Comparison of AIRS and CrIS Radiances & Retrievals

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NASA Sounder Science Team Meeting
MARRIOTT Greenbelt MD. 13-16 November, 2012
# Satellite Instrument Characteristics

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Spatial resolution</th>
<th>spectral res. (cm(^{-1}))</th>
<th>spectral rng. (cm(^{-1}))</th>
<th>spatial sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIRS (2002 - )</td>
<td>14 - km</td>
<td>(\sim 1200) resolving power (0.5 – 2.5 cm(^{-1}))</td>
<td>650-2665</td>
<td>Contiguous Cross-track scan 90 FOVs</td>
</tr>
<tr>
<td>CrIS (2011 - )</td>
<td>14 - km</td>
<td>0.8 max OPD (full res) 0.625, 1.3, 2.6 cm(^{-1})</td>
<td>650-2550</td>
<td>Contiguous Cross-track Scan 30 3x3FOV Arrays</td>
</tr>
</tbody>
</table>

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**FTS Response**

\[
\Delta \nu_{ua} = 0.625 \text{ cm}^{-1}
\]

**Grating HWHM**

\[
\begin{align*}
\Delta \nu_{ua} &= \Delta \nu_{ua} \\
&= 1.43 \Delta \nu_{ua}
\end{align*}
\]

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*After: H. E. Revercomb: “High Resolution Workshop-GIFTS-HES” 26 Apr 2006*
1. Use co-located clear sky samples of CrIS and AIRS retrievals and radiance spectra

2. Defined “clear sample” as: psfc > 950 hPa; difference between CrIS and AIRS window BT < 2 K, AIRS window BT > 270 K, difference between the secant (AIRS LZA) and the secant (CrIS LZA) < 0.2

3. Transform CrIS radiance spectra to AIRS radiance spectra by:
   - Zero expanding CrIS interferogram to a max OPD which is a factor of 1/40 x original (i.e., ± 32 cm) and FFT the expanded IFGM to a fine scale spectrum (0.015 cm⁻¹)
   - Convolute CrIS unapodized fine scale spectrum to AIRS spectral points using the AIRS Spectral Response Functions (SRFs)
Spectral Resolution Comparison

Simulated AIRS from CrIS by applying AIRS SRFs directly to fine scale (i.e., 1/40 x nominal spacing) observed CrIS radiance spectrum.

Example shows that the CrIS inherent spectral resolution is equal to or greater than that of the AIRS.

October 6, 2012
**Simulation of AIRS From CrIS**  
*(Double Difference Method)*

1. Use co-located clear sky samples of CrIS and AIRS retrievals and radiance spectra

2. Defined “clear sample” as: Cloud Mask for both AIRS and CrIS are set to “Clear”; difference between CrIS and AIRS retrieved surface skin temperature <2 K, AIRS surface temperature >270 K, difference between the secant (AIRS LZA) and the secant (CrIS LZA) < 0.2

3. Transformed CrIS radiance spectra to AIRS radiance spectra by computing the observed minus PCRTM calculated CrIS radiance difference, performing a 40 times expanded scale (interferogram zero filled) interpolation and applying the AIRS SRFs to produce CrIS observed – calculated difference spectra on the AIRS spectral scale (Tobin et. al., 2007).

4. Produced CrIS simulated AIRS spectra by adding the results of (3) to the PCRTM calculated AIRS radiance spectrum

* Corrects for local zenith angle and residual spectral response differences
Mean Brightness Temperature Spectra

April 27, 2012 (760 “Clear” Spectra)

(Filtered AIRS Channels)

* PCRTM (CrIS sounding and AIRS LZA)

Observed CrIS simulated AIRS Vs Observed AIRS

Calculated AIRS Vs Observed AIRS

* PCRTM (CrIS sounding and AIRS LZA)
Mean and Standard Deviation Results

April 27, 2012 (760 “Clear” Spectra)

AIRS - CrIS (All AIRS Channels)

AIRS - Calc* (All AIRS Channels)

AIRS - CrIS (Filtered* AIRS Channels)

AIRS - Calc* (Filtered AIRS Channels)

* PCRTM (CrIS sounding and AIRS LZA)
Mean and Standard Deviation Results

April 27, 2012 (760 “Clear” Spectra)

