



Validation of AIRS Spectral Radiances with the Scanning HIS Aircraft Instrument

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Sainte Adele, Canada
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TOPICS

1. Scanning-HIS

Oklahoma, ARM UAV “Grand Tour”

(SHIS on Proteus at 15 km, 16 Nov 2002)



Fall 2002 - Oklahoma

2. AIRS Radiance Validation

Gulf of Mexico,
Terra/Aqua 2002

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



3. AIRS Assessment of MODIS Calibration

A light blue world map is centered in the background of the slide. The map shows the outlines of the continents in a darker shade of blue. The text 'S-HIS Uplooking' is overlaid on the map, centered horizontally and vertically.

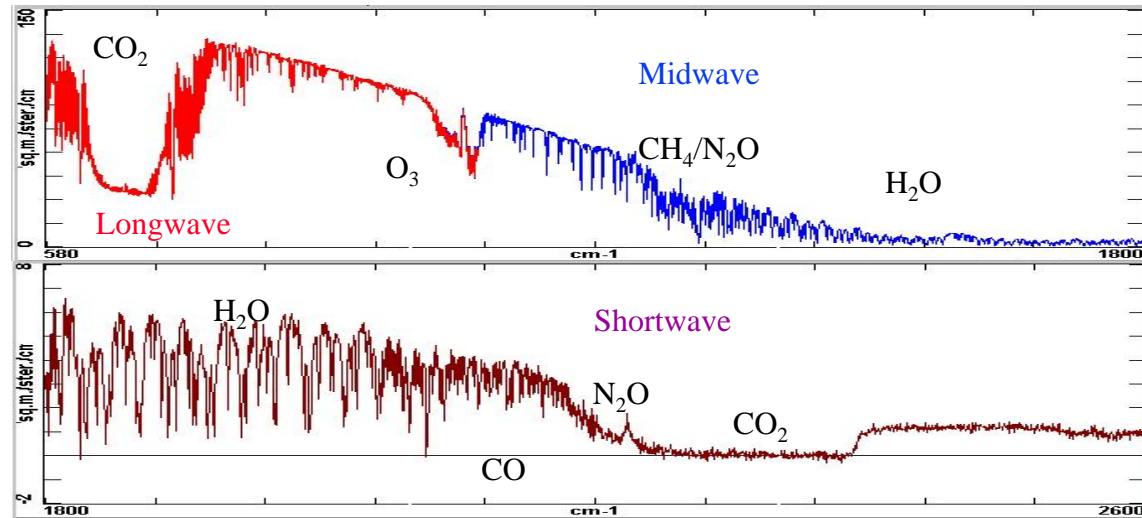
S-HIS Uplooking

UW Scanning HIS: 1998-Present

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

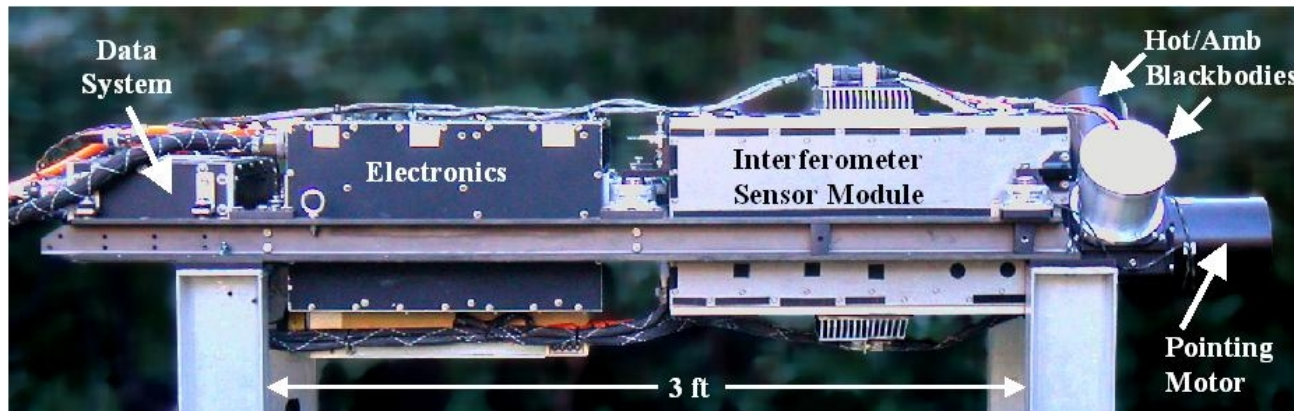
Characteristics

- Spectral Coverage:** 3-17 microns
- Spectral Resolution:** 0.5 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



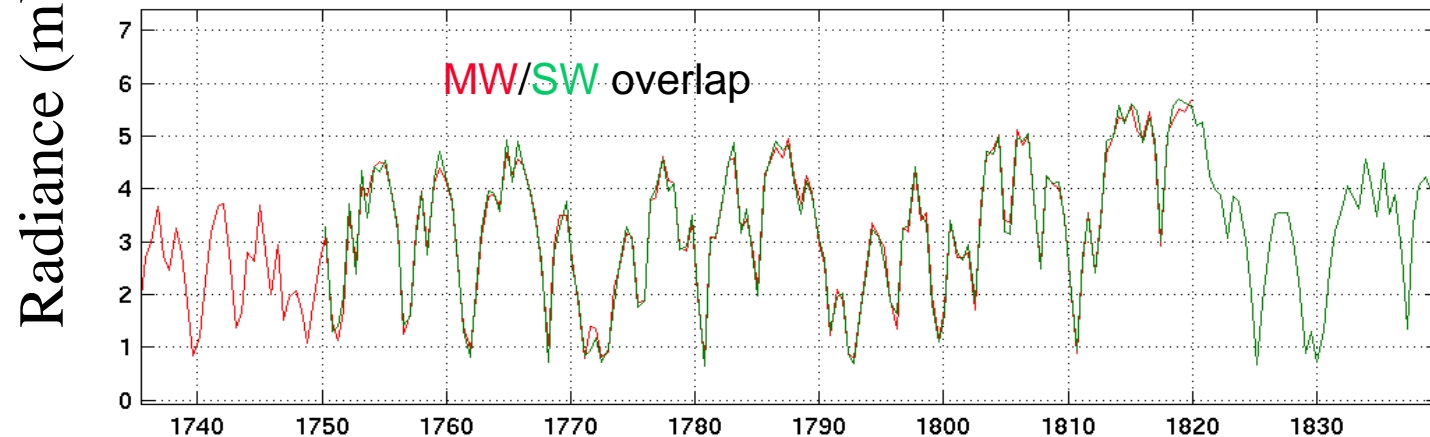
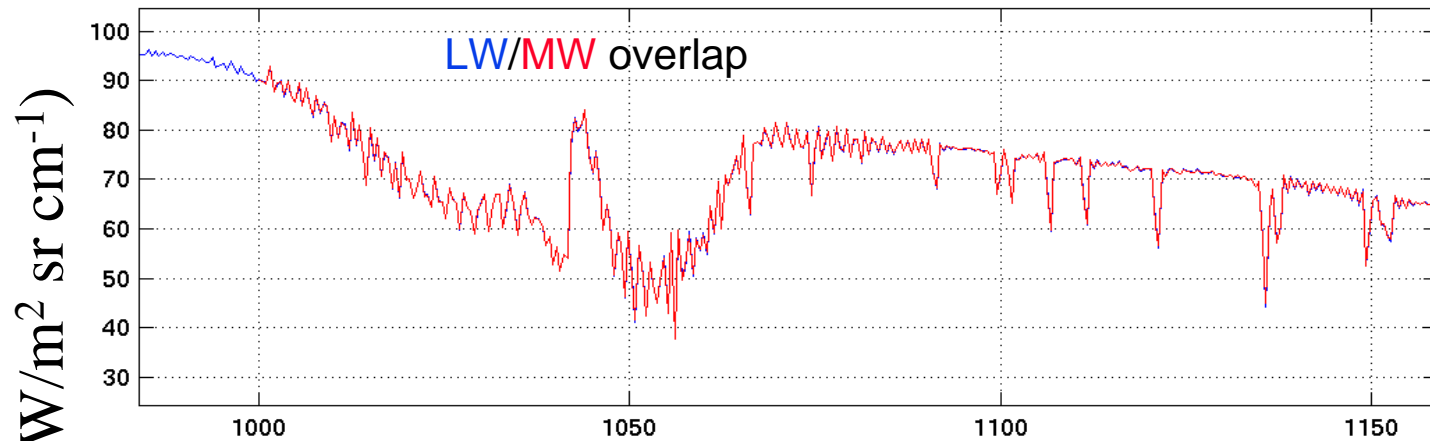
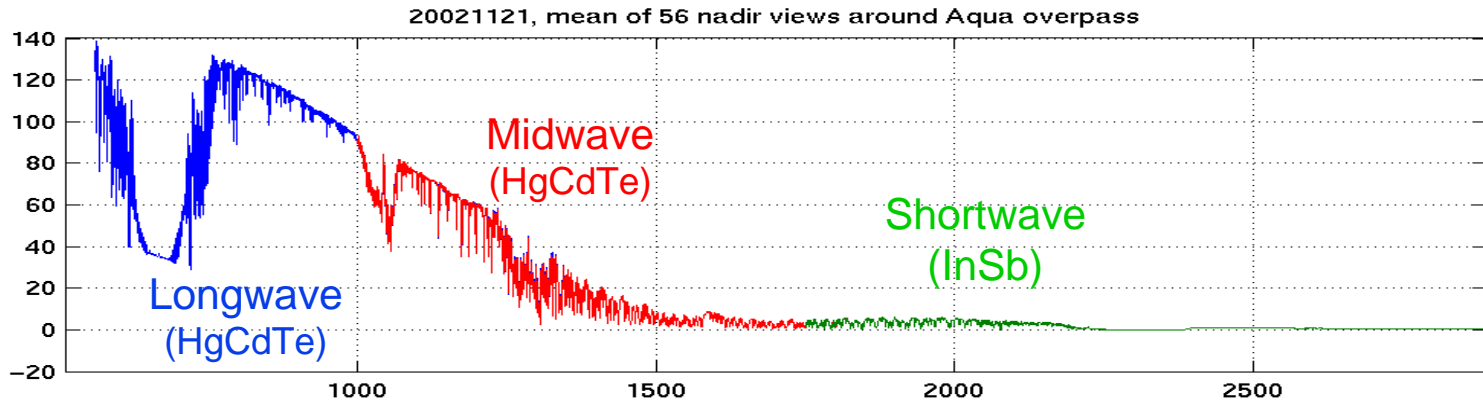
SSEC Scanning HIS on 1st ARM-UAV Mission with Proteus, October 2002



