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Climate of the Past
Discussions

Interactive comment on "Marine sediment records as indicator for the changes in Holocene Saharan landscape: simulating the dust cycle" *by* S. Egerer et al.

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Response to Anonymous Referee 3

We would like to thank the reviewer for constructive comments on the paper and especially for pointing out shortcomings in the model setup description.

Major comments:

1. *As far as it can be understood from the paper the vegetation reconstruction for*

6K conditions (shown in Figure 1) is based on a reconstruction by pollen data that was published in 1998. As can be seen in the figure this reconstruction provides only a crude vegetation pattern with constant vegetation cover for different longitudinal bands. That is certainly based on the fact that the data availability is limited in this region. It is not entirely clear if the vegetation cover at 0K is computed using the vegetation model JSBACH? If that is the case, then it should be clearly explained why the vegetation cover at 6K is not also simulated by JSBACH, which would have provided more spatial detail. If JSBACH is unable to provide a reasonable vegetation reconstruction at 6K, then why use it for 0K? This should be clarified. In Figure 1 the fractional vegetation cover for the 6K conditions according to the color scale is more than 0.5 for most of the Sahara. In fact this dense vegetation cover should inhibit the dust emission completely, but apparently this is not the case in the model. Please explain. Apart from the fractional vegetation cover, which vegetation type is assumed for 6K vegetation cover in the Sahara?

Vegetation 0k:
In JSBACH, a standard vegetation map for pre-industrial conditions is prescribed and was derived from Hagemann (2002) based on satellite data.

Vegetation 6k:
We do not want to study feedbacks of the climate-vegetation model, but rather study the effect of a prescribed vegetation cover on dust emission and transport and thus it is sufficient to provide a vegetation reconstruction indicated by paleorecords. A more detailed description of the vegetation reconstruction will be added to the experimental setup: Roughly, steppe vegetation is assumed between 10°N and 20°N and savanna vegetation between 20°N and 30°N. In the land surface component JSBACH of ECHAM, biomes are represented as a composition of plant functional types (PFT). Vegetation fraction and cover

fractions of all eleven PFTs, surface albedo and water conductivity are set accordingly. Thereby, steppe is linked to C4 grasses and a vegetation cover of 58%. Savanna is composed of 80% C4 grasses and 20% tropical evergreen forest, where vegetation is covering 80% of the land (Hagemann, 2002).

Vegetation fraction > 0.5:
The vegetation at 6k consisted mainly of grasses and some shrubs and thus vegetation of low stature with a relatively low roughness length (compared to e.g. trees). Dust emission depends highly on the distribution of vegetation and not only on the total amount of vegetation. We assume that vegetation is somehow distributed in patches. Because of the distribution and the low stature vegetation there still remain larger areas of bare soil, which serve as sources of dust. Additionally, dust can be emitted from gaps within the with grasses and shrubs vegetated area. So the model approach, that dust emission occurs for higher fractions of vegetation, does not seem unrealistic to us. We will add this issue in the discussion part of the revised manuscript.

Specification of 6k vegetation:
Following Hoelzmann et al. (1998), steppe vegetation is assumed approximately between 10°N and 20°N and savanna vegetation approximately between 20°N and 30°N. Steppe is linked to C4 grasses and a vegetation cover of 58 %. Savanna is composed of 80 % C4 grasses and 20 % tropical evergreen forest, where vegetation is covering 80 % of the land (Hagemann, 2002). The specification will be added to the experimental setup.

2. *For the differences in lake levels for the different simulation it is unclear on what data the 6K lake distributions are based. Are the extents of the lake levels at 6K taken from a reconstruction or do they only represent the maximum possi-*

ble lake extent based on the distribution of enclosed topographic depressions as indicated in the low- est right figure? This should also be made clear in the text. The resulting differences in dust emissions may be biased by the fact that the ECHAM-HAM model assumes all topographic depressions as preferential sources. However, this underestimates the po- tential importance of alluvial dust sources, which are probably important dust sources in the Sahara and may be unaffected by lake level changes. The lake sediment source type should be discussed in more depth.

Lakes 6k:
The 6k lake fraction represents the maximum possible lake extent, which is considered as paleolakes in Tegen et al. (2002). The underestimation of dust emission caused by assuming the maximum possible lake extent is mentioned as a source of error in the discussion.
To us, it is not fully clear to which alluvial dust sources, which may be unaffected by lake level changes, the Referee refers to. We assume that the areas, which were covered with lakes at 6k, are nowadays the most productive dust sources, e.g. the Bodele Depression and parts of West Africa (Middleton and Goudie 2001, Engelstaedter and Washington 2007). Thus, alluvial dust sources are considered here. Smaller alluvial sources, e.g. close to former river systems, can, however, not be captured with the coarse resolution of our model.

3. *Regarding the dust emission and deposition fluxes, in Figure 2 global results are shown. If only Saharan land surface conditions are modified for 6K compared to 0K, the differences in the rest of the world can only be due to the changed orbital parameters. This should be stated clearly in the text. Figure 2 would be more useful if not only the fluxes for 0k and the differences between 0K-6K would be shown, but if the actual emission and deposition fluxes for 6K would be shown as well in additional panels.*

   Emission and deposition fluxes for 6k are depicted in additional panels as requested. In the results section (page 5276, line 15) it is stated that changes in dust emission and deposition apart from the modified area occur thus due to differences in orbital forcing.

Minor comments:

- *The title does not really reflect the content of the paper. The work focuses on the dust modelling, while the title implies that the investigation of the sediment records is at the center of the work, which is not the case. The title should be modified to better reflect the content of the paper.*

  We agree and will change the title to better reflect the focus of our study, that is the link between marine sediment records and changes in Saharan land surface. We propose as a new title: 'The link between marine sediment records and changes in Holocene Saharan landscape: simulating the dust cycle'

- Page 5272, line 3: 'at variance' is replaced by 'inconsistent'.

- Page 5273, Model description: We used version ECHAM6.1-HAM2.1. We will correct the specification in the manuscript.

- Page 5278, line 8: We will replace 'low stature vegetation' by 'low vegetated areas'

- Table 1: Indeed, in both studies modern dust is represented (10 years mean for 2000-2009). Changes in the setup and differences in the machine are probably responsible for the deviations. In our study, we used a 30 years amip climatology for sst and sic, whereas Stanelle et al. (2014) used yearly sst and sic. Further, a different vegetation distribution was used. Due to those differences the present day simulations of Stanelle et al. (2014) and the one in our study do not seem

comparable. Also, the present day simulation in our study is only run for model validation and not further used. Thus we decided to skip the extra comparison with an extra present day run.

- Table 2: Yes.

- Table 3: Greenhouse gas levels are reflected in the table to denote them rather to compare between 0k and 6k. The Table was changed by stating greenhouse gases only once now.