Instrument Team Presenters: GHG

Teresa Campos: GOTHAAM

NCAR Facility Measurements of CO, CO_2 & CH_4

Configuration and Performance Expectations

Teresa Campos, Kirk Ullmann, Ed Kosciuch, and Frank Flocke
NCAR ACOM and EOL/RAF

AGES Meeting September 27-29, 2022

NCAR

NSF

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GOTHAAM CO, CO_2 & Methane Measurement Configuration

Instruments:	Picarro G2401-m CO_2, CO, methane and water vapor Wavelength-scanned CRD spectrometer Default 140-torr cavity pressure configuration Aero-Laser AL5002 CO Vacuum UV resonance fluorescence method Excitation: 151 ± 5 nm and emission: 170 – 200 nm
Calibrations:	1-2 times hourly, coordinated with NO_x and O_3 in situ sensors Traceable to WMO network maintained by NOAA GML CCGG
Inlet:	Unheated solid strut HIMIL, dedicated Perpendicular pick-off with an aft-facing 45 degree bevel cut ¼" i.d. stainless steel tubing
Data:	Preliminary field data will be included in RAF LRT netcdf files, within 24 hrs of flight Final quality data submitted in ICARTT format within 6 months of project end

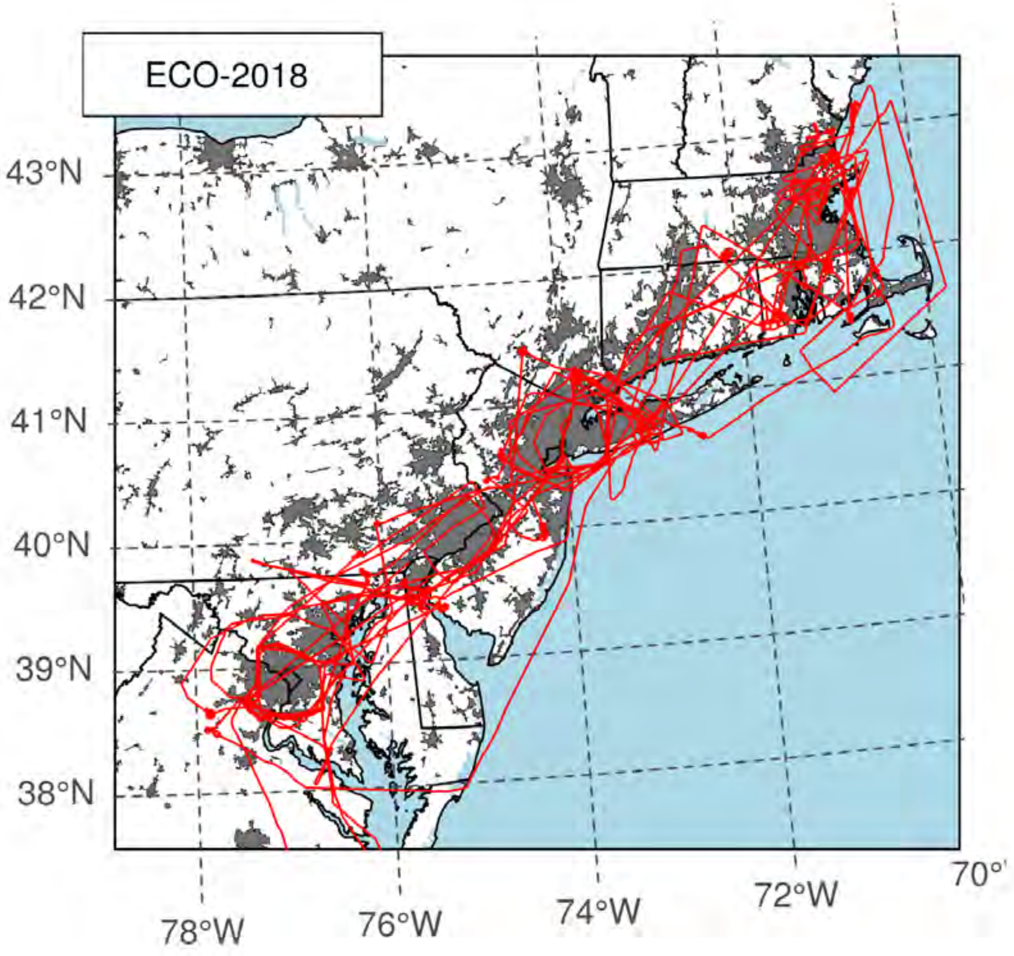
Performance Specifications

	Time Res	Measurand	LLOD	Precision	Uncertainty
Picarro G2401-m : (Default configuration)	1.3-2 s			(1-min,1σ)	(± 2σ)
		CO_2 (µmol/mol)	0.1	0.02	± 0.1 µmol/mol
		CH_4 (nmol/mol)	3.0	0.2	± 1.6 nmol/mol
		CO (nmol/mol)	3.0	3.0	± 0.1%
		H_2O (µmol/mol)	4.0	4.0	± 5%
Aero-Laser AL5002:	2 s			(1-sec,1σ)	(± 2σ)
		CO (nmol/mol)	2.0	1.6	1.6 ± 3%

