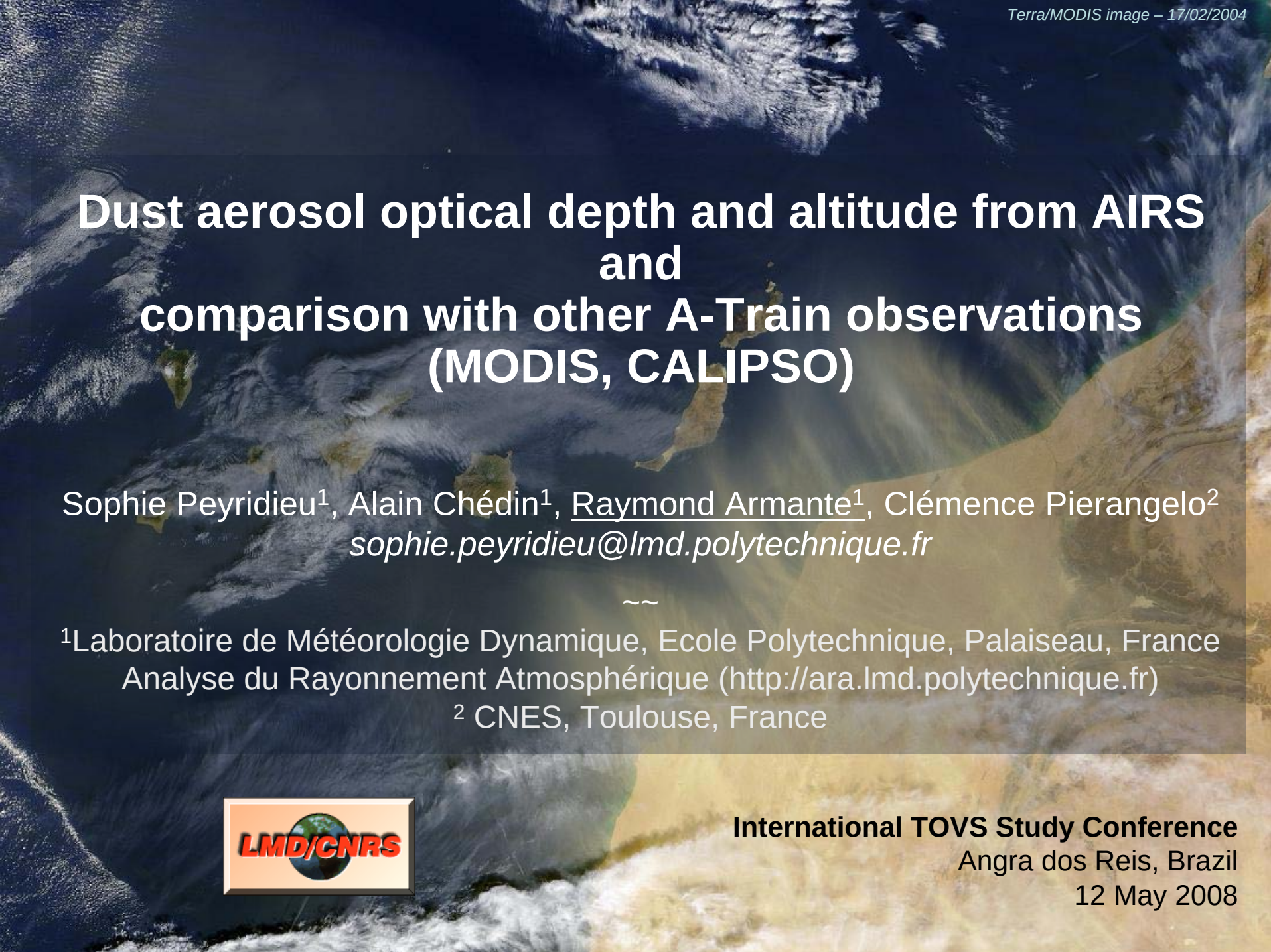

Dust aerosol optical depth and altitude from AIRS and comparison with other A-Train observations (MODIS, CALIPSO)

Sophie Peyridieu[1], Alain Chédin[1], Raymond Armante[1], Clémence Pierangelo[2]
sophie.peyridieu@lmd.polytechnique.fr

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[1]Laboratoire de Météorologie Dynamique, Ecole Polytechnique, Palaiseau, France
Analyse du Rayonnement Atmosphérique (http://ara.lmd.polytechnique.fr)
[2] CNES, Toulouse, France

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Why study aerosols ?

