and emissions on the concentration and composition of air pollutants are largely unknown. Thus, we performed a series of model experiments for present-day (2010) and future (2050) using the state-of-the-art Community Earth System Model (CESM_2.1.3) for two shared socioeconomic pathways (SSPs): SSP1 and SSP3. Our results revealed that future LULCC will have mild effect on both O3 and PM2.5, whereas future change in climate could worsen air quality increasing by ~20% in many regions. Future changes in emissions could reduce O3 by 20-40% over the US and Europe, while in mid-Africa it would elevate in both future scenarios. This contrasts with PM2.5 where it is largely reduced in SSP1 by ~20 mg m^-3 (35%) and increased by a similar magnitude in SSP3 particularly over India and China. Worse O3 air quality is observed due to the combined (total) effect in SSP3 which is due to non-linear interaction of local meteorology, NOx, and volatile organic compounds (VOCs). US and Europe are expected to have improved air quality in SSP1 and SSP3, whereas many parts of South America and Asia will have worse air quality by 2050 more evident in SSP3. This study emphasizes the importance to consider changes in emission, climate, and land use for better air pollution control planning and management in the future.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality
Session 4 Poster

The Hygroscopicity of Functionalized Insoluble Aerosol Surfaces

Chun-Ning Mao
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Author list (excluding presenting author)

Kanishk Gohil (1); Akua Asa-Awuku (1)

Abstract

Not only soluble particles but the insoluble particles can provide surfaces and act as cloud condensation nuclei (CCN). However, the role of surface chemistry is not yet understood for insoluble particles. In this study, we measured the water-uptake ability of polystyrene latex (PSL) particles with different functionalized group on the particles surface. PSL particles are spherical, non-porous, uniform in size, and the surface can be modified with different functionalized group. Three models, traditional Kohler (TK), Flory-Huggins Kohler (FHK) and the Frenkel-Halsey-Hill adsorption theory (FHH-AT) were used to analyze the CCN activation of the PSL particles. Among the three models, FHH-AT with two fitting parameters, $A_{\text{FHH}}$ and $B_{\text{FHH}}$, agrees best with the measurements. $A_{\text{FHH}}$ represents the interaction between first layer of the water molecules and the nuclei surface, while $B_{\text{FHH}}$ represents the interaction between the bulk nuclei and other layers of water molecules. We demonstrate that the single parameter hygroscopicity of FHH-AT is also developed. The hygroscopicity of FHH-AT decreases with an increasing diameter in theory and measurements.

Early Career Scientist

YES, I am an early career scientist.

IGAC Regional Working Groups
The Chemical Controls on the Uptake of Ozone to Seawater

Miss Lucy V Brown
University of York, United Kingdom

Author list (excluding presenting author)

David Loades (1); Katherine Weddell (1); Yousif Assiri (1); Matthew Jones (1); Rosie Chance (1); Stephen Andrews (1); Birgit Quack (2); Lucy J. Carpenter (1)

Abstract

Ozone uptake to the ocean accounts for approximately a quarter of ozone deposited from the atmosphere globally, and displays large geographical variance. Despite this, in global atmospheric models a constant value for oceanic dry deposition is typically applied due to the lack of accurate parameterisations and understanding of the chemical controls to deposition. Here, ozone uptake to discrete sea surface microlayer and underlying water samples was measured using a heterogeneous flow reactor aboard the CONNECT SO-287 trans-Atlantic research cruise. Measured uptakes are parameterised against biogeochemical and physical properties, including iodine speciation, concentration and composition of dissolved organic carbon, sea surface temperature and surface tension. Ambient atmospheric dry deposition of ozone was also measured during the cruise using eddy covariance, allowing assessment of the impact of chemical controls on overall deposition. Further, the second order rate constant and temperature dependence of the heterogeneous reaction between ozone and iodide, thought to be one of the main drivers of ozone deposition to the ocean, was re-measured and used to calculate ozone uptake due to iodide. This suite of measurements allows us to assess the links between atmospheric dry deposition and the chemical composition of seawater, according to reactions happening at the interface between the atmosphere and the ocean surface.

Early Career Scientist

YES, I am an early career scientist.
Session 4 Poster

Daily cycle of sea spray aerosols emission

Dr J. Michel Flores
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Author list (excluding presenting author)

Guillaume Bourdin (2), Alex Kostinski(3), Emmanuel Boss(2), Yuval Steinberg (4), Orit Altaratz(1), Miri Trainic (1), Yinon Rudich(1), Flora Vincent(4), Daniella Schatz(4), Assaf Vardi(4) & Ilan Koren(1)

Abstract

Ocean-atmosphere fluxes play a critical role in the climate system. Sea-spray aerosols (SSA), formed at the ocean surface, impact atmospheric chemistry, Earth’s radiative balance, cloud formation, and rain. Understanding their production mechanisms is crucial to accurately describe their radiative effect and cloud microphysical properties. We discovered a ubiquitous 24-hour rhythm to the SSA number concentration ($N_{SSA}$), with concentrations increasing after sunrise, remaining higher during the day, and returning to predawn values after sunset. We found this behavior while sailing over 42,000km across the Atlantic Ocean, Caribbean Sea, and Pacific Ocean and in a semi-natural mesocosm setup in a Norwegian fjord. In the open ocean measurements, neither atmospheric nor oceanic physical properties had significant links to the $N_{SSA}$ daily cycle. While the magnitude of day-to-nighttime increase in $N_{SSA}$ positively correlated with the daily mean sea surface temperature, it inversely correlated with the chlorophyll-a concentration. Additionally, the daily patterns of SSA correlated to the size of seawater particles smaller than ~1 µm: during the day, the mean particle size increased, driven by photosynthetic growth and secretion of extracellular polymeric substances, and at night, the mean size decreased. In the mesocosm setup, we induced a bloom of *Emiliania huxleyi* (cosmopolitan bloom-forming microalgae). We measured the $N_{SSA}$ by bubbling. We found a clear daily cycle of $N_{SSA}$ in pre-bloom conditions, which decreased during the bloom and disappeared in the demise phase of the *E. huxleyi* bloom. Concomitantly, the total $N_{SSA}$ continuously decreased from pre-bloom conditions to the bloom and demise phases, suggesting two parallel mechanisms are affecting the SSA emitted. The open ocean measurements and mesocosm observations point to a day-to-night modulation of bubble-bursting dynamics controlled by microorganisms. In a new laboratory-based experimental setup, we began exploring the effect of photosynthetic microorganisms on the water surface tension and hence the daily $N_{SSA}$ cycle.

Early Career Scientist

NO, I am not an early career scientist.
Performance analysis of air pollution control device WAYU at a semi urban site in Agra, India.

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Author list (excluding presenting author)
Dr Anita Lakhani

Abstract

Worldwide a number of air pollution control strategies are implemented for improving the quality of air. Control at source is one of the practices to reduce pollution load. Wind augmentation and purifying unit (WAYU) has been developed by National Environmental Engineering Institute, India to remove particulate matter (PM) and gaseous pollutants from different pollution hot spots. In the present study the authors have attempted to analyze the performance of WAYU for PM$_{2.5}$ and PM$_{10}$ at different locations in Dayalbagh, Agra. High speed wind generators are used in WAYU with flow rate of 2500 m$^3$/h and the filter deployed is made of non-woven fabric with long operation cycle and reasonable efficiency to filter out PM$_{2.5}$ and PM$_{10}$. The analysis shows PM$_{2.5}$ and PM$_{10}$ reductions in the range of 2.9 % to 11 % and 14.6 to 32.1 % respectively from inlet air. The efficiency of device varies as pollution load and particle size distribution pattern changes. It is suggested that such control devices may be useful in reduction of air pollution in hot spot areas. The rate of removal of PM depends on the size-segregated particulate matter pollution load in the ambient air.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Session 4 Poster

A co-benefit analysis of the Climate and Air Quality impact from changes in near-term climate forcers in future Climate, Land-use and air pollutant emission mitigation scenarios

Dr Steven T Turnock
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Author list (excluding presenting author)

Robert Allen (3); Alex T. Archibald (4,5); Mohit Dalvi (1); Gerd Folberth (1); Paul T. Griffiths (4,5); James Keeble (4,5); Carly L. Redington (6); Eddy Robertson (1); Fiona M. O’Connor (1)

Abstract

The major surface air pollutants, particulate matter (aerosols) and ozone, are important in terms of their impact on regional air quality and human health, but they also act as near-term climate forcers (NTCFs), influencing the magnitude and rate of climate change. Future mitigation policies should be designed in such a way as to maximise co-benefits to both air quality and climate from changes in NTCFs. Here we use results from UKESM1 (an Earth system model with interactive chemistry and aerosols) to assess the impact on both air pollutants and climate forcing in different future scenarios for emission mitigation, climate change and land-use, conducted as part of the Aerosol and Chemistry Model Intercomparison Project (AerChemMIP). We compare results from the sensitivity scenarios to a baseline future climate and emission scenario to assess the impact on climate, through effective radiative forcing (ERF), and air quality, by changes in surface concentrations of O$_3$ and PM$_{2.5}$. In addition, the impacts on human health attributable to exposure from air pollutants in each scenario are estimated using population attributable fractions of relative risk. Scenarios that apply strong mitigation measures for all NTCFs (aerosols, tropospheric O$_3$ precursors and methane) have the largest combined benefits to global climate, air quality and public health. Scenarios for individual NTCFs show that mitigating solely aerosols have a benefit to air quality and health but a climate penalty. It is only when aerosol mitigation is combined with reductions in methane that maximum co-benefits are achieved. Future scenarios considering solely the changes in both climate and land-use show a small, but non-negligible, detrimental impact on future air quality and human health. These results show that future mitigation measures need to consider the combined impacts on both air quality, human health and climate from changes in NTCFs to achieve maximum co-benefits.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

CCMi: Chemistry Climate Model Initiative
Session 4 Poster

Ozone deposition to the Arctic sea ice: Observations and 1D modelling during the 1-year MOSAiC expedition

Johannes G.M. Barten
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Author list (excluding presenting author)

Laurens N. Ganzeveld (1); Gert-Jan Steeneveld (1); Byron W. Blomquist (2,3); Helene Angot (4,5); Stephen D. Archer (6); Ludovic Bariteau (2,3); Detlev Helmig (7); Dean Howard (3,5); Jacques Hueber (7); Hans-Werner Jacobi (8); Kevin M. Posman (6); Maarten C. Krol (1,9)

Abstract

We quantify for the first time the impact of ozone (O\textsubscript{3}) deposition to the Arctic sea ice on the Planetary Boundary Layer (PBL) O\textsubscript{3} concentrations and budget using year-round flux and concentrations observations as part of the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) campaign and simulations with a Single-Column atmospheric chemistry and meteorological Model (SCM).

By deriving the surface resistance from eddy-covariance O\textsubscript{3} flux observations we find a median surface resistance on the order of 20 000 s m\textsuperscript{-1}, resulting in a dry deposition velocity of ~ 0.005 cm s\textsuperscript{-1}. This surface resistance to snow and ice is up to an order of magnitude larger than currently used values in atmospheric chemistry and transport models. The SCM is able to accurately represent the yearly cycle with maxima above 40 ppb in the Arctic winter and minima around 15 ppb at the end of summer. However, the observed springtime Ozone Depletion Events (ODEs) are not captured by the SCM. In winter, the modelled PBL O\textsubscript{3} budget is governed by dry deposition at the surface mostly compensated for by downward turbulent transport of O\textsubscript{3} towards the surface. In summer, advection also poses a substantial, mostly negative, contribution to the simulated PBL O\textsubscript{3} budget. During episodes with low wind speeds (< 5 m s\textsuperscript{-1}) and shallow boundary layers (< 50 m) the 7-day mean removal rate by dry deposition can reach up to 1.0 ppb h\textsuperscript{-1}.

