



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.

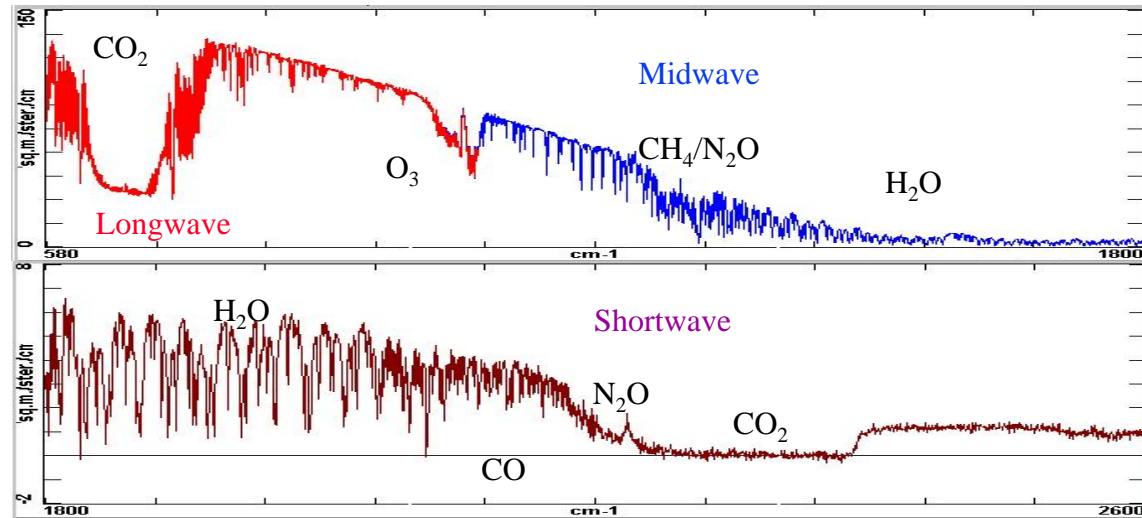
S-HIS Uplooking

UW Scanning HIS: 1998-Present

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

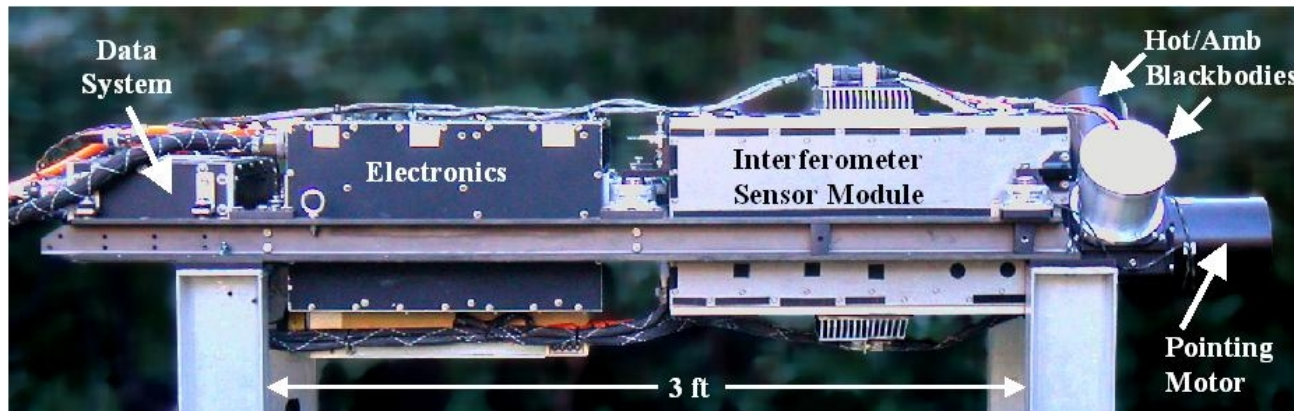
Characteristics

- 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



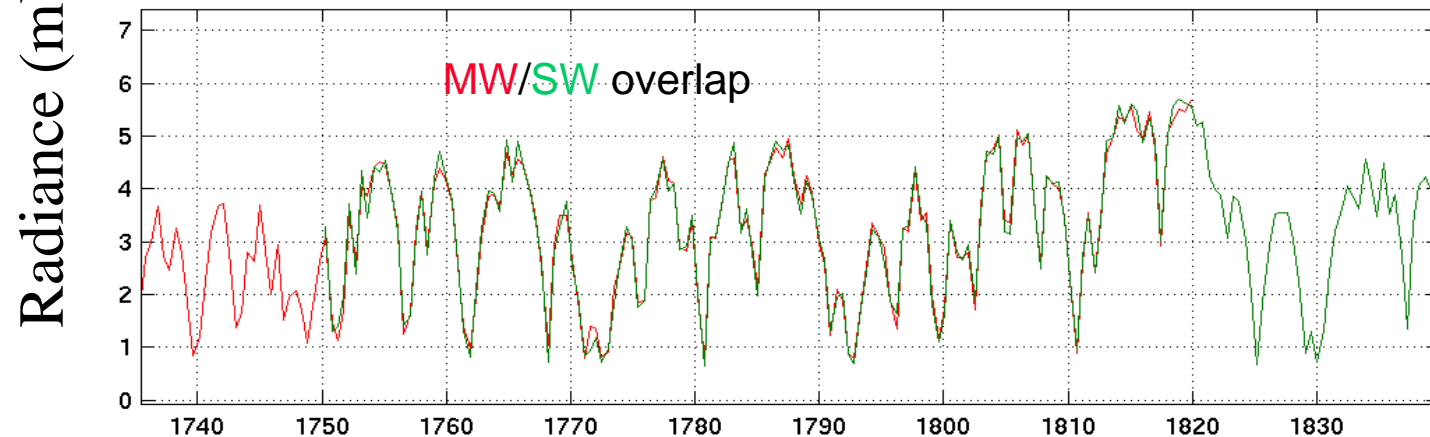
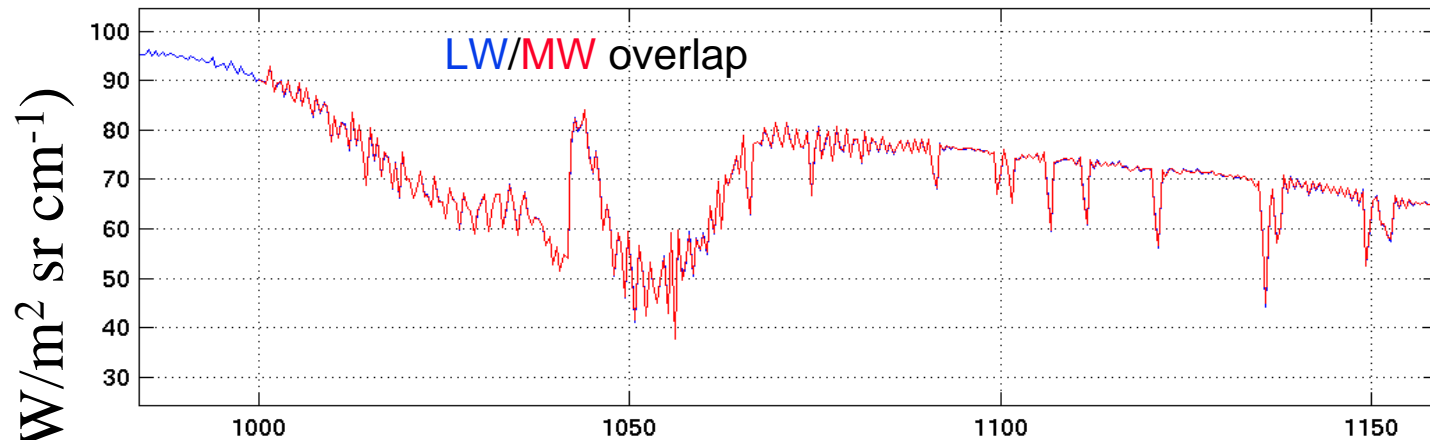
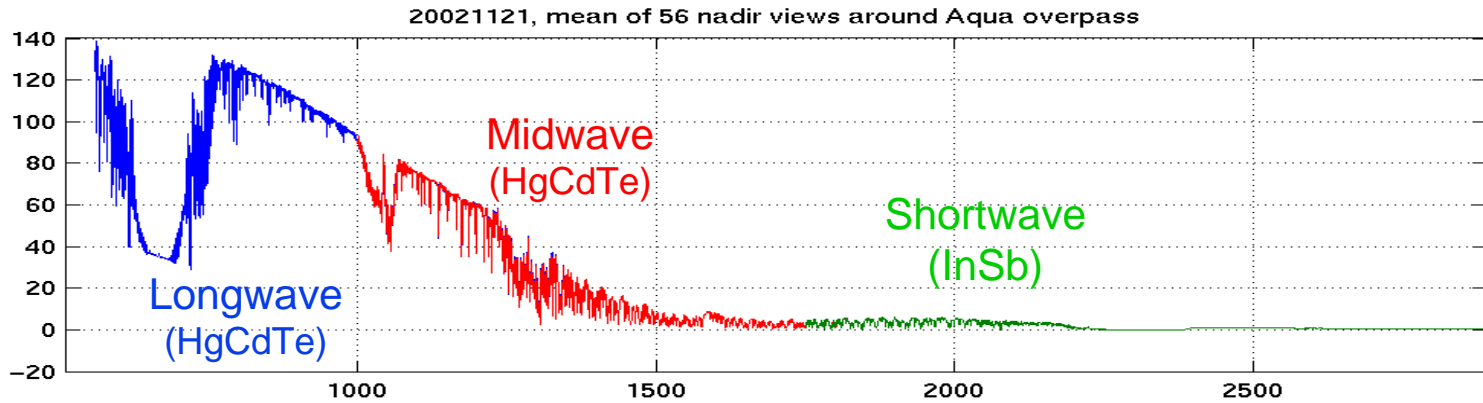
SSEC Scanning HIS on 1st ARM-UAV Mission with Proteus, October 2002



