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

New techniques and technologies for monitoring the atmosphere

July 31, 2020, *8:30-10:15 am MDT*

Register for the eGMAC at https://www.esrl.noaa.gov/gmd/annualconference/
to receive webinar information

Session Overview: This session will focus on new or improved analytical methods for atmospheric data collection and could include topics such as new technologies, expanding capabilities, sampling techniques, citizen science, logistical challenges of measurement, and novel use of existing data.

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Session Chair: Brad Hall Moderator: Aleya Kaushik

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

Time	Title / Abstract	Presenter & Affiliation
08:30-08:35	**Opening Remarks**	**Brad Hall, NOAA GML**
08:35-08:50	**New NOAA/GML techniques for evaluation of remote sensing greenhouse and trace gas retrievals using the AirCore**	**Bianca Baier** NOAA Global Monitoring Laboratory
08:50-09:05	**Development of a pressurized AirCore for low altitude trace species profiling**	**Isaac Vimont** NOAA Global Monitoring Laboratory
09:05-09:20	**European perfluorocarbon emissions inferred through atmospheric measurements**	**Dan Say** University of Bristol
09:20-09:30	**Break**	
09:30-09:45	**A Cavity-Enhanced Ultraviolet Absorption Instrument for High-Precision, Fast Time-Response Ozone Measurements**	**Tom Hanisco** NASA Goddard Space Flight Center
09:45-10:00	**Single photon LIF: A new benchmark for atmospheric measurements of nitric oxide**	**Andrew Rollins** NOAA Chemical Sciences Laboratory
10:00-10:15	**Development Efforts Toward Increasing Density and Coverage of Vertical Profile Measurements of Greenhouse Gases through Ride-along and Commercial Flight Opportunities**	**Kathryn McKain** NOAA Global Monitoring Laboratory

SESSION ABSTRACTS

Bianca Baier

Title: New NOAA/GML techniques for evaluation of remote sensing greenhouse and trace gas retrievals using the AirCore

Abstract: The NOAA/GML AirCore is a balloon-borne system that collects whole-air samples from the surface to the lower stratosphere (~30 km). Routine NOAA/GML AirCore flights are conducted on a monthly basis, with samples that are measured for carbon dioxide (CO_2), methane (CH_4) and carbon monoxide (CO), and are traceable to World Meteorological Organization (WMO) scales. With the ability to survey over 98% of the atmospheric column, it serves as an important remote sensing evaluation tool at a low operational cost. We discuss planned efforts to expand NOAA/GML's remote sensing evaluation capabilities in northeastern Colorado. In particular, these activities include long-term, continuous EM27/SUN Fourier Transform Spectrometer (FTS) retrievals of total-column greenhouse gases at a new nearby tower site that will be evaluated by calibrated monthly AirCore profiles and continuous in situ tower-based greenhouse gas observations. The EM27/SUN will thus act as a ground-based "transfer standard" in northeastern Colorado for spaceborne greenhouse and trace gas retrievals. Finally, we describe testing under way for a UAS platform that offers a pathway for efficient recovery of the AirCore and scientific payload to within 0.5 km. This recoverable platform is an exciting new technology for high-altitude atmospheric sampling and satellite evaluation that has the potential to be employed from both land- and ship-based launch locations.

Isaac Vimont, Colm Sweeney, Tim Newberger, Bianca Baier, Pieter Tans

Title: Development of a pressurized AirCore for low altitude trace species profiling

Abstract: We present the continuing development of a pressurized AirCore for use with Unmanned Aerial Vehicles (UAV). While the original AirCore is a powerful tool for vertical column measurements of trace species, it is a passive sampling system, and relies on the atmospheric pressure gradient to drive sample collection. In cases of low altitude vertical, and horizontal flight, an active system is needed.

NOAA's GML has been developing an active, pressurized version of the AirCore that is currently configured to fly on a multi-rotor UAV, but can be deployed on a variety of platforms, including fixed wing. This sampling system has been demonstrated to provide spatially and temporally accurate profiles for CO_2, CH_4, and CO by direct comparison with a research grade analyzer. An initial tracer release experiment demonstrated the ability of this system to detect plumes of CH_4 from small leaks with low flow rates. Finally, we detail critical modifications to the laboratory analyzers which make the measurements of both these pressurized AirCores as well as our passive AirCores.

Dan Say

Title: European perfluorocarbon emissions inferred through atmospheric measurements

Abstract: Perfluorocarbons (PFCs) are amongst the most potent greenhouse gases listed under the United Nations Framework Convention on Climate Change (UNFCCC). With atmospheric lifetimes in the order of thousands to tens of thousands of years, PFC emissions represent a permanent alteration to the global atmosphere on human timescales. While the industries responsible for the vast majority of these emissions - aluminum smelting and semi-conductor manufacturing - have made improvements in terms of efficiency and abatement measures, the global mean mole fraction of three PFCs, namely PFC-14 (tetrafluoromethane, CF_4), PFC-116 (hexafluoroethane, C_2F_6) and PFC-218 (octafluoropropane, C_3F_8), continue to grow. Here we report a multi-decadal (2003 - 2019) time-series of in situ PFC measurements from four European observatories. We used the longest of these records, taken from Mace Head on the west coast of Ireland, to estimate northern hemispheric baseline trends. For PFC-14, the baseline growth rate grew across the measurement period, apart from a dip in 2008/09 associated with the 2008 financial crisis. In contrast, the baseline growth rates of PFC-116 and PFC-218 remained comparatively stable. We used an inverse modelling framework to infer PFC emissions for northwest Europe. For PFC-14 and PFC-116, emissions from northwest Europe declined between 2010 and 2019, but no significant trend was observed for PFC-218. After 2010, Europe's emissions of PFC-218 were dominated by a single source in northwest England, consistent with the location of a PFC manufacturer. We hypothesize that, if accurate emissions information were made available for this site, this source could provide the ideal basis for a tracer release experiment, allowing for the validation of the meteorology and its parametrization within our atmospheric transport model.

