Contribution of MetOp-A/IASI to the study of Essential Climate Variables

R. Armante, V. Capelle, A. Chédin, C. Crevoisier, N. Jacquinet-Husson, N. A. Scott, C. Stubenrauch, C. Bouttamine, L. Crépeau, A. Feofilov, J. Pernin, M. Siméon, T. Thonat, and C. Tsamalis

Laboratoire de Météorologie Dynamique, Ecole Polytechnique, 91128 Palaiseau Cedex, France

http://ara.abct.lmd.polytechnique.fr

Summary

Since its launch onboard MetOp-A in October 2006, IASI contributes to the establishment of robust long term data records of several essential climate variables. We focus here on 4 of them that are retrieved at LMD: (i) clouds: physical and microphysical properties; (ii) greenhouse gases: mid-tropospheric integrated content of CO_2, CH_4 and CO; (iii) dust aerosols: AOD, altitude, and radius; (iv) continental surface characteristics: spectral emissivity and skin temperature. The suite of long time series of climate variables retrieved from IASI continues to expand, and will soon be extended to the processing of IASI onboard MetOp-B.

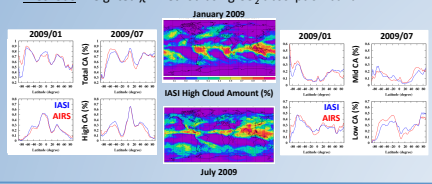
With already 5 years of observations, that add to the 10 years of observation from the Aqua/AIRS instrument, and two more missions to come, IASI has the potential to monitor the evolution of these variables on the long-term, to assess potential trends, and to detect signatures of specific climate events, such as ENSO or other sources of climate variability. Based on both its exceptional spectral and radiometric stability and its ability to characterize simultaneously several climate variables, IASI has already demonstrated that it can and will play a major role in the monitoring and understanding of climate evolution and variability in the coming years.

Clouds

Objective : to understand cloud formation in combination with upper tropospheric relative humidity and aerosols and cloud radiative budget.

IASI contribution: retrieval of cloud pressure, temperature, emissivity of all clouds; ice water path, effective particle size and indication of particle shape of semi-transparent cirrus, day and night.

Methods: weighted χ2 method using CO_2 absorption band.

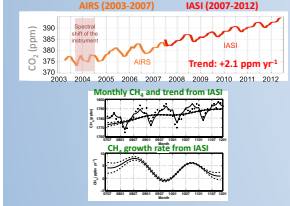


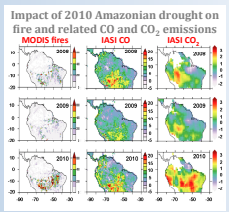
Greenhouse gases

Objective: to better understand surface sources and sinks of greenhouse gases and the related processes (transport, flux).

IASI contribution: mid-tropospheric integrated contents of CO_2, CH_4 and CO over both land and sea, day and night.

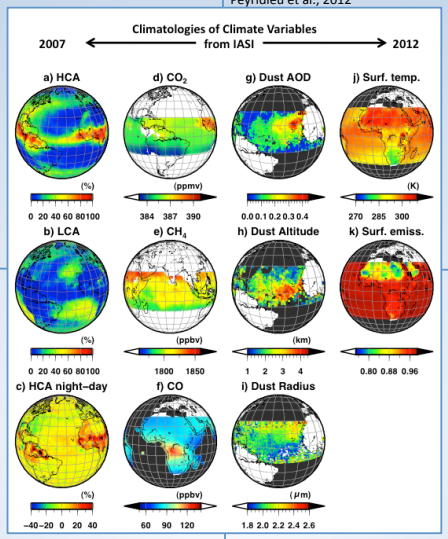
Methods: non linear inference scheme for CO_2 and CH_4 and spectral double differential approach for CO.





Chédin et al., 2003
Crevoisier et al., 2009ab, 2013
Thonat et al., 2012

macc



macc
Pierangelo et al., 2004
Peyridieu et al., 2012

Péquignot et al., 2006
Capelle et al., 2012

esa ghg cci

Aerosols

Objective: retrieval of the dust optical properties, vertical distribution, size and analysis of their interaction with the climate system

IASI contribution:

- Observations available **daytime** and **nighttime**, over **ocean** and over **land**
- Access to the **mean aerosol layer altitude** and to **the particle size.**
- 10 µm : preferential detection of **dust aerosol coarse mode**

Method: proximity recognition in brightness temperature within Look Up Tables.

Comparisons between **AERONET coarse-mode AOD** and **IASI 10µm AOD**

Over sea: Persian Gulf — **Daily scale:** Dakar. — **Over desert:** solar village

Correlation between AERONET coarse-mode AOD and IASI 10µm AOD over 25 AERONET sites (over sea and monthly) during the IASI period (~533 items): R=0.854

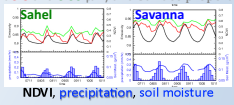
Land surface properties

Objective: Obtain an accurate estimation of spectral emissivity (often considered as constant) and surface temperature in order to improve the retrieval of tropospheric properties and to estimate the radiative budget.