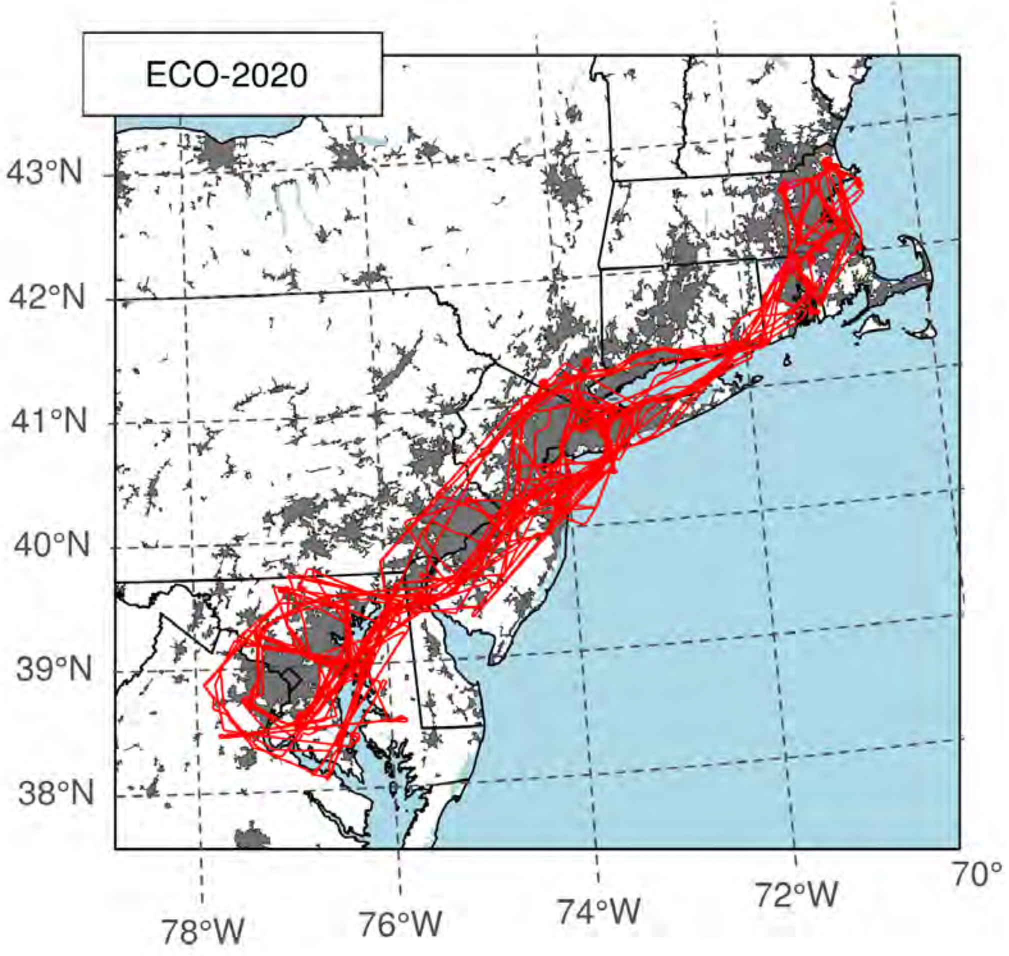
Colm Sweeny: CUPIDS

ECO Campaign

Aircraft measurements from Washington DC to Boston



20 flights in 2018
(04/08/2018 – 05/12/2018)



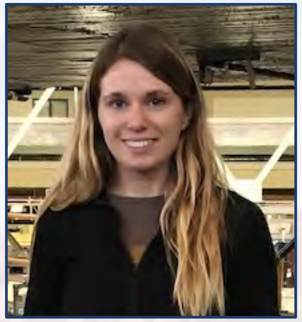
28 flights in 2020
(04/16/2020 – 05/16/2020)

Jeff Peischl: AEROMMA/FROG-NY

NOAA LGR/GHG on the NASA DC-8 measuring CO, N_2O, CO_2, CH_4, C_2H_6, & O_3

and NOAA LGR at FROG-NY measuring CO, H_2O (& N_2O)

Jeff Peischl
Instrument PI
CIRES/NOAA



Kristen Zuraski
CIRES/NOAA

assistants
pending

NOAA CHEMICAL SCIENCES LABORATORY

CIRES

Instruments

- Los Gatos Research $N_2O/CO/H_2O$ analyzer, modified for flight similar to the one flown during FIREX-AQ, but with a ***better N_2O measurement***
- Picarro $CO_2/CH_4/CO/H_2O$ analyzer, with an option for ***low cavity pressure mode*** allowing for measurements to the ***top of the DC-8 vertical profiles***
- Aerodyne C_2H_6 analyzer, for fast C_2H_6 measurements

- single channel O_3 chemiluminescence (see Rollins/Waxman NOyO3)

- LGR $CO/H_2O/(N_2O)$ analyzer at flux tower in New York City for FROG-NY

Science Goals

- Quantifying CH_4 emissions from major North American cities
  - C_2H_6 is necessary to distinguish natural gas emissions from microbial sources (landfills, wastewater treatment)
- Critically evaluating CO_2, CO, and CH_4 emissions inventories for megacities
- Continuing O_3 eddy covariance flux analysis over the ocean (building on ATom analysis)

Drew Gentner: NYC-METS

Greenhouse and other trace gas measurements at NYC-METS

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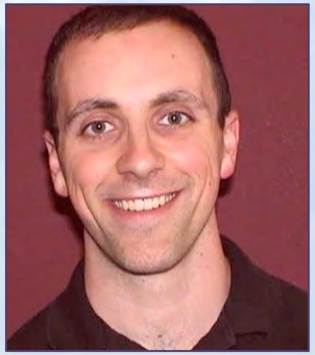
Aerodyne



