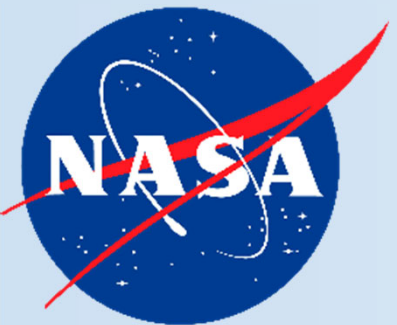


DLH/CRDS Instrument Suite Overview

Josh DiGangi, Glenn Diskin
NASA Langley Research Center

SARP 2022 Payload Briefing
06/15/2022

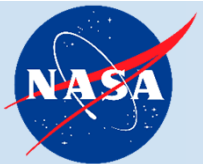




Payload Overview

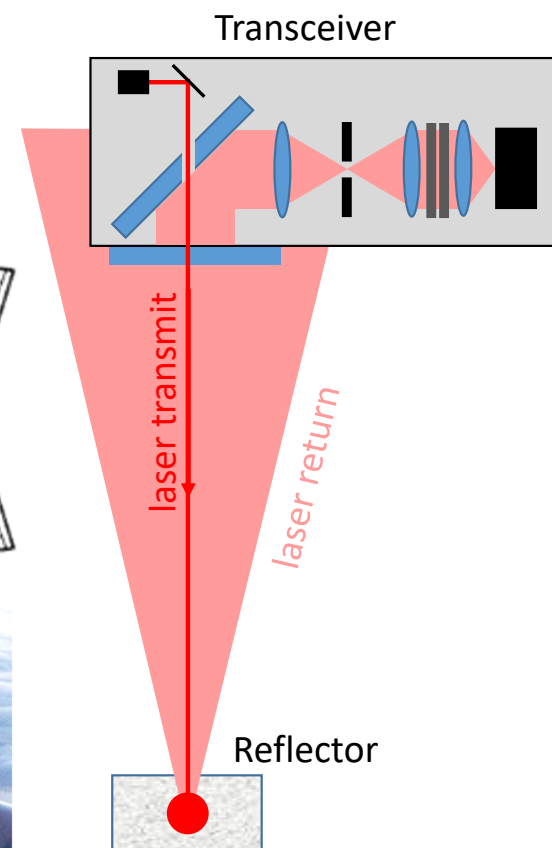
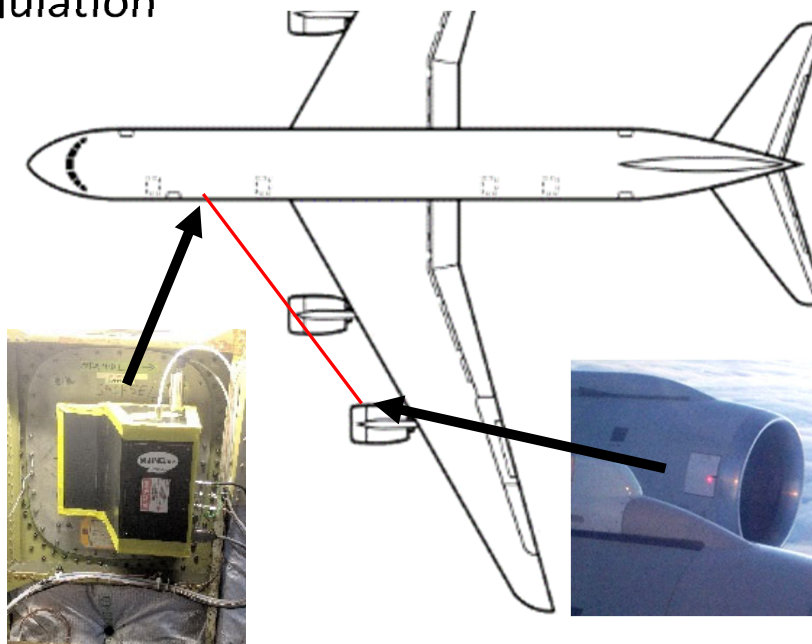
Instrument	Technique	Species	Data Rate	Precision (1σ)	Accuracy (1σ)
DLH	Open Path Absorption Spectroscopy	H ₂ O _(v)	1 Hz, 20 Hz	0.1% or 0.1 ppm	5%
DLH-SP		H ₂ O _(v)	1 Hz, 20 Hz	TBD	5%
CRDS	Cavity Ringdown Spectroscopy	CO ₂	0.4 Hz	0.1 ppm	0.1 ppm
		CH ₄	0.4 Hz	1 ppb	1%
		CO	0.4 Hz	4 ppb	2%
	Differential UV Absorption	O ₃	0.5 Hz	2 ppb _v	5 ppb _v

