RMetS
Royal Meteorological Society

Air Quality and Climate Impacts of COVID-19 Lockdowns

Virtual Event

Thursday 18th November 2021, 11.00am – 4.00pm

Provisional Programme:

Time	**Speaker**	**Title**
11.00	ACSG chairs/RMetSoc	**Welcome from the ACSG chairs**
11.05	Dr Stuart Grange	The impact of COVID-19 lockdowns on air quality in European urban areas
11.30	Prof Zongbo Shi	Abrupt but smaller than expected changes in surface air quality attributable to COVID-19 lockdowns
11.55	Prof Hartmut Boesch	Diagnosing air quality changes in the UK during the COVID-19 lockdown using satellites
12.20	Dr Robin Lamboll	CovidMIP: Real-time emissions tracking for updating emissions scenarios to include lockdown
12.45		**Break**
14.00	Prof David Stevenson	COVID-19 lockdown NOx emission reductions can explain most of the coincident increase in global atmospheric methane
14:25	Prof Ulrich Schumann	Climate impacts of air traffic and contrail changes over Europe during COVID-19
14:50	Dr Melanie Hammer	Effects of COVID-19 lockdowns on fine particulate matter concentrations
15:15	Dr Susan Anenberg	Inconsistent NO_2 drops during COVID-19 lockdowns: lessons for protecting near-term public health and designing longer-term environmental policies.
15:40		Discussion
16:00		**Meeting Close**

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This meeting is part of the Royal Meteorological Society National Meetings programme, open to all, from expert to enthusiast, for topical discussions on the latest advances in weather and climate. Non-members are welcome to attend these meetings.

Abstract:

Dr Stuart Grange
Swiss Federal Laboratories for Materials Science and Technology, Switzerland

The implementation of non-pharmaceutical interventions across the world in early 2020 to slow the transmission of SARS-CoV-2, the virus which causes COVID-19 had many positive environmental impacts, including the reduction of air pollutant emissions and subsequent improvements in air quality. Concentrations of nitrogen dioxide (NO_2) and ozone (O_3) in European urban areas were especially affected. To investigate and quantify the changes in these pollutants' concentrations, observations from 246 ambient monitoring sites in 102 urban areas in 34 European countries were analysed between February and July, 2020. Counterfactual, business-as-usual time series were calculated using random forest machine learning models trained on surface meteorological variables to account for natural weather variability. The analysis suggested that NO_2 reduced by 33 % on average while O_3 increased by 21 to 30 % depending on site type classification at the time when the reduction of population mobility was at its greatest. Despite NO_2 concentrations decreasing by approximately a third, total oxidant (NO_2 + O_3 = O_x) changed little, suggesting that the reductions of NO_2 were substituted by increases in O3. The analysis suggests that the expected reductions in NO_2 across Europe in the next decade might be accompanied by additional O_3 concentrations. Thus, management of non-traffic emission sources may be required to mitigate or avoid this likely, and undesirable situation in European urban areas.

Biography:

Stuart Grange is an air quality and data scientist from New Zealand with a particular interest in local air quality and vehicles. Stuart is currently based at Empa in Zürich, Switzerland but studied in New Zealand and the United Kingdom (the University of York) where he developed his domain-specific air quality and programming knowledge. Stuart enjoys extracting additional information from routinely collected data sets in the air quality domain (and other domains) and is a very keen runner and enjoys getting into the countryside and mountains to explore.

