Scanning HIS: Upwelling and Downwelling Emission Spectra from the ER2

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TC4 Science Team Meeting
25-27 April 2007

Topics

1. Scanning HIS (S-HIS) Summary
   - The NIST Connection: Recent results
2. Derived Products
3. Satellite Validation Capability and Goals (desired spacecraft)
   - Current IASI Validation Mission
4. Science Goals (desired coordination)

1. Scanning-HIS Summary
(High-resolution Interferometer Sounder)

UW Scanning HIS: 1998-Present

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

Characteristics

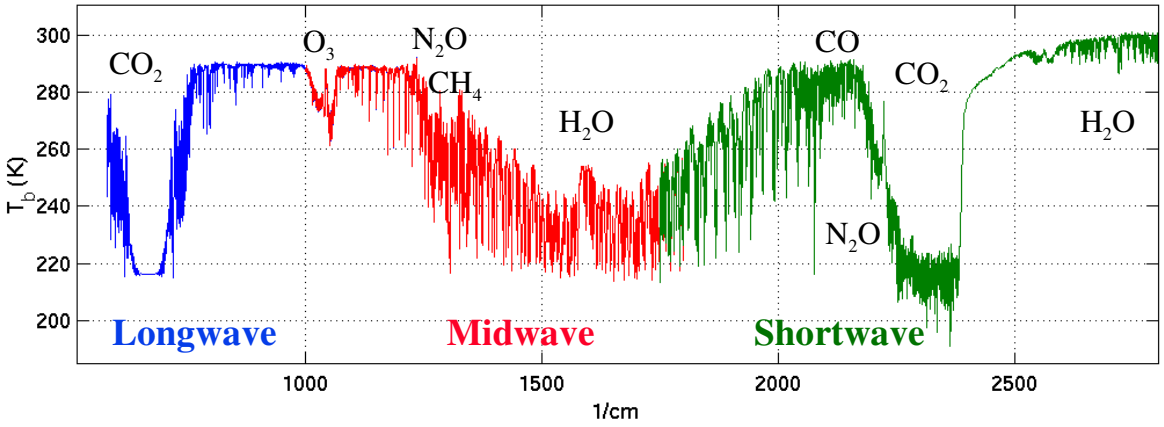
Spectral Coverage: 3-17 microns

Spectral Resolution: 0.5 cm^{-1}

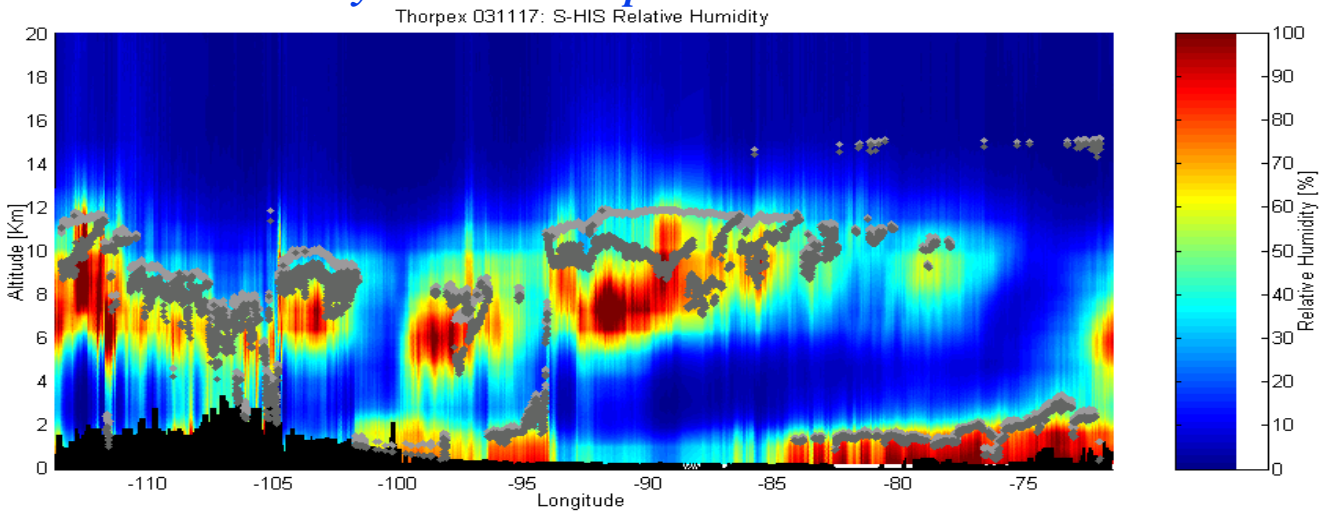
Resolving power: 1000-6000

Footprint Diam: 2 km @ 20 km

Cross-Track Scan: Programmable including uplooking zenith view



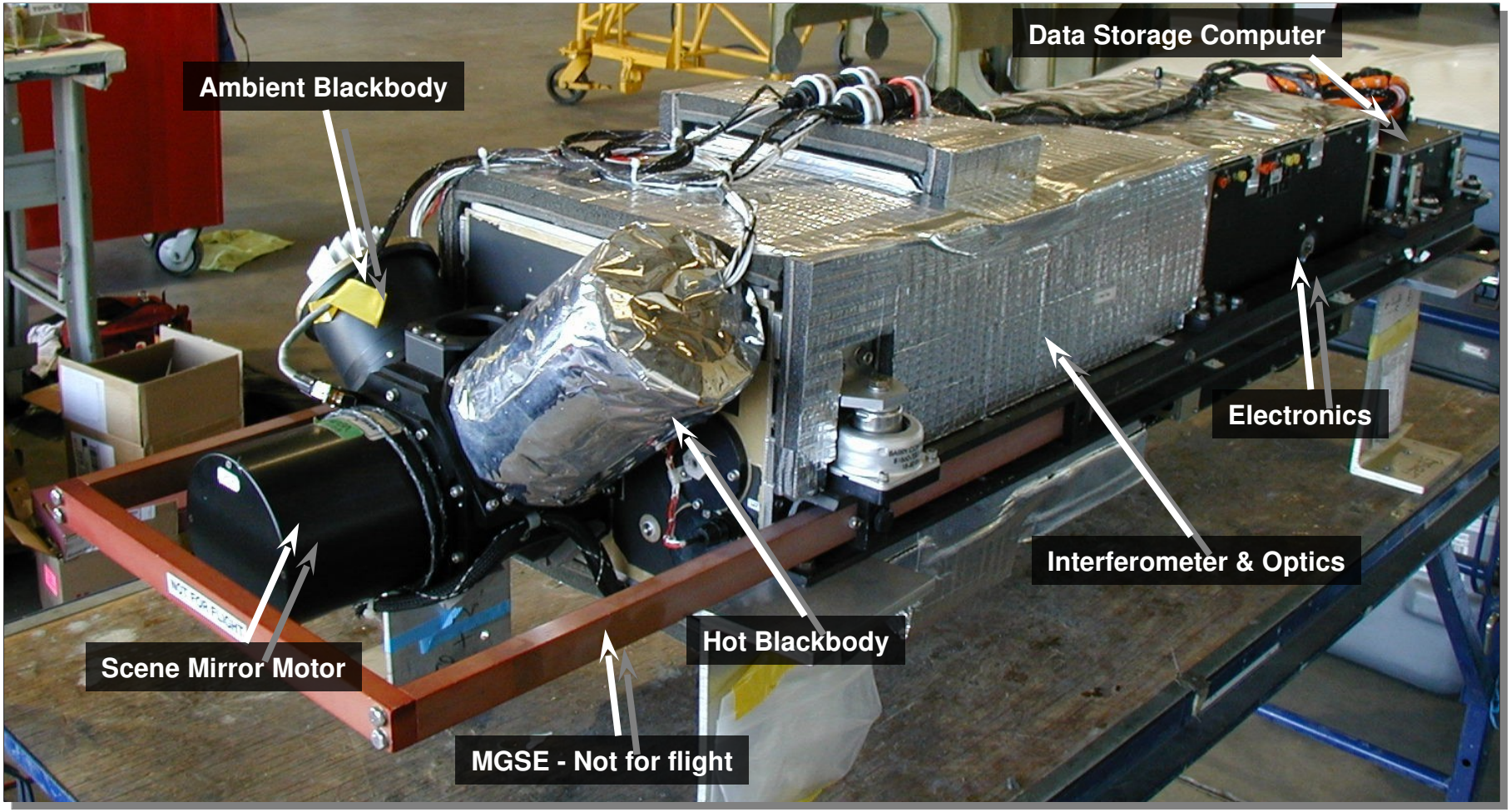
Relative Humidity Retrieval compared to lidar cloud boundaries



Applications:

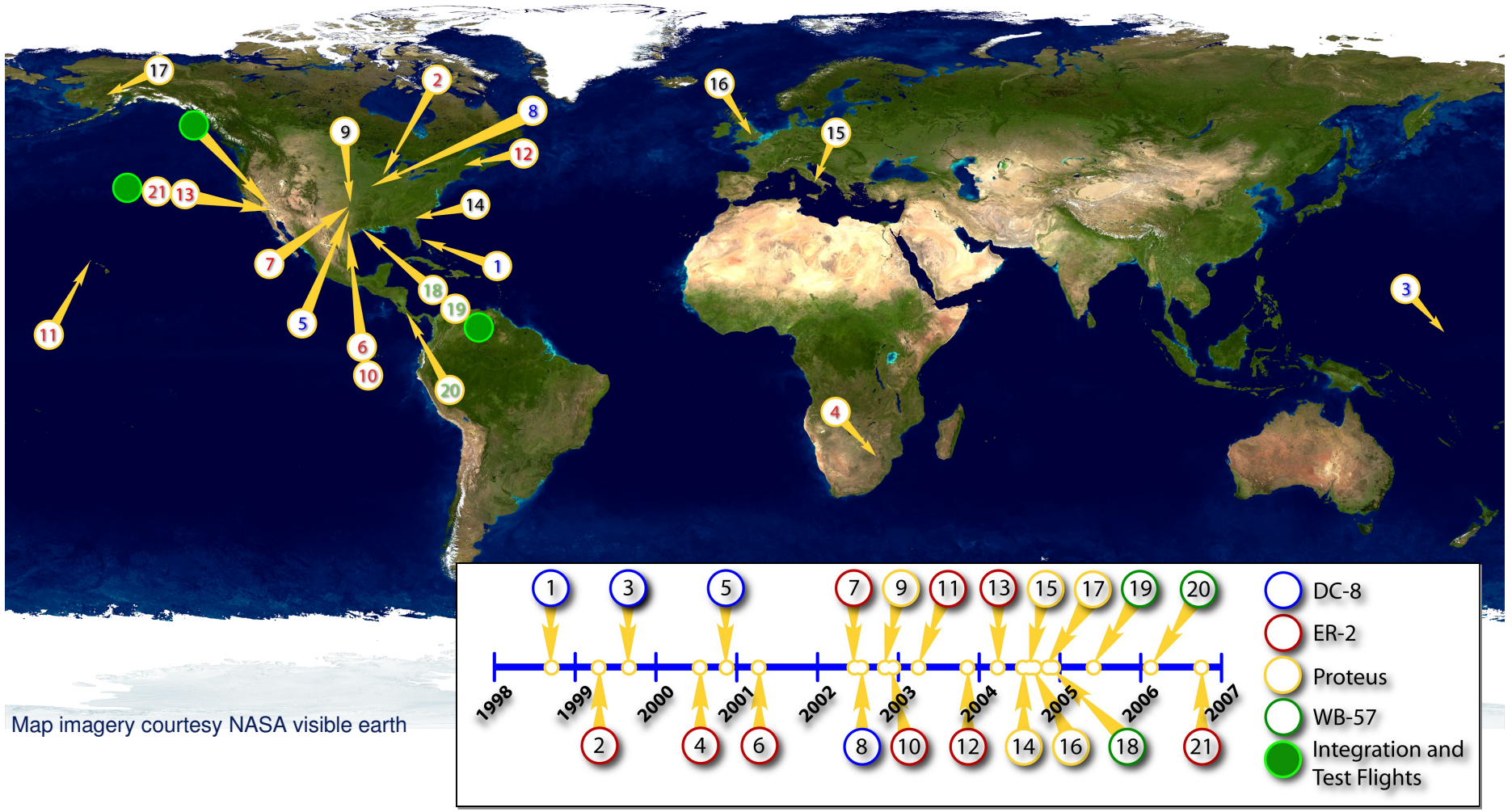
- Radiances for Validation & Radiative Transfer
- Temp & Water Vapor Retrievals
- Cloud Radiative Prop.
- Surface Emissivity & T
- Trace Gas Retrievals

