

Dust aerosol optical depth and altitude retrieved from hyperspectral infrared observations (AIRS, IASI) and comparison with other aerosol datasets (MODIS, CALIOP, PARASOL)

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Previous work

Pierangelo et al. 2004, ACP : Dust altitude and optical depth from AIRS

Pierangelo et al. 2005, GRL : Effective radius of the coarse mode from AIRS

Peyridieu et al. 2009, ACPD : 6 years of dust AOD and altitude from AIRS
(in final prep for ACP)

Why study aerosols in the infrared ?

- Observations available daytime and nighttime, over ocean and over land
- Access to the mean aerosol layer altitude
- 10 µm : preferential detection of dust aerosol coarse mode

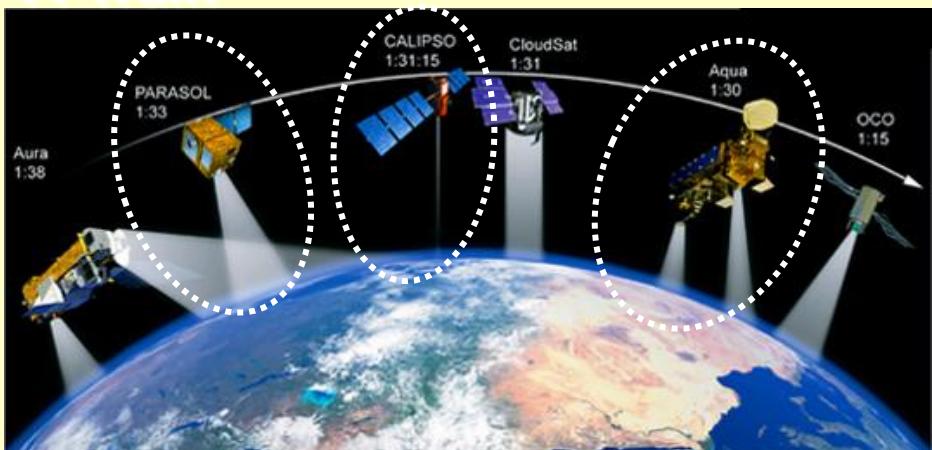
... But :

- Sensitivity to atmospheric thermodynamics
- Sensitivity to surface properties

AIRS (2003-) and IASI (2007-) offer a long series of observations
for monitoring aerosols in the infrared

Observation & validation instruments :

A-Train



AIRS / Aqua

MODIS / Aqua

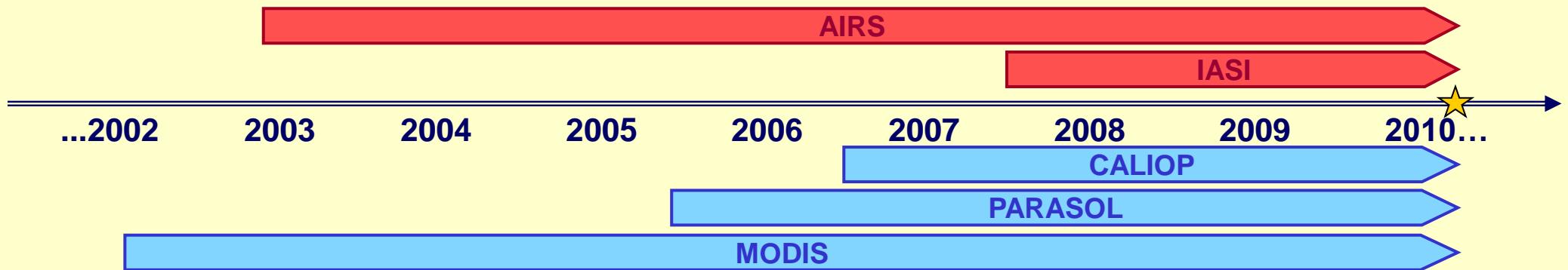


Metop

PARASOL
(POLDER)

CALIOP / CALIPSO

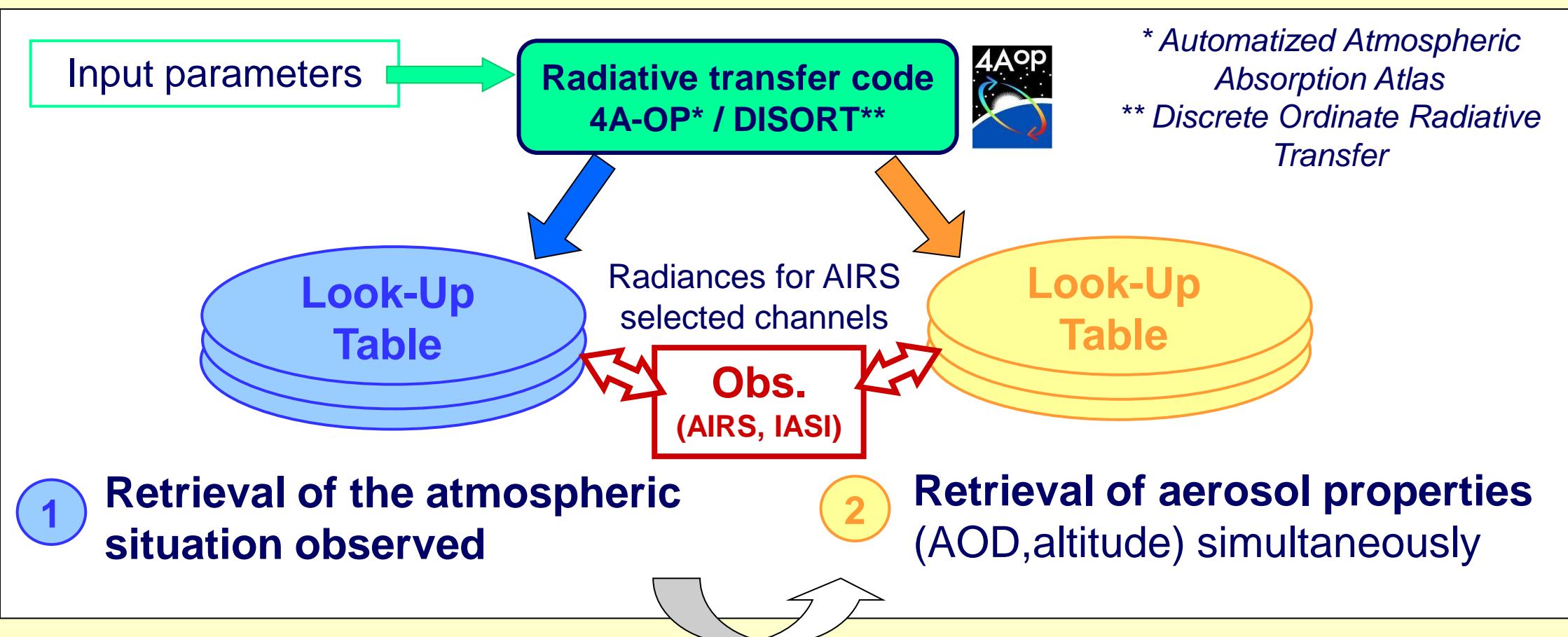
IASI : Metop



Inversion method : A look-up table approach

Input parameters :

Gas spectral properties (GEISA), atmospheric and geometric parameters (TIGR), aerosol parameters

