Quantitative analysis of relationships between mineral dust and deep convection over land with IASI

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Introduction and data

The impact of mineral dust on convective clouds over semi-arid land regions in Africa, Arabia and East-Asia (see Fig. 1) is estimated by analysis of one year of IASI observations.

The principle component based retrieval scheme for mineral dust (Klüser et al., 2011; 2012) from IASI observations has been complemented by a simultaneous retrieval of cloud ice crystal properties. IASI observations are analysed at 1°x1° running windows daily for 2009, separately for Metop‘s descending and ascending orbits in individual analysis regions.

Methodology

Histograms of cloud properties are derived for different dust classes (**b**ackground: AOD<0.2, **m**oderate: 0.2≤AOD<0.75 and **h**igh: AOD≥0.75).

Bayesian statistics is used to estimate the probability distributions of h and m class cloud properties (e.g. effective radius), taking into account meteorology in terms of Cloud Top Temperature (CTT) distributions of the different observation classes:

$$\hat{H}_m(R_e) = \sum_{CTT}\left[\frac{P(CTT,R_e)\cdot H(CTT)_m}{H(CTT)_b}\right]$$

$$\Delta H_m(R_e) = H_m(R_e) - \hat{H}_m(R_e)$$

Such approach allows for analysing histogram deviations (Fig. 2) from the estimated background distribution under the same CTT distribution without errors introduced by seasonal subsetting (e.g. Klüser and Holzer-Popp, 2010).

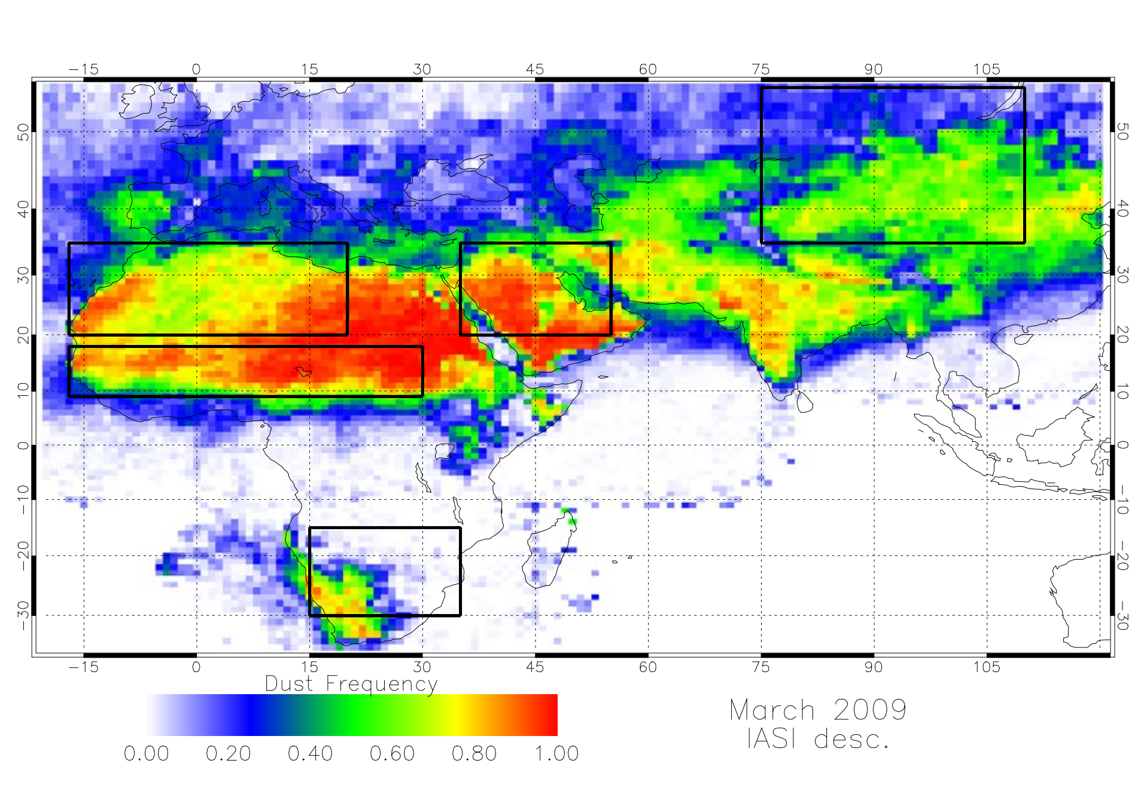

Fig. 1: Analysis regions for this study highlighted by the black boxes. The background colour indicates the dust observation frequency (with $AOD_{0.5\mu m}$>0.2) from IASI for descending orbits in March 2009.

