



# **NAST/SHIS Cal-Val: Selected Examples**

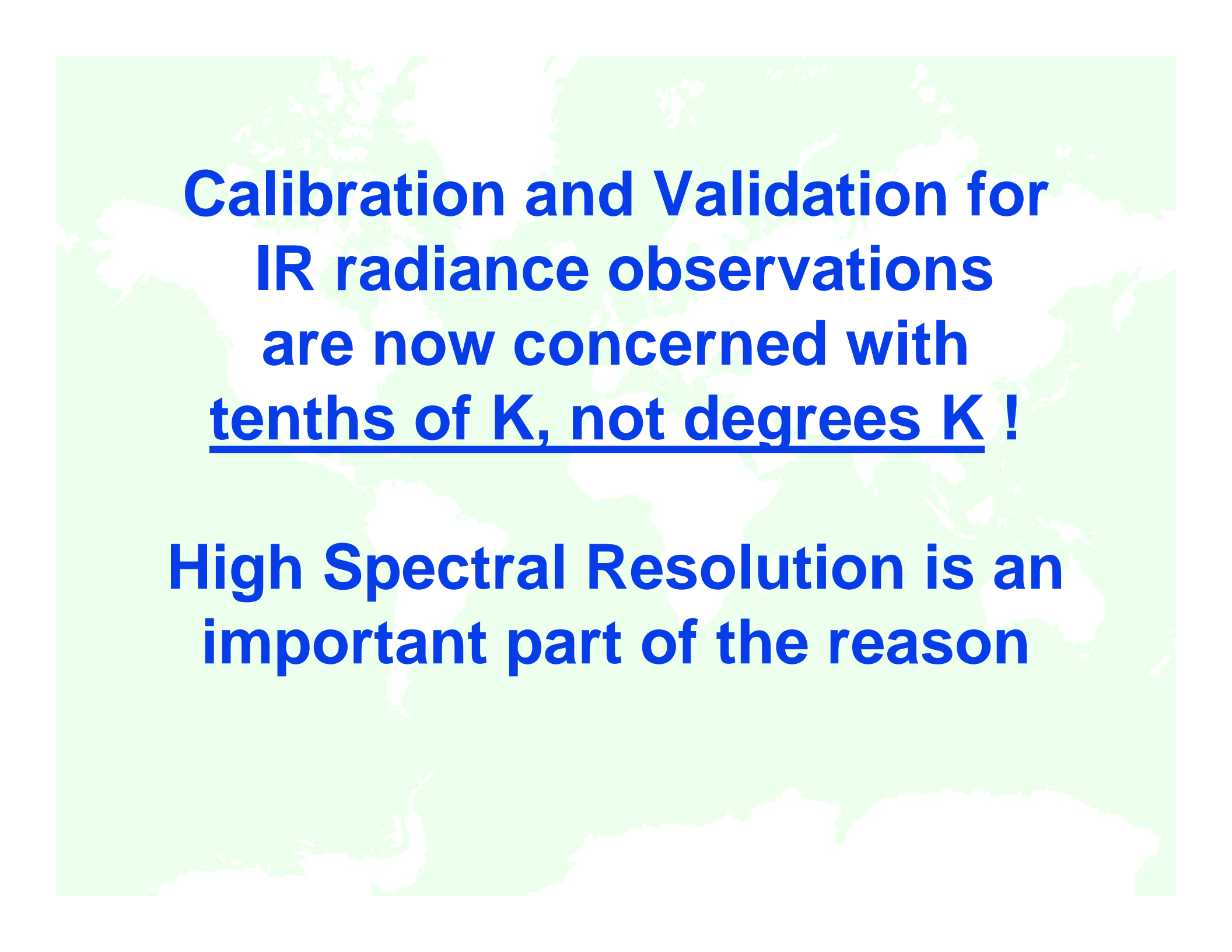
**Hank Revercomb**

---

**University of Wisconsin - Madison  
Space Science and Engineering Center  
(SSEC)**



**NAST-2 Development Workshop  
NASA LaRC, 10-11 July 2003**

A light green world map is visible in the background of the slide, showing the continents and oceans.

**Calibration and Validation for  
IR radiance observations  
are now concerned with  
tenths of K, not degrees K !**

**High Spectral Resolution is an  
important part of the reason**

# TOPICS

1. NAST Non-linearity
2. Scanning-HIS



Fall 2002 - Oklahoma

**Oklahoma, ARM UAV “Grand Tour”**  
(SHIS on Proteus at 15 km,  
16 Nov 2002)

3. AIRS Radiance Validation:

**Gulf of Mexico,  
Terra/Aqua 2002**

(SHIS on ER2 at 20 km,  
21 Nov 2002)



A world map with a light blue background and dark blue outlines of continents. The map is centered on the Atlantic Ocean, showing North America, South America, Europe, Africa, Asia, and Australia.

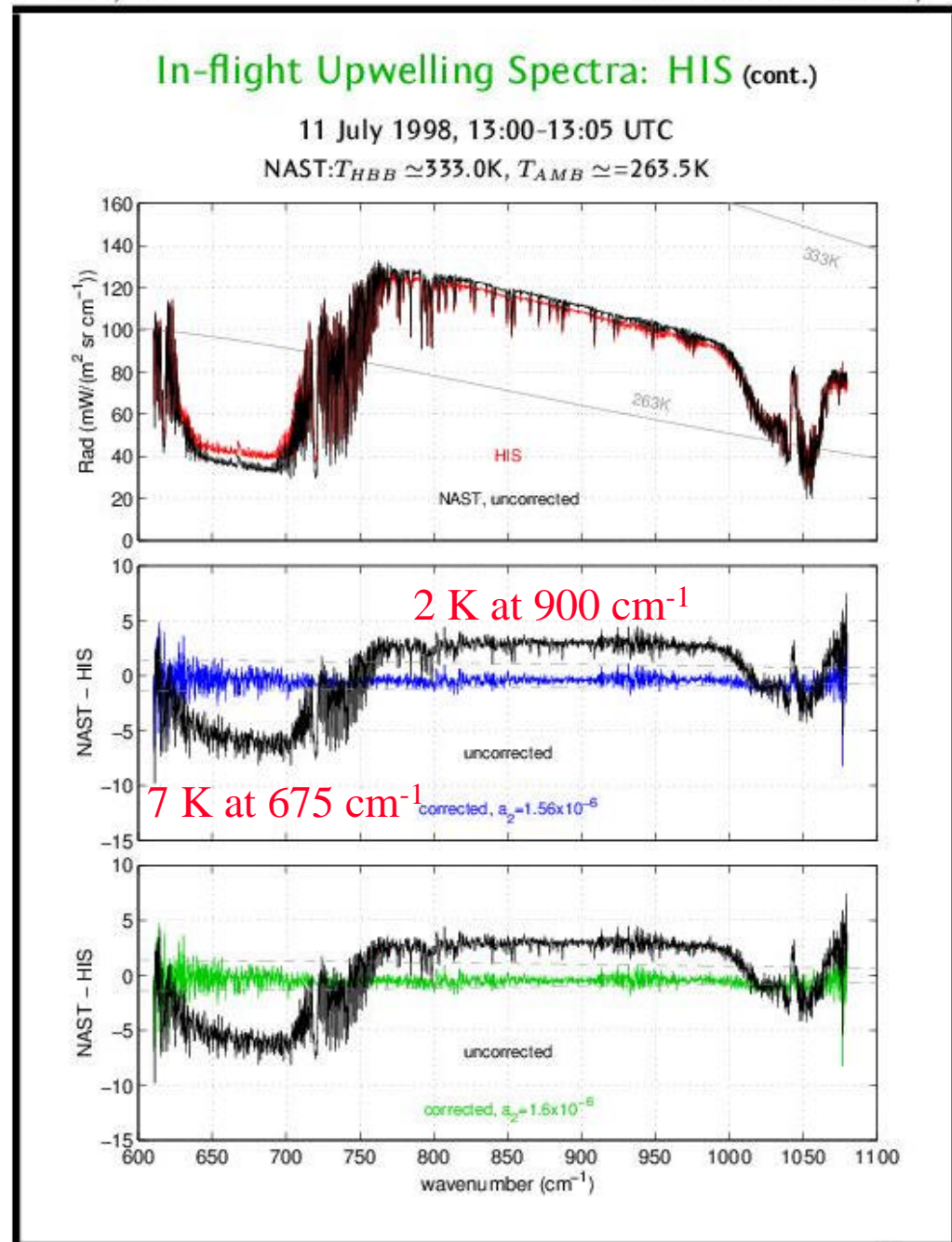
# **NAST Non-linearity**

# NAST-HIS Comparison: Long-wave Non-linearity

Original HIS used linear  
Ar:Si detectors at 6 K

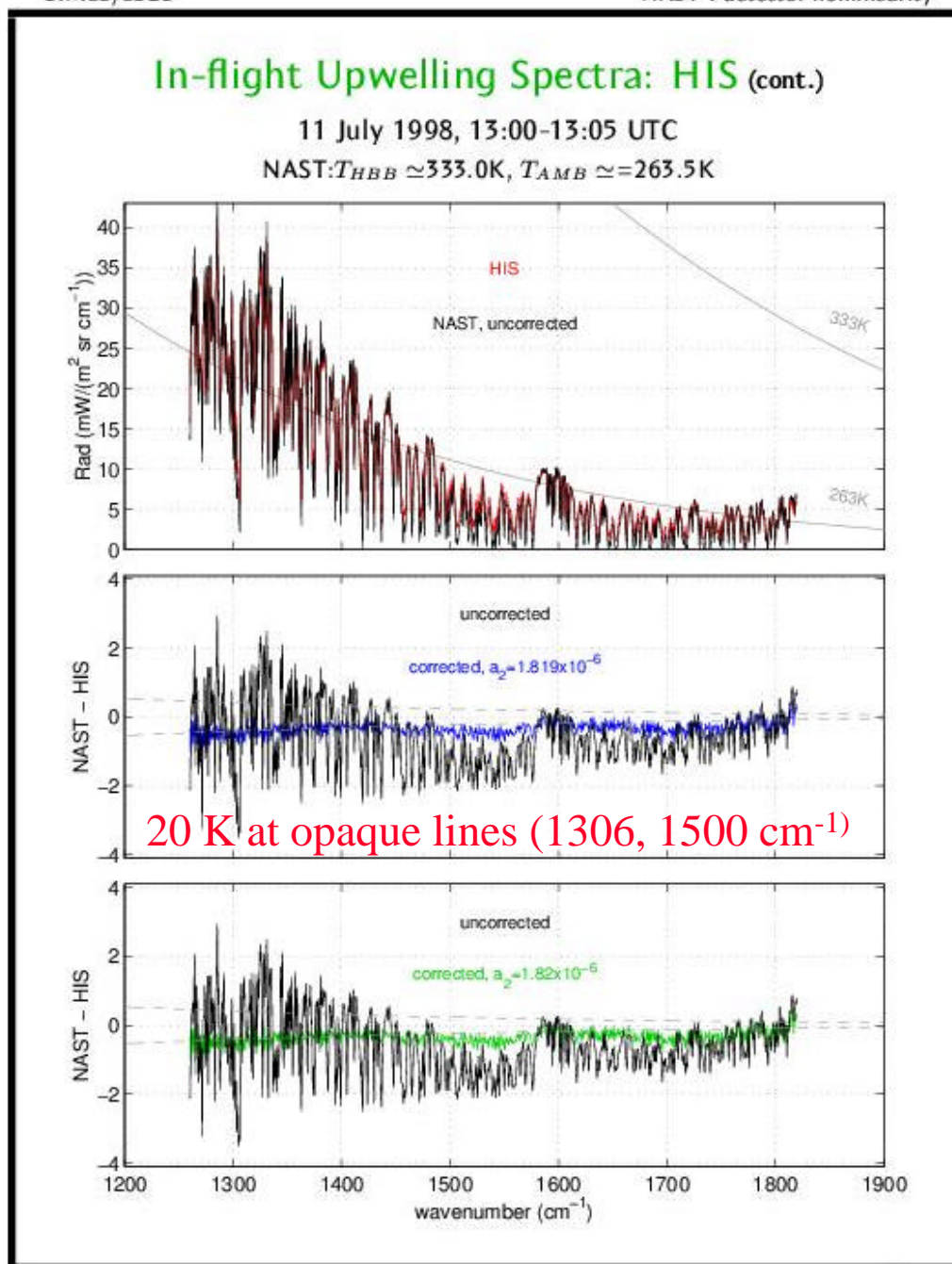
NAST non-linearity  
correction works well,  
but the correction is large  
(SHIS is smaller by  $\approx 2.5$ )