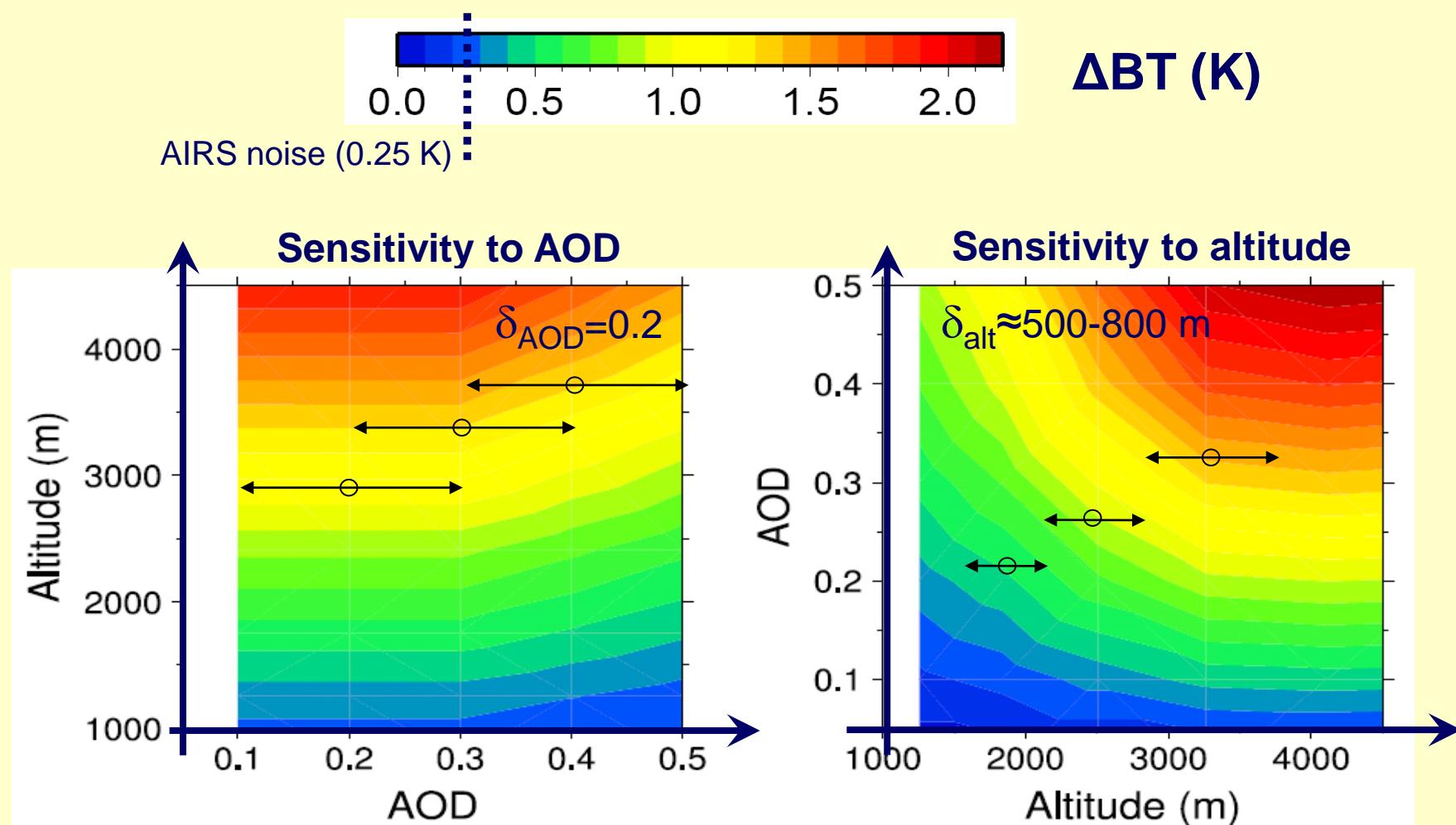


Calculations for 7 view angles, 567 TIGR situations, AOD (8 values), Altitude (9 values)
 Aerosol model : MITR (Mineral Transported) from OPAC database

[Peyridieu et al., ACPD 2009]

Illustration of the sensitivity of TIR channels to aerosols :

Exemple of AIRS channel #166 (1074.5 cm^{-1} , $9.3 \mu\text{m}$)



Channels for aerosol retrieval :

- AOD are retrieved even if the scattering particle is at low altitude
- Altitude are best retrieved for $\text{AOD} \geq 0.10$

→ Results obtained from AIRS :

- Parameters : **10 µm AOD** and **mean altitude**
- January 2003 to September 2009 – Monthly
- Tropical region (30°S – 30°N) – over ocean
- $1^{\circ}\times 1^{\circ}$ lat-lon grid

→ 6-year (2003–2008) climatology

→ Comparisons with other aerosol products :

- **MODIS/Aqua** Level-3 : $0.55\text{ }\mu\text{m}$ AOD
- **CALIOP/CALIPSO** Level-2 v2.01 : Aerosol layer product
« centroid » altitude
- **PARASOL** Level-2 $3^{\circ}\times 3^{\circ}$ grid aerosol product :
non-spherical coarse mode optical depth at 550 nm



Aerosol retrieval using IASI observations

IASI has been flying onboard Metop-A since October, 2006.

Archive currently available : July 2007 – November 2009 ([2+ years](#))

8461 channels, spectral resolution $\approx 0.50 \text{ cm}^{-1}$

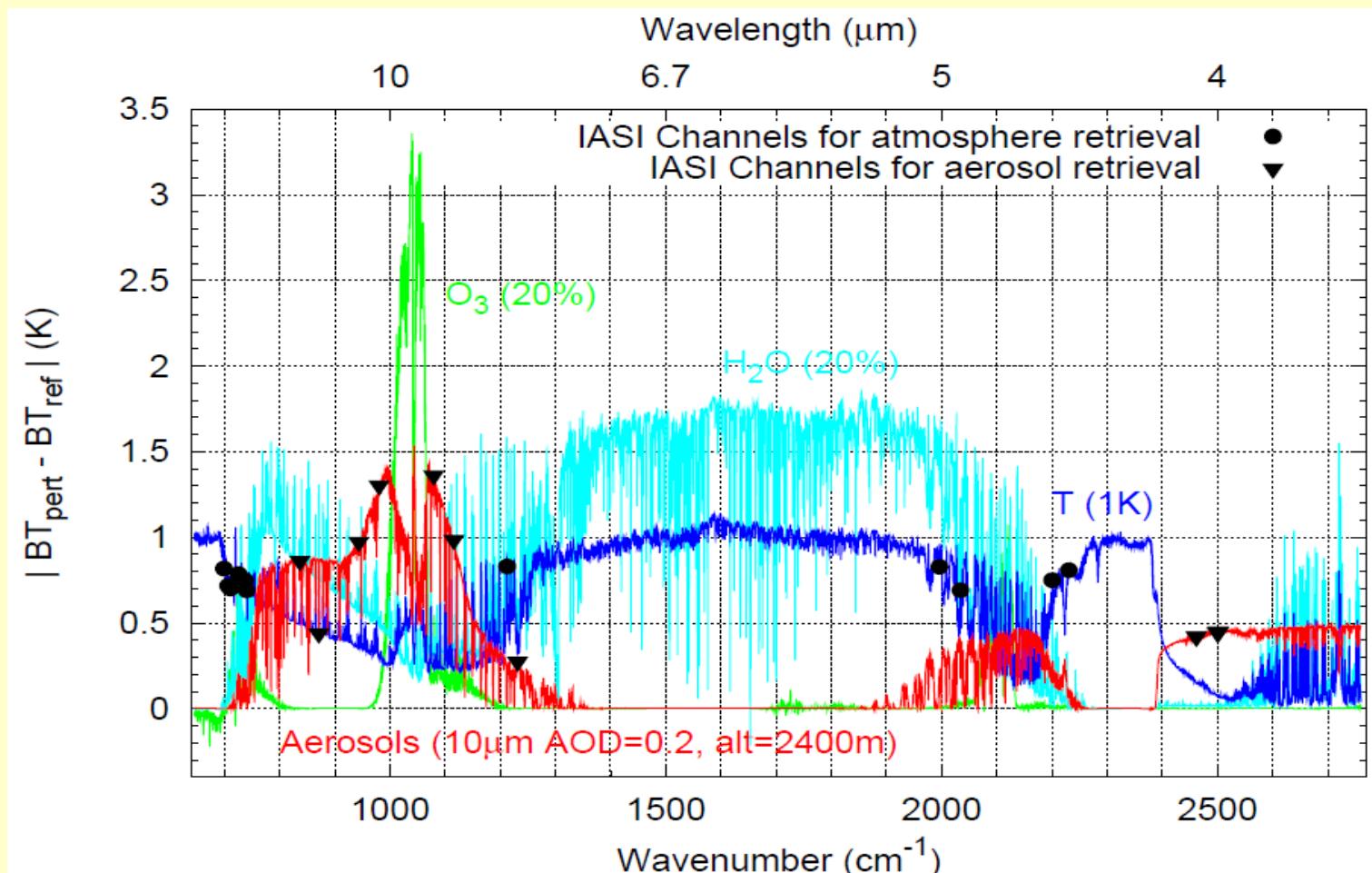
IASI higher spectral resolution allows selection of [finer channels](#), more specifically sensitive to aerosol properties.

The inversion method developped for AIRS is now being applied to IASI observations.