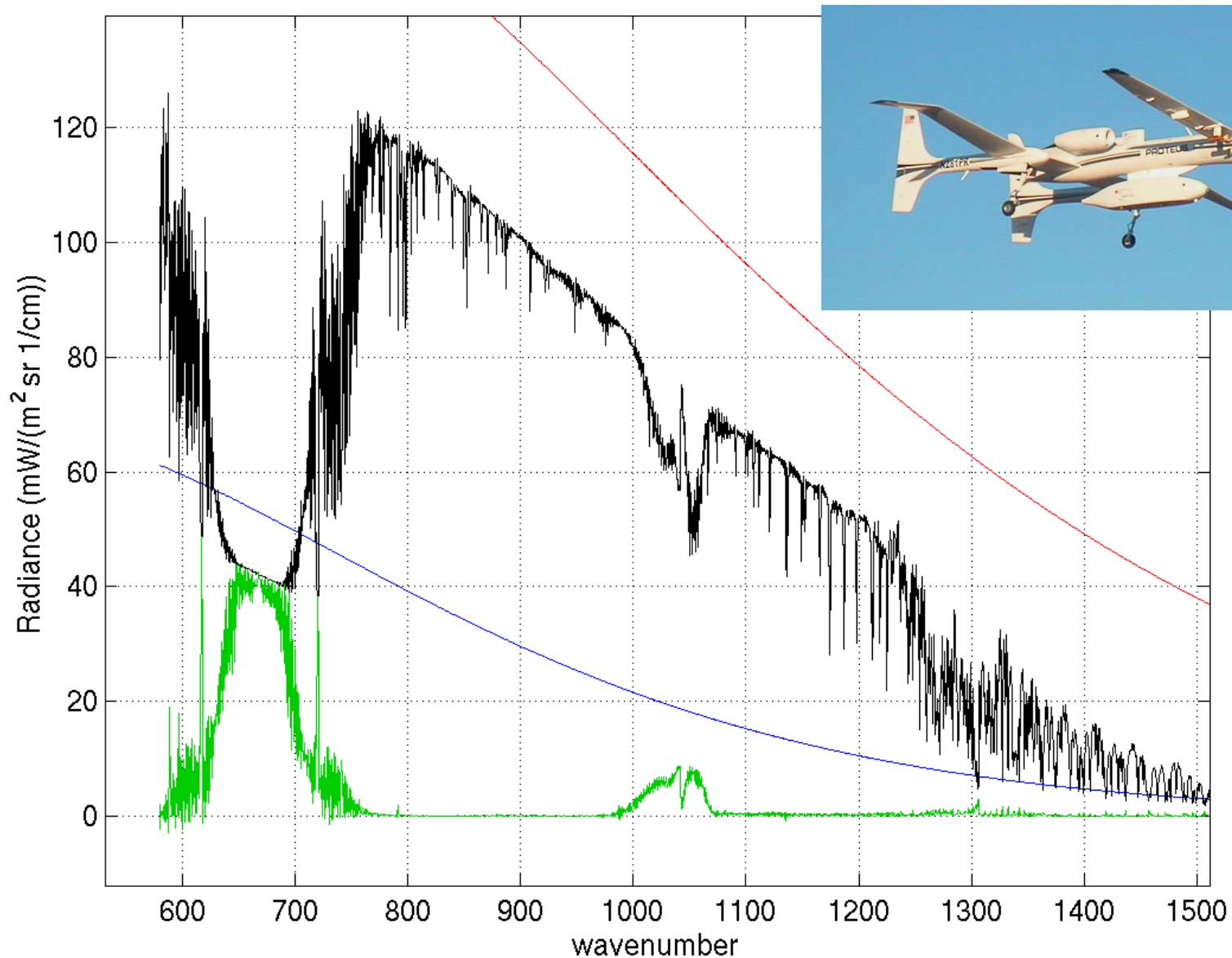
S-HIS scans cross-track downward & looks upward



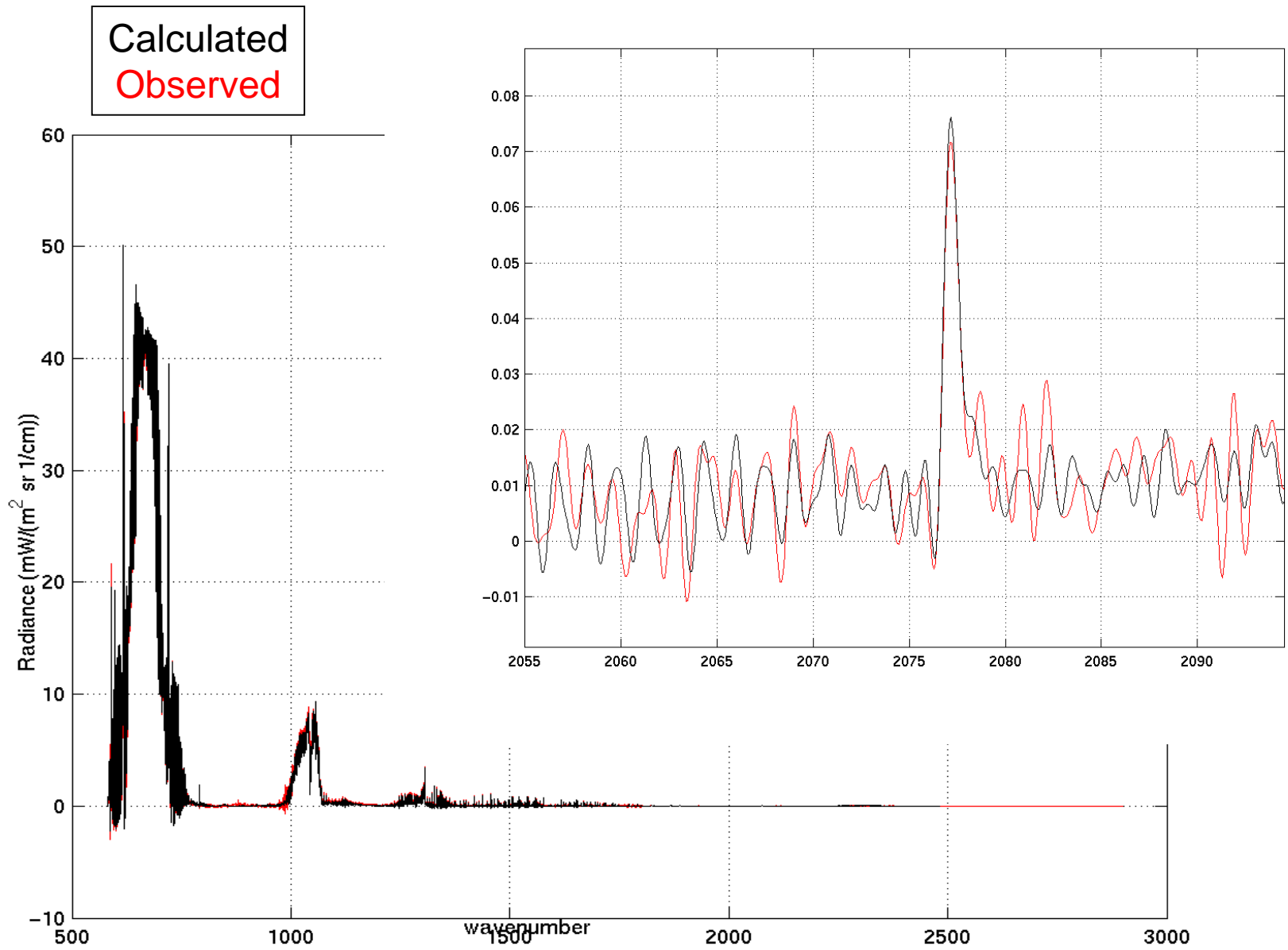
Scanning-HIS Band Overlap Agreement



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 H₂O above 14km

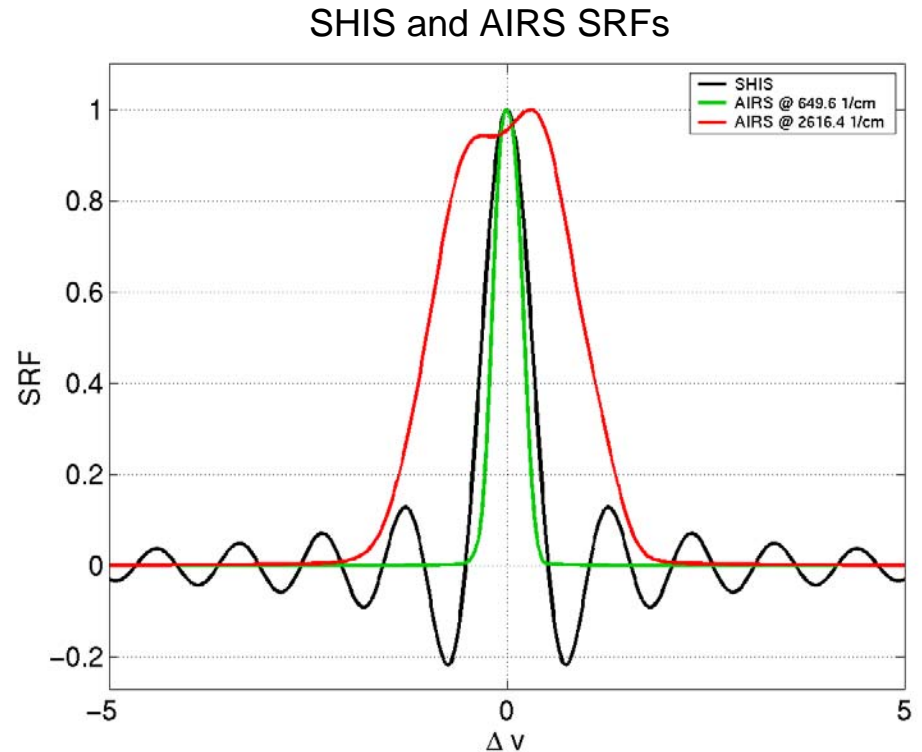
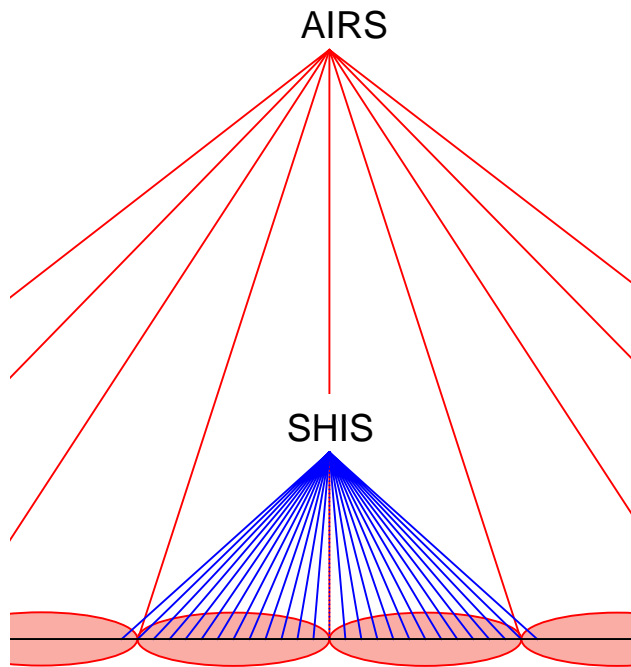
A world map with a light blue background and white landmasses, serving as a background for the title text.