Detectors with smaller  
non-linearity would  
reduce calibration  
uncertainty



## NAST-HIS Comparison: Mid-wave Non-linearity

Brightness Temperature corrections are larger for the mid-wave than for the long-wave



# NAST-AERI Comparison: Long-wave Non-linearity

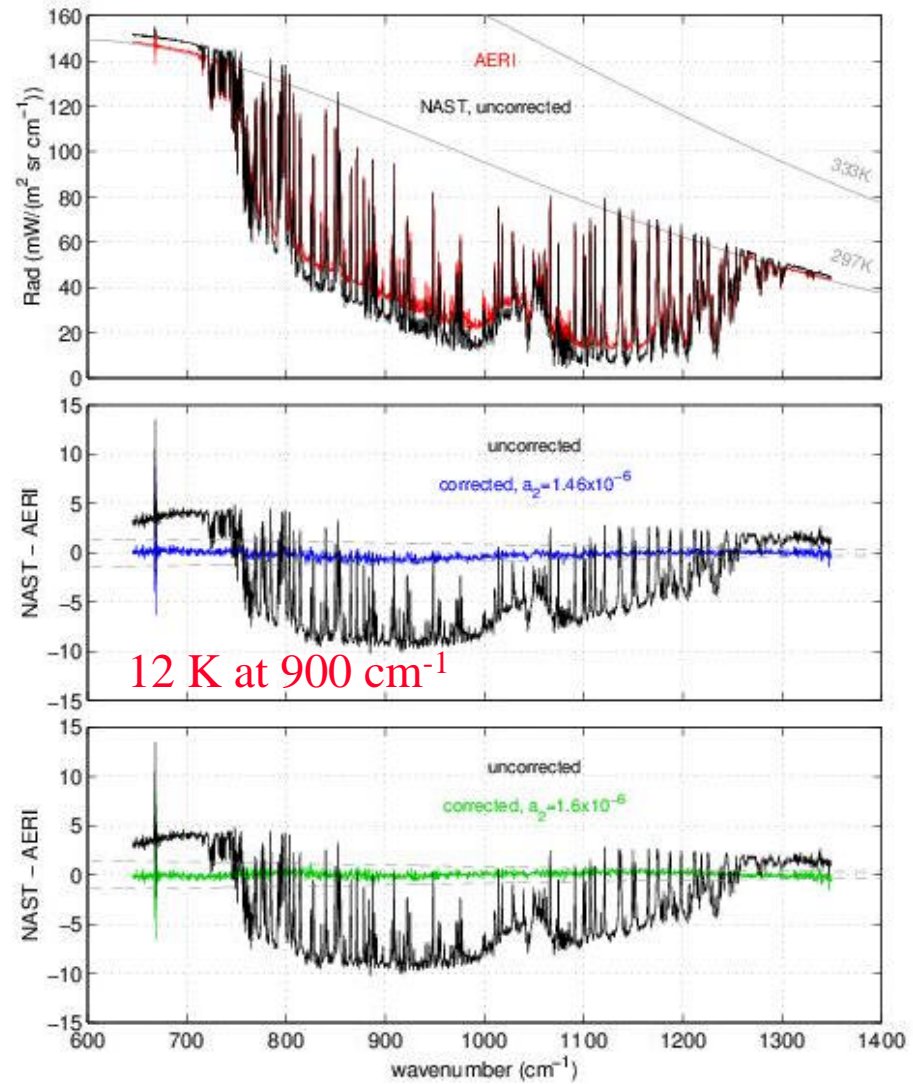
AERI Non-linearity  
correction is about an  
order of magnitude smaller

Uplooking is a more  
sensitive test than  
downlooking in the  
Long-wave

## Ground-based Downwelling Spectra: AERI (cont.)

26 June 1998, 01:44-02:00 UTC at Wallops Island, VA.

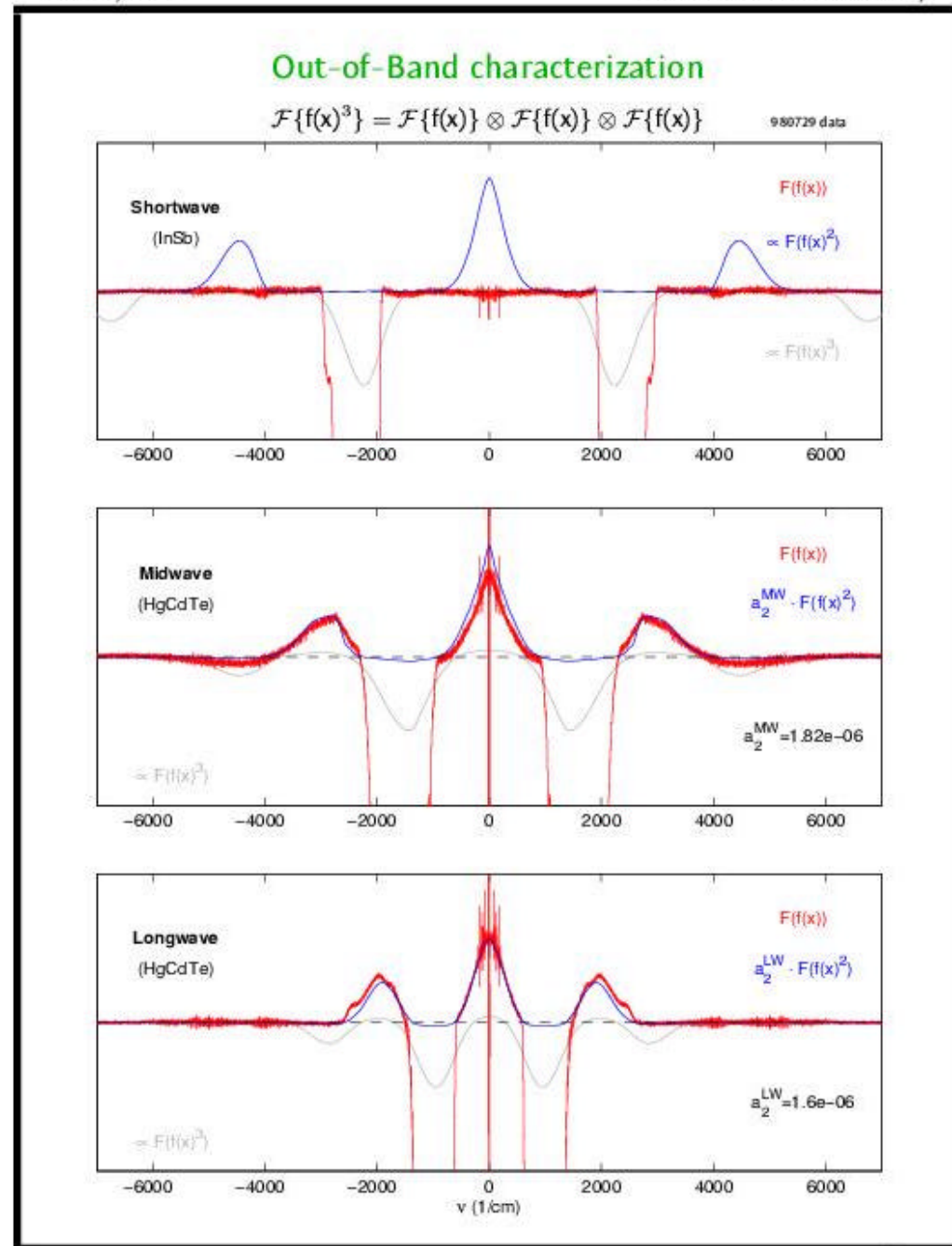
NAST:  $T_{HBB} \simeq 333.0\text{K}$ ,  $T_{AMB} \simeq 297.5\text{K}$



# Out-of-band Non-Linearity Signature

Access to out-of-band spectral signatures is important to identifying and evaluating any source non-linearity

Should allow the numerical filter to be bypassed for testing





A world map with a light blue background and dark blue landmasses. The map is centered on the Atlantic Ocean, showing the Americas on the left and Europe, Africa, and Asia on the right. The text "S-HIS Uplooking" is overlaid in the center of the map.

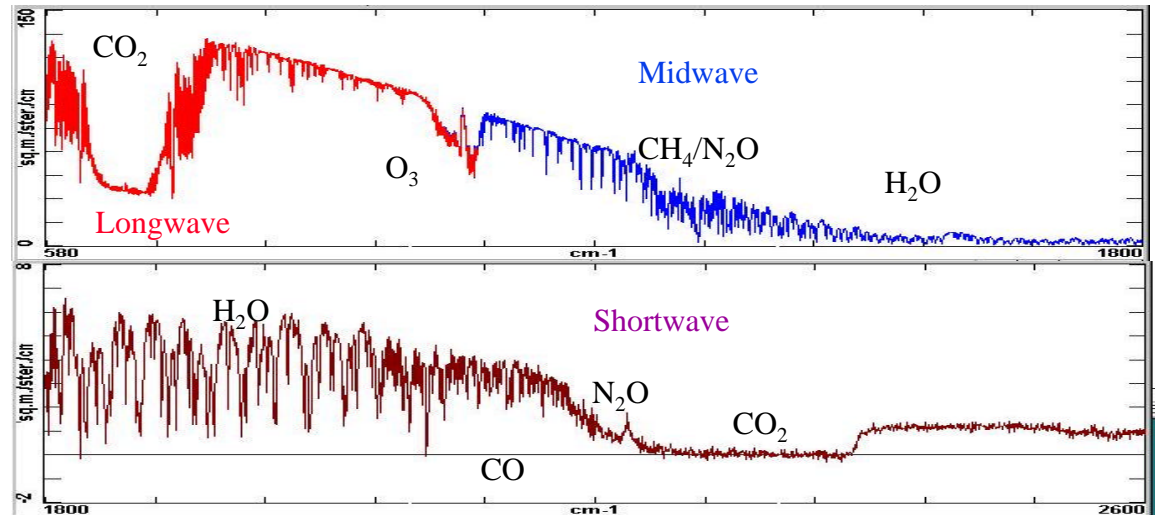
# **S-HIS Uplooking**

# UW Scanning HIS: 1998-Present

(HIS: High-resolution Interferometer Sounder, 1985-1998)

