Radiometric inter-comparison of IASI: IASI-A / IASI-B, IASI / AIRS, IASI / CrIS

Denis Jouglet (CNES-DCT/SI/MO)
Jordi Chinaud (CNES-DCT/ME/EI)
Xavier Lenot (C-S)
and the IASI TEC team (CNES)

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OUTLINE

- Introduction / objectives
- IASI / AIRS, IASI / CrIS: Methodology and results
- IASI-A / IASI-B: Methodology and results
- Conclusions
Introduction

Objectives of the radiometric inter-comparison

- For the IASI TEC: External monitoring of the IASI calibration
  » Participation to the IASI-B in-flight commissioning
- For the users (GSICS):
  » To ensure the consistency of the IASI calibration with the TIR sensors community
  » Checks the long term data quality (climatology)

Principles:

- Statistics (biases) on a very large dataset
- Work by couples:
  » IASI-A / AIRS, IASI-B / AIRS, IASI-A / CrIS, IASI-B / CrIS, IASI-A / IASI-B
- Observations in normal operations (IASI L1C)
- Focus on same geophysical scenes observed by the two sensors (same place, same time, same viewing conditions)
  ➔ Check the calibration differences only
- No correction of spectra by simulation
Reminder of AIRS, IASI, CrIS characteristics

<table>
<thead>
<tr>
<th>Instrument</th>
<th>IASI-A</th>
<th>IASI-B</th>
<th>AIRS</th>
<th>CRIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satellite</td>
<td>Metop-A</td>
<td>Metop-B</td>
<td>Aqua</td>
<td>NPP</td>
</tr>
<tr>
<td>Launch date</td>
<td>2006</td>
<td>2012</td>
<td>2002</td>
<td>2011</td>
</tr>
<tr>
<td>Local time</td>
<td>21h30</td>
<td></td>
<td>13h30</td>
<td></td>
</tr>
<tr>
<td>Techno</td>
<td>FTS</td>
<td></td>
<td>Grating</td>
<td>FTS</td>
</tr>
<tr>
<td>Spatial resolution (nadir)</td>
<td>12 km</td>
<td></td>
<td>14 km</td>
<td></td>
</tr>
<tr>
<td>Spectral range</td>
<td>645 – 2760 cm(^{-1}) / 3.62 – 15.5 (\mu m)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of channels</td>
<td>8461</td>
<td></td>
<td>2378</td>
<td>1305</td>
</tr>
<tr>
<td>Spectral coverage</td>
<td>Continuous</td>
<td></td>
<td>Partial</td>
<td></td>
</tr>
<tr>
<td>Spectral resolution</td>
<td>0.5 cm(^{-1})</td>
<td></td>
<td>0.4 – 2.1 cm(^{-1})</td>
<td>0.625 – 2.5 cm(^{-1})</td>
</tr>
</tbody>
</table>

Typical IASI, AIRS and CRIS spectra
Methodology for IASI / AIRS, IASI / CrIS

- **Similar scenes: SNOs** (Simultaneous Nadir Overpasses)
  - Tolerance in simultaneity: 20 min
  - ~30 scenes every 3 days for IASI / AIRS (12000 in 5 years)
  - Always at high latitudes

- **Spatial match:**
  No collocation, differences in spatial sampling
  ➔ Regional averaging of the soundings pixels over a 300 km × 300 km area around the orbit crossing point

- **Spectral match:**
  Differences in spectral resolution and sampling
  ➔ Construction of 33 broad pseudo-bands, each PB ~100 elementary channels averaged
  ➔ The AIRS missing channels are considered when calculating the IASI coefficients

- **For each pseudo-band,**
  \[ \Delta T = \frac{(L_{ASI} - L_{AIRS})}{\partial L / \partial T} (\sigma, 280K) \]
Long term IASI-A / AIRS inter-comparison

- **Bias and deviation over 5 years:**
  - AIRS & IASI radiometric calibrations are very close (|ΔT| < 0.1 K)
  - Largely < absolute radiometric calibration specification (0.5 K for each)
  - Small differences under investigation

