Retrieving the effective radius of Saharan dust coarse mode from AIRS

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Introduction

- IPCC 2001: **Radiative forcing** of dust aerosol poorly known

- **dust size**: a key parameter for shortwave radiative forcing

- **In-situ** measurements show a high variability [Reid et al., 2003]

- present **satellite** retrievals from ***visible*** radiances not yet satisfactory (MODIS) [Lévy et al., 2003]

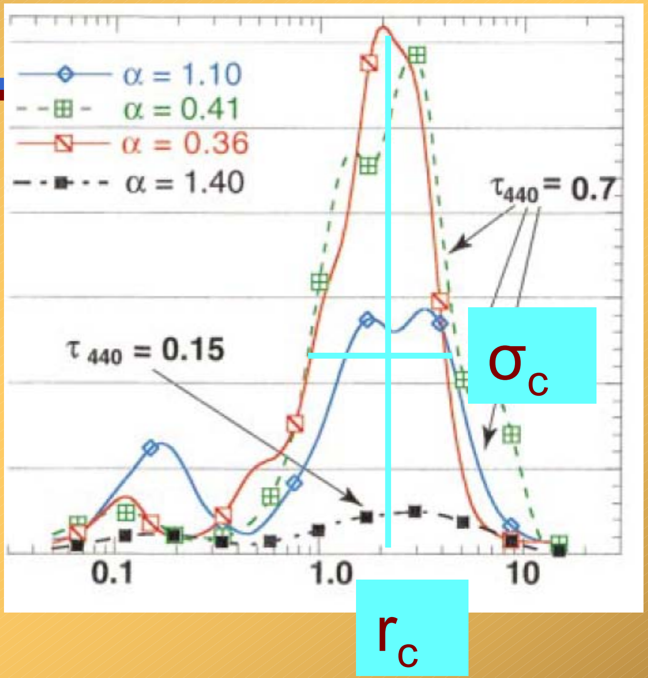
→ New approach: characterization of dust size from high resolution ***infrared*** measurements (AIRS)

Dust size distribution

Bimodal lognormal distribution
- accumulation mode: r_a, σ_a
- coarse mode: : r_c, σ_c

4 parameters

$$n(r) = \frac{C}{r} \exp\left[\frac{1}{2} \left(\frac{\log(r) - \log(r_m)}{\log(\sigma)} \right)^2 \right]$$



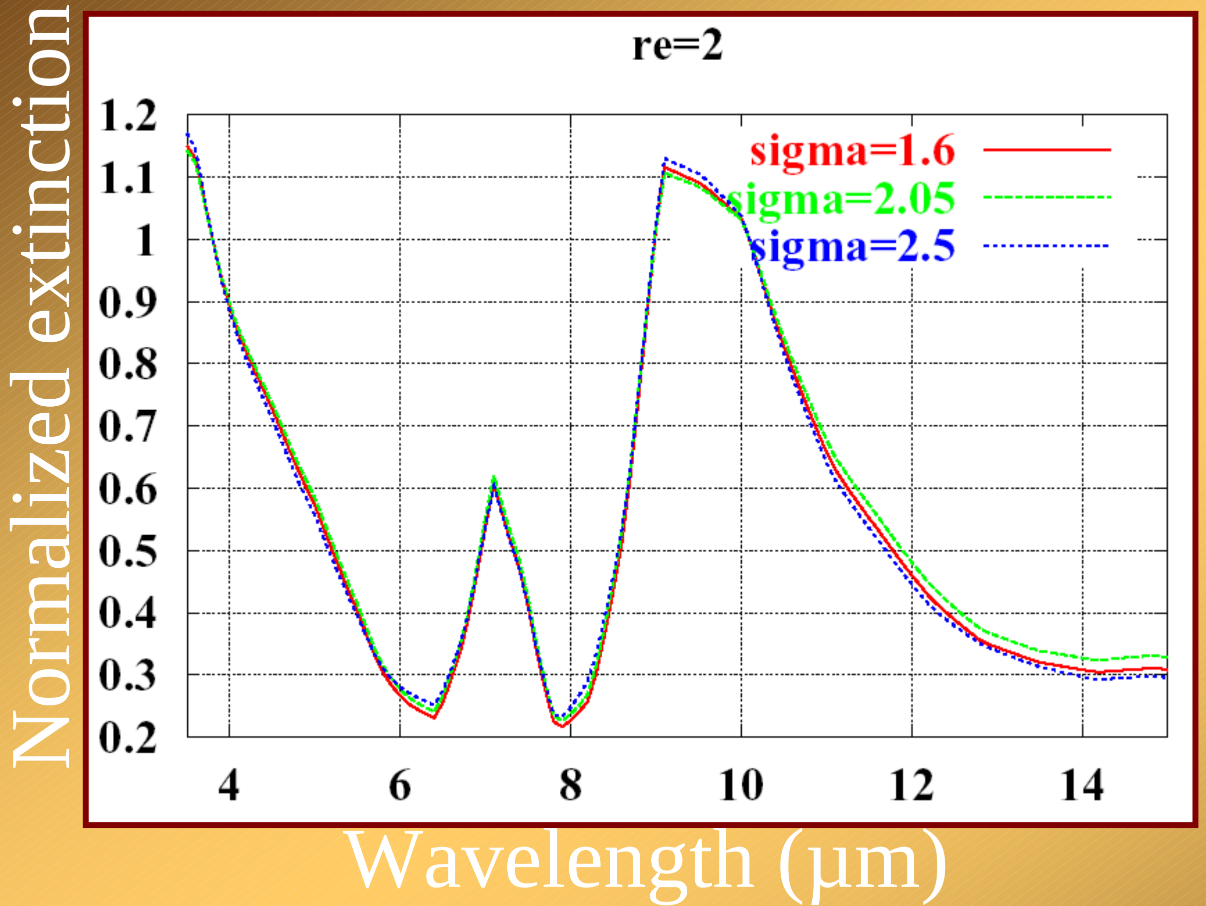
Exemple of bimodal aerosol size distribution (Dubovik et al., 200

