

NOAA Global Monitoring Laboratory
Virtual Global Monitoring Annual Conference (eGMAC)
Understanding Atmospheric Concentrations of Trace Gases
Affecting Ozone and Climate

June 22, 2020, 8:30 am MDT

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Session Overview: Measurements of trace gases can provide insight into a wide range of topics, from quantifying emission changes in response to policy decisions, to inferring variability in fundamental properties of the atmosphere. This session will include the interpretation of measurements of medium- to long-lived trace gases that influence ozone depletion and climate. Implications of these results for understanding the human response to national and international policy decisions, stratospheric ozone recovery, and variability in atmospheric oxidation rates and dynamics on large scales will be highlighted.

Session Chair: Stephen Montzka

Chat Moderator: Brad Hall

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

Time	Title	Presenter and Affiliation
0830-0835	Introduction	Steve Montzka
0835-0850	Gross primary production over the North American Arctic and Boreal region inferred from atmospheric carbonyl sulfide measurements	Lei Hu NOAA Global Monitoring Laboratory, USA
0850-0905	A 3D-model inversion of methyl chloroform to constrain the atmospheric oxidative capacity	Stijn Naus Wageningen Univ. The Netherlands
0905-0920	Investigating the drivers of inter-annual variability in methyl bromide atmospheric levels	Mindy Nicewonger NAS/NRC/NOAA Global Monitoring Laboratory, USA
0920-0930	Break	
0930-0945	Near-global CFC-11 Trends as Observed by Atmospheric Infrared Sounder from 2003 to 2018	Xianglei Huang University of Michigan, USA
0945-1000	Investigation of East Asian emissions of CFC-11 using atmospheric observations in Taiwan	Karina Adcock University of East Anglia, UK
1000-1015	How reliably can we estimate inter-annual changes in global emissions of long-lived trace gases from atmospheric measurements?	Steve Montzka NOAA Global Monitoring Laboratory, USA
1015-1030	Predicting Inter-annual Variability of Long-Lived Trace Gas Levels at the Surface From Satellite Measurements in the Stratosphere	Eric Ray NOAA Chemical Sciences Laboratory, USA

SESSION ABSTRACTS

Understanding Atmospheric Concentrations of Trace Gases Affecting Ozone and Climate

0835-0850 Lei Hu

NOAA Global Monitoring Laboratory and CIRES, USA

Title: Gross primary production over the North American Arctic and Boreal region inferred from atmospheric carbonyl sulfide measurements

Abstract: Gross primary production (GPP) is the largest flux component in the global carbon cycle. It currently exceeds respiration and controls the overall land carbon sequestration. A measurement-based history of atmospheric carbonyl sulfide (COS), a powerful proxy for GPP, has suggested substantial increases in global GPP during the past century [Campbell et al., 2017]. This drastic change has resulted in an increase in global net land uptake, and contributed substantially to an enhanced seasonal cycle amplitude of atmospheric CO₂ in northern high latitudes. Although both models and observations agree upon a past increase of global GPP, substantial uncertainties remain in the magnitudes, trends, and seasonality of GPP on regional scales. Over the North American Arctic and Boreal region, simulated annual GPP magnitudes from terrestrial ecosystem models differ by a factor of 10 among models participating in the multi-scale synthesis and terrestrial model inter-comparison project.



Despite the paramount importance of GPP in the carbon cycle, it is extremely difficult to directly measure GPP on nearly all scales. In this study, we present a new regional modeling effort that allows us to constrain regional GPP from atmospheric COS measurements for the North American Arctic and Boreal region. The derived plant uptake of COS and inferred GPP from this new regional modeling framework are consistent with fluxes measured by the eddy covariance flux towers within the modeled uncertainties. Our COS-based GPP estimates show remarkably similar spatial and temporal variation as two satellite-based GPP proxies such as solar induced chlorophyll fluorescence (SIF) and MODIS near-infrared reflectance of vegetation (NIRv) over the North American Arctic and Boreal region. Furthermore, our results offer direct observational evidence of strong temperature control of GPP in the northern high latitudes and a mechanistic explanation on seasonal-cycle amplification of carbon fluxes over the northern high latitudes due to past warming.