- Open path instruments – samples air in free stream
- Extractive instruments – involves sampling air
- *In situ* analysis – measurements made and viewable in real time
- Science applications
 - Air quality/atmospheric chemistry research
 - Emissions inventories for predictive computer models
 - Satellite measurement validation



Diode Laser Hygrometer (DLH)

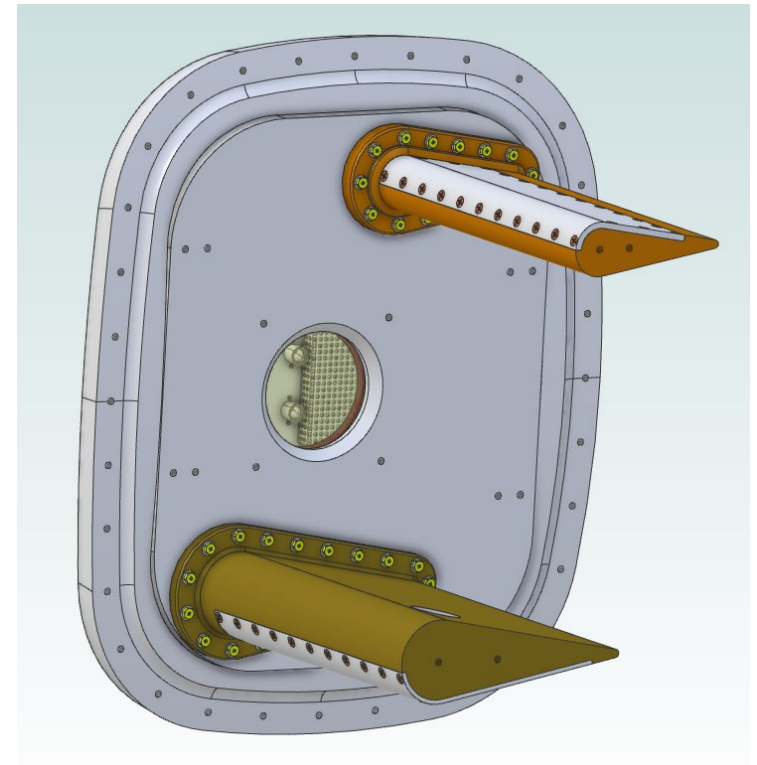
- Open path spectrometer measures water vapor through light absorption over the ambient path
- Line-locked wavelength modulation spectroscopy @ $1.4\ \mu\text{m}$
- Three absorption line with different magnitudes: measures water vapor from $< 1\ \text{ppm}_v$ – 4%
- Different versions for more than 10 aircraft, DC-8 heritage 20+ years





Diode Laser Hygrometer – Short Path (DLH-SP)

- Combines traditional “long path” DLH with a shorter path between two fins onto a single DC-8 window plate
- Same fundamental method as DLH
- New version, first flight during SARP 2022
- Advantages of shorter path:
 - More localized measurements
 - Less cloud scatter interference
- Disadvantages of shorter path:
 - Shorter path = less precision
 - Greater chance of interference from cabin leaks, other fuselage effects