Our study highlights the importance of an accurate description of the dry deposition mechanism to Arctic sea ice in global and regional atmospheric chemistry and transport models to simulate Arctic O\textsubscript{3} concentrations.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

CATCH: the Cryosphere and Atmospheric Chemistry, PACES: Air Pollution in the Arctic: Climate, Environment, and Societies, TOAR: Tropospheric Ozone Assessment Report
Session 4 Poster

Applying an integrated modelling approach for urban air quality management in South Africa

Prof Rebecca M Garland
Smart Places, CSIR, South Africa. Unit for Environmental Science and Management, School of Geo and Spatial Science, North-West University,, South Africa. now at Department of Geography, Geoinformatics, and Meteorology, University of Pretoria, South Africa

Author list (excluding presenting author)


Abstract

Available monitoring data across Gauteng Province, South Africa show that ambient air pollutant concentrations often exceed South Africa’s National Ambient Air Quality Standards (NAAQS), especially for PM and ozone, and has not been improving. A spatially and temporally heterogeneous mix of pollutants with varying concentrations is present across the three metros within Gauteng Province, Johannesburg, Ekurhuleni and Tshwane (herein referred to as JET), which makes effective air quality management a difficult task. Thus, any effective interventions to improve air quality in JET needs to consider and address a wide range of emission sources, across many different economic sectors and throughout a large region, taking into account considerable uncertainties owing often to limited data availability. While air quality management in the region has been supported by Air Quality Management Plans, both at city and provincial level, none of these plans have been based upon an integrated assessment, including optimization of costs and benefits towards the goal of complying with the NAAQS to minimize negative impacts on human health. A modelling platform was developed for JET using local, high-resolution information together with the chemical transport model CAMx to improve and tailor the integrated assessment model GAINS. The resulting GAINS-JET model has been applied, for the first time, to support urban air quality management. It was found that to meet PM annual NAAQS (20 µg/m$^3$ for PM$_{2.5}$) by 2030, nearly the fully identified technical emission mitigation potential would need to be explored, implying rapid strengthening of emission limit values. Meeting NAAQS would lead to ~3200 fewer premature deaths attributable to PM$_{2.5}$ in 2030 in JET. The results from this study will be presented with an assessment of uncertainties and further research needs, and lessons learned from developing and applying this platform that could be applied to other data scarce cities.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

ANGA: African Group on Atmospheric Sciences
Session 4 Poster

Links between oceanic ozone uptake and biogenic organic matter found in the sea surface microlayer

Miss Katherine A Weddell
University of York, United Kingdom

Author list (excluding presenting author)

Lucy Carpenter (1); Rosie Chance (1); Liselotte Tinel (2); Matthew Jones (1); Claire Hughes (1)

Abstract

Dry deposition is a major sink of tropospheric ozone, and a large proportion of this deposition is to the ocean surface. Organic matter at the sea surface, which is primarily produced by marine biota such as phytoplankton, likely plays a key role in ozone deposition. However, there are large uncertainties associated with this process. This study investigates how organic matter composition in the sea surface microlayer (SML) and underlying seawater impacts ozone deposition. Fatty acid compounds such as lipids, free fatty acids, and dicarboxylic acids are important organic matter components, and because they are surface active they have the potential to react with tropospheric ozone at the ocean surface. There are, however, few measurements of dissolved fatty acids compounds in seawater. A solid phase extraction (SPE) method with a modified styrene divinyl benzene sorbent was used to extract fatty acid compounds from SML and underlying seawater samples. Samples were collected weekly off the coast of Plymouth during an 18-month campaign. The extracted fatty acid compounds were converted into their methyl esters and analysed via GC-MS. The method measured saturated and unsaturated, as well as dicarboxylic acids and provides a convenient alternative to traditional extraction methods such as liquid-liquid extraction. Concentrations of the fatty acids are comparable to literature values and over the 18 months sampled, their concentrations remained fairly constant. Nevertheless, unsaturated fatty acids show increased variability in the summer months which could be attributed to increased biological activity. This time series data will be compared to ozone flux data for the region to assess the relationship between surface fatty acid compounds and ozone uptake.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report
Fluorescent biological aerosol particles over the central Pacific Ocean: covariation with ocean-surface biological activity indicators

Kaori Kawana
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Author list (excluding presenting author)

Kazuhiko Matsumoto; Fumikazu Taketani; Takuma Miyakawa; Yugo Kanaya

Abstract

Organic matters originating from sea-surface marine ecosystems are uplifted by wind in the course of sea spray aerosol (SSA) formation, and these biological particles could affect the cloud processes by acting as cloud condensation nuclei (CCN) and ice nucleating particles (INP). However, their origins, abundance, and roles are poorly characterized. In this study, combining wideband integrated bioaerosol sensors and DNA-staining techniques, shipboard observations of fluorescent aerosol particles were carried out over the central Pacific Ocean during March 2019 to identify bioaerosols and determine their spatio-temporal distribution. To understand the origins of and processes associated with bioaerosols, we conducted correlation analyses of fluorescent particle number concentration, wind speed, and a variety of chemical and biological indicators, including chlorophyll a, bacteria, marine organic gel particles such as Transparent Exopolymer Particles (TEPs) and Coomassie Stainable Particles (CSPs).

When oceanic air masses were dominant, we identified certain types of fluorescent particles as bioaerosols with marine origins, because their number concentrations were highly correlated with concentrations of TEPs and bacteria (R: 0.80–0.92) after considering the wind speed effect. When the transport from Asian continent was prominent, another type of fluorescent particles correlated with CSPs irrespective of wind speed, implying that the fluorescent particles advected from land were mixed with those of marine origins. Finally, we developed equations to derive atmospheric bioaerosol number density in the marine atmosphere from a combination of biogenic proxy quantities (chlorophyll a, TEPs and bacteria) and wind speed. These results suggest that TEPs aggregated with bacteria in the sea surface could be transported into the atmosphere by wind to form fluorescent bioaerosols.

We also present results from another cruise over the North Pacific and Arctic Ocean to discuss the impact of the biological particles on the fluorescent bioaerosols and cloud droplets as CCN and INP.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities
IGAC Regional Working Groups
Total ozone reactivity measurements from a Norway spruce in late summer

Steven Job Thomas
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Author list (excluding presenting author)
Toni Tykkä (1); Heidi Hellén (1); Federico Bianchi (2); Arnaud P. Praplan (1).

Abstract

Total reactivity studies based on the emission of biogenic volatile organic compounds (BVOCs) with the hydroxyl radical (OH) have observed a significant fraction (up to 96%) of reactivity to remain unexplained (Nölscher et al., 2013, Praplan et al., 2020). Similar studies conducted in forest environments' ambient air have also revealed a high fraction of missing reactivity (Praplan et al., 2019, Yang et al., 2016). Of late, total ozone reactivity was measured in forests, confirming its use as another comprehensive index to identify and analyse unmeasured BVOCs from emissions (Matsumoto, 2021; Matsumoto, 2014; Sommariva et al., 2020). Since ozone is a selective atmospheric oxidant, total ozone reactivity studies will help narrow down the unidentified reactive compounds or classes of compounds causing the unexplained reactivity.

In this study, a tool to measure total ozone reactivity called Total Ozone Reactivity Monitor (TORM; Helmig et al., 2021) was deployed at the second Station for Measuring Ecosystem-Atmosphere Relations (SMEAR II) in Hyytiälä, southern Finland. The branch of a Norway spruce was placed in an enclosure, and the emissions were observed using a dynamic flow-through technique (Hakola et al., 2017) between August 6 and September 9, 2020. An online thermal desorption gas chromatograph coupled with a mass spectrometer (TD-GC-MS) was set up to conduct simultaneous BVOC emission analyses.

Total ozone reactivity measured showed a clear diel pattern, with highest reaching late afternoon. Calculated reactivity from the compounds identified by TD-GC-MS could account for only 22% of the measured reactivity by TORM. From the known fraction, sesquiterpenes contributed the most (~21%). Daily average temperatures were higher during the first half of the measurement period. Still, total ozone reactivity and missing reactivity were highest when daily average temperatures were slightly lower during the latter half. This might reflect a change in the composition of the unidentified reactive species.

Early Career Scientist

YES, I am an early career scientist.
Characteristics of soil NO emissions from a UK suburban greenspace and SE Australian Eucalyptus forest

Mr Hyunjin An
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Author list (excluding presenting author)

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Abstract

Nitrogen oxides (NO\textsubscript{x}=NO+NO\textsubscript{2}) play an essential role in the atmospheric oxidation of volatile organic compounds, resulting in ozone and secondary organic aerosol formation. It is therefore critical to fully characterise NO\textsubscript{x} sources and sinks. While anthropogenic emission sources associated with high-temperature combustion processes dominate, natural sources including soil emissions contribute significant proportions of the reactive nitrogen budget in rural and remote areas but are poorly understood.

In this study, soil NO emissions were determined by measuring NO concentrations in soil chambers during the Observation System for Clean Air (OSCA) campaigns at a suburban greenspace in Manchester, UK (Jun-Jul 2021, Jan-Feb 2022) and the Characterising Organics and Aerosol Loading over Australia 2020 (COALA-2020) field campaign near Sydney, SE Australia (Jan-Mar 2020). NO emission rates were estimated from the difference in NO concentrations between a sample and reference chamber.

Sample chamber concentrations were higher than the reference during all OSCA and COALA campaign periods. Averaged NO concentrations of sample and reference chambers were 1.76±0.92 and 0.79±0.85 ppb respectively during the OSCA summer and 0.91±0.37 and 0.48±0.37 ppb during the winter. NO levels were much lower during the COALA campaign with average sample and reference chamber concentrations of 0.47±0.63 and 0.04±0.38 ppb, respectively.

NO emission rates were correspondingly higher from the suburban soils (0.022±0.006 nmol·m\textsuperscript{-2}·s\textsuperscript{-1} in summer and 0.011±0.003 nmol·m\textsuperscript{-2}·s\textsuperscript{-1} in winter) than the remote Eucalyptus forest (0.007±0.01 nmol·m\textsuperscript{-2}·s\textsuperscript{-1}). The soil NO emission rates showed clear diel and seasonal patterns and strongly correlated with soil characteristics, vegetation cover and meteorological conditions indicating they are biogenic in origin. The complexity of the relationships, however, suggests that both rhizosphere and above-ground ecosystem processes influence soil NO production and emission.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

AMIGO: Analysis of eMIssions usinG Observations, GEIA: Global Emissions Initiative
Optical properties, chemical compositions and potential sources of Methanol-soluble BrC in an urban area of northern Taiwan.

Dr. Yu-Chieh Ting
National Taiwan University, Taiwan

Author list (excluding presenting author)
Yi-Ru Ko (1); Cheng-Hua Ma (2); Cheng-Chih Hsu (3); Yu-Hsiang Cheng (4); Chuan-Hsiu Huang (5)

Abstract

Brown carbon (BrC) has been of great concern over the world due to its significant contribution to light absorption and radiative forcing. However, its optical properties, chemical constituents and sources have been poorly constrained in climate model due to the variability of spatial and temporal characteristics. In this study, daily PM$_{2.5}$ samples were collected from January to November 2021 in urban Taipei, Taiwan. The seasonal variations of optical properties of methanol-soluble organic carbon (MSOC) were evaluated and quantified. The Absorption Ångström Exponent of MSOC ranged from 4.03 – 6.83, with averages of 5.29 ± 0.6, and the annual mass absorption efficiency was 0.83 ± 0.37 m$^2$ g$^{-1}$. The estimated fractional radiative forcing by MSOC to elemental carbon was most significant in spring (13.90 ± 4.38%), which may greatly affect the atmospheric photochemistry and climate. In addition, the methanol extracts were analyzed by a HPLC-DAD-HRMS (high performance liquid chromatography-diode array detector-electrospray ionization high resolution mass spectrometer) platform to identify the BrC chromophores. Nitrophenolic compounds, especially 4-Nitrocatechol, 1-nitro-2-naphthol and 3-methoxy-4-nitrophenol, were putatively identified to dominate the light absorption at UV-Vis wavelength range in winter, attributed to the contribution of fossil fuel combustion and aged biomass burning. However, less BrC chromophores were found in summer, in which 4-nitrosonaphthalene-1,3-diol might be one of the significant contributors to the light absorption, potentially contributed by fossil fuel and biomass burning.

Although many of BrC optical properties, chemical compositions and potential impacts remain unconstrained, the result presented in this study is the first time to investigate BrC chromophores in PM$_{2.5}$ throughout the year in Taiwan. This study provides an insight into the physicochemical and optical properties of BrC in Taiwan, and further comprehensive study is needed to understand the impact of BrC on air quality and climate locally and regionally.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon

IGAC Regional Working Groups

China Working Group
Prediction of aerosol pH in the marine boundary layer of the Southern Ocean using ISORROPIA-II model.

Mr Sive Xokashe
University of Cape Town, South Africa

Author list (excluding presenting author)
Jessica M. Burger(1), Kurt A. M. Spence(1), Katye E. Altieri(1)

Abstract

Aerosol acidity is a fundamental parameter of aqueous chemistry that impacts the lifetimes of pollutants, biogeochemical cycles, human health, and climate. However, despite this importance, aerosol pH effects on these processes are difficult to constrain, in part because there are no direct methods to measure aerosol pH. The lack of observations in remote clean atmosphere makes quantifying pH of aerosol even more challenging.

Here, we present a dataset of aerosol chemical composition collected in the marine boundary layer of the summertime Southern Ocean during a cruise from Cape Town (34.11°S, 18.03°E) to Antarctica (70°S, 2.11°W), which was used as an input to the thermodynamic model ISORROPIA-II to estimate the pH of marine aerosols. The thermodynamically predicted aerosol pH from filter-based samples (collected daily) are generally acidic. The estimated submicron pH ranged from -0.67 to 4.37 with an average value of 0.27 while the supermicron pH was 1.67 to 4.68 with an average value of 2.98. The variation in predicted submicron pH was explained by Na+/SO₄²⁻ ratio, while no apparent relationship was observed with temperature and relative humidity. Supermicron pH did vary as a function of relative humidity, and there was a significant correlation between supermicron pH and the molar ratio (with the inclusion of non-volatile cations). Other factors such as the impact of wind speed on the fractionation of seasalt and the impact of sea-ice on pH will be discussed.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

CATCH: the Cryosphere and Atmospheric Chemistry

IGAC Regional Working Groups

Southern Hemisphere Working Group
Session 4 Poster

Total VOC reactivity and its relationship with Organic Aerosols in an Urban Region in East Asia

Jonalyn C Madriaga

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Abstract

Volatile organic compounds (VOCs) can undergo a series of photochemical oxidation in the presence of various oxidants to generate secondary pollutants and secondary organic aerosols (SOAs) which are known to have detrimental impact on human health, air quality, and climate. The total OH reactivity of VOCs (VOCs-OH reactivity) can serve as a tool to effectively characterize the contributions of various VOCs to secondary production pathways of gas and particle phase pollutants. In this study, the total VOCs-OH reactivity and its relationship to the total organic aerosol concentration, and ozone concentration is investigated. The concentration of multiple VOCs, total OA concentration, and ozone were measured in Taichung City, Taiwan on March 2022. VOCs and total OA concentration were quantified using Proton Transfer Reaction Time-of-Flight Mass Spectrometer (PTR-ToF-MS) and Aerosol Mass Spectrometer (AMS), respectively. The mean hourly concentrations for the total OA, calculated total VOCs-OH reactivity, and ozone were 9.08 ± 4.30 µg/ m³, 6.66 ± 3.28 s⁻¹, and 28.53 ± 17.62 ppb, respectively.

Results showed that the calculated total VOCs-OH reactivity had a significant moderate positive relation with total OA concentration (r=0.40; p <0.05; N=116). Both were also found to exhibit diurnal variations peaking around 19:00-20:00. These can serve as an indication of the formation of SOAs contributed by the VOCs in the area. The average concentrations of the VOCs in the area such as acetonitrile, acetaldehyde, acetone, isoprene, methyl vinyl ketone, methyl ethyl ketone, benzene, toluene, xylene, trimethylbenzene, naphthalene, and limonene were also determined. Most of these VOCs exhibited strong diurnal variations which also peaked between 07:00-08:00 and 19:00-20:00, and decline on 12:00-13:00. The PTRMS and AMS datasets will be analyzed in further detail to investigate the sources of SOAs in the study area.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities


IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group
Session 4 Poster

Interfacial photochemistry of marine diatom lipids: Abiotic production of volatile organic compounds and new particle formation

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Author list (excluding presenting author)

Xinke Wang (2,3); Christian George (2); Sanja Frka (1)

Abstract

The sea surface microlayer (SML) represents the widest environmental interface with a major environmental importance. It is enriched with surface active organic matter (OM) accumulating at the air–water interface and forming surface films. Also present in the SML OM pool, although in a low degree, are biogenic lipids, known to play a significant role in formation and stabilization of the SML, as well as in the physico-chemical, and morphological properties of the marine surface films. When irradiated, biogenic surface films may undergo unique photochemical reactions leading to abiotic production of unsaturated and functionalized volatile organic compounds (VOCs) acting as precursors for the secondary organic aerosol (SOA). Although previous studies demonstrated photoinduced VOCs production from artificial surfactants in laboratory grade water, saline solutions, and biofilm-containing solutions comprising a mixture of different microorganisms, these experiments were typically conducted under far from ambient conditions or for a very limited number of authentic samples.

To investigate the potentially underestimated VOCs sources under more realistic conditions, the analyzed biogenic OM was produced by an authentic diatom culture. Additionally, lipid material was isolated to further investigate phytoplankton lipid material as the main driver of surfactant release and, thus, abiotic photochemical VOCs production. Experiments were conducted in a photochemical reactor and an atmospheric simulation chamber, to study VOCs formation upon irradiation and their implications for aerosol formation and growth, respectively. An improved chemical characterization of the biogenic surfactants and their interfacial photochemical processing is highly desirable to better understand the abiotic VOCs sources, and to improve our understanding of their subsequent impact on the climate.

This research was financed by the European Union’s Horizon 2020 research and innovation programme - EUROCHAMP-2020 Infrastructure Activity under grant agreement No 730997, COGITO project and Croatian Science Foundation project BiREADI IP-2018-01-3105.

Early Career Scientist

NO, I am not an early career scientist.
**Abstract**

In the polar regions the usual OH radical formation pathway (ozone photolysis and reaction of O(1D) and H2O) is limited by the low water vapour concentration. However, gases emitted from the snowpack can be precursors of HOx radicals and ozone, thereby controlling the oxidising capacity of the lower atmosphere above snow-covered regions.

Snowpack reactive nitrogen emissions (NOx and HONO) can lead to OH production through rapid cycling of RO2 → HO2 → OH and photolysis of HONO. Research into reactive nitrogen species in polar environments has predominantly focused on the photolysis of nitrate, which it has been established produces NOx, but with far less investigation into HONO. Previous studies of HONO in the polar boundary layer and snowpack interstitial air suggest a photolytic snowpack source but the exact mechanism for HONO production is poorly understood; models of HONO sources and sinks often cannot rationalise the measured HONO concentrations.

A LOng Path Absorption Photometer (LOPAP) was used to investigate the net HONO flux above snow in the Clean Air Sector at Halley VI Research Station in coastal Antarctica. We present mixing ratio measurements of HONO in ambient air as well as an estimate of its flux from the snow by the flux-gradient method. These findings will help further our understanding of the atmospheric budgets of reactive nitrogen and HOx above snow-covered regions.


**Early Career Scientist**

YES, I am an early career scientist.
IGAC Activities

CATCH: the Cryosphere and Atmospheric Chemistry
Abstract

Recent CAPRAM mechanism developments and model results on tropospheric multiphase and heterogeneous chemistry are presented.

Biomass burning (BB) is a significant air pollution source, with global, regional and local impacts on air quality, public health and climate. Anhydrosugars and methoxyphenols are key tracers emitted through BB that can undergo complex multiphase chemistry in the atmosphere contributing to secondary organic aerosol (SOA) formation. However, their chemical multiphase processing is not yet well understood and investigated by models. Thus, detailed model studies with a new developed CAPRAM biomass burning module (CAPRAM-BBM1.0) were performed. The newly developed CAPRAM-BBM1.0 includes 2991 reactions.

Mercury is a neurotoxic element emitted predominantly as gaseous elemental mercury ($Hg^0$) into the atmosphere. There, mercury undergoes active chemical processing in the gas and aqueous phase forming oxidised mercury ($Hg^{II}$) that is even more toxic. Thus, it is crucial to understand the tropospheric transformation of $Hg^0$ and $Hg^{II}$ vice versa. Numerous studies revealed missing oxidation and reduction processes probably due to often sparsely considered multiphase processes. Therefore, a comprehensive multiphase mercury chemistry mechanism, the CAPRAM-Hg1.0 modules, was developed. First model investigations of multiphase Hg processing were performed for Chinese polluted summer conditions and the results were compared to ambient measurements.

Dust aerosols constitute a major fraction of particulate matter in the troposphere and play a major role in tropospheric chemistry by providing an active surface for heterogeneous reactions. Heterogeneous reactions can alter the gas-phase and particle-phase composition and aerosol properties. To better clarify their role in the troposphere, we developed a heterogeneous module, CAPRAM-het, and performed simulations for low and high dust conditions. Model results show that gas-phase concentrations of tropospheric trace gases barely change under low dust conditions, but are reduced in the high dust case. Reductions of 30% and 40% are observed for NO and $NO_2$ respectively.

Early Career Scientist

NO, I am not an early career scientist.
The Role of Water Vapor on Photo-bleaching of Organic Aerosol Particles

Rachel E O'Brien
University of Michigan, USA

Author list (excluding presenting author)
Hongmin Yu (1,2); Alexandra Klodt (3); Laurel Nicks (2); Natalie Warren (2); Churchill Wilkinson (2); Marley Adamek (2); Monica Dibley (2); Christopher Lim (4); Carolyn Jordan (5); Bruce Anderson (5); Christopher Cappa (6); Jesse Kroll (4); Sergey Nizkorodov (3)

Abstract
Organic aerosol particles can influence the climate through either directly absorbing or scattering solar radiation or by acting as nuclei for cloud droplets. Some aerosol particles are dominantly scattering while others contain organic molecules that can absorb solar radiation in the visible region, termed brown carbon (BrC). We still have large uncertainties in the magnitude of these climate effects and a better understanding of the possible removal processes is needed. One removal process is photolysis, where absorption of solar radiation leads to fragmentation of the organic molecules and the loss of particle mass and/or color. However, the photolysis rates and the overall extent of mass that can be removed via direct photolysis in laboratory experiments does not match what is used in models and often differs from ambient measurements. In particular, the role of water vapor, and its impact on the viscosity of the particles during photo-aging is an area of uncertainty. In addition, longer term photo-aging studies point to multi-generational products that can form in the particles, influencing their lifetime and behavior. Here, we will combine results from work in our lab looking at photolysis at different relative humidity values of biogenic secondary organic aerosol as well as BrC from both biomass burning organic aerosol and urban secondary organic aerosol to evaluate gaps in our ability to predict the longer-term fate of these particles in the atmosphere.

Early Career Scientist
NO, I am not an early career scientist.
Ozone flux at the sea surface: eddy covariance observations and biogeochemical controls

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Author list (excluding presenting author)

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Abstract

Dry deposition of ozone is an important sink in the global tropospheric ozone budget, approximately a third of which occurs over the oceans. However, direct measurements of this deposition are sparse, and our understanding of the processes which control it incomplete. The few observational studies that do exist report notably disparate values, leading to great uncertainty in model estimates of the tropospheric ozone burden and deposition rates in the marine environment. This uncertainty is compounded by the unquantified effects of organic molecules in the sea-surface microlayer. Existing global models typically assume a fixed surface resistance for ozone over the ocean. Where variable resistance is used, it is parameterised predominantly from sea surface temperature and iodide concentration. Questions remain regarding the importance of the reactivity of organic compounds in the microlayer towards ozone, and of the enhancement of deposition we wind-induced turbulence in the surface water.