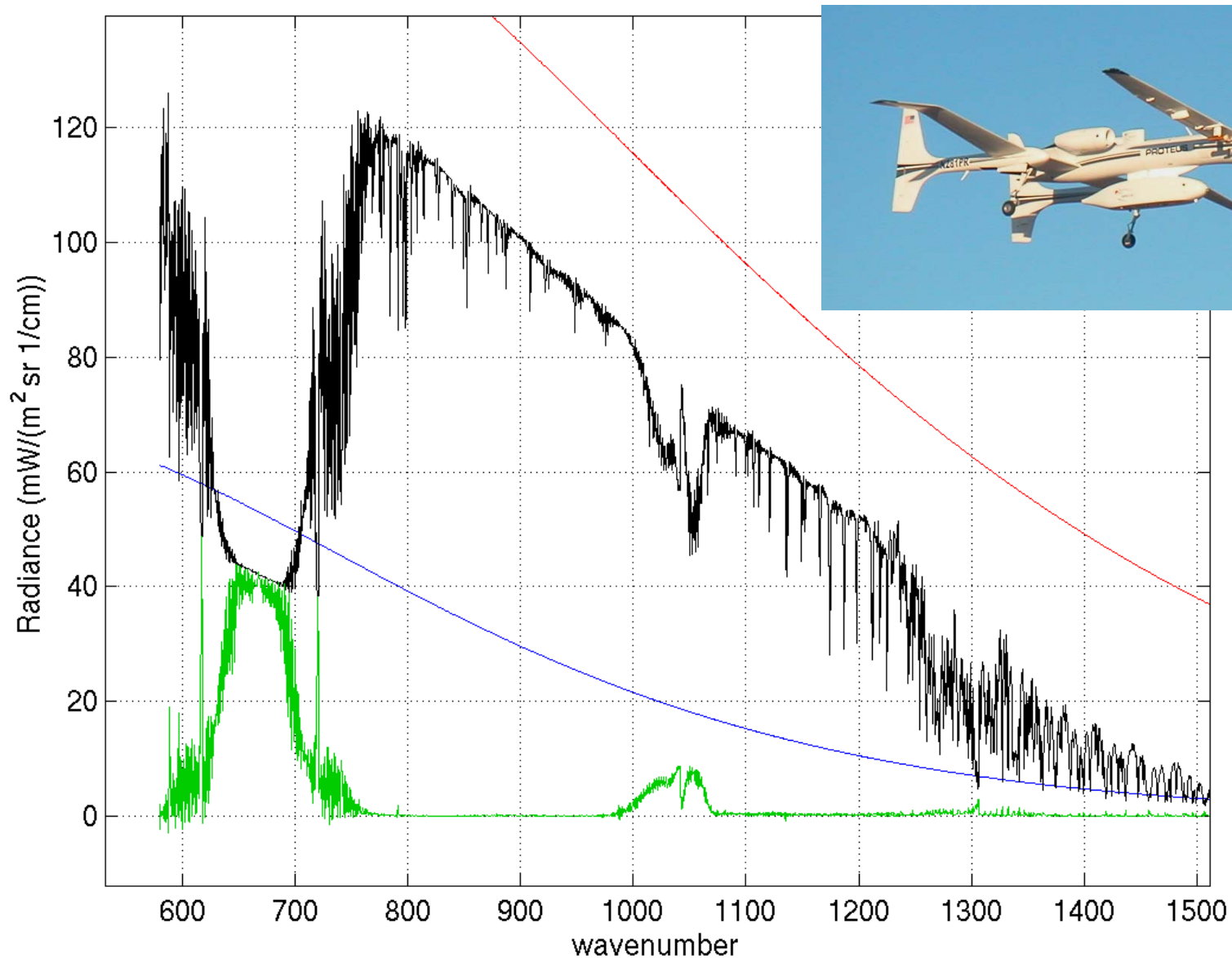
S-HIS scans cross-track downward & looks upward



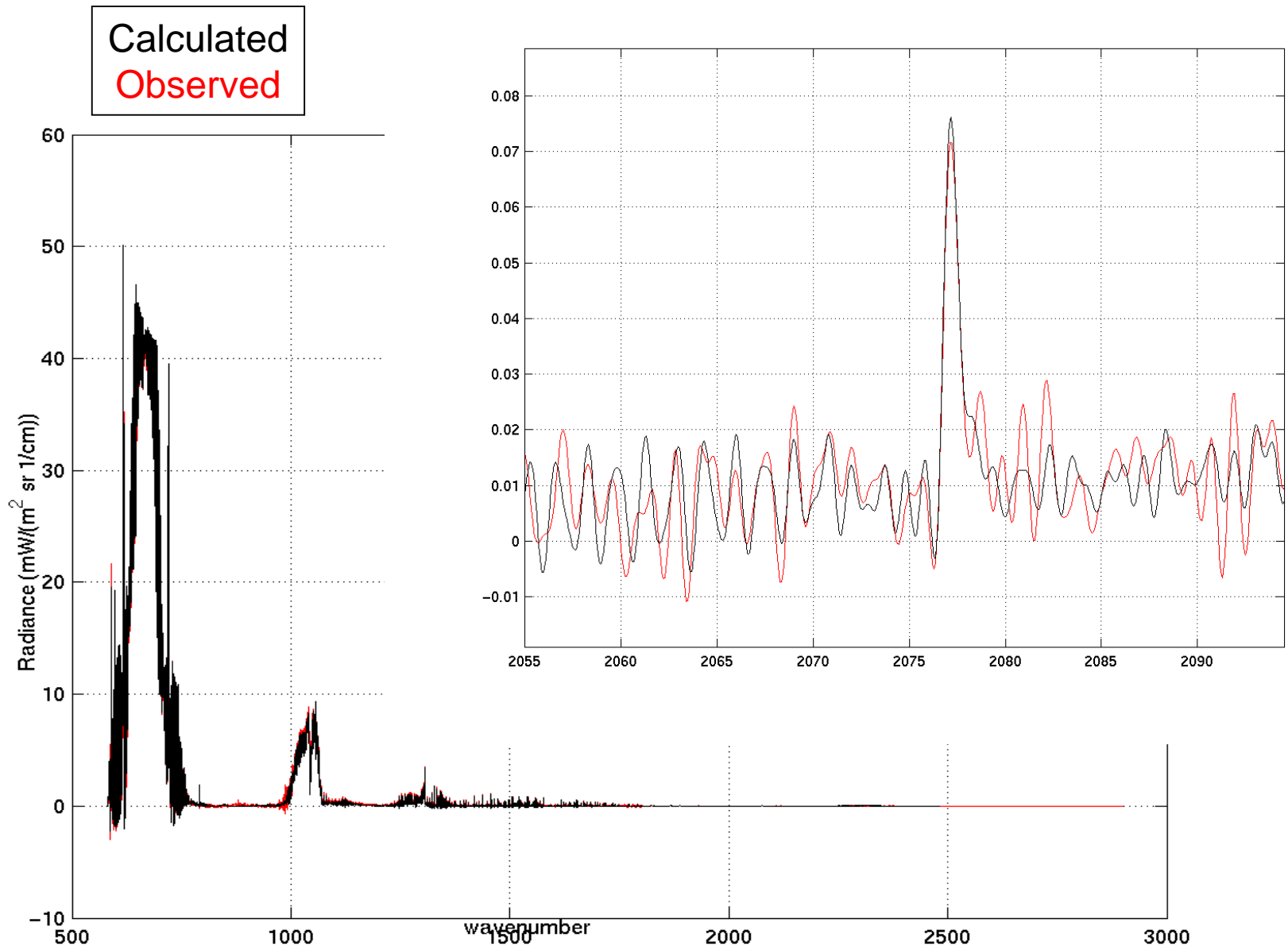
Scanning-HIS Band Overlap Agreement



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

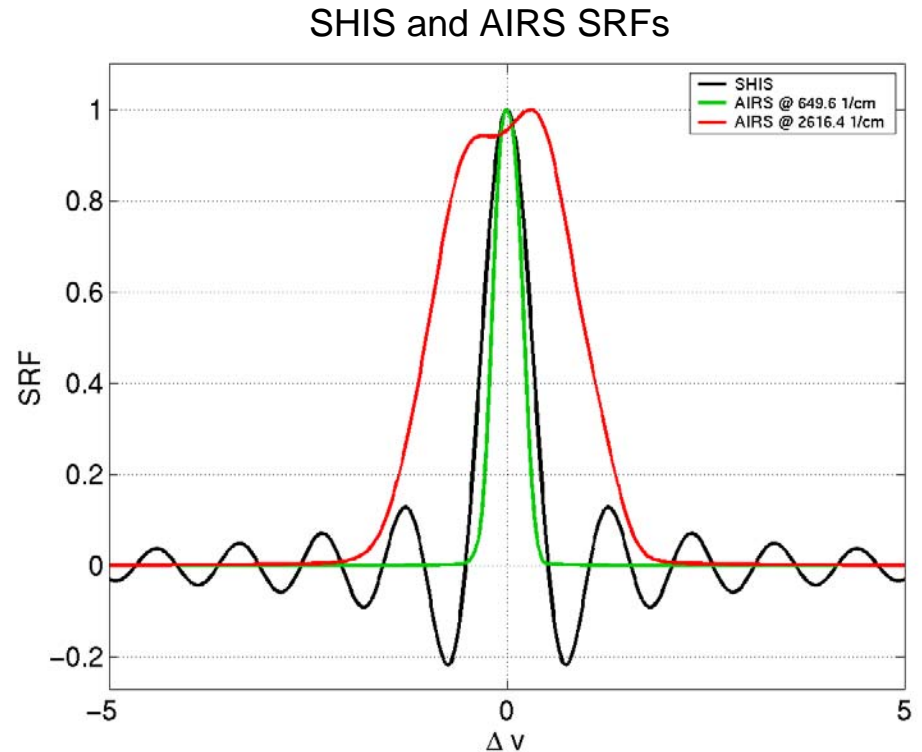
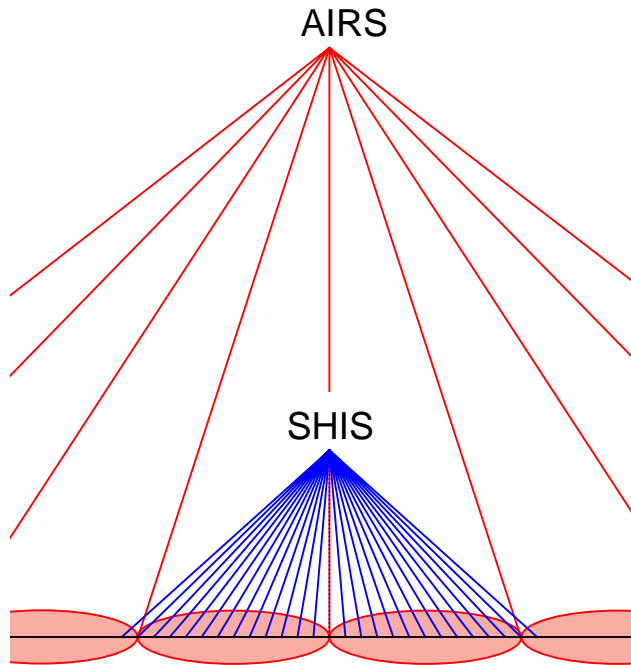
A world map with a light blue background and white landmasses, serving as a background for the title text.

