



# High Spectral Resolution IR Observing & Instruments

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**Remote Sensing Seminar, Maratea, Italy, 22-31 May 2003**  
**Supported by CNR-IMAA(Potenza) & EUMETSAT(Darmstadt)**

**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



Fall 2002 - Oklahoma

## 1. Scanning-HIS

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

## 2. AIRS Radiance Validation:

Gulf of Mexico,  
Terra/Aqua 2002

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



A light blue world map is centered in the background of the slide. The map shows the outlines of continents and oceans in a pale blue color.

**Scanning HIS  
with Calibration Summary  
& 1st Uplooking Spectrum**

# UW Scanning HIS: 1998-Present

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

## Characteristics

**Spectral Coverage:** 3-17 microns

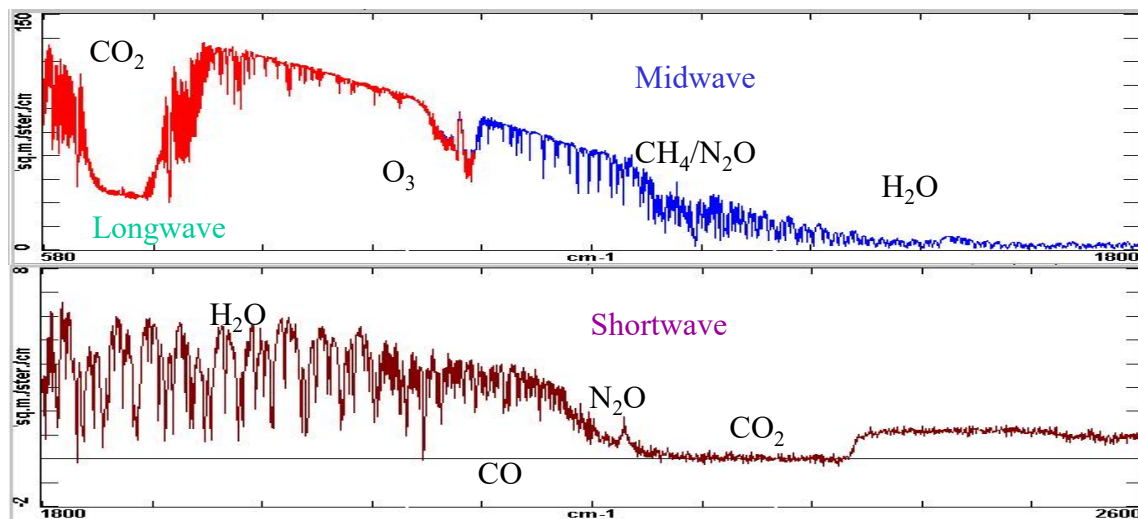
**Spectral Resolution:**  $0.5 \text{ cm}^{-1}$

**Resolving power:** 1000-6000

**Footprint Diam:** 1.5 km @ 15 km

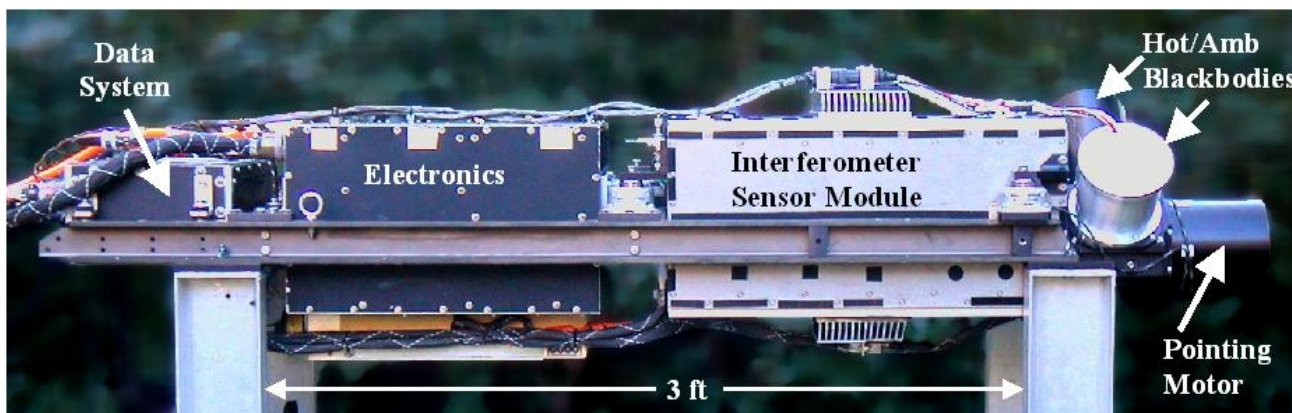
**Cross-Track Scan:** Programmable

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

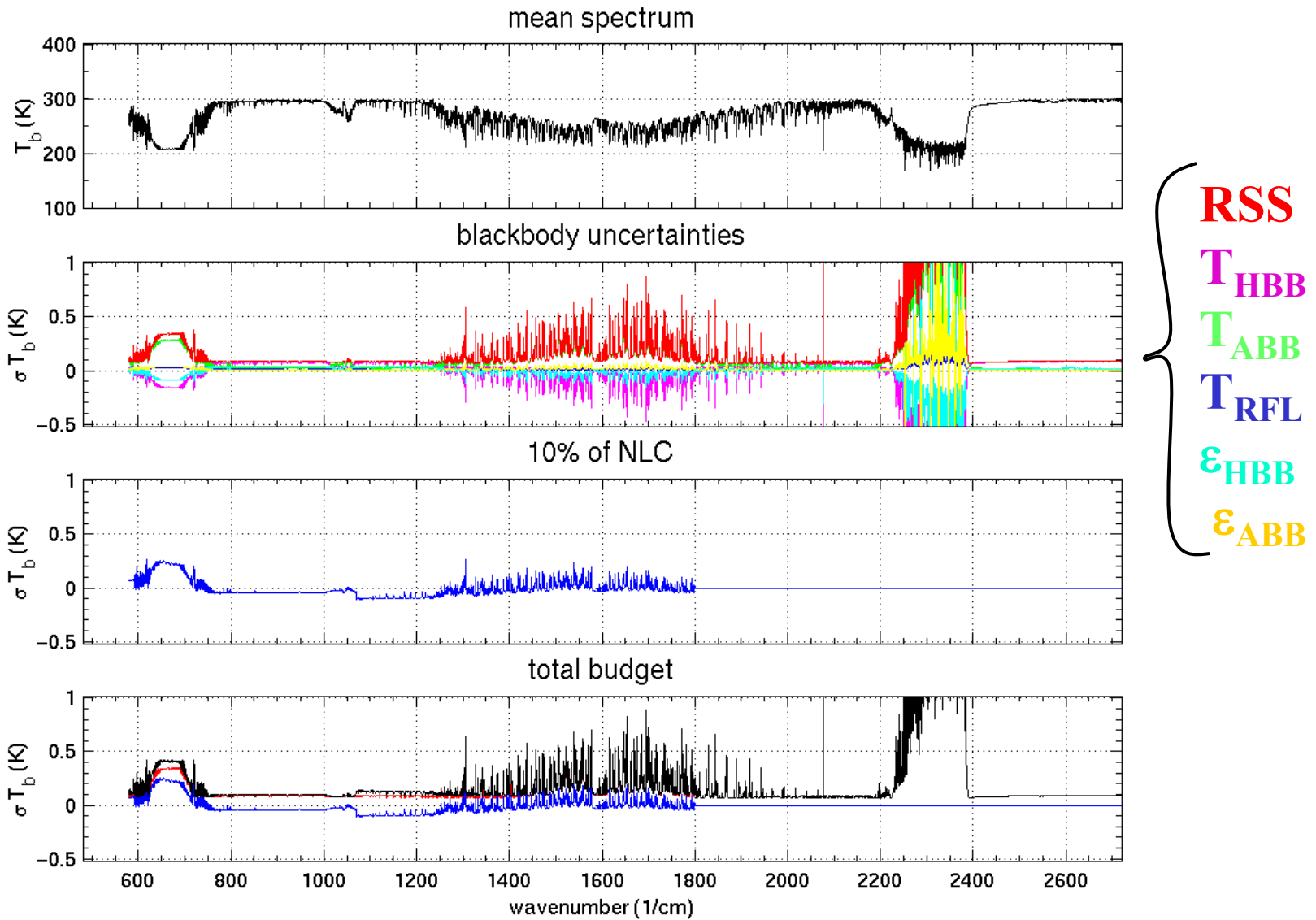


**S-HIS scans cross-track downward & looks upward**



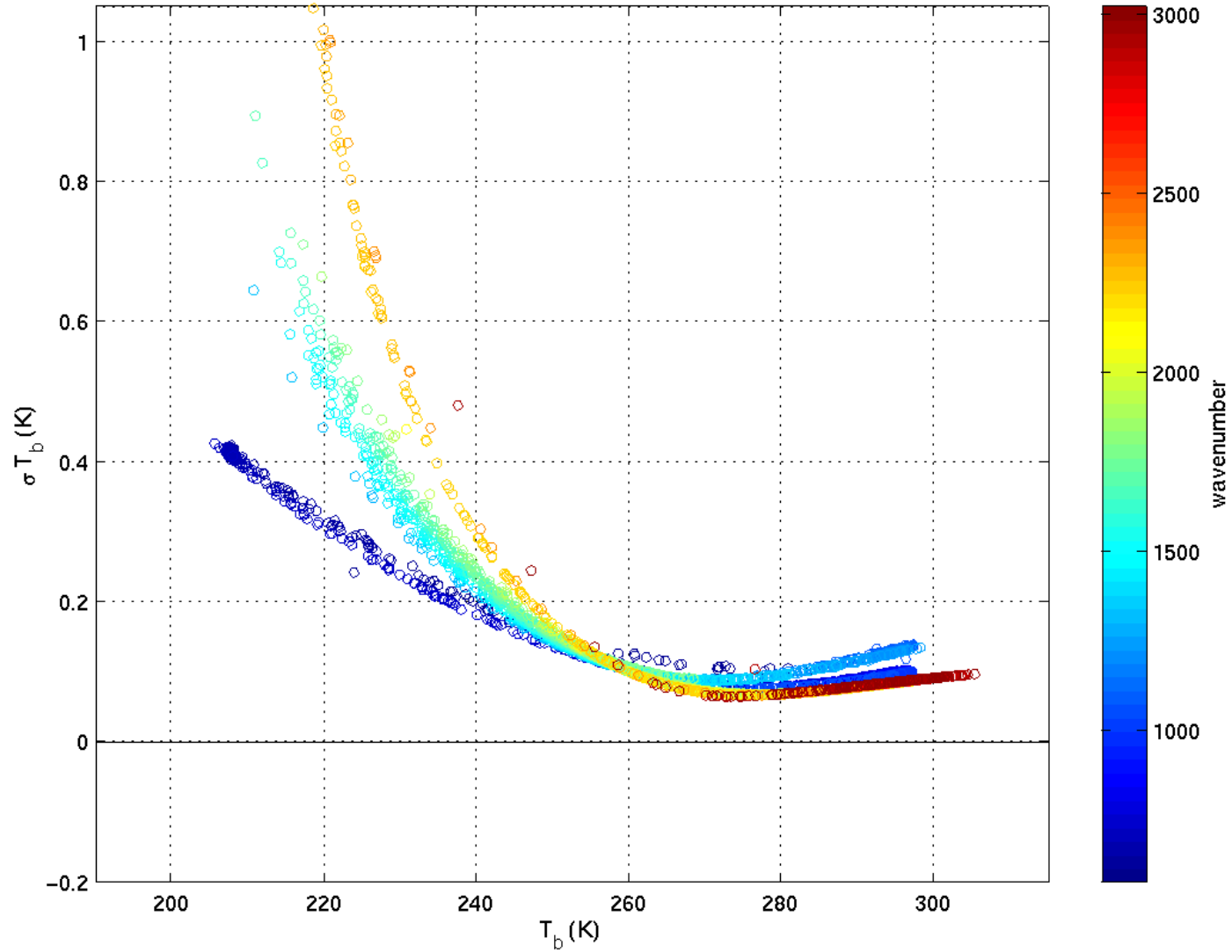
# Scanning-HIS Radiometric Calibration Budget for 11/21 case

