CMAS Conference 2020

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https://www.cmascenter.org/conference/2020/index.cfm

Session Presentations

1. Air Quality, Climate and Energy (10/28)

2020-10-28

Sadia Afrin
Presentation: 2476
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS presentation slides 2020_Sadia Afrin.pdf*

Afrin: The air quality trade-offs of wildfire and prescribed burning

Sadia Afrin, Fernando Garcia-Menendez, Shannon Koplitz, Kirk Baker

Wildland fires, including both wildfires and prescribed burns, are the largest source of fine particulate matter ($PM_{2.5}$) emissions in the U.S. While wildfires are unplanned, prescribed burns are a controlled application of fire to accomplish land management objectives, such as wildfire hazard mitigation and ecological restoration. However, the degree to which prescribed fire may also mitigate the severe air quality impacts of wildfires is not well understood. Here, we examine the trade-offs between the air quality impacts of prescribed burning and the avoided air pollution from wildfire using comprehensive regional-scale chemical transport modeling. We simulate the impact of two 2016 wildfires in western North Carolina, the Party Rock and Chestnut Knob fires. We use wildfire emissions generated with the SmartFire-BlueSky Pipeline emissions modeling framework. We also create prescribed fire emission profiles based on existing fuel beds at the Chimney Rock and South Mountain State Parks, where the wildfires occurred, and estimate their consumption of different vegetative fuels. Based on the fuel loads subsequent to prescribed fire, we simulate the emissions and smoke impacts of hypothetical wildfires

that would have occurred at the State Parks if prescribed fire treatment had been previously applied to the area burned. We find that the avoided air quality impacts of wildfires are higher than the added impacts of all prescribed fires needed to treat the wildfire area. A smaller population is affected by increased $PM_{2.5}$ concentrations from prescribed fires compared to the that benefiting from the avoided exposure to wildfire air pollution. The approach and findings presented can support decision-making, and the use of efficient land management approaches.

Yusuf Alizade Govarchin Ghale
Presentation: 2538
Presentation *https://www.cmascenter.org/conference/2020/slides/YusufetaI_CMAS_2538.pdf*

Ghale: Impacts of drying up of Urmia Lake, the second largest hypersaline lake in the world, on particulate matter concentration in the northwestern Iran

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Urmia Lake, the largest lake in the Middle East lost most of its water surface area over the past 20 years. The maximum water surface area of the lake was observed (i.e., 6000 km2) in the 1990s, while more than 90% of this area was lost in 2015. Salinization and desertification caused by the drying up of the lake has led to dust storms from the lake bed, which have negative impacts on the environment. In this study, ground-level PM10 data of Urmia station, the closest air quality station to the lake located in the northwestern Iran and MODIS derived AOD data observed between 2010 and 2017 were analyzed to investigate the effects of Urmia Lake desiccation on the aerosol pollution. In total, 129 days with daily mean AOD values more than 1 were observed in the study area, which indicated the severity of air pollution and dust emission from the dried bottom of the lake. Statistical methods such as Multiple Linear Regression (MLR) and Linear Mixed Effect (LME) models were applied on AODs and meteorological data to predict ground-level PM10 variations in Urmia station. The results indicated that LME model with R2 vale of 0.95 performed better than MLR model. The RMSE and AME values of LME were estimated about 23.22 µg/m3 and 16.59 µg/m3, respectively. Based on the results of this study regional dust storms and other air pollution factors originating from other countries such as Iraq affect the air quality of the northwestern Iran too. The regional and international cooperation is necessary to have a better environmental management and sustainable development in the region.

Calvin Arter
Presentation: 2513
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS_2020_Calvin_Arter.pdf*

Arter: On-road Sector Emissions Impact on $PM_{2.5}$ and O3 - related Health Risks in the Northeast and Mid-Atlantic U.S.

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On-road vehicular emissions contribute to the formation of fine particulate matter and ozone which can lead to increased adverse health outcomes near the emission source and downwind. In this study, we

present a transportation-specific modelling platform utilizing CMAQ-DDM to estimate the impact of on-road vehicular emissions from five vehicles classes; light-duty autos, light-duty trucks, medium-duty trucks, heavy-duty trucks, and buses, on $PM_{2.5}$ and O3 concentrations at a 12x12 kilometer scale for twelve states and Washington D.C. as well as four large metropolitan statistical areas in the Northeast U.S. in 2016. CMAQ-DDM allows for the tracking of contributions from on-road vehicular emission changes in each state to pollution levels and health effects in downwind states. In the region we considered, light-duty trucks were responsible for the most $PM_{2.5}$ -attributable premature mortalities at 1,234 with 46% and 26% of those mortalities from directly emitted particulate matter and ammonia, respectively; and O3 - attributable premature mortalities at 1,129 with 80% of those mortalities from NOX emissions. We also found the individual impacts of each vehicle class and source region on each state in the region to construct a full source-receptor matrix of on-road vehicular impacts. We then monetized the total damages by summing premature mortalities from both $PM_{2.5}$ and O3 to determine the largest damages-per-ton estimates from each vehicle class, precursor, and source region. The largest damages-per-ton estimate is approximately $4 million per ton of directly emitted primary particulate matter in the New York-Newark-Jersey City MSA from buses in the New York-Newark-Jersey City MSA. By quantifying the impacts at a source region, vehicle class, and precursor-specific level; this study allows for a comprehensive understanding of the largest vehicular sources of air quality-related premature mortalities in a heavily populated part of the U.S. and can inform policies aimed at reducing those impacts.

Daniel Cohan
Presentation: 2445
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS-Texas-wind-solar-coal-cohan-2020.pdf*

Cohan: Air quality benefits of replacing coal with wind and solar in Texas

Daniel S. Cohan, Ricky Morse, Sarah Salvatore, and Joanna H. Slusarewicz

The United States is undergoing a rapid shift away from coal for the generation of electricity. Since 2006, the market share of coal has fallen by more than half, while wind and solar have grown tenfold. Texas provides a crucial microcosm of these trends. Texas power plants consume more coal and natural gas and emit more carbon dioxide than those in any other state. However, Texas also generates more wind power than any other state and has a rapidly growing solar industry. Previous work by our research group has shown that wind and solar power are generated at complementary times, with West Texas winds blowing most strongly at night, South Texas sea breezes peaking on summer afternoons, and solar power peaking midday. By taking advantage of this complementarity, solar and wind farms can produce power more reliably, making them better able to replace the output of coal or natural gas plants. However, we have not previously examined the extent to which the electricity from existing coal plants could be replaced by new wind and solar power.

Here, we compute the half-hourly power generation that could be produced by each wind and solar farm in the ERCOT interconnection queue. We use NREL's System Advisor Model to model the output of proposed wind and solar farms based on weather data for the years 2009-2011. We then explore the extent to which recent coal generation in ERCOT could be replaced with power from those proposed facilities. Through optimization modeling, we identify combinations of wind and solar sites that are best suited to displacing various percentages of the power load currently provided by coal. Annualized costs of the wind and solar farms are compared to the direct and societal costs of continuing to operate the

coal plants. Air pollution and health impacts of the coal power plants are computed by linking results from the CAMx photochemical model with the BenMAP health effects model, as well as by applying reduced form models. We find that over 95% of coal generation can be directly replaced by wind and solar power, even without the use of storage, at a small fraction of the annual costs of coal.

Paelina DeStephano
Presentation: 2449
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS_DeStephano_10142020.pdf*

DeStephano: A method for identifying challenges to air quality management and developing robust management strategies

Paelina DeStephano1, Steven J. Smith2, Christopher G. Nolte3, and Daniel H. Loughlin3 1 ORISE research participant, U.S. EPA 2 Pacific Northwest National Laboratory 3 U.S. EPA Office of Research and Development

In the U.S., more than 130 million people live in areas that do not meet the National Ambient Air Quality Standards. State environmental agencies face the challenge of determining how to achieve these standards and maintain good air quality into the future while simultaneously working to meet greenhouse gas reduction targets and ensure reliable and affordable energy. Identifying strategies for meeting air, climate, and energy goals over the long term is difficult given the uncertainties inherent in the future.

Predictive modeling generally extrapolates from current trends; however, as modelers look farther in the future, these trends are less certain. Challenges may arise from new and emerging sources of emissions or increasing demands for energy that are driven by population growth, economic transformation, and a changing climate. Consumer behaviors and attitudes can also result in challenges, particularly if trends of increasing house size, vehicle mass, and commute distances continue.

In this project, we are using a human-earth systems model, GCAM-USA. We will be conducting a combinatorial analysis, examining combinations of different assumptions about population, economic transformation, climate impacts, consumer behavior, and technology change. These results of hundreds of GCAM-USA runs will then be examined, identifying which combinations of assumptions result in challenges to air, climate, and energy goals.

In a second phase of the project, we will repeat the initial analysis with combinations of policies that have been identified by stakeholders at state agencies. These include a range of policies directed at transportation, renewable energy, and energy efficiency. Evaluating these policies across a large set of scenarios will provide insights regarding their relative efficacy over wide-ranging conditions. This information can help state agencies refine policies in the face of emerging trends and develop policies that are robust to an array of future scenarios.

This presentation will detail the methodology outlined above, discuss lessons learned through stakeholder interactions, and provide preliminary results from model runs exploring a subset of the scenario dimensions.

Timothy Glotfelty
Presentation: 2505
Presentation
https://www.cmascenter.org/conference/2020/slides/CMAS_2020_Presentation_Timothy_Glotfelty.pdf

Glotfelty: Representing the Impact of Residential Energy Choice and Land Use Change on Future Air Quality and Climate: A Case Study of Sub-Saharan Africa

Timothy Glotfelty, Diana Ramírez-Mejía, Jared Bowden, Adrian Ghilardi, Ashley Bittner, Andrew Grieshop, Robert Bailis, Pamela Jagger, and J. Jason West

The climate and air quality of Sub-Saharan Africa is of significant interest in part because of the tight coupling between human activity, ecosystem dynamics, and atmospheric processes in this region, as use of biomass for residential energy and land use change (LUC) can influence regional climate and air quality. Here we present how we generate current emissions inventories for Sub-Saharan African residential energy use, future emission scenarios reflecting shifts to cleaner residential energy choices, and a methodology to adequately reflect the impact of LUC on both air quality and climate. We plan to use these emissions and LUC estimates to drive online coupled Weather Research and Forecasting Model with Chemistry (WRF-Chem) simulations that quantify how LUC and emissions have impacted the current air quality and climate of Sub-Saharan Africa (2001-2017), and the impacts of future emissions and LUC to 2040. We develop a business as usual scenario and two policy intervention scenarios for Sub-Saharan Africa in which residential biomass energy is phased out and replaced with either liquefied petroleum gas (LPG) or electricity.

To determine the impact of LUC, we utilize the Dinamica EGO model framework to generate future LUC projections by building probabilistic relationships between the observed LUC in the MODIS MCD12Q1 product spanning the period 2001-2007 and other static land surface properties. To validate simulations we compare simulated LUC projections for the period 2008-2012 to observed LUC for the same period. The validated model is then used to simulate the LUC for our full retrospective period of 2001-2017, and in future scenarios to 2040. To simulate the impact of LUC on biogenic volatile organic compounds and dust, a relationship is derived between monthly leaf area index and annual soil erodability, and the MODIS land use categories. These relationships are used in turn to reclassify LUC simulations (2001-2040) into LAI and soil erodability values.

Current residential emissions are derived following a similar methodology as the Diffuse and Inefficient Combustion Emissions in Africa (DICE-Africa) inventory, with other emissions sectors provided by the historical Shared Socioeconomic Pathway (SSP) gridded emissions inventory. The DICE-Africa inventory is used for residential sector emissions as it accounts for many different Sub-Saharan African fuel types and processes overlooked in traditional global inventories. To generate future emissions projections, current trends in energy usage from the DICE-Africa dataset are projected to 2040. To fully harmonize our DICE-Africa projection with future SSP emissions, we utilize the Global Change Analysis Model (GCAM) and constrain residential energy use following our business as usual, LPG-centric, and electricity-centric future scenarios under conditions representative of the SSP3 scenario. We present the methodologies used to generate these datasets and comparisons with other available emissions and land use datasets.

Fanqi Jia
Presentation: 2458
Presentation *https://www.cmascenter.org/conference/2020/slides/Jia_CMAS2020.pdf*

Jia: The role of non-traditional control measures in cost-effectively meeting state emission reduction targets

Fanqi Jia, Steven J. Smith, Alexander Macpherson, David Bielen, Christopher G. Nolte, Daniel H. Loughlin

Nitrogen oxides (NOx) are a precursor of troposphere ozone (O3), which is harmful to public health and the environment. Many areas in the U.S. experience unhealthy concentrations of O3, and reducing NOx emissions is a strategy that is being taken to reduce O3 formation. Measures for reducing NOx can be categorized as "traditional", including end-of-pipe control devices and changes to fuel combustion, or "non-traditional", such as switching to low- or zero-emitting fuels and improving energy efficiency. Historically, air quality management has focused on traditional measures, but it is possible that non-traditional measures may be advantageous, particularly since these measures can reduce greenhouse gases as well as demands for water. Energy system and integrated assessment models provide frameworks for evaluating the relative cost-effectiveness of traditional and non-traditional controls and can identify strategies that combine these options to achieve emission reduction targets at least cost. Here we use the GCAM-USA human-earth system model to determine state-level control strategies for achieving various levels of NOx reduction. We then demonstrate how the resulting state-specific marginal abatement cost curves (MACCs) provide insights into emission reduction opportunities at the sectoral and technology level and how traditional and non-traditional controls be can used together to meet emission abatement targets most cost-effectively. An advantage of our method is that it quantifies the cost-effectiveness of nontraditional controls, such as the dollar-per-ton of NOx reduction associated with end-use energy efficiency measures. We examine the results for several states, comparing the model-derived control strategies for each.

Jia Jung
Presentation: 2487
Presentation *https://www.cmascenter.org/conference/2020/slides/Jia-Jung_2020_CMAS.pdf*

Jung: Role of sea fog over the Yellow Sea on air quality with the direct effect of aerosols

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To investigate the impact of sea fog over the Yellow Sea on air quality with the direct effect of aerosols, we performed four model simulations with the WRF-CMAQ two-way coupled model, in conjunction with the up-to-date emission inventory over East Asia and dynamic chemical boundary conditions provided by hemispheric model simulations. During the spring of 2016, prevailing westerly winds and anticyclones caused the formation of a temperature inversion over the Yellow Sea, providing favorable conditions for the formation of fog. The inclusion of the direct effect of aerosols enhanced its strength. On foggy days, we find dominant changes of aerosols at an altitude of 150-200 m over the Yellow Sea resulted from the production through aqueous chemistry (~12.36% and ~3.08% increases in sulfate and ammonium) and loss via the wet deposition process (~-2.94% decrease in nitrate); we also find stronger wet deposition of all species occurring in the PBL. Stagnant conditions associated with reduced air temperature caused by the direct effect of aerosols enhanced aerosol chemistry, especially in coastal regions, and it exceeded the loss of nitrate. The transport of air pollutants affected by sea fog extended to a much broader region. Our findings show that the Yellow Sea acts as not only a path of long-range transport but also as a sink and source of air pollutants. Further study should investigate changes in the impact of sea fog on air quality in conjunction with changes in the concentrations of aerosols and the climate.

Surendra Kunwar
Presentation: 2539
Presentation
https://www.cmascenter.org/conference/2020/slides/CMAS2020virtual_presentation_17oct2020_Surendra_final.pdf

Kunwar: Studying the influence of climate change and variability on mid-21st century $PM_{2.5}$ by dynamical downscaling

Surendra B. Kunwar, Jared H. Bowden, George Milly, Michael Previdi, Arlene M. Fiore, J. Jason West

Anthropogenic climate change and associated natural feedback emissions like biogenic VOCs and wildfires can potentially affect air quality in the coming decades, but the noise of climate variability can obscure the climate change signal. Here we aim to quantify the impacts of climate change and variability on US $PM_{2.5}$ levels at fine spatial resolution by statistically combining probability distributions from multi-year global model ensembles with dynamical downscaling over the continental US. Our approach uses a 3-member ensemble of GFDL-CM3 global chemistry-climate model simulations that vary only in initial conditions for the period 2006-2100 under the RCP8.5 scenario, but with aerosol and O3 precursor emissions fixed at 2005 levels to isolate the impact of climate change on air quality. Empirical Orthogonal Function (EOF) analysis of the simulations has identified eastern US regions that vary coherently in $PM_{2.5}$, and in each of those regions, we select four present (2006-2020) and four future (2050-2060) years that are representative of high and medium annual mean $PM_{2.5}$ levels. We then dynamically downscale the GFDL-CM3 meteorology and air quality of the selected eight years to 12-km with the regional models WRF and CMAQ. The 3-member GFDL-CM3 model simulations (2o spatial resolution) from 2006 to 2060 provide a broader context for the downscaled CMAQ air quality simulations, and an additional global climate model with interactive aerosols, NCAR CESM, has a 12 ensemble member simulation (1o spatial resolution) with aerosols held at 2005 levels for the same future scenario as the GFDL model provides more context and statistics. Using $PM_{2.5}$ probability distributions from the coarse global models, we construct fine scale mean annual $PM_{2.5}$ probability distributions in individual 12 km grid cells of the downscaled CMAQ simulations for the present and future. By examining the differences in fine scale mean annual $PM_{2.5}$ distributions between the present and the future, we quantify the effects of climate change and climate variability on $PM_{2.5}$ and also on related human mortality.

Dan Loughlin
Presentation: 2484
Presentation *https://www.cmascenter.org/conference/2020/slides/Loughlin_GLIMPSE_CMAS2020.pdf*

Loughlin: The GLIMPSE Project: A decision support tool for air quality management

Dan Loughlin, Chris Nolte, Carol Lenox, Tai Wu, Andrew Kreider, and Shutsu Wong (USEPA); Samaneh Babaee, Paelina DeStephano, Fanqi Jia, and Sarah Simm (ORISE/ORAU); Steve Smith, Yang Ou, and Maridee Weber (PNNL)

The U.S. EPA is developing a decision support tool for air quality management called GLIMPSE, an acronym for GCAM Long-term Interactive Multi-Pollutant Scenario Evaluator. GLIMPSE is built upon the Global Change Analysis Model (GCAM), an open source human-earth system model whose development is led by Pacific Northwest National Laboratory. GCAM includes representations of the energy, water, agriculture, land use, and climate systems, simulating their co-evolution through 2100. The model has a relatively high level of technological detail within the energy system, including the electric sector, industry, buildings, and onroad and nonroad transportation. Technologies compete

against each other for market share based on their relative costs and other factors. Emissions associated with the resulting technological pathway are reported.

GLIMPSE works with GCAM and with a variant of GCAM with state-level resolution (GCAM-USA). GCAM-USA includes representations of major national environmental and energy policies, including the Cross-State Air Pollution Rule, the Corporate Average Fuel Economy standards, New Source Performance Standards for air pollutants, and the Tier 3 engine and fuel emission standards. It also includes many state and regional policies, including the Regional Greenhouse Gas Initiative and Zero Emission Vehicle targets.

From an air quality planning perspective, GLIMPSE has a number of potential uses. For example, GLIMPSE can estimate emissions for specific scenarios. For example, one could examine future air pollutant and greenhouse gas (GHG) emissions under baseline assumptions as well as alternative assumptions about population growth, economic growth, technology change, and climate change.

With its state-level resolution and coverage of both air pollutants and greenhouse gas emissions, GLIMPSE also provides states with a tool for helping develop and evaluate policy options. For example, if states have identified specific policy measures, such as specifying energy efficiency and renewable energy targets, GLIMPSE can be used to quantify the resulting impacts on emissions. GLIMPSE also supports an optimization capability. Emission reduction targets can be specified by the user, then GLIMPSE automates the selection of control measures for meeting those targets at low cost.

In this presentation, we will discuss the capabilities, computational and user requirements, applications to date, and plans for making GLIMPSE available with training in 2021.

Michael MacKinnon
Presentation: 2469
Presentation *https://www.cmascenter.org/conference/2020/slides/MacKinnon_CMAS_Final-2020.pdf*

MacKinnon: Assessment of the Air Quality and Health Impacts of Fuel Cell Electrification of Port Activities at a Major Port Complex

Dr. Michael Mac Kinnon, Dr. Shupeng Zhu, Andre Paradise, Dr. Donald Dabdub, Dr. Scott Samuelsen

Communities located adjacent to goods movement hubs (such as major ports) experience degraded air quality (AQ) as a result of emissions from on-road and off-road diesel equipment including heavy-duty diesel trucks (HDDT), cargo and materials handling equipment (CHE), ships, and rail technologies. In response, California is pursuing transitions to more efficient and cleaner freight systems by introducing zero-emission technologies as the alternative to conventional technologies. Equipment and vehicles powered by hydrogen fuel cells represent a potential zero-emissions pathway for freight technologies at ports, including HDDT, CHE, ships, and rail applications, referred to collectively as fuel cell electric technologies (FCET). This work assesses the AQ and human health impacts of deploying FCET to provide goods movement services at California ports. A specific focus is given to the South Coast Air Basin due to existing AQ challenges and the presence of significant activity from the San Pedro Bay Port Complex which includes the Ports of LA and Long Beach. Sets of future vehicle and equipment scenarios are developed spanning a range of potential FCET penetrations and assessed to quantify how FCET provides improvements in primary and secondary pollutant concentrations and the corresponding value of human health benefits. Additionally, reductions in greenhouse gas (GHG) emissions are assessed accounting for the transition from diesel fuel-powered combustion vehicles to hydrogen fuel cell-

powered vehicles. We find that the use of FCET could offer significant reductions in ground level ozone (-2 to -5 ppb) and $PM_{2.5}$ in both summer (-0.59 to -02.57 µg/m3) and winter (-0.99 to -2.26 µg/m3) depending on the level of deployment. Additionally, these reductions occur in locations of the SoCAB where they are most needed including areas experiencing the highest background levels and in communities unfairly burdened by pollution. When AQ improvements are translated into avoided human health effects occurring across the SoCAB population, health savings are significant and potentially reach $3.2 to $7.2 million per day during peak pollutant formation periods. The results emphasize the importance of addressing the AQ impacts of port activities via the replacement of current diesel equipment with zero emission equipment.

Megan Mallard
Presentation: 2485
Presentation *https://www.cmascenter.org/conference/2020/slides/mallard-cmas_final-2020.pdf*

Mallard: Dynamically Downscaled Projections of Phenological Changes across the Contiguous United States

Megan S. Mallard, Kevin Talgo, Jared Bowden, and Tanya L. Spero

Phenological indicators (PI), used to study the timing of plant and animal cycles in response to seasonal changes, can also be useful metrics to analyze the impact of climate change on agricultural systems and ecosystem services. Here, projected changes to the wintertime dormancy in plants (assessed using Chilling Units, or "CU"), onset of spring (expressed using the Extended Spring Index), and the frequency of hard freezes after spring onset (false springs) are examined within a regional climate modeling application using the Weather Research and Forecasting (WRF) model to downscale two global climate models to 36-km grid spacing. Over the contiguous U.S. (CONUS), a historical (1995-2005) and future period (2025-2100) are simulated under Representative Concentration Pathways 4.5 and 8.5. Consistent with prior studies, spring onset is projected to occur earlier, with CONUS-average changes ranging between 12 to 36 days by the end of the century. False springs are projected to become more frequent in the complex terrain of the western CONUS while decreasing in frequency in regions of the eastern U.S. CU are found to decrease in the southern CONUS, which would negatively impact the productivity of deciduous fruit trees and other plants the following growing season, while portions of the western and northern CONUS experience increased CU. However, regional errors over the historical period in some of the PI used here exceed their projected end-of-century changes, indicating the need for improving simulated 2-m temperatures and the frequency with which they exceed certain thresholds that heavily influence these PI.

Daniel Schuch
Presentation: 2540
Presentation *https://www.cmascenter.org/conference/2020/slides/Schuch-CMAS-2020.pdf*

Schuch: Responses of ozone to changes to emissions under the Representative Concentration Pathway 4.5 scenario over Brazil

Daniel Schuch, Yang Zhang, Maria de Fatima Andrade, Edmilson Dias de Freitas and Michelle L. Bell

In this work, the Weather Research and Forecasting Model with Chemistry is applied to simulate air quality over Brazil for a short time period under three future emission scenarios, including current legislation (CLE), mitigation scenario (MIT), and maximum feasible reduction (MFR) under the Representative Concentration Pathway 4.5 (RCP4.5). The main objective is to determine the sensitivity

of the concentrations of ozone (O3) to changes in emissions under these emission scenarios and to determine the temporal tendency for different scenarios and Brazilian regions.

Ana Paula Stein Santos
Presentation: 2496
Presentation *https://www.cmascenter.org/conference/2020/slides/role-of-mussel-culture-in-CH4-and-CO2-emission-cmas2020.pdf*
Extended Abstract *https://www.cmascenter.org/conference/2020/abstracts/Extended-abstract_mussel-culture-in-CH4-and-CO2-emission-2020-santos.pdf*

Stein Santos: The role of mussel culture in CO2 and CH4 emissions

Ana Paula Stein Santos, Marcelo Gomes da Silva, Danilo Francisco Trovo Garofalo, Viviane Cristina Bettanin, Katia Naomi Kuroshima, Gilberto Caetano Manzoni, Ana Paula Packer, Leonardo Hoinaski, Davide Franco

This study evaluates the mussel production influence on the coastal emission of CO2 and CH4 in Southern Brazil. Our study area was Armação do Itapocoroy inlet, municipality of Penha, Santa Catarina state, Brazil. In southern Brazil the most important mariculture takes place. This activity could contribute to organic matter inputs and consequently to the production of GHG. However, ocean and coastal emissions have never been quantified in Brazil. We collect samples between October 02 and 04 2018 inside the mussel farm (Perna Perna) and in control sites (without mariculture activity). GHG fluxes were obtained by the static chamber sampling and analyzed through gas chromatography. Physical-chemical parameters (salinity, temperature, turbidity, pH, Eh, conductivity, dissolved oxygen-DO, suspended particulate matter, and total dissolved solids-TDS) was carried out in situ. Concentrations of chlorophyll-a, total organic phosphorus (TOP), nutrients (PO3-, SO42-, NO2-, NO3-, NH4+, SiO4-4), and metals were also measured. CO2 flows varied between -81.8 and 76.1 mg C-CO2 m-2 d-1, while the CH4 flows ranged from -0.2 to 2.5 mg C-CH4 m-2 d-1. For CO2, the first and last days performed positive fluxes to the atmosphere. The second day of sampling presented negative flux (-2.2 mgC-CO2m-2d-1), suggesting carbon sequestration. Carbon sequestration also occurred in control and mussel farm sites. CH4 fluxes are only positives and have shown significative higher concentrations in control sites, suggesting that mussel culture did not influence on methane emissions. CO2 flux showed a low positive correlation with TSD (r = 0,16) and Salinity (r = 0,15). CH4, showed low positive correlations with Turbidity (r = 0,25), Dissolved Oxygen (r = 0,29) and Nitrate (r = 0,25). Our preliminary results reveal that mussels farming in the sampling site do not influence positively on the CO2 and CH4 emissions.