- **Temporal monitoring**
  - IASI & AIRS are stable
  - No seasonal or inter-annual effect

- **Study of the correlation of ΔT with:**
  - Scene temperature (surface or atmosphere)
    » Small trend: non-linearity in one instrument?
  - Scene temperature non-uniformity:
    » Increase in dispersion
    » Effect on input dataset
  - Etc.
IASI-A / AIRS & IASI-B / AIRS inter-comparison

- Biases and standard deviations

- Biases < ~0.1 K \(\Rightarrow\) Very well cross calibrated
- Same patterns
- Similar datasets:
IASI-A / CrIS & IASI-B / CrIS inter-comparison

- Biases and standard deviations

  Biases < ~0.2 K \(\Rightarrow\) Very well cross calibrated
  Amount of data still to increase
  Similar datasets:

- IASI-A / CrIS (PB method), 1561 scenes. Black: bias, yellow: bias +- 1 sigma
- IASI-B / CrIS (PB method), 386 scenes. Black: bias, yellow: bias +- 1 sigma

Wave numbers covered by broad band pseudo-channel (cm\(^{-1}\))
Similar scenes:
IASI-A and B are on the same orbit with a 180° shift
- Numerous common observations between 2 consecutive tracks, but:
  » never simultaneous: ~50 min temporal shift
  » off-nadir: from 0° to 39°, opposite angles

Selection on the most relevant scenes
- Dedicated tool (next slide)
- 20 scenes per day in routine

Spatial match:
- Regional averaging of the soundings
  (area 300 × 300km or less)

Spectral match:
- ΔT calculated at
  » Elementary channel level
  » Broad pseudo-band level
  (same as IASI/AIRS or IASI/CrIS)
Selection aims at reducing the effects of:

- **Off-nadir geometry** = The lines of sight A & B are always different
  - Focus on the central area ➔ same atmospheric thickness
  - Need for homogeneous atmospheres (typical size ~16 km)
- **50 min time delay**
  - Need for stable scenes
  - Need for homogeneous atmospheres (same atmosphere even if moving)

Selection tool computes a quality index:

- Based on external data
- **Homogeneous scenes:**
  - Low inter-pixel and intra-pixel variance of the IIS for A & B
  - Clouds & snow: none or full in A & B
- **Stable scenes:**
  - Focus on oceans at night
  - Low differences in IIS A & B temperatures
  - Clouds & snow: same amount between A & B
  - Low variations in ECMWF profiles (“geophysical NeDT”)
Direct IASI-A / IASI-B inter-comparison

- Biases over a relevant dataset (homogeneous and stable scenes, night)
  - Biases < \( \sim 0.1 \) K \( \Rightarrow \) Very well cross calibrated
  - Standard deviations mainly due to geophysics
  - Impact of the dataset selection:

  With diurnal data

  More stringent quality index, but
  75\% delay A/B > 0
  25\% delay A/B < 0
Combination of IASI / AIRS and IASI / CrIS for IASI-A / IASI-B

- Biases $< ~0.1$ K $\Rightarrow$ Very well cross calibrated
- Confirmation of the direct comparison
- Effect on B1?
- Small differences: dataset selection?
CONCLUSIONS

● The tool for inter-comparison is operational for the 5 couples of sensors:
  IASI-A / AIRS, IASI-B / AIRS, IASI-A / CrIS, IASI-B / CrIS, IASI-A / IASI-B

● Major result: very accurate cross-calibration!
  ✦ Bias entre between 0 K and 0.2 K, < radiometric absolute specification of 0.5 K
  ✦ IASI-B very close to IASI-A (bias ~0.1 K) ➔ continuity of the IASI mission

● Work on-going:
  ✦ Increase the size and relevance of the dataset
  ✦ Go further in the interpretation of small differences
  ✦ Perform IASI / AIRS and IASI / CrIS at high spectral resolution
  ✦ Perform a spectral inter-calibration?

● The tool should be operational for a long time (decades for climatic studies)
  ➔ Inclusion of the future sensors (IASI-C, IASI-NG, etc.)