Toward a decade of dust infrared aerosol properties observed by infrared hyperspectral sounders (AIRS, IASI/Metop-A,IASI/Metop-B) and first analysis of the dust diurnal cycle

V. Capelle[1], A. Chédin[1], M. Pondrom[1], R. Mechri,
C. Crevoisier[1], R. Armante1, L. Crépeau[1], N. A. Scott[1]

[1]LMD / IPSL, Ecole Polytechnique, Palaiseau, France

Remote sensing of dust aerosols in the IR

Why study aerosols in the infrared ?

- Aerosols are large contributor to the earth radiative balance
- They are also a large source of uncertainty
- We want to retrieve dust optical properties (AOD, altitude)

Interest of satellite observation:

- **global** and **continuous** observation
- **high resolution** (spatial, spectral, or both).

Interest of the infrared :

- Observations available **daytime** and **nighttime**, over ocean and over **land (desert)**
- Access to the **mean aerosol layer altitude**
- 10 µm : essentially detection of **dust aerosol Coarse Mode (CMo)**

IASI-A, IASI-B and AIRS (in progress) retrieval :

- **several observations per day, including night-time measurements: 8h30 AM, 9h30 AM, 1h30 PM, 9h30 PM, 9h30 PM and 1h30 AM.**

Radiative transfer simulations/inversion scheme

1) **Pre-processing:** . All radiative transfer simulations are performed off line once for all.

Input parameters

- Aerosols Microphysics
  - 1 size distribution
  - 2 refractive index
- Atmospheric information
- Spectroscopy
- Surface parameters

4AOP/DISORT

LUT atmospheres — No scattering

LUT aerosols — With scattering

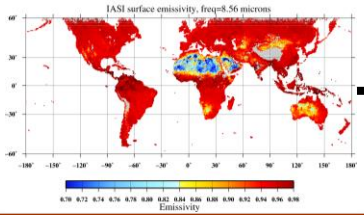
IDRIS, ECMWF, climserv

2) **Inversion:** (~40mn CPU per day)

Satellite observation: AIRS, IASI…

LUT atmospheres

Atmospheric Situation (T, H2O, etc..)



Capelle et al., 2012,

LUT aerosols

Aerosols properties

- 10µm AOD
- mean altitude
- Surface temperature
- (effective radius)

Since 2003 for AIRS

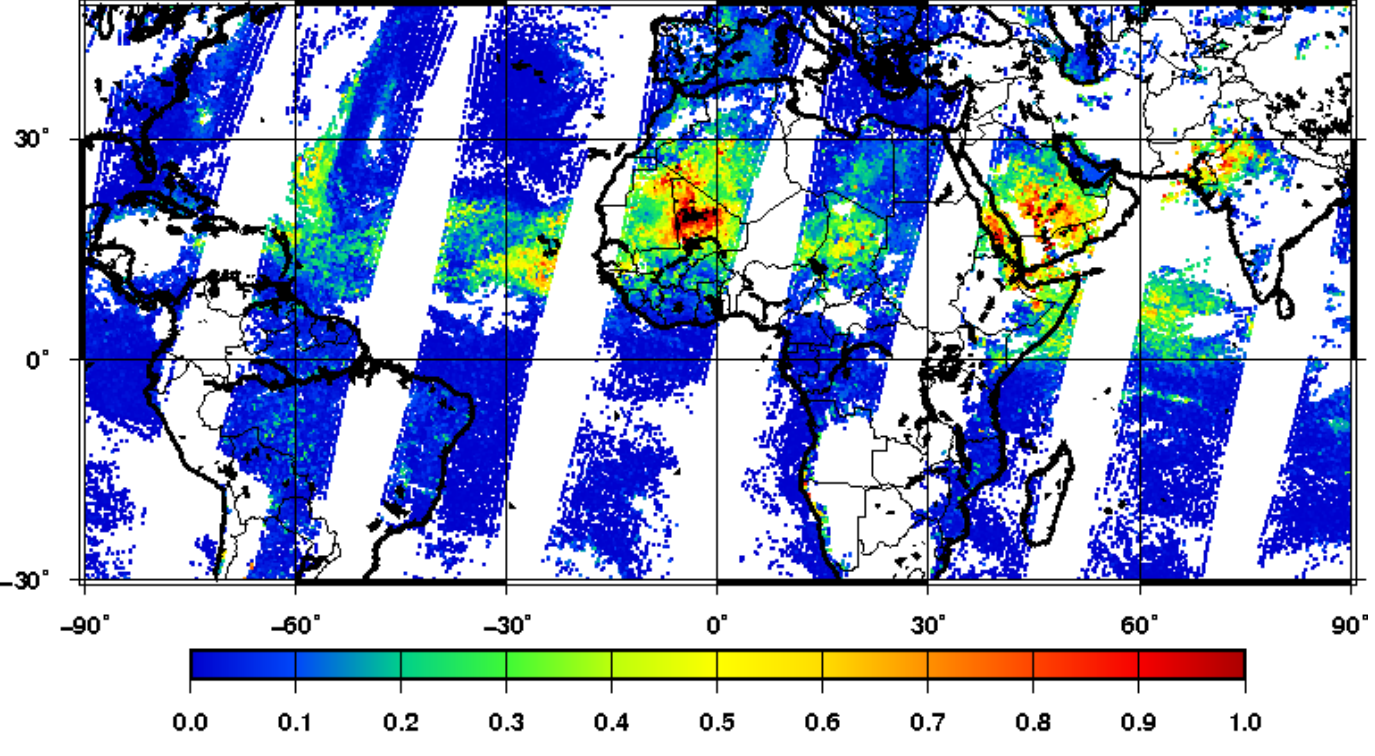
Since 2007 for IASI

http://ara.abct.lmd.polytechnique.fr/

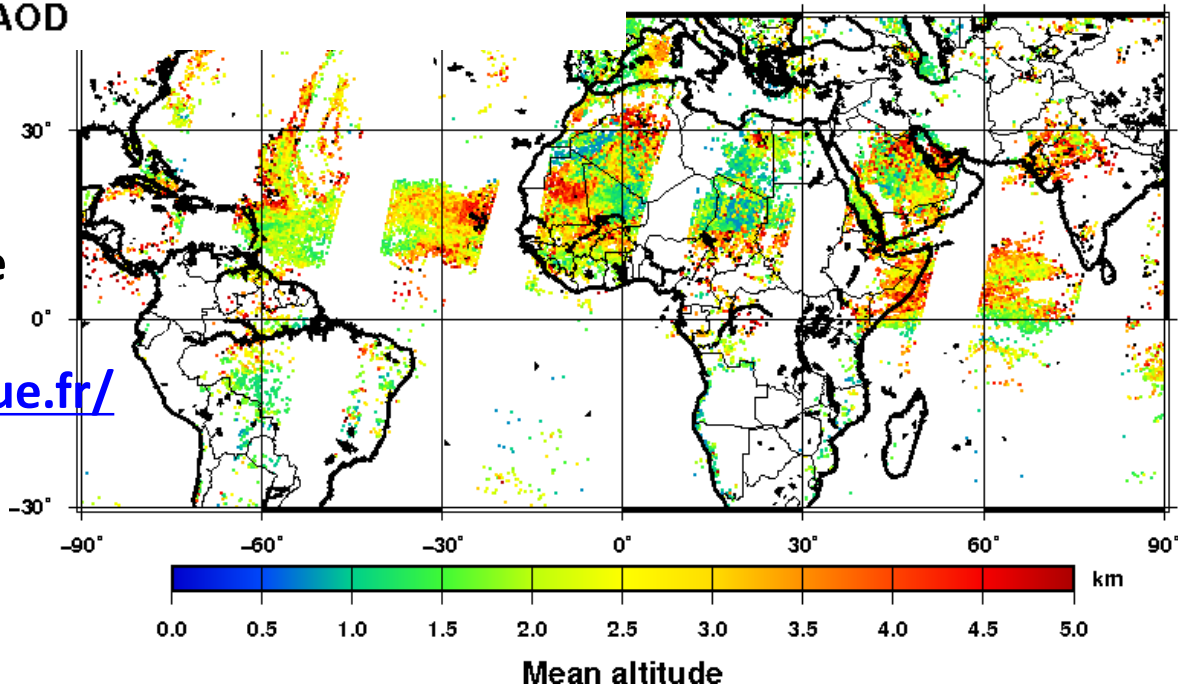
Pierangelo et al. 2004, ACP; Pierangelo et al. 2005, GRL; Peyridieu et al. 2010, ACP; Peyridieu et al. 2013, ACP; Capelle et al. 2014, ACP.

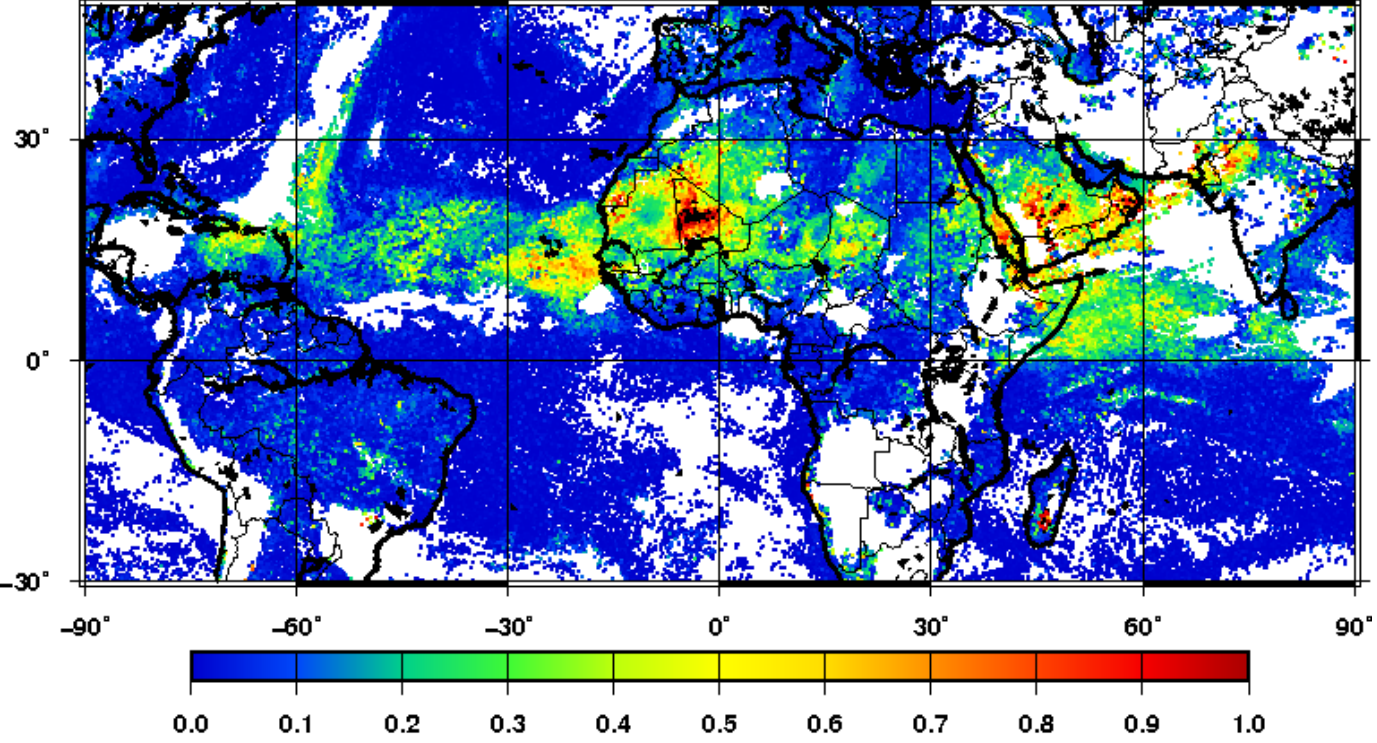
~9 years of IASI-A

16th June 2013, Descending orbit: IASI-A



IASI retrievals up to Day-1 can be visualized or downloaded on http://ara.abct.lmd.polytechnique.fr/