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



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

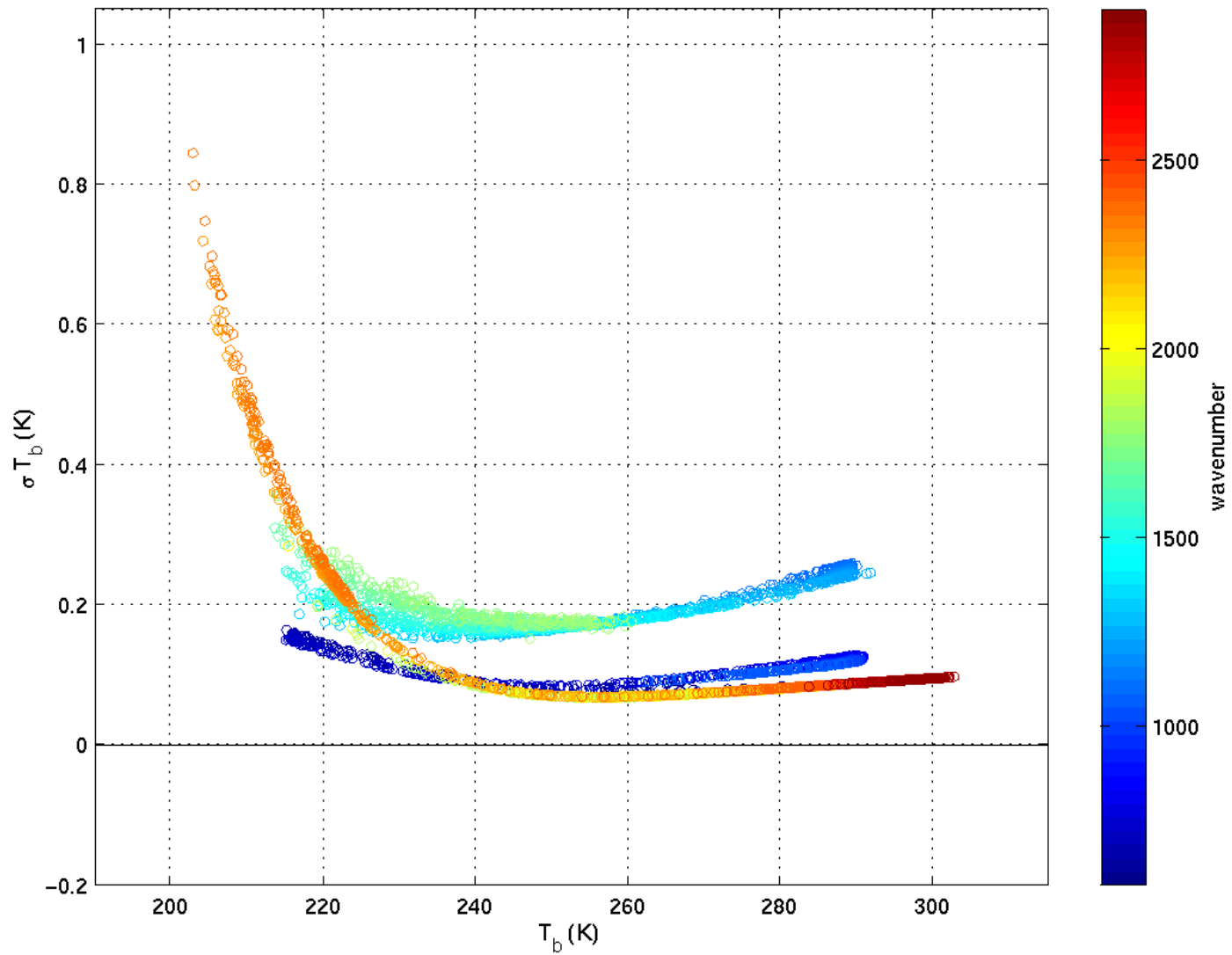
$$T_{\text{ABB}} = 260\text{K}, T_{\text{HBB}} = 310\text{K}$$





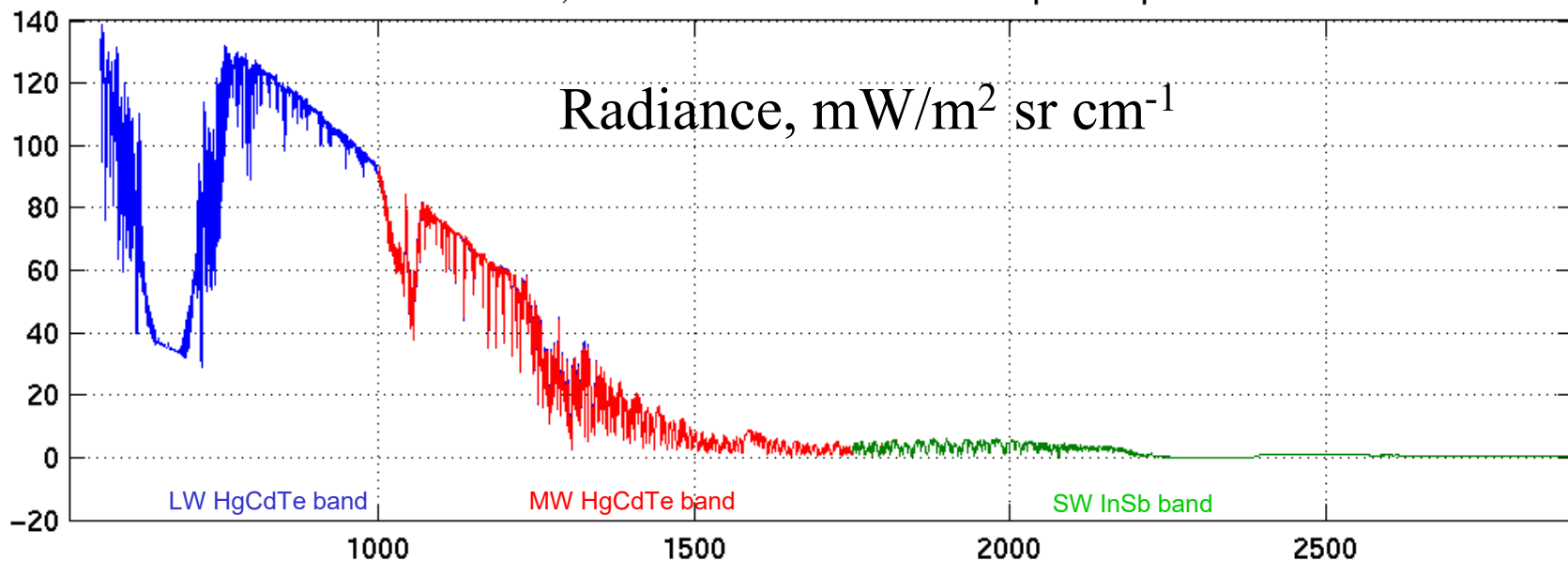
# Scanning-HIS Radiometric Calibration Budget for 11/16 case

$$T_{\text{ABB}} = 227\text{K}, T_{\text{HBB}} = 310\text{K}$$

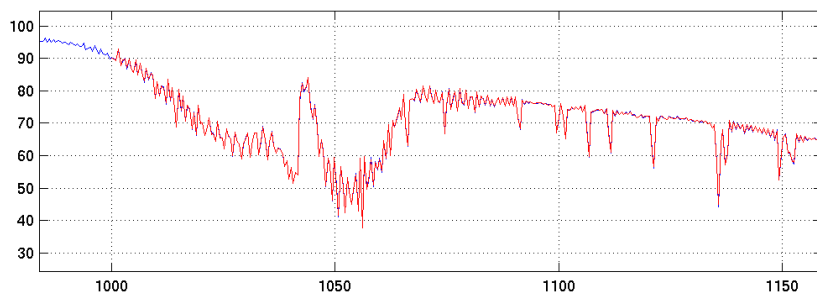


# Scanning-HIS LW/MW and MW/SW Band Overlap

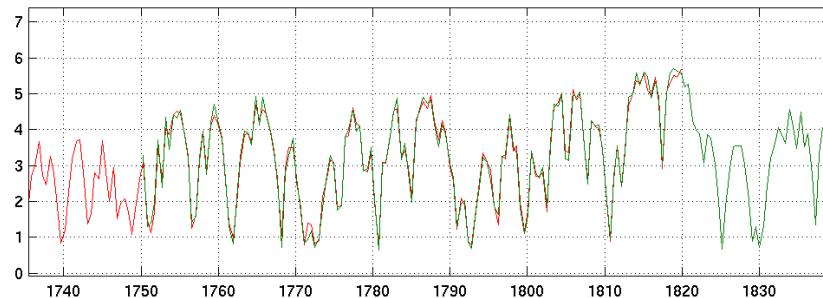
20021121, mean of 56 nadir views around Aqua overpass



