Daily observation of dust aerosols infrared optical depth and altitude from IASI and AIRS and comparison with other satellite instruments

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Why we are interested in dust aerosols?

Dust aerosols

- affect the earth's radiative budget with participation in both the direct and indirect effects, in both spectra solar and terrestrial,
- influence the hydrological cycle by acting as cloud condensation and ice nuclei,
- modify the oxidizing capacity of the atmosphere and thus the concentration of some tropospheric trace gases,
- participate in the fertilization with iron of the ocean and
- degrade the restitution of atmospheric and surface parameters from satellite instruments.

Remote sensing of aerosols in the IR

- Remote sensing in the visible domain has been widely used to obtain better characterization of aerosols and their effect on solar radiation.
- On the opposite, remote sensing of aerosols in the infrared (IR) domain still remains marginal.

Advantages of infrared remote sensing:

- retrieval of **aerosols mean altitude** and **coarse mode effective radius** in addition to optical depth at 10 μm,
- possibility of observations during **night and day**, over **land and sea**.

Drawback: the influence of atmospheric state.

Characteristics of AIRS and IASI

	AIRS	IASI
Launch	May 2002	October 2006
Satellite	Aqua	MetOp-A
Local time (night/day)	1:30/13:30	21:30/9:30
Instrument	Grating spectrometer	Fourier transform spectrometer
Spectral range	650-2665 cm^{-1} / 3.7-15.4 µm (non continuous)	645-2760 cm^{-1}/ 3.62-15.5 µm
Spectral resolution	0.5-2 cm^{-1}	0.5 cm^{-1} (apodized)
Spatial resolution at nadir	13.5 km	12 km
Channels	2378	8461
Full swath width	2300 km	2200 km

IASI will provide observations for more than 15 years on board of MetOp-A, B, C.

Aerosols inversion method in the IR

I. Construction of Brightness Temperature Look Up Tables

Spectroscopy database
Jacquinet-Husson et al., 2008

Thermodynamic data set
Chédin et al., 1985
Chevallier et al., 1998

OPAC

Mineral transported model
Aerosol software package
Hess et al., 1998

Radiative transfer model
Scott and Chédin, 1981

DISORT

Scattering algorithm
Stamnes et al., 1988

Look Up Tables
Atmosphere

Look Up Tables
Aerosols

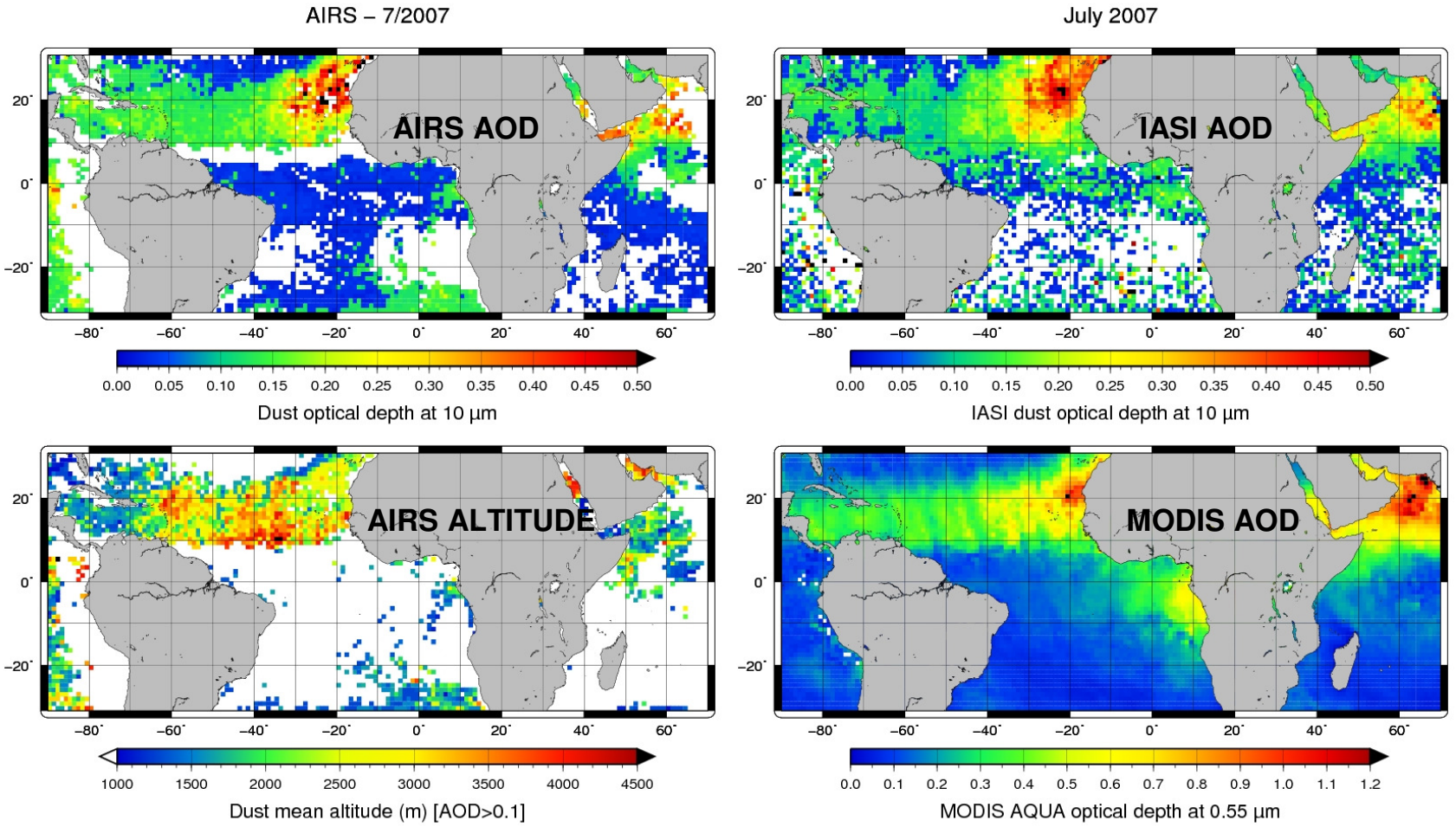
II. Application of cloud mask.

