Atmos. Chem. Phys. Discuss., 10, C2266–C2270, 2010
www.atmos-chem-phys-discuss.net/10/C2266/2010/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Mineral dust effects on clouds and rainfall in the West African Sahel" *by* L. Klüser and T. Holzer-Popp

L. Klüser and T. Holzer-Popp

lars.klueser@dlr.de

Received and published: 30 April 2010

We wish to thank the anonymous referee #2 for his helpful suggestions.

Overall Response:

In the revision step we will add a third satellite dataset (from ENVISAT, where the aerosol retrieval SYNAER is capable of aerosol type separation) to the statistical analysis of the data. Thus some restructuring of the manuscript is required which we will also use to strengthen the interpretation of the statistical results.

Responses to specific comments:

1 We will remove the word "rainfall" from the title and also the analysis of the warm-rain-

likelihood introduced in the original version of the manuscript. We rather concentrate on analysing the effects on cloud cover, top temperature and ice phase fraction observed under dusty conditions.

2 This is somewhat misleading, as TRMM is only used for determination of the seasonality. The MSG dataset (BMDI dust observations and APOLLO cloud observations) is analysed independently by the same means as the MODIS dataset – but due to the BMDI and APOLLO limitations it does not provide as much information as MODIS. With removing the WRL from the analysis and adding the ENVISAT dataset, the same analysis will be presented from three satellites (Aqua, MSG, ENVISAT), only effective radius observations are solely provided for MODIS. The similarities and differences between the effects observed in these three satellite datasets will be discussed in more detail and with special emphasis on the strengths and limitations of the different methods, which impact on the analysis results.

3 We mainly refer to the literature but in the revised manuscript we will add a more detailed description of the retrievals, as the discussion of the strengths and limitations (see response to point 2) requires this information.

4 We will substitute the warm clouds analysis by total clouds in order to correctly address the impact of mineral dust on mixed phase cloud's ice fraction.

5 The reason for not presenting the results on a geographical distribution is the sample size which could get insufficiently low for some regions and the problem of the proper presentation of statistical results on a map. From the histogram analysis it gets clear, that "simple" correlation analysis cannot provide the same information as obtained with this method. Nevertheless we will calculate "mean effects" for several cloud properties for a regionally mapped grid (spatial representation of the effects) and add a discussion on this analysis with special respect to the meteorological conditions.

6 We agree with the reviewer's comment. Unfortunately aerosol (and more or less also cloud) observations form satellite are not height resolved, thus we cannot give the an-

ACPD

10, C2266–C2270, 2010

swer directly from the observations. But we see that the statistical properties of the cloud parameters change with the presence of mineral dust. We will add a detailed discussion on the interpretation of these results with respect to the limitations and prerequisites of the methods used. Moreover we will clarify the possible underestimation of dust events masked by clouds as pointed out by the reviewer. But generally in our understanding also dust above clouds, e.g. shallow cumulus convection, can affect these by the stabilisation of the atmospheric layer due to solar heating.

7 In fact the differences in the histograms seem to be rather small. But when looking into the relative differences as e.g. done fig fig.4 and fig.5 it becomes clear that there is some systematic variation which corresponds well to the general theories of aerosol cloud interactions. We present both the histogram difference plots and the histograms themselves as we want to show the type of distribution of each cloud parameter once. As indicated above, we will also add observations form ENVISAT to enlarge the database of the analysis, which strengthens the interpretation of the results with respect to different retrieval methods and observation times. Moreover we will provide a more detailed discussion on the effects presented in tables 1-3.

8 Vertically integrated water vapour does not provide a full characterisation of the air mass by means of wind and relative humidity criteria. But nevertheless, as neither aerosol nor cloud observations are height resolved, it follows that somehow a vertically integrated separation of the air mass (flow) has to be used for the analysis. Although WVC is not really a physical air mass separator, BMDI is, as all IR dust indices, very sensitive to this property (Klüser and Schepanski, 2009; and references herein). Moreover this paper showed that WVC is quite robust in separating the moist monsoonal air mass from the dry air mass of the Sahara, when the total lower tropospheric column is regarded. Moreover we will refer to “moist and dry air mass” rather than to “Harmattan and monsoon flow” in order to point out the method of air mass separation used here. We will add some more detailed discussion on this topic.

9 We found some evidence from analysis not included in the paper, but the statistical

ACPD

10, C2266–C2270, 2010

robustness and the possibility of attributing it to the influence of mineral dust were insufficient due to low sampling rates (see Fig 1b). As already indicated in response to comment 1 we will remove the wording “rainfall” from the title and will concentrate on the effects on cloud properties.

10 OK

Responses to minor comments and technical corrections:

“harmattan” OK

P6168 l20 OK

P6168 We will include a definition of the meaning of ITCZ as used here

P6169 OK

P6170 L12 The analysis is only indirectly based on TRMM observations, as they are only used for separating the seasons. But with including the ENVISAT dataset it will really become three satellites. We will point out here that the fourth satellite dataset (from TRMM) is only used for season determination (as also the word “rainfall” will be removed from the title)

P6170 L22 We will provide this information in the revised manuscript

P6172 L27 There are several definitions found in the literature, mainly from May to September, but also from June to September, May to October etc. That is the reason why we intend to use rainfall observations from satellite to define the seasons rather than fixed month of the year. Moreover the onset and ceasing of the monsoon varies from year to year, which is not accounted for the definitions found in the literature as listed above.

P6173 L 13 The fine mode fraction as retrieved in the MODIS dark target retrieval. This is the fraction of fine mode aerosol optical depth in the total AOD which can be used to characterise the aerosol. As we will provide a more detailed dataset description (see

ACPD

10, C2266–C2270, 2010

response to point 3), we will also clarify the wording “fine mode fraction” in the revised manuscript.

Fig 1 In this manuscript we define the Sahel region as the land region inside the highlighted area in Fig 1 and not by isohyets. As for the monsoon season a large variety of definitions is found in the literature also for the Sahel domain. For the analysis of gridded satellite observations it is more convenient to use a geographical definition (by latitude and longitude) rather than by the isohyets. From Fig 1 it becomes clear that there is a strong gradient of annual precipitation in the region we are interested in. In order to present a more detailed view on the precipitation patterns in the region, we will include maps of the seasonal variation of precipitation in the regions (by monthly accumulated precipitation for all seasons). The presented TRMM precipitation data shown in Fig 1 are the same ones used to determine the seasonality.

Fig 3-6 We will reproduce the figures with an appropriate number of tickmarks.

Fig 4 We agree and will change the colours in the revised manuscript.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 6167, 2010.