Computations with Mie code	Visible (0.55 µm)	Infrared (10 µm)
AOD acc / AOD coarse	1.0	0.08

-Advantage of the infrared:
monomodal distribution
(coarse mode: r_c, σ_c)

2 parameters

Dust size distribution



σ_c=geometric standard deviation

No effect of the width of the size distribution

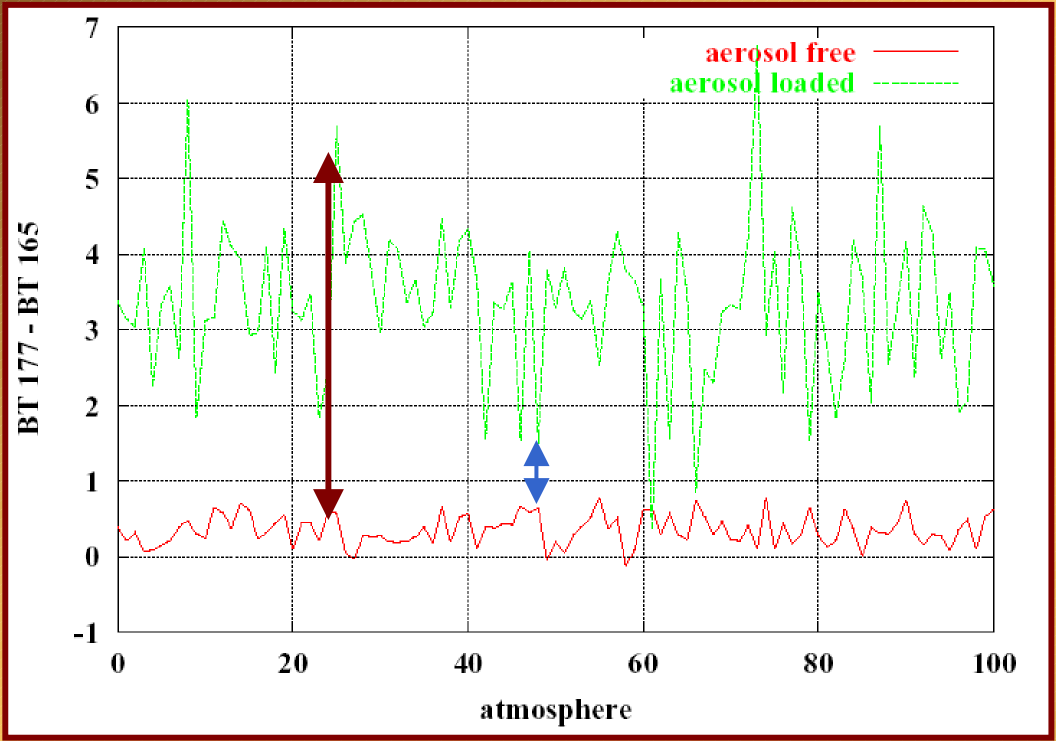
Choice: σ_c=2.2

1 parameter

→ Only one parameter is to be considered: coarse mode effective radius r_e

Sensitivity study (1)

