Far-Infrared Spectroscopy of the Troposphere
- FIRST -

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CERES Science Team Meeting

Acknowledgement: Sponsors & Partners

- NASA ESTO
- NASA Radiation Sciences Program
- NASA UARP
- NASA Langley

- Space Dynamics Laboratory
- Harvard Smithsonian Center for Astrophysics
- Raytheon Vision Systems
- ITT
- DRS Technologies
- JPL
- NIST
- U. Wisconsin
- Imperial College
- Numerous members of scientific community

Overarching Objectives

- To improve understanding Earth's climate and climate change through a combination of new observations and innovative data analysis

- Work focuses on:
  - "Far-Infrared" part of the spectrum 15 - 100 μm
    - FIRST; INFLAME; CORSAIR; FIDTAP
  - Solar spectrum via measurement of atmospheric heating rates
    - INFLAME

- Approach:
  - Develop new technology where needed (IIP, ATI, ACT)
  - Exploit existing data sets as applicable (EOS, IIP)
  - Generate new data sets to fill voids in knowledge (CLARREO)

Demonstrate accurate, stable instruments & related technology for space based on well-defined science measurement objectives

Overview

Since 2001 six projects have been funded by NASA:

- **IIP's**
  - **FIRST (IIP 2001)**
  - **INFLAME (IIP 2004)**
  - **CORSAIR (IIP 2007)**
- **Advanced Technology Initiative (ATI)**
  - **FIDTAP (2006-2008)**
- **Campaigns (NASA Radiation Sciences Program)**
  - **FORGE/RHUBC**
    - **Wisconsin 2007**
    - **Atacama Desert, Chile, 2009**
- **Data analysis (EOS Science Team Re-Competition)**
  - **CERES/AIRS analysis and Far-IR residuals**

Where we are now

- **FIRST instrument**
  - **Demonstrated beamsplitter, FTS, focal plane technologies for far-IR**
  - **Participating in science campaign (FORGE/RHUBC)**
  - **Successful comparison against AERI; AIRS**
  - **Unique testbed available for evaluating new detectors, blackbodies, etc.**
- **INFLAME instruments**
  - **Entering build and calibration phase - flight demo in January 2009**
- **FIDTAP**
  - **Successfully demonstrates new far-IR detectors April 2008**
- **CORSAIR selected**
- **CERES/AIRS far-IR studies well underway**

Instrument Incubator Program - IIP
Far-Infrared Spectroscopy of the Tropsophere - FIRST

Description and Objectives

Measure the Far-Infrared spectrum
of the Atmosphere and Earth (10 to 100 μm)

Far-IR observations are the key to understanding the greenhouse effect and the radiative feedbacks associated with increased anthropogenic forcings

Far-IR key to understanding cirrus effects, etc.

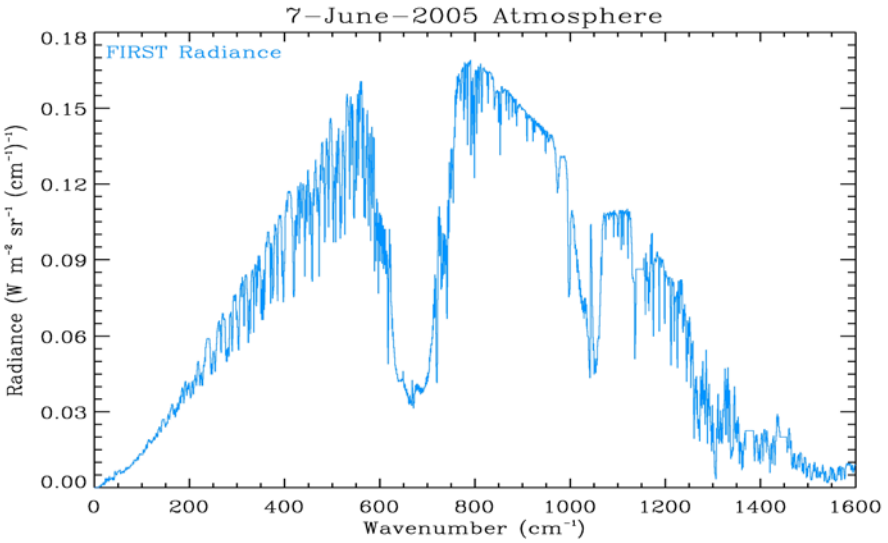
Approach

- Simulate space environ.

- Develop
  - High-throughput Michelson FTS
  - Broad-bandpass beamsplitter
  - Advanced detector system

Partners

Utah State Univ. – Interferometer
Harvard SAO – Beamsplitters
19-member science advisory team



