The Cryosphere Discussions

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Comment on tc-2022-150

Anonymous Referee #2

Referee comment on "Representation of soil hydrology in permafrost regions may explain large part of inter-model spread in simulated Arctic and subarctic climate" by Philipp de Vrese et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2022-150-RC2, 2022

The study "Representation of soil hydrology in permafrost regions may explain large part of inter-model spread in simulated Arctic and subarctic climate" by de Vrese et al. evaluates the impact of model settings influencing the hydrology in boreal and Arctic regions in the land surface model JSBACH. The purpose of the study is mainly to showcase the significant consequences of these settings on the simulated regional and even global climate, not so much to present new ways to resolve these shortcomings. But that is to be expected, given the magnitude of the problem.
The study follows a logic setup and the results are of great interest to the readers of TC. The manuscript is well written and I recommend publication after addressing the following points:

Major comment:
The authors focus the results on annual averages, but in most cases do not present the seasonality, which is important for understanding the changes. Two concrete examples in the following, but this aspect should be taken into account more throughout the entire manuscript:
L. 449 ff: This is a really important paragraph which should be extended by presenting the seasonality of the effects. As an example, 0.2mm per day corresponds to about 70mm per year, but I guess this difference will mostly accumulate in summer and fall when most of the evaporation occurs? Are there differences in the snowfall which could possibly affect the insulation of the snowpack and thus ground temperatures? Same for the cloud feeback, total incoming radiation (short- plus long-wave) should generally reduce for cloudy skies in summer, but increase in winter. So when is cloudiness increased, all year or mainly in summer?
L. 519 ff: same here, would be really nice to present the seasonality of the effects. The authors emphasize the importance of permafrost many times, and the winter aspect, especially the snow cover, is highly important for permafrost occurrence and thaw.

Minor comments:
-Introduction: there are very relevant model studies on paleoclimate that should be cited, e.g. Renssen, H., Isarin, R. F. B., Vandenberghe, J., Lautenschlager, M., & Schlese, U. (2000). Permafrost as a critical factor in paleoclimate modelling: the Younger Dryas case in Europe. Earth and Planetary Science Letters, 176(1), 1-5.
-Sect. 2.2 Why is the W2D setup not presented here?
-L. 251 ff, "supercooled water": this implementation seems weird, the increasing ice content should simply decrease the hydraulic conductivity, thus limiting and finally suppressing both vertical and lateral flow? I agree that setting water mobility to zero for temperatures below the freezing point is better than allowing free flow as in unfrozen soils, but making the hydraulic conductivity dependent on water/ice content should be really straight-forward solution.
-Fig. 8: My opinion, but I think the figure would be easier to read if the authors selected a more "traditional" design. Since the graphs are labelled a,b,c,d anyway, they could for example distinguish the individual bars in each plot by colors, but re-use the same colors in all plots.
-Fig. 10 i: explain the grey area in the caption