Difference between 2 AIRS channels
BT 177 (8.14 µm) – BT 165 (9.32 µm):

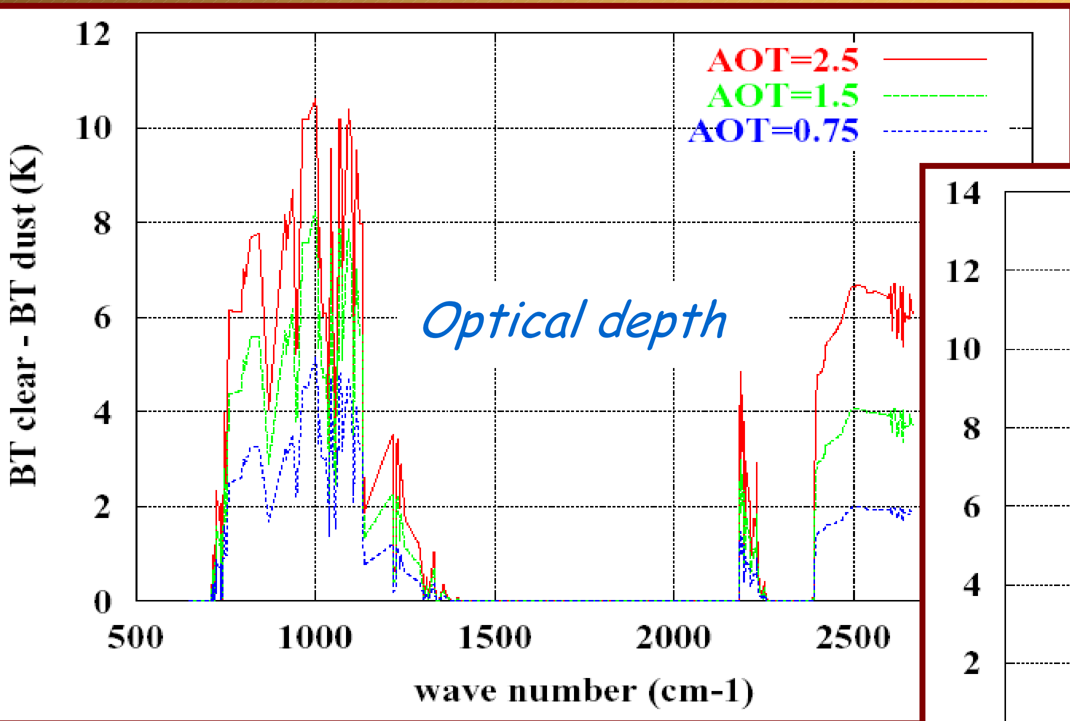


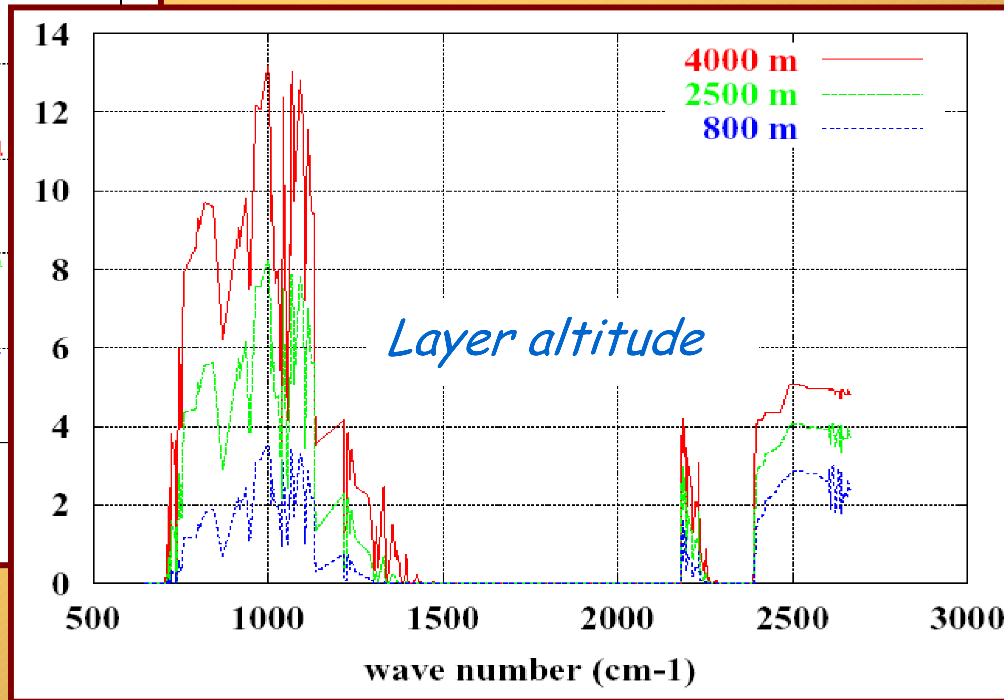
1. BT sensitive to atmospheric situation (temperature and gas profiles)
2. The impact of dust depends on the atmospheric situation

