Infrared Measurements of Carbon Monoxide

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Infrared Correlation Radiometer for GEO-CAPE

Why Measure Carbon Monoxide?

- CO is created by incomplete combustion or oxidation processes including industry, cars, and widespread burning.
- The main sink of CO is oxidation by OH, so high CO levels can potentially affect the oxidizing capacity of the atmosphere.
- Reaction of CO with OH in the presence of NO_x leads to the formation of tropospheric O_3 .
- CO lifetime is between a week and two months depending on atmospheric processes.
- Lifetime of weeks is long enough to be transported without becoming evenly mixed, so CO is a useful chemical tracer of atmospheric motion.

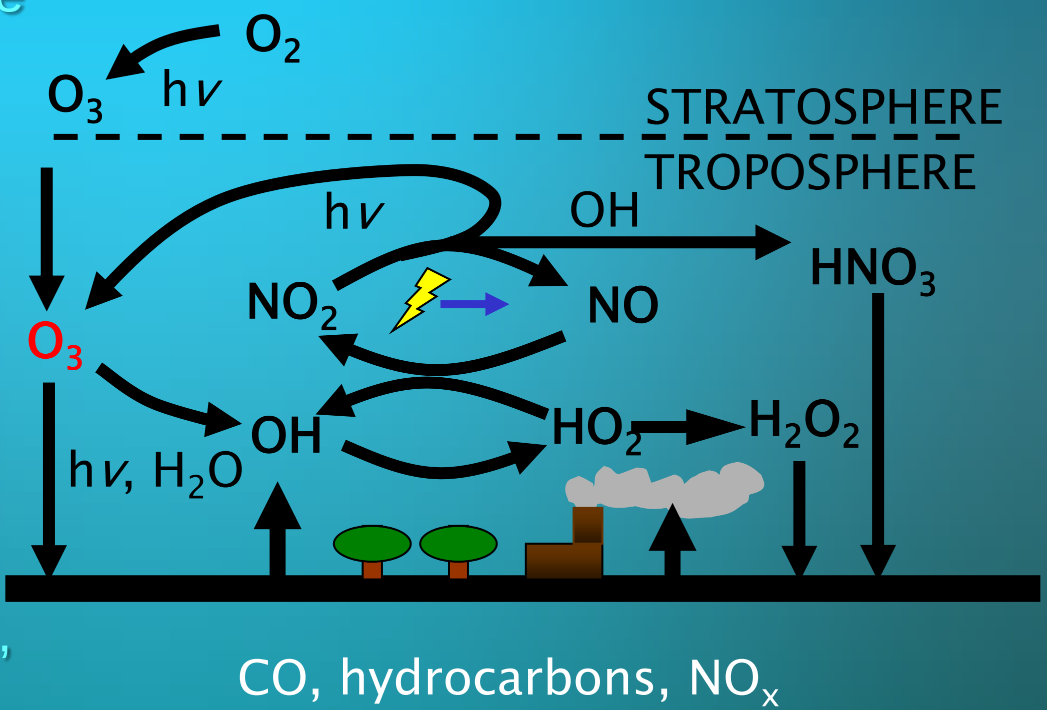
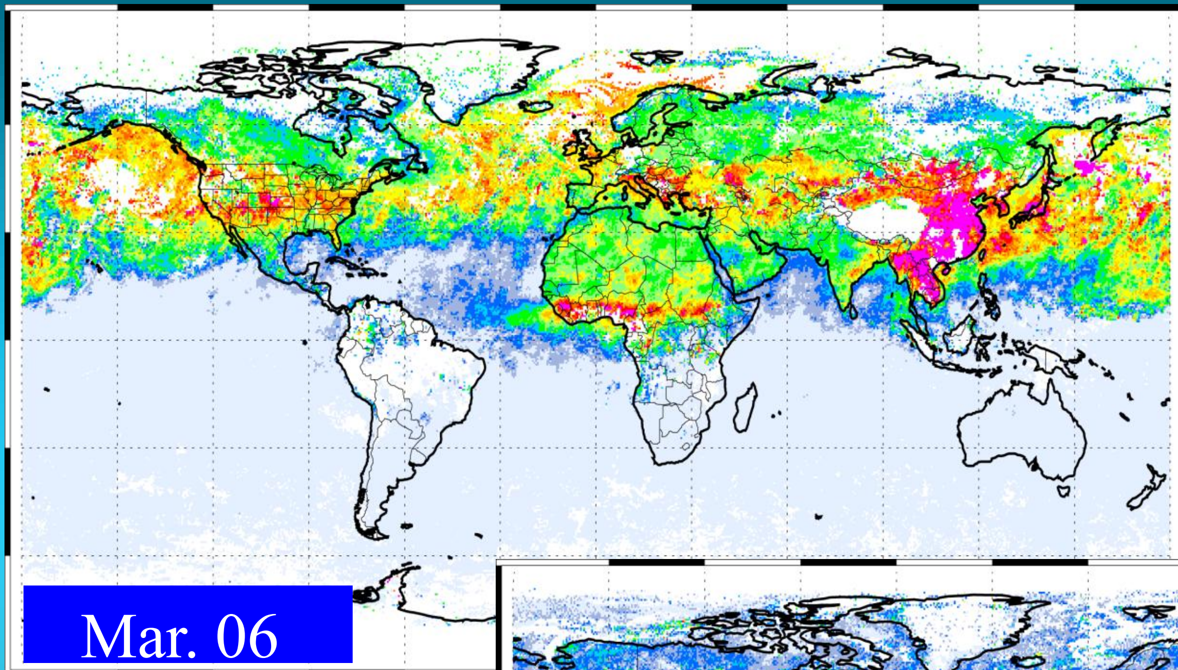
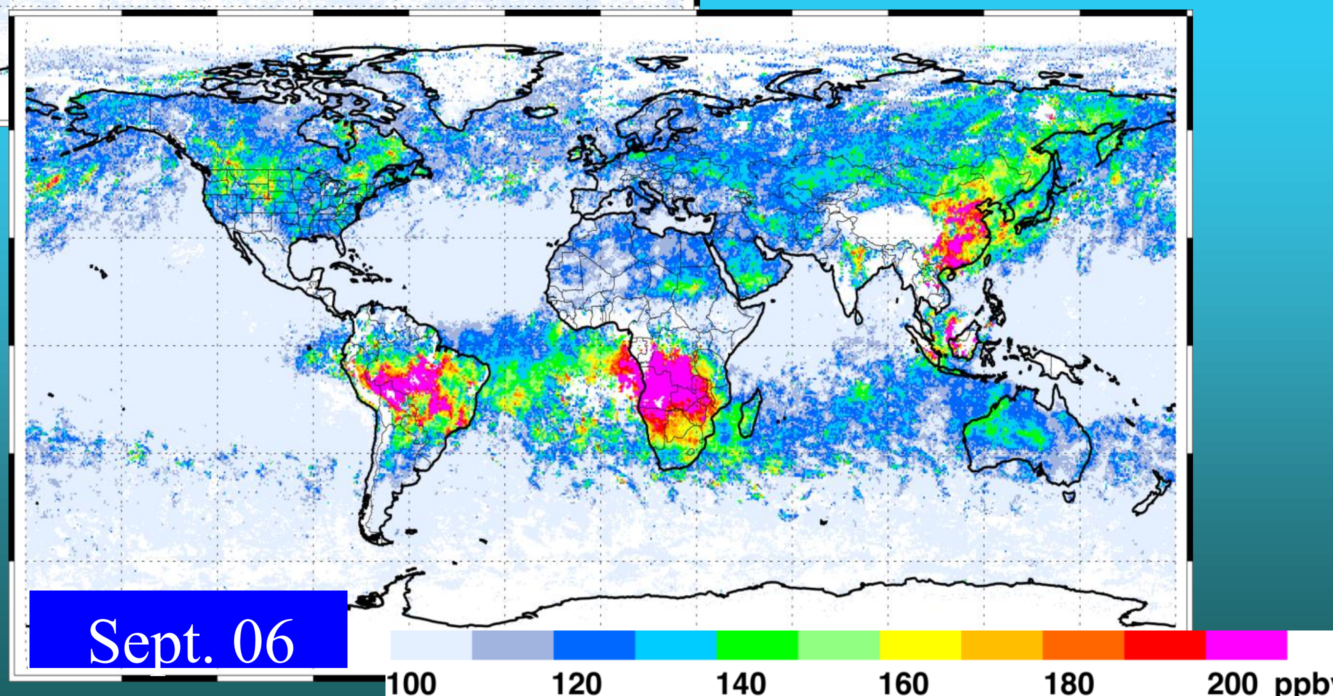


Fig: Daniel Jacob, Harvard University

NASA Gas Correlation Radiometer MOPITT

MOPITT has provided 10 years of seasonal variability of CO in the mid-troposphere.





Mid-troposphere (700 hPa) Carbon Monoxide

CO Science Highlights from MOPITT

Long-Range Transport of Pollution: Examination of the impact of localized sources on large scale air quality including intercontinental CO transport .