Andrew Lambe
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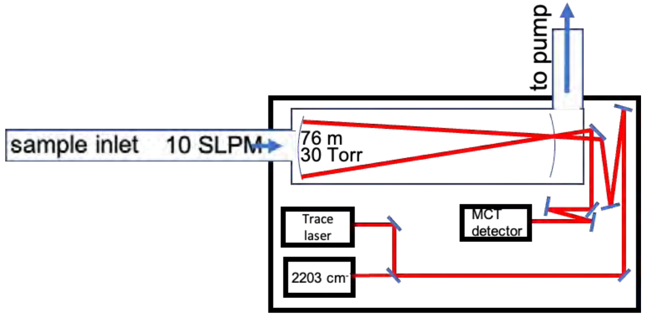
Aerodyne Research

Yale ENVIRONMENTAL ENGINEERING

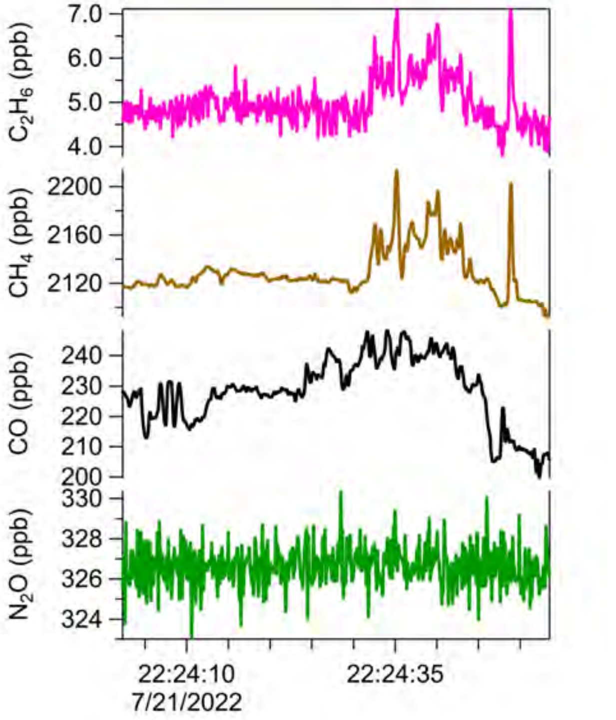
GHG and trace gas measurements at the Manhattan Site as part of NYC-METS

Aerodyne TILDAS (High-resolution CO, N_2O, CH_4, C_2H_6)



- High resolution IR spectrometer
- Operation at 10 Hz
- Time response <0.1 s
- 2203 cm^{-1}
  - CO: 150 ppt (1 s)
  - N_2O: 100 ppt
- 2998 cm^{-1}
  - CH_4: 500 ppt
  - C_2H_6: 50 ppt

High-resolution data snapshot (2022 prelim)



LiCOR 7000 (High-resolution CO_2, H_2O)

- Non-dispersive IR
- Continuous reference cell
- Operation at 4Hz
- Flow ~4 SLPM
- Time response <0.2 s
- Precision (1 s): 25 ppb

Also at the Manhattan and downwind Coastal CT site:

- Ozone
- SO_2
- NO/NO_2
- CO
- CO_2
- 10 Hz 3-D winds

NOAA Aerodyne Research Yale ENVIRONMENTAL ENGINEERING

Overview of science goals and foci

- Investigating urban emissions using multi-instrument source apportionment of traditional and emerging sources (VOCs, GHGs, trace gases, etc.)
- Examining fluxes in dense urban areas to aid emissions inventories
- Opportunities to examine vertical gradients (over 10 m) of GHGs and VOCs-SVOCs with onshore flow at the coastal CT site

Xinrong Ren

Aircraft and Mobile Measurements of GHGs during NEC-AQ-GHG 2023

Xinrong Ren[1], Phil Stratton[1,2], Paul Kelley[1,2], Winston Luke[1], Russ Dickerson[2], and Pete DeCarlo[3]

[1]NOAA Air Resources Laboratory (ARL) [2]University of Maryland [3]Johns Hopkins University

Cessna 402 Research Aircraft

To be deployed on same days to make simuletanous measurements of GHGs, other air pollutants, and met parameters on the ground and in the air.

- $CO_2/CH_4/CO$ (Picarro 2401-m)
- Ethane (Aeris Ultra)
- Black carbon (AE43 Aethalometer)
- Met and other air pollutants

NOAA's ARC (Air Resources Car)

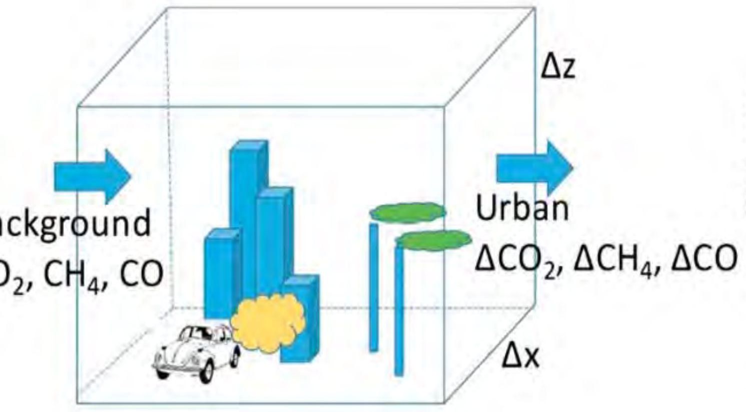
- $CO_2/CH_4/CO$ (Picarro 2401)
- Ethane (Aeris Ultra)
- $^{13}CO_2/^{13}CH_4$ isotope (Picarro G2201-i)
- Black carbon (AE43 Aethalometer)
- Met and other air pollutants

