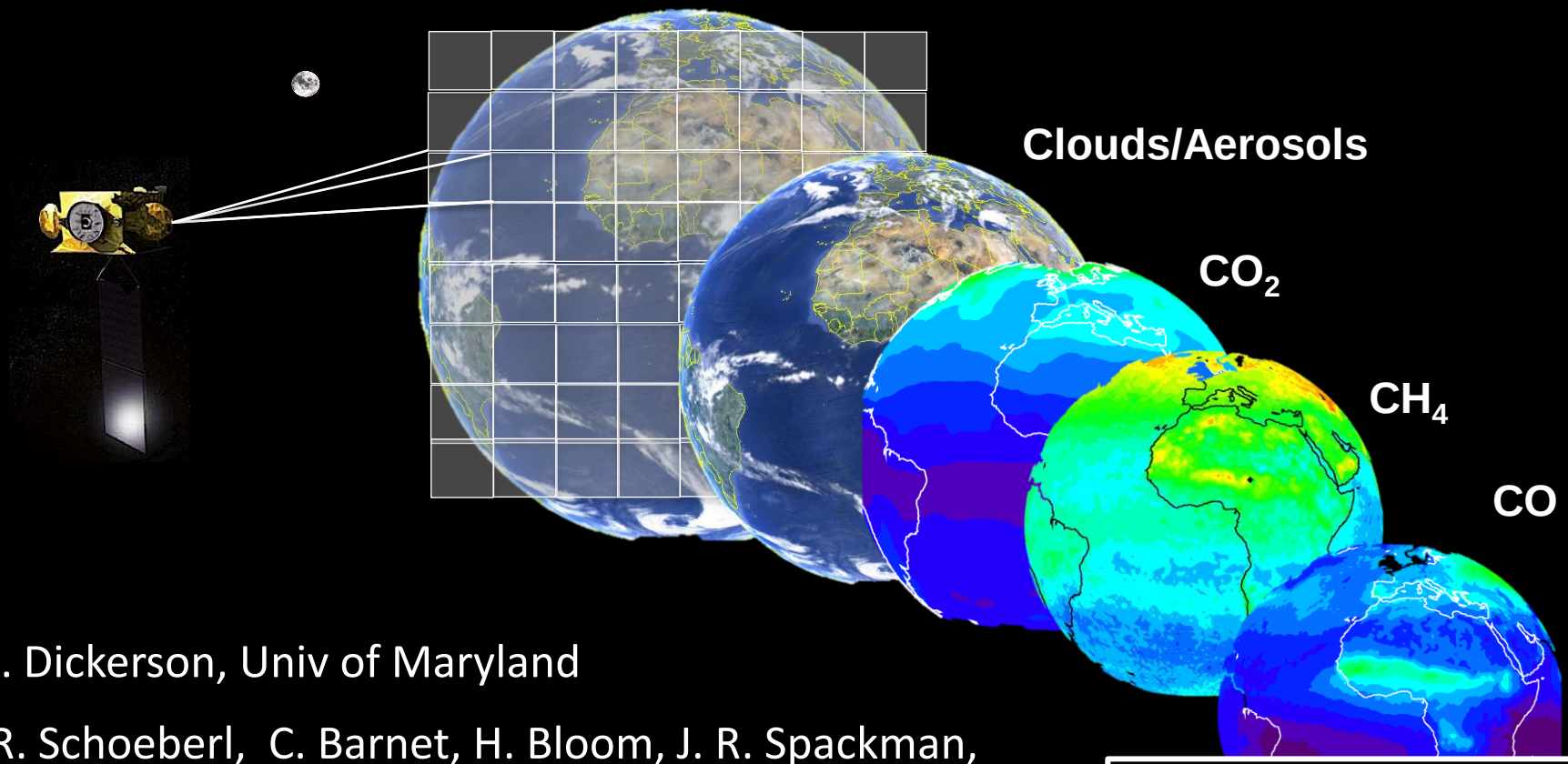
GRIPS

The Geostationary Remote Infrared Pollution Sounder



R. R. Dickerson, Univ of Maryland

M. R. Schoeberl, C. Barnet, H. Bloom, J. R. Spackman, Science & Technology Corporation (STC)

M. McHugh, B. T. Marshall, L. L. Gordley, GATS

C. Fish and A. Marchant, Space Dynamics Laboratory

STC GATS Space Dynamics LABORATORY Utah State University Research Foundation

Key Points

- **GRIPS can make more carbon gas (CO, CH_4, CO_2) measurements in a day at higher resolution than existing sensors can make in a month** - GRIPS also measures aerosols, clouds and N_2O.
- **GRIPS uses a simple trace gas sensor technique**, GFCR, upgraded to take advantage of newest imaging array technology.
- **GRIPS is light weight, low power and has a flexible design footprint** to take advantage of various GEO hosting opportunities.
- **Significant investment has already been made** in GRIPS sensor design, breadboarding, testing and algorithm development - GRIPS can be ready for deployment quickly.
- GRIPS data can be used to track anthropogenic and biomass burning plumes and **improve air quality forecasts**.

Outline

- Science – carbon gases and air quality
- Orbit – advantages of GEO
- Sensor – gas filter correlation radiometer
- Instrument – design details
- Measurements – using the data
- Summary

