

NOAA Global Monitoring Laboratory
Virtual Global Monitoring Annual Conference (eGMAC)

Local and Regional Sources of Pollution and their Impacts

July 10, 2020, 8:30-11:15 am MDT

Session Overview: Air quality and climate mitigation efforts require reliable and up to date estimates of emissions from different sources. Regulatory emission inventories have often been limited in scope in terms of gases, sources, spatio-temporal scales and have often relied on limited or outdated information. As a result, local and regional emission estimates for anthropogenic and biomass burning sources are often quite uncertain and can be significantly biased. Observations from intensive ground or airborne campaigns, in-situ measurement networks and remote sensing provide objective constraints to quantify and attribute air pollution levels and emissions. Presentations will showcase applications of advanced observing and modeling tools to characterize local and regional sources of a variety of pollutants, including greenhouse gases, criteria pollutants and air toxics at the local and regional scales.

Session Chairs: Gaby Pétron, Isaac Vimont, Xin (Lindsay) Lan

All times below are in Mountain Daylight Time (UTC -6).

<u>Time</u>	<u>Title / Abstract</u>	<u>Presenter & Affiliation</u>
08:40-08:55	The Arctic Carbon Cycle and its Response to Changing Climate	Lori Bruhwiler NOAA GML
08:55-09:10	Carbon Monitor: a new daily living dataset of global CO₂ emissions from fossil fuel and cement production	Philippe Ciais IPSL LSCE
09:10-09:25	Unexpected and significant biospheric CO₂ fluxes in the Los Angeles megacity revealed by atmospheric radiocarbon (¹⁴CO₂)	John Miller NOAA GML
09:25-09:40	Tracking atmospheric greenhouse gases in Toronto, Canada	Felix Vogel ECCC
09:40-10:00	Break/Discussion	
10:00-10:15	Background evaluation for an urban study: Washington DC and Baltimore	Anna Karion NIST
10:15-10:30	Exploring urban methane emissions from TROPOMI CH₄ and CO observations	Genevieve Plant University of Michigan
10:30-10:45	Evaluating public-transit platforms as a cost-effective component of urban monitoring and initial observations during the covid-19 lockdown	Logan Mitchell University of Utah
10:45-11:00	Quantifying mobile source nitrogen oxides emissions during the covid-19 pandemic	Brian McDonald NOAA CSL

SESSION ABSTRACTS

08:40-08:55 **Lori Bruhwiler, NOAA Global Monitoring Laboratory**

Title: The Arctic Carbon Cycle and its Response to Changing Climate

Abstract: The Arctic has experienced the most rapid change in climate of anywhere on Earth. Over the last half century, the mean annual surface temperature has increased at over twice the rate of the global average. This polar amplification of surface air temperature is likely to have far ranging effects on the carbon cycle. After briefly reviewing the range of physical responses to climate change in the Arctic and what we can expect in the future, I will discuss the current evidence for changes in the Arctic carbon cycle both from the top-down (atmospheric observation) point of view, and from the bottom-up (flux measurement) point of view. Do the top-down and bottom-up observations agree? What carbon cycle changes can be robustly detected at the current time?



08:55-09:10 **Philippe Ciais, IPSL Laboratoire des Sciences du Climat et de l'Environnement**

Title: Carbon Monitor: a new daily living dataset of global CO₂ emissions from fossil fuel and cement production

Contributors and Affiliations: Zhu Liu (Tsinghua University), Philippe Ciais (Laboratoire des Sciences du Climat et de l'Environnement), Zhu Deng (Tsinghua University), Steven Davis (University of California, Irvine), Bo Zheng (Laboratoire des Sciences du Climat et de l'Environnement LSCE), Yilong Wang (Laboratoire des Sciences du Climat et de l'Environnement LSCE), Duo Cui (Tsinghua University), Biqing Zhu (Tsinghua University), Xinyu Dou (Tsinghua University), Piyu Ke (Sun Yat-sen University), Taochun Sun (Capital Normal University), Rui Guo (Tsinghua University), Chenxi Lu (Tsinghua University), runtao Guo (Tsinghua University), Olivier Boucher (Institute Pierre-Simon Laplace, Sorbonne Université / CNRS, Paris, France), François-Marie Bréon (Institut Pierre-Simon Laplace), Eulalie Boucher (Laboratoire des Sciences du Climat et de l'Environnement LSCE), and Frederic Chevallier (LSCE)