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 $\Delta v = v/1200$, SHIS $\Delta v = \sim 0.5 \text{ cm}^{-1}$) and sampling



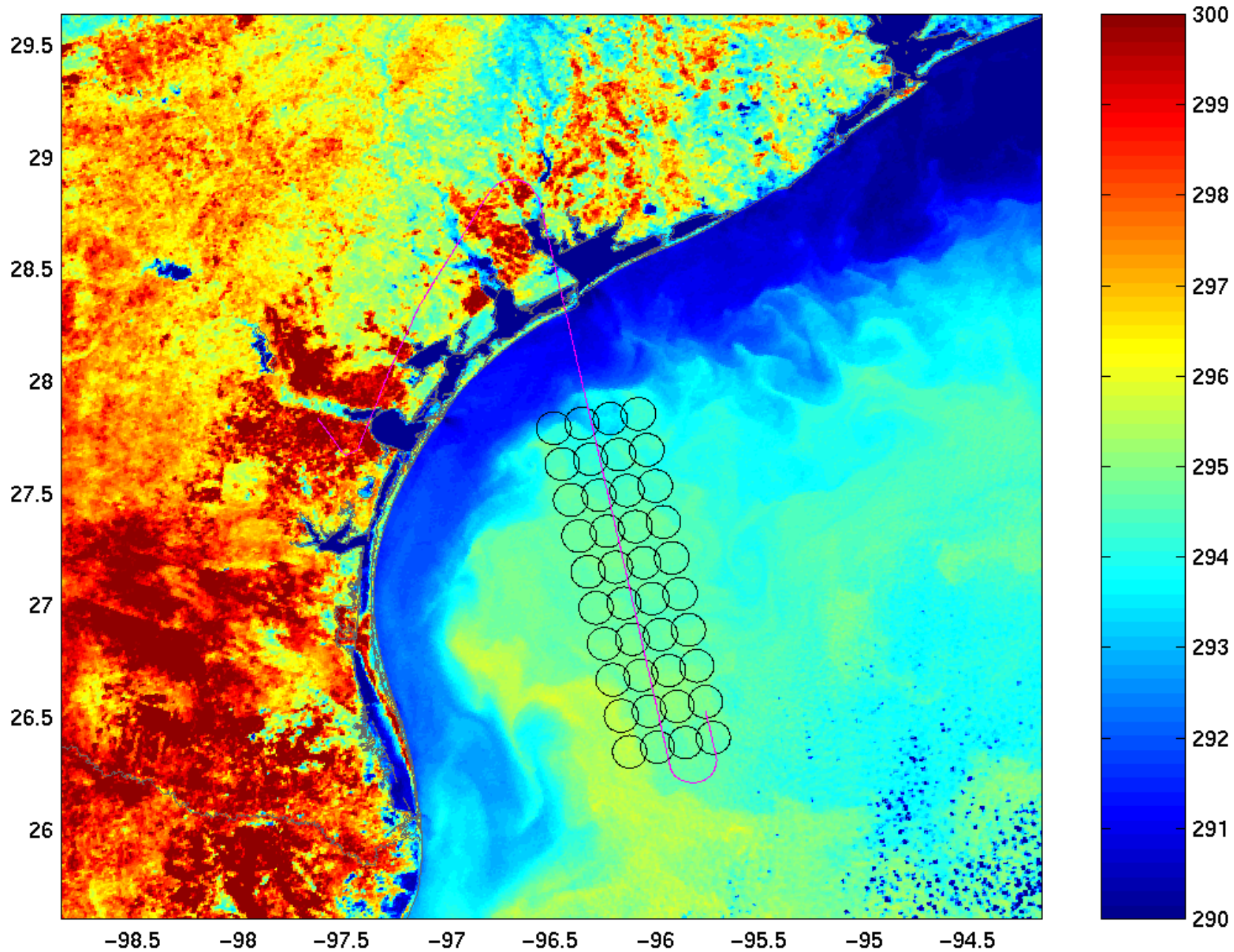
AIRS / SHIS Comparison steps

0. Average SHIS data within AIRS FOV(s) & compare
 - No attempt to account for view angle, altitude, spectral differences.

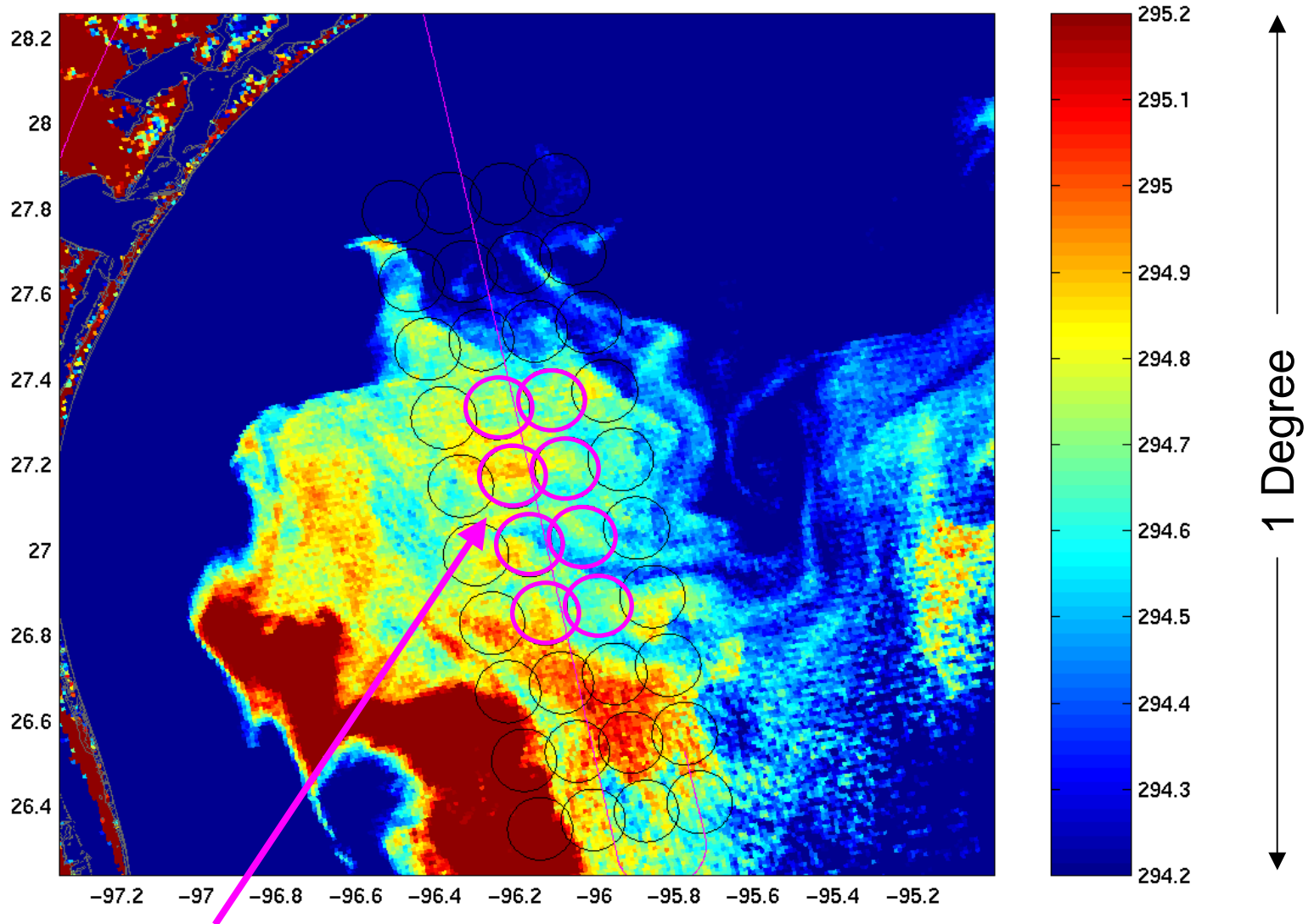
1. Compare Residuals from calculations:
 $(\text{obs-calc})_{\text{SHIS}}$ to $(\text{obs-calc})_{\text{AIRS}}$
 - SHIS and AIRS calcs each done at correct altitudes, view angles, spectral resolution and sampling.
 - Monochromatic calcs done using same forward model, atmospheric state, and surface property inputs.

2. Difference Residuals: Spectral Resolutions made similar
 - valid comparison except for channels mainly sensitive to upper atmosphere, above proteus altitude

MODIS 12 μm Band Tbs(K) & near-nadir AIRS FOVs



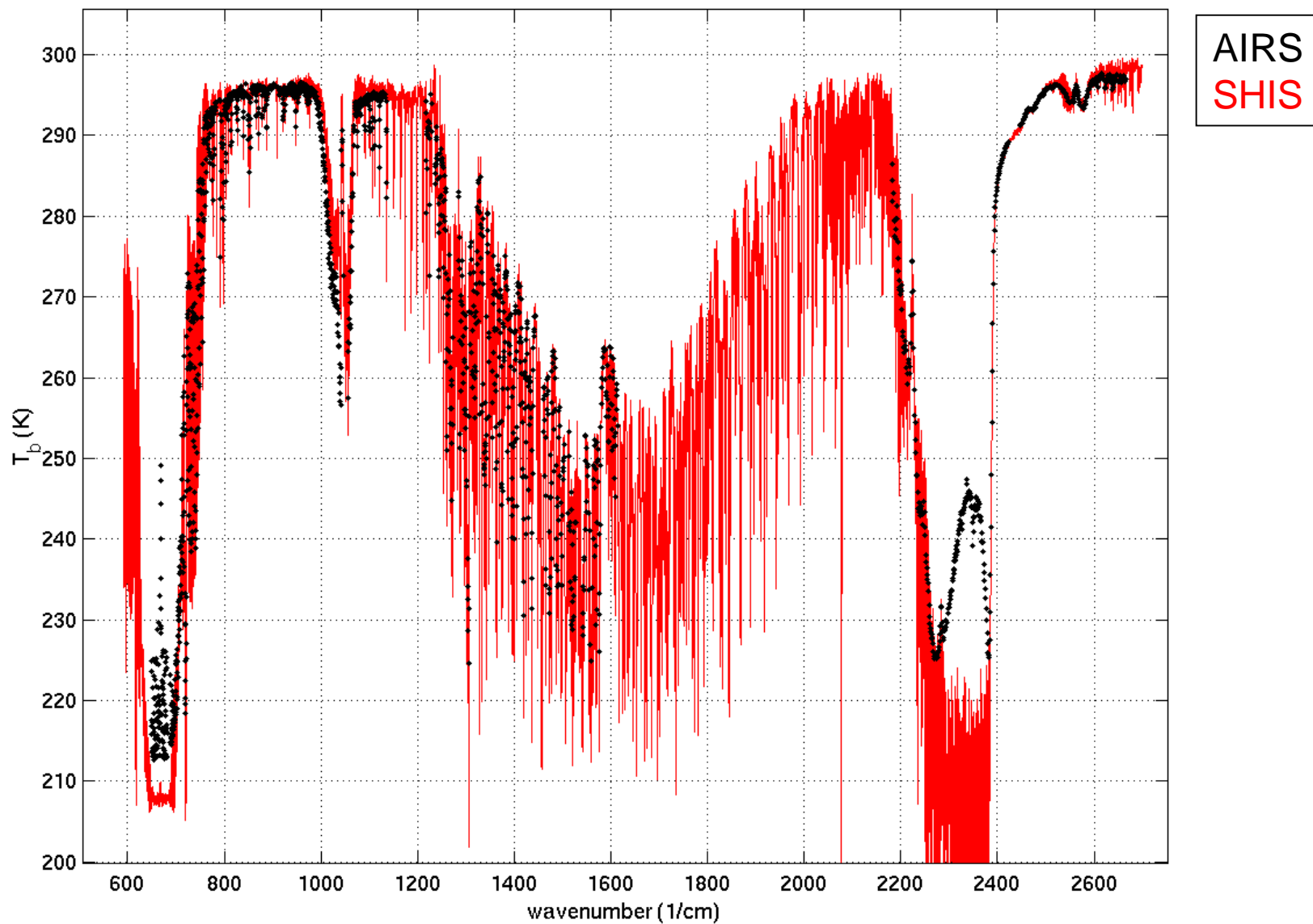
MODIS 12 micron Band & near-nadir AIRS FOVs