UW Scanning HIS



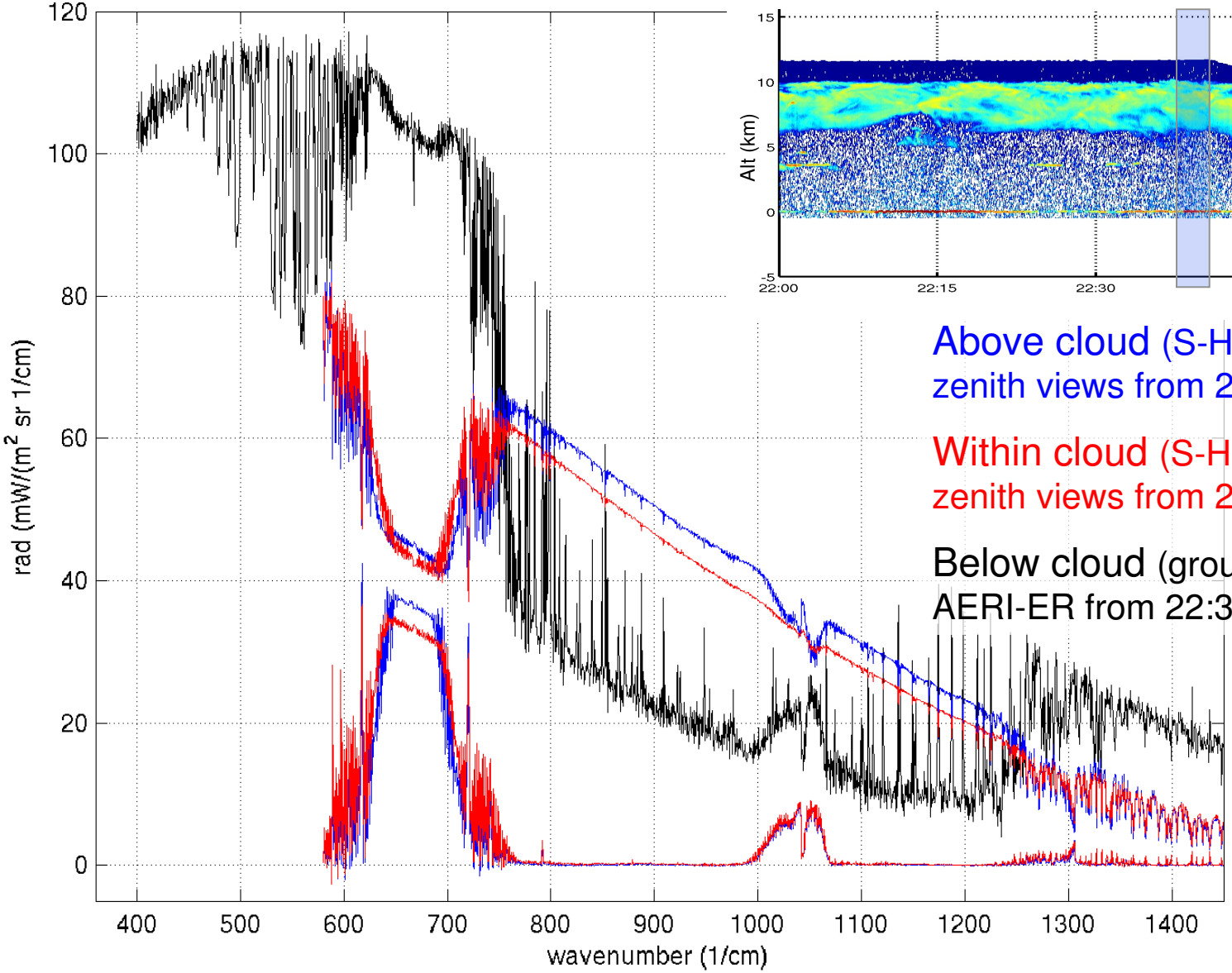
S-HIS Aircraft Platforms

S-HIS Flight Experience



Map imagery courtesy NASA visible earth

Sample Scanning HIS up and down views (from arctic MPACE, 10/17/04)

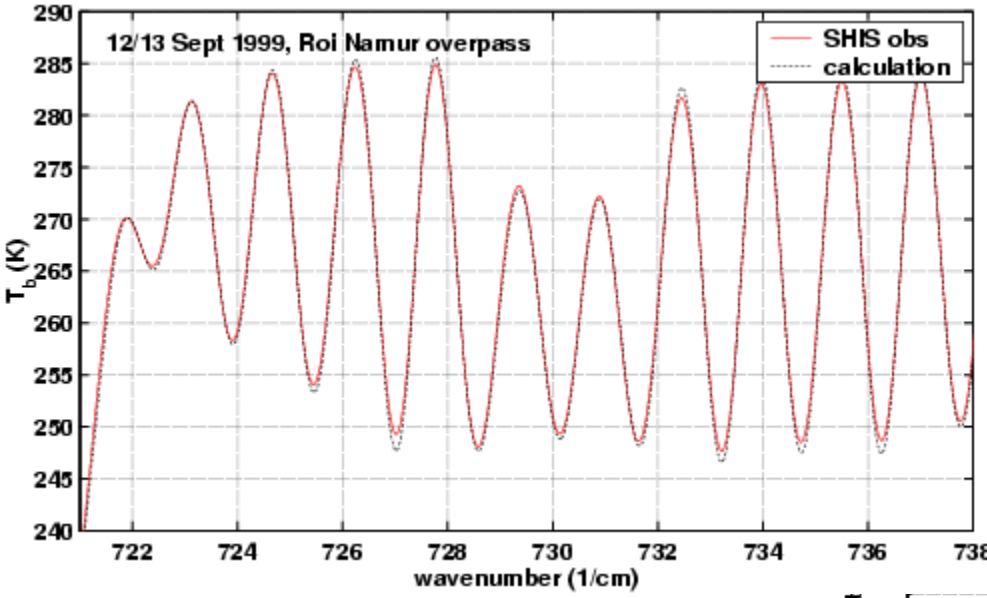


Above cloud (S-HIS nadir and zenith views from 22:35 to 22:40)

Within cloud (S-HIS nadir and zenith views from 22:55 to 23:00)

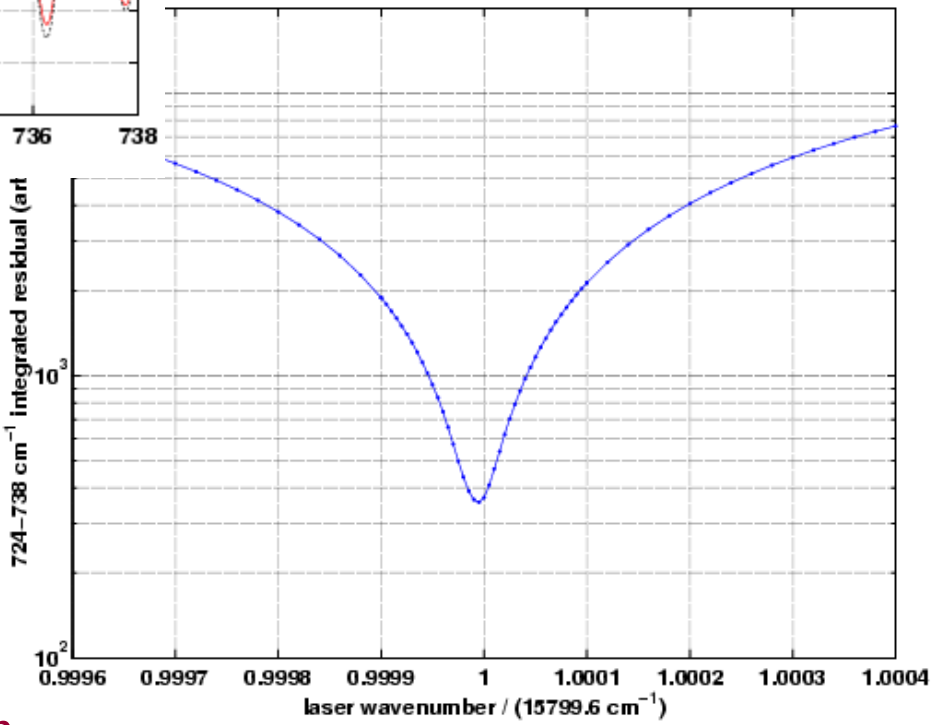
Below cloud (ground based AERI-ER from 22:35 to 23:00)

Atmospheric Spectral Calibration: S-HIS



Atmospheric CO_2 lines

AIRS does similar atmospheric spectral calibration



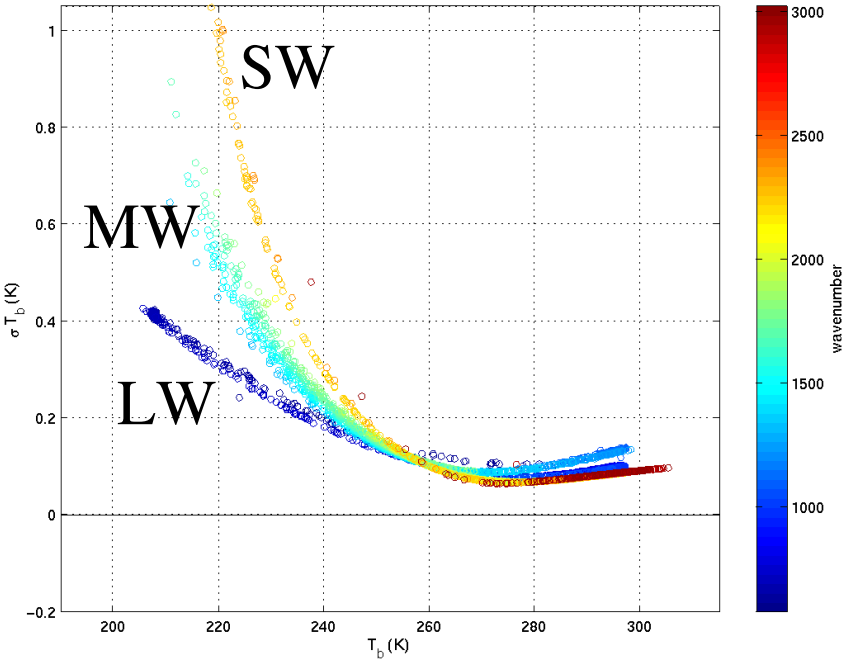
Wavenumber Scale chosen to minimize difference

Estimated accuracy =1.2 ppm (1 sigma)

With many samples, the 3-sigma accuracy is < 1 ppm

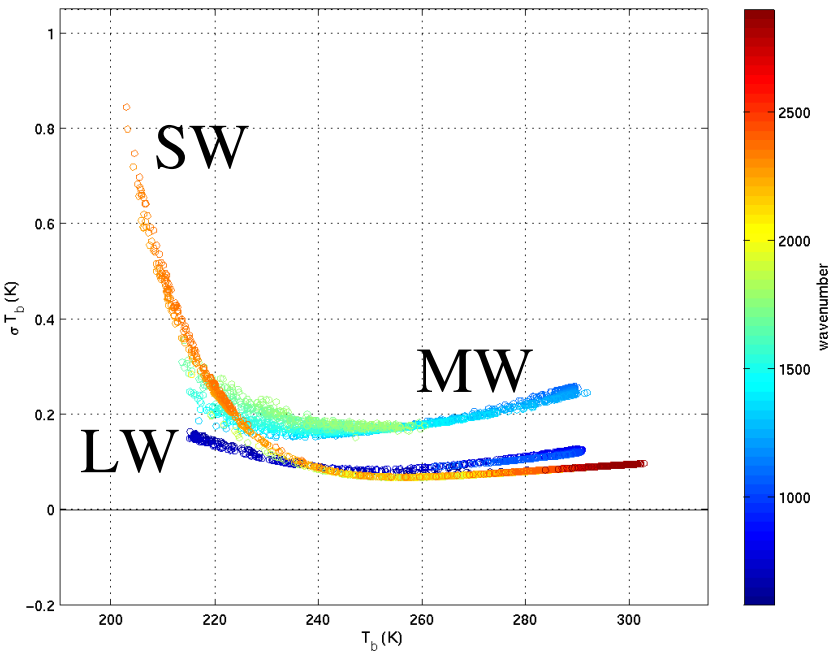
Scanning-HIS Radiometric Calibration 3-sigma Error Budget

