Remote sensing of mineral dust with IASI

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Motivation

The aim:
A simple (and fast) dust AOD retrieval scheme without line-by-line radiative transfer calculations and without a priori information of atmospheric state

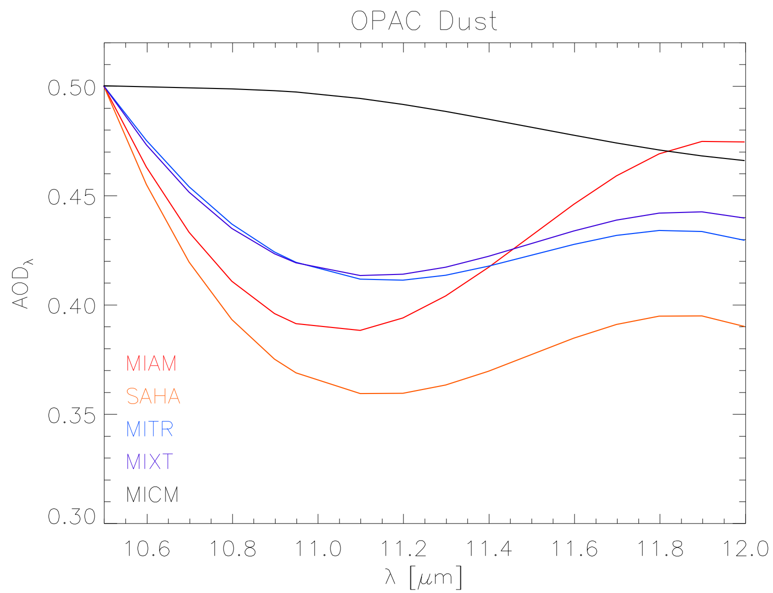
- mineral dust large partical fraction leads to significant extinction in TIR
- surface emissivity spectra approximately linear in [10.5µm,12.0µm]
- strong dust extinction peak at 9-10µm → significant extinction at 10.5µm
- surface emissivity and dust extinction spectra: rather smooth
  atmospheric gas apsorption spectra: mainly narrow lines
- IASI spectral resolution sufficient to avoid major gas absorption lines
- different dust models can be distinguished by IASI observations
- BT spectra sensitive to dust layer height in [10.5µm,12.0µm]
- retrieval over land and ocean

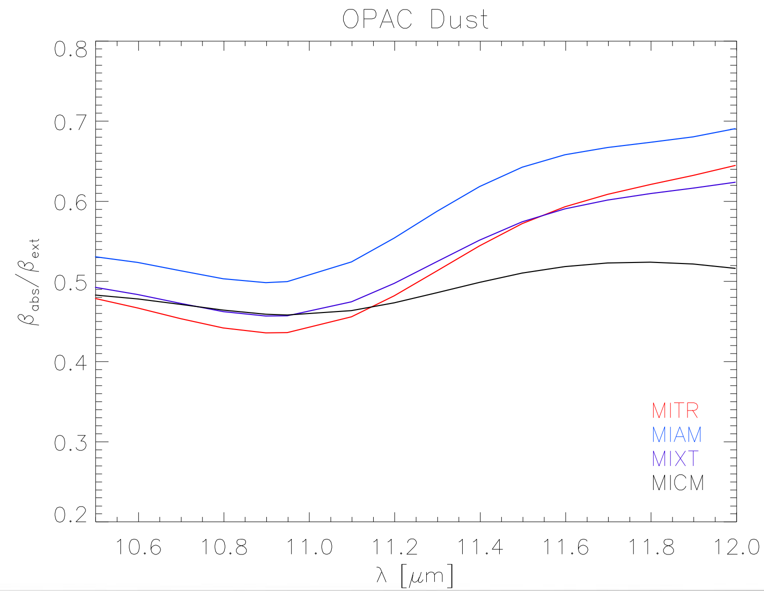
Definition of dust models

- 5 dust models:

MITR	(transported)	particle size ↓
SAHA	(observed Saharan)	
MIAM	(accumulation mode)	
MIXT	(mixture)	
MICM	(coarse mode)	

- MITR, MIAM, MICM:
  OPAC dust models
- SAHA:
  observed Saharan dust
  no absorption fraction
  (Thomas et al., JGR, 2009)
- MIXT:
  equally weighted average of 4 above