Development of Data Assimilation Techniques: Advances in data assimilation of satellite trace gas measurements into chemical transport models motivated by validated MOPITT data .

Improvement of Emissions Using Inverse Modeling: Emission studies using MOPITT measurements and inverse modeling to constrain surface CO fluxes and assess the accuracy of current inventories.

Investigations of Tropospheric Chemistry: Integration of MOPITT retrievals of CO, and NO2, aerosol, fire and lightning flash counts from other satellite observations, to provide a method for investigating tropospheric ozone production and its spatial and temporal distribution.

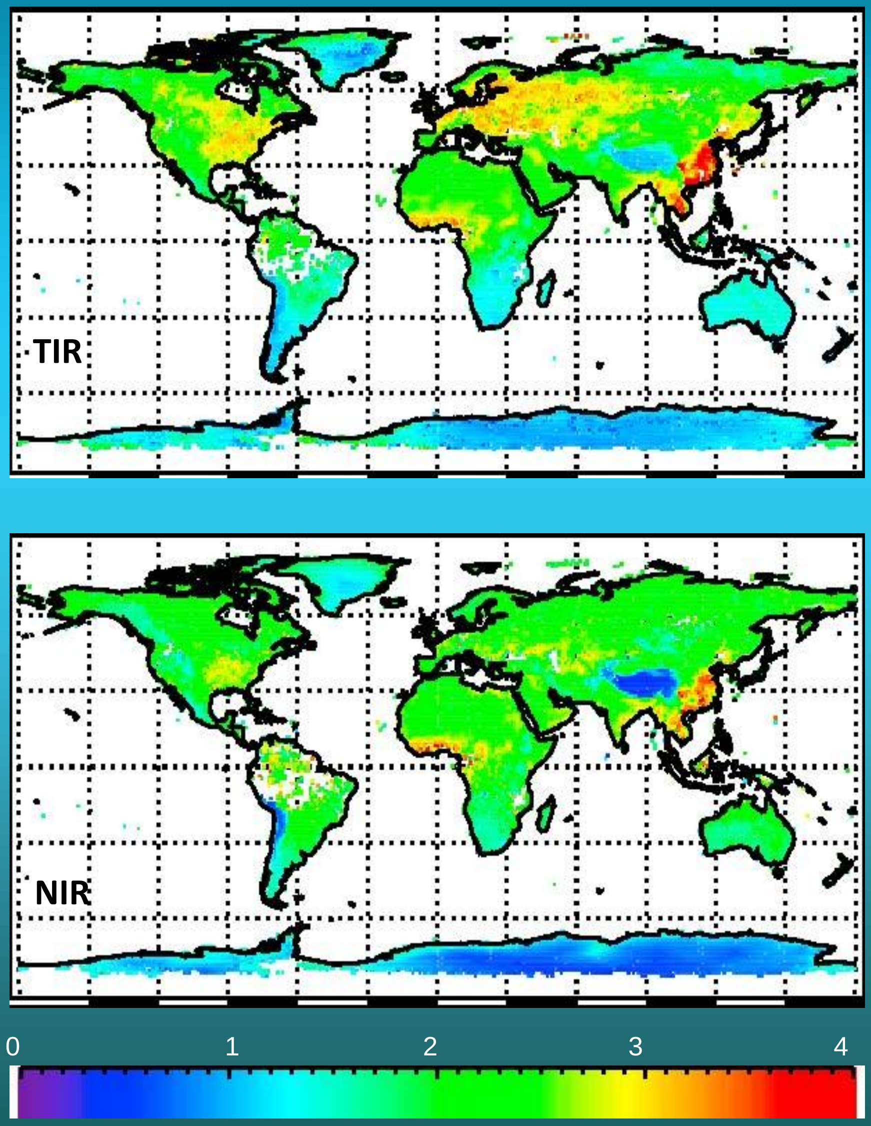
Quantifying Seasonal and Inter-Annual Pollutant Variability: A global record of the inter-annual variability of tropospheric air quality using the multi-year MOPITT dataset. Quantifying variability due to fire sources that vary year-to-year according to climatic impact on rainfall & vegetation drying.

Investigation of Vertical Transport In the Troposphere: MOPITT CO retrievals distinguish vertical structure in the tropospheric profile, particularly in the tropics.

Field Campaign Support: Near real time MOPITT CO data for flight planning.

Impressive, and MOPITT results lead to new science questions focused on CO near the surface.

Combining TIR and NIR CO from space achieves vertical resolution.