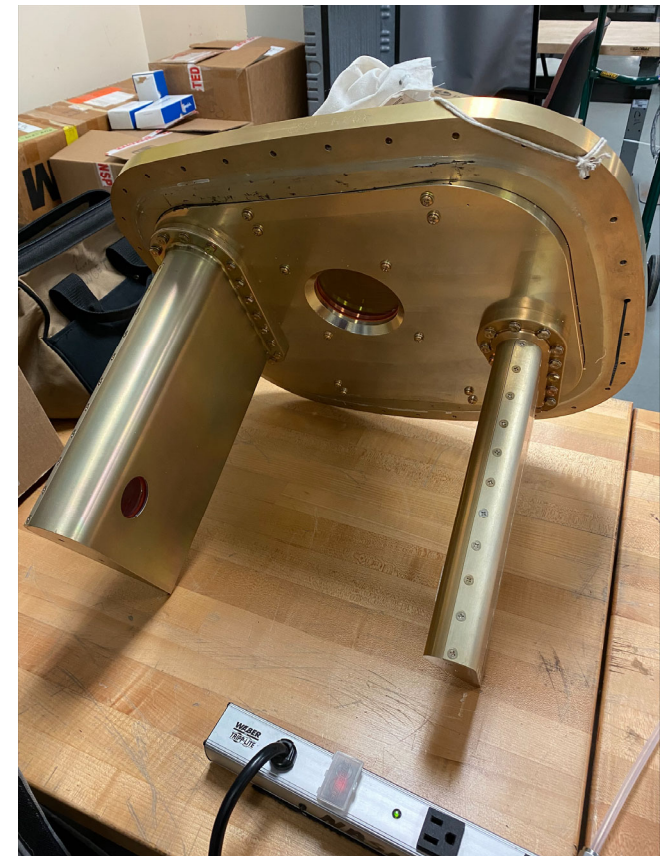


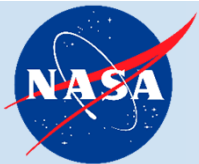


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****Update: not available for SARP** 😞





CRDS Picarro – Cavity Ringdown Spectroscopy

Beer-Lambert Law:

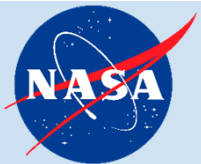
$$A = \sigma(\lambda) \cdot d \cdot c$$

Amount of light absorbed

Absorption cross-section

Distance of light path

Volume concentration of absorbing species



Picarro – Cavity Ringdown Spectroscopy

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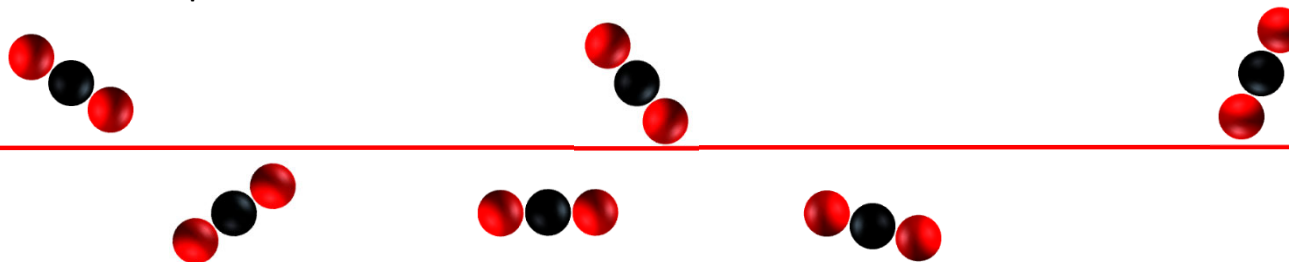
Amount of light absorbed

Absorption cross-section

Distance of light path

Volume concentration of absorbing species

Laser λ



Detector



CRDS Picarro – Cavity Ringdown Spectroscopy

Beer-Lambert Law:

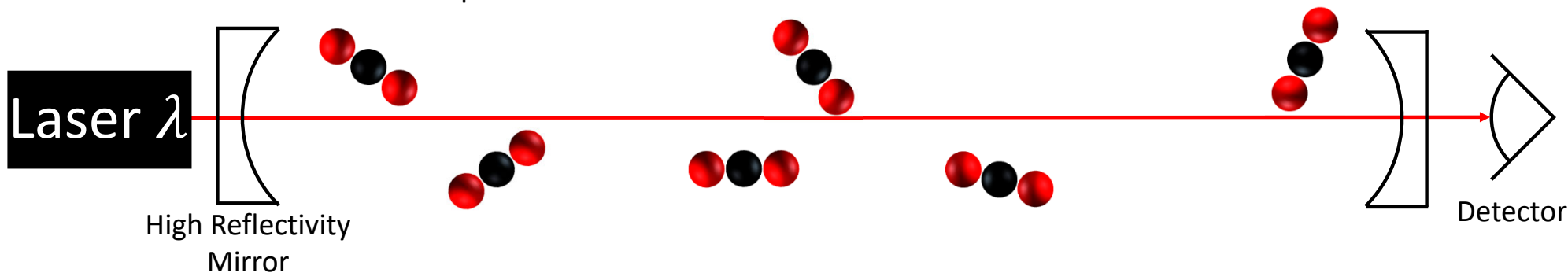
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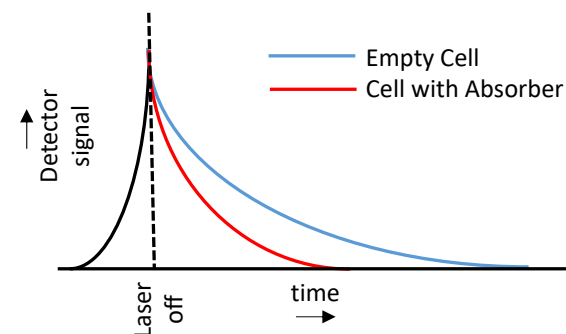
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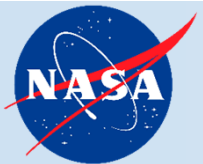
Distance of light path

