Far-Infrared Spectroscopy of the Troposphere

*FIRST*

Flight Results & Preliminary Comparisons with CERES, AIRS, and MODIS

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CERES Science Team Meeting – November 2005
FIRST – Overview

- Program developed under NASA Instrument Incubator Program (IIP)
- Develop technology necessary for routine measurement from space of the far-infrared spectrum 15 to 100 µm
- Many compelling science issues (greenhouse effect; cirrus etc.)
- FIRST is a Michelson FTS @ 0.625 cm\(^{-1}\) spectral resolution
- Global coverage requirement
  - Necessitates high throughput interferometer
  - 100 detector array \(\diamond\) 0.47 cm\(^2\) sr throughput
- One focal plane requirement
  - Necessitates broad bandpass beamsplitter (10 to 100 µm)
- IIP requires technology to be demonstrated in a relevant environment
- FIRST successfully demonstrated June 7 2005 on high altitude balloon from Ft. Sumner, NM

Completed on schedule and within original proposed budget
FIRST on the Flight Line June 7 2005
FIRST Flight Specifics

- Launched on 11 M cu ft balloon June 7 2005
- Float altitude of 27 km
- Recorded 5.5 hours of data
- 1.2 km footprint of entire FPA; 0.2 km footprint per detector
- 15,000 interferograms (total) recorded on 10 detectors
- Overflight of AQUA at 2:25 pm local time – AIRS, CERES, MODIS
- Essentially coincident footprints FIRST, AQUA instruments
- FIRST met or exceeded technology development goals
  - Optical throughput demonstrated by spectra from center and edge of focal plane detectors
  - Exceeded spectral bandpass – 20 to 1600 cm\(^{-1}\) demonstrated vs. 100 to 1000 cm\(^{-1}\) required
- FIRST, AIRS, CERES, MODIS comparisons in window imply excellent calibration (≈1 K agreement in skin temperature)

FIRST records complete thermal emission spectrum of the Earth at high spatial and spectral resolution
FIRST “First Light” Spectrum

7-June-2005 Atmosphere

Preliminary Calibration
FIRST, AIRS, MODIS and CERES Window Radiance Comparisons

- Four AIRS footprints very close to FIRST
- Several CERES Window channel footprints close to FIRST
- MODIS footprint nearly coincident with FIRST

- FIRST Radiance at 900 cm\(^{-1}\) is 0.15 W m\(^{-2}\) sr cm\(^{-1}\)
  - Corresponds to a skin temperature of 318 K if emissivity = 1.0
  - Air temperature at Ft. Sumner ~ 90 F or 305 K
  - IR emissivity from AIRS $\diamond$ Skin temp for FIRST is 320 K

- AIRS skin temperature closest to FIRST is 319 K

- MODIS skin temperature in pixel nearly coincident with FIRST is 322 K

- CERES Window Channel (844 to 1227 cm\(^{-1}\))
  - Measured radiance is 41.75 W m\(^{2}\) sr\(^{-1}\) closest to FIRST
  - Computed radiance using ABQ sonde, 318 K skin Temp is 41.83 W m\(^{2}\) sr\(^{-1}\)
  - Computed radiance for 297 K skin temp is 30.76 W

Conclude that within 1 -2 K CERES, AIRS, and MODIS support FIRST skin temperature, and hence, absolute calibration of the FIRST instrument
FIRST Spectra
Comparisons with L-B-L using AIRS Retrievals

L-b-L does not yet include FIRST Instrument Response Functions
FIRST Spectra Compared with L-b-L Simulation
Demonstration of FIRST Recovery of Spectral Structure

Note: FIRST, LbL spectra offset by 0.05 radiance units
FIRST Spectra
Comparisons with L-B-L using AIRS Retrievals

Preliminary calibration
Radiance Comparison

First graph:
- X-axis: Frequency (cm⁻¹)
- Y-axis: Radiance (mW/m²sr/cm⁻¹)
- Blue line: FIRST Spectrum
- Red line: Modeled Spectrum

Second graph:
- X-axis: Frequency (cm⁻¹)
- Y-axis: Difference (mW/m²sr/cm⁻¹)

L-b-L does not yet include FIRST Instrument Response Functions
FIRST – Status and Summary

- FIRST successfully completed technology demonstration flight 6/2005
  - Met or exceeded technology goals

- Preliminary calibration applied here from flight blackbody

- Measured entire thermal emission spectrum on one focal plane with one instrument

- Agreement in window with CERES, AIRS, and MODIS is excellent

- Fidelity of measured far-IR spectra with L-b-L codes is outstanding

- Continuing to improve calibration:
  - Absolute cal. using laboratory and flight blackbodies
  - Improved phase corrections

- Anticipate deployment in future campaigns and science opportunities
FIRST Lands Safely after a Successful Flight