Clim. Past Discuss., 9, C813–C817, 2013
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Climate of the Past Discussions
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Interactive comment on "Impact of the Megalake Chad on climate and vegetation during the late Pliocene and the mid-Holocene" *by* C. Contoux et al.

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Received and published: 21 May 2013

First the authors would like to thank the referee for reviewing the manuscript and for his useful comments. We answer the referee's specific comments below, and corresponding changes will be integrated to the manuscript. Technical corrections are welcome and will be taken into account.

Page 1369, line 17: "It would be interesting here to describe how the extent and shape of MLC was chosen for the simulations where a lake is imposed."

We thank the reviewer for this relevant comment, it is important to mention how this extent was calculated. We added this description in the text: "In order to be the closest

possible from Schuster et al. (2005) topographic reconstruction of the MLC extent, we ran the HYDRA routing surface model (Coe, 2000) with direct outputs of the standard Pliocene coupled model simulation, which totally fills the MLC which then outflows in the Benue river, providing the maximum extent of the MLC. The simulated extent and shape were then regridded to 1°x1° resolution and define the MLC boundary condition as shown in Fig 1."

Page 1370, line 19: "More detail about the SST distribution used would be useful here, how confident can we be in it? What is the reason for using anomalies?"

This comment was also done by the other reviewer, and we added more description on the Plio_max SSTs. Anomalies are used in order to avoid model biases. With this method, we add the changes between one simulated climate (Pliocene or mid Holocene) and the simulated preindustrial climate, to the modern climatology (from observations). This suppresses the inherent model biases, only adding the change simulated by the model. Of course, there is no guarantee that this change is right. About the description of Plio_max SSTs, in addition to what we added in response to the other reviewer, we added: "This insolation forcing globally warms the northern hemisphere SSTs and cools the southern hemisphere SSTs compared to the Plio simulations. Temperatures in the Gulf of Guinea are cooler than in the Plio simulation." About the confidence: there are two things we can say. First, Pliocene SSTs (Plio experiment) have been calculated using the PlioMIP protocol. They are compared to other simulations in Haywood et al. 2013, and show generally low levels of warming, with SSTs and ocean SATs very comparable to MRI and CCSM models. The uncertainty then comes from the model's response to orbital forcing. Second, PRISM3 SST reconstruction (Dowsett et al., 2009) was designed in order to capture "mean interglacial conditions" via the warm peak averaging technique (see Dowsett and Robinson, 2006 & Dowsett, 2007). Thus, our Plio_max SSTs, which represent extreme interglacial conditions, should be at least as warm as the PRISM3 SST reconstruction for the North Atlantic sites. Unfortunately, Plio_max SSTs have the same drawbacks than Plio SSTs, and although

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1.5 to 2 degrees warmer, they are still several degrees colder than PRISM3 SSTs. Nevertheless, all of PlioMIP models are unable to reproduce the PRISM3 SSTs with a modern day insolation, so this is not a particular feature of our simulations.

Page 1377 "Differences between models, including that of Krinner should be addressed in terms of each results reliability/uncertainty."

It is difficult to state on the reliability of these results, or say that one is better than the other. We added a discussion on the robustness of our results and of Krinner's in the discussion section, which was rewritten and now reads like this: "Tests carried out with our configuration but with the Hoelzmann et al. (1998) water surface conditions lead to inhibition of deep convection over the MLC and wetlands, and weak redistribution of precipitation with no significant increase over the latitudinal average, suggesting the surface boundary condition is not the driver of the differences between the two studies. Although other relatively minor differences exist in the setup of K12 compared to this study, it seems the key factor triggering the higher sensitivity of the model to the presence of surface water in K12 study is the different boundary layer parameterization, which leads to more convection. The remote effect of surface waters in North Africa might thus be underestimated in state-of-the-art climate models which have good skills on the global scale but which are not tuned to properly represent a given region. In our simulations the megalake feedback is similar in the three climatic contexts, small biome changes outside the Chad basin are only noticeable in the Plio max configuration. This suggests a wider impact of the MLC in a more humid background climate, the threshold to trigger a remote impact of the MLC being harder to attain in our simulations than in K12, because of a standard parameterization of the boundary layer. Nevertheless, a robust feature is what happens above and in the direct vicinity of the lake (i.e. reduction of deep convection because of colder surface, and redistribution of moisture at the north and east via increase surface winds and anticyclonic circulation). These mechanisms take place probably everytime that a megalake is present in a warm climate. Remote impact of the megalake Chad alone or with extended wetland area is mostly

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not simulated in these studies, but the response of climate to this forcing is dependent on boundary layer parameterization, and maybe also on convection parameterization (Chikira et al., 2006)"

Page 1371, line 16 and Page 1372, line 2: “Pre-industrial CO2 levels of 280 ppm are used for the mid-Holocene experiment where as we might expect a slightly lower value. This choice should be discussed especially with consideration for the BIOME4 predictions which may be significantly different depending on the CO2 level used. It may be appropriate to test the impact of lower CO2 on the BIOME4 predictions. Attached are BIOME4 predictions for 6000 years ago driven by HadCM3 using 265 ppm (Fig1) and 280ppm (Fig2)."

We thank the reviewer for this comment, and we agree that we have never considered a lower value than 280 ppm for the mid-Holocene. We used 280 ppm because it is the value imposed by the PMIP3 protocol for the mid Holocene. It is highly probable that CO2 changes impact the vegetation pattern, but it is not the purpose of this study, which only considers the impact of a MLC on climate and vegetation. Nevertheless, your figures depict a drastic change for only 15 ppm CO2 change. Our experiments are carried out using the anomaly method to force the BIOME4 model, as done in Salzmann et al. 2008 or Pound et al. 2011. I suppose it is not the case in the simulations you show in these figures, hence the important changes seen (?). In any case, your simulation of vegetation with 280 ppm seems to be in better agreement with the BIOME6000 vegetation map than the 265 ppm-one, at least from what I can see on the figures. This suggests that a 265 ppm value makes it even more difficult to reproduce the wet conditions of North Africa at 6kyr.

Page 1393, Fig 6 and Page 1393 Fig 7, “How is significance tested/calculated here?”

We thank the reviewer for noticing this lack of information. Significance is calculated by a Student test. We added “difference is significant at 95% in a Student test” in the captions of Fig 6 and 7.

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Page 1364, line 24: “Consider rephrasing as anyone understanding terms such as ’Soudanian’ would surely already be familiar with the region.”

The reviewer is right. Replaced by “tropical humid (sudanian)”.

Page 1368, line 5: “missing ’the’ (beneath the continental water surface.)” Corrected.

Page 1368, line11: “missing ’the’ (and the surface scheme)” Corrected.

Page 1370, line14: “missing ’the’ (Because the precession parameter)”.Corrected. (this is a typical French complex. English teachers at school keep telling us not to put “the” everywhere, so we end up removing them more than necessary.)

Page 1370, line15: “northerly, not northern”. Corrected.

Interactive comment on Clim. Past Discuss., 9, 1363, 2013.