8 AIRS FOVs used in the following comparisons

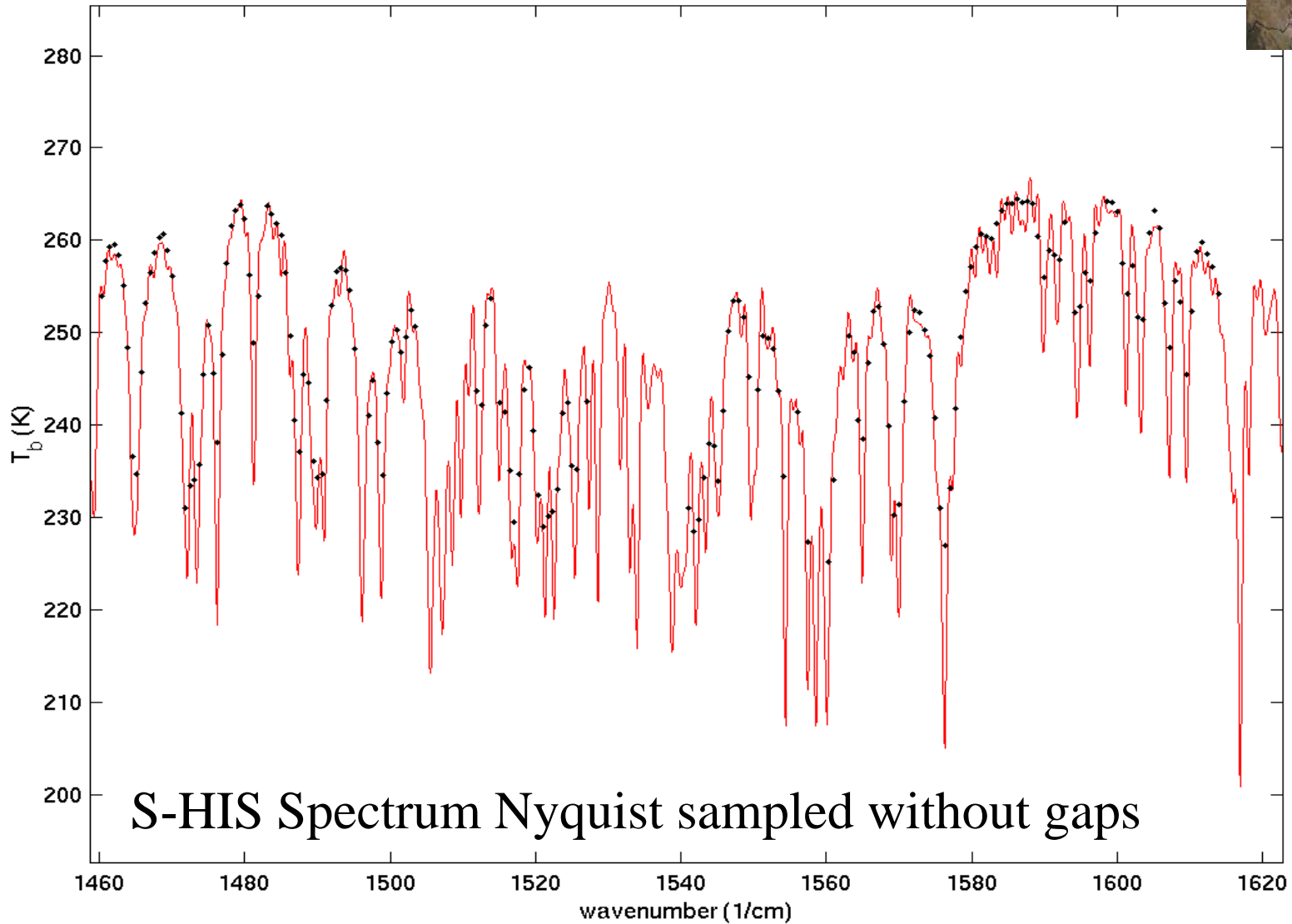
“comparison 0”

8 AIRS FOVs, 448 SHIS FOVs, PC filtering

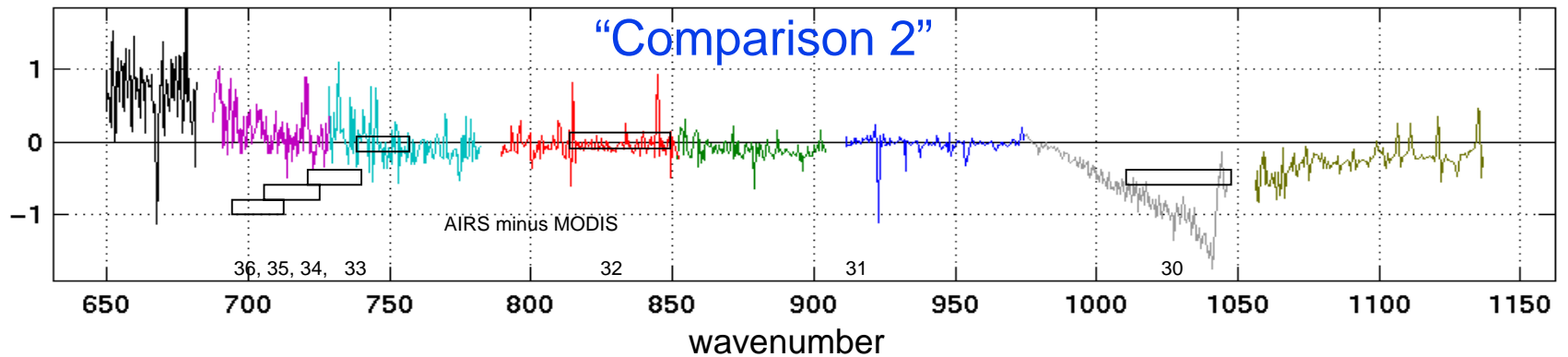
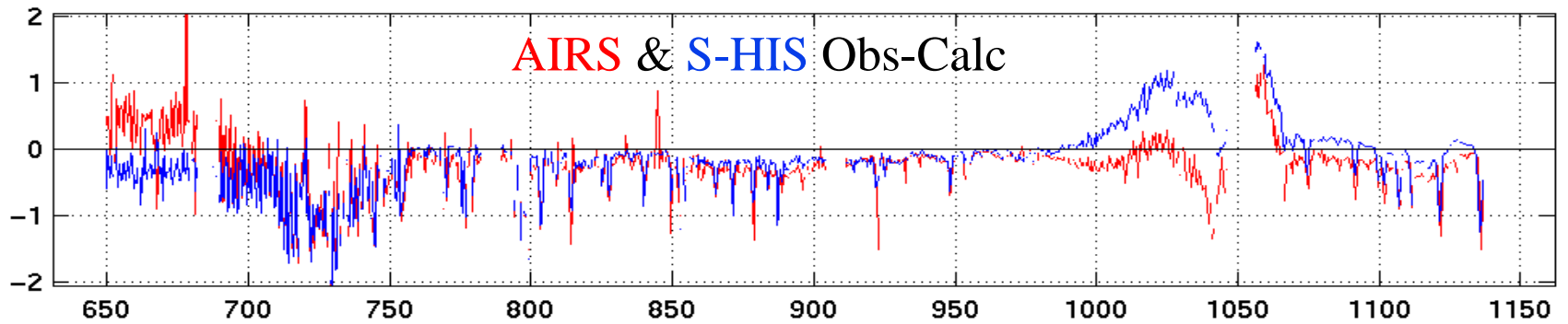
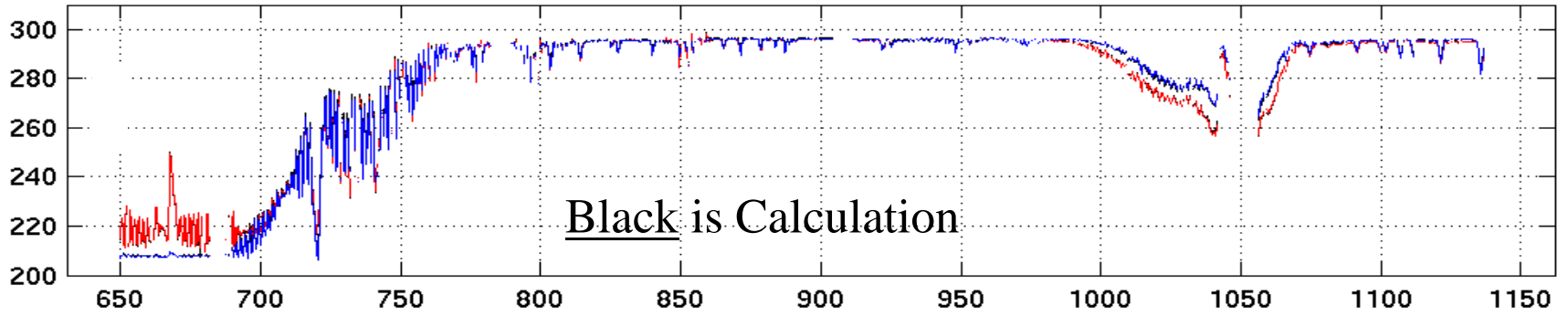


“comparison 0”

