Remote sensing of mineral dust with IASI

Lars Klüser\textsuperscript{1,2} and Thomas Holzer-Popp\textsuperscript{1}

\textsuperscript{1} German Aerospace Center (DLR), Wessling, Germany
\textsuperscript{2} University of Augsburg, Institute of Physics, Augsburg, Germany
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 particle 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 absorption 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)
  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

\[ \text{BTD}_\lambda = (T_\lambda - T_{12.0}) \]

BTD\(_\lambda\) can be expressed as 2\(^{nd}\) order polynomial \(f\) of AOD

\[ f(AOD) = \alpha + \beta \cdot \text{AOD} + \gamma \cdot \text{AOD}^2 \]

BTD is sensitive to surface emissivity especially at low AOD\(_{10.5}\)
Simulated BTD spectra

$BTD_\lambda$ is sensitive to $T_{sfc}$ and $T_{dust}$ especially at mid-band wavelengths.

$AOD_{10.5} = 0.5$

$T_{sfc} = 290K$

$T_{dust} = 270K$
Simulated BTD spectra

BTD spectral shape depends on:

- dust model \((\text{DM})\)
- viewing geometry \((\Theta_v)\)
- 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 $\lambda$ 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 $[\varepsilon_{10.5}, T_{dust}, DM] \text{ (with } T_{sfc} \geq BT_{12.0})$:

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

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

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

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

5. smallest $\delta AOD$ selects best fitting conditions ($AOD, \varepsilon_{sfc}, T_{dust}, DM$)
First example results: Feb 01-11, 2009

retrieved IR AOD

transfer to SW

dust

Tibesti
First example results: Feb 01-11, 2009

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 $\lambda<10.5\mu m$ possible

• OPAC has only monomodal dust models, determine conversion factors to $\text{AOD}_{0.5}$ 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