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



21 November 2002
on ER2

T_{ABB} = 227K, T_{HBB} = 310K

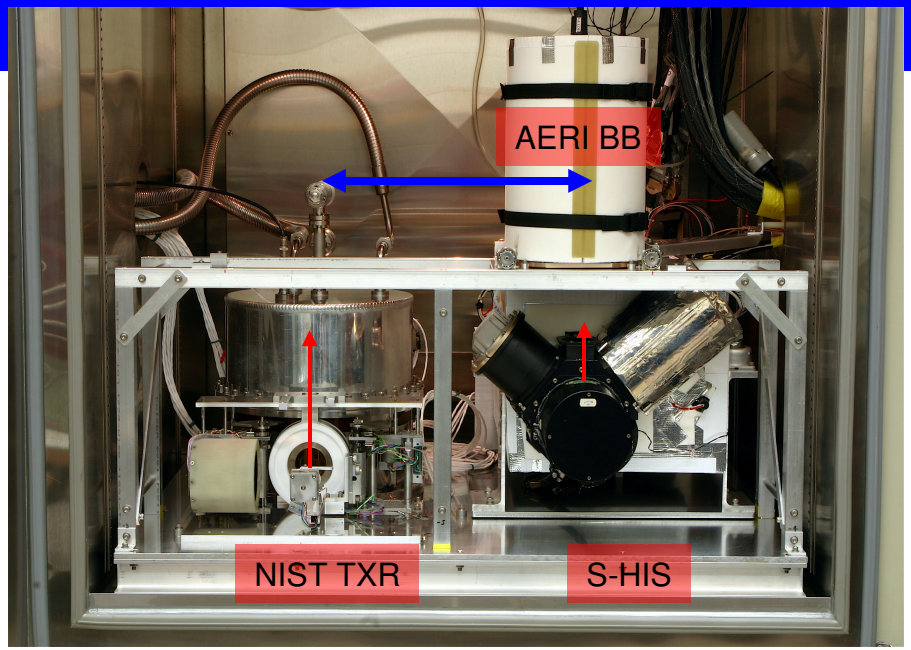


16 November 2002
on Proteus

The Scanning HIS NIST Connection

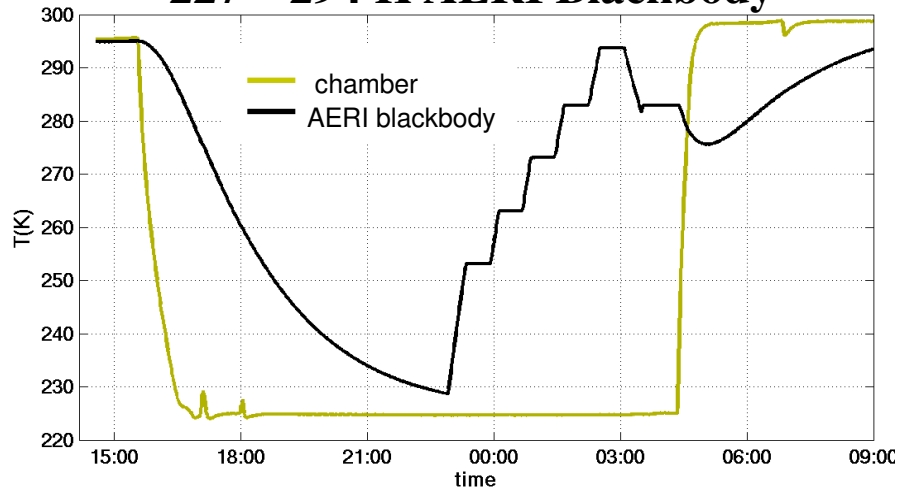
Confirming UW S-HIS & AERI Absolute Accuracy: The NIST Connection

Recent end-to-end radiance evaluations conducted under S-HIS flight-like conditions with NIST transfer sensor (TXR) such that S-HIS satellite validation & AERI observations are traceable to the NIST radiance scale

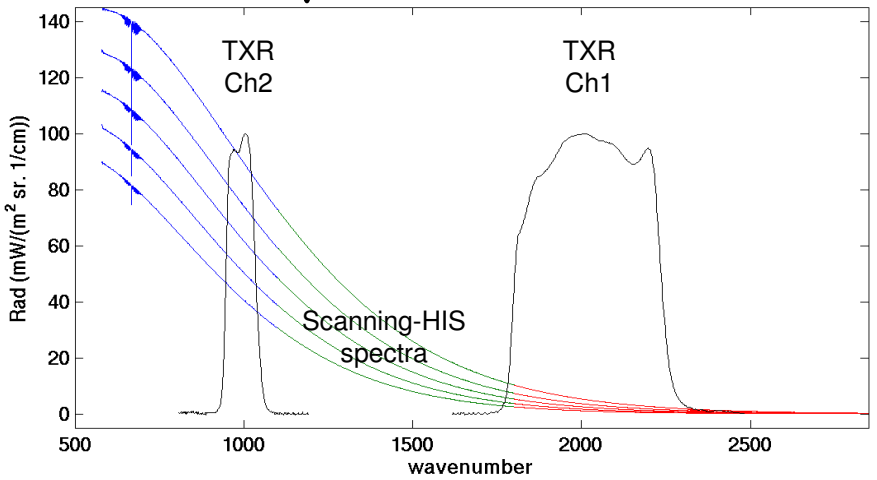


January 2007, testing at UW/SSEC

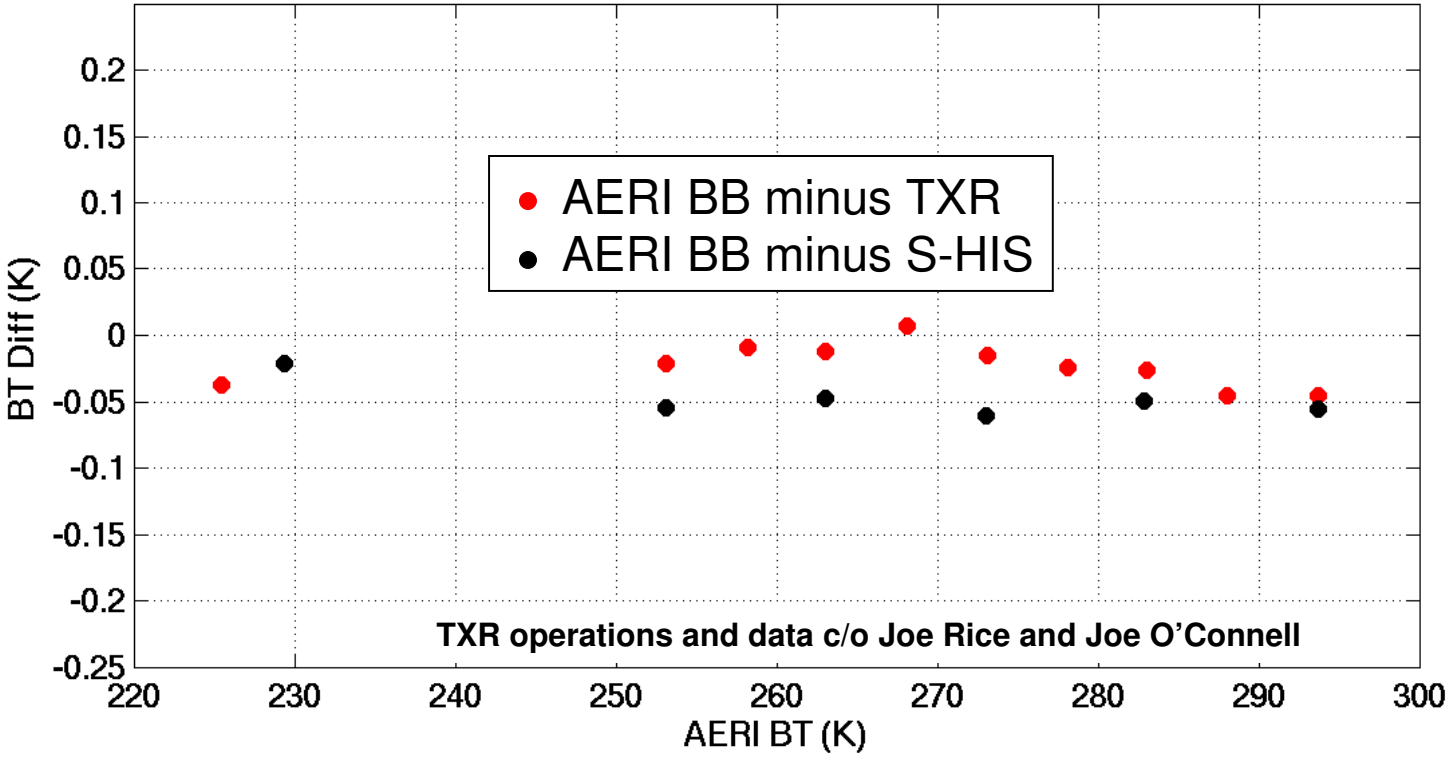
227 – 294 K AERI Blackbody



10 & 5 μm NIST TXR Channels

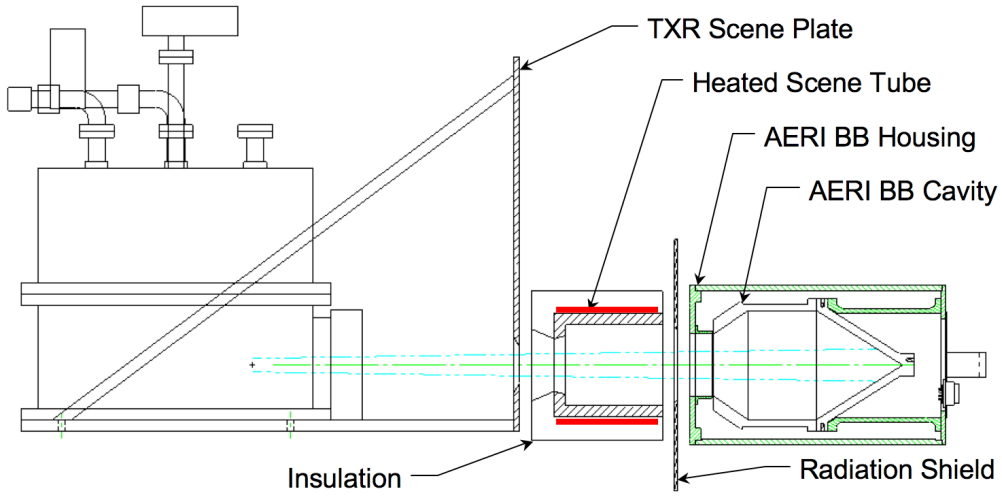


Preliminary S-HIS/NIST 10 μm results agree well -from January 2007



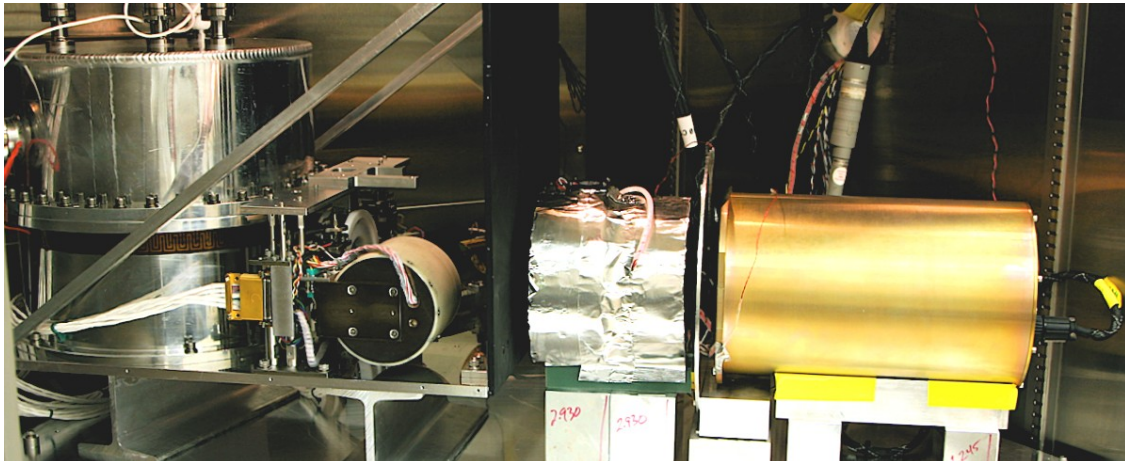
- AERI & S-HIS agree to about **50 mK**
- NIST TXR & S-HIS agree to about **30 mK** in the mean
- Both well within propagated 3-sigma uncertainties (NIST TXR analysis still being refined)

Recent AERI Blackbody Reflectivity Test with NIST TXR Confirms Emissivity Estimates



NIST Transfer Radiometer (TXR) used to detect reflection from heated tube (up to background +100 ºC) surrounding direct FOV

<u>Preliminary Analysis</u>:
5 & 10 μm emissivity
within <0.0003
of expected value
(and closer to 1)

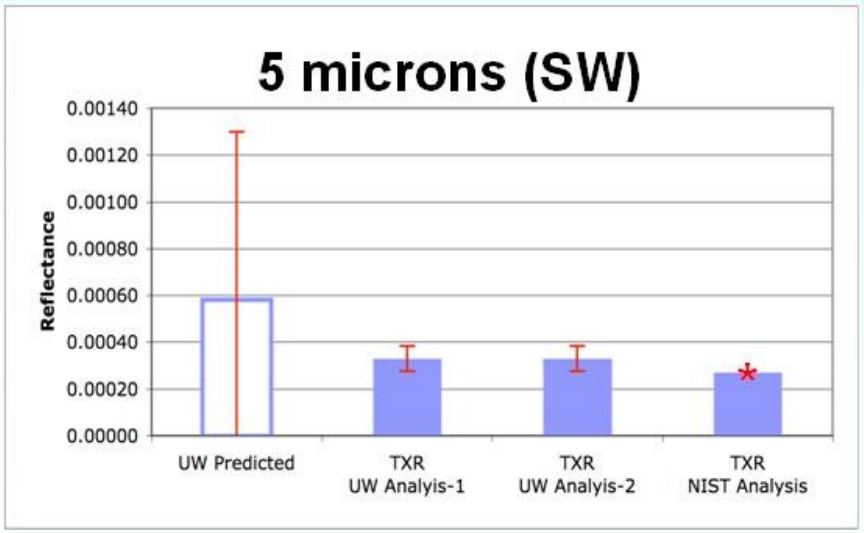


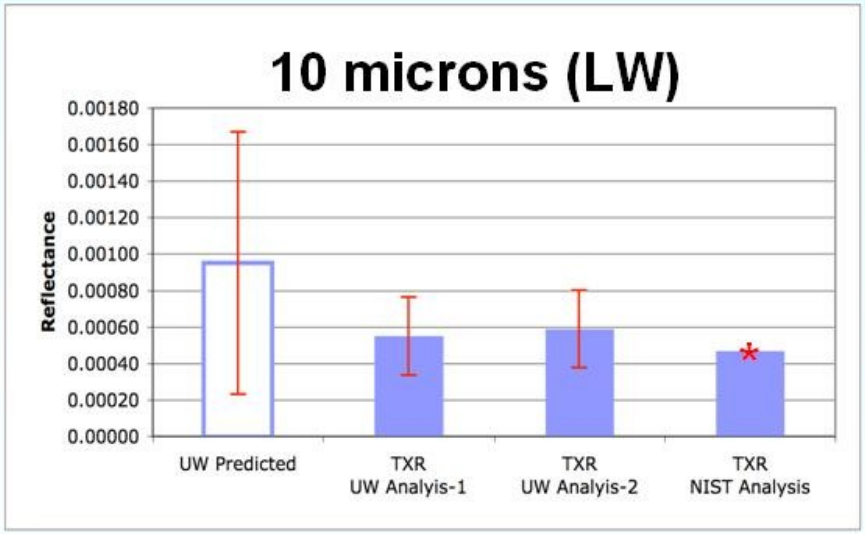
January 2007

SSEC

Analysis Summary

AERI Blackbody Reflectance





Measurements confirm estimated emissivity well within uncertainty (3-sigma estimates)