Air Quality and Climate

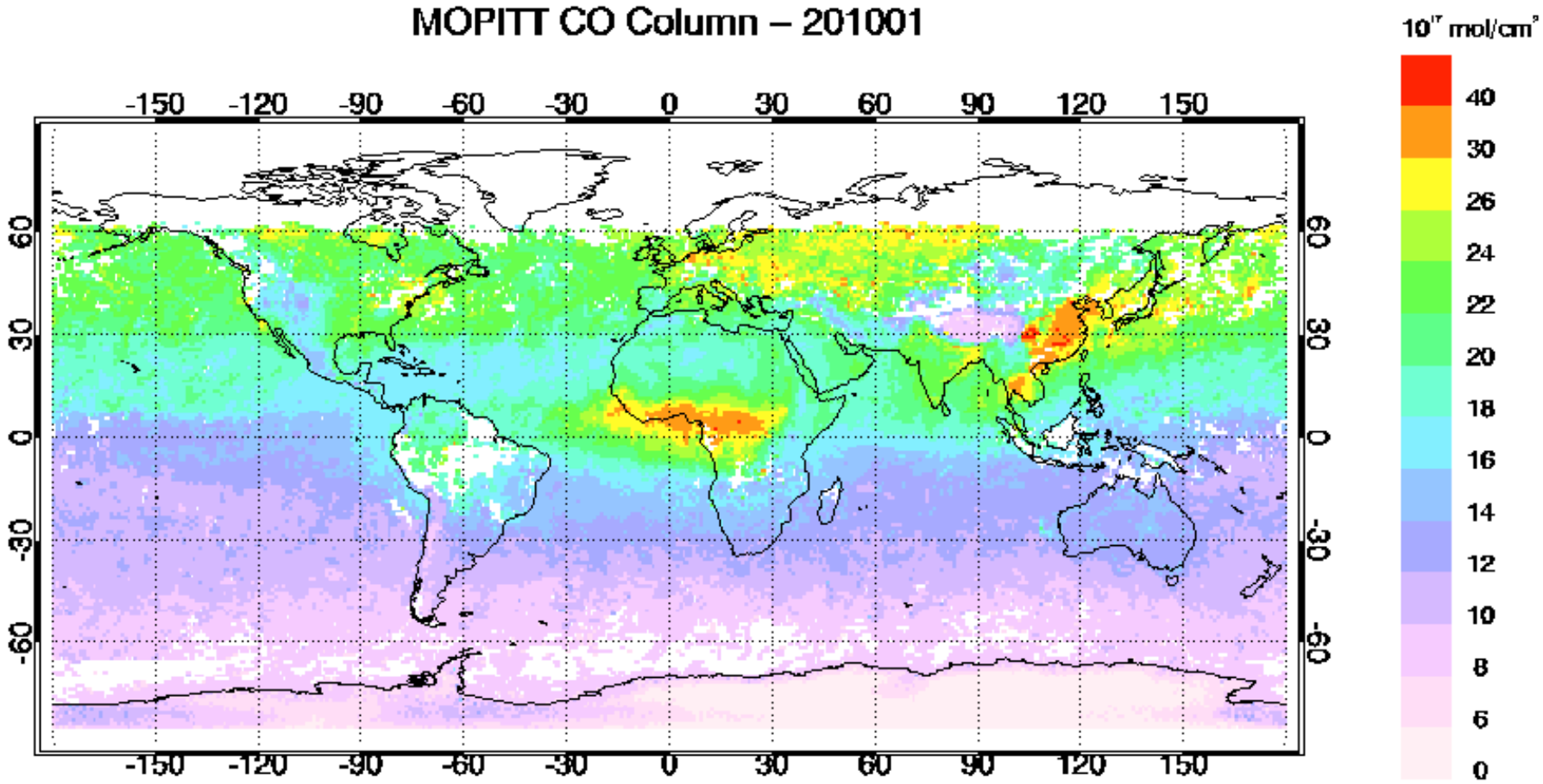
Why measure CO, CO_2, CH_4 – the carbon gases?

1. CO, CO_2, and $CH_4$are the key carbon gases that affect air quality – major anthropogenic and biomass burning sources – and climate
2. These gases can be used to "fingerprint" sources of CO, CO_2, and CH_4– distinguishing anthropogenic and natural sources and fluxes
3. CO emissions are strongly correlated with the emission of black carbon. Black carbon has been recognized as a key component of greenhouse warming (JGR, 2013, doi: 10.1002/jgrd.50171)

No existing or planned instrument can measure these carbon-containing gases at the spatial and time resolution required to assess pollution sources.

GRIPS can make measurements of CO, CO_2, CH_4, and aerosols to quantify sources, fluxes, diurnal variations, and export from continental source regions.

