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Climate of the Past Discussions

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Interactive Comment

Interactive comment on "On the importance of initial conditions for simulations of the Mid-Holocene climate" *by* H. Renssen et al.

H. Renssen et al.

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Author's reply to referee #1

We would like to thank the referee for the thorough review.

Below we provide a detailed reply to all comments

Major comments

Referee's major comment (1) Additional analyses should be provided on the differences between the different initial states. Numbers provided for the ocean overturning suggest that they only differ in the surface ocean, which could be one of the reasons why there is only a small impact on the final results. This deserves some discussion

Reply: The deep ocean is certainly influenced by the initial results. Please note that the “global ocean temperature” (Table 1, Figure 1a) is integrated over all depths, implying that it provides information on the deep ocean. This global ocean temperature takes about 600 years (576 years to be precise) to reach the 6 ka equilibrium. We include now also the surface temperature curve (new Figure 1b), which shows that in 6kPI the surface reaches the 6 ka equilibrium values in about 200 years (181 years to be precise). The difference in the response times can be attributed to relatively slow warming of the deep oceans. Consequently, in the preindustrial initial state used for 6kPI, the deep ocean is significantly cooler than in the initial state used for 6k9k and 6kTR. Despite this temperature difference, the overall overturning circulation had a similar strength in both initial states. We have clarified this in the revised manuscript in Section 2.

Referee’s major comment (2) A figure showing a latitude-depth section of temperature, salinity or density for the initial and final states could be interesting. I have difficulties to figure out that every thing is so similar between the simulations that it is a waste of time to run a long transient simulation on the Holocene, when snap shots on small periods of interest would be sufficient.

Reply: As suggested, we have included in the revised manuscript a latitude-depth section for temperature for the initial and final states of 6kPI and 6k9k (new Figure 2ab). Figure 2a shows that, compared to the preindustrial initial state, the 9 ka initial state was particularly warmer at high latitudes due to the relatively high summer insolation values around this time (see discussion by Renssen et al., 2005a,b). As a result the deep and intermediate waters formed at high latitudes are also warmer than in the preindustrial case. An exception is formed by the northern tropics that are slightly cooler in the 9 ka case. A comparison of the final states of 6k9k and 6kPI (Figure 2b) shows that this anomaly pattern has disappeared, leaving no consistent anomalies in agreement with Figure 1a. The same is true for the final state of 6kTR (not shown). This is discussed in a new paragraph in Section 3.

Referee’s major comment (3) The simulations do not include the remnant ice sheet.

Could the fresh water induced by the ice-sheet affect the ocean circulation in such a way that the 6ka simulation would not be simply in equilibrium with the insolation forcing?

Reply: According to reconstructions (e.g., Peltier, 1994), the Laurentide Icesheet was totally gone by 7 ka. Assuming that the system adjusts within 600 yrs (see our response to major point 1), the impact of this remnant ice-sheet on the 6 ka climate would thus be negligible. This is confirmed by sensitivity experiments that were performed to test the impact of three different effects of the remnant Laurentide Icesheet on the early Holocene climate: 1) effect of meltwater, 2) effect of surface albedo, and 3) effect of topography. In Renssen et al. (2005a), we have tested the effect of topography and surface albedo of a remnant Laurentide Icesheet on the early-Holocene climate in the same model. As expected, the climate was cooler, especially in the summer season (-0.4°C North of 60°N). After removal of this remnant ice sheet, the model quickly returned to the state without remnant Laurentide Icesheet (Renssen et al., 2005a). Wiersma et al. (2006) have studied the impact of the background meltwater flow from the Laurentide Icesheet in ECBilt-CLIO. They found that this meltwater causes a cessation of deep convection in the Labrador Sea, resulting in an overall weakening of the maximum meridional overturning in the Atlantic Ocean by 7 Sv. This caused a cooling in the North Atlantic region, with a maximum temperature decrease of 2°C in the Labrador Sea (Wiersma et al. 2006). Unpublished sensitivity experiments have revealed that this weakened overturning state is not stable and that it returns to the state with Labrador Sea deep convection within 600 years if the background meltwater flow is removed. In the revised manuscript, we have added a new paragraph to Section 2 to discuss this issue.