**NIST analysis still being conducted*

2. S-HIS Derived Products

- **Radiance Residuals**
  (TES/AIRS/IASI/Calculation minus S-HIS)
- **Temperature & Water Vapor Soundings**
- **Cloud Characterization**
  (cloud top pressure, IR optical depth, effective particle size)

3. S-HIS Satellite Validation Capability and Goals

- **Radiance Validation with TES (Aura), AIRS (Aqua) & IASI (Metop)**
- **Tropospheric Ozone Validation for above satellites**

Overall Calibration/Validation Goal

Make full use of the fundamental advantage of high resolution infrared spectra (Goody and Haskins, J of Climate, 1998) to provide a new standard of accuracy for weather and climate applications

- **High resolution should make it possible to confidently achieve a consistent, high absolute accuracy calibration across all IR sensors**
- **Airborne Spectrometers with a maintained NIST connection make this performance testable**

S-HIS Radiance Validation Results Summary

- **Aircraft Validation** (of high resolution spectra): New, highly accurate capability proven 2002-2007
- **AIRS**: Mean differences generally <0.2 K with small standard deviations [Tobin et al., JGR, 2006]
- **TES**: Better than 0.5 K agreement in most regions (also characterized small, spectrally correlated noise from variable sample-position-errors) [Shephard et al., JGR, submitted April 2007]
- **IASI**: Preliminary results very promising for validation results comparable to AIRS at higher spectral resolution & contiguous spectral coverage

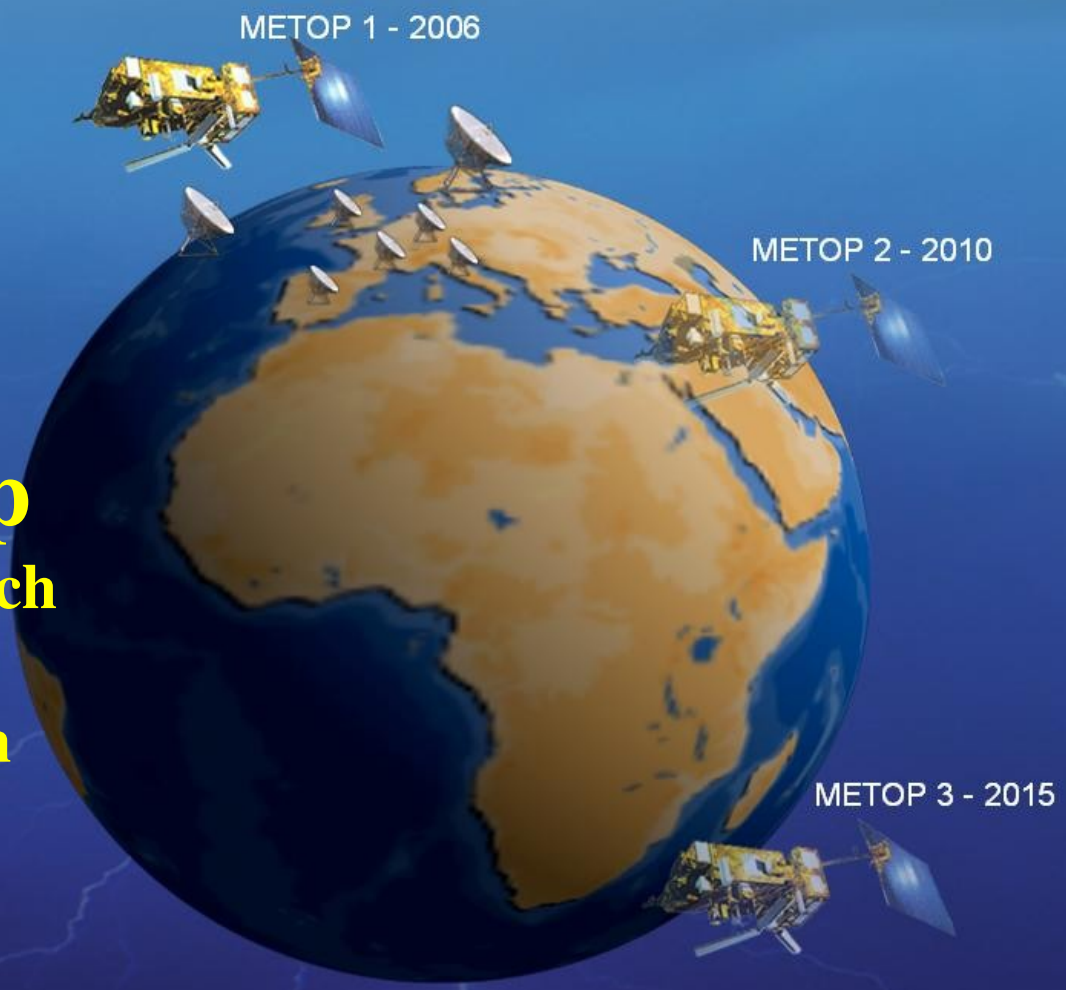
Current Metop-IASI Validation Mission on WB57 (IPO sponsored)

IASI shows great promise, based on our early assessment

IASI

METOP

- Eumetsat Polar System Elements
- 14 years of operation
- >95% reliability on 5 years



IASI on Metop

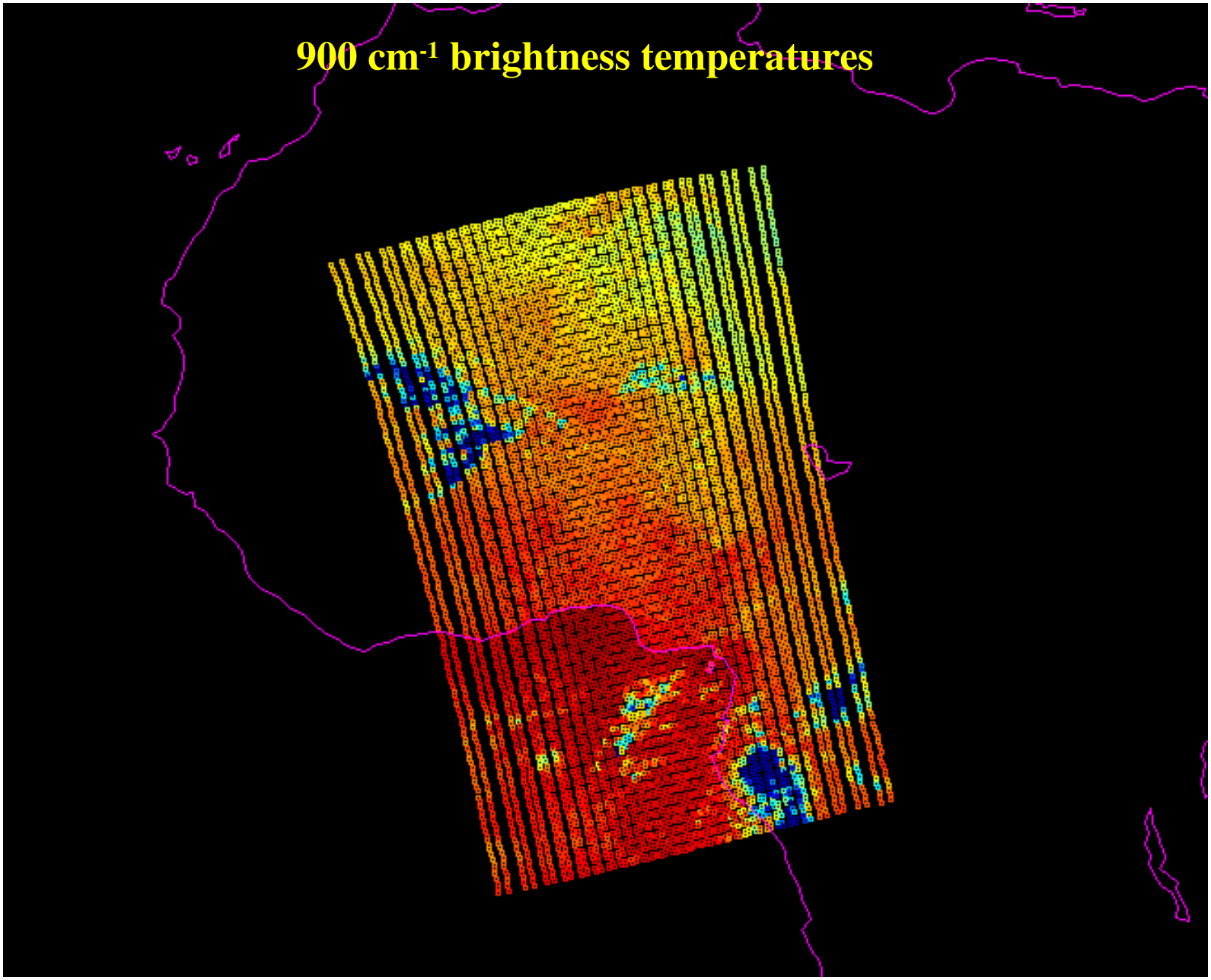
19 October 2006 launch

- full cross-track scan
- 2x2 12 km pixels
  sample 50x50 km

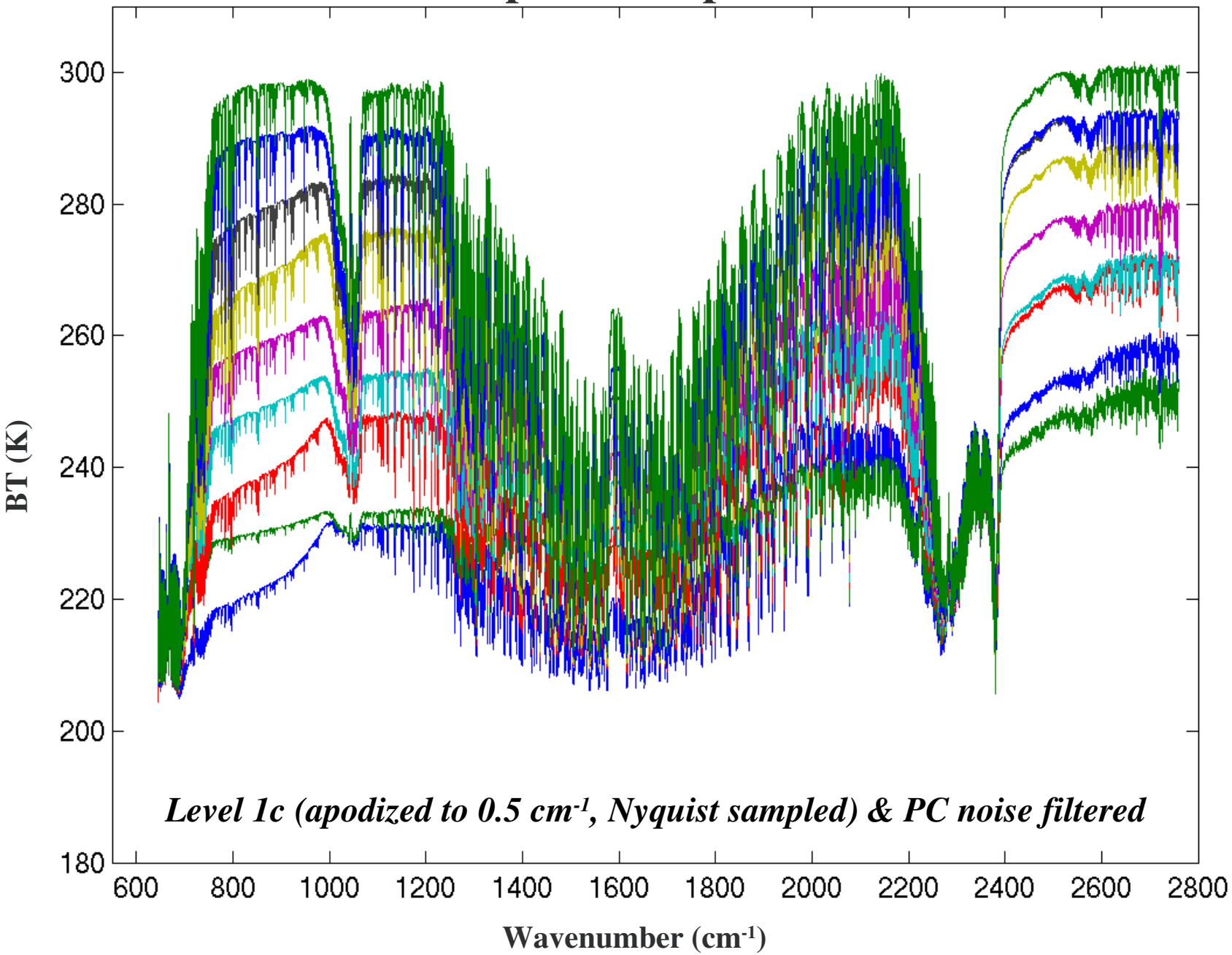
Joint Airborne IASI Validation Experiment (JAIVEx)