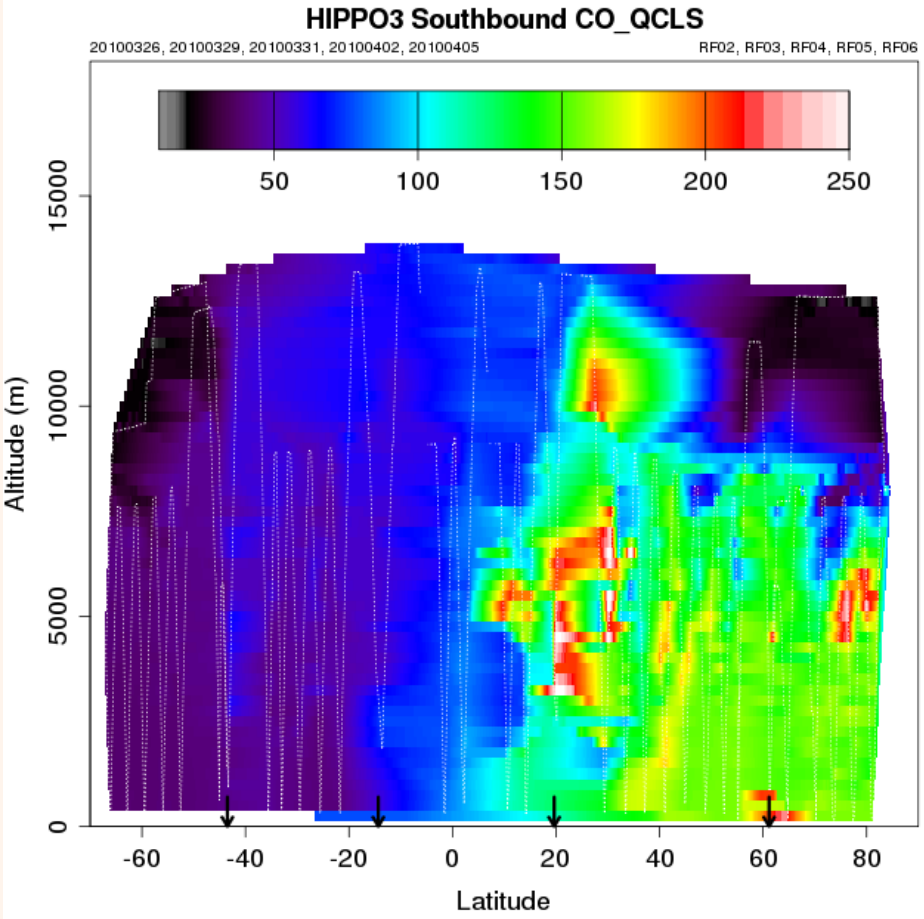
MOPITT Carbon Monoxide



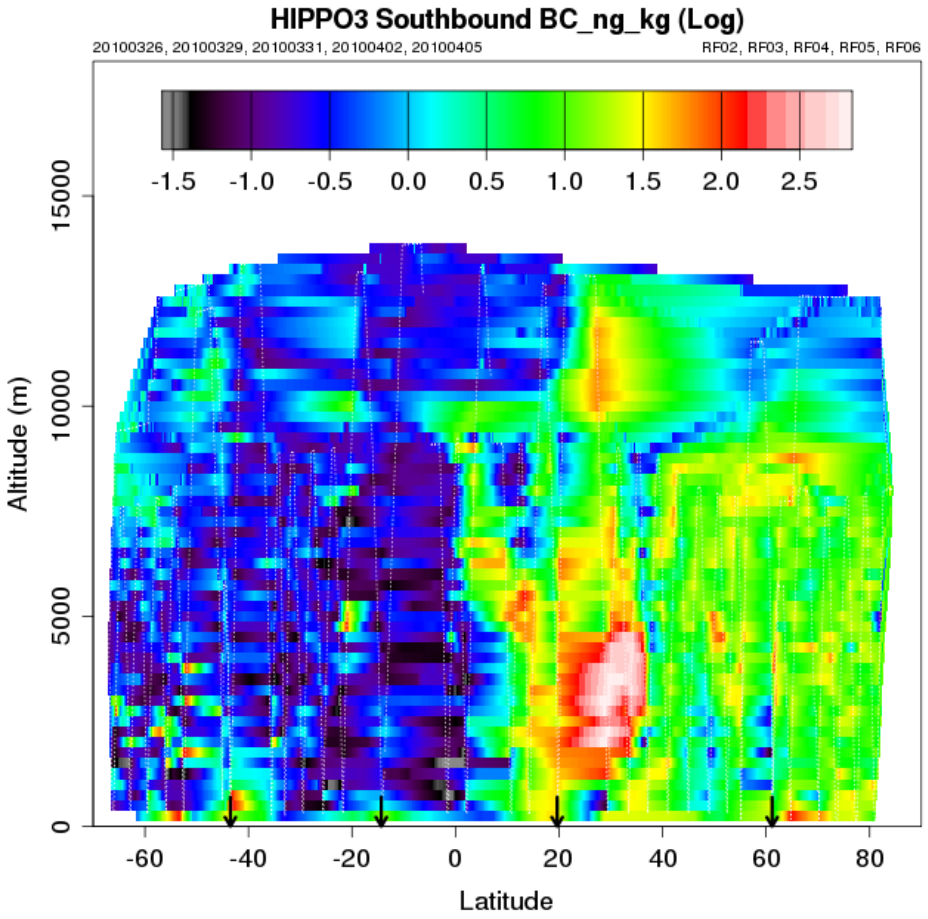
http://www.acd.ucar.edu/mopitt/MOPITT/data/plots5j/maps_mon.html

HIAPER Pole-to-Pole Observations (HIPPO) of Carbon Cycle and Greenhouse Gases Study

CO
26 Mar – 5 Apr 2010

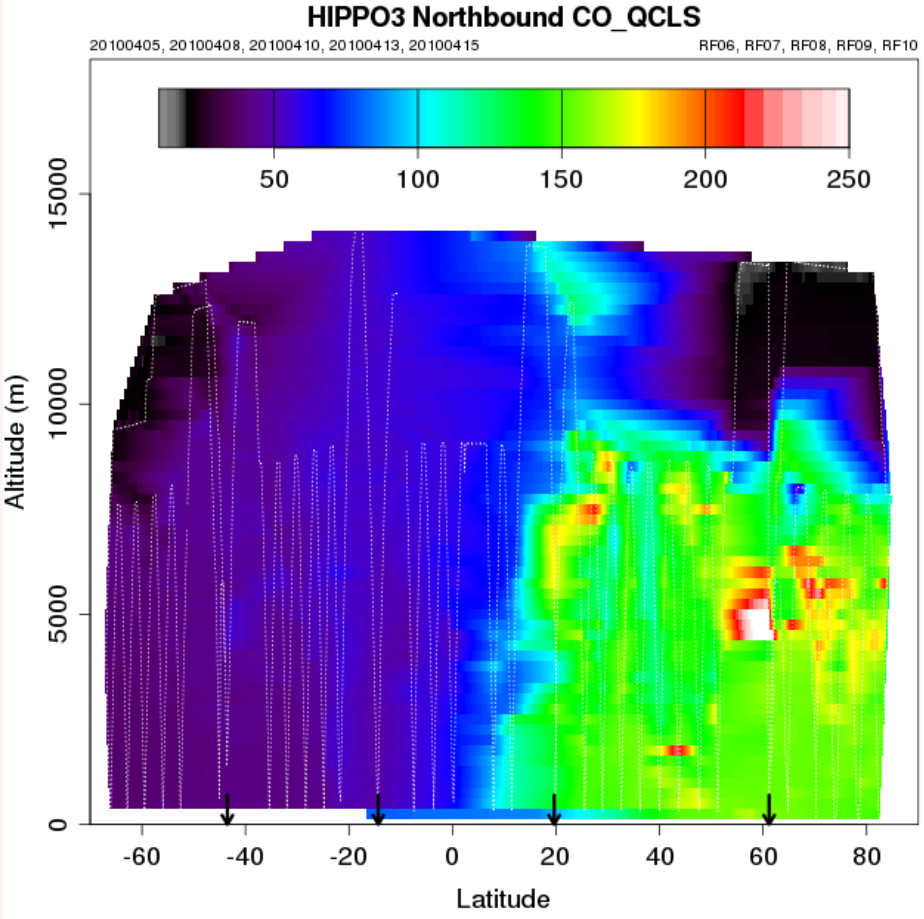


Black Carbon
26 Mar – 5 Apr 2010

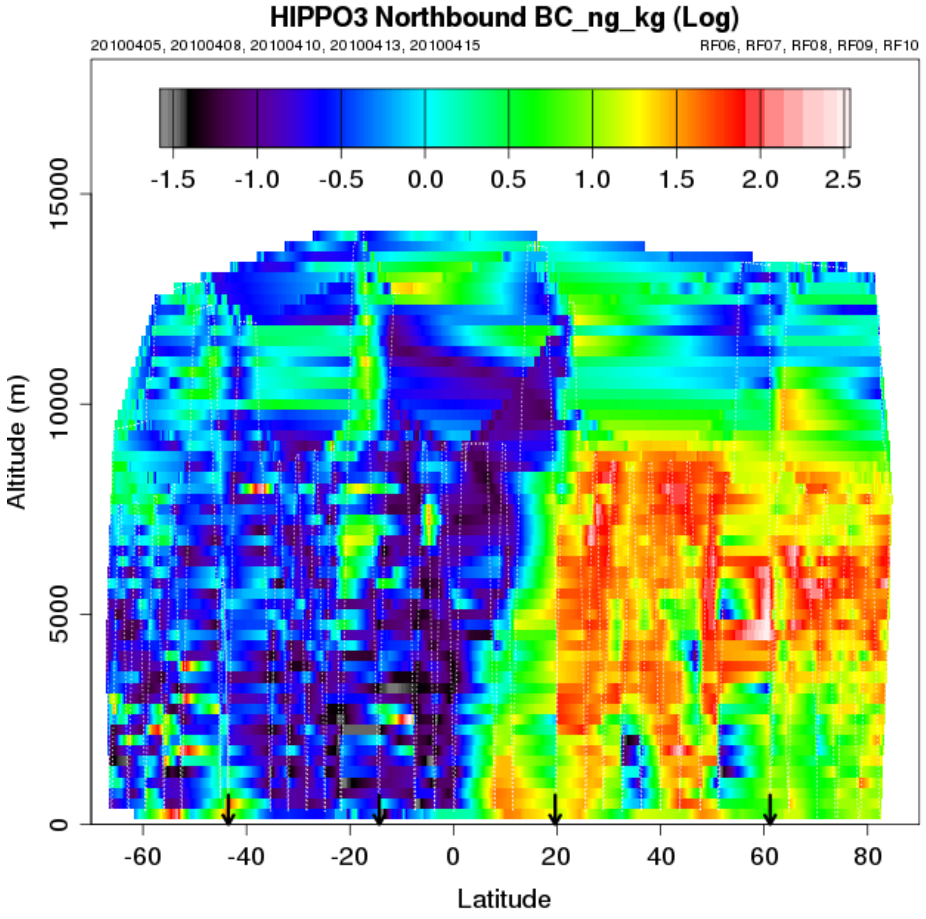


HIAPER Pole-to-Pole Observations (HIPPO) of Carbon Cycle and Greenhouse Gases Study