CO total column concentration, (10^{18} molecules/cm2)

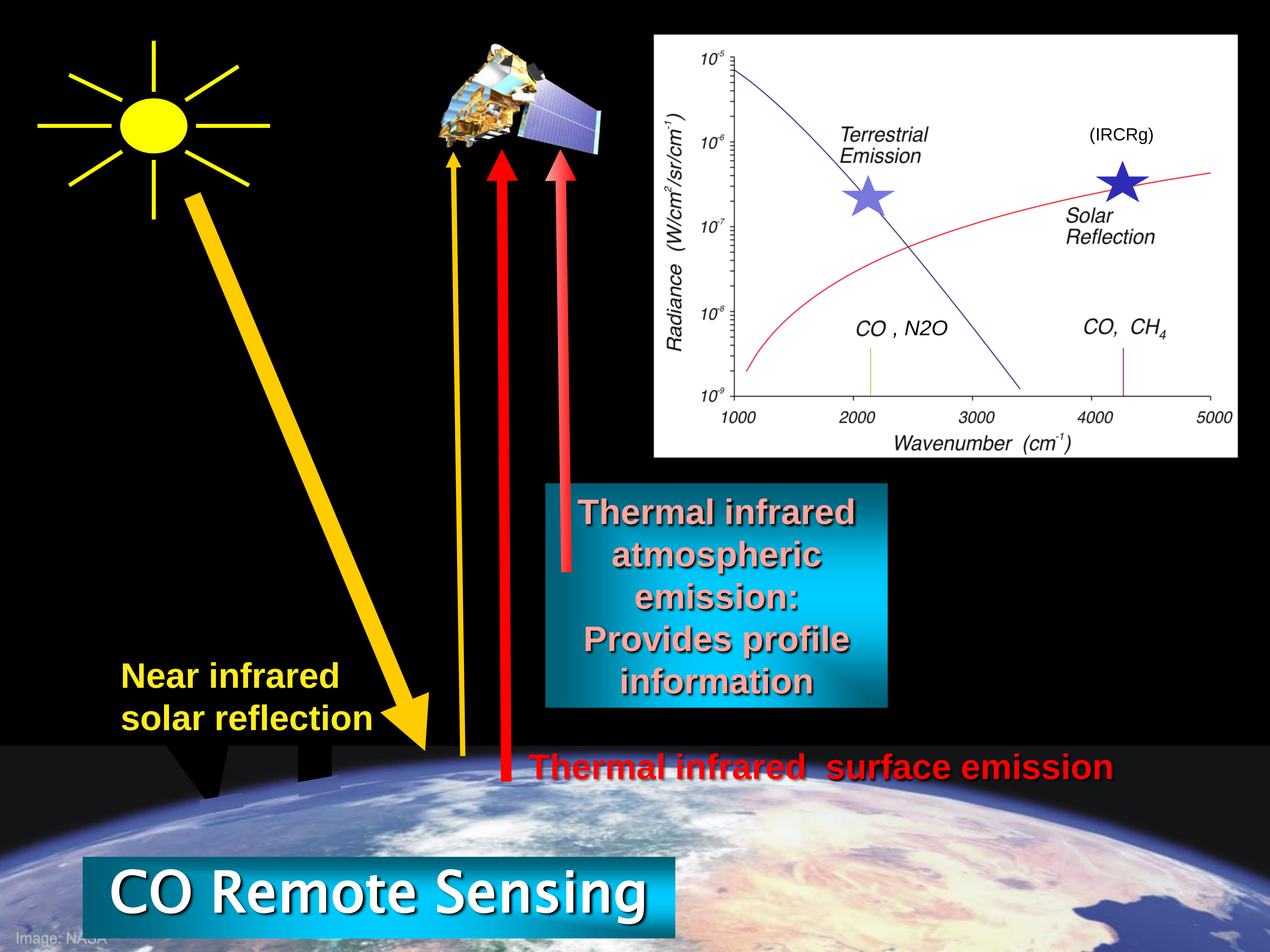
Mid-troposphere CO as archived by MOPITT for March 2006.

These data are part of MOPITT's 10-year record, based on CO measured at 4.67 um (TIR).

Lower-troposphere CO for March 2006 as presented in new work * by the MOPITT retrieval team.

This team estimates a factor of 5 more instrument noise in NIR than in TIR measurements.

Deeter, M. N., D. P. Edwards, J. C. Gille, and J. R. Drummond (2009), CO retrievals based on MOPITT near-infrared observations, *J. Geophys. Res.*, 114, D04303, doi:10.1029/2008JD010872.