→ Aerosols are a key component of the troposphere

→ Strong effects on climate :

- Direct effects on radiation : parasol effect, greenhouse effect
- Indirect effects : Cloud Condensation Nuclei (CCN), clouds, precipitations…

Aerosols radiative forcing : **-2.0 to + 0.2 W.m^{-2}** (global estimation IPCC 2007)

→ High variability of types, spatial and time distribution, particles shape and size




This study will focus on dust aerosols

Ongoing studies :

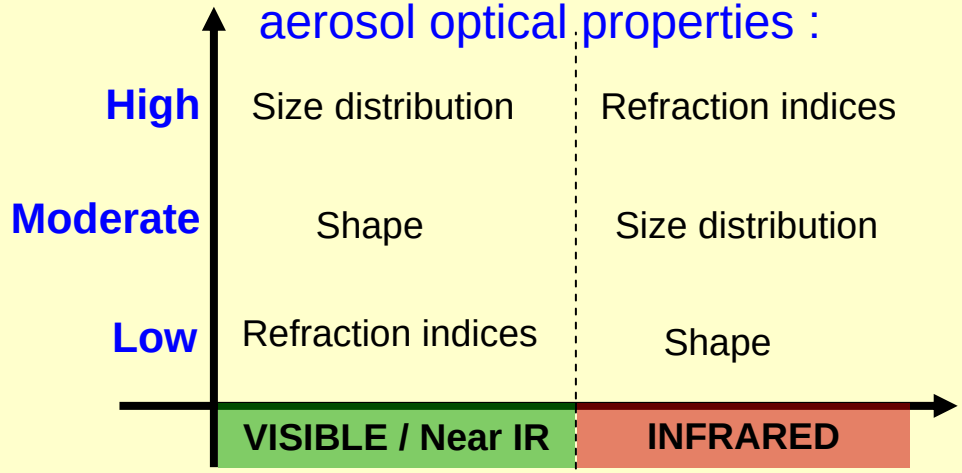
A majority of studies is still carried on in the visible part of the spectrum, whereas aerosols have an effect in both the visible and the infrared !

Complementarity infrared / visible :

VISIBLE / Near IR (around 0.55 µm) :
Sensitive to small particles
(i.e. carbonaceous aerosols, biomass burning, dust -accumulation mode)

INFRARED (around 10 µm) :
Sensitive to large particles
(i.e. dust -coarse mode)

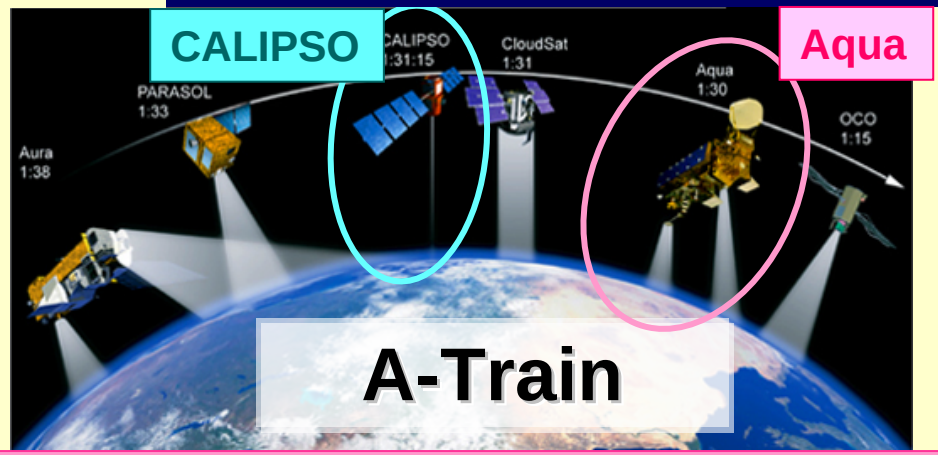
Impact of aerosol microphysics on aerosol optical properties :



Importance of infrared radiation to aerosols remote sensing :

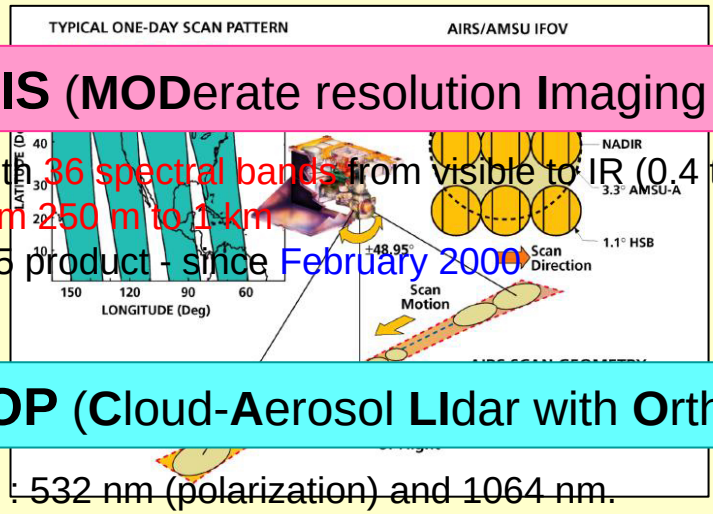
- Allows retrieval of mean altitude
- Day and night observations (not possible in the visible)
- Observation over deserts