0850-0905 Stijn Naus¹, M. Krol¹, S. Montzka², P. Patra³

¹Wageningen University, The Netherlands; ²NOAA Global Monitoring Laboratory, USA; ³JAMSTEC, Japan.

Title: A 3D-model inversion of methyl chloroform to constrain the atmospheric oxidative capacity

Abstract: The hydroxyl radical (OH) is the primary atmospheric oxidant. In this role, OH is involved in the removal of a wide variety of atmospheric pollutants and greenhouse gases. Despite the central role of OH in atmospheric chemistry, important metrics such as interannual variability and trends in OH on large spatial scales remain poorly constrained. This is mainly due to its low abundance and short lifetime of seconds. Over the past



decades, the anthropogenically emitted methyl chloroform (MCF) has been uniquely qualified as a tracer to indirectly constrain OH on large spatio-temporal scales.

Here, we present results from an inversion of MCF observations from the NOAA surface network that covers the 1998-2018 period, performed in the 3D chemistry-transport model TM5. We derived interannual variations in the global oxidation of MCF that bring simulated mole fractions of MCF within 1-2% of the assimilated observations from the NOAA-GMD surface network at most sites.

We find that MCF observations can be reproduced with small OH interannual variability (<2%) and no significant trend in OH. However, we also find large and systematic adjustments in the spatial distribution of OH (up to 30%). Given the unexpectedly large amplitude of these spatial adjustments, we suggest that instead, at high latitudes, the ocean might have become a source instead of a sink of MCF (as hypothesized in Wennberg et al., 2004). This reversal provides a more realistic explanation for the biases, possibly complimentary to adjustments in the OH distribution.

Wennberg, Paul O., et al. "Recent changes in the air-sea gas exchange of methyl chloroform." *Geophysical research letters* 31.16 (2004).

0905-0920 **Mindy Nicewonger**

NOAA Global Monitoring Laboratory, NRC/NAS Post-doctoral Fellow

Title: Investigating the drivers of interannual variability in methyl bromide atmospheric levels

Abstract: Methyl bromide is an important ozone-depleting gas with production phased out or regulated as part of the Montreal Protocol. The global budget of methyl bromide is now mainly controlled by natural emissions which could be strongly impacted by future climate changes. In the Halocarbons and other Atmospheric Trace Species (HATS) group in the Global Monitoring Laboratory, observations of the abundance of methyl bromide have been made at several surface sites globally for the past 25+ years. In this study, I am focused on understanding and quantifying the drivers of the variability in methyl bromide atmospheric levels over the past two decades. The surface observations show interannual variability in methyl bromide mixing ratios that are strongly correlated with the temporal trends in the El Niño Southern Oscillation, particularly with the positive, El Niño phase. Using a multi-box atmospheric and oceanic model, I investigate which sources and/or sinks are responsible for the large variations in methyl bromide mixing ratios during El Niño events. Using this information, it is possible to gain insight into how the budget of methyl bromide, and ultimately stratospheric ozone levels, could be impacted by future changes in climate.



0930-0945 **Xiuhong Chen¹, Xianglei Huang¹, L. Larrabee Strow²**

¹University of Michigan, USA; ²University of Maryland at Baltimore County, USA

Title: Near-global CFC-11 Trends as Observed by Atmospheric Infrared Sounder from 2003 to 2018

Abstract: Recent studies have indicated the slowdown of the decline of CFC-11 concentration since 2012. Ground-based observations used in such studies cannot provide spatial trends over the entire globe. Here we show that the CFC-11 time-varying behaviors can be seen by double differencing nadir-view, clear-sky brightness temperatures (dABTs) of four AIRS (Atmospheric Infrared Sounder) channels in the CFC-11 absorption bands. We further retrieve CFC-11 surface concentration and its secular trend from such AIRS observations over the near globe (55°S to 55°N) for the period of January 2003 to December 2018. The retrieved trends CFC-11 at 11 ground sites by NOAA and Japan Meteorological Agency are in good agreement with the trends derived from in-situ



measurements. Our results show that, from 55°S to 55°N, the CFC-11 trends from January 2003 to December 2012 are all negative, ranging from -2.5 to -1 ppt/yr. In contrast, the trends from January 2003 to December 2018 are slowed down by as much as ~ 0.5-1 ppt/yr over a large portion of areas. These findings delineate, for the first time, the near-global spatial distribution of the CFC-11 trends from 2003 to 2018.

