Validation of AIRS Spectral Radiances with the Scanning HIS Aircraft Instrument


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TOPICS

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)

3. AIRS Assessment of MODIS Calibration
**UW Scanning HIS: 1998-Present**

**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

20021121, mean of 56 nadir views around Aqua overpass

Longwave (HgCdTe)
Midwave (HgCdTe)
Shortwave (InSb)

LW/MW overlap

MW/SW overlap

Radiance (mW/m² sr cm⁻¹)
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$_2$O above 14km
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 ~±35deg 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
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

S-HIS Spectrum Nyququist sampled without gaps
AIRS Compared to S-HIS, 21 Nov 2002

Black is Calculation

AIRS & S-HIS Obs-Calc

“Comparison 2”

AIRS minus MODIS
AIRS Compared to S-HIS, 21 Nov 2002

Black is Calculation

AIRS & S-HIS Obs-Calc

“Comparison 2”
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)
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
Fantastic AIRS - MODIS Agreement for Band 22 (4.0 µm)!

AIRS Tb (K)

AIRS minus MODIS (K)

AIRS Histogram

MODIS

Uniform Scenes Selected
MODIS Band 22 (4.0 µm)

AIRS-MODIS mean = -0.05 K

Little Dependence on Scene Temperature

Little Dependence on X-track View Angle

Little Dependence on Solar Zenith Angle
Summary of AIRS-MODIS mean Tb differences

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

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

No Shift

MODIS shifted

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
• 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.