→ retrieving dust properties from infrared radiances first requires knowledge of the atmospheric situation

Sensitivity study (2)

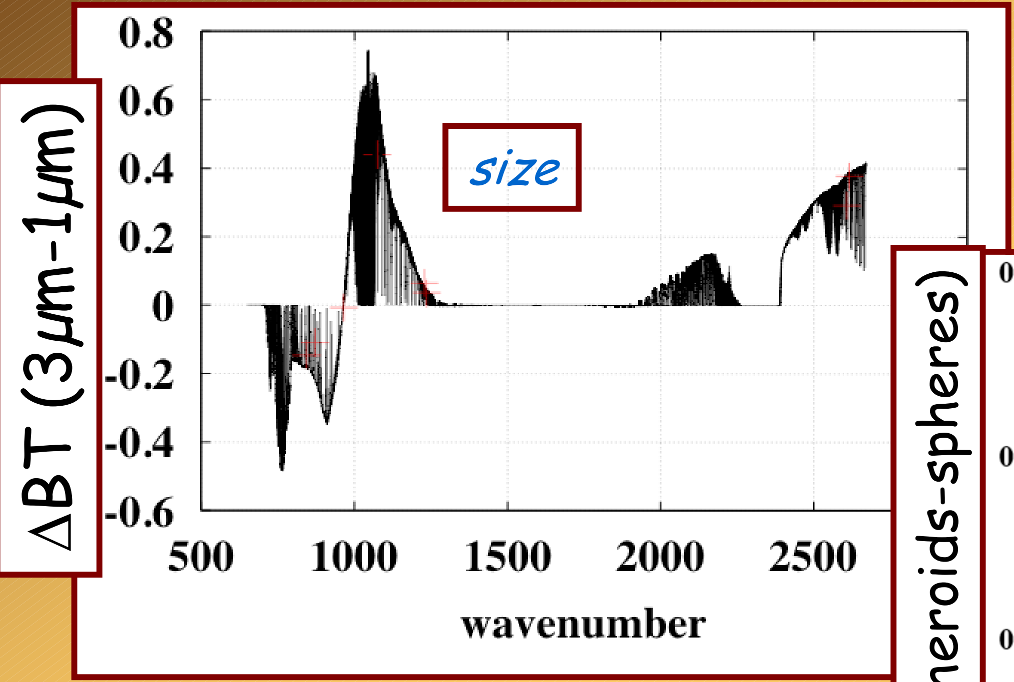
Signature of dust (BT clear – BT dust) for 324 AIRS channels :

