Final author's response to "interactive comments on ***Tropical vegetation response to Heinrich Event 1 as simulated with the UVic ESCM and CCSM3*** by D. Handiani et al."

By Handiani et al.

**Response to Anonymous Referee#1**

The authors want to thank the editor and anonymous referee #1 for the helpful comments and suggestions. In the following we answer individually to each of the referee #1 comments.

*General comments*

*Handiani and co-authors present a numerical study on the tropical vegetation response to a collapse of the AMOC under LGM conditions, mimicking HE1, with two climate models of different complexity (UVic and CCSM3). This paper is well written, with appropriate references (a few could be added, see specific comments) and clear figures. My main concern is about the novelty of the work presented here. As mentioned by the authors, previous modeling work has already tackled the issue of the vegetation response to an AMOC collapse (e.g.: Scholz et al 2003, Köhler et al, 2005, Menviel et al, 2008, cited in this paper, see also Bozbiyik et al, 2011). Yet, none of these studies provides a detailed model/data comparison for the tropical sites, which is one of the most interesting results presented here. However, a very similar study can be found in Handiani et al, 2012 and the new version of the UVic model used here has not changed the conclusions of this previous study. The new results come from the CCSM3 model + LPJ, a model of higher complexity. The use of this model, with a better representation of the hydrological cycle, is an improvement compared to the previous study of Handiani et al (2012).* ***However, I do not agree with the statement that similar response of vegetation patterns are found with both models.***

***In my opinion, the vegetation pattern simulated with UVic+TRIFFID and CCSM3+LPJ show important differences. I would like more detailed discussion focused on explaining/discussing these differences between the two models.*** *In my opinion the concerns and comments detailed above do not warrant a rejection of the paper.* ***However, I highly recommend that the main results and conclusions be better highlighted. More importantly, I think it is critical that the authors detail how exactly this study brings new information to a subject that has already been discussed in prior publications****.*

**Answer***:*

- We implemented the recommendations. We included more specific results regarding the vegetation pattern differences between the UVic ESCM and the CCSM3 in the abstract (p. 1, lines 22-26) of the revised manuscript.
- We also improved our discussion and conclusion sections to highlight our new results compared to the earlier publications. As an example: we discuss the response of surface

temperature and precipitation due to AMOC changes in the two models and continue with the vegetation response to the change in climate conditions (p. 12-13). As far as we know, there have only been very few studies that compare the response of vegetation cover under HE1-like climate conditions in different earth-system models. For example, Kageyama et al. (2010) also compare two such models, but both contain a simplified atmospheric component, there is less emphasis on vegetation change and no biome reconstruction and detailed model-data comparison. Furthermore, Kageyama et al. (2013) focus on atmospheric and oceanic variables only and do not take vegetation changes into account.

*Specific comments*

*1. Introduction*

*This section is well written, with appropriate references. Concerning modeling work about the response of vegetation to changes in the AMOC, the authors could add a reference to the work of Tjallingii et al, (2008), Bozbiyik at al (2011) and Woillez et al (2012). The author also missed the modeling work of Claussen et al (2003). When presenting vegetation changes in the tropics simultaneous to North Atlantic temperature changes during HE1, the authors should also mention the type of vegetation before the event. e.g.: "some examples are found in Eastern tropical Africa, where grassland and dry shrubland occurred due to a fairly cold and dry climate" The reader does not know which vegetation type is replaced by grassland and shrublands.*

**Answer***:* We implemented the suggestions:

- by adding literature references accordingly (p. 3, lines 8-14).
- by describing the vegetation pattern during the Last Glacial Maximum (LGM) to inform the reader regarding changes in vegetation during the HE1 period (p. 2, lines 22-32 and p. 3, lines 1-7), by adding the reconstructed LGM biomes from pollen records in Fig. 4a and the reconstructed LGM biomes from model outputs of UVic ESCM and CCSM3 in Figs. 5a and 5b.

*2. Models and experimental design*

*The author mention P.5363 L1 that the UVic ESCM contains a parameterization of anomalous near-surface winds but we learn only P.5364, L19 that this feature is new compared to the model version used in the previous study from Handiani et al, 2012. For easier reading, this paragraph should be moved to the beginning of the section. Description of the LGM simulations: please present briefly the LGM boundary conditions (which ice sheet reconstruction was used?). Do the boundary conditions between the UVic and CCSM3 simulations differ? Please also recall the location of the freshwater flux in the HE1 experiments for both models.*

*P.5365, L5: refer to Table 2.a, b instead of Table 2.*

**Answer***:* We implemented the suggestions. The explanation of parameterization of the wind feedback for the UVic ESCM is now on p. 4, lines 19-24. Information regarding the LGM

simulation can be found in Sect. 2. Boundary conditions, ice sheet configuration, and the location of the freshwater forcing in each model are described on p. 5, lines 12-32.