Data from spaceborne observations :



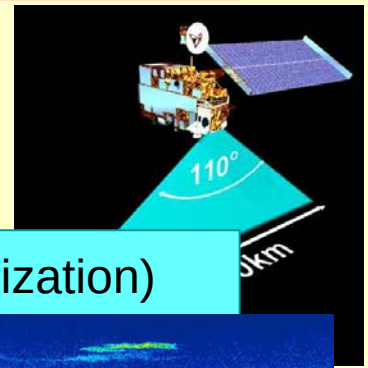
Aqua **AIRS** (**A**tmospheric **I**nfra**r**ed **S**ounder)

★ 2378 spectral channels spectrometer – bands 3.7 to 15.4 µm
★ Spectral resolution : 0.5 to 2 cm-1 – Spatial resolution : 13.5 km at nadir
★ 324 channels archived at LMD – Data from January 2003 to present



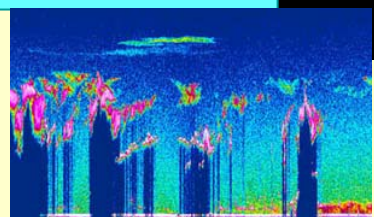
Aqua **MODIS** (**MOD**erate resolution **I**maging **S**pectroradiometer)

★ Imaging radiometer with 36 spectral bands from visible to IR (0.4 to 14.4 µm)
★ Spatial resolution : from 250 m to 1 km
★ Data : MYD08_M3.005 product - since February 2000



CALIPSO **CALIOP** (**C**loud-**A**erosol **LI**dar with **O**rthogonal **P**olarization)

★ Lidar – 2 wavelengths : 532 nm (polarization) and 1064 nm.
★ Vertical resolution : 30 to 60 m – Horizontal resolution : 333 m.
★ Data : Level 2 Cloud/Aerosol Layer product - since June 2006.



Aerosols products :

→ Retrievals from our study :

	AOD	Altitude	Time period
AIRS (10 µm)	Available over ocean In progress over land*	Available over ocean In progress over land*	Jan.2003 to Dec.2007

→ Data used for validation :

	AOD	Altitude	Time period
MODIS (0.55 µm)	Available ocean + land *(except on deserts)*		Feb.2000 to Mar.2008
CALIOP (532 nm)	Available ocean + land *(latest release v2.01)*	Available ocean + land	Jun.2006 to Feb.2008

* *cf. surface emissivity maps developed by Eric Péquignot (Pequignot et al., J.Appl.Meteor.Climatol., in press)*

Inversion method : a « Look-Up Table » approach

More details in [Pierangelo et al., ACP 2004]

Step 1 : Off-line calculation of the Look-Up Tables

- ≈ 600 tropical atmospheric situations
- 5 AOD + interpolation
- 4 altitudes + interpolation

Radiative transfer :
4A + DISORT

Look-Up Table :
Simulated BT
(8 AIRS channels*)

4A : RT Line-by-line model (clear sky)
DISORT : RT code accounting for scattering

Step 2 : Inversion

Principle : proximity search (minimizing a distance between simulated and observed BTs)

Observed BT
(8 AIRS channels*)