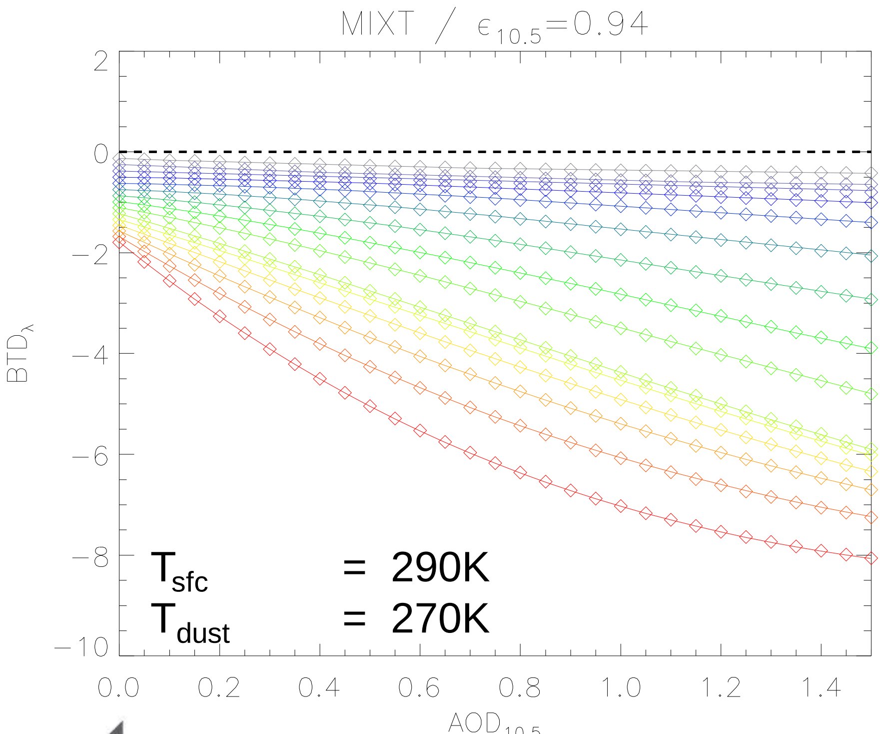


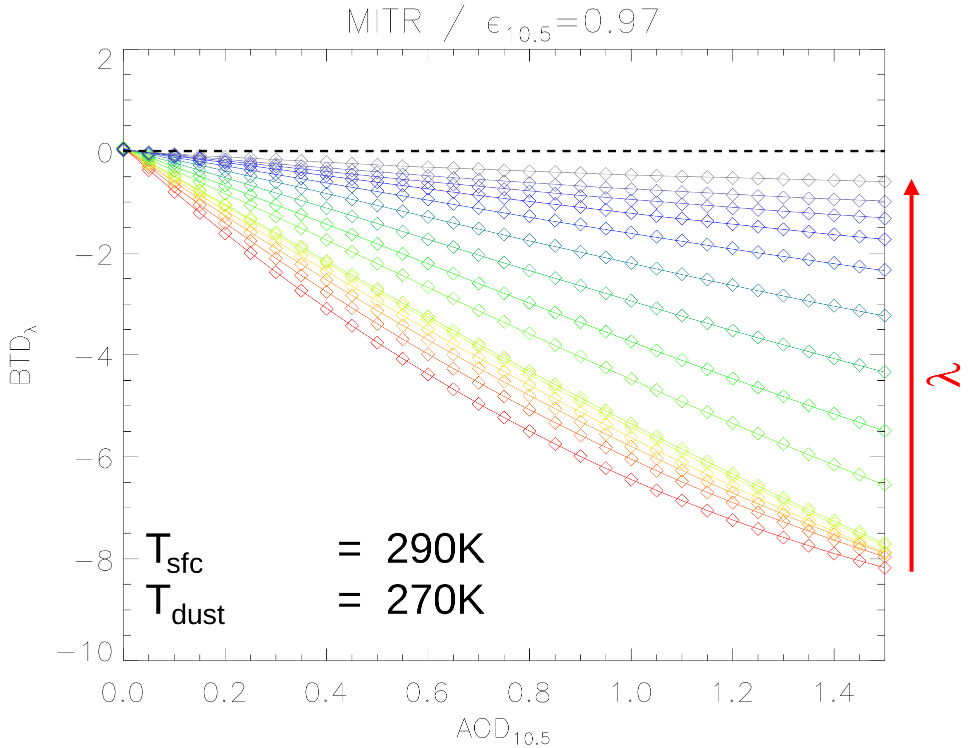


Simulated BTD spectra

$$BTD_\lambda = (T_\lambda - T_{12.0})$$

BTD_λ can be expressed as 2^{nd} order