Selection of IASI channels :

1st step : **11 channels** (sensitive to T, H₂O) **for atmosphere retrieval**

2nd step : **9 channels** (sensitive to aerosols) **for aerosol retrieval**



Sensitivity of IASI Channels to different atmospheric constituents
4A-OP and 4A-OP/DISORT spectra for TIGR mean tropical atmosphere

→ Results obtained from IASI :

- Parameters : **10 µm AOD** and **mean altitude**
- June–September 2007–2009 – Monthly
- Tropical region (30°S – 30°N) – over ocean
- 1°x1° lat-lon grid

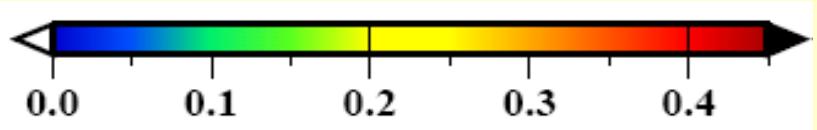
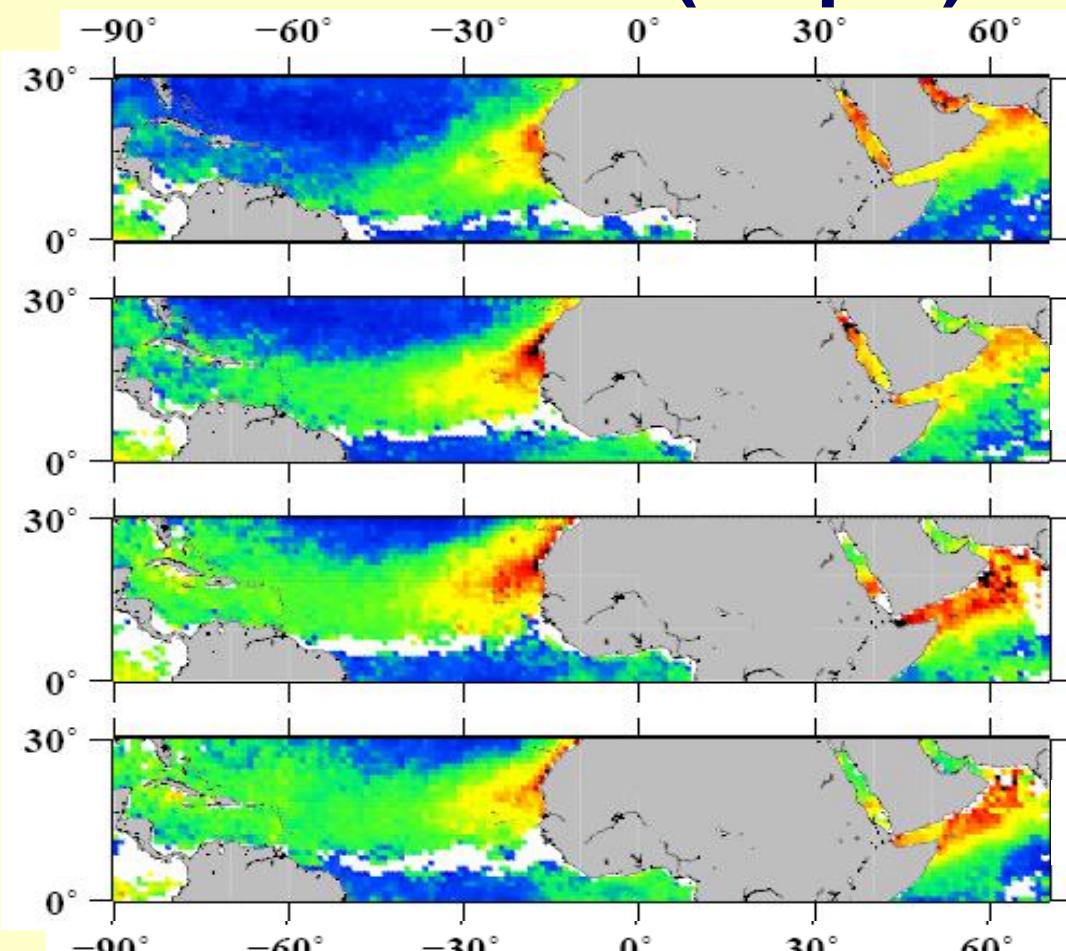
Preliminary

→ Comparisons with other aerosol products :

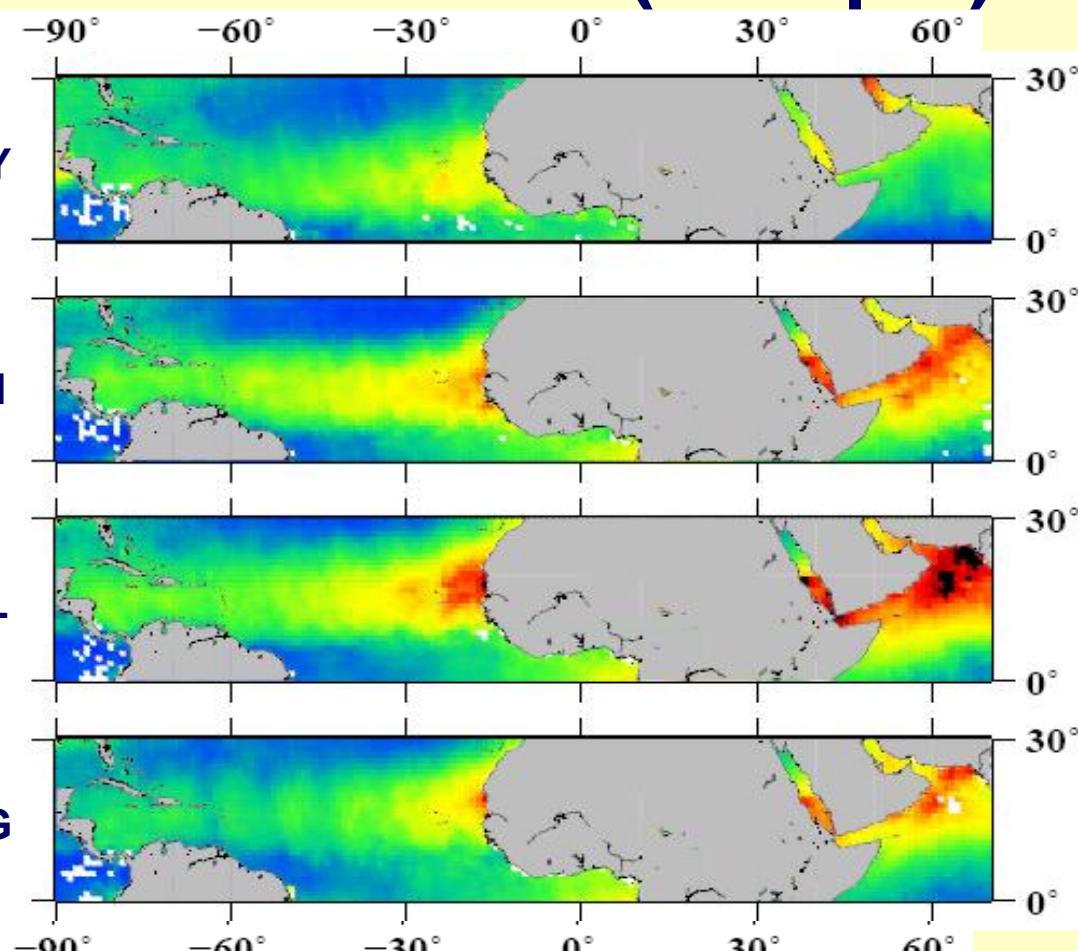
- **AIRS/Aqua retrieved 10µm AOD and altitude**
- **MODIS/Aqua Level-3 : 0.55 µm AOD**
- **CALIOP/CALIPSO Level-2 v2.01 : Aerosol layer product « centroid » altitude**
- **PARASOL Level-2 3°x3° grid aerosol product : non-spherical coarse mode optical depth at 550 nm**

6-year (2003–2008) climatology (monthly AOD)

AIRS AOD (10 μm)



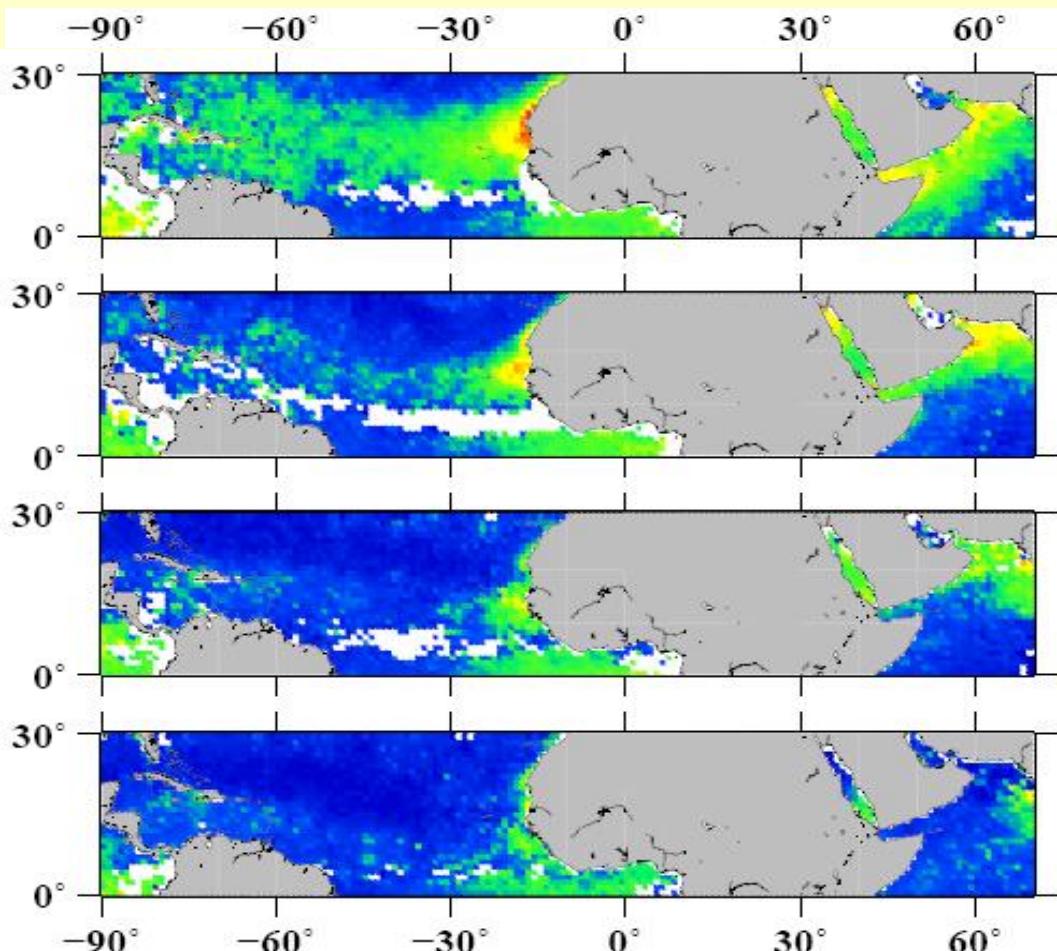
MODIS AOD (0.55 μm)