Proximity search

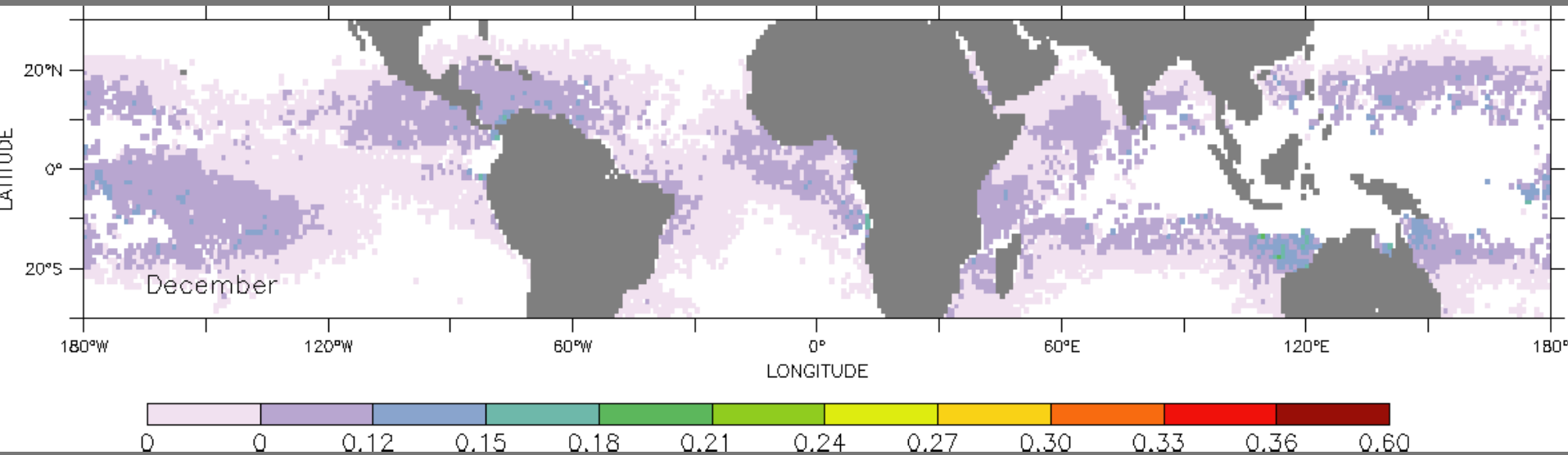
→ **10 µm AOD**
→ **Altitude**

* *8 channels selected for their sensitivity to dust and mid-troposphere*

Aerosol optical depth (AOD) :

Maps over ocean
Jan.2003 to Dec.2007
30°N-30°S

→ AIRS 5-year averages : month by month



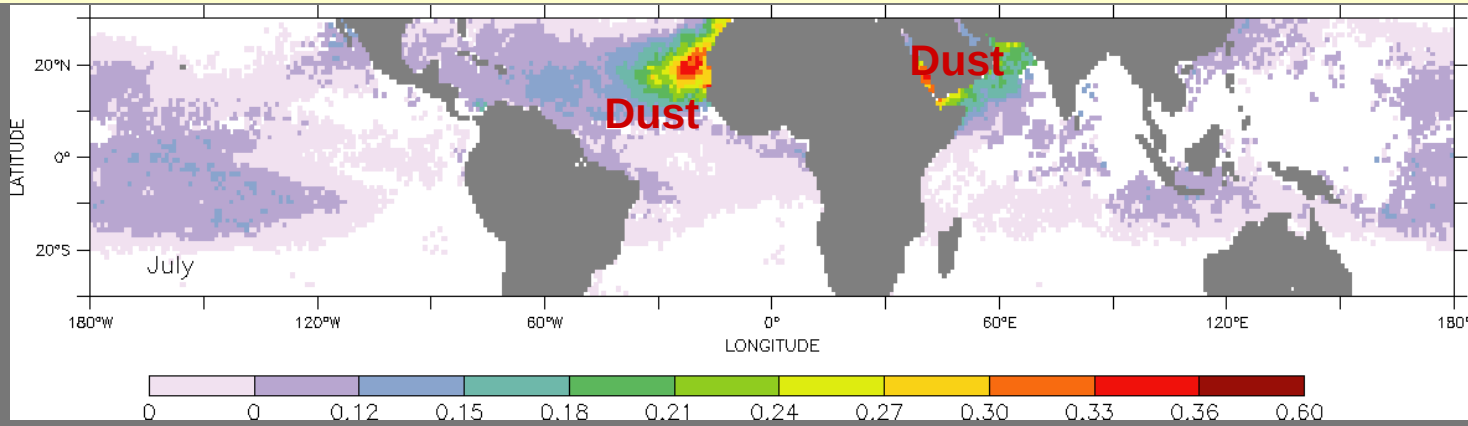
AIRS at 10 µm : sensitive to dust

Aerosol optical depth (AOD) :