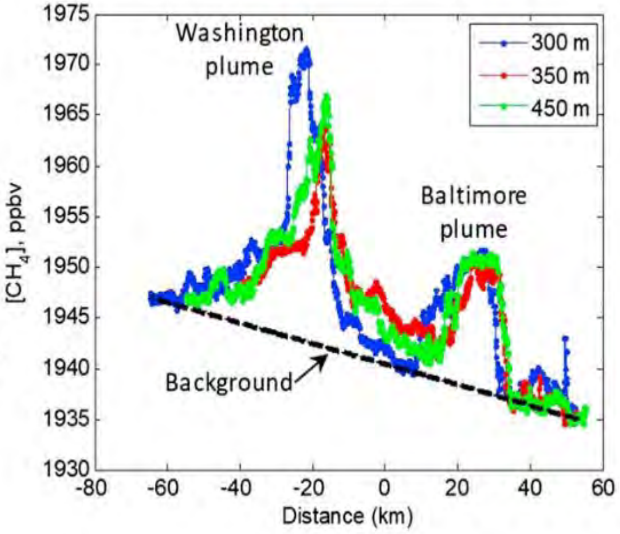
Aircraft Measurements of GHGs during NEC-AQ-GHG

Aircraft mass balance approach

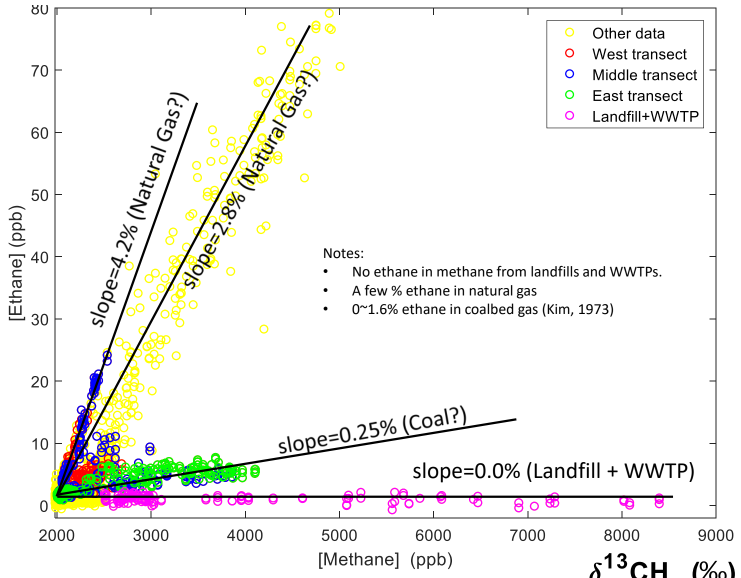
$$E.R. = \int_{z_i}^{z_f}\int_{x_i}^{x_f}\left([C]_{x,z} - \left[C_{bg}\right]_{x,z}\right)\cdot U_{\perp}\cdot k_x\,dxdz$$

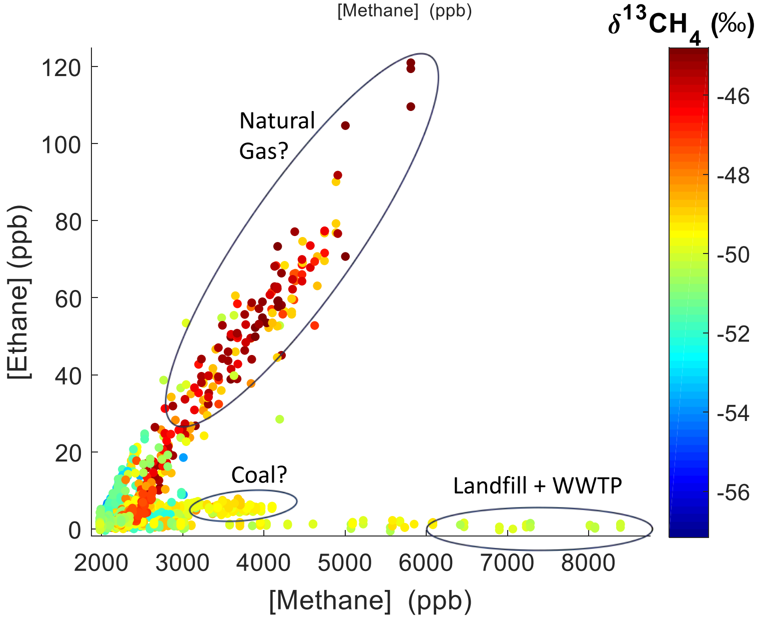
$E.R.$: emission rate (flux)
$[C]_{x,z}$: concentrations (downwind)
$[C_{bg}]_{x,z}$: concentration in background
$U_{\perp}$: perpendicular wind speed
k_x : scaling factor for $U_{\perp}$