Volume concentration of absorbing species

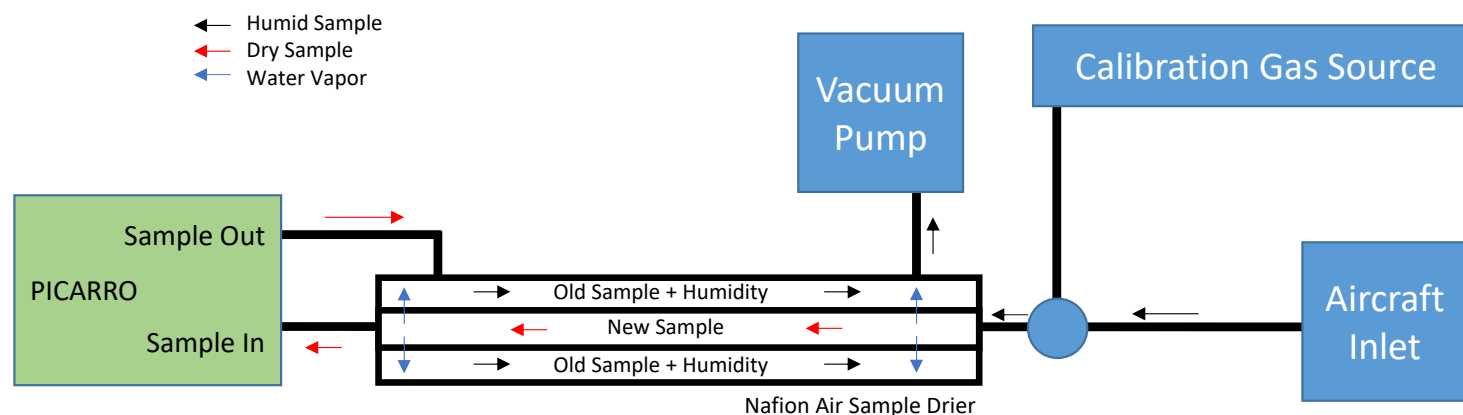


- Mirrors create light “trap”
- Rate light leaks out depends on mirror reflectivity and concentration of absorbing species
- Can achieve equivalent light paths of kilometers with 1 m cell