CO Remote Sensing
Near infrared solar reflection
Thermal infrared atmospheric emission: Provides profile information
Thermal infrared surface emission
Radiance (W/cm²/sr/cm⁻¹)
Wavenumber (cm⁻¹)
1000
2000
3000
4000
5000
Terrestrial Emission
(IRCRg)
Solar Reflection
CO , N2O
CO, CH4
Image: NASA

CO Measurements Chronology

Measurement of tropospheric CO from space requires a technique capable of high effective spectral resolution * and * high signal-to-noise

- Shuttle/MAPS (1981): gas correlation radiometer. TIR. First-ever demonstration of any trace constituent measurement from space.
- Terra/MOPITT (1999): gas correlation radiometer. TIR & now NIR. *Longest data record.*
- Envisat/SCIAMACHY (2002): grating spectrometer. NIR. *First demonstration of NIR column retrieval.*
- Aqua/AIRs (2002): grating spectrometer. TIR. *Large spatial coverage.*
- Aura/TES (2004): FTS. TIR. *Coincident tropospheric O_3 measurements.*
- *(Aura/MLS (2004): microwave limb sounder. upper atmosphere only.*
- Metop/IASI (2006): FTS. TIR. *Large spatial coverage, coincident O_3 . 1^{st} of 3 missions .*

Next: DS specified a gas correlation radiometer for CO on GEO-CAPE.

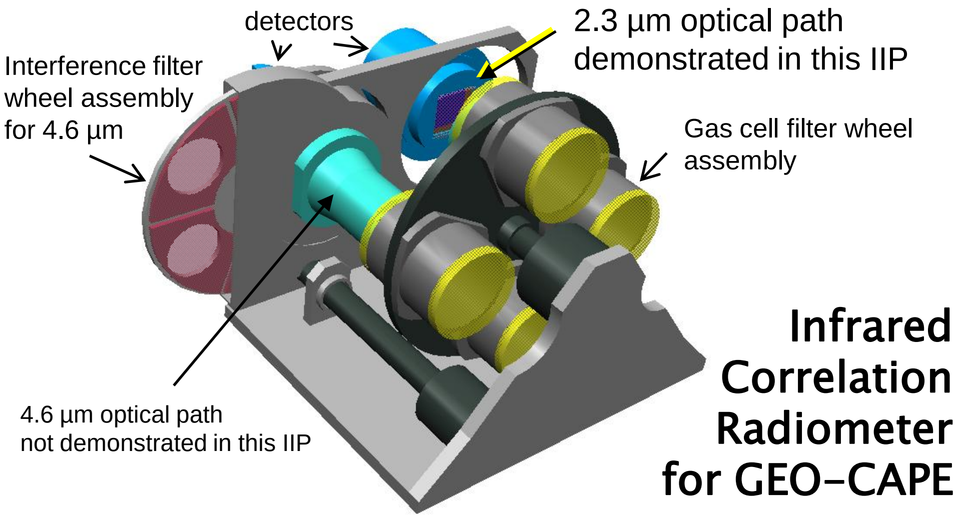
Infrared Correlation Radiometer for GEO-CAPE (IRCRg)

PI: Doreen Neil / NASA (LaRC)

Objective

- Characterize the noise and spectral performance of a laboratory prototype of the SWIR (2.3 mm) subsystem of an infrared gas filter correlation radiometer for geostationary carbon monoxide (CO) measurements.
- Verify the analytical instrument model to guide evolving GEO-CAPE mission implementation decisions.

Measurements at both 2.3 μm and 4.6 μm are required to obtain lower tropospheric CO. The Decadal Survey's focus on the lower troposphere placed emphasis on the 2.3 μm measurements.



Approach:

- Design and fabricate the 2.3 μm subsystem of an infrared gas filter correlation radiometer specifically tailored for geostationary measurements.
- Characterize performance to quantify instrument response functions (spectral , spatial, radiometric, and polarization), and explicitly, an end-to-end noise performance characterization.
- Incorporate these characterizations into the CO measurement modeling system for use in GEO-CAPE mission formulation and payload system engineering.

Co-Investigators: Jack Fishman, William Luck (NASA); David Edwards (NCAR); Lackson Marufu (UMd); Sam Yee (APL)

Key Milestones

• Internal design and cost	08/08
• Contracts in place	02/09
• System Requirements Review	06/09
• Critical Design review	08/09
• Test Plan Review	03/10
• Breadboard Assembly complete	03/10
• Characterizations complete	09/10
• Instrument Performance Model complete	01/11
• IRCRg Final report	01/11