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# **Far-Infrared Spectroscopy of the Troposphere**

## **\* *FIRST* \***

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

**Marty Mlynczak, *NASA Langley Research Center***

**Dave Johnson, *NASA Langley Research Center***

**Harri Latvakoski, *Utah State University Space Dynamics Laboratory***

**Ken Jucks, *Harvard Smithsonian Center for Astrophysics***

**David Kratz, *NASA Langley Research Center***

**Xu Liu, *NASA Langley Research Center***

**Ferenc Miskolczi, *NASA Langley Research Center***

**Gail Bingham, *Utah State University Space Dynamics Laboratory***

# FIRST – Overview

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- Program developed under NASA Instrument Incubator Program (IIP)
- Develop technology necessary for routine measurement from space of the far-infrared spectrum 15 to 100  $\mu\text{m}$
- Many compelling science issues (greenhouse effect; cirrus etc.)
- FIRST is a Michelson FTS @ 0.625  $\text{cm}^{-1}$  spectral resolution
- Global coverage requirement
  - Necessitates high throughput interferometer
  - 100 detector array  $\diamond$  0.47  $\text{cm}^2 \text{sr}$  throughput
- One focal plane requirement
  - Necessitates broad bandpass beamsplitter (10 to 100  $\mu\text{m}$ )
- 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**

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# FIRST on the Flight Line June 7 2005

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# FIRST Flight Specifics

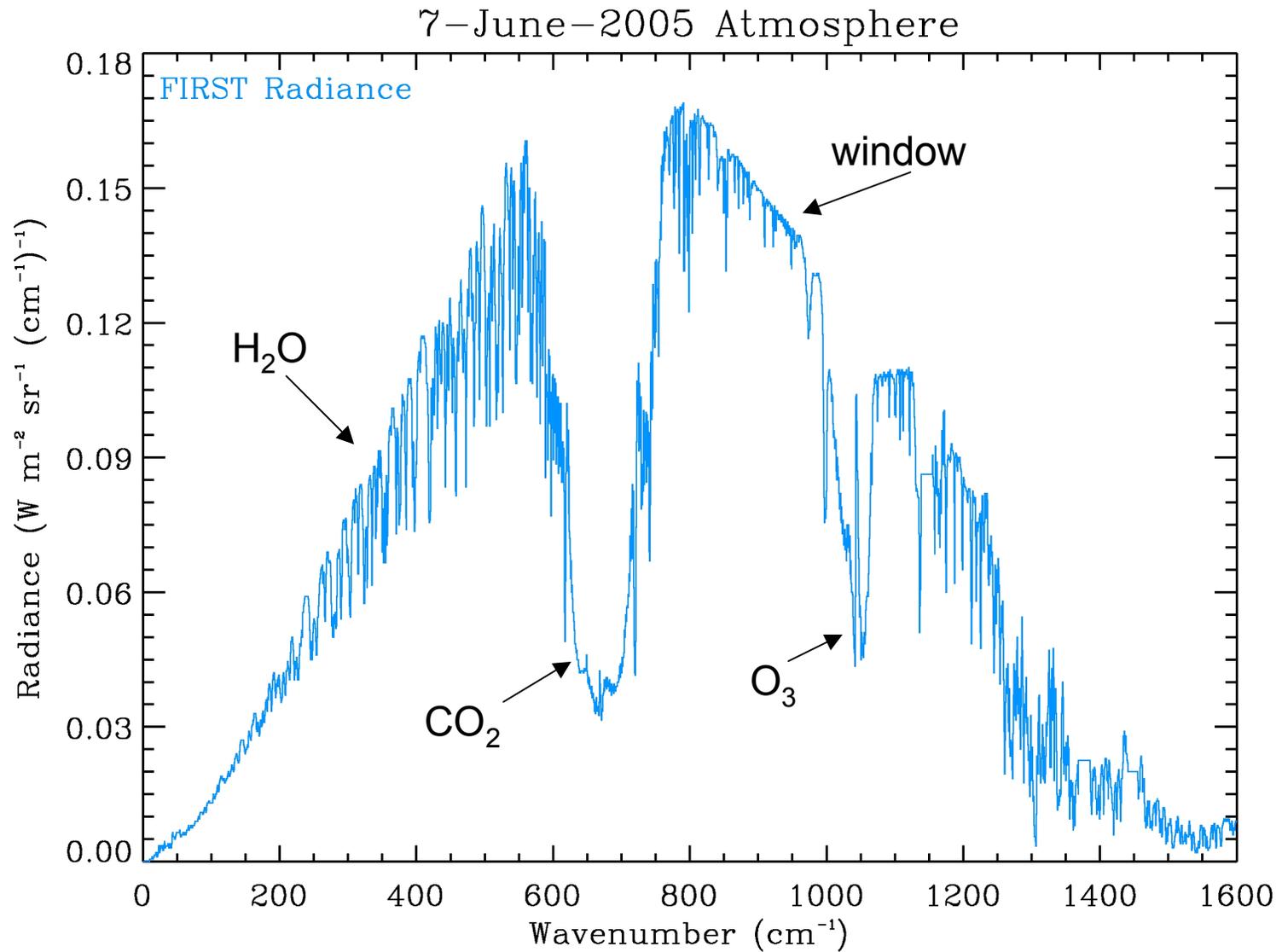
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- Launched on 11 M cu ft balloon June 7 2005
- Float altitude of 27 km
- Recorded 5.5 hours of data
- 1.2 km footprint of entire FPA; 0.2 km footprint per detector
- 15,000 interferograms (total) recorded on 10 detectors
- Overflight of AQUA at 2:25 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  $\text{cm}^{-1}$  demonstrated vs. 100 to 1000  $\text{cm}^{-1}$  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**