Tom Hanisco, Reem A. Hannun Andrew K. Swanson, Steve A. Bailey, Thaopaul Bui, Ilann Bourgeois, Jeff Peischl, Thomas B. Ryerson, Glenn S. Diskin

Title: A Cavity-Enhanced Ultraviolet Absorption Instrument for High-Precision, Fast Time-Response Ozone Measurements

Abstract: The NASA Rapid Ozone Experiment (ROZE) is a broadband cavity-enhanced UV absorption instrument for the detection of *in situ* ozone (O_3). ROZE uses an incoherent LED light source coupled to a high-finesse optical cavity to achieve an effective pathlength of ~104 m within a small optical cell volume. Due to its high-sensitivity and compact physical footprint, ROZE demonstrates a 1σ precision of 80 pptv (0.1 s) and 31 pptv (1 s), as well as an instrument response time of 50 ms. ROZE can be operated in a range of field environments, including low- and high-altitude research aircraft, and is particularly applicable to O_3 vertical flux measurements using eddy covariance analysis. ROZE was successfully integrated aboard the NASA DC-8 aircraft during July–August 2019 and validated against a well-established chemiluminescence measurement of O_3. A flight within the marine boundary layer also

demonstrated flux measurement capabilities, and we observed a mean O_3 deposition velocity of 0.029 ± 0.005 cm s^{-1} to the ocean surface. The performance characteristics detailed below make ROZE a robust, versatile instrument for field measurements of O_3.

Andrew Rollins

Title: Single photon LIF: A new benchmark for atmospheric measurements of nitric oxide

Abstract: Nitric oxide (NO) is central to many atmospheric chemical processes. Reactions between NO and the hydroperoxyl radical exert significant control over atmospheric hydroxyl radical abundance. NO catalyzes ozone production in the troposphere, and oxidation of NO leads to the formation of nitrate aerosols. Stratospheric nitrogen oxides suppress levels of reactive halogens which otherwise would destroy ozone.

Decades of research have overwhelmingly relied on measurements of nitrogen oxides using the chemiluminescent (CL) detection of NO. We have recently developed a new technique for the measurement of NO that relies on single-photon laser induced fluorescence (LIF). The new LIF technique has many advantages over CL, including lower detection limit, less labor-intensive operation, and the potential for real-time measurements of NO isotopic ratios. The instrument has so-far been deployed during the 2019 NASA/NOAA FIREX-AQ campaign on the NASA DC-8 and also has run continuously for two months during the NOAA CSL COVID-AQS study during 2020. Here I will describe the principle of operation of this instrument and results from initial campaigns.

Kathyrn McKain

Title: Development Efforts Toward Increasing Density and Coverage of Vertical Profile Measurements of Greenhouse Gases through Ride-along and Commercial Flight Opportunities

Abstract: The NOAA Global Greenhouse Gas Reference Network aircraft program is currently comprised of routine vertical profile measurements at 13 sites in North America sampling 1-2 times per month up for a total of ~250 vertical profiles per year. In the NOAA GGGRN aircraft network, flask air samples are collected at fixed altitudes up to 5-8 km asl and are analyzed for CO_2, CH_4, and more than 50 other trace gases and isotopes. Since the NOAA aircraft network began over 20 years ago, the data have been used in a huge variety of analyses, but, by themselves, are too sparse to provide information on inter-annual variability in fluxes and on fluxes at sub-continental scales, which are crucial for diagnosis and attribution of the carbon-cycle and which were an original purpose of the program.

Given this critical and long-standing limitation of routine aircraft measurements of CO_2 and CH_4, we envision greatly increasing the density and coverage of greenhouse gas vertical profile measurements through the deployment of continuous measurement systems on commercial regional flights. This

presentation will describe multiple efforts that are underway in the NOAA Global Monitoring Laboratory to define the capabilities and requirements of such a program. First, we describe an effort to develop a more autonomous and robust measurement system which will allow for aircraft measurements to be routinely collected on ride-along flights without the presence of technical staff in East and Central Africa, where data collection would otherwise be extremely challenging. We also describe a collaboration with a jet manufacturer to investigate potential air sampling strategies on a model of aircraft that will be widely used for regional commercial flights. Lastly, we investigate the potential increase in data coverage from such a program with different numbers instrumented regional jets using historical flight tracks from the AMDAR (Aircraft Meteorological Data Reports) program and describe an observing system simulation experiment (OSSE) to investigate the potential impact of such a program on the accuracy of carbon flux estimates for the continental U.S. and North American Arctic.