*A PCRTM (AIRS sounding and AIRS LZA)

*A PCRTM (CrIS sounding and AIRS LZA)

*A PCRTM (CrIS sounding and AIRS LZA)
Observed minus Calc Bias & STD Results
(each on their own spectral Scale)
April 27, 2012 (760 “Clear” Spectra)
Direct Broadcast “Dual-Regression” Retrieval Algorithm

Global Clear Soundings

Global Cloudy Soundings

Radiances (calculated with clear FM)

Radiances (calculated with cloudy FM)
8 cloud height classes (100-900 hPa)

Clear trained EOF regression results

Cloud trained EOF regression results

Cloud Top Altitude
level where $T(\text{cloudy}) > T(\text{clear})$ for $p > p_{\text{cl}}$

Final Profile
• clear-trained above,
• cloud-trained below cloud level

AIRS, CrIS, and IASI Sounding Channels

- In the retrieval channels from 665 cm$^{-1}$ to 2400 cm$^{-1}$ are used.
  
  - AIRS = 1258 (30 PCs)
  - CrIS = 1245 (30 PCs)
  - IASI = 7021 (50 PCs)
Ground Remote Atmospheric Sounding Project (GRASP) Validation Campaign (16 – 30 April, 2012)

A comprehensive data set for validating and improving satellite and ground based remote sensing measurements

- **Satellite** sounding data was collected and processed for all Metop, Aqua, and Suomi NPP orbits within view of Hampton University (HU)
- **Radiosondes** were launched from HU at satellite overpass times
- Quasi continuous **upward looking FTS** measurements were made for determining PBL temperature, moisture, and trace gas structure
- **Raman LIDAR** measurements were made for deriving cloud, aerosol, and free troposphere temperature and water vapor profiles
- Continuous measurements of **surface meteorological and radiative flux parameters** \( (P, T, Q, V, LW\text{ Flux}, SW\text{ Flux}) \) were obtained
- **All-sky camera** operated for identifying cloudiness during radiation and meteorological measurements
GRASP Statistics (25-60N; 60-100W)
GRASP (Mean Double Difference)
Aqua and Suomi NPP orbits, Eastern NA April 27, 2012

**AIRS granules**
- Start times: 07:17 UTC
- AIRS granule size: 90x270 (24300 FOVs)

**CrIS granules**
- Start times: 07:12 UTC
- CrIS granule size: 90x270 (24300 FOVs)
AIRS & CrIS Retrievals (April 27, 2012)

You Can See The Great lakes
Retrieval Reflections of 20 cm\textsuperscript{-1} Mean Radiance Differences (April 27, 2012)
The GH is a fully autonomous aircraft
The GH communicates with the ground via both satellite and direct line-of-sight links
The GH flight mission is monitored and controlled using a ground station that is staffed by pilots and a mission director
The GH instruments are remotely operated by scientists and a payload manager
Suomi NPP Cal/Val Flight (Oct. 6 2012)
Suomi NPP Cal/Val Flight (Oct. 6 2012)

Solid = Std (d)
Dashed = Bias (d)
Suomi NPP Cal/Val Flight (Oct. 6 2012)

Solid = Std (d)
Dashed = Bias (d)
Summary

✦ Sounding Accuracies
  - Accuracies better than
    - 2 K & 20 % Absolute (Relative to GDAS)
    - 0.5 K & 5 % Relative (Instrument Differences)

✦ Synoptic Scale Retrieval Bias
  - Synoptic scale patterns of AIRS/CrIS retrieval differences result from small synoptic scale differences in radiance observations.
  - Although relatively small, could be significant for the detection of small scale time tendencies for convective weather forecasting or water vapor wind determination from consecutive AIRS and NPP sounding data.
  - Given the magnitude of ultraspectral sounders in orbit today (AIRS, CrIS, IASI-A, IASI-B), these biases can be eliminated through cross calibration of the various sensor retrievals.
  - The next step is to eliminate synoptic scale bias differences in the radiance and retrieval data so to be able to detect time tendencies of atmospheric stability and water vapor motion wind profiles from consecutive AIRS and CrIS and IASI-A and IASI-B thermodynamic retrievals.