2. COVID-19 and Impacts on Emissions and Air Quality (10/29)

2020-10-29

Saravanan Arunachalam
Presentation: 2557
Presentation
https://www.cmascenter.org/conference/2020/slides/Arunachalam_COVID19_CMAS2020.FINAL.pdf

Arunachalam: Impact of COVID-19 related shutdown on onroad and aircraft transportation emissions and their impacts on O3 and $PM_{2.5}$ in the U.S. using Sensitivity Modeling Techniques

Saravanan Arunachalam, Calvin Arter and Gavendra Pandey
Institute for the Environment, University of North Carolina at Chapel Hill

During the peak of the pandemic, 3.6 billion humans went into hiding globally. This led to drastic reductions in economic activity, specifically related to fossil fuel combustion focused on the transportation sector. Daily global CO2 emissions decreased by 17% by April compared to 2019 levels, with onroad transportation sector seeing a 50% decrease and the aviation sector seeing a 75% decrease. Within the U.S., these reductions vary by state and based on when social distancing measures were put in place. In the onroad emissions sector, while passenger vehicle activity reduced a lot due to large segment of the society working from home, vehicular activity due to freight did not see as much of a reduction. In fact, in some urban areas of the U.S., freight activity actually saw a modest increase compared to pre-pandemic period. Overall, weekly reductions in onroad activity during the pandemic was as high as 48% nationally, with individual states ranging from 35% (Arkansas) to 63% (New Jersey) during specific weeks. Similarly, U.S. wide aviation operations saw steep declines as well (> 70%), with some of the largest airports like Atlanta Hartsfield and New York John F. Kennedy seeing reductions of > 75 – 80% compared to pre-pandemic period. With such large scale reductions in transportation – related activity and their associated emissions, we find motivation to assess the impacts of these on ambient air quality and potential gains in public health due to reduced air pollution exposures. We use CMAQ instrumented with the Decoupled Direct Method (DDM) to compute sensitivities of predicted O3 and $PM_{2.5}$ from individual states and airports to three input variables – light duty vehicles, heavy duty vehicles and aircraft operations. We will show illustrative results from select states and airports to show how O3 and $PM_{2.5}$ and associated health risk changed due to reduced activity from the transportation sector. We also use information from this forced natural experiment to assess the ability of the model to capture such changes compared to observations.

Shannon Capps
Presentation: 2440
Presentation *https://www.cmascenter.org/conference/2020/slides/Capps2020CMAS.pdf*

Capps: Evaluating Correspondence of Changes in Indicators of Driving Behavior and TROPOMI Tropospheric Nitrogen Dioxide Column Density during COVID-19 in US Cities

Scott Natter, Drexel University, Computer Science, Philadelphia, Pennsylvania, USA
Shannon Capps, Drexel University, Civil, Architectural, and Environmental Engineering, Philadelphia, Pennsylvania, USA

In this study, we evaluate how tropospheric nitrogen dioxide (NO$$_2$$) column number densities, as reported by TROPOMI, have changed as a result of COVID-19 responses and policies. We use high temporal and spatial resolution data indicative of human behavior including mobility and driving direction requests as representative of the transportation sector, which contributes more than 50% of emissions of oxides of nitrogen. Specifically, we analyze how these representative values vary with NO$$_2$$ column density changes over the pre-pandemic and pandemic period. As we are analyzing the reduction in passenger vehicle emissions, the geographic foci are urban Combined Statistical Areas where traffic is typically more dense. Policy indicators such as stay-at-home orders are also considered. Though meteorology also plays a role in NO$$_2$$ column densities, clear correspondence between indicators of driving behavior and this pollutant are identified in select cities.

Daniel Goldberg
Presentation: 2498
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS-slides-Goldberg-102920.pdf*

Goldberg: Disentangling the impact of the COVID-19 lockdowns on urban NO2 from natural variability

Daniel Goldberg, Susan Anenberg, Gaige Kerr, Debora Griffin, Chris McLinden, Zifeng Lu, David Streets

TROPOMI satellite data show substantial drops in nitrogen dioxide (NO2) during COVID-19 physical distancing. To attribute NO2 changes to NOX emissions changes over short timescales, one must account for meteorology. We find that meteorological patterns were especially favorable for low NO2 in much of the U.S. in spring 2020, complicating comparisons with spring 2019. Meteorological variations between years can cause column NO2 differences of ~15% over monthly timescales. After accounting for sun angle and meteorological considerations, we calculate that NO2 drops ranged between 9.2 – 43.4% among twenty cities in North America during spring 2020, with a median of 21.6%. Of the studied cities, largest NO2 drops (>30%) were in San Jose, Los Angeles, and Toronto, and smallest drops (<12%) were in Miami, Minneapolis, and Dallas. These normalized NO2 changes can be used to highlight locations with greater activity changes and better understand the sources contributing to adverse air quality in each city.

Marc Guevara Vilardell
Presentation: 2438
Presentation
https://www.cmascenter.org/conference/2020/slides/20201010_CMAS_MGuevara_Emissions_COVID19.pdf

Guevara: Time-resolved emission reductions for atmospheric chemistry modelling in Europe during the COVID-19 lockdowns

Marc Guevara1, Oriol Jorba1, Albert Soret1, Hervé Petetin1, Dene Bowdalo1, Kim Serradell1, Carles Tena1, Hugo Denier van der Gon2, Jeroen Kuenen2, Vincent-Henri Peuch3, and Carlos Pérez García-Pando1,4
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To control the spread of the COVID-19 disease, European governments implemented emergency measures going from light social distancing to strict lockdowns, depending on the country. As a consequence, many industries, businesses and transport networks were forced to either close down or drastically reduce their activity, which resulted in an unprecedented drop of anthropogenic emissions. This work presents the Copernicus Atmosphere Monitoring Service (CAMS) European regional emission reduction factors associated to the COVID-19 lockdowns (CAMS-REG_ERF-COVID19), an open source dataset of daily-, sector- and country-dependent emission reduction factors for Europe linked to the COVID-19 restrictions. The resulting dataset covers a total of six emission sectors, including: road transport, energy industry, manufacturing industry, residential and commercial combustion, aviation and shipping. The time period covered by the dataset starts from 21 February, when the first European localised lockdown was implemented in the region of Lombardy (Italy), and is updated on a regular basis to provide the most recent information. The CAMS-REG_ERF-COVID19 dataset is based on a wide range of information sources and approaches, including open access and measured activity data and meteorological data, as well as the use of machine learning techniques. We combine the computed emission reduction factors with the Copernicus CAMS European gridded emission inventory to spatially and temporally quantify reductions in emissions from both criteria pollutants and greenhouse gases, as

well as to assess the contribution of each pollutant sector and country to the overall reductions. The resulting gridded and time-resolved emission reductions are used to perform an air quality modelling study to evaluate its potential on reproducing observed air pollutant concentration changes in selected regions across Europe. Clear improvements of the modelled results are found when considering the emission reduction factors.

Cesunica Ivey
Presentation: 2502
Presentation *https://www.cmascenter.org/conference/2020/slides/Ivey_COVID_Impacts-2020.pdf*

Ivey: Traffic, Precursor Emissions, and Ozone in the South Coast Air Basin During California's COVID-19 Shutdown

Cesunica E. Ivey1,2, Ziqi Gao3, Shams Tanvir2, Khanh Do1,2, Arash Kashfi Yeganeh1,2, Matt Barth2, Armistead Russell3, Charles L. Blanchard4, Sang-Mi Lee5 Department of Chemical and Environmental Engineering, University of California, Riverside, Riverside, CACenter for Environmental Research and Technology, Riverside, CA Department of Civil and Environmental Engineering, Georgia Institute of Technology, Atlanta, GA Envair, Albany, CA South Coast Air Quality Management District, Diamond Bar, CA

In the spring of 2020, unprecedented shifts in human activity in response to the COVID-19 pandemic led to observable changes in the natural environment, specifically air pollutant concentrations. In Spring of 2020, the South Coast Air Basin of California (USA) experienced noticeable declines in on-road activity and primary traffic-related pollutant emissions. However, secondary ozone concentration trends were not consistent across the basin. The upwind site in Pasadena, CA experienced overall increases in maximum daily 8-hour ozone (MDA8) during the shutdown, whereas the downwind site in Crestline, CA experienced an overall decrease in MDA8. Typically, the highest MDA8 concentrations are observed at locations downwind of the Los Angeles city center, indicating a shift in the spatial peak of ozone production due to major decreases in precursor emissions during the COVID-19 shutdown. Higher temperatures in late April led to higher than average MDA8 concentrations in both locations. Further, by aggregating traffic-related emissions at census tract level, we related air quality to local transportation emissions and disproportionate impacts on environmental justice communities. The COVID-19 shutdown provided a preview of the potential impacts of large-scale emissions reductions on ozone formation in the South Coast Air Basin.

Daiwen Kang
Presentation: 2499
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS2020_Kang.pdf*

Kang: Air Quality Changes under COVID-19 Social Distancing in the United States: Observational Analysis and Modeling Sensitivity Study

Daiwen Kang, Christian Hogrefe, Rohit Mathur, Benjamin Murphy, Vlad Isakov, George Pouliot, Robert Gilliam, Fahim Sidi, and Tanya Spero

The rapid spread of coronavirus disease 2019 (COVID-19), declared as a pandemic by the World Health Organization (WHO), prompted the national and local governments around the world to take unprecedented measures to restrict human activity such as lockdowns, social distancing, and strict travel bans. The dramatic and varying scales of responses to COVID-19 offer a rare opportunity to assess the impacts of real-world reductions in emissions on local, regional and global air quality and to investigate the relative contributions of different source sector emission perturbations. In this study,

fine particulate matter ($PM_{2.5}$) and ozone (O3) measured from U.S. EPA's AIRNOW network before and after the start of social distancing are analyzed to assess the change in air quality during the period of social distancing. The temporal and spatial variations will be analyzed in response to publicly available mobility data collected since the start of social distancing. Another objective of this study is to examine how predictions of various air pollutant concentrations from the Community Multiscale Air Quality (CMAQ) modeling system simulates the estimated reduction of anthropogenic emissions induced as a result of changing activity patterns. Sensitivity studies based on the 2016 modeling platform are performed by incorporating real-time observed mobility data such as Google mobility data and vehicle miles traveled (VMT) data through CMAQ's Detailed Emission Scaling Isolation and Diagnostic (DESID) module and analyzed to develop an initial estimate of the likely impacts. The strengths and weaknesses of the modeling system in response to quick and dramatic emission changes from different sectors will be identified and presented.

DISCLAIMER

The views expressed in this paper are those of the authors and do not necessarily represent the views or policies of the U.S. EPA.

Hossein Khajehpour
Presentation: 2533
Presentation *https://www.cmascenter.org/conference/2020/slides/cmas2020-2533-Khajehpour.pdf*
Extended Abstract *https://www.cmascenter.org/conference/2020/abstracts/2533-COVID-19.pdf*

Khajehpour: Association between the exposure to long-term $PM_{2.5}$ concentration and COVID-19 death rate at the provincial level in Iran

Hossein Khajehpour, Farzaneh Taksibi, Mansour Shamsipour, Mohammad Sadegh Hassanvand

In this study, we investigated the association between exposure to long-term ambient $PM_{2.5}$ and the COVID-19 death rate at the sub-national (provincial) levels in Iran. Daily averaged $PM_{2.5}$ concentrations from the ambient air quality monitoring stations were collected and processed to calculate the annually-averaged concentrations. Also, the most effective number of lag days is studied to account for the most consistent mortality percentage of the infected cases hospitalized due to COVID-19. Then the resulted death percentage and the long-term exposures are regressed to check the correlation among the variables. Our results support the conclusion of the previous research works in other countries that the long-term exposure to higher concentrations of $PM_{2.5}$ increases the risk of the lethality of the COVID-19 cases.

Fei Liu
Presentation: 2467
Presentation *https://www.cmascenter.org/conference/2020/slides/2020-CMAS-Virtual-Conference_FeiLiu.pdf*

Liu: Abrupt decline in tropospheric nitrogen dioxide after the outbreak of COVID-19

Fei Liu, Joanna Joiner, Bryan Duncan, Nickolay A. Krotkov, Lok N. Lamsal, Aaron Page, Sarah A. Strode, Yasuko Yoshida, Sungyeon Choi, Bo Zheng, Can Li, Henk Eskes, Ronald van der A, Pepijn Veefkind, Pieternel F. Levelt, Oliver P. Hauser, and the OMI NO2 team

To combat the spread of COVID-19, government sealed off cities reporting large numbers of infected people, starting January 23, 2020 in Wuhan, China; this included halting public transportation and

closing local businesses. Policy interventions to reduce the spread of COVID-19 have environmental and economic impacts. Tropospheric nitrogen dioxide (NO2) indicates economic activities, as nitrogen dioxide is primarily emitted from fossil fuel consumption. Satellite measurements show dramatic drop in tropospheric NO2 vertical column densities after the outbreak of COVID-19. We estimate the impact of COVID-19 control measures on global anthropogenic emissions by taking advantages of the changes of observed NO2 from space. We also relate to this reduction to government's actions, including the announcement of the first report and the date of lockdown. Our analysis offers insights into the unintended environmental and economic consequences through reduced economic activities.

Sujit Maji
Presentation: 2541
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS2020_SujitMaji_IITMPune.pdf*

Maji: Simulation of particulate matter over mega-cities of India during COVID-19 : Preliminary results

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With the advent of COVID-19 strong control measures had been taken (by applying lock-down) which significantly affected the vehicular, industrial, and other outdoor activities resulting in reduced air pollution. We have calculated percentage change of pollutants during lock-down from observation and implemented a percent reduction for different pollutants in line of that in emission inventory. We have simulated $PM_{2.5}$ (particulate matter of aerodynamic radius less than 2.5 micron) over India at 12 Km horizontal resolution using WRF-Chem (Weather and Research Forecast model) version 3.9.1 during 25th Mar 2020 - 14th Apr 2020 for two scenarios (a) normal emission , and (b) reduced emission during lock-down due to COVID-19. Two different sets of meteorology : FNL with a horizontal resolution of 1 degree, and IITMGEFS with a horizontal resolution of 12 Km have been utilized for comparison. Model outputs were evaluated with the observation data from SAFAR (System of Air Quality Forecasting and Research) observational network over four cities : Delhi, Ahmedabad, Mumbai and Pune. Model simulation using the reduced emission captures the observed reduction and pattern of $PM_{2.5}$ concentration well. Site to site comparison indicates possibility of stepwise implementation of lock-down across different areas. Calculated statistical metrics shows higher Index of agreement (IOA) values at some stations (> 0.5) compared to the all stations (< 0.5). This is due to inability of model to capture spatial heteorologenity/emission variability at very high resolution. Mean biases indicates model have well predicted $PM_{2.5}$ for the whole period (1.1 at Ahmedabad, -5.48 at Mumbai and, -9.7 at Pune). Model simulation using normal emission have over-predicted the observed values and differed significantly from predicted values using reduced emission. From our above study we can conclude: (1) There was a significant reduction in particulate pollutants during implementation of first lock-down (25 March -14 April 2020) over India and, (2) Our calculated emission inventory represents the reduced emission over mega-cities.

Rabab Mashayekhi
Presentation: 2517
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS2020_RMashayekhi.pdf*

Mashayekhi: Quantifying the impact of COVID-19 on air quality in major Canadian cities

Rabab Mashayekhi1, Radenko Pavlovic1, Jacinthe Racine1, Michael D. Moran2, Patrick M. Manseau1, Annie Duhamel1, Ali Katal1, Jessica Miville1, David Niemi1, Si Jun Peng1, Mourad Sassi1, Debora Griffin2 and Chris McLinden2
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2 Air Quality Research Division, Environment and Climate Change Canada, Toronto, Ontario, Canada

In this study, we have investigated the impact of reduced activity levels due to COVID-19 lockdown measures on air quality in four major Canadian cities: Montreal, Toronto, Calgary, and Vancouver. First, near-real-time hourly surface measurements of NO2, $PM_{2.5}$, and O3 were analysed for two periods, a 'pre-lockdown' period from 15 February to 14 March 2020, and a 'lockdown' period from 22 March to 2 May 2020, during which lockdown measures were in full force everywhere in Canada. The observed mean diurnal concentrations during both periods in 2020 were compared to the same periods in the previous decade (2010-2019). Higher-than-usual seasonal declines were observed in average NO2 from the pre-lockdown to lockdown periods in 2020. For $PM_{2.5}$ Montreal was the only city that had a higher-than-usual seasonal decline, while for O3 all four cities remained within the previous decadal range. In order to isolate the impact of lockdown-related emissions changes from other factors such as seasonal changes in meteorology and emissions and meteorological variability, a modelling scenario analysis was conducted with the GEM-MACH air quality model for the lockdown period on a 10-km grid that covered most of Canada and the U.S. Two simulations were performed and compared, the first a counterfactual simulation with Business-As-Usual (BAU) baseline emissions and the second a simulation with "lockdown scenario" emissions, which were based on an estimated 80% decrease in air traffic, 60% decrease in on-road transportation, 30% decrease in industrial activity, and 20% increase in emissions from residential heating. Compared to the BAU simulation, NO2 surface concentrations in the four metropolitan areas for the COVID-19 emissions scenario were lower by 31% to 33% on average. For $PM_{2.5}$ surface concentrations less pronounced average decreases ranging from 6% to 17% were predicted. Maximum decreases of up to 41% for NO2 and 22% for $PM_{2.5}$ were predicted for grid cells near major airports and highway intersections or close to city centers. O3 surface concentrations, on the other hand, showed increases up to a maximum of 18% close to city centers and slight decreases over the suburbs, while Ox (odd oxygen) decreased over these cities.

Zach Rewolinski
Presentation: 2480
Presentation *https://www.cmascenter.org/conference/2020/slides/rewolinski-Impacts-of-COVID-19-Pandemic-2020.pdf*

Rewolinski: Impacts of COVID-19 Pandemic on Activity and Emissions

Zach Rewolinski, James Li, Anthony Nguyen, Daniel R. Kowal, and Daniel S. Cohan

Responses to the COVID-19 pandemic have led to major declines in economic activity, but there is a lack of research quantifying how this has impacted activity and emissions on a sector-by-sector basis. Analyzing the changes in activity and emissions across sectors allows us to comprehend the unique impact that COVID-19 has had on the United States. Moreover, by examining local policies which have impacted emissions in specific regions, we can gain knowledge regarding the relationships between restrictions, transportation, power generation and consumption, and associated emissions on a local

level. By bringing these relationships to light, we can offer insight into why emissions are changing, and how to lower emissions further.

In this study, we use publicly available data that describes power plant activity, electricity demand, and vehicle activity to quantify changes in emissions and energy consumption across various regions of the United States. We incorporate data on policies and restrictions enacted in order to examine how the timing and stringency of those policies may have influenced activity and emissions. In comparing 2020 data to historical data, we find that 1) vehicle activity dropped sharply and then rebounded; 2) electricity demand fell in the industrial and commercial sectors but rose for residential consumers; and 3) power plant emissions began falling even before the pandemic due to diminished coal use amid low natural gas prices and a growing prevalence of renewable energy.

Nicholas Van Haasen
Presentation: 2492
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS-Presentation-vanhaasen-2020.pdf*

Van Haasen: Effects of COVID-19 on Transportation and Air Quality in the North Central Texas Region

Nicholas Van Haasen and Vivek Thimmavajjhala

The novel coronavirus, COVID-19, was first confirmed in North Texas on March 9, 2020. By March 24, 2020, counties (Collin, Dallas, Denton, and Tarrant) issued orders to mitigate the spread of COVID-19. Some independent school districts were closed indefinitely. By the end of March, the governor issued a one-month executive order that only allowed Texans to leave their homes for essential activities. On May 1, 2020, the region started to reopen businesses. Later in June, as confirmed COVID-19 cases continued to increase, the reopening was systematically halted and slowly started to reverse. The effects of such a closure on the economy, the constraints placed on individuals to social distance, and the stay-at-home orders all culminated in profoundly impacting the North Central Texas region. We, NCTCOG, monitored the impacts of the COVID-19 pandemic on our regional transportation and air quality. We collected and analyzed several metrics including, but not limited to, highway traffic volume, vehicle speed, and crash statistics; transit ridership, airport passengers, bike/pedestrian; and air quality levels. Since the North Central Texas region is in nonattainment for the pollutant ozone, tracking ozone measures is a key component of our current and ongoing analysis, which we plan to continue in the forthcoming months.

Jiani Yang
Presentation: 2437
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS2020_2437_JianiYang.pdf*

Yang: The Improvement of the Air Quality due to Traffic Halting in Los Angeles during the COVID-19 Outbreak

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Background: On March 19, 2020, the government of California ordered all 40 million Californians to stay at home in the coming weeks as the result of the escalation of the coronavirus disease 2019 (COVID-19) pandemic. As lockdowns were implemented, the significant changes caused by these restrictions brought the dramatic improvement in air quality in metropolitan cities such as Los Angeles (LA Basin).

Methods: We use real-time data from The South Coast Air Quality Management District (South Coast AQMD), and California Department of Transportation (PeMS) to evaluate the anthropogenic drivers of the pollution sources. We fit the regression analysis to compare the correlation of 7 variables including traffic flow, truck flow, traffic speed, NO2, CO, $PM_{2.5}$, and O3. We also mapped the monthly spatial variation and hourly heatmap of those 7 variables in 2020 to understand the impacts of the lockdown on different locations in the LA Basin.

Results: In the Los Angeles Basin, the traffic flow on highways started to drop an intensely by 20.86 % when initiating the stay at home order and it continued decreasing by 32.92% the first week, 30.94% the second week, 37.9% the third week, and 33.57% at the fourth week following the lockdown compared to corresponding dates during the year of 2019. The average truck flow for each sensor is generally higher in 2020 than 2019 before lockdown. The general weekly drops have also been observed for the truck flow on the highways by 1.63% the first week, then it raises back to 18.31% the second week, and declined again by 10.98% the third week, and declined by 2.55% at the fourth week following the county-wide lockdown. Accordingly, the change of traffic trigged the intensive decline of NO2 by 44.23% the first week, 12.96% the second week, 50.64% the third week, 32.65% the fourth week following the lockdown; We found a dramatic drop in $PM_{2.5}$, NO2, CO during the first week after initiating the stay at home order. The correlation (Pierson r) between truck flow change and changes of NO2, CO, and $PM_{2.5}$ is 0.91(****),0.88(****),0.74(**); The correlation between traffic flow change and changes of NO2 is 0.87(****), CO is 0.81(***), and $PM_{2.5}$ is 0.62(**). The correlation between traffic speed change and changes of NO2 is -0.84(****), CO is -0.78 (***), and $PM_{2.5}$ is -0.59(*). We found that a decline of 1% in NO2, CO and $PM_{2.5}$ is associated with the decline of 15.79%, 17.15% and 9.43% in the truck flow; A decline of 1% in NO2, CO and $PM_{2.5}$ is associated with the decline of 11.26%, 9.43% and 20.96% in traffic flow; A decline of 1% in NO2, CO and $PM_{2.5}$ is associated with the increase of 3.45%, 3.13% and 5.21% in traffic speed. The results are all statistically significant.

Conclusion: The drop in truck flow is mainly responsible for the drop of NO2 and CO. The lockdowns provided a large-scale experiment into air quality research. The result of this research would provide an important reference for the policy markers regarding truck management in light of air quality control to prepare the 2028 Summer Olympics in LA.

3. Emissions Inventories, Models, and Processes (10/28)

2020-10-28

Swetaleena Dash
Presentation: 2525
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS_presentation-Swetaleena-2020.pdf*

Dash: Assessment and Development of National Emission Inventory of Major Air Pollutants from Open Municipal Solid Waste Burning in India (2018)

Swetaleena Dash1, Saroj Kumar Sahu1*, Poonam Mangaraj1, G Beig2

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Municipal Solid Waste (MSW) management is one of the major environmental issues of Indian cities, also one of the most important challenges of developing countries. Unmanaged MSW becomes a crucial element for the transmission of numerous ailments as well as provides the ground for open burning of the waste. Open burning can happen at the source of the waste production or at a collection site. In India, the waste management problems are aggravated by poor waste segregation at the source leading to lesser treatment and higher open burning. The extremely low calorific value accompanied with high moisture content of the MSW combustion makes it more vulnerable to public health. In the present work, the per capita waste generation in urban and rural as well as major cities have been taken into account to estimate a gridded fine resolution emission inventory of MSW based air pollutants load in 2018 for Indian geographic region. It is found that nearly 180 million tons (MTs) of MSW is being produced every year where the major fraction is being burnt in open. The India level emission for the pollutants i.e. PM10, $PM_{2.5}$, CO, NOX, SO2, BC, and OC have been estimated to 746.98 Gg/yr, 693.62 Gg/yr, 3574.82 Gg/yr, 199.55 Gg/yr, 26.68 Gg/yr, 53.36 Gg/yr and 693.2 Gg/yr respectively is illustrated in this work. The findings will be an important tool for policymakers as well as the regional air quality modeling studies.

Sebastian Orlando Espitia Cano
Presentation: 2554
Presentation *https://www.cmascenter.org/conference/2020/slides/espitia-cano-Presentation_cmas_2020.pdf*

Espitia Cano: Redistribution of the EDGAR global emissions inventory using local spatial proxies: Assessment of environmental equity metrics.

Espitia Cano, Sebastian Orlando; Montejo-Barato, Alejandra; Morales, Ricardo

Air quality models are essential tools for proper air quality management. However, the quality of atmospheric chemical transport modeling and its use as a tool to inform public policy decisions, strongly depends on the quality of emission inventories. In Colombia, the use of these models has been limited, and only a handful of cities systematically build and revise spatially distributed local atmospheric emissions inventories. Therefore, chemical transport modelling uses detailed emissions from local sources within city limits but has to rely heavily on the use of global emission inventories everywhere outside city limits. Global emission inventories have a resolution of 11 km, and use limited local information to spatially allocate emissions. This dependence on global inventories hinders the applicability of atmospheric modeling for the design of air quality management plans. Therefore, it is necessary to have an improved spatial distribution of the emissions beyond the city limits of Bogotá. In this study we use the chemical transport model WRF-Chem v3.9.1. to evaluate the impact of redistributing global emissions according to local spatial proxies in combination with detailed local emission information. Anthropogenic emissions from the global emissions inventory EDGARv4.3.1 were merged with a local emissions inventory for the city of Bogota. Two simulation scenarios were evaluated and compared with the observed concentrations from the air quality monitoring network for Bogotá. The base-case (Scenario 1) used the default EDGAR spatial distribution of emissions. In the second scenario (Scenario 2), the emissions from industrial, commercial and mobile sources of the EDGARv4.3.1 inventory were redistributed according to the spatial distribution of the population without considered

Bogotá (population density data files were obtained the most recent census in Colombia (DANE 2020)). The modeling period for this assessment was February 2018. Three nested domains were used with resolutions of 27 km, 9 km, and 3 km respectively and 41 vertical levels. Gas phase chemistry is described by the RACM mechanism, and aerosol physics by the MADE modal scheme. SOA formation is described with the Volatility Basis Set. Biogenic emissions and biomass burning are also included using MEGAN and FINN-emission-inventory respectively. Our simulations suggest that even the limited use of spatial redistribution applied in the sensitivity Scenario 2 can have a positive impact on improving modeling metrics when compared to the observations. Most of the improvements are achieved in the surroundings of Bogotá due to the redistribution of emissions from the EDGARv4.3.1 inventory. Those areas are also the most densely populated, and those with worse air quality. The improved allocation of emissions were then used to compute environmental inequality metrics in the city of Bogotá, and were compared with similar metrics calculated using observations. We believe this approach is a step forward to extend the use of air quality modelling in the country, and are a temporary fix while better local atmospheric emissions are available.

Alison Eyth
Presentation: 2495
Presentation
https://www.cmascenter.org/conference/2020/slides/CMAS_2017_platform_Eyth_101620.pdf

Eyth: Development of a 2017 Emissions Modeling Platform

A. Eyth, M. Strum, J. Vukovich, C. Farkas, J. Godfrey, R. Mason, S. Roberts, C. Allen, J. Beidler

The EPA has developed an emissions modeling platform for the year 2017 based on the 2017 National Emissions Inventory (NEI). Some of the sectors were developed in a consistent way with the 2016v1 Collaborative Emissions Modeling Platform released in the fall of 2019. The 2017 modeling platform has been used for some preliminary air quality modeling studies of the year 2017. The magnitude of emissions in the platform will be reviewed along with some of recent improvements regarding the modeling of the emissions.

Kristen Foley
Presentation: 2448
Presentation *https://www.cmascenter.org/conference/2020/slides/KFoley_EQUATES_CMAS_2020.pdf*

Foley: Development of 2002-2017 meteorology, emissions, and air quality modeling for the Northern Hemisphere and the Conterminous United States

Kristen Foley, George Pouliot, Alison Eyth, Norm Possiel, Michael Aldridge, Chris Allen, Wyat Appel, Jesse Bash, Megan Beardsley, James Beidler, David Choi, Brian Eder, Caroline Farkas, Rob Gilliam, Janice Godfrey, Barron Henderson, Christian Hogrefe, Shannon Koplitz, Rich Mason, Rohit Mathur, Chris Misenis, Havala Pye, Lara Reynolds, Matthew Roark, Sarah Roberts, Donna Schwede, Karl Seltzer, Darrell Sonntag, Kevin Talgo, Claudia Toro, Jeff Vukovich

EQUATES: **E**PA's Air **QUA**lity **T**im**E** **S**eries Project

The US EPA is developing a set of modeled meteorology, emissions, air quality and pollutant deposition from 2002 through 2017. Modeled datasets cover the Conterminous US at a 12km horizontal grid spacing and the Northern Hemisphere at a 108km using WRFv4.1.1 for meteorology and CMAQv5.3.2 for air quality modeling. New hemispheric and North American emissions inventories were developed using, to the extent possible, consistent input data and methods across all years. The new emissions

datasets and CMAQ output will be made publicly available to support a wide variety of human health and ecological applications. Model estimated trends will be used for dynamic and diagnostic evaluation of the CMAQ system to inform model development and build confidence in the use of the model for quantifying the impact of meteorological and emissions changes on air quality. This presentation will describe the development of the emissions inventories and model simulations and will provide initial evaluation results.

Amin Hassani
Presentation: 2559
Presentation *https://www.cmascenter.org/conference/2020/slides/amin-hassani-CMAS-conference-presentation-2020.pdf*

Hassani: Tehran emission inventory development using a new bottom-up emission inventory calculation and reporting system

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2- Tehran Air Quality Control Company
3- PhD candidate, Energy engineering department, Sharif university of technology
4- Associate professor, Mechanical engineering department, Sharif university of technology

The Emission Inventory system is a web-based, user-friendly platform that has been developed to calculate and update Tehran emission inventory. Using this system, it is possible to import source specific input data (including traffic volume, fleet composition, fuel consumption, population distribution etc.,) and calculate emission from following sources with high spatio-temporal resolution:

Mobile Sources (exhaust, non-exhaust, evaporative and cold start emission)
Power plants
Bus Terminals
Airports
Household, general and commercial Sources
Refineries
Railways
Petrol Stations
Industries
Here are different applications of the system:
Tracking emission rates for regulatory purposes and police making
Running if-then scenarios
Permitting and compliance
Providing data for national programs
Tracking GHGs and GHG mitigation activities
Easy to use system with minimum technical background
Capabilities of generating various types of reports
Custom-made to regional and local needs

In the presentation we will introduce the system and will discuss how the system works, input data, emission calculation methodology and different applications of the system. Also, The results for Tehran city will be presented.

Nicholas Heath
Presentation: 2518
Presentation *https://www.cmascenter.org/conference/2020/slides/Heath_CMAS_2020_Final.pdf*

Heath: Using CrIS Ammonia Observations to Improve Decision Making on $PM_{2.5}$ Control Policies

Nicholas Heath, Matthew Alvarado, Amy McVey, Karen Cady-Pereira, Jeana Mascio, Mark Shephard

Air quality managers and forecasters need accurate emissions estimates of $PM_{2.5}$ precursors, such as ammonia (NH3), to analyze and forecast how these emissions impact human health and air quality. However, current emission inventories are too uncertain to provide reliable estimates of the health effects of NH3. Observations from the Cross-track Infrared Spectrometer (CrIS) provide an opportunity to address this problem and improve NH3 emissions estimates using inversion-based modeling techniques. Moreover, as new CrIS instruments are expected to be launched over the next two decades as part of the JPSS series, designing an infrastructure and methodology to use these observations in operational air quality policymaking and forecasting will provide benefits extended through 2030 and possibly beyond. In the current study, CrIS total-column NH3 observations are used in a finite-difference mass-balance approach to constrain NH3 emissions in the Community Multiscale Air Quality (CMAQ) model. CMAQ is run over the continental United States using 12 km grid spacing for June 2015. A baseline simulation is made with unperturbed NH3 emissions. Then, a second simulation is performed with NH3 emissions perturbed by 20%. The resulting total column concentrations of NH3 are compared to CrIS observations to derive a monthly-mean scaling factor for the a priori NH3 emissions. This scaling factor accounts for the relationship of NH3 concentrations to NH3 emissions in the baseline model run and is used to derive updated emissions, which are utilized in a final CMAQ simulation. This finite-difference inversion method has been incorporated into Amazon Web Services, and the data will be made publicly available. It will ultimately allow air quality managers and other stakeholders to obtain more accurate NH3 emissions estimates that can be implemented directly into their air quality modeling.

Hossein Khajehpour
Presentation: 2482
Presentation *https://www.cmascenter.org/conference/2020/slides/cmas2020-2482.pdf*
Extended Abstract *https://www.cmascenter.org/conference/2020/abstracts/2482-SNA-of-PM-in-Tehran.pdf*

Khajehpour: Sensitivity Analysis of $PM_{2.5}$ Concentrations to the Emission Sources in the Megacity of Tehran

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There are various ways to estimates the share of different emission sources in air pollution. Emission inventory from different sources shows the share of sources in total primary emissions of pollutants during a specific time and in a limited geographical area. However, the observed concentration at specific point is a result of the dispersion of pollutants released from different sources of emissions and

formation of secondary pollutants by chemical reactions in the atmosphere. Therefore, identifying the complete contribution of different sources to the concentration is possible either through source apportionment or through sensitivity analysis of validated dispersion models to emission sources. In this study, based on the sensitivity analysis of a validated $PM_{2.5}$ dispersion model in Tehran using ADMS-Urabn, the contribution of different sources in air pollution concentration at receptor point in Tehran has been estimated. According to the results of the emission inventory, the share of various sources in primary $PM_{2.5}$ emission rate in the Tehran megacity is 49%, 10%, 4% and 37%, for industries and power plants, domestic and commercial, agriculture, and mobile sources, respectively. However, based on sensitivity analysis study, the contribution of these sources to the concentration at the Sharif University Station, a concentrated residential area in the middle-western of Tehran, is estimated to be 19%, 34% and 47% from the emissions from industry and power plant, domestic and commercial, and mobile sources, respectively. The observed difference illustrates the functionality and necessity of the sensitivity analysis approach of emission sources in planning the environmental management of air pollution as a complement to emission inventory and source apportionment studies.

Lina Luo
Presentation: 2481
Presentation *https://www.cmascenter.org/conference/2020/slides/2020-CMAS-Meeting_Lina-Luo.pdf*
Extended Abstract *https://www.cmascenter.org/conference/2020/abstracts/CMAS-CONFERENCE-2020-EXTENDED-ABSTRACT-Lina-Luo.pdf*

Luo: Enhanced Representation of Agricultural Emissions of Reactive Nitrogen in Fertilizer Emissions Scenario Tool for CMAQ (FEST-C)

Lina Luo and Daniel S. Cohan, Department of Civil and Environmental Engineering, Rice University, Houston, TX

Fertilizer-intensive agriculture has become the largest source of reactive nitrogen emissions in the United States. Almost half of added nitrogen on croplands is lost to the environment in multiple reactive forms, including the air pollutants ammonia (NH3) and nitric oxide (NO), and a potent greenhouse gas, nitrous oxide (N2O). Furthermore, NH3 and NO are important precursors of secondary air pollutants, fine particulate matter ($PM_{2.5}$) and ozone (O3). Integrated assessments show that agriculture is now the leading contributor to $PM_{2.5}$ pollution-related health impacts. Managing nitrogen emissions are thus essential to mitigate their negative effects on air quality and climate. Some farming practices such as fertilizer management could reduce emissions of all forms of reactive nitrogen species (Nr, including NH3, NO, HONO, and N2O), while others such as no-tillage could generate trade-offs among different species. Therefore, there is a need to not only predict Nr emissions but also illuminate how these emissions vary with different farming practices.

Currently, the process-based mechanistic nitrogen (N) scheme in the Community Multiscale Air Quality (CMAQ) model computes emissions as functions of meteorological conditions and soil properties (chemical and physical), and part of these soil properties are derived from agroecosystem modeling with the Fertilizer Emissions Scenario Tool for CMAQ (FEST-C). FEST-C is a regional-scale integrated ecosystem assessment model adapted from the field-scale Environmental Policy Integrated Climate (EPIC) model. EPIC simulates how soil properties and N-cycling processes are affected by farming practices and weather conditions. Obtaining soil properties from FEST-C enables Nr emissions to be modeled with spatio-temporal detail during the growing season. However, since only some of the required soil properties are extracted from FEST-C, CMAQ cannot dynamically reflect how soil properties and also Nr emissions change with farming practices. In this study, instead of linking agroecosystem (FEST-C) and air

quality (CMAQ) models, we take an alternative method that directly uses FEST-C with modifications to its N-cycling schemes to generate Nr emissions. Because FEST-C neglects NO and nitrous acid (HONO) emissions from N-cycling and N2O emissions from nitrification, we update its nitrification and denitrification schemes to predict NH3, NO, HONO, and N2O emissions adapted from mechanisms in the DayCENT model. To evaluate the performance of enhanced FEST-C modeling, we compare its estimates of agricultural Nr with those from a mechanistic soil N scheme and other existing schemes. Our enhanced FEST-C could not only consistently generate Nr emissions but also enables us to estimate how they vary with farming practices to identify practices which could yield co-benefits for air quality and climate.

Congmeng Lyu
Presentation: 2446
Presentation *https://www.cmascenter.org/conference/2020/slides/Clyu_CMAS2020.pdf*

Lyu: Evaluating a Framework for Refining Ammonia Emissions Estimates with Satellite-based Observations with Regional Air Quality Modeling

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Shannon Capps, Drexel University, Civil, Architectural, and Environmental Engineering, Philadelphia, PA, USA
Matthew Lombardo, Johns Hopkins University, Baltimore, Maryland, USA
Mark Shephard, Environment and Climate Change Canada, Toronto, Ontario, Canada
Amir Hakami, Carleton University, Civil and Environmental Engineering, Ottawa, Ontario, Canada
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Steven Thomas, University of Melbourne, School of Earth Science, Melbourne, Victoria, Australia
Peter Rayner, University of Melbourne, School of Earth Science, Melbourne, Victoria, Australia

The Community Multiscale Air Quality (CMAQ) model calculates the impact of emission on atmospheric composition, including inorganic aerosols, while considering the transport and reactions of chemical constituents. Adjusting emissions by comparing modeled concentrations with observations is possible when the science processes are well understood as is the case for inorganic species such as ammonia (NH3). Four-dimensional variational data assimilation leverages differences in simulated and actual observations to revise estimates of emissions with spatial specificity. In this study, we evaluate the capacity of a CMAQ-based data assimilation system to improve NH3 emissions, which are relatively uncertain given the diversity of emissions processes in the agricultural sector. To do so, a Python-based four-dimensional variational framework (py4dvar) is integrated with CMAQ and its adjoint to constrain NH3 emissions with observations from the satellite-based Cross-track Infrared Sounder (CrIS). Pseudo-observation tests are conducted with the CrIS observation operator to evaluate the extent to which emissions are expected to be recovered with the assimilation. Then, the framework is ported to a 2017 modeling platform for assimilation of CrIS NH3 observations. Three suitable periods are selected from April through October 2017 for assimilation.

Poonam Mangaraj
Presentation: 2524
Presentation *https://www.cmascenter.org/conference/2020/slides/Poonam_CMAS2020F.pdf*

Mangaraj: Inventory of multi-pollutant emissions from the predominant sectors in India: Road Transport and Thermal Power Plant

Poonam Mangaraj1, Saroj Kumar Sahu1, Swetaleena Dash1, G Beig2

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The urge to understand the sources of emissions, particularly those from the traditionally dominant sectors is the initial gesture to meet the major requirements of regional air quality management. The up-surging demand for personal transport equipment has put forth the transport sector of India to witness a rapid transitional phase about several policy interventions related to emission norms. Along a similar line, the power sector too is of a high priority in the national planning processes in India where nearly 70 % of electric energy demand is met by the fossil fuel based thermal power plants. Emissions from road transport as well as thermal power stations have significant impacts on the regional as well as global climate change. Having said that, this study attempts to develop a very high resolution gridded ~ (10km X 10km) Emission Inventory (EI) to assess the load of $PM_{2.5}$, PM10, CO, NOx, VOC, SO2, BC and OC emission from the above-mentioned two sectors over Indian sub-continent for the base year 2018. Emissions of 1522.1 Gg y-1 $PM_{2.5}$, 1550.3 Gg y-1 PM10, 14864.5 Gg y-1 CO, 11523.2 Gg y-1 NOx, 8802.6 Gg y-1 VOC, 1896.7 Gg y-1 SO2, 673.1 Gg y-1 BC and 1009.7 Gg y-1 OC were estimated for on-road transport sector. Followed by the emissions of 378.8 Gg y-1 $PM_{2.5}$, 1452.1 Gg y-1 PM10, 37.9 Gg y-1 CO, 2045.5 Gg y-1 NOx, 0.7 Gg y-1 VOC, 7386.5 Gg y-1 SO2, 18.9 Gg y-1 BC and 0.6 Gg y-1 OC were estimated for thermal power plants. This assessment would give an overview of emissions from road transport and power plants which can be critical sensitive input to atmospheric chemical transport models. Ultimately, this inventory could be used to ascertain the impacts on the atmospheric composition and air quality, on human health and environment, and on options for mitigation.

Yu Morino
Presentation: 2497
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS2020_Morino_v1.pdf*

Morino: Emissions of condensable particulate matter from stationary combustion sources

Yu Morino,1 Satoru Chatani,1 Kiyoshi Tanabe,1 Yuji Fujitani,1 Katsuyuki Takahashi,2 Kei Sato,1
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Emission factors of particulate matters (PM) from stationary combustion sources have been measured without dilution or cooling in Japan and other Asian countries, thus condensable PM were not included in the PM emission inventory. In our previous studies (Morino et al., ES&T, 2018), emissions of organic aerosol (OA) in condensable PM were estimated without any consideration of dependence of condensable PM emissions to temperature and total OA concentrations. In this study, we modified the emission data by considering the effect of temperature and total OA concentrations on the condensable PM emissions.

George Pouliot
Presentation: 2464
Presentation *https://www.cmascenter.org/conference/2020/slides/Pouliot_CMAS2020_EQUATES-fireEmissions.pdf*

Pouliot: A Multi-Year Reanalysis of EPA's Fire Emissions Inventory

George Pouliot,Kristen Foley,James Beidler,Jeff Vukovich, Kirk Baker

The EPA estimates area burned and emissions from wildland fires, prescribed fires, grassland fires, and crop residue burning every three years for the National Emissions Inventory (NEI). For NEI and non-NEI years, different methods and datasets have been applied. To fully characterize the air quality (AQ) impacts of different fire types, a consistent method for inventories was developed and retrospectively applied. A multi-year reanalysis of fires from 2002 - 2017 was developed using the best available data and methods to estimate emission factors and fire activity. The new long term fire emissions estimates will be used in 2002-2017 CMAQ simulations for long-term AQ trend analysis and human health and ecological applications. A sensitivity analysis will be used to compare national approaches vs. the use of state and local data. Comparisons with the 2016v1 platform and the 2017 NEI will be presented.

Flavia Ribeiro
Presentation: 2466
Presentation *https://www.cmascenter.org/conference/2020/slides/PresentationCMAS-FRibeiro-Nova-2020.pdf*

Ribeiro: Future scenarios in vehicular emissions and the impact of new vehicle technologies, fuel and mobility trends on air quality

Ribeiro, Flávia Noronha Dutra
Umezaki, Arissa Sary
Chiquetto, Júlio Barboza

The present work estimates future trends of active fleet, emission factors, and vehicular ativity in the Metropolitan Region of Sao Paulo, Brazil. Then, several scenarios are developed to investigate the impact of changes in fuel and in modes of transportation and electrification. The emissions are calculated for 2028 and 2038, including criteria pollutants, greenhouse gases, and heat. Additionally, simulations using SMOKE and WRF-CHEM are performed to test some of the changes in emissions totals. Current trends point to an increase in greenhouse gases and heat emissions in Sao Paulo. Despite a decreasing tendency in most criteria pollutants, secondary pollutants may not follow the same trend. Additionally, the increased contribution to climate change is disturbing, particularly joined by an increase in vehicular anthropogenic heat, raising concerns of synergistic effects between global warming and urban heat island. Among the different scenarios tested, the measures that show better results in emission totals are increase in the use of biofuels, such as sugarcane ethanol, and decrease in private passenger cars activity. Simulations show the influence of atmospheric conditions on the pollutants concentrations.

Karl Seltzer
Presentation: 2454
Presentation *https://www.cmascenter.org/conference/2020/slides/karl-seltzer-20201028_CMAS_v3.pdf*

Seltzer: Reactive Organic Carbon Emissions from Volatile Chemical Products

Karl Seltzer, Ben Murphy, Venkatesh Rao, Elyse Pennington, Madeleine Strum, Kristin Isaacs, Havala Pye

Volatile chemical products (VCPs) are an increasingly important source of anthropogenic reactive organic carbon (ROC) emissions. Among these sources are everyday items, such as personal care products, general cleaners, architectural coatings, pesticides, adhesives, and printing inks. These emissions have long been accounted for in the US EPA's National Emission Inventory (NEI) as the solvent sector, but new inventory methods have suggested the NEI could be biased low by factors of 2-

3. As the influence of VCPs on secondarily formed pollutants grows in relevance, the need to resolve these differences becomes increasingly important. Here, we develop VCPy, a new framework to model ROC emissions from VCPs throughout the United States, with additional applications to spatially allocate these emissions to regional and local scales. In this framework, fate and transport assumptions are a function of the use timescale for product-use categories and the evaporation timescales of individual compounds within these categories, which are a function of their physiochemical properties. Since ingredients in these product categories are considered individually, determination of speciated emission profiles is explicit. This approach also enables quantification of emission volatility distributions and the abundance of different compound classes. Overall, we find National-level emissions of ROC from VCPy to be consistent with the NEI, but State and County-level estimates can differ substantially. In addition, we test the sensitivity of predicted emission factors to uncertain parameters, such as use and evaporation timescales, through Monte Carlo analysis, evaluate the inventory using published emission ratios, and map emissions to common chemical mechanisms for ease of research use in the chemical transport modelling community.

Nasimeh Shahrokhi
Presentation: 2477
Presentation *https://www.cmascenter.org/conference/2020/slides/Nasimeh-Shahrokhi-CMAS-2020.pdf*

Shahrokhi: Urban Scale Inverse Framework Using Carbon Monoxide Total Column Retrievals from TROPOMI for Tehran: Preliminary Results

Nasimeh Shahrokhishahraki1, 2, Peter J. Rayner1, 2, Jeremy D. Silver1, Steven Thomas1, and Robyn Schofield1, 2
1 School of Earth Sciences, The University of Melbourne
2 The Centre of Excellence for Climate Extremes (CLEX)

Improved air quality estimations rely on decreasing uncertainties in the modeling system and, principally, emission inventories (EIs), which contain spatiotemporal data about the emission sources and released ratio of pollutants. Improving EIs will improve air quality forecasts and provide a more qualified basis for policy. An inverse framework is applied in this study to derive a posteriori EIs using the comparison of observed and modeled concentration with a priori EIs in urban scale for Tehran. This study uses global datasets to prepare fine-resolution inventory data for an urban area. Emissions Database for Global Atmospheric Research (EDGAR), Gridded Population of the World, Night-time Lights Composite datasets, and Fossil Fuel Data Assimilation System are used to downscale the spatiotemporal resolution of global EIs to the finer scale. The resultant high-resolution inventory is applied to run the forward WRF-CMAQ Modeling System to simulate the concentrations of air pollutants. The TROPOspheric Monitoring Instrument (TROPOMI) data product and surface measurements are used to compare with the modeled concentration of CO. After comparison, an adjoint model is applied to generate gradients to provide directions for gradient-based optimization in four-dimensional variational data assimilation (4D-Var). The main goal of the inverse modeling framework is refining knowledge of the CO-EIs in the target urban area. Independent satellite and in-situ measurements are utilized to assess the inverse framework capability in improving CO-EIs.

Amir Souri
Presentation: 2436
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAQ_Oct_2020_Souri.pdf*

Souri: Non-linear Joint Inversion of NOx and NMVOC Emissions Using Satellite Observations over East Asia

Amir H. Souri, Caroline R. Nowlan, Gonzalo González Abad, Lei Zhu, Donald R. Blake, Alan Fried, Andrew J. Weinheimer, Jung-Hun Woo, Qiang Zhang, Christopher E. Chan Miller, Xiong Liu, and Kelly Chance

Ozone is a secondary pollutant that adversely affects both human health and crop yields. Concern over ozone and its precursors over East Asia has globally gained more attention, since this pollutant can spread hemispherically through the atmosphere, affecting the background levels in various places. Promisingly, Chinese governmental regulatory agencies have started taking action to reduce the magnitude of several ozone precursors since 2011-2012 by implementing selective catalytic reduction for thermal power plants under the clean air act. On the other hand, countries such as South Korea and Japan have undergone a hiatus in the reduction of NOx emission primarily due to increases in the number of diesel vehicles and thermal power plants. Unraveling the origin of ozone is complicated by a number of factors including the nonlinearity of ozone formation to sources, primarily from nitrogen oxides (NOx) and non-methane volatile organic compounds (NMVOC). Therefore, to be able to quantify the impact of recent emission policies in Asia on tropospheric ozone and oxidation capacity of the atmosphere we are required to provide a top-down estimate of emission inventories using well-characterized observations. For the first time, we provide a joint non-linear analytical estimate of NOx and NMVOC during the KORUS-AQ campaign by simultaneously incorporating both SAO's new product of HCHO columns from Ozone Mapping and Profiles Suite Nadir Mapper (OMPS-NM) and NASA's Ozone Monitoring Instrument (OMI) tropospheric NO2 columns into a regional chemical transport model (here CMAQ). Results demonstrate a promising improvement in the performance of the model in terms of HCHO and NO2 columns, which in turn, it enabled us to quantify the effect of the emission changes on different pathways of ozone formation and HOx chemistry.

Madeleine Strum
Presentation: 2461
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS2020_Strum-ImprovingEPAsSPECIATE_Program_v11.pdf*

Strum: Improving EPAs SPECIATE Program

Madeleine Strum, EPA, OAQPS; Marc Menetrez EPA ORD; George Pouliot, EPA ORD; Art Diem, EPA OAQPS; Casey Bray, EPA OAQPS; Venkatesh Rao, EPA OAQPS; Julia Black, EPA OAQPS; Souad Benromdhane, EPA OAQPS; Heather Simon, EPA OAQPS; Ben Murphy, EPA ORD; George Pouliot, EPA ORD; Havala Pye, EPA ORD; Amara Holder, EPA ORD; Mike Hays, EPA ORD; Ingrid George,EPA, ORD; Alison Eyth, EPA OAQPS; Libby Nessley, EPA ORD; Justine Geidosch, EPA OTAQ; Ying Hsu and Frank Divita (Abt Associates), B.H. Baek (UNC School of the Environment), Tejas Shah (Ramboll)

EPA continues to update SPECIATE, the U.S. Environmental Protection Agency's (EPA) repository of chemical speciation profiles of many types of air pollution sources. This presentation discusses the most recent improvements to the SPECIATE program, culminating in one of the quickest-ever releases of the updated version, SPECIATE 5.1, on July 20, 2020. It also reviews the profiles of importance for use emissions platforms used for air quality modeling and the EPA's National Emissions Inventory (NEI). The updated version, SPECIATE 5.1, completed about a year after SPECIATE 5.0, added 92 total profiles (16 organic gas, 18 particulate matter and 58 mercury profiles). These will assist the user community with PM, VOC, and mercury species characterization related, primarily, to oil and gas (VOC), fires (PM) and geothermal power (Hg). The release also includes improvements to the database structure, species properties information and interface with the Speciation Tool. Finally, we have completed updates to

the Web Browser and added a browser's user's guide as well as a data developer's guide, providing the structure for how submitters can submit/prepare data for SPECIATE use. For the first time, our Data Developer's Guide/Template was used for community-developed data submission to SPECIATE. The SPECIATE Workgroup continues seek new data for future versions of SPECIATE. Priorities for profile sources have been presented in previous CMAS conferences and include region-specific oil and gas profiles for VOC, fires profiles for VOC and $PM_{2.5}$, and residential wood combustion profiles for VOC. We will review these needs and identify other source categories for which updated speciation would improve our estimates of air toxics in the NEI.

Sina Voshtani
Presentation: 2545
Presentation
https://www.cmascenter.org/conference/2020/slides/cmas2020_presentation_sinavoshtani.pdf

Voshtani: Evaluating methane emissions using extended Kalman filter and Iterative Kalman smoother inversions with CMAQ: Application of OSSEs

Sina Voshtani, Richard Ménard , Thomas Walker , Amir Hakami

Inverse modelling capabilities based on the extended Kalman filter (EKF) and the iterative Kalman smoother (IKS) approaches are developed with the Community Multiscale Air Quality (CMAQ) regional model at 36 km resolution. The analyses use observations from five satellite instruments (GOSAT, SCIAMACHY, IASI, AIRS, TES) to estimate methane emission corrections in three main source categories: agriculture, energy plus industry, and waste. First, we process methane anthropogenic emissions of EDGARv5 and map it into SMOKE, and second, we modify CMAQ to account for methane. Our study addresses the spatial distribution of prior and posterior methane emissions, treated as a tracer in CMAQ, and the impact of different types of observations. To show that the methods can work properly, we conduct an observing system simulation experiments (OSSEs) on a realistic configuration of atmospheric inversion that maintains the average kernel of the corresponding satellite instruments. OSSEs are carried out with different methane prior emissions and flux distributions. Both approaches show a degree of robustness to account for the estimation of the emissions and their bias and uncertainties, as opposed to the classical variational method with a frozen error statistic. Still, the method requires aggregation of source regions and some expert knowledge to define such aggregations.

The results and performance of both methods are assessed. They both prove to reproduce the "truth" in most of the cases. IKS provides a faster rate of error variance reduction compared to EKF, partly due to a larger amount of measurements assimilated through a forward-backward integration of the inverse model. EKF, on the other hand, promises less computational cost. We further discuss the objective of using real observations and deducing realistic statistics for the emission, transport, and satellite observation errors.