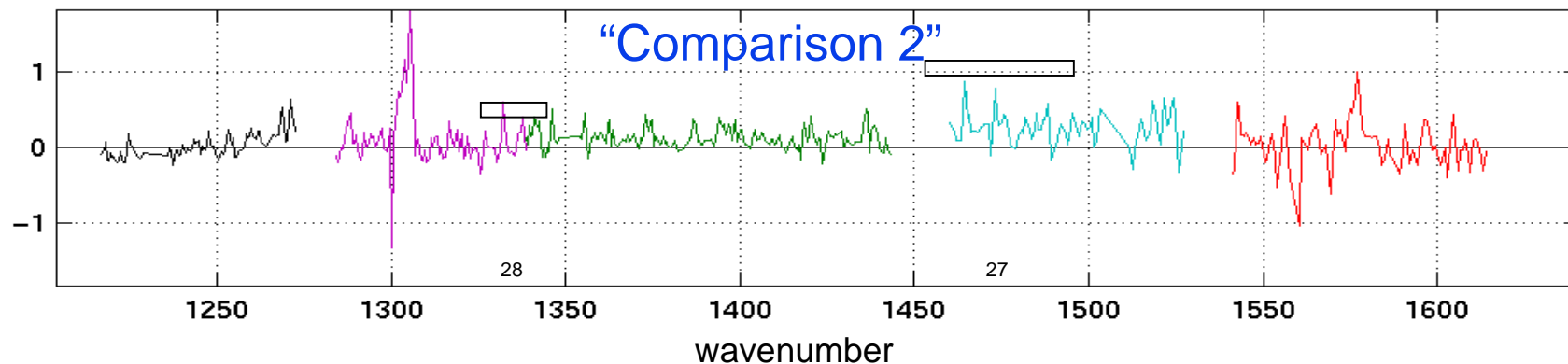
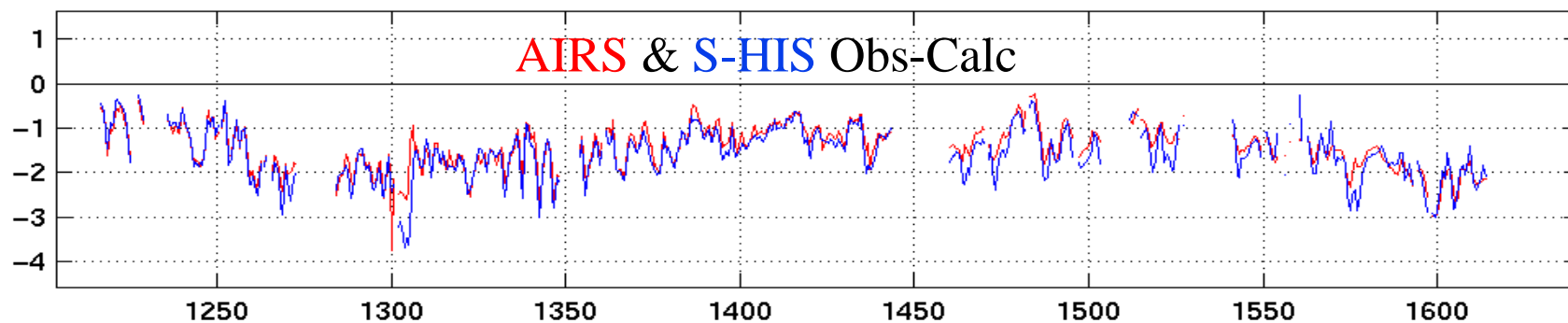
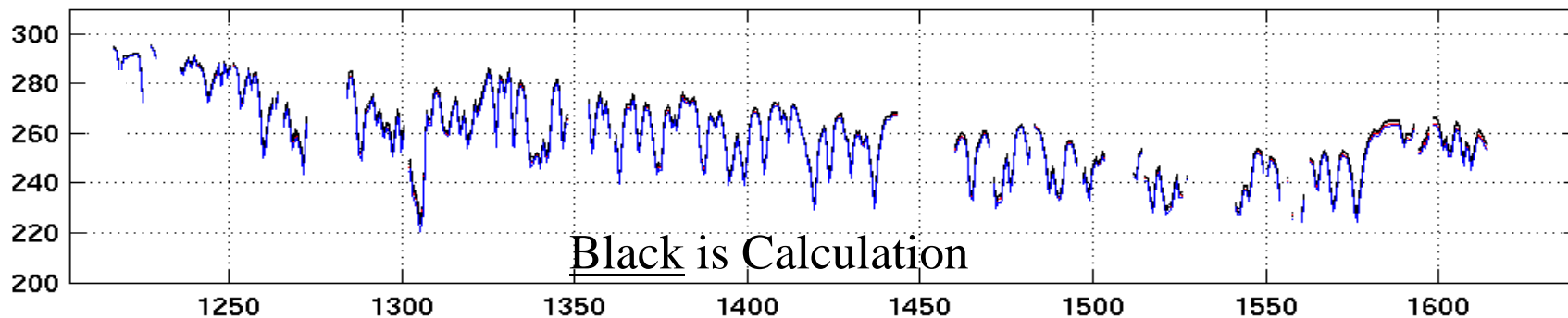
8 AIRS FOVs, 448 SHIS FOVs, PC filtering



