Response to Comment on "Climate-Driven Ecosystem Succession in the Sahara: The Past 6000 Years"

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The Lake Yoa record and archaeological data provide adequate evidence that mid-Holocene aridification did not occur abruptly across all of North Africa. Modeling results on the issue of abrupt versus gradual desiccation of the Sahara are sufficiently diverse that paleoecological data from a continuous natural archive can usefully guide the evaluation of model parameters responsible for this diversity.

We thank Brovkin and Claussen (*1*) for their insightful comment and the opportunity to clarify our findings (*2*). We agree with the authors to the point that our reconstruction of gradual desiccation of the terrestrial ecosystem in the east-central Sahara does not necessarily imply weak biogeophysical feedback in the western Sahara and that land-atmosphere and/or atmosphere-vegetation interactions there may have been sufficiently different to have resulted in a distinct regional trajectory of mid-Holocene desiccation. The principal objective of our study (*2*) was to correct the popular notion (e.g., *3*–*6*) that the iconic record of Saharan dust deposition in marine sediments off the Mauritanian coast (*7*) represents Holocene landscape evolution across North Africa, including the central and eastern Sahara, and that climate-modeling results (*8*) supposedly support this exaggerated viewpoint.

We consider our paleoecological record from northern Chad to be representative for a sizable portion of the central and eastern Sahara (*2*). The conclusions of our study are consistent with the regional chronologies of multi-indicator archaeological evidence from shifting prehistoric occupation sites in the Egyptian and Sudanese Sahara, which similarly suggest a continuous southward retreat of monsoonal rainfall causing gradual environmental deterioration during the middle Holocene (*9*), notwithstanding transitory climatic perturbations that are a common feature of all desert margins.

We are aware of the moisture gradient between the western and eastern parts of the Sahara that is treated as such in recent climate-vegetation simulations (e.g., *10*–*12*). However, some state-of-the-art general circulation climate models (*13*) have suggested that landscape desiccation was gradual in both the eastern and western Sahara, consistent with our reconstruction, whereas other experiments with similar models (*11*, *14*) simulated mid-Holocene vegetation collapse exactly for the region where Lake Yoa is located [blue shaded area in figure 1 in (*1*)]. Also, the mechanisms considered responsible for abrupt vegetation changes observed in various model output are diverse: a positive vegetation-climate feedback due to modification of surface albedo (*15*, *16*), a threshold response of vegetation to particular modes of climate variability (*14*), microscale vegetation-soil feedback (*12*, *17*), or a transition from negative to positive vegetation-climate feedback at increasing time scales (*18*). Clearly, modeling results on the issue of abrupt versus gradual desiccation of the Sahara are sufficiently diverse that paleoecological data from a continuous natural archive (*2*) can usefully guide the evaluation of model parameters responsible for this diversity.

We subscribe to the caution formulated by Brovkin and Claussen (*1*) about the inferred rapidity of the mid-Holocene transition from a "green" to a barren Sahara recorded in the Ocean Drilling Program site 658 sediment sequence (*7*). Here we agree with Holmes (*19*) that the abrupt increase in dust flux at that location may be partly due to the relatively sudden desiccation of one or more large and shallow lake basins in the source area of dust delivered to the Atlantic Ocean offshore Mauritania; today this is mostly northern Mauritania and central Algeria. However, we are less optimistic than Brovkin and Claussen that a new summary of terrestrial climate-proxy records from the western Sahara will conclusively resolve the issue of whether ecosystem changes there were gradual or abrupt. All known depositional sequences from the region are incomplete over the critical time interval, and a continuous and high-quality paleoenvironmental archive comparable to the Lake Yoa sequence is unlikely to be found.

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