

Dust infrared optical depth and altitude retrieved from 6 years of AIRS observations: a focus on Saharan dust using A-Train synergy (MODIS, CALIOP)

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Sorry I'm not attending the meeting!

Please refer to **Didier Tanré** if you have any questions, or see

Peyridieu et al., ACPD 2009 (submitted)

Introduction

Remote sensing in the visible domain has been widely used to obtain a better characterization of aerosols and their effect on solar radiation. On the opposite, **remote sensing of aerosols in the thermal infrared** domain still remains marginal but needed for the evaluation of their total radiative forcing. Infrared remote sensing provides a way to retrieve other aerosol characteristics, including their **mean altitude** [Pierangelo et al., ACP, 2004]. Moreover, observations are possible at night and day, over land and ocean. We present the results obtained from **6 years of AIRS observations** [Peyridieu et al., ACPD, submitted, 2009] with emphasis on the comparison with CALIPSO/CALIOP Level-2 product.

Method

Radiative transfer simulations :

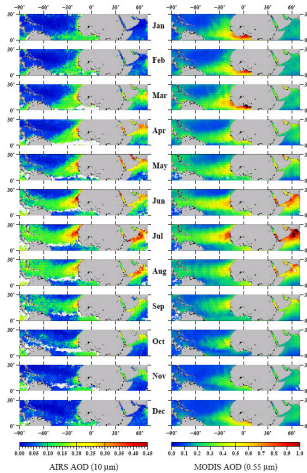
Brightness temperatures are calculated using the **radiative transfer code 4AOP/DISORT at selected wavelengths** and stored in two different Look-Up Tables (LUT), for 7 channels sensitive to temperature and water vapor, and 8 channels sensitive to aerosols. The LUTs sample 7 view angles (0° to 30°), 8 infrared AOD values (0.0 to 0.8) and 9 altitudes of the aerosol layer (≈800m to ≈6000m), for a wide range of typical tropical atmospheric situations from the TIGR database. The aerosol model used in the simulations is MITR (« mineral transported ») from OPAC [Hess et al., 1998].

Inversion principle :

- 1) Determination of an **atmospheric situation** the closest to the situation observed using 7 channels mostly sensitive to temperature and water vapor,
- 2) **Simultaneous retrieval of both aerosol properties (AOD, altitude)** from 8 channels mostly sensitive to aerosols. The proximity recognition in the LUT is made only for atmospheric situations found in step 1.

Results : AIRS AOD compared to MODIS

Aerosol properties have been retrieved over the tropics (30°S-30°N) from AIRS observations for the period January 2003 – December 2008. The size of AIRS spot is 13.5 km at nadir and our product is averaged on a 1°x1° grid for each month.

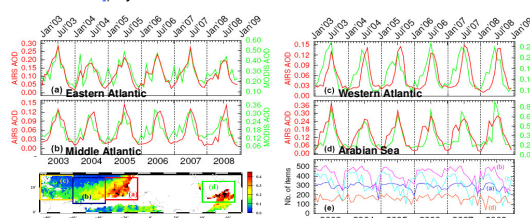


6-years of aerosol data over North Atlantic :

← **Figure 1** : 6-year (2003-2008) climatology of AIRS (10µm, left) and MODIS (0.55 µm, right) aerosol optical depth (AOD).

↓ **Figure 2** : Time series of AIRS and MODIS AODs over four regions ((a) to (d), see map) of the North Atlantic Ocean and Arabian Sea. The number of items found in the corresponding regions is shown in box (e).