III. Retrieving atmospheric situation by using the LUTs for Atmosphere.

IV. Retrieving aerosols properties (optical depth, mean altitude and coarse mode effective radius) by using the LUTs for Aerosols.

$$D_{spot}(AOD, alt) = \left[\alpha \sum_{j=1,8} \frac{(TB^{j}_{calc} - TB^{j}_{obs})^2}{\sigma^2_j} + \beta \sum_{k=1,5} \frac{(\Delta TB^{k}_{calc} - \Delta TB^{k}_{obs})^2}{\sigma^2_k} \right]$$

Aerosols products from IR

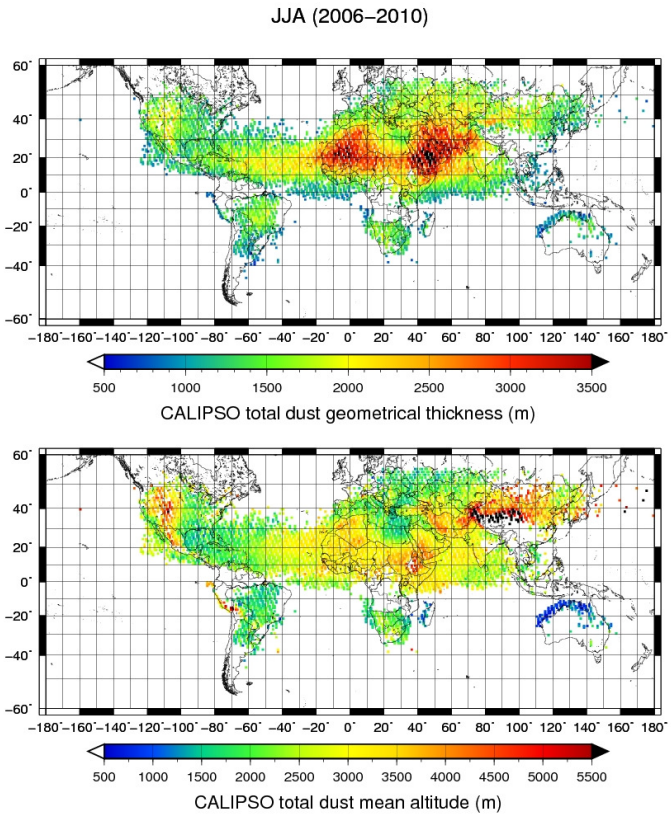


8 years of AIRS observations and more than 3 years of IASI observations with space-time resolution of 1 degree – 1 month.