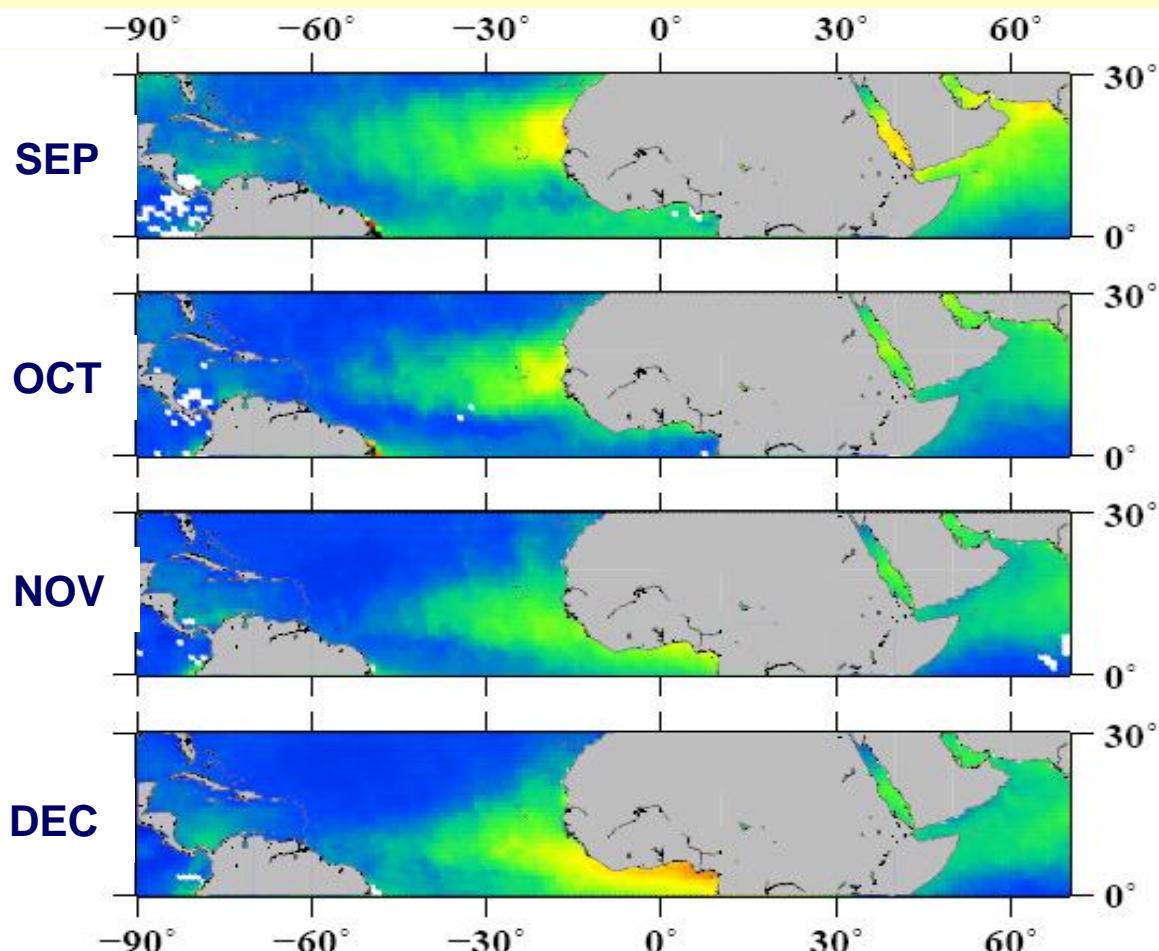
[Peyridieu et al., ACPD 2009]

6-year (2003–2008) climatology (monthly AOD)

AIRS AOD (10 μm)



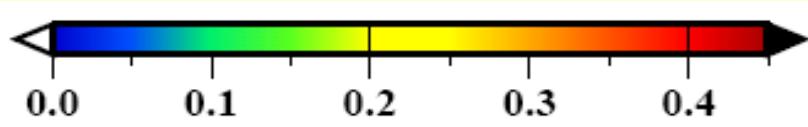
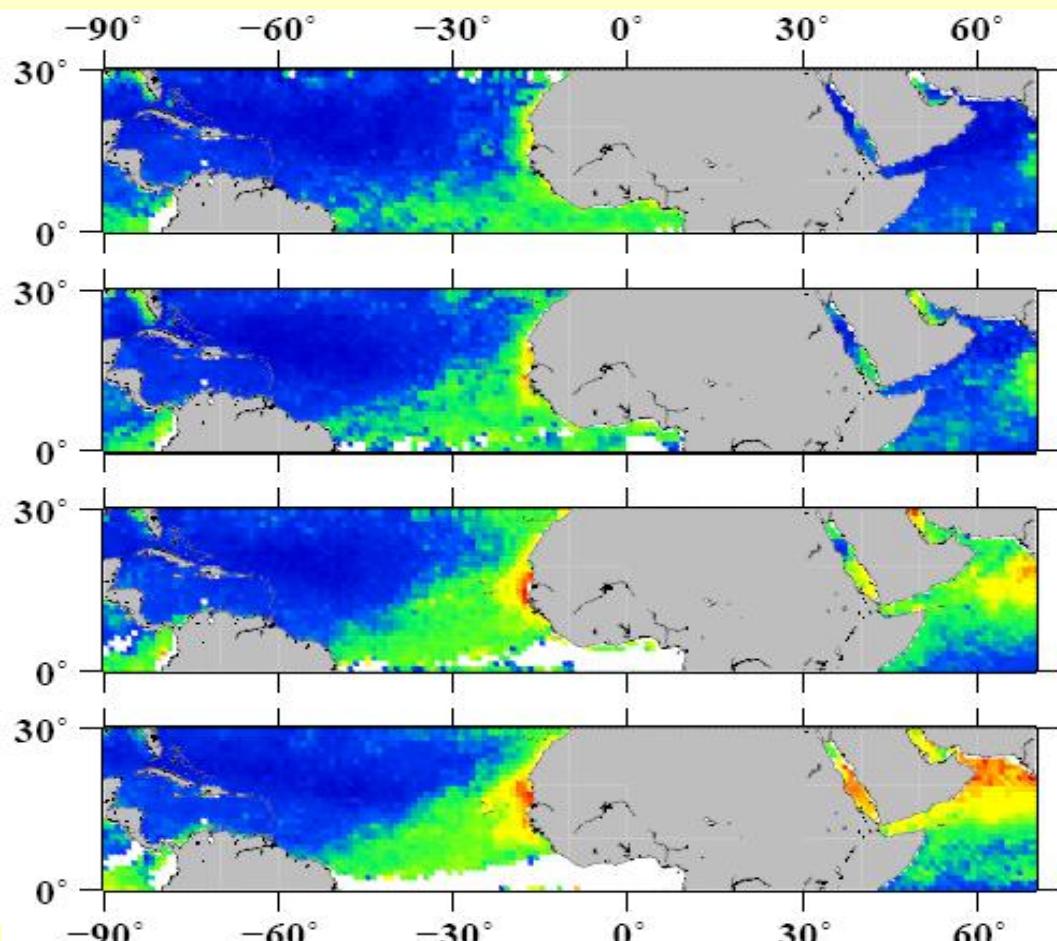
MODIS AOD (0.55 μm)