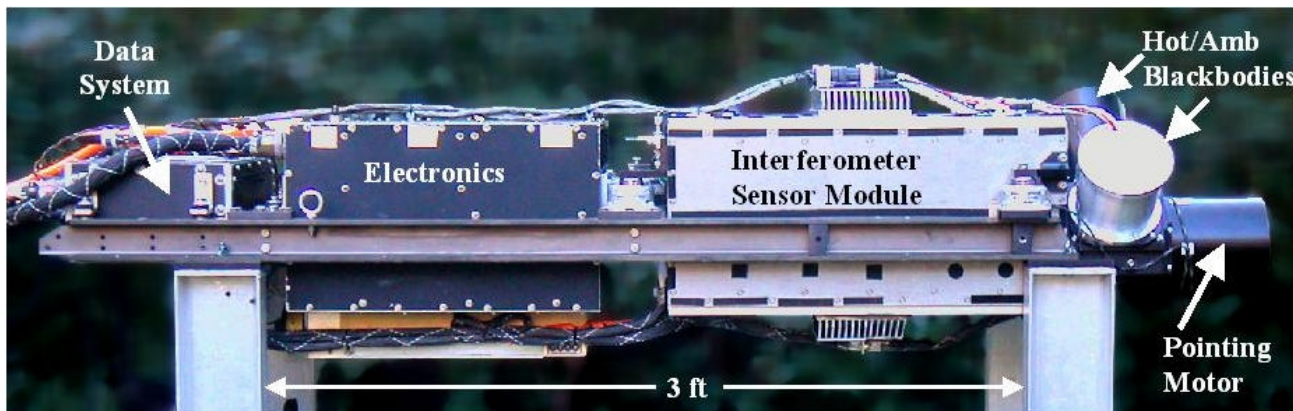
## Characteristics

- Spectral Coverage:** 3-17 microns
- Spectral Resolution:**  $0.5 \text{ cm}^{-1}$
- Resolving power:** 1000-6000
- Footprint Diam:** 1.5 km @ 15 km
- Cross-Track Scan:** Programmable including uplooking zenith view



## Applications:

- ◆ Radiances for Radiative Transfer
- ◆ Temp & Water Vapor Retrievals
- ◆ Cloud Radiative Prop.
- ◆ Surface Emissivity & T
- ◆ Trace Gas Retrievals



# SSEC Scanning HIS on 1st ARM-UAV Mission with Proteus, October 2002

---

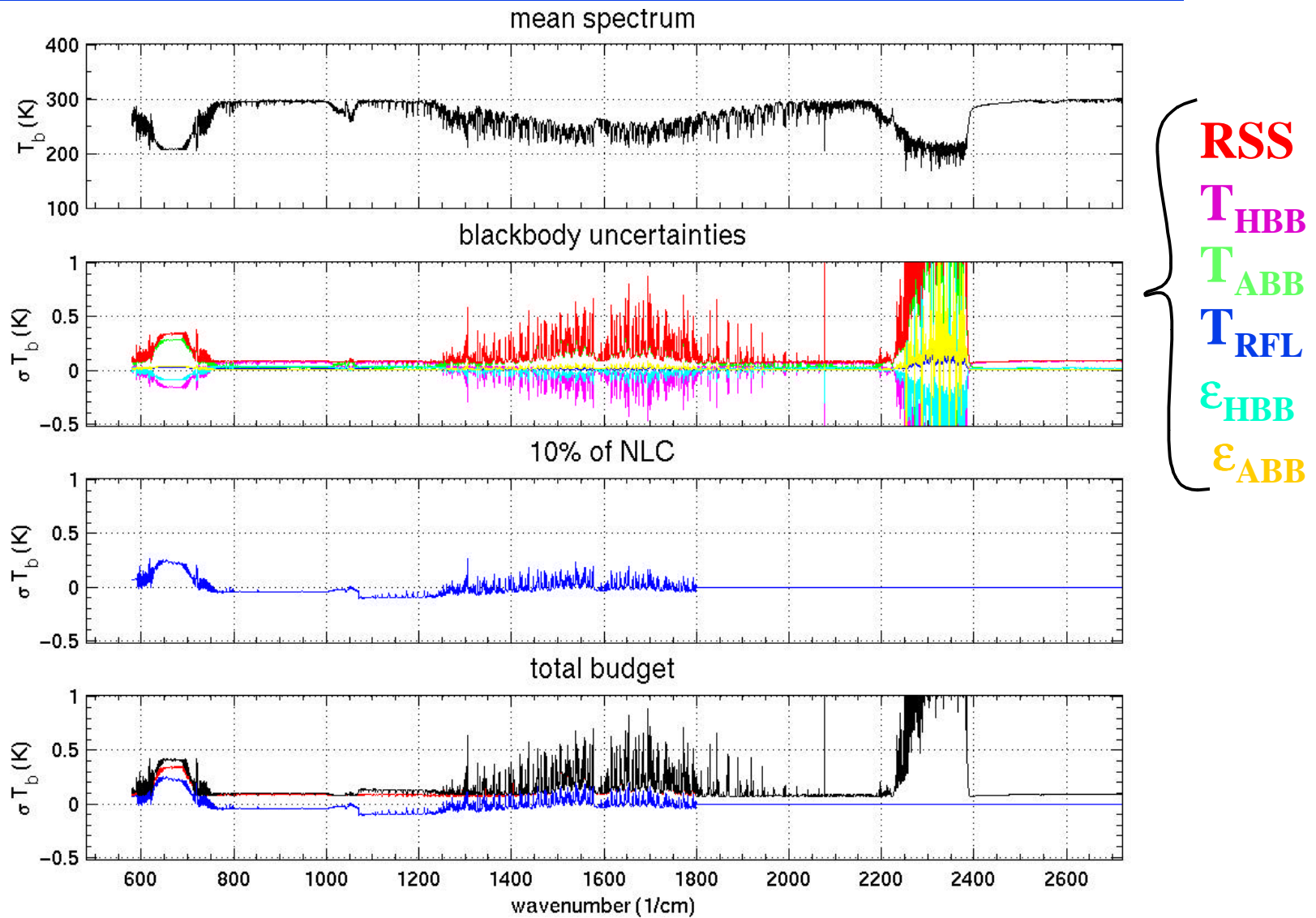


**S-HIS scans cross-track downward & looks upward**



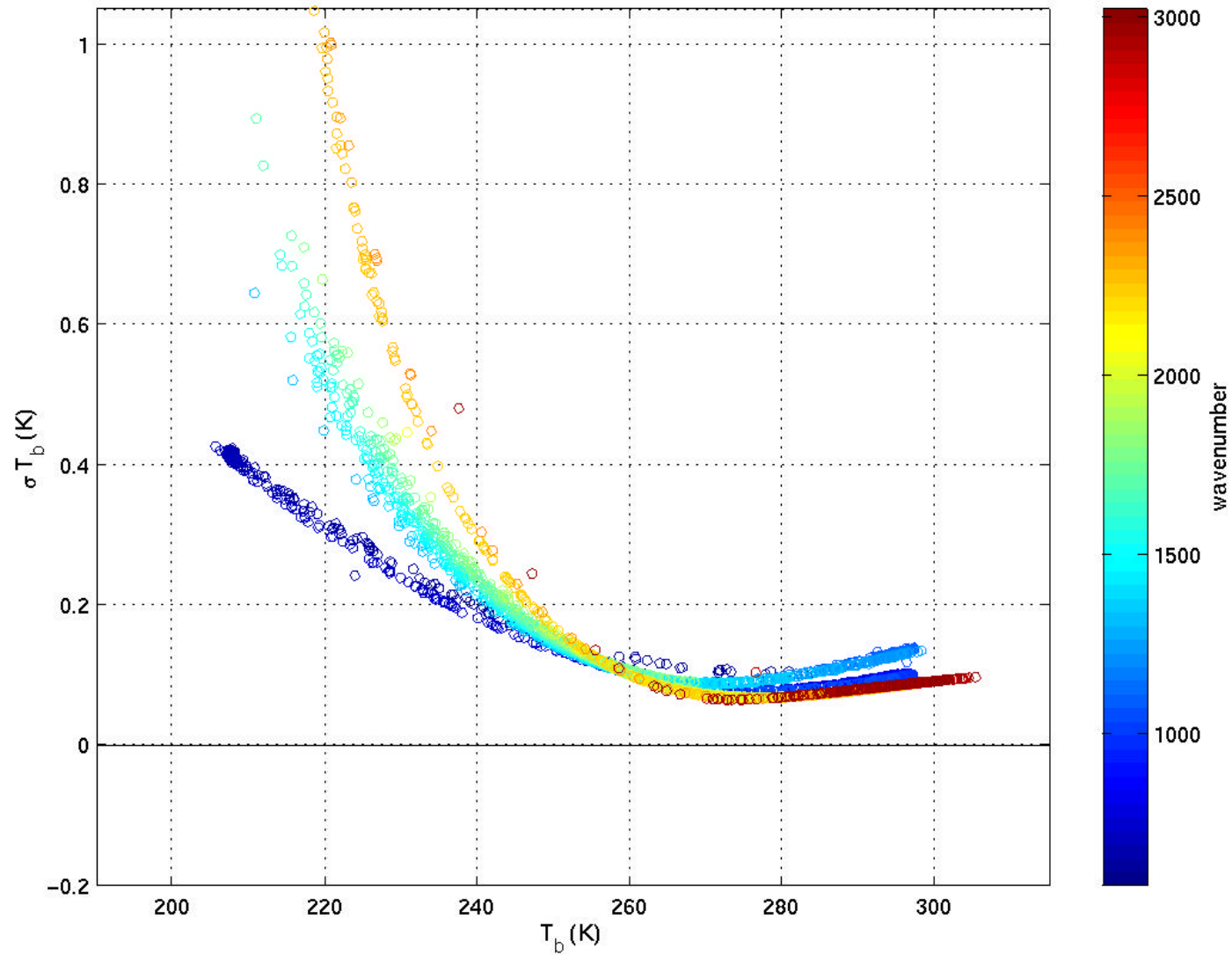
# Scanning-HIS Radiometric Calibration Budget for 11/21 case

$$T_{ABB} = 260K, T_{HBB} = 310K$$



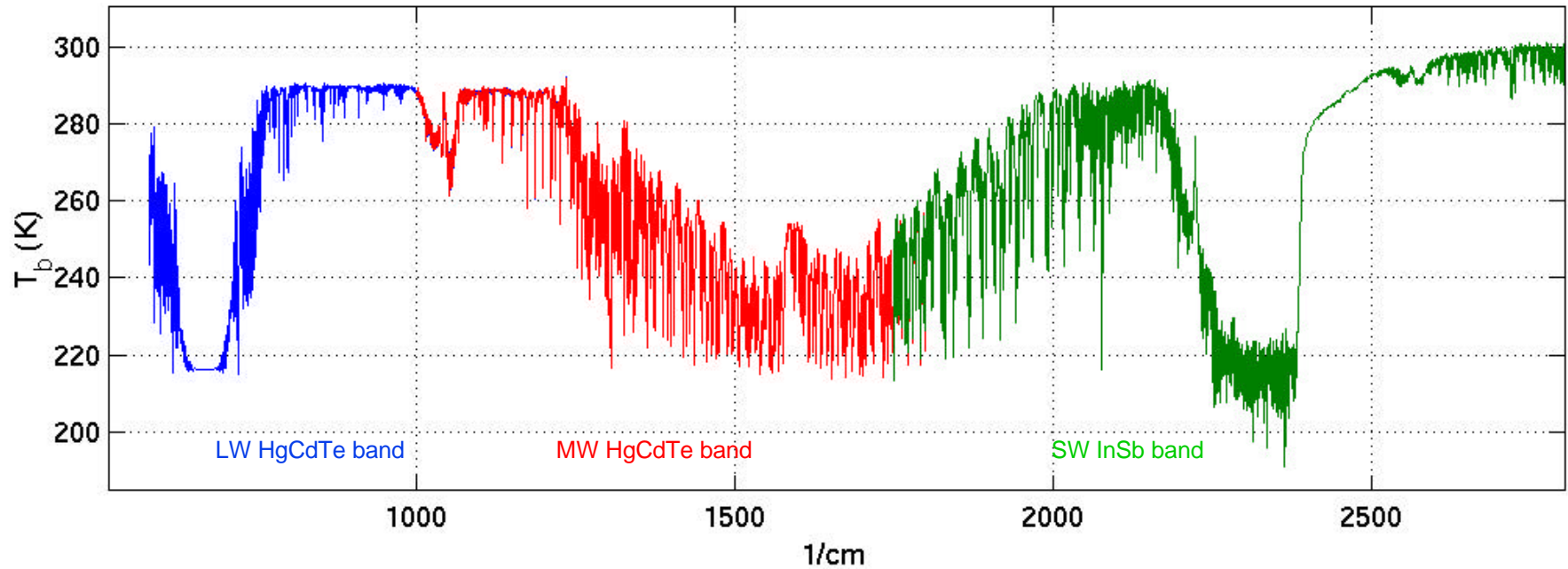
# Scanning-HIS Radiometric Calibration Budget for 11/21 case