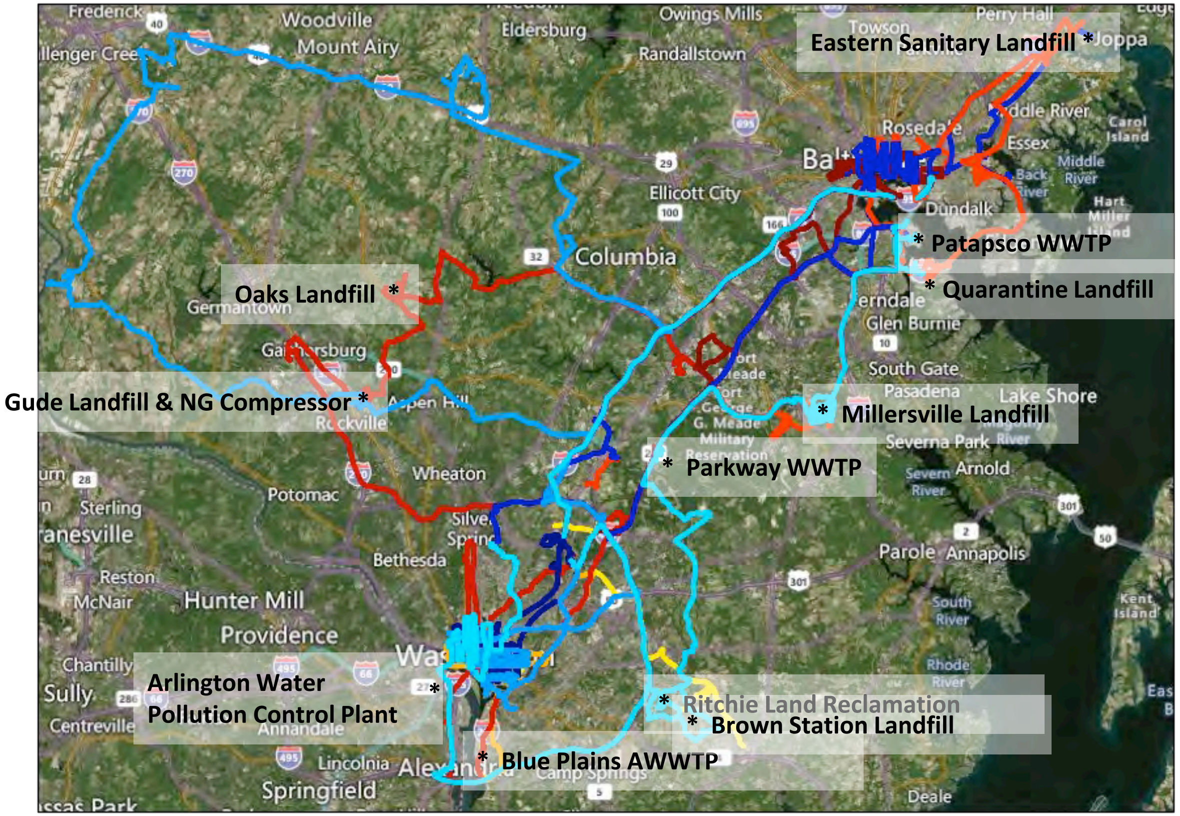
$\Delta[C_2H_6]/\Delta[CH_4]$ and $^{13}CH4$ for souce identification