4. Machine Learning and Reduced Form Models Developments and Applications (10/27)

2020-10-27

Yunsoo Choi
Presentation: 2470

Presentation *https://www.cmascenter.org/conference/2020/slides/yunsoo_choi_uh_novel-cmaq-cnn-2020.pdf*

Choi: A Novel CMAQ-CNN Hybrid Model to Forecast Hourly Surface-Ozone Concentrations Fourteen Days in Advance

Alqamah Sayeed, Yunsoo Choi, Ebrahim Eslami, Jia Jung, Yannic Lops, and Ahmed Khan Salman

Issues regarding air quality and related health concerns have prompted this study, which develops an accurate and computationally fast, efficient hybrid modeling system that combines numerical modeling and machine learning for forecasting concentrations of surface ozone. Currently available numerical modeling systems for air quality predictions (e.g., CMAQ, NCEP EMP) can forecast 24 to 48 hours in advance with sufficient accuracy. In this study, we develop a modeling system based on a convolutional neural network (CNN) model that is not only fast but covers a temporal period of two weeks with a resolution as small as a single hour for 255 stations. The CNN model uses forecasted meteorology from the Weather Research and Forecasting model (processed by the Meteorology-Chemistry Interface Processor), forecasted air quality from the Community Multi-scale Air Quality Model (CMAQ), and previous 24-hour concentrations of various measurable air quality parameters as inputs and predicts the following 14 day hourly surface ozone concentrations. The model achieves an average accuracy of 0.91 in terms of the index of agreement for the first day and 0.78 for the fourteenth day while the average index of agreement for a one day ahead prediction from the CMAQ is 0.77. Through this study, we intend to amalgamate the best features of numerical modeling (i.e., fine spatial resolution) and a deep-neural network (i.e., computation speed and accuracy) to achieve more accurate spatio-temporal predictions of hourly ozone concentrations. Although the primary purpose of this study is the prediction of hourly ozone concentrations, the system can be extended to various other pollutants.

Cesunica Ivey
Presentation: 2494
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS_2020_ML-ivey.pdf*

Ivey: Machine Learning Applications for State Implementation Planning

Khanh Do, Arash Kashfi Yeganeh, Cesunica E. Ivey
Chemical and Environmental Engineering, University of California, Riverside
Center for Environmental Research and Technology, University of California, Riverside

California's South Coast Air Basin (SoCAB) is well-known for poor air quality due to its unique terrain and high levels of anthropogenic emissions. In this study, we use machine learning (ML) to recognize the natural pattern of ambient air pollutants in SoCAB and to explore the link between precursor emissions, meteorology and $PM_{2.5}$/ozone. We investigated the historical changes of $PM_{2.5}$ and ozone using 25 years of air pollutant, emissions, and meteorology data. We tested the random forest regression (RFR) algorithm under multiple configurations to tune the prediction and provide the best air quality predictions. We first trained the RFR model with hourly meteorology and air pollutant data from 1994 to 2018. Meteorological data were retrieved from Ontario and Los Angeles International Airport monitoring stations, and air quality data were retrieved from the Fontana (CA) air monitoring station. The RFR training features were NO, NO2, surface temperature, dew point temperature, visibility, surface pressure, relative humidity, wind speed, and wind direction. The RFR model was trained in five-year increments from 1994 to 2018. The R2 ranged from 0.6 – 0.7 for historical hourly predictions. The model also enabled predictions of 2023 $PM_{2.5}$ and ozone using input data from a 2023 CMAQ simulation. The

freedom of choosing input features enabled the investigation of $PM_{2.5}$ and ozone sensitivity to fluctuations in key variables, such as temperature and NOX. These promising results indicate that ML can accelerate air quality research by augmenting traditional air quality modeling, reducing simulation time, and exploiting large datasets for historical simulations and future air quality predictions.

Samuel Jones
Presentation: 2474
Presentation *https://www.cmascenter.org/conference/2020/slides/ML-Methods-to-Predict-Air-Pollution-Concentration-for-Policymakers-20201026.pdf*

Jones: Machine Learning Methods to Predict Air Pollution Concentration for Policymakers

Samuel H. Jones, Kun Zhang, Nicholas Muller, Peter Adams

Machine learning techniques have been employed to discover insights, solve and accurately predict many highly complex problems in the past two decades. This work applied these advancements to atmospheric pollution modeling. This paper represents a step toward applying machine learning to mimic chemical transport models (CTM). The ultimate goal is to develop a machine learning-based atmospheric chemistry model that is both accurate and computationally efficient. This paper took one small step toward that goal by developing a machine learning algorithm that: learns causes and effects of three chemical species from the area emission inputs and concentration outputs of a CTM, lays a groundwork for learning other atmospheric chemical interactions, and reduces computational costs for simulating atmospheric pollution to make these simulations more accessible to policymakers on a standard personal computer with a modest GPU. This work does not provide an adequate substitute for a CTM for our target audience but represents a step in that direction.

Alper Unal
Presentation: 2546
Presentation *https://www.cmascenter.org/conference/2020/slides/alicanMertan_presentation-2020.pdf*

Unal: Air Quality Forecasting Using Deep Learning Techniques

Alican Mertana, Alper Ünalb
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Machine learning is the study of algorithms that allows machines to learn through experience. With the recent advances in computing power and the availability of the large-scale data, deep learning methods (a sub field of machine learning) started to achieve successful results on a diverse set of problems and gain lots of popularity. One of the many areas where deep learning achieved great success is forecasting. In this work, we investigate the usage of fully connected feed forward neural networks, also known as multilayer perceptron (MLP), recurrent neural networks (RNN) and its variants. We formulate the air quality forecasting as a regression problem where the previous hourly PM10 measurements are used to estimate the future PM10 values. We compare the performance of different models and settings on our dataset, which consists of hourly PM10 measurements of Adana from 2009 to 2019. This paper presents comparison of results using different Deep Learning Techniques.

5. Model Development (10/27)

2020-10-27

Ross Beardsley
Presentation: 2515
Presentation
https://www.cmascenter.org/conference/2020/slides/BeardsleyR_CMAS2020_CarbonBond6_Revision5_clean.pdf

Beardsley: Revision 5 of the Carbon Bond 6 Mechanism (CB6r5)

Ross Beardsley and Greg Yarwood

The first version of CB6 was completed in 2010 and the first revision to be widely used was revision 2 (CB6r2) in 2013 which introduced heterogeneous reaction of organic nitrates (ONs) and updated reactions of isoprene and aromatics. The current version of CMAQ has CB6r3 (introducing ON improvements for winter ozone) and CAMx has CB6r4 (adding iodine and dimethyl sulfide for marine environments). However, the CB6 core inorganic reactions were last updated in 2010. For CB6r5, we performed a literature review that considered 152 of the 233 reactions in CB6r4 with focus on inorganic and simpler organic reactions. We revised reaction rates for 47 reactions and added one new reaction. CB6r5 tends to predict higher ozone concentrations than CB6r4 over land although CB6r5 has lower ozone over portions of the Gulf of Mexico. Chemically, the ozone changes due to CB6r5 updates are associated with small changes (generally increases) in nitrogen dioxide (NO2) in regions where ozone production is NOx-limited. Quantitative performance evaluation for 8-hour average ozone in Texas during June 2012 found that CB6r5 performs similarly to CB6r4 with statistical metrics for both mechanisms meeting recommended criteria. The ozone changes associated with CB6r5 updates are too small for ozone model performance evaluation to assess their validity when taking into consideration that models have uncertainties other than the chemistry including emissions, boundary concentrations, deposition and meteorology. We recommend additional testing and evaluation to understand how CB6r5 mechanism updates influence CAMx and CMAQ model performance for ozone and other pollutants.

Bryan Berman
Presentation: 2443
Presentation *https://www.cmascenter.org/conference/2020/slides/BB_CMAS_Presentation-2020.pdf*

Berman: Modeling indoor aerosol inorganic thermodynamics with ISORROPIA

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Many indoor aerosols originate from the outdoor environment. However, certain aerosol components may be physically or chemically processed upon transport from outdoors to indoors. For instance, temperature and relative humidity (RH) gradients between the indoors and the outdoors may influence the repartitioning of certain aerosol components. Cummings and Waring (2019) developed a model that simulates indoor organic aerosol (OA) concentration, composition, partitioning behavior, and secondary formation. We expand this model to predict inorganic aerosol (IA) repartitioning by integrating the thermodynamic model, ISORROPIA, which predicts concentrations of various inorganic species in the aerosol and gas phases at chemical equilibrium. To our knowledge, this is the first instance of applying ISORROPIA in an indoor model to simulate indoor IA thermodynamics. Specifically, we modeled inorganic concentrations and compared them to indoor aerosol concentration measurements from

aerosol mass spectrometer (AMS) data obtained by Avery et al. (2019). To evaluate the model, sulfate normalized indoor-to-outdoor concentration ratios, which may be used to distinguish repartitioning losses from physical loss mechanisms, were computed for inorganic nitrate (NO3-) and ammonium (NH4+) ([I/O]NO3/SO4 and [I/O]NH4/SO4) across the simulation set. Our simulated [I/O]NO3/SO4 and [I/O]NH4/SO4 were then compared to observed data from Avery et al. (2019). Both exhibited qualitatively similar exponentially decaying curves with respect to the indoor-outdoor temperature differences, ΔT as well as outdoor-indoor RH difference, ΔRH in the summer. Additionally, the exponential trends were in agreement when sufficient indoor ammonia sources were modelled, from both human occupants and surface reservoirs. This model evaluation serves as a proof of concept towards modeling chemical processes of inorganic aerosols and gases at key points in a heating, ventilating, and air-conditioning (HVAC) system, in the summer and winter, with ISORROPIA. Therefore, future work will involve exploring how HVAC systems influence indoor aerosol composition and chemical processing, with a focus on indoor aerosols of outdoor origin.

Patrick Campbell
Presentation: 2475
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS_2020_Campbell_Final.pdf*

Campbell: An Improved National Air Quality Forecasting Capability Using the NOAA Global Forecast System. Part I: Model Development and Community Application

Patrick C. Campbell1,2, Youhua Tang1,2, Pius Lee1, Barry Baker1,2, Daniel Tong1,2, Rick Saylor1, Ariel Stein1, Jianping Huang3,4, Ho-Chun Huang3,4, Edward Strobach3,4, Jeff McQueen3, Ivanka Stajner3, Dorothy Koch5, Jose Tirado-Delgado5,6, and Youngsun Jung5
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6. Eastern Research Group, Inc (ERG)

There is an ongoing transition at NOAA to use a new dynamical core in their Global Forecast System (GFS) and Limited Area Models (LAMs) known as the Finite Volume Cubed-Sphere (FV3), developed at both NASA and NOAA's Geophysical Fluid Dynamics Laboratory over the past few decades. There are also efforts at NOAA to upgrade FV3-GFS to version 16, which includes a number of significant developmental advances to the model configuration, data assimilation, and underlying model physics, particularly for atmospheric composition to weather feedback. Simultaneous to the GFSv16 upgrade, we are coupling the GFSv16 with the Community Multiscale Air Quality (CMAQ) model to form a "next-generation" National Air Quality Forecasting Capability (NAQFC) that will continue to protect human and ecosystem health in the U.S. In Part I (of II) for this work, we describe the vision and development of the FV3-GFSv16 coupling with the "state-of-science" CMAQ model version 5.3.1. The direct GFS-CMAQ coupling is based on the seminal version of the NOAA-ARL Atmosphere-Chemistry Coupler (NACC), which will ultimately form the next NAQFC system (i.e., NACC-CMAQ) and include numerous scientific advancements that will be highlighted. Such advancements include satellite-based data acquisition technology to improve land cover and soil characteristics, and wildfire smoke and dust predictions that are vital to predictions of $PM_{2.5}$ concentrations during hazardous events impacting society, ecosystems, and health. We also demonstrate the capability of the NACC-CMAQ system as an additional community research model/tool for atmosphere-chemistry coupling, as well as other ways that NOAA-ARL can

facilitate NACC-CMAQ community usage for air quality modeling applications. Part II of this work will provide more details into the science advancements and evaluation of NACC-CMAQ.

Xiaoyang Chen
Presentation: 2543
Presentation *https://www.cmascenter.org/conference/2020/slides/Xiaoyang-Chen_CMAS2020.XC4.pdf*

Chen: Evaluation of the Offline-coupled GFSv15-FV3-CMAQv5.0.2 in Support of the Next-generation National Air Quality Forecast Capability over the Contiguous United States

Xiaoyang Chen, Yang Zhang, Kai Wang, Daniel Tong, Pius Lee, Youhua Tang, Jianping Huang, Patrick C. Campbell, Jeff Mcqueen, Havala O.T. Pye, Benjamin N. Murphy, and Daiwen Kang

The next-generation of the operational National Air Quality Forecast Capability (NAQFC) consists of the Finite Volume Cube-Sphere dynamic core (FV3)-based Global Forecast System (GFS) and the Community Multiscale Air Quality (CMAQ) modelling system. In this study, the forecast skill of offline-coupled GFSv15-CMAQv5.0.2 is comprehensively evaluated for the year 2019. The forecast system shows good overall annual-mean performance but larger seasonal and monthly biases for temperature and relative humidity at 2-m and wind speed at 10-m, and moderate-to-large biases for hourly precipitation. It shows an overall good forecast skill in predicting annual and seasonal mean maximum daily average 8-h ozone (O3), despite a significant overprediction near the Gulf Coast during O3 season. While the forecast system performs well in forecasting fine particles ($PM_{2.5}$) for warm months (May-September), it significantly overpredicts for other months, particularly in the U.S. EPA designated regions 5 and 7 (mostly in the Midwest), and the states of Oregon and Washington, due mainly to the high predicted concentrations of fine fugitive, coarse-mode, and nitrate components. Underpredictions in the southeastern U.S. and California during summer are attributed to missing sources and mechanisms of secondary organic aerosol formation from biogenic volatile organic compounds (VOCs) and semi- or intermediate-VOCs. Categorical evaluation indicates that GFSv15-CMAQv5.0.2 can predict well the exceedance of "moderate" classification but not well for the "unhealthy for sensitive groups" in the U.S. air quality index system, due to the aforementioned $PM_{2.5}$ overprediction. The region-specific, time-specific, and categorical evaluations in this work can provide a scientific basis for the further development of NAQFC, in particular in improving the emissions and model chemical representations, as well as the development of the science-based bias correction method to improve forecasting skill for O3 and $PM_{2.5}$.

George Delic
Presentation: 2444
Presentation *https://www.cmascenter.org/conference/2020/slides/george-delic-HiPERiSM_CMAQ-2020.pdf*
Extended Abstract *https://www.cmascenter.org/conference/2020/abstracts/CMAS-CMAQ-2020-delic.pdf*

Delic: CMAQ 5.3 Parallel Performance for a 101-Day Simulation

George Delic, HiPERiSM Consulting, LLC, P.O. Box 569, Chapel Hill, NC 27514

This presentation covers thread parallel performance results for CMAQ 5.3 for a 101-day simulation and extends the results in [1]. Here attention is focused on the Gear, Rosenbrock, and EBI solvers in the Chemistry Transport Model (CTM), for both FSparse [1], and the legacy JSparse [2] algorithms. The former implements OpenMP thread parallelism for all three solvers in the CTM. The results include

execution performance and numerical precision for the first quarter of the 2016 annual CONUS scenario provided by the U.S. EPA [3]. Both the legacy (EPA) JSparse and the FSparse thread parallel versions are compared in a hybrid MPI+OpenMP version on a heterogeneous cluster of 14 nodes with a total of 192 cores. The implementation of thread parallelism in the horizontal advection science procedures (HADV) will also be discussed since these dominate the fraction of total wall clock time with increased number of MPI processes.

[1] G. Delic, Modern Environmental Science and Engineering, Vol. 5, Nr. 9, 2019, pp. 775-791. Full text available at: https://www.researchgate.net/publication/338581080_A_Thread_Parallel_Sparse_Matrix_Chemistry_Algorithm_for_the_Community_Multiscale_Air_Quality_Model [https://www.researchgate.net/publication/338581080_A_Thread_Parallel_Sparse_Matrix_Chemistry_Algorithm_for_the_Community_Multiscale_Air_Quality_Model]
[2] M. Jacobson and R.P. Turco (1994), Atmos. Environ. 28, 273-284
[3] The author gratefully acknowledges help from Kristen Foley (EPA), Ed Anderson (GDIT), and Elizabeth Adams (UNC) in providing model input data and resolving implementation issues.

Chris Emery
Presentation: 2510
Presentation https://www.cmascenter.org/conference/2020/slides/CMAS_2020_Emery_CAMx7.pdf

Emery: New Features and Updates in CAMx Version 7

Chris Emery, Gary Wilson, Greg Yarwood

We summarize several updates and improvements available in version 7.0 of the Comprehensive Air quality Model with extensions (CAMx; www.camx.com). A major update includes enhancements to the way large datasets are provided to the model, including: (1) support for netCDF v3/4 file formats for large gridded fields (emissions, meteorology, and initial/boundary conditions); (2) a new 3-D gridded emissions file in netCDF for certain non-point source sectors that are emitted above the surface and have traditionally been input to the model as elevated point sources (fires, lightning NOx, aircraft); (3) support for multiple point, 2-D and 3-D gridded input emission files (removing the requirement to merge emission sectors into single files); and (4) enhanced I/O for Probing Tools. CAMx v7 also includes a bi-directional ammonia algorithm, updates to secondary organic chemistry, chemistry for oceanic dimethyl sulfide (DMS), the addition of eight primary $PM_{2.5}$ elemental species (Fe, Mg, Mn, Ca, K, Al, Si, Ti), several enhancements to the Decoupled Direct Method (DDM) tool, updates to support source apportionment for 1-way nested applications between hemispheric and regional scales, and an increased capacity for larger Probing Tool applications.

Siqi Ma
Presentation: 2530
Presentation *https://www.cmascenter.org/conference/2020/slides/Ma_LISTOS_CMAS_2020.pdf*

Ma: Improving ozone and nitrogen dioxide forecasting over the Long Island Sounds with dynamical boundary conditions, rapid emission refresh, and chemical data assimilation

Siqi Ma1,2, Daniel Tong2,3,*, Lok Lamsal4,5, Julian Wang6, Youhua Tang3,6, Tianfeng Chai4, Pius Lee6, Patrick Campbell3,6, Barry Baker3,6, Rick Saylor6
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Although Air quality in the United States has improved remarkably in the past decades, ground-level ozone continues to rise to exceed the national ambient air quality standards in many nonattainment areas, including the Long Island Sounds (LIS) and its surrounding areas. Accurate prediction of high ozone episodes is highly desirable to assist air quality and health agencies in mitigating the harmful effects of air pollution. Here we employ a suite of forecasting techniques, including rapid emission refresh and chemical data assimilation, to assess the effectiveness of different techniques on improving forecasting performance for ozone (O3) and nitrogen dioxide (NO2) with a high-resolution (3 km) Community Multi-scale Air Quality (CMAQ) modeling system over the LIS region. All simulations were conducted for a high ozone episode (August 25~31, 2018) during the 2018 Long Island Sound Tropospheric Ozone Study (LISTOS), which provides abundant observations for evaluating model performance. The results show that each of these forecasting techniques employed in this study is able to enhance the capability of the forecasting model. Individually, the most significant improvement comes from the dynamic boundary conditions derived from NOAA National Air Quality Forecast Capability (NAQFC), which increases the correlation coefficient (R) of O3 from 0.81 to 0.93 and reduces the Root Mean Square Error (RMSE) from 14.97 ppb to 8.22 ppbv, compared to that without the NAQFC boundary conditions. This is due in part to the accuracy in NAQFC prediction and the relatively small model domain used in this study that is more susceptible to the influence of regional transport. The results that applied multi-method adjustments with both dynamic BCs and data assimilation (optimal interpolation) presented the best simulating ability on surface activities, while it resulted in significant overestimations when reproducing the vertical profiles of O3 and NO2. Therefore, the decrease of NOx emission adjustment, which decreased the emission levels, showed a positive influence on vertical simulation. This study demonstrates a high-resolution O3 forecasting system that has high performance on both surface and vertical simulation, and this system has already been applied for the daily predictions of O3, NO2 and $PM_{2.5}$.

Gavendra Pandey
Presentation: 2551
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS_Gavendra_Final-2020.pdf*

Pandey: Effect of Atmospheric stability on Modeling Air Quality In and Around a Major Airport

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The impact of airport operations on air quality is a key public health concern for the population surrounding an airport. Air pollution regulations require the assessment of this impact using dispersion models. Modeling dispersion of aircraft-related sources poses challenges because of the large number and variety of airport sources, which include aircraft, ground operation vehicles, and traffic in and out of the airport, most of which are mobile. Emissions from these sources are transient, buoyant, and occur at different heights from the ground. Quantifying these emissions as well as modeling the governing processes is challenging. An added complexity occurs when the airport is situated near a shoreline where meteorological conditions are far from being spatially uniform. These features that characterize

the dispersion of airport emissions are being incorporated into the model described in this paper. The relative importance of each of these features is being evaluated by comparing model estimates of NOx and SO2 with corresponding measurements made during a field study conducted at the Los Angeles International Airport (LAX) during February and March of 2012 as part of the LAX Air Quality Source Apportionment Study (AQSAS). We focused on SO2 measurements, a useful tracer of aircraft operations, made at four locations named AQ, CN, CE, and CS. This paper focuses on the impact of shoreline meteorology on dispersion. In the current phase of the project, we used components of AERMOD and AERMET as the building blocks of the new model. We modified results from AERMET to account for the formation of the internal boundary layer that is formed when stable air from the ocean flows onto the warmer land surface of the airport. Simulations with unmodified AERMET yielded concentrations that were substantially higher than the concentrations at AQ and CS and much lower than those at CN and CE. Model performance, characterized with Q-Q plots, improved substantially by replacing meteorological parameters such as friction velocity and Monin-Obukhov (M-O) length during stable conditions with those corresponding to neutral conditions. The fraction of model estimates within a factor of two of the observations improved from 34 to 51% at the CN site and at the CS site, by up to 25%. The ratio of medians of the observed to the modeled concentrations improved from 4.2 to 2.8 at the CS site and showed little change at the CN site. The correlation coefficients between the monthly averaged diurnal profiles improved from -0.08, -0.28, 0.53, and -0.37 to -0.04, 0.39, 0.60, and 0.31 for AQ, CN, CS, and CE, respectively.

Elyse Pennington
Presentation: 2471
Presentation *https://www.cmascenter.org/conference/2020/slides/pennington-CMAS-2020.pdf*

Pennington: A Model to Represent SOA Formation from Volatile Chemical Products

Elyse Pennington, Karl Seltzer, Havala Pye, Melissa Venecek, John Seinfeld

Volatile chemical products (VCPs) have important implications for air quality but are not well characterized. Field studies have demonstrated the prevalence of gas-phase VCPs in urban environments, but few chamber studies have been performed to quantify their ability to form secondary organic aerosol (SOA). Quantitative structure-activity-relationships (SAR) models describe the properties and activities of compounds based on their chemical structure and are useful in the absence of empirical data. We use existing SAR models to estimate reactivity against OH and other oxidants, volatility, partitioning and heterogeneous uptake coefficients, and other parameters relevant to SOA formation. Oxidation products and SOA yields are estimated using multigenerational oxidation schemes and compared to published yields. We compile the results of these simulations to present a broad level understanding of the ability of VCPs to form SOA. A binned volatility model predicts SOA formation from VCPs that are currently unspeciated in air quality models. This model improves our understanding of the environmental fate of VCPs, specifically the impact on SOA mass and speciation. This model can be implemented in CMAQ to better represent anthropogenic SOA formation.

Arman Pouyaei
Presentation: 2452
Presentation
https://www.cmascenter.org/conference/2020/slides/CMAS_2020_CTRAIL_Arman_Pouyaei.pdf

Extended Abstract
https://www.cmascenter.org/conference/2020/abstracts/Extended_Abstract_CTRAIL_Arman_Pouyaei-2020.pdf

Pouyaei: Concentration Trajectory Route of Air pollution with an Integrated Lagrangian model (C-TRAIL Model v1.0) derived from CMAQ

Arman Pouyaei, Yunsoo Choi, Jia Jung, Bavand Sadeghi, Chul Han Song

We introduce a novel Lagrangian model (Concentration Trajectory Route of Air pollution with an Integrated Lagrangian model, C-TRAIL version 1.0) output from CMAQ Eulerian-based air quality model for validating the source–receptor direct link by following polluted air masses. To investigate the concentrations and trajectories of air masses simultaneously, we implement the trajectory-grid (TG) Lagrangian advection scheme in the CMAQ model version 5.2. The TG algorithm follows the concentrations of representative air "packets" of species along trajectories determined by the wind field. The diagnostic output from C-TRAIL accurately identifies the origins of pollutants. For validation, we analyze the results of C-TRAIL during the KORUS-AQ campaign over South Korea. Initially, we implement C-TRAIL in a simulation of CO concentrations with an emphasis on the long- and short-range transport effects. The output from C-TRAIL reveals that local trajectories were responsible for CO concentrations over Seoul during the stagnant period (17–22 May 2016) and during the extreme pollution period (25–28 May 2016), highly polluted air masses from China were distinguished as sources of CO transported to the Seoul Metropolitan Area (SMA). We conclude that during the study period, long-range transport played a crucial role in high CO concentrations over the receptor area. Furthermore, for May 2016, we find that the potential sources of CO over the SMA were the result of either local transport or long-range transport from the Shandong Peninsula and, in some cases, from regions north of the SMA. By identifying the trajectories of CO concentrations, one can use the results from C-TRAIL to directly link strong potential sources of pollutants to a receptor in specific regions during various time frames.

Youhua Tang
Presentation: 2451
Presentation *https://www.cmascenter.org/conference/2020/slides/Tang-cmas-2020-D.pdf*

Tang: An Improved National Air Quality Forecasting Capability Using the NOAA Global Forecast System. Part II: Science Advancements and Evaluations

Youhua Tang1,2, Patrick C. Campbell1,2, Pius Lee1, Barry Baker1,2, Daniel Tong1,2, Rick Saylor1, Ariel Stein1, Jianping Huang3,4, Ho-Chun Huang3,4, Edward Strobach3,4, Jeff McQueen3, Ivanka Stajner3, Dorothy Koch5, Jose Tirado-Delgado5,6, and Youngsun Jung5
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The existing NOAA National Air Quality Forecasting Capability (NAQFC) is using CMAQ 5.0.2 with cb05 chemical mechanism driven by the North American Mesoscale Forecast System (NAM). As one of our efforts to upgrade this system, the Part I described the overview of the next-generation upgrade that uses the latest CMAQv5.3.1 CB6r3-Aero7 model, driven by the NOAA operational forecast based on the Finite Volume Cubed-Sphere (FV3)-Global Forecast System (GFS), version 16. The meteorological preprocessor for CMAQ was also overhauled based on the seminal version of the NOAA-ARL Atmosphere-Chemistry Coupler (NACC), i.e., NACC-CMAQ. Differing from the normal WRF-ARW/CMAQ

system, the interpolation-based coupler can use various meteorological output to drive CMAQ even they are in different grids. Here in Part II, we evaluate NACC-CMAQ against numerous observation networks (e.g., U.S. EPA AirNow) for the effect of different scientific configurations and NOAA-ARL advancements on the surface $PM_{2.5}$/ozone predictions over the contiguous United States (CONUS) in summer 2019. The NACC-CMAQ prediction interpolated by FV3GFSv16 meteorology showed better results than that driven by the corresponding WRF downscaling meteorology. We tested the NACC-CMAQ for the impacts of its existing scientific packages, including the dry deposition schemes of Surface Tiled Aerosol and Gaseous Exchange (STAGE) versus M3Dry, and the runs with and without bidirectional NH3 exchange, compared to AIRNow network for summer 2019. Besides these standard NACC-CMAQ features, we also tested the modules developed in NOAA-ARL, such as the inline FENGSHA dust module with updated land/soil datasets. The fire emission based on Global Biomass Burning Emissions Product eXtended (GBBEPx) can be available in near real-time, and using that emission improved the model's correlation coefficient. An updated global lateral boundary condition based on Tang et al. (2020, https://doi.org/10.5194/acp-2020-587) improved the surface ozone prediction over CONUS. This tuning effort and evaluation will help not only improve the NAQFC's prediction, but also serve as the testbed for the NOAA future inline regional air quality modeling system.