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



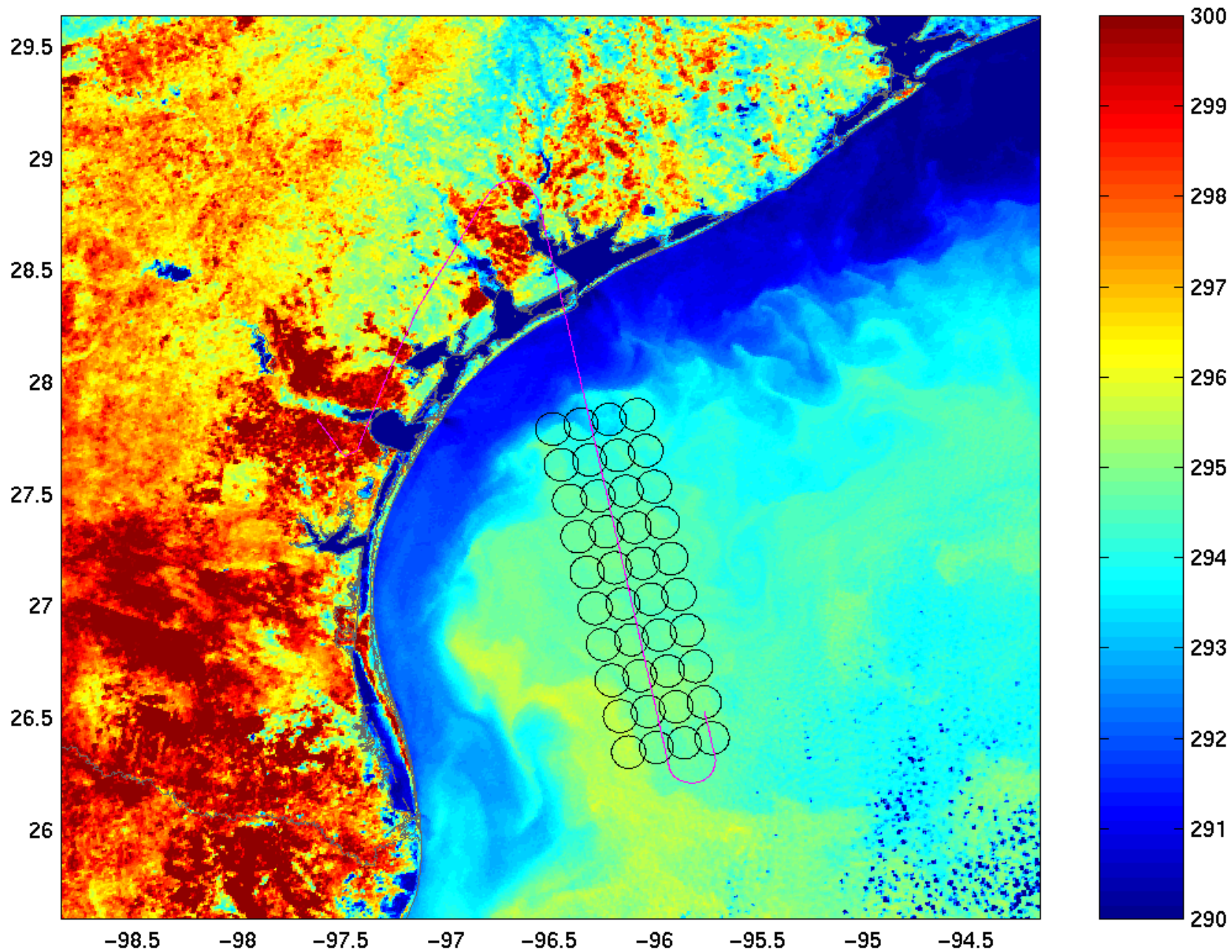
AIRS / SHIS Comparison steps

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

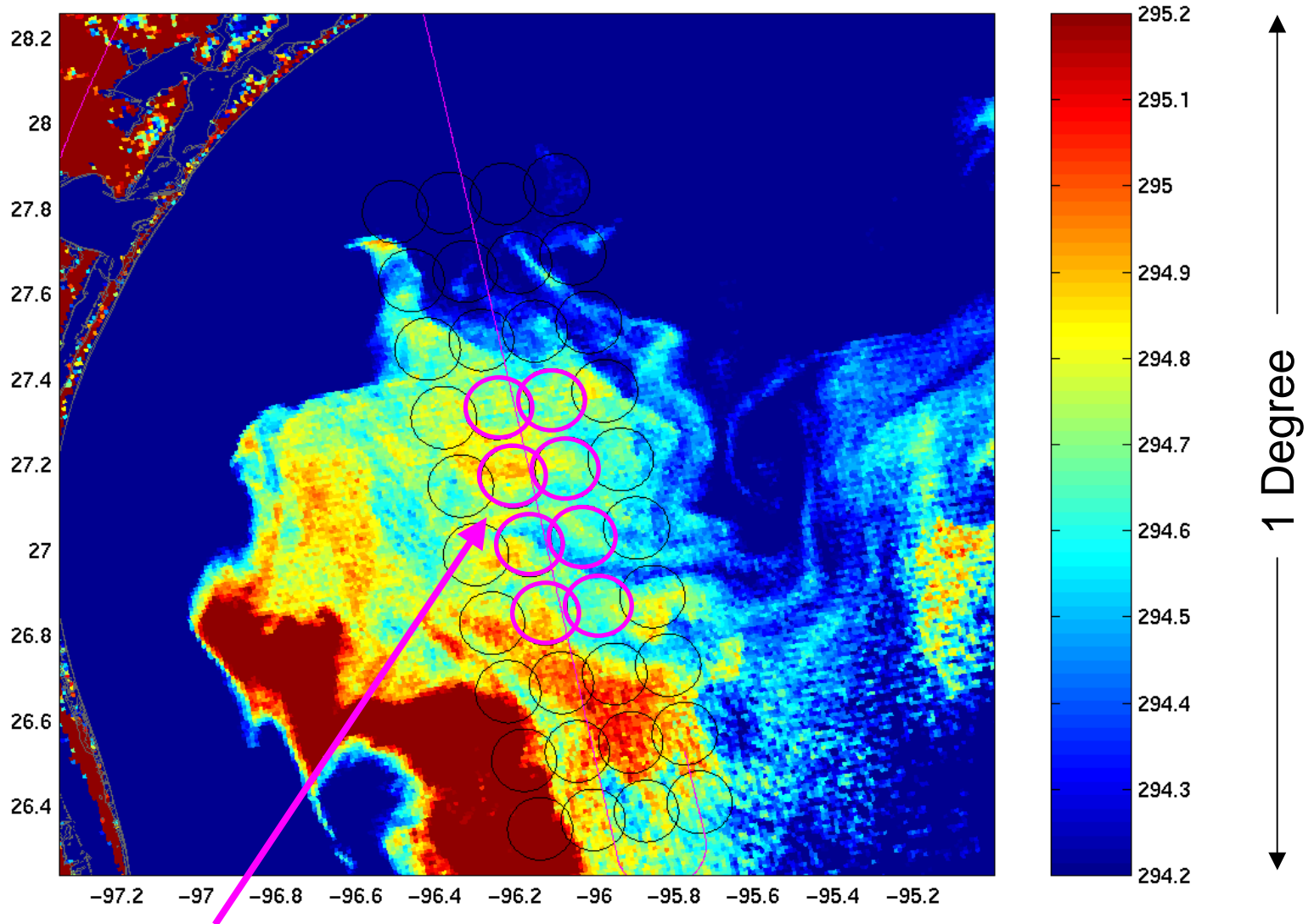
1. Compare Residuals from calculations:
 $(\text{obs-calc})_{\text{SHIS}}$ to $(\text{obs-calc})_{\text{AIRS}}$
 - SHIS and AIRS calcs each done at correct altitudes, view angles, spectral resolution and sampling.
 - Monochromatic calcs done using same forward model, atmospheric state, and surface property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



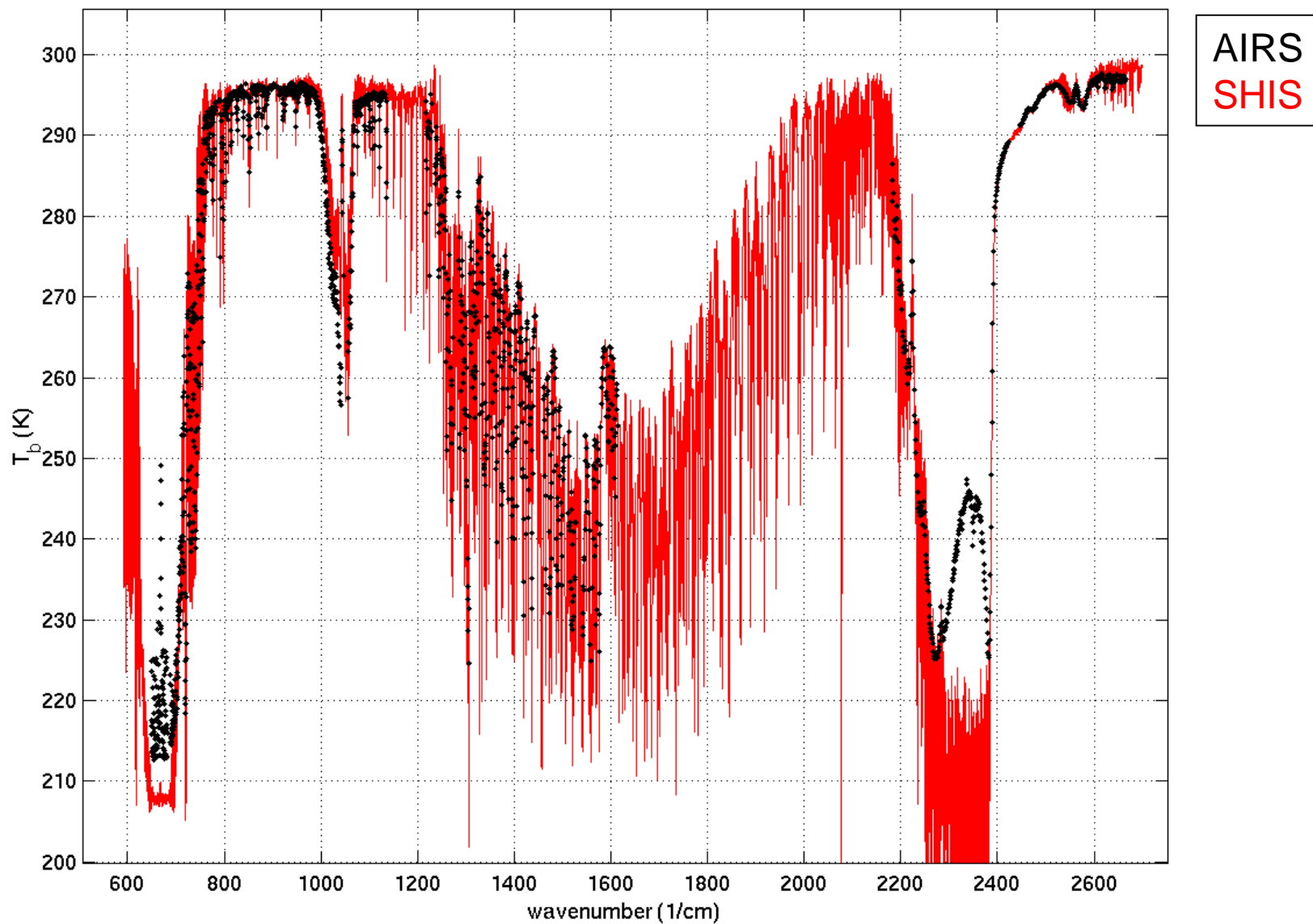
MODIS 12 micron Band & near-nadir AIRS FOVs