- **What:** Metop and Aqua satellite under-flights for radiance and retrieval validation
- **Who:** NPOESS Airborne Sounder Testbed team (NAST-I/M & S-HIS on NASA WB57) & UK team (ARIES on Facility for Airborne Atmospheric Measurements BAe146-301)
- **When:** 14 April to 4 May 2007
- **Where:** Comparisons over the Gulf and Oklahoma ARM site reached from Houston airbase
  - 16 April (day): Aqua ARM site
  - 19 April (night): Metop ARM site
  - 20 April (night): Metop Gulf of Mexico

Cross-track scan pattern for 3 Sample Granules

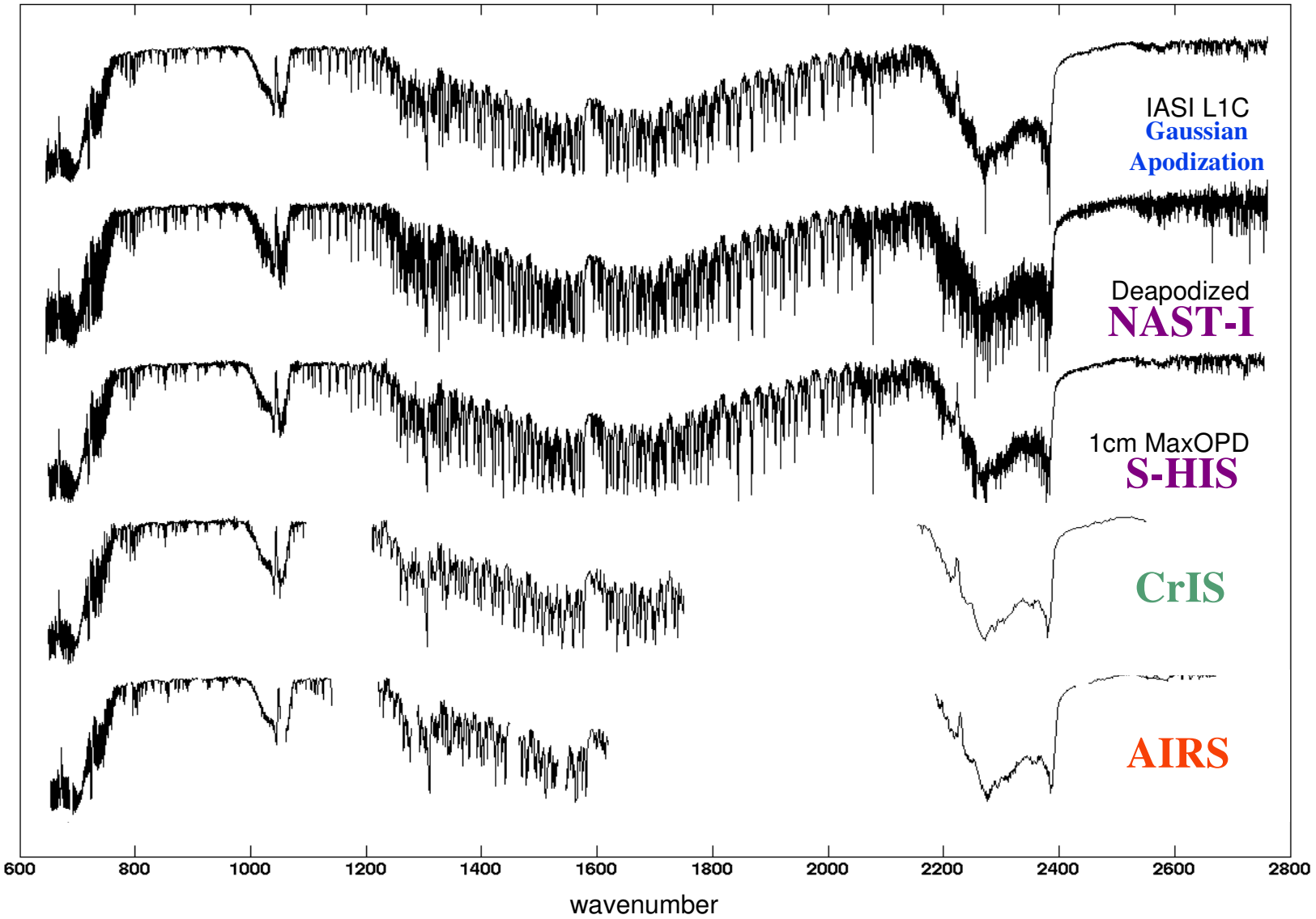


Sample IASI spectra

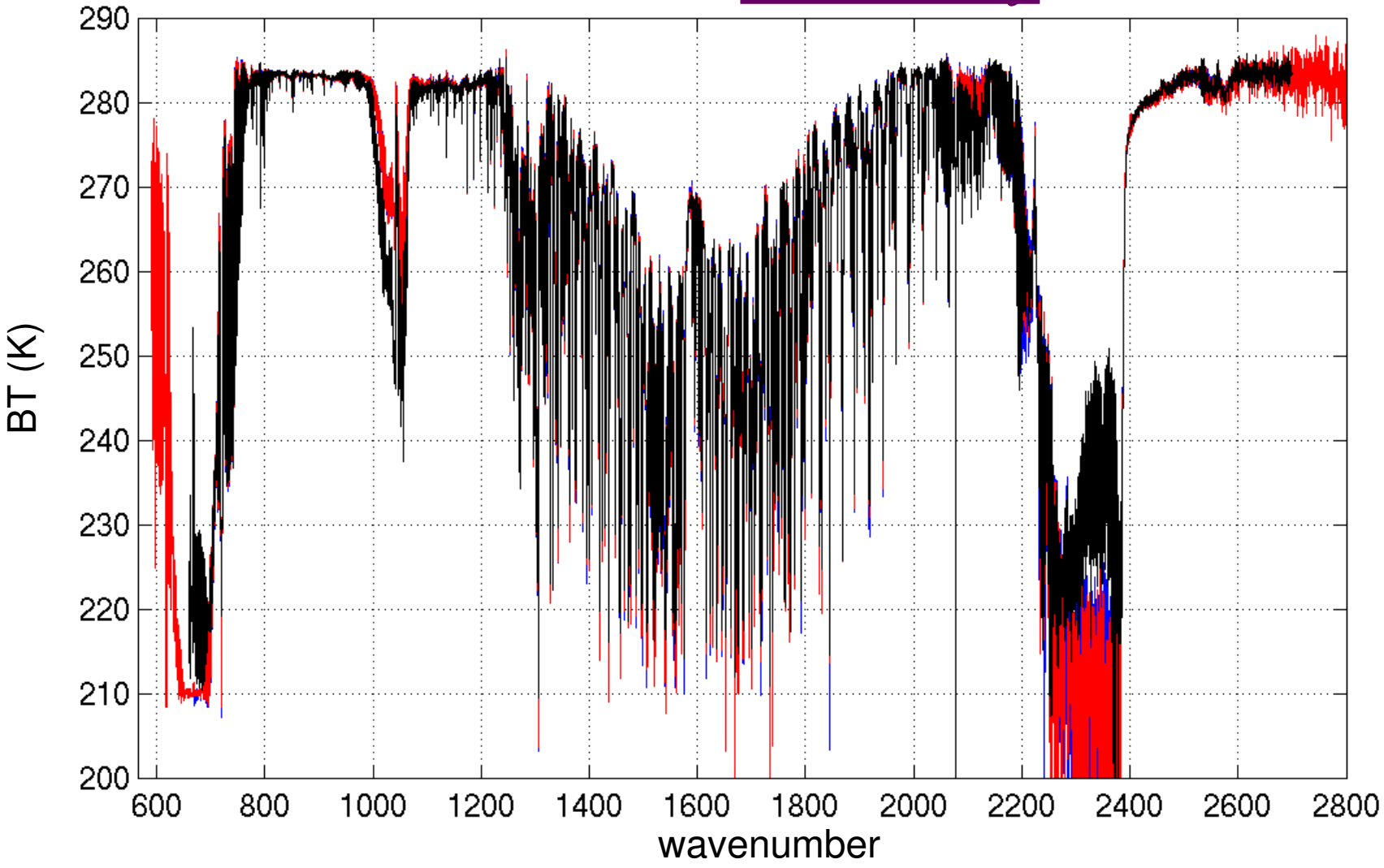


IASI T_b Spectrum:

Processed to represent S-HIS & NAST-I, AIRS & CrIS

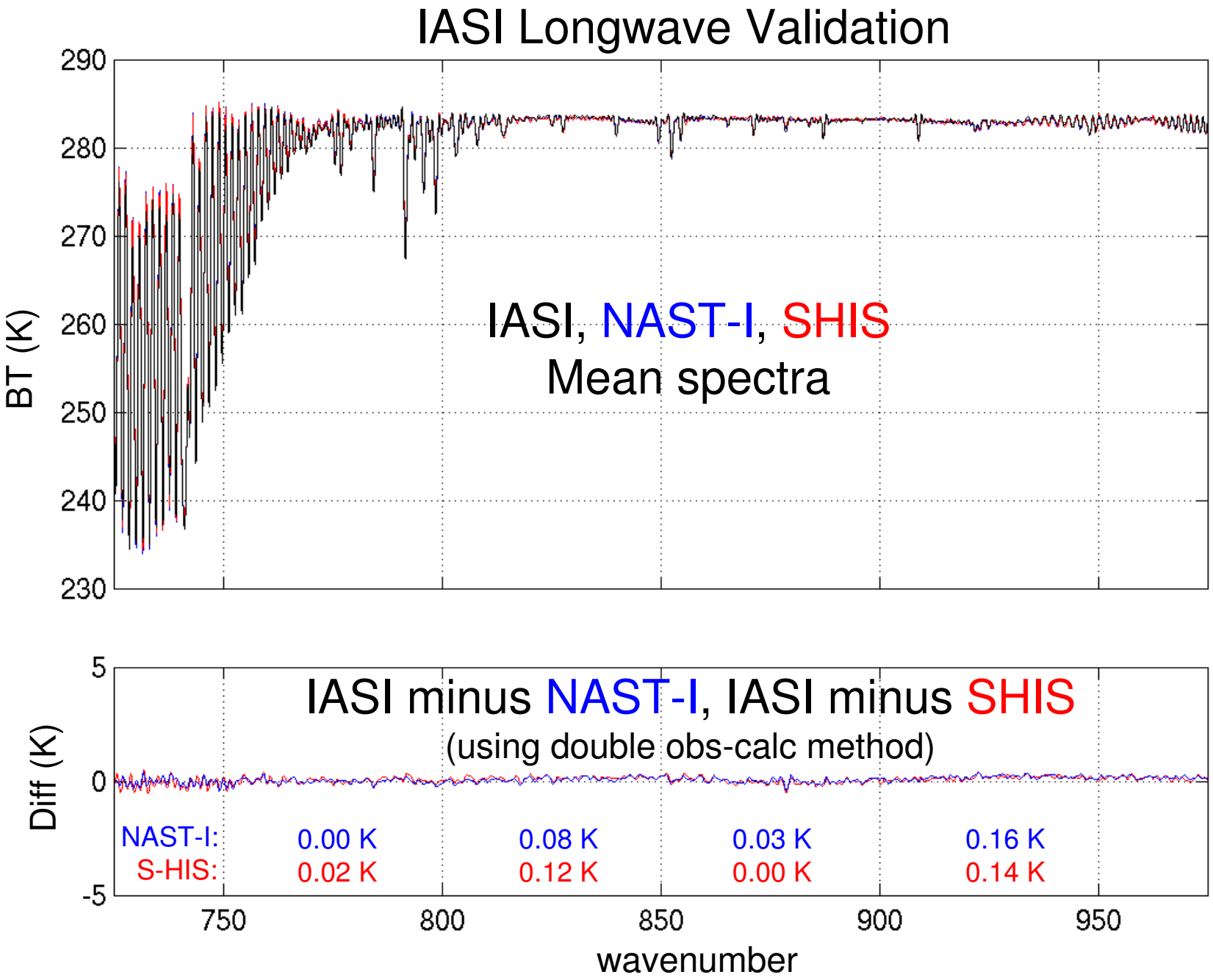


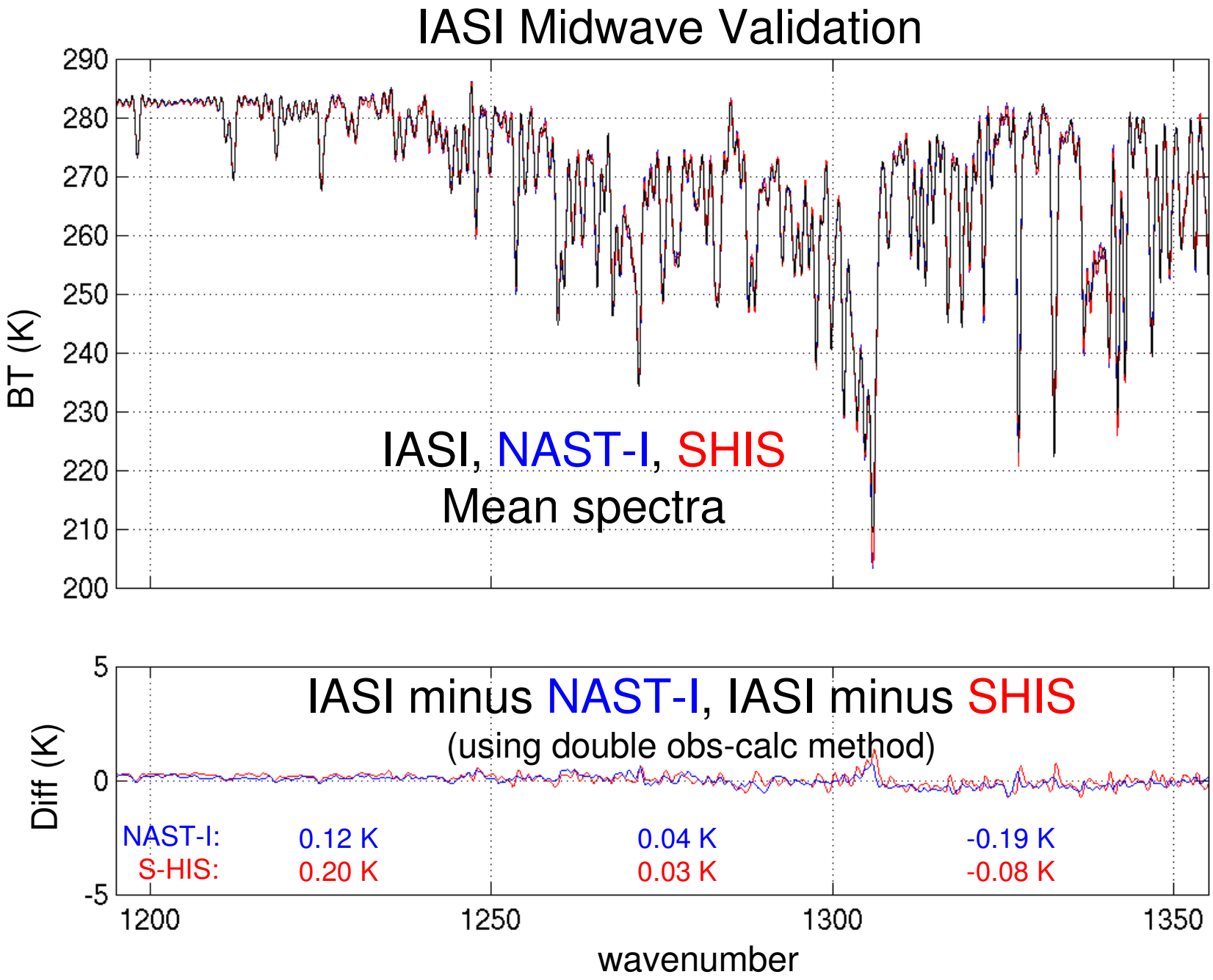
All Bands- Preliminary!

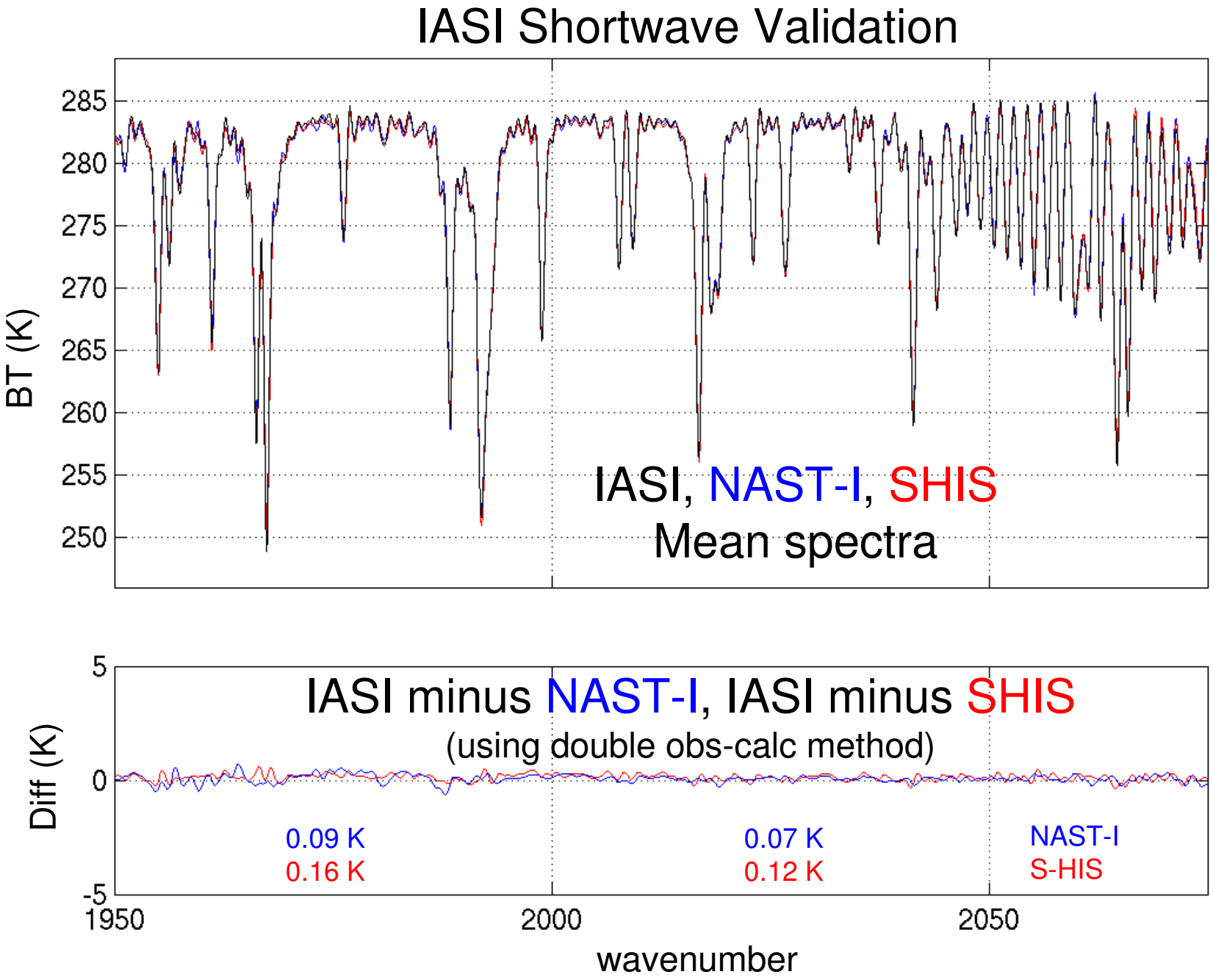


IASI, NAST-I, and SHIS Mean Spectra

(IASI L1C and NASTI spectra processed to match SHIS spectral resolution)


IASI Longwave Validation
290
280
270
260
250
240
230
BT (K)
IASI, NAST-I, SHIS
Mean spectra
5
0
-5
Diff (K)
IASI minus NAST-I, IASI minus SHIS
(using double obs-calc method)
NAST-I:
S-HIS:
0.00 K
0.02 K
0.08 K
0.12 K
0.03 K
0.00 K
0.16 K
0.14 K
750
800
850
900
950
wavenumber

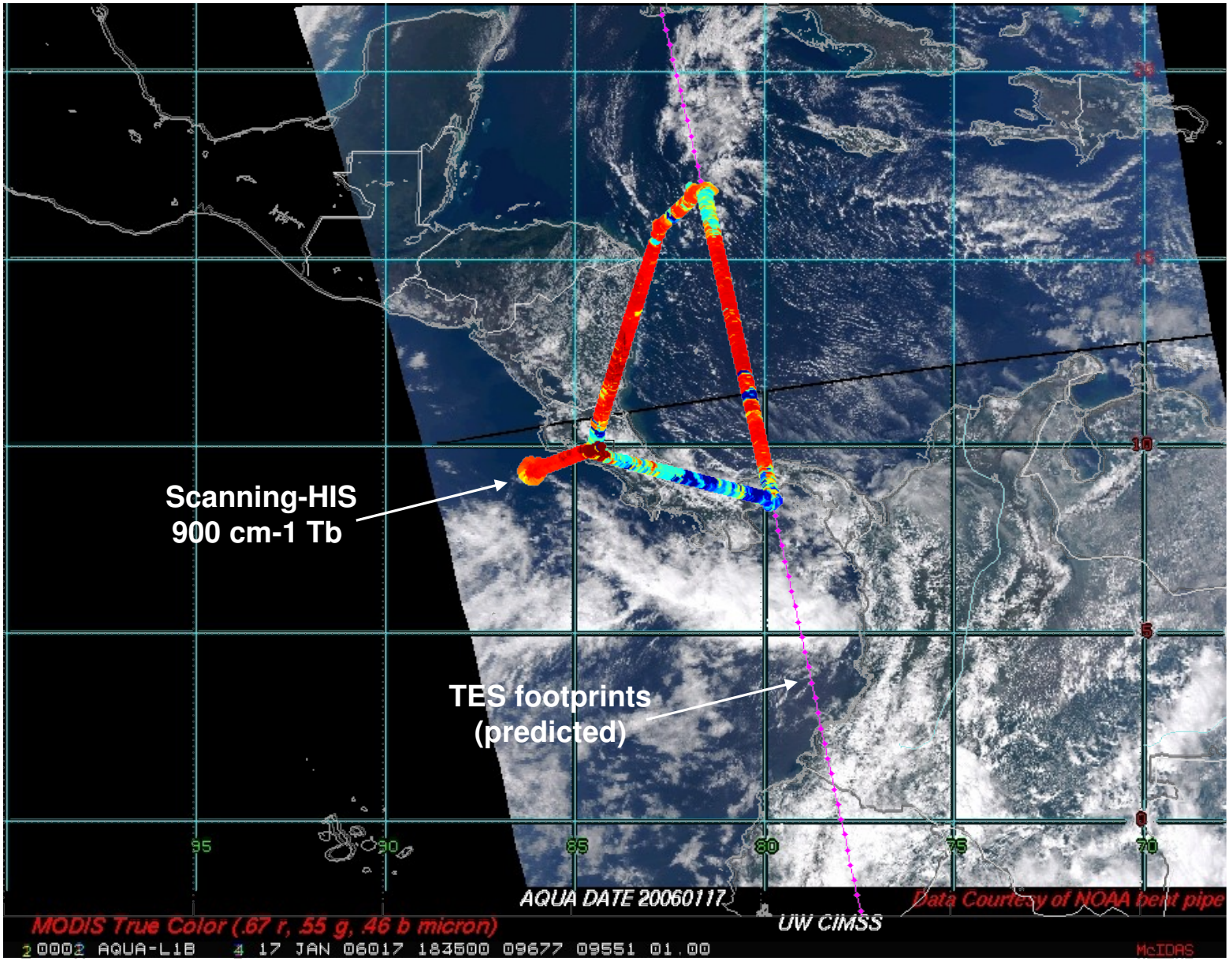

IASI Midwave Validation
BT (K)
290
280
270
260
250
240
230
220
210
200
IASI, NAST-I, SHIS
Mean spectra
Diff (K)
5
0
-5
IASI minus NAST-I, IASI minus SHIS
(using double obs-calc method)
NAST-I:
S-HIS:
0.12 K
0.20 K
0.04 K
0.03 K
-0.19 K
-0.08 K
1200
1250
1300
1350
wavenumber


IASI Shortwave Validation
BT (K)
285
280
275
270
265
260
255
250
IASI, NAST-I, SHIS
Mean spectra
Diff (K)
5
0
-5
IASI minus NAST-I, IASI minus SHIS
(using double obs-calc method)
0.09 K
0.16 K
0.07 K
0.12 K
NAST-I
S-HIS
1950
2000
2050
wavenumber