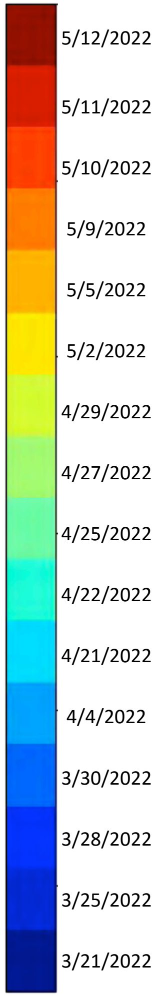


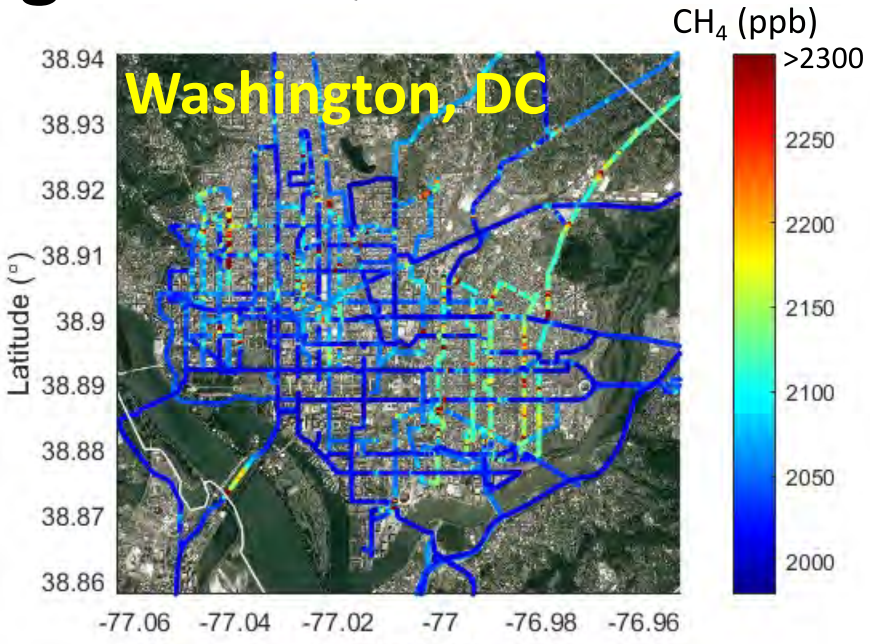


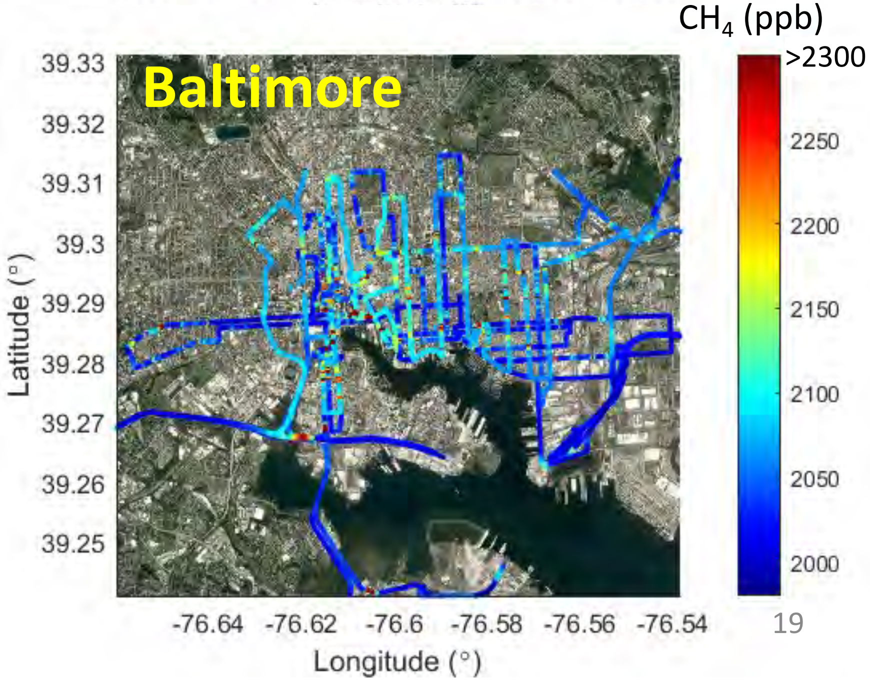
Mobile Measurements of GHGs during NEC-AQ-GHG 2023

- Major point sources survey
- Street-level GHG measurements
- Emission estimate based on observed species ratios and enhancements









Mobile measurements in DC-Balt in Spring 2022

Similar measurements to be conducted in NYC

Kevin Cossel: NYC-METS

Open-path dual-comb spectroscopy (DCS) for greenhouse gases and small VOCs

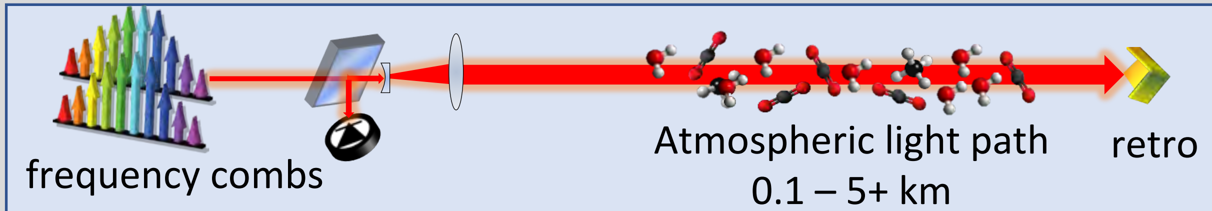
NIST team

Kevin Cossel (kevin.cossel@nist.gov)
Griffin Mead
Nathan Malarich
Fabrizio Giorgetta
Esther Baumann
Ian Coddington
Nathan Newbury

NIST
National Institute of Standards and Technology

Open-path DCS

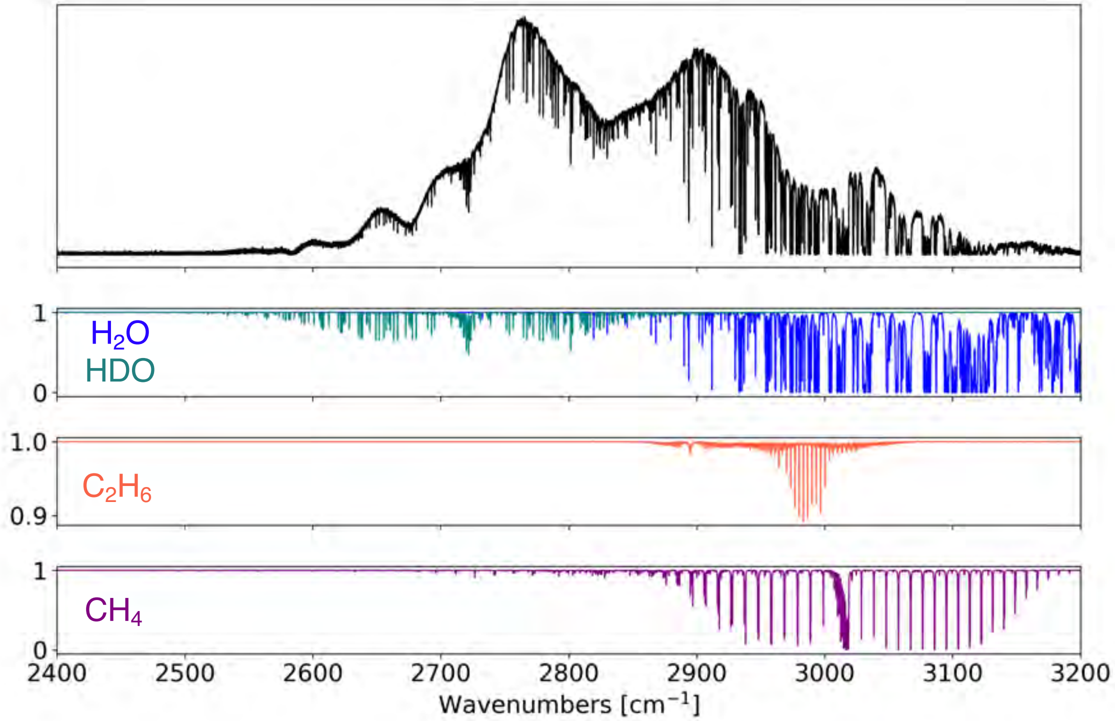
NIST



I Coddington Optica, 3, 414 (2016)
KC Cossel, Advances in Spectroscopic Monitoring of the Atmosphere, pp 27-93 (2021)