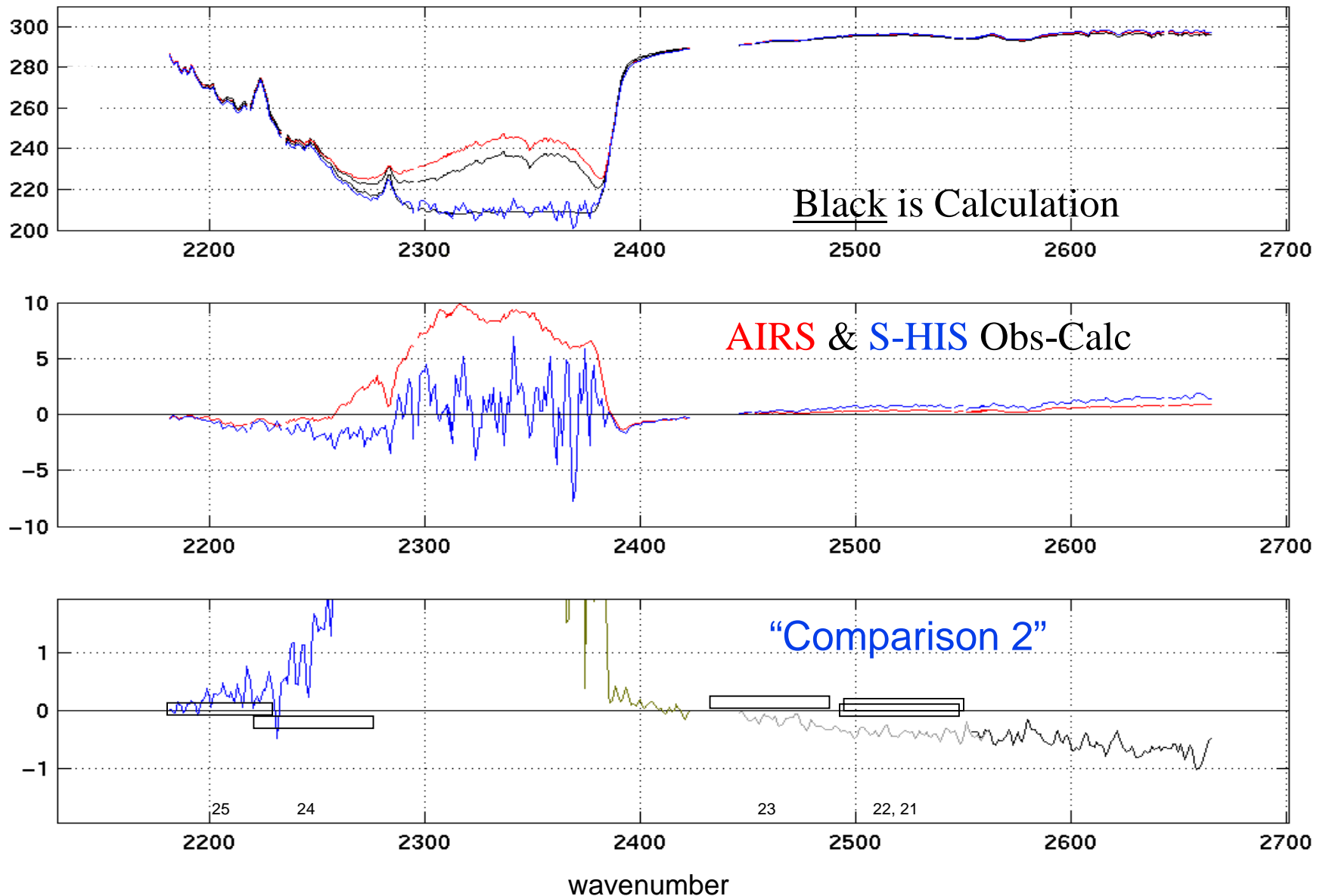
AIRS Compared to S-HIS, 21 Nov 2002



AIRS Compared to S-HIS, 21 Nov 2002

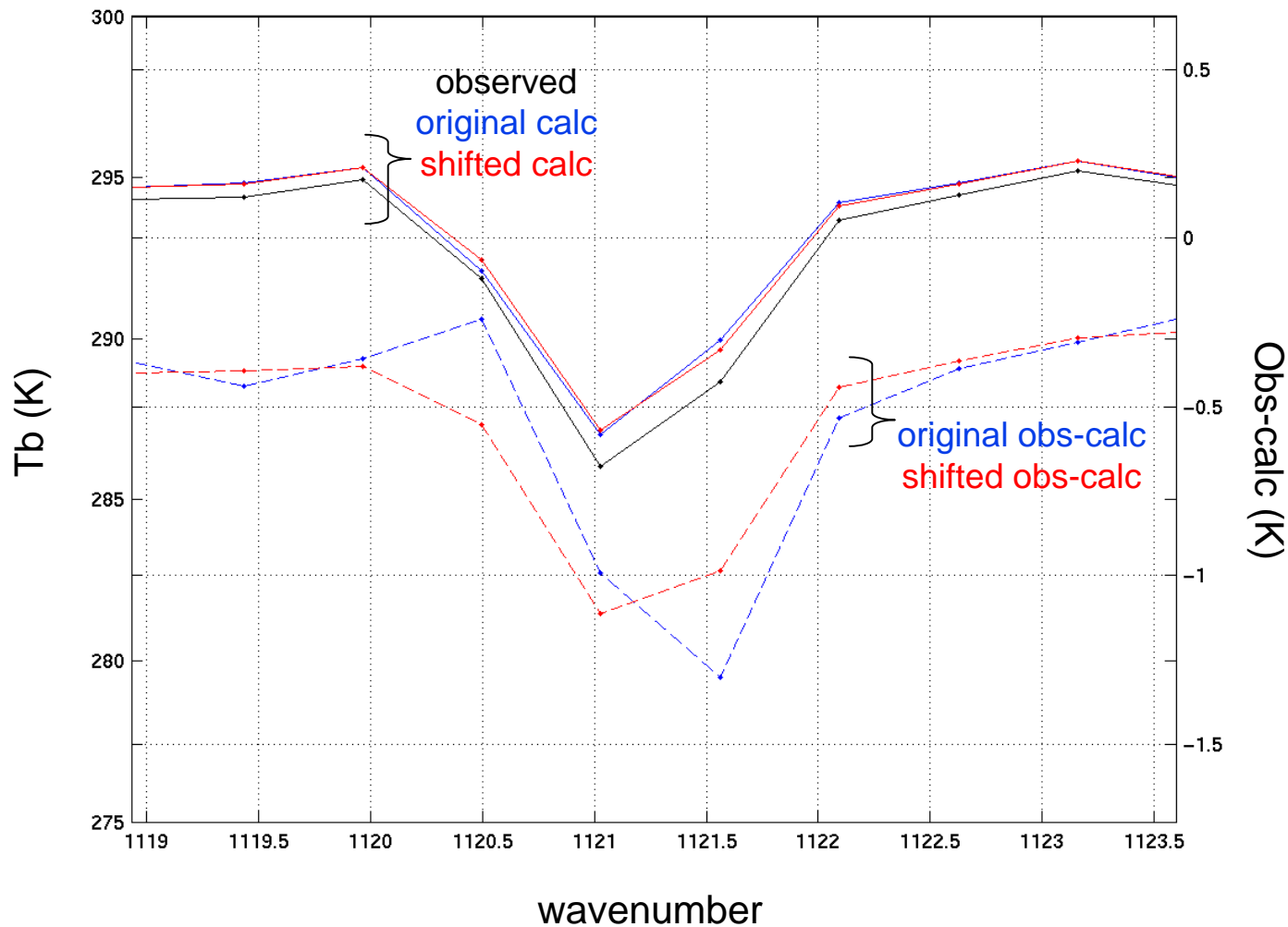


AIRS Compared to S-HIS, 21 Nov 2002



Different viewing angle make daytime comparisons less accurate

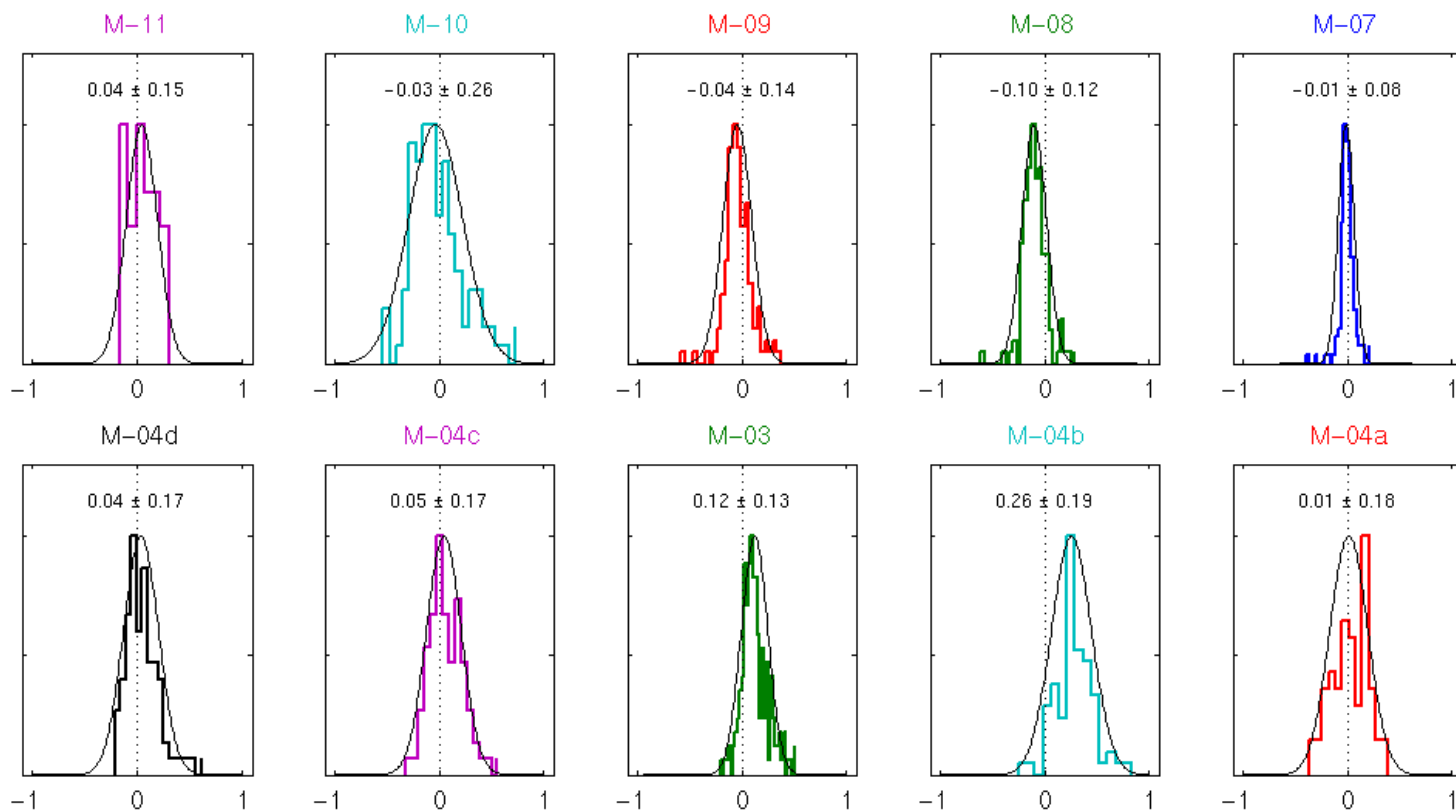
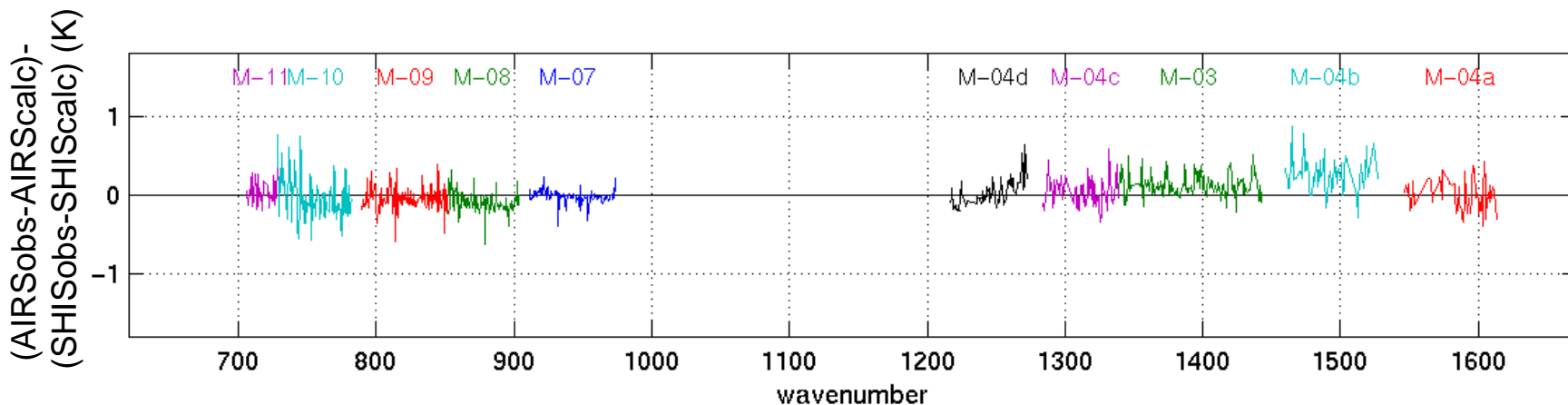
Small Spectral Shift (3% of resolution) in AIRS Module-05 identified from S-HIS Validation



Tobin, et al., CALCON 2003, presented S-HIS Spectral Calibration

“Comparison 2” (21 November 2002)

Excluding channels strongly affected by atmosphere above ER2



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

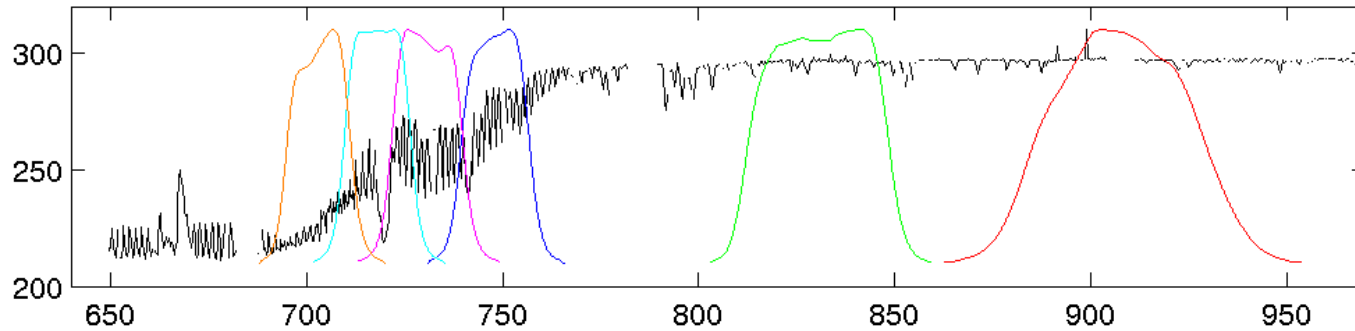
**High Spectral Resolution is an
important part of the reason
(Goody & Haskins, J Climate, 1998)**

A world map with a light blue background and dark blue outlines of continents, serving as a background for the title text.

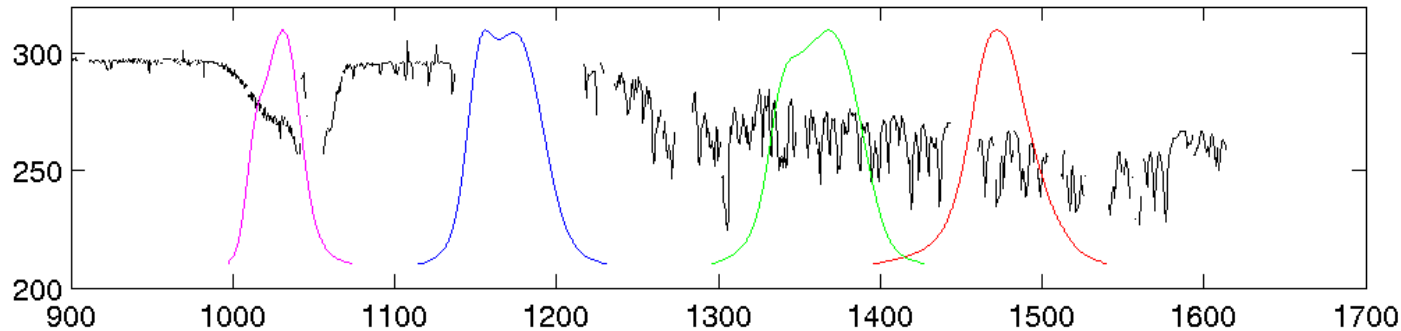
AIRS Assessment of MODIS Calibration

AIRS spectrum and Aqua MODIS Band Spectral Response Functions

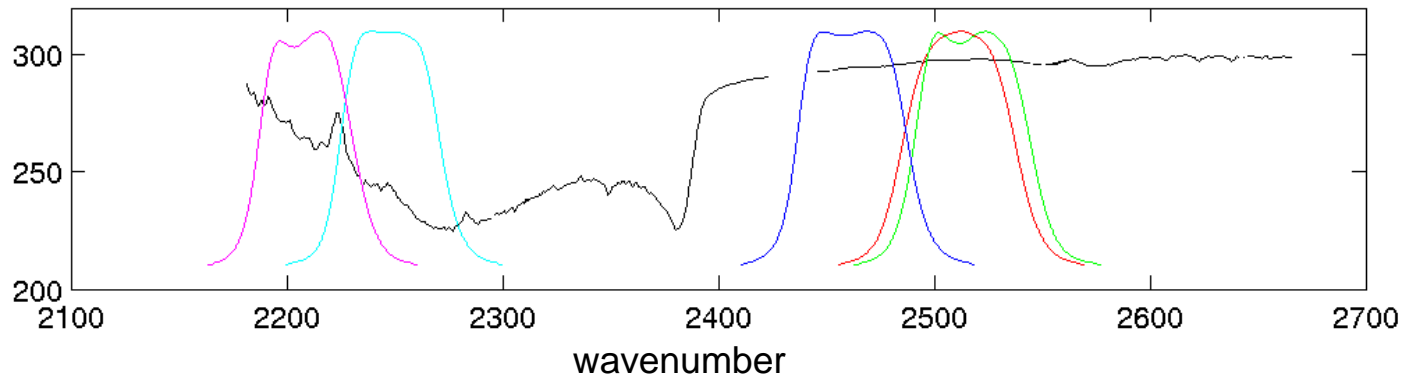
MODIS Band /
wavelength(μm)