Abstract: We constructed a near-real-time daily CO₂ emission dataset, Carbon Monitor, to quantify daily variations of CO₂ emissions from fossil fuel combustion and cement production since January 1st 2019 at national level with near-global coverage. Daily CO₂ emissions are estimated from a diverse range of activity data, including: hourly to daily electrical power generation data of 29 countries, monthly production data and production indices of industry processes of 62 countries/regions, daily mobility data and mobility indices of road transportation of 416 cities worldwide. Individual flight location data and monthly data were utilised for aviation and maritime transportation sectors estimates. This manifests the dynamic nature of CO₂ emissions through daily, weekly and seasonal variations as influenced by workdays and holidays, as well as the unfolding impacts of the COVID-19 pandemic (7.8% decline of CO₂ emission globally from Jan 1st to Apr 30th in 2020 when compared with the same period in 2019).

09:10-09:25 John Miller, NOAA Global Monitoring Laboratory

Title: Unexpected and significant biospheric CO₂ fluxes in the Los Angeles megacity revealed by atmospheric radiocarbon (¹⁴CO₂)

Contributors: John Miller (1) Scott Lehman (2), Kristal Verhulst (3), Charles Miller (3), Riley Duren(3), Vineet Yadav (3), Sally Newman(4)

Affiliations: 1. NOAA/GML, Boulder, CO 80305, 2. INSTAAR, U. of Colorado, Boulder, CO 80309, 3. NASA/JPL, Pasadena, CA 91109, 4. Bay Area Air Quality Management District, San Francisco, CA 94105

Abstract: It is normally assumed that emissions and concentrations of CO₂ in and around cities are dominated by fossil fuel-combustion. This is surprisingly not the case for the Los Angeles megacity area, despite its naturally dry climate. Measurements of atmospheric ¹⁴CO₂, the gold standard for identifying fossil fuel-CO₂ emissions in the atmosphere, quantify not only the influence of fossil fuel combustion but, by residual, the biospheric contribution as well. Here, we report results from an air sampling network for CO₂ and radiocarbon (¹⁴C) measurements within the Los Angeles megacity monitoring network. Unsurprisingly, mid-day CO₂ enhancements above background at our three sites in Los Angeles are very high, averaging 16 ppm. However, our analysis using radiocarbon reveals that only ~80% of the observed CO₂ variability resulted from fossil fuel combustion. The remaining ~20% came from biogenic sources. We quantify the contributions of possible sources to this unexpectedly large biospheric contribution. We find that the biospheric component of the L.A. CO₂ signal exhibits seasonal behavior with maximum net uptake of carbon in mid-summer (July). This contrasts with the seasonality of unmanaged ecosystems around the L.A. region, which tend to show maximum uptake earlier in the spring. The seasonality of these unmanaged ecosystems corresponds more closely to rainfall, while the seasonality of the biospheric CO₂ signal we infer from our CO₂ and ¹⁴CO₂ measurements corresponds with residential water usage patterns. This suggests a substantial role for managed, urban ecosystems in regulating the biospheric carbon fluxes of the Los Angeles region. We will also discuss the implications of our results for urban fossil fuel emissions monitoring using surface and space-based approaches.



