

Interactive comment on “Masked millennial-scale climate variations in South West Africa during the last glaciation” by I. Hessler et al.

I. Hessler et al.

ihessler@marum.de

Received and published: 13 February 2012

First of all we want to thank Reviewer 1 for taking the time to conduct the review and comment on our manuscript.

We are particularly thankful for Reviewer 1's comment that we also should consider the simplest possible explanation for the lack of a vegetation signal to abrupt climate change which is that the climate response to those events is too weak in the study area or that the vegetation is simply not sensitive enough. In the revised version this point will be added in chapter 5.2 (Abrupt climate variations in the African tropics).

Mg/Ca based summer sea surface temperature (SST) reconstructions of ODP Site 1078 reveal several warming episodes coinciding with HSs (Hessler et al., 2011).

C2643

Thus, there is evidence for an impact of high-latitude abrupt climate change on our study area. However, we need to consider that the climatic response to HSs may be simply too weak to noticeably affect the vegetation in Angola and the southern Congo Basin.'

We think that the University of Victoria (UVic) Earth System Climate Model (ESCM) is actually an appropriate choice in the context of our study due to its inclusion of a dynamic vegetation component (TRIFFID, Cox, 2001) and a land-surface component (MOSES2, Cox et al., 1999), providing the opportunity to model possible changes in the vegetation cover due to high-latitude abrupt climate variations. We also want to emphasise that we consider the results of the UVic ESCM simulations only as one possible but plausible explanation of the vegetation data. To clarify this point we will add a sentence in the Discussion section 5.3 (Are millennial-scale climate changes masked in South West Africa?).

We, therefore, hypothesise that the at least partial cancellation of the increased precipitation and evaporation results in a mitigation of the HSs response in South West Africa. As a result, the climatic impact on the study area is too weak to affect the vegetation composition, as evident from our pollen record (Figure 2A) and model experiments (Figure 3E). However, we want to emphasise that the UVic ESCM simulations only provide one possible but plausible explanation for the absence of HSs in the vegetation record of ODP 1078.

We agree with Reviewer1 on the point that the UVic ESCM has a simplified atmospheric component and is hence likely not capable of capturing shifts of the Intertropical Convergence Zone. However, support to our decision to apply the UVic ESCM for our purposes is given by the review of Stouffer and co-workers (2006), which showed convincingly that for present-day conditions the results from the Earth System Models of Intermediate Complexity (EMICs) are qualitatively comparable to

C2644

simulations of those models that contain an Atmospheric General Circulation Model (AGCM), which we also will mention in section 3.3. (Models and experiments).

Although this may be a limiting factor, Stouffer et al. (2006) showed convincingly for present day conditions that EMIC results are qualitatively comparable to the results of models that contain an Atmospheric General Circulation Model.

Furthermore, in order to test the reliability of the UVic ESCM, we compared them with results from HS1 and LGM simulations using the state-of-the-art Community Climate System Model Version 3 (CCSM3) (Merkel et al., 2010). The CCSM3 has a comprehensive atmospheric and land model component and shows a similar partial cancellation of changes in evaporation and precipitation (discussion paper page 3524 line 12-17). To emphasise the similarity of the UVic and CCSM3 model results we will add some highlighting sentences in the revised version of this manuscript in the Discussion section 5.3. (Are millennial-scale climate changes masked in South West Africa?)

We further want to highlight that our model results are supported by simulations conducted with a comprehensive climate model (CCSM3) (Merkel et al., 2010). The CCSM3 simulations suggest a similar partial cancellation of changes in evaporation and precipitation over South West Africa. Although the patterns and amplitudes slightly differ (not shown), they nevertheless support the findings from the UVic ESCM simulations.

There are certainly several water hosing experiments conducted with coupled GCMs and other models showing different amplitudes of e.g. the precipitation response to abrupt climate change in tropical Africa etc. However, our point is that the vegetation record does not show a response, which indeed implies that the effect of e.g. the precipitation change is not strong enough to change vegetation during abrupt climate events. This would be consistent with the rather weak signal in our study area shown

C2645

by other models as mentioned by Reviewer 1. A comprehensive intercomparison study, however, would be beyond the scope of this paper. The UVic results supported by the CCSM3 results give us a hint about the possible reason for the weak signal. It appears that it is the opposing changes in precipitation and evaporation that possibly mitigates the actual effect of abrupt climate change in the region, which is then too weak to affect the vegetation cover to a degree that may be recorded in the pollen composition of marine sediments. Therefore, we actually disagree with the statement that one can not learn something new from a "simple" model.

Specific comments:

Page 3512, line 13 => We called it "subcontinent" since it is referring to the land mass of Africa south of the equator and not only the country South Africa. However, in the revised version of the manuscript we will change it.

In general, atmospheric and oceanic processes controlling the tropical African climate and hence the vegetation composition is highly complex and still only partly understood (Gasse et al., 2008).

Although several tropical African vegetation and climate reconstructions indicate an impact of HSs in Southern Hemisphere Africa, our vegetation record shows no response.

Page 3513, line 8 => In the revised version we will remove the word "thermal" when we referring to Broecker (1998) and cite Stocker and Johnson (2003) when we use the term "thermal bipolar seesaw".

....the temperature decreases in the north and heat accumulates in the south which is representing the concept of the bipolar see-saw (Broecker, 1998; EPICA members. 2006; Barker et al., 2009).