CRDS Picarro – Cavity Ringdown Spectroscopy



- Sample dehumidification

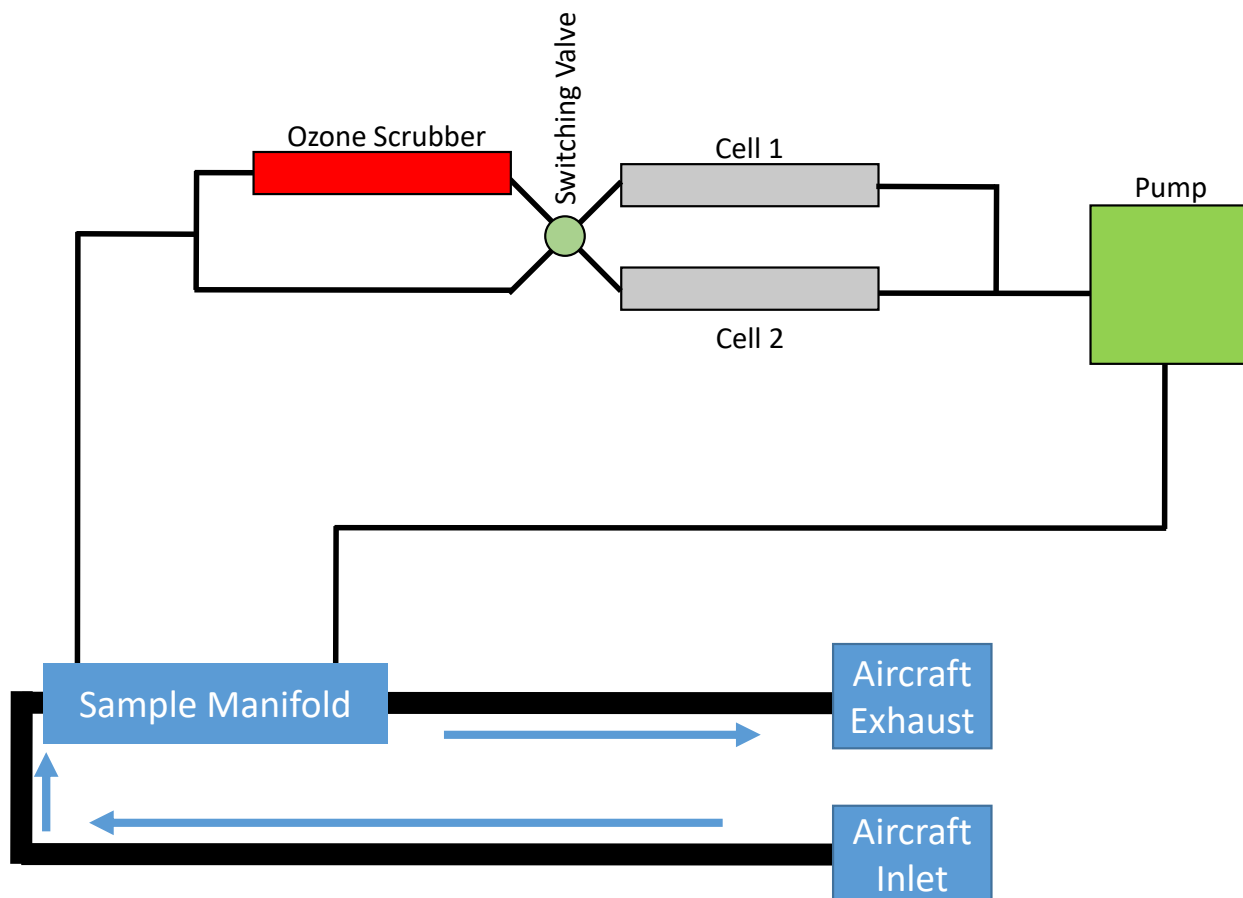
- Amount of humidity in air not insignificant when measuring concentrations
- Water vapor absorption can also bias cavity ringdown measurement
- Convention: CO_2 , CH_4 , CO concentrations reported in moles/mole dry air (dry molar fraction)

- Calibration

- Hourly with single known concentration – track instrument background drift
- Weekly with three known concentrations – track instrument response



CRDS Ozone – Differential UV Absorption Spectroscopy



- Air alternates in each cell between sample and reference (scrubbed) air
- Cell switch at 1 Hz, providing 2 second differential measurements
- Sample manifold keeps sampling and exhaust pressure constant



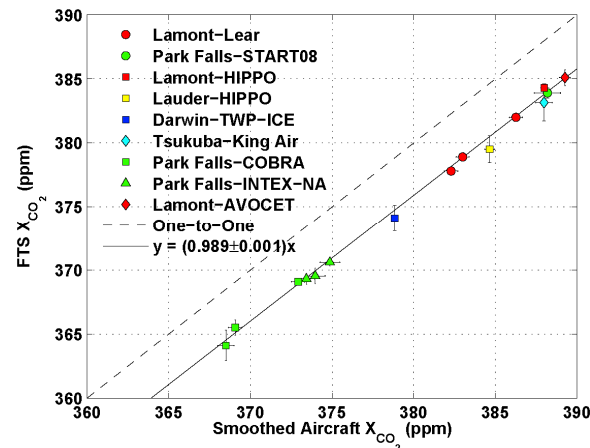
Applications: Satellite/Remote Sensor Calibration

TCCON Sites
(Feb 2021)



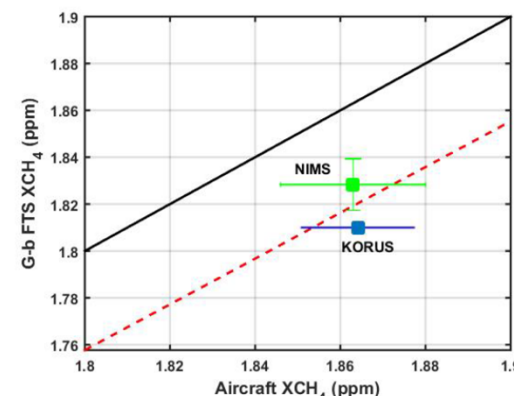
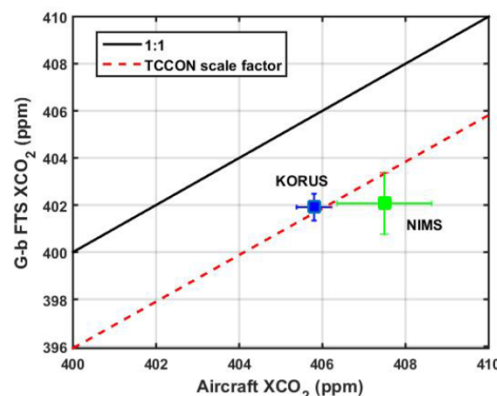
<https://tcon-wiki.caltech.edu/Main/TCCONSites>