CO
5 – 15 Apr 2010

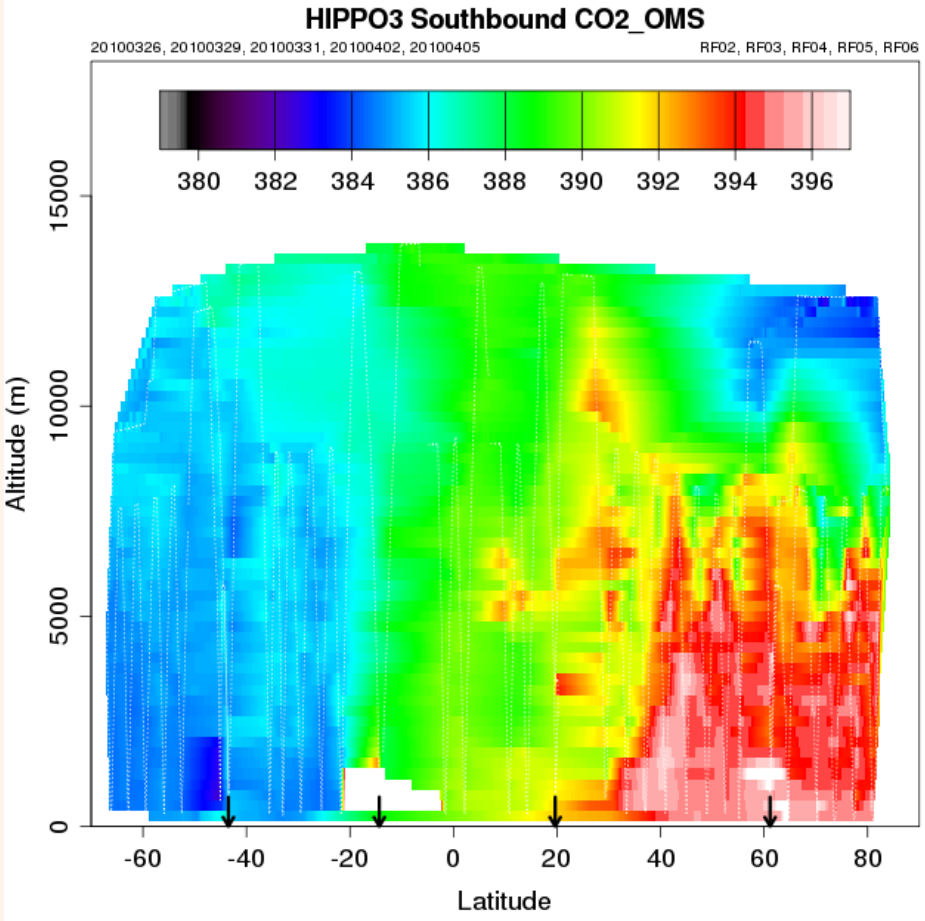


Black Carbon
5 – 15 Apr 2010

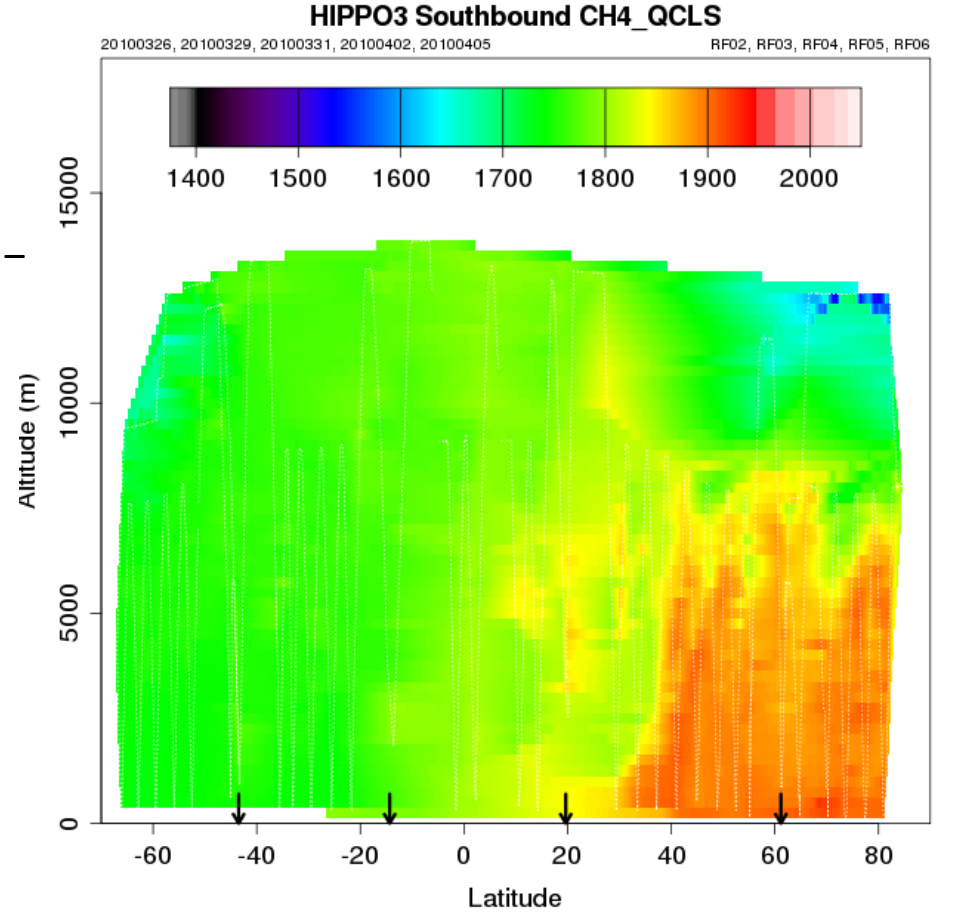


HIAPER Pole-to-Pole Observations (HIPPO) of Carbon Cycle and Greenhouse Gases Study

