

Towards the daily observation of dust aerosols infrared optical depth and altitude from IASI and AIRS with one spot resolution: comparison with MODIS and CALIPSO

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Introduction

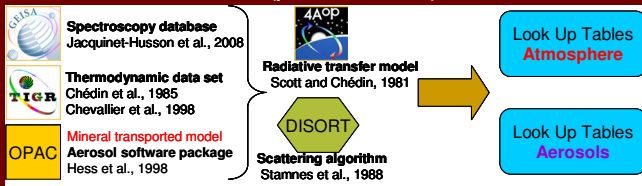
Dust aerosols affect the earth's radiative budget via the direct, the indirect and the semi-direct effects, they also influence the hydrological cycle by acting as cloud condensation and ice nuclei, furthermore they modify the oxidizing capacity of the atmosphere and thus the concentration of some tropospheric trace gases, likewise they participate in the fertilization with nutrients of the ocean, as well they deteriorate the air quality and finally they degrade the restitution of atmospheric and surface parameters from satellite measurements.

Observation from space, being global and quasi-continuous, is a first importance tool for aerosol studies. Remote sensing in the visible domain has been widely used to obtain better characterization of these particles and their effect on solar radiation. On the opposite, remote sensing of aerosols in the infrared domain still remains marginal. Yet, not only the knowledge of the effect of aerosols on terrestrial radiation is needed for the evaluation of their total radiative forcing, but also infrared remote sensing provides a way to retrieve other aerosol characteristics, including their mean altitude. Moreover, observations are possible at night and day, over sea and land and more specifically over deserts, where the restitution of aerosol properties from solar remote sensing is rather challenging.

Method

At LMD, a method has been specifically designed to retrieve simultaneously coarse mode dust aerosol 10 μm optical depth and mean layer altitude from high spectral resolution infrared sounders observations (Figure 1) and applied to more than 9 years of AIRS observations and 4.5 years of IASI observations with results being obtained at a space-time resolution of 1 degree-1 month (Pierangelo et al., 2004, Peyridieu et al., 2010).

Radiative transfer simulations (performed off-line):



Inversion principle :

- 1) Determination of the best atmospheric situation using channels mostly sensitive to temperature and water vapor,
- 2) Simultaneous retrieval of both aerosol properties (DOD, altitude) from channels mostly sensitive to aerosols. The proximity recognition in the LUT is made only for atmospheric situations found in step 1.

Figure 1

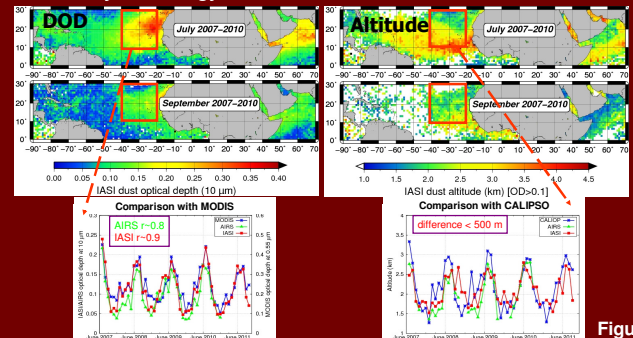


Figure 2

Results

The method has recently been upgraded to a daily resolution opening the way to (i) a more acute view of dust aerosols variability in time, something very important due to their relatively small lifetime of about one week in the troposphere; this should in turn permit a better study of dust aerosols implication in the atmospheric processes, (ii) a validation against daily products from either MODIS or CALIPSO, allowing a better and more direct comparison between the products leading to a better estimate of their accuracy and (iii) the use of dust infrared optical depth and altitude in data assimilation into numerical models, in order to further improve their performances.