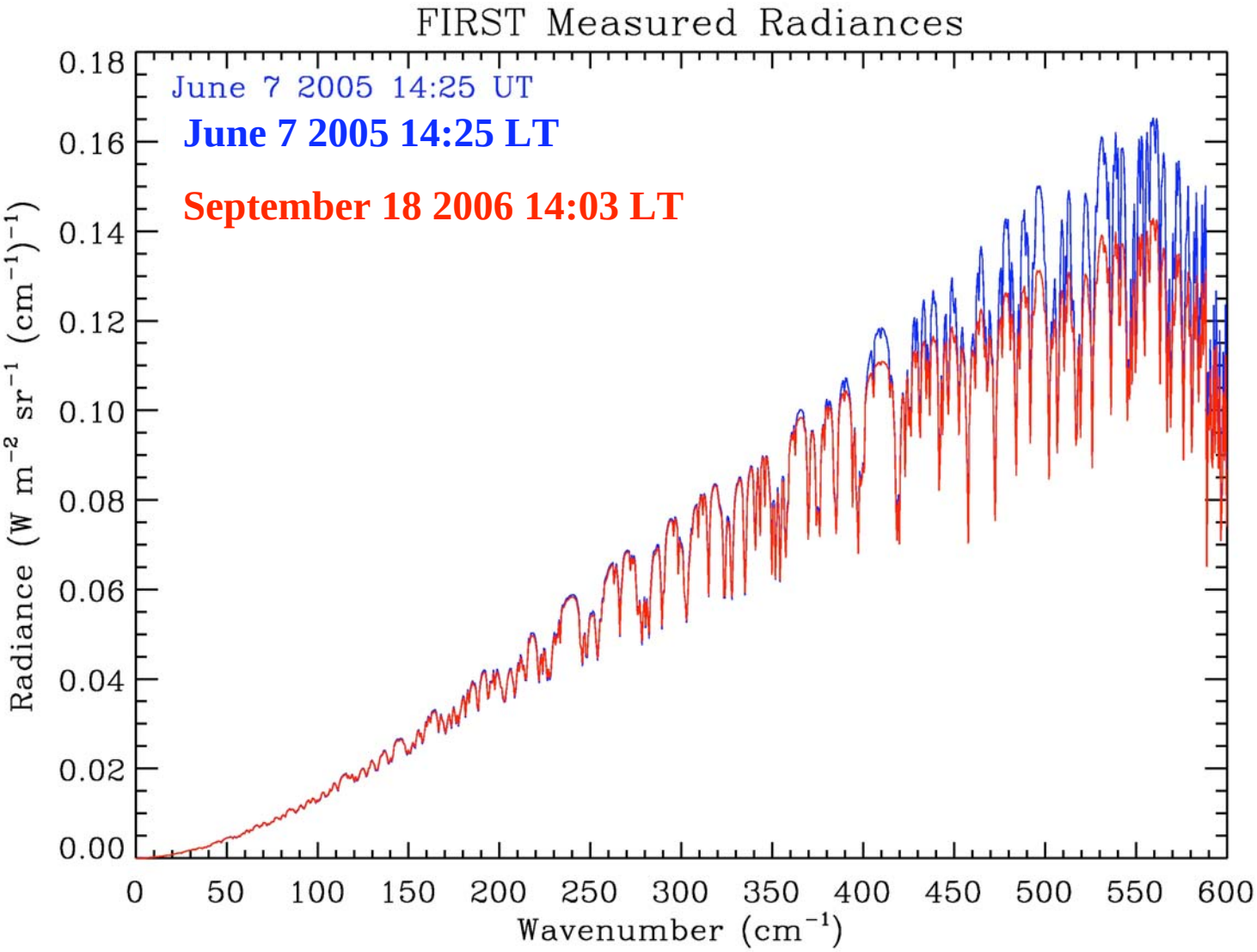
FIRST spectrum from flight demo 7 June 2005
Complete infrared spectrum observed

Status

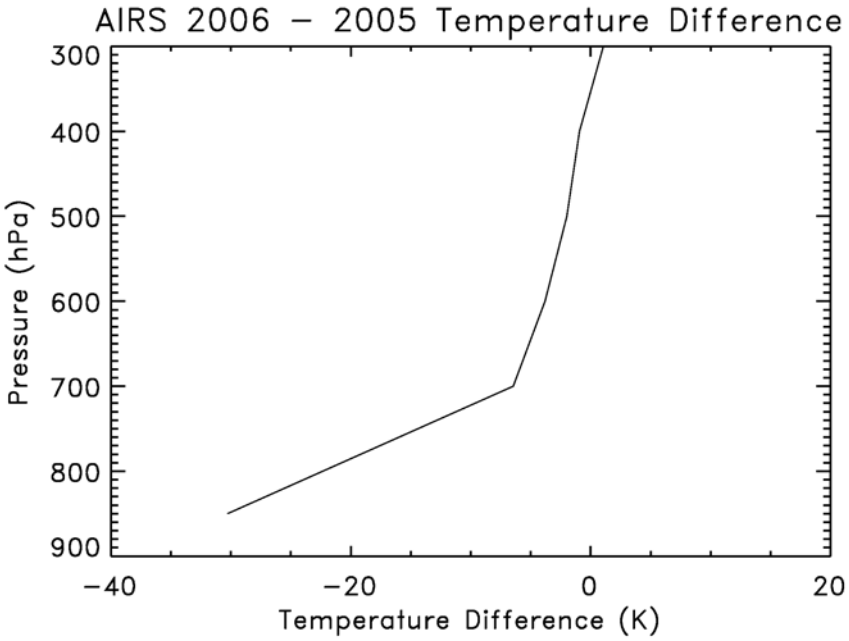
6/2005 – Successful flight demo/balloon flight
9/2006 – Second flight for CALIPSO validation
3/2007 – Ground calibration vs. AERI at UW
4/-10/2009 - RHUBC/FORGE campaign Chile
10/2010 - CORSAIR detector evaluation @ LaRC