LW/MW overlap

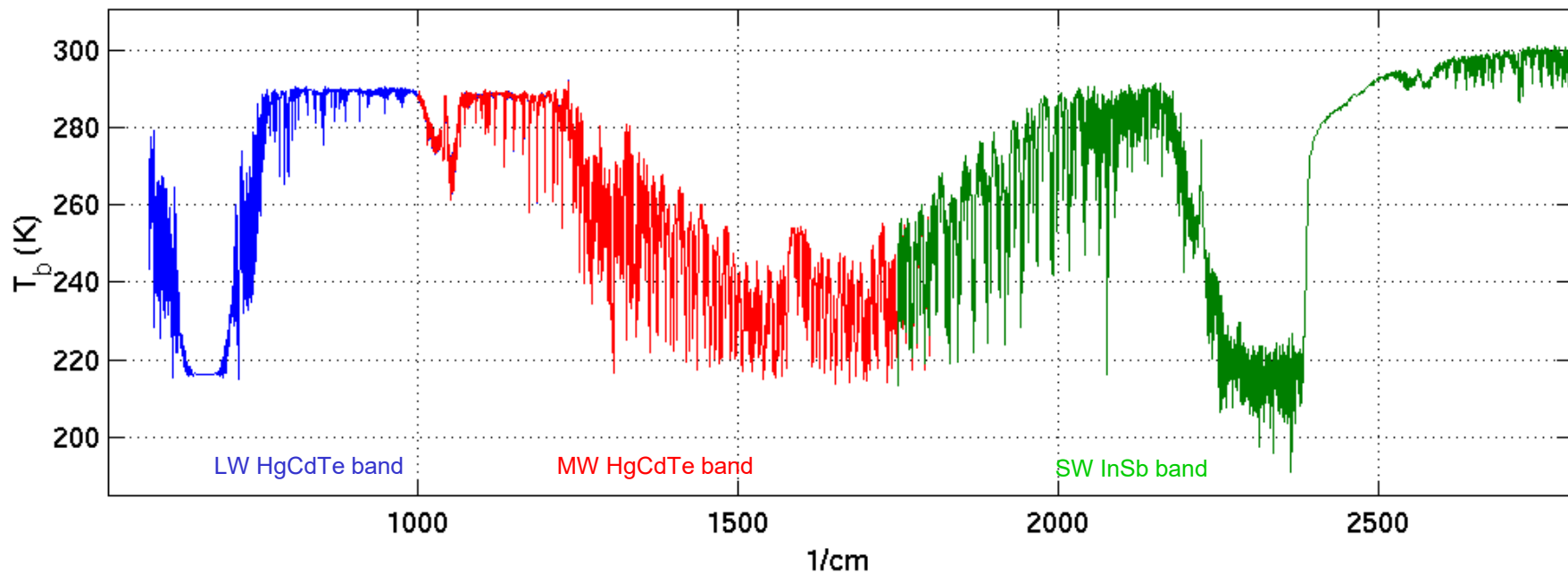


MW/SW overlap

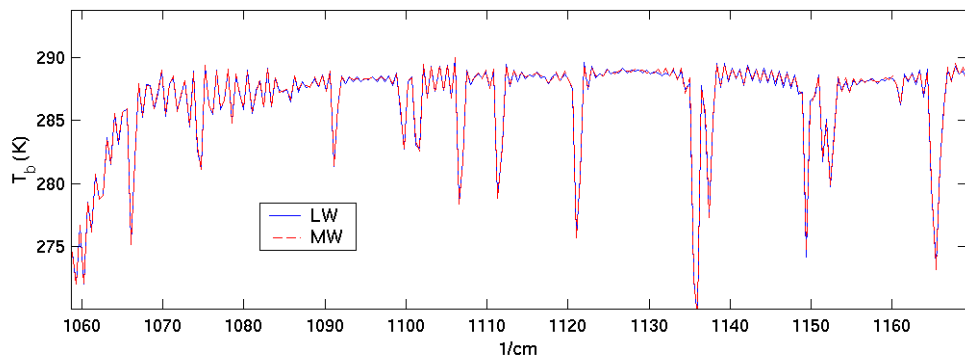


# Scanning-HIS LW/MW and MW/SW Band Overlap

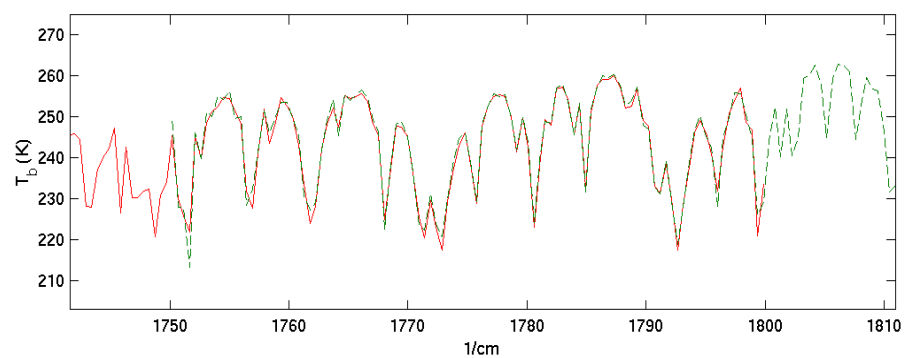
11-16-2002



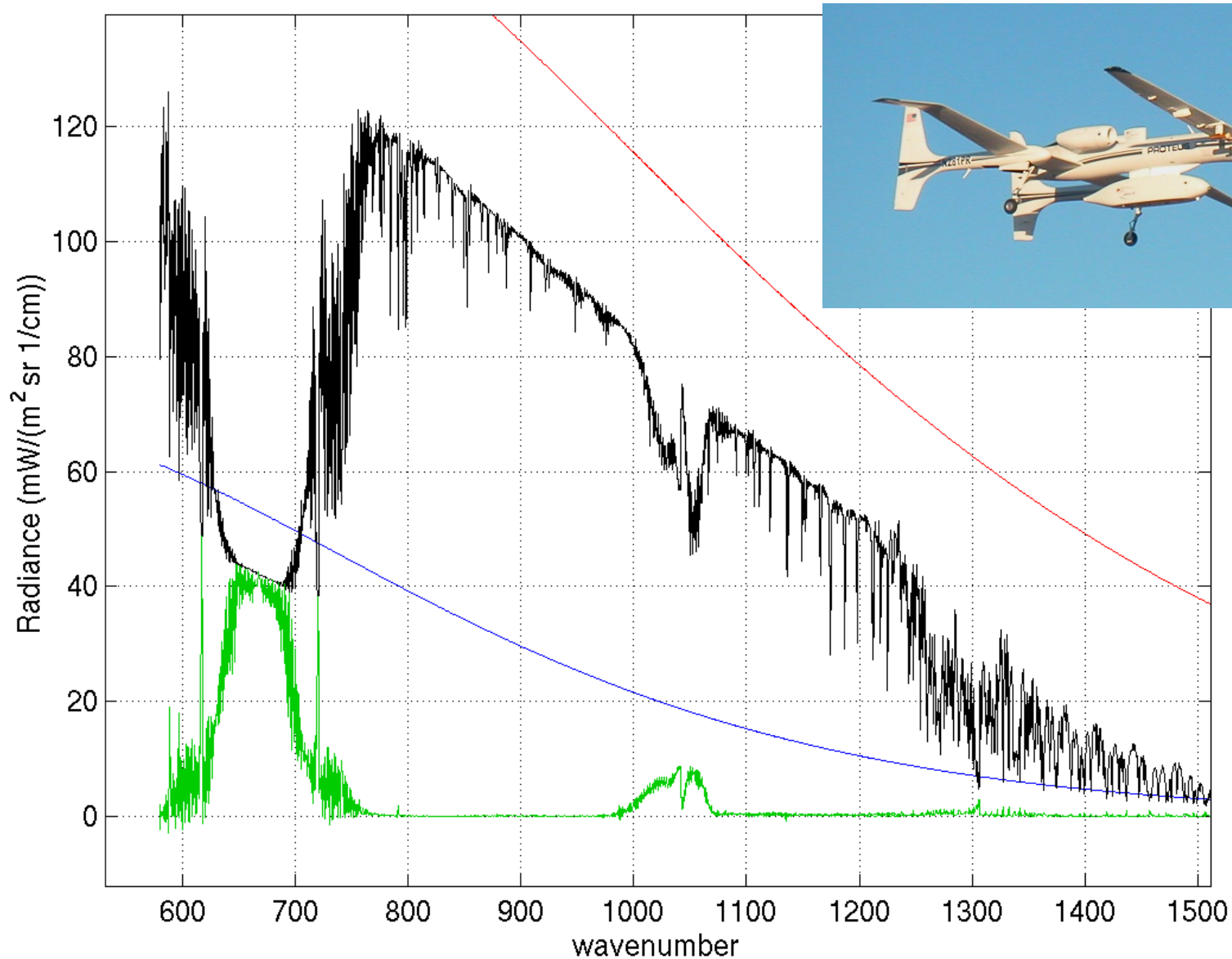
LW/MW overlap



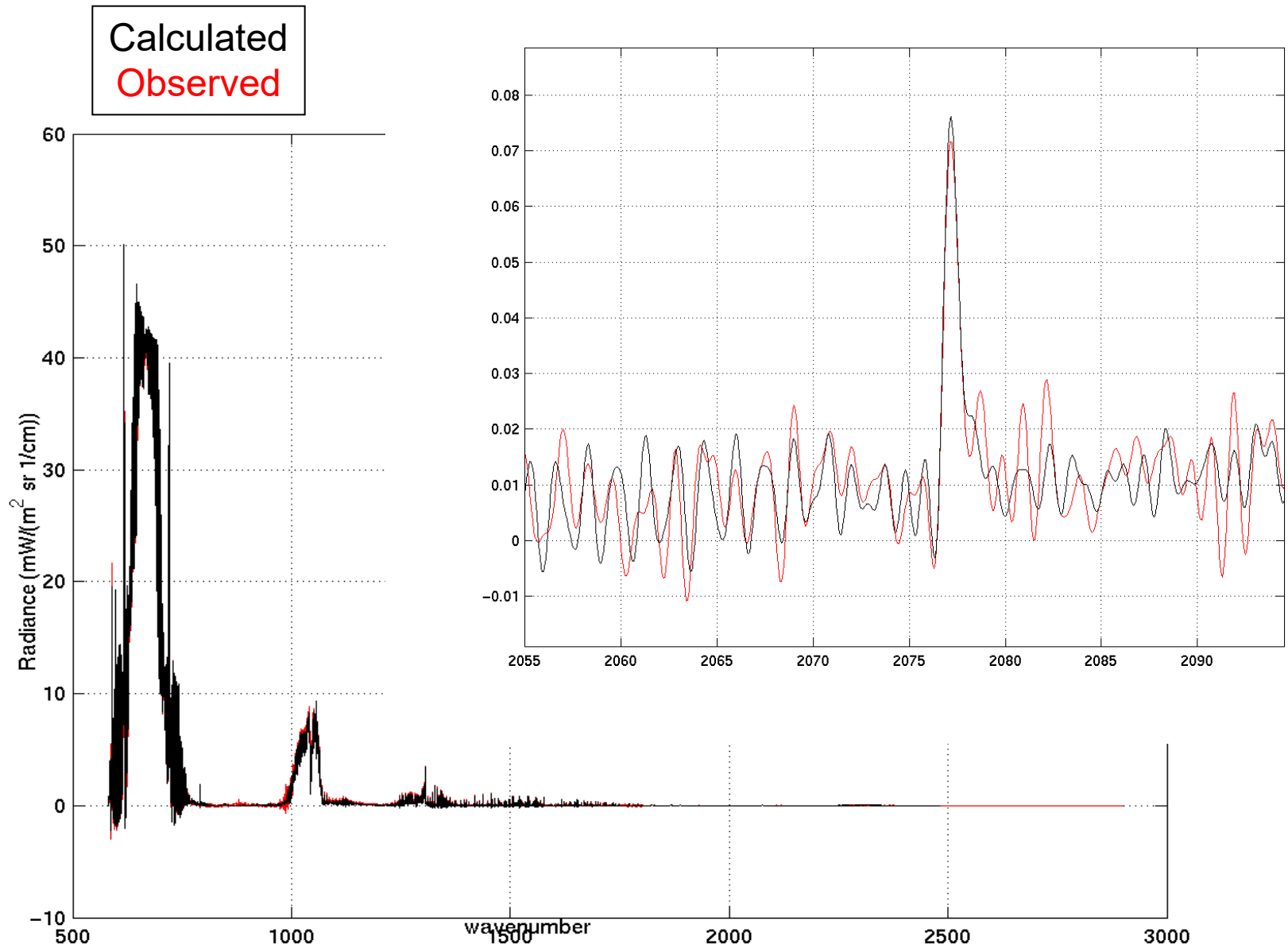
MW/SW overlap



# 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

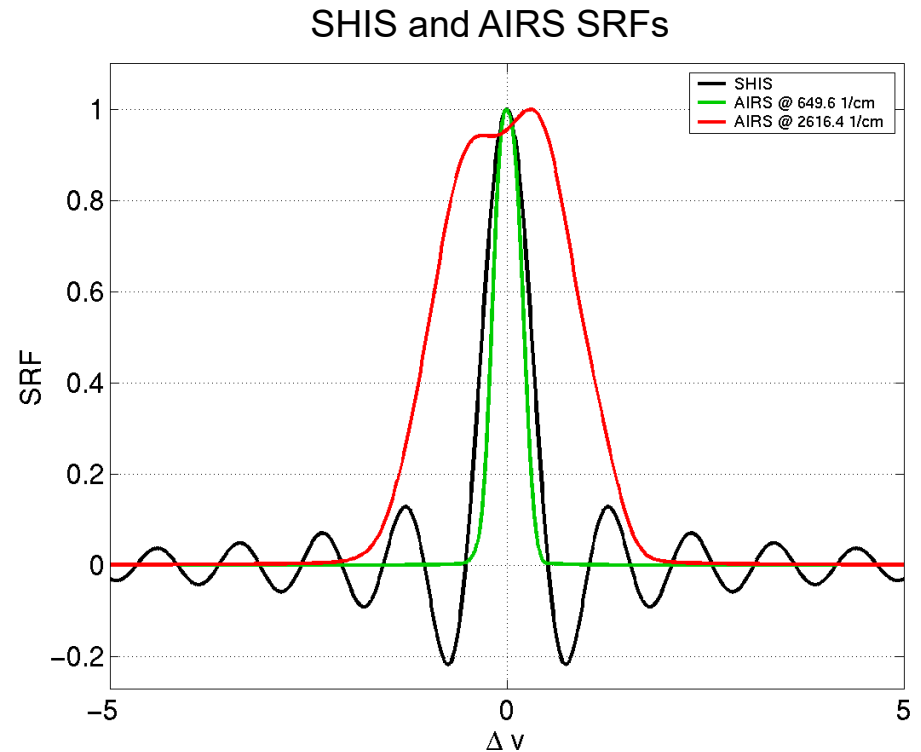
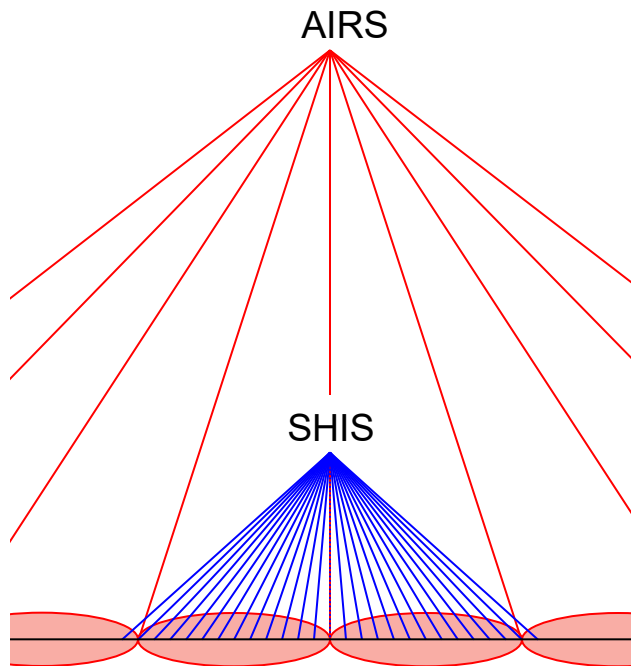
A world map with a light blue background and dark blue landmasses, centered on the Atlantic Ocean. The map is slightly faded and serves as a background for the text.