polynomial f of AOD



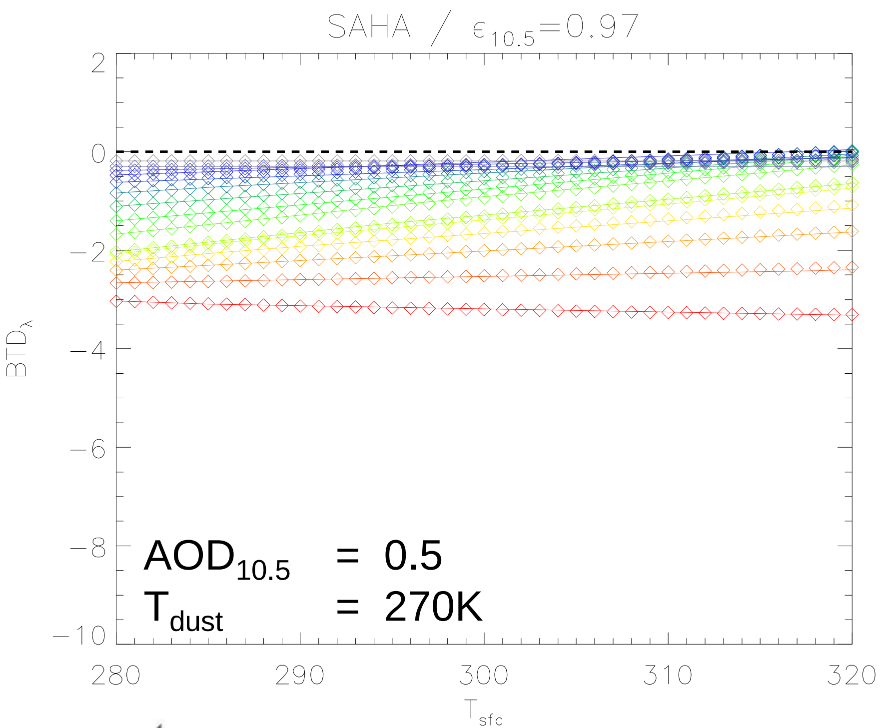


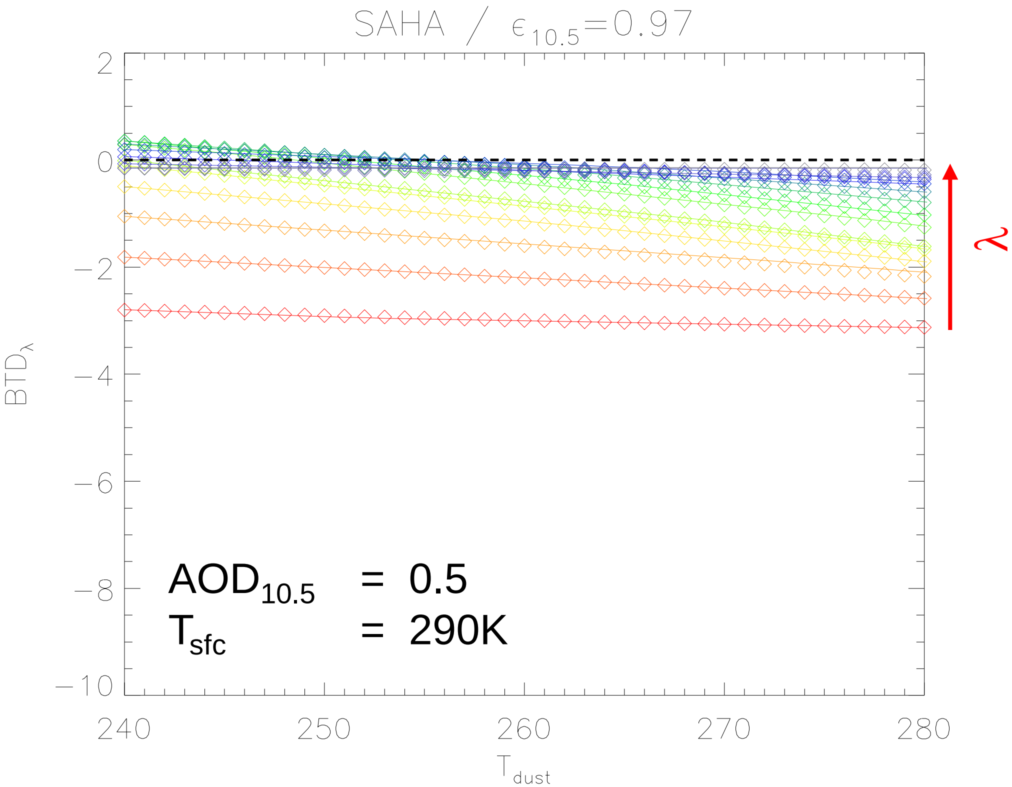
BTD is sensitive to surface emissivity especially at low $AOD_{10.5}$