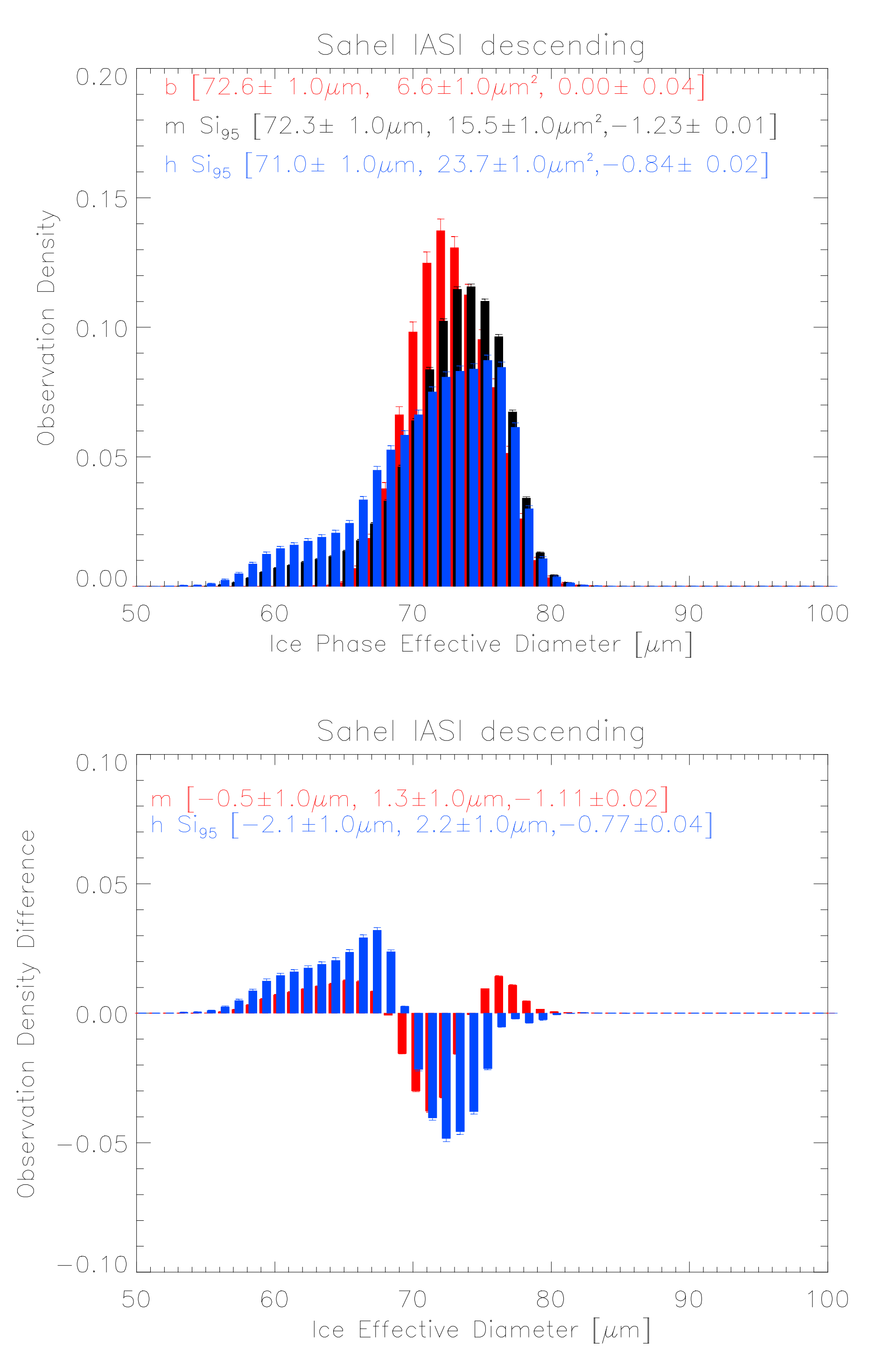

Fig. 2: Ice cloud effective diameter observation histograms (top) and their deviation from background for descending orbits over the Sahel.

Results

In most cases the typical expected aerosol effects are observed by IASI for the relationship between dust and ice clouds: Cloud optical depth is increased and effective diameter is reduced under dusty conditions. Ice water path (IWP) is generally increased at high dust loads (Tab. 1 and 2).

The relationship between dust and ice cloud properties is also analysed by means of distribution percentiles as functions of dust AOD (Fig. 3). In both cases presented (optical depth and effective diameter) the spread between the 20% and 80% percentiles increases monotonically with rising dust AOD. Such widening of the distribution percentile spread is observed in almost all regions at descending and ascending orbits.

	Sahel	Maghreb	Arabia	Kalahari	Mongolia
D_{eff} [µm]	-0.5±1.0 -2.1±1.0	-1.4±1.0 -2.2±1.0	-1.2±1.0 -2.8±1.0	-0.5±1.0 -2.5±1.0	-0.5±1.0 -2.1±1.0
CiOD	+0.6±0.2 +1.8±0.2	+0.4±0.2 +2.2±0.2	+0.1±0.2 +1.5±0.2	-0.0±0.2 +1.5±0.2	+0.6±0.2 +1.8±0.2
IWP [g/m²]	+1±1 +3±1	+0±1 +4±1	+0±1 +3±1	+0±1 +3±1	+1±1 +3±1
COV [%]	-5.5±2.0 -7.4±2.0	+2.7±2.0 -3.3±2.0	+4.7±2.0 -0.9±2.0	-2.3±2.0 -6.5±2.0	-5.5±2.0 -7.4±2.0

Tab. 1: Mean deviations from background for moderate (red) and heavy (blue) dust conditions for each region and cloud property derived from descending orbits.