~9 years of IASI-A
+ ~3 years of IASI-B

16th June 2013,
Descending orbit:
IASI-A + IASI-B

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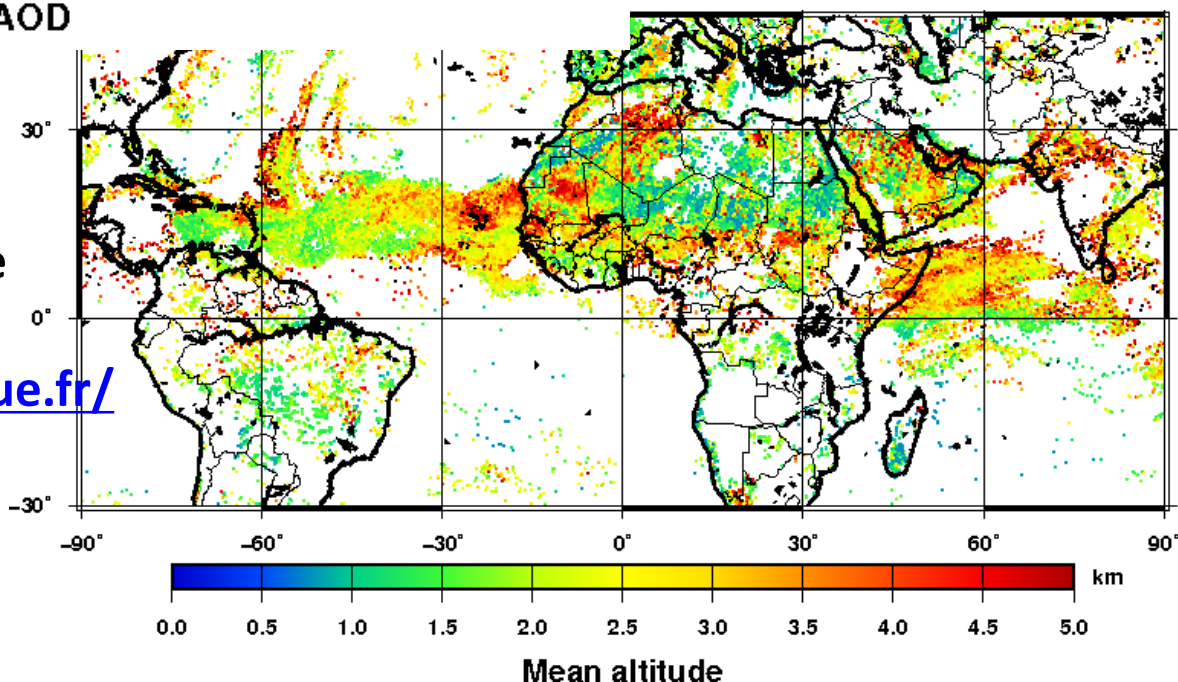

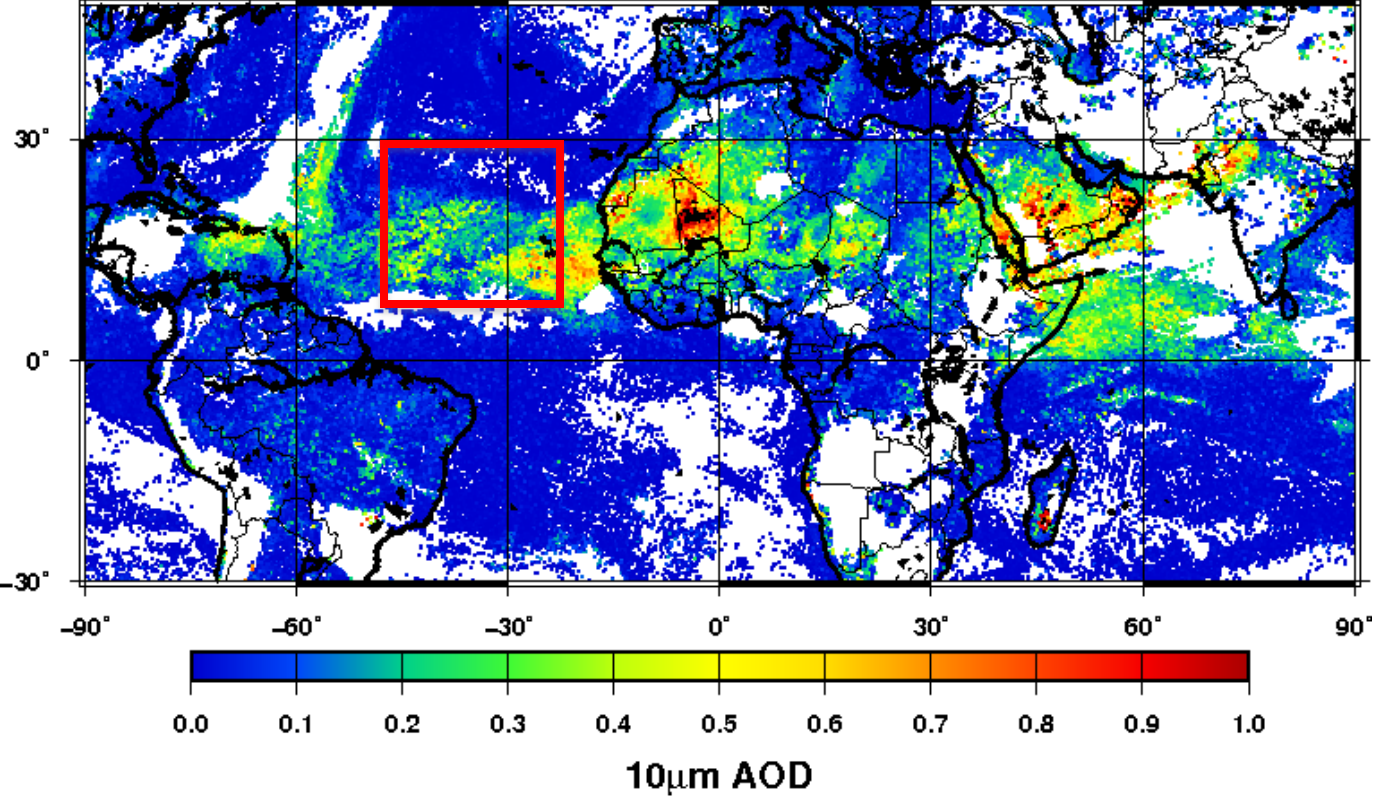

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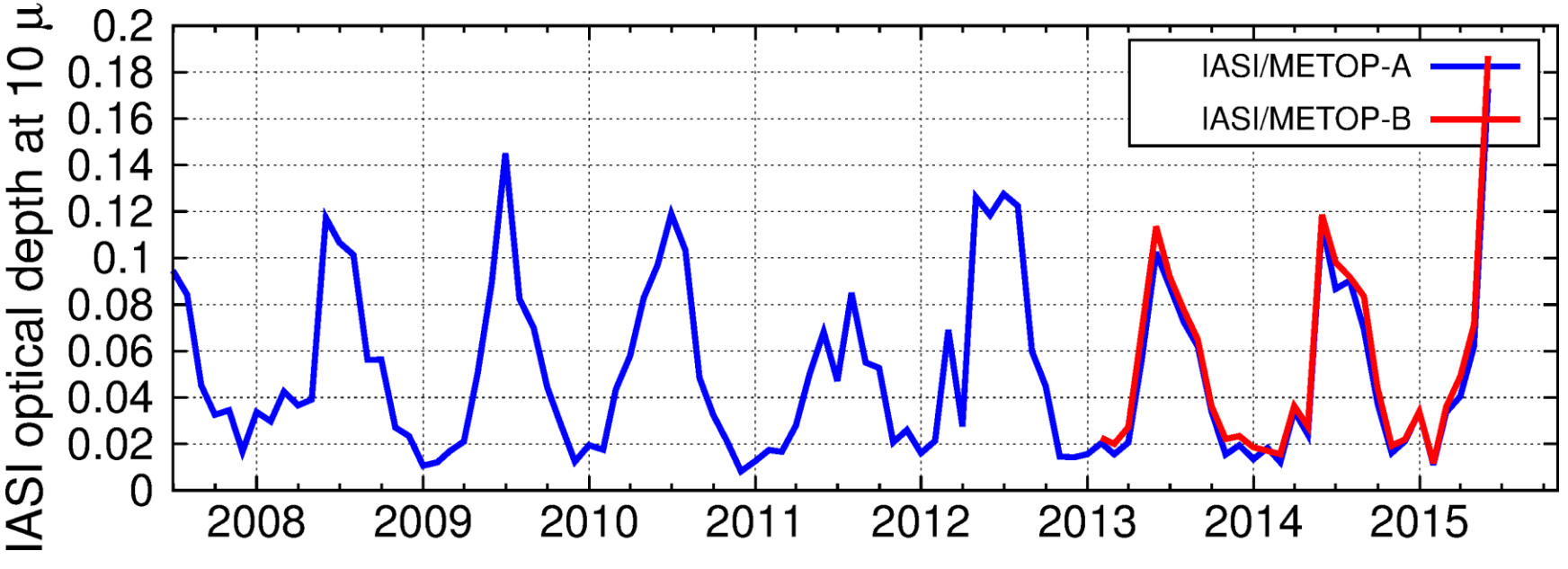