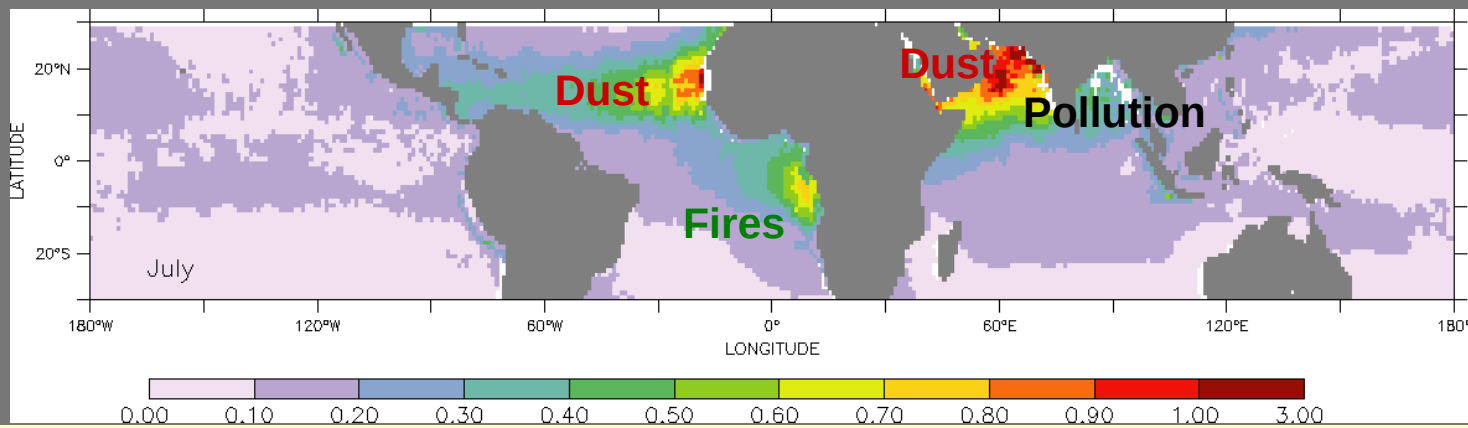
Maps over ocean
Jan.2003 to Dec.2007
30°N-30°S

→ **July (5-year average) : peak of Northern Hemisphere dust season**

AIRS (10µm)
sensitive to dust



MODIS (0.55µm)
sensitive to
{dust + fires
+ pollution}

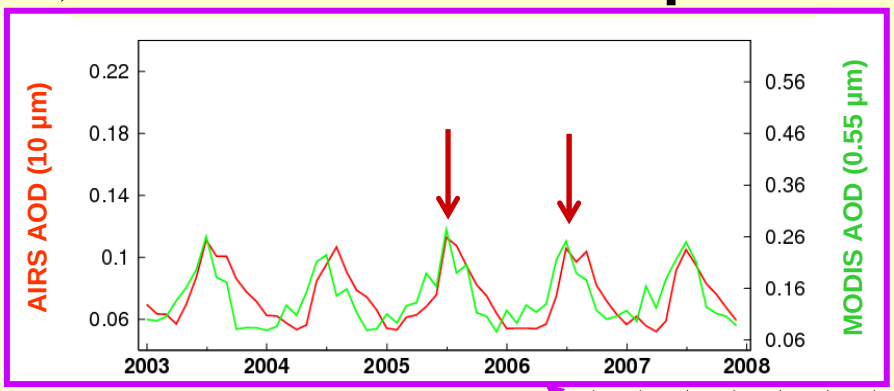


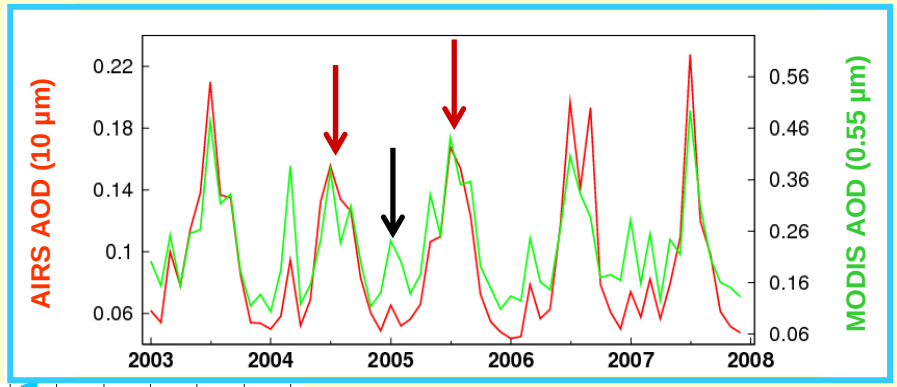
→ Very interesting coupling between AIRS (10 µm) and MODIS (0.55 µm) …
…towards a « deconvolution » of dust and biomass burning aerosols signals

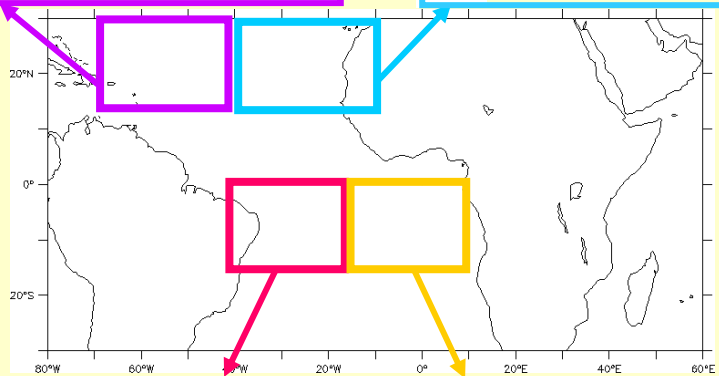
Aerosol optical depth (AOD) :