$$f(AOD) = \alpha + \beta \cdot AOD + \gamma \cdot AOD^2$$

Simulated BTD spectra

BTD_λ is is sensitive to T_{sfc} and T_{dust} especially at mid-band wavelengths





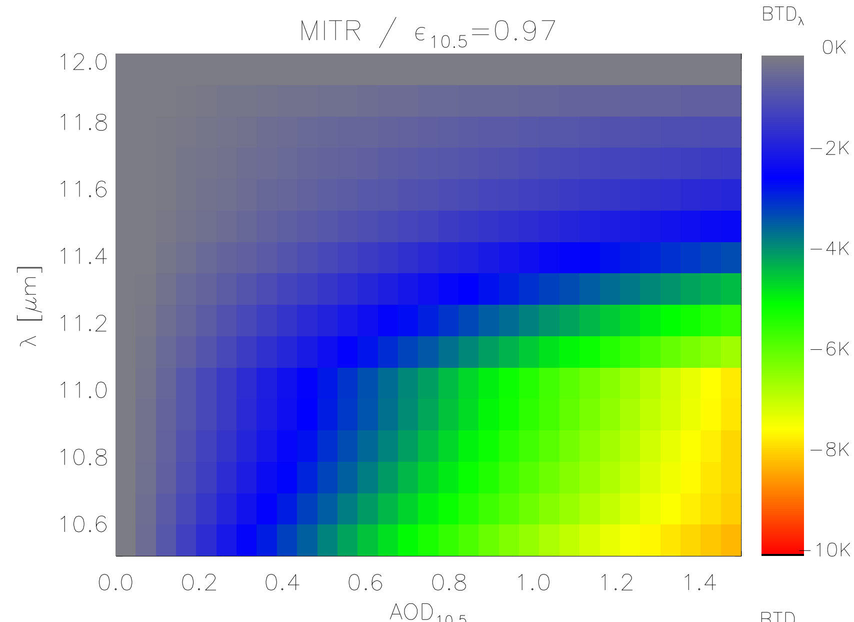
T_{sfc}- and T_{dust}-sensitivity of BTD_λ:

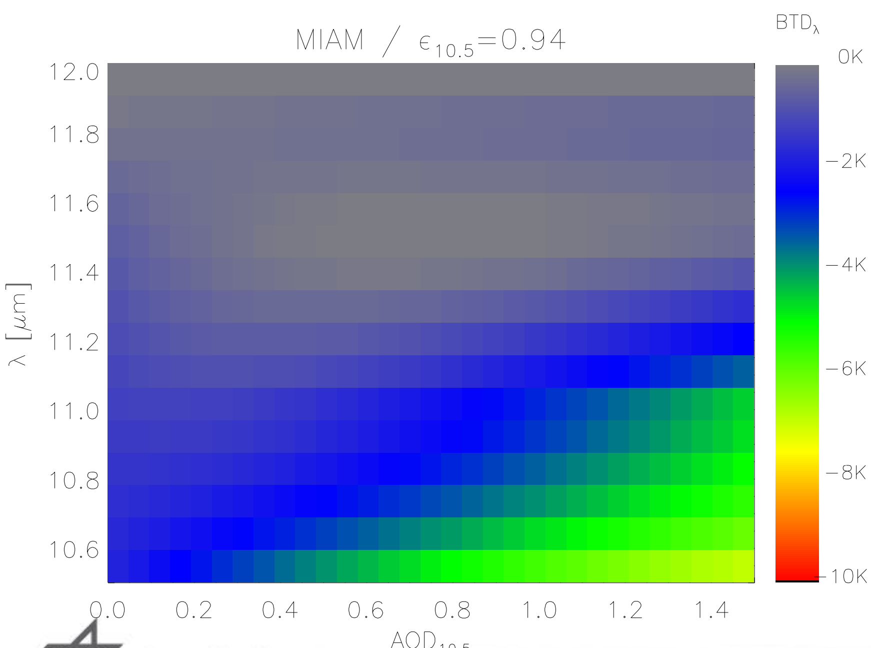
a function of dust model, ε_{sfc} and AOD

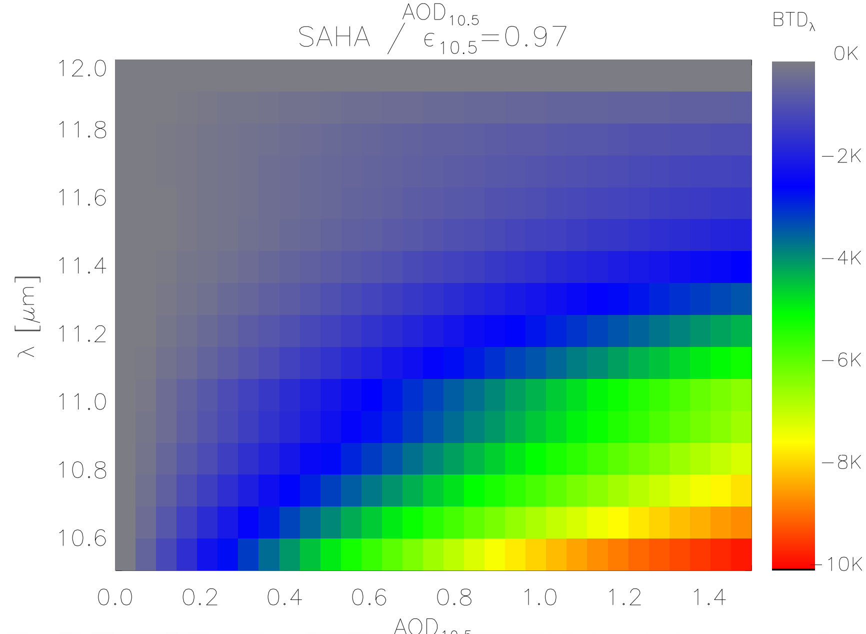
Simulated BTD spectra

BTD spectral shape depends on:

- dust model (DM)
- viewing geometry (Θ_v)
- surface emissivity ($\varepsilon_{10.5}$)
- surface temperature (T_{sfc})
- dust layer temperature (T_{dust})







Retrieval method

1. internal cloud screening by BTD-, IIS tests and expected spectral shape
2. IASI BT spectra separated in 0.1µm bins centered at λ in [10.5µm,11.6µm]

$$BT_\lambda = \max(\{T_{\lambda \pm 0.05\mu m}[IASI]\})$$

3. calculate set of 11 $AOD_{10.5}$ values for each [$\varepsilon_{10.5}$,T_{dust}, DM] (with $T_{sfc} \geq BT_{12.0}$):

$$AOD_{10.5,\lambda} = f^{-1}\left(\alpha_{\varepsilon_{sfc},T_{dust},DM},\beta_{\varepsilon_{sfc},T_{dust},DM},\gamma_{\varepsilon_{sfc},T_{dust},DM},BTD_\lambda\right)$$