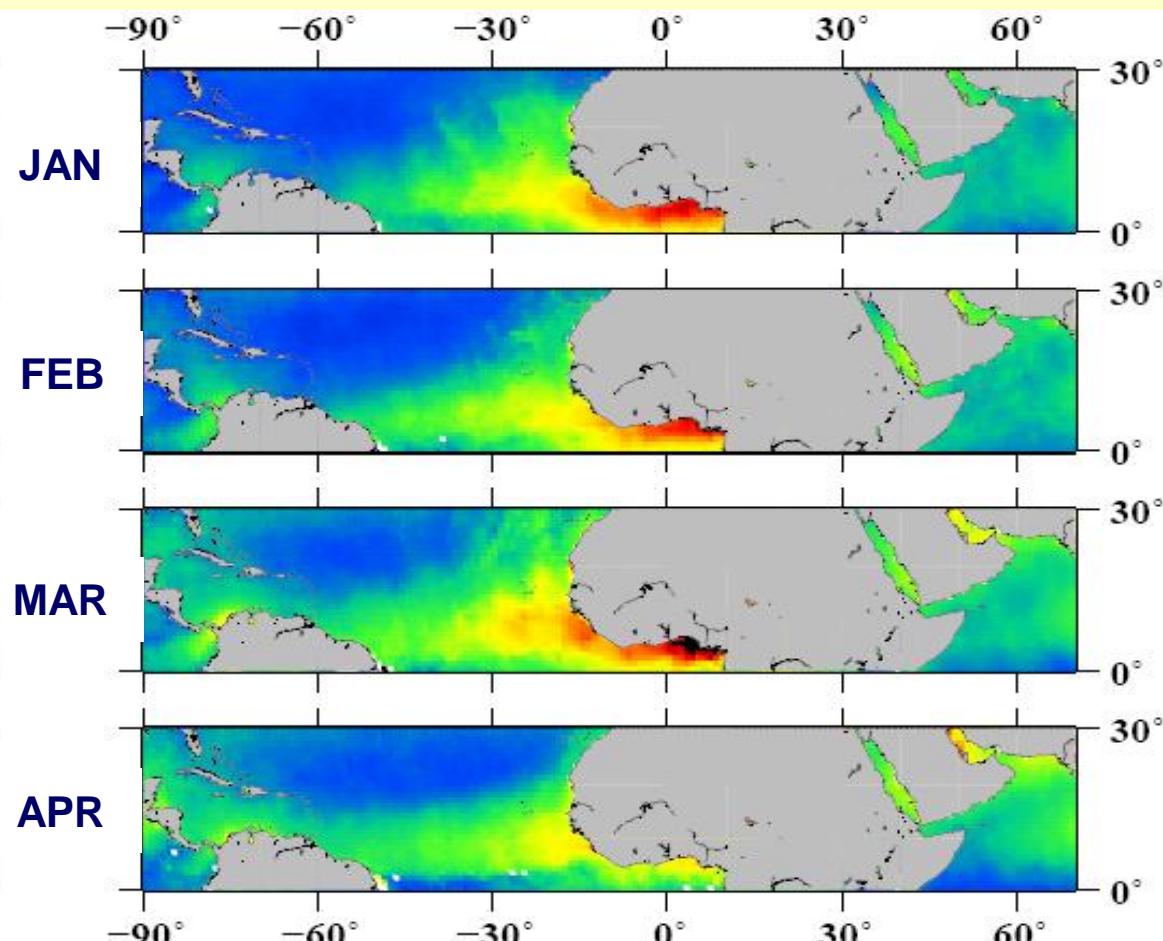
[Peyridieu et al., ACPD 2009]

6-year (2003–2008) climatology (monthly AOD)

AIRS AOD (10 μm)



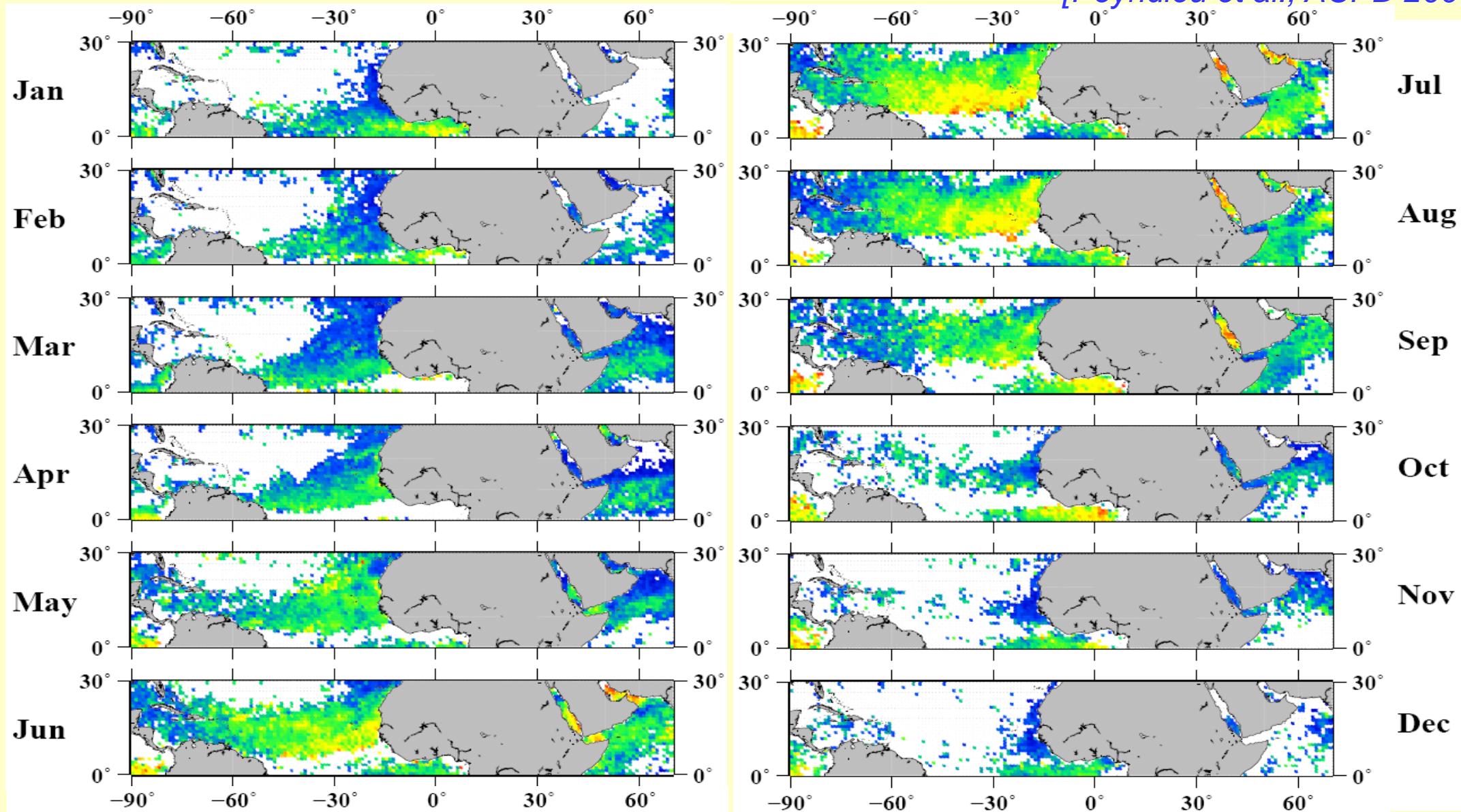
MODIS AOD (0.55 μm)



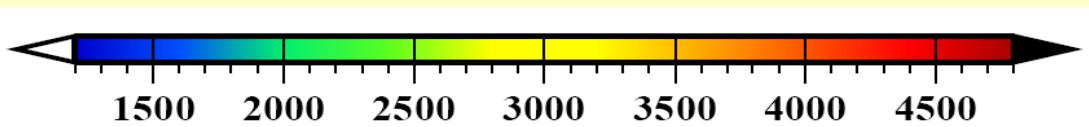
[Peyridieu et al., ACPD 2009]

6-year (2003–2008) climatology (monthly Mean Altitude)

[Peyridieu et al., ACPD 2009]



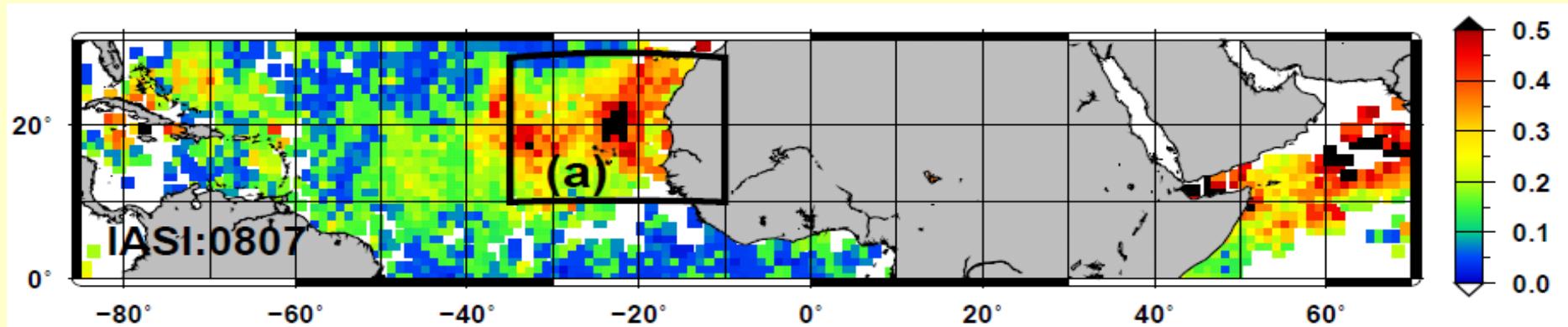
AIRS mean altitude (m)
for AOD ≥ 0.10



10 μm dust aerosol optical depth, over ocean :