*3. Results*

*3.1 Climate changes*

*The regional pattern and amplitude of the surface air temperature anomaly is indeed very different between the two models. The difference is most pronounced in the North Atlantic, which should also be mentioned in the text. Why is the cooling in the UVic simulation limited to about only -3°C when it reaches at least -9°C with CCSM3?*

*Explaining the mechanisms responsible for these contrasted responses to a freshwater flux is not the main focus of this paper, but a brief explanation would be welcome. Which model is more in agreement with data?*

*The response of the hydrological cycle to the freshwater input in the North Atlantic is also very different between UVic and CCSM3. Is the ITCZ well represented in UVic?*

**Answer***:*

The much more diffusive heat transport in the simplified atmospheric component of the UVic ESCM most possibly causes the limited surface cooling in the North Atlantic Ocean in the UVic ESCM HE1 experiment. The atmosphere is represented by only one layer, the advective transport of moisture is vertically averaged and thus there is no vertical circulation or convection, which also influences the precipitation pattern in the model, most distinctly around the tropical rain belt. A brief explanation of the responsible mechanism for the contrasting results in both models can be found in Sect. 4, p. 12, lines 24-32 and p. 13, lines 1-12. Nevertheless, the UVic ESCM represents a shift in the tropical rainbelt by simulating less precipitation over the equatorial northern Atlantic Ocean and more precipitation over the southern Atlantic Ocean as a result of lower temperatures over the North Atlantic Ocean (Figs. 1b and 1e). Detailed results are described in Sect. 3.1.

*3.2 The vegetation cover response*

*Broadleaf evergreen trees: Fig.2.a and 2.b do not show the same pattern in the response of this PFT. The decrease in equatorial Africa is found only in CCSM3, and the decreases simulated in South America with UVic are not found in CCSM3. The response of the Sahel region is also different. Therefore, I do not agree with the sentence P5367, L10 saying that "the pattern was similar in CCSM3".*

*Needleleaf evergreen trees: this PFT is indeed relatively unaffected in both experiments. But do we have significant fractions of this PFT in the tropical regions? The regions showing a decrease are very small. How many grid cells of the Sahel region show a decrease and is it worth to comment on it?*

*Deciduous trees: the increase in Central Brazil is much larger in CCSM3 than in UVic. Please comment on it.*

*It seems that vegetation changes in tree cover in UVic occur only on the margins of the forested areas. It could be worth to add a figure with the vegetation distribution in both models for the control LGM experiments. As can be seen on Fig.4 the forest extension is very different and I would say that the differences in the vegetation response for the HE1 experiments strongly depend on the control vegetation state.*

*P.5368, L6-21: Fig.3 nicely shows the opposite response of trees and grass and the differences in the amplitude of the vegetation response in UVic and CCSM3. But I found this paragraph rather difficult to read. You should try to focus more on the main message from Fig.3*

**Answer***:*

- We withdrew the statement regarding the broadleaf evergreen trees response.
- We withdrew the statement regarding the needleleaf evergreen trees and include the new statement on p. 9, lines 1-4.
- We rewrote the statement regarding deciduous trees in the Sahel, see p. 9, lines 4-5. Then the discussion of deciduous trees changes in Central Brazil is continued and we also included the different responses of deciduous trees between the two models, p. 9, lines 5-8.
- The discussion of Fig. 3 (p. 9, lines 21-33 and p. 10, lines 1-7) was slightly restructured and rephrased for more clarity.

*3.3 Biome distribution comparison*

*I would be interested to see also a figure with the biome data and simulation results for the LGM. Do the models correctly simulate vegetation changes in agreement with data? How does the vegetation simulated in the LGM control simulations agree or disagree with reconstructions for HE1 and the LGM?*

**Answer***:* We implemented the suggestion. We added the reconstructed LGM biomes from pollen records in Fig. 4a and the LGM biomes reconstructed from the UVic ESCM and CCSM3 model output in Figs. 5a and 5b, respectively. The comparison between the models and proxy records for the LGM and HE1 periods is incorporated in Sec. 3.3 on p. 11, lines 4-31).

*4. Discussion*

*"This suggests that these regions were most sensitive to a shift of the tropical rainbelt in response to a slowdown of the AMOC" How much does that conclusion depend on the control glacial vegetation distribution? As mentioned previously the most sensitive regions seem to be the forest edges, which are very different between UVic and CCSM3.*

**Answer***:* We withdrew the statement. Indeed the Sahel region shows a robust response of the vegetation cover to HE1-like climate conditions in both models. This pattern is clearly shown in the annual mean anomalies of averaged tree and grass cover in the tropical Africa between the HE1 and the LGM periods (Figs. 3c and 3d).