Here we present recent field measurements of ozone flux over the ocean using the eddy covariance method alongside chemical analyses of the sea surface microlayer within the flux footprint. Measurements from the Penlee Point atmospheric observatory (UK south coast) from 2018 to 2021 allow for assessment of seasonal effects on ozone flux; the highest monthly averages were 2-3 higher than the lowest, with iodide reactivity alone unable to account for the variation. Similar measurements have also recently been completed during a trans-Atlantic cruise to investigate spatial variation of ozone deposition and reactive species in the surface water across the equatorial Atlantic.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report
Iodide oxidation at the gas air-water interface in cold environments

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Abstract

Recently, both gas phase iodine species and particulate iodine (iodate and iodide) have been measured in the upper troposphere and the lower stratosphere. This may influence stratospheric ozone depletion both indirectly through activation of iodide to molecular halogens and directly through the aqueous phase reaction of ozone with iodide. Also in the troposphere, this reaction contributes to the turnover in iodine cycling. The bulk aqueous phase kinetics of this reaction have been reasonably well established for dilute solutions, though over a too narrow temperature range only. The product of this reaction, IO, is reacting with I to I$_2$(g) under most circumstances. Sakamoto et al. have suggested that in addition IO(g) may be formed. The primary reaction of iodide with O$_3$ depends on pH. Solute strength effects and the extent of a surface reaction have not been sufficiently established.

Here we determine the temperature dependence of the oxidation of iodide by ozone and assess the parameters that control IO radical and I$_2$ formation. We used a trough reactor coupled to Cavity Enhanced – Differential Optical Absorption Spectroscopy (CE-DOAS) in order to study the reactivity in the range of temperatures from 255.15 to 291.15 K, in dilute aqueous solution and concentrated ammonium sulfate solutions. Preliminary results show that the IO/I$_2$ ratio is in the range of $10^{-3}$ – $10^{-2}$. While the O$_3$ loss kinetics indicate the importance of a surface reaction, I$_2$ formation seems to occur mostly in the bulk aqueous phase. The IO formation mechanism at the interface as proposed in the literature is questioned in this study due to the dependence of its mixing ratio on iodide concentration and O$_3$ mixing ratio. Indeed, molecular modeling investigations (ONIOM QM/MM method) indicate that the formation of IO is unlikely at the interface. We suspect that IO formation results from secondary chemistry.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

CATCH: the Cryosphere and Atmospheric Chemistry
Session 4 Poster

Seasonal measurements of hydroperoxy methylthioformate (HPMTF) over the North Atlantic Ocean

Dr Thomas James Bannan
University of Manchester, United Kingdom

Author list (excluding presenting author)

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Abstract

Marine ecosystems are an important component of the climate feedback system. One of the main pathways for ocean-climate interaction is through the atmospheric oxidation of DMS (dimethyl sulphide), a gas released from phytoplankton in the sea surface. DMS derived products are known to be important in marine cloud formation and hence influence the Earth’s radiation budget. Aerosol-Cloud interactions currently represent one of the largest uncertainties in climate modelling. Our research focuses on airborne measurements using real-time high resolution instruments to identify and quantify trace oceanic biogenic gases on board the FAAM research aircraft. Here we present aircraft measurements made over the North Atlantic Ocean using an iodide-high resolution time-of-flight chemical ionisation mass spectrometer (HR-ToF-CIMS), across multiple seasons during the NERC funded ACSIS campaigns between 2018 and 2022 of a DMS oxidation product, hydroperoxy methylthioformate (HPMTF), that has recently been identified (Veres et al., 2020). This new oxidation mechanism involves an intramolecular hydrogen shift in the peroxy radical (MSP, CH3SCH2OO•), a primary product from hydrogen abstraction reaction of DMS oxidation. A further hydrogen shift then forms the stable product hydroperoxymethyl thioformate (HPMTF, HOOCH2SCHO). Our results greater extend the original atmospheric observations and indicate that HPMTF is most commonly observed just above the sea surface. For the first time we have also shown that under certain conditions, such as those from a jet stream, HPMTF can be transported long distances and throughout the atmosphere. Initial atmospheric observations and laboratory studies suggest that approximately 30-60% of DMS emitted from oceans is oxidised via the formation of HPMTF (Veres et al, 2020; Berdnt, 2019). This has potentially significant climate implications, none of which are currently represented in global climate models.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities
Abstract

The effects of aerosol particles on the microphysical property of clouds influence the radiation balance in the atmosphere, with implications to regional and global climate. Thus, there is great interest in understanding cloud-aerosol interactions, and particularly the hygroscopic growth of particles in the vicinity or near clouds. Here we focus on the Amazon region, which is particularly sensitive to changes in the physicochemical distributions of atmospheric particles due to low background concentrations and high levels of water vapor. The objective is to study the hygroscopic growth of aerosol particles in the central Amazon by observing how the particle backscatter increases with relative humidity. Data from a micropulse lidar and radiosondes from the Green Ocean Amazon (GoAmazon) experiment in Manaus-Brazil, from January 2014 to December 2015, were used. For simultaneous radiosonde and lidar measurements, cases of well-mixed atmosphere were identified by constraining the vertical variations of meteorological parameters (water vapor mixing ratio, potential temperature, wind speed, and direction). About 1/3 of the afternoon soundings (2pm LT, or 18 UTC) satisfied the criteria. Aerosol backscatter at 532 nm were calculated from the micro pulsed lidar signal, and plotted against relative humidity to calculate the growth factor, $f(RH) = \beta(RH)/\beta(RH_{ref})$, and the hygroscopic growth parameter, $\gamma$. We show that measurement uncertainty in $f(RH)$ needs to be considered in order to obtain $\gamma$ values that do not depend on the arbitrary choice of reference relative humidity. Our initial results indicate a prevalence of low hygroscopic growth parameters, of around 0.15, coinciding with literature reports of organic aerosols in the natural regions.
Session 4 Poster

Airborne observations over the North Atlantic Ocean reveal the first gas-phase measurements of urea in the atmosphere

Miss Emily Matthews
University of Manchester, United Kingdom

Author list (excluding presenting author)

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Abstract

Despite the reduced nitrogen (N) cycle being central to global biogeochemistry, there are large uncertainties surrounding its sources and rate of cycling. Here, we present the first observations of gas-phase urea (CO(NH₂)₂) in the atmosphere from airborne high-resolution mass spectrometer measurements over the North Atlantic Ocean. We show that urea is ubiquitous in the marine lower troposphere during the Summer, Autumn and Winter flights but was found to be below the limit of detection during the Spring flights. The observations suggest the ocean is the primary emission source but further studies are required to understand the processes responsible for the air-sea exchange of urea. Urea is also frequently observed aloft due to long-range transport of biomass-burning plumes. These observations alongside global model simulations point to urea being an important, and as yet unaccounted for, component of reduced-N to the remote marine environment. Since we show it readily partitions between gas and particle phases, airborne transfer of urea between nutrient rich and poor parts of the ocean can occur readily and could impact ecosystems and oceanic uptake of CO₂, with potentially important atmospheric implications.

Early Career Scientist

YES, I am an early career scientist.
Session 4 Poster

The influence of soil moisture on soil NO\textsubscript{x} emissions: sensitivity to inputs and a more robust model parameterization

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Author list (excluding presenting author)

Allison Steiner (1); Eric Kort (1)

Abstract

Soils represent a significant source of nitrogen oxides (NO\textsubscript{x}) to the atmosphere, and its emission is largely influenced by environmental conditions. Environmental factors such as temperature and soil moisture are the primary drivers of soil NO\textsubscript{x} emissions ($S_{\text{NO}_x}$) and assumptions about these relationships can have an outsize influence on modeled emissions behavior. Here, we update a recent $S_{\text{NO}_x}$ model to address broad spatial variations of soil moisture on $S_{\text{NO}_x}$ and soil NO\textsubscript{x} pulsing. We run the default and updated model over the contiguous United States (U.S.) for 2011-2020 using input soil moisture data from ERA5-Land, MERRA-2 and NLDAS2-Mosaic and compare $S_{\text{NO}_x}$ magnitudes between the two parameterizations. Our results show that the choice of soil moisture product has a significant influence on modeled $S_{\text{NO}_x}$ estimates when using the default parameterization, with large differences in emissions estimates depending on the soil moisture product used. The updated parameterization greatly reduces these differences, and produces more consistent emissions estimates regardless of the soil moisture product used to drive the model. Further, our updated parameterization allows for maximum emissions potential at wetter soil moisture conditions than the default parameterization, resulting in broadly increased emissions in non-arid regions. This suggests that $S_{\text{NO}_x}$ may be underestimated in many wetter regions, including much of the Eastern U.S. Improving the representation of NO\textsubscript{x} sources is essential for accurately representing the formation of harmful secondary pollutants, such as ozone and particulate matter.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

AMIGO: Analysis of eMIssions usinG Observations
Wintertime Atmospheric Chlorine Chemistry on Aerosol Particles and Snow

Prof. Dr. Kerri Pratt
University of Michigan, USA

Abstract

Atmospheric chlorine chemistry is prevalent in wintertime mid-latitude environments from the dark reaction of $\text{N}_2\text{O}_5$ with chloride-containing surfaces to produce ClNO$_2$. Nitryl chloride (ClNO$_2$) photolyzes to produce highly reactive Cl atoms and NO$_2$, which alter atmospheric oxidation pathways and air quality. We conducted measurements of atmospheric trace gases, particles, and snow in two polluted urban locations in Michigan during wintertime to investigate the dominant chloride-containing surfaces resulting in this chemistry. We observed road salt aerosol to be the primary chloride source resulting in ClNO$_2$ production. Our single-particle measurement methods showed that only a fraction of the particulate surface area contained chloride. We developed a new approach to parametrize $\text{N}_2\text{O}_5$ uptake and ClNO$_2$ yield that considers the heterogeneity of the aerosol population. This new approach more accurately simulated ClNO$_2$, compared to traditional mass-based methods, which assume homogeneous distribution of chemical components across all particles and which frequently overestimate ClNO$_2$ production. In addition, we conducted vertical gradient and snow chamber experiments showing that ClNO$_2$ can be produced from the reaction of $\text{N}_2\text{O}_5$ on the saline snowpack, serving as an addition chloride source in the wintertime environment. This work improves our understanding of wintertime chlorine chemistry, and our new approach to simulating $\text{N}_2\text{O}_5$ uptake and ClNO$_2$ production is expected to be applicable to other heterogeneous reactions.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

CATCH: the Cryosphere and Atmospheric Chemistry
Session 4 Poster

Implementation of HONO into the chemistry-climate model CHASER (V4.0) and its roles to the tropospheric chemistry

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Author list (excluding presenting author)

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Abstract

Nitrous acid (HONO) plays a critical role in the atmospheric chemistry as it contributes to the cycles of NO$_x$ and HO$_x$, yet this role has been not fully understood. In this study, the chemistry-climate model CHASER (MIROC-ESM) was introduced three HONO formation mechanisms: gas-phase kinetic reactions (GRs), direct emission (EM), and heterogeneous reactions on cloud/aerosol particles (HRs) to explore HONO’s importance to the tropospheric chemistry.

In this study, the retrieved global abundance of tropospheric HONO was calculated as 1.4 TgN. HRs and EM, of the three source pathways, provided 63% and 26% to the net HONO production, as calculated respectively. However, the model revealed significant negative biases for daytime HONO in the Asian off-coast region, compared with the airborne measurement by EMeRGe-Asia-2018 (Effect of Megacities on the Transport and Transformation of Pollutants on the Regional to Global scales), indicating the existence of unknown daytime HONO sources. We found that the combination of enhanced aerosol uptake of NO$_2$ and surface-catalyzed HNO$_3$ photolysis was the most promising daytime source for HONO in this region.