36 / 14.2
35 / 13.9
34 / 13.7
33 / 13.4
32 / 12.0
31 / 11.0



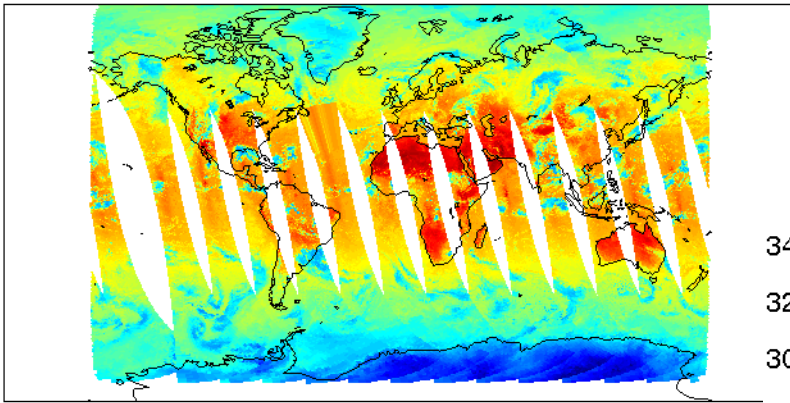
30 / 11.0
29 / 9.7
28 / 7.3
27 / 6.8



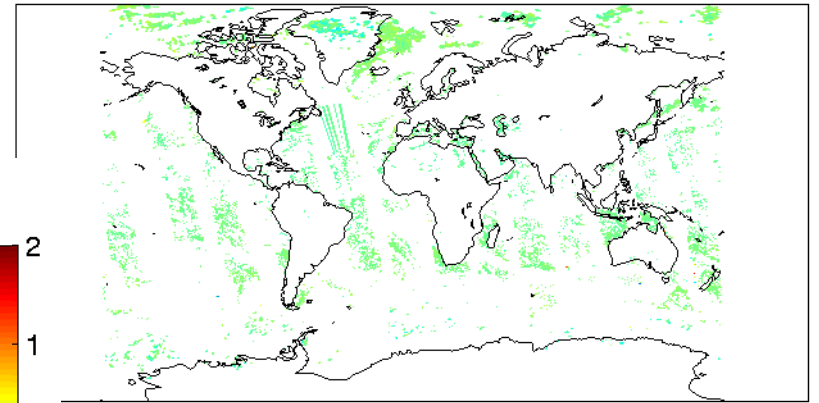
25 / 4.5
24 / 4.4
23 / 4.1
22 / 4.0
21 / 4.0

wavenumber

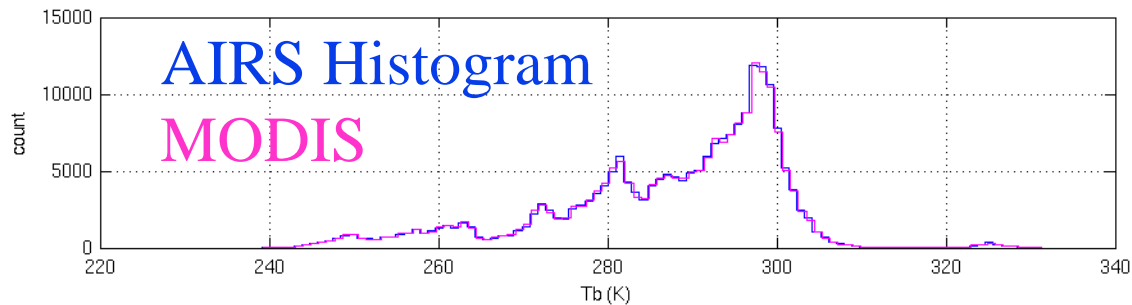
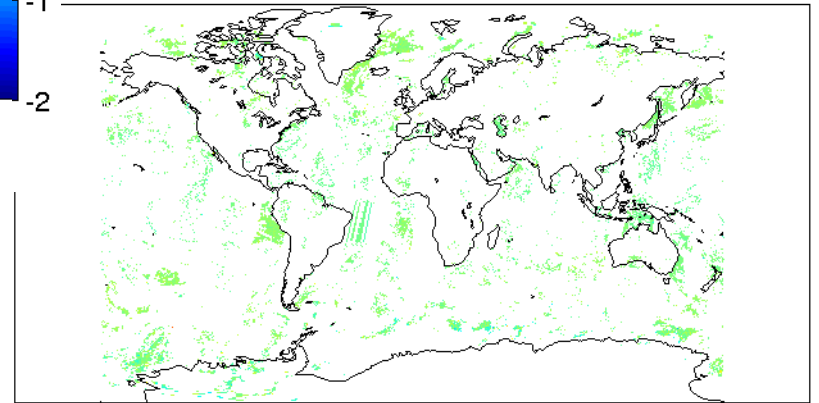
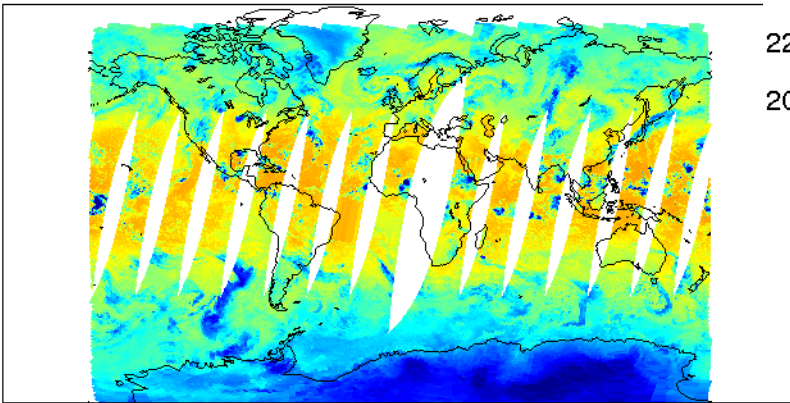
Fantastic AIRS - MODIS Agreement for Band 22 (4.0 μ m)!



AIRS Tb (K)



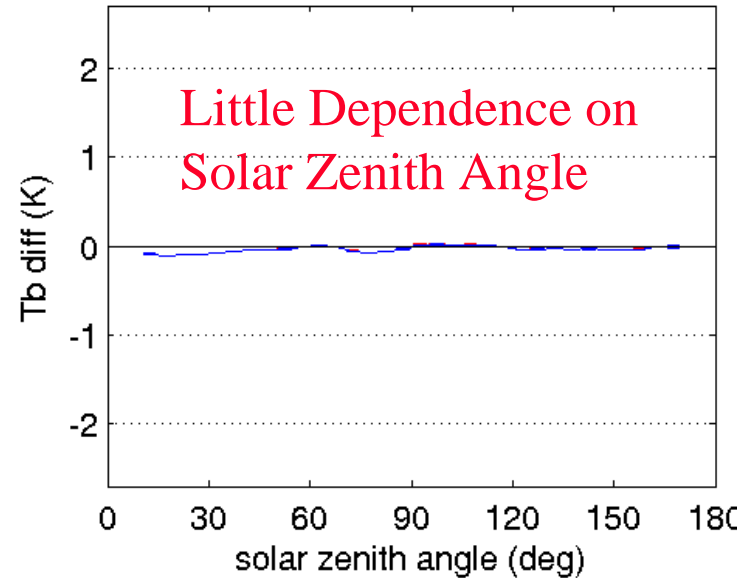
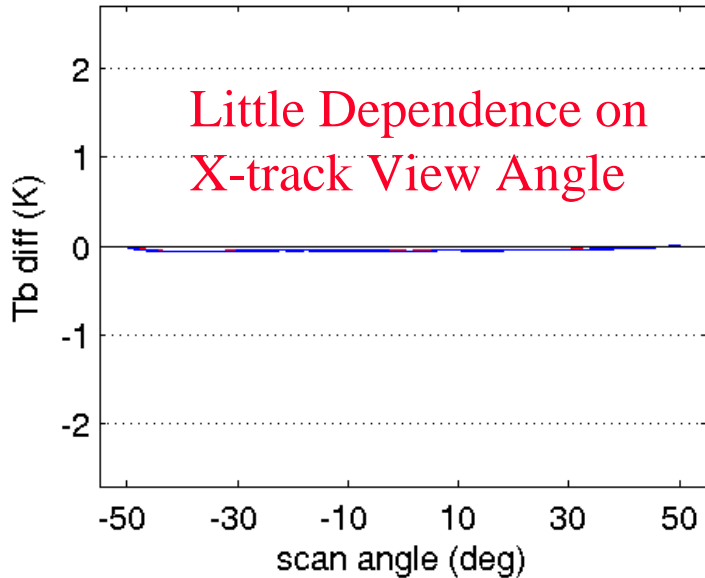
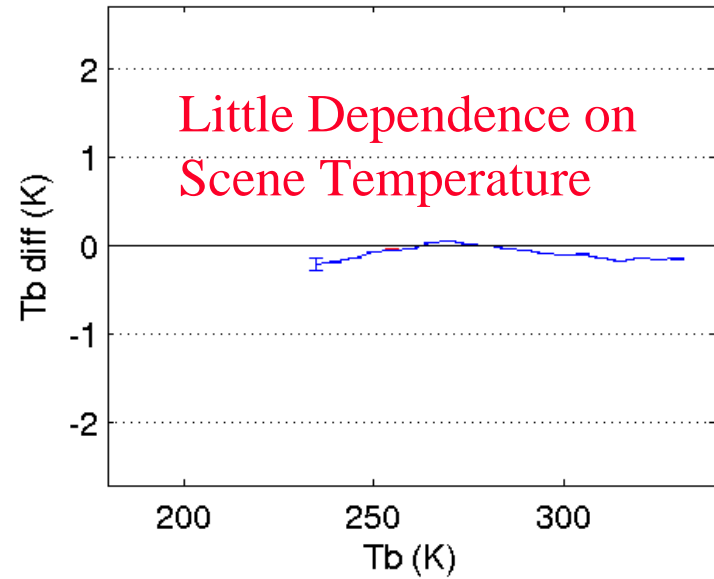
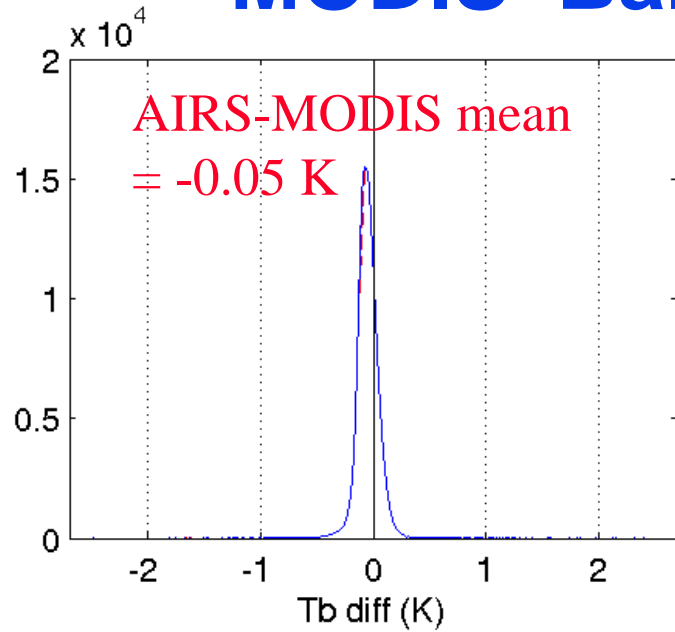
AIRS minus MODIS (K)