	Sahel	Maghreb	Arabia	Kalahari	Mongolia
D_{eff} [µm]	-0.5±1.0 -2.4±1.0	-1.8±1.0 -3.7±1.0	+0.2±1.0 -2.1±1.0	-3.0±1.0 -4.6±1.0	-2.6±1.0 -5.8±1.0
CiOD	+0.4±0.2 +1.8±0.2	+0.3±0.2 +1.7±0.2	+0.0±0.2 +1.4±0.2	-0.2±0.2 +1.0±0.2	-0.4±0.2 +0.1±0.2
IWP [g/m²]	+0±1 +3±1	+0±1 +3±1	+0±1 +2±1	+0±1 +2±1	+0±1 +0±1
COV [%]	-1.8±2.0 -2.1±2.0	-1.3±2.0 -1.9±2.0	-1.1±2.0 -1.4±2.0	-2.0±2.0 -2.6±2.0	-2.5±2.0 -2.4±2.0

Tab. 2: Mean deviations from background for moderate (red) and heavy (blue) dust conditions for each region and cloud property derived from ascending orbits.

Conclusions

IASI observations have been used to analyse relationships between airborne mineral dust and ice cloud properties over semi-arid and arid land regions. While for ice effective diameter and optical depth the effects also known for liquid water clouds (smaller crystals, higher optical depth) can generally be observed, the relationship between dust and ice cloud fraction is not as clear. Ice water path is generally increased under dusty conditions indicating the suitability of dust particles as ice nuclei.

The deviation of cloud property observation density distributions from background conditions indicates not only a shift of cloud median properties, but also a significant widening of the distributions as a function of dust AOD.

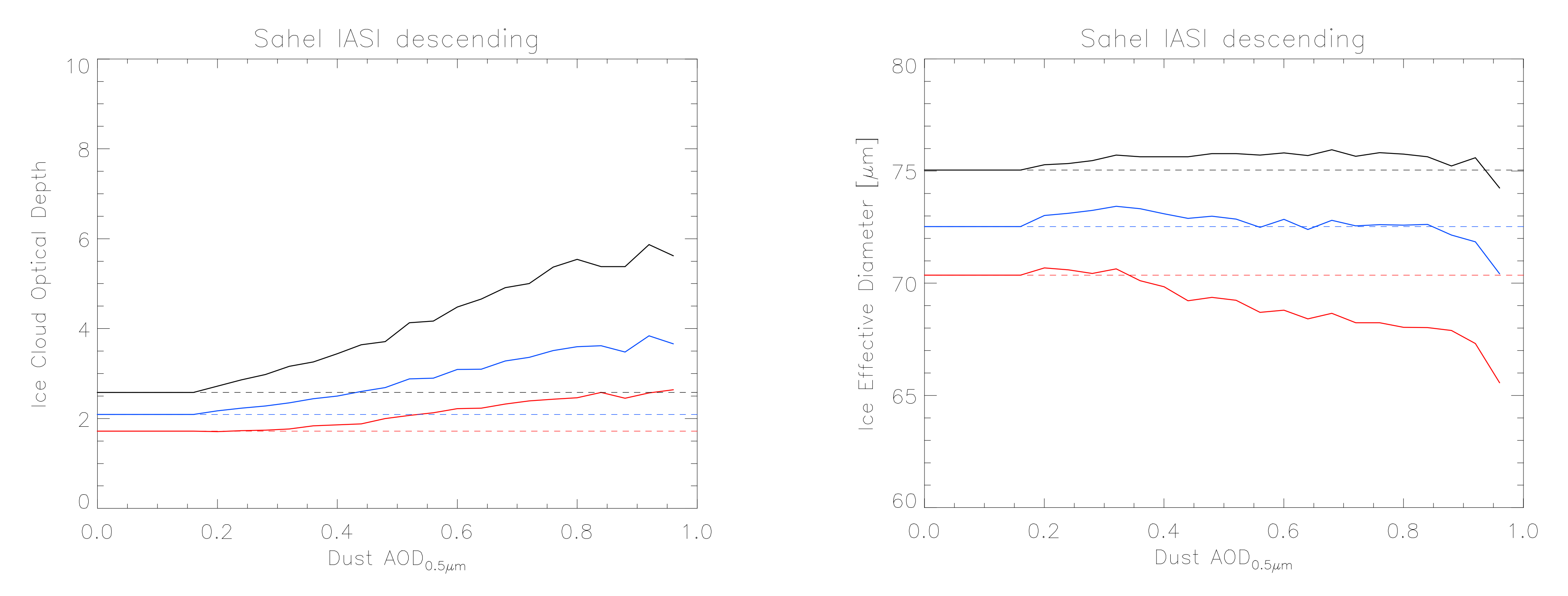

Fig. 3: 20% (red) 50% (blue) and 80% (black) percentiles of ice cloud optical depth (left) and effective diameter (right) as function of Dust AOD (Sahel, descending orbits). Dashed lines represent background conditions.

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