Inclusion of HONO reduced the levels of global tropospheric NO$_x$ (NO + NO$_2$) by 20.4%, thereby weakening the tropospheric oxidizing capacity (OH, O$_3$) occurring for remote regions and upper altitudes, which in turn, increased CH$_4$ lifetime (13%) and tropospheric CO abundance (8%). The simulated reduction effect to global ozone level reduced the model overpredicts for tropospheric column ozone against satellite OMI (Ozone Monitoring Instrument) for a large regions of the North hemisphere. In contrast, HRs on aerosol surfaces in China (Beijing) enhanced OH and O$_3$ winter mean levels by 600–1700% and 10–33%, respectively. Overall, our findings suggest that a global model that does not consider HONO heterogeneous mechanisms may erroneously predict the effect of HONO in remote areas and polluted regions.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

CCMi: Chemistry Climate Model Initiative

IGAC Regional Working Groups

Japan National Committee
Multiphase photodegradation of 1-nitropyrene in the atmospheric relevant conditions - a new approach to studying solid-water interactions

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Author list (excluding presenting author)
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Abstract
Nitropolycyclic aromatic hydrocarbons (nitro-PAHs) are ubiquitous atmospheric pollutants whose increased concentration affects air quality and human health. It is known that they can be primary or secondary pollutants, and transformation reactions in the atmosphere are being increasingly studied. In this work, photodegradation of 1-nitropyrene, which is the predominant primary nitro-PAH, was studied. In order to understand the influence of atmospheric aqueous phase on the degradation of 1-nitropyrene, we upgraded the already existing multiphase system [1] in a bulk reactor: with a water-solid (particles) interface resembling cloud droplets. The basic idea is to determine the atmospheric lifetime and the parameters influencing pollutant’s residence in the atmosphere, and also to investigate the interaction between water and particles with different chemical properties. Photodegradation of 1-nitropyrene is studied in the presence of a surfactant, which directly enhances the interaction between particles and water and is expected to affect the kinetics of 1-nitropyrene photodegradation.


Early Career Scientist
YES, I am an early career scientist.

IGAC Activities
MAP-AQ: Monitoring, Analysis and Prediction of Air Quality, PACES: Air Pollution in the Arctic: Climate, Environment, and Societies

IGAC Regional Working Groups
Southern Hemisphere Working Group
Session 4 Poster

How does ground-level ozone affect the growth and quality of lettuce crops?

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Author list (excluding presenting author)

Martin McAinsh (1), Carly Stevens (1), Thane Goodrich (2), Kirsti Ashworth (1)

Abstract

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report
Session 4 Poster

Improving our understanding of upper tropospheric NOx using GEOS-Chem and TROPOMI cloud-sliced observations

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Author list (excluding presenting author)

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Abstract

Nitrogen oxides (NOx = NO + NO2) are long-lived in the upper troposphere (UT, ~8-12 km, 450-180 hPa), playing an important role in the production of tropospheric ozone which is a particularly potent greenhouse gas in this part of the atmosphere (Worden et al., 2011). Significant uncertainties exist in our understanding of UT NOx, with chemical transport models (CTMs) predicting lower NOx in the UT than in-situ aircraft measurements (e.g. Silvern et al., 2018). Key UT NOx sources include lightning, aircraft emissions and transport of long-lived reservoir compounds. Here we present seasonal mean UT NO2, obtained by cloud-slicing of TROPOMI NO2 partial columns (Marais et al., 2021) and compare these observations to simulations using the 3D global CTM GEOS-Chem. GEOS-Chem calculates UT NO2 50 % lower than the cloud-sliced observations on average, with strongest agreement found over regions of high anthropogenic NOx emissions and high lightning flash rates. Highest discrepancy between model and measurement is found over remote and oceanic regions, implying incomplete understanding of background UT NOx chemistry. We use GEOS-Chem to investigate UT reactive nitrogen cycling through an examination of reaction kinetics and the sources and sinks of NOx reservoir compounds. We identify sinks of peroxypropionyl nitrate (PPN) not previously included in GEOS-Chem which improve the comparison of cloud-sliced and modelled NO2, as well as the comparison of aircraft measured and modeled PPN. We also investigate UT NOx sources by considering new ways to parameterize NOx production by lightning. We note that the largest cloud-sliced vs modeled NO2 discrepancies correspond to areas of strong lightning radiance as measured by the Lightning Image Sensor on board the International Space Station. Therefore we examine ways to parameterize lightning NOx production efficiency as a function of radiance rather than purely as a function of lightning flash rate.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report
Phthalate esters in PM$_{2.5}$ aerosols in six urban areas of Taiwan

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Author list (excluding presenting author)

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Abstract

Phthalates esters (PAEs) are endocrine disrupters as hazardous air pollutants from various plasticizers of polymeric materials. Exposure to the PAEs in environment is thereby of great concern. In this study, spatial distribution and seasonal variation in the ambient concentrations of major phthalates associated to fine particulate matters (PM$_{2.5}$) were investigated in six cities in Taiwan during the period of January to December 2020. The phthalates studied included dimethyl phthalate (DMP), diethyl phthalate (DEP), diisobutyl phthalate (DIBP), di-n-butyl phthalate (DBP), benzyl buty phthalate (BBP), di(2-ethylhexyl) phthalate(DEHP) and di-n-octyl phthalate (DNOP). The results indicate that the total PAEs concentrations of PM$_{2.5}$ aerosols in six sampling sites exhibited large differences, ranging from 1.5 to 313.63 ng m$^{-3}$. In addition, DBP and DEHP were the most abundant PAEs at all the six sampling sites in Taiwan, accounting for 20-80% of total PAEs in PM$_{2.5}$. Besides, it was found that the ambient levels of PAEs were elevated during summer and autumn, showing a significant temperature dependency, suggesting that the PAEs could be released mostly from fugitive sources. The results of this study show that PAEs were ubiquitous in the urban areas of Taiwan and the potential sources were subject to further investigations.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

PACES: Air Pollution in the Arctic: Climate, Environment, and Societies
Challenges for the GOSAT-GW satellite mission to better quantify anthropogenic emissions of greenhouse gases and air pollutants for climate policy

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Tsuneo Matsunaga (1); Takafumi Sugita (1); Hisashi Yashiro (1); Isamu Morino (1); Makoto Saito (1); Hirofumi Ohyama (1); Satoshi Inomata (1); Kohei Ikeda (1); Yu Someya (1); Tamaki Fujinawa (1); Yukio Yoshida (1); Yousuke Yamashita (1); Astrid Mueller (1); Matthias Frey (1); Tazu Saeki (1); Nobuko Saigusa (1); Yugo Kanaya (2); Takashi Sekiya (2); Prabir Patra (2); Masayuki Takigawa (2); Yasuko Kasai (3); and Tomohiro Sato (3)

Abstract

Emissions inventories are one of key research elements in tackling the climate change issues. The bottom-up inventories provide, for example, accurate estimates of greenhouse gases (GHG) emissions from fossil fuel use, but can have large uncertainties in other sectors and are restricted to managed lands. Inventories can also be derived by the top-down approach using atmospheric inverse models, complementing the bottom-up methods by providing integrated constraints on surface fluxes from all sectors/processes. For these models a variety of observations are used, including those from ground-based, ship, aircraft and satellite platforms. In particular, recent improvements in the capability of satellite observations of atmospheric composition are providing great advances on spatial resolutions. Among several plans to launch GHG and air quality (AQ) observing satellites in near future, a plan is in progress in Japan to launch the “Global Observing SATellite for Greenhouse gases and Water cycle (GOSAT-GW)”, that will make observations of carbon dioxide (CO$_2$), methane (CH$_4$), and nitrogen dioxide (NO$_2$) at a horizontal resolution of 3 km or less. The missions of GOSAT-GW include (1) monitoring of whole atmosphere-mean concentrations of GHGs, (2) validation of nationwide anthropogenic emissions of GHGs, and (3) detection of GHGs emissions from large sources, such as megacities and power plants. We will provide an overview of the mission/project and some highlights, and discuss future perspectives in supporting the Global Stocktake (GST) mechanism, a key element in the Paris Agreement.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

ACAM: Atmospheric Chemistry and the Asian Monsoon, AMIGO: Analysis of eMIssions usinG Observations, GEIA: Global Emissions Initiative

IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group, Japan National Committee
Session 5 Invited

Space-based observations of nitrogen dioxide inequality in U.S. cities

Sally Pusede
University of Virginia, USA

Abstract

Poor air quality disproportionately harms communities of color and low-income communities in U.S. cities. Research to describe, explain, and inform decision-making related to these inequalities has been limited by the lack of observations resolving neighborhood-level atmospheric pollutant gradients and providing temporal information useful for source identification. In this talk, I present work advancing use of the TROPOMI satellite sensor to describe nitrogen dioxide (NO₂) inequalities in U.S. cities. I discuss controls over intraurban NO₂ inequalities, evaluating their temporal variability on multiple scales. Through this temporal variability, I describe work quantifying the contribution of toxic diesel emissions and exploring relationships between NO₂ inequalities, climate variables, and regional ozone air quality.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

AMIGO: Analysis of eMissions usinG Observations, MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

Americas Working Group
Historically, air quality concerns have focussed on outdoor air pollution. Interest in indoor air pollution has only more recently been piqued, particularly since the Coronavirus pandemic. As we spend on average 90% of our time indoors the quality of the air we breathe is important to our wellbeing. A major contributor to poor indoor air quality is VOCs stemming from the use of consumer products, both aerosolised and non-aerosolised. Product formulation regulations and consumer warnings typically concern dermal and oral exposure with regards to applicant safety to ingredients, often disregarding inhalation risks. Additionally, research into, and concerns over contamination of soil and water is often favoured over the potential of long-range atmospheric transport. Poor ventilation in homes, out-dated occupational hazard regulations, and a general lack of data on consumer product inhalation risks only serve to increase consumer exposure to solvent, fragrance, and aerosolised-product propellant VOCs. This talk reviews the difficulties faced regulating novel pollutant species, the short-comings of potential building design and ventilation solutions, and the difficulties of controlling how the public use consumer products in their own private homes.

Early Career Scientist

YES, I am an early career scientist.
Session 5 Oral

Global air quality and public health co-benefits from transitioning to a low carbon future

Dr Carly Reddington
Institute for Climate & Atmospheric Science, University of Leeds, United Kingdom

Author list (excluding presenting author)

Steven Turnock (1); Luke Conibear (2); Charlotte Weaver (3); Lea Berrang Ford (3); Stephen Arnold (4)

Abstract

Understanding the costs and benefits of climate change mitigation and adaptation options is crucial to justify and prioritise future decarbonisation pathways to achieve net zero. In this work, we quantified future worldwide air quality and public health co-benefits of decarbonisation to limit end-of-century warming to either 2ºC (scenario SSP1-2.6) or 1.5ºC (scenario SSP1-1.9), relative to a future reference pathway (scenario SSP2-4.5). We used simulated fine particulate matter (PM$_{2.5}$) concentrations from the Coupled Model Intercomparison Project (CMIP6) experiments and estimated the mortality burden attributable to exposure to ambient PM$_{2.5}$ using population attributable fractions of relative risk. Our analysis incorporated projected changes in population demographics and other health relevant factors.

We found that implementation of decarbonisation scenarios will produce substantial global reductions in population exposure to PM$_{2.5}$ pollution and associated premature mortality. Even the more moderate 2ºC-compliant mitigation scenario (SSP1-2.6) could avert ~3.5M (95% uncertainty interval (95UI): 3.0-4.0M) deaths worldwide in 2050, with ~4.2M (95UI: 3.5-4.8M) deaths averted in the more stringent 1.5ºC scenario (SSP1-1.9), compared with the future reference pathway. We will present detailed results based on world region and population income levels.

Despite substantial improvements in global air quality from decarbonisation, even with the strongest air pollution controls as implemented in the SSP1-1.9 and SSP1-2.6 scenarios, a large fraction of the world’s population (~85%) would remain exposed to concentrations above the World Health Organisation Air Quality Guideline (WHO AQG) for PM$_{2.5}$ at the end of the 21st century. We estimated that a 24% reduction in the projected 2100 SSP1-1.9 global PM2.5 exposure would be required to enable 50% of the world’s population to be in compliance with the WHO AQG.

Early Career Scientist

NO, I am not an early career scientist.
Session 5 Oral

Particulate Matter Pollution and Science-Policy Interface in South Korea

Mr Sungeun Kim
KAIST, Korea, Republic of

Author list (excluding presenting author)

Sungeun Kim (1); Chihyung Jeon (1)

Abstract

Since 2013, air pollution by particulate matter (PM) has become a society-wide concern in South Korea. Heavy media coverage of the adverse health effect of PM propelled the public’s fear, leading to fast-growing civic activism on bad air quality. As PM abatement turned into a pressing policy agenda, the South Korean government drastically increased public funding for atmospheric science research. Government-funded science was expected to elucidate the forming mechanisms of PM, specify its causes, and thereby provide effective solutions to alleviate the breathing conditions of the nation-state. More importantly, many anticipated that sophisticated knowledge of the transboundary mobility of PM would reveal the significant contribution of Chinese emissions to South Korean air. In both policy arena and public discourse, atmospheric chemistry was imagined as the solution for domestic politics as well as complicated international relations between China and Korea. Analyzing recent media reports, scientific papers, and policy decisions on the South Korean particulate matter crisis, this paper examines how these cultural and political contexts shaped the course of government-funded atmospheric science. It suggests that the production and interpretation of air knowledge was never solely a scientific matter but closely coupled with ethical judgments, moral responsibilities, and cultural meanings of bad air. While the government-funded science projects were often expected to provide straightforward answers for severe environmental problems, the interplay between science and policy turned out to be much more complicated. The paper concludes by providing some recommendations to better facilitate the communication and utilization of government-funded atmospheric science in making major policy decisions.

Early Career Scientist

YES, I am an early career scientist.
Quantifying the contributions of reactive gas emissions to past a future climate change.

Prof William J Collins  
University of Reading, United Kingdom

Abstract

Reactive gas emissions can have multiple effects on climate. They may directly interact with shortwave or longwave radiation, their photochemical reactions may produce or deplete radiatively active gases such as ozone, or they may change the oxidising capacity of the troposphere affecting the lifetimes of other reactive gases.

Here we present results from a multi-model inter-comparison (AerChemMIP) where individual reactive gases were perturbed, and follow these through their impacts on tropospheric and stratospheric ozone and oxidising capacity to calculate an Effective Radiative Forcing (ERF) that includes these effects (which we term "chemical adjustments"). These forcing efficiencies are then combined with the historical evolution of reactive gas emissions to quantify their contributions to historical climate. This finds that hydrocarbon emissions (methane, CO and non-methane VOCs) have contributed almost as much to the current warming as emissions of CO2.

Early Career Scientist

NO, I am not an early career scientist.
Session 5 Oral

Platform for Standardization, Characterization and Calibration of low-cost Air and Water sensors in Chile: Challenges and Opportunities

Camilo Rodriguez-Beltran
EnviroHealth Dynamics Lab, Research Center in Technology for Society (C+), School of Engineering, Universidad del Desarrollo, Chile

Author list (excluding presenting author)

Camilo Rodriguez-Beltran (1), Zoë Fleming (1)(2), Nicolas Zanetta (1)(3), Felipe Olivares (1), Macarena Troncoso (1)(4)

Abstract

Chile has a vast and varied environment to measure, from the arid north to cold and stormy Patagonia, from the Pacific to the high Andes. Monitoring stations for air quality are concentrated in the urban centres and near industrial or mining areas and are a long way from being able to monitor the diversity in air quality across the country. Some towns have never had their air quality measured and other towns which have just one monitoring station are aware of huge local differences within the town that they cannot prove. It has been widely accepted that low-cost sensors and low-cost sensor networks hold the potential for greatly increasing spatial coverage, facilitating the understanding of new insights into environmental process dynamics. However, some trade-offs are also recognized with regards to robustness, calibration requirements and accuracy of low cost sensors when compared to high–end commercial sensors.

A novel Chilean Research fund (Fondequip Mayor ANID) grant has allowed us to build up a platform of 1) Reference instruments that measure the standard air quality parameters (Ozone, NOx, SO2, NOx, CO, CO2, CH4, Particulate Matter, Organics (GC)) and Meteorology and water flow measurements and also water quality parameters and 2) Standard laboratory settings in order to mimic environmental conditions for the in-lab characterization of novel sensors. Since 2022 we have been setting up the instrumentation and using it to evaluate environmental variables in diverse geographically locations across Chile, this will be complemented by creating a mobile laboratory that will transport the platform to remote locations. This is to our knowledge the first attempt to build a platform for characterization and calibration of environmental diagnosis in Chile and in the Southern Cone, this project has already built up a large network of national scientists, international advisors, private-public associates and non-governmental organisation representatives.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups
Southern Hemisphere Working Group, Americas Working Group
Empirical Determination of instantaneous tropospheric ozone production regimes

Saewung Kim
University of California, Irvine, USA

Author list (excluding presenting author)
Alex Guenther, Gracie Wong, Julie Devlin, Rokjin Park, Hyunmin Kim, Jiyi Lee, Kyungjin Kim

Abstract
The ozone production sensitivity to NOX and VOCs has been considered a quintessential representation of the non-linear nature of tropospheric photochemistry. The graphical representation of the non-linear nature was developed by the US EPA in late 1970, widely known as an ozone isopleth. The isopleth is clearly demonstrating that any one of the ozone precursors - NOX and VOCs does not prescribe the intensity of ozone production. Therefore, the identification of the precursor mixture imbalances nominally called NOX or VOC saturated regimes became of particular interest for both air pollution reduction and photochemical research perspectives.

In the 1980s, several frameworks to determine the ozone production regimes using observational field datasets were developed to explore photochemistry in the studied locations. As much as these multiple frameworks have enhanced our ability to probe photochemistry, the various frameworks may differently diagnose the ozone production regimes. This is partly, if it is not mainly, caused by the chemical species each framework using has a wide range of atmospheric lifetimes.

The current status motivates us to reexamine the conceptual frameworks, particularly as advances in atmospheric chemistry analytical techniques allow us to constrain the impacts of peroxy radicals directly. We will discuss the evaluations of the instantaneous ozone production regime using total OH reactivity and pernitric acid (HO2NO2) observations.

Early Career Scientist
NO, I am not an early career scientist.
Session 5 Oral

NASA GEOS Composition Forecast System, GEOS-CF: Overview, Applications, and Future Directions

K. Emma Knowland
Morgan State University, GESTAR-II, USA. Global Modeling and Assimilation Office, NASA Goddard Space Flight Center, USA

Author list (excluding presenting author)

Christoph A. Keller (1,2), Carl A. Malings (1,2), Pamela A. Wales (1,2), Krzysztof Wargan (2, 3), Callum R. Wayman (2,3), Brad Weir (1,2), Lesley E. Ott (2), Steven Pawson (2)

Abstract

NASA’s Global Modeling and Assimilation Office (GMAO) produces high-resolution analysis and forecasts for weather, aerosols, and air quality in support of NASA’s mission to better understand the Earth as a system. Since 2019, the NASA Global Earth Observing System (GEOS) model provides global near-real-time historical estimates and daily 5-day forecasts of atmospheric composition to the public at an unprecedented horizontal resolution of 0.25 degrees (~25 km) from the surface up to the lower mesosphere. This composition forecast system (“GEOS-CF”) combines the quasi-operational GEOS weather forecasting model with the state-of-the-science GEOS-Chem chemistry model to deliver detailed analysis of a wide range of air pollutants, including the policy-relevant species such as ozone, carbon monoxide, nitrogen oxides, sulfur dioxide and fine particulate matter (PM$_{2.5}$).

The GEOS-CF is an emerging tool for scientists and the public health community and is being developed jointly with several government and non-profit partners. This presentation will cover the GEOS-CF modeling framework, stakeholder applications and future development activities. Novel data access and visualization options are evolving to support stakeholders including US EPA, US Army Public Health, UNEP and cities in the Global South (e.g., Rio de Janeiro, Brazil and Dakar, Senegal) as well as NASA missions (e.g., a priori estimates for trace gas retrievals by TEMPO, ground-based instrument teams and field campaigns). The GEOS-CF system continues to mature to include multi constituent data assimilation, near-real time emission adjustment estimates, and down-scaling methods to urban-scale. Enabling data access on Google Earth Engine, Amazon Web Services, and other platforms is allowing us to integrate our state-of-the-science air quality information onto platforms used by stakeholders, air quality managers, and the public.

Early Career Scientist

NO, I am not an early career scientist.
**Session 5 Oral**

**Impacts on climate change and air quality in Indian agriculture: Research, Policy and Regulations.**

**Dr. Kumaresan Palaniyappan**
Directorate of water technology Centre, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

**Author list (excluding presenting author)**

Pazhanivelan, S (1), Ragunath, K.P (2), GeethaLakshmi, V (3), Raju, M (4), Rajavel, M (5), Sivamurugan, A. P (6), Kumaraperumal, R (7), Balakrishnan, N (8) and Srinivasan, G (9)

1 Director, Water Technology Centre, TNAU, Coimbatore, 2 Assistant Professor Water Technology Centre, TNAU, Coimbatore, 3 Vice Chancellor, TNAU, Coimbatore, 4 Professor, Water Technology Centre, TNAU, Coimbatore, 5 Assistant Professor Department of Crop Physiology, TNAU, Coimbatore, 6 Assistant Professor Water Technology Centre, TNAU, Coimbatore, 7 Assistant Professor, GIS&RS, TNAU, Coimbatore, 8 Research Fellows, Water Technology Centre, TNAU, Coimbatore.

**Abstract**

Scientific studies of agricultural air quality, including estimates of greenhouse gas emissions and possible sequestration, an important growing area of agricultural science that poses substantial difficulties to policymakers and regulators. Modelling, emission controls, and farm operation all need to be improved. Controlling greenhouse gas and particulate matter emissions from agriculture is notoriously difficult since it affects human's food. Current policies mix insufficient science with social and political overlays to cover a wide range of operations in a complex business. Furthermore, agricultural emissions come from both point and area sources. Agricultural emissions play a significant influence in numerous atmospherically mediated environmental and public health concerns in Indian states. These atmospheric processes have an impact on odour, particle matter exposure, eutrophication, acidification, toxic exposure, climate, and infections, among other things. Agricultural emissions contribute to global issues caused by greenhouse gas emissions. Agricultural emissions vary in space and time, as well as in how they interact with the many processes and media affected. Agriculture accounts for approximately 80% of total emissions, odour, and pathogen emissions in India. Agriculture also uses fossil fuels for fertiliser production and farm operations, resulting in the emission of carbon dioxide, nitrogen oxides, sulphur oxides, and particulates. The quantification point and nonpoint sources, the biosphere-atmosphere exchange of ammonia, reduced sulphur compounds, volatile organic compounds, greenhouse gases, odour and pathogens, and the primary and secondary emissions of particle matter are all current research priorities. Given the substantial concerns voiced about the amount and impact of agricultural air emissions, policies and regulations must be pursued and enacted in order to make real progress in decreasing these emissions and their associated environmental problems. Economic and technical options must be enabled, supported and supplemented by appropriate policies and institutions that build bridges to integrate climate change concerns in food and agricultural policies.

**Early Career Scientist**

YES, I am an early career scientist.