AIRS Histogram
MODIS

Uniform Scenes
Selected

MODIS Band 22 (4.0 μ m)

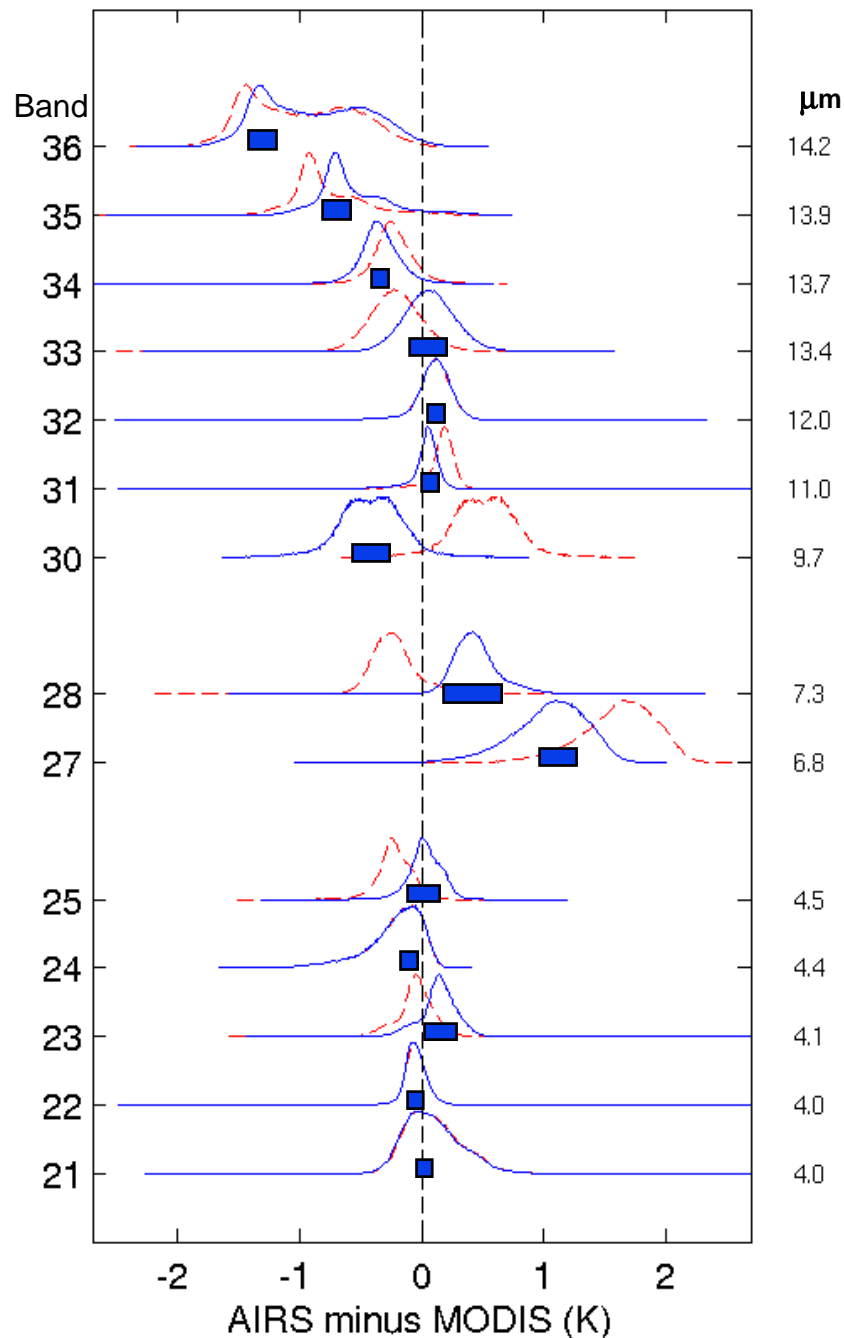


Summary of AIRS-MODIS mean Tb differences

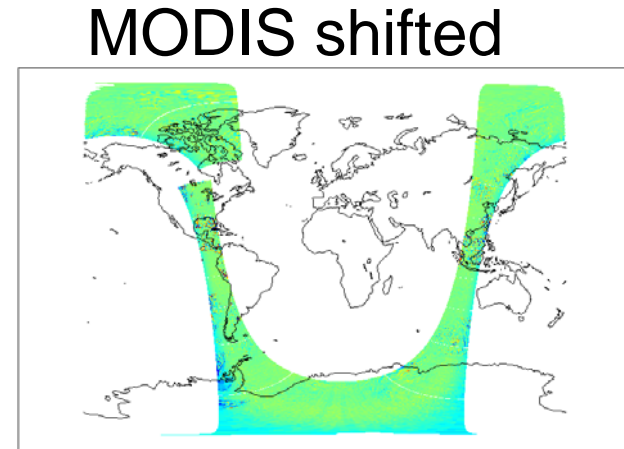
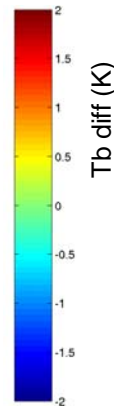
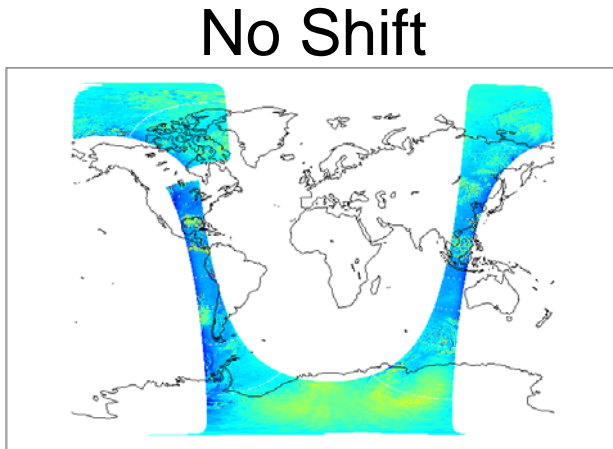
Red=without accounting for convolution error
Blue=accounting for convolution error with mean correction from standard atmospheres

■ p-p Convolution Error (CE) Estimate

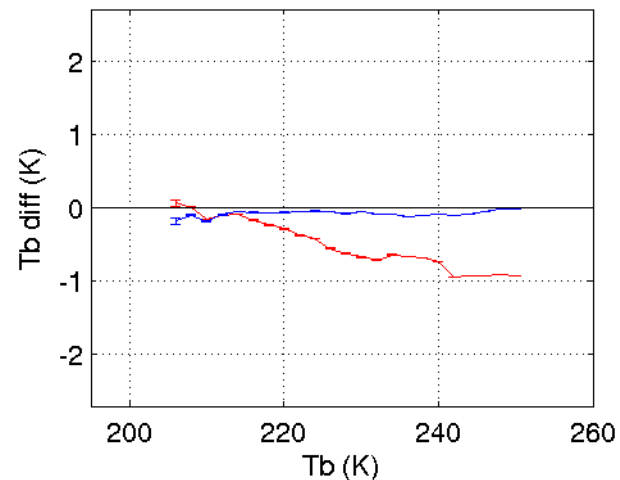
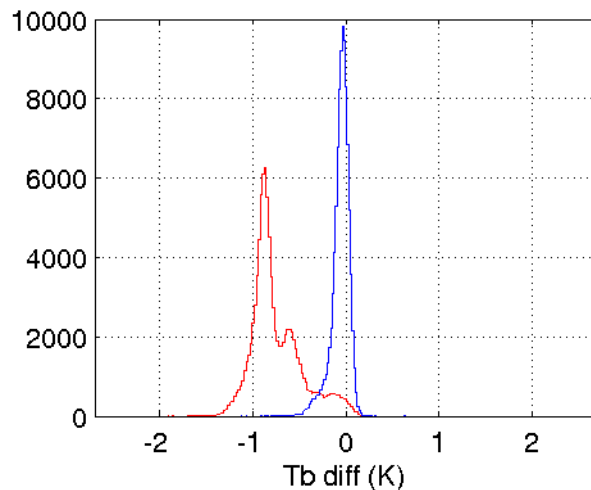
| Band | Diff | CE | Diff | Std | N |
|------|-------|-------|-------|------|---------|
| 21 | 0.10 | -0.01 | 0.09 | 0.23 | 187487 |
| 22 | -0.05 | -0.00 | -0.05 | 0.10 | 210762 |
| 23 | -0.05 | 0.19 | 0.14 | 0.16 | 244064 |
| 24 | -0.23 | 0.00 | -0.22 | 0.24 | 559547 |
| 25 | -0.22 | 0.25 | 0.03 | 0.13 | 453068 |
| 27 | 1.62 | -0.57 | 1.05 | 0.30 | 1044122 |
| 28 | -0.19 | 0.67 | 0.48 | 0.25 | 1149593 |
| 30 | 0.51 | -0.93 | -0.41 | 0.26 | 172064 |
| 31 | 0.16 | -0.13 | 0.03 | 0.12 | 322522 |
| 32 | 0.10 | 0.00 | 0.10 | 0.16 | 330994 |
| 33 | -0.21 | 0.28 | 0.07 | 0.21 | 716940 |
| 34 | -0.23 | -0.11 | -0.34 | 0.15 | 1089663 |
| 35 | -0.78 | 0.21 | -0.57 | 0.28 | 1318406 |
| 36 | -0.99 | 0.12 | -0.88 | 0.43 | 1980369 |



Shifting MODIS Band 35 (13.9 μm) by 0.8 cm^{-1} Works to Remove Mean bias and Scene Tb Dependence



AIRS-MODIS: un-shifted, shifted



(ce (0.21K) not included here)

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 & climate applications, and a calibration reference for other IR instruments

Summary (2)

- High spectral resolution Aircraft comparisons provide a way to periodically test the absolute calibration of spacecraft instruments with instrumentation that can be carefully re-calibrated with reference standards on the ground.

This capability is especially valuable for assuring the long-term consistency and accuracy of weather and climate observations

International TOVS Study Conference, 13th, TOVS-13, Sainte Adele, Quebec, Canada, 29
October-4 November 2003. Madison, WI, University of Wisconsin-Madison, Space Science and
Engineering Center, Cooperative Institute for Meteorological Satellite Studies, 2003.