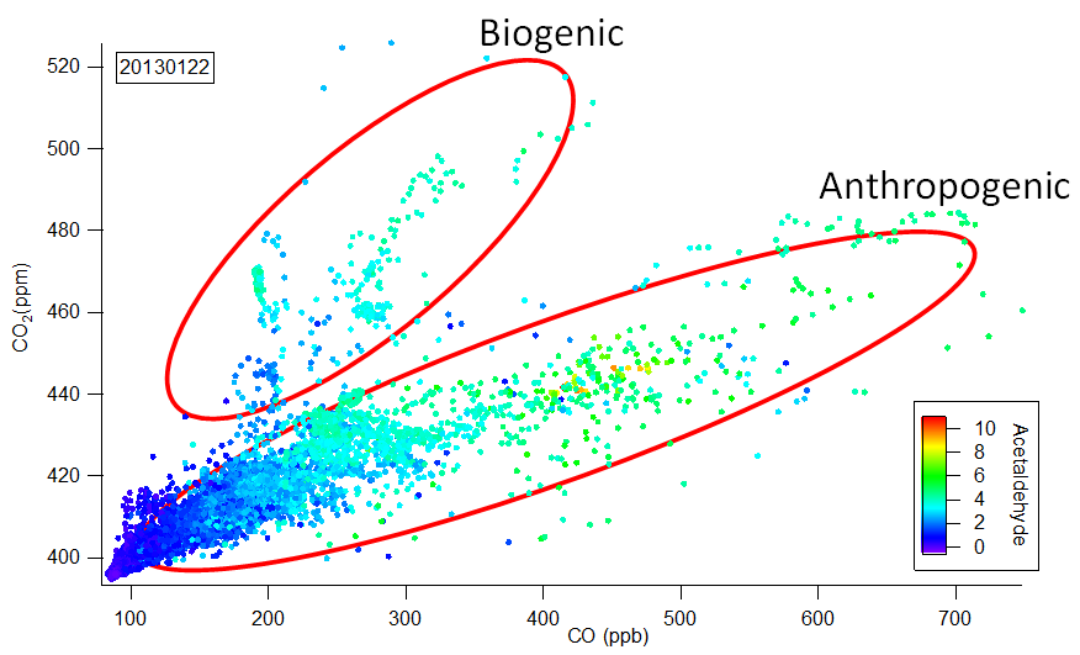
CO_2
26 Mar – 5 Apr 2010



CH_4
26 Mar – 5 Apr 2010



CO and CO_2 tracer correlations can be used to infer sources



At left, DISCOVER-AQ observation in Central Basin, California (from Melissa Yang and Stephanie Vay, preliminary analysis)

- GRIPS has application in South America to separate biomass burning sources of CO_2 from biogenic (respiration) and pollution sources.
- Turnbull (2011 JGR doi:10.1029/2011JD016691) showed that CO correlates strongly with fossil CO_2 in polluted Asian air and the CO:CO_2 ratio is proportional to the efficiency of combustion.

GRIPS Science Traceability

Requirements		Instrument/Mission Design
1. Trace gases CO, CO_2, CH_4	→	1. Thermal or short wave IR absorption bands for these gases
2. A high precision observing system that can get data down into the PBL	→	2. Solar reflected short wave IR
3. As many cloud free measurements as possible	→	3. Multiple LEOs or GEO
4. Measurements at different times of day	→	1. Multiple LEOs or GEO

* Multiple LEOs is cost prohibitive so from here we focus on GEO *

GEO Orbit

- Geostationary orbit has several advantages:
  - Instruments can “stare” at the same scene longer increasing S/N
  - GEO instruments can harvest more cloud free pixels than LEO orbiters since clouds move during the day
  - GEO instruments can observe the diurnal cycle
  - GEO orbit is populated by communication, surveillance and weather satellites that provide a number of hosting opportunities
- Geostationary orbit disadvantages:
  - No global coverage (target the most critical regions)
  - No polar coverage (OCO should do that better)

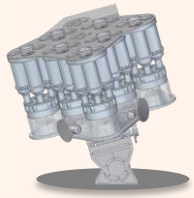
GRIPS Wavelengths

Constit.	Wavelength	Purpose	Complimentary Instrument
CO	2.33 µm	CO over land (surface, MT, Col)	MOPITT
CO	4.64µm	CO over land and water (MT, Col)	IASI, MOPITT
CH_4	1.66µm	Methane over land	GOSAT, OCO2, ABI
CO_2	2.05µm	CO_2 over land	GOSAT, OCO2
N_2O	3.88µm	Albedo, photon path, mass, fires	ABI
O_2	0.76µm	Photon path, clouds, mass	ABI
Aerosols	2.13, 0.87, 0.75, 0.66, 0.44	Aerosols, land and water, fires	MODIS, ABI, VIIRS
Cirrus	1.38	Cirrus interference	MODIS, ABI
H_2O	1.3	Water column, interference	

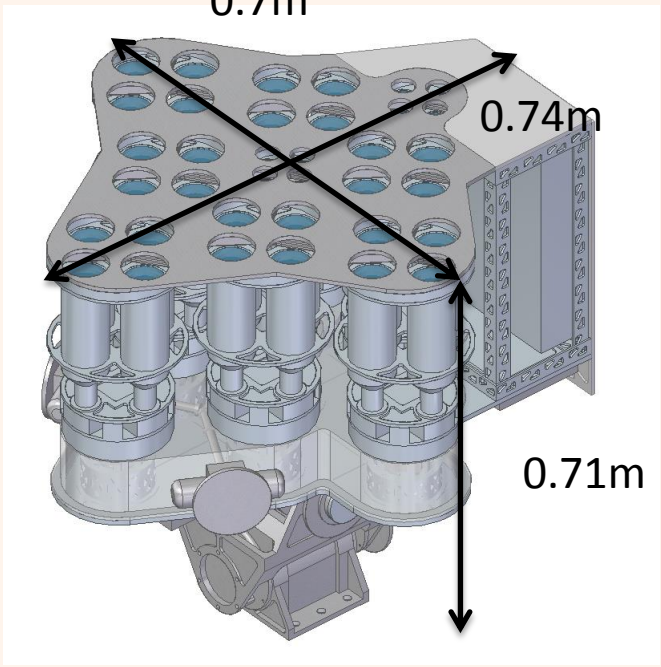
GRIPS: Gas Filter Correlation Radiometer (GFCR)

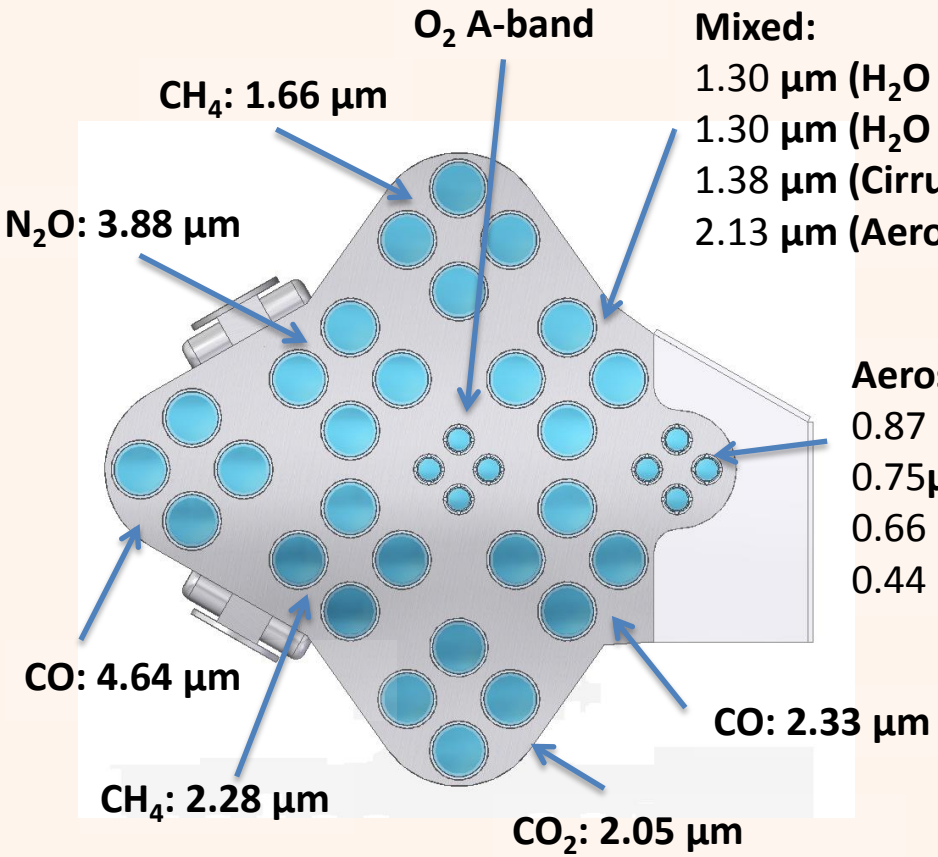
GFCR: highly reliable, strong heritage, simple design