Journal articles forthcoming

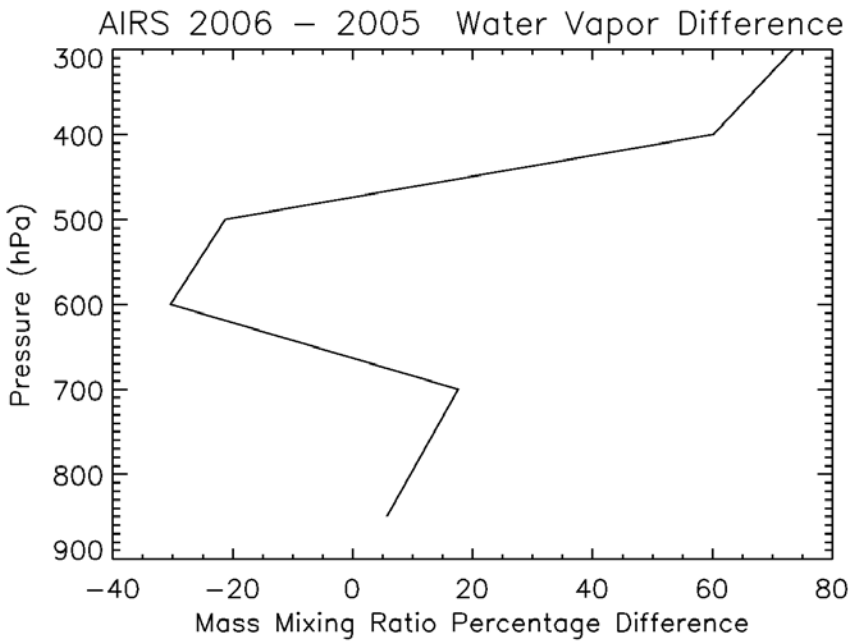
FIRST Radiances June 2005 and September 2006
- Clear Sky -