# **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

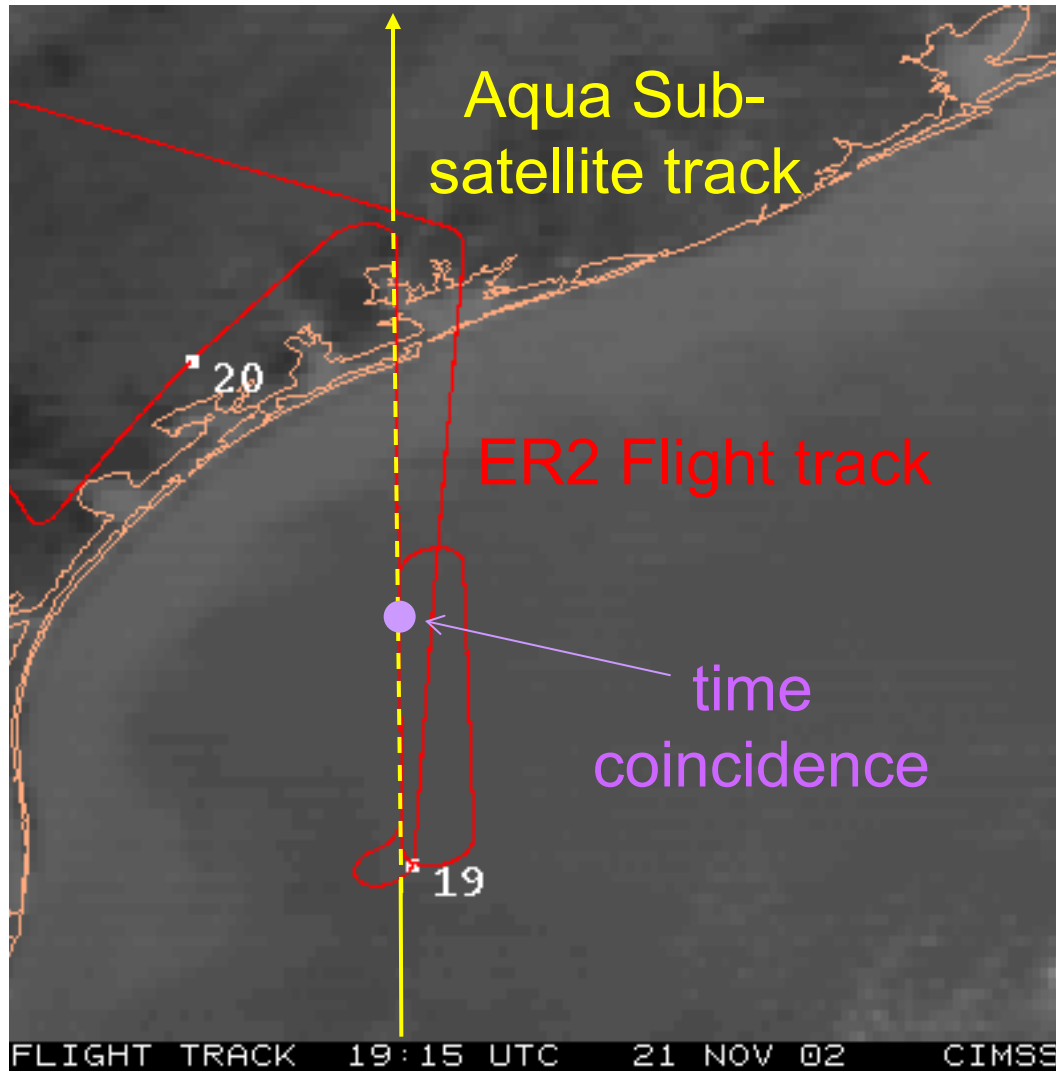
0. Average SHIS data within AIRS FOV(s) & compare
  - No attempt to account for view angle, altitude, spectral differences.
  
1. Compare Residuals from calculations:  
 $(\text{obs-calc})_{\text{SHIS}}$  to  $(\text{obs-calc})_{\text{AIRS}}$ 
  - SHIS and AIRS calcs each done at correct altitudes, view 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



# Terra/Aqua Experiment-2002

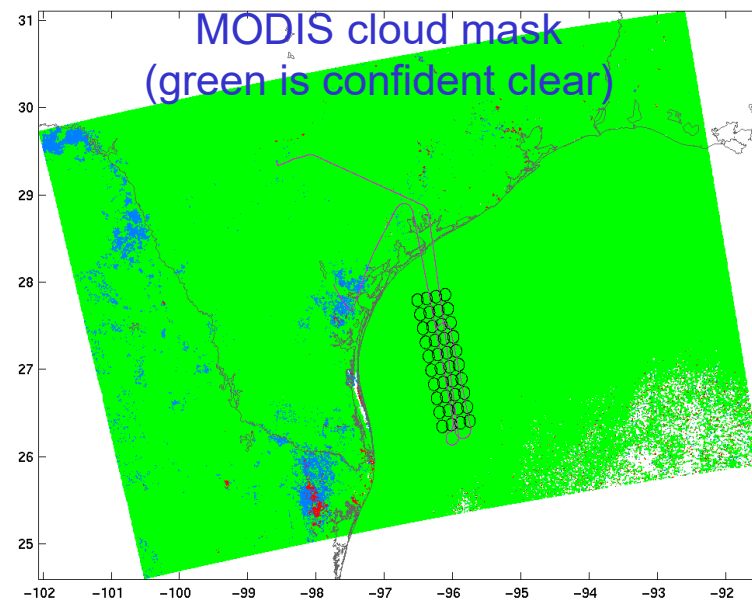
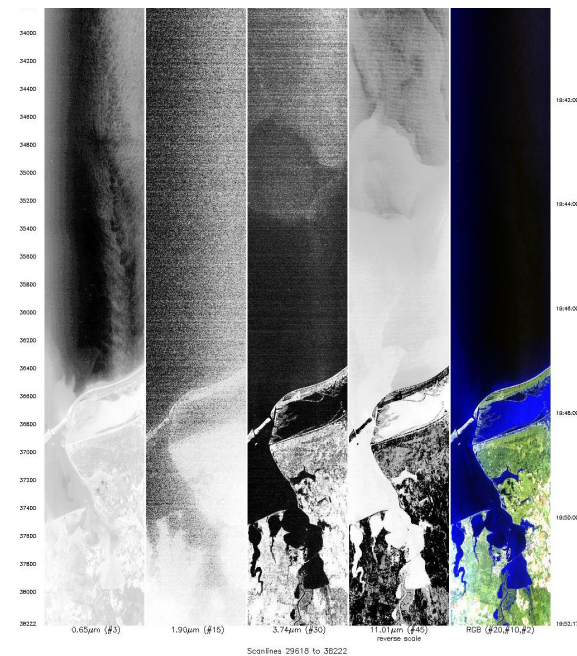
19:40 UTC (daytime), Gulf of Mexico