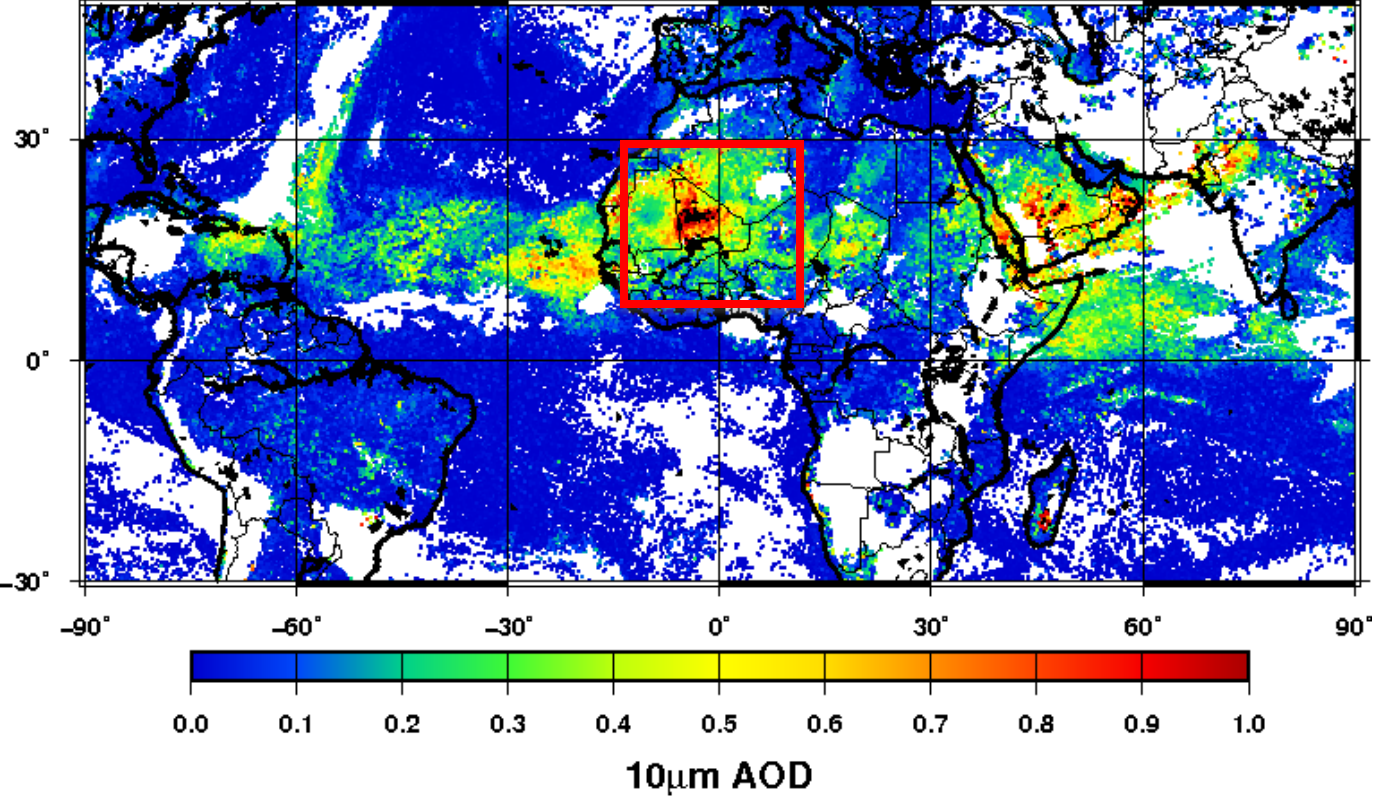

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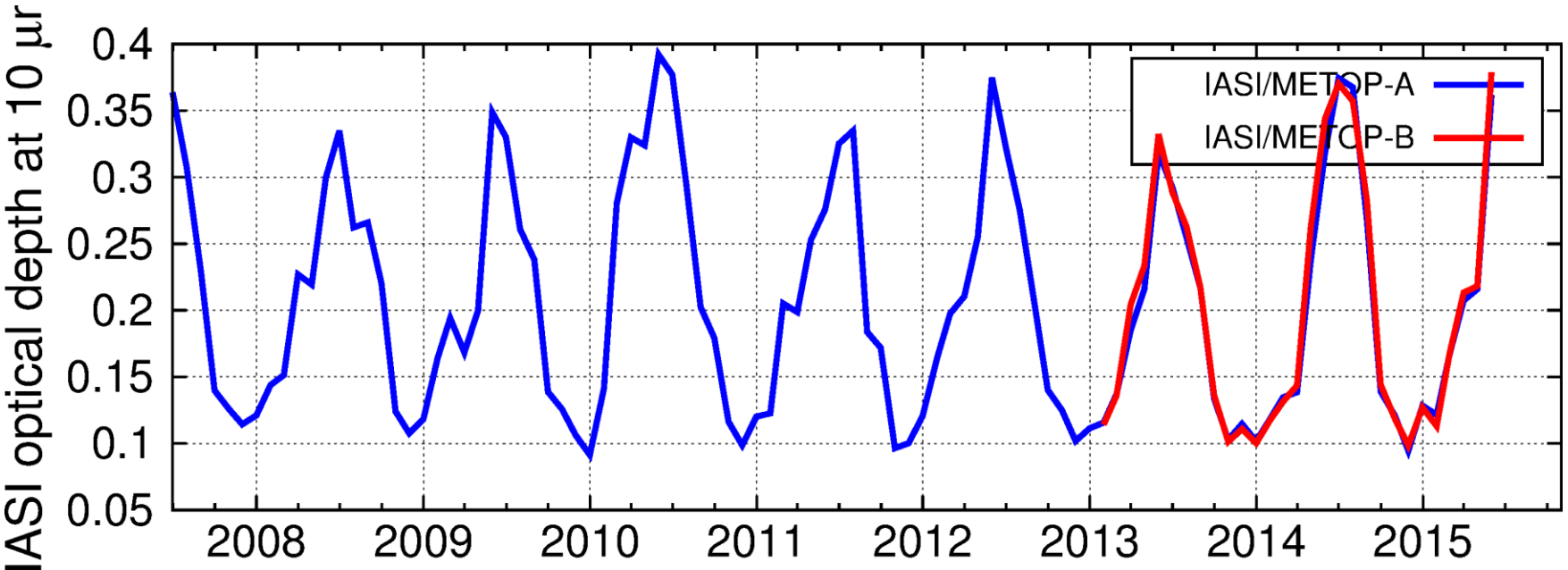
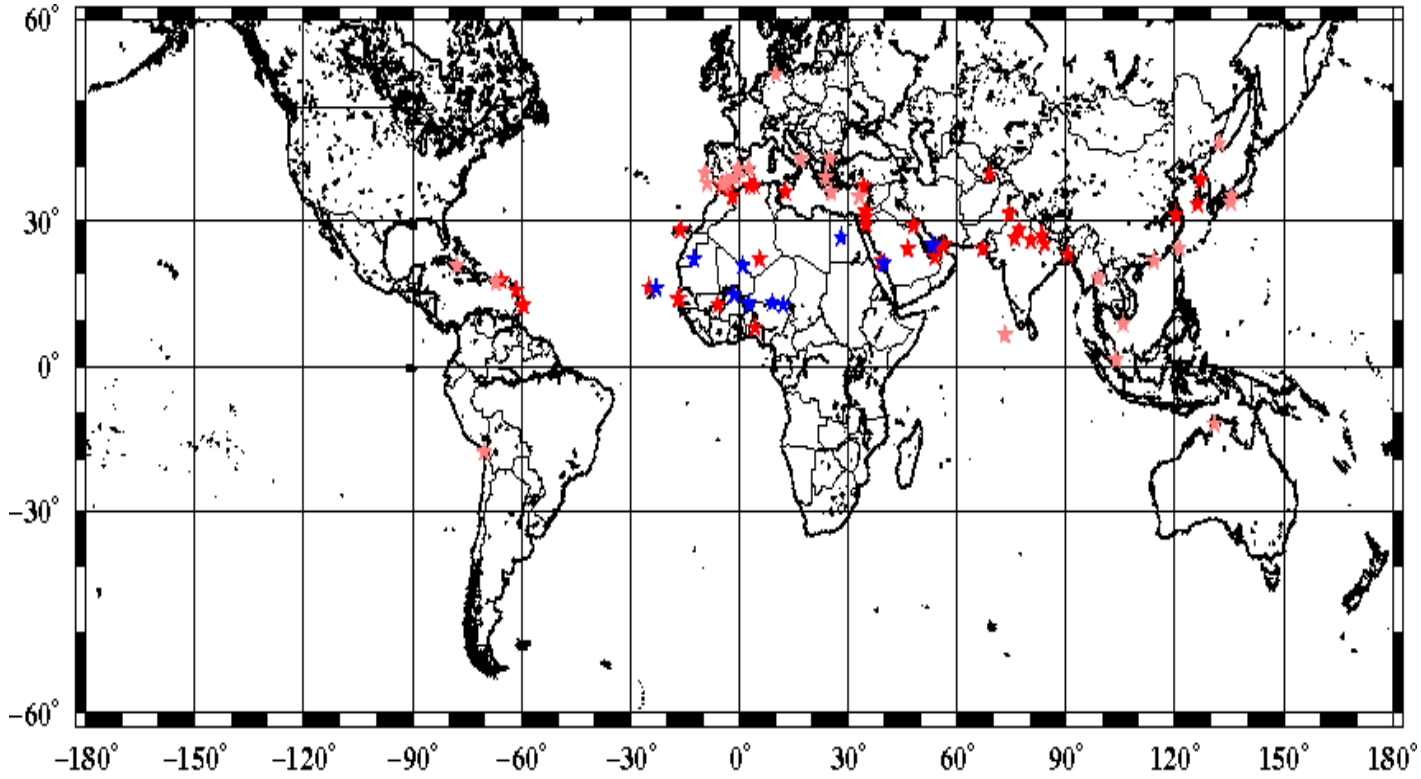


Validation with AERONET Coarse Mode (CMo) AOD over 8 years of IASI observation (Jul 2007 – Jun 2015)



✧ 77 AERONET ground-based sites analyzed over all the IASI period (when AERONET data do exist!)