**IGAC Activities**

AMIGO: Analysis of eMissions using Observations, GEIA: Global Emissions Initiative
IGAC Regional Working Groups

MANGO: Monsoon Asia and Oceania Networking Group, Japan National Committee, Americas Working Group
Session 5 Poster

Identifying key barriers to pollution and GHG emission reductions from Chinese agriculture for 2030.

Ms Connie O’Neill
Stockholm Environment Institute, United Kingdom

Author list (excluding presenting author)

Eleanor Jew (1), Ailish Graham (2); Malley, C (3); Kevin Hicks (3); Catherine Oliver (1); James Luk (1) and Lisa Emberson (1).

Abstract

Globally, agriculture is a major source of air pollution and greenhouse gases. As the world’s largest producer of crops and livestock, agriculture in China is crucial both in meeting global food demand as well as in supporting rural livelihoods. The demand driven Stockholm Environment Institute agricultural emissions model was applied to estimate agricultural emissions in China. Food balance data from the Food and Agriculture Organisation (FAO) were the primary input data for the present day scenario and this was projected to 2030 using the China Agricultural Outlook. We show that in 2017, agriculture in China contributed 13.6Mt CH4, 10.9Mt NH3 and 1.2Mt PM2.5. By 2030, under a baseline scenario, emissions will increase by 18%, 20% and 6 % respectively. Multiple mitigation options are available to reduce agricultural emissions. Through a combination of ‘on-farm’ and demand side measures, CH4 and NH3 emissions could be reduced by 52 and 86% compared to the baseline scenario, while PM2.5 emissions from crop burning could be eliminated. However, implementation of these mitigation options remains challenging. Through digital surveys with approximately 55 farmers and 36 stakeholders we explore the feasibility of the modelled mitigation options and identify key barriers which must be overcome to reduce agricultural emissions in China. The methods and insights drawn from this work can be applied to other regions in which agriculture is a key emissions source.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

GEIA: Global Emissions Initiative

IGAC Regional Working Groups

China Working Group
Assessing the impacts of future changes in air pollution on human health and crop productivity in China for 2030.

Prof Lisa Emberson
University of York, United Kingdom

Author list (excluding presenting author)

Connie O'Neill (1); Ailish Graham (2); Sam Bland (1); Pritha Pande (1); Nathan Booth (3); Chris Malley (1)

Abstract

China currently has one of the highest air pollution burdens globally, population weighted exposure of PM2.5 is estimated at approximately 52 μg/m$^3$ and ozone concentrations during the growing season are often in excess of 40ppb in the agriculturally important North China Plain. These high levels of pollution have been shown to have adverse effects on both human health and crop productivity at current day concentrations. Here we estimate future impacts on human health of aerosol burdens using global burden of disease methods to relate PM2.5 concentrations to changes in premature mortality between the current day (2017) and 2030. We also explore the effects of future changes in ozone concentration on wheat yields (one of China’s most important staple crops) over the same time period. This is achieved using the DO3SE-Crop model which extends the former DO3SE deposition model by including a crop growth module capable of estimating the combined effects of climate and ozone on photosynthesis and senescence and ultimately on crop carbon allocation, biomass and yield. DO3SE-Crop is evaluated against a site-specific ozone FACE experiment conducted in Xiaoji between 2007 and 2009. Human health and crop impacts are assessed for a range of emission scenarios, developed using a demand driven agricultural emissions model that incorporates both on-farm mitigation options and diet based interventions to reduce emissions. These emission estimates are used to create ‘business as usual’ and ‘maximum feasible reduction’ emission scenarios from which concentration fields across China are estimated through application of the WRF-Chem model. We consider the results in the context of health related SDGs and China’s agricultural outlook targets for 2030.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report, GEIA: Global Emissions Initiative

IGAC Regional Working Groups

China Working Group
Session 5 Poster

RADICAL: Developing an electronic sensor for detecting short-lived atmospheric radicals and other gases

Mr Adrien Gandolfo
School of Chemistry, University College Cork, Ireland

Author list (excluding presenting author)

Justin Holmes; Vaishali Vardhan; Subhajit Biswas; Tamela Maciel; Stig Hellebust; John Wenger

Abstract

RADICAL: Developing an electronic sensor for detection of short-lived atmospheric radicals and other gases

Atmospheric radicals, particularly hydroxyl and nitrate, are the drivers of chemical processes that determine atmospheric composition and thus influence air quality and climate. However, the detection of these short-lived atmospheric radicals is far from routine, and only a few labs worldwide can accurately measure their concentrations in air. Current techniques for measuring radicals are largely based on spectroscopic methods, which although sensitive and robust, are technically complex, cumbersome and expensive.

This presentation will provide an overview, and a discussion of the latest results, from the EU-funded project ‘RADICAL’ which is developing a small, low-cost sensor to electrically detect short-lived atmospheric radicals in real-time. This will be the first gas sensor built from an array of junctionless nanowire transistors, which has proven popular for liquid-based sensors. Although challenging to produce, RADICAL sensors not only have the potential to be rolled out on a global scale but can also be adapted to detect other important atmospheric gases, particularly on short-timescales. The project team is open to new ideas and future collaborations to investigate how these sensors might be best applied in real-life environmental monitoring situations.

Website: radical-air.eu

Early Career Scientist

YES, I am an early career scientist.
Abstract

Climate change is impacting urban infrastructure, economic development, and public health. Over the last decade, cities at the most local levels of governance have taken leadership to speed up the process of climate action. Cities in partnerships with research, academic institutions, and consultancies are developing climate mitigation and adaptation plans that remain poorly resourced. The development of these plans, primarily informed by various IPCC reports, poses challenges in making them actionable at the urban scale. However, this confluence of bottom-up climate action from cities across the globe and top-down environmental leadership from national and international bodies can accelerate our goals for net-zero emissions and provide equitable climate adaptation. We will discuss the Climate Action Plan for the Chicago Region and share our experiences, challenges, successes, and vision for inclusive growth of all sections of society at regional scales and how regional solutions can be scaled with national and global support and accelerate climate action.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Regional Working Groups

Americas Working Group
Introducing NOAA’s Earth’s Radiation Budget (ERB) Program

Victoria Breeze
National Oceanic and Atmospheric Administration (NOAA), USA

Author list (excluding presenting author)
Gregory Frost (1)

Abstract

Beginning in 2020, the US Congress has appropriated funds to the National Oceanic and Atmospheric Administration (NOAA) with the mandate to improve the understanding of aerosol impacts on Earth’s energy balance. NOAA responded by creating the Earth’s Radiation Budget (ERB) Initiative. ERB seeks to answer the mandate through: establishing a capability to observe and monitor stratospheric conditions; detecting and accurately simulating the impacts of natural and human-caused aerosol injections in the stratosphere and troposphere; and deriving co-benefits for Earth system prediction through better understanding of aerosols and clouds.

For the first two years, the Initiative has focused entirely on directed projects, broadly split between modeling and measurement for both the stratosphere and troposphere, with the greater emphasis on stratospheric observations. In 2021 the Initiative established the ERB Program within NOAA’s Climate Program Office’s Earth System Science and Modeling Division as the extramural portion of the ERB Initiative, supporting competitive research awards. This poster introduces the IGAC community to ERB and encourages interest in ERB and NOAA’s shared mission.

Early Career Scientist

NO, I am not an early career scientist.
Session 5 Poster

Spatially Resolved Reduced Order Impact Modeling for Black Carbon to Inform Policy Scenarios

Lyssa M Freese
Massachusetts Institute of Technology, Department of Earth, Atmospheric and Planetary Sciences, USA

Author list (excluding presenting author)

Sebastian Eastham (2)
Cecilia Han Springer (3)
Noelle E. Selin (1,4)

Abstract

As various climate and air quality policies are explored, it is important to be able to understand the role that location and timing of emissions have on earth system feedbacks and the impacts on communities. In this work, we construct a reduced form black carbon model based on a chemical transport model, GEOS-Chem, to better inform the impacts of black carbon emissions from various locations based on a large ensemble of policy scenarios. Due to the reduced computational cost of this model, we can run dozens of policy scenarios over multiple decades to assess uncertainties in these scenarios.

We create a Green’s Function representation of GEOS-Chem black carbon response to an impulse of emissions, which is indirectly diagnosed by taking the derivative of a simulation forced by a step-increase in emissions. We calculate Green’s Functions for 5 countries in Southeast Asia, as well as the entire Southeast Asian region. This results in a spatially resolved and normalized source receptor model, condensing the key information from GEOS-Chem into a five-dimensional map (location of emissions, and concentration latitude, longitude, time, and height), which can be convolved with any emissions time series to approximate the spread of black carbon from the desired source region.

Because this reduced form model can simulate the effects of decades of black carbon emissions in minutes, we use it to assess ensembles of dozens of emissions policies over multiple decades for the early retirement of Chinese-funded coal power plants in Southeast Asia and their impact on black carbon concentrations. We investigate different approaches to the early retirement of coal power plants and their impacts on cumulative pollution over a period of fifty years, with a particular focus on the transboundary impacts in China.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

CCMi: Chemistry Climate Model Initiative

IGAC Regional Working Groups

China Working Group
NOAA’s Next-Generation Space-based Capabilities for Observing Atmospheric Composition

Gregory Frost
NOAA Office of Oceanic and Atmospheric Research, USA

Author list (excluding presenting author)

Shobha Kondragunta (2); Monika Kopacz (1); Victoria Breeze (1); Kathryn Mozer (1); Shiv Das (1,3)

Abstract

The USA’s National Oceanic and Atmospheric Administration (NOAA) is actively engaged in planning its next-generation operational space-based capabilities for observing Earth’s atmospheric composition. In 2021, NOAA initiated its Geostationary (GEO) Extended Observations mission (GeoXO), a ground-breaking effort to advance Earth observations from GEO orbit. GeoXO will continue and significantly expand observations provided by NOAA’s current GOES-R Series, while bringing new operational capabilities to address emerging environmental issues and their societal consequences. The combination of GeoXO’s hyperspectral observations in the ultraviolet, visible, and infrared along with visible and infrared day and night imaging will provide an exciting new ability to continuously measure the abundance and sources of trace gases and aerosols over much of North America.

At the same time, NOAA has begun gathering input for potential atmospheric composition capabilities on its next-generation operational Low-Earth-Orbiting (LEO) mission that will follow the current Joint Polar Satellite System (JPSS), slated to continue through the 2030’s. NOAA is exploring a move towards a disaggregated and distributed LEO architecture, with the goal of launching sensors and missions in a more agile way in the future. The precise formulation of this distributed LEO system will depend heavily on how the data from current sensors are used, their impacts on applications critical to NOAA’s stakeholders, and the opportunities for improving future sensors.

This presentation will highlight the potential atmospheric composition products from these next-generation NOAA GEO and LEO missions, which offer new opportunities for understanding, monitoring, and predicting air quality, weather, and climate, their interconnections, and their relationships with human health and environmental justice. We welcome active engagement of the user community in designing and developing applications for these future satellite atmospheric composition missions.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

Relative contributions of fossil fuel and biomass burning sources to Black Carbon aerosol on the Southern Atlantic Ocean Coast and King George Island (Antarctic Peninsula)

Dr. Sérgio J. Gonçalves Jr.
Radioecology and Global Changes Laboratory (LARAMG), Rio de Janeiro State University/Brazil, Brazil

Author list (excluding presenting author)
Newton Magalhães (1); Renata C. Charello (2); Heitor Evangelista (1); Ricardo H. M. Godoi (2).