11/21/2002

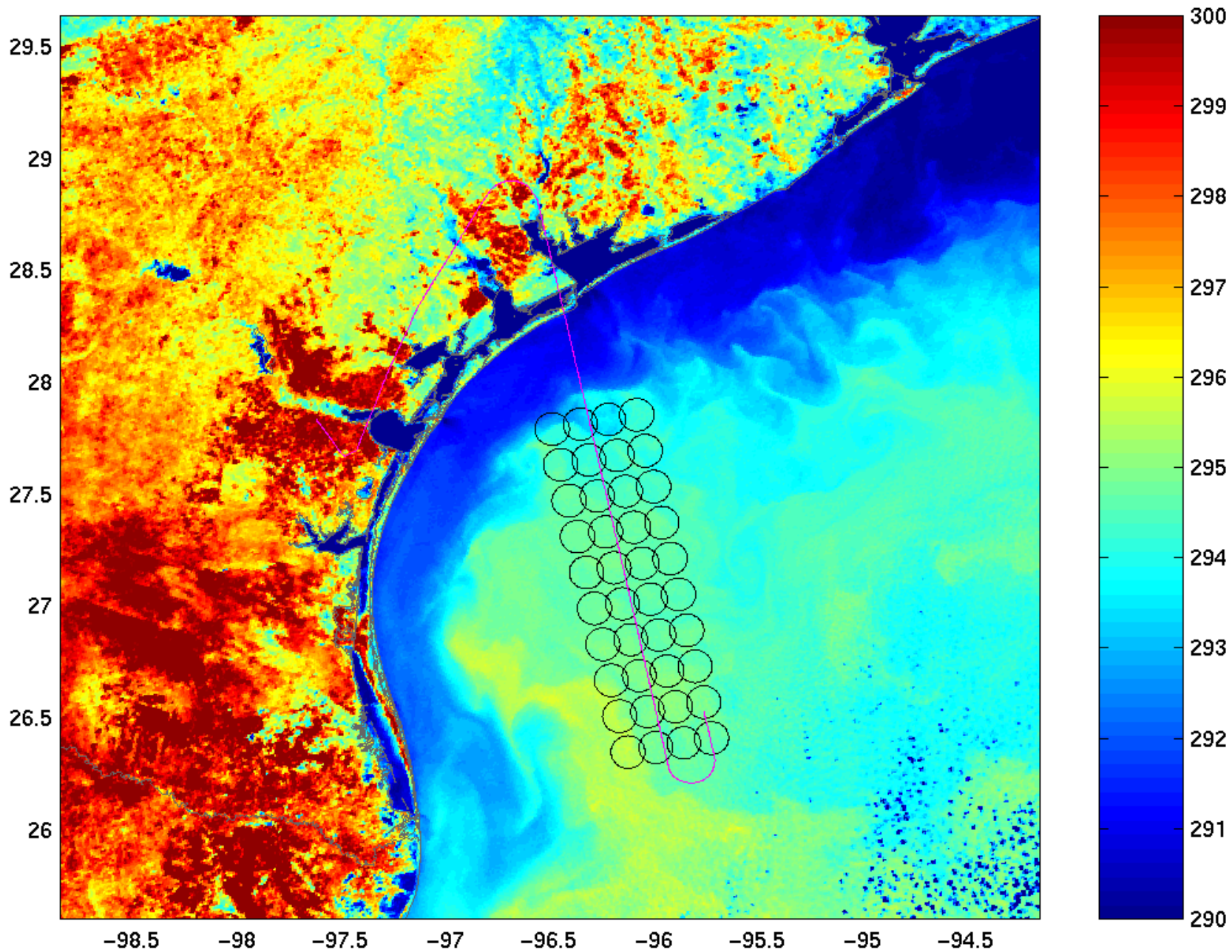


## MAS Quicklooks flight leg 5

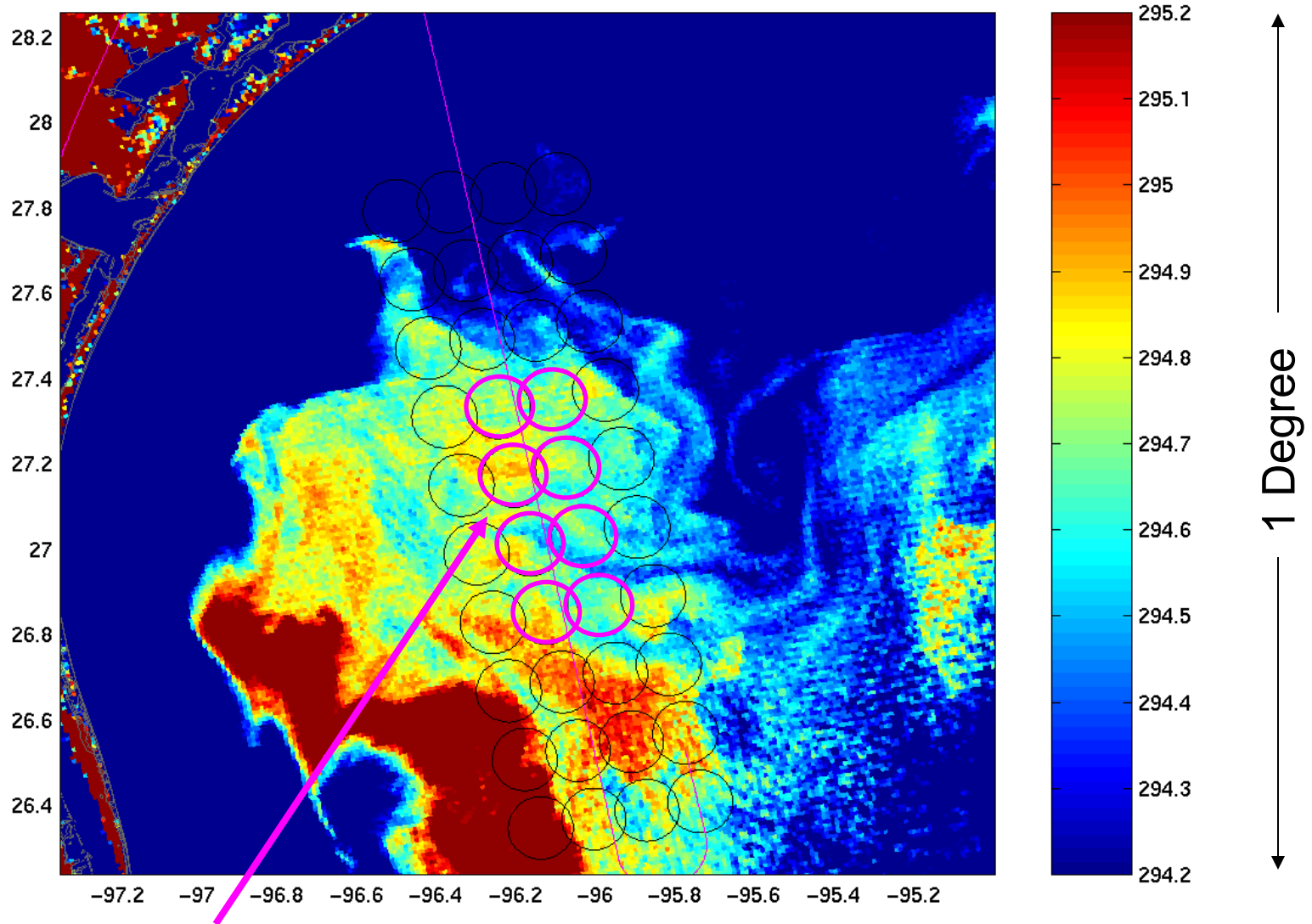
0.65mm 1.90mm 3.74mm 11.01mm RGB



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



# MODIS 12 micron Band & near-nadir AIRS FOVs

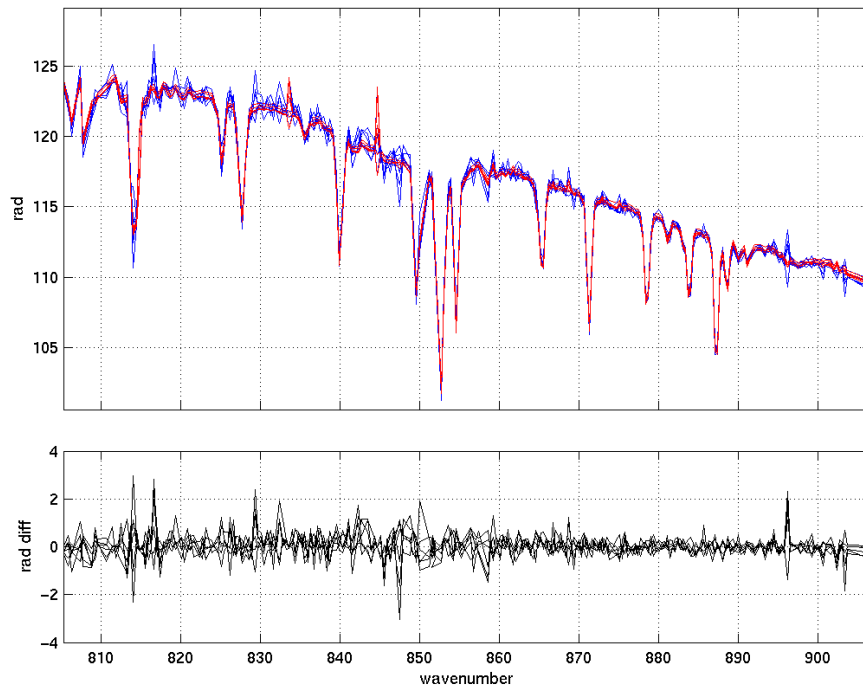


**8 AIRS FOVs used in the following comparisons**

# PC Noise Filtering of SHIS and AIRS

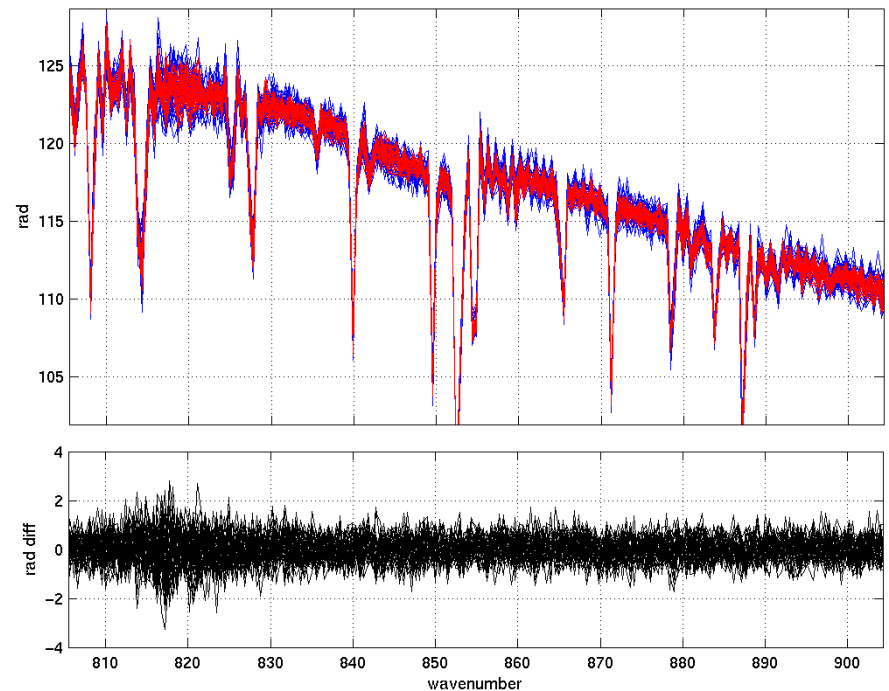
noise normalized, 20 PCs per band

Original AIRS  
PC Filtered AIRS



granule 196, scan lines 113, 114, 115;  
rows 45, 46. Bad\_Flag==0

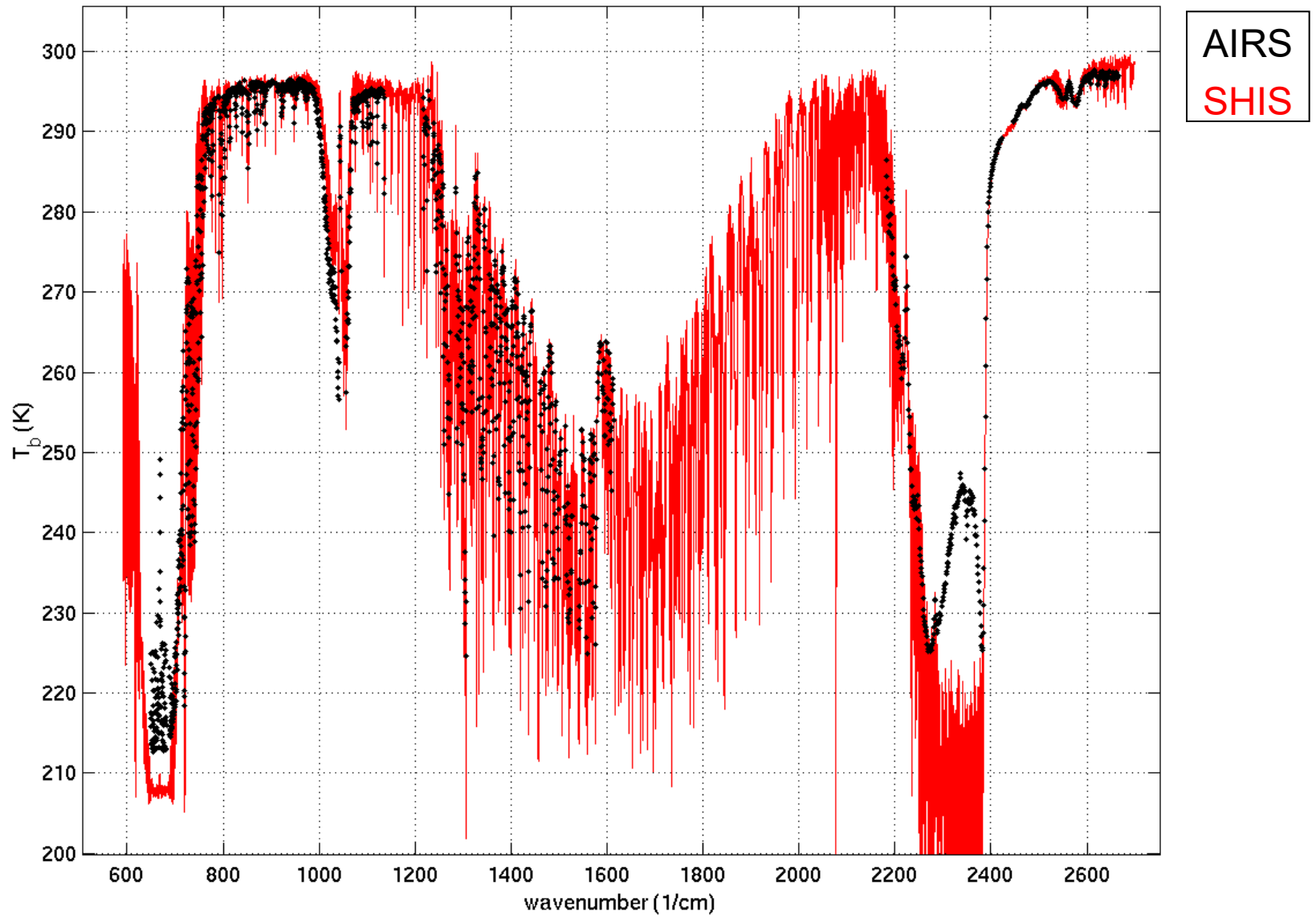
Original SHIS  
PC Filtered SHIS



41 nadir spectra along flight line #5  
(note: 2km spatial resolution adds real scene variability)