Jose Tirado
Presentation: 2549
Presentation https://www.cmascenter.org/conference/2020/slides/CMAS-2020-Jose-Tirado.pdf

Tirado: National Air Quality Forecast Capability prediction updates and current operational skill

Jose Tirado-Delgado1,9, Dorothy Koch1, Youngsun Jung1, Ivanka Stajner2, Jeff McQueen2, Pius Lee3, Jianping Huang2, 5, Ho-Chun Huang2, 5, Edward Strobach2, 5, Youhua Tang3,6, Daniel Tong3, 6, Patrick Campbell3, 6, Ariel Stein3, James Wilczak4, Irina Djalalova4,8, Phil Dickerson7
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The National Weather Service (NWS) National Air Quality Forecast Capability (NAQFC) provides operational Air Quality predictions of ozone, fine Particulate Matter ($PM_{2.5}$), smoke and dust for the continental United States (CONUS), Alaska, and Hawaii. The forecast guidance is available to the general public at airquality.weather.gov and as GIS webservice at *https://idpgis.ncep.noaa.gov/arcgis/rest/services/NWS_Forecasts_Guidance_Warnings*. The current operational model is an implementation of the Community Multiscale Air Quality (CMAQ) V5.0.2 model with NEI 2014v2 linked with the NOAA National Centers for Environmental Prediction (NCEP) North American Mesoscale (NAM) regional weather prediction model at 12 km to 48 hours for 06 and 12 UTC cycles. This capability includes a bias corrected product using the Kalman Filter Analog (KFAN) technique to reduce prediction errors for both ozone and $PM_{2.5}$. This presentation provides an overview of the current operational model performance and experimental updates planned for future possible operational implementation. Future updates include the development of a new chemistry meteorology coupler, the NOAA-ARL Atmosphere-Chemistry Coupler (NACC), to link the most recent version of CMAQ (V5.3.1) with NOAA's next-generation operational Global Forecast System (GFSv16) that uses the NOAA

Geophysical Fluid Dynamics Laboratory Finite Volume Cubed-Sphere (FV3) dynamical core. This upgrade will allow for several improvements including the extension of our forecast guidance from 48 to 72 hours with bias correction and improved emissions processing of aerosols. Wildfire smoke improvements will use emissions estimates based on NOAA-NESDIS Blended Global Biomass Burning Emissions Product extended (GBBEPx) and dust emissions processing and estimates will benefit from an improved inline FENGSHA dust module. We will also use one member of the operational Global Ensemble Forecast System (GEFS) at 25 km that will include aerosols for improving chemical lateral boundary conditions including influxes of dust and smoke aerosols. We will present results of these recent updates and future plans to include inline chemistry for the FV3 LAM.

Kai Wu
Presentation: 2456
Presentation *https://www.cmascenter.org/conference/2020/slides/KaiWu-CMASpre-2020.pdf*

Wu: Modeling ammonia and its uptake by secondary organic aerosol over China

Kai Wu, Christopher D. Cappa, Shupeng Zhu

Atmospheric ammonia (NH3) can affect nitrogen deposition, particle acidity, gas-particle partitioning, and, potentially, aerosol uptake process. One aspect of the atmospheric chemistry of ammonia insufficiently considered to date is the impact of interactions between gas-phase ammonia and secondary organic aerosol (SOA) on air quality. Laboratory studies indicate that NH3 can react with SOA, converting gas-phase NH3 into particulate organic matter, with consequent impacts on particulate matter composition and properties. In this study, we use a modified version of the CMAQ model to simulate the potential importance of the SOA-ammonia uptake mechanism on air quality over China in summer and winter 2017, considering a range of assumed NH3 uptake coefficients (10-3-10-5). Our results show that uptake of NH3 by SOA leads to a decrease in gas-phase NH3 concentration, by as much as 27.5% and 19.0% for the highest uptake coefficient scenario of 10-3 in summer and winter, respectively. The largest reduction of ammonia occurs over the Sichuan Basin and North China Plain. The reduction of gas-phase NH3 engenders a decrease of ammonium nitrate, by up to 30%, but has little impact on the ammonium sulfate concentration. Uptake of NH3 does not significantly affect SOA concentrations owing to overall moderate changes in aerosol acidity, and thus small effects on SOA formation from isoprene (which is sensitive to pH). Altogether, NH3 uptake led to a reduction in the average $PM_{2.5}$ concentration up to 8.9% and 8.7% for the highest uptake coefficient (10-3) in summer and winter, respectively. These results indicate the need for better constraints on the NH3-SOA uptake coefficient.

Shuping ZHANG
Presentation: 2447
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS-HONO2020.pdf*

Zhang: Significant contribution of heterogeneous reactions to the nitrous acid formation during winter in Beijing, China

Shuping Zhang, Golam Sarwar, Jia Xing, Biwu Chu, Chaoyang Xue, Arunachalam Sarav, Tao Ma, Dian Ding, Haotian Zheng, Yujing Mu, Fengkui Duan, Hong He

Nitrous acid (HONO) plays important roles in atmospheric chemistry since it undergoes photolysis during the day and produces hydroxyl radical (OH) which reacts with organic and inorganic compounds and alters atmospheric composition. In this study, we apply the Community Multiscale Air Quality

(CMAQv5.3) model to simulate air quality in China for December 2015 and compare model predictions with observed data in Beijing. The CMAQv5.3 model severely underestimates observed HONO concentration (Normal Mean Bias = -95%). We revise the original HONO formation reactions and also implement several additional HONO formation reactions. The revised chemistry substantially enhances HONO prediction and improves the model performance (Normal Mean Bias = -5%). Model results suggest that the heterogeneous reaction on the ground surface is the most significant reaction contributing ~80% of the predicted night-time and ~60% of the day-time surface HONO concentration. Enhanced HONO production increases OH concentrations. Predicted OH concentration without the updated HONO chemistry is substantially lower than the observed data. However, the model with the updated HONO chemistry successfully reproduces the observed OH concentration. The updated model also enhances ozone, inorganic aerosols, and secondary organic aerosols in Beijing winter. The presentation will include additional analysis and a comparison of model predictions with available observed data in China.

6. Modeling to Support Exposure and Health Studies and Community-scale Applications (10/29)

2020-10-29

Jacob Becker
Presentation: 2529
Presentation *https://www.cmascenter.org/conference/2020/slides/jacob-becker-CMAS2020.pdf*

Becker: Mapping yearly global surface ozone through Regionalized Air Quality Model Performance corrections and Bayesian Maximum Entropy data fusion of observations and model output for 19902017

Jacob S. Becker, Marissa N. DeLang, Kai-Lan Chang, Marc L. Serre, Owen R. Cooper, Martin G. Schultz, Sabine Schröder, Xiao Lu, Lin Zhang, Makoto Deushi, Beatrice Josse, Christoph A. Keller, Jean-François Lamarque, Meiyun Lin, Junhua Liu, Virginie Marécal, Sarah A. Strode, Kengo Sudo, Simone Tilmes, Stephanie Cleland, Elyssa Collins, J. Jason West

Station based observations provide high fidelity estimates of ground-level ozone, but provide low spatial coverage, while models are less accurate but have the advantage of global coverage. We use the Bayesian Maximum Entropy (BME) and Regionalized Air Quality Model Performance (RAMP) frameworks to integrate observations from 7,269 globally distributed surface monitoring sites from the Tropospheric Ozone Assessment Report and 1,565 sites from the Chinese National Environmental Monitoring Center Network, with nine global atmospheric chemistry models. Observations and models from 1990-2017 were first aggregated into daily maximum 8-hour average (mda8) values for each year. Then, a multi-model composite is created with the M3 Fusion method which weights models in a given continent and year by their predictive ability. We then further refine this composite with RAMP, a non-homogenous, non-linear, non-homoscedastic bias correction. RAMP corrects on a smaller scale than M3 fusion by correcting each model point based on the model trends at the nearest observations. Posterior to this, BME corrects the RAMP estimate by matching observations, with the observational influence decreasing across space and time until the output matches the multi-model or RAMP composite. The method successfully incorporates observations, as quantified by an R2 increase from 0.28 when using only the M3 Model to 0.49 when using the RAMP corrected model when compared to monitor values. BME

greatly increases R2 to 0.81 when using the M3 Model and 0.83 when using the RAMP corrected model as the global background. Our final product estimates annual global surface ozone for each year between 1990 and 2017 at 0.1° resolution.

Golnoosh Bizhani
Presentation: 2460
Presentation *https://www.cmascenter.org/conference/2020/slides/RWDI_Peel_CMAS2020.pdf*

Bizhani: Air Quality Impact of Off Peak Delivery of goods in the Regional Municipality of Peel

Martin Gauthier, Jeff Lundgren, Greg Conley, Julia Veerman, Jyotsna Kashyap, Golnoosh Bizhani, Louise Aubin, Nancy Lotecki, Kathie Brown

Over the past six years the Regional Municipality of Peel has undertaken a project to develop a flexible and comprehensive air quality modelling system, the purpose of which is to study the impacts of potential emission scenarios, and to guide policy decisions relating to public health, urban growth, and sustainability programs. The modeling system is based on WRF/SMOKE/CMAQ and has been used with nested 36-km, 12-km, 4-km and 1-km resolution grids to perform year-long model simulations for year 2015. The Regional Municipality of Peel has simulated the impact on air quality of an Off-peak delivery (OPD) emission scenario, where delivery of goods occurs during evening and overnight hours. Emissions processing was performed using SMOKE to temporally and spatially allocate the truck delivery emissions in the off-peak period. This presentation will lay out assumptions and methodology and will present preliminary results of the impact of OPD on air quality and the potential for using the modelled results for Health impact assessment.

Michael Breen
Presentation: 2491
Presentation *https://www.cmascenter.org/conference/2020/slides/breen_cmas_2020.pdf*

Breen: Integrating CMAQ Model into Smartphone App (TracMyAir) for Modeling Exposures to Ambient $PM_{2.5}$ and Ozone

Michael Breen, Catherine Seppanen, Vlad Isakov, Sarav Arunachalam, Miyuki Breen, James Samet, Haiyan Tong, Wayne Cascio

Epidemiological studies of ambient fine particulate matter ($PM_{2.5}$) and ozone (O3) often use outdoor concentrations from central-site monitors as exposure surrogates. Failure to account for variability of indoor infiltration of ambient $PM_{2.5}$ and O3, time spent indoors, and personal inhalation rates can introduce exposure errors. Personal air pollution measurements are often not feasible, and currently available exposure models require substantial technical expertise and near real-time exposure estimates are not possible since they require collection, organization and processing of large and diverse input data. To address these limitations, we developed a smartphone-based exposure model called TracMyAir, which automatically determines individual-level exposure metrics in real-time for ambient $PM_{2.5}$ and O3. The input data for TracMyAir includes: (1) outdoor concentrations from the nearest air pollution monitors, (2) outdoor temperatures and wind speeds from the nearest weather stations, (3) the user's geolocation and physical activity level (PAL) from smartphone sensors, and (4) the user's home building characteristics and operating conditions. We previously linked a building infiltration model, geolocation-based microenvironment model, and PAL-based inhalation rate model to determine

personal exposures and inhaled doses. In this study, we integrated the CMAQ air quality model into the TracMyAir smartphone app to account for the spatio-temporal variability of outdoor $PM_{2.5}$ and O3 concentrations, and enable future forecasting capabilities. The extended TracMyAir app is being evaluated in a pilot study in central North Carolina. Using CMAQ to account for the variability of outdoor air pollutants can improve TracMyAir's exposure assessments for epidemiological investigations, in support of improving health risk assessments. Also, CMAQ's forecasting capability would enable TracMyAir to be used for public health strategies to help at risk individuals reduce their exposures to ambient air pollutants, such as wildfire smoke.

Emma D'Ambro
Presentation: 2441
Presentation
https://www.cmascenter.org/conference/2020/slides/D_AmbroMurphy_CMAQPFAS_CMAS2020.pdf

D'Ambro: CMAQ-PFAS development for predicting the fate and transport of per- and polyfluoroalkyl substances (PFAS) in the atmosphere

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Per- and polyfluoroalkyl substances (PFAS) are a class of man-made compounds whose emissions to air may contribute, via transport and deposition, to concentrations in surface water, ground water, and private well water in the vicinity of large point sources. Air quality modeling techniques can be used to quantify air concentrations and deposition fluxes to help parse the role of exposure pathways such as direct inhalation and ingestion via contaminated water. We apply the Community Multiscale Air Quality model (CMAQ) version 5.3.2 to a case study in Eastern North Carolina to model the PFAS emissions and transport at fine scale (1 km) from the Chemours Inc. Fayetteville-Works. The 26 PFAS with the largest emissions by mass are identified and added explicitly to CMAQ, along with an aggregate "other PFAS" species to represent the balance of the emissions. An updated deposition parameterization (Surface Tiled Aerosol and Gaseous Exchange, STAGE) is utilized along with estimated chemical properties for each species to simulate the deposition flux to specific, sub-grid land surface types. Thus, the updated model (CMAQ-PFAS) captures the dynamic transformations and removal processes that affect the extent of atmospheric transport of PFAS. The Fayetteville-Works site is unique as it is the only fluoropolymer manufacturer to our knowledge to provide a detailed accounting of quantified speciated emissions. We evaluate the impacts on air concentration and deposition of assuming consistent emissions throughout the year versus daily varying emissions. Next, we evaluate the role of explicit speciated emissions relative to different lumping mechanisms within CMAQ-PFAS. Finally, we examine the role of chemistry on fate, namely phase transformations, by assuming a hydrolysis of acyl fluorides to carboxylic acids with a simplified approach assuming instantaneous conversion. Our findings will help inform the level of emissions detail needed from other facilities for accurate future modeling efforts.

Disclaimer: The views expressed in this presentation are those of the authors and do not necessarily reflect the views or policies of the U.S. EPA.

CHENG-PIN KUO
Presentation: 2479
Presentation *https://www.cmascenter.org/conference/2020/slides/2020_cmas_cpkuo.pdf*

Kuo: Assessing Heterogeneity of the Burden of Disease of $PM_{2.5}$ Exposure at Diverse Urbanizations with CMAQ-fused Data

Cheng-Pin Kuo a, Joshua S. Fu a
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Global Burden of Disease (GBD) of $PM_{2.5}$ exposure has been estimated by several previous studies and reports with different methodologies. However, although most of the researches considered the heterogeneity of spatial $PM_{2.5}$ exposure, they still used national-wide risk to estimate GBD and also overlooked the distribution of population and heterogeneous risks for people living at diverse levels of urbanizations. Thus, the following estimation of GBD must be largely biased. To approximate the facts, the diverse $PM_{2.5}$ exposure risk in diverse urbanizations and ambient $PM_{2.5}$ concentration should be applied simultaneously to estimate GBD. Also, the uncertainty between different methods should be quantified. Our objective is to identify the potential concerns and quantify the uncertainty of present GBD methodology with different risk and $PM_{2.5}$ exposure data. In this study, we developed a systematic methodology to calculate localized $PM_{2.5}$ exposure risk estimates and their heterogeneity in a rural and urban area. With collecting hospital emergency visit data, address data, air quality data, meteorological data, 1 km* 1km $PM_{2.5}$ emission data and 1 km * 1 km land-use patterns data, we used case-crossover study design and conditional logistic regressions to model the relationship between short-term $PM_{2.5}$ exposure and the consequent risks. Furthermore, to quantify the urbanization levels, we applied the heterogeneity index of the land-use living pattern (HLUL) and neighboring $PM_{2.5}$ emission densities of patients, estimating the risk for patients living in diverse levels of urbanizations. Also, to evaluate the uncertainty of using different $PM_{2.5}$ exposure data, we compared the measurement-applied estimates with CMAQ-fused results for areas with and without monitoring sites. We found that people residing in more urbanized areas would have a higher vulnerability of short-term $PM_{2.5}$ exposure for cardiovascular disease and these areas have higher hospital admissions due to higher population density. Meanwhile, we identified the overall uncertainty using different methods ranging from 14%-138% in our study area. In conclusion, we suggest the city or country without the local burden of disease estimations could utilize our approach to build their own estimations. Furthermore, the proposed burden of disease map would also facilitate re-assessment of the potential risk of present urban planning strategies, and provide a quantified reference for air quality implementation plans and emergency episode-response plans.

James Kelly
Presentation: 2468
Presentation *https://www.cmascenter.org/conference/2020/slides/JKelly_CMAS_exposure-2020.pdf*

Kelly: Examining $PM_{2.5}$ concentrations and exposure using multiple models

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Epidemiologic studies have found associations between fine particulate matter ($PM_{2.5}$) exposure and adverse health effects using exposure models that incorporate monitoring data and other relevant information. Here, we use nine $PM_{2.5}$ concentration models (i.e., exposure models) that span a wide range of methods to investigate i) $PM_{2.5}$ concentrations in 2011, ii) potential changes in $PM_{2.5}$ concentrations between 2011 and 2028 due to on-the-books regulations, and iii) $PM_{2.5}$ exposure (population-weighted concentrations) for the U.S. population and four racial/ethnic groups. The exposure models include two geophysical chemical transport models (CTMs), two interpolation methods, a satellite-derived aerosol optical depth-based method, a Bayesian statistical regression model, and three machine learning methods. We focus on annual predictions that were re-gridded to 12-km resolution over the conterminous U.S., but also considered 1-km predictions in sensitivity analyses. The exposure models predicted broadly consistent $PM_{2.5}$ concentrations; however, differences in national concentration distributions (median standard deviation: 1.00 ug m-3) and spatial distributions over urban areas were evident. $PM_{2.5}$ concentrations were estimated to decrease by about 1 ug m-3 on average due to modeled emission changes between 2011 and 2028, with decreases of more than 3 ug m-3 in areas with relatively high 2011 concentrations. About 50% of the population was estimated to experience $PM_{2.5}$ concentrations less than 10 ug m-3 in 2011 and $PM_{2.5}$ improvements of about 2 ug m-3 due to modeled emission changes between 2011 and 2028. Two inequality metrics generally yielded consistent information and suggest that the modeled emission reductions between 2011 and 2028 would reduce exposure inequality on average for the four racial/ethnic groups.

Brandon Lewis
Presentation: 2520
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS-Presentation-lewis-2020.pdf*

Lewis: Air Pollution and Environmental Justice Modeling: The Case for North Carolina's Concentrated Animal Feeding Operations (CAFO) and Hog Industry

Brandon Lewis*, Viney P. Aneja, William H. Battye

Concentrated animal feeding operations (CAFOs) produces tons of animal waste, which can inherently pollute air, soil and water when not properly processed and filtered. The concentration of hog production in North Carolina have raised concerns of the disproportionate exposure of air pollution on vulnerable communities. Pollutants such as ammonia, hydrogen sulfide, acetaldehyde, and methanol are emitted by CAFOs and at high enough concentrations could affect human health. This research investigates the exposure of ammonia and hydrogen sulfide and possible health impacts of nearby community members looking at the disparities that may exist between different subpopulations. Characteristic data from 483 hog facilities within Duplin County including locations and hog inventory were gathered and processed for point source dispersion modeling. Emission factors from the U.S. Environmental Protection Agency in cooperation with Carnegie-Mellon University were used in the calculation of ammonia and hydrogen sulfide emission rates. We used HEM-3, Human Exposure Model,

to estimate ambient concentrations of ammonia and hydrogen sulfide and the subsequent exposures on communities within Duplin County. We combine this with Census demographic data (2010) using spatial analysis to investigate whether exposures to these pollutants differ by race/ethnicity, age, income, education, and language proficiency. Based on these estimations, we assess associated health risks extenuating estimated concentrations. In this work, we limit our analysis to Duplin County, North Carolina. Results show that the average annual estimated concentration of ammonia in Duplin county is 6.05 µg/m3, and the average annual estimated concentration of hydrogen sulfide is 0.06 µg/m3. The max average annual ambient concentration estimated is 51.67 µg/m3 and 0.52 µg/m3 for ammonia and hydrogen sulfide, respectively. Among vulnerable populations within Duplin County results show that people of low income, minorities, people with low educational attainment, and the linguistically isolated are disproportionately exposure to higher levels of ammonia and hydrogen sulfide on average. The linguistically isolated are estimated to experience 101% higher levels of exposure and people with low educational attainment more that 45% higher levels. Block group characterizations indicate a high prevalence of hogs and associated higher pollutant exposures in the two highest quintile compared with the lowest quintiles for each of these subpopulations. The partial distribution of ammonia and hydrogen sulfide exposures and hog facilities among communities may have adverse health effects and environmental impacts.

Havala Pye
Presentation: 2450
Presentation *https://www.cmascenter.org/conference/2020/slides/202010_final_pye_cmas_clean.pdf*

Pye: Role of secondary organic aerosol in cardiovascular and respiratory disease mortality in the United States

Havala Pye,1 Cavin Ward-Caviness,1 Ben Murphy,1 Wyat Appel,1 Karl Seltzer2
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Fine particulate matter, $PM_{2.5}$, is associated with negative health outcomes including cardiovascular and respiratory disease deaths. Over the past few decades, the composition of $PM_{2.5}$ in the United States has undergone significant changes including a decrease in sulfate and increase in relative abundance of secondary organic aerosol (SOA). Combined with advances in modeling of SOA formation pathways (e.g oxidation of monoterpenes, isoprene, and anthropogenic volatile organic compounds) the role of SOA and its components in cardiovascular and respiratory disease death rates can be examined in a way not previously possible. In this work, we use $PM_{2.5}$ constituent concentrations from the Community Multiscale Air Quality (CMAQ) modeling system v5.3.1 (ww.epa.gov/cmaq) to examine the relationship between $PM_{2.5}$ organic aerosol (OA) components and combined cardiovascular and respiratory disease deaths. Using county-level data from the Centers for Disease Control and Prevention, we associated county-level cardiorespiratory mortality rates with SOA while adjusting for a broad array of relevant confounders. We find SOA is strongly associated with mortality independent of total $PM_{2.5}$ mass. Spatial variability in SOA across the U.S. is associated with a larger increase (per unit mass) in cardiorespiratory mortality rates than total $PM_{2.5}$; with the largest associations of SOA with mortality coming from counties in the southeastern U.S. Results indicate biogenic and anthropogenic carbon sources both play a role in the overall SOA association.

Komal Shukla

Presentation: 2542
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS_PPT_KS_Oct10-2020.pdf*

Shukla: Zip-code Level Air Quality and Health Impacts Screening Tool for Environmental Policy Evaluation in New York City

Saravanan Arunachalam, Komal Shukla*, Catherine Seppanen, Brian Naess, Charles Chang, David Cooley, Frank Divita, Andreas Maier,Sarah Johnson

Increasing $PM_{2.5}$ concentration levels are linked with deteriorating human health in megacities of the world. Current tools for estimating air quality, exposure, and health impacts provide county-wide, annual estimates but tools are needed for analysis at the neighborhood scales for the evaluation of energy and air planning policies. The goal of this study is to integrate two reduced form models – COBRA (Co-Benefits Risk Assessment Health Impacts screening tool) and C-TOOLS (Community Air Quality Tools)– that predict air pollution exposures and health impacts. Along with integrating these tools, we added custom higher resolution input datasets for emissions, health incidences and population for New York City (NYC) to allow for a finer-grained, more localized analysis (by zip code tabulation area (ZCTA) rather than county level) of the health benefits from air quality management decisions and perform rapid evaluation of various policy options. In this study, we used emissions inventories from the EPA's 2016 modeling platform, and augmented with NYC-specific high resolution activity-based inventories for the energy sector, buildings, commercial cooking and transportation. These were spatially allocated at each of 192 ZCTAs in all 5 boroughs in NYC, while retaining the ability to model air quality and health benefits due to implementing various policy scenarios for each of 12 individual emissions source categories. C-TOOLS uses these emissions to calculate $PM_{2.5}$ concentrations from all these sources at a network of receptors at high spatial resolution, and are then averaged for each ZCTA. The total $PM_{2.5}$ concentration is composed of primary $PM_{2.5}$ from C-TOOLS, and secondary $PM_{2.5}$ estimates from COBRA. Secondary $PM_{2.5}$ estimates in COBRA are derived using a source-receptor matrix that uses estimates of $PM_{2.5}$ precursor emissions at the zip-code level. The total $PM_{2.5}$ concentrations are then used with NYC-specific population and health incidence data (focused on both mortality and morbidity) in an updated version of COBRA. The novel integrated combined tool (C-TOOLS + COBRA for NYC) with a single web-based user interface will enable high-resolution assessments for each ZCTA or NYC-wide, and perform rapid evaluation of various policy options, specifically those that are already on the books such as the NYC Roadmap to 80x50 . The tool would allow users to analyze air quality and health benefits due to $PM_{2.5}$ from emissions reductions (or increase) scenarios. The key outputs of the novel integration would include changes in $PM_{2.5}$ concentrations, changes in incidence of mortality and morbidity due to $PM_{2.5}$, and monetary value of the public health impacts. In this presentation, we will present initial results from the air quality estimates at the zip-code level for $PM_{2.5}$ and its components, and comparisons against observations in NYC.

Alejandro Valencia
Presentation: 2514
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS2020_Presentation-valencia.pdf*

Valencia: Improving emissions inputs via mobile measurements to estimate fine-scale Black Carbon monthly concentrations through geostatistical space-time data fusion

Alejandro Valencia, Saravanan Arunachalam, Vlad Isakov, Brian Naess, and Marc Serre

Isolating air pollution sources in a complex transportation environment to quantify their contribution is challenging, particularly with sparse stationary measurements. Mobile measurements can add finer spatial resolution to support source apportionment, but they exhibit limitations when characterizing long term concentrations. Dispersion models can help overcome these limitations. However, they are only as reliable as their input emissions inventories. Herein, we developed a method to revise emissions and improve dispersion modeling predictions using stationary/mobile measurements. One specific revision estimated an adjustment factor of ~306 for warehouse emissions, indicating a significant underestimation of our initial estimates. This revised emission rate scaled up nationally would correspond to ~3.5% of the total Black Carbon emissions in the U.S. Nevertheless, domain revisions only contribute to a 4% increase of area source emissions while improving R2 values by up to 56%. After revising emissions for the dispersion model, we combine this model with stationary/mobile measurements through Bayesian Maximum Entropy (I-DISP BME) data fusion and compare to BME using only measurements (Flat BME). A 10-fold conventional cross-validation (representative of months with mobile measurements) shows that all BME methods have R2 values that range from 0.787 to 0.798. A 2-fold cross-validation (representative of months with no mobile measurements) shows that the R2 for I-DISP BME increases by a factor 90 when compared to Flat BME.

Robson Will
Presentation: 2483
Presentation *https://www.cmascenter.org/conference/2020/slides/presentation_cmas_robson_will-2020.pdf*

Will: Analysis of the performance of the WRF model in high latitude region of the southern hemisphere

Robson Will
Leonardo Hoinaski

This study analyzes the performance of the microphysics and boundary layer parameterizations of the WRF model in three cities in the south of Brazil, with different geographical conditions: one with high altitude (R1), one in the coastal region (R2), and one in the middle of the continental region (R3). The use of mesoscale meteorological models such as WRF is essential to enable exposure-response studies between atmospheric conditions and air quality-related diseases. The absence of local meteorological data makes it impossible to carry out assessments on the relations between air pollution, climate, meteorology, and hospital admissions. The errors and the association measures are performed using Bias, RMSE, correlation index, and Dpielke for five meteorological elements: temperature, atmospheric pressure, relative humidity, wind speed, and planetary boundary layer. Results for temperature show that different parameterizations are best suited for each of the analyzed regions, R1 (mp_physics-6, bl_pbl_physics-1, ρ = 0.46), R2 (mp_physics - 10, bl_pbl_physics - 7, ρ = 0.54) and R3 (mp_physics-6, bl_pbl_physics-7, ρ = 0.38). The differences between the configurations are repeated for the other climatic elements, demonstrating that the use of a single parameterization is not the best option to describe the meteorological conditions on a regional scale, requiring the division of each region in smaller areas considering geographic factors. We found combinations of parameters that can be a reference for new studies involving atmospheric pollution and meteorology in the entire high latitude region of the southern hemisphere, which has been little studied so far.