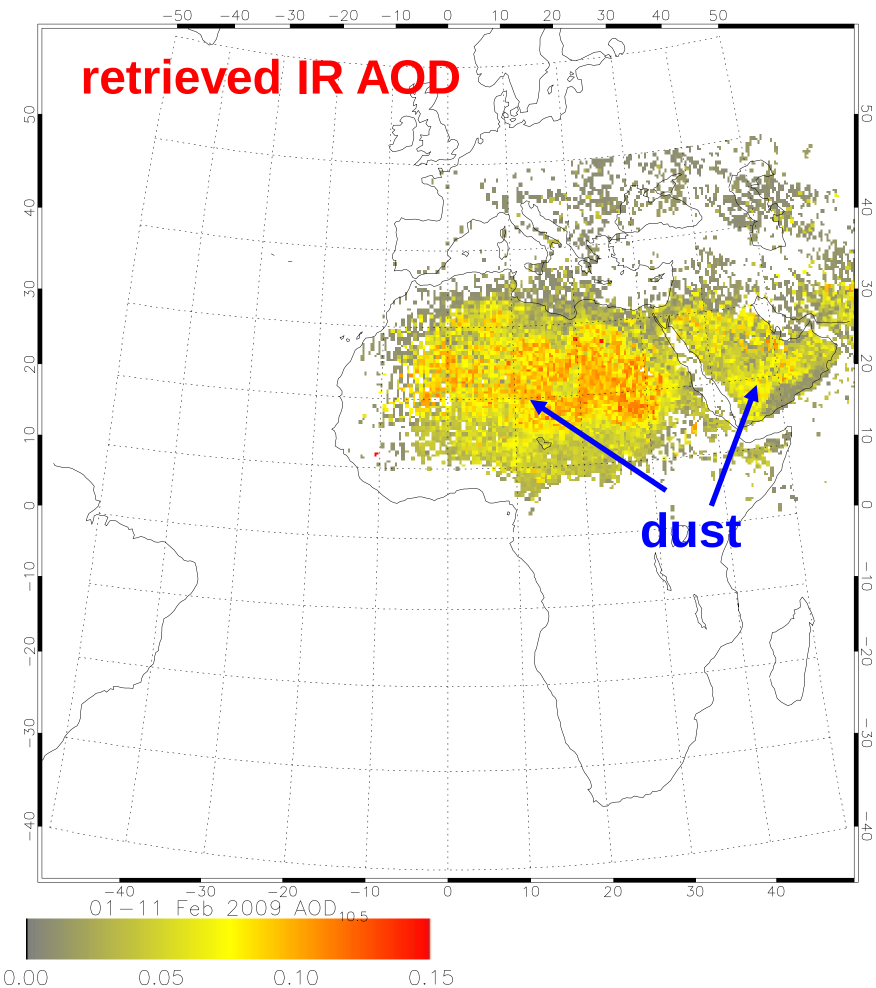
4. calculate weighted mean $AOD_{10.5}$ and variability index:

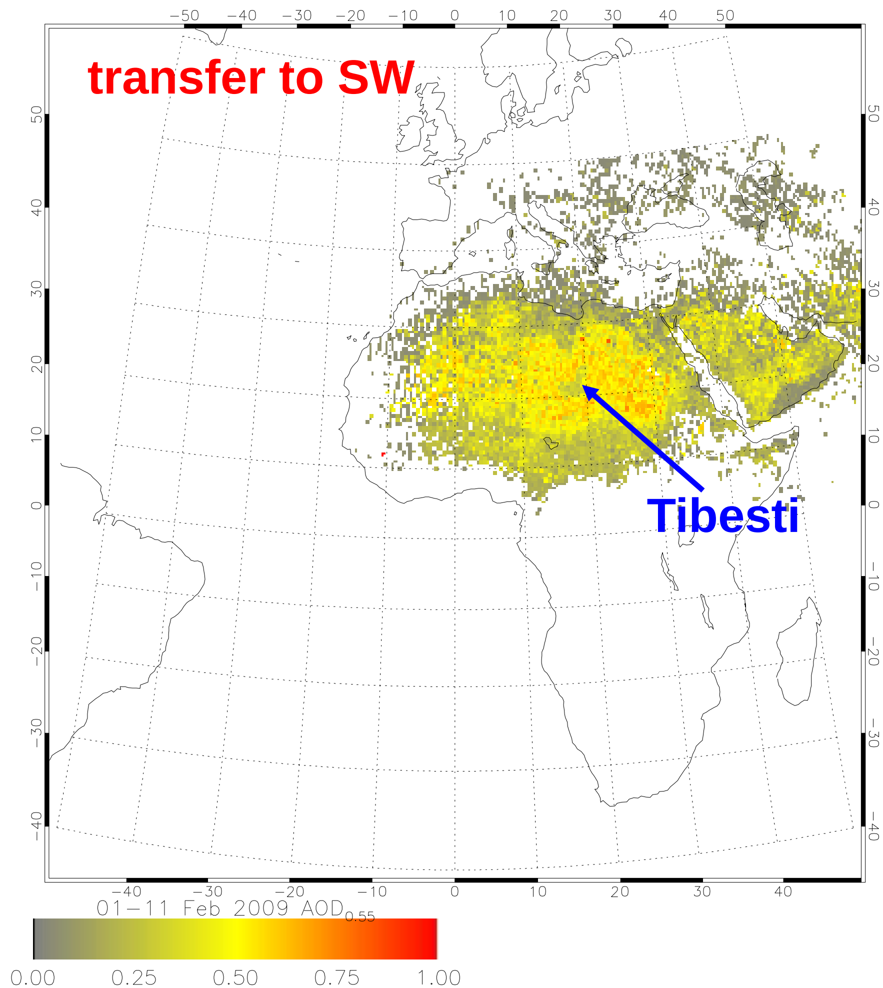
$$\overline{AOD}_{10.5}(\varepsilon_{10.5},T_{dust},DM) = \sum_\lambda \left(\frac{|BTD_\lambda|}{\sum_\lambda |BTD_\lambda|} \cdot AOD_{10.5,\lambda} \right)$$

$$\delta AOD_{10.5}(\varepsilon_{10.5},T_{dust},DM) = \frac{\sigma(\{AOD_{10.5,\lambda}\})}{\langle\{AOD_{10.5,\lambda}\}\rangle} \overset{!}{<} 1.5$$

5. smallest δAOD selects best fitting conditions (AOD,ε_{sfc},T_{dust},DM)

First example results: Feb 01-11, 2009





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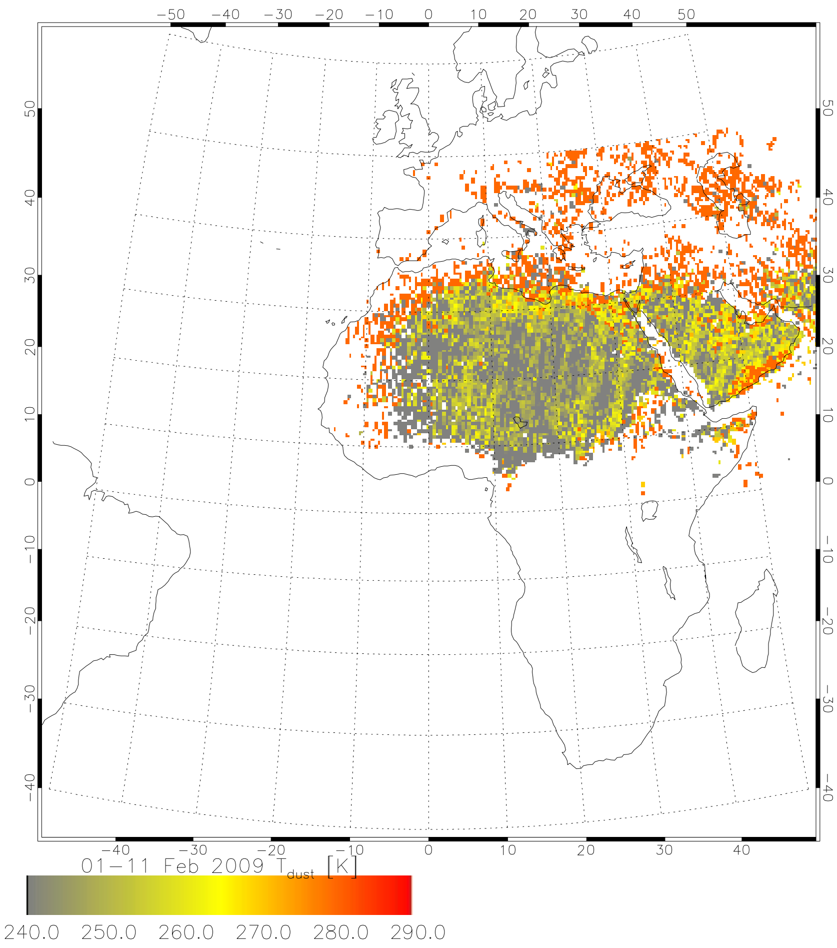