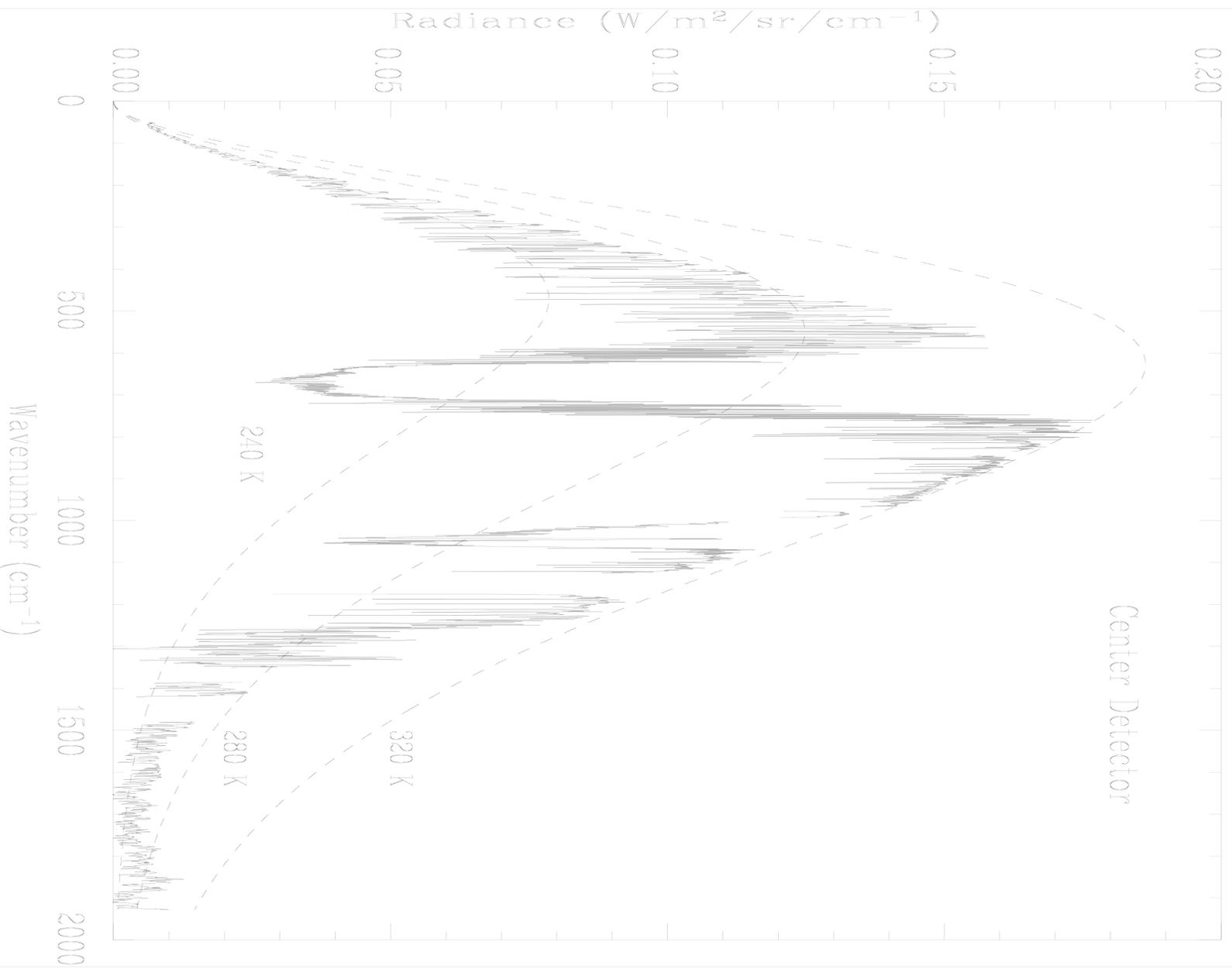
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# FIRST "First Light" Spectrum