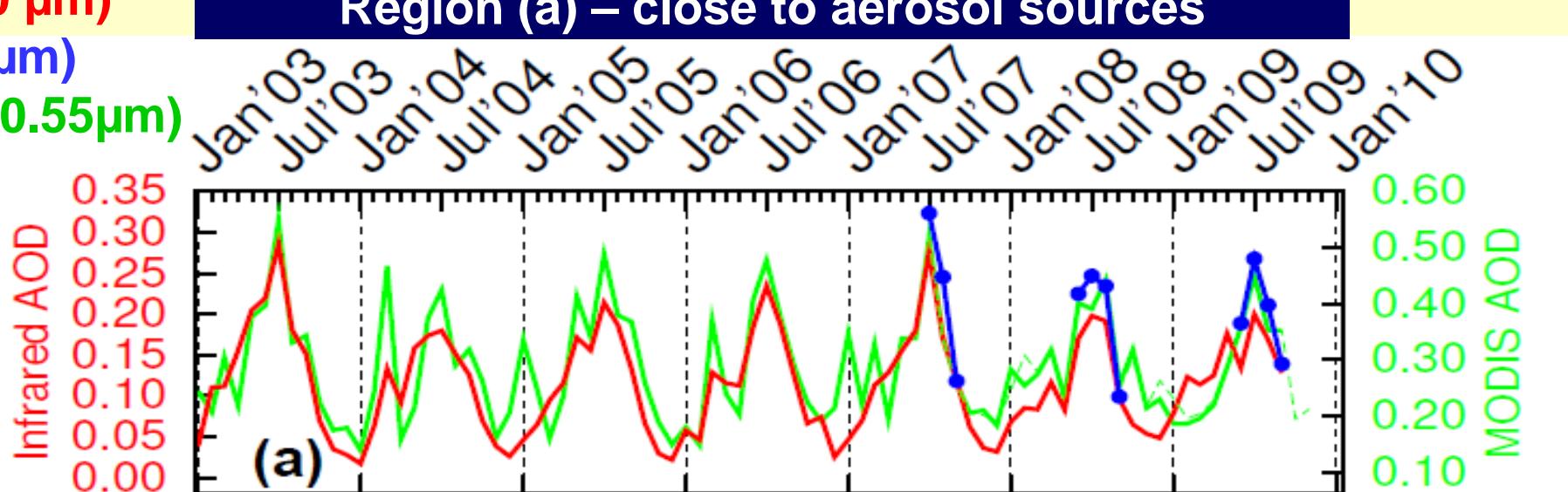
Time series : Comparison with MODIS

[Peyridieu et al., ACPD 2009]



- ~~ AIRS (10 μm)
- ~~ IASI (10 μm)
- ~~ MODIS (0.55 μm)

Region (a) – close to aerosol sources

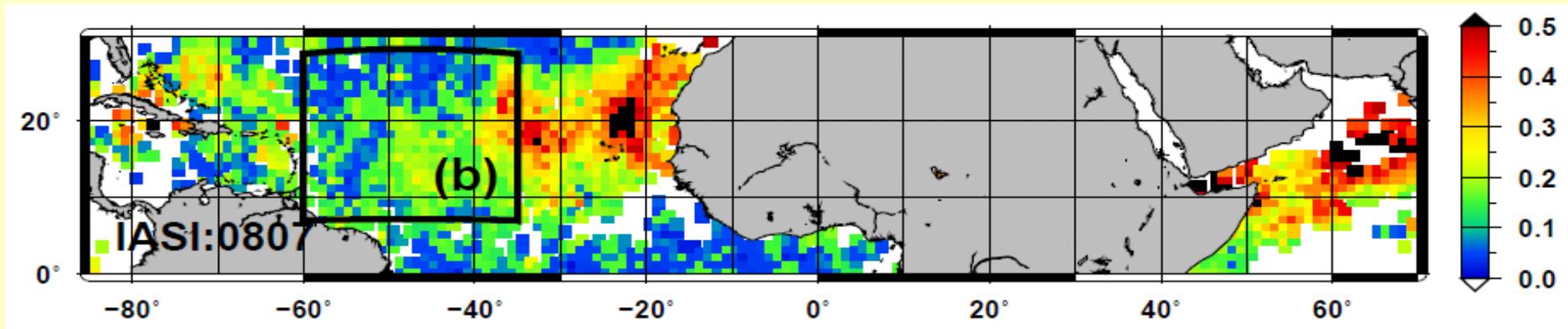


- Very good agreement found between AIRS and MODIS (dust season : JJA)
- IASI [preliminary] slightly larger than AIRS dust AOD
- Winter peaks : biomass burning aerosols seen by MODIS

10 μm dust aerosol optical depth, over ocean :

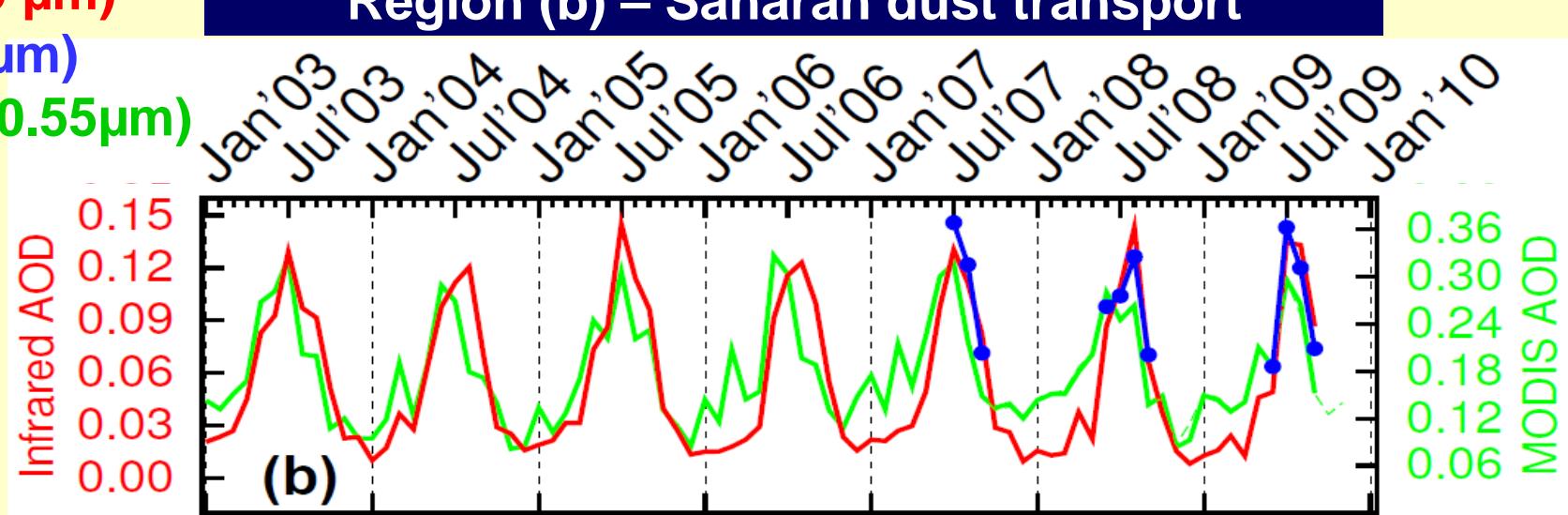
Time series : Comparison with MODIS

[Peyridieu et al., ACPD 2009]



- ~~ AIRS (10 μm)
- ~~ IASI (10 μm)
- ~~ MODIS (0.55 μm)

Region (b) – Saharan dust transport

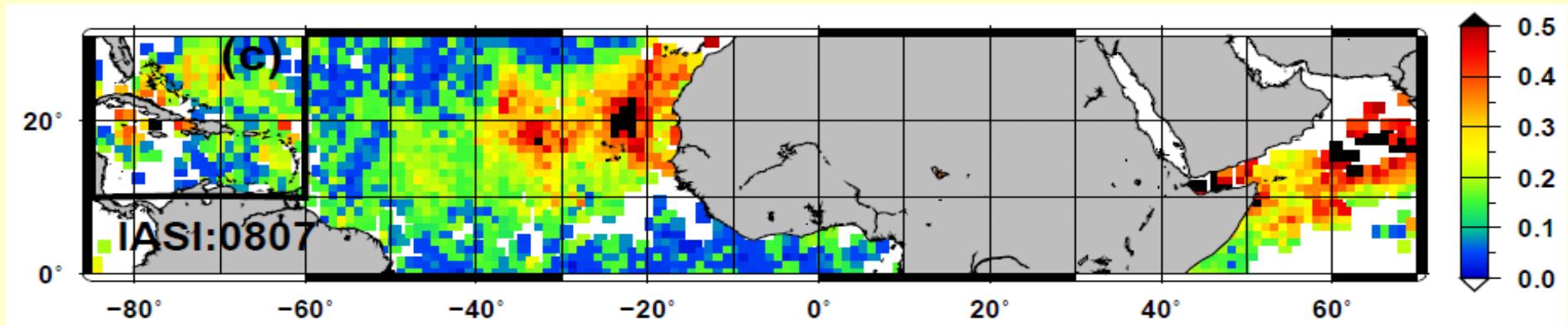


- Very good agreement found between AIRS/IASI and MODIS
- Background signal observed by MODIS (aerosol fine mode)