Cause of Far-IR Radiance Differences 2006 - 2005

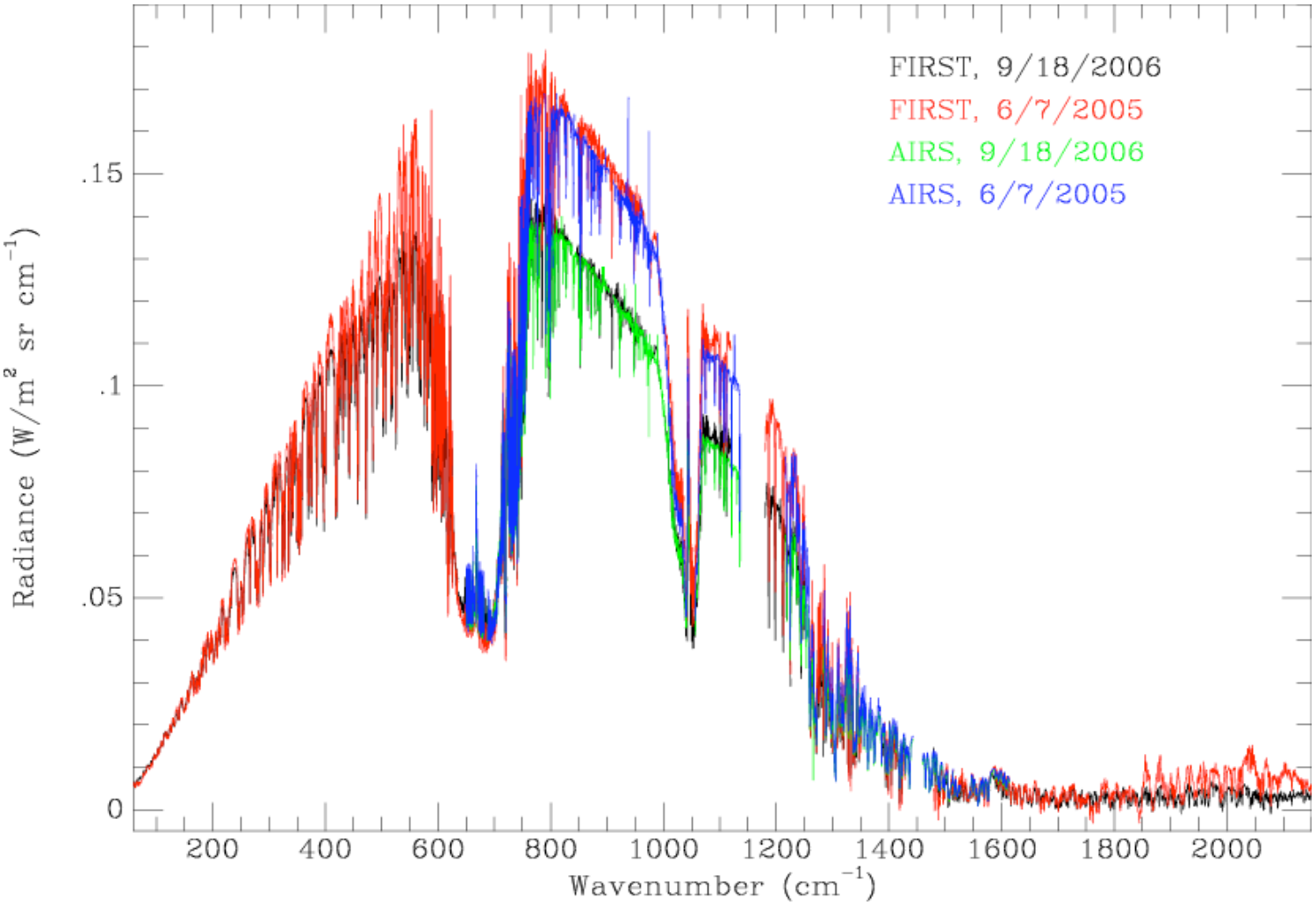


Lower troposphere much cooler

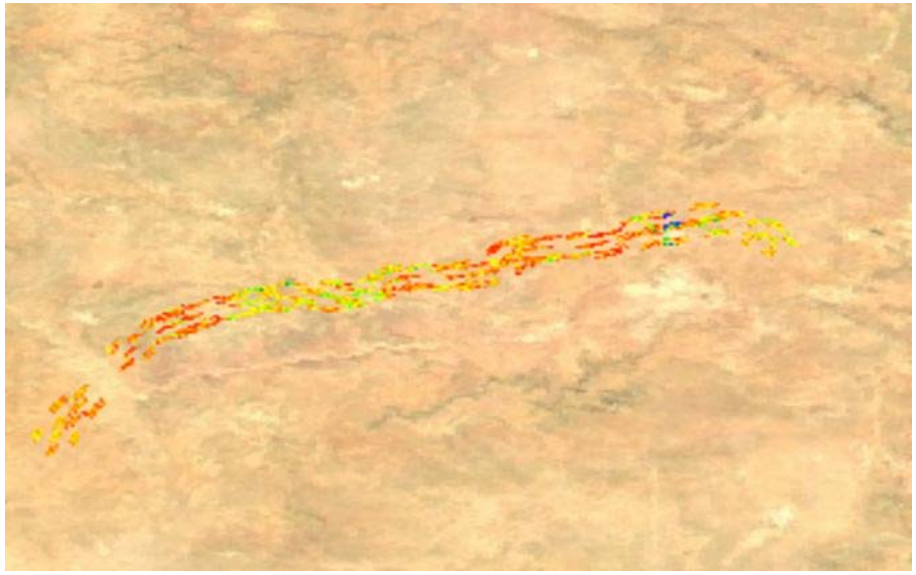