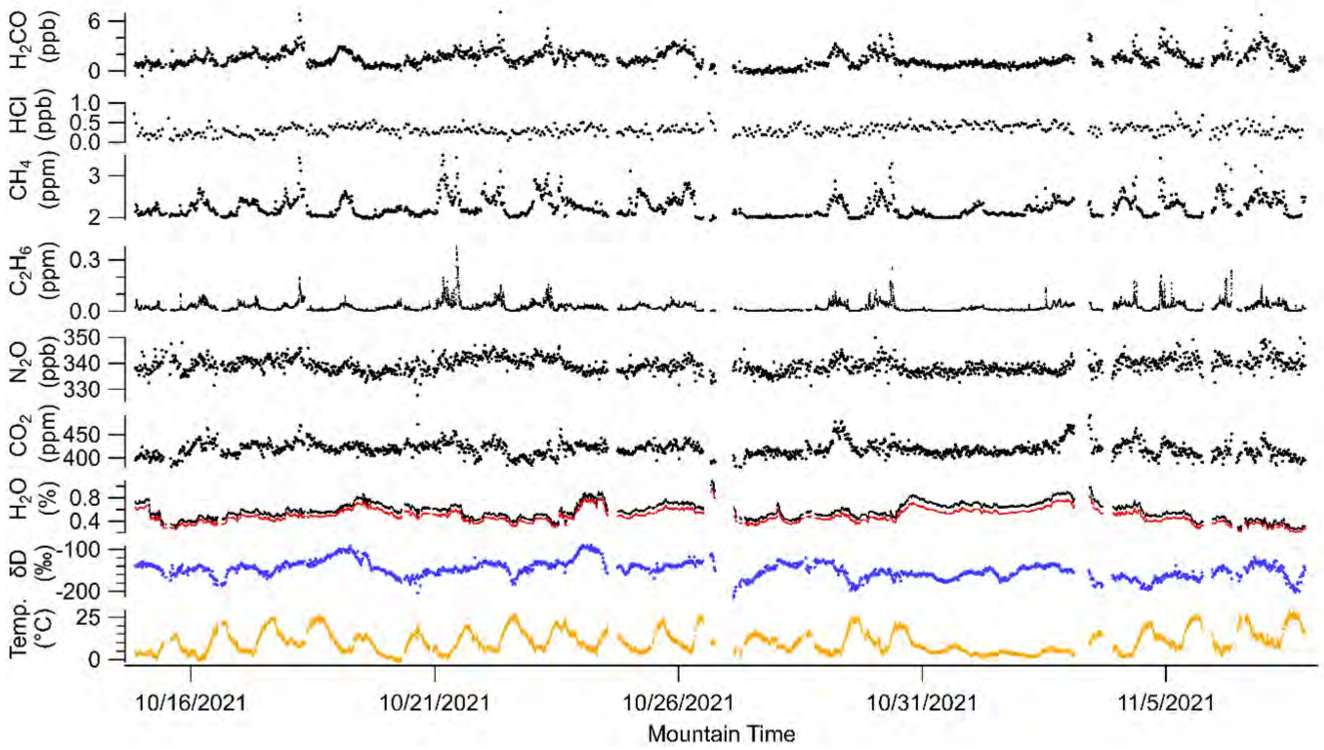
- Broad, high-res spectrum, no instrument lineshape
- Multi-species detection (ppb level)
- Long open-air paths
- Emissions from point and area sources

Example spectrum



+ other species (formaldehyde, propane, methanol, …)