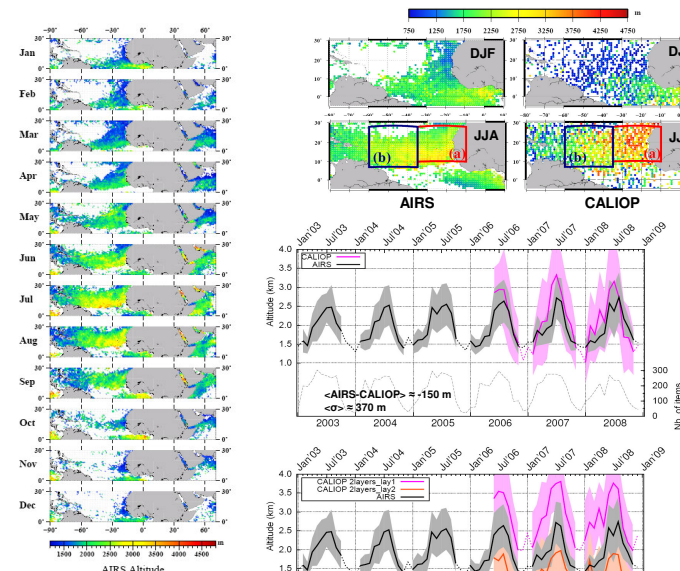
The agreement between AIRS and MODIS AOD products is very good; the lag observed for AIRS in region (c), far from the Saharan dust sources, can be explained by the late arrival of the dust coarse mode, as seen (not shown, see [Peyridieu et al., ACPD 2009, submitted]) by PARASOL/Polder and AERONET observations.



Results : AIRS altitude compared to CALIOP/CALIOP

6-year climatology of aerosol altitude retrieved from AIRS :

Mean aerosol altitude is retrieved from AIRS simultaneously with AOD. In the infrared, the altitude retrieved is the altitude at which half of the AOD is above and half of the AOD is below.



↑ **Figure 3** : 6-year (2003-2008) climatology of AIRS retrieved altitude. For significance purposes and due to the low sensitivity of channels at low AODs, altitude is shown only for 10 µm AOD ≥ 0.10.

Mean altitude comparisons between AIRS and CALIOP are satisfactory. However one should keep in mind that because of the extreme difference in spatial resolutions it is not straightforward to compare these two products.

↖ **Figure 4** : Seasonal averages for AIRS (left) and CALIOP (right) mean altitude. CALIOP L-2 product (single layer cases, 5-km horizontal resolution, centroid) has been averaged on a 1°x1° grid.

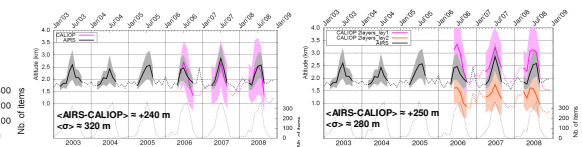
The agreement between the two instruments is satisfactory in DJF, when dust layers are mostly found between 0° and 10°N. In JJA, the main dust season, dust layers are found at 2500–3500 m above the ocean, by both instruments. Dust layers seem to be found at higher altitudes near the ITCZ (8–10°N). Dust at high altitudes (>4000m) seen by CALIOP north of 20°N may be fine mode dust layers, not seen by AIRS.

↖ **Figure 5a** : Time series of AIRS retrieved mean altitude (black) compared to CALIOP/CALIOP altitude Level-2 product (magenta) for region (a) (Eastern Atlantic).

For a robust comparison, cases where only **one aerosol layer** (flagged as « dust » or « polluted dust » with a high level of confidence) is detected by the lidar have been considered. The small number of items outside the dust season indicates that altitude retrievals should be considered with caution.

↖ **Figure 5b** : Same as Fig. 5a, but for 2-layer cases detected by CALIOP.

↘ **Figure 5c** (single layer cases, left) and **5d** (2-layer cases, right) : Same as Figs. 5a and 5b, but for region (b) (middle Atlantic)



Conclusions and future work

We show that aerosol properties – such as aerosol optical depth and mean altitude – can be retrieved from infrared sounders observations. **6 years of AIRS observations** have been analyzed showing good agreement with other aerosol data. **Aerosol optical depth results show a very good agreement with MODIS AOD.** The lags observed between the two time series can be explained by the different coarse mode / fine mode behavior, varying with longitude. **Altitude results compare well with active lidar data from CALIOP,** when considering either single or two-layer cases. The difference seen between the peak-to-trough amplitudes likely results from the large difference in the respective spatial resolutions. The spatial averaging of AIRS is indeed expected to smooth local extreme values measured by CALIOP. **The next release of CALIOP data (v3)** is expected to bring improved aerosol classification and more reliable AOD data (not used from v2). This new dataset could modify our present conclusions and hopefully improve the agreement.

The inversion of aerosol properties using IASI observations is in progress. The very high spectral resolution should allow finer determination of aerosol properties including AOD, mean altitude, effective radius [Pierangelo et al., GRL 2005] and even mineralogical composition. Various aerosol models and averaging methods will be investigated.

