IASI RADIANCES CLIMATOLOGY

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Why using IASI for Climate studies?

Climatology needs long data series (>30 years) of very stable and well characterized observations

• IASI is a very stable instrument
• Very well calibrated: a reference for re-calibration of infrared sensors (WMO’s GSICS)
• 15 years of data and more with the continuation with IASI-NG
• Full coverage of Earth twice a day with consistent observations (and processing).
• Very large information content on atmospheric essential climate variables (ECVs)

In summary IASI is well sized to deliver FCDR and TCDR for Climate monitoring (trends and attribution). It can also be valuable in study of processes, or seasonal forecast.

**IASI gives an opportunity of establishing a global climatology fully independent of model**

Such statistics allow to compress strongly the data (representing 2MB/s, 170GB/d, 63 TB/y) to keep the climate signal.

• Already 8 years of data
METHODOLOGY

- Use of IASI L1c Radiances (no model, keep consistency in spectra, more stable processing, good previous examples).
- Use of AVHRR cloud fraction delivered in L1C since June 2010
- Averaged radiances for
  - All pixels
  - Cloudfree (cf=0.0)
  - Cloudy overcast (cf >0.95)
- All viewing angles or at nadir (Viewing angle <17°)
- Periods: Month (all pixels), trimesters (nadir), year
- Global (1 figure for whole Earth like altimetry). Options:
  - Sea/land/all
  - Day/night/all
  - Region: ENSO34, ENSOWP, Tropical oceans (20S-20N), Antarctica

- Conversion radiances > Brightness Temperatures
- Plot of Estimators (Proxies)
- Mapping in boxes 1°*1° available
**DATA USED IN CLIMATOLOGY**

IASI Level 1C spectra archived at Ether center  
Period of time : March 10 (June 10) to February 14  
Includes AVHRR cloud fraction in IASI pixels

<table>
<thead>
<tr>
<th>Cloud mask count</th>
<th>1.36E+07</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average cloud mask</td>
<td>69,2419</td>
</tr>
<tr>
<td>Clear pixels count</td>
<td>1.49E+06 89,06</td>
</tr>
<tr>
<td>Cloudy (&gt;=95%) pixels count</td>
<td>7.25E+06</td>
</tr>
<tr>
<td>Cloud mask</td>
<td>39,5504</td>
</tr>
</tbody>
</table>

| Ch. mean rad Clear mean Cloud mean All rms Clear rms Cloud rms all sk. Clear sk. Cloud sk. Kurt. Clear kurt. Cloud kurt. all_Tb clear_Tb cloud_Tb |
|------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 1 4.273E-04 4.051E-04 4.400E-04 5.81E-05 3.30E-05 6.39E-05 0.953 1.898 0.591 3.152 7.820 2.382 214.42 211.84 215.8 |
| 3 4.430E-04 4.256E-04 4.583E-04 7.09E-05 3.47E-05 7.87E-05 0.749 2.116 0.408 2.872 9.167 2.143 216.25 214.28 217.96 |
| 4 4.827E-04 4.849E-04 4.960E-04 8.57E-05 3.47E-05 9.42E-05 0.072 0.863 -0.042 2.601 9.829 2.179 220.63 220.87 222.04 |
| 5 4.823E-04 4.843E-04 4.958E-04 8.59E-05 3.49E-05 9.45E-05 0.090 0.899 -0.027 2.609 9.824 2.179 220.61 220.82 222.04 |
| 6 4.425E-04 4.240E-04 4.580E-04 7.03E-05 3.50E-05 7.80E-05 0.794 2.149 0.440 2.887 9.117 2.135 216.28 214.17 218.00 |
| 7 4.249E-04 3.976E-04 4.401E-04 6.40E-05 3.67E-05 7.00E-05 0.968 2.019 0.579 2.983 7.701 2.214 214.31 211.12 216.04 |
EXPLOITATION OF THE STATISTICS

● Through Proxies
  ✦ Monitoring of ECVs
  ✦ Monitoring of Trace gases

● Based on full spectra:
  ✦ Intercomparison of Monthly mean spectra of various years
  ✦ Comparison with Simulated spectra computed with ERA Interim outputs and RTTOV (clear spectra only)

● Inversion
  ✦ Retrieval of annual variations of Ts, Ttropo, T Tropopause, T LS and T HS, Mean Humidity, Total Ozone, Total CO2, Total CO, Total CH4, Total N2O using Measurements and jacobians computed with 4A and mean profiles
RESULTS FOR GLOBAL SCALE

- Monthly periods are pertinent for statistics
- Cloud fraction:
  - Very stable around 0.66
  - Number of cloudfree pixels very stable around 0.15
  - Cloud overcast constant around 0.42
- Maximum temperature (out of sun reflectance)
  - Very small variations for the sea
  - Sine cycle for Ts all pixels
- Mean Tb (proxy of OLR) : small smooth sine variations
- Proxy of tropopause and stratosphere show consistent variations
Dec 13 not the coldest

Jan 14 not the coldest but warmest

Feb 14 cold
Inverse ECVs Variations

\[ \Delta T_B(T) = \sum_{nl=1}^{nl=3} \frac{\partial T_B}{\partial T}(nl) \cdot \Delta T(nl) + \sum_{ngas=1}^{ngas=5} \frac{\partial T_B}{\partial q_{gas}} \cdot \Delta q_{gas}(ngas) \]

<table>
<thead>
<tr>
<th>Year</th>
<th>Ts</th>
<th>Ta</th>
<th>Humidity</th>
<th>CO₂</th>
<th>Ozone</th>
<th>N₂O</th>
<th>CO</th>
<th>CH₄</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 11 to Day 12</td>
<td>-0.1</td>
<td>-0.05</td>
<td>1.6</td>
<td>-1.4%</td>
<td>1.05%</td>
<td>-2.3%</td>
<td>4%</td>
<td>0.4%</td>
</tr>
<tr>
<td>June 10 to Day 11</td>
<td>-0.1</td>
<td>-0.05</td>
<td>1.0</td>
<td>-2%</td>
<td>0.96%</td>
<td>-2.5%</td>
<td>1.5%</td>
<td>1.2%</td>
</tr>
<tr>
<td>Jan to Dec 2012-2011</td>
<td>0.05</td>
<td>0.06</td>
<td>0.10</td>
<td>2.4%</td>
<td>1.05%</td>
<td>-0.4%</td>
<td>2%</td>
<td>0.4%</td>
</tr>
</tbody>
</table>

- Inversion performed based on presumed value of CO₂ mean variation
  ✦ Simple assumptions
  ✦ Inversion for regions where only one component is important
  ✦ Iterative process until good fit
  ✦ Values of Jacobians for mean atmosphere (here mean tropical, mean MLS, 1050 more suitable)
- Inversion matrix
- Include low troposphere
### Lower Troposphere

<table>
<thead>
<tr>
<th>January–December</th>
<th>Anomaly °C</th>
<th>Anomaly °F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UAH</strong></td>
<td>+0.16</td>
<td>+0.29</td>
</tr>
<tr>
<td><strong>RSS</strong></td>
<td>+0.09</td>
<td>+0.16</td>
</tr>
</tbody>
</table>

### Mid-troposphere

<table>
<thead>
<tr>
<th>January–December</th>
<th>Anomaly °C</th>
<th>Anomaly °F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UAH</strong></td>
<td>+0.01</td>
<td>+0.02</td>
</tr>
<tr>
<td><strong>RSS</strong></td>
<td>+0.07</td>
<td>+0.13</td>
</tr>
<tr>
<td><strong>UW–UAH</strong></td>
<td>+0.07</td>
<td>+0.13</td>
</tr>
</tbody>
</table>

### Stratosphere

<table>
<thead>
<tr>
<th>January–December</th>
<th>Anomaly °C</th>
<th>Anomaly °F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UAH</strong></td>
<td>-0.42</td>
<td>-0.76</td>
</tr>
<tr>
<td><strong>RSS</strong></td>
<td>-0.41</td>
<td>-0.74</td>
</tr>
</tbody>
</table>

Consistent with NCDC outputs

http://www.ncdc.noaa.gov/sotc/global/2012/13
METHODOLOGY ISSUES

- Sensitivity to cloud test based on AVHRR cloud fraction

- Sensitivity to acquisition gaps
Bias is widely due to cloud test based upon AVHRR
⇒ Need updates of level1C Processing chain
⇒ Use IASI stand alone cloud test
ALL ANGLES OR NADIR ONLY?
RESULTS ON CLIMATE

Restricted to 2010-2014

- Mean budget is determined by North Hemisphere (May to Sept warmer than Oct to April and impact of solar surface radiation deficit visible in 2013 budget).
- No measurement of any variation of mean global surface temperature (plateau?)
- No detection of any variation of the OLR
- Sea surface temperature in tropical oceans (20N-20S) exhibits a low slow increase
- Larger or lower Ozone depletion clearly detectable. Same for events with large fires and strong CO.
CONCLUSIONS

• Climatology of IASI radiances is robust even it is could be improved (Cloud test and flag of incomplete orbits).
• Inversion gives consistent result with Climate observations by ground-based networks.
• It allows to analyze impact of climatic events (e.g. ENSO episodes) at global or regional scales with the same observing technique and simultaneous measurements.
• Comparison with ERA Interim shows that statistics parameters are very consistent. Simulations must still be improved with the use of IASI cloud masks.
• Climatology must be extended to IASI-A from 2006 to 2010.
• It must also be continued with Metop-B as soon as I/C will be definitively assessed.
• Interannual variations are around 0.05 K. Analysis and monitoring requires instrument with intercalibration better than 0.02K and consistent absolute calibration.
MERCI DE VOTRE ATTENTION

QUESTIONS?
AUTRES STATISTIQUES

- Validation par comparaison avec statistiques IASI
- Evaluation des valeurs par canal
- Ecart type
- Skewness
- Kurtosis
Averaged over all view angles spectra ≈ spectra under 30°

Performed with 4AOP-2012 with Tigr2000 mean atmospheres