Preliminary Calibration

FIRST Radiance June 7 2005 14:25 LT



# FIRST, AIRS, MODIS and CERES Window Radiance Comparisons

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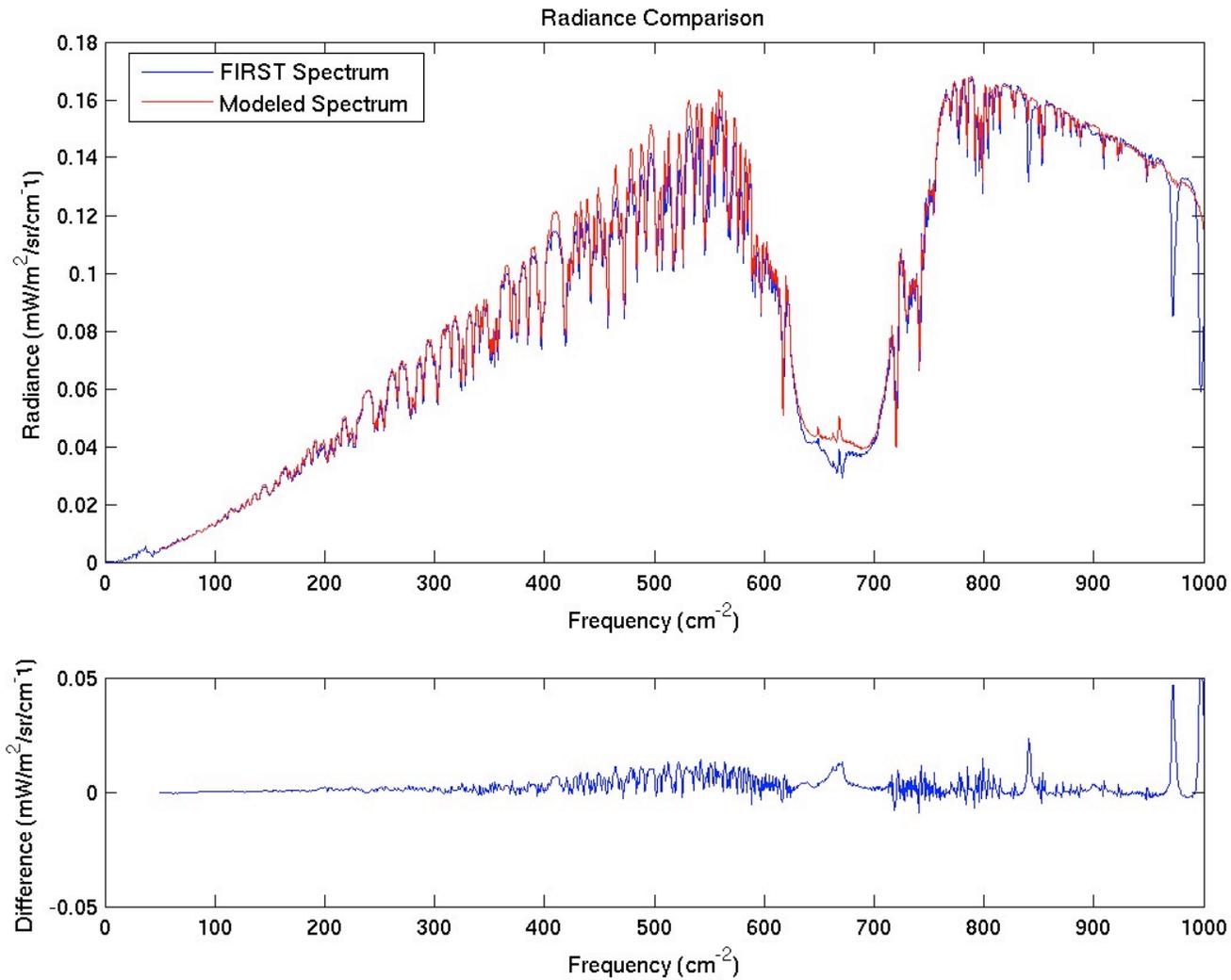
- Four AIRS footprints very close to FIRST
- Several CERES Window channel footprints close to FIRST
- MODIS footprint nearly coincident with FIRST
  