S-HIS Tropospheric Ozone Validation

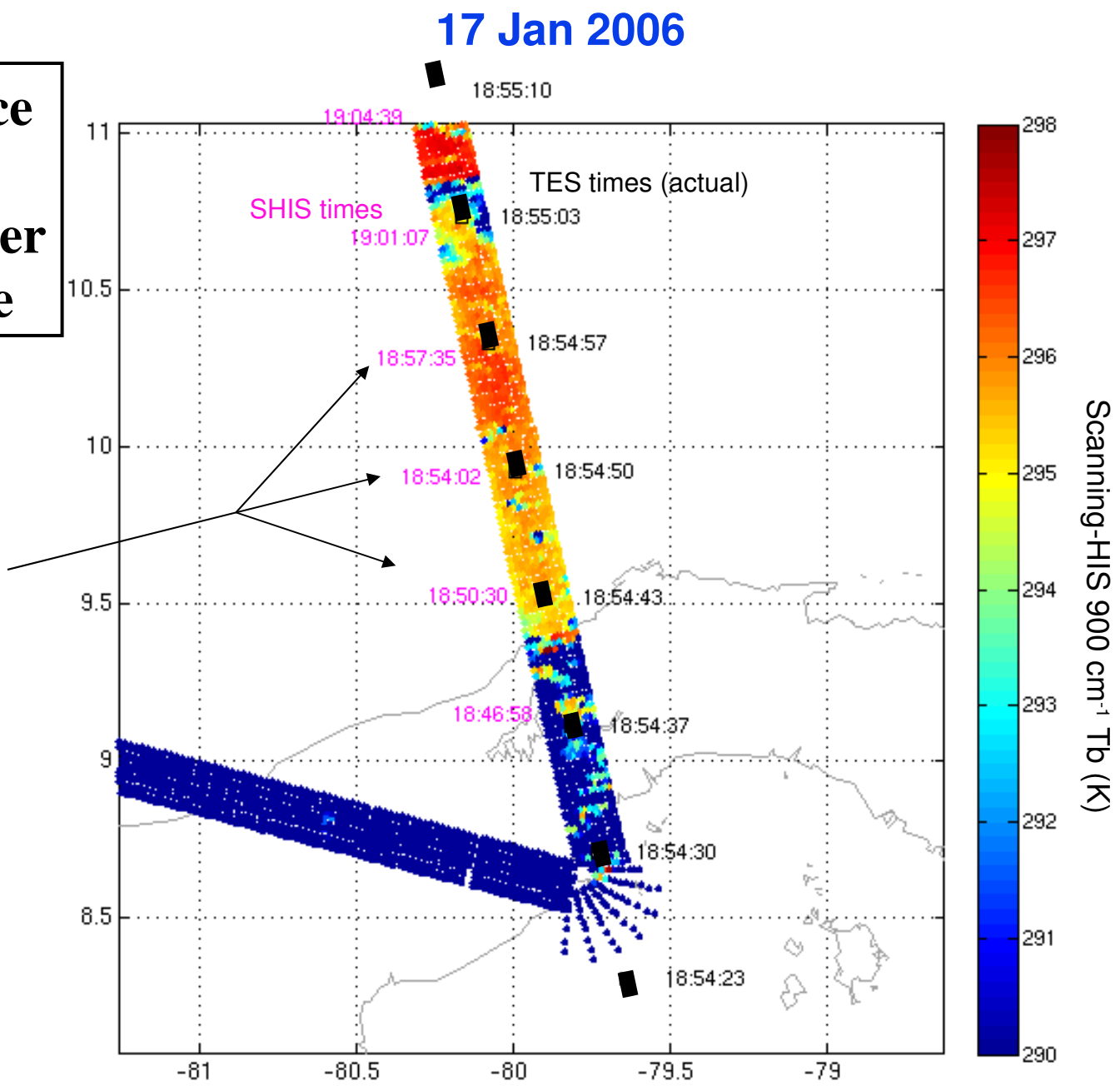
Example from TES during CRAVE, 17 January 2006

Scanning HIS 900 cm^{-1} map over 17 Jan 2006 Aqua MODIS Visible image



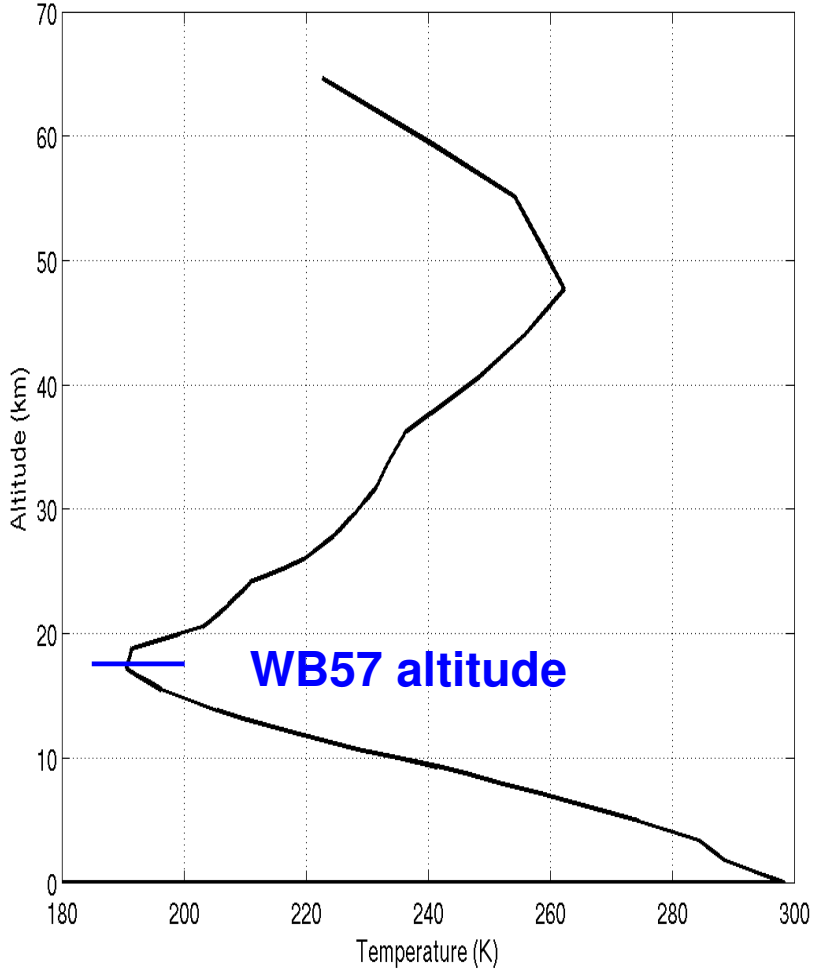
TES Radiance Validation Footprints over S-HIS image

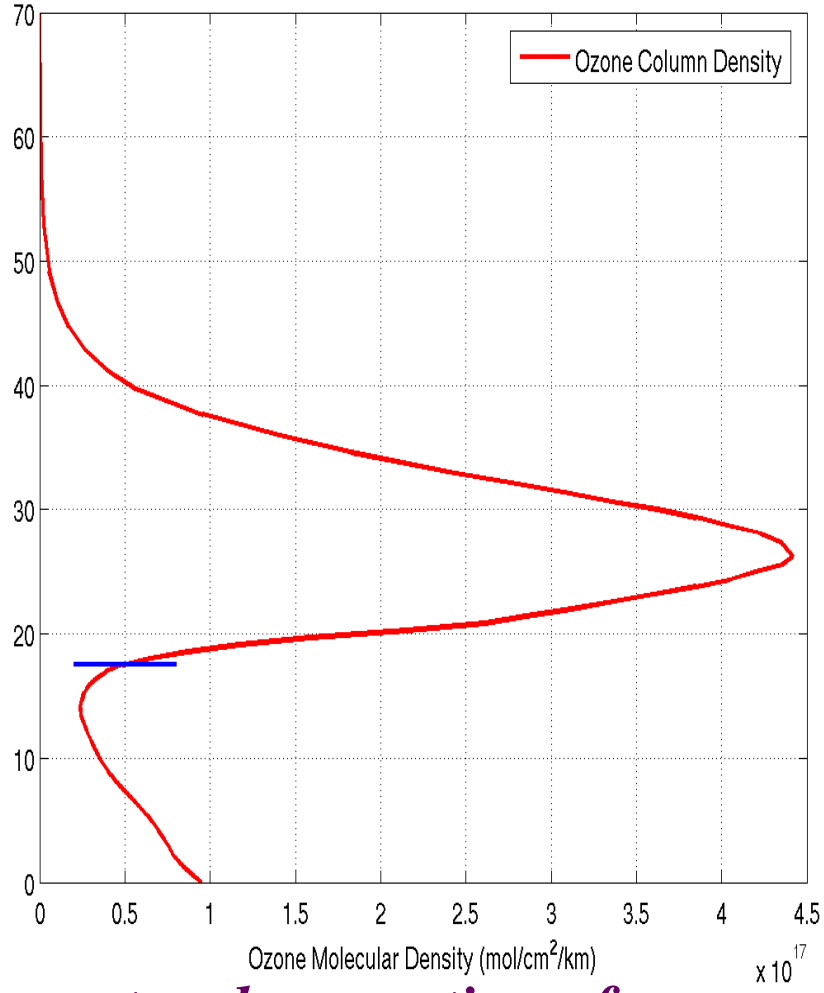
TES/SHIS time & space coincidence



TES Temperature and O3 Retrieval

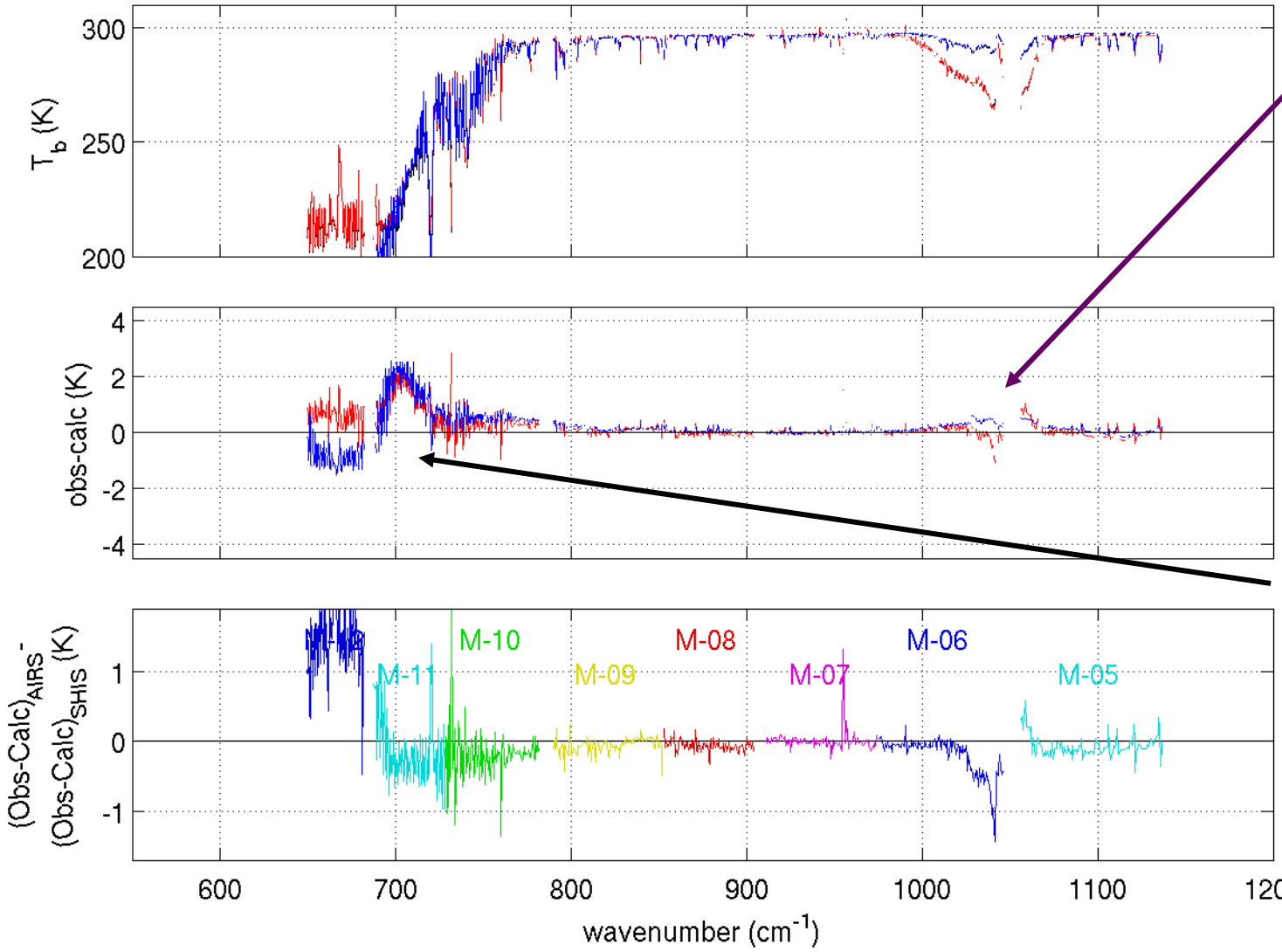
18:55:45 UTC





Flying at tropopause gives natural separation of tropo- & stratospheric ozone

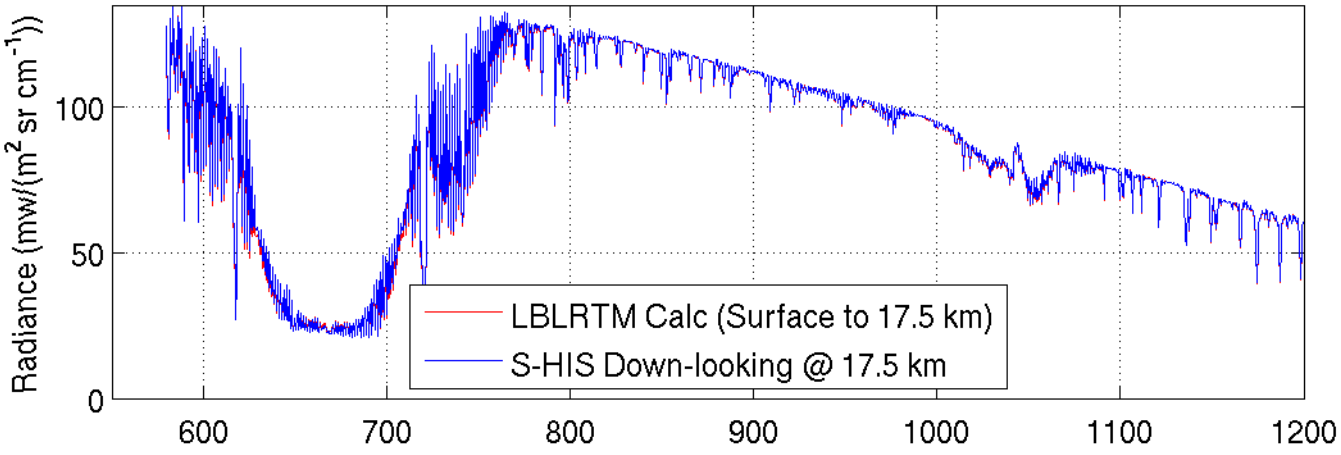
LBLRTM Calculation from TES retrieval (T, WV, O_3) Compared to S-HIS and AIRS