Peyridieu et al., 2010

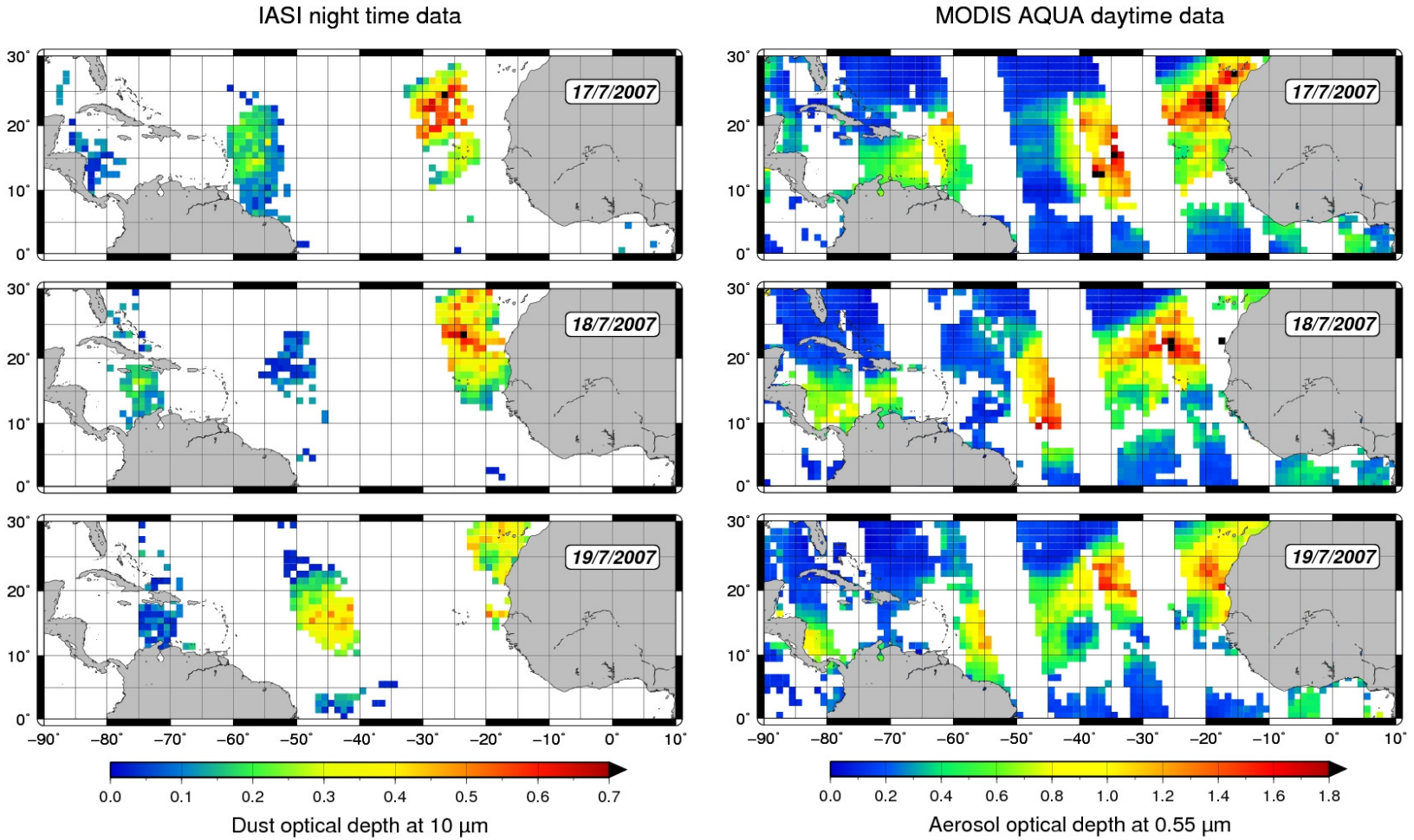
Towards a better resolution : 1 day-1 spot

- Aerosols present strong variability with average residence time of roughly one week in the lower troposphere, so the best possible resolution (spatial and temporal) is necessary for their optimal observation and use (study of their implication in the atmospheric processes).
- Use of daily data for assimilation in numerical models and improvement of their performances.
- AIRS or IASI provide aerosol altitude with good spatial coverage on a daily basis when CALIPSO multiannual data must be used.



