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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 4

We would like to thank the reviewer for constructive comments on the paper and especially on the importance of an analysis of climatic conditions and the hint of an updated data set for terrigenous fluxes at ODP site 658.

Major comments:

(1) Though I enthusiastically support the aim of the study, there are several ways in which the manuscript needs to be improved in my view. First and foremost is that the authors need to build confidence that the very small wind changes simulated by the model are realistic. Given the apparent underestimation of Holocene changes in North African precipitation by global-scale GCMs (e.g., Braconnot et al., 2007; Perez-Sanz et al., 2014), it seems possible that this and other models may also underestimate wind changes, and thus incorrectly attribute dust changes solely to land surface changes. Paleo SST and biogenic sediment data from the margin suggest very substantial reductions in coastal upwelling during the mid-Holocene; Holocene biogenic sediment fluxes correlate strongly with dust fluxes (e.g., Adkins et al., 2006; Fig. 9 of McGee et al., 2013). Are the very small differences in winds indicated by this model consistent with this observation? If not, the mismatch between observations of upwelling changes and unchanging model winds should at least be noted, and its significance discussed. Related to this point, the authors should discuss and plot the changes in winds and precipitation that accompany their addition of estimated mid-Holocene vegetation and lake extent into the model – that is, how are winds and precipitation in the full 6ka simulation different from the AO6kaLV0ka simulation?

As proposed by the referee, we have plotted changes in simulated winds and precipitation between experiment $AO_{6k}LV_{0k}$ and $AO_{6k}LV_{6k}$ and the control run, respectively (see attached Fig. 1 and Fig. 2). We found that in experiment $AO_{6k}LV_{6k}$, precipitation is overestimated in the southern Sahara and is in agreement with data north of 20°N according to reconstructions by Bartlein (2011). Thus, we conclude that the extent and strength of the monsoon and corresponding surface winds during the mid-Holocene are likely not underestimated by the model. A weakening of south-west winds in experiment $AO_{6k}LV_{6k}$ of about 3-4 m/s compared to the control run and of 2 m/s in experiment $AO_{6k}LV_{0k}$ was found during summer. Similar to the PMIP results, in experiment $AO_{6k}LV_{0k}$, precipitation and the northward propagation of the

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Westafrican monsoon during summer is underestimated in comparison with paleoevidence (Bartlein 2011). We will extend the Appendix by comparing and discussing precipitation and wind change plots for experiments $AO_{6k}LV_{6k}$ and $AO_{6k}LV_{0k}$ to the control, as requested.
Subsequently, we can relate reduced surface winds to reductions in coastal upwelling during the mid-Holocene as noted by Adkins et al. (2006). We also conclude that changes in orbital forcing alone are not the driver of changes in precipitation and surface winds, but land surface-climate feedbacks play an important role.

(2) Second, the authors should make some important changes in how they compare to sediment core data. For ODP658C, they should compare to the flux data of Adkins et al., 2006 rather than the fluxes presented in deMenocal et al., 2000; the Adkins record accounts for sediment redistribution and gives a better estimate of vertical sediment rain rates. In addition, as pointed out previously by reviewer 1, the authors should ensure that the grain size of the dust being simulated and compared to fluxes along the margin is similar to that in the cores; McGee et al. (2013) report the grain size distribution of the eolian fraction, and eolian material deposited at these sites is quite coarse.

We agree that it is better to compare to core data of Adkins et al. (2006) rather than to the ones given by deMenocal et al. (2000). Accordingly, we will change Fig. 4, Fig. 5 and Table 4 in the manuscript (see attached Table 1, Fig. 3 and Fig. 4). Deposition fluxes indicated by the core data of Adkins et al. (2006) show an increase of fluxes by factor 2.4 between 0k and 6k, which matches the result of our study, where we find a factor between 2 and 3. Log correlation coefficients change to 0.89 for $0k$ and 0.85 for $6k$. On Page 5277, line 1, we reference to both studies, but mention that values are taken from the Adkins et al. (2006) study. A discussion about grain size distribution along the margin is included in the answer to referee 1 and we will add a comparison of grain size distribution of observed and modeled deposition fluxes in the revised

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manuscript.

Minor comments:

- *Page 5270, line 22: Is insolation here averaged over the entire hemisphere and the entire sum- mer?*

  Yes, insolation is averaged over the entire Northern hemisphere and for the summer season (JJA). In average, that is 437.37 W/m^2 for 0k and 457.91 W/m^2 for 6k, which makes and increase of 4.5% for 6k.

- *Page 5270, line 24: This could be stated more precisely. The land-sea temp gradient at 6 ka may have been high prior to monsoon onset in late spring, but after monsoon onset land surface temperatures should actually cool in North Africa due to more moisture availability and thus greater partitioning of absorbed radiation into latent heat.*

  The specification 'prior to monsoon onset in late spring' will be added.

- *Page 5271, line 12: Note that the timing of the mid-Holocene rise in dust in McGee et al. is esti- mated as 4.9 $\pm$ 0.2 ka rather than the 5.5 ka age estimated solely from the ODP658C record. It's still uncertain which is right, but the range should be noted.*

  The different timing will be considered in the manuscript (Abstract and Introduction).

- *Page 5271, line 17: Explain how changing SSTs are thought to impact dust accumulation. Do Adkins et al really state that the dust flux changes are solely driven by SSTs, and not other aspects of early/mid-Holocene climate?*

  The increased solar radiation during the mid-Holocene led to a strengthening of the Westafrican monsoon, which weakened surface winds leading to reduced

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coastal upwelling intensity and sea surface temperature deviations. Dust emission occurs above a certain threshold wind velocity and thus less dust could be transported, when surface winds are reduced. Thus, Adkins et al. (2006) linked changes in African aridity to changes in coastal upwelling intensity. Changes in SST are rather an indicator of a varying upwelling intensity. The formulation will be corrected.

- *Page 5279, line 18: Increased rainfall averaged over what area?*

  All the results relate to the area of North Africa as defined in Table 6. 'In North Africa' will be added in the former sentence and the reference to Table 6 will be added as already proposed by Referee 1.

- *Page 5306: Over what area is dust emission averaged?*

  Emissions are averaged over North Africa (17°W - 40°E; 10°N - 30°N).

- Other comments will be changed as suggested.

Marine sediment records						
No	Site	lat [°N]	lon [°E]	Acc. flux [$gm^{-2}a^{-1}$]		Reference
				$0k$	$6k$	
10	ODP 658C	20.75	-18.58	19.2	8.1	Adkins et al. (2006)

Table 1. Dust accumulation fluxes obtained from marine sediment cores close to the northwest African margin for $0k$ and $6k$.