- TCCON
 - Global network of solar-tracking NIR spectrometers
 - Primary validation for numerous flight instruments
 - OCO-2, GOSAT, TROPOMI
 - Column CO_2 , CH_4 , N_2O , HF, CO, H_2O , HDO
- All core instrument measurements can be used for validation
- Common target of opportunity during many campaigns
- In situ data comparisons help discover, correct biases



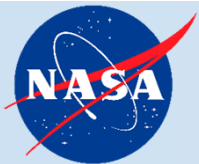
Multicampaign Summary
of TCCON Comparisons

Mod from D. Wunch et al.,
AMT, 3, 1351 (2010).

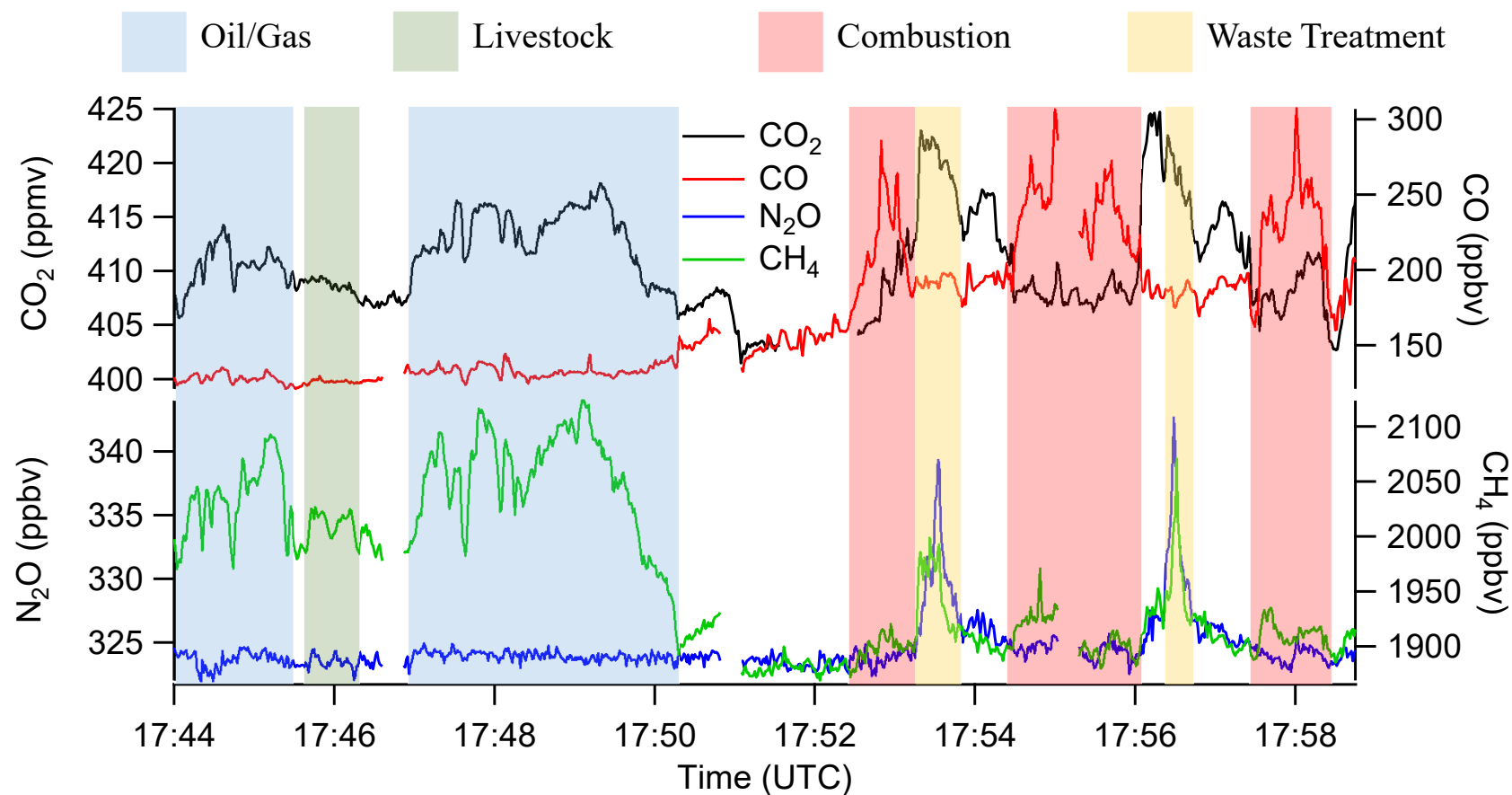


Anmyeondo TCCON Comparison during KORUS-AQ

Y.-S. Oh et al, AMT, 11, 2361 (2018)