- FIRST Radiance at  $900 \text{ cm}^{-1}$  is  $0.15 \text{ W m}^{-2} \text{ sr cm}^{-1}$ 
  - Corresponds to a skin temperature of 318 K if emissivity = 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  $1227 \text{ cm}^{-1}$ )
  - Measured radiance is  $41.75 \text{ W m}^2 \text{ sr}^{-1}$  closest to FIRST
  - Computed radiance using ABQ sonde, 318 K skin Temp is  $41.83 \text{ W m}^2 \text{ sr}^{-1}$
  - Computed radiance for 297 K skin temp is  $30.76 \text{ W}$

**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

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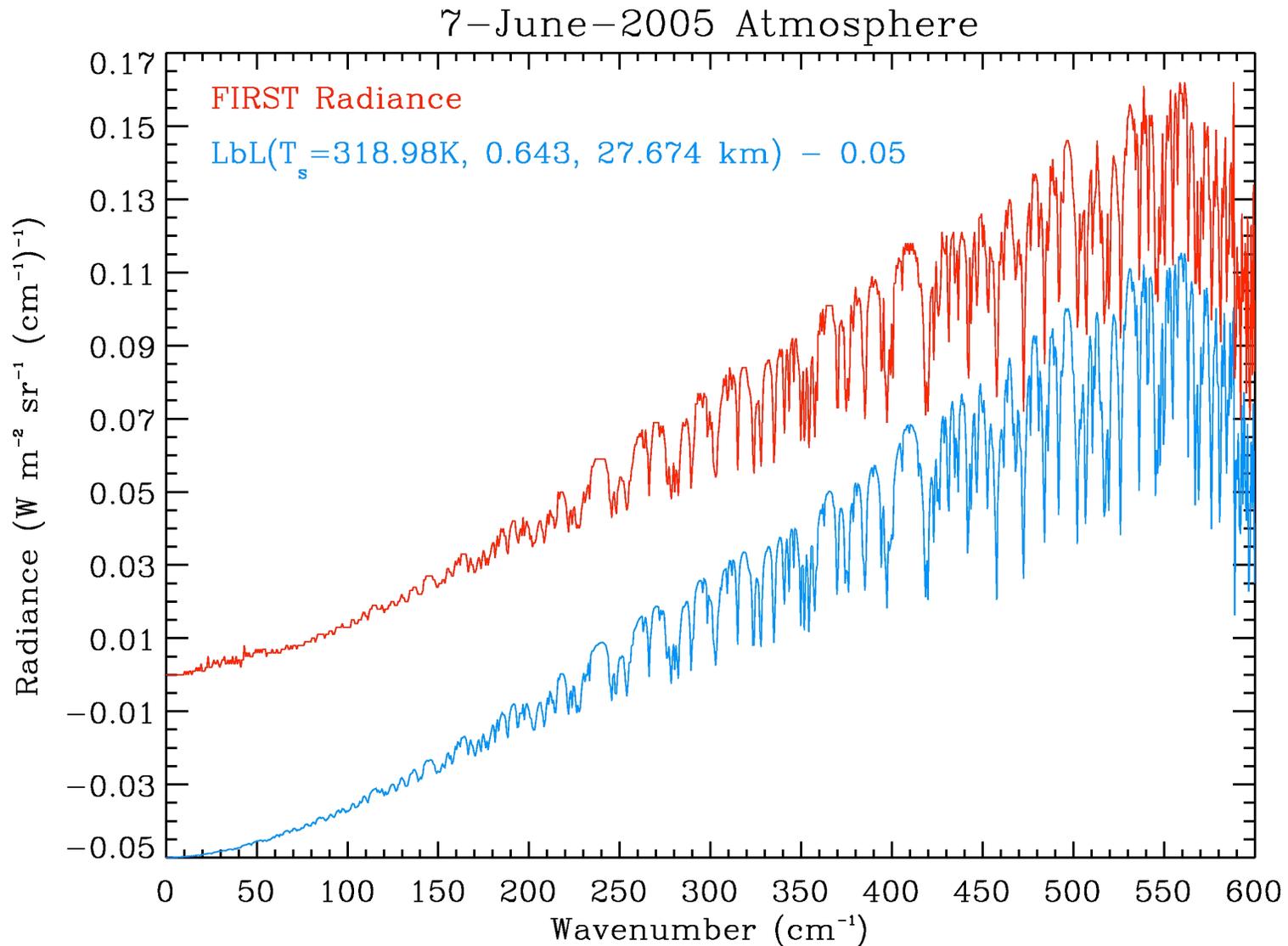