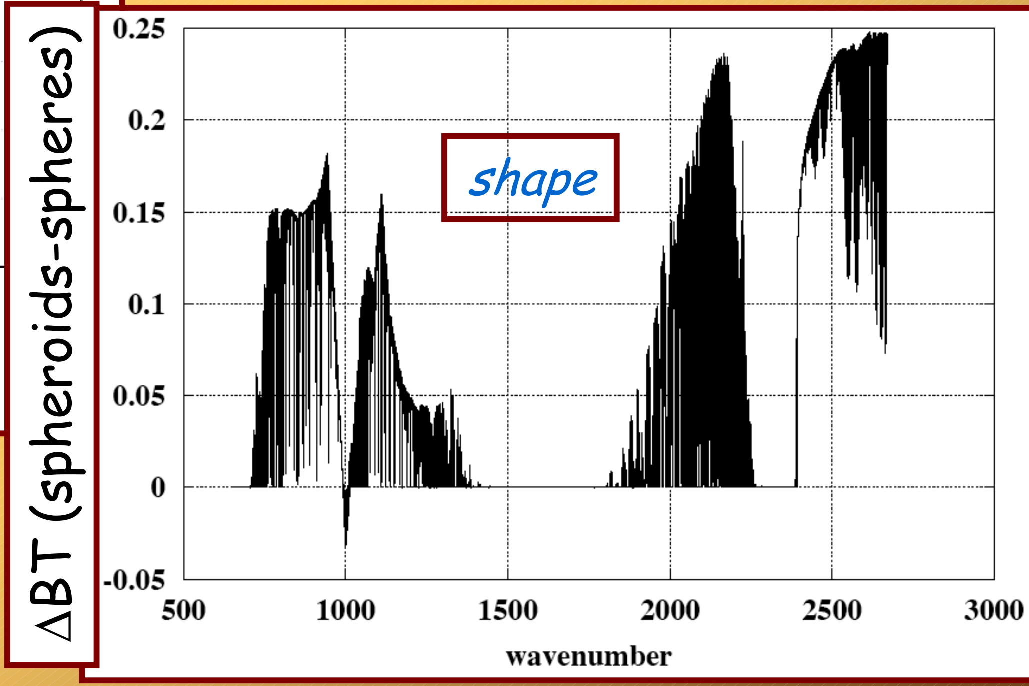




→ Effect of dust optical depth and dust layer altitude: a few K

Sensitivity study (3)





→ Effect of dust size and shape: a few tenths of K

Method : a 2-step process

Step 1

Pierangelo et al, ACP, 2004

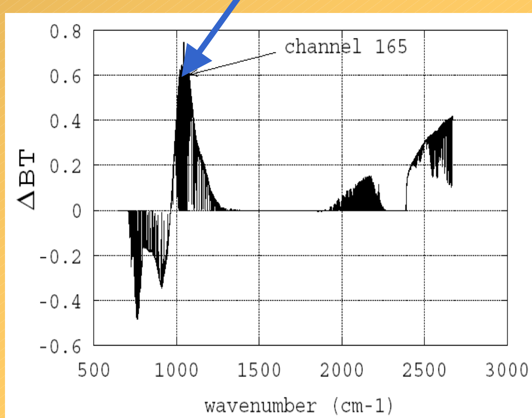
8 channels BTs

Look-Up-Tables

atmosphere (TIGR)
+ dust AOD (at 10 µm) + dust altitude

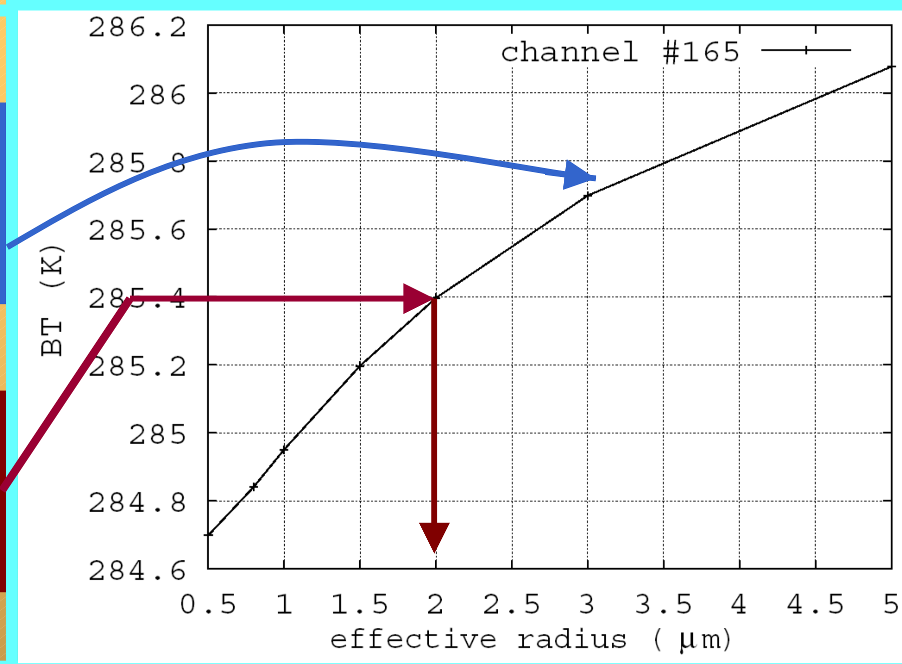
Step 2

Channel 165
(1072.5 cm^{-1})