Matt Woody

Presentation: 2457
Presentation *https://www.cmascenter.org/conference/2020/slides/Woody_HEM4_CMAS-2020.pdf*

Woody: The Human Exposure Model, Version 4 (HEM4)

Matthew Woody, Ted Palma, Mark Morris, Darcie Smith, Steve Fudge, Chris Stolte, David Lindsey, and Jill Mozier

The U.S. Environmental Protection Agency (EPA) has released an updated version of its Human Exposure Model (HEM). EPA uses HEM to perform risk assessments for sources emitting air toxics to ambient air by combining (1) the atmospheric dispersion model, AERMOD, with included meteorological data, and (2) U.S. Census Bureau population data at the Census block level. Based on the inputs for source parameters and the meteorological data, AEMROD estimates the magnitude and distribution of ambient air concentrations in the vicinity of each source. Exposure estimates generated in HEM are based on the ambient air concentrations predicted by AERMOD. These exposure estimates are combined with pollutant health reference values (a library of which is also included) to estimate cancer risks and noncancer hazards, cancer incidence, and other risk measures. New features in HEM4 will include the ability to model outside the US (with user-supplied receptors), additional mapping and data viewing functionality, and the latest version of AERMOD with additional AERMOD options beyond those available in the previous version. This presentation will showcase the features of the new HEM4 and demonstrate the usefulness of the model and the summary programs.

Shunliu Zhao
Presentation: 2548
Presentation *https://www.cmascenter.org/conference/2020/slides/cmas2020-shunliu-zhao.pdf*

Zhao: Adjoint Estimates of Benefits per Ton of Reducing $PM_{2.5}$ precursor emissions in the U.S.

Shunliu Zhao, Burak Oztaner, Amir Hakami, Petros Vasilakos, Armistead G. Russell, Amanda Pappin, and the Adjoint Development Team

Benefit-per-ton (BPT) estimates are used by the U.S. EPA to quantify the human health impacts of reducing air pollutant emissions (Fann et al., 2009). Forward modelling approaches have been normally used with regional or sector-based emission reductions for estimating BPTs. Here we use the backward CMAQ adjoint model (CMAQ-ADJ; Zhao et al., 2020) to calculate the monetized benefits of reducing $PM_{2.5}$ primary and precursor emissions including those of $PM_{2.5}$, NOX, NH3, and SO2.

Source attribution of health impacts is based on various concentration response functions (CRFs) which link average $PM_{2.5}$ concentrations with mortality counts, and subsequent monetization using the value of statistical life. The variations in time (e.g., seasons) and space in BPT values shed additional light on the cost effectiveness of emission reduction measures. We evaluate BPTs for the U.S. at 36 and 12 km resolutions. We find that our BPT estimates at the two resolutions generally conform with each other and with existing estimates using other approaches; however, the adjoint model allows for greater granularity in delineating source impacts.

In addition to presenting our BPT estimates, our presentation will also include results from sensitivity analyses as to how BPT estimates are affected by the choice of model resolution and the CRF. We also discuss how using episodic simulations to represent annual health benefit estimation would impact BPT estimates. Finally, we compare our BPT estimates with those from reduced form models, and discuss limitations of adjoint BPTs.

7. Multiscale Model Applications and Evaluations (10/27)

2020-10-27

Sharmin Akter
Presentation: 2534
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS_2020_pdf-*SHARMIN_AKTER.pdf

Akter: Modeling the Contribution of Long-Range Transport to Nitrogen Deposition in U.S. Hydrological Regions

Sharmin Akter [1] , Michael Crowl [2], and Kristina Wagstrom [2]

The excessive deposition of atmospheric nitrogen containing species to aquatic systems and watersheds can lead to harmful algae growth and loss of biodiversity, particularly in coastal waterways. It increases the risk of acidification and hypoxia by reducing oxygen levels for living organisms in marine environments. It is important to determine the major species, source sectors, and source regions responsible for atmospheric nitrogen deposition to develop effective watershed management systems. We use the Comprehensive Air Quality Model with extensions (CAMx) version 6.0, along with the Particulate Matter Source Apportionment Technology (PSAT), to identify and separate source region contributions to atmospheric nitrogen deposition. We model the amount of atmospheric nitrogen deposition from each of the 18 Hydrologic Regions (2-digit Hydrological Unit Code) in the United States and southern Canada and northern Mexico. CAMx+PSAT provides the source-receptor relationships for atmospheric nitrogen concentrations and deposition. We use emissions, meteorology, boundary conditions, and ozone column inputs from the United States Environmental Protection Agency's 2011 Modeling Platform. We evaluate the dry and wet deposited mass of atmospheric nitrogen containing species against measurements. This information will aid environmental regulators in developing watershed management plans to protect the health of aquatic and terrestrial ecosystems.

Mastooreh Ameri
Presentation: 2528
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS-2020_Mastooreh Ameri.pdf*

Ameri: Investigating the influences of dust storms on precipitation in Iran using WRF-CHEM model

Mastooreh Ameria, Khosro Ashrafia, Sarmad Ghaderb, Mohammad Amin Mirrezaeia
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Aerosols affect the climate system in various ways, including direct reflection, absorbing incoming or outgoing short or long-wave radiation, or affecting cloud albedo and precipitation processes. Sand and dust storms are common meteorological hazards in arid and semi-arid regions. In this study, the main focus is on the role of dust storms on Iran's precipitation patterns. Dust storms originating from the west and southwest of Iran have the ability to affect weather through the changes in atmospheric humidity. These impacts are addressed using the Weather Research and Forecasting model coupled with chemistry (WRF-Chem 3.6.1). First, by comparing the Air Quality Monitoring stations of 30 provinces of Iran, Synoptic data of the capital cities and satellite maps of Aqua/AIS and MERRA-2 satellites, three four-day periods of dust storm events were selected which coincide with rainfall. Also, the extensive

distribution of precipitation through the domain was considered in determining the spatial-temporal precipitation patterns. Moreover, WRF physics and precipitation parameters have been chosen based on the appropriate schemes for Iran. In order to improve the accuracy of the simulation, the latest modification of microphysics and Cumulus parametrization schemes that have great importance for precipitation predictions has been applied. Second, the simulation variables such as temperature, pressure, wind speed and direction were validated by station reports. There was a reasonable positive correlation between simulated and observed data. The results of WRF-CHEM simulations depicted that in most diagrams, there is often a decline in the amount of precipitation, especially at the end of dust storm periods, in comparison to the WRF run series. Considering the aerosol-cloud feedbacks, the mean cumulative precipitation for the dust episodes during March, April and May were changed respectively from 12.45 mm to 12.84 mm, 31 mm to 30.86 mm and 8.79 mm to 7.78 mm. Also, the highest anomaly in total cumulative precipitation values was 0.8 mm, which was observed in the last day of May episode. Besides, the predicted PM10 and $PM_{2.5}$ values in western and southwestern regions such as Ahvaz, Zabol and Genaveh were less than observed values, which is acceptable, as these regions are exposed to high levels of dust storms. Moreover, at the early stages of the dust storm, there is a decline in values of precipitation caused by radiative forcing and humidity reduction and then, rainfall rises due to indirect effects including, CCN activation. Finally, the results revealed that aerosols play a pivotal role in precipitation patterns and the dominant impact is reducing the rainfall amounts, especially in the regions which are severely affected by dust storms.

Wanying CHEN
Presentation: 2532
Presentation *https://www.cmascenter.org/conference/2020/slides/wanying-chen-Source-apportionment-of-ozone-Pearl-River-Delta-2020.pdf*
Extended Abstract *https://www.cmascenter.org/conference/2020/abstracts/chen-Extended-abstract-2020.pdf*

Chen: Source apportionment of ozone under different synoptic patterns in the Pearl River Delta region

Wanying CHEN, Yiang CHEN, Xingcheng LU, Jimmy C.H. FUNG*

In recent years, with the effective control of fine particulate matter ($PM_{2.5}$) by the government, the concentration of $PM_{2.5}$ in the Pearl River Delta (PRD) region has decreased gradually. However, the pollution problem characterized by a high concentration of ozone is sequentially emerging. In the case of relatively stable emissions, the meteorological condition is an essential factor affecting ozone pollution. Therefore, exploring the contribution of various source regions and source categories to the O3 concentration under different synoptic patterns is an integral part of regional atmospheric environmental research. In this work, the Comprehensive Air Quality Model with extension (CAMx) modeling system with Ozone Source Apportionment Technology (OSAT) module was applied to analyze the influence of particular synoptic patterns, including sea high pressure, equalizing pressure field and subtropical high pressure, on ozone concentration and source contribution covering the PRD region. The results showed that the concentration of ozone increased under three meteorological conditions. Under distinctive synoptic patterns, the emissions outside PRD have the most significant contribution invariably. Preceded by the cross-boundary transport, mobile and biogenic sources attribute to the highest contribution under subtropical high pressure and sea high pressure, respectively. With the effect of the subtropical high pressure, the local contribution in the PRD region increased significantly,

especially in Guangzhou (+7.9%) and Huizhou (+6.3%), compared with the monthly mean contribution. As the equalizing pressure field changed the direction of the southernly prevailing wind in April, the contribution of emissions outside the PRD increased by 6.3%, compared with the monthly contribution. Our results indicated that collaborative emission control measures should be strengthened with the surrounding area. Combined with the meteorological situation, controlling the endogenous emission in the PRD plays a pivotal role in preventing O3 pollution.

Shih Ying Chang
Presentation: 2472
Presentation *https://www.cmascenter.org/conference/2020/slides/changsy-TDep_MMF_CMAS_2020_v3.pdf*

Chang: TDep Measurement Model Fusion (MMF) method to fuse modeled and measured air quality data to estimate total deposition with Python geoprocessing

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To assess spatial and temporal trends in annual atmospheric deposition, the Total Deposition Science Committee (TDep) under the National Atmospheric Deposition Program (NADP) developed a measurement-model fusion (MMF) method to estimate fluxes of total, wet, and dry deposition of sulfur, nitrogen, base cations, and chloride. The TDep method provides interpolated maps of annual deposition from the year 2000 to the present, using a modeling approach that fuses the Community Multiscale Air Quality (CMAQ) model data with data from ambient air quality and wet deposition monitoring sites. Due to its large spatial coverage, fine spatial resolution (i.e. 4 x 4 km2), and multiple data sources, the TDep approach involves complex geoprocessing steps that require an organized and iterable implementation to support ongoing data production and future process enhancements. In an effort to modernize and streamline the method and facilitate the development of new features, a new modularized Python geoprocessing TDep application was developed. The TDep dry deposition estimates are constructed by combining measurement-adjusted, CMAQ-modeled dry deposition fluxes with “measured” dry deposition fluxes cast as the product of spatially resolved CMAQ-modeled deposition velocities and ambient pollutant concentrations measured in the Clean Air Status and Trends Network (CASTNET). The TDep wet deposition estimates are constructed by first fusing an annual modeled precipitation field (Parameter-elevation Regression on Independent Slopes Model; PRISM) with precipitation data measured by NADP networks (National Trends Network; NADP/NTN and Mercury Deposition Network). The fused precipitation grid is combined with annually aggregated NADP/NTN precipitation chemistry measurements to calculate the wet deposition. Wet and dry deposition grids are combined to estimate the total annual deposition of pollutants. In this presentation, we will focus on the methodology of the TDep MMF method and the development and structure of the updated Python geoprocessing application. The developed Python framework breaks down the TDep approach into six modules: (1) data ingestion, (2) data interpolation, (3) bias adjustment for modeled data, (4) data fusion, (5) data aggregation, and (6) product export. Through the modularized framework, the Python application has greatly reduced the complexity of the codebase and will support streamlined processing. The new TDep framework will facilitate future improvements to the TDep MMF method, such as inclusion of satellite

data or CMAQ-modeled wet deposition to improve the accuracy of interpolation for locations without available monitoring sites.

James East
Presentation: 2490
Presentation *https://www.cmascenter.org/conference/2020/slides/2020-10-19_CMAS_EastJames_noaudio.pdf*

East: Implementing satellite NO2 data assimilation in CMAQ for identifying emissions biases and improving regional boundary conditions

James East, Barron Henderson, Shannon Koplitz, Sergey Napelenok, Fernando Garcia Menendez, Allen Lenzen, Brad Pierce

We adapt a composition assimilation framework to identify potential biases in NOX emissions on the regional and hemispheric scale. The assimilation framework was developed as a part of NASA HAQAST and can be used to improve model agreement with satellite retrievals directly or to infer emissions updates. Assimilated results are useful for hemispheric-scale modeling as boundary conditions for free running simulations, while emissions inferences are valuable for emissions quality assurance and rapid emission updates at either scale. The results in this presentation will focus on inferring emissions updates, which can subsequently be used in free running simulations.

We apply a 3-D variational data assimilation technique in CMAQ over the continental US (CONUS) to fuse satellite-based NO2 observations measured by OMI and TROPOMI with modeled NO2. We relate the analysis increment (the difference between the assimilated and unassimilated total NO2 vertical column) to emissions biases through a sensitivity parameter to infer spatially resolved monthly average emissions changes.

On the regional scale over the US, we find that modeled NO2 columns have a small but ubiquitous low bias compared to satellite NO2, but that much of this difference occurs in the upper troposphere. This leads to an iterative inference of lightning NO production rates first and then anthropogenic emissions. After accounting for lightning NO, a priori anthropogenic emissions generally produce modeled columns that match the satellite-infused column and do not require updating. However, over some urban areas and shipping channels, we infer small emissions increases on the order of 2-3%. There are larger widespread analysis increments in the northwestern US and southern Canada, which may be attributable to uncertainties in soil NOX emissions.

Results suggest possible biases on natural and anthropogenic emissions inside the CONUS domain. In addition, these results lay the framework for assimilation on the hemispheric scale. The presentation will introduce initial hemispheric results of the analysis increment and top-down constraints on uncertain emissions outside the CONUS domain that are currently underway.

Tugce Erdem
Presentation: 2544
Presentation *https://www.cmascenter.org/conference/2020/slides/Presentation-TugceErdem-2020.pdf*

Erdem: Estimating Societal Damages from Aviation Emissions in Canada

Tugce Erdem, Yasar Burak Oztaner, Marjan Soltanzadeh, Amir Hakami, and the Adjoint Development Team

Aviation emissions contribute to adverse health impacts mainly resulting from landing/take-off, from cruising emissions of primary particulate matter and precursors of secondary particulate matter and ozone. Ground service vehicles and airport-related traffic that are non-aircraft emissions also cause a significant rise in health impacts. This study applies the adjoint version of the U.S. Environmental Protection Agency's air quality model, the Community Multi-scale Air Quality (CMAQ) model to quantify location-specific aviation benefit-per-tons (BPTs), or the health-related benefits of reducing one additional unit mass of pollutants associated with aviation emissions for use in benefit-cost analysis and health policy assessment. The analyses are performed for a national scale (12 km) and include BPT estimates for cruising and landing/take-off phases of commercial flights. Our estimates show that aviation associated health benefits can be as high as $1,370,000 per ton of reduction of $PM_{2.5}$ and $53,000 per ton of reduction of NOx emissions. The largest health benefit estimates are attributed to landing/takeoff that contributes to a quarter of the benefits.

Christina Feng Chang
Presentation: 2459
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS_2020_FengChang_etal.pdf*

Feng Chang: On the Sensitivity of a Machine Learning-Based Model to Predict Chlorophyll- Using Multi-Media Modeling Environmental Predictors

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In the past, we have introduced the concept of using multi-media modeling and machine learning (ML) to assess environmental variables (predictors) that affect water quality by using Lake Erie as a case study. Since then, we have improved our water quality model by utilizing outputs from updated versions of the numerical prediction models. This time, we will focus on the influence of each set of predictors (meteorological, air quality, hydrological and agricultural) by varying the usage of the ML-based model inputs through various sensitivity tests. In-situ chlorophyll-α (chlor-α) measurements, which serve as a proxy for harmful algal blooms (HABs), are provided by the Lake Erie Committee Forage Task Group (LEC FTG) for the 2002-2012 period. Meteorological weather variables from WRF, hydrological variables from VIC, nitrogen deposition from CMAQ, and agricultural management practice variables from EPIC for the 11-year period are used to fit a random forest ML model to predict chlor-α concentrations. We discuss the importance of explanatory variables that originate from these individual modeling systems, and analyze the contribution of each covariate in the model to better understand the occurrence of high chlor-α concentrations. As HABs and hypoxia continue to threaten water bodies across the nation, lessons learned from developing and testing this ML-based approach can be used to tackle water quality problems in other lakes or coastal areas and inform policy decisions.

Lucas Henneman
Presentation: 2489
Presentation
https://www.cmascenter.org/conference/2020/slides/Henneman_CMAS20201006_share.pdf

Henneman: Four decades of United States on-road air pollution: spatial-temporal trends assessed by ground-based monitors, air quality models, and satellites

Lucas RF Henneman, Huizhong Shen, Armistead G Russell, Corwin M Zigler

On-road emissions sources have been strictly regulated over the past 40 years due to their propensity to increase traffic-related air pollution (TRAP) concentrations. Epidemiologists have linked increased exposure to TRAP with many adverse health impacts and inequities; often, these studies employ simple metrics such as road proximity or more complex modeled air pollutants to estimate exposure. We assess the ability of distance-based metrics, two long-term CMAQ modeling products, and multiple satellite records to reproduce observed spatial TRAP gradients and their evolution over time using a hierarchical linear regression. Overall, road proximity explained decreasing variability in observed spatial-temporal trends as time passed between 1980 and 2019. CMAQ simulated CO and EC concentrations are more sensitive to road proximity in space and time than other TRAP pollutants and the model largely captures observed NO2 trends from 2002-2010, suggesting that emissions estimates during that period were accurate, at least in a relative sense. We show that California's on-road vehicle regulations contributed to decreases in NO2, NOx, and EC concentrations in California. In the 11 other states that adopted California's light-duty automobile regulations, however, the near road decreases in TRAPs were statistically similar to the reductions in states that did not adopt their standards, though there is some indication that the CO and EC decline was greater near roads in states that adopted California's policies than other states.

Christian Hogrefe
Presentation: 2453
Presentation
https://www.cmascenter.org/conference/2020/slides/HogrefeEtAl_CMAS_Presentation_AQMEII4_CMAQ_Final.pdf

Hogrefe: Impacts of Differences in Land Use Characterization and Dry Deposition Schemes on AQMEII4 CMAQ Simulations

Christian Hogrefe, Jesse Bash, Jon Pleim, Donna Schwede, Rob Gilliam, Kristen Foley, Wyat Appel, and Rohit Mathur
Center for Environmental Measurement and Modeling, Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, NC 27513, USA

Phase 4 of the Air Quality Model Evaluation International Initiative (AQMEII) is focused on the diagnostic intercomparison and evaluation of dry and wet deposition of trace gases and aerosols simulated by regional-scale air quality modeling systems. Using the common emissions and boundary conditions datasets developed for AQMEII4, CMAQv5.3.1 simulations for the years 2010 and 2016 were performed over a North American modeling domain with both the M3DRY and STAGE dry deposition schemes. Meteorological fields for these simulations were prepared with WRFv4.1.1 using the Pleim-Xiu land-surface model and MODIS land-use classification scheme. CMAQ sensitivity simulations with both M3DRY and STAGE were performed for 2016 in which the WRFv4.1.1 Pleim-Xiu land-surface model was configured to use the NLCD40 land-use classification scheme and satellite-derived leaf area index (LAI) and vegetation fractions. Fields of surface characteristics, meteorological and concentration variables, dry deposition velocities, and deposition fluxes were analyzed to quantify the impacts of different land use characterizations and dry deposition schemes on simulated air quality and to gain mechanistic

insights into model behavior. Results show that variability in the estimated dry deposition sink results from both differences in representation of the underlying land use and model process formulation and that the magnitude of both effects was comparable in the simulations analyzed in this study. CMAQ driven by the WRF configuration using MODIS yields consistently lower O3 and higher $PM_{2.5}$ than the WRF configuration using NLCD40 and satellite-derived LAI and vegetation fractions. Using M3DRY results in lower $PM_{2.5}$ year-round and generally lower O3 during the summer and higher O3 during winter compared to using STAGE for both 2010 and 2016. Land-use specific dry deposition velocities calculated by M3DRY and STAGE will be intercompared using diagnostic information about different surface resistance pathways generated as part of the AQMEII4 CMAQ simulations.

Shannon Koplitz
Presentation: 2488
Presentation
https://www.cmascenter.org/conference/2020/slides/CMAS2020_Koplitz_Simon_etal_recorded.pdf

Koplitz: Changes in Ozone Production Chemistry across the U.S. between 2007 and 2016: An Integrated Modeling Assessment

Shannon Koplitz, Heather Simon, Luke Valin, Andrew Whitehill, Barron Henderson, Ben Wells, Jenny Liljegren, Gail Tonnesen
US EPA

Anthropogenic nitrogen oxide (NOx) and VOC emissions in the U.S. have declined substantially over the last decade, altering the NOx-VOC chemistry and ozone (O3) production characteristics of many areas. In this work we use multiple air quality analysis tools to assess how these large reductions in NOx and VOC have affected ozone production regimes across the U.S. between 2007 and 2016. We first compare observed and modeled evolution of NOx-limited and VOC-limited O3 formation regimes using a day-of-week analysis. This comparison builds confidence in the model's ability to capture ozone changes due to chemistry and meteorology both within years and across periods of large emissions decreases. Day-of-week analysis, however, cannot definitively differentiate between emissions and meteorology impacts. We therefore supplement this analysis with sensitivity calculations from CAMx-HDDM to characterize modeled shifts in ozone formation chemistry between 2007 and 2016 in different regions of the U.S. This work provides insights into how O3 production chemistry has evolved in large population centers in the U.S.

Yukui Li
Presentation: 2558
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS-2020-conference-Yukui-Li.pdf*

Li: Source Contributions to Ozone in Connecticut

Yukui Li, UConn

According to American Lung Association's "State of the Air 2020" report, every county in Connecticut continued to earn an F for ozone in spite of a slight decrease in the number of the most unhealthy days. There is an urgent need to lower ozone concentrations in Connecticut.

We model the point sources contributing to ozone concentrations in Connecticut in 2016 using both the Comprehensive Air Quality Model with Extensions (CAMx) and the Community Multiscale Air Quality Modeling System (CMAQ) and their respective source apportionment tools: Ozone Source

Apportionment Tools (CAMx-OSAT) and Integrated Source Apportionment Method (CMAQ-ISAM). For consistency, we use emissions and meteorological inputs based on the US EPA's 2016beta platform for both models using a domain covering the full United States, southern Canada, and northern Mexico.

We model the contributions from nine major sources in the region with the goal of narrowing down the top contributing sources. These sources include Roseton Generating, Arthur Kill Generating Station, Bowline Generating Station, East River Generating Station, 74th Street Station, Astoria Gas Turbine Power, Astoria Generating Station, Ravenswood Generating Station, E F Barrett Power Station, Northport Generating Station, Holtsville Facility, and Bergen Generating Station (New Jersey). As a first estimate of the impact of these sources, instead of tracking the emissions specifically from the source, we track the contribution from all sources within the grid cell. This provides a quicker approach to narrow down the major contributors. We quantify the impact of these high emitting sources to average and peak ozone concentrations in Connecticut from April-October 2016. This will aid in the development of effective, targeted ozone policies to improve the air quality in Connecticut.

CAMx-OSAT shows that the boundary conditions and remaining sources (i.e. those not explicitly tracked) account for over 99% of the average ozone concentration between June and August of 2016. The nine selected source grids combined contribute less than one half a percent of the average ozone concentration.

Thalia Alejandra Montejo Barato
Presentation: 2553
Presentation *https://www.cmascenter.org/conference/2020/slides/MontejoBarato-CMAS2020.pdf*

Montejo-Barato: Atmospheric emission reduction scenarios in Colombia: Assessing the sectoral contributions to aerosol, NOx, and Ozone population-weighted concentration

Alejandra Montejo-Barato, Sebastian Espitia-Cano, Ricardo Morales Betancourt, Jorge Bonilla, Claudia Aravena

Air quality modelling is a widely used tool to represent the complex meteorological and chemical processes that take place in the atmosphere and ultimately determine the air quality at a given location. These tools, however, have not been thoroughly utilized in Colombia, and have often been left out of the analysis and design of environmental public policy. In this work, we use the chemical transport model WRF-Chem version 3.9.1 to evaluate the impact of different economic sectors on air quality in Colombia and its capital, Bogotá. Three nested domains located in northern South America were used with resolutions of 27 km, 9 km, and 3 km, and 120x120, 126x126 and 132x132 cells respectively with 41 vertical levels. Gas-phase chemistry is described by the RACM mechanism, and aerosols are described with the two-moment, modal aerosol scheme MADE-VBS. Anthropogenic emissions from the global emissions inventory EDGARv4.3.1 were merged with a local emissions inventory for the city of Bogota. Biogenic emissions are also included using MEGAN. Biomass burning emissions were included using the FINN emission inventory. A base case simulation was generated for the three domains. To attribute the sectoral contributions to $PM_{2.5}$, NOx, and Ozone concentration, five scenarios were defined disaggregating anthropogenic emissions into Agricultural, Electric Power Generation, Industrial, Mobile, Commercial and other´s sectors. Our simulations show that in Colombia, the sectors with the greatest contribution to $PM_{2.5}$ concentrations are Mobile and Industrial with a mean contribution of 2.8 and 2.3 〖μg/m〗^3 respectively. the attribution of mobile sources in Colombia to the average concentration of O3 is 2.12 ppb and for NOX it is 2.12 ppb. For the city of Bogotá, the local impacts of Industrial, Mobile, and Resuspended Particulate Matter were evaluated. It was found that the paving of unpaved roads and

the heavy-duty vehicles renewal and can generate a maximum reduction of 8.0 and 2.0 〖μg/m〗^3of $PM_{2.5}$ respectively. The O3 and NOX change were minimum in the tree scenarios evaluated and a maximum reduction of 2.2 ppb of SO2 due to technology change from coal to natural gas in the industry, was shown to benefit low- and middle-income communities. A first analysis of the impact of potential reductions on environmental inequality was also explored using the modeling results.