$T_{ABB} = 260\text{K}$ ,  $T_{HBB} = 310\text{K}$

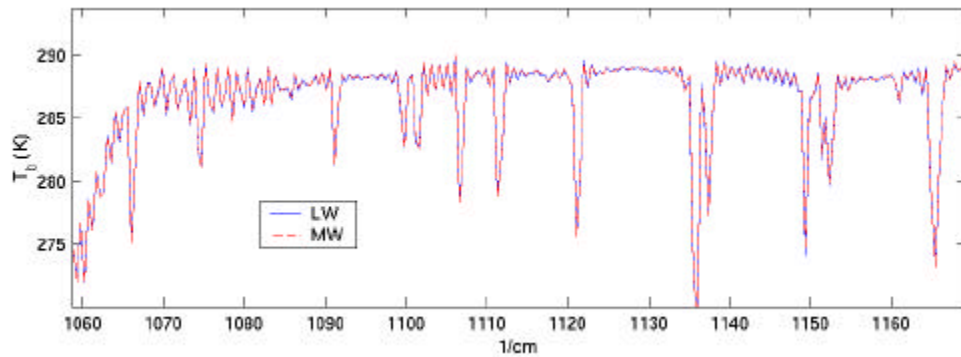


# Scanning-HIS LW/MW and MW/SW Band Overlap

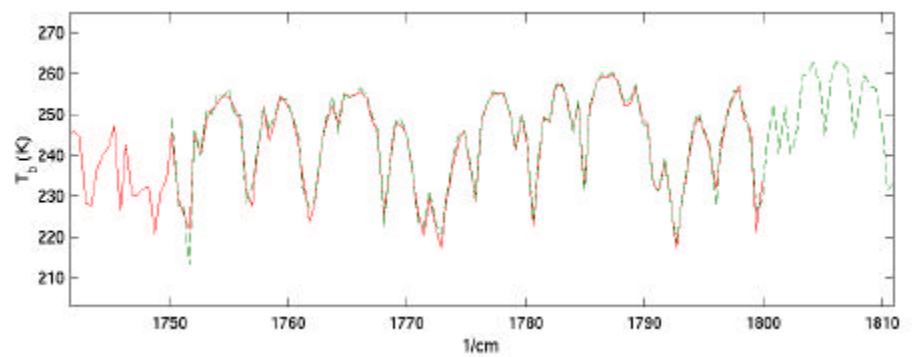
11-16-2002



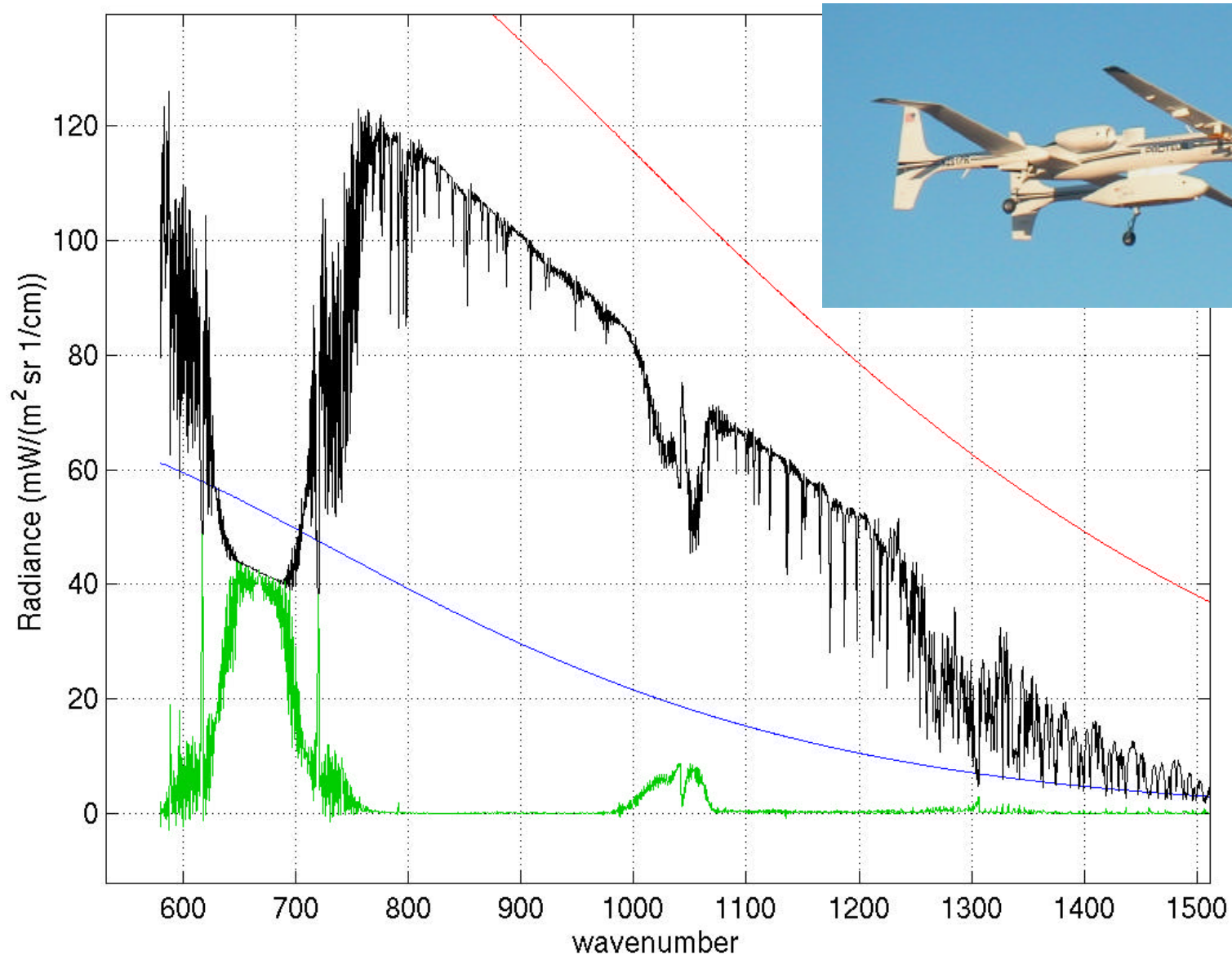
LW/MW overlap



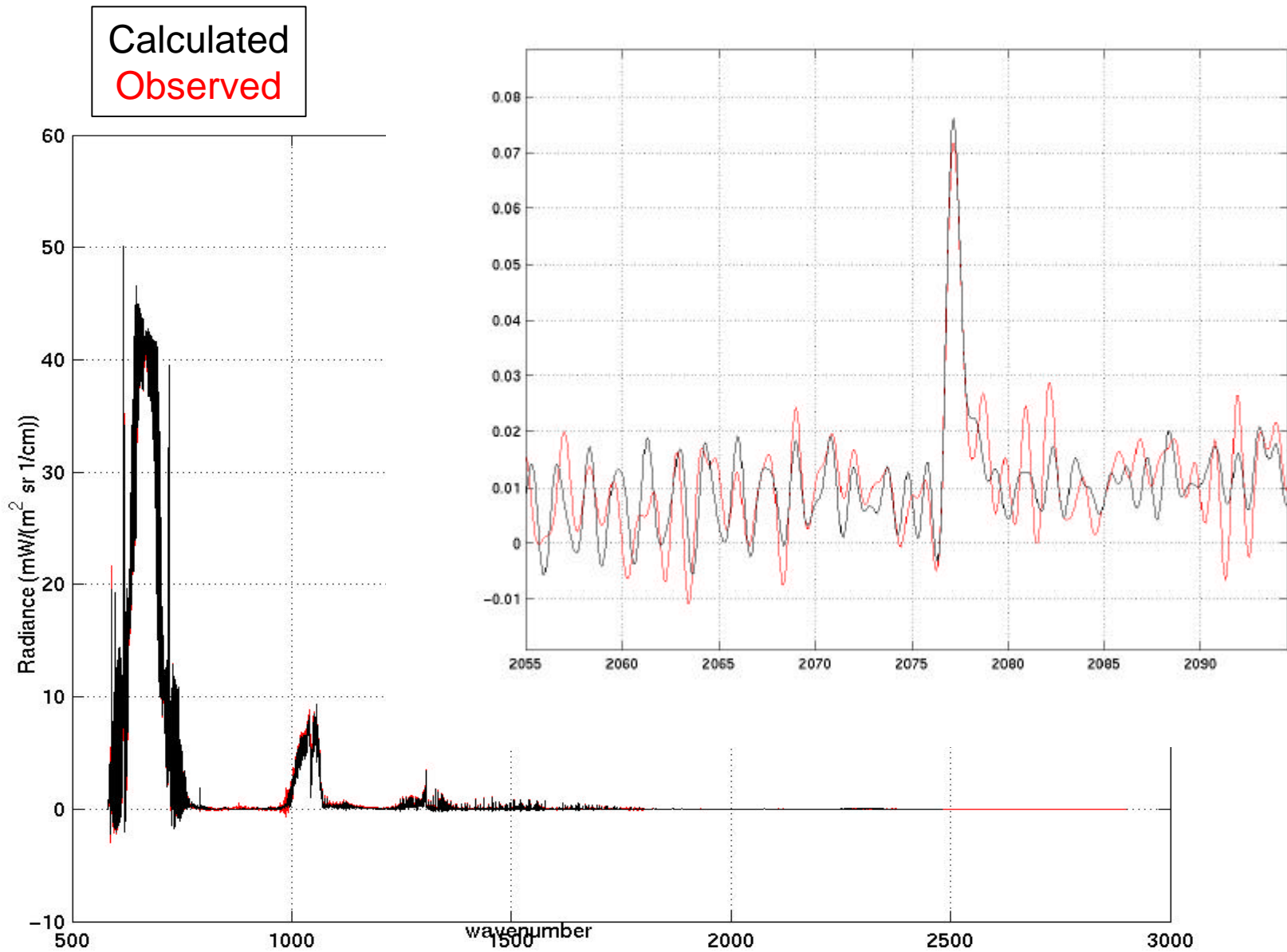
MW/SW overlap



# S-HIS zenith and cross-track scanning Earth views 11-16-2002 from Proteus @ ~14km



## Observed and Calculated zenith views from Proteus @ ~14km



Calculation based on 18Z ECMWF analysis, with 0.0004 cm H<sub>2</sub>O above 14km



