Radiometric and Spectral Consistency of Hyperspectral Infrared Sounders

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CrIS Operational Concept

- **CrIS on NPP**
  - 2,200 km Swath
  - ±50° Cross track Scans
  - 30 Earth Scenes

- **Decode Spacecraft Data**
  - CrIS SDR Algorithm
  - Co-Located ATMS SDRs

- **Applications**
  - NWP, EDR
  - Global Temperature, Moisture, Pressure Profiles

- Figures from ITT Exelis
Spectral Coverage and Resolution of AIRS, IASI, and CrIS

**AIRS: 2002**

**IASI-A: 2006**

**IASI-B: 2012**

**CrIS: 2011**

**CrIS: 2011 - Full Resolution**

From Hank Revercomb
Motivation

- Hyperspectral IR sounders have served as benchmark measurements for the GSICS community.
  - Polar orbiting sensor: HIRS, AVHRR, AATSR
  - Geostationary: Imagers and Sounders

- With more hyperspectral IR sounders on-orbit, are there any radiometric and spectral differences among them?
  - Now: AIRS → Metop-A/IASI → NPP/CrIS → Metop-B/IASI
  - Future: JPSS-1/CrIS and MetOp-C/IASI ....

- Understanding the root causes of the radiometric differences of these sounders will benefit for CrIS Cal/Val program
Approach

• Direct comparison
  – CrIS versus IASI (Metop-A and –B)

• Indirect comparison:
  – Through the third sensor, CrIS-VIIRS versus IASI-VIIRS

• Objectives
  – Reduce uncertainties caused by the methodology
  – Identify the differences at the sensor calibration level
  – Understanding the root causes of these differences
Simultaneous Nadir Overpass (SNO)

All data are from IDPS.

Only nadir and uniform scenes were selected.

Using the same collocation algorithms to collocate CrIS/IASI with VIIRS.
Collocating CrIS/IASI with VIIRS: Accurately computing FOV Shape

The method based on the algorithm can detect the VIIRS geolocation errors.

M6.3x released, code bugs were fixed

EP V35 Upload

VIIRS Geolocation errors
Collocate VIIRS with CrIS/IASI

Histogram of VIIRS M16 radiances in CrIS FOV

CrIS FOV footprint

VIIRS Pixels

CrIS/IASI FOV Spatial Response

50%
Scene Uniformity Effects

CrIS - IASI at 900.00 cm⁻¹

BT Diff. [K]

VIIRS STD/Avg M16
Resample IASI to CrIS

Fourier Transform

1. De-Apodization
2. Truncation
3. Apodization

Re-sampling error very small

Inverse Fourier Transform
IASI and CrIS SNO Spectra

Metop-A IASI and CrIS

Average Spectra

North (339)

South (431)

Metop-B IASI/ and CrIS

North (153)

South (133)

SNOs in 10/2012, 12/2012, and 02/2013

SNOs in 03/2013
CrIS vs. IASI: CrIS Band 1

North Pole
- CrIS
- IASI
- CrIS-IASI

South Pole
- Metop-A
- IASI

North Pole
- Metop-B
- IASI
CrIS vs. IASI: CrIS Band 2

North Pole

CrIS
IASI

CrIS-IASI

South Pole

Metop-A

North Pole

CrIS
IASI

CrIS-IASI

South Pole

Metop-B
CrIS vs. IASI: CrIS Band 3

North Pole

IASI

CrIS

CrIS-IASI

South Pole

IASI

CrIS

CrIS-IASI

Metop-A

Metop-B

wavenumber (cm⁻¹)
How about CrIS/IASI versus VIIRS?

CrIS/IASI spectra are overlapped with VIIRS SRFs for M13, M15, and M16, and I5

\[
L_i = \frac{\int_{\nu_1}^{\nu_2} R(\nu) S_i(\nu) d\nu}{\int_{\nu_1}^{\nu_2} S_i(\nu) d\nu}
\]

\begin{align*}
12.0 \mu m & \quad 10.8 \mu m \\
4.05 \mu m & \quad 2.05 \mu m
\end{align*}

wavenumber (cm\(^{-1}\))

BT (K)
Be careful for out-of-band response!

Center wavenumber and band correction coefficients are calculated using the above SRFs.
This relationship is used to compensate CrIS convolution results.
For a non-linear detector

Hypothetical detector-response curve exhibiting nonlinearity. The horizontal axis represents the absolute magnitude of the photon flux and the vertical axis represents the measured dc signal.

From Abrams et al. 1994
Non-linearity Coefficient Changes

Longwave band

Middlewave band

![Graph showing non-linearity coefficient changes for CrIS FOVs in Longwave and Middlewave bands.]
BAND 1

Metop-A

Old a2

New a2

Metop-B

Old a2

New a2
IASI/CrIS vs. VIIRS M15

Old a2

New a2

Metop-A

Old a2

New a2

Metop-B
IASI/CrIS vs. VIIRS M16

**Metop-A**

**Metop-B**

**New a2**
Conclusion

- Inter-comparison of CrIS with IASI indicate that the consistency between CrIS and IASI is around 0.1-0.2 K at most spectral regions.
  - Band 1: CrIS is warmer than IASI, especially for cold scenes
  - Band 2: CrIS and IASI agrees well at water vapor absorption region.
  - Band 3: Spectral inconsistency for shortwave sharp transition regions between CrIS and IASI

- CrIS/IASI vs. VIIRS band M15 and M16.
  - The differences are more apparent at cold scenes (180-200K) than at warm scenes (above 260K).
  - CrIS-VIIRS BT difference shows stronger scene-dependent features at M15 than IASI.

- The detector nonlinearity plays an important role for the differences among CrIS, IASI, and VIIRS.

- Newly-proposed nonlinear coefficients for CrIS will reduce the differences of CrIS-IASI and CrIS-VIIRS. After evaluation, these nonlinear coefficients will be released for operational data processing.
Thank you
BAND 1

MetOp-A

New a2

MetOp-B

New a2