8 AIRS FOVs used in the following comparisons

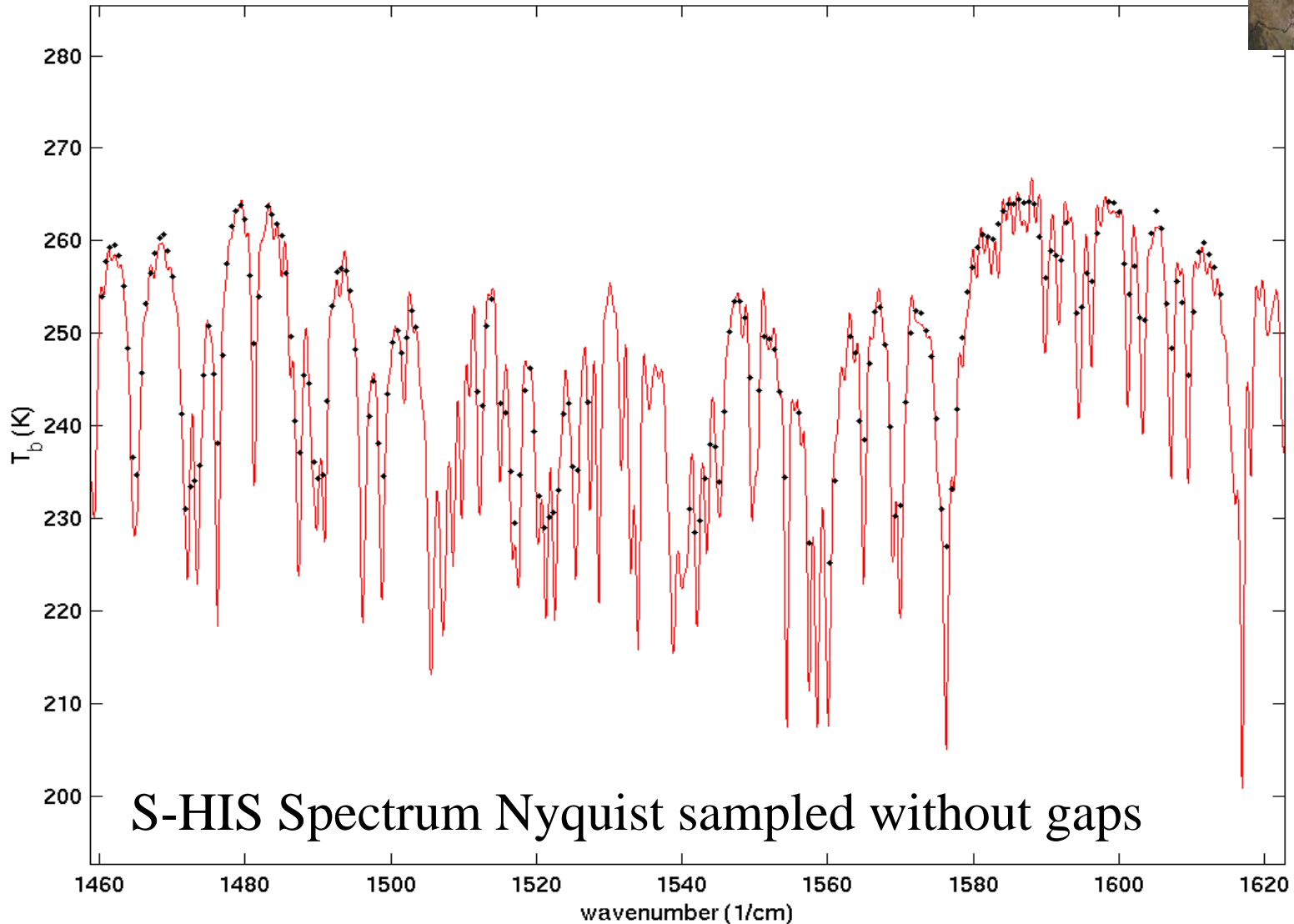
“comparison 0”

8 AIRS FOVs, 448 SHIS FOVs, PC filtering

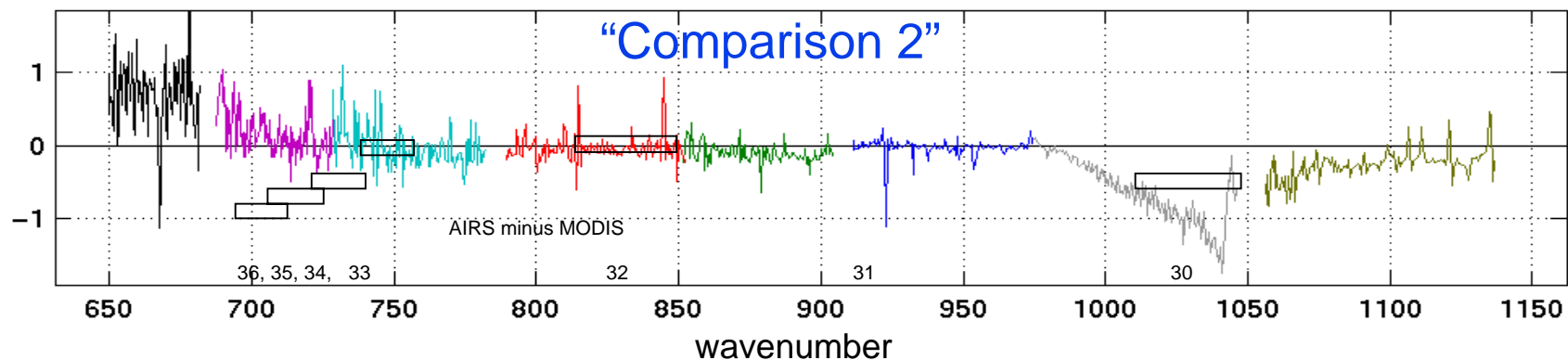
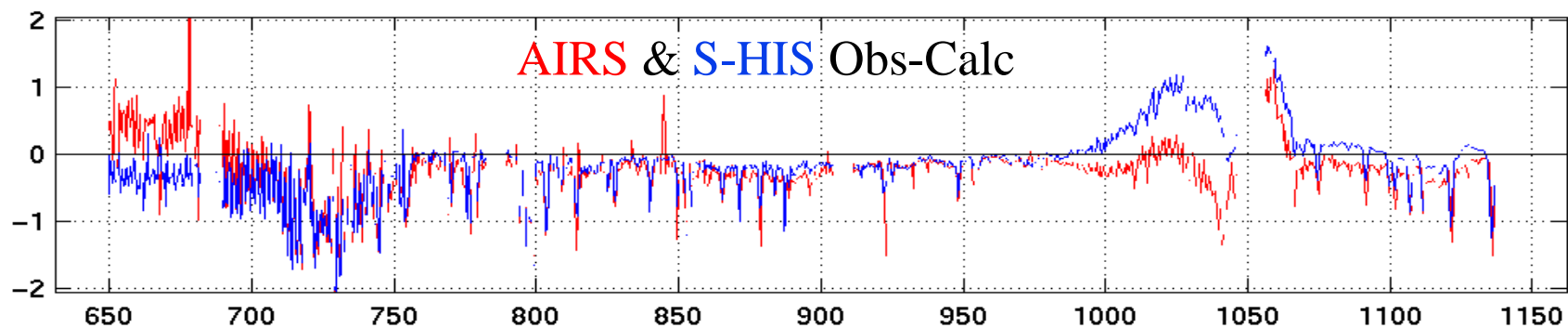
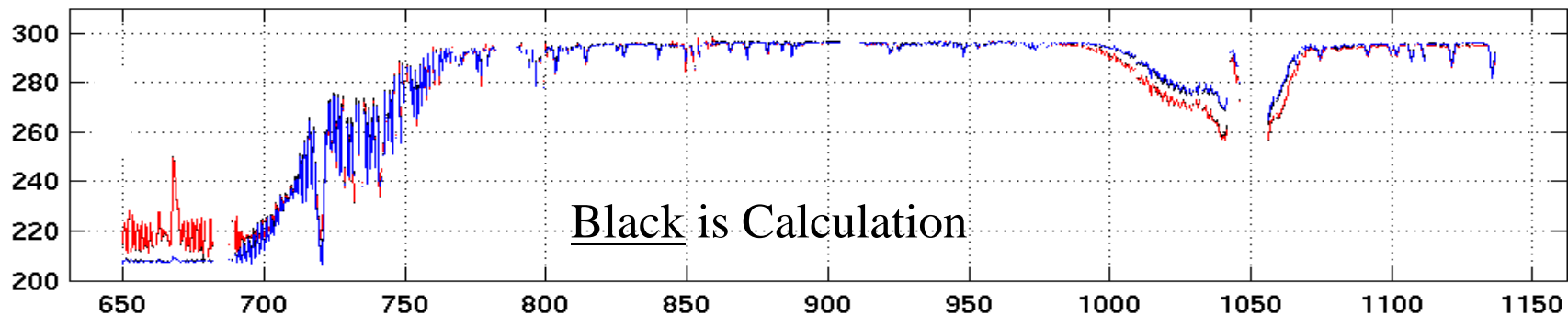


“comparison 0”