Referee's major comment (4) Several regions could potentially provide instabilities resulting from abrupt changes in vegetation. The focus of this paper requires a discussion on the behaviour of the vegetation at the global scale. Results for Africa then could be provided as a specific case, but we have first to make sure that the adjustment of the

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different types of vegetation converge towards the same solution at the global scale, and that other regions do not have spurious behaviours.

Reply: As mentioned in Section 3 of the revised manuscript, we have performed a student-t test on vegetation cover and found no regions with significant differences at a 95% level. This is consistent with our analysis of global climate, with temperature and precipitation also showing no significant differences at the 95% level. The vegetation cover maps thus do not provide any additional information and we have therefore decided not to include it in this paper.

Minor comments

Referee's minor comment (1) An additional figure showing the global adjustment of vegetation would be welcome.

Reply: We have constructed a figure showing the time series of global vegetation cover. This shows that the vegetation reached the level of the final 6 ka equilibrium in 200 years (i.e. it reaches the average level of the last 100 yrs), which is the response time-scale of the surface climate (see Figure 1b). We have decided not to show these time-series, as they do not provide any additional information.

Referee's minor comment (2) Figure for the ocean (see comment 2 above) also needed.

Reply: As requested, we have added a figure (Figure 2ab) in the revised manuscript showing a latitude-depth profile for temperature for the initial and final states of 6kPI and 6k9k.

Referee's minor comment (3) Model and experimental setup. Please provide rapid description of the major differences between model versions, together with the role they have on the simulated climate.

Reply: Compared to version 2, the present model version 3 simulates a climate that is closer to modern observations. The most important improvements in the new version

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are a new land surface scheme that takes into account the heat capacity of the soil, and the use of isopycnal diffusion as well as Gent and McWilliams parameterization to represent the effect of meso-scale eddies in the ocean (Gent and McWilliams 1990). This is briefly discussed in Section 2 of the revised manuscript.

Referee's minor comment (4) Provide a discussion on the limitation of the 9ka simulation compared to the "real world". Is there some effect neglected that could affect the conclusions (ex ice-sheet).

Reply: For the effect of the remnant ice sheet, please read our reply to major point 3. We have compared the 9 ka results with proxy data at high latitudes (Renssen et al., 2005ab). This comparison shows a general agreement with data, suggesting that the 9 ka simulation provides a reasonable representation of the "real world".

Referee's minor comment (5) Explain which adjustment of the model is at the origin of the different conclusions for North Africa.

Reply: Model version 3 is different on a number of points (please read our reply to minor point 3) and the model has also been re-tuned. As a result, the climate over Africa is somewhat different, but it is impossible to point to one specific adjustment that has changes the sensitivity of our model to Holocene forcings in northern Africa.

Referee's minor comment (6) The conclusion of the minimum time of adjustment is interesting. This should be better emphasised and discuss. How is this estimation made? What are the important criteria? How long should the simulation be run to have no statistical differences at the surface (I suppose 100 to 200 years). Discuss which time scale in the adjustment is due to vegetation, which time scale is due to vegetation, and how they combine to produce the final result.

Reply: We have defined the adjustment time as the moment at which the final 6 ka level is reached in Figure 1a (global mean ocean temperature) and b (10-year running mean of global mean surface temperature). For the 6kPI experiment, this adjustment time is about 600 years (or 576 years to be exact) for the global mean ocean temperature and 200 years (181 yrs to be exact) for the surface temperature. The vegetation also adjusts to the forcing in about 200 years. We clarify this issue in the last paragraph of Section 3 of the revised manuscript.

Interactive comment on Clim. Past Discuss., 2, 315, 2006.

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