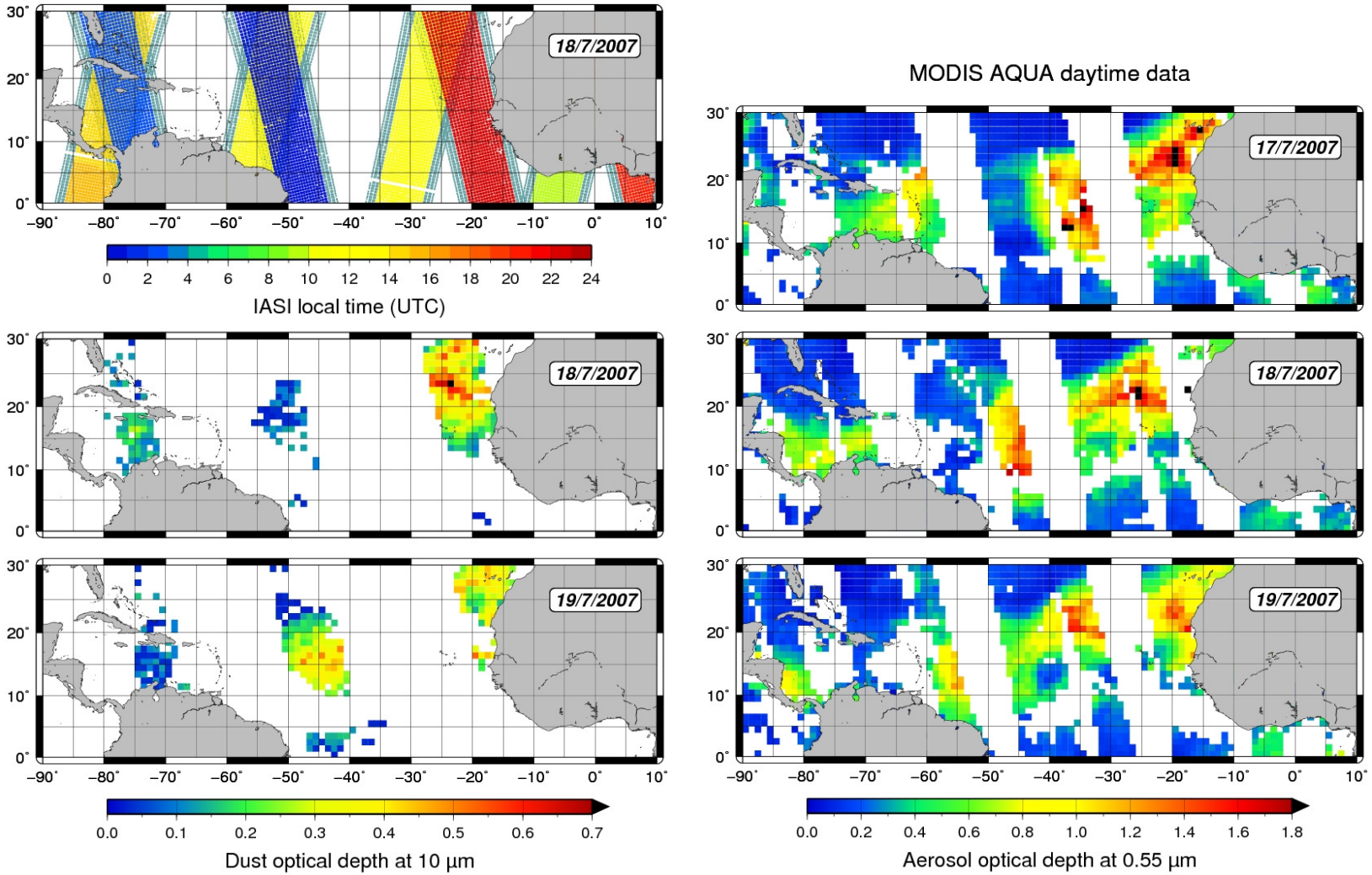
Tsamalis et al., EGU, 2011

Daily optical depth from IASI



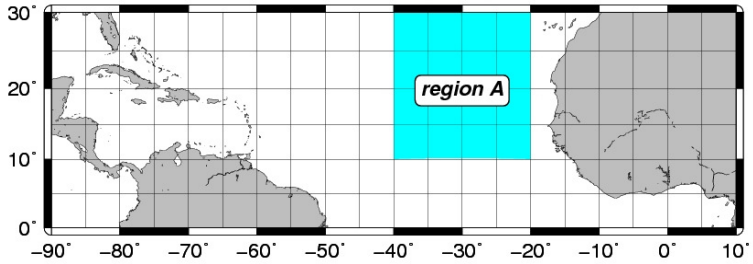
Good spatial correlation between IASI and MODIS