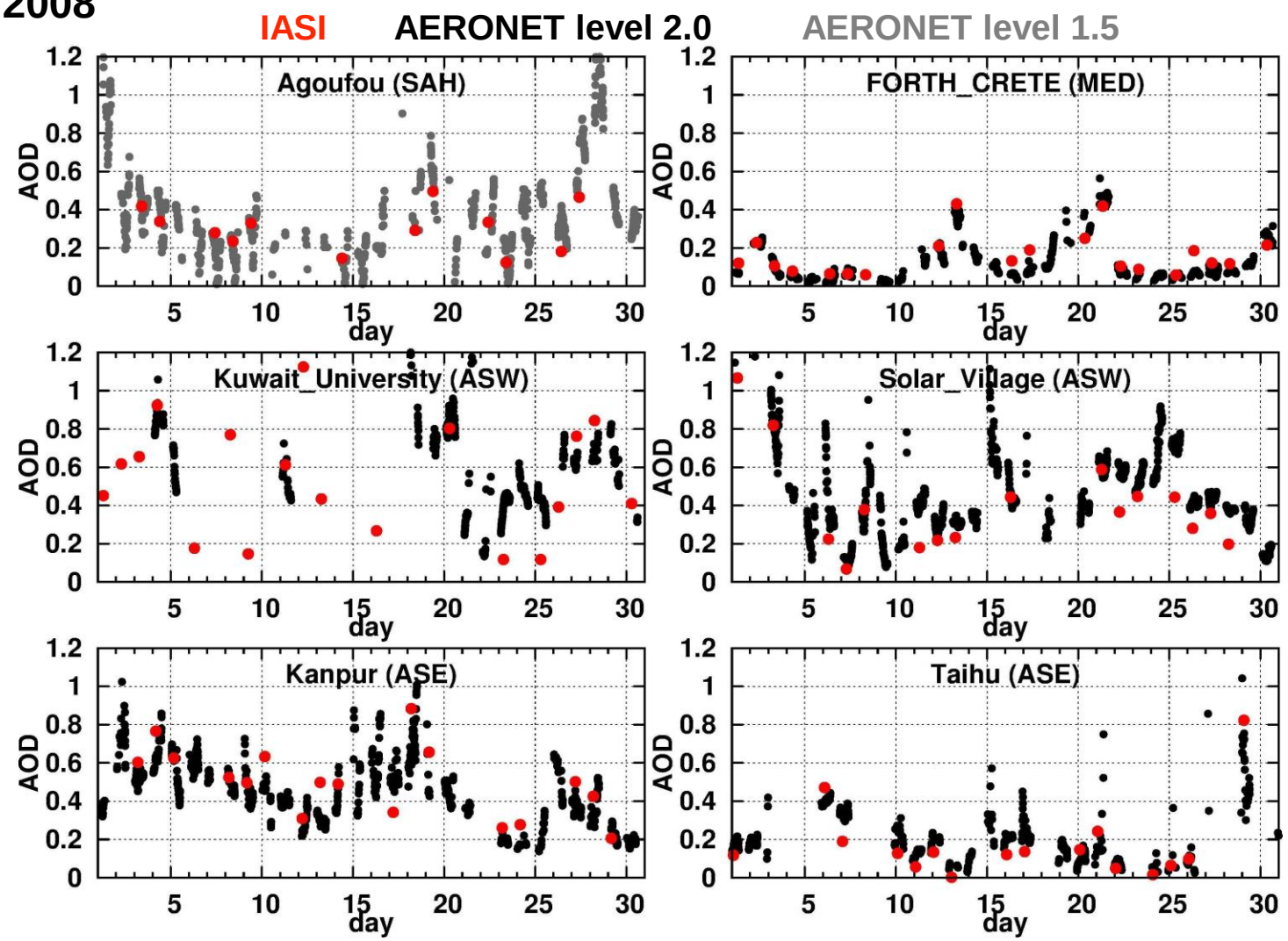
✧ Mean CMo AOD > 0.05 over the 8 years

✧ Box of 0.25° around AERONET site

✧10µm IASI AOD is converted to 500nm using the size parameter and refractive indices values used in the inversion.

IASI/AERONET coarse mode AOD comparisons

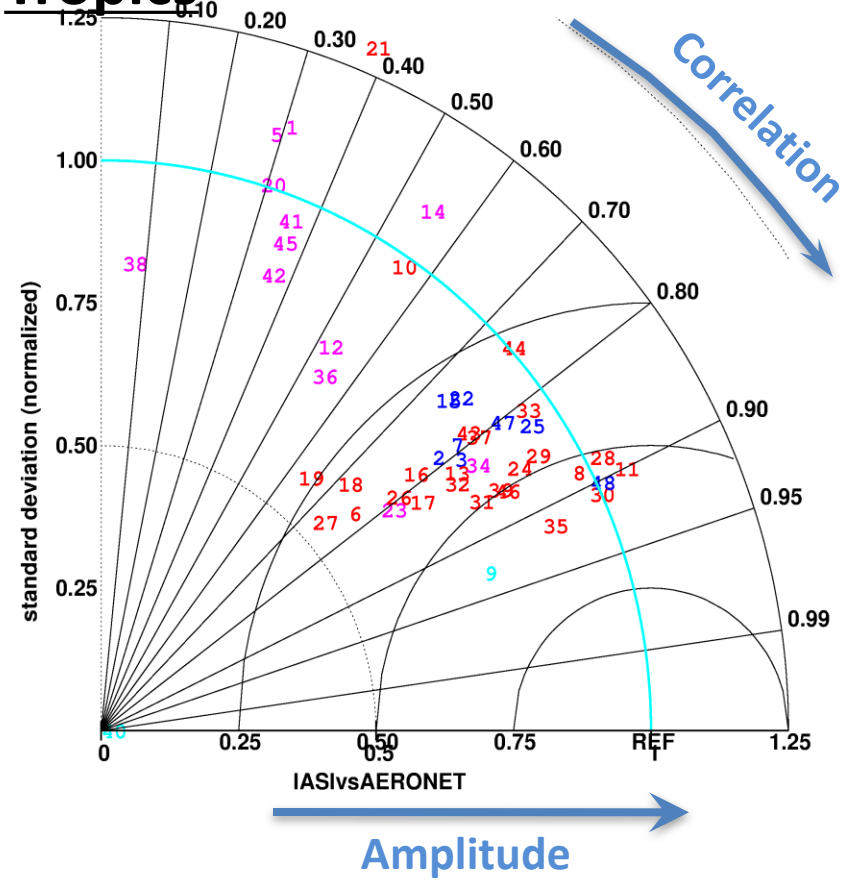
May 2008



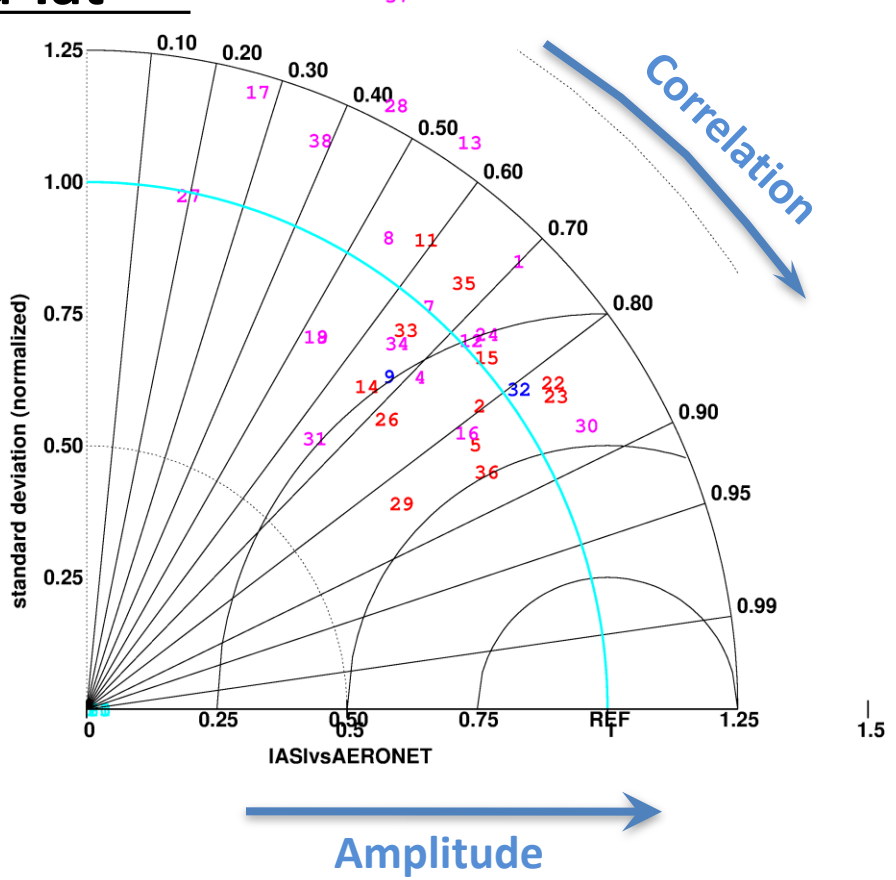
IASI/AERONET coarse mode AOD comparison

Taylor Diagrams of AOD AERONET (level 2.0) – AOD IASI **from July 2007 to June 2015**

Tropics



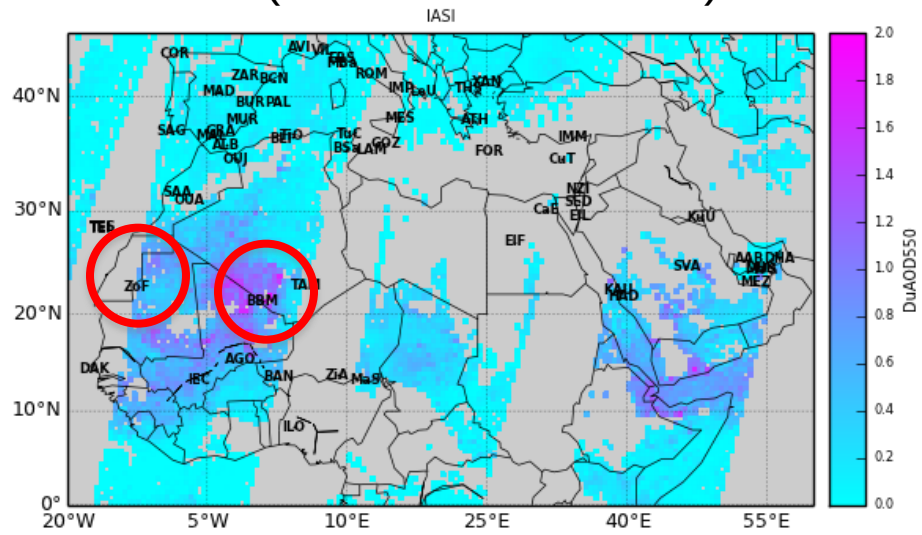
Mid-lat



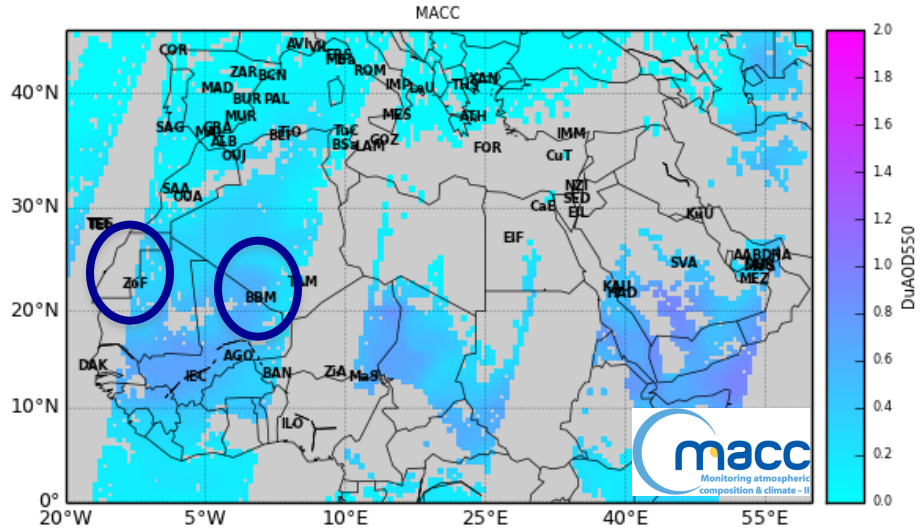
- **AERONET sites with mean AOD <0.05 over the whole IASI period have been removed**
- **Light colors: sites with mean AOD < 0.08. Correlation is in general smaller**
- **For other sites:**
  - **Tropics: mean correlation = 0.75 ; mean amplitude = 0.89**
  - **Midlat : mean correlation = 0.71 ; mean amplitude = 0.92**

