Toward a decade of dust infrared aerosol properties observed by infrared hyperspectral sounders (AIRS, IASI/Metop-A, IASI/Metop-B) and first analysis of the dust diurnal cycle

V. Capelle¹, A. Chédin¹, M. Pondrom¹, R. Mechri, C. Crevoisier¹, R. Armante¹, L. Crépeau¹, N. A. Scott¹

¹LMD / IPSL, Ecole Polytechnique, Palaiseau, France
Remote sensing of dust aerosols in the IR

Why study aerosols in the infrared?
- Aerosols are large contributor to the earth radiative balance
- They are also a large source of uncertainty
- We want to retrieve dust optical properties (AOD, altitude)

Interest of satellite observation:
- global and continuous observation
- high resolution (spatial, spectral, or both).

Interest of the infrared:
- Observations available daytime and nighttime, over ocean and over land (desert)
- Access to the mean aerosol layer altitude
- 10 μm: essentially detection of dust aerosol Coarse Mode (CMo)

IASI-A, IASI-B and AIRS (in progress) retrieval:
- several observations per day, including night-time measurements: 8h30 AM, 9h30 AM, 1h30 PM, 9h30 PM, 9h30 PM and 1h30 AM.
**Radiative transfer simulations/inversion scheme**

1) **Pre-processing**: All radiative transfer simulations are performed off line once for all.

**Input parameters**

- **Aerosols Microphysics**
  - 1 size distribution
  - 2 refractive index

- **Atmospheric information**

- **Surface parameters**

- **Spectroscopy**

---

2) **Inversion**: (~40mn CPU per day)

- **Satellite observation**: AIRS, IASI...

- **Atmospheric Situation** (T, H2O, etc.)

- **LUT atmospheres**

- **LUT aerosols**

**Aerosols properties**

- 10μm AOD
- Mean altitude
- Surface temperature
- (Effective radius)

Since 2003 for AIRS
Since 2007 for IASI

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

_Pierangelo et al. 2004, ACP; Pierangelo et al. 2005, GRL; Peyridieu et al. 2010, ACP; Peyridieu et al. 2013, ACP; Capelle et al. 2014, ACP._
16th June 2013,
Descending orbit: IASI-A

~9 years of IASI-A

IASI retrievals up to Day-1 can be visualized or downloaded on
http://ara.abct.lmd.polytechnique.fr/
16th June 2013,
Descending orbit: IASI-A + IASI-B

~9 years of IASI-A + ~3 years of IASI-B

IASI retrievals up to Day-1 can be visualized or downloaded on http://ara.abct.lmd.polytechnique.fr/
16th June 2013,
Descending orbit: IASI-A + IASI-B

~9 years of IASI-A + ~3 years of IASI-B

10µm AOD

IASI optical depth at 10 µ

16th June 2013,
Descending orbit:
IASI-A + IASI-B

~9 years of IASI-A
+ ~3 years of IASI-B
Validation with AERONET Coarse Mode (CMo) AOD over 8 years of IASI observation (Jul 2007 – Jun 2015)

- 77 AERONET ground-based sites analyzed over all the IASI period (when AERONET data do exist!)
- Mean CMo AOD > 0.05 over the 8 years
- Box of $0.25^\circ$ around AERONET site
- 10µm IASI AOD is converted to 500nm using the size parameter and refractive indices values used in the inversion.
IASI/AERONET coarse mode AOD comparisons

May 2008

IASI  AERONET level 2.0

- Agoufou (SAH)
- Kuwait_University (ASW)
- Kanpur (ASE)

AERONET level 1.5

- FORTH_CRET (MED)
- Solar_Village (ASW)
- Taihu (ASE)
AERONET sites with mean AOD < 0.05 over the whole IASI period have been removed
Light colors: sites with mean AOD < 0.08. Correlation is in general smaller
For other sites:
- Tropics: mean correlation = 0.75 ; mean amplitude = 0.89
- Midlat : mean correlation = 0.71 ; mean amplitude = 0.92
Comparison with MACC reanalysis 550nm Dust AOD

22th June 2011

IASI (converted to 550nm)

MACC DuAOD550

=> Ongoing activity for the whole IASI period
Altitude validation with CALIOP

532 Total Attenuated Backscatter – 2011-06-27T01-38-19ZN (IASI date-hour = 20110626-2100)

IASI altitude on the CALIOP track.
Comparison with AERONET coarse mode AOD

- With IASI and AIRS, 4 observations per day (9:30 AM, 1:30 AM, 9:30 PM, 1:30 PM).
- Unique opportunity to have two measurements during night-time.
- IASI and AIRS AOD present variability similar to AERONET during day-time.
With IASI and AIRS, 4 observations per day (9:30 AM, 1:30 AM, 9:30 PM, 1:30 PM).
Unique opportunity to have two measurements during night-time.
IASI and AIRS AOD present variability similar to AERONET during day-time.
With IASI and AIRS, 4 observations per day (9:30 AM, 1:30 AM, 9:30 PM, 1:30 PM). Unique opportunity to have two measurements during night-time.

IASI and AIRS AOD present variability similar to AERONET during day-time.
First results of diurnal cycle: July climatology from 8 years

AGOUFOU (Sahara)

ΔAOD=0.3

AOD departure from AOD(13:00PM)

ΔALT=2 km

ΔAOD<0.05

ΔALT<0.5 km

AOD departure from AOD(13:00PM)

=> Strong implication for aerosol radiative effect determination
CONCLUSIONS and FUTURE WORK:

- 2 measurements per day of 10µm coarse-mode AOD, mean altitude and surface temperature at each IASI pixel (9:30 AM and 9:30 PM).
- Observations available **daytime** and **nighttime**, over **ocean** and over **land** for **tropics** and **midlatitude** regions.

- ~8 years of observations (July 2007-now) for IASI-A; ~2 years for IASI-B
- **With AIRS**, 2 additional measurements per day (1:30 AM and 1:30 PM)
- Possibility to study the daily evolution of AOD and altitude

(!!! see also poster S5-105 on surface temperature validation!!!)

**Perspectives:**

- Better analyze the link between the refractive index and aerosol type
- Adapt the size estimation at IASI pixel resolution
- Go further in the analysis of the diurnal cycle
- IASI provides valuable information on aerosol properties and suits for Long-term evolution (IASI-1, 2, 3 + IASI-NG-1, 2, 3 )
Near Real time

IASI-A data are processed every day for Day -1


=> Soon + IASI-B
Validation of surface temperature

See poster S5-105:
Ts comparison from satellites to ECMWF (IASI, AATSR, MODIS (TERRA and AQUA)

IASI 10µm monthly mean AOD for August 2011
The conversion from infrared to visible AOD

Conversion factor = \( C_{\text{ext}}(10\mu m)/C_{\text{ext}}(0.55\mu m) \)

- IR to visible conversion depends on an accurate knowledge of the size distribution (\( \sigma, R_{\text{eff}} \)) and of the refractive index at 10 \( \mu m \) and 0.55 \( \mu m \).

**Problem:**
- Ratio highly variable
- Micro-physical parameters of 2\textsuperscript{nd} order in IR compared to AOD

\[ \Rightarrow \text{Conversion factor between 1 and 2} \]
\[ \Rightarrow \text{Currently, this conversion degrades our results} \]
\[ \Rightarrow \text{2 indices are used in the inversion to take into account sensitivity to the ratio:} \]
\[ \Rightarrow \text{Balkanski et al., 2007 (mean ratio} \sim 0.85) \]
\[ \Rightarrow \text{Volz, 72,73 (mean ratio}=0.57) \]