Mike Moran
Presentation: 2519
Presentation *https://www.cmascenter.org/conference/2020/slides/MoranEA_Multi-Model_Evaluation_19thCMAQ_27-29Oct2020_v2.pdf*

Moran: Ongoing Multi-model Evaluation of Operational Air Quality Forecasts over North America: 20172020

Moran, M.D., P.M. Manseau, S.J. Peng, I. Stajner, J. Flemming, J. McQueen, P. Lee, M. Razinger, and R. Pavlovic

Since 2017 three agencies that produce daily operational air quality forecasts for North America have been exchanging their forecasts daily, allowing a side-by-side comparison and ongoing evaluation of these forecasts. The three participating agencies are Environment and Climate Change Canada (ECCC), the U.S. National Oceanic and Atmospheric Administration (NOAA), and the European Centre for Medium-range Weather Forecasts (ECMWF). As well, ECCC has developed a multi-model verification system that receives and ingests the North American AQ forecasts from the ECCC regional AQ forecast system, the NOAA-NWS regional AQ forecast system, and the ECMWF-CAMS global AQ forecast system and then evaluates these forecasts using near-real-time North American hourly surface measurements of O3, NO2, and $PM_{2.5}$. This new verification system, which holds daily forecasts from January 2017 onwards, automatically generates monthly multi-model performance statistics for North American daily maximum forecasts of O3, NO2, and $PM_{2.5}$ at the end of every month. While the system computes a number of standard statistical metrics, it also computes a new, pollutant-specific Air Quality forecast Performance Index (AQPI), which combines unitless measures of model bias, error, and correlation, to track and compare overall monthly performance and trends for the three AQ forecast models and three species. By exchanging these forecast scores on a regular basis, this international collaboration provides useful information to each agency on multi-model performance, including peer performance, seasonal variations, and the impacts of model upgrades implemented by each agency.

Heather Simon
Presentation: 2511
Presentation *https://www.cmascenter.org/conference/2020/slides/Simon_CMAS_2016v1ModelEval-2020.pdf*

Simon: Evaluation of CMAQ and CAMx ozone and $PM_{2.5}$ using the 2016v1 emissions inventory

Heather Simon, Shannon Koplitz, Norm Possiel, Barron Henderson, Sharon Phillips, Chris Misenis, Alison Eyth, Jeff Vukovich, Caroline Farkas
US EPA Office of Air Quality Planning & Standards

Over the past year, EPA has coordinated with state and local air agencies and multi-jurisdictional organizations (MJOs) in a collaborative effort to compile the 2016v1 emissions modeling platform. We have recently applied this new emissions platform with CMAQv5.3.1 and CAMxv.7beta. Here we

present a model performance evaluation for ozone and $PM_{2.5}$ species using ambient network data across the US. We supplement surface comparisons with vertical profile sonde evaluations and vertically integrated satellite comparisons evaluations. Finally, we completed a series of sensitivity simulations testing the sensitivity of ozone and $PM_{2.5}$ performance to various model inputs and configuration options. We highlight key findings from those sensitivity runs in terms of ozone and $PM_{2.5}$ performance.

Nash Skipper
Presentation: 2550
Presentation
https://www.cmascenter.org/conference/2020/slides/nash_skipper_usbO3_cmas2020.pdf

Skipper: Estimating US background ozone levels using data fusion

T. Nash Skipper, Yongtao Hu, M. Talat Odman, Barron H. Henderson, Christian Hogrefe, Rohit Mathur, Armistead G. Russell

US background (US-B) ozone is the ozone that would be observed in the absence of US anthropogenic emissions. US-B ozone originates from noncontrollable sources (e.g., wildfires, stratosphere-troposphere exchange, non-domestic pollution) and can vary significantly by region, elevation, and season. Typically, US-B ozone is quantified using a chemical transport model (CTM), though results are uncertain due to potential errors in model process descriptions and inputs. There are also significant differences in various model estimates of US-B ozone. A method to fuse observed ozone with US-B ozone simulated by a regional CTM (CMAQ) has been developed. We apportion the model bias as a function of space and time to US-B and US anthropogenic (US-A) ozone. Trends in ozone bias are explored across different simulation years and varying model scales. The estimated bias differs by season and location, by model resolution, and by ozone origin (US-B vs. US-A). Exploration of these findings can help illuminate the timing and location of biases within the model and inform the planning of more targeted research to investigate specific causes of bias. With the application of our data fusion bias adjustment method, we estimate a significant improvement in the agreement of adjusted US-B ozone.

Pradeepa Vennam
Presentation: 2521
Presentation *https://www.cmascenter.org/conference/2020/slides/Vennam_HCAMx_CMAS2020.pdf*

Vennam: Enhancement and Testing of Hemispheric CAMx

Pradeepa Vennam, Chris Emery, Lynsey Parker, Jeremiah Johnson, Greg Yarwood

Air quality planning in the US is increasingly reliant on quantifying and assessing contributions from international transport of air pollution. This study follows from our 2019 work to enhance and further evaluate CAMx applications on the hemispheric scale (H-CAMx) in preparation for local and regional regulatory and policy use. The advantages and tangible benefits of linking H-CAMx with regional CAMx applications include chemical consistency, seamless integration of the CAMx Source Apportionment (SA) technology, and immediate availability of future CAMx enhancements for applications at all scales. Continuing with a 2016 hemispheric dataset developed by EPA for CMAQ, we developed and evaluated the use of satellite data to derive ozone top boundary conditions to characterize stratospheric ozone, and developed a set of monthly-averaged, spatially-variable hemispheric initial/boundary conditions from our global modeling archive. These monthly data are applicable for H-CAMx applications for a range of years , while improving representativeness over the use of default profiles and shortening

model spin-up. We tested and evaluated H-CAMx sensitivity to vertical resolution and sub-grid convection by applying alternate meteorological model configurations. We will present comparisons among these H-CAMx sensitivity runs, and from 2016 runs of GEOS-Chem and H-CMAQ, to deep ozone profiles from 22 global ozonesonde launch sites as well as to surface-level ozone measurements from 67 global monitoring sites.

8. Regulatory Modeling and SIP Applications (10/28)

2020-10-28

Sam Grainger
Presentation: 2503
Presentation *https://www.cmascenter.org/conference/2020/slides/Sam-Grainger-CMAS-on-BC-to-NO2-Ratios-2020.pdf*
Extended Abstract *https://www.cmascenter.org/conference/2020/abstracts/Sam-Grainger-CMAS-extended-abstract-2020.pdf*

Grainger: Inner-city source apportionment using spatial modelling of Black Carbon (BC) to Nitrogen Oxide (NOx) ratios; a case study in Glasgow, Scotland.

Grainger, S.T.

The UK Government considers air pollution to be a grave threat to human health, and with public controversy, the UK has installed a series of monitoring stations over the country to measure air pollutants. These air pollutants include various Nitrogen Oxides (including Nitrogen Monoxide, Nitrogen Dioxide and Oxides of Nitrogen) and Black Carbon. Two of the most researched monitoring stations nationwide are within the city of Glasgow, namely the High Street and Townhead monitoring stations, which measure air quality at the roadside and in urban ambient air, respectively. While these monitoring stations are well researched, the supply of air pollution within the complex inner-city location has been poorly understood because of the overemphasis on nearby road emissions. However, this work uses the ratio between Nitrogen Monoxide vs Black Carbon and Nitrogen Dioxide vs Black Carbon to understand better the source of air pollution at more distant sources. The ratio of BC to Nitrogen Oxides is taken to be low when either from re-suspended particles or from particularly dirty processes. Alternatively, when the ratio between BC and Nitrogen Oxides is high, sources of nitrogen are taken to be present such as vehicular emissions and industrial sources. When this understanding is combined with advanced statistical analysis, though RStudio's OpenAir package (as developed by Carslaw) together with simple back-trajectory analysis, it is possible to show new and undiscovered sources of air pollution which are overwhelmed by the local phenomenon, but undoubtedly contribute to the total source apportionment of air pollution. In this way, new and undiscovered sources of air pollution were discovered at the High Street monitoring station, which included a local brewery, multi-story car park, and several major road junctions. While the Townhead monitoring station now shows effects from a major bus station, highway intersection and a major source of immediately local air pollution from cook smoke from an adjacent restaurant. Such a technique could readily be used at other monitoring stations internationally to support source apportionment studies.

Rebecca Matichuk
Presentation: 2509

Presentation
https://www.cmascenter.org/conference/2020/slides/Matichuketal_19thAnnual_CMAS_Presentation_Oct28th_2pmSession.pdf

Matichuk: Predicting Ozone in the Colorado Front Range using EPAs Air Quality Model

Rebecca Matichuk,1 Christian Hogrefe,2 Gail Tonnesen,1 Rob Gilliam,2 Sergey Napelenok,2 Bill Hutzell,2 Daiwen Kang,2 Jesse Bash,2 Rohit Mathur,2 George Pouliot,2 Wyat Appel,2 Gordon Pierce,3 Kevin Briggs,3 Kira Shonkwiler3
1 EPA, Region 8, Office of Air and Radiation, Air Toxics, Radiation, & Modeling Branch
2 EPA, Office of Research & Development, Center for Environmental Measurement and Modeling
3 Colorado Department of Public Health and Environment

The Denver Metro/North Front Range (DMNFR) ozone nonattainment area (NAA) in Colorado has had unhealthy levels of ozone for the past decade. State and national air quality programs have focused on reducing the emissions of volatile organic compounds (VOCs) and nitrous oxides (NOx), both of which are precursors to ozone formation, to address the elevated ozone in this area. It is speculated that the effects of these emission reductions may be partially offset by increasing levels of background ozone and increases in local emissions from population growth and extensive oil and gas development in the area. Background ozone includes contributions from wildfires, biogenic emissions, lightning NOx emissions, international anthropogenic pollution, and stratospheric intrusions.

A collaborative effort among EPA Region 8, the Office of Research and Development (ORD), the Office of Air Quality Planning and Standards (OAQPS) and the Colorado Department of Public Health and Environment (CDPHE) have developed a hemispheric-to-regional scale air quality model platform to simulate the transport and chemistry of ozone in the DMNFR NAA in Colorado and to estimate source contributions to simulated ozone. The platform uses the Weather Research and Forecasting (WRF) model and EPA's 2014 National Emissions Inventory (NEI) and the latest Community Multiscale Air Quality (CMAQ) model that includes the Integrated Source Apportionment Method (ISAM). This study focuses on July and August 2014 to align with two Colorado field studies that provided an extensive set of measurement data to evaluate the air quality model platform. This study assesses model performance through a comprehensive evaluation and detailed comparisons with measurements of meteorological variables, ozone, and ozone precursor species from a variety of surface, airborne and mobile platforms. Initial results show that the CMAQ model is biased low for ozone and its precursors during high ozone episodes. ISAM results for both the regional and hemispheric scale simulations are analyzed to quantify the contributions of various anthropogenic and natural emission sources to simulated ozone in the DMNFR, particularly during high ozone episodes.

Andre Paradise
Presentation: 2462
Presentation
https://www.cmascenter.org/conference/2020/slides/$PM_{2.5}$*_Standard_Presentation_CMAS-2020.pdf*

Paradise: An Economic Valuation of the Health Benefits of Decreasing the Fine Particulate Matter National Ambient Air Quality Standard in California

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The Clean Air Act requires the United States Environmental Protection Agency (EPA) to review routinely the National Ambient Air Quality Standards (NAAQS) for fine particulate matter ($PM_{2.5}$). The current NAAQS, set in 2012, mandates that levels of $PM_{2.5}$ do not exceed an annual average of 12 µg/m3 and a 24-hour average of 35 µg/m3. However, the Independent Particulate Matter Review Panel recently concluded that the current $PM_{2.5}$ standard does not protect public health adequately. Instead, the standard should be replaced with concentrations not exceeding an annual average of 8-10 µg/m3 and a 24-hour average of 25-30 µg/m3. In this study, the potential health benefits from implementing the proposed air quality (AQ) standard is evaluated for California based on both observational and simulated air quality data. Two baselines are generated: 1) a 2018 case constructed using satellite and ground-based observational data, and 2) a 2035 case based on California Air Resources Board emission projections. Both cases are then fully developed at a 4 km x 4 km resolution using the Community Multiscale Air Quality (CMAQ) model. Also, for both cases, three scenarios are assessed for statewide attainment of 1) the current AQ standard, 2) the lenient AQ standard (10 µg/m3 annually and 30 µg/m3 daily), and 3) the stringent AQ standard (8 µg/m3 annually and 25 µg/m3 daily). Finally, the health benefits between each of the attainment scenarios and their corresponding baseline are quantified using the BenMAP model. Research results indicate that significant monetary health benefits are expected for both cases when the air quality standard is updated to any of the proposed versions. Furthermore, results support the conclusions of the Independent Particulate Matter Review Panel which state that a reduction in the $PM_{2.5}$ standard would yield socio-economic benefits and protect public health.

MARCUS TRAIL
Presentation: 2516
Presentation *https://www.cmascenter.org/conference/2020/slides/marcus-trail-Ramboll_CMAS_Presentation_9oct20.pdf*

Trail: Investigating Sources of Ammonia Uncertainty in Modeling the Salt Lake City $PM_{2.5}$ Nonattainment Area

Marcus Trail, Chris Emery, Chris Lindhjem, Tejas Shah, Greg Yarwood

During periodic winter stagnation episodes in the Salt Lake basin, fine particulate ($PM_{2.5}$) concentrations can exceed the national air quality standard, primarily due to a buildup of ammonium nitrate. This study investigated causes for an ammonia (NH3) emissions shortfall in the photochemical modeling system employed by the Utah Division of Air Quality (UDAQ) to support the recent Salt Lake City $PM_{2.5}$ State Implementation Plan (SIP). We reviewed NH3 emission inventories and recently measured concentration patterns; investigated modeling uncertainties and deficiencies, updated the UDAQ modeling system and refined modeled NH3 emissions; and re-evaluated modeling results and $PM_{2.5}$ sensitivity to NH3 and NOx emissions. We achieved major improvement in simulated NH3 and ammonium nitrate concentrations by scaling up NH3 emissions from gasoline vehicles by a factor of about 2.5, a modification that is supported by evidence in the literature. We also found that model-measurement comparisons benefited from a reduction in vertical mixing and an increase in snow albedo that enhances photochemical production of nitrate. However, the model was insensitive to the introduction of bi-directional NH3 surface exchange and other chemical modifications. Our modeling results indicate that with these changes, the inorganic $PM_{2.5}$ chemical environment in the basin can spatially and temporally vary between ammonia-limited and nitrate-limited, which is consistent with

past field studies. This chemical balance has major implications for accurately projecting future $PM_{2.5}$ according to anticipated sector-specific emission inventory changes.

Jeongran Yun
Presentation: 2535
Presentation
https://www.cmascenter.org/conference/2020/slides/Yun_CMASconference2020_final.pdf

Yun: Evaluation of four different methods to calculate relative response factors and estimated future year ozone design values

Jeongran Yun, Winston Hao, Eric Zalewsky, Ruby Tian, and Kevin Civerolo
Division of Air Resources, New York State Department of Environmental Conservation

Estimated design values for the future year (DVFs), as calculated from air quality modeling results, are used for a model attainment demonstration for the ozone National Ambient Air Quality Standards (NAAQS). The DVF for ozone is calculated by multiplying a baseline 5-year weighted design value by a model-derived Relative Response Factor (RRF). An RRF for a site represents a fractional change in ozone at the site between base and future year air quality modeling results based on emissions changes. EPA's guidance for modeled attainment demonstration recommends calculating an RRF for a site using the 3x3 method that uses a 3x3 grid cell array surrounding the monitoring site. Ozone model performance in coastal areas is often poor due to the land/water interface in the air quality and meteorological models. Therefore, the RRF/DVF may not be reliable when including water cells (more than 50 percent of the grid cell area is water) for those monitoring sites located in coastal areas like the New York City metropolitan area. The guidance allows for consideration of a modified 3x3 method (considering a removal of the unrepresentative cells) for those monitoring sites that may be affected by a specific local topographic or geographical feature such as a water body. In this study, four different RRF/DVF calculation methods will be evaluated for those monitoring sites in coastal areas. The first method is the EPA's recommended 3x3 method. The second method is a modified 3x3 method that uses a 3x3 grid cell array eliminating the grid cells that are classified as water cells and that do not contain the monitoring site. This method includes a water cell in the RRF calculation if the monitoring site is located in water cell. The third method is a further modified 3x3 method that excludes all water cells including the water cell in which the monitoring site is located. The fourth method is a 1x1 method that uses one grid cell where the monitoring site is located. The Community Multiscale Air Quality (CMAQ) and Comprehensive Air quality Model with eXtensions (CAMx) modeling results will be used for the evaluation using both the 2016/2023 version 1 modeling platform and the 2011/2017/2023 modeling platform.

Xuguo ZHANG
Presentation: 2506
Presentation
https://www.cmascenter.org/conference/2020/slides/CMAS_Presentation_XuguoZHANG_2020.pdf

Zhang: Improved health co-benefits of ozone and nitrogen oxides upon Chinas integrated air quality control policies during 2015-2019

Xuguo Zhang, Jimmy C. H. Fung*, Alexis K. H. Lau, Md Shakhaoat Hossain, Peter K. K. Louie, and Wei (Wayne) Huang

Ozone (O3) pollution had been worsening in China, posing significant challenges to human health. The Nitrogen Dioxide (NO2) control would trigger the rising of O3 in the response of released control policies. This study, proposing a novel sensitivity analysis methodology, explored the effectiveness of the integrated sectoral air quality control policies from health co-benefits perspective. Air quality improvement and the health co-benefits for the two-pollutant were calculated to obtain an in-depth understanding of the O3 control. The results showed that the integral health co-benefits of the two-pollutant had been improving, although the O3 concentration was deteriorating. The region-based annual averaged NO2 concentration exhibited a larger reduction in Hong Kong (HK) than that in the Pearl River Delta Economic Zone (PRD EZ). The super-regional control scenario presented little impact for NO2, indicating a short lifetime of NO2, affected more by local sources. The 13th Five-year Plan measures brought significant health improvement for Shenzhen and HK. The less strengthened NO2 control regions should learn from the regions with greater NO2 reduction, because of larger health benefits gained. The control policies on power, traffic, industry, and other area sectors demonstrated a considerable health improvement for the major PRD EZ cities and HK. Joint national control efforts could make the domain-wide health risks under the safety line. The increasing power demand of electric vehicles offset the health co-benefits in the power generation sector, calling for strengthened efforts in the traffic sector, particularly for the regions with O3 formation of volatile organic compounds limited regime.

9. Remote Sensing/Sensor Technology and Measurements Studies (10/27)

2020-10-27

Waluyo Eko Cahyono
Presentation: 2555
Presentation *https://www.cmascenter.org/conference/2020/slides/Cahyono-CMAS-2020.pdf*

Cahyono: State of Acid Deposition on Some Monitoring Sites in Indonesia

Waluyo Eko Cahyono, Wiwiek Setyawati, Retno Puji Lestari, Asri Indrawati and Dyah Aries Tanti

Acid deposition represents the mix of air pollutants that deposit from the atmosphere. Acid deposition emerged as the result of the impact of air pollution due to the increased emissions of SOx and NOx. This study aims to identify the state of acid deposition through rainwater monitoring in selected sites. The two components of acidic deposition are dry deposition and wet deposition. Acid deposition samples in Indonesia were collected using rainwater sampler in several sites during the period of 2009-2018, namely Serpong, Bandung, Jakarta and Kototabang . In each site, measurement of rainwater precipitation, pH, electro conductivity, and analysis of ions were performed. The characteristic of wet deposition pollutant in Serpong showed the NH4+ and NO3- ions are the most dominant, while in Jakarta and Bandung showed the influence of NH4+ and SO42-. H+ and Cl- ions were the prominent feature found in remote areas of Kototabang as the representative of rural area. Monitoring of dry deposition in sub urban site is considthered as a part of acid deposition observation, in which can be used for the assessment of acid deposition impact to environment. Dry deposition measurement was conducted using filter pack method to determine the particulate component of Na+, K+, Ca2+, Cl-, NO3-, and SO42- in aerosol and gases of SO2, HNO3, NH3, and HCl. The air is inhaled using a pump with a flow rate of 1 L/min for 14 days continuously, and then passed into a four stage filter pack,

whereas in each filter set is specifically absorbed each chemical component. Pollutant sources from agricultural and farm sectors nearby the sampling sites potentially lead to high level of NH3 in gas phase, while anthropogenic activities contributed to increase the SO42- concentration in aerosol phase.

Fernando Campo
Presentation: 2486
Presentation *https://www.cmascenter.org/conference/2020/slides/Campo-et-al-2020.pdf*
Extended Abstract *https://www.cmascenter.org/conference/2020/abstracts/Campo-et-al-2020.pdf*

Campo: Deployment of Mobile and Fixed Air Sensor Platforms in the City of Florianpolis, Brazil: Preliminary Results

Fernando Campo, Andy Blanco-Rodríquez, Robson Will, Thiago Vieira Vasques, Nathan Campos Teixeira, Davide Franco, Alejandro García-Ramírez, Leonardo Hoinaski

In this work, we present the preliminary results of deploying mobile and fixed air sensor platforms in the city of Florianópolis, Brazil, as a way of addressing the matter of collecting locally representative air quality data. The basic structure of the sensor nodes consists of: an Arduino Mega, an array of electrochemical gas sensors, a GPS module for geo-location, an SD card for data storage, a Real-Time Clock, and an ESP8266 module for Wi-Fi communication. Each node measures gaseous pollutants that are regulated by the Brazilian environmental laws. Both mobile and fixed nodes use digital gas sensors for IoT from SPEC Sensors; the fixed node, in particular, includes an array of Alphasense B4 series sensors for air quality networks.

The problem of local representativeness of air quality data is an issue for government offices and environmental agencies. The lack of relevant information may result in a deficient estimation of air pollution and on the implementation of poorly effective air quality management policies. This topic is especially relevant in Brazil, where regulatory monitoring is still limited. The high costs of the regulatory stations and their maintenance, as well as the lack of qualified staff, hamper the deployment of spatially broader and denser monitoring networks.

The main objective of this presentation is to discuss the performance of the sensor platforms according to some expected behavior and the influence of environmental conditions. The way to tackle this is by checking the existence of a correspondence between the sensor responses, the daily and weekly traffic patterns, and the levels of air pollution expected at different locations. Another analysis compares the outputs of Alphasense versus SPEC sensors, as well as the mobile node versus a Sniffer 4D V1 multi-gas detector. Finally, the effect of environmental variables such as temperature and relative humidity on the electrochemical sensors is analyzed.

The air sensors systems developed are still in its prototype phase and require further enhancements and assessment, especially what regards to laboratory calibrations, in-field co-location with regulatory monitoring stations, and long term performance. However, the results that this work presents point to more basic problems on the platforms that require improvement and also define a pathway for future analysis and processing of new data. These platforms have the potential for increasing the spatial and temporal resolution of monitoring networks in the city, as well as for opening the way to new monitoring services and applications such as the creation of air pollution maps, the detection of “hotspots” in the city, citizen science and education on air pollution topics, assessment of personal

exposure to gas contaminants and evaluation of the impacts that the performance of physical activities on polluted environments has to the human health.

Peiyang Cheng
Presentation: 2465
Presentation
https://www.cmascenter.org/conference/2020/slides/2020_CMAS_Cheng_Presentation.pdf

Cheng: Using Geostationary Satellite Observations to Improve Air Quality Simulation for the 2016 Ozone Season

Peiyang Cheng, Arastoo Pour-Biazar, Andrew T. White

An accurate estimate of insolation is critical for air quality simulations since the production rates of many criteria air pollutants can be greatly affected by the strength of solar radiation. This study implemented the Geostationary Operational Environmental Satellite (GOES)-based cloud assimilation technique developed by White et al. in a WRF-SMOKE-CMAQ modeling framework to improve the estimation of photolysis rates and criteria gases. The simulation was carried out on a 12-km domain to study the 2016 ozone season over the contiguous United States (CONUS). Results from this study will be presented.

Jingting Huang
Presentation: 2527
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS2020_HUANG.pdf*

Huang: Toward understanding the physical processes impacting uncertainties in satellite retrieved aerosol optical depth

Jingting Huang [1,2], W. Patrick Arnott [2], James C. Barnard [2], Heather A. Holmes [1,2]
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Determining the surface air pollution concentrations is a key component to investigating the human and environmental impacts of air pollution globally. Surface concentrations from monitors are not available in many locations, therefore data from satellite remote sensing or chemical transport models have been increasingly used to estimate surface pollutant concentrations worldwide. While this increases the spatial coverage of the pollution estimates there are still uncertainties in these methods that require investigation. This presentation will focus on uncertainties in satellite remote sensing products that estimate aerosol optical depth (AOD).

Increased efforts are needed to minimize uncertainties in satellite aerosol retrieval algorithms that determine AOD in response to a knowledge gap associated with representative parameterized aerosol properties and surface reflectance characterization. The overarching goal of this study is to recognize the underlying physical processes that contribute to low-quality satellite AOD retrievals. We outline a conceptual 1-D radiative transfer model (RTM) together with a traditional propagation of error approach to estimate uncertainties in satellite AOD products using analytical equations. This simplified form of the RTM helps to identify critical surface albedo (CSA), critical single scattering albedo (CSSA), and critical asymmetry parameter (CAP) for use in uncertainty analysis of satellite AOD; at a critical value, the top-of-atmosphere (TOA) reflectance is insensitive to significant variability in AOD. Even a slight low bias (~1%) in the single scattering albedo (SSA), asymmetry parameter (g) or surface albedo (A), especially

when prescribed aerosol optical properties and underlying surfaces with albedo are close to their critical values, will lead to significant errors (>100%) in satellite AOD retrievals. While the 1-D RTM used in this study can only describe limited aspects of uncertainties that arise in the satellite remote sensing of aerosols, the results presented are expected to physically and mathematically provide a preliminary framework for the application of the critical value method on the upcoming refinement of satellite aerosol retrieval algorithms.

Hossein Khajehpour
Presentation: 2526
Presentation *https://www.cmascenter.org/conference/2020/slides/cmas2020-2526.pdf*
Extended Abstract *https://www.cmascenter.org/conference/2020/abstracts/2526-RS-Wastes-in-Tehran.pdf*

Khajehpour: Remote Sensing-Based Estimates of Agricultural Waste Burning in Tehran, Iran

Farzaneh Taksibi, Hossein Khajehpour, Yadollah Saboohi

Policymakers use emission rates of different sources to determine the causes of air pollutants and to target controlling actions. Emissions inventories are an essential input to dispersion models that estimate air quality. Potential regulatory actions can be predicted by applying estimated emissions reductions to emissions inventory data in air quality models. Methods to determine the relative significance of emissions sources include emission inventories, source apportionments, and sensitivity analyses of emissions. The choice of the proper method depends on the availability of data, time, expertise, and cost. The VIIRS Nightfire products can detect thermal anomalies to study the spatial and temporal changes built on the well-established MODIS Fire and Thermal Anomalies product. In this method, unaccounted emission sources that are unknown to the policymakers will be identified. One of the main unidentified sources is the crop residue burning and agricultural wastes. This study provides a remote sensing methodology for identifying the time and place of the thermal anomalies around Tehran with the help of VIIRS Nightfire products, which offers a quantitative estimation of the temperatures of sub-pixel heat sources. This is used to evaluate the spatiotemporal distribution of uncontrolled burning and its impact on Tehran's air quality. In this case, thermal anomalies around Tehran are investigated from 2017 to 2019, and their impact on PM concentrations at nearby air quality monitoring stations is analyzed. Based on topographic and meteorological conditions, and with the Hysplit model's help, the effect of agricultural waste burning on Tehran is evaluated. Finally, the nonsystematic emission sources' effectiveness on Tehran's air quality through sensitivity analysis of the observed concentration is analyzed.