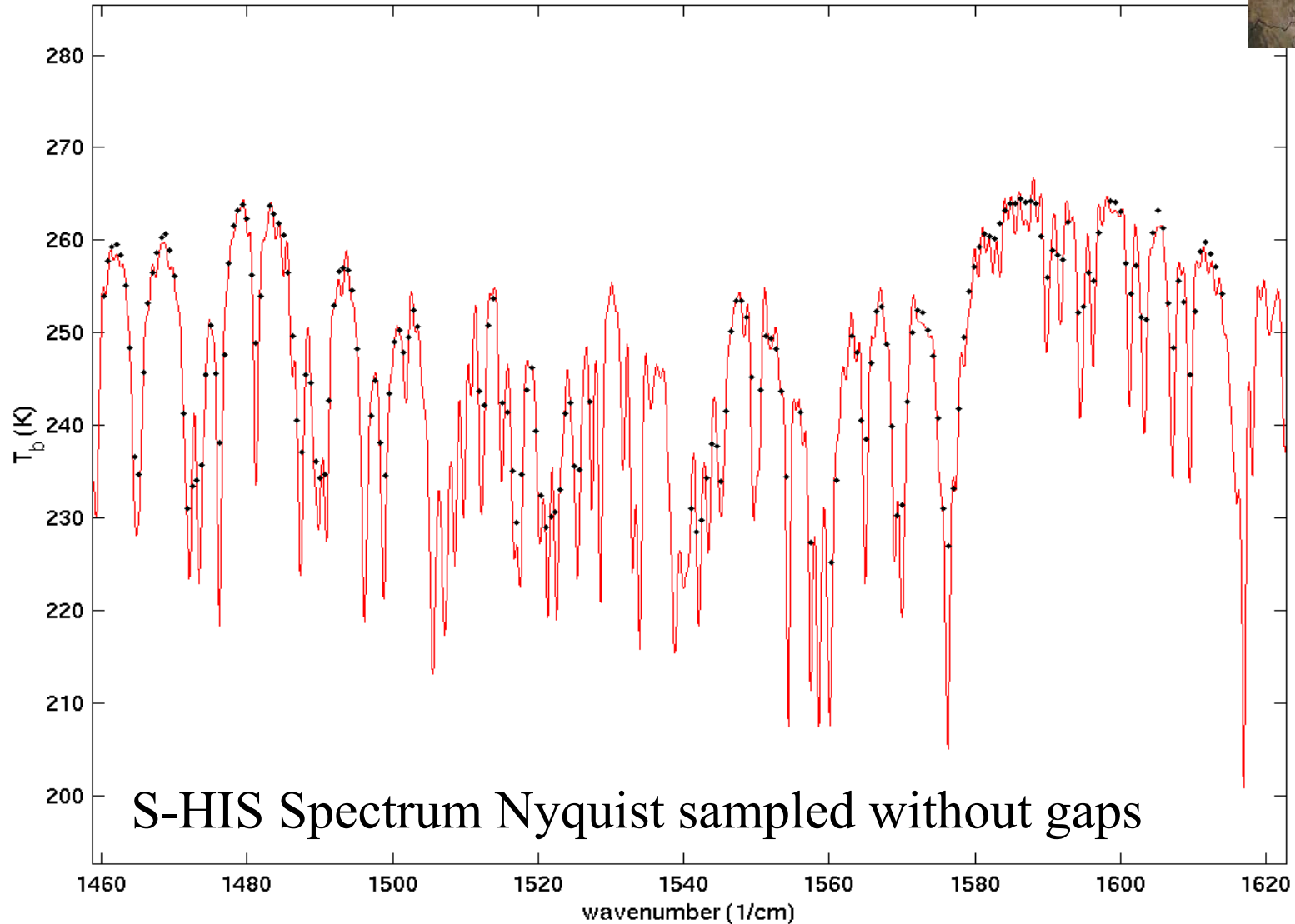
# “comparison 0”

8 AIRS FOVs, 448 SHIS FOVs, PC filtering

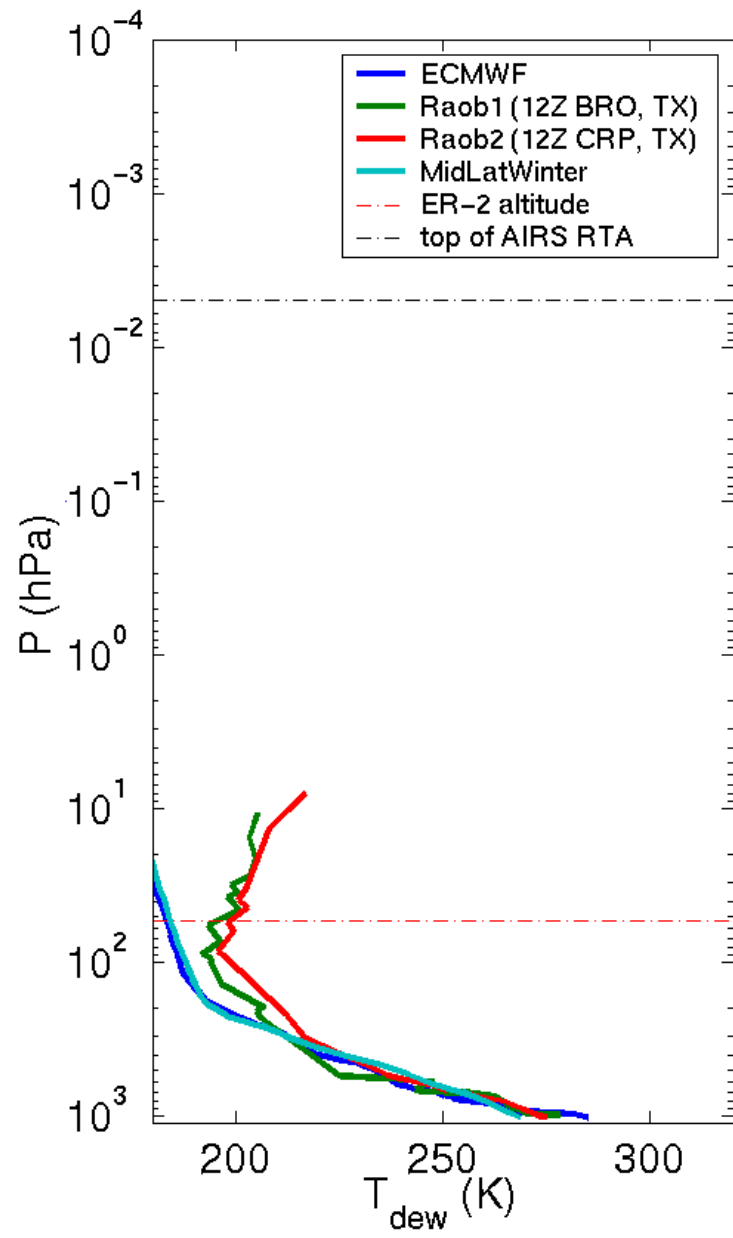
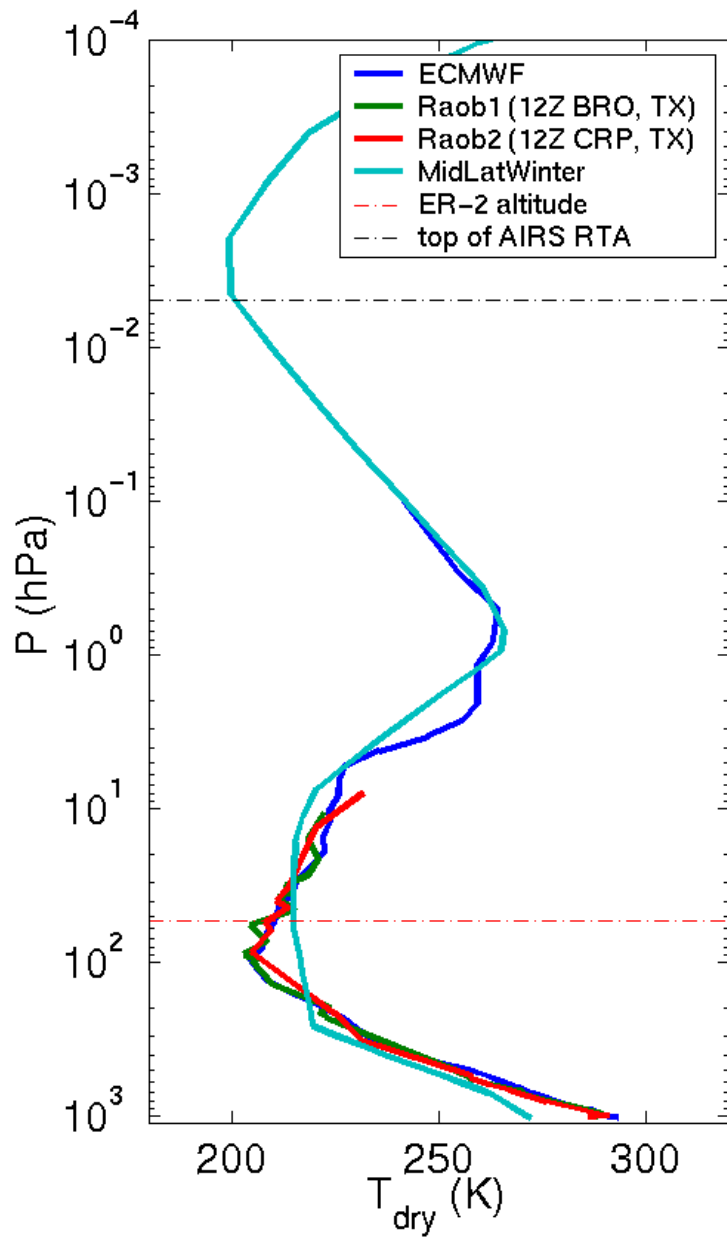


# “comparison 0”

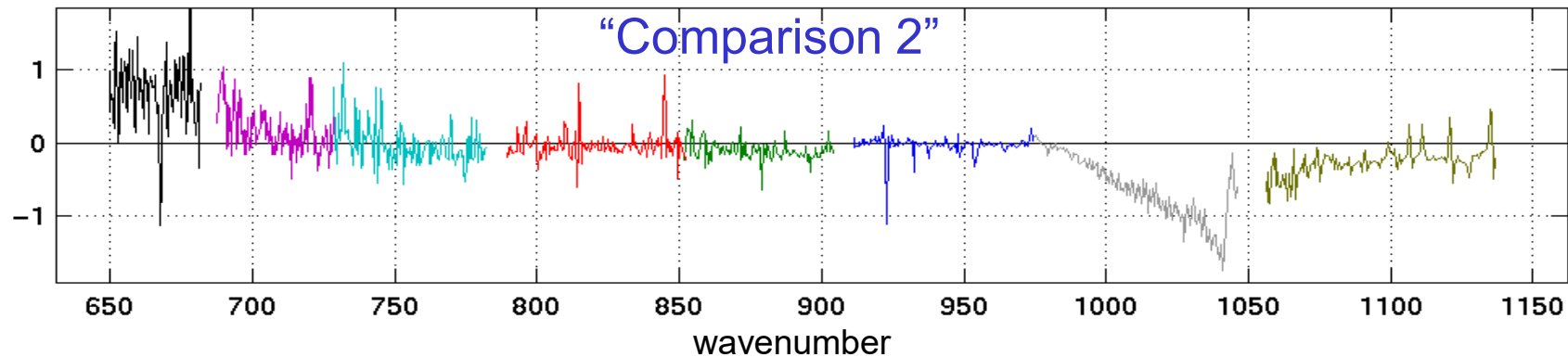
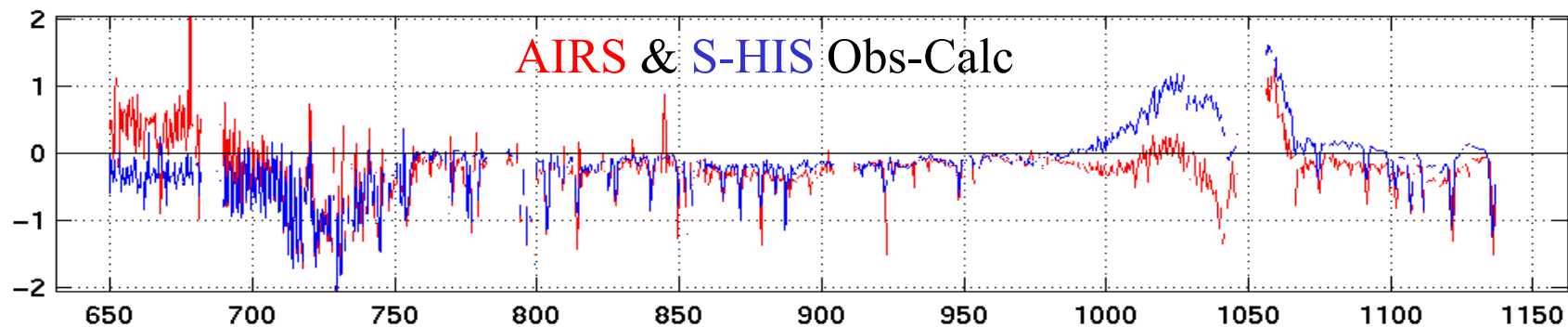
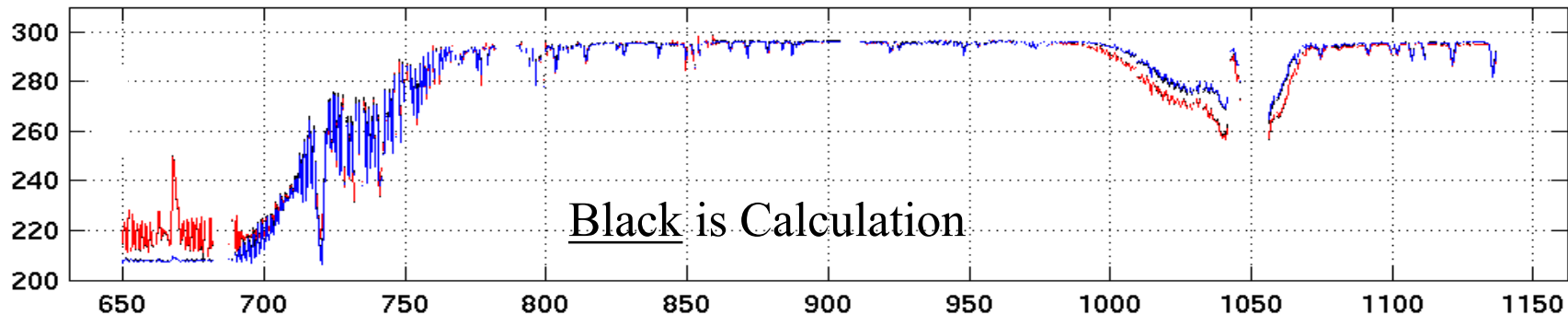
8 AIRS FOVs, 448 SHIS FOVs, PC filtering