- Space Heritage: MOPITT, HALOE
- GRIPS SBIR prototype, DAGR, has completed development and testing at SDL
- Aircraft instrument using GRIPS design being developed for CH_4 leak detection will be deployed in Oct 2013
- GRIPS design is simple with no moving parts (except gimbal) – all elements are space qualified



GRIPS Instrument





Mixed:
1.30 **µm (H_2O - vacuum)**
1.30 **µm (H_2O – HF filter)**
1.38 **µm (Cirrus)**
2.13 **µm (Aerosol)**

Aerosols:
0.87 **µm**
0.75**µm**
0.66 **µm**
0.44 **µm**

Specifications	
Mass	70 kg
Power	50 WDC
Data Rate	6.0 Mbit/s
Ready for Integration	June 2018

GRIPS Scan Pattern

Full disk scan ~1.5 hours;
100s for each square

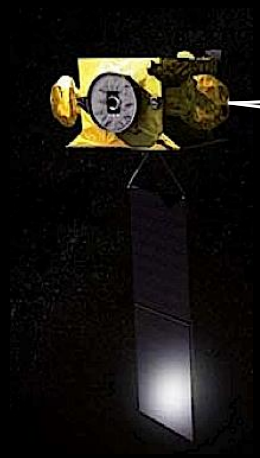
Lunar calibration target

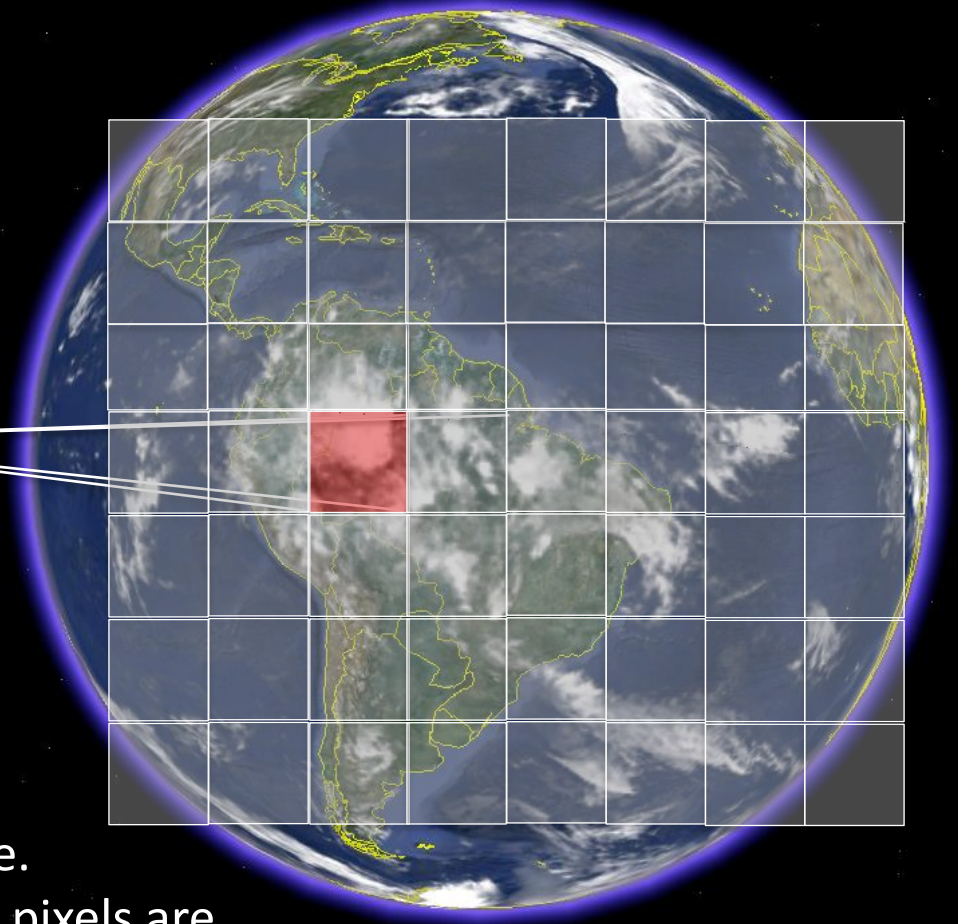
720km

900 x 900 pixels

720km

1.5^0 FOR

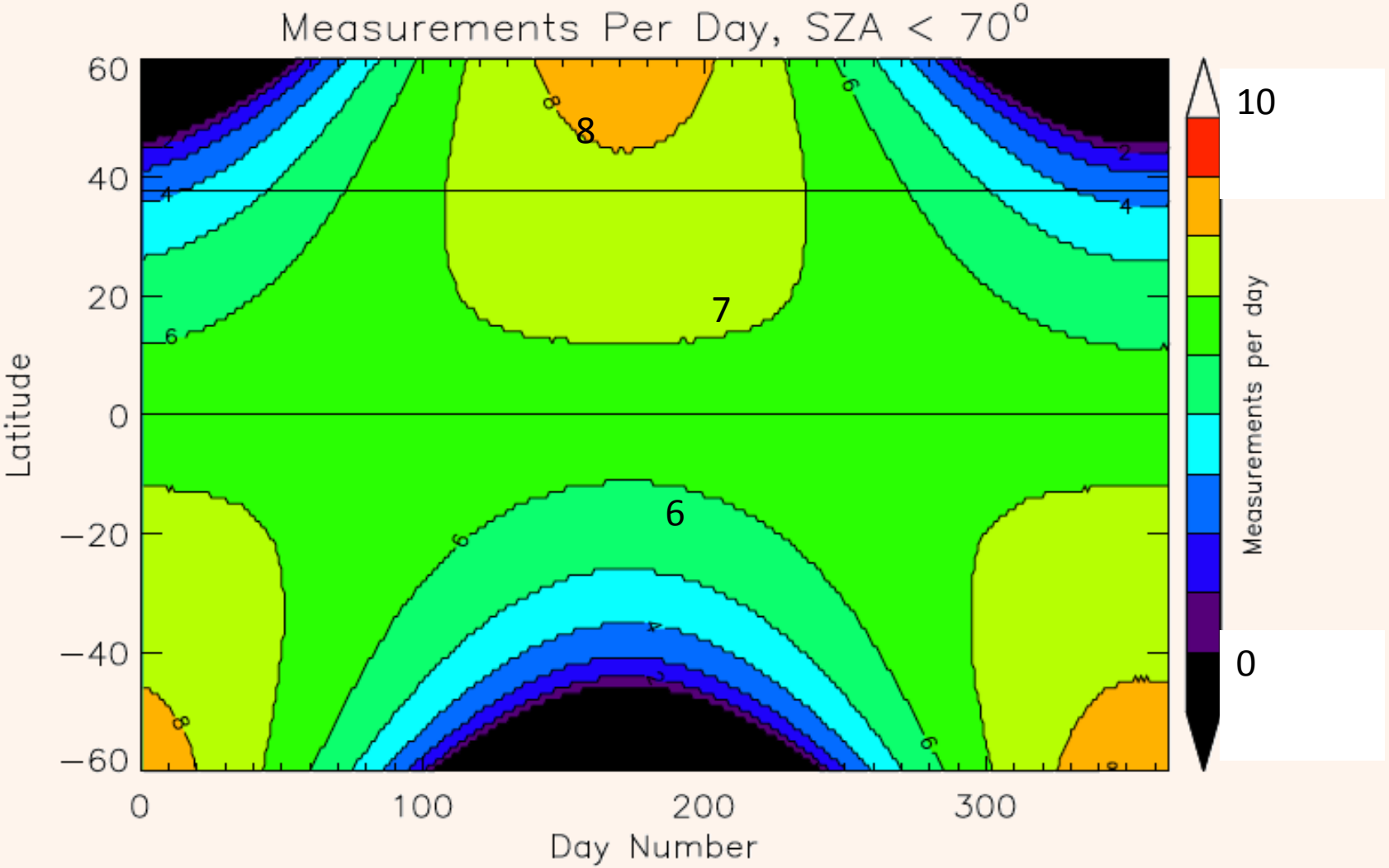




90 x 90 super pixels inside a square.

Super pixel size is 8 km, individual pixels are 0.8 km, but averaged to form the super pixel.

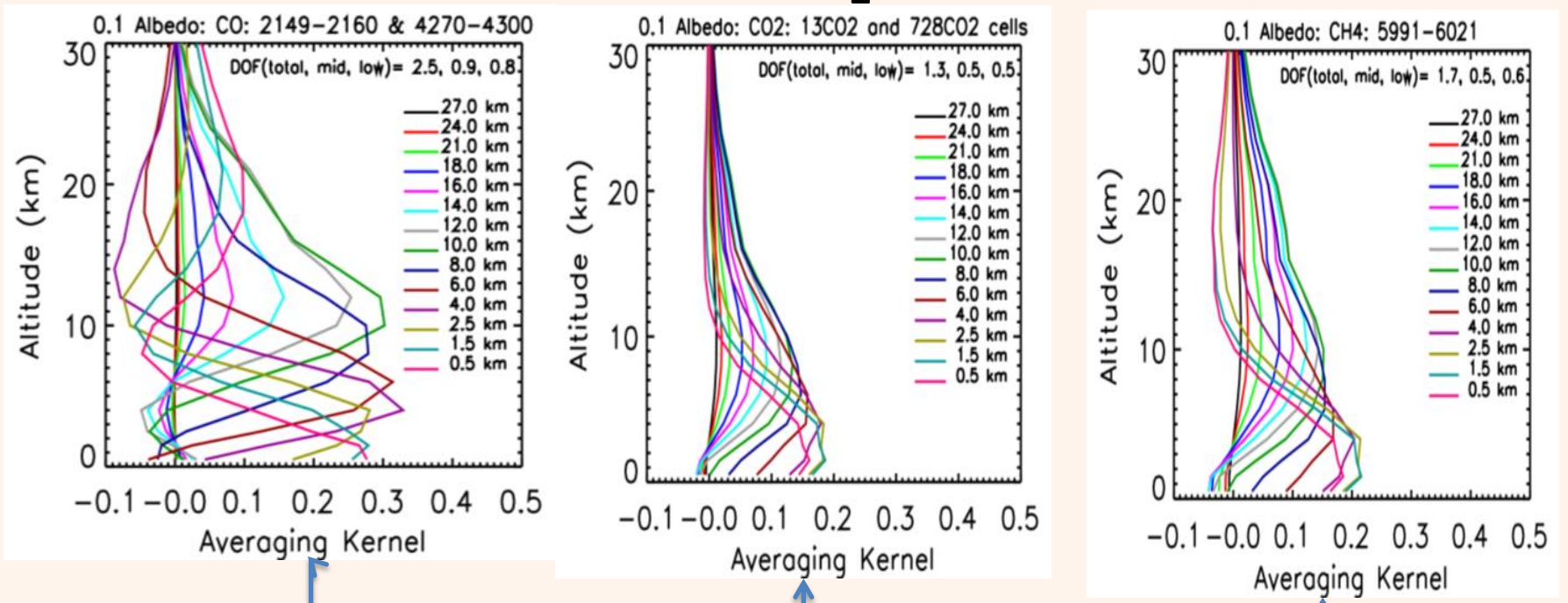
GEO Provides Multiple Measurements Per Day



GRIPS can provide multiple measurements per day at spatial resolution comparable or better than existing counterparts but with more than 100 times improved temporal resolution.