Professor Zongbo Shi
University of Birmingham, UK

In response to the COVID-19 crisis, governments around the world introduced severe restrictions on behavior or lockdowns, which led to the cessation of a large swathe of economic activity and thus reduced air pollutant emissions. This offers a unique opportunity to understand how air pollution levels respond to large scale "interventions". A very large number of studies reported a major improvement in air quality across the global cities. However, many of them may have overestimated the impact of lockdowns on air quality because they did not account for important confounding factors such as changes in meteorological conditions. Here, we quantitatively evaluated changes in ambient NO_2, O_3, and $PM_{2.5}$ concentrations arising from lockdown-associated emission changes in a number of global cities by applying a "deweathering" and a "detrending" technique based on machine learning algorithms. Our results show that sudden decreases in deweathered NO_2 concentrations and increases in O_3 were observed in almost all cities. However, the decline in NO_2 concentrations attributable to the lockdowns was not as large as expected, at reductions of 10 to 50%. Accordingly, O_3 increased by 2 to 30% (except for London), the total gaseous oxidant (O_x = NO_2 + O_3) showed limited change, and $PM_{2.5}$ concentrations decreased in most cities studied but increased in London and Paris. Our results demonstrate the need for a sophisticated analysis to quantify air quality impacts of interventions and indicate that true air quality improvements were notably more limited than some earlier reports or observational data suggested.

Biography:
Zongbo Shi is a professor of Atmospheric Biogeochemistry at the University of Birmingham. Zongbo did his PhD in China University of Mining and Technology (Beijing). He was awarded a JSPS fellowship in 2005 and a NERC fellowship in 2011. Since 2011, he is leading a large research group working on sources, processes and impacts of airborne particles by applying lab, field and data science techniques. Zongbo has published over 130 peer-reviewed articles. He received a number of UKRI and BEIS research grants, including a recent NERC capital grant to build two air quality supersite laboratories for UK atmospheric science community.

Professor Hartmut Boesch
University of Leicester, UK
The dramatic and sudden reduction in anthropogenic activity due to lockdown measures in the UK in response to the COVID-19 outbreak has resulted in a concerted effort to estimate local and regional changes in air quality, though changes in underlying emissions remain uncertain. Here we combine satellite observations of tropospheric NO_2 from TROPOspheric Monitoring Instrument and the Goddard Earth Observing System (GEOS)-Chem 3D chemical transport model to estimate that NO_x emissions declined nationwide by ∼20% during the first lockdown (23 March to 31 May 2020). By applying a uniform 20% lockdown period emission reduction to the GEOS-Chem anthropogenic emissions over the UK we could determine that decline in lockdown emissions led to a national decline in $PM_{2.5}$ of 1.1 $\mu g\ m^{-3}$, ranging from 0.6 $\mu g\ m^{-3}$ in Scotland to 2 $\mu g\ m^{-3}$ in the southwest. The decline in emissions in cities (>40%) is greater than the national average and causes an increase in ozone of ∼2 ppbv in London and Manchester. The change in ozone and $PM_{2.5}$ concentrations due to emission reductions alone is about half the total change from 2019 to 2020. We have extended the analysed to include subsequent lockdowns in 2021 in the UK which have shown lower reduction in traffic.

Biography:
Hartmut Boesch is a Professor in the School of Physics and Astronomy of the University of Leicester and the Head of Earth Observation Science. He is also a Divisional Director of the National Centre for Earth Observation NCEO. His research focussed on the exchange of trace gases between the surface and the atmosphere using remote sensing methods of atmospheric composition from satellites, aircraft and the ground. He is a science team member for the NASA OCO-2/-3 and the CNES/UK MicroCarb missions and a member of ESA Missions Advisory Group for the Copernicus Anthropogenic Carbon Dioxide Monitoring mission.

Dr Robin Lamboll
Imperial College London, UK
Lockdown lowered human emissions, but how much, and does it really matter in the long run? In this talk, we investigate ways to track emissions changes in real time, along with the flaws inherent in such methods and the extent to which this is useful outside of lockdown. We show how these techniques can be used to put together data for climate models by updating pre-existing emissions projections with historical emissions and basic assumptions about how to project these for the near-term future. We use this data as the basis for CovidMIP, the model intercomparison project for lockdown impacts, where we compare results from 12 earth system models to look for robust effects. We present early-term results from CovidMIP which indicate that the average long-term effects of lockdown itself on climate change are negligible on global metrics, though short-term and regional effects can be detected in aerosol optical density. This increases our confidence in pre-2020 climate projections that do not account for lockdown and emphasises the importance of systemic, long-term measures for climate change action.