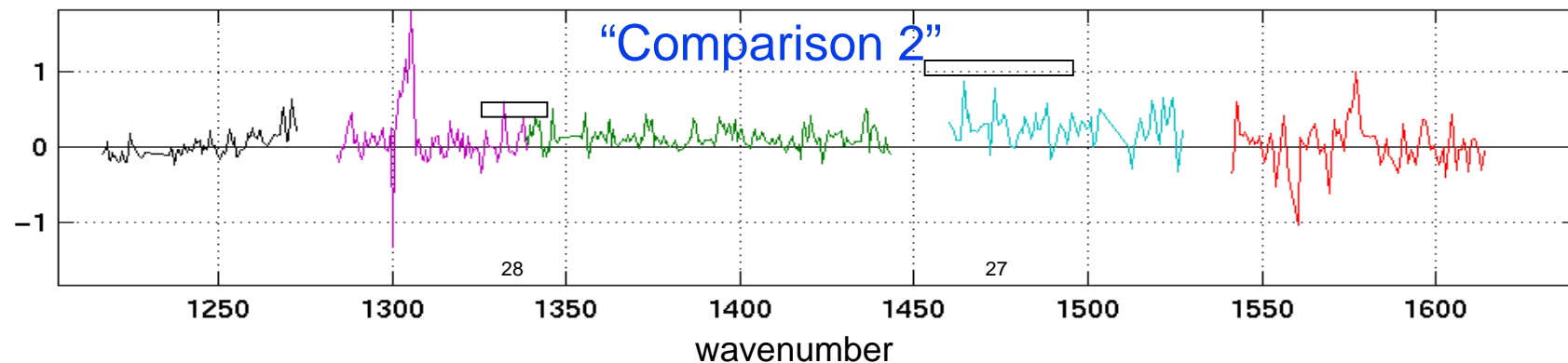
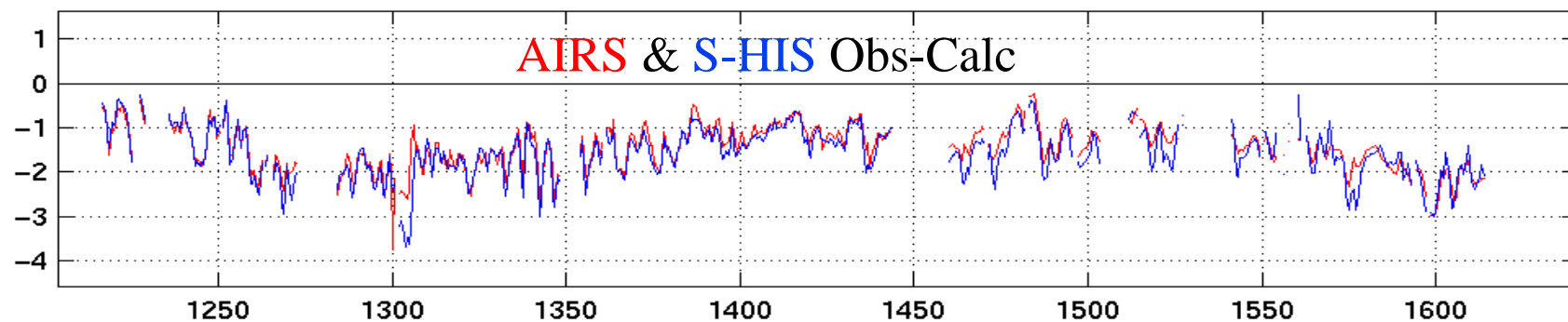
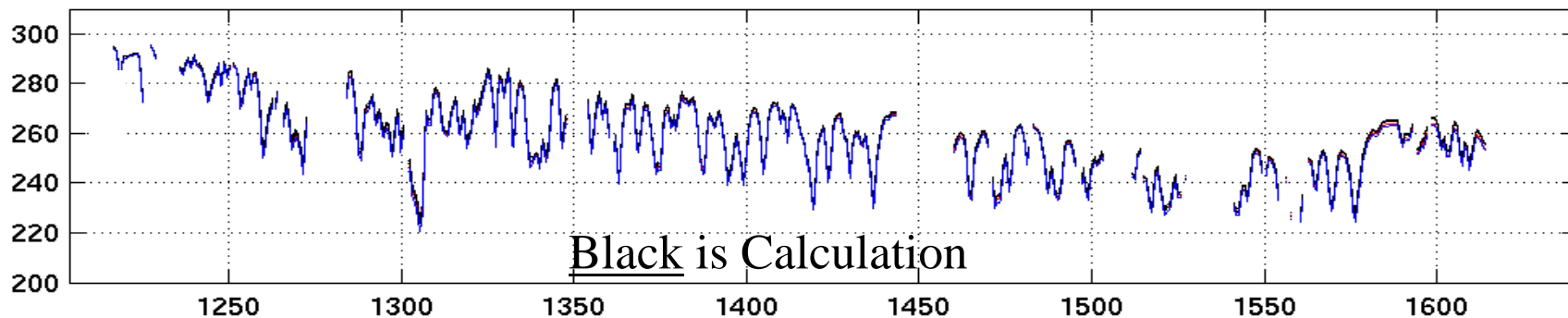
8 AIRS FOVs, 448 SHIS FOVs, PC filtering