Time series over ocean
Jan.2003 to Dec.2007

→ Time series : comparison AIRS vs. MODIS





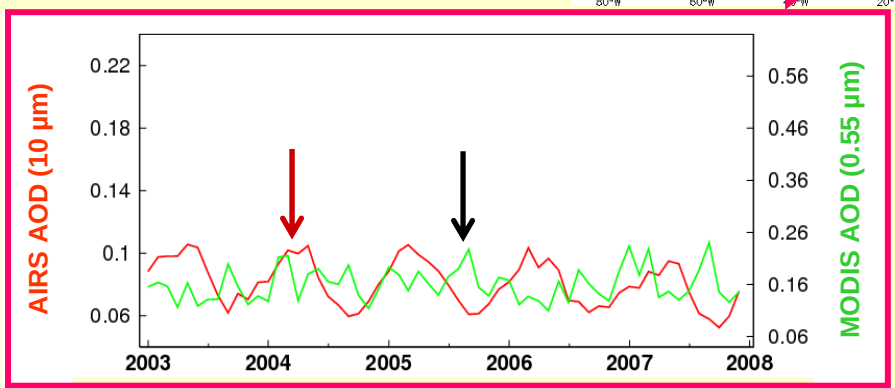


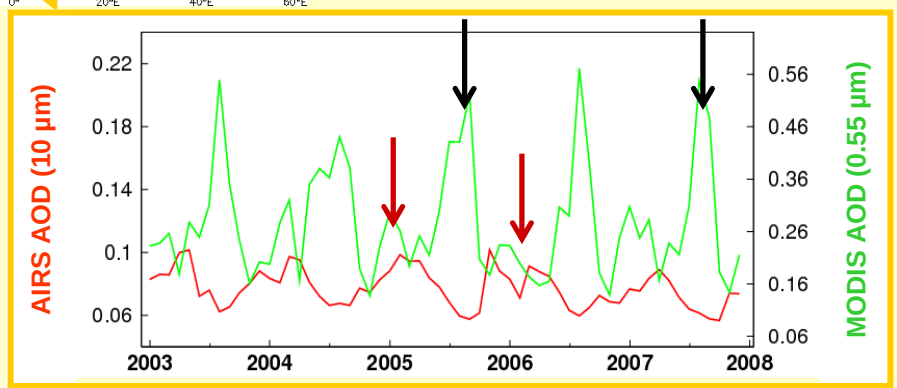
Warning :
Different scales for AODs !

