IASI: SUMMARY OF A SUCCESS STORY AND PERSPECTIVES

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11/04/2016
BIRTH OF THE IASI PROJECT

1989: identified as a priority for CNES during the Scientific Prospective Seminar at cap d’Agde

1996: phase B

1997: cooperation with Eumetsat on a new model for CNES: 3 identical instruments (meaning operations & storage of flight models)

1998: Phase C/D

Oct 2006 : launch of IASI-A on METOP-A

April 2007: 1st IASI conference

Sept 2012 : launch of IASI-B on METOP-B

2016 : 10 years in operation!
Séminaire de prospective, Cap d’Agde, 1989

La première priorité : la mission GLOBSAT

**Recommandations sur la programmation spatiale des années 1995-2000**

**Instrumentation de base**

<table>
<thead>
<tr>
<th>Spectromètre infrarouge</th>
<th>profils de température, profils d’humidité, propriétés radiatives des surfaces (nuages, sols...), contenus intégrés : CH₄, CO, N₂O, O₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOMOS-T</td>
<td>profils de composants mineurs température et aérosols dans la stratosphère (occultation stellaire), contenu intégré, profil d’ozone (mode SBUV)</td>
</tr>
<tr>
<td>SONIA-C</td>
<td>imagerie visible/infrarouge des nuages (résolution héliométrique, échantillonnage kilométrique)</td>
</tr>
<tr>
<td>SCARAB</td>
<td>bilan radiatif</td>
</tr>
<tr>
<td>Radiomètre</td>
<td>chlorophylle, production primaire, eaux côtières, écosystèmes marins, échanges de CO₂ à l’interface air/mer, cycle du carbone dans l’océan</td>
</tr>
<tr>
<td>Couleur de l’eau</td>
<td></td>
</tr>
</tbody>
</table>

**Options**

| POLDER                  | aérosols, biosphère continentale et marine, effets directionnels du bilan radiatif, nuages |
|                        |                                                                                           |
| LIRED                   | altimétrie des nuages                                                                    |
30 November 1989
First meeting of the « Infrared Spectrometer » MAG following the Cap d’Agde CNES seminar where the GLOBSAT (aka IASI) mission was proposed
12 October 1990

First meeting of IASI French SAG
To organize the interfaces with the scientific community
November 1991

EUMETSAT issues the requirements for an operational interferometer thermal sounder.
IASI instrument

**Nadir looking FTS**
- 12 km pixel x 4 @ nadir
- + scanning = +/- 48.3°

- Spectral coverage = 645-2760 cm\(^{-1}\)
- Spectral resolution = 0.5 cm\(^{-1}\)
- Radiometric noise ~ 0.25-0.5 K

**Priorities:**

**Numerical Weather Predictions**
- Temperature and humidity profiles each kilometer in the troposphere, (1 K, 10% accuracy)

**Tropospheric chemistry and climate**
- Integrated concentrations or vertical profiles for a series of target trace gases
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### EVOLUTION OF THE IASI PROGRAM

<table>
<thead>
<tr>
<th>Year</th>
<th>Events</th>
</tr>
</thead>
</table>
<pre><code>  | • End of METOP program in 2020 |
</code></pre>
| 2012 | • First extension of IASI program at CNES  
      | • Launch of -B and -C delayed: 2006, 2012, 2018  
      | • IASI A is flying WITH IASI B |
| 2015 | • Second extension of IASI program at CNES  
      | • Extension of IASI operations at CNES on the 2016-2020 period |
Infrared Atmospheric Sounding Interferometer (IASI)

- Fourier Transform Spectrometer based on a Michelson interferometer
  - (8461 “channels”)

- IASI developed by CNES, under CNES-EUMETSAT cooperation
- Operational level 1 processor developed and delivered by CNES
- IASI TEC at Toulouse
- IASI SIOV and Cal/Val level 1 performed by CNES
IASI OBJECTIVES

First goal: IASI is an instrument developed for Eumetsat and the european meteorological centers

But CNES also wanted to foster the use of IASI data for meteorology and other areas of application (climate, air quality monitoring, environment, etc.) by supporting research, distributing high level products, and initiating new services.

Contribution and support to research:
- Expand IASI sounding to cloudy pixels (Level1)
- Improve Level 2 products
- Study additional products
- Implement and distribute Level 3 or Level 4 products

CNES is supporting French laboratories for these research activities
## IASI PRODUCTS

<table>
<thead>
<tr>
<th>GEOPHYSICAL VARIABLES</th>
<th>ACCURACY</th>
<th>VERTICAL RESOLUTION</th>
<th>HORIZONTAL SAMPLING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature Profile</td>
<td>1K (cloudfree)</td>
<td>1 km</td>
<td>25 km (cloudfree)</td>
</tr>
<tr>
<td>Humidity Profile</td>
<td>10% (cloudfree)</td>
<td>1 - 2 km (troposphere) (cloudfree)</td>
<td>25 km (cloudfree)</td>
</tr>
<tr>
<td>Ozone total amount</td>
<td>5% (cloudfree)</td>
<td>N/A</td>
<td>25 km (cloudfree)</td>
</tr>
<tr>
<td>Ozone Vertical distribution</td>
<td>10% (cloudfree)</td>
<td>2 or 3 pieces of independant information</td>
<td>25 km</td>
</tr>
<tr>
<td>Fractional cloud cover</td>
<td>10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cloud top temperature</td>
<td>2K</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cloud emissivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO, CH4, N2O column</td>
<td>10%</td>
<td>N/A</td>
<td>100 km</td>
</tr>
<tr>
<td>SO2, CFCs</td>
<td>10%-20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sea Surface Temperature</td>
<td>&lt;0.5 K (cloudfree)</td>
<td></td>
<td>25 km</td>
</tr>
<tr>
<td>Land Surface Temperature</td>
<td>1K (cloudfree)</td>
<td></td>
<td>25 km</td>
</tr>
<tr>
<td>Land Surface Emissivity</td>
<td>1%</td>
<td></td>
<td>25 km</td>
</tr>
</tbody>
</table>

Operational Meteorology (NWP)

Climate monitoring

Atmospheric Chemistry
Lessons learned with IASI onboard MetOp-A

• IASI benefits three communities that will be more and more connected
• Covering continuously the whole TIR domain is very useful.
• To retrieve several variables, other atmospheric data (cloud, T, WV) are mandatory.
• Spectral and radiometric stabilities are very important
• Retrievals over land/sea by day/night
Concordiasi Campaign, Aug-Nov 2010

Antarctic ozone, profiles

O$_3$ IASI profiles retrieved by the ULB/LATMOS Forli algorithm, for Aug 26 2010 are compared to the sondes data launched at Mc Murdo.
Numerical Weather Prediction application
Despite the high number of other data, IASI is the first contributor as a unique instrument. It enables to gain 4 hours for weather forecasts over Europe at D+3.
Combining Metop-A + Metop-B gives a global daily coverage

**Near-real time (D+1) delivery**

Daily map (1st June 2013) of dust aerosol AOD as seen from IASI/Metop-A + IASI/Metop-B
Retrieval algorithm to convert radiances into concentrations + auxiliary data: temperature profile, H$_2$O content, emissivity, etc.
IASI publications between 2007 and now

Total number of data: 310

- Climate (50)
- Composition (96)
- Weather (56)
- Volcano (24)
- RT & retrievals (87)
- Spectra/Radiances (24)
- Instrument (23)
WHAT WORKED BETTER THAN WE ANTICIPATED

Many more molecules
Sensibility close to ground if thermal contrast
Coupling of meteorological/atmospheric composition
Operational applications: SO$_2$/ash volcanic plumes, pollution forecasts
IASI/METOP towards Operational applications

- Pollution forecast
- Fire detection
- Volcanic plumes

- Ozone peaks
- Long-range pollution
- Aviation threat
SYNERGY WITH OTHER ATMOSPHERIC MISSIONS

Missions under development

2014 2016 2018/19


TOVS AQUA GOSAT MetOp-A

ENVISAT AURA

MetOp-SG IASI-NG

MTG Sentinel4

Merlin Microcarb

Sentinel 5

OCO-2 S5P

Earth-Care ADM-AEOLUS

IASI-NG

- To ensure the continuity of IASI for NWP, atmospheric chemistry and climate, applications
- To improve the characterization of the lower part of the stratosphere, the UT/LS region and more generally the whole atmospheric column
- To improve the precision of retrievals and to allow the detection of new species

**IASI-NG goal is to improve the IASI demonstrated performances by a factor of 2:**

- Spectral sampling: 0.125 cm⁻¹
- Spectral resolution: 0.25 cm⁻¹

Signal/noise: two times better
Spatial sampling and horizontal resolution like IASI (pixel ~ 12 km diameter)
Improvement on pollution forecast 3 EU controlled pollutants (CO, O₃ and NH₃)

Better tracking of long range pollution (e.g. fire emissions)

Improved volcano alerts Early alerts possible + SO₂ and ash tracking

Atmospheric profiling

Essential Climate Variables monitoring and understanding Clouds, GHG, aerosols

IASI-NG has the potential for strongly benefiting the NWP, chemistry and climate communities, in addition to assuring the continuity of high quality observations delivery
Radiometric performances at 0.25 cm\(^{-1}\) spectral resolution
Level 1c