09:25-09:40 Felix Vogel, Environment and Climate Change Canada

Title: Tracking atmospheric greenhouse gases in Toronto, Canada

Contributors: Felix Vogel¹, Sebastien Ars¹, Nasrin Mostafavi Pak^{1,2}, Doug Worthy¹, Elton Chan¹, Jennifer Murphy² and Debra Wunch²

Affiliations: ¹Environment and Climate Change Canada, ²University of Toronto



Abstract: Today, cities already account for a significant share of global greenhouse gas (GHG) emissions and with rapid urbanization, their importance will be growing in the future. The Greater Toronto and Hamilton Area (GTHA) is Canada's biggest metropolitan area with ca. 7M inhabitants. The GTHA is also the fastest growing urban area in US&CA and expected to reach 8.5M by 2030. In the same time, ambitious mitigation activities are aimed at reducing GHG emissions by 65% relative to 1990 (and 30% relative to 2020).

For over a decade ECCC has monitored atmospheric GHGs in Toronto and has progressively expanded the network across the GTHA to include in-situ GHG analyzers, carbon isotope observations and ground-based remote sensing instrumentation as well as mobile surveys, performed in collaboration with the University of Toronto. Together with atmospheric modelling tools, these observations are used to inform and test our recently developed emission inventories for CO₂ and CH₄.

Here, we present our observational network and key findings concerning long-term trends and the importance of different sources for atmospheric GHGs in the GTHA. Furthermore, we discuss our observations collected during the COVID lockdown period to assess the qualitative and quantitative impacts on atmospheric GHGs in the GTHA.

10:00-10:15 Anna Karion, NIST

Title: Background evaluation for an urban study: Washington DC and Baltimore

Contributors: Anna Karion, Sharon Gourджи, Kim Mueller, Israel Lopez Coto, Subhomoy Ghosh, James Whetstone, Xinrong Ren, Russ Dickerson

Affiliations: ¹ NIST, Gaithersburg, MD, ² University of Maryland, College Park, MD

Abstract: Regional and urban-scale studies rely on isolating enhancements from the region of interest from a background signal to estimate fluxes or evaluate trends of greenhouse gases. Because the size of a metropolitan area is small relative to a region or continent, the air masses entering the urban domain have significant temporal and spatial variability in their concentrations, and generally cannot be assumed to be uniform and smooth in time or space.



In this study, we construct several different background time series for our in-situ tower-based observing network in the Washington, DC and Baltimore, Maryland metropolitan regions. Several of these backgrounds rely on transport and flux-model output, while others utilize observations upwind of the domain. In this work, we first evaluate the backgrounds in a synthetic data framework, and then we evaluate them against real observations during periods with minimal influence from the urban domain. We find that observation-based backgrounds capture variability better than model-based backgrounds, although care must be taken to avoid bias from biospheric fluxes near the background stations in summer. Model-based backgrounds also perform well when the upwind fluxes are well-known and can be modeled accurately. Lastly, we explore the signal to noise ratios for the CO₂ observations at towers located in the Washington DC and Baltimore, MD urban areas to understand the implication of background errors on an inverse analysis. Our results provide guidance for urban network design and background determination and evaluation.

10:15-10:30 Genevieve Plant, University of Michigan

Title: Exploring urban methane emissions from TROPOMI CH₄ and CO observations

Contributors: G. Plant¹, E.A. Kort¹, J.D. Maasakkers², I. Aben²

Affiliations: ¹ Department of Climate and Space Sciences and Engineering, University of Michigan, Ann Arbor, MI, USA

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Abstract: Recent studies have shown that urban methane emissions often exceed inventory estimates, however these studies are limited to a handful of cities and regions. To assess the impact of these emissions on climate, the implications on fugitive losses from the natural gas supply chain, and to inform urban mitigation efforts, a larger and more representative sampling of cities is required. We collected recent aircraft observations downwind of major cities along the East Coast of the United States and used tracer:tracer ratios of methane and carbon monoxide to estimate methane emissions at the urban scale. While allowing for robust, data-driven results, the aircraft measurements are limited in their temporal and spatial extent. Launched in late 2017, the TROPospheric Monitoring Instrument (TROPOMI) on board the Copernicus Sentinel-5 Precursor satellite provides daily, global coverage of methane and carbon monoxide. We explore the feasibility of estimating urban methane emissions by analyzing enhancement ratios of coincident methane and carbon monoxide measurements from TROPOMI over urban domains. We will present analysis of the same U.S. East Coast cities that were the subject of our aircraft campaign for methodological verification and discuss the potential to study a more representative sampling of cities across the U.S. and the world.