***L-b-L does not yet include FIRST Instrument Response Functions***

# FIRST Spectra Compared with L-b-L Simulation

## Demonstration of FIRST Recovery of Spectral Structure

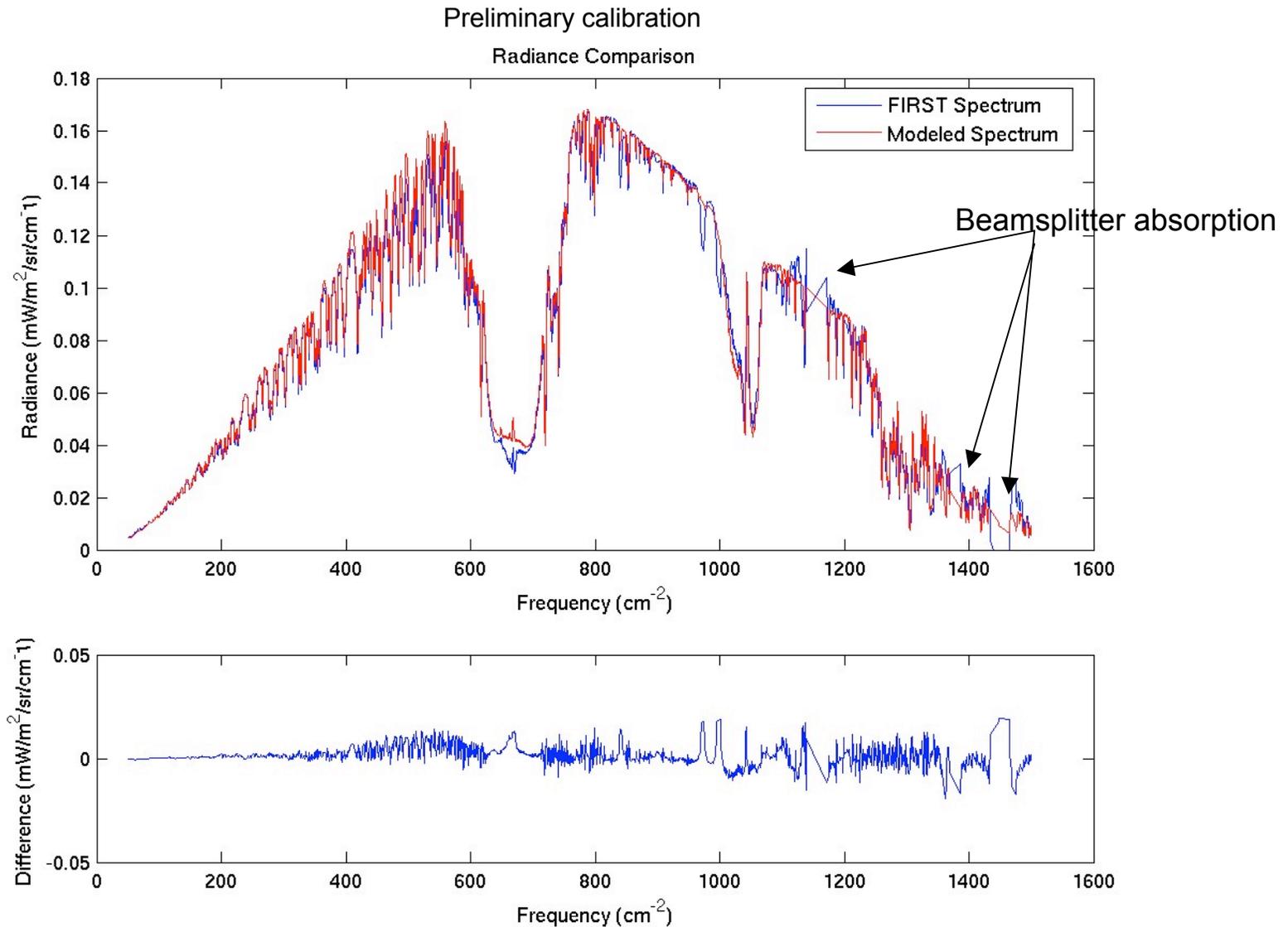
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*Note: FIRST, LbL spectra offset by 0.05 radiance units*

# FIRST Spectra

## Comparisons with L-B-L using AIRS Retrievals



***L-b-L does not yet include FIRST Instrument Response Functions***

# FIRST – Status and Summary

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- 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
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# FIRST Lands Safely after a Successful Flight

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