Ratio IR /VIS ~ 0.3-0.4

→ **Dust season**

→ **Fire season** = dry season



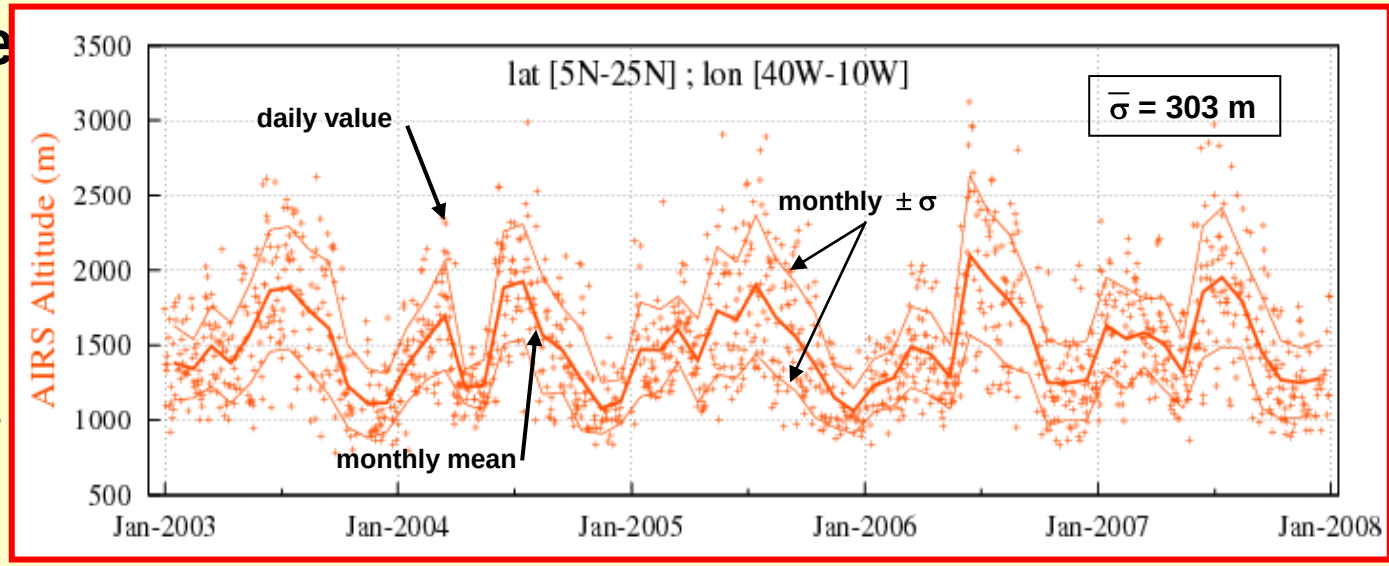


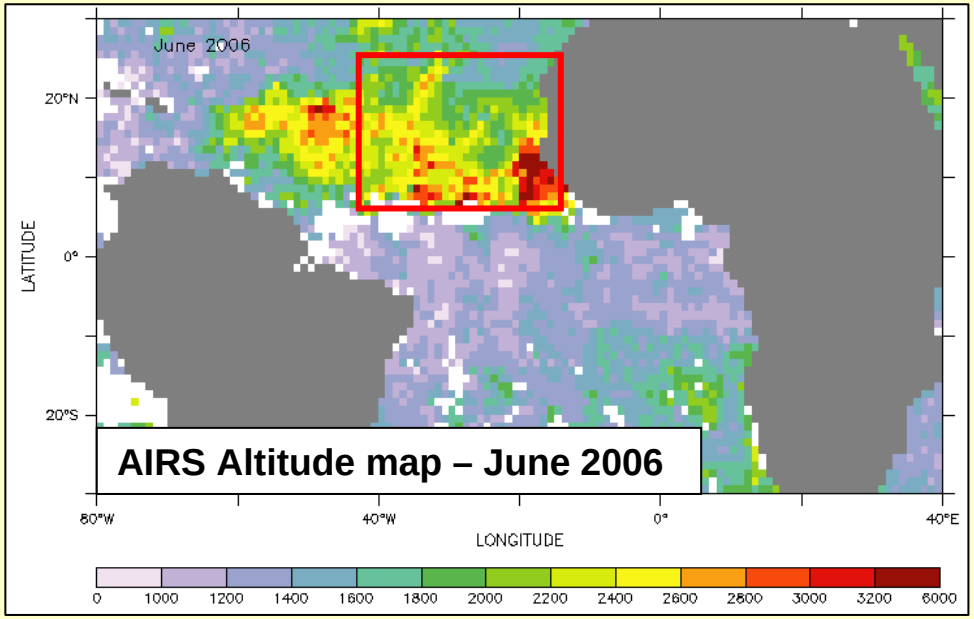
→ Mean altitude

MODIS : cannot retrieve altitude…

AIRS : Vertical sounder.

(Each channel has a weighting function and « peaks at a different altitude)





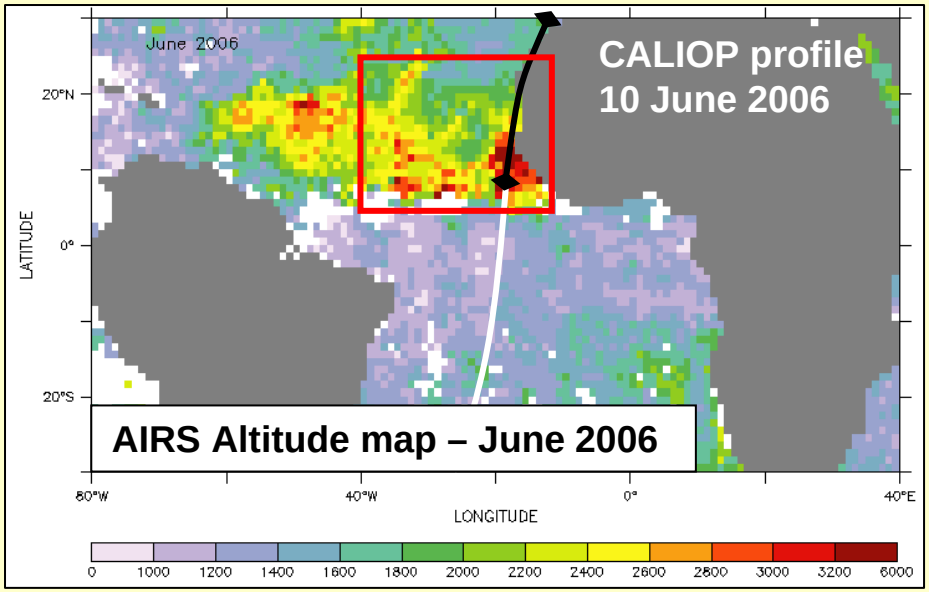
This time series shows :