GRIPS Averaging Kernels

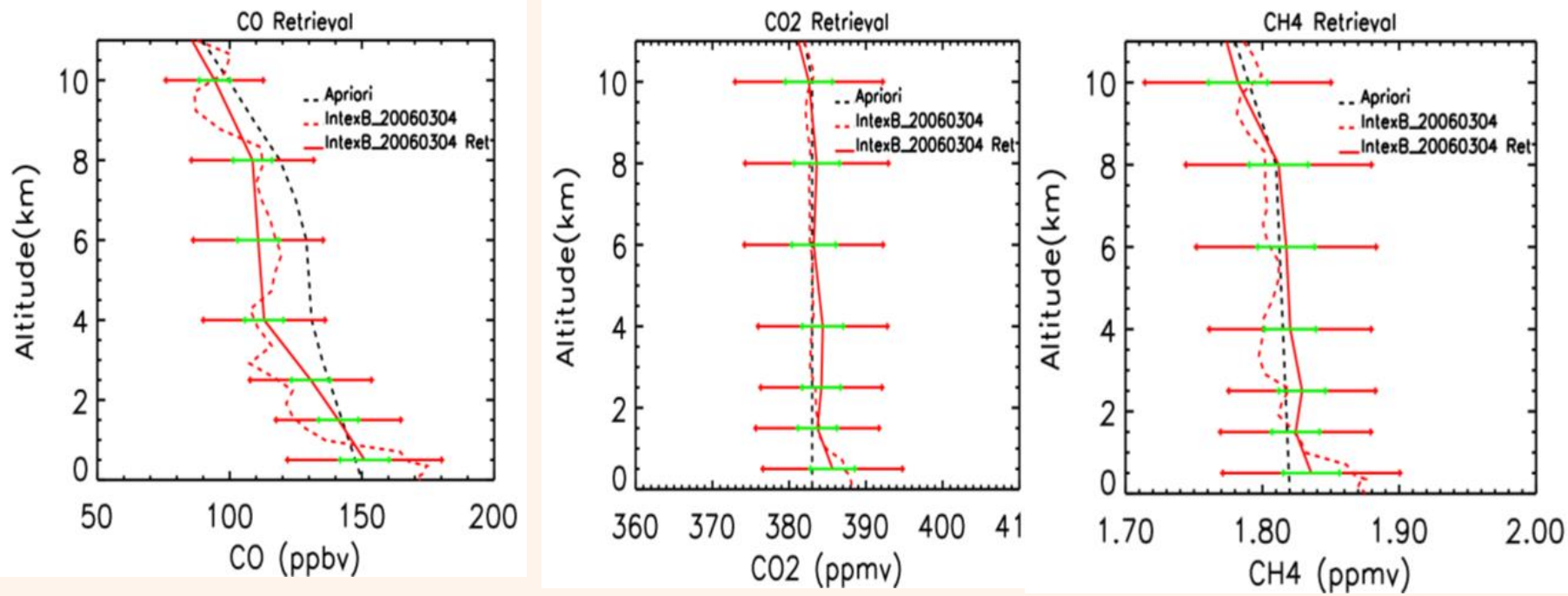
CO **CO_2** **CH_4**



GRIPS averaging kernels (also called vertical resolution functions) demonstrate its unique capability in sounding various vertical layers including the PBL. Other sensors (OCO-2) can only report total column.

GRIPS Simulated Retrievals

CO **CO_2** **CH_4**



Simulations demonstrate the high retrieval performance of GRIPS especially in PBL that most of the existing sensors can't rival.

Intex B data and GRIPS Retrievals

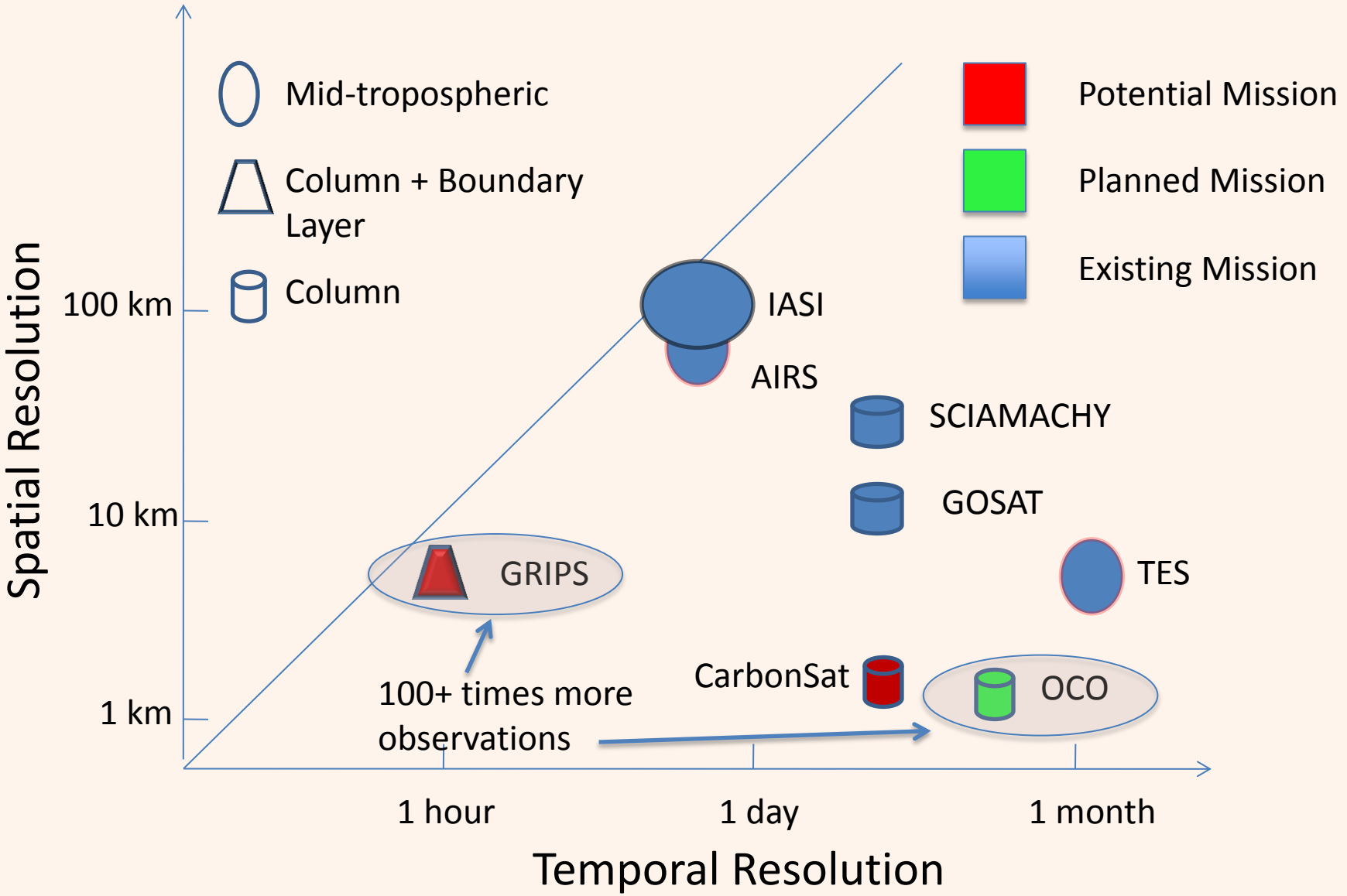
Apriori ----------

Intex B data ----------

Single shot retrieval 1σ error ——————

10 shot retrieval average 1σ error ——————

Comparison of Satellite CO-CH_4-CO_2 Sensors



Summary

- GRIPS is an innovative carbon gas sensor that enables low cost, low risk, high spatial and temporal observations from GEO
- GRIPS will be able to track biomass burning and pollution and identify sources and sinks of CO, CO_2, and CH_4
- GRIPS can make more carbon gas (CO, CO_2, CH_4) measurements in a day at higher resolution than existing sensors can make in a month
- GRIPS uses a standard trace gas sensor technique, GFCR, upgraded to take advantage of the newest imaging array technology
- Significant investment has already been made in GRIPS sensor design, breadboarding, testing and algorithm development
- GRIPS is light-weight, low power and has a flexible design to take advantage of various GEO hosting opportunities
- GRIPS can be ready for integration by 2018