Infrared Atmospheric Sounding Interferometer

IASI on METOP-A
Radiometric and Spectral Performances measured during commissioning

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Instrument radiometric Noise (1/2)

- Non apodised spectra (L0 product)
- Measured on Black Body at 293 K : specified at 280 K
- In-flight noise very close to the one measured during on-ground test

Radiometric instrument noise (NeDT at 280 K) measured on 2006/12/04 and 2007/09/25, as well as the predicted noise for a 20% loss of instrument gain at 850 cm$^{-1}$.

The radiometric instrument noise is directly related to the instrument gain (the detector temperature is stable).
Radiometric instrument noise (2/2)

Monitoring of the evolution of the instrument gain through the ratio of calibration coefficient slopes

The decrease of the ratio of calibration coefficient slopes at 850 cm⁻¹ is proportional to the loss of instrument gain due to ice contamination.

Loss of gain December 2006 – September 2007: less than 13%

20 % loss is expected to be reached in May 2008
Radiometric calibration – orbital stability verification

- First component
  - Offset calibration coefficient
  - Cold Space views (CS1)
  - Lack of parasitic flux
    - CS1 vs CS2 comparison
  - Temporal stability (filtering)

- Second Component
  - Slope calibration coefficient
  - Black Body views (BB)
  - Lack of sensitivity to BB environment
  - Temporal stability (filtering)

- External Calibration Mode
- Broadband pseudo-channels
Radiometric calibration – orbital stability verification

Results on Offset calibration coefficient (14 consecutive orbits)

- **Observation:** No Parasitic flux in CS1 or CS2
- **Orbital fluctuations caused by lag on filtered parameters**
  - In April/May: 0.02 K (B1), 0.03 K (B2), 0.04 K (B3) peak to peak
  - Reduced to: 0.008 K (B1), 0.012 K (B2), 0.016 K (B3) after 27th of June
- **Reminder:** specification +/- 0.15 K (scaled to 280 K)
Radiometric Post-Calibration

- Correction of scan mirror reflectivity variation with incidence angle
  - Minor effect (0.07 K at 280 K) but close to the specification (0.1 K)
  - Very close to the one observed during ground testing

\[
\text{CS}_2 \text{ raw} = 0.002 \times B(280\text{K})
\]

\[
\text{CS}_2 \text{ corr.} = \text{CS}_1
\]
Radiometric calibration — IASI versus AVHRR

Method

- Slope of AVHRR (ch4) vs IASI radiances
- Analysis of slopes vs IASI scan angle

Good fit with cosine of the scan angle
Polarization of AVHRR scanning mirror?
IASI effect: slight asymmetry
Radiometric calibration — IASI versus AIRS

Summary results (case 16th of April 2007)
- IASI External Calibration Mode. Very uniform situation
- 9 pseudo-channels / 49 soundings / 210 K in atmospheric window
- Differences scaled to 280 K reference temperature

- Intercalibration error << 0.1K (average of the 49 soundings)
Radiometric calibration — Summary

- **IASI stability on mid-term temporal range (orbit) very good**
  - In particular, no impact of beginning/end of eclipse, terminator crossing, etc.

- **IASI interpixel calibration error**: a few 0.01 K (typ. 0.05 K)

- **Intercalibration with AVHRR**
  - Small differences: -0.2 K < DT < 0.4 K (scaled at 280 K), very plausibly attributed to AVHRR (viewing angle dependency)
  - IASI spec (absolute): +/- 0.5 K at 280 K

- **Intercalibration with AIRS**
  - SNO: Simultaneous nadir observations
  - Differences measured at 9 positions of the IASI mission band
  - 3 controls done: differences < 0.1 K at 280 K

- **Long term (over months) stability of the NWP bias monitoring**
IPSF : In-Flight Straylight analysis

- Use of moon pass inside Cold Space Field of View (CS2)
  - Level lower than observed during ground testing
    - Closer to the predictions performed before the test
    - B1 : 0.17 % of input signal
    - B2 : 0.11 % of input signal (no measure on ground)
    - B3 : 0.3 % of input signal
    - Main impact for P4 when the moon is in P2
The spectral positions of the spectra samples must be known better than $2 \times 10^{-6}$ i.e. $\Delta \nu / \nu < 2 \times 10^{-6}$.