Dust optical depth obtained at the resolution 1°-1 day

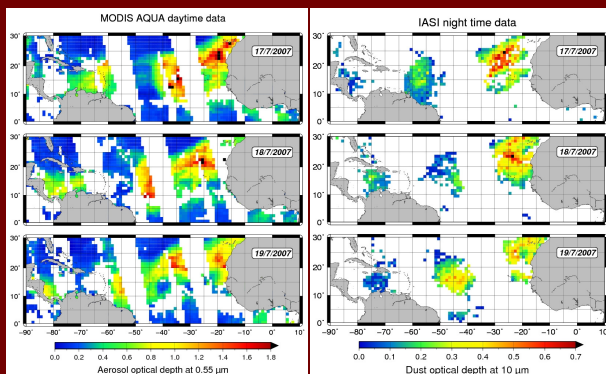


Figure 3: (Left) aerosol optical depth at 0.55 μm from MODIS on board Aqua for 17-19 July 2007 and (right) dust aerosol night time optical depth at 10 μm from IASI for the same days. \Rightarrow good spatial correlation between the two measurements

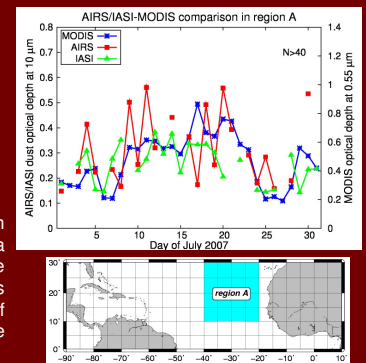


Figure 4: (Up) Mean daily optical depth from AIRS and IASI (left axis) and MODIS Aqua (right axis) for the region (filled in cyan) in the bottom figure. IASI temporal evolution is smoother because of the greater number of grid points. (Bottom) The region for the calculation of mean optical depth.

Towards a better resolution: 1 spot - 1 day

The next step was to retrieve the dust optical parameters with a spatial resolution of one spot by applying a slight modification to the method.

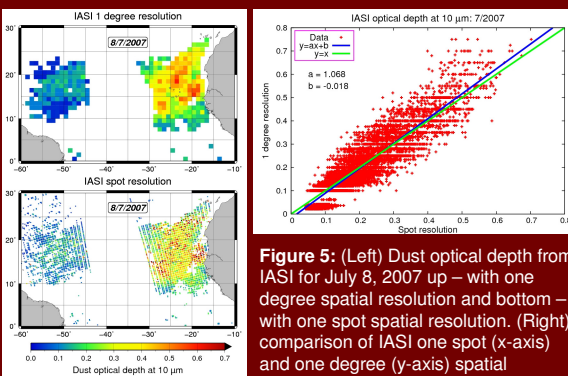


Figure 5: (Left) Dust optical depth from IASI for July 8, 2007 up - with one degree spatial resolution and bottom - with one spot spatial resolution. (Right) comparison of IASI one spot (x-axis) and one degree (y-axis) spatial resolution for the whole month of July 2007.

\Rightarrow The two resolutions compare well, which it is also confirmed on a monthly basis, by using all the available daily data: the correlation coefficient is 0.92.

Dust mean altitude obtained at the resolution 1°-1 day

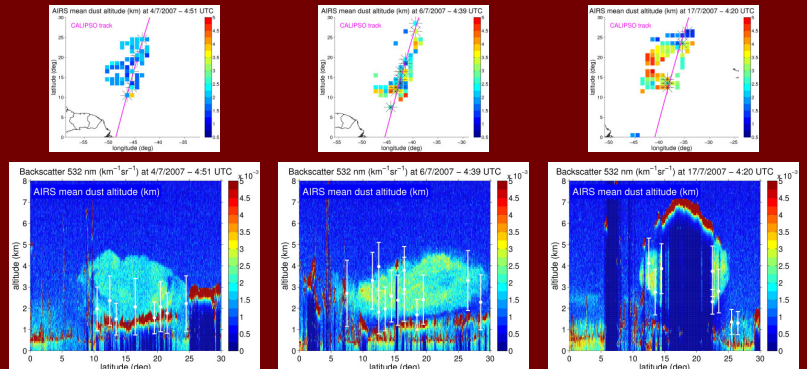


Figure 6: (Up) AIRS mean dust altitude for 4 (left), 6 (middle) and 17 (right) July 2007 and the CALIPSO track for the same days. Note that the two products can be compared as they are part of the A-Train constellation. The stars indicate the points that will be used in the bottom figures for the comparison with CALIPSO. (Bottom) The CALIPSO total backscatter attenuated coefficient at 532 nm for the respective days, superimposed on the AIRS mean altitude and its standard deviation (white bars).

\Rightarrow AIRS the dust altitude compared well with CALIPSO, although with a general tendency to underestimate it. It should be noted that, especially the altitude retrieval is important, as, although CALIPSO is certainly more adequate to provide this information, its space coverage remains quite limited.