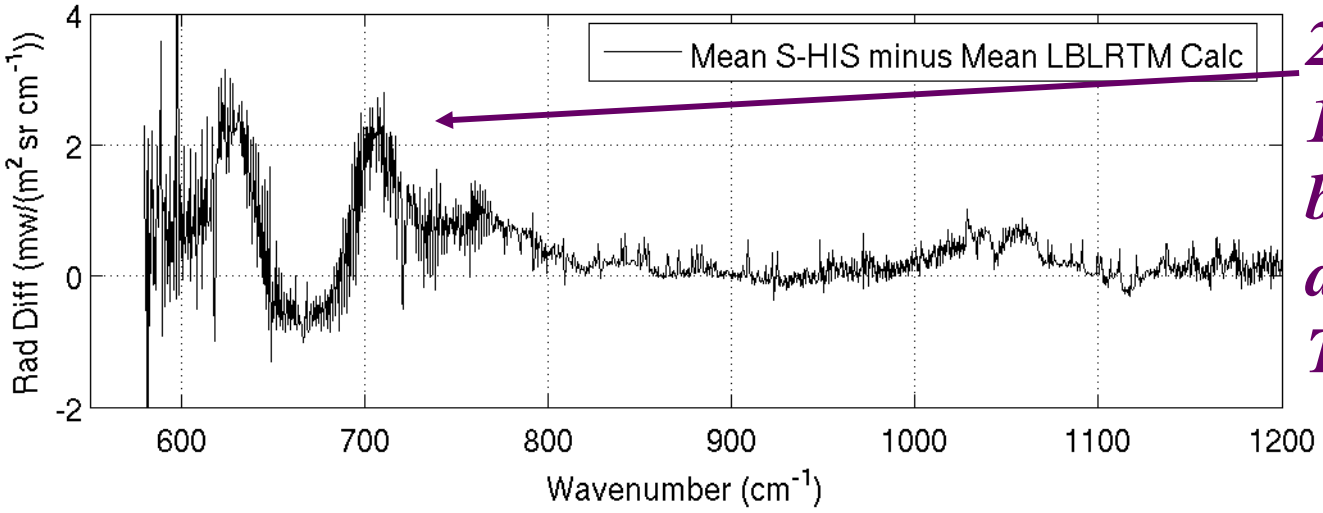


O_3 radiance agreement is good

Issue with Upper Trop Temperature (S-HIS shows colder tropopause & warmer below)

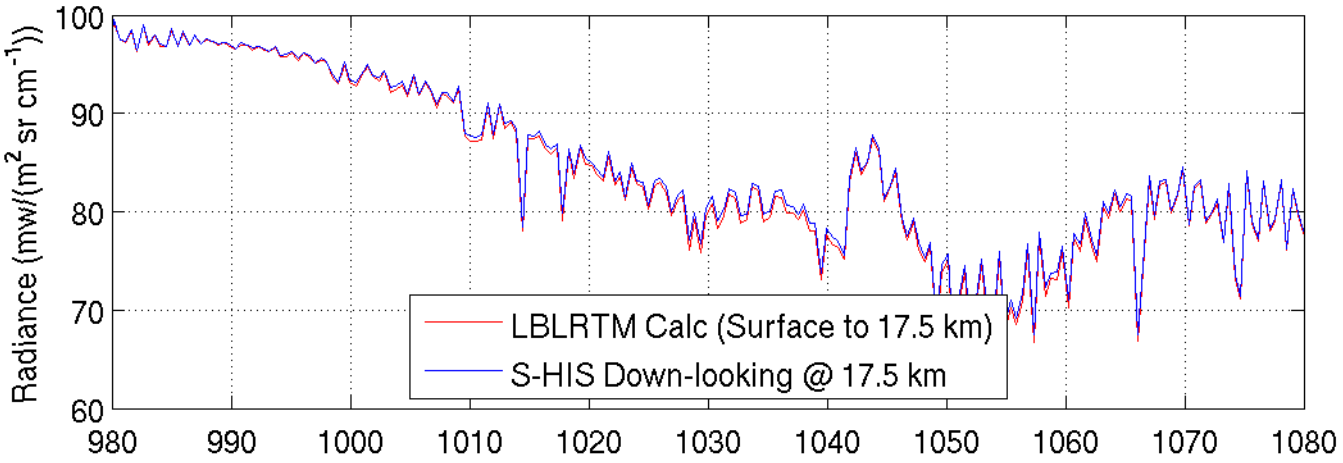
LBLRTM Calculation from TES retrieval (T, WV, O_3) Compared to S-HIS

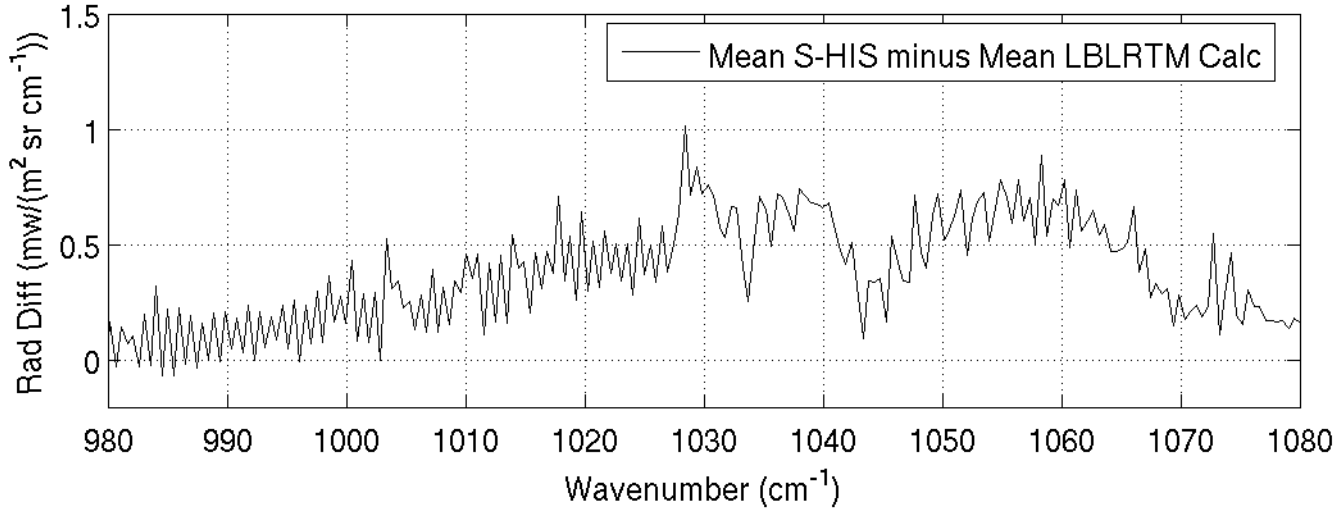




2 sides of 15 µm band agree on T issue

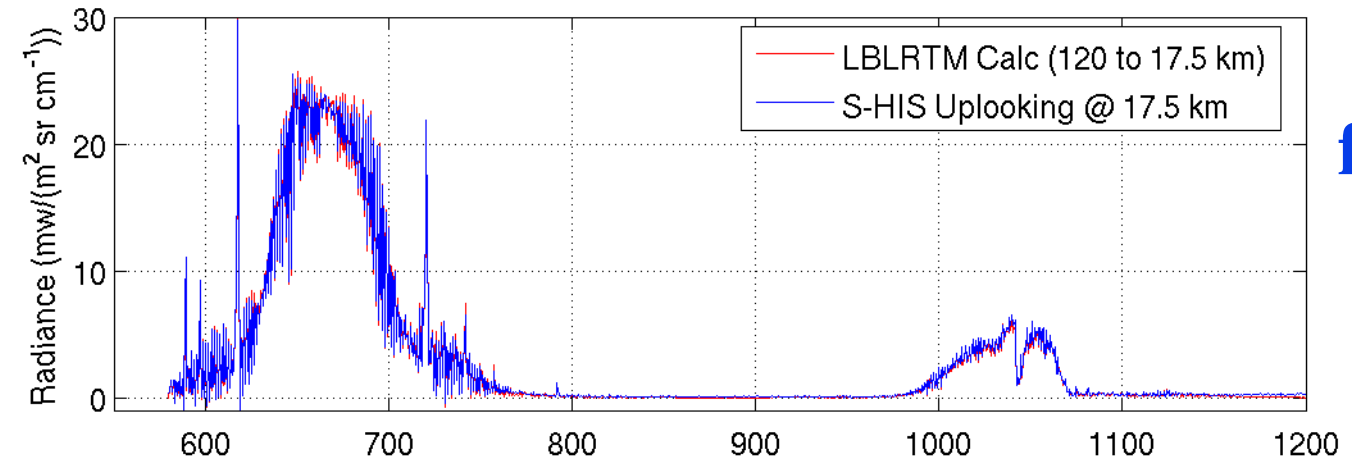
Tropospheric Ozone Radiance Comparison: S-HIS & LBLRTM from TES Retrievals

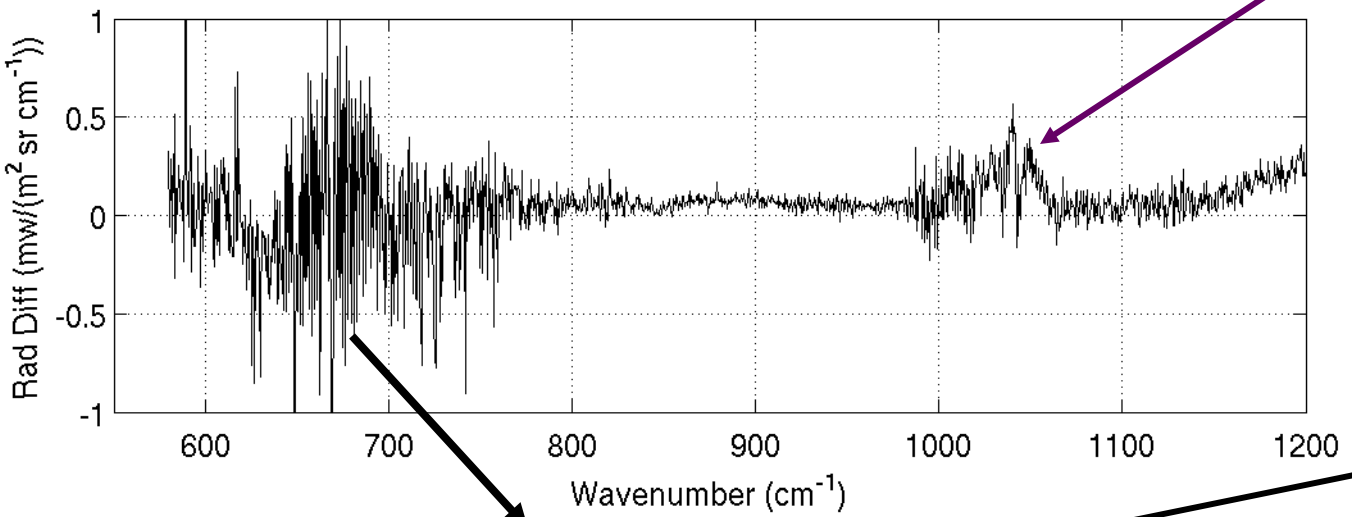


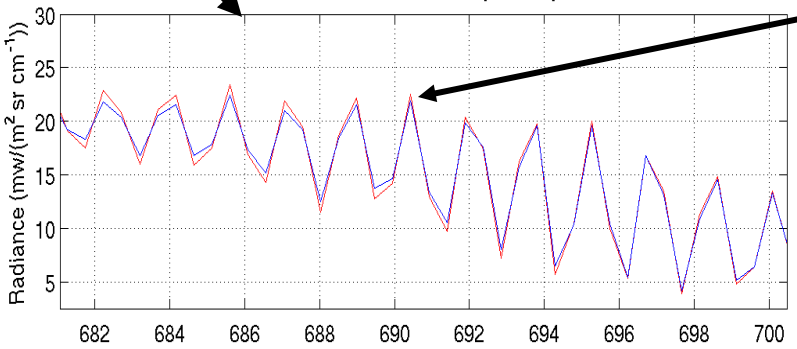


S-HIS radiance agreement to about 4% (suggesting 4% less ozone, if T profile right)

Stratosphere from uplooking S-HIS







O_3 radiance agreement is good to about 5% (S-HIS higher)

S-HIS implies smaller Strato. Temperature lapse rate (smaller on/off line amplitudes)

4. S-HIS Science Goals

- **Study of TTL Temperature and Water Vapor structure for convective and stable atmospheric states**
- **Study of lidar (CALIPSO), Radar (CloudSat) and IR cloud properties and the impact on OLR and flux**

Relative Humidity Retrieval compared to lidar cloud boundaries