Biography:
Dr Robin Lamboll is a research associate at the Center for Environmental Policy at Imperial College London, and previously worked at the Grantham Institute for Climate Change and the Environment. Dr Lamboll works on interdisciplinary open-source software, applying data science techniques to extrapolate human emissions estimates and projections, and integrated assessment models of climate impacts. Dr Lamboll has a PhD in the physics of solar cells and an MSci in Natural Sciences from the University of Cambridge.

Professor David Stevenson
University of Edinburgh, Scotland
Compared to 2019, the global growth rate of atmospheric methane rose by about 50% in 2020, reaching 15 ppb/yr. Models of global atmospheric chemistry show that reductions in nitrogen oxide (NOx) emissions reduce levels of the hydroxyl radical, and lengthen the methane lifetime. Using estimates of NOx emission reductions associated with COVID-19 lockdowns around the world in 2020, together with model-derived regional and sectoral sensitivities of methane to NOx emissions, we find that NOx emissions reductions can fully explain the observed surge in the global methane growth rate. Whilst changes in NOx emissions are probably not the only important factor that has influenced methane since the beginning of 2020, it is clear that they are a key factor that will need to be included within any attribution study, and that they may well be the dominant driver of these recent methane changes. Better constraints on the influence of NOx on methane help quantify the role of NOx emissions in the past and future evolution of methane. I will round off with some geoengineering speculation on the possible use of targetted NOx emissions to reduce global methane levels.

Biography:
David Stevenson is Professor of Atmospheric Chemistry Modelling at The University of Edinburgh. He studied Geophysics at Liverpool University, Meteorology at Reading University and has a PhD in Volcanology from The Open University. He worked for five years at the Met. Office, developing and applying global models of air pollution and climate change, before moving to Edinburgh in 1999. He uses models and measurements to help understand methane, ozone, aerosols, reactive nitrogen and hydrogen. He has contributed to reports from the Intergovernmental Panel on Climate Change and the Royal Society.

Professor Ulrich Schumann
German Aerospace Center (DLR), Germany
Contrail cirrus are aviation induced ice clouds in the upper troposphere which cause a regional warming of the Earth-atmosphere system and a local cooling of the Earth surface and globally a net radiative forcing of order 0.1 W/m^2. In contrast to long-lived greenhouse gases, the radiative forcing follows the amount of contrail cirrus without time delay. During the still ongoing COVID-19 pandemic, air traffic got strongly reduced. In April 2020, air traffic over Europe got reduced by 90 % compared to the same month in 2019. Hence, changes in contrail cirrus amounts were expected to reach observable magnitude. These changes may have caused observable changes in top-of-the atmosphere (TOA) longwave and shortwave radiative fluxes(irradiances). Here we report results of a study in which cirrus coverage and TOA irradiances were derived from geostationary satellite observations (METEOSAT-SEVIRI) and compared with model analysis based on EUROCONTROL air traffic data, aircraft emission calculations, numerical weather prediction data from ECMWF, and a contrail cirrus prediction model (CoCiP). In addition to results for a 6-month period that have been reported earlier (https://doi.org/10.1029/2021GL092771, https://doi.org/10.5194/acp-21-7429-2021) we show results covering a full-year period. In spite of strong interannual variability, aviation-induced changes in cirrus optical depth and longwave

TOA irradiances are observable and the observed changes are approximately consistent with the model predictions. Some implications will be discussed.

