# Retrieving dust aerosol optical depth and altitude using AIRS data

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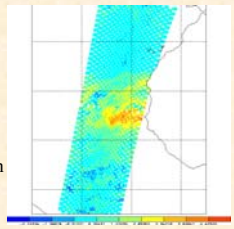
## Introduction :

- Radiative forcing of mineral dust poorly known, especially in the infrared (IPCC 2001)
- Aerosol effect on AIRS radiances : correction for retrieval of other atmospheric parameters

## 1. Ability of AIRS in detecting dust aerosol :

Advantages of infrared :

- •night detection
- • altitude retrieval
- • spectral composition
- • over deserts



*BT 177 – BT 165 (K.), April 27th 2003, night time*
*→ ability of AIRS in detecting dust events*

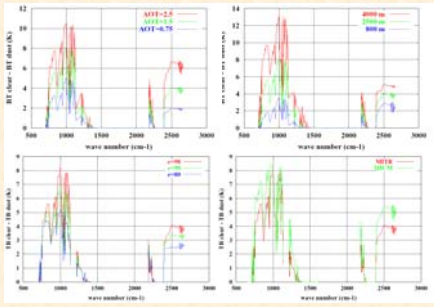
## 2. Simulations of mineral dust effect on AIRS brightness temperatures using a high spectral resolution radiative transfer code including scattering

AIRS high spectral resolution →line-by-line code
Dust optical properties → scattering

**Radiative transfer code :**
*for each line :*

Gas parameters
Atmospheric and geometric parameters
Aerosol parameters
→ 4A Automatized Atmospheric Absorption Atlas
→ Molecular transmittance profiles
→ (Spectral Contraction)
→ DISORT Discrete Ordinate Radiative Transfer
→ Radiances

Line-by-line + DISORT= huge computation time! (but very good accuracy)
Spectral contraction : for each level, and for small spectral intervals : average molecular transmittance



*Effect of mineral aerosol on AIRS brightness temperatures for 324 channels, as a function of aerosol optical thickness (a), aerosol layer altitude (b), surface emissivity (c), and aerosol model (d) (MITR = mineral transported, MICM=mineral coarse mode). Except for (a), AOT=1.5.*

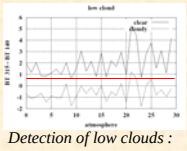
→ Retrieval of Aerosol Optical Thickness (AOT) and altitude, over sea, with one aerosol model ( Mineral transported from the Optical Properties of Aerosol and Clouds data base (OPAC), [Hess et al., 1998], to describe dust far from its sources)

## 3. Cloud mask :

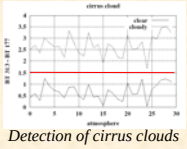
Because cloud masks usually aim at providing high-confidence clear-sky pixels, they may consider aerosol loaded situations as cloudy.

→Special cloud mask : 3 tests

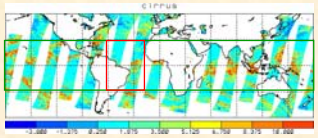
- •Low cloud mask BT 315 – BT 140 < 0.5 (for dust : >1 )
- •Cirrus cloud mask BT 313 – BT 177 > 1.5 (for dust : <0 )
- •Medium altitude cloud mask BT 286 – reg(AMSU 5,6,8)

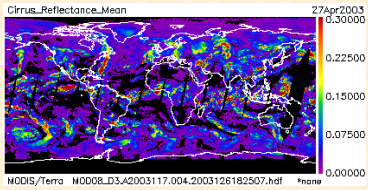


*Detection of low clouds :*
*Simulations for 30 random atmospheric profiles*



*Detection of cirrus clouds*






*Comparison between Aqua-AIRS cirrus detection (BT 315 – BT 140), (top map) 27th april 2003, and Terra-MODIS cirrus reflectance, (bottom map)*

| | MODIS cloudy | MODIS partly cloudy | MODIS clear |
|---|---|---|---|
| AIRS cloudy | 50.39 % | 3.60 % | 0.12 % |
| AIRS partly cloudy | 4.29 % | 2.33 % | 0.10 % |
| AIRS clear | 12.87 % | 17.27 % | 9.02 % |