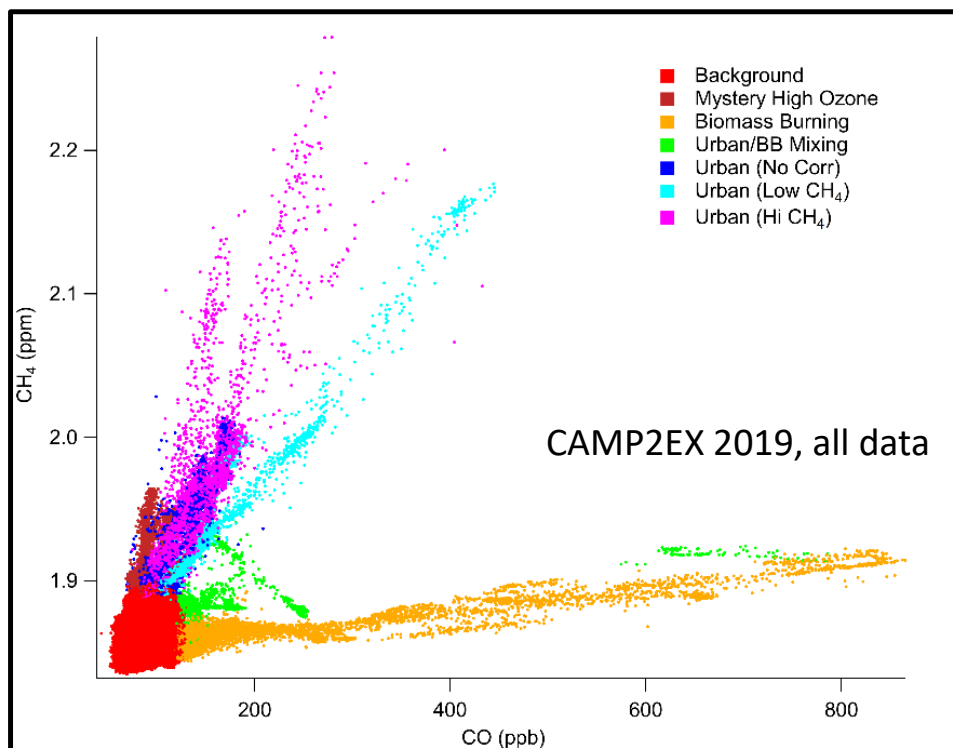


Applications: Trace Gas Correlation Analysis

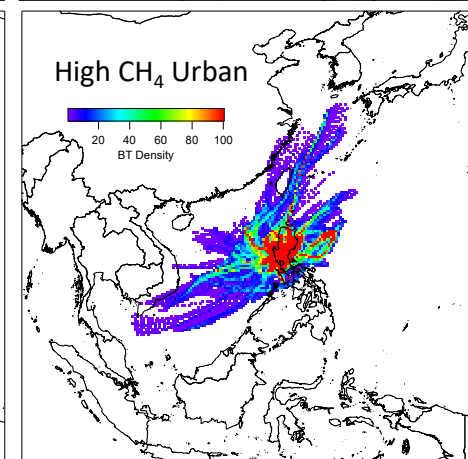
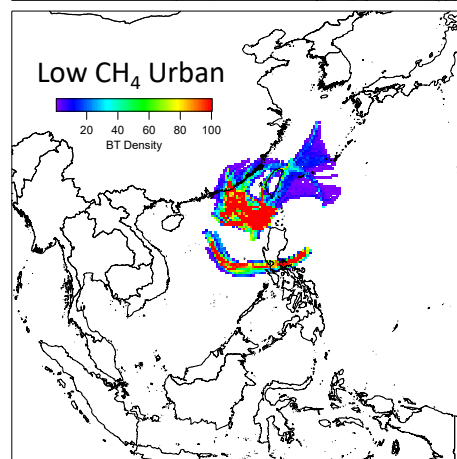
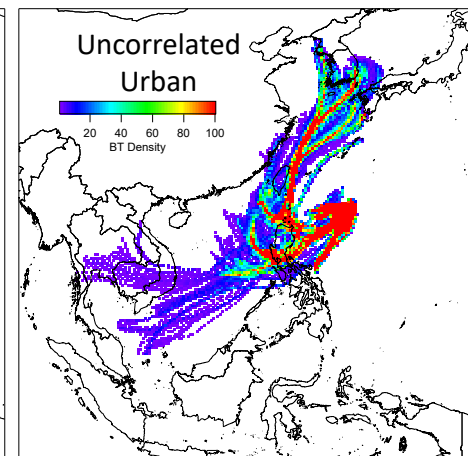
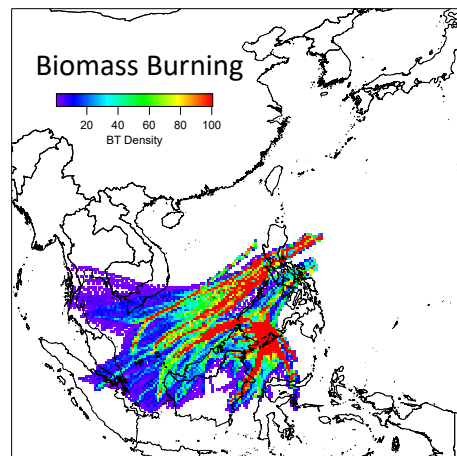




Applications: East Asia Chemical Influence Apportionment