10:30-10:45 Logan Mitchell, University of Utah

Title: Evaluating public-transit platforms as a cost-effective component of urban monitoring and initial observations during the Covid-19 lockdown

Contributors: Logan E. Mitchell¹, Derek Mallia¹, Lewis Kunik¹, Ben Fasoli¹, Ryan Bares¹, Kevin Gurney², Daniel L. Mendoza³, John C. Lin¹

Affiliations: ¹Department of Atmospheric Sciences, University of Utah, Salt Lake City, UT, ²School of Informatics, Computing and Cyber Systems, Northern Arizona University, Flagstaff, ³Pulmonary Division, University of Utah, Salt Lake City, UT



Abstract: Urban environments are often characterized by spatial and temporal variability, each of which present challenges for measurement strategies aimed at understanding greenhouse gas emissions and air quality. In Salt Lake City, UT we have deployed GHG and air quality instrumentation on light-rail train cars that traverse the city through a range of urban typologies. Here we will present advances in using these measurements within an inverse modeling framework driven by a high-resolution atmospheric transport model to demonstrate how public transit based mobile platforms can be used to reduce inverse modeling uncertainties relative to

stationary monitoring sites. Initial results suggest that a single high-precision instrument installed on a mobile platform can provide information that is comparable to a measurement network with several high-precision stationary sites or a high-density network constructed with lower cost/precision instruments. Lastly, we will show preliminary light-rail data from the Covid-19 March/April lockdown period of 2020 compared to 2019.

10:45-11:00 Brian McDonald, NOAA Chemical Sciences Laboratory

Title: Quantifying Mobile Source Nitrogen Oxides Emissions during the COVID-19 Pandemic

Contributors: Brian McDonald¹, Stuart McKeen^{1,2}, Jeff Peischl^{1,2}, Kenneth Aikin^{1,2}, Steven Brown¹, Meng Li^{1,2}, Rebecca Schwantes^{1,2}, Megan Bela^{1,2}, Colin Harkins³, Daven Henze³, Shobha Kondragunta⁴, Xinrong Ren^{5,6}, Russell Dickerson⁶, Elena Lind⁷, Jennifer Kaiser^{8,9}, Jeffrey Geddes¹⁰, Gregory Frost¹, Michael Trainer¹

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Abstract: The COVID-19 pandemic is an unprecedented event impacting society, the economy, and human activity. Satellite retrievals of nitrogen dioxide (NO₂) have revealed decreases in the tropospheric column over many regions of the world, which has important implications for oxidative chemistry. Here, we take a systematic approach to assess how nitrogen oxides (NO_x = NO + NO₂) emissions have changed due to the COVID-19 pandemic in the US. In the US, mobile source engines account for around half of the anthropogenic NO_x emissions, and the other half due to power plants and other industrial sources. We update the Fuel-based Inventory of Vehicle Emissions (FIVE) during the COVID-19 pandemic, accounting for changes in gasoline and diesel fuel sales. We assess the FIVE inventory in several US cities with separated passenger and truck traffic count data (e.g., Los Angeles, San Francisco, Atlanta, Boston, and New York City). Overall, we estimate that at the low point of traffic activity, mobile source NO_x emissions decreased across the US by ~50% relative to business-as-usual conditions, and during the reopening/recovery phase by ~30%. The FIVE inventory is simulated in the Weather Research Forecasting with Chemistry (WRF-Chem) model and we evaluate how the NO₂ column has changed due

to reduced mobile source NO_x emissions. We evaluate the model with TROPOMI satellite, Pandora spectrometer, aircraft, and routine monitoring site data.