*Comparison between AIRS cloud mask and MODIS cloud mask for a tropical zone (red square), for one day (27th april 2003).*
*MODIS cloud coverage = 89.5 %*
*AIRS cloud coverage = 60.2 % (tropical, green rectangle : 65.1 %)*

## 4. Retrieval algorithm of aerosol properties

**Channel selection :**

- •Sensitivity to aerosols
- •No or weak sensitivity to atmospheric variable gases (water vapor, ozone)
- •Surface transmittance (~ weighting function : altitude)
- •Different wavelength bands (different sensitivity to altitude and optical depth)
- •Possibility of contraction (condition : contraction effect < 0.05 K)

→ 10 channels

| AIRS channel | Wavenumber (cm-1) | wavelength (µm) | Surface transmittance | Contraction (cm-1) |
|---|---|---|---|---|
| 134 | 843 | 11.86 | 0.55 | 0.1 |
| 135 | 871 | 11.48 | 0.25 | 0.05 |
| 140 | 965 | 10.36 | 0.68 | 0.1 |
| 165 | 1072 | 9.33 | 0.6 | 0.05 |
| 166 | 1074 | 9.31 | 0.35 | 0.02 |
| 177 | 1227 | 8.15 | 0.55 | 0.05 |
| 179 | 1236 | 8.1 | 0.25 | 0.01 |
| 181 | 1250 | 8 | 0.2 | 0.01 |
| 313 | 2607 | 3.84 | 0.6 | 0.1 |
| 315 | 2616 | 3.82 | >0.9 | 0.1 |

**Approach :**

- • 567 TIGR atmospheric situations (tropical)
- • 5 aerosol optical depth :
  0, 0.4, 0.75, 1.5, 2.5 + interpolation
- • 4 altitude levels 4A :
  38 (500-1000m), 35 (2000-2700m), 33 (3500-4500m), 31 (5300-6000m)
- • 1 aerosol model :
  Mineral transported from OPAC database

→ **Look-Up-Tables**

Distance to minimize : $\sum_{i=1,10} \frac{(BT_{calc} - BT_{obs})^2}{\sigma_i} + \sum_{4diff} \frac{(\Delta BT_{calc} - \Delta BT_{obs})^2}{\sigma_{diff}}$

**Validation :**

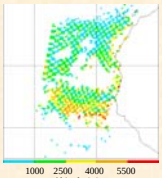
→Validation of the algorithm with computed spectra : 90% of good retrieval for optical depth and altitude (good representativity of atmospheric situations + information contained in the 10 selected channels sufficient to retrieve AOT and altitude)

## 5. Results :

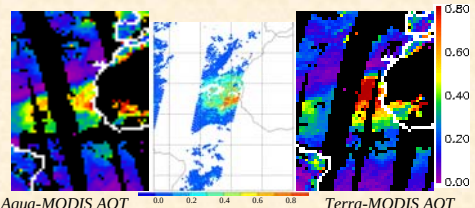
**Comparison with MODIS**

Dust event of April 27th 2003 :

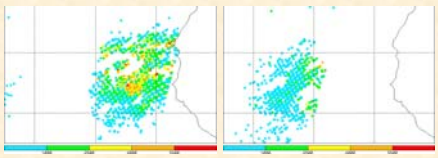
- • Good comparison of retrieved AOT with MODIS AOT
- • retrieved altitude : vertical resolution limited to 1500 m at the moment.




*Dust altitude retrieval, 9th July*
*→ Summer transport at higher altitudes than winter transport : must be checked with more events.*




*Aqua-MODIS AOT 26th April (local ECT=1.30 p.m.)*
*Aqua-AIRS AOT 27th April (local ECT=1.30 a.m.)*
*Terra-MODIS AOT 27th April (local ECT=10.30 a.m.)*



*Dust altitude retrieval : 27th April, 28th April :*
*→ dust deposition over the Atlantic Ocean.*

## Conclusions :

-We have shown that a subset of 10 AIRS channels is able to retrieve both AOT and altitude of mineral dust aerosols.
-AIRS night detection : completes MODIS daytime retrievals.

*FUTURE WORK :*

-Validation of the retrieval using model simulations, lidar data (GLAS)
-More systematic intercomparison with MODIS
-Retrieval over land, using MODIS or AIRS emissivity
-Multilayer perceptron instead of look-up-tables
-Retrieval of aerosol spectroscopy instead of one unique aerosol model