Time series

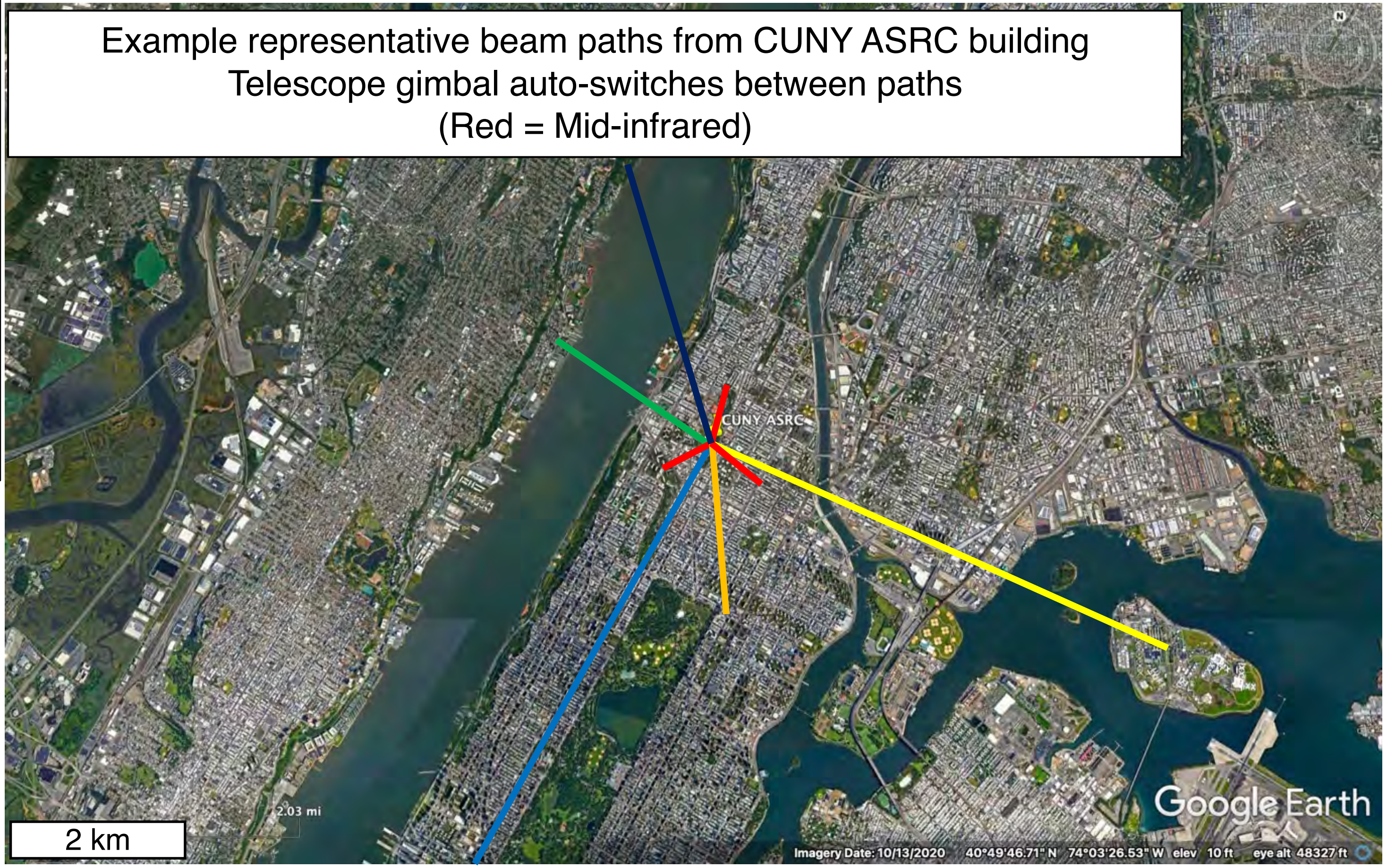


AGES plan

Goals:
- characterize urban emissions of GHGs and spatial-temporal variability
- Use C_2H_6 to apportion thermogenic, biogenic sources of CH_4
- Look at other tracers for source apportionment
- Compare point and open-path measurements
- Look at sources of H_2CO and relationship to ozone formation

<u>Near-Infrared (1.4-1.7 µm) System</u>
- 1-14+ km path lengths
- CH_4, CO_2, (maybe NH_3)

<u>Mid-Infrared (3-5 µm) System</u>
- 0.3 – 1 km path lengths
- ppb-level sensitivity, ~2 minute time resolution
- CH_4, N_2O, CO_2
- H_2CO
- C_2H_6, Other small VOCs
- HDO/H_2O (<10 per mil)



Contact: Kevin Cossel, kevin.cossel@nist.gov

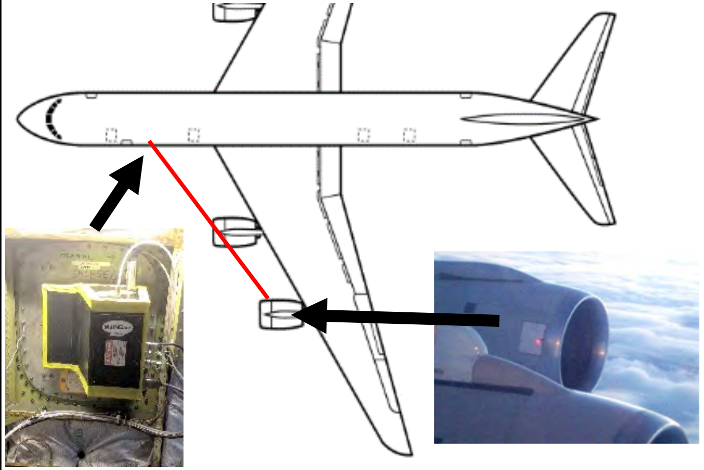
We are looking for postdocs/grad students and collaborators!

Glen Diskin: AEROMMA

Measurements of CO, CO_2, CH_4, N_2O, and H_2O(v), using the ***DACOM***, ***DLH,*** and ***LI-COR*** instruments, in support of AEROMMA

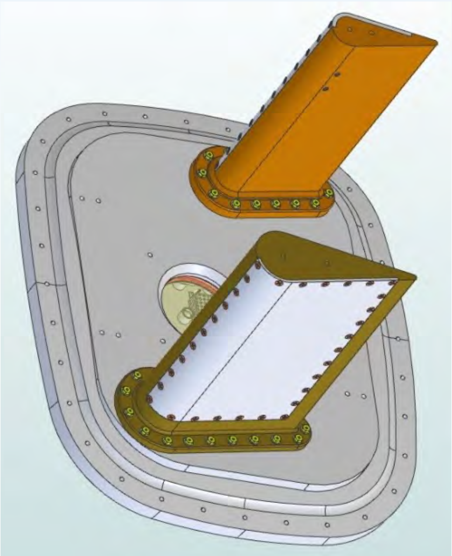
Glenn Diskin, Joshua DiGangi – NASA LaRC
Yonghoon Choi, Mario Rana – SSAI / NASA LaRC

Instrument	Species	Measurement Rate	Precision (1σ) (1 sec)	Accuracy
DLH, DLH-SP*	H_2O(v)	20 Hz	0.1% or 0.05 ppmv	5% or 1 ppmv
DACOM, 4-Channel Version*	CO	1-5 Hz	<1% or 1 ppbv	2%
	CH_4	1-5 Hz	<0.1%	1%
	N_2O	1-5 Hz	<0.1%	1%
	TBD	1-5 Hz	TBD	TBD
LI-COR 7000	CO_2	1-5 Hz	0.05 ppmv	0.15 ppmv
* Under Development				



<u>Measurement / Analysis Interests</u>

- Evaluation of New Instruments
- DLH vs DLH-SP, or DLH-SP vs itself
- DACOM 4-channel vs Peischl



- Emission Ratios
    - CO:CO2, CO:CH4, others
- Biomass, Urban, Industrial
    - Marine/Urban Interface
- Stratospheric Influence, Other Dry Layers