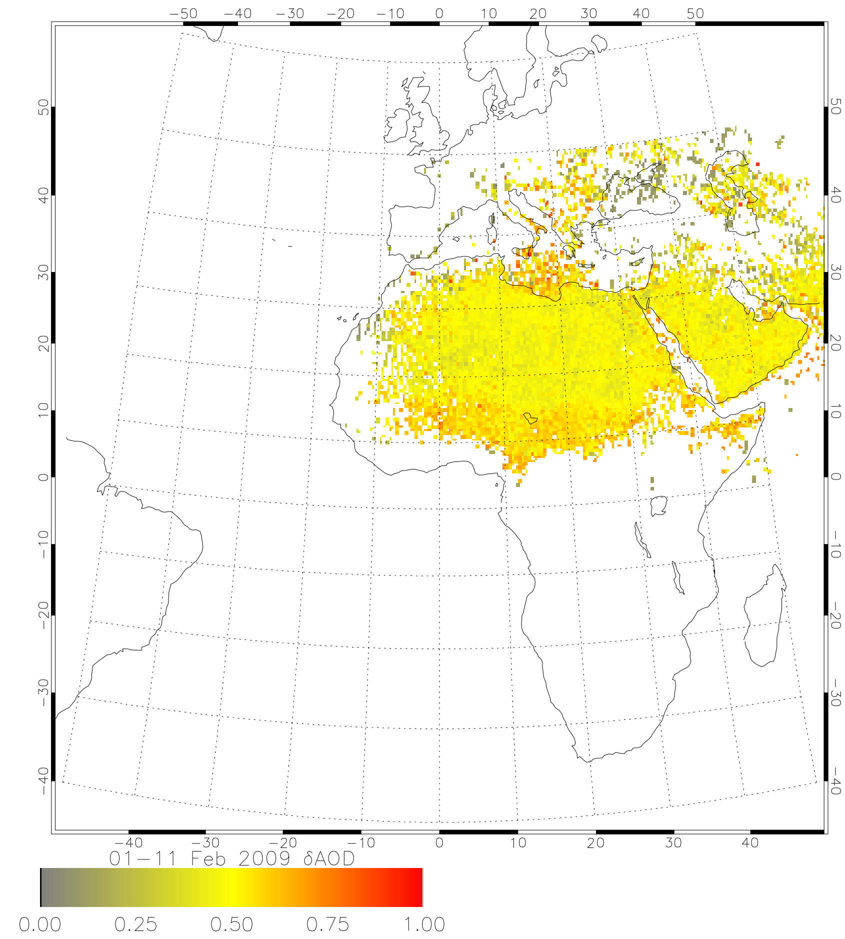

low AOD: high T_{dust} retrieved (insufficient information)
retrieval quality flag gives information on reliability

Planned method improvements and evaluation

- include a statistically derived dust model from fit between IASI BTD spectra and AERONET AOD
  (depending on DM, Ångström exponent)

- use a priori emissivity map / spectra for weighting in the retrieval statistics
  → extension to λ<10.5µm possible

- OPAC has only monomodal dust models, determine conversion factors to $AOD_{0.5}$ statistically
  (depending on dust model and temperature)

- evaluate against AERONET and other satellite data

→ so far only testcase, calculation of larger dataset required

Summary

- a fast method for dust AOD retrieval from IASI has been presented, which accounts for different dust types, surface emissivity and dust layer temperature

- AOD is calculated from 11 different wavelength observed BTD

- statistical information of the AOD set is used to determine the most likely dust model, surface emissivity and dust layer temperature

- a first test case shows high dust loads over the Arabian Peninsula and parts of the Sahara

- a larger dataset will be generated for evaluation and improvements