Mid-troposphere much drier

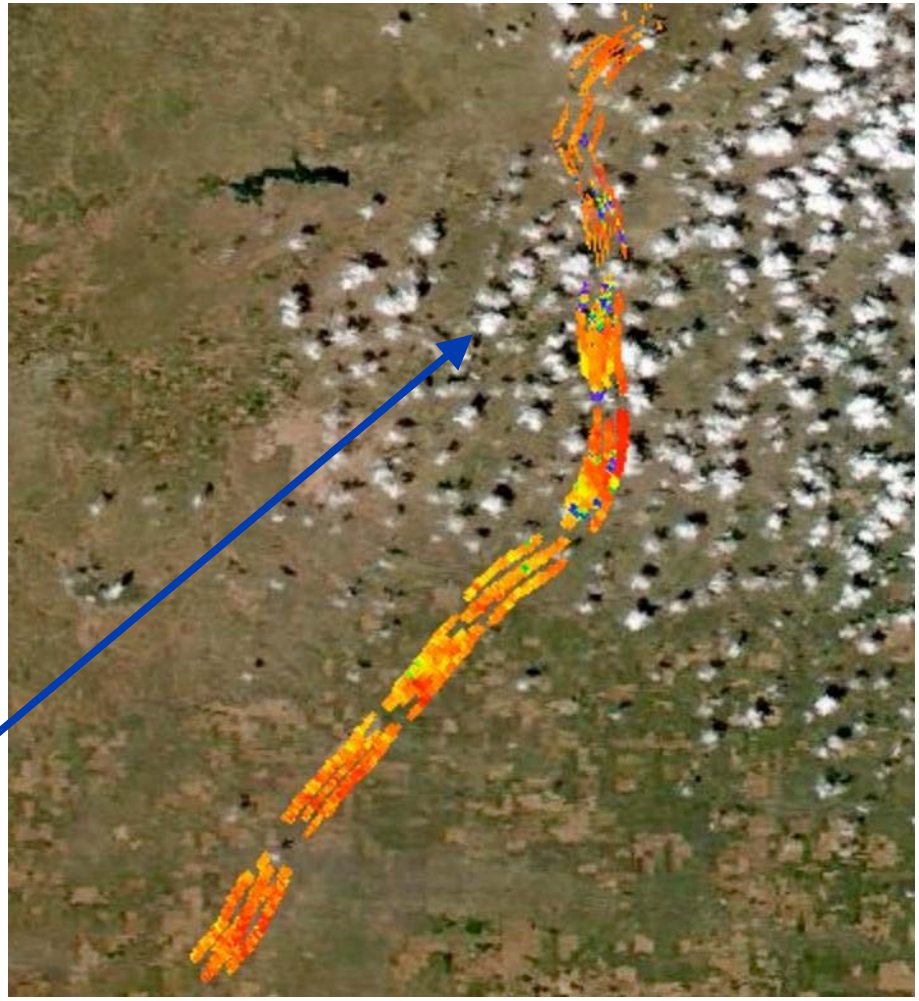
FIRST & AIRS Radiance comparison



FIRST 820 cm^{-1} Brightness Temperature
250 m MODIS Visible Imagery