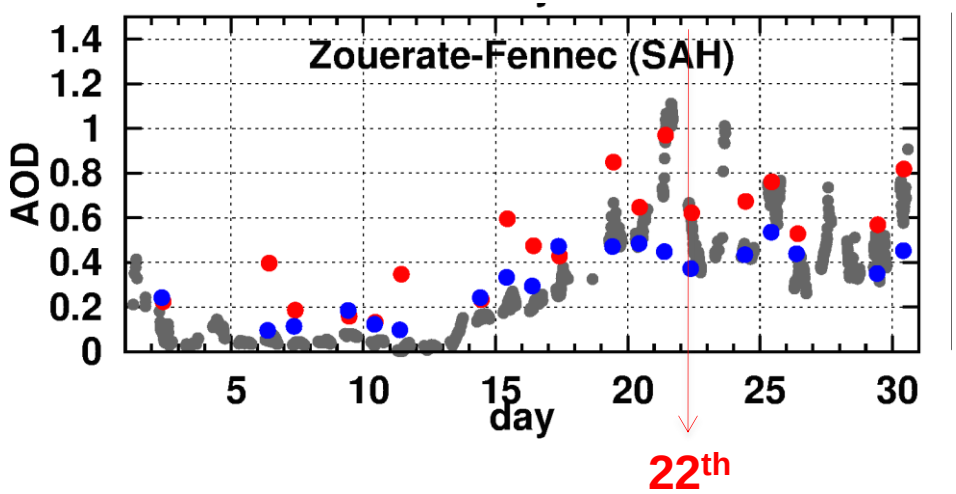
Comparison with MACC reanalysis 550nm Dust AOD 22th June 2011

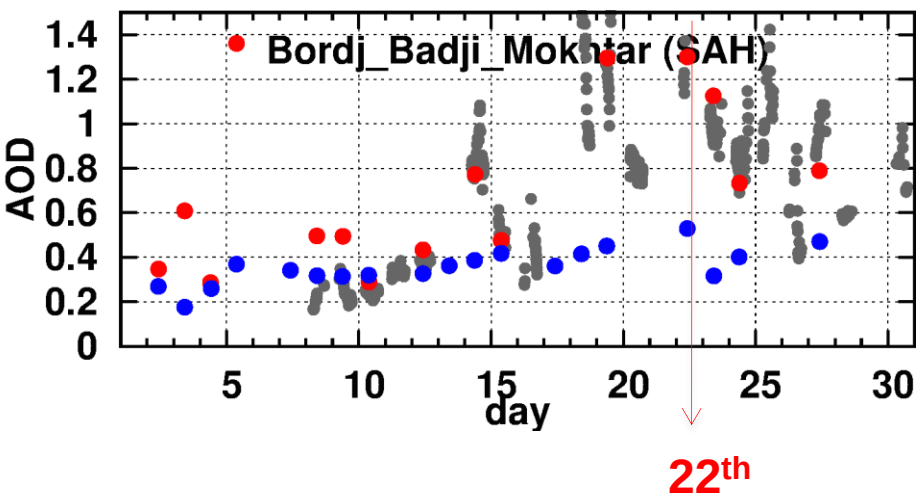
IASI (converted to 550nm)