10 μm dust aerosol optical depth, over ocean :

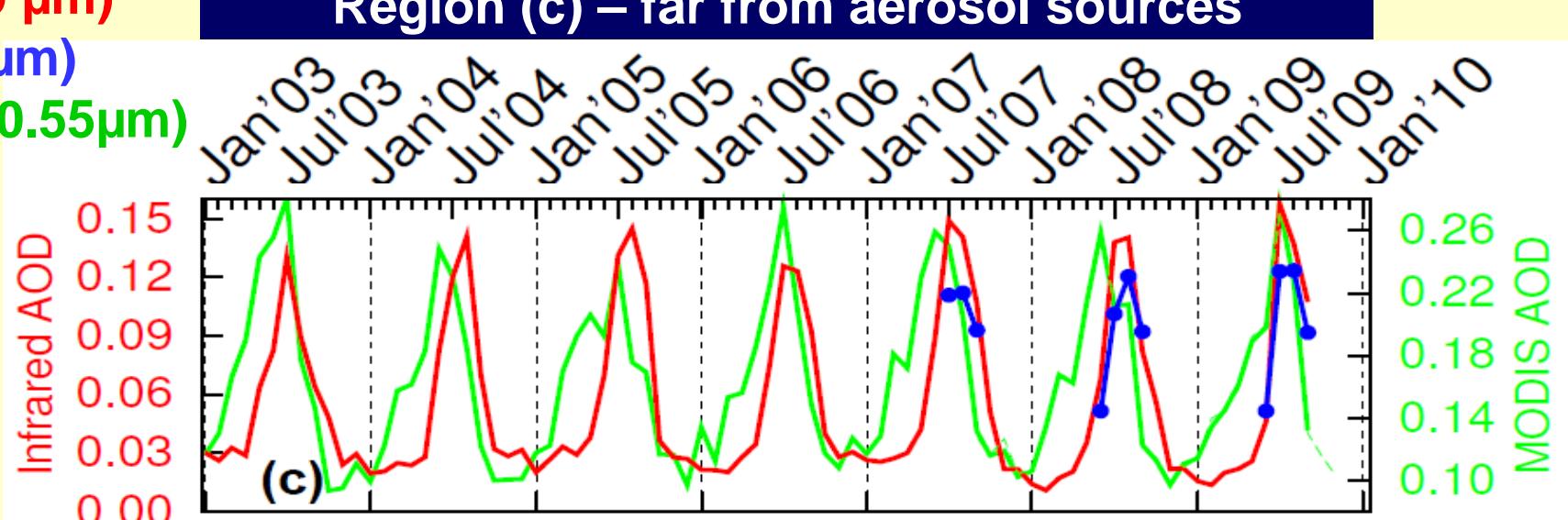
Time series : Comparison with MODIS

[Peyridieu et al., ACPD 2009]



- ~~ AIRS (10 μm)
- ~~ IASI (10 μm)
- ~~ MODIS (0.55 μm)

Region (c) – far from aerosol sources

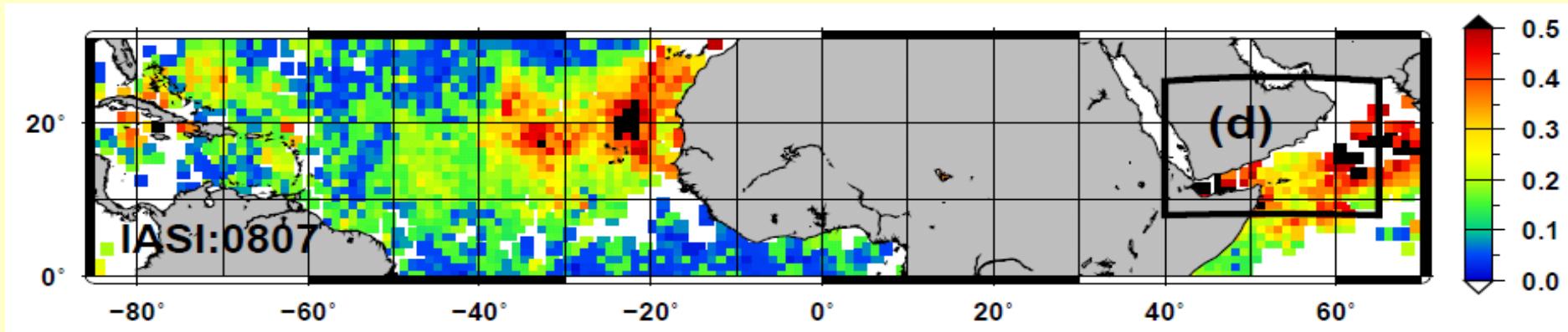


- 2-months lag between MODIS and AIRS/IASI AOD series : late arrival of the coarse mode in this remote region
- Confirmed by PARASOL and AERONET observations

10 μm dust aerosol optical depth, over ocean :

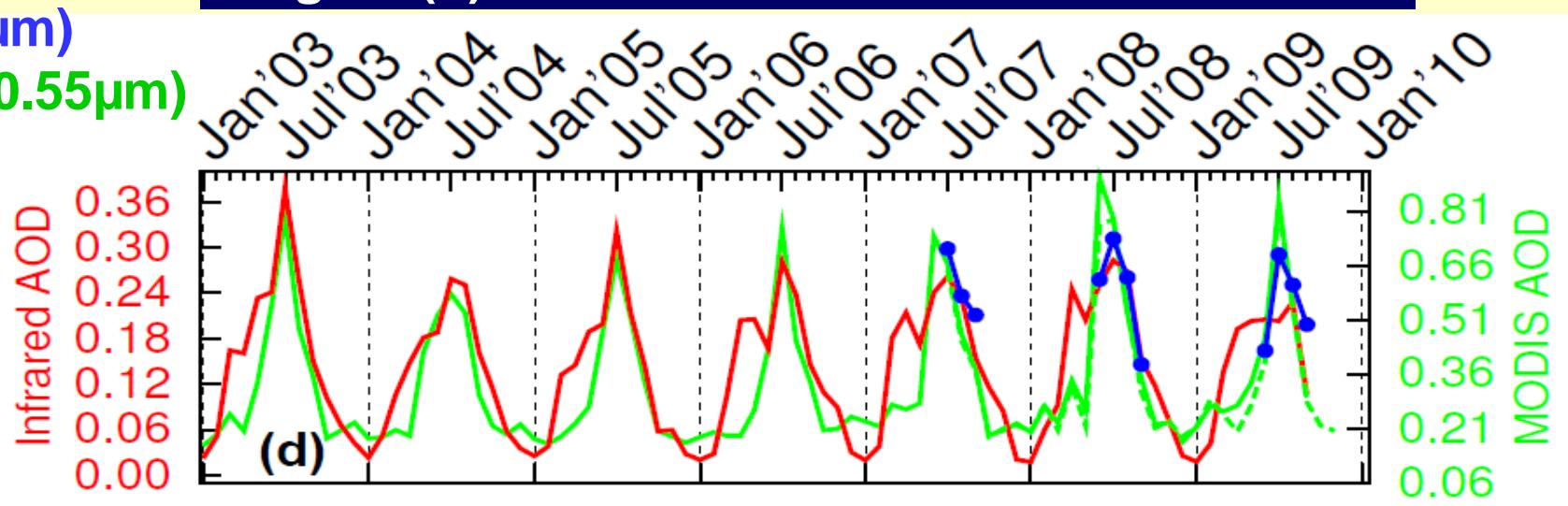
Time series : Comparison with MODIS

[Peyridieu et al., ACPD 2009]



- ~~ AIRS (10 μm)
- ~~ IASI (10 μm)
- ~~ MODIS (0.55 μm)