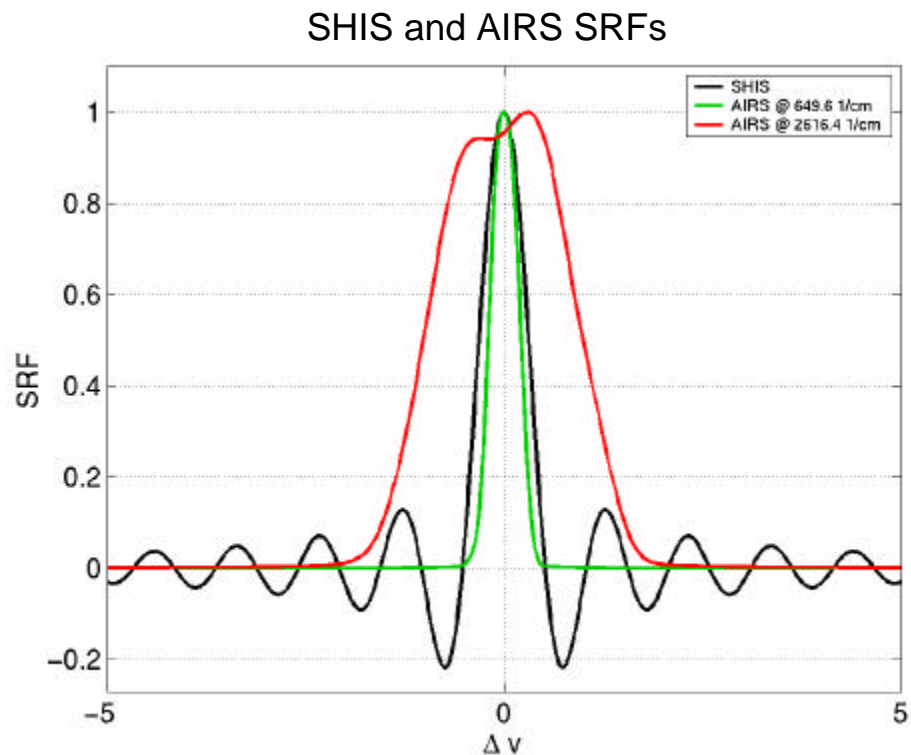
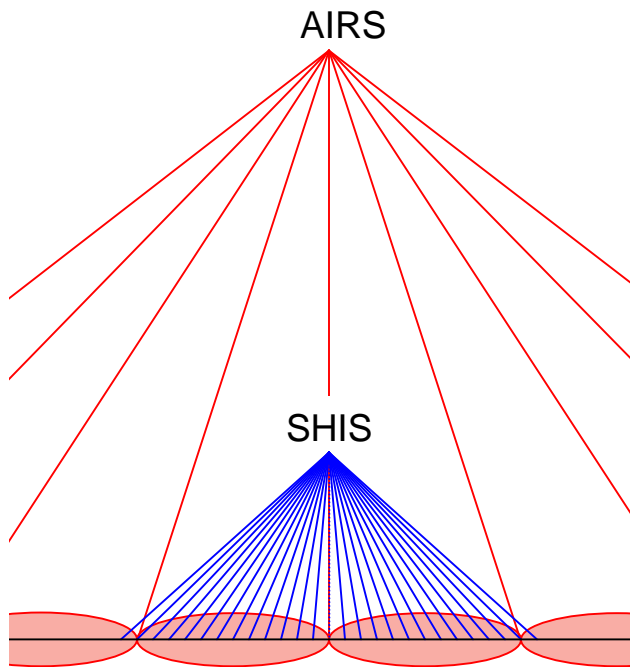
A world map with a light blue background and dark blue landmasses, centered on the Atlantic Ocean. The map is slightly faded and serves as a background for the title text.

# **Radiance Validation of AIRS with S-HIS**

# AIRS / SHIS Comparisons

A detailed comparison should account for:

- instrumental noise and scene variations
- Different observation altitudes (AIRS is 705km, SHIS is ~20km on ER2, ~14km on Proteus)
- Different view angles (AIRS is near nadir, SHIS is  $\sim\pm 35$ deg from nadir)
- Different spatial footprints (AIRS is ~15km at nadir, SHIS is ~2km at nadir)
- Different spectral response (AIRS  $\Delta\nu = \nu/1200$ , SHIS  $\Delta\nu = \sim 0.5 \text{ cm}^{-1}$ ) and sampling



# AIRS / SHIS Comparison steps

## 0. Average SHIS data within AIRS FOV(s) & compare

- No attempt to account for view angle, altitude, spectral differences.

## 1. Compare Residuals from calculations:

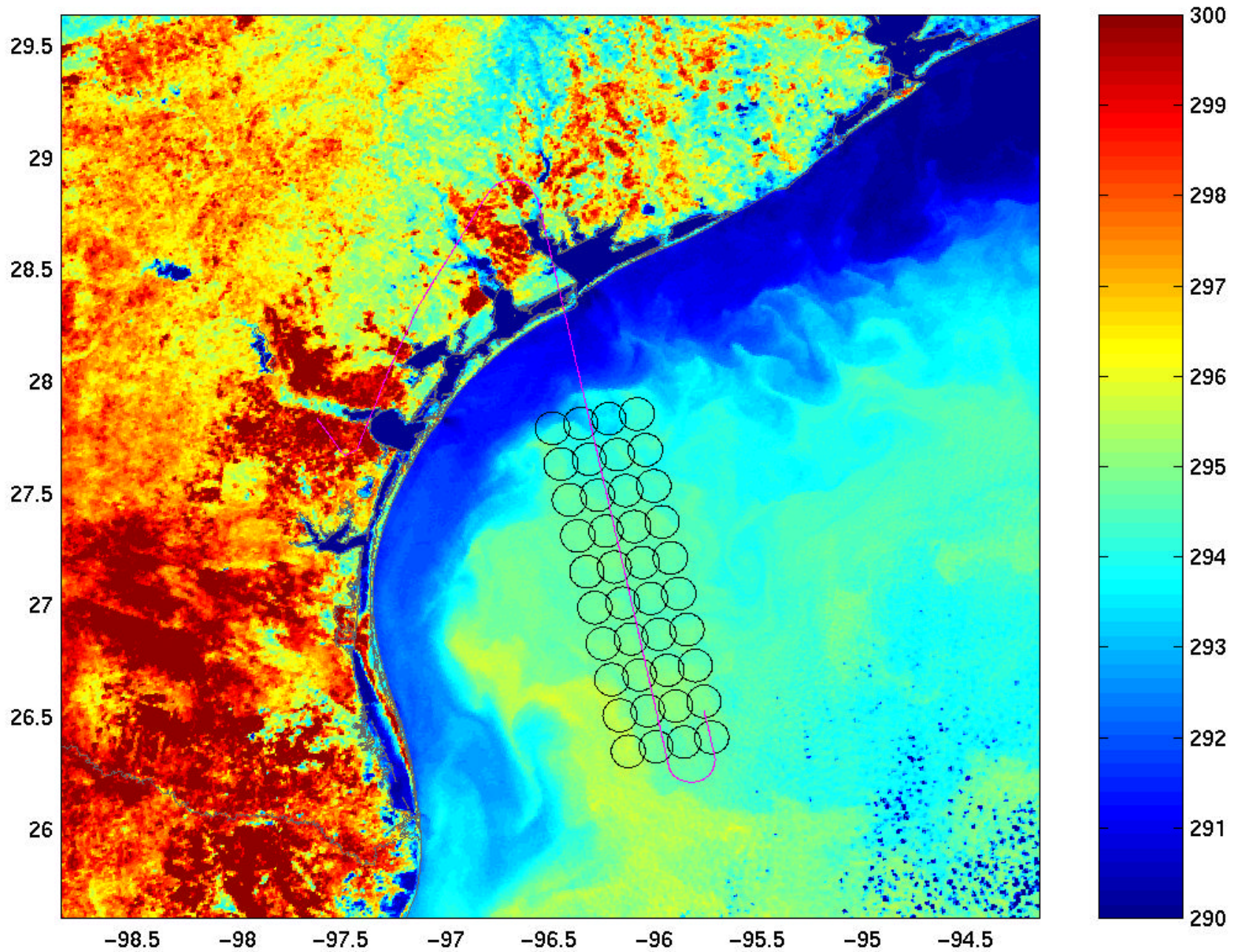
$$(\text{obs-calc})_{\text{SHIS}} \text{ to } (\text{obs-calc})_{\text{AIRS}}$$

- SHIS and AIRS calcs each done at correct altitudes, view angles, spectral resolution and sampling.
- Monochromatic calcs done using same forward model, atmospheric state, and surface property inputs.

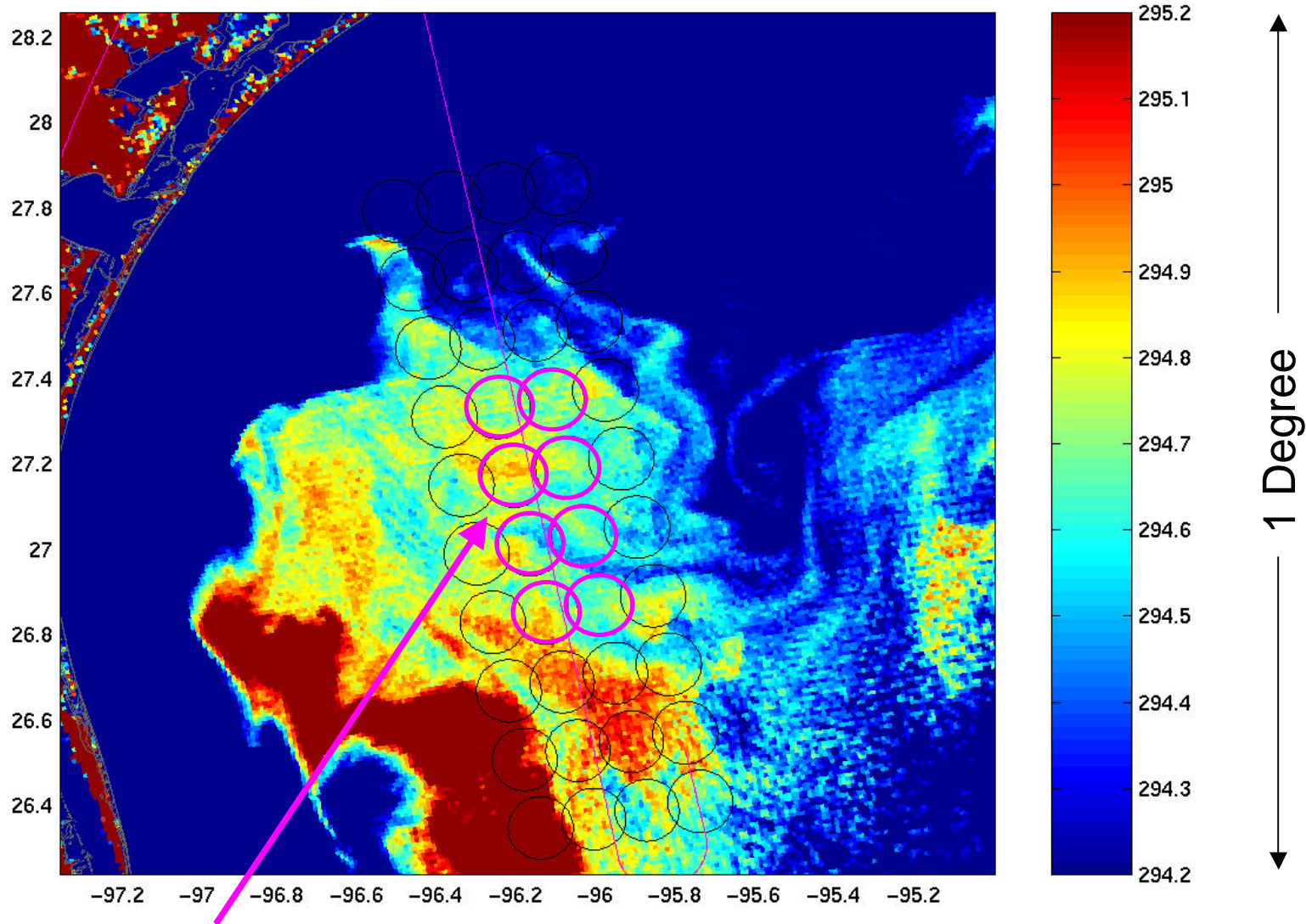
## 2. Difference Residuals: Spectral Resolutions made similar

- valid comparison except for channels mainly sensitive to upper atmosphere, above proteus altitude