MACC DuAOD550



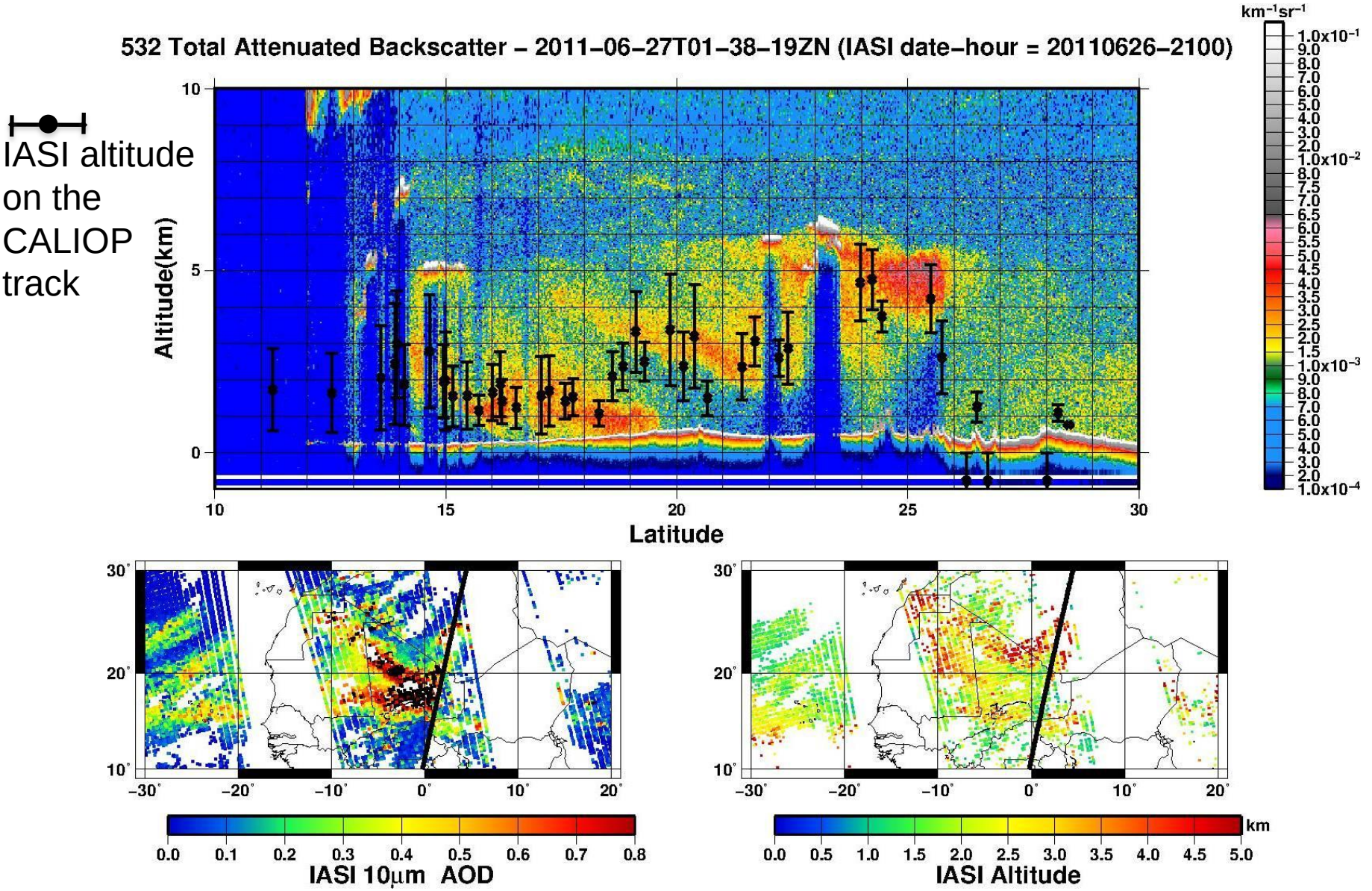




=> Ongoing activity for the whole IASI period

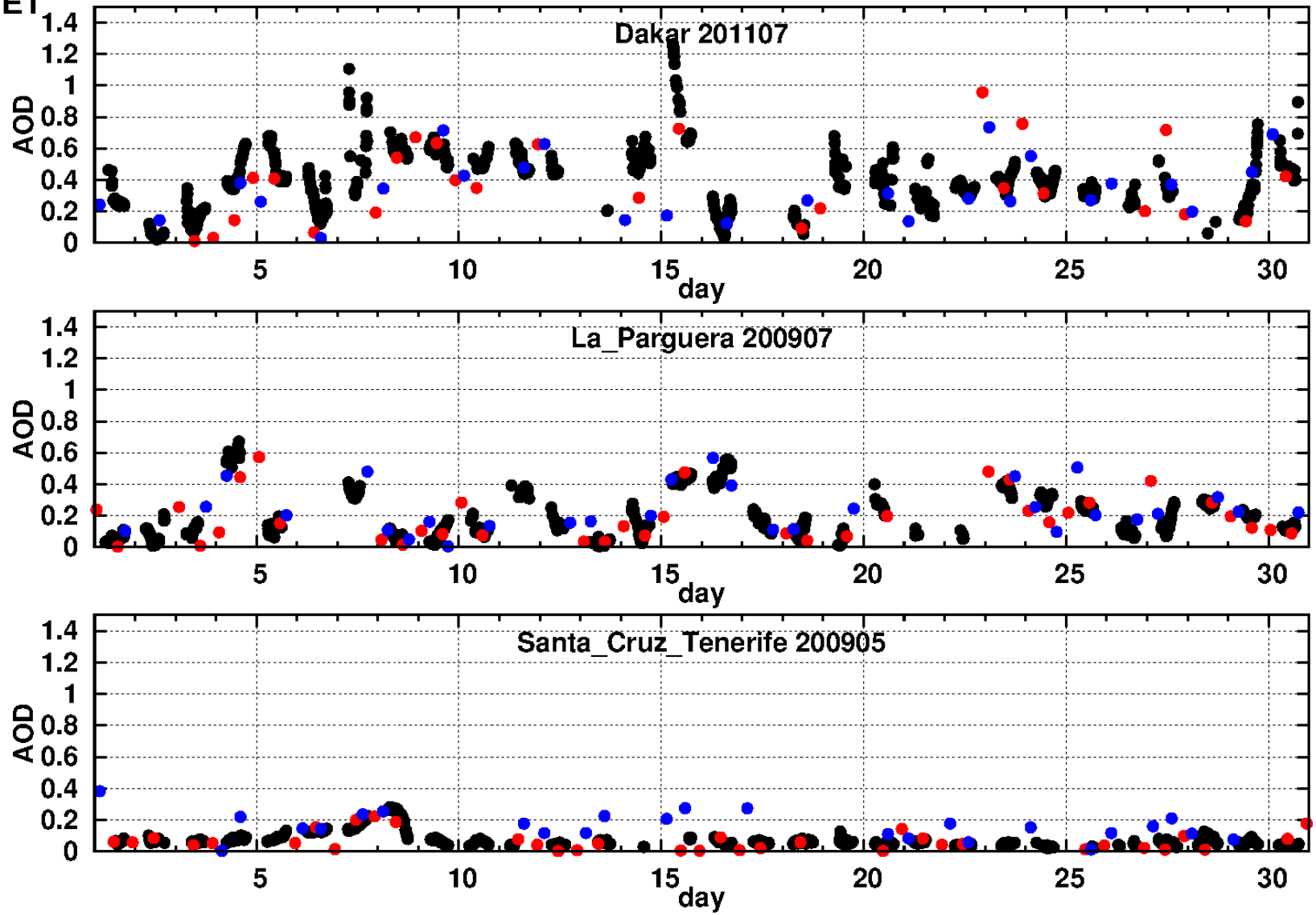
Altitude validation with CALIOP

IASI altitude on the CALIOP track



Comparison with AERONET coarse mode AOD

AERONET
IASI
AIRS



- With IASI and AIRS, **4 observations per day** (9:30 AM, 1:30 AM, 9:30 PM, 1:30 PM).
- Unique opportunity to have two measurements during **night-time.**
- **IASI and AIRS AOD present variability similar to AERONET during day-time**

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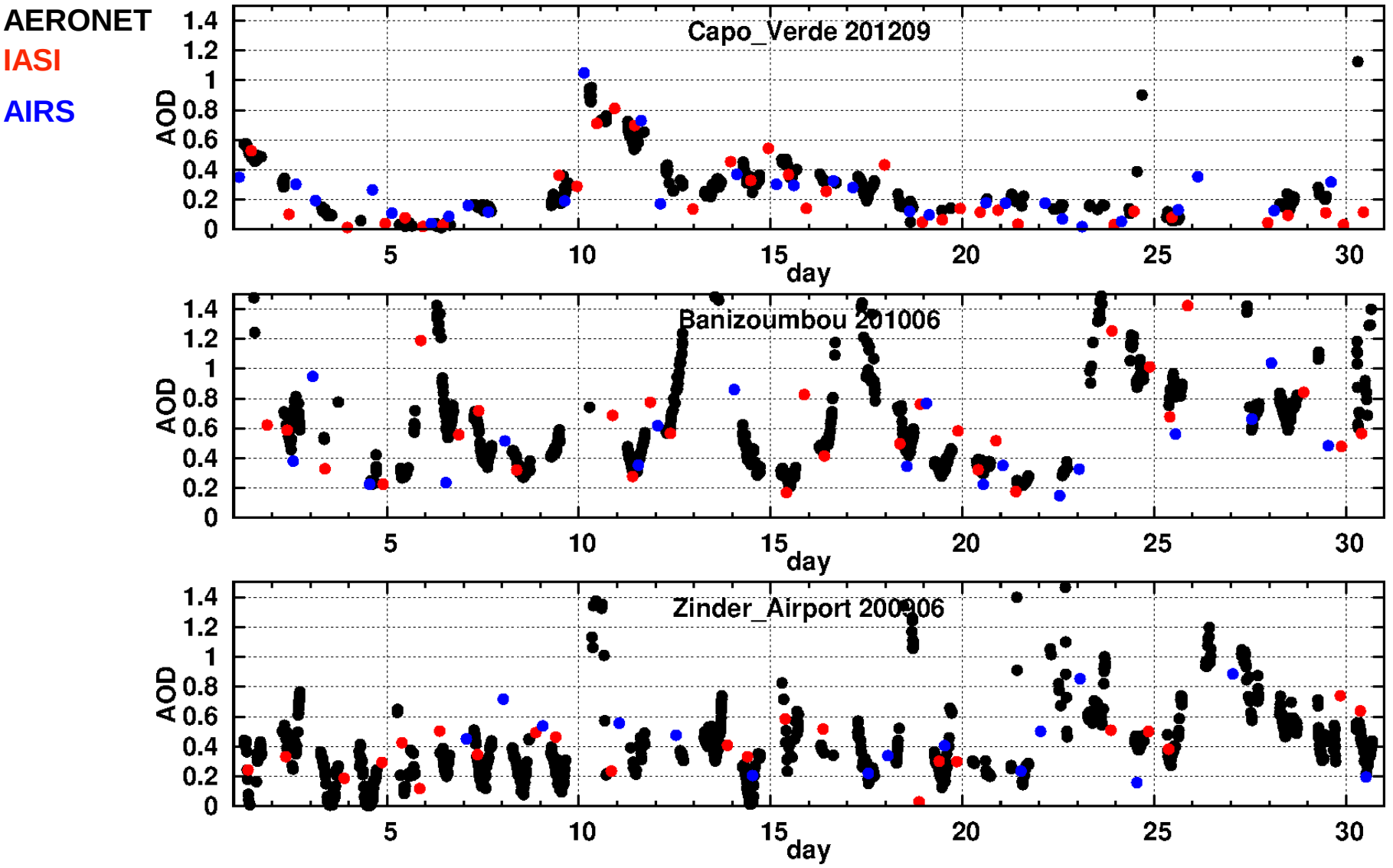

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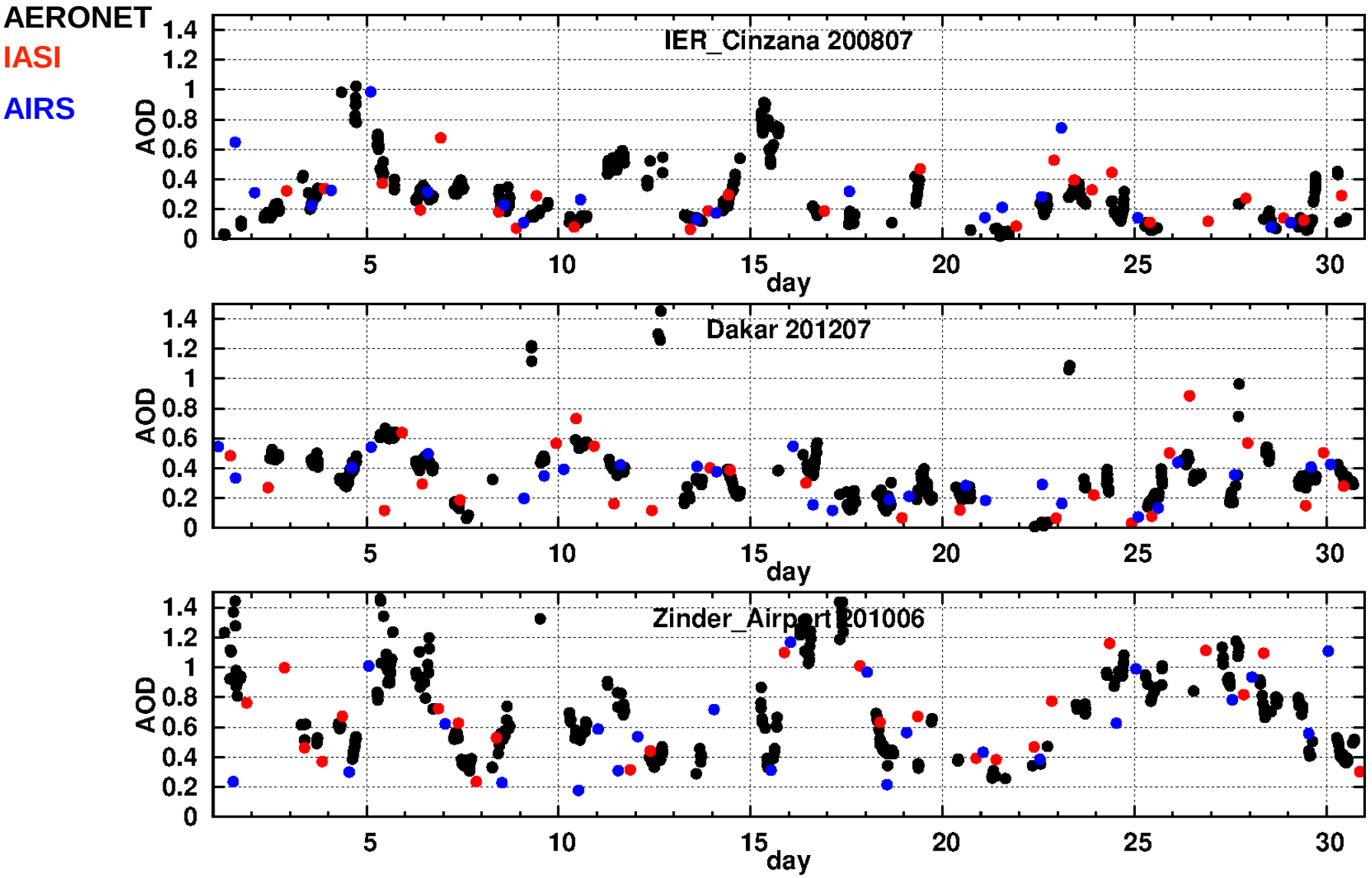