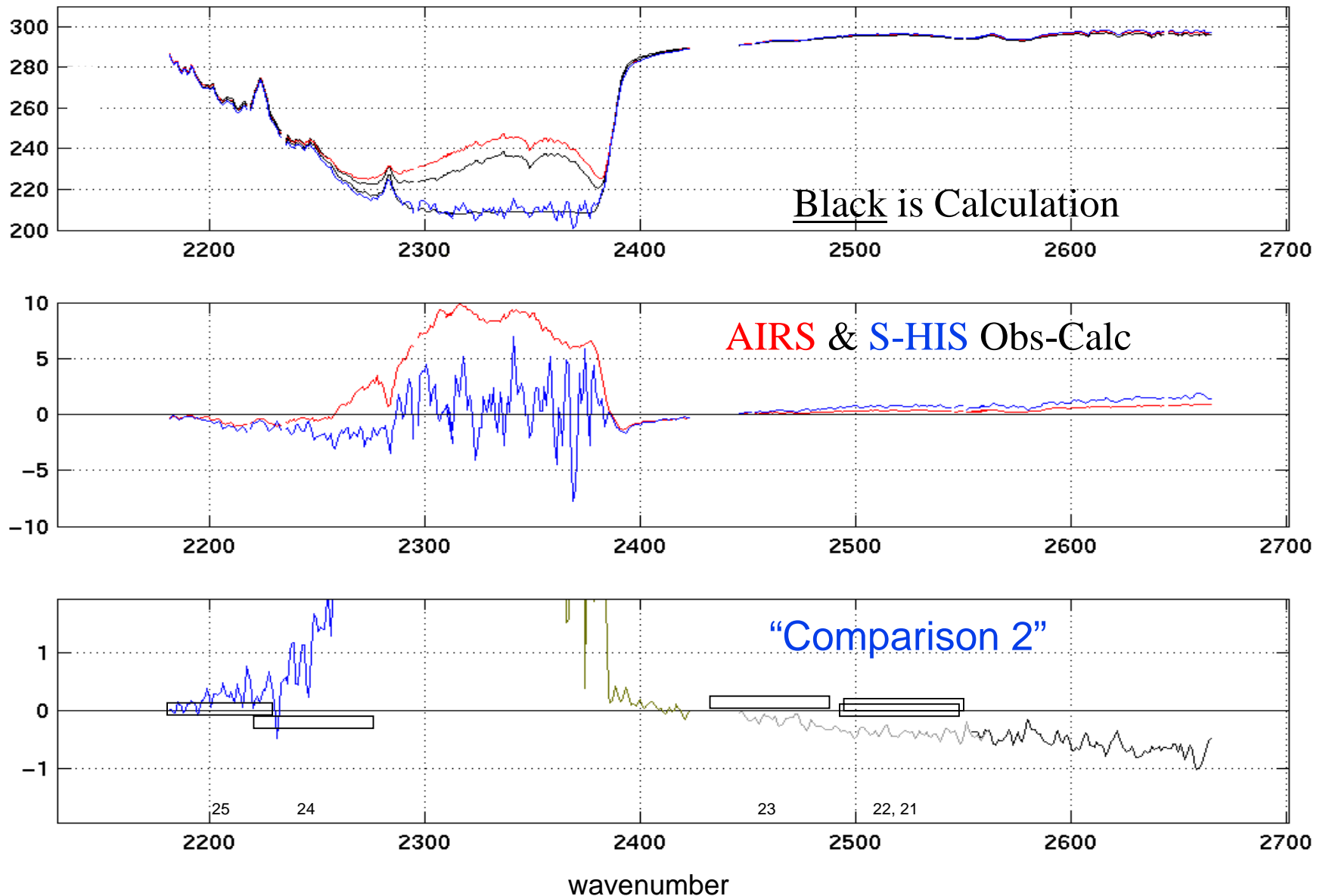
AIRS Compared to S-HIS, 21 Nov 2002



AIRS Compared to S-HIS, 21 Nov 2002

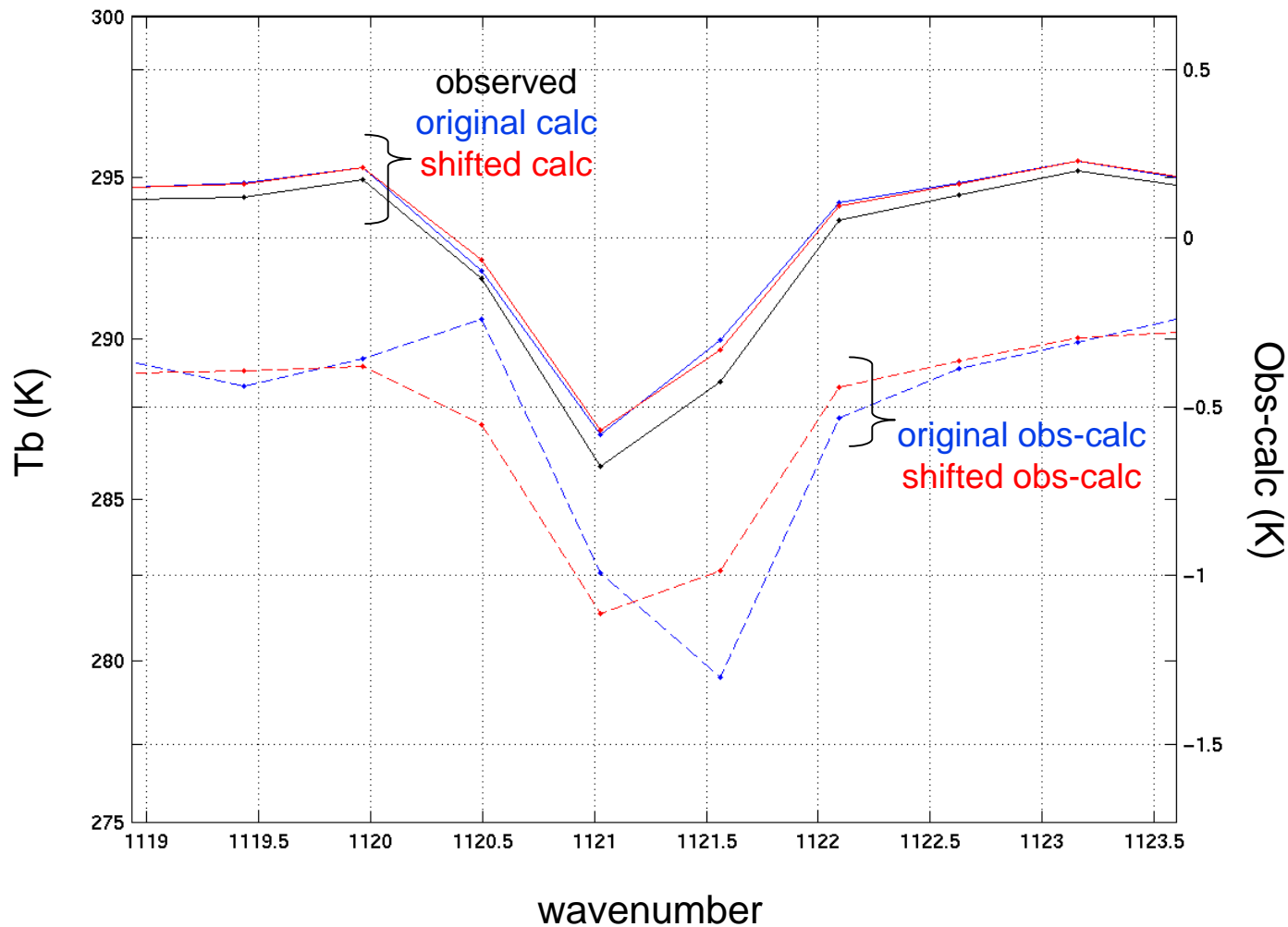


AIRS Compared to S-HIS, 21 Nov 2002



Different viewing angle make daytime comparisons less accurate

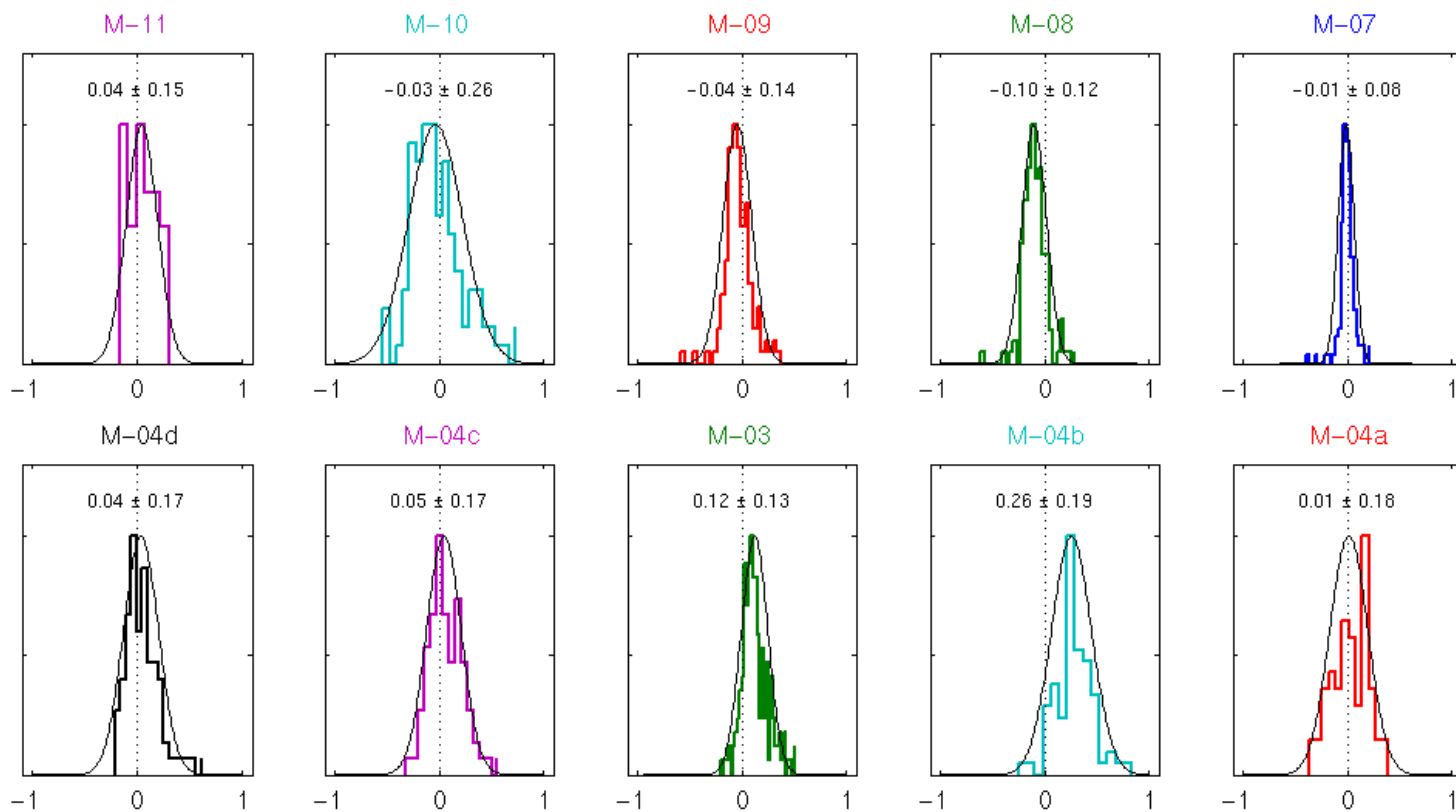
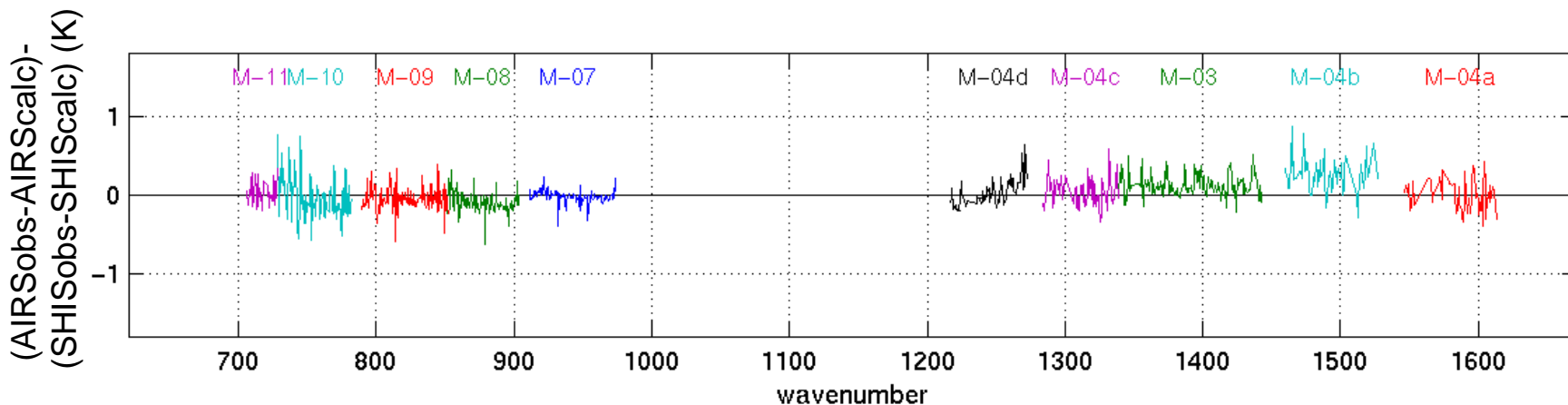
Small Spectral Shift (3% of resolution) in AIRS Module-05 identified from S-HIS Validation



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 !**

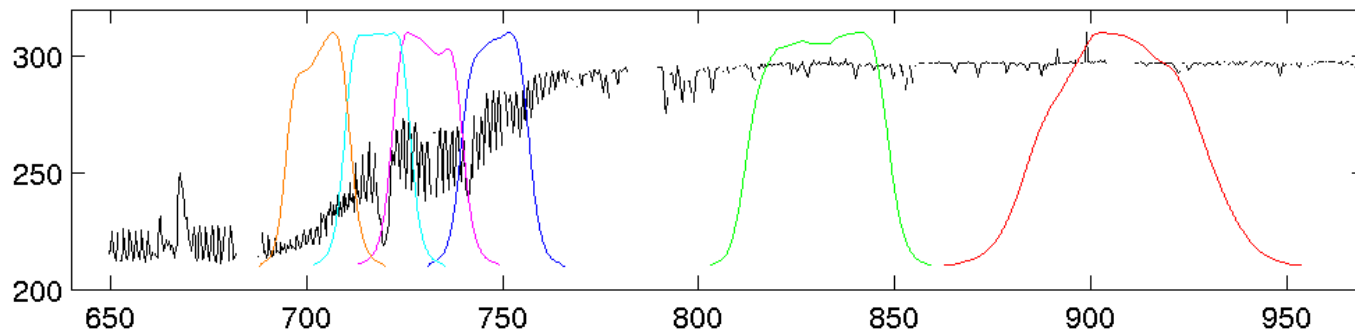
**High Spectral Resolution is an
important part of the reason
(Goody & Haskins, J Climate, 1998)**

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

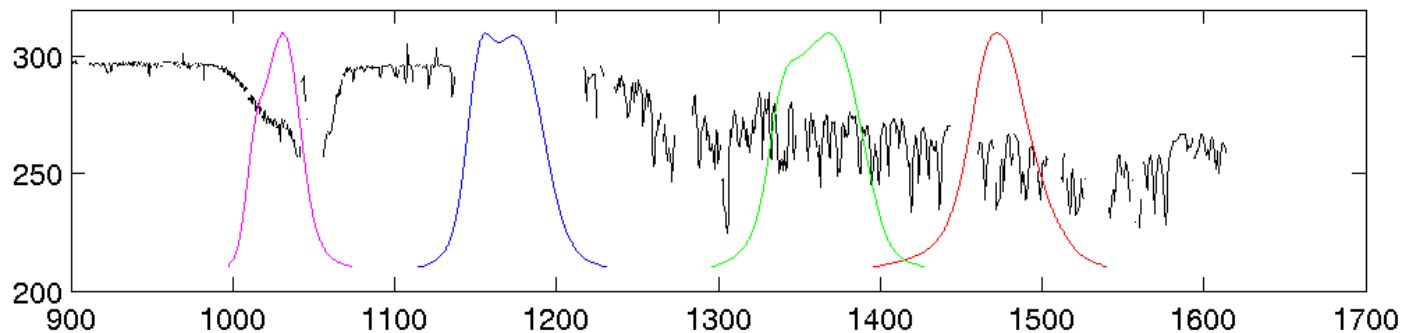
AIRS Assessment of MODIS Calibration

AIRS spectrum and Aqua MODIS Band Spectral Response Functions

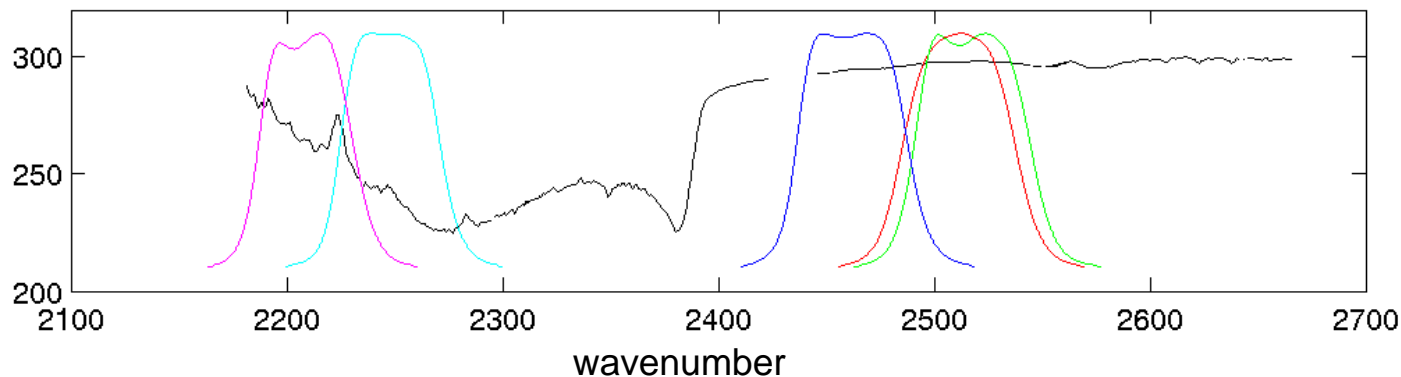
MODIS Band /
wavelength(μm)