0945-1000 **Karina Adcock**
University of East Anglia, UK

Title: Investigation of East Asian emissions of CFC-11 using atmospheric observations in Taiwan

Abstract: There has recently been an unexpected slowdown in the decline of CFC-11 mixing ratios in the atmosphere. The slowdown has been attributed to an increase in global CFC-11 emissions in part from eastern China. We independently assessed these findings by evaluating enhancements of CFC-11 mixing ratios in air samples collected in Taiwan between 2014 and 2018. The NAME (Numerical Atmospheric Modeling Environment) particle dispersion model was used to find the likely source of the enhanced CFC-11 observed in Taiwan to be East China. Other halogenated trace gases were also measured to find positive interspecies correlations. These correlations in combination with published emission estimates from China and eastern China, were used to calculate a combined CFC-11 emissions estimate for “(eastern) China”. For 2014–2018, we estimate an emission of 19 ± 5 Gg yr⁻¹ (gigagrams per year) of CFC-11 from (eastern) China, approximately one-quarter of global emissions. Comparing this to previously reported CFC-11 emissions estimated for earlier years, we estimate CFC-11 emissions from (eastern) China to have increased by 7 ± 5 Gg yr⁻¹ from the 2008–2011 average to the 2014–2018 average, which is consistent with the emission increases attributed to this region in an earlier study.



1000-1015 **Steve Montzka¹, Geoff Dutton¹, Eric Ray², Robert Portmann², Martyn Chipperfield³**
¹NOAA Global Monitoring Laboratory, USA; ²NOAA Chemical Sciences Laboratory, USA, ³Univ. of Leeds, UK.

Title: How reliably can we estimate inter-annual changes in emissions of long-lived trace gases from atmospheric measurements?

Abstract: The unexpected increase in global CFC-11 emission that we documented in mid-2018 is likely the result of a violation of the Montreal Protocol on Substances that Deplete the Ozone Layer. The finding has prompted an international effort by scientists, industry, policymakers, and non-governmental organizations to identify the underlying causes for this breach of the Protocol and minimize the associated emissions. In this second phase of the issue, one of our roles as atmospheric scientists is to provide accurate and timely feedback on any emission mitigation efforts being undertaken, so that their effectiveness can be reliably assessed. Atmospheric measurements of long-lived trace gases at remote sites around the world, like those conducted in NOAA/GML, provide an objective evidence-based means for deriving emission magnitudes and their changes over time. Factors other than emissions influence trace gas concentration at Earth’s surface, however, potentially confounding the interpretation of concentration data for understanding global emission changes, particularly on inter-annual timescales. In order to provide reliable estimates of year-to-year changes in emission, such influences must be carefully considered. In this talk I’ll review some of the progress that we have made in quantifying the impacts of non-emissive influences on trace gas abundances measured at Earth’s surface.



These factors are particularly critical to understand as we attempt to estimate year-to-year changes in global CFC-11 emissions as these mitigation actions are set in motion.

1015-1030 Eric Ray¹, R. Portmann¹, J. Daniel¹, S. Montzka², G. Dutton², B.Hall², F. Moore², K. Rosenlof¹,
¹NOAA Chemical Sciences Laboratory, USA; ²NOAA Global Monitoring Laboratory, USA and CIRES, Univ. of Colorado, USA



Title: Predicting Interannual Variability of Long-Lived Trace Gas Levels at the Surface From Satellite Measurements in the Stratosphere

Abstract: We have recently shown that variability on one to five-year time scales of a number of long-lived trace gases at the Earth's surface is largely determined by stratospheric transport variability driven by the QBO (Ray et al., 2020). This variability is important to account for in the calculation of annual emissions of trace gases such as CFC-11. In this work we examine the connection between interannual variability in CFC-11 measurements in the stratosphere from the ACE satellite instrument to those from the NOAA surface network. ACE satellite measurements now cover six consecutive QBO cycles and reveal many interesting features of the interannual variability of trace gas transport from the stratosphere to the troposphere. We use lagged correlations and regression techniques to show how the stratospheric observations can be used to explain past surface trace gas interannual variability, predict future variability and improve the uncertainty on emission estimates.