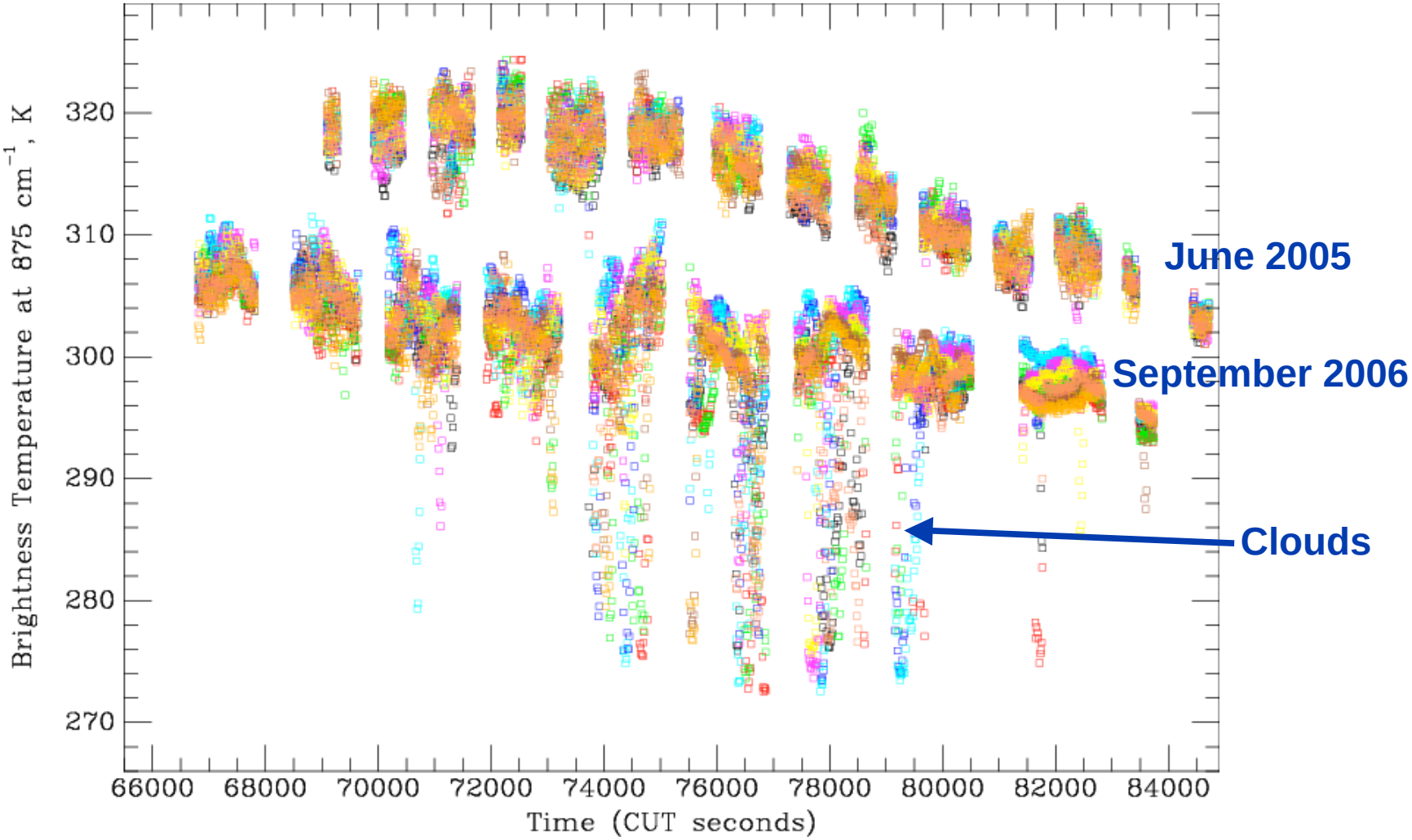


June 7, 2005

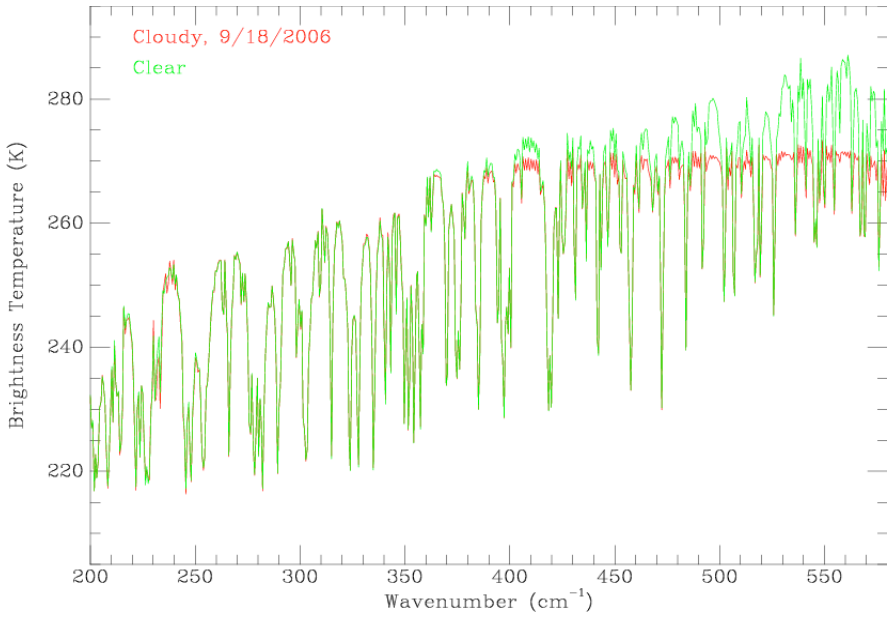


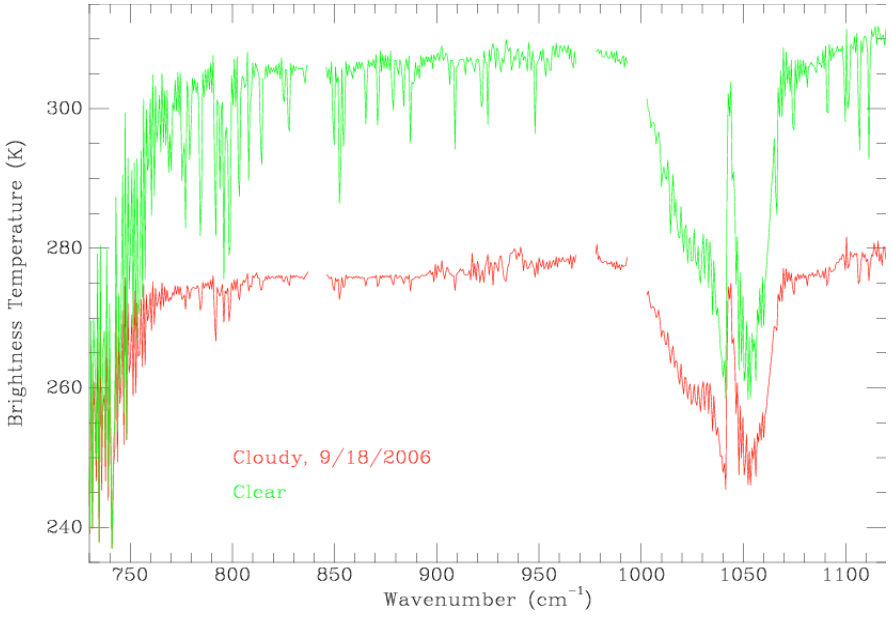
September 18, 2006;
Note clouds in image