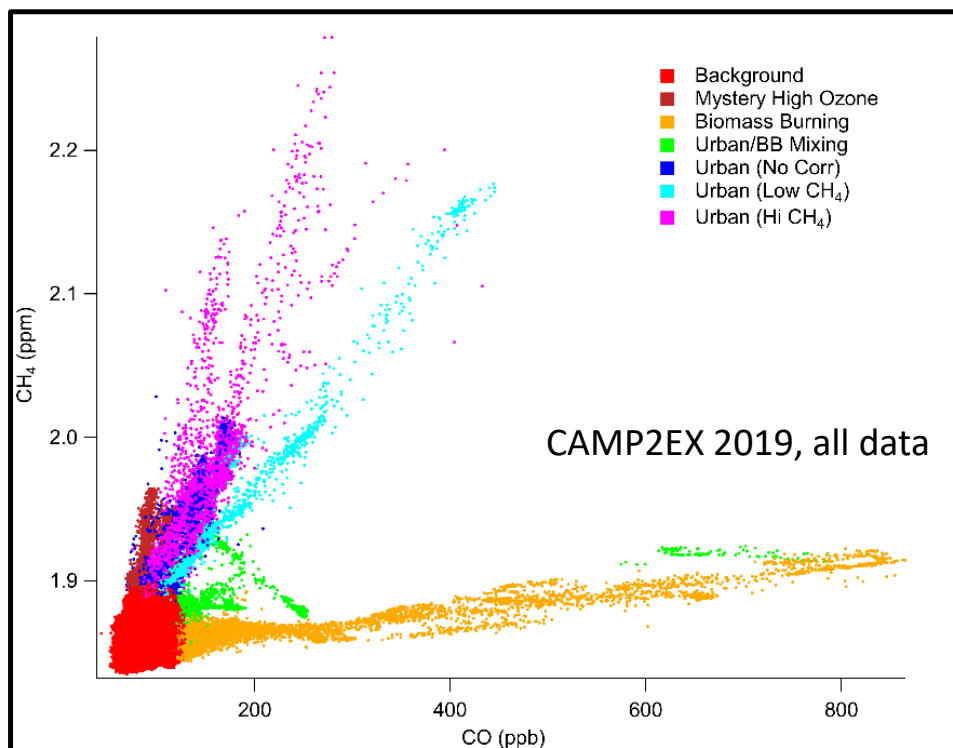


- Ratios of CH_4 :CO used to isolate different pollution sources
- Can use as an emission marker to investigate source chemistry in the region



48 h HYSPLIT Backtrajectories along flight track (<https://www.ready.noaa.gov/HYSPLIT.php>)

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