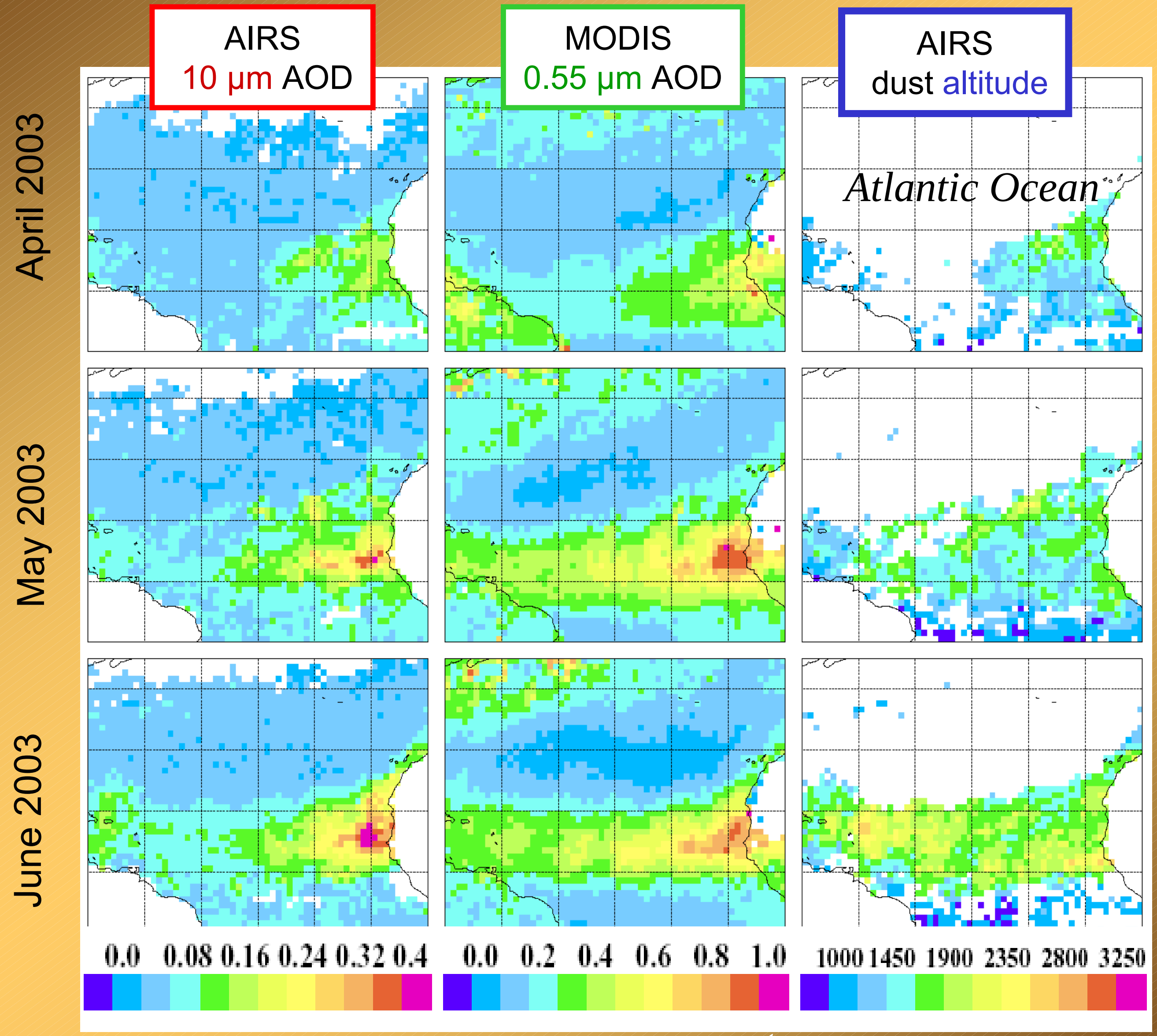
BT 165(re)
calculated

BT 165
observed



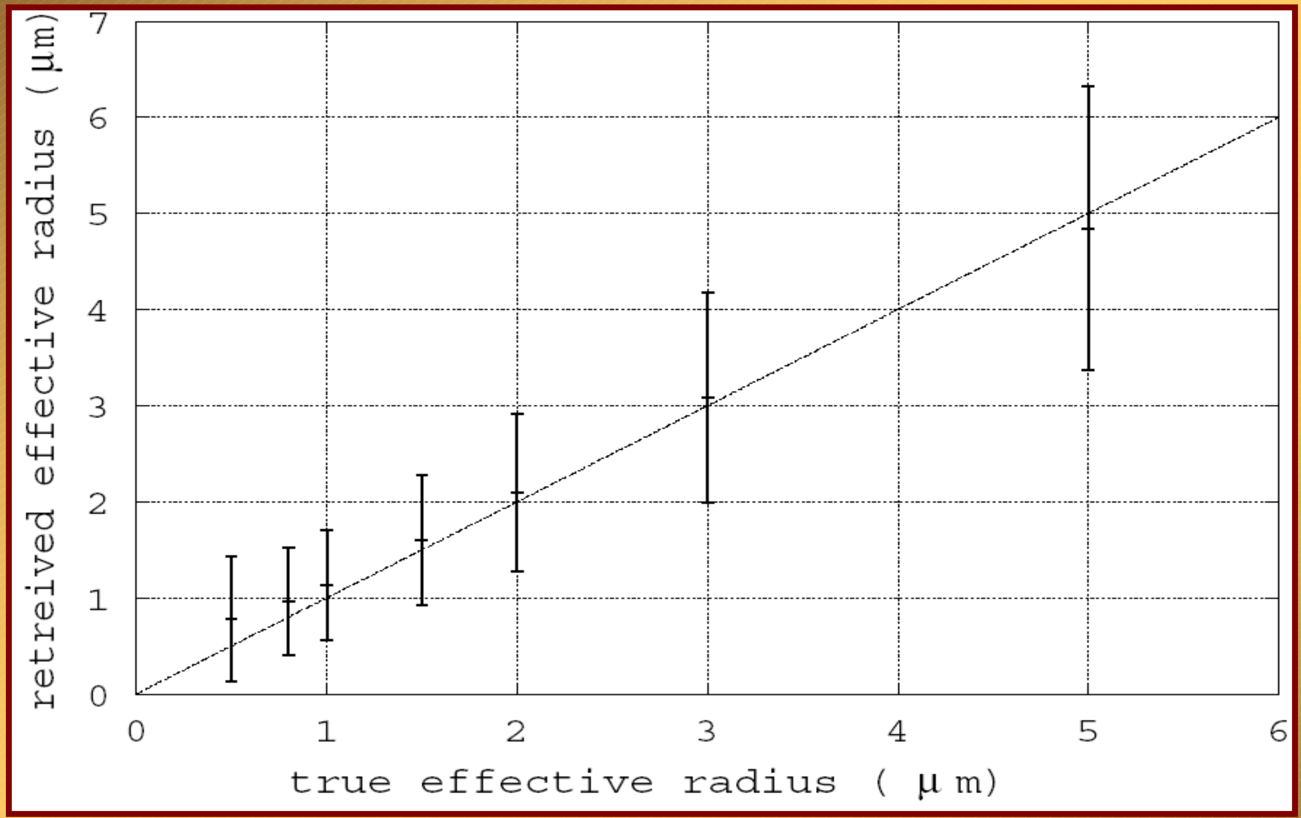
Step 1 : Results

Case study : Saharan dust over the Atlantic Ocean, April to June 2003



(Pierangelo et al., *ACP*, 2004)

Step 2 : algorithm performance



60,000 simulations (changing atmospheric situation, dust AOD and altitude)

Conditions: AOD > 0.2, altitude > 1300 m

Estimate of the error for a single retrieval: 0.5 to 1.5 µm

→ Good performance of the algorithm over the 1-5 µm range

Comparison with AERONET

coarse mode effective radius (µm)		April	May	June
AIRS		2.02	2.27	2.14
AERONET (Capo-Verde)	Spherical particles	1.67	1.78	1.67
	non spherical particles	1.89	1.71	1.67

Possible reasons for discrepancies:

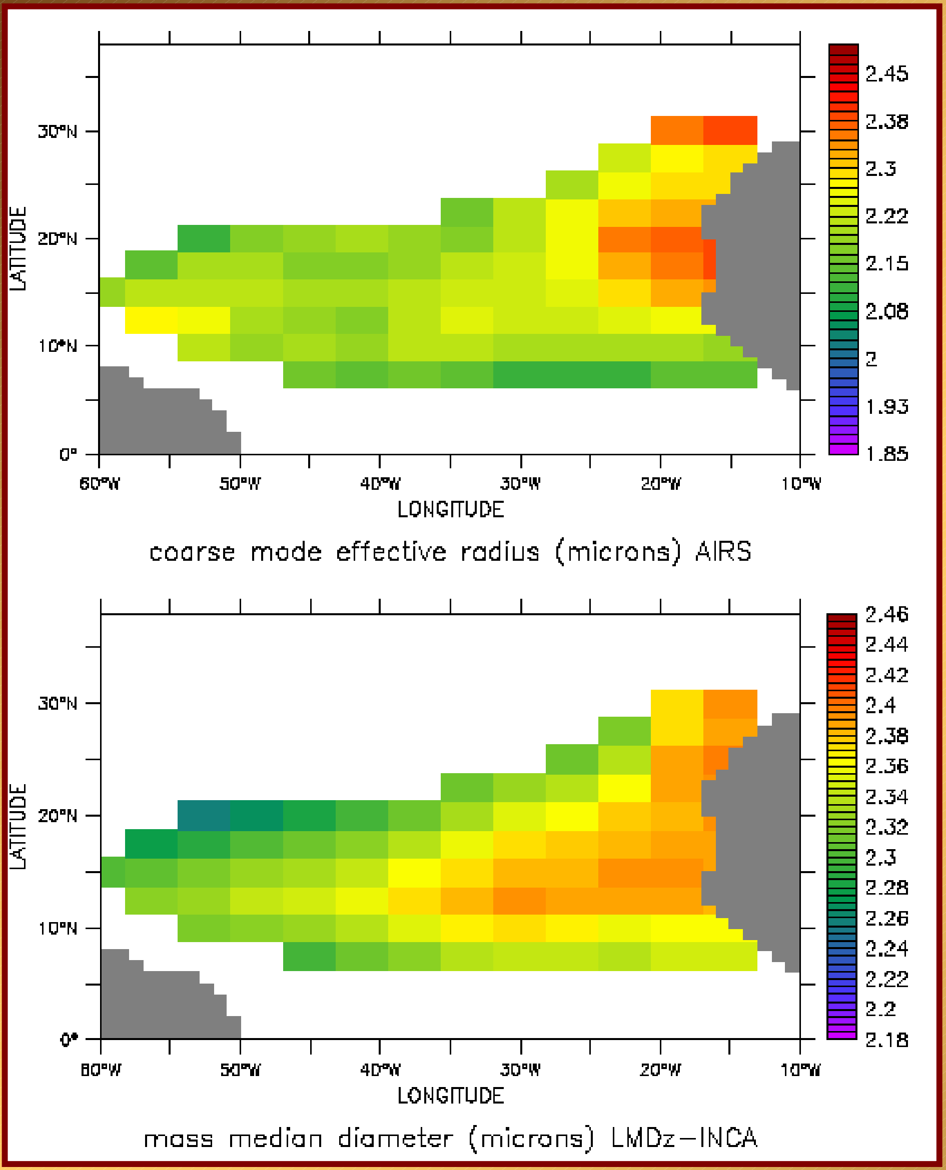
-only ***2 to 5 days per month*** for AERONET and AIRS (not the same!)

-AERONET: ***day-time***, AIRS: ***night-time***

-AERONET less sensitive to bigger particles (***size parameter*** ≈ 15), may explain overestimation

→Good agreement with climatological value (2.15 µm) *[Tanré et al., 2001]*

Results: comparison with GCM



⚠ *LMDz-INCA:* mass median diameter for a monomodal distribution
AIRS: effective radius for the coarse mode

- **East-west gradient:** preferential settling of big particles (2.4 to 2 μm)
- **AIRS sizes decrease more abruptly than LMDz-INCA**: accumulation mode less sensitive to dry deposition than coarse mode
- **30˚N:** higher radius for both AIRS and LMDz-INCA

Conclusions

- New method to constrain dust size distribution
- First time that dust size is retrieved from infrared radiances
- Results for April to June 2003 in good agreement with in situ measurements
- Reduction of the coarse mode effective radius of dust particles with transport distance (2.4 to 2 µm)
- Geographical pattern in agreement with LMDz-INCA simulations

- **Promising extension to IASI** (higher spectral sampling)
- **Possibility to retrieve other microphysical properties**: dust aspect ratio, or composition (e.g. quartz content) could be retrieved with the same procedure?