Nov. 22, 2015

Editor, *TC*

Dear Tobias,

Thank you for handling our manuscript (#tc-2015-12). Following the comments of the two anonymous reviewers and you, we have carefully revised the manuscript. We revised the Figures 4, 6 and 8 and some texts as suggested. The detailed responses to each comment of the reviewers are attached in this letter.

- The results and discussion section is rather long. I suggest a separation of the results and discussion sections. This would also better highlight your results. However this is a matter of style and you may decide.

[Response] Thanks for the suggestion. In the BGD online version, the results and discussion sections are mixed in one section. It is very hard to separate the results and discussion from the mixed section now. We think this style may be helpful for readers to understand Figure 8 and 9. Thank you for your understanding.

- The caption of figure 8 is very long and the different described lines partly hard to find in the figure. Hence, include a legend to the figure including the most important lines. Include A and B for the left and right figure.

[Response] We revised Figure 8 and the legend following your suggestion.

- References:
o Update Rawlins et al. (2015);
o Any news about the McGuire et al. (in prep.)? Only published or accepted manuscript can be cited in the final manuscript.

[Response] We updated Rawlins et al. (2015) in the references list. McGuire et al. (in prep) has not been accepted yet, so we deleted this reference in the final manuscript and left Rawlins et al. (2015).

Best regards,
Shushi Peng (on behalf of all co-authors)

Responses to Anonymous Referee #1

This study uses nine land-surface models to simulate soil temperature (Ts) in permafrost regions during the period 1960-2000. Most models are well known and used in the land surface component of Earth System Models participating CMIP5 project. The different models are using different forcing datasets for climate and other model boundary conditions. The results were used to compare trends of simulated Ts at different depths during four decades and to assess the uncertainty of modeled Ts trends. The results were also used to identify which factors were most important for driving the Ts trends and to quantify the sensitivity of changes in near-surface permafrost area to warming.

The study distinguish the uncertainty caused by assigned parameter values and model structure from the uncertainty attributable to uncertain climate forcing data, and highlight the large uncertainty in soil temperature simulations on regional and global scales in permafrost areas. Publication of this kind of paper will be very timely and beneficial for further permafrost simulations in CMIP6 and will give a better understanding of the range of uncertainty in future projections of permafrost thermal state and distribution. The revised manuscript is well written and organized. It is clearly within the scope of The Cryosphere.

I will recommend that it should be published and have only some few minor comments and suggested changes as indicated below.

[Response] Thank you.

P18, L413-417: I propose to clarify, for example: "In addition, important processes in permafrost regions such as the dynamics of excessive ground ice (e.g. ice wedge growth and degradation) and thermokarst lakes (formation, expansion and drainage) should be developed and evaluated in land surface models to improve the prediction of future permafrost feedbacks (e.g. van Huissteden et al., 2013; Lee et al., 2014).

[Response] We revised it.

P34, Table 1: The bottom boundary geothermal heat flux is assumed to be zero in 8 of the 9 models. As far as I see this is not commented and could be more clarified/discussed in e.g. section 3.2 (P12-13). E.g. Nicolsky et al. 2007 made a consideration of this.

Nicolsky, D., Romanovsky, V., Alexeev, V., and Lawrence, D.: Improved modeling of permafrost dynamics in a GCM land-surface scheme, Geophys. Res. Lett., 34, L08501, doi:10.1029/2007GL029525, 2007.

[Response] We added this in the text (P12, L265-268). “For the bottom boundary geothermal heat flux, eight out of the nine model assumes to be zero. The ignored boundary geothermal heat flux is valid for the upper 20-30 m of soil within century scale (Nicolsky et al., 2007), but for millennium or longer glacial-interglacial cycle permafrost simulation, the bottom boundary geothermal heat flux should not be ignored”.

P21-22, Conclusions: To make it easier for readers that only reads the conclusions I suggest that you re-define the abbreviations for each of the variables Ts, Ta, LWDR, NSPA and regional mean Ts at their first appearance in the conclusions.

[Response] We re-defined the abbreviations in the conclusions.

P23, L515-517: See also a recent promising modeling approach for ground temperatures using remote sensing data and reanalysis products presented by Westermann et al. 2015.

Westermann, S., Østby, T. I., Gisnås, K., Schuler, T. V., and Etzelmüller, B.: A ground temperature map of the North Atlantic permafrost region based on remote sensing and reanalysis data, The Cryosphere, 9, 1303-1319, doi:10.5194/tc-9-1303-2015, 2015.

[Response] We cited Westermann et al. (2015) as one modeling approach for ground temperature integrating remote sensing data in their model (P23, L524-526). “These images could be used to independently evaluate soil surface temperature in models on a large scale or be integrated in ground temperature models (e.g. Westermann et al., 2015), although they have their own uncertainties.”

Responses to Anonymous Referee #2

In my opinion the authors have with few exceptions responded to and accounted for the comments of referee #1 and referee #2 in an adequate way. I understand the main concern from referee #2 that it would be ideal to separate the model and forcing uncertainty by running all the models with the same forcing and boundary conditions. I do however understand that this might not be feasible, and in my view this study adds valuable new knowledge on the three main objectives with the current approach.

[Response] Thank you for the review.

The three comments that in my opinion still need to be better accounted for or responded to are as follows.

- The negative Ts trend below 2.5m depth is now mentioned in the text and figure legend. However it is not explained or discussed in the text. This is in my opinion needed as it is a striking feature for instance in figure 5.

[Response] We added the explanation in the text (P11, L240-243): "UW-VIC shows a negative trend of Ts (i.e. cooling) at depths deeper than 2.5m, which may be related to higher soil heat capacities with increased soil moisture, resulting in cooler summertime soil temperatures and shallower active layers in the regions (Koven et al., 2015)."

Koven, C. D., Schuur, E. A. G., Schädel, C., Bohn, T. J., Burke, E. J., Chen, G., Chen, X., Ciais, P., Grosse, G., Harden, J. W., Hayes, D. J., Hugelius, G., Jafarov, E. E., Krinner, G., Kuhry, P., Lawrence, D. M., MacDougall, A. H., Marchenko, S. S., McGuire, A. D., Natali, S. M., Nicolsky, D. J., Olefeldt, D., Peng, S., Romanovsky, V. E., Schaefer, K. M., Strauss, J., Treat, C. C. and Turetsky, M.: A simplified, data-constrained approach to estimate the permafrost carbon-climate feedback, Philos. Trans. A. Math. Phys. Eng. Sci., 373(2054), doi:10.1098/rsta.2014.0423, 2015.

- Figure 4 and 6 now includes notes about the extreme values. I would however suggest that at least figure 6 is changed to include a wider range of values, as most of the figure now simply shows dark red or blue.

[Response] Thank you. We re-plotted Figure 4 and 6 with a wider range of values following your suggestion.

- The last sentence in section 2.1 ("some of their interactions") is still note explained. I would suggest ending the sentence after "… each driver on Ts", and then explain how the interactions come in to this analysis.

[Response] Following your suggestion, we added the explanation of the interactions in section 2.1 (P8, L161-165) and discussed the possible interactions in section 3.3. “Differences between two simulations were used to separate the controlling effect of each driver on Ts. The interaction between CO_2 and Ta, precipitation such as enhanced vegetation growth by increased Ta/precipitation could loss less water under higher CO2 condition, are also included in the differences between the two simulations.”