Maria Makarova
Presentation: 2463
Presentation *https://www.cmascenter.org/conference/2020/slides/EMME_Makarova-2020.pdf*

Makarova: Emission Monitoring Mobile Experiment (EMME): an overview and results of the St. Petersburg (Russia) megacity campaigns of 2019-2020

Maria Makarova1, Frank Hase2, Dmitry Ionov1, Carlos Alberti2, Stefani Foka1, Thomas Blumenstock2, Vladimir Kostsov1, Thorsten Warneke3, Yana Virolainen1, Anatoly Poberovskii1
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2 Institute of Meteorology and Climate Research IMK-ASF, Karlsruhe Institute of Technology, Karlsruhe, Germany
3 University of Bremen, Germany

In 2019 and 2020, the mobile experiment EMME (Emission Monitoring Mobile Experiment) was conducted within the St. Petersburg agglomeration (Russia) aiming to estimate the emission intensity of greenhouse (CO2, CH4) and reactive (CO, NOx) gases for St. Petersburg which is the largest Northern megacity. The area of St. Petersburg urban agglomeration is about 1440 km2. As of 2018, the city has a population of ~5.4 million people (the official data for 2018); according to unofficial data the population is now more than 7 million. The entire campaign consisted of 11 mostly cloudless days of measurements in March–April 2019 and 6 days in March-early May 2020. In 2020, the EMME experiment was carried out during three days before the COVID-19 pandemic lockdown and three days during the lockdown. The core instruments of the campaign were two portable FTIR spectrometers Bruker EM27/SUN which were used for ground-based remote sensing measurements of the total column amount of CO2, CH4 and CO at upwind and downwind locations on the opposite sides of the city. The NO2 tropospheric column amount was observed along a circular highway around the city by continuous mobile measurements of scattered solar visible radiation with OceanOptics HR4000 spectrometer using the DOAS technique.

The estimates of the St. Petersburg area fluxes for the considered greenhouse and reactive gases were obtained by coupling a box model and the results of the EMME observational campaign using the mass balance approach. The area fluxes for St. Petersburg city center were estimated as (89 ± 28) kt km-2 yr-1 of CO2, (135 ± 68) t km-2 yr-1 of CH4, (251 ± 104) t km-2 yr-1 of CO and (66 ± 28) t km-2 yr-1 of NOx.

Coupling the EMME 2019&2020 observations with HYSPLIT simulations and the a priori information on CO2 emissions from the ODIAC database, we evaluated the total CO2 emission from St.Petersburg megacity which amounts to (76±5) million tons per year for 2019 and (68±7) million tons per year for 2020.

Acknowledgements

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Junhua Zhang
Presentation: 2500
Presentation
https://www.cmascenter.org/conference/2020/slides/ZhangJ_MODIS_LAI_CMAS_2020.pdf

Zhang: Examination of the MODIS Leaf Area Index (LAI) Product for Use in Air Quality Modeling

Junhua Zhang, Michael D. Moran, Paul A. Makar, and Shailesh Kharol

Leaf Area Index (LAI), which is defined as the amount of leaf area per unit surface of the ground (m2/m2), is used in air quality models for land surface process parameterizations and for calculating biogenic emissions. The MODIS (Moderate Resolution Imaging Spectroradiometer) LAI product provided by NASA (*https://modis.gsfc.nasa.gov/data/dataprod/mod15.php*) has been widely used by the air quality modeling community for such purposes, including the estimation of biogenic emissions using

MEGAN (Model of Emissions of Gases and Aerosols from Nature, *https://sites.google.com/uci.edu/bai/megan/data-and-code/lai*). However, some limitations of the MODIS LAI product have been identified, such as the unreasonably low LAI estimated for evergreen needleleaf boreal forests in the Northern Hemisphere during wintertime due to snow cover and low sun angle (e.g., Fig. 4 of Messina et al., 2016, *https://doi.org/10.5194/acp-16-14169-2016*) and gaps in coverage due to missing retrievals in regions with persistent cloud cover. Considerable effort has been devoted to improving the MODIS LAI product (e.g., Yuan et al., 2011, *https://doi.org/10.1016/j.rse.2011.01.001*), but some issues persist, such as very low LAI over boreal forests in the wintertime even after the data were reprocessed (e.g., Fig. 9C of Yuan et al., 2011).

To investigate these issues further, the 8-day MODIS Collection 6 (C6) LAI Product at 500-m resolution (MCD15A2H, *https://lpdaac.usgs.gov/documents/2/mod15_user_guide.pdf*) was examined for North America. Statistics were calculated for a 17-year period (2003-2019) by month and by land cover type as defined in the "Land Cover Type 1" Science Data Set (SDS) of the Collection 6 MODIS Land Cover (MCD12Q1) Product (*https://lpdaac.usgs.gov/documents/101/MCD12_User_Guide_V6.pdf*). Different data filtering options were tested, and comparisons were performed with North American LAI fields calculated independently from the Biogenic Emissions Landuse Database, version 4 (BELD4; *https://www.epa.gov/air-emissions-modeling/biogenic-emission-sources and http://doi.org/10.5281/zenodo.3620734)*. This presentation will show results from this analysis, and will discuss possible approaches to address some current limitations of satellite-derived LAI.

10. Wildfire Emissions and Air Quality (10-29)

2020-10-29

Ece Ari Akdemir
Presentation: 2507
Presentation *https://www.cmascenter.org/conference/2020/slides/Wildfire-Plume-Transportation-akdemir-2020.pdf*

Ari: Emissions and Transport of $PM_{2.5}$ from Australian 2019-2020 Wildfires: Integrated Satellite and Modeling Analysis

Ece Ari*, William. H. Battye, and Viney P. Aneja

Wildfires (bushfires) are connected with Australia's ecology and culture. This is due to highly flammable biota and shortfall of precipitation in Australia. These wildfires affect air quality and emit $PM_{2.5}$. In the past century, the occurrence of wildfires has increased. Form November 2019 to January 2020 Southeast Australia faced devastating wildfires. This study analyzes air quality impact associated with Australia wildfires that occurred during 29th December 2019 to 4th of January 2020. The emission of $PM_{2.5}$ was analyzed using satellite products from the Moderate Resolution Imaging Spectroradiometer (MODIS) and Fire Information for Resource Management System and the WORLDVIEW system. Daily calculated $PM_{2.5}$ emissions range from 24*106 kg/day to 265*106 kg/day. Using the HYSPLIT model evaluation determined the impact of $PM_{2.5}$ in Tasmania, New Zealand, and inner Australia during this time.

Karen Ballesteros-Gonzalez
Presentation: 2552

Presentation
https://www.cmascenter.org/conference/2020/slides/KarenBallesteros_presentation_CMAS2020.pdf

Ballesteros-Gonzalez: COVID-19 lockdown reveals the extent of regional biomass burning over air quality in Colombia: Assessment using Chemical Transport Modelling and Observations

Ricardo Morales, Karen Ballesteros, Juan Felipe Espinosa, Fernando Garcia

Smoke from biomass burning (BB) deteriorates air quality and negatively impacts human health. However, precisely quantifying their impact is not straightforward, as many anthropogenic and natural sources concurrently influence atmospheric composition at a given location. Therefore, abrupt declines in anthropogenic emissions, such as those resulting from sharply reduced traffic during SARS-COV-2 related lockdowns during the first semester of 2020, provided unique natural experiments to uncover hitherto underestimated effects on air quality. In Colombia full lock-downs caused historically low traffic volumes, as well as reduced industrial activity caused by both disruptions in the supply chain as well as historically low demand from March 20 to April 26 in Bogotá. However, during the SARS-COV-2 lock-down an air quality environmental emergency was declared in Bogotá from March 5 to April 3. Despite the strict lock-down measures already in place in Colombia, severe air pollution episodes continued, in tandem with massive BB events in Northern South America (NSA). This new evidence, enabled by the unprecedented reduction in local mobile and industrial sources, highlights the teleconnections between fires linked to expanding agricultural frontiers and deforestation, and air quality in distant cities. In this work we used the Weather Research and Forecasting Model coupled with Chemistry (WRF-Chem) to estimate the $PM_{2.5}$ contribution (_$PM_{2.5}$) from open BB during a full lock-down in Colombia, and quantified diverse short-term effects associated with BB. Three nested modeling domains cover the northern half of South America with 120, 126, and 132 grid cells, at a horizontal resolution of 27, 9, and 3 km, centered in Colombia are used for domain 1 (D01), domain 2 (D02), and domain 3 (D03), respectively. Forty-one vertical levels are used, spaced to give higher resolution in the boundary layer. NCEP-FNL products are used for meteorological boundary and initial conditions for D01. D02 and D03 boundary and initial conditions were passed down from parent domain. Gas-phase pollutants are processed using MOZART chemical mechanism. Aerosols are described with the two-moment four size-bins sectional aerosol scheme MOSAIC. Anthropogenic emissions from EDGAR are used, and diurnal variation profiles were applied to manufacturing, transformations industry, and road transportation. Local emission inventory of Bogotá was merged with EDGAR in D03. We applied estimated emissions reductions during the lockdowns to local emissions inventory and used 31.2% of PM from re-suspension, 20% of VOCs and NOx, and 35% of CO from road transportation sector during March 15 to March 28, period before full lock-down measures were applied. Base on Inter-American Development Bank additional reduction factors of 87% for transportation sector, and 9% for industry and transformation sectors were applied for three domains after March 20. Biogenic emissions from MEGAN were included in all simulations. BB emission inventory from GFED4s was mapped to three simulations domains and was chemically speciated to MOZART chemical mechanism. Simulation results showed that model underestimates by 50% BB aerosols concentration regionally. Additionally, it was estimated higher mortality in densely populated areas, especially over Colombia with about 70% of cases in NSA. Our sensitivity analysis suggest that BB aerosols can be responsible for thousands of excess hospital emergency visits associated with respiratory diseases.

Stephanie Cleland
Presentation: 2547
Presentation *https://www.cmascenter.org/conference/2020/slides/Cleland_CMAS_Presentation-2020.pdf*

Cleland: A BME Space/Time Data Fusion Method for Estimating Smoke Concentrations and the Associated Health Impacts of the 2017 California Wildfires

Stephanie Cleland, J. Jason West, Yiqin Jia, Stephen Reid, Sean Raffuse, Susan O'Neill, Ana Rappold, Marc Serre

Exposure to wildfire smoke causes a range of adverse health outcomes. This health risk in combination with a predicted increase in the frequency and severity of wildfires due to climate change suggest the importance of accurately estimating smoke concentrations and quantifying the health impacts of smoke exposure. While chemical transport models (CTMs) and the spatial interpolation of observations are often used to assess smoke exposure, geostatistical methods can combine surface observations with modeled and satellite-derived concentrations to produce more accurate exposure estimates during wildfires.

Here we use a novel approach to estimate ground-level $PM_{2.5}$ during the October 2017 California wildfires. We use the Constant Air Quality Model Performance (CAMP) and Bayesian Maximum Entropy (BME) methods to bias-correct and fuse together three concentration datasets: permanent and temporary monitoring stations, a CTM, and satellite observations. Four different BME space/time kriging and data fusion methods were evaluated for accuracy. We then used the most accurate $PM_{2.5}$ estimations in a health risk assessment to calculate the excess respiratory, cardiovascular, and asthma hospital admissions attributable to exposure to fire-originated $PM_{2.5}$.

All BME methods produce more accurate estimates than the standalone CTM and satellite products, emphasizing the importance of combining multiple datasets to estimate smoke exposure. Performing a non-linear bias-correction on the modeled concentrations, via CAMP, notably improves accuracy. The data fusion of observations with the CAMP-corrected CTM provides the best overall $PM_{2.5}$ estimate (R2=0.73), especially in station-scarce regions. Including satellite data does not improve overall performance. Using these ground-level $PM_{2.5}$ estimations, we estimate approximately 60,000 people were exposed to very unhealthy air (daily average $PM_{2.5}$ ≥150.5 µg/m3) and 15.3 million people were exposed to concentrations greater than the EPA's 24-hour $PM_{2.5}$ standard, 35 µg/m3. We further estimate that smoke exposure during the fires caused 260 (95% CI: 124, 435), 73 (95% CI: -11, 171), and 28 (95% CI: 19, 85) excess respiratory, cardiovascular, and asthma hospital admissions, respectively.

Archana Dayalu
Presentation: 2512
Presentation *https://www.cmascenter.org/conference/2020/slides/Dayalu_CMAS_2020_finalslides.pdf*

Dayalu: Identifying Smoke-Impacted Regions using the Optical Properties of Brown Carbon Aerosol

Archana Dayalu
Matthew J. Alvarado

Biomass burning in Central America can significantly impact air quality in the United States. Specifically, the agricultural fire season in Mexico's Yucatán Peninsula (Yucatán), extending from April to May, has been linked to multiple air pollution events in and around the US Gulf Coast states. Yet, characterizing

regions impacted by biomass burning remains an ongoing challenge. In this study we explored different methods for determining the presence and amount of brown carbon aerosol (BrC) to identify biomass burning smoke intrusions into the Houston-Galveston-Brazoria (HGB) area from the Yucatán. We derive Absorption Ångstrom Exponent (AAE) and Extinction Ångstrom Exponent (EAE) using NASA's Ozone Monitoring Instrument (OMI) measurements of aerosol optical depth at 1°×1°. We use the AAE/EAE ratio in the 354nm-388nm wavelength window to establish pixels likely characterized by high BrC and, therefore, biomass burning smoke. We analyzed data for 99 days between 2005 and 2020 with approximately half the days corresponding to a known or suspected smoke intrusion into the region. Using a k-means clustering algorithm, we find that pixels corresponding to AAE values of 4.5 (SD=0.4) and EAE values of 1.4 (SD=0.1) are likely impacted by BrC aerosol. Our analysis is supported by airmass trajectories modeled by NOAA's HYSPLIT model and a suite of smoke and fire maps. Our analysis provides a method for stakeholders to identify smoke-impacted pixels and provide likely attribution to smoke source. Future development will include finer resolution measurements from the NASA TEMPO mission, scheduled for launch in 2022.

Sam Faulstich
Presentation: 2531
Presentation *https://www.cmascenter.org/conference/2020/slides/Evaluating-Fire-Emissions-Inventories-with-Bayesian-Statistics-2020.pdf*

Faulstich: Evaluating Fire Emissions Inventories in the Western U.S. With the Development of a Bayesian Model

Samantha Faulstich, Xia Sun, A. Grant Schissler, Matthew J. Strickland, Heather A. Holmes

Understanding the impacts of wildfire smoke on nearby communities requires knowing the amount and composition of emissions released by the wildfire into the atmosphere. This may seem easily measurable using the vast network of ground-based air quality monitoring sites, but these instruments capture pollution from all sources, making it difficult to isolate pollution exclusively from wildfire smoke. Fire emissions inventories can be used to estimate smoke emissions from an individual wildfire by using empirical data to model fire behavior. Outputs from the fire emissions inventories can also be used in atmospheric transport models, like CMAQ, a chemical transport model, or HySplit, a Lagrangian particle trajectory calculator that simulates smoke plume transport and dispersion. Emissions from a wildfire can be impacted by many variables, including fire behavior, weather, fuel characteristics (amount, type, moisture content), and combustion type (i.e., flaming vs. smoldering). Variability in any of these factors leads to differences in the chemical speciation and amount of gasses and aerosols released into the atmosphere by a wildfire. Each fire emissions inventory models these variables as inputs to the emissions model, but each inventory adopts a different method or dataset to determine these variables, leading to different wildfire smoke emissions estimates from each inventory. Evaluating the differences between inventories is crucial to understanding their effects on modeling wildfire emissions, and how these differences are propagated through smoke plume dispersion modeling used to determine downwind smoke plume concentrations.

Determining the differences between fire emissions inventories and how their contrasting methods of input variable modeling can impact second order modeling of other air quality characteristics requires a direct comparison. Four fire emissions inventories will be compared and discussed: the Missoula Fire Lab Emission Inventory (MFLEI), Global Fire Emissions Database (GFED) version 4s, the Fire INventory from

NCAR (FINN), and the Wildland Fire Emissions Information System (WFEIS). Results of these fire emissions inventories for the entire year of 2013 and a single, large fire that impacted the Reno, Nevada area (the Yosemite Rim Fire) will be presented. Factors such as burned area, primary emissions of $PM_{2.5}$ and CO, and the average daily emissions rate are compared to highlight differences amongst the fire emissions inventories. To aid in the comparison of these emissions inventories, a Bayesian single level model was developed for each fire emissions inventory, using data from the fire emissions inventories as prior information. These models are compared, allowing for understanding of what each fire emissions captures as a distribution curve. Results show that each fire emissions inventory had a similar amount of burned area for both 2013 as a whole and the Yosemite Rim Fire, but primary emissions and the average daily emissions rate differed greatly between fire emissions inventories. Results from the Bayesian single level model show that MFLEI had less variability in the model than other fire emissions inventories. The primary $PM_{2.5}$ emissions concentrations from each of these fire emissions inventories were used in HySplit to investigate how variations in fire emissions inventory modeling methods can impact smoke plume transport modeling. These comparisons will be used to inform the selection of the fire emissions inventory used for a broader project related to the human health impacts of wildfire smoke in the Reno area.

Cenlin He
Presentation: 2439
Presentation
https://www.cmascenter.org/conference/2020/slides/CMAS_conference_CenlinHe_2020Oct.pdf

He: Improving U.S. fine particulate matter air quality forecasts during wildfire based on chemical data assimilation

Cenlin He, Piyush Bhardwaj, Rajesh Kumar

Fine particulate matter ($PM_{2.5}$) continues to be a major air quality problem in the U.S., especially during wildfires. To improve the $PM_{2.5}$ forecasts during fire seasons, this study develops a chemical data assimilation system by coupling the Weather Research and Forecasting (WRF) model, the Community Multiscale Air Quality (CMAQ) model, and the community Gridpoint Statistical Interpolation (GSI) system to assimilate MODIS and GOES aerosol optical depth (AOD) retrievals. The WRF-CMAQ modeling system follows the EPA model configuration and uses theNational Emissions Inventory (NEI), with a horizontal grid spacing of 12 x 12 km2. The background covariance matrix used in the assimilation is generated by contrasting two simulations using different WRF physics configurations and anthropogenic and biomass burning emissions. We select the 2018 summer fire season as a case study considering data availability and quality of GOES AOD retrievals. We find that the WRF simulation generally captures the meteorological fields. Before assimilation, the WRF-CMAQ first- and second-day forecasts significantly underestimates AOD (mean bias of -0.1 and correlation of < 0.2) compared with MODIS and GOES retrievals, and surface $PM_{2.5}$ concentrations (mean bias of -1.3 and correlation of 0.1) compared with the EPA AirNow in-situ network measurements. With the assimilation of MODIS AOD at 15 Z, 18 Z, and 21 Z (UTC) every day, the model forecasts substantially improve AOD (mean bias of -0.05 and correlation of > 0.7) and surface $PM_{2.5}$ (mean bias of 0.2 and correlation of 0.2), with similar improvements for the first- and second-day forecasts. The diurnal cycles of surface $PM_{2.5}$ forecasts are largely improved particularly during afternoon and night. The assimilation of GOES AOD every 3 hours on each day shows similar but slightly smaller improvements in AOD and $PM_{2.5}$ forecasts, likely due to the relatively less accurate AOD retrievals of GOES than MODIS. We are also evaluating model forecasts against fire-related field

campaign (e.g., WE-CAN) measurements, and quantifying the effect of assimilating MODIS and GOES AOD together to investigate the benefit gained from using the high temporal resolution of geostationary satellite data.

Pius Lee
Presentation: 2473
Presentation *https://www.cmascenter.org/conference/2020/slides/CMAS_Oct2020_Pius_Lee.pdf*

Lee: A methodology to model wildfire emission for operational NAQFC consideration verified in the Firex-AQ Campaign

Youhua Tang1,2, Patrick Campbell1,2, Pius Lee1, Daniel Tong1,2,3, Barry Baker1,2, Rick Saylor4, Jeff McQueen5, Jianping Huang5,6 , Ho-Chun Huang5,6, Li Pan5,6, Ivanka Stajner5, Shobha Kondragunta7, Xiaoyang Zhang8, Dorothy Koch9, Jose Tirado9,10, and Youngsun Jung9
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The NOAA Air Resources Laboratory (ARL) has led research and pre-implementation testing of the National Air Quality Forecasting Capability (NAQFC) since 2003. Field campaigns represent collection of large amount of in-situ data critical for verification and pin-pointing deficiencies of the chemical and/or physical processes modeled in NAQFC. We will share past experiences how large campaigns had enriched the development and improvement of the NAQFC. In particular, how they enabled incremental and process-specific improvements in NAQFC. Discussion will be focusing on similar benefits of utilizing high quality observation from the Firex-AQ campaign to pin-point short-comings in the research version of NAQFC (dubbed as the "-β" version) which provided real-time forecasting support for Firex-AQ. The NAQFC- β consists of NOAA's Geophysical Fluid Dynamics Laboratory based FV3 dynamic core driven Global Forecast System (GFS) as the meteorological model and US EPA's CMAQ5.0.2 as its Chemical Transport Model. The Premaq module serves as the interface processor between GFS and CMAQ. This study high-lighted wild fires associated emissions, transport and removal of pollutants due to depositions. During the campaign wild fire associated particulate matter (PM) emissions resulted in spikes of large surface level PM concentrations. Our NAQFC-β based forecast provided to the campaign managers evidence-based information to assist them in making deployment decisions. We will share lessons learned on how NAQFC-β captured the episodic wild fire events by utilizing surface, remotely sensed, and in-situ flight data in its multiple platform data verification. We will provide examples on how sector-wise evaluation can identify specific NAQFC-β deficiencies.

Yunyao Li
Presentation: 2536
Presentation *https://www.cmascenter.org/conference/2020/slides/yunyao-Li_CMAS2020.pdf*

Li: Improving CMAQ Wildfire Prediction

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Biomass burning releases a vast amount of aerosols into the atmosphere, often leading to severe air quality and health problems. The Community Multiscale Air Quality (CMAQ) model is a comprehensive multipollutant air quality modeling system developed and maintained by the US Environmental Protection Agency's (EPA) Office of Research and Development (ORD). In this study, two improvements related to wildfire emission transport are added to the CMAQ V5.3.1. First, we added the Sofiev et al. (2012) plume scheme which is based on FRP to the CMAQ model. The original plume rise scheme in the CMAQ is base on Briggs (1969). Previous study shows that the difference in the calculated plume injection height caused great differences in the pollution transport and downwind pollution concentration. Second, we added biomass burning (BB) intermediate-volatile organic compounds (IVOC) emission to the CMAQ fire emission input data, and put two new IVOC related chemistry reactions into the cb6r3_ae6_aq mechanism. The improved model is used to simulate FIREX-AQ and Camp Fire cases with the blended Global Biomass Burning Emissions Product from MODIS, VIIRS, and geostationary satellites (GBBEPx). For the Camp Fire case, after adding the IVOC and related chemistry reactions to the model, the O3 mixing ratio is reduced by 50%, $PM_{2.5}$ concentration is reduced by 10%, and NOx is increased by 1 ppbv in the downwind region compared to the simulation results using original CMAQ model.

Jeff Vukovich
Presentation: 2508
Presentation
https://www.cmascenter.org/conference/2020/slides/Rx_Fire_diurnal_profile.Vukovich.CMAS.v4.pdf

Vukovich: Diurnal profiles for prescribed burns: Review, Recommended Updates, and Next Steps

Jeffrey M Vukovich, USEPA OAQPS

Currently diurnal profiles being used for prescribed fires will be reviewed. A methodology for updating these profiles using state permit data and satellite remote sensing data will be described. Lastly, results and recommendations for updated profiles will be discussed.

Cheng-En Yang
Presentation: 2478
Presentation *https://www.cmascenter.org/conference/2020/slides/2020CMAS_YCE.pdf*

Yang: Projections of Wildfire Impacts on Future Air Quality Changes

Cheng-En Yang, Joshua S. Fu, Xinyi Dong, Yongqiang Liu, and Yang Liu

Wildland fires have been a well-known issue that causes severe public health threats and property damage over the Western United States (WUS) especially in recent years. Rising surface temperatures, drier soil moisture, and lower atmospheric humidity as a result of increasing anthropogenic emissions have induced a more fire-prone environment in WUS. In this presentation, we will illustrate how future air quality in WUS would be influenced by wildfires through a series of CMAQ simulations. during the 2050–2059 fire seasons. Through controlling two different wildfire emission data sets, one from an empirical fire model driven by meteorological conditions from the U.S. Forest Serviceand the other one based on socio-economic activities from the International Institute for Applied Systems Analysis, we will demonstrate the projections of ozone and $PM_{2.5}$ concentration changes at state- and city-level due to

wildfires, which is essential to quantify air quality changes for health impact researches and to decision-making strategies for environmental management.

Hongmei Zhao
Presentation: 2523
Presentation
https://www.cmascenter.org/conference/2020/slides/Biomass_burning_emissions_Hongmei Zhao-2020.pdf

Zhao: Emissions of biomass burning and its impacts on air quality in Northeastern China

Hongmei Zhao, Guangyi Yang, Daniel Q. Tong, Xuelei Zhang, Aijun Xiu

Biomass burning is a major source of particulate matter (PM) and reactive trace gases emissions in China. Especially in the post-harvest season in the Northeastern China, open field crop residue burning and regional haze happened frequently in the past few years. In this study, we developed a near-real-time biomass burning emission inventory based on fire radiative power (FRP) obtained from the Visible Infrared Imaging Radiometer Suites (VIIRS) active fires datasets, and quantified the contribution of open biomass burning to surface $PM_{2.5}$ (particulate matter with diameter less than 2.5 μm) concentrations using air quality modeling. Higher levels of aerosol and pollutant gases emissions were concentrated in the Songnen Plain and Sanjiang Plain, the main grain producing areas in this region, and were associated with dense fire points. There were two emission peaks observed: after harvesting (October to November) and before planting (March to April). Furthermore, modeling results showed that open biomass burning contributed to 52.7% of $PM_{2.5}$ concentrations during a regional haze episode over Northeastern China. The burning ban enforced in 2018 have caused the $PM_{2.5}$ concentrations decreased by 48.1% during the post-harvest season over this region. Results of this study demonstrate the effectiveness of regulatory control in reducing fire emissions and lowering region-wide $PM_{2.5}$ concentration.

Shupeng Zhu
Presentation: 2442
Presentation *https://www.cmascenter.org/conference/2020/slides/shupeng-zu-economic-footprint_2020.pdf*

Zhu: The economic footprint of California wildfires in 2018

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Recent increases in the frequency and scale of wildfires worldwide have raised concerns about the influence of climate change and associated socio-economic costs. In the western U.S., the hazard of wildfire has been increasing for decades. Between 1972 and 2018, the annual burned area in California

increased fivefold, due at least in part to anthropogenic climate change. Over the same period, the state's population and the economy grew by 92% and about 440%, respectively. The combination of these trends has led to escalating impacts of wildfire on human well-being that reached new highs during the extremely large and destructive fires of 2017 and 2018. However, most previous estimates of these impacts have focused on direct damages: numbers of structures destroyed, the value of destroyed infrastructure, and lives lost. Here, we use a combination of physical, epidemiological, and economic models to comprehensively estimate the economic impacts of California wildfires in 2018, including the value of destroyed and damaged capital, the health costs related to air pollution exposure, and indirect losses due to broader economic disruption cascading along with regional and national supply chains. To better estimate the wildfire-related air quality impact, a systematic method is developed in a combination with both ground and satellite observation, the GFED4 fire emissions database, the GEOS-Chem air quality model, and the BenMAP health-economic tool. We find that wildfire damages in 2018 totaled $148.5 (126.1-192.9) billion (roughly 1.5% of California's annual GDP), with $27.7 billion (19%) in capital losses, $32.2 billion (22%) in health costs, and $88.6 billion (59%) in indirect losses. Our results reveal that the majority of economic impacts related to California wildfires may be indirect and often affect industry sectors and locations distant from the fires (e.g., 52% of the indirect losses—31% of total losses—in 2018 were outside of California). Our findings and methods provide new information for decision-makers tasked with protecting lives, and key production sectors and reducing the economic damages of future wildfires.

Full list of Presentations by Session and Author