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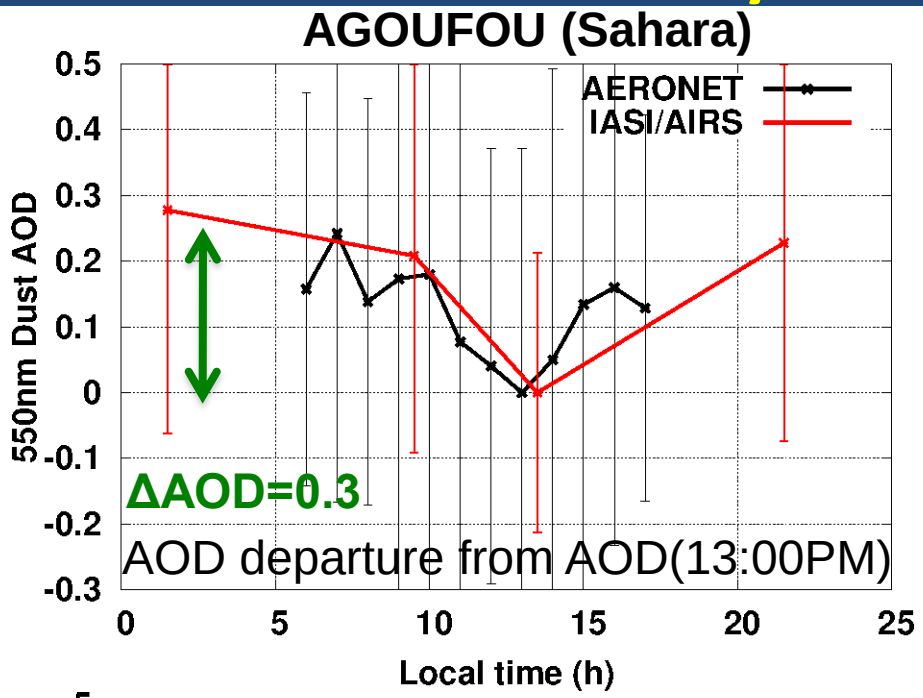
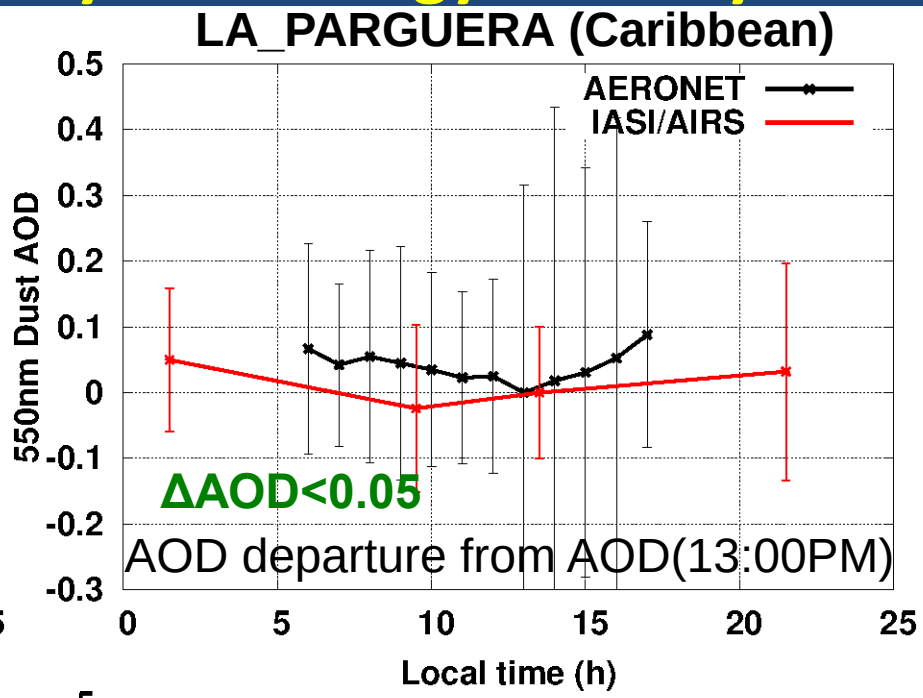
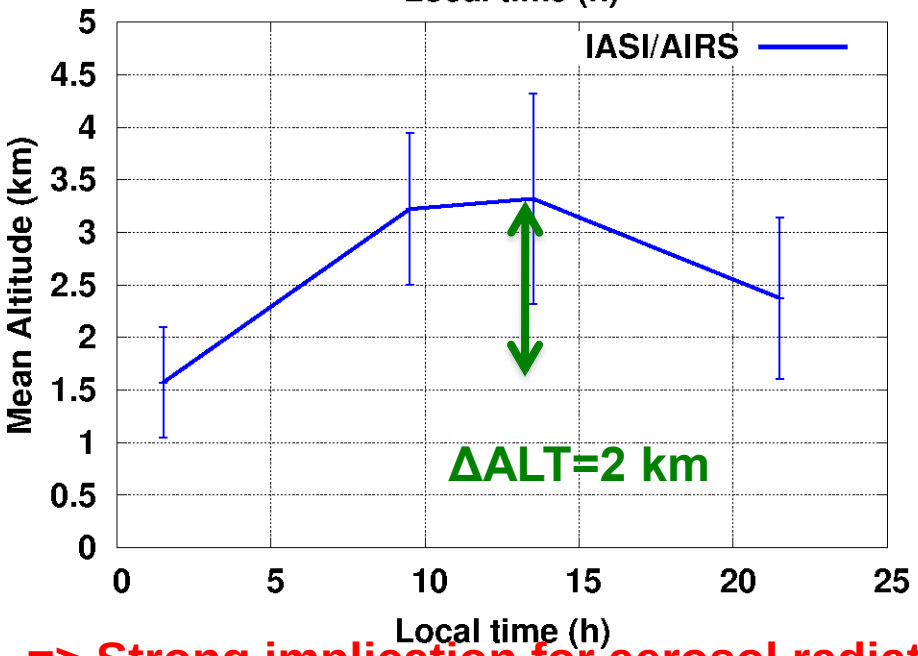
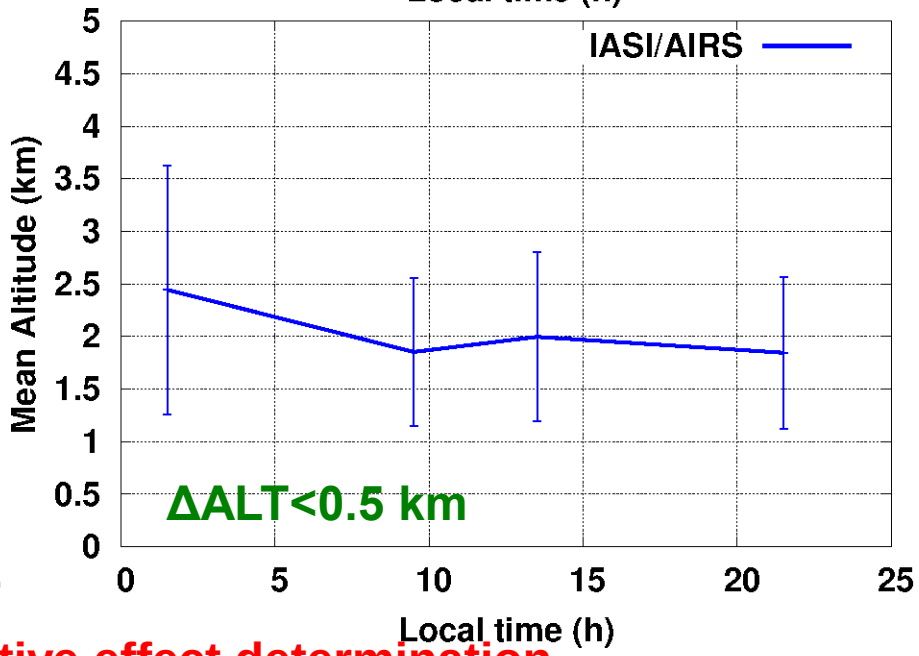
First results of diurnal cycle: July climatology from 8 years









=> Strong implication for aerosol radiative effect determination

CONCLUSIONS and FUTURE WORK:

- **2 measurements per day of 10µm coarse-mode AOD, mean altitude and surface temperature at each IASI pixel** (9:30 AM and 9:30 PM).
- Observations available **daytime** and **nighttime**, over **ocean** and over **land** for **tropics** and **midlatitude** regions.
- **~8 years of observations** (July 2007-now) for IASI-A; ~2 years for IASI-B
- **With AIRS, 2 additional measurements** per day (1:30 AM and 1:30 PM)
- Possibility to study the daily evolution of AOD and altitude
- (!!! see also poster S5-105 on surface temperature validation!!!)

Perspectives:

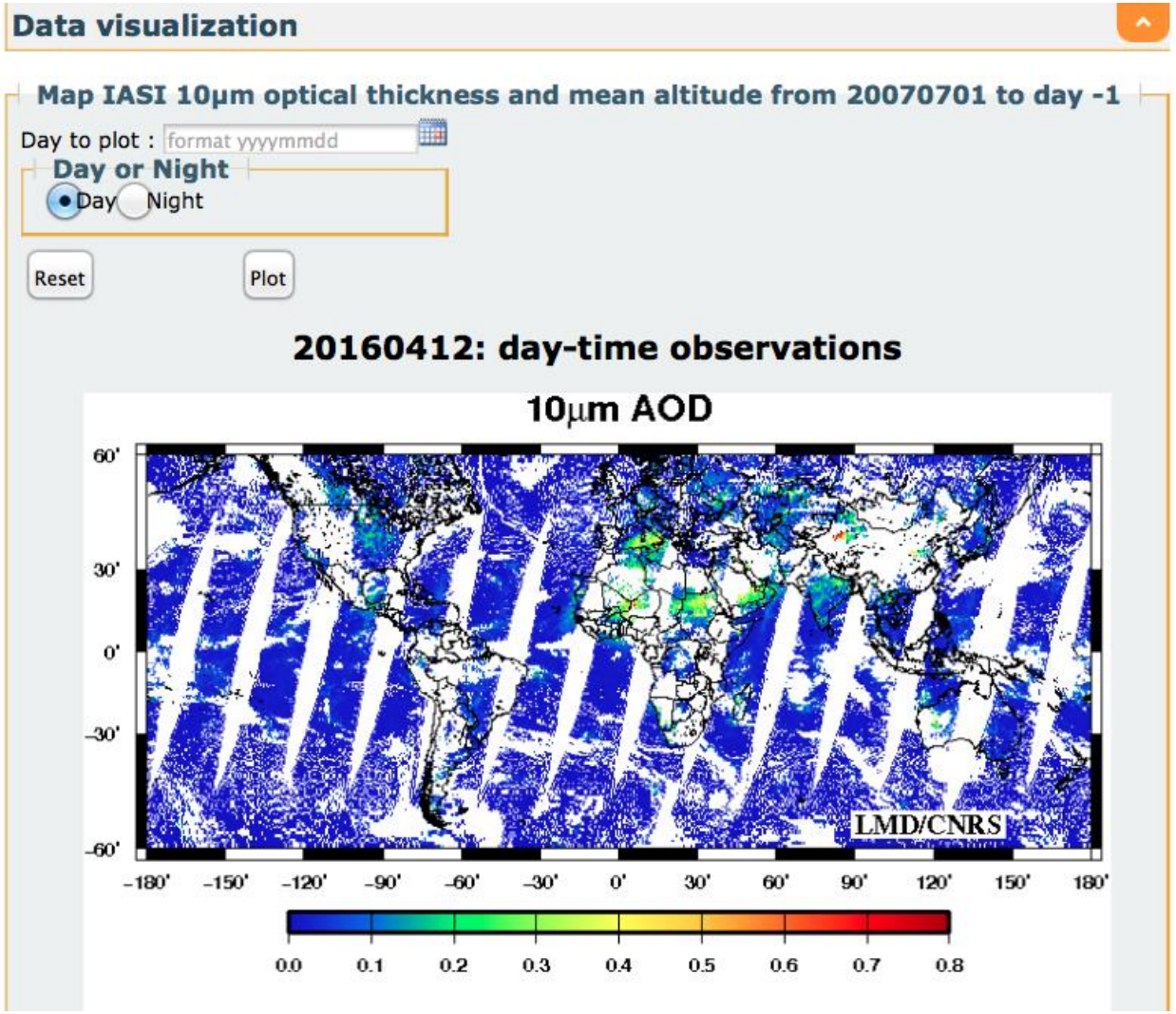
- Better analyze the link between the refractive index and aerosol type
- Adapt the size estimation at IASI pixel resolution
- Go further in the analysis of the diurnal cycle
- IASI provides valuable information on aerosol properties and suits for Long-term evolution (IASI-1, 2, 3 + IASI-NG-1, 2, 3)