Brightness Temperature at 875 cm^{-1}



Comparison of FIRST Cloudy and Clear Spectra September 2006

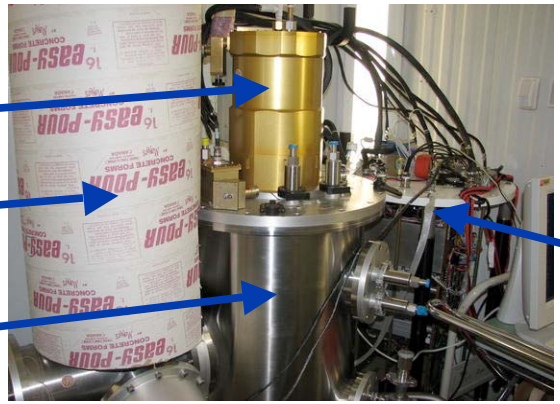




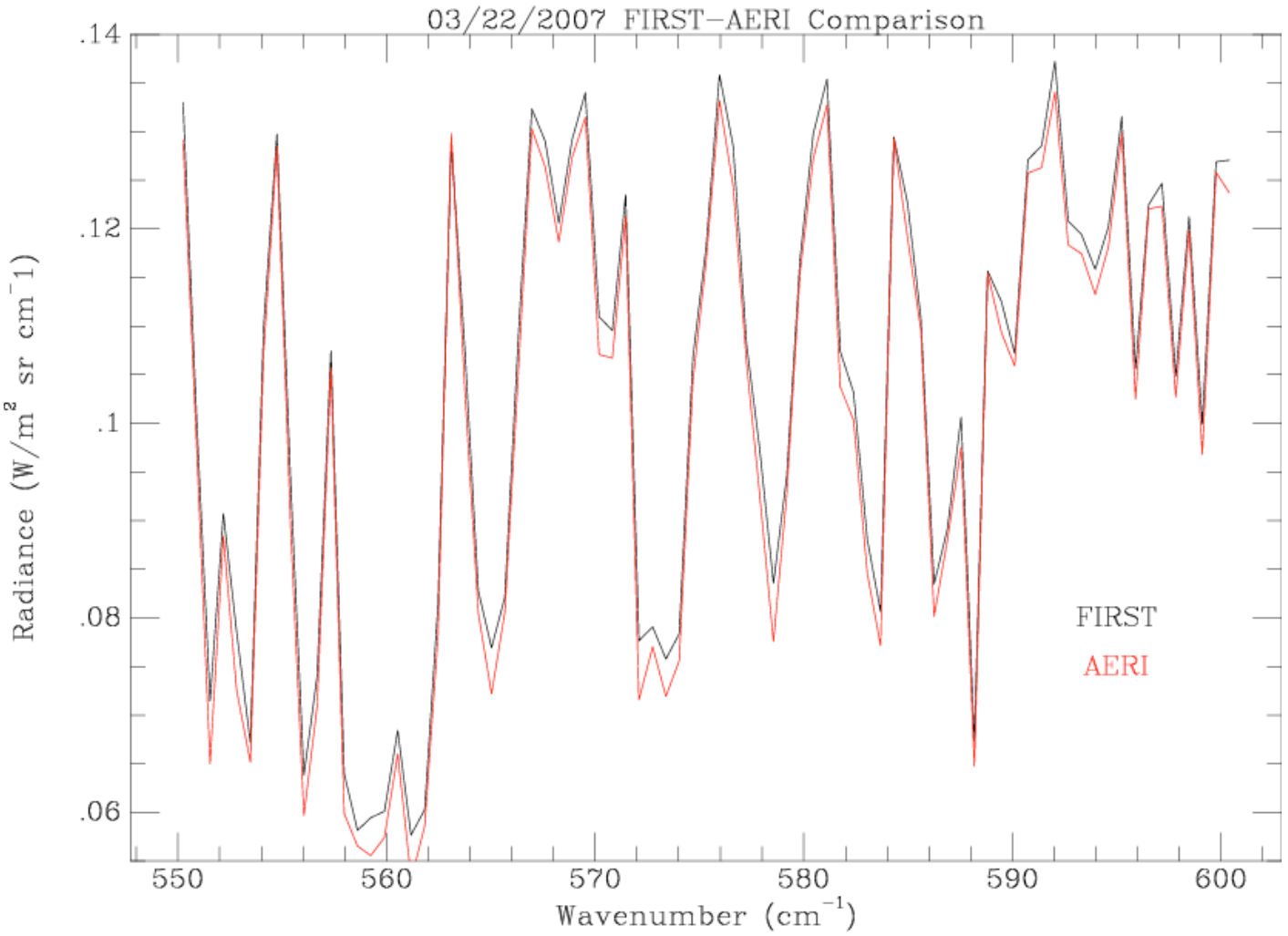
Far-Infrared

Mid-Infrared

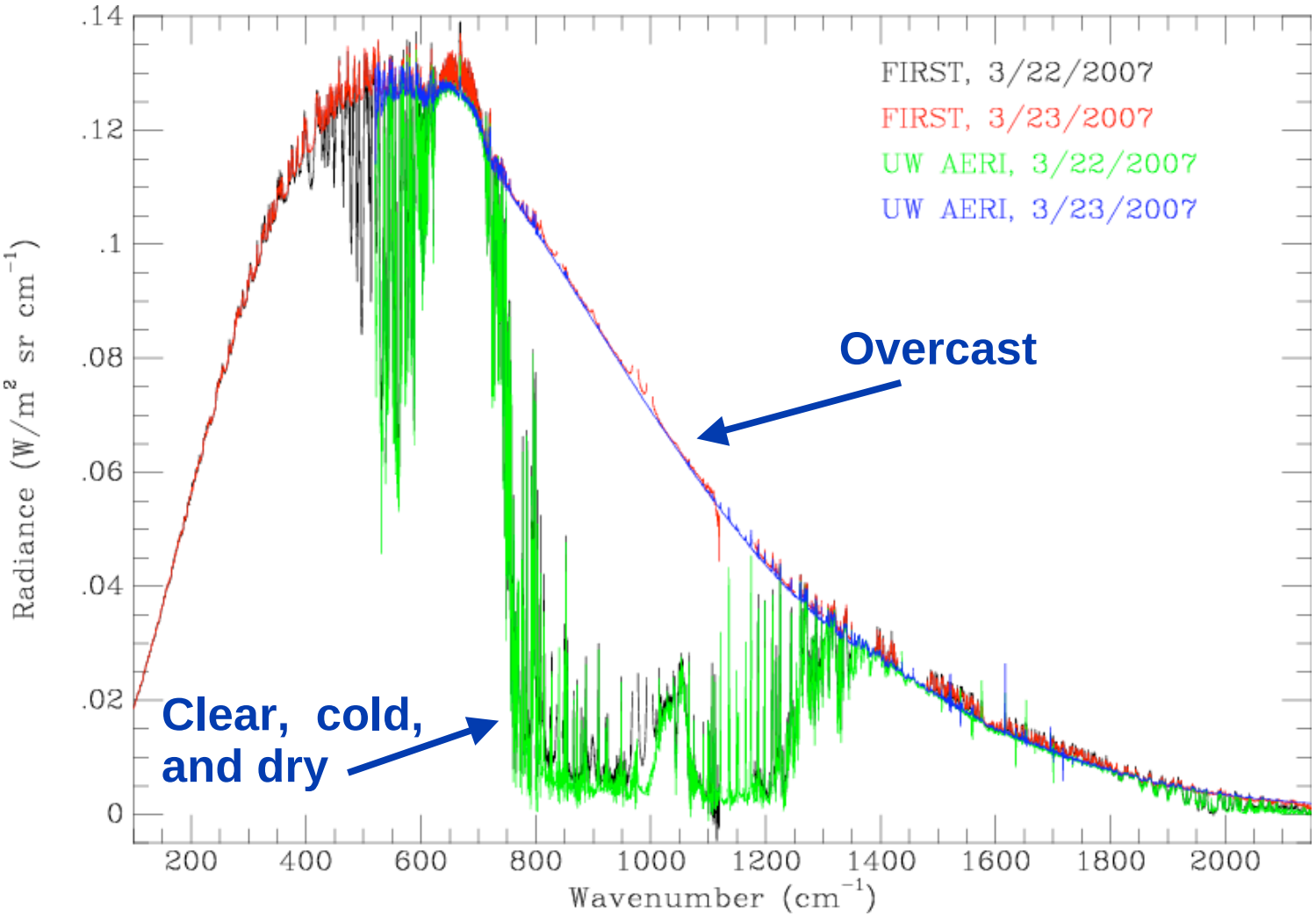
FIRST at University of Wisconsin
March 2007