In terms of spectral sample the specification is band dependant:

<table>
<thead>
<tr>
<th>cm$^{-1}$</th>
<th>cm$^{-1}$</th>
<th>Sample fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>650</td>
<td>0.0013</td>
<td>0.0052</td>
</tr>
<tr>
<td>1200</td>
<td>0.0024</td>
<td>0.0096</td>
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<tr>
<td>2000</td>
<td>0.0040</td>
<td>0.0160</td>
</tr>
<tr>
<td>2500</td>
<td>0.0050</td>
<td>0.0200</td>
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</tbody>
</table>

IASI is a Michelson Interferometer:

- No variation of the spectral calibration inside the band is expected.
- Off axis detectors induce a high sensitivity of the spectral calibration.
  \( \Rightarrow \) Need for an Instrument Spectral Response Function Estimation Model.
  - Parameters are pre flight or in flight characterised and in flight estimated.
Spectral calibration: instrument model inputs

- **Pre-flight characterisation:**
  - Sampling laser wavelength
  - Moving corner cube displacement law (linear)
  - Beam splitter and compensator plate (width, angles)
  - Instrument Point Spread Functions (one per detector) Y and Z field angles and weights

- **In flight characterization off line at TEC:**
  - Fixed cube corner offset (shear)
  - Instrument Point Spread Functions (Y and Z field angles)

- **In flight characterisation near real time:**
  - Interferometer axis position (Y and Z coordinates)
Fixed Cube Corner Offset

- Accurate determination
  - STD < 0.1 µm

- Very stable:
  - Small drift
  - < 0.5 µm
  - Over 7 months
Spectral Calibration

- Long term stability of the interferometric axis position
  - 5.5 months period
    - 3rd of April
    - 15th of September
  - Average in rad
    - January
      - Y = -170 $10^{-6}$
      - Z = -360 $10^{-6}$
    - April
      - Y = -190 $10^{-6}$
      - Z = -380 $10^{-6}$
  - Small evolution
    - 11th of July
      - 30 µrad
      - Equivalent to $\Delta v/v = 5 \times 10^{-7}$
      - Spectral Database update

11/07/2007 parameters updating
Spectral Calibration : Verification method (1/3)

- Data set selection
  - External calibration mode Nadir viewing
    - 16/01/2007 9 consecutive orbits
    - 13/04/2007 9 consecutive orbits
    - 04/06/2007 4 consecutive orbits
  - Homogeneous scenes
    - IIS Radiiances variance < 0.6 Kelvin
  - Only contiguous scenes are selected
    - Smaller set = 6 spectra
    - Larger set = 250 spectra
    - Total selected spectra = 6295
    - Number of contiguous sets = 175
  - For each set of contiguous scenes
    - Computation of the average spectrum
    - Computation of the corresponding 4AOP (using GEISA spectroscopy) simulated spectrum
Spectral Calibration : Verification method (2/3)

- 10 spectral windows are selected (8 used)

- For each spectral window
  - Computation of the correlation coefficient between averaged measured spectrum and simulated corresponding spectrum
  - By varying the spectral scaling factor $\Delta \nu/\nu$
  - The position of the maximum of the correlation coefficient gives the relative spectral shift error
  - The value of the maximum gives the quality index of the determination

- The results are filtered using the quality index
  - Quality index > 0.990
Spectral Calibration : Verification method (3/3)
Spectral Calibration: Results for Level 1B Band 3

- Errors bars show the standard deviation of the determinations.

- Considering the method sensitivity with the atmospheric knowledge the spectral performances are clearly inside the specification.
Spectral Calibration Verification: Sensitivity to the method

- 2 methods give coherent but different results especially in band B1 (long wave)
  - Correlation between derivative of the spectra (best results)
    - Remove dependency to low frequencies present in the spectra, if any.
  - Correlation between radiances

Intercalibration between the 4 IASI pixels (FOV #1 as reference)
Spectral performance: Ghost analysis (1/2)

- **Ghost origin:** sampling jitter (harmonic) caused by a micro vibration
- **Analysis done on BB spectra**
  - Validation of simple model using ground and flight measurements
- **Amplitude estimated from real part of BB spectra**

<table>
<thead>
<tr>
<th>Std Dev</th>
<th>P1 CD0</th>
<th>B2</th>
<th>B3</th>
<th>B3/B2</th>
<th>Flight/ground</th>
<th>Comment</th>
<th>Comment</th>
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<tbody>
<tr>
<td>Ground Test</td>
<td>SM0410110948</td>
<td>0.24</td>
<td>0.42</td>
<td>1.74</td>
<td>B2</td>
<td>B3</td>
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<td>SM0612051715</td>
<td>0.25</td>
<td>0.42</td>
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<td>0.26</td>
<td>0.43</td>
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<td>0.46</td>
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<td>1.09</td>
<td>1.09</td>
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<td>1.74</td>
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<td>0.35</td>
<td>0.55</td>
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<td>SM0701191324</td>
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<td>1.23</td>
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<td>1.4</td>
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<tr>
<td>Cal/Val A</td>
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<td>0.56</td>
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<td>1.32</td>
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<td>Cal/Val B</td>
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<td>0.56</td>
<td>1.73</td>
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<td>0.55</td>
<td>1.74</td>
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<td>589 samples</td>
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<tr>
<td></td>
<td>SM0705091530</td>
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<td>0.53</td>
<td>1.69</td>
<td>1.29</td>
<td>1.25</td>
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<tr>
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<td>0.32</td>
<td>0.54</td>
<td>1.71</td>
<td>1.31</td>
<td>1.28</td>
<td>520 samples</td>
</tr>
</tbody>
</table>
Spectral performance : Ghost analysis (2/2)

- **Use of atmospheric spectra:**
  - Analysis of a small number of measurement sessions
  - Concentration on B2 band (H₂O) : very low radiometric noise -> high sensitivity
  - Confirmation of previous preliminary results
    - Noise measured on atmospheric spectra very close to noise measured on Calibration Views (after elimination of atmospheric variability)
    - Estimation of the perturbation close to the noise level (at the minimum)

- **Amplitude of the ghost**

<table>
<thead>
<tr>
<th></th>
<th>Amplitude RMS</th>
<th>Amplitude Max</th>
<th>Shape Error Index 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% of ISRF maximum</td>
<td>Measured</td>
<td>Specified</td>
</tr>
<tr>
<td>Band 2</td>
<td>0.32</td>
<td>0.45</td>
<td>0.009</td>
</tr>
<tr>
<td>Band 3</td>
<td>0.54</td>
<td>0.76</td>
<td>0.015</td>
</tr>
</tbody>
</table>

- **No evidence of external contribution to the micro-vibration**
- **Recommendation**
  - No release of LFD (locking and filtering device)
Conclusions

- After more than 9 months in orbit
  - IASI is performing very well
    - all mission requirements are met
    - both instrument and processing

- All performances very stable in the long term
  - Radiometry, spectral, geometry

- L1 commissioning using mainly IASI, AVHRR & HIRS data
  - Some verifications done with respect to AIRS and IASI Balloon data
Routine phase

- During the routine phase, IASI Technical Expertise Center (IASI TEC) located in CNES/Toulouse will take care of
  - In-depth Performance monitoring
  - Processing parameters updating

- In parallel with the operational monitoring performed by the EUMETSAT EPS/CGS teams
  - Near Real Time
  - Radiances monitoring (wrt Radiative Transfer)
Thank you

- Visit the CNES IASI Web site
  - http://smcs.cnes.fr/iasi