Near Real time

IASI-A data are processed every day for Day -1

http://ara.abct.lmd.polytechnique.fr/index.php?page=aerosols

=> Soon + IASI-B

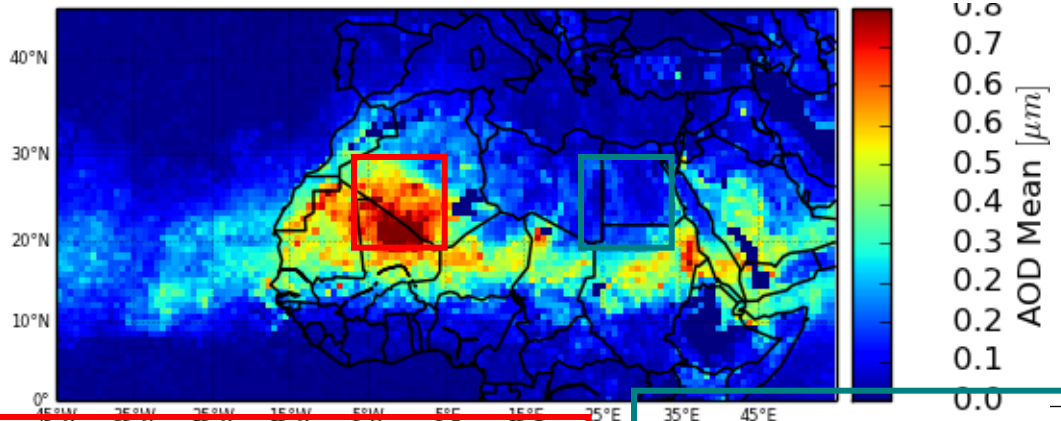


Validation of surface temperature

See poster S5-105:

Ts comparison from satellites to ECMWF (IASI, AATSR, MODIS (TERRA and AQUA)

IASI 10µm monthly mean AOD for August 2011

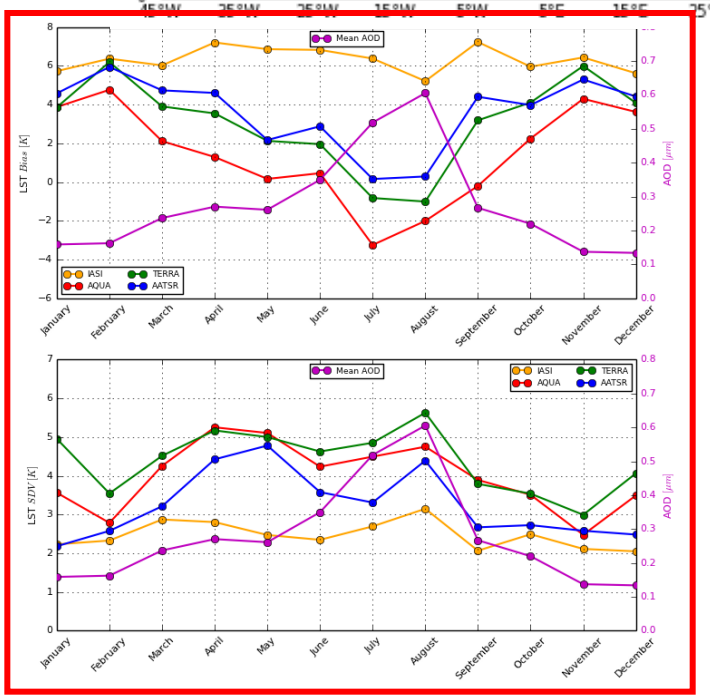


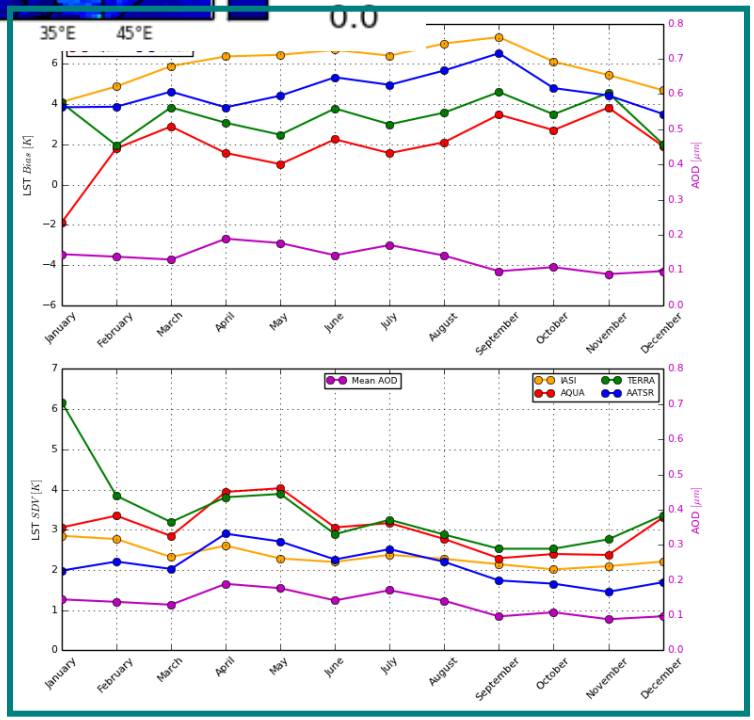
IASI

AATSR

MODIS/TERRA

MODIS/AQUA





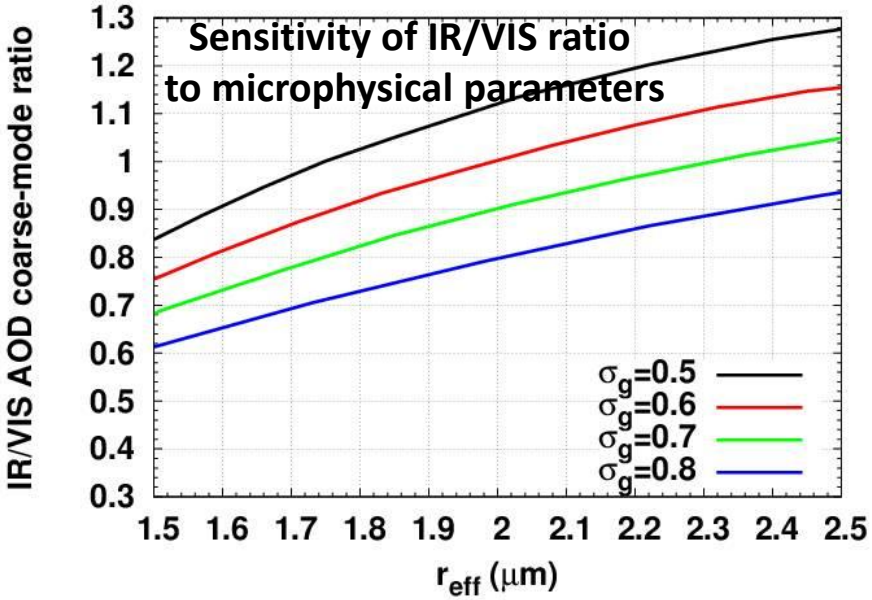
The conversion from infrared to visible AOD

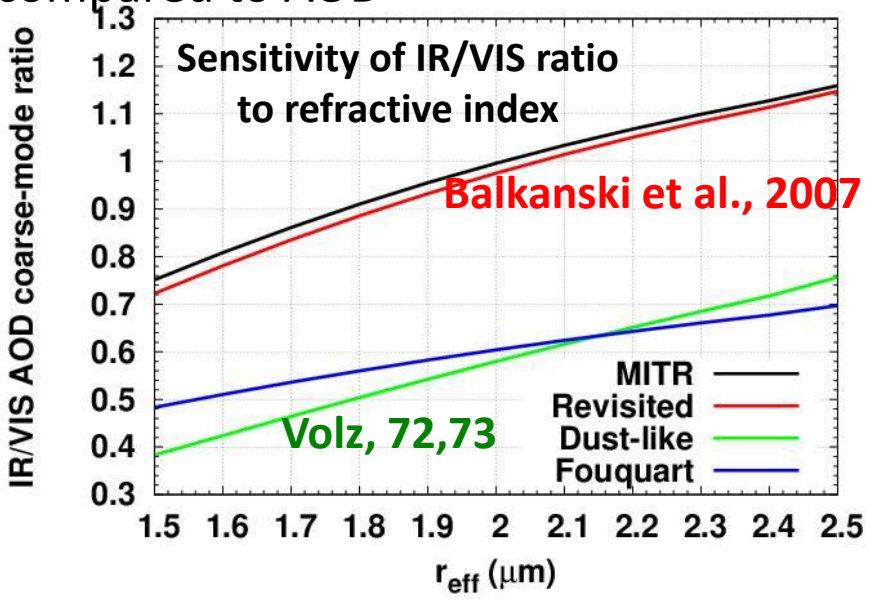
Conversion factor = $C_{ext}(10\mu m)/C_{ext}(0.55\mu m)$

➢IR to visible conversion depends on an accurate **knowledge of the size distribution (σ, R_{eff})** and of **the refractive index at 10 µm and 0.55 µm.**

Problem:

- ➢ Ratio highly variable
- ➢ micro-physical parameters of 2nd order in IR compared to AOD





⇒ **Conversion factor between 1 and 2**

⇒**Currently, this conversion degrades our results**

⇒ **2 indices are used in the inversion to take into account sensitivity to the ratio:**

- ⇒ **Balkanski et al., 2007 (mean ratio ~0.85)**
- ⇒ **Volz, 72,73 (mean ratio=0.57)**