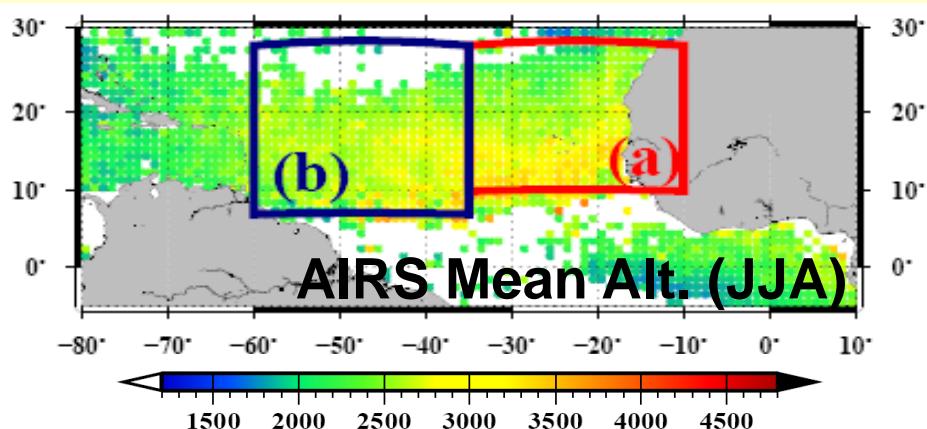
Region (d) – close to dust sources from Arabia



→ Good agreement between AIRS/IASI and MODIS

Dust layer mean altitude, over ocean :

Time series : Comparison with CALIOP



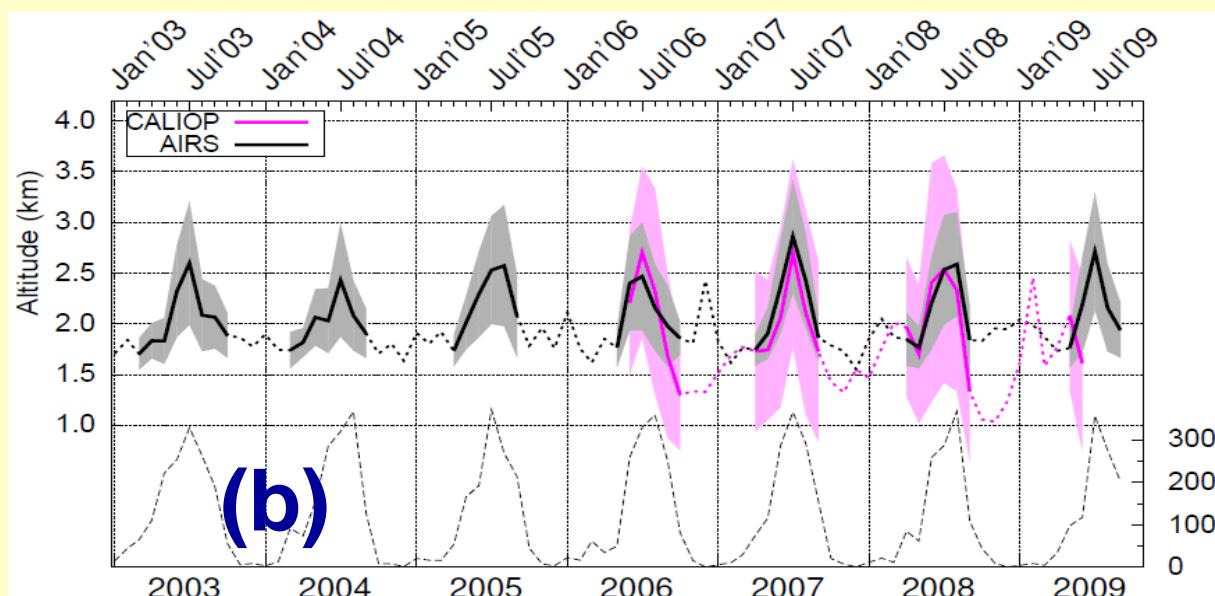
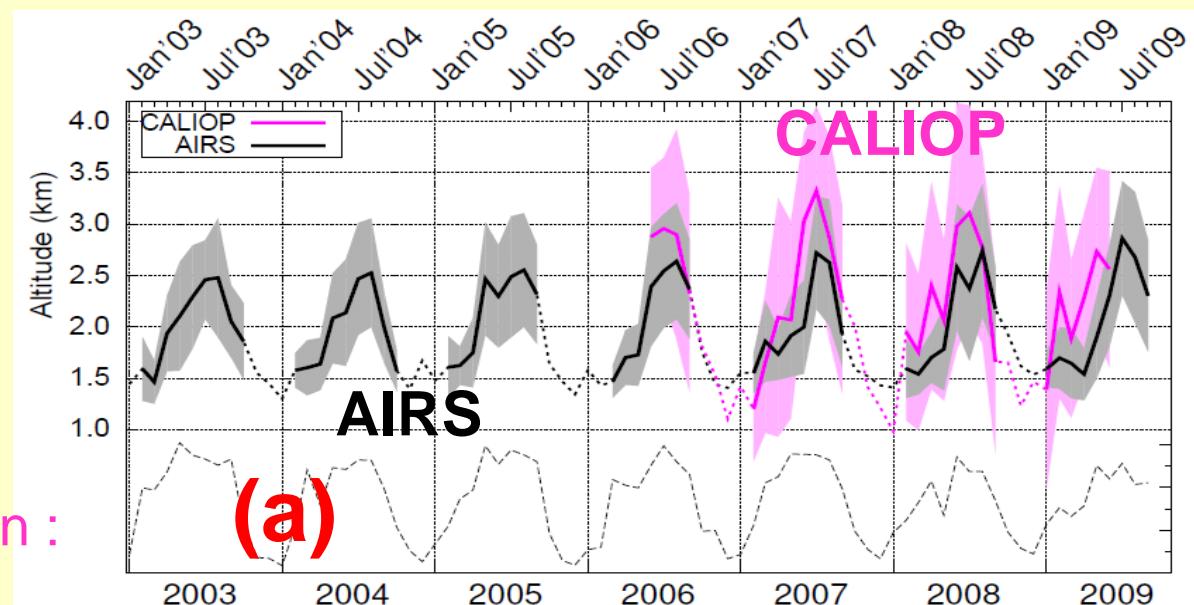
→ Preliminary CALIOP data selection :

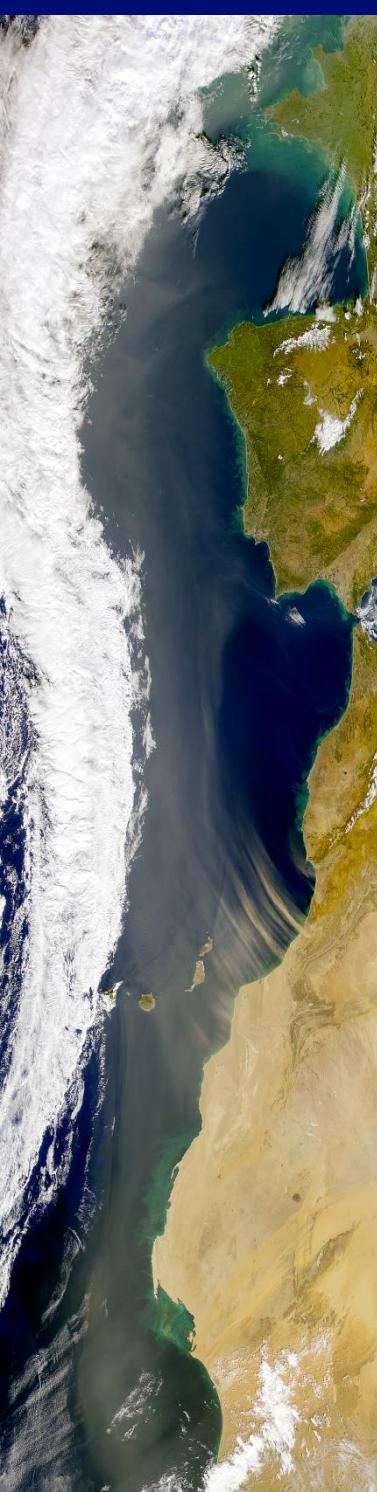
1 dust aerosol layer cases
(64% of CALIOP data)

Mean stats. june 2006 – june 2009

(a) $\langle \text{AIRS-CALIOP} \rangle \approx -180 \text{ m}$
 $\langle \sigma \rangle \approx 375 \text{ m}$

(b) $\langle \text{AIRS-CALIOP} \rangle \approx +220 \text{ m}$
 $\langle \sigma \rangle \approx 340 \text{ m}$





Conclusion

- **Infrared remote sensing** is required for the study of aerosols (altitude, coarse mode, total radiative forcing, land/desert, night/day)
- **~7 years of AIRS data :**
 - AOD comparison with MODIS : very good agreement even far from the sources; expect possible deconvolution between different types (dust/biomass burning) of aerosols and different modes of the dust (fine/coarse)
 - Altitude comparison with CALIOP : good agreement in spite of the large differences in space-time resolutions. Version 3 is expected to provide CALIOP AODs
 - Comparison with PARASOL needed to assess the role of coarse mode vs. fine mode particles
- **IASI observations** : preliminary results are very encouraging

Perspectives

- Validation with CALIOP v3
- **Process IASI data (in progress):**
 - Dust **AOD, mean altitude, effective radius** retrieval over ocean
 - Retrieval over land using retrieved T_s and surface emissivities
 - Inter-comparison, validation