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Climate of the Past Discussions

Interactive comment on "Palaeo plant diversity in subtropical Africa – ecological assessment of a conceptual model of climate–vegetation interaction" *by* V. P. Groner et al.

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We prepared the authors response to the discussion comments under the assumption that we could also provide a revised track change version of the manuscript, as it was demanded by the Editor. Since this was not possible in the framework of the discussion structure, we here provide a supplementary comment to the comment of referee #2 in order to show more clearly the changes in the manuscript. The response to the comment of referee #1 does not include direct changes in the manuscript and is therefore not considered here.

Specific comment #1 – niche definition p.2670 l.20-26: "Claussen et al. (2013) assume

that each plant type can occupy a share of 1/N of the ecological space. The assumption of niche stability/conservatism - a concept that assumes species maintaining the parameters of their ecological niche following environmental change (Huntley et al., 1989; Peterson et al., 1999; Peterson, 2011; Stigall, 2012) - prohibits the replacement of disappearing plants by remaining plant types. These assumptions are hereinafter referred to as the "niche approach" (Claussen et al., 2013)."

p.2673 l.28 - p.2674 l.4: "The niche approach also implies that once a specific plant type retreats owing to water scarcity, there may not be any other type that is able to occupy its place in the ecological space. From an ecological point of view, existing plants likely benefit from the extinction of others by having less competition and more resources available. It is questionable whether these succeeding species can occupy the niches (ecological space) of disappearing species, including their way of using resources, and overtake their ecosystem functions, or if they just occupy the available barren area (geographical space)."

specific comment #2 - terminology p.2676 l. 20 "Throughout this paper, we use the terminology of phytogeographical plant types after Hely et al. (2014) whenever we refer to our work, including the descriptions of the adjusted model and simulations as well as results, discussions and conclusions. Since literature often refers to the terminology of physiognomic vegetation types, we stick with their terminology in citations and indicate the corresponding phytogeographical plant types after Hely et al. (2014) in brackets to prevent confusions."

specific comment #4 - Li p.2679 l. 8 "Values for Limax are chosen to qualitatively represent the variety of these aggregated properties following observation-based classifications (Hely et al., 2006, 2009)."

specific comment #7 – implications for earlier studies p. 2676 l.3 "These difficulties are not inconsistent with previous studies that proposed strong climate-vegetation feedback, resulting in abrupt shifts from a stable "green" state to a stable "desert" state.

For example, simulations by Claussen et al. (1999) were performed with the lowest possible number of PFTs, one tree and one grass. The low diversity implies a high likelihood for abrupt transitions (Scherer-Lorenzen, 2005; Claussen et al., 2013)."

p.2688 l.10 "Claussen et al. (2013) argued ecologically reasonable that it is difficult to determine the origin of system stability as the overall feedback strength depends on species composition. These difficulties are not inconsistent with previous studies that proposed strong climate-vegetation feedback, resulting in abrupt shifts from a stable "green" state to a stable "desert" state. Simulations by Claussen et al. (1999) were performed with the lowest possible number of PFTs, one tree and one grass. The low diversity implies a high likelihood for abrupt transitions (Scherer-Lorenzen, 2005; Claussen et al., 2013). In previous studies that focused on multiple stable states of the climate-vegetation system in North Africa, including those of Claussen et al. (1998), Liu et al. (2006a) and Bathiany et al. (2012), it was argued that an abrupt change emerging from the loss of stability of one of the stable climate-vegetation states causes abrupt changes in both the vegetation record and the hydroclimatic record. Our study, however, supports the hypothesis of Claussen et al. (2013) that in an ecosystem with rich plant diversity, multiple stable states can exist, even if the hydroclimate record shows a gradual transition. Hence the latter studies do not invalidate the earlier considerations."

specific comment #8 – abstract "We here critically re-assess a conceptual model dealing with the potential effect of plant diversity on climate-vegetation feedback, and provide an improved version adjusted to plant types that prevailed during the African Humid Period (AHP). Our work contributes to the understanding of the timing and abruptness of vegetation decline at the end of the AHP, investigated by various working groups during the past two decades using a wide range of model and palaeoproxy reconstruction approaches. While some studies indicated an abrupt collapse of vegetation at the end of the AHP, others suggested a gradual decline. Claussen et al. (2013) introduced a new aspect in the discussion, proposing that plant diversity in terms of moisture requirements could affect the strength of climate-vegetation feedback. In a

conceptual model study, the authors illustrated that high plant diversity could stabilize an ecosystem, whereas a reduction in plant diversity might allow for an abrupt regime shift under gradually changing environmental conditions. In the light of recently published pollen data and the current state of ecological literature, the conceptual model by Claussen et al. (2013) reproduces the main features of different plant types interacting together with climate, but it does not capture the reconstructed diversity of AHP vegetation. Especially tropical gallery forest taxa, indirectly linked to local precipitation, are not appropriately represented. With a new model version adjusted to AHP vegetation we can simulate a diverse mosaic-like environment as reconstructed from pollen, and we observe a stabilizing effect of high functional diversity on vegetation cover and precipitation. Sensitivity studies with different combinations of plant types highlight the importance of plant composition on system stability, and the stabilizing or destabilizing potential a single plant type may inherit. The model's simplicity limits its application, however it provides a useful tool to study the roles of real plant types in an ecosystem and their combined climate-vegetation feedback under changing precipitation regimes."

specific comment #13 – last paragraph about DGVMs "For further studies on the effect of plant diversity on the stability of climate-vegetation systems, we propose not to complicate the conceptual model any further by introducing more ad hoc tunable parameters, but to transfer the lessons learned from this study to a comprehensive dynamic vegetation model. Our Earth System Model MPI-ESM did not show abrupt transitions of large scale vegetation cover in previous transient Holocene simulations, and the understanding we gained in this study can help to investigate whether this is an effect emerging from the representation of diversity in our land surface model JSBACH. This process-based model offers the possibility to represent different degrees of plant diversity in various plant properties, and a variety of interactions with the atmosphere to address arising question: Could a more complex model depict AHP plant diversity and reproduce the results from our qualitative conceptual study? Would changes in plant diversity stabilize or destabilize the climate vegetation system in coupled GCM simulations? Could new PFTs designed after pollen reconstructions better represent plant

diversity in subtropical Africa? Could the implementation of additional processes in JSBACH, such as root- or light-competition, or additional plant properties, such as fire-resistance, lead to new effects on the climate-vegetation system stability? In summary, a deeper understanding of the role that plant diversity can play in climate-vegetation interaction, and an improved representation of plant diversity based on pollen reconstructions, could in coupled GCM simulations allow for a more realistic consideration of plant-plant interaction and climate-vegetation feedback."

technical corrections - role of Sudanian type p.2684 l.13 "The system has now simplified to just two plant types and those are nearing their thresholds, which causes the increase in fluctuations. The increase in fluctuations is one of the proposed early warning signals for regime shifts (Scheffer et al., 2001, 2009)".

p. 2685 l.17 "This is mainly because the Sudanian type was prescribed the highest potential effective leaf area, and its removal leaves the interaction with climate to the Saharan and the Sahelian type, which are both sensitive to changes in precipitation and respond abruptly when their minimum thresholds PiC1 are crossed."

Interactive comment on Clim. Past Discuss., 11, 2665, 2015.