Daily optical depth from IASI



Good spatial correlation between IASI and MODIS

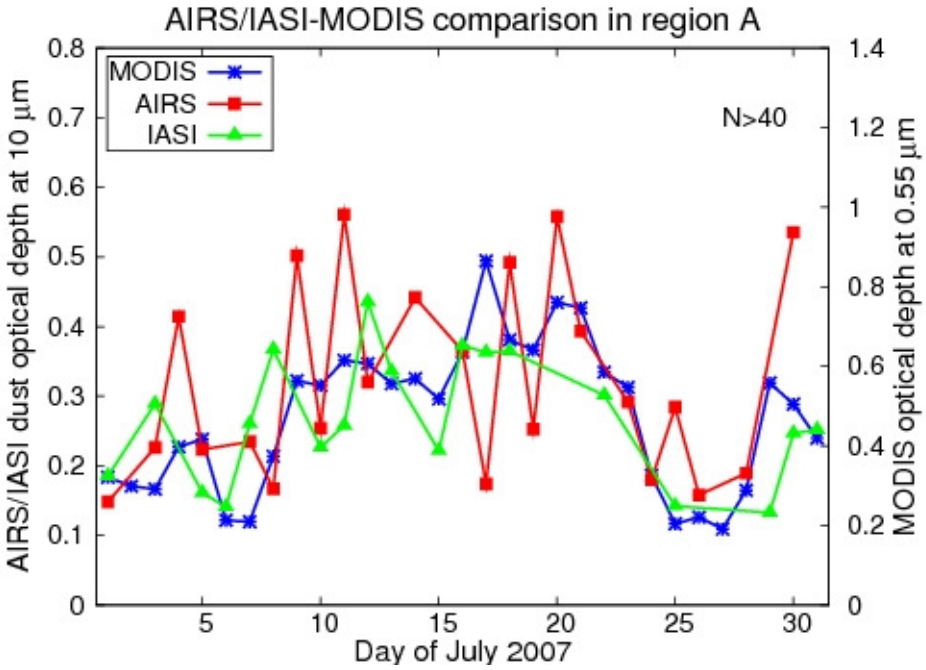
AIRS and IASI daily optical depth comparison with MODIS



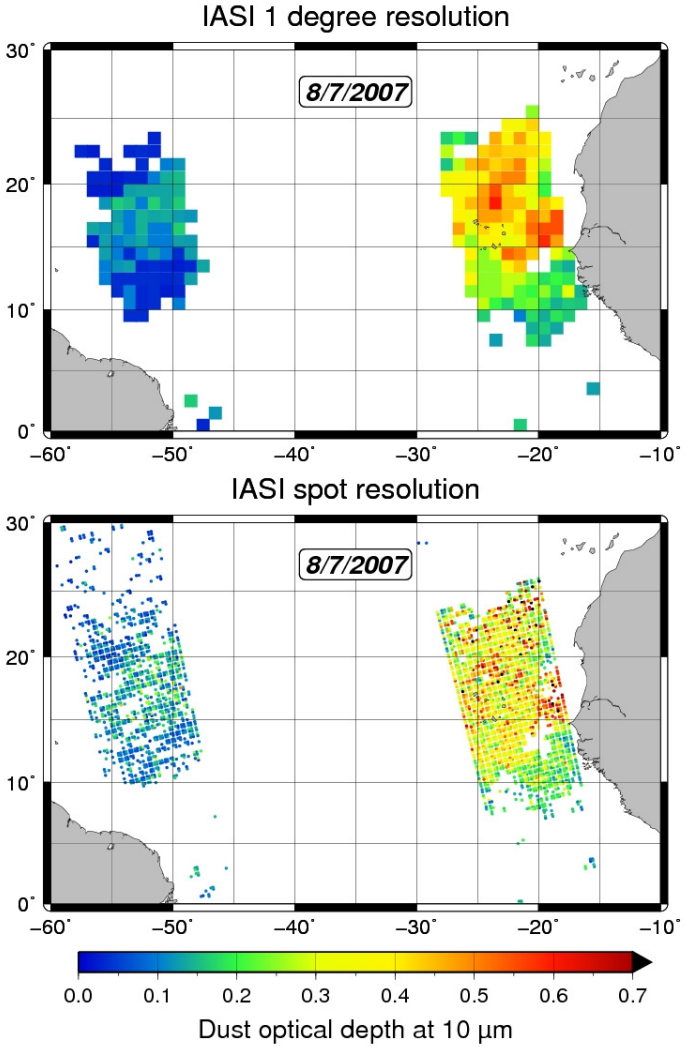
Preliminary results (still too noisy) depict good temporal correlation with coefficients:

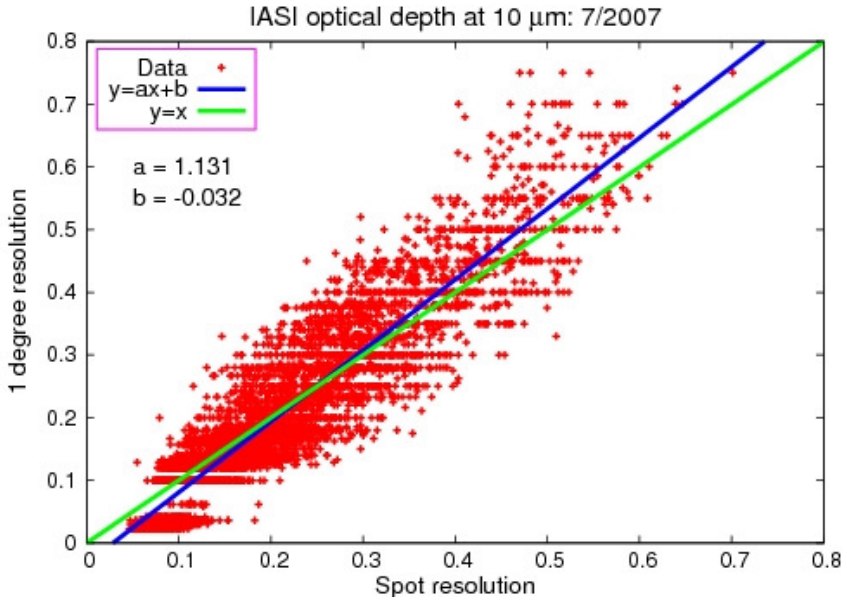
- AIRS – MODIS: R^2=0.51
- IASI – MODIS: R^2=0.56

While there is better agreement with IASI.