# MODIS 12 $\mu\text{m}$ Band Tbs(K) & near-nadir AIRS FOVs



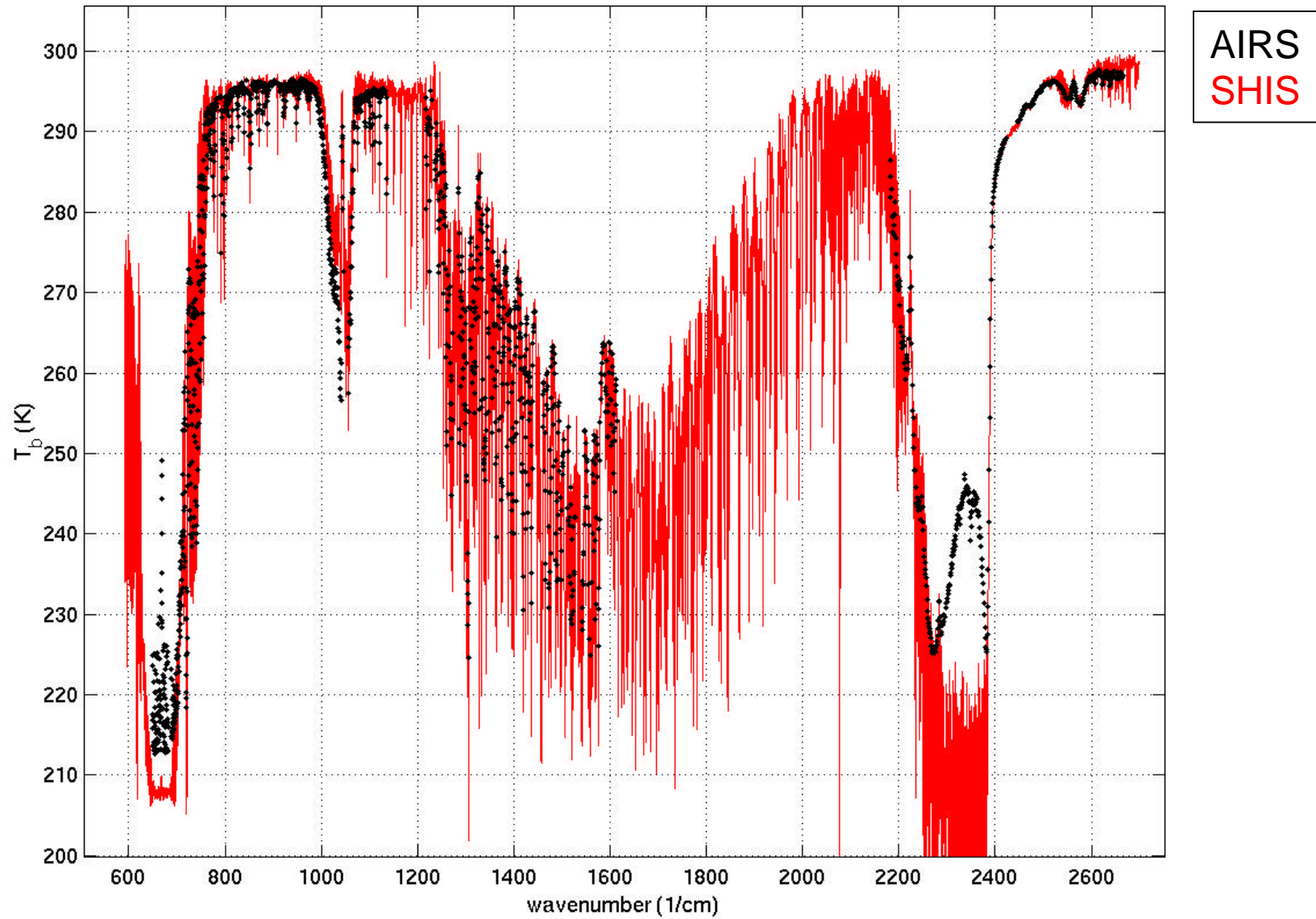
# MODIS 12 micron Band & near-nadir AIRS FOVs



**8 AIRS FOVs used in the following comparisons**

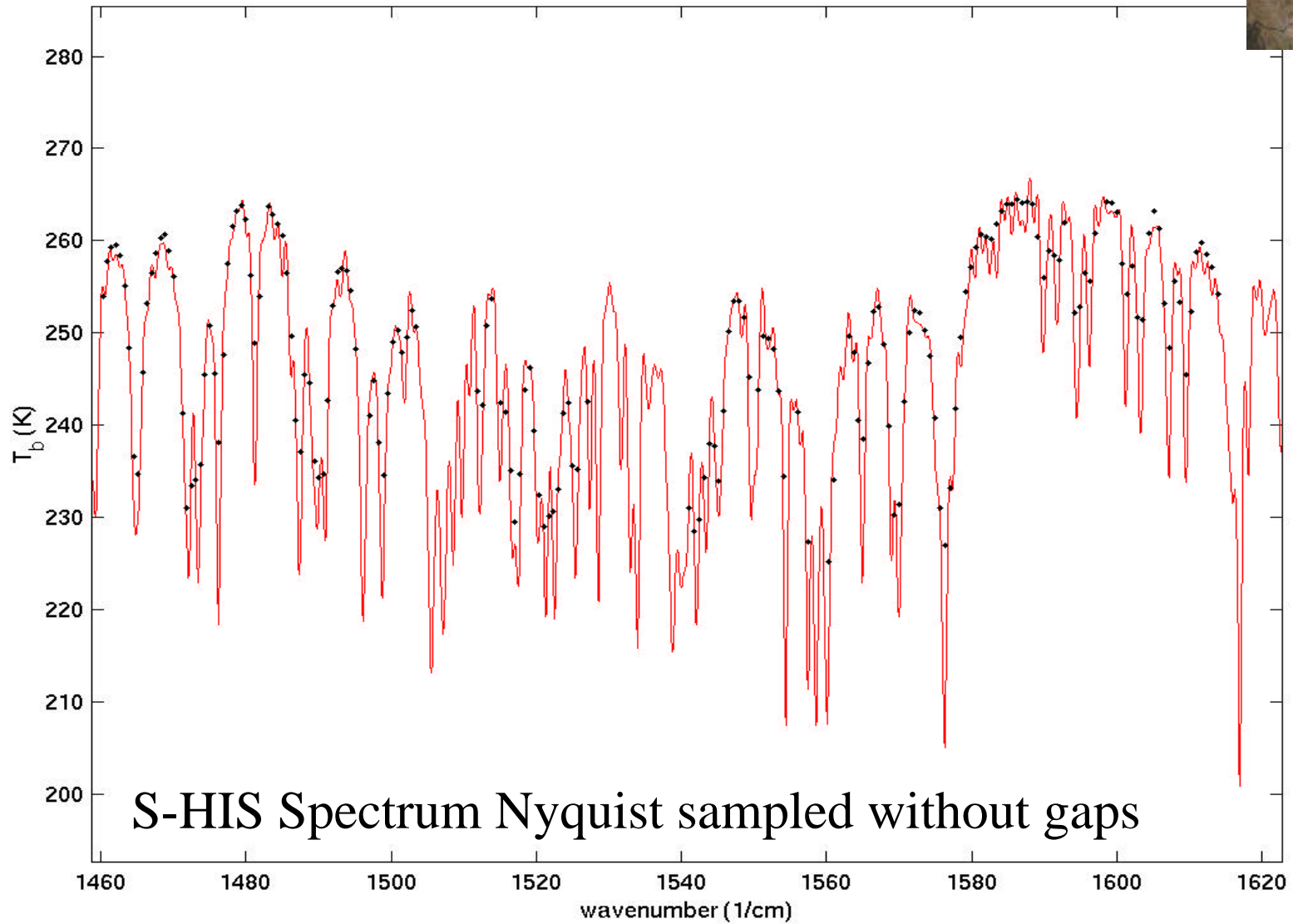
# “comparison 0”

8 AIRS FOVs, 448 SHIS FOVs, PC filtering

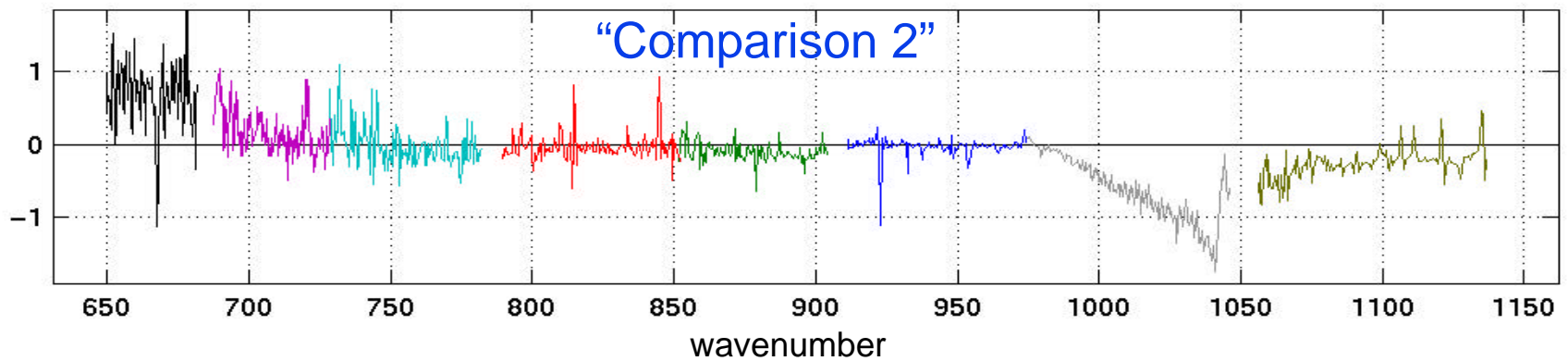
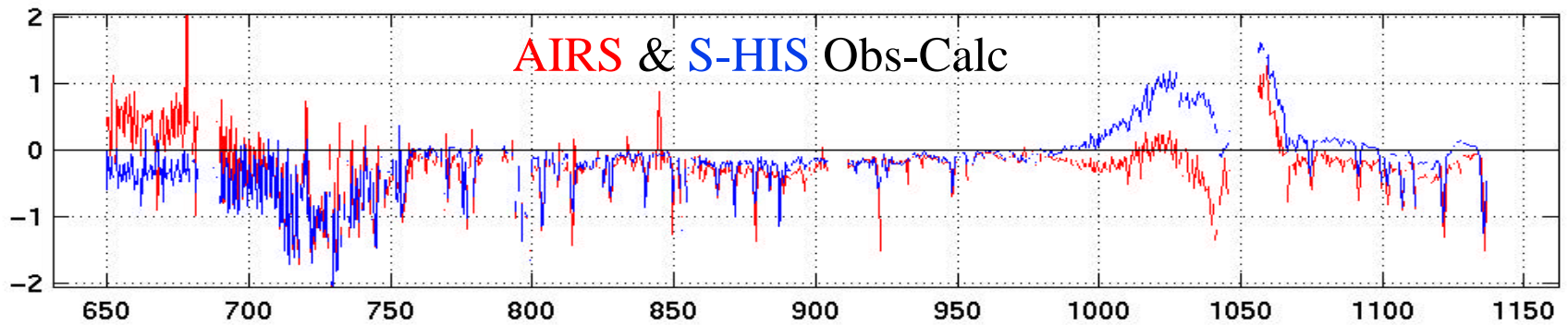
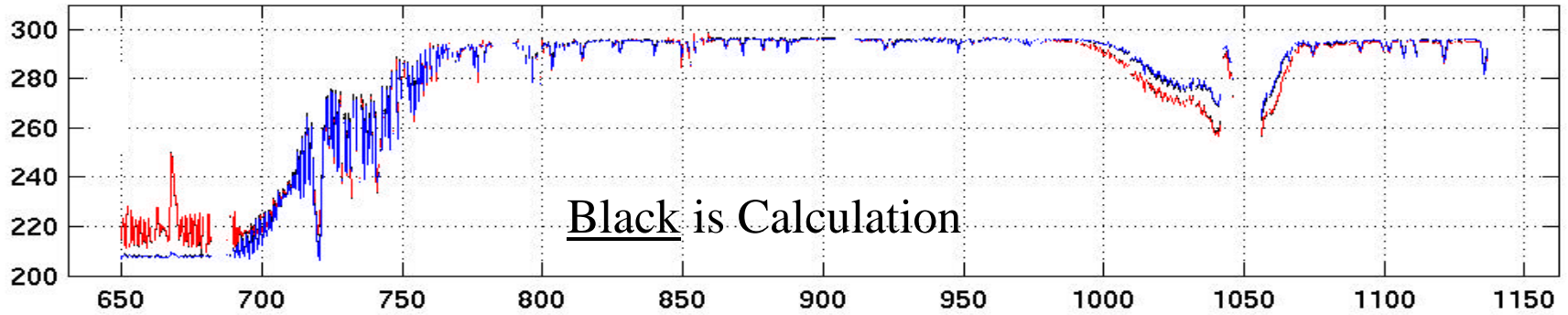


# “comparison 0”

8 AIRS FOVs, 448 SHIS FOVs, PC filtering

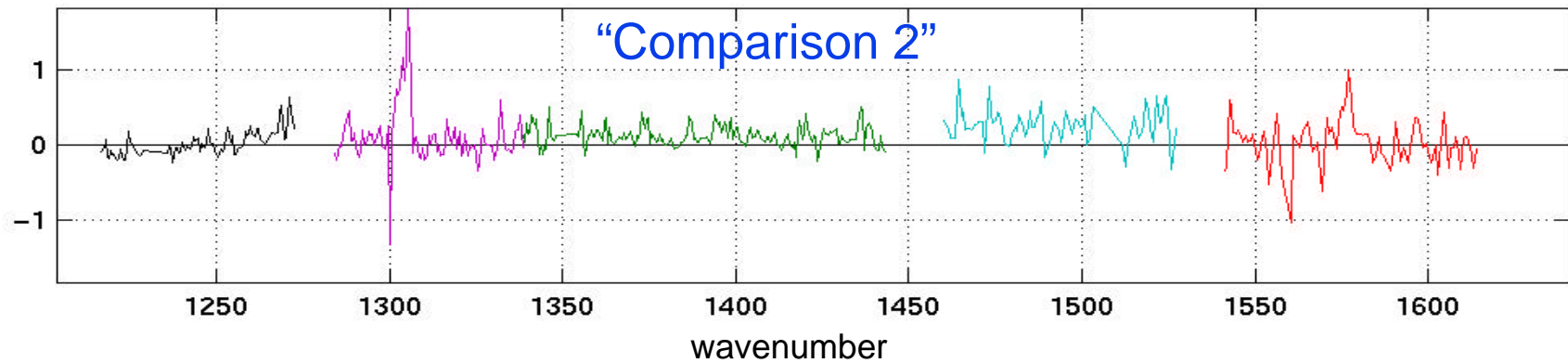
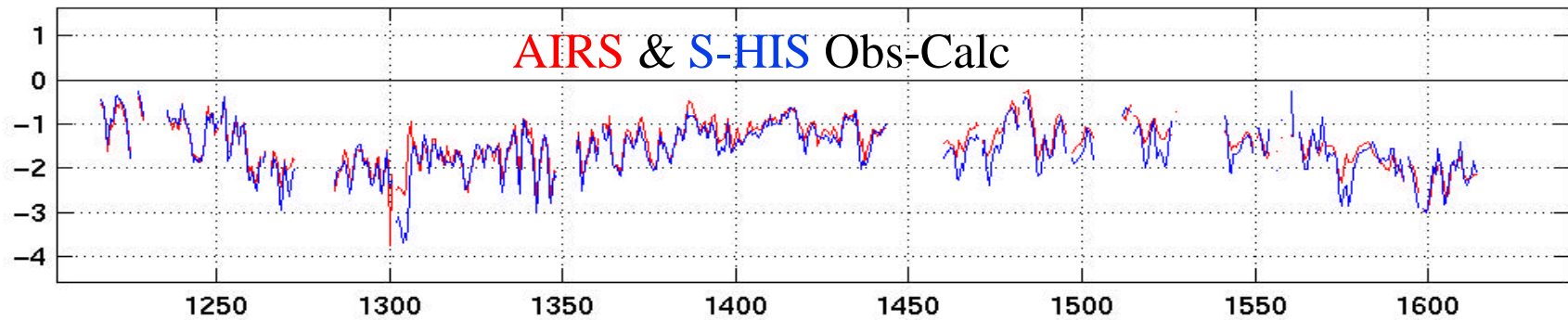
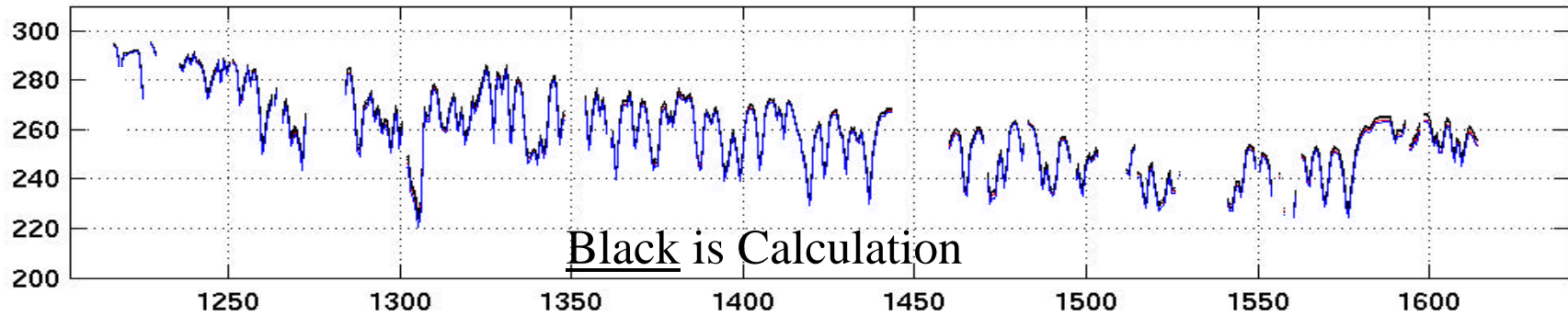


# AIRS Compared to S-HIS, 21 Nov 2002

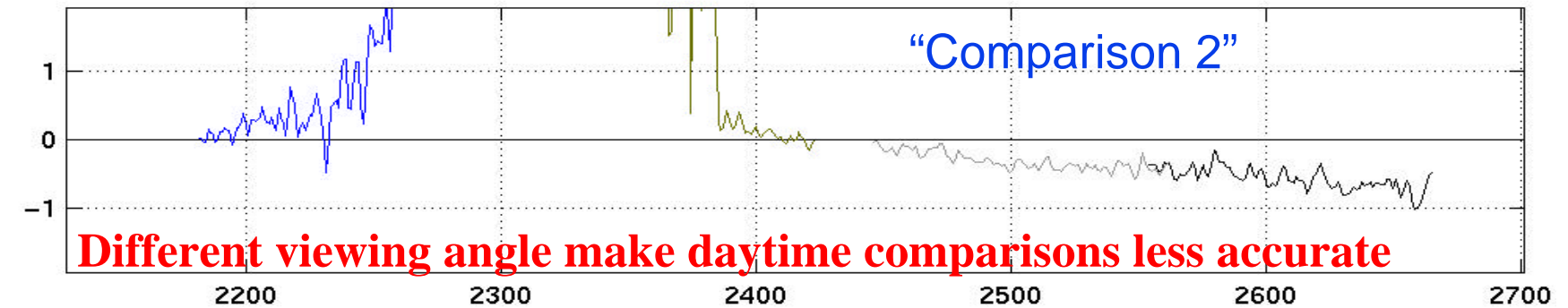
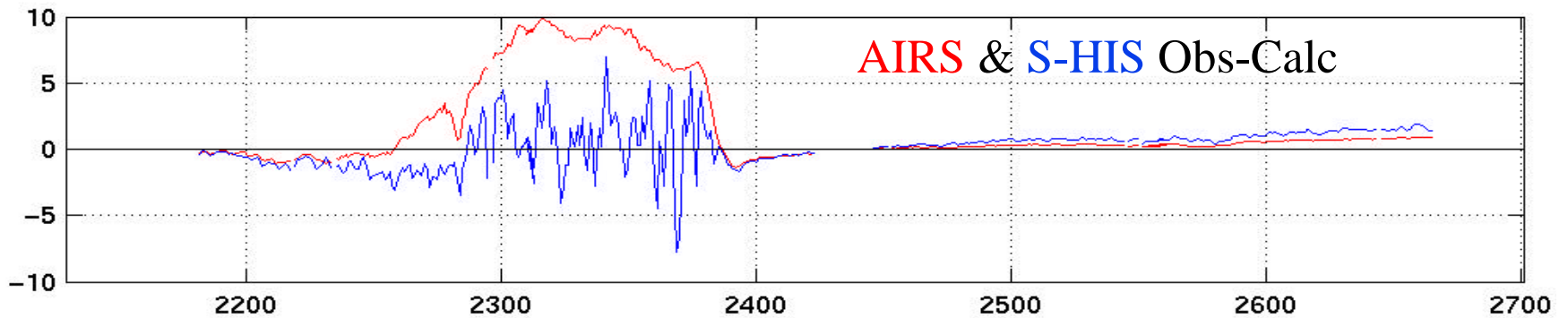
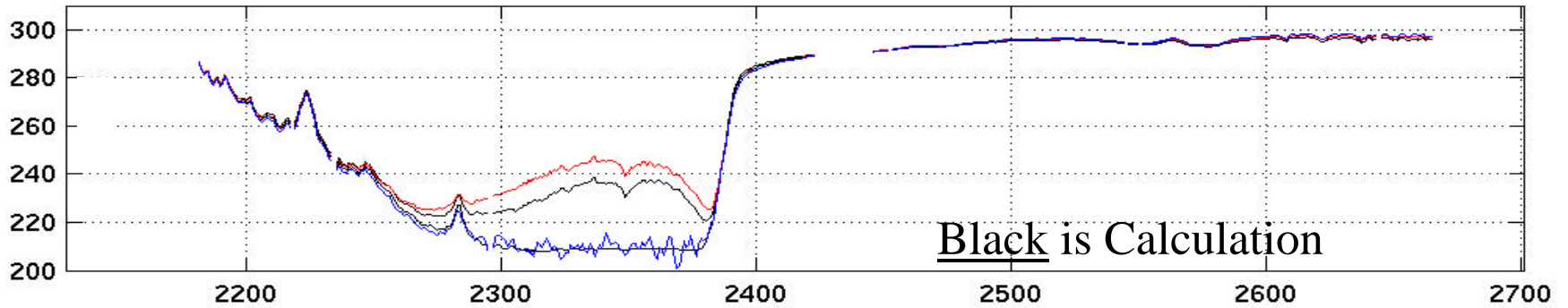




# AIRS Compared to S-HIS, 21 Nov 2002



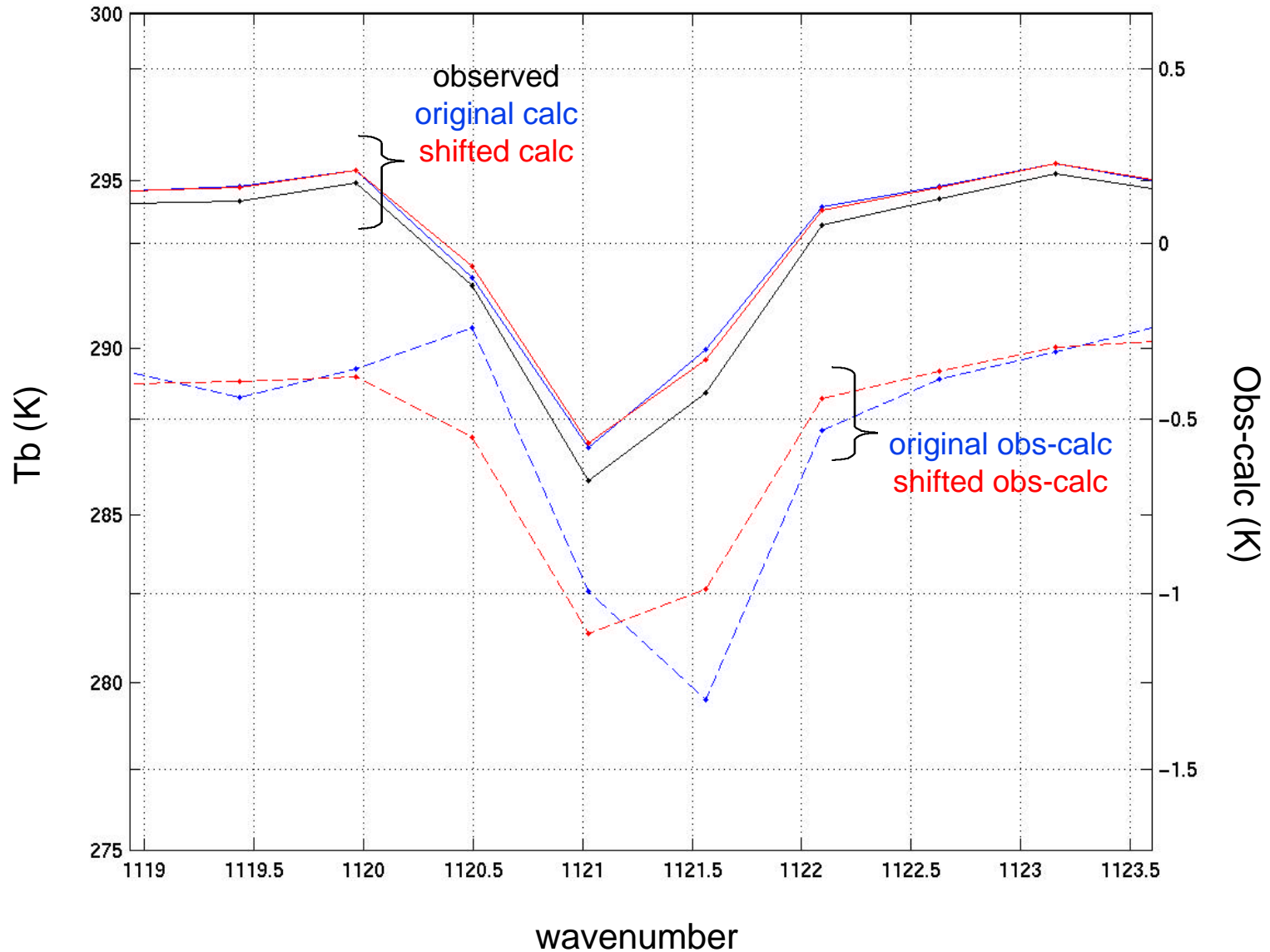
# AIRS Compared to S-HIS, 21 Nov 2002



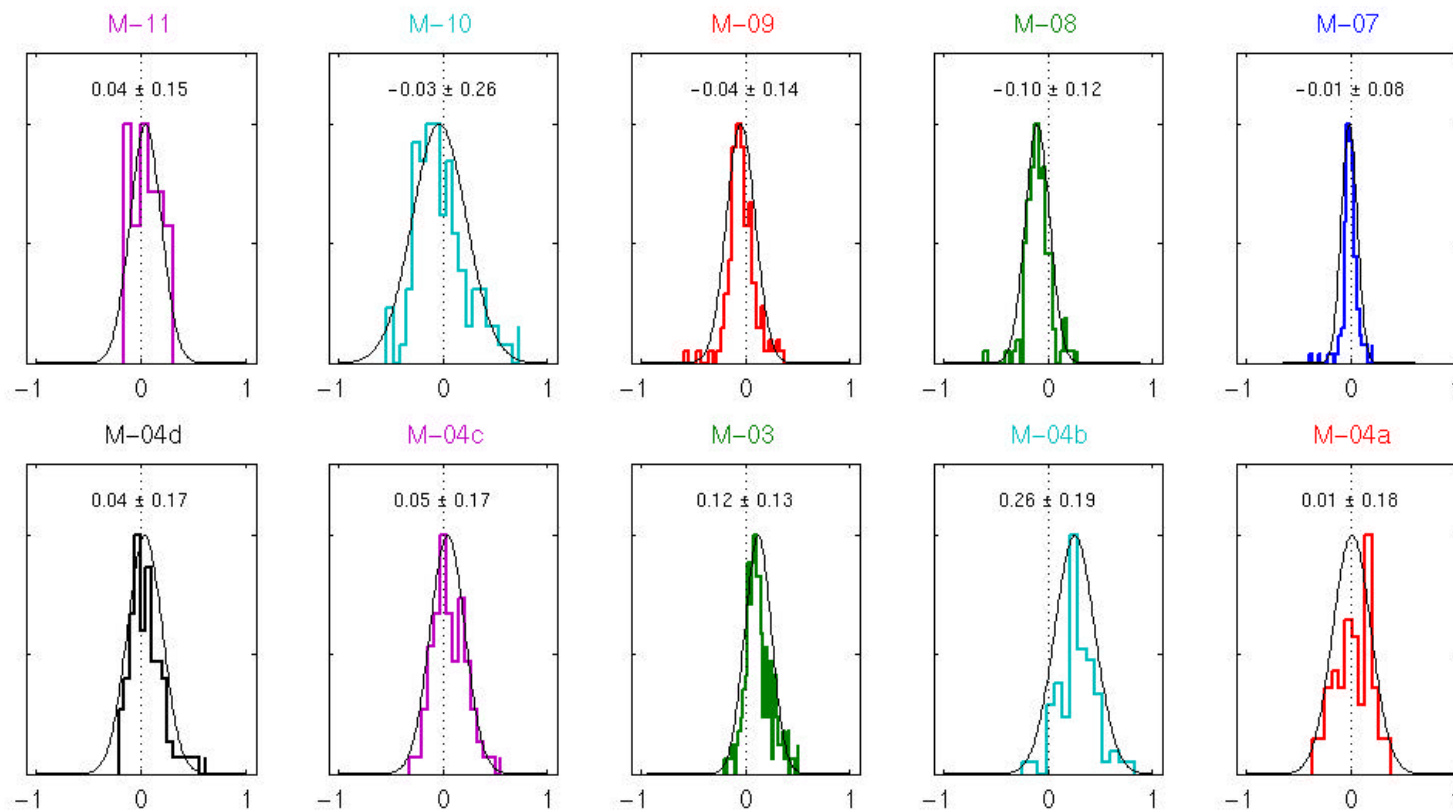
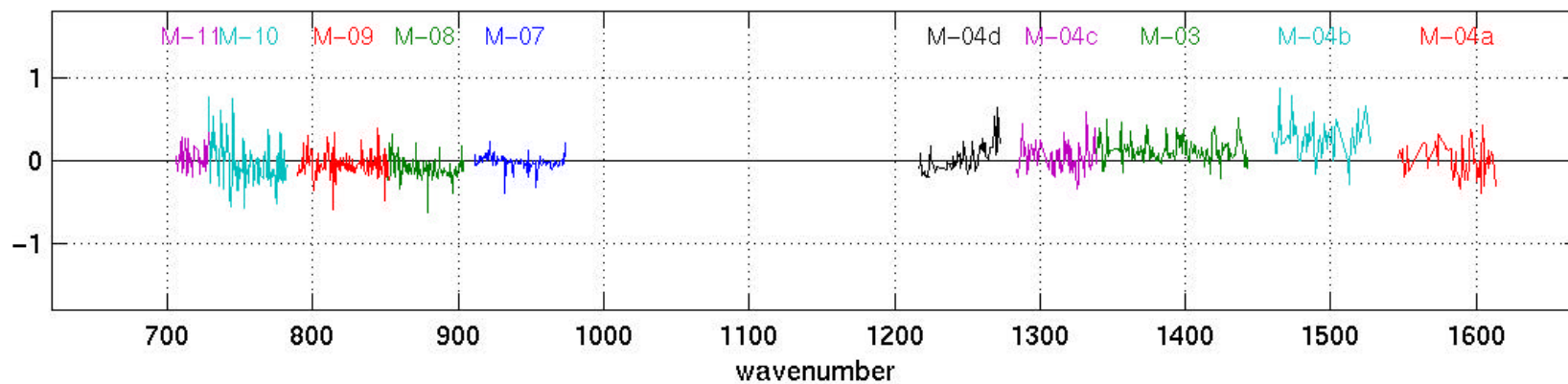
**Different viewing angle make daytime comparisons less accurate**

wavenumber

# Small Spectral Shift (3% of resolution) in AIRS Module-05 identified from S-HIS Validation

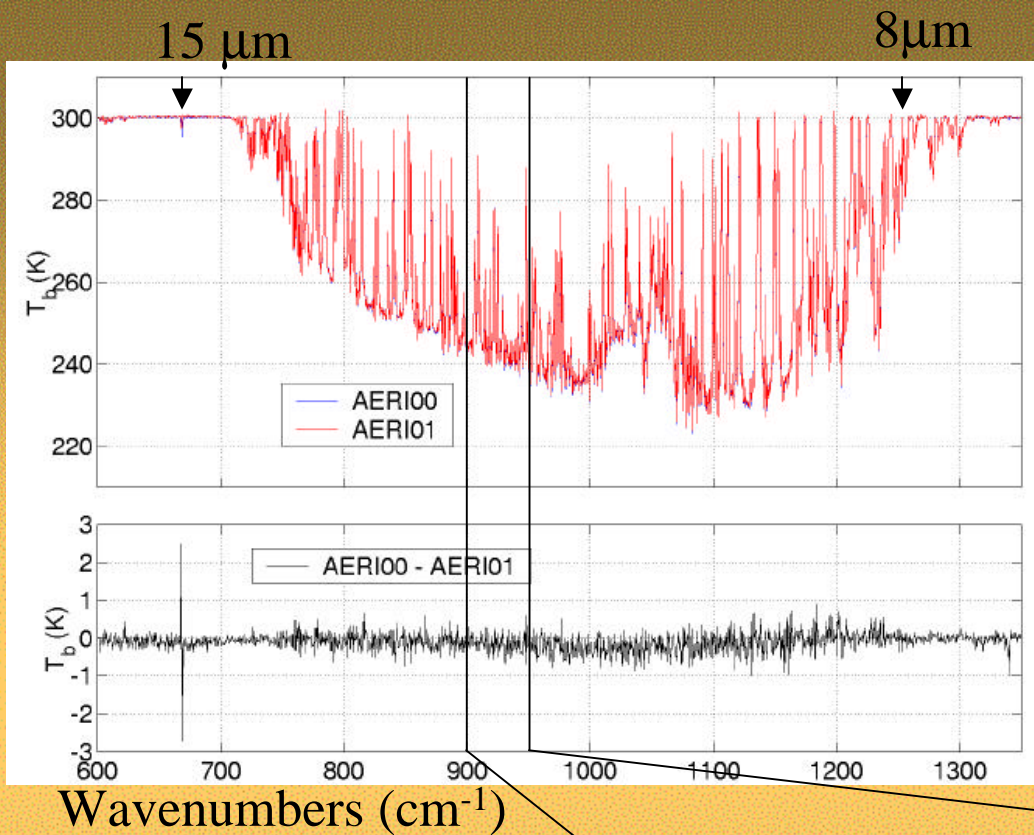


(AIRSobs AIRScalc -



## Summary

- The calibration uncertainty of advanced high spectral resolution observations are approaching the 0.1 K desired for climate applications
- Aircraft high spectral resolution observations from Scanning-HIS [& its cousin the NPOESS Airborne Sounder Testbed (NAST)] are now proven tools for the detailed validation of satellite based observations
- AIRS is providing high quality global radiances for atmospheric sounding and climate applications



**Big  $\ln$   $\sigma$   $T_e$   $\mu$   
 Overlay of  
 2 Observations**