IASI contribution: Surface temperature and emissivity continuous spectrum at 0.05 µm resolution between 3.7 and 14.0 µm for monthly grid (1°X 1°) or for each IASI spots.

Method: Physical inversion of the RTE using a fast RT model.

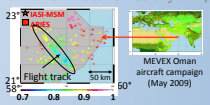
Seasonal variations of IASI emissivity (at 3.8 and 8.55 µm) and surface properties



NDVI, precipitation, soil moisture

→ Opportunity of long-term monitoring of continental surfaces at global scale, including critical regions (Sahel, etc).

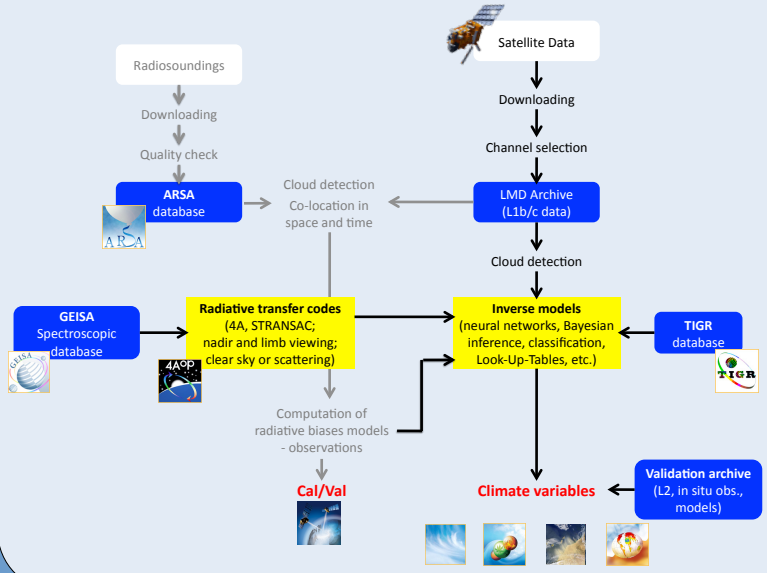
Comparison between IASI emissivity and ARIES "in-situ" emissivity at 9 µm



→large spatial variations of emissivity at very local scales consistent (10% variation for an area < 0.5°)

LMD processing chain of satellite observations

These activities rely on a processing chain of satellite observations that has been developed for many years at LMD and that includes: permanent validation and improvement of the GEISA spectroscopic database and of the radiative transfer code 4A (which are respectively the official database and code for IASI Cal/Val activities at CNES), development of dedicated cloud and aerosol detection schemes, retrieval processes, and validation activities.



GEISA

Atmospheric radiation analysis requires accurate description of spectral properties of atmospheric gases and particles. The spectroscopic database GEISA was initiated in 1975, with its latest update in 2011 (Jacquinet-Husson, JQSRT, 2011; 58 coauthors, 26 laboratories). GEISA is presently the largest spectral bank in the world. It is used by more than 300 laboratories (atmospheric physics, astrophysics, planetology). GEISA is the reference database for IASI Level 1 Cal/Val activities and operational processing. GEISA is freely accessible from the Ether expertise center website (http://ether.ipsl.jussieu.fr/).

4A

The **4A (Automatized Atmospheric Absorption Atlas)** fast and accurate line-by-line radiative transfer code (Scott & Chédin, 1981) is developed and maintained LMD. It has been made operational (OP) in cooperation with the French company Noveltis (http://www.noveltis.net/4AOP/). It is the reference code for the CNES/EUMETSAT IASI Level 1 Cal/Val activities and operational processing.

TIGR

The **Thermodynamic Initial Guess Retrieval (TIGR)** data set, in its latest version, is a climatological library of 2311 representative atmospheric situations selected by statistical methods from 80,000 radiosonde reports (Chédin et al., 1985; Chevallier et al., 1998). Each situation is described, from the surface to the top of the atmosphere, by the values of the temperature, water vapour and ozone concentrations on a given pressure grid.

ARSA

For a wide range of applications (forward and inverse models validation, verification of satellite measurements), LMD has elaborated the **Analyzed RadioSoundings Archive (ARSA)** database, extended on a monthly basis, starting from observations by worldwide distributed radiosonde stations and combining them with surface and other auxiliary observations.

Cal./Val.

To be fully useful for weather, climate and environmental applications, satellite observations must be qualitatively and quantitatively controlled during the instruments lifetime: any radiometric systematic error not identified in the level1 radiances may propagate as errors in the retrieved variables. At LMD, **two complementary approaches: (i) an intercalibration approach** and **(ii) a "stand alone" approach** have been developed which aim at identifying, and eventually at correcting, deviations or trends (natural, spurious) between pairs of channels of different instruments (in LEO/LEO or GEO/LEO modes). In close collaboration with CNES, LMD contributes to the monitoring and intercomparison of IASI radiances with companion instruments in the framework of the **Global Space-based Inter-Calibration System (GSICS) of WMO.**