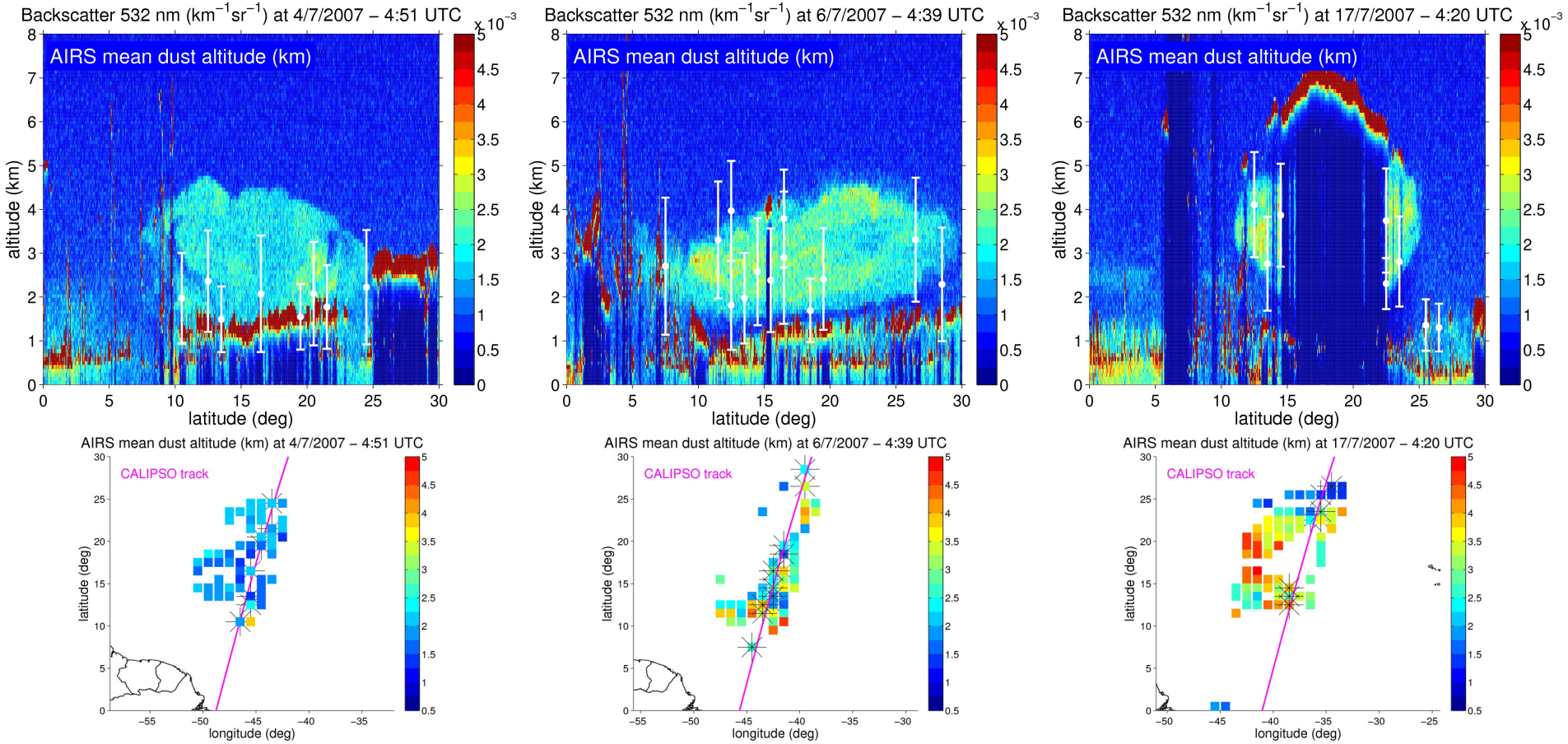
Achieving spatial resolution of 1 spot





- Slight modification of the inversion method permits the optical depth retrieval with 1 spot spatial resolution.
- Comparison between 1 degree resolution and spot resolution for IASI during July 2007 demonstrates good correlation with coefficient R^2=0.93.

AIRS altitude comparison with CALIPSO



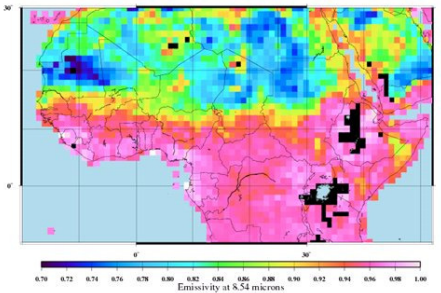
First results with daily resolution demonstrate relatively successful retrieval, although AIRS tends to underestimate the dust altitude, while they still need improvement. Similar study with IASI under development but more complicated.

Conclusions and perspectives

- Dust aerosol properties with the best possible resolution (1 day-1 spot) retrieved from AIRS and IASI for July 2007 (the most active month of the dust season above the tropical Atlantic Ocean) compared with
  - MODIS for the optical depth
  - CALIPSO for the altitude

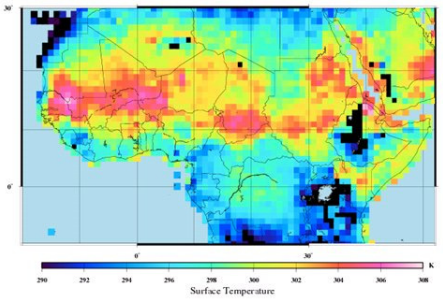
  → indicate that, most of the time, the infrared daily products compare well with these two instruments daily observations.

- Further developments of the algorithm (more dust aerosol models, zenith angle up to 40° instead of 30°).
- Improvement and quantification of errors for daily products.
- Retrieving aerosol properties during daytime.
- Retrieving aerosol properties above continents and particularly above deserts (difficult to achieve at solar wavelengths) by using the IASI surface properties (emissivity and surface temperature from Capelle et al., in preparation).



Emissivity at 8.54 μm – May 2010

Surface temperature – May 2010



Thank you!

We thank the ICARE Data and Services Center for providing access to the CALIPSO data (http://www.icare.univ-lille1.fr).
MODIS data were obtained through NASAs Giovanni, an online visualization and analysis tool, developed and maintained by the NASA GES DISC.

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