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



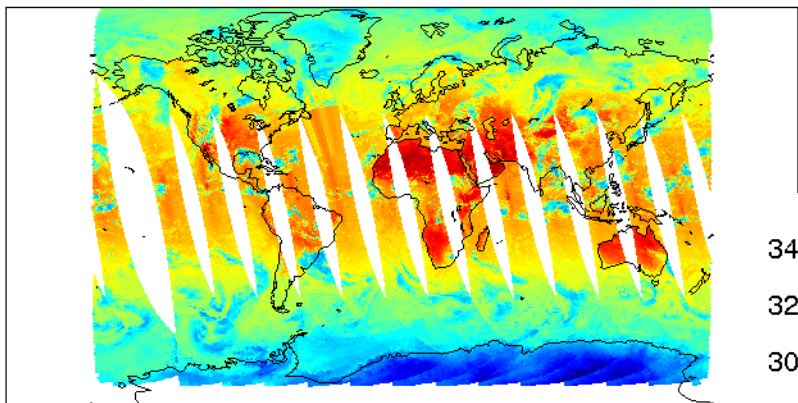
30 / 11.0
29 / 9.7
28 / 7.3
27 / 6.8



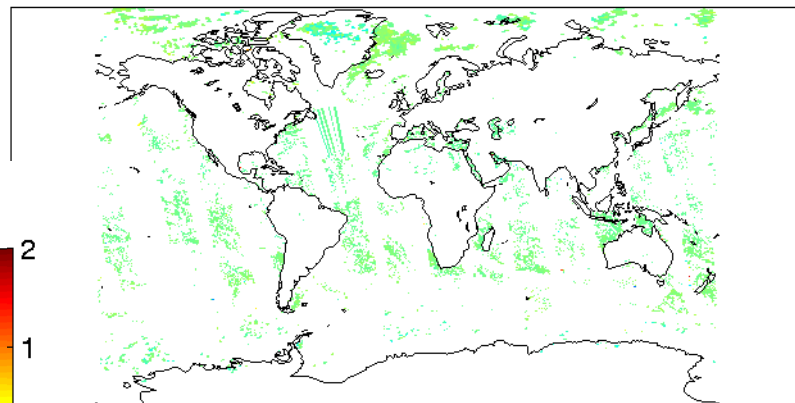
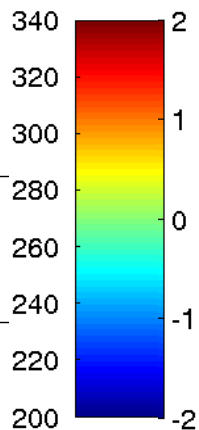
25 / 4.5
24 / 4.4
23 / 4.1
22 / 4.0
21 / 4.0

wavenumber

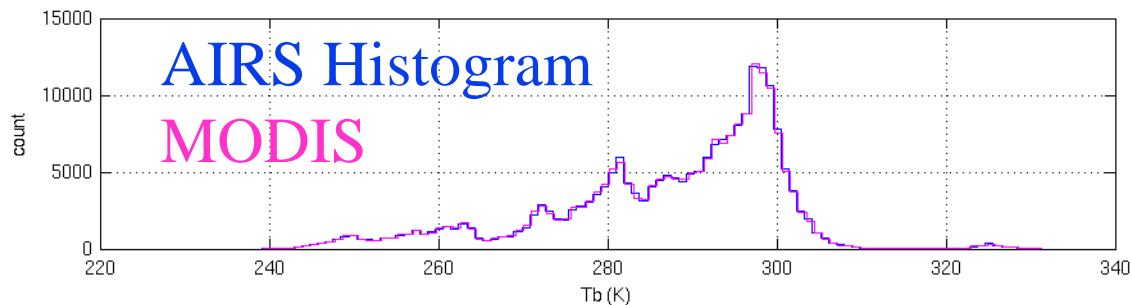
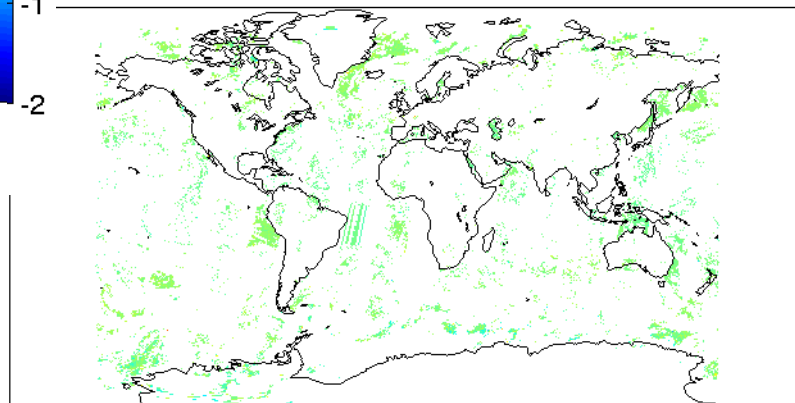
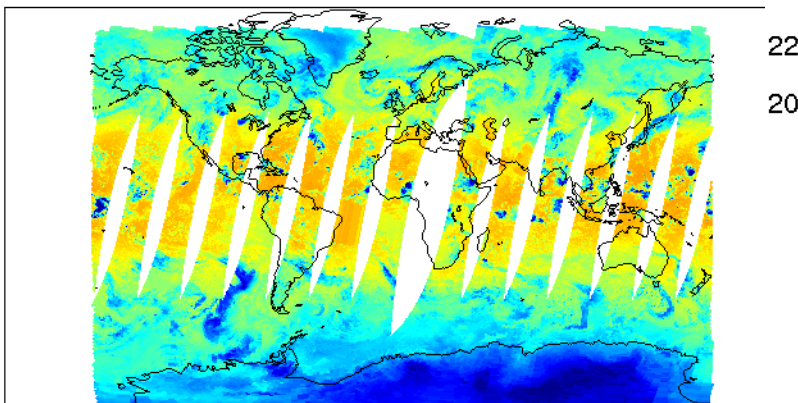
Fantastic AIRS - MODIS Agreement for Band 22 (4.0 μ m)!



AIRS Tb (K)

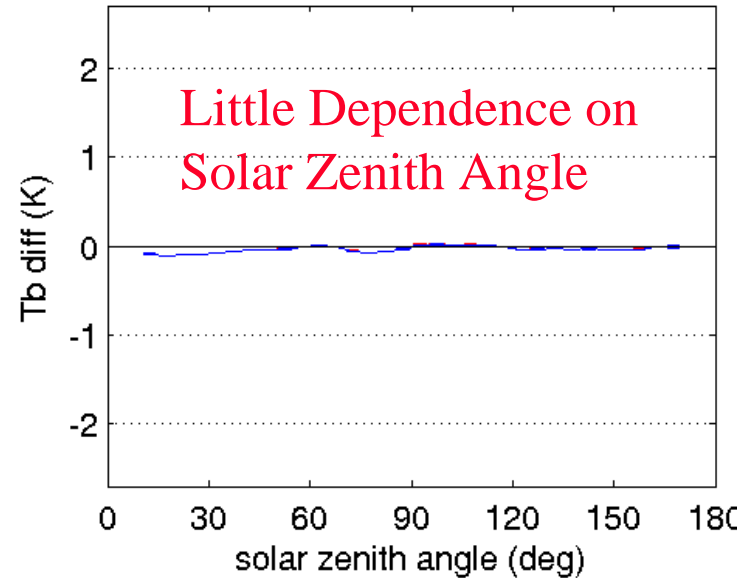
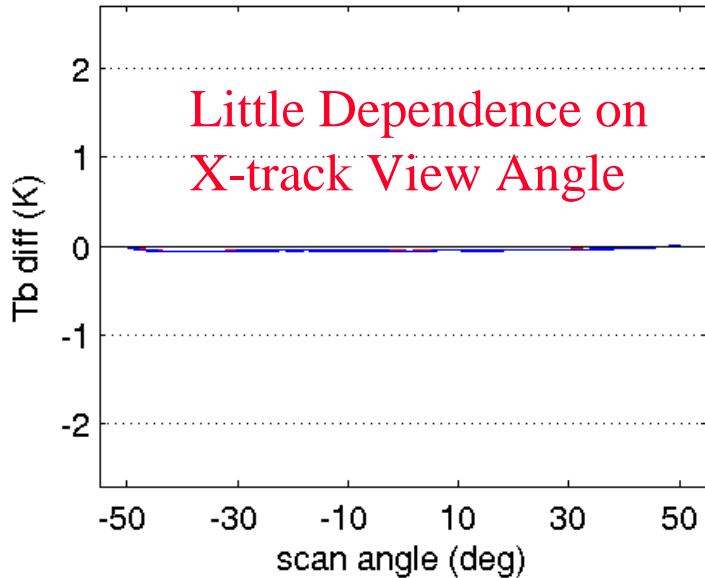
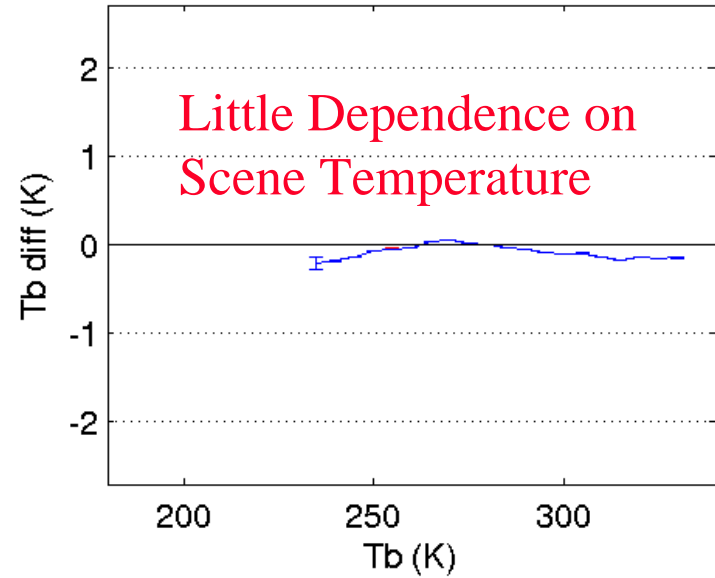
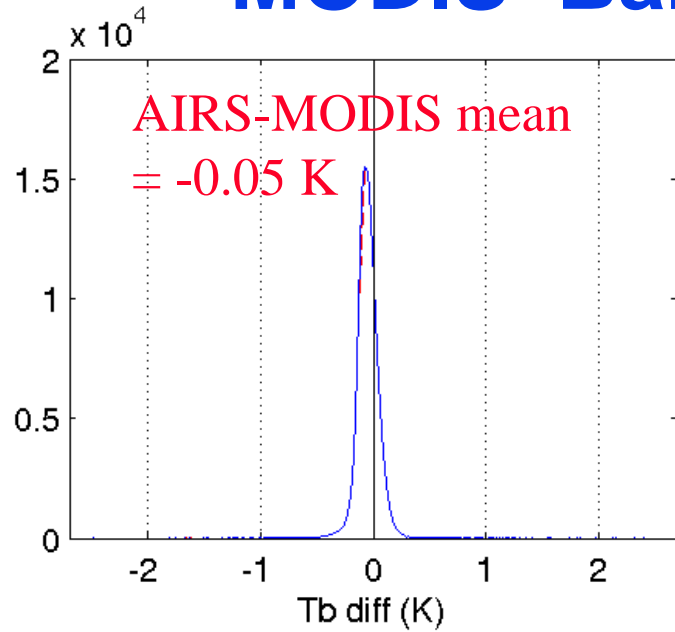


