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The Cryosphere
Discussions

Interactive comment on "Detecting the permafrost carbon feedback: Talik formation and increased cold-season respiration as precursors to sink-to-source transitions" *by* Nicholas C. Parazoo et al.

Anonymous Referee #2

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Overall impression

In the current study, Parazoo and colleagues have used the land surface model CLM4.5 to simulate permafrost state and changes from 2010 to 2300 under strong warