Major results of IASI in Atmospheric chemistry

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Outline

- Context
- Why such excellent results
- Teams working with IASI
- Basic products CO and O3
- Detection of minor trace gases: ammonia, methanol, formic acid, nitric acid

Applications
- Air quality monitoring
- Emissions
- Transport
- Climate monitoring

Operational use

Remaining issues

Perspectives: from detection to quantisation
3 years after first IASI data dissemination, 2\textsuperscript{nd} IASI international conference in Sevrier (25\textunderscore 29 January, 2010)

The excellent performances of IASI were confirmed: very good accuracy, very stable.

It allows many applications to be developed, among them Atmospheric chemistry, for which very convincing results have been obtained.

It paves the way to GMES Sentinel 5 and more applications from IASI-NG on post EPS.
What are the reasons of these good results?

- AC is one of the IASI’s target => the instrument was also designed for this purpose:
  - Spectral coverage and resolution
- AC applications was prepared by ISSWG to which several Pis contributed actively (Co chair and several scientists)
- Strongly supported by CNES
- AC products are in the list of level 2 products
- Spectroscopic information is good
- IASI characteristics allow development of applications:
  - Swath
  - Availability
  - Stability
  - Accuracy
  - Combination with other measurements
Atmospheric concentrations

IASI spectrum

Operational L2 products from Eumetsat processing
- T and humidity profiles, cloud information
- CO₂, CH₄, N₂O columns
- O₃ total and partial columns
- CO columns

Science L2 products from various processing chains
- NOAA (AIRS Team)
- France: LATMOS/ULB + LMD, LA, LISA, LPMAA, Cerfacs, Noveltis for CNES
- Others: Leicester, University of Basilicata, SRON, RAL
- ECMWF

Cloud free scenes

A majority of users takes Eumetcast data for NRT processing
Even if Eumetsat data are starting to be validated with a good quality, a large majority developed its own inversion
Average 1°x1°, 10 days, 18-28 August 2008

Trace gas products from IASI
VALIDATION – Ozone columns and profiles

Preliminary comparisons with GOME-2 partial columns (from operational profiles)

LISA, C. Keim

ULB, A. Boynard
Medium-lived trace gases

Carbon monoxide

Comparisons with other satellite data;
Preliminary cross-validation

IASI

MOPITT

TES < IASI < MOPITT

George et al., ACPD 2009
Tropospheric sources

Ammonia

2008 average

Clarisse et al., Nature Geo 2009

Target feature at 867.75 cm⁻¹

Mapping from local to global scale

28 emission hotspots identified
Tropospheric sources

→ VOCS

HCOOH, CH$_3$OH

F. Karagulian, A. Razavi

September 2008

High correlation HCOOH/CO/fire

→ Biomass burning

April 2009

High correlation HCOOH/CH$_3$OH

Weak correlation HCOOH/CO/fires

→ Biogenic emissions?
Nitric acid

No vertical information in the measurement → stratospheric column has to be subtracted

**Using a stratospheric assimilated field (Bascoe)**

\[
[HNO_3]_{tropo} = \frac{[HNO_3]_{total}}{IASI} - [HNO_3]_{strato/BASCOE}
\]

Global but requires computational efforts
Stratospheric contamination remain

**Using a background column**

\[
d[HNO_3]_{tropo} = \frac{[HNO_3]_{total}}{IASI} - [HNO_3]_{background}
\]

Simple, robust but tropical regions mainly. Provides a tropospheric “enhancement” rather than a column
Tropospheric O$_3$ over Europe during the heat wave in July 2007

Eremenko et al, G. Dufour, M. Eremenko

Eremenko et al, GRL, 2009
Chemistry/Transport

Australian fires (February 2009)

Integrated from 7 to 15 February 2009

Enhancement ratios $\Delta X/\Delta CO$ vs. time → chemistry in the fire plume

*Coheur et al.*, ACP, 2009
SO₂ depletion

\[ \text{SO}_2 + \text{OH} \rightarrow \text{HSO}_3 \]

\( K \approx 7.0 \times 10^{-7} \text{ s}^{-1} \)
e-folding time of 18 days

\( \text{T}_0 + 1 \text{ month: evidence for H}_2\text{SO}_4 \text{ aerosols} \)
A word on climate: $\text{CO}_2 / \text{CH}_4$

NN retrieval approach
retrieval of an UT integrated content representative of the 11–15 km range

Retrieval @ 5°x5° resolution
Uncertainty ~2ppmv (0.5%)

$\text{CH}_4$: 4 days average (October 2008) on a 4x4° grid

Crevoisier et al., ACP, 2009

Razavi et al., ACPD, 2009
O3 (ECMWF)

Verify against MLS (20090615-20090630)

BASELINE
No O3 OBS

BASELINE
+SBUV+OMI

BASELINE
+IASI 16 O3 Channels
• Near-real time CO total column data from IASI produced by LATMOS-ULB have been assimilated in the GEMS/MACC near-real time analysis began on 12 February 2009, 0z

• Data look good. Departures and standard deviations are a considerably smaller than they were for the previously monitored (and assimilated) EUMETSAT CO product

• Analysis is drawing to the data. Bias and standard deviation of departures are reduced.
OPEN ISSUES

- Thermal Contrast: Difference between surface TB and air temperature at maximum of Weighting function (highest concentration)
- Allows to access to Pollution in boundary layer
- But reduces the signal in the total column and induces differences between day and night
- Ground emissivity amplifies the effect
- Clouds (impact currently evaluated)

Averaging kernels (San Joaquin)

Averaging kernels for NH3 (Clarisse)
Conclusions

IASI measures a dozen of species with a range of lifetimes, *routinely* and *globally* twice a day

- Long-lived species (years)
  - **Climate**
  - + CO, O₃ (months)
  - **Chemistry, AQ, Transport**

- Short-lived species + aerosols (days)
  - **Sources, emission inventories**

IASI a demonstrated its capability in detecting minor species
Time is now to quantify the emissions
It is one goal of the GMES Sentinel 5

This will be obtained thanks to a higher spectral resolution and lower noise which will be present on the next generation of IASI IASI-NG which will fly on the Post EPS
It has been demonstrated that Humidity profiles and temperature profile will also benefit of increased performances of IASI-NG