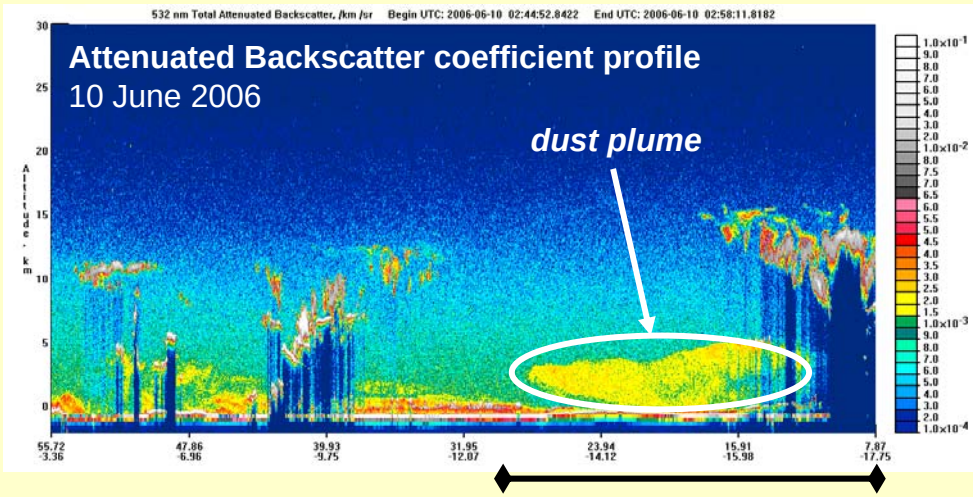
> Daily variability and seasonal cycle

> As reported by [Chiapello et al., 2002], [Maring et al., 2003] : Summer transport is generally observed higher (SAL : « Saharan Air Layer ») than winter transport (MBL : « Marine Boundary Layer »)

A-Train Synergy → Validation with CALIOP Lidar onboard CALIPSO

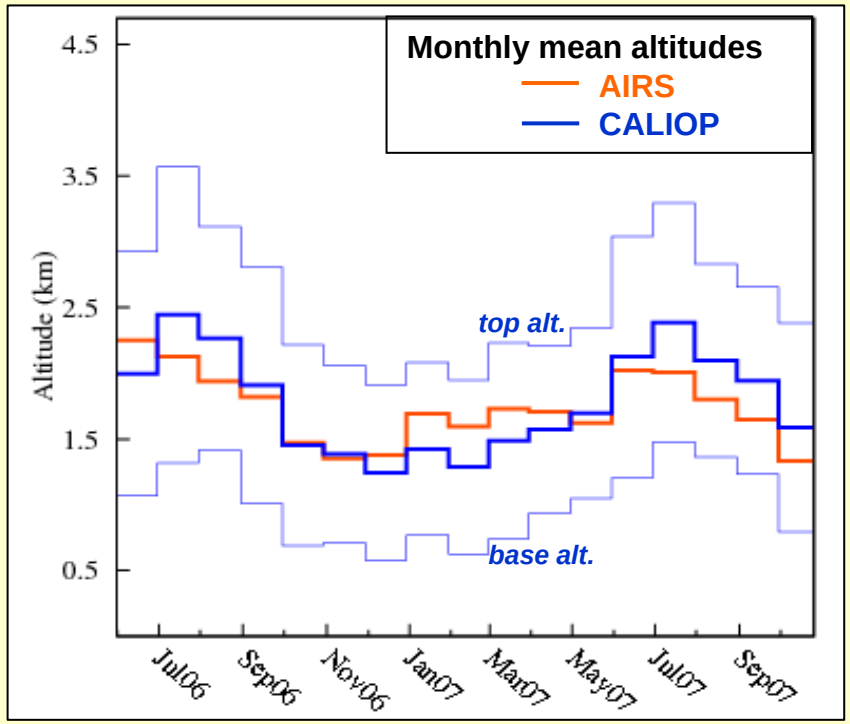
→ Mean altitude : validation with CALIOP Lidar data





Comparison AIRS / CALIOP :

CALIOP data restricted to 1 layer cases



mean error = 47 m
standard deviation = 230 m

→ Remarkable agreement between CALIOP active lidar and AIRS passive sounder.

Conclusion

✓ **Infrared remote sensing** brings new variables : **altitude,** r_{eff} …

✓ **Complementarity visible / infrared** :
Possible deconvolution between different types of aerosols (biomass burning / dust) and different modes of the dust (accumulation mode / coarse mode)

✓ Results obtained from **5 years of AIRS** observations over the tropical region :

Optical depth (AOD) :
Good agreement with MODIS

Mean altitude :
Remarkable agreement with CALIOP
[Peyridieu et al., in review]

Perspectives

→ **AIRS data** : retrieval over land (in progress)

→ **Validation with CALIOP :** Altitude and AOD (in progress)

→ **Process data from IASI** (launched Oct. 2006 onboard Metop)