Biography:
Prof. Dr. Ulrich Schumann studied Mechanical Engineering in Berlin, promoted on turbulence in Karlsruhe and habilitated in Meteorology in Munich, Germany. He works on various aspects of contrail cirrus and airborne measurements, and lectures on aviation climate impact at the University Munich. He was the Director of the Institute of Atmospheric Physics of the German Aerospace Center (DLR) until mid-2012. He contributed to the IPCC report on Aviation and Climate in 1999 and got awarded, among others, with the Alfred-Wegener-Medal of the German Meteorological Society in 2001, the Aachen-Munich Prize in 2005, and the Lewis Frey Richardson Medal of the European Geosciences Union in 2007 and presented the Ludwig-Prandtl Memorial Lecture to the German Society for Applied Mathematics and Mechanics in 2021.

Dr Melanie Hammer
Washington University in St. Louis, USA
The role of fine particulate matter ($PM_{2.5}$) as the leading global environmental risk factor for mortality motivates attention to assessing the effects of COVID-19 lockdowns on ambient $PM_{2.5}$ concentrations. By combining satellite and ground-based data with model simulation, we map global $PM_{2.5}$ concentrations for January-April 2018-2020, with a focus on China, Europe, and North America. Comparison of $PM_{2.5}$ during the lockdown months in 2020 to the same time period in the previous two years (2018 and 2019) reveals interannual variability that appears to be much larger than the differences in emissions. The impact of lockdowns over Europe and North America was small, and only over northeast China, where pollution levels are typically high and the strictest lockdowns were implemented, did the decrease in particle pollution from human activity dominate interannual differences caused by natural meteorological fluctuations. Based on our observation-constrained simulations, we derive quantitative changes in population-weighted mean $PM_{2.5}$ concentrations during the lockdowns of -11 to -15 $\mu g/m^3$ across China, +1 to -2 $\mu g/m^3$ across Europe, and 0 to -2 $\mu g/m^3$ across North America. In addition to the meteorological influences, the decreases are traced to anthropogenic emission reductions, mostly due to transportation. This work demonstrates the complex relationship between emission sources and $PM_{2.5}$ concentrations and the importance of natural variability on short-term changes in $PM_{2.5}$.

Biography:
Dr Hammer completed a PhD at Dalhousie University in Nova Scotia, Canada, in 2019 and is currently a visiting research associate at Washington University in St. Louis with Dr. Randall Martin's research group. Dr Hammer uses a combination of satellite remote sensing, models, and ground measurements to investigate atmospheric aerosols and their role in air quality. Current research is focused on using satellite remote sensing observations combined with chemical transport modelling and ground-measurements to provide high-quality, spatially complete estimates of surface fine particulate matter.

Dr Susan Anenberg

George Washington University, USA

Lockdowns related to the COVID-19 pandemic produced unparalleled changes in human activity and passenger vehicle traffic specifically. However, air quality changes were variable across cities. We explored factors driving changes in traffic-related air pollution in cities across the U.S. to understand the role of meteorology versus anthropogenic emissions in controlling urban nitrogen dioxide (NO_2) levels. We then leveraged this natural experiment and the unmatched spatial resolution of TROPOspheric Monitoring Instrument (TROPOMI) satellite measurements to explore contributions of passenger vehicle traffic to NO_2 disparities across US neighborhoods. We found that inequity in NO_2 exposure persists even despite the success of air quality regulations in bringing down emissions, that the current generation of satellite instruments is capable of monitoring these NO_2 disparities, and that future strategies to reduce NO_2 disparities will need to target emissions from heavy-duty vehicles.

Biography:

Susan Anenberg is an Associate Professor of Environmental and Occupational Health and of Global Health at the George Washington University Milken Institute School of Public Health. Dr Anenberg studies the health implications of air pollution and climate change, from local to global scales. Dr Anenberg has been a Co-Founder and Partner at Environmental Health Analytics, LLC, the Deputy Managing Director for Recommendations at the U.S. Chemical Safety Board, an environmental scientist at the U.S. Environmental Protection Agency, and a senior advisor for clean cookstove initiatives at the U.S. State Department.