Abstract
Carbonaceous aerosols, particularly those containing Black Carbon (BC), can have an impact on climate. The incomplete combustion of fossil fuels and biomass produces BC, which can heat the atmosphere and increase ice melting, but little is known about the sources of BC in Antarctica. The contribution of distant origin (biomass burning) and local emissions (fossil fuel) to atmospheric BC concentrations in King George Island (Antarctic Peninsula) and the Southern Ocean was quantified. Onboard the Brazilian Oceanographic Research Ship Almirante Maximiano, we measured BC concentrations with multi-wavelength Aethalometers AE-33 and AE-42. The results show that the region is influenced by both local sources and air masses from neighboring continents. The region's main source of carbonaceous aerosols was fossil fuel combustion, with a total average concentration of 42 ng m⁻³. The data suggest that biomass burning from low and mid-latitudes in South America contributes to biomass burning across the Antarctic Peninsula and the Southern Ocean around 62°S latitude. We revealed that fossil fuels are the primary source of atmospheric BC concentrations over the Austral summer and autumn. Local BC sources include scientific stations, local tourism, and traffic. Our work highlights the severity of Antarctica exploration's problematic sustainability challenges.

Early Career Scientist
YES, I am an early career scientist.

IGAC Activities
CATCH: the Cryosphere and Atmospheric Chemistry

IGAC Regional Working Groups
Southern Hemisphere Working Group
Attribution of Tropospheric Ozone to Sources of NOx and VOC Precursor Emissions in a Global Chemistry-Climate Model (CESM1.2.2-CAM4-Chem) for the 2000-2018 Period

Mr Aditya Nalam
Institute for Advanced Sustainability Studies, Potsdam, Germany. Freie Universitaet Berlin, Germany

Author list (excluding presenting author)

Tim Butler (1,2), Aura Lupascu (1)

Abstract

Tropospheric ozone (trop-O3) is a regional air pollutant and an important greenhouse gas. Major sources of trop-O3 are: transport from the stratosphere; and photochemical production within the troposphere involving reactions of ozone precursors: oxides of nitrogen (NO and NO2, collectively NOx) and volatile organic compounds (VOC), including methane.

Trop-03 has an atmospheric lifetime of about a few weeks making it transportable over inter-continental distances. This makes ozone precursor emissions from one “source” region affect the ozone concentration at local and remote “receptor” regions, making it important for us to understand source-receptor relationships. These source-receptor relationships can be modelled using the source-attribute technique (also known as Tagging) where ozone molecules are tagged/labelled with their source identities allowing a direct attribution of sources in receptor regions, thereby, the relative contribution of various sources can be obtained.

Simulations using CESM 1.2.2- CAM4-Chem are performed for a global study of trop-03 source attribution for the 2000-2018 period. Here, we modify the default chemical mechanism to output the ozone and its tags attributed to the source region/sector of its emitted precursors. For example, an NO molecule originating from biogenic source would be called NO_BIO, and all the other chemical species emanating from NO_BIO (NO2, NO3, O3 etc.) will hold the tag “BIO”.

Separate simulations are performed for tagging trop-03 with its NOx and VOC precursor emission sources. We specify separate tag identities for emissions from anthropogenic, biogenic, biomass burning, and aircraft sources. Additional tags are specified for lightning NOx in the NOx-tagged simulation, and for methane in the VOC-tagged simulation. Here, all surface-based anthropogenic emissions hold tags representing the geographical location at which the emissions occur. Further, the ship-NOx emissions hold tags representing the ocean basin from which they are emitted.

The design of these simulations and some prominent results will be presented

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

CCMi: Chemistry Climate Model Initiative
Sensitivity of Climate and Composition to Concomitant Idealised Future Changes in Methane and Hydrogen Emissions

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Author list (excluding presenting author)
Vaishali Naik (1); Larry W. Horowitz (1)

Abstract

Rapid methane mitigation has been recognized as a global priority, with over 100 countries signing onto the Global Methane Pledge, which aims to achieve at least a 30% reduction in anthropogenic methane emissions compared to 2020 levels by 2030. Multiple studies (e.g. UNEP, 2021) have shown that this is both technologically and economically feasible. However, methane concentrations are increasing. While there are uncertainties about what is driving this increase, anthropogenic methane emissions have likely continued to increase throughout the past decade (Saunois et al, 2020). These divergent outcomes for methane emissions in the future are reflected in the Shared Socioeconomic Pathways (SSPs) formulated for the 6th Coupled Model Intercomparison Project Phase 6 (CMIP6). Recently, there has also been renewed global interest in hydrogen as countries strive to meet climate goals. A future hydrogen economy can also bring about additional associated changes in ozone precursor emissions as well as hydrogen emissions, which can cause climate and composition impacts in addition to those that come from methane emission changes alone (Warwick et al., 2022). Due to the methane self-feedback effect, methane concentrations change non-linearly with methane emissions, and this nonlinearity is described by the feedback factor, f. Other studies have quantified f as well as other climate and composition impacts for either increasing or decreasing methane emissions. The first goal of this study is to explore the climate and composition sensitivity to both increasing and decreasing methane emissions of the atmospheric chemistry-climate model, GFDL AM4.1, driven by both methane and hydrogen emissions. The next goal is to quantify how different the outcomes will be if we were to allow methane emissions to continue to increase before it decreases, compared to if we were to decrease emissions directly. Lastly, this study will also explore the additional impacts of ozone precursor and hydrogen emissions.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

CCMi: Chemistry Climate Model Initiative, TOAR: Tropospheric Ozone Assessment Report
Session 5 Poster

Utilizing satellite data to advance the understanding and modeling capability of land-atmospheric chemistry interactions and air quality

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Author list (excluding presenting author)

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Abstract

At the 2021 IGAC conference, we summarized some past and active research efforts relevant to IGAC activities that aim to advance the understanding of the connections between land surface conditions (i.e., soil moisture and vegetation) and ozone related processes, particularly ozone dry deposition and biogenic emissions of VOCs, NOx, and HONO, in different latitude regions/biomes. There, we demonstrated how various satellite, aircraft and ground-based observations together could help improve the process-level understanding and model predictive skill of ozone. At this year’s conference, updates on some of these studies will be shared, such as considering the ozone effects on plants in the model; and assessing the interactions between biogenic emissions, anthropogenic combustion emissions (with the newly released Hemispheric Transport of Air Pollution v3 inventory being applied in the model simulations), and the perturbations of biomass burning to several elements of the Earth system. We will also introduce an in-development review article on utilizing satellite data to advance the understanding and modeling capability of land-atmospheric chemistry interactions and air quality. Under such a topic, this review covers not only the science advances, but also implications from satellite calibration/validation activities regarding the uncertainty and representativeness of satellite data, as well as the status of end user/stakeholder engagements.

Early Career Scientist

NO, I am not an early career scientist.
**Session 5 Poster**

**Non-CO2 Forcers and their Climate, Weather, Air Quality and Health Impacts – New Project FOCI**

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**Author list (excluding presenting author)**

Ranjeet Sokhi, and FOCI team

**Abstract**

While overall the global warming with the causes and global processes connected to well-mixed greenhouse gases (GHGs), especially CO2, and their impacts on global to continental scales are well understood with a high level of confidence, there are knowledge gaps concerning the impact of many non-CO2 radiative forcers leading to low confidence in the conclusions. This relates mainly to specific anthropogenic and natural precursor emissions of short-lived GHGs and aerosols and their precursors. These gaps and uncertainties also exist in their subsequent effects on atmospheric chemistry and climate, through direct emissions dependent on changes in e.g., agriculture production and technologies based on scenarios for future development as well as feedbacks of global warming on emissions, e.g., permafrost thaw. In addition to the atmospheric radiative forcing (gaseous or aerosols), albedo changes connected to land use and land cover can play a role, depending on the adaptation or mitigation measures included in different scenarios.

Thus, the main goal of the project FOCI is to assess the impact of key radiative forcers, where and how they arise, the processes of their impact on the climate system, to find and test an efficient implementation of these processes into the global Earth System Models and into Regional Climate Models, and finally to use the tools developed to investigate mitigation and/or adaptation policies incorporated in selected scenarios of future development targeted at Europe and other regions of the world. We will develop new regionally tuned scenarios based on improved emissions to assess the effects of non-CO2 forcers. Mutual interactions of the results and climate services producers and other end-users will provide feedback for the specific scenarios preparation and potential application to support the decision making, including climate policy.

**Early Career Scientist**

NO, I am not an early career scientist.

**IGAC Activities**

CCMi: Chemistry Climate Model Initiative
The need for comprehensive understanding of secondary aerosol formation mechanisms in the development of PM2.5 reduction policy in Jakarta, Indonesia

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Author list (excluding presenting author)

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Abstract

Jakarta has warm tropical climate with abundant solar radiation. The weather is characterized by temperature ranged between 24 - 35°C and average RH of 74% throughout the year. Jakarta is a home of over 10 million population and over 20 million registered motor vehicles, about 75% are motorcycles. Air quality monitoring stations (AQMS) measuring criteria pollutants in Jakarta run by national and provincial agencies/bodies. The work reported here was part of the study to develop Jakarta Grand Design for Air Pollution Control.

In this paper we examined the long-term observation of PM10, PM2.5, NO2 and SO2 as the primary pollutants, so that effective control strategies can be established. Analyses were based on 2010 -2020 PM10, NO2 and SO2 monitoring data from 5 (five) stations of Jakarta Provincial Government and 2015 – 2020 PM2.5 data from 2 (two) AirNow sites. Evaluation and policy advices were drew by relating air quality data analysis with the review results of emission inventory studies.

Both PM10 and PM2.5 did not show significant trends; however, significantly negative trend of NO2 and positive but significant trend of SO2 were observed. The results showed that overall during 2010 - 2020, PM10 and PM2.5 exceeded daily NAAQS by 30 – 90% of the time, while NO2 and SO2 exceedances ranged from 0% to 40%. It was found that the ratios of PM2.5 to PM10 were between 54 to 94%, suggesting relatively large portion of PM2.5 in PM10. On the other hand, emission inventory studies showed that the largest emissions from all sources were NO2 (59%), while PM and SO2 emissions only accounted for 26% and 15%. These results imply that significant portion of PM2.5 could be of secondary aerosols. To control PM2.5 levels, it is not enough to only reduced PM emissions, but the policy should also address the precursor emissions.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

IGAC Regional Working Groups

Southern Hemisphere Working Group
Aerobiology of SARS-Cov-2 in a tropical condition: a case study in a Brazilian Slum

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Abstract

The coronavirus (SARS-CoV-2) represents one of the Anthropocene’s most significant public health challenges. Since atmospheric gases and aerosols can bring serious respiratory risks, this situation can worsen in places where weather conditions are unfavorable for the dispersion of pollutants. The transmission of pathogens by aerosols or droplets has been shown to be highly predominant in confined spaces. Seasonal causes of respiratory pathologies cannot be attributed to a single factor. Some behaviors may be related to environmental conditions and their parameters (e.g., temperature, humidity, solar and ultraviolet radiation) that favor the spread of the virus in the air. In Brazil, around 13.6 million people live in slums (“favelas”), which is an agglomeration of poor households. Worldly, 1 billion people live in such conditions. Due to its architecture of pilled habitations, the environment of slums has poor ventilation, and high humidity and is mainly shaded by confined walls. A case study in Santa Marta’s slum (Rio de Janeiro/Brazil) was conducted, where there are open sky sewage ditches in between narrow alleys. The sewage discharged produces water splashes, and sewage droplets microparticles could launch and disperse in the slum’s atmosphere, reaching the indoor environment. We monitored aerosols in the outdoor environment, near the open sewage. The SARS-CoV-2 has been detected ranging from 0.25-0.5 µm, demonstrating that there is virus circulation in the slum atmosphere. Environmental parameters were correlated, considering the tropical climatic condition, and statistics surveys for the COVID-19 database were implemented, suggesting a connection between the worsening of COVID-19 cases and such conditions. A correlation with local sanitization was carried out, and the results showed a significatively lowered with improved sanitization levels ($r = -0.74$). More studies about mitigating COVID-19 in underserved community sites are needed, but a permanent sanitization activity may induce positive social behavior to combat this disease.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

MAP-AQ: Monitoring, Analysis and Prediction of Air Quality

COVID-19 related abstracts

yes