# Atmospheric Profiles

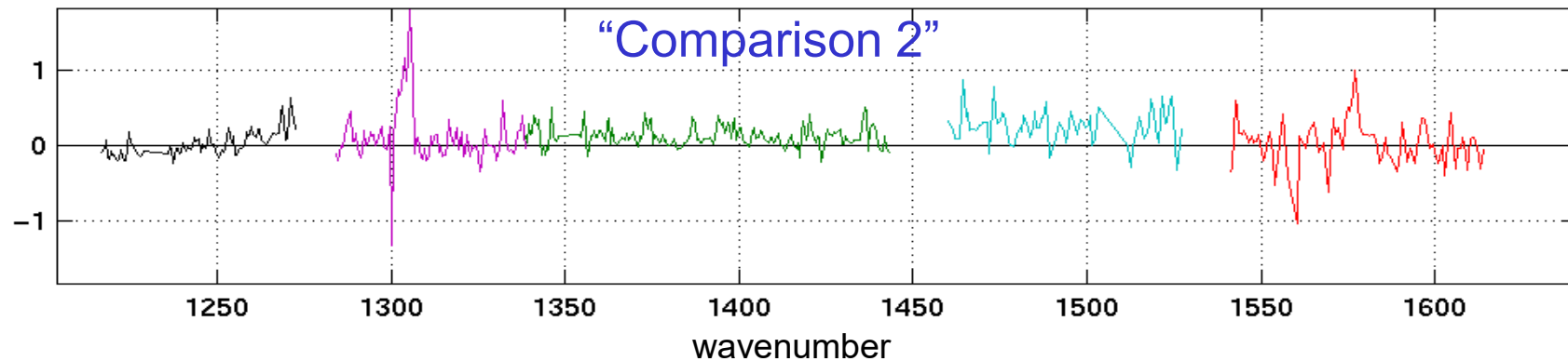
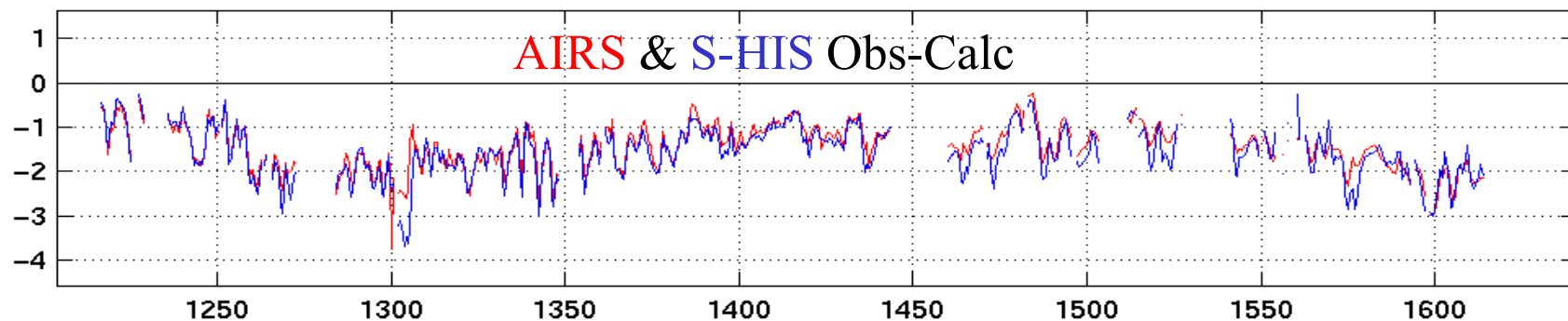
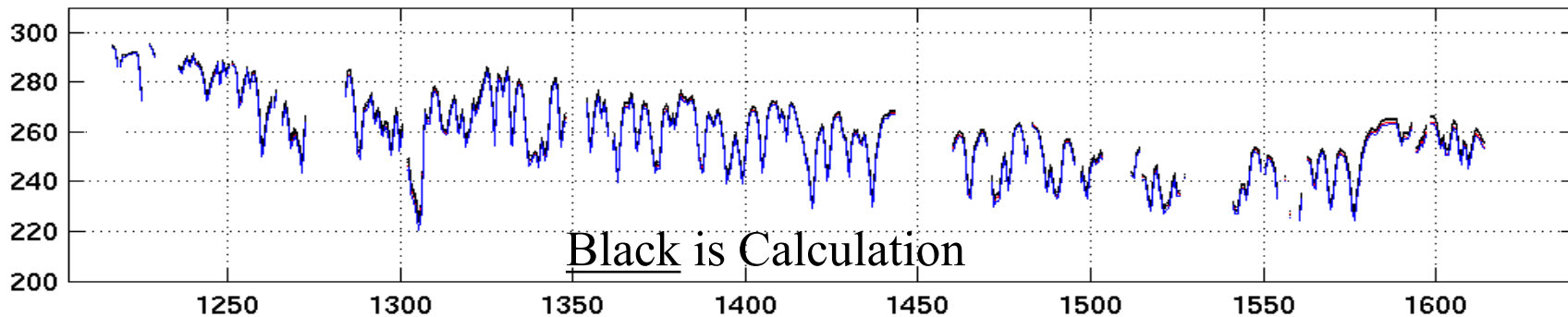


# AIRS Compared to S-HIS, 21 Nov 2002

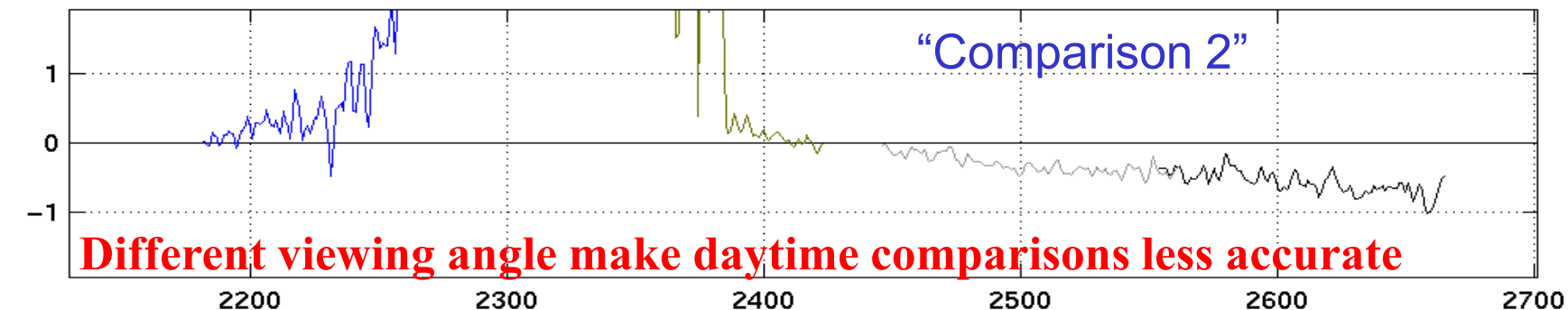
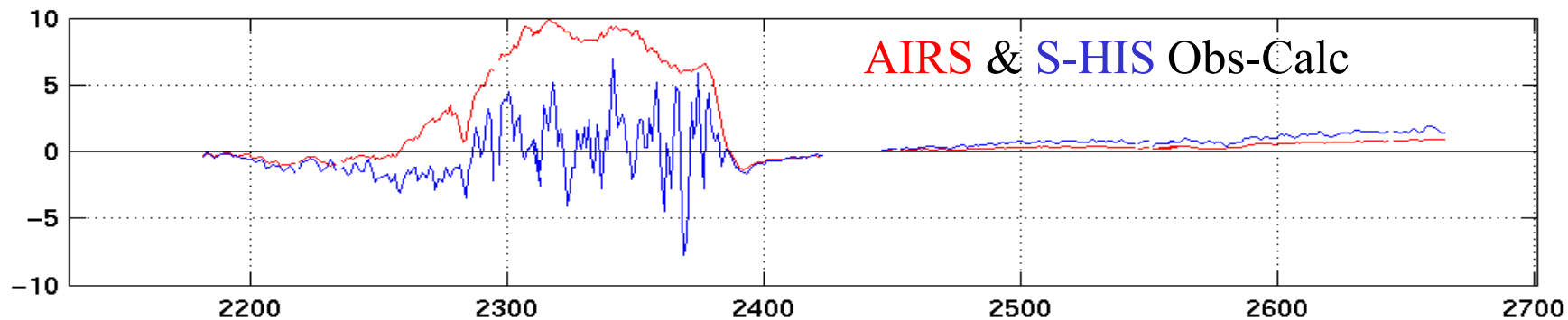
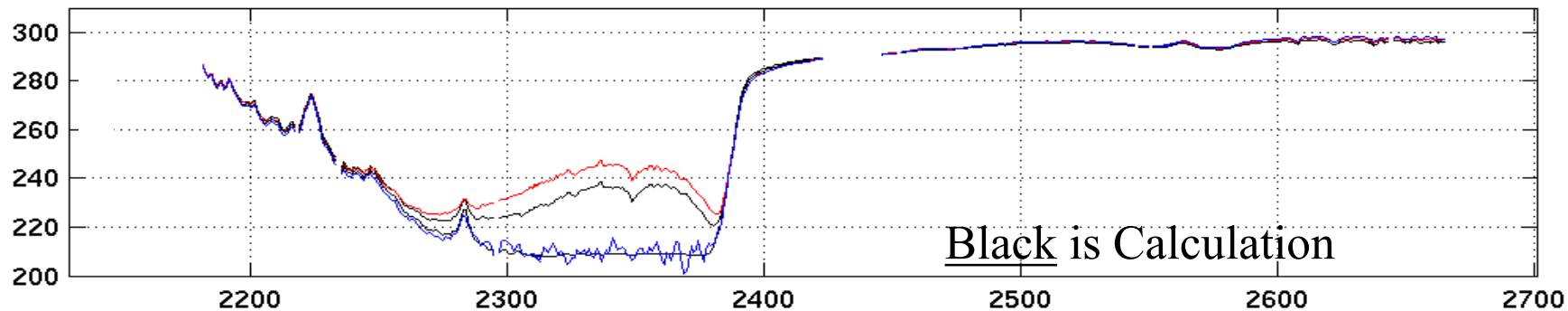