AIRS minus MODIS (K)



Uniform Scenes
Selected

MODIS Band 22 (4.0 μ m)

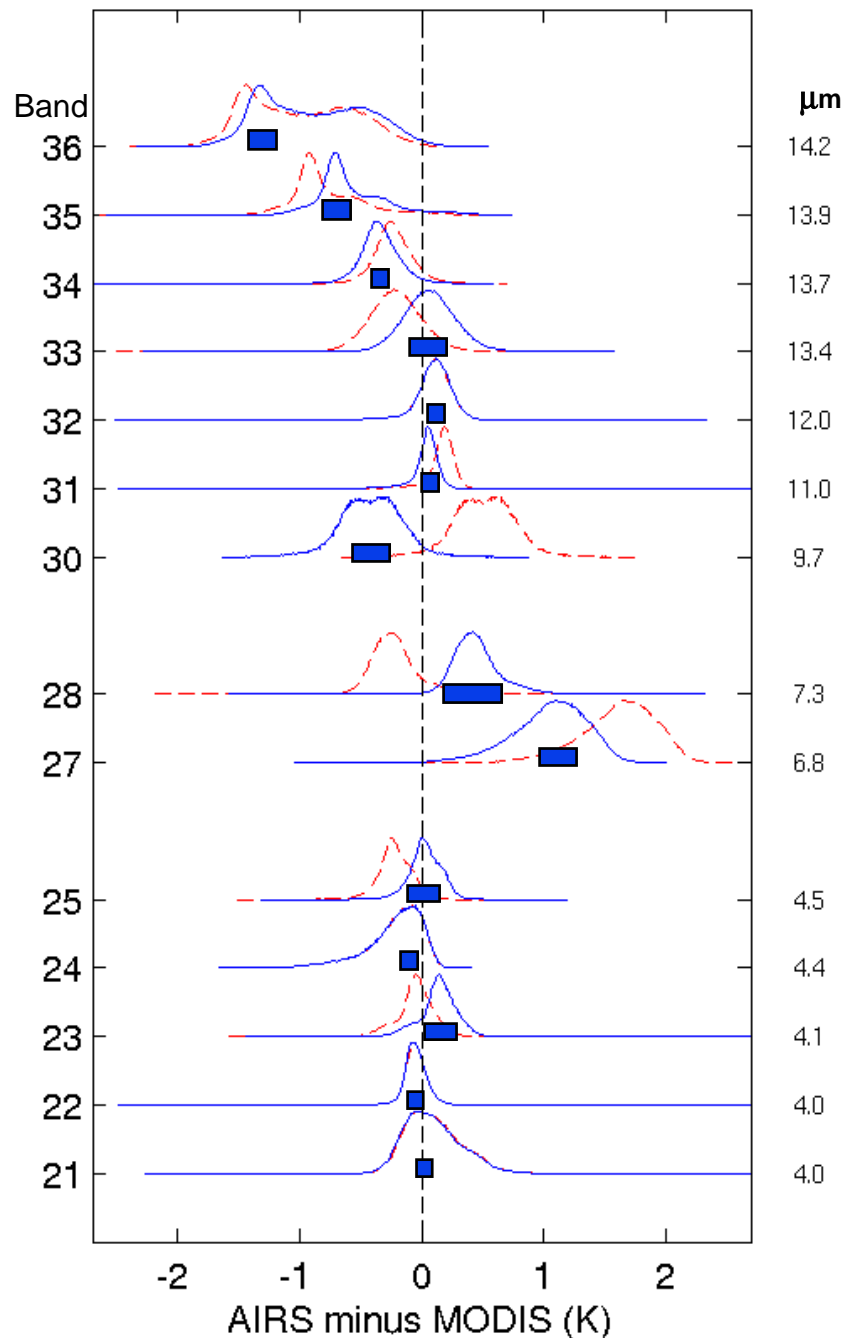


Summary of AIRS-MODIS mean Tb differences

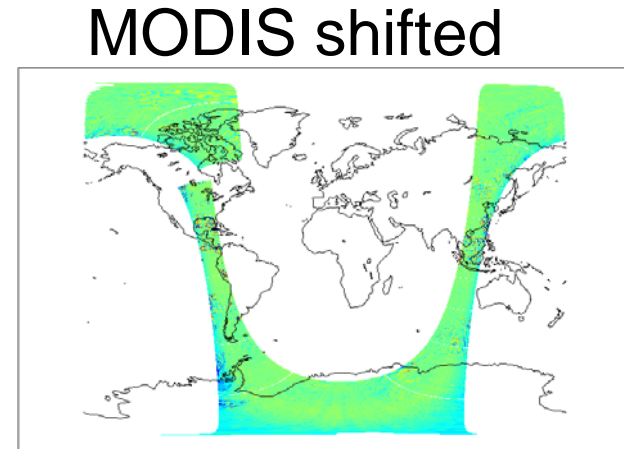
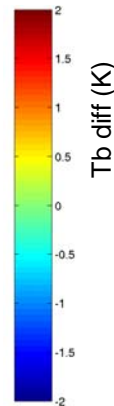
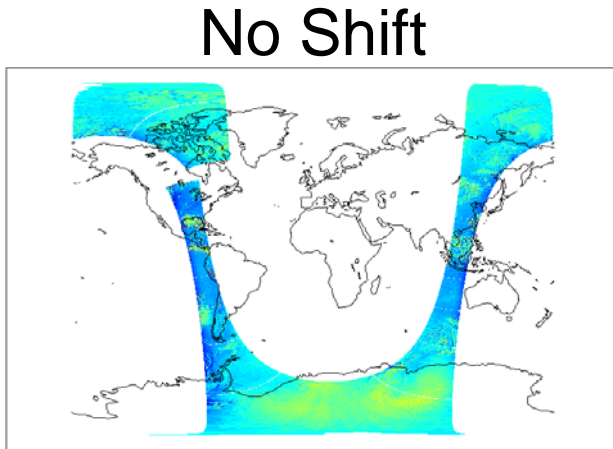
Red=without accounting for convolution error
 Blue=accounting for convolution error with mean
 correction from standard atmospheres

■ p-p Convolution Error (CE) Estimate

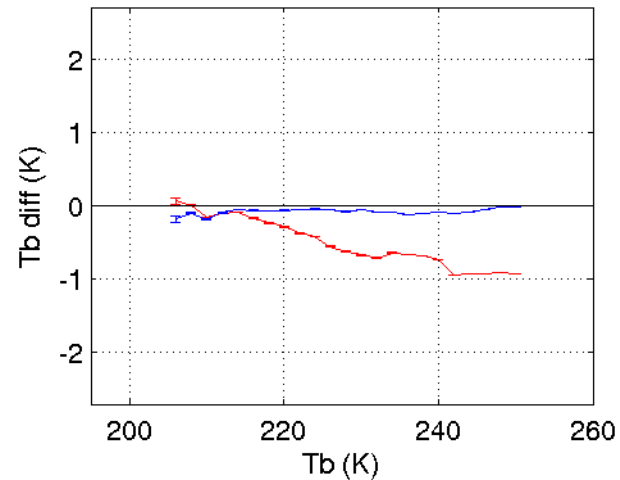
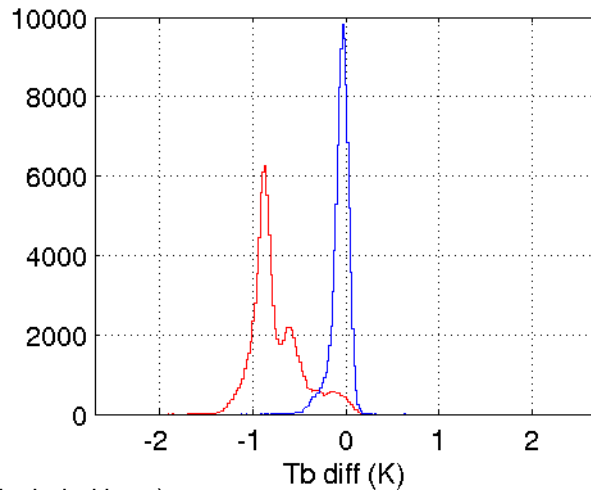
Band	Diff	CE	Diff	Std	N
21	0.10	-0.01	0.09	0.23	187487
22	-0.05	-0.00	-0.05	0.10	210762
23	-0.05	0.19	0.14	0.16	244064
24	-0.23	0.00	-0.22	0.24	559547
25	-0.22	0.25	0.03	0.13	453068
27	1.62	-0.57	1.05	0.30	1044122
28	-0.19	0.67	0.48	0.25	1149593
30	0.51	-0.93	-0.41	0.26	172064
31	0.16	-0.13	0.03	0.12	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 ($13.9 \mu\text{m}$) 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