C2646

Page 3523, line 14 => We did not state that southern African temperature follow Northern Hemisphere insolation but that it seems that our ODP 1078 *Podocarpus* record follows Tierney et al.'s (2008) Lake Tanganyika TEX₈₆ temperature record which is the one following Northern Hemisphere insolation. However, since the sentence appears to be a bit ambiguous and the mentioning of the Northern Hemisphere insolation in connection with Lake Tanganyika temperatures is indeed not of relevance in our study we changed the related sentence and paragraph as following.

Within dating uncertainties, there is an apparent similarity of our Podocarpus record to the east African Lake Tanganyika TEX₈₆ record which is considered to represent the lake's surface temperature (Figure 4; Tierney et al., 2008). Although the amount of precipitation and the duration of the rainy season is thought to be the main limiting factor for the tropical vegetation development, the temporal evolution of Afromontane Podocarpus resembles that of tropical East African temperature (Figure 4; Tierney et al., 2008). This suggests that in tropical high altitudes the temperature effect dominates over precipitation. As already suggested by Tierney et al. (2008) and supported by our data, it would also indicate that the warming in tropical Africa occurs several thousand years before the rise in atmospheric carbon dioxide concentration.

Page 3527, line 1 => We will change "reduced solar insolation" to "reduced insolation".
Due to reduced insolation and the presence of large ice sheets in the high latitudes of the Northern Hemisphere the African summer monsoon circulation was weaker during the last glacial compared to today (Braconnot et al., 2000; Gasse, 2000; Janicot, 2009; Revel et al., 2010).

References:

Broecker, W.S., 1998. Paleoocean circulation during the last deglaciation: A bipolar seesaw? *Palaeoceanography* 13, 119-121.

Cox, P.M., Betts, R.A., Bunton, C.B., Essery, R.L.H., Rowntree, P.R. and Smith, J.,
C2647

1999. The impact of new land surface physics on the GCM simulation of climate and climate sensitivity *Climate Dynamics* 15 (3), 183-203-203.

Cox, P.M., 2001. Description of the TRIFFID dynamic global vegetation model Hadley Center technical note 24, 1-17.

Merkel, U., Prange, M. and Schulz, M., 2010. ENSO variability and teleconnections during glacial climates *Quaternary Science Reviews* 29 (1-2), 86-100.

Stocker, T.F. and Johnsen, S.J., 2003. A minimum thermodynamic model for the bipolar seesaw *PALEOCEANOGRAPHY* 18 (4), 1087.

Stouffer, R., Yin, J., Gregory, J., Dixon, K., Spelman, M., Hurlin, W., Weaver, A., Eby, M., Flato, G., Hasumi, H., Hu, A., Jungclaus, J., Kamenkovich, I., Levermann, A., Montoya, M., Murakami, S., Nawrath, S., Oka, A., Peltier, W., Robitaille, D., Sokolov, A., Vettoretti, G. and Weber, S., 2006. Investigating the causes of the response of the thermohaline circulation to past and future climate changes *Journal of Climate* 19 (8), 1365-1387.

Tierney, J.E., Russell, J.M., Huang, Y., Damste, J.S.S., Hopmans, E.C. and Cohen, A.S., 2008. Northern Hemisphere Controls on Tropical Southeast African Climate During the Past 60,000 Years *Science* 322 (5899), 252-255.

Interactive comment on *Clim. Past Discuss.*, 7, 3511, 2011.

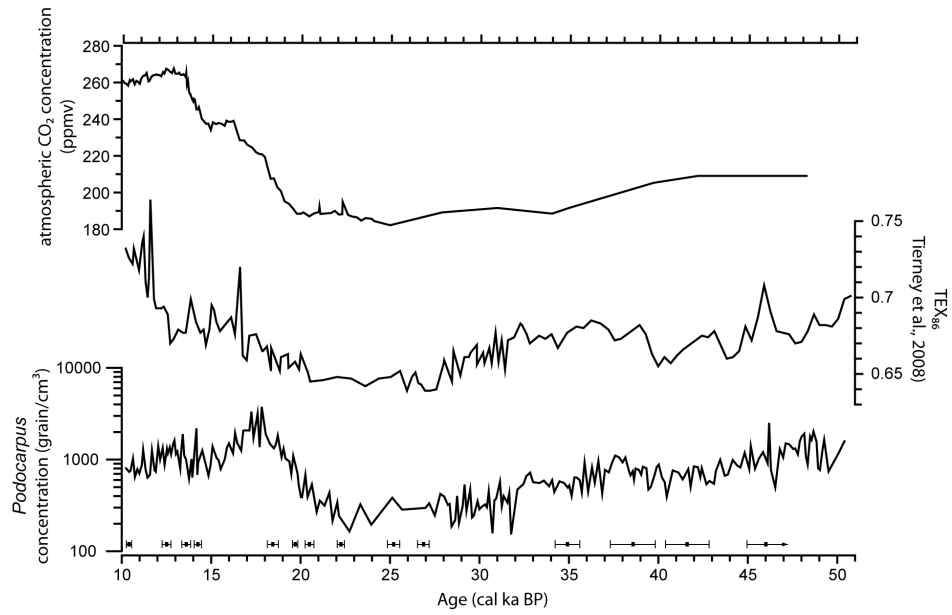


Fig. 1. new Figure 4. Concentrations of Podocarpus (grains/cm³) from ODP Site 1078 (bottom curve). Concentrations are given on log₁₀ scale in [grains/ml]. TEX₈₆ (middle) is considered to represent lake surfac