AERI - FIRST Detail



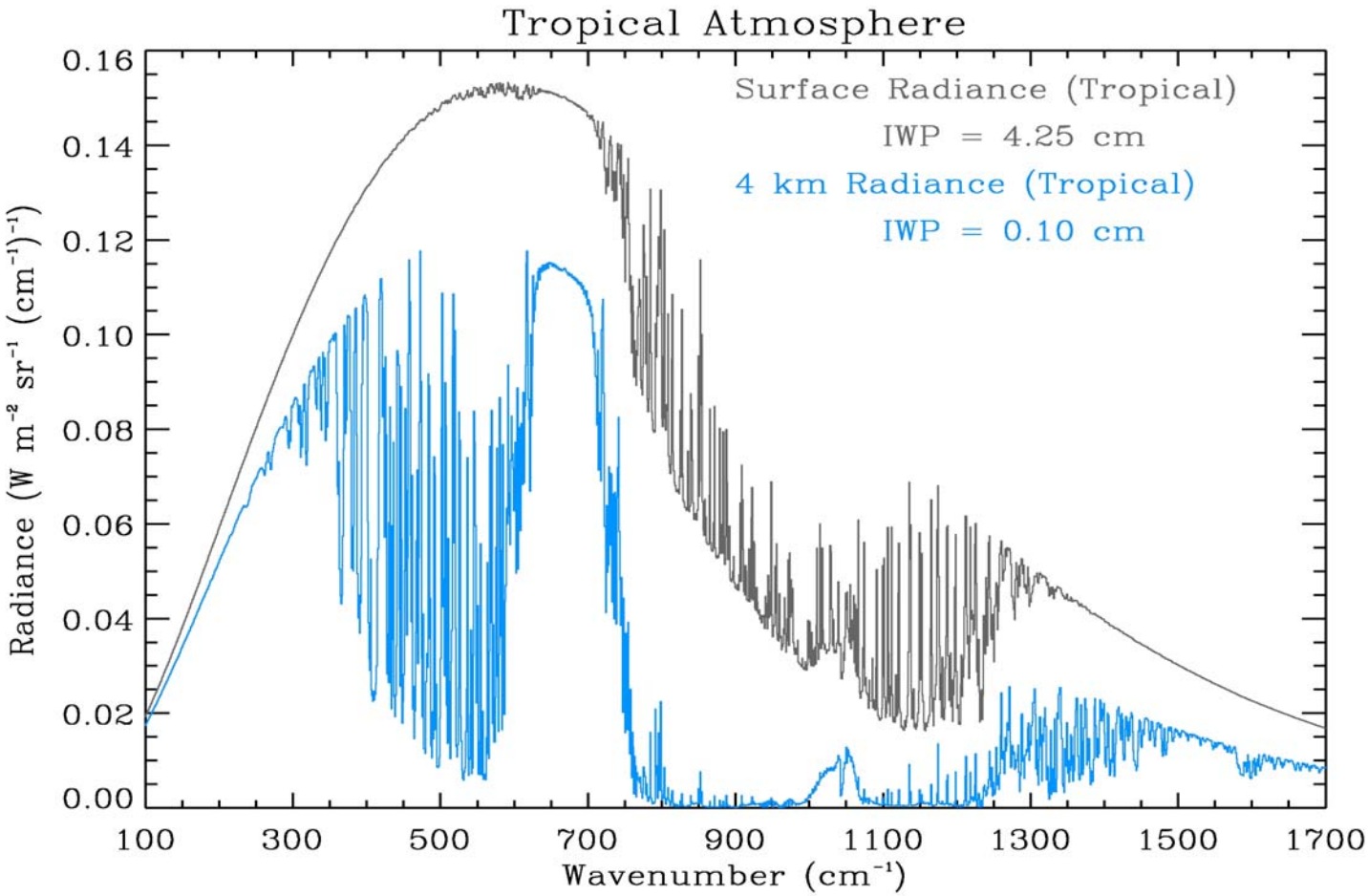
AERI & FIRST Comparison



RHUBC/FORGE

- August to October 2009
- Chajnantor, Chile
- ARM Mobile Facility; FIRST; other instruments
- Radiosondes launched during daily observing periods
- Science
  - Spectroscopy of far-IR
  - Radiative cooling
  - Cirrus forcing
  - Extensive cross-calibration against AERI-ER
  - Extensive evaluation against LBL codes

RHUBC/FORGE
Ground-based, Uplooking, Low H_2O



View from Chajnantor, Chile site for RHUBC/FORGE
H = 17,500 feet; p = 500 mb; H_2O < 0.4 mm

Calibrated Observations of Radiance Spectra from the Atmosphere in the far-InfraRed - CORSAIR

Major Technology Elements

- Passively Cooled Detectors (Raytheon Vision Systems)
  - Antenna Coupled Terahertz Devices
  - Potential for 100 to 1000 times more sensitive (D*) than pyroelectric
- SI Traceable Blackbodies in Far-IR (SDL; NIST)
  - Flight prototype blackbody w/ well-characterized emissivity
  - On-orbit emissivity monitor in far-IR
- Broad Bandpass Beamsplitters (ITT)
  - Cover 5 to 50 μm region in 1 beamsplitter
  - Potentially enables 1 instrument to cover CLARREO range
- Detector evaluation to take place in FIRST @ Langley in Year 3
  - LaRC; JPL; Raytheon

Langley Projects and Relation to CLARREO

Sensor Technology and Science

FIRST
- Far-IR FTS, beamsplitter
- Calibration
- Focal plane design

INFLAME
- Highly stable FTS design

CORSAIR
- High sensitivity, uncooled det's.
- Calibrated, SI traceable BB's in far-IR
- Efficient, broad bandpass beamsplitter

FIDTAP
- Sensitive, broadband, cryogenic, far-IR detectors

RHUBC/FORGE
- Cross-calibration
- Cirrus radiative forcing
- Radiative cooling
- Spectroscopy

CERES/AIRS
- Assess far-IR/TOA radiation balance