# AIRS Compared to S-HIS, 21 Nov 2002



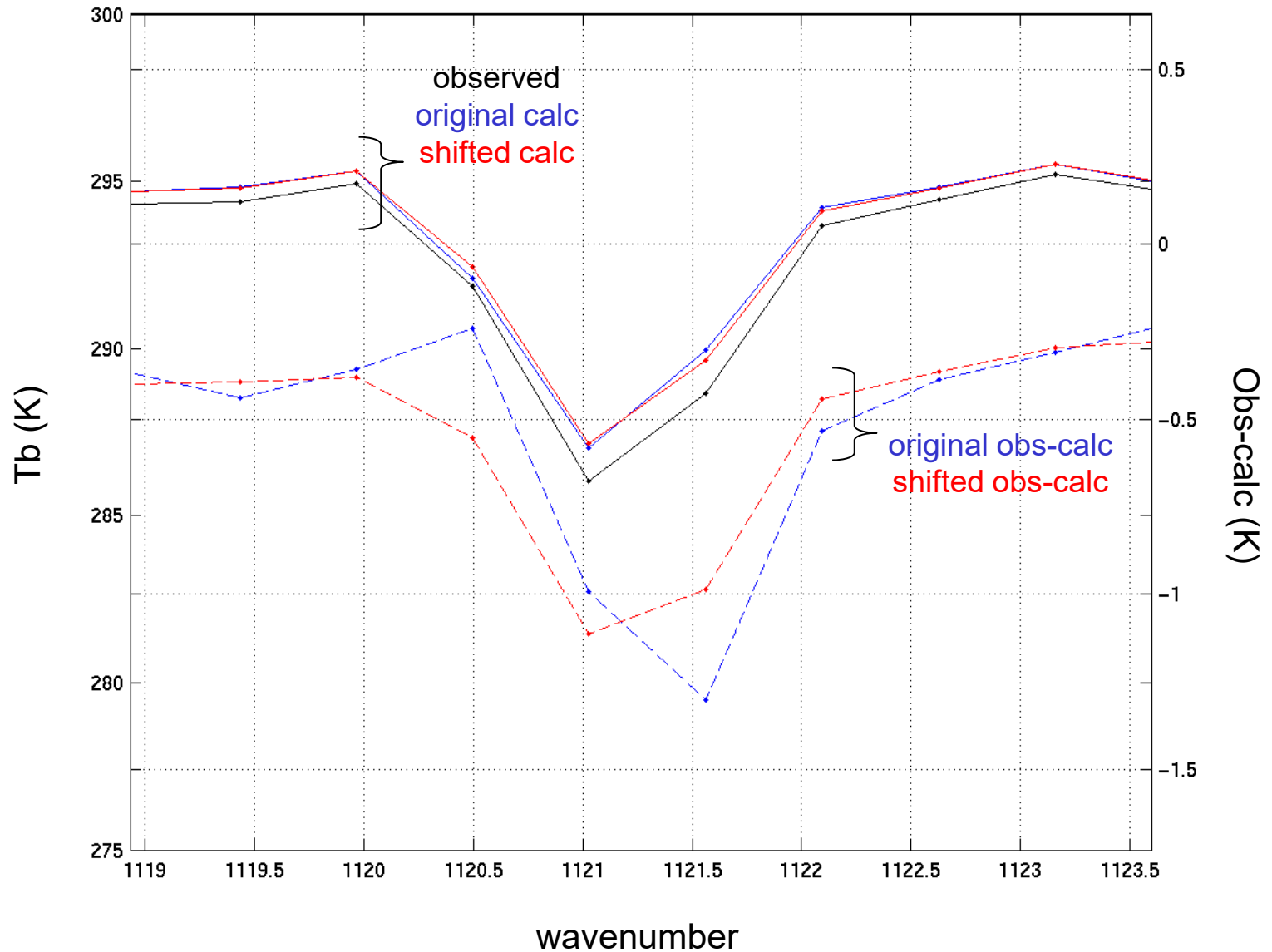
# AIRS Compared to S-HIS, 21 Nov 2002



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

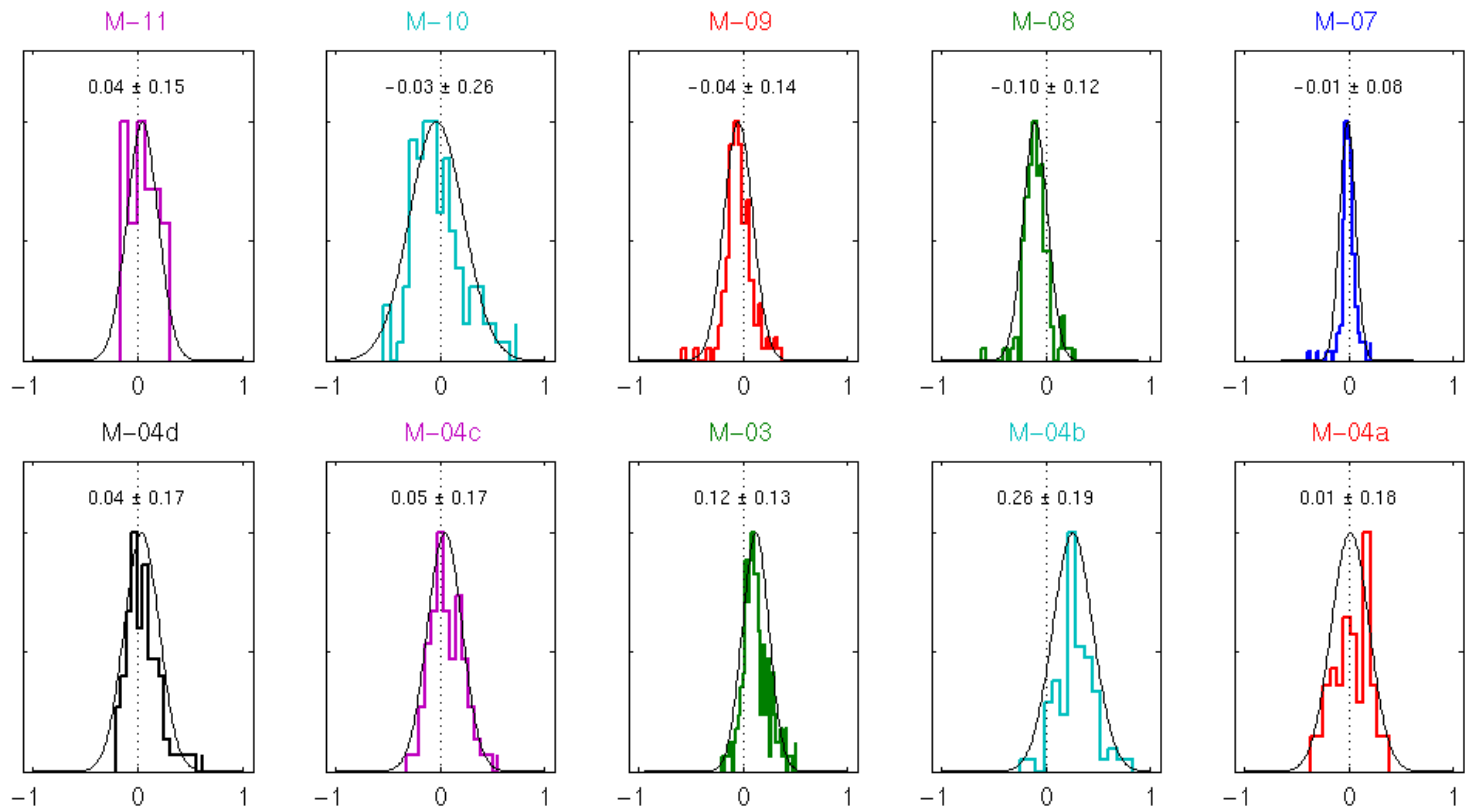
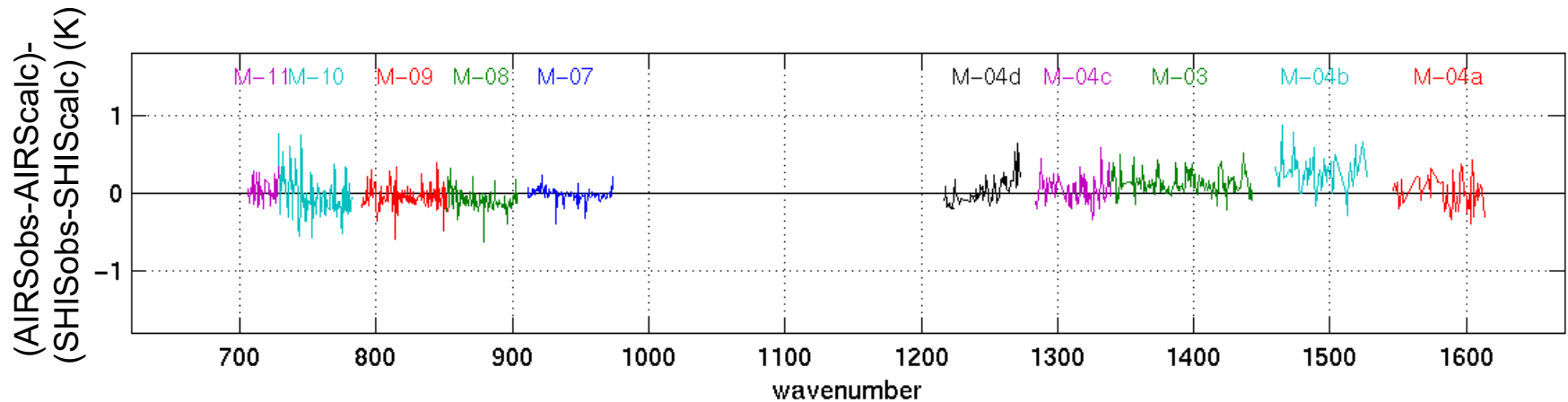
wavenumber

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

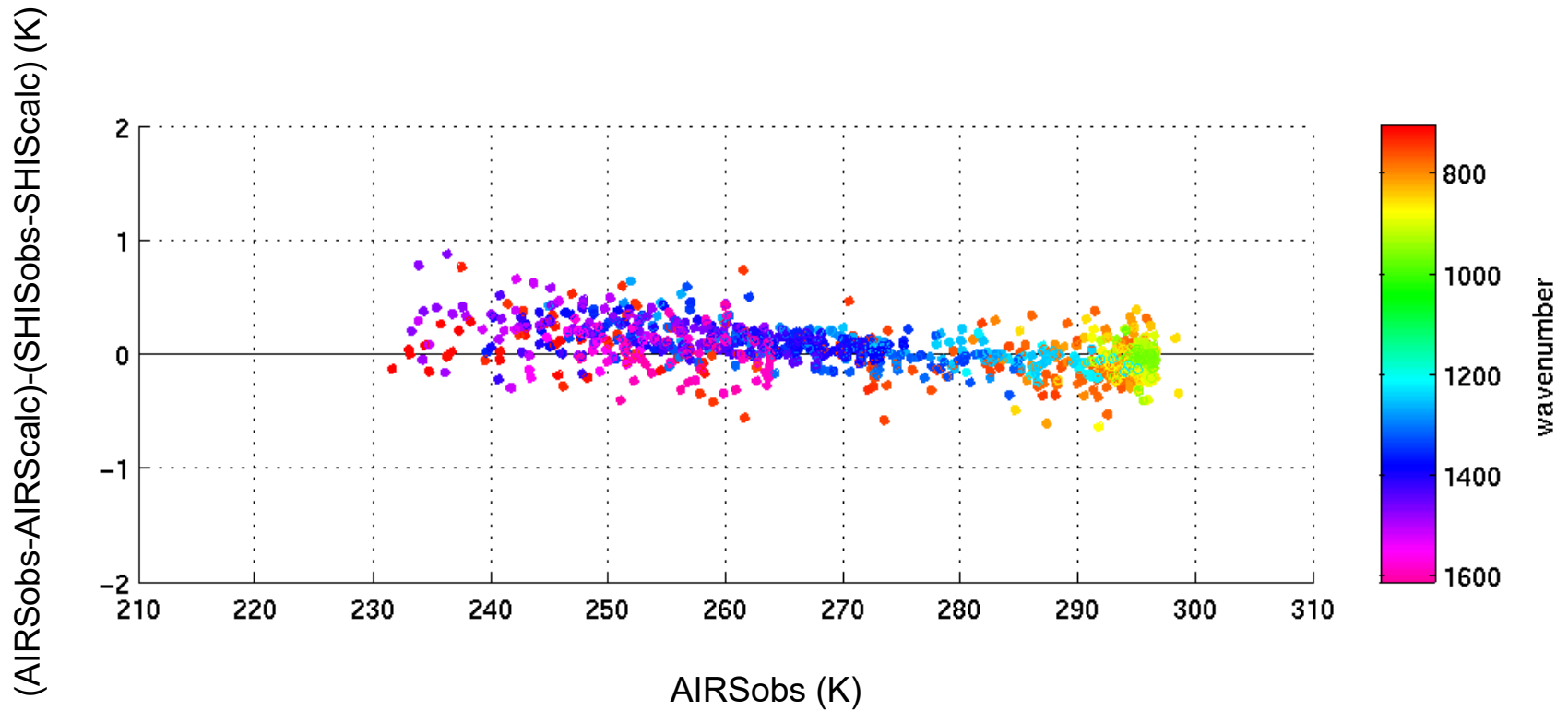


# “Comparison 2” (21 November 2002)

Excluding channels strongly affected by atmosphere above ER2



“Comparison 2” (21 November 2002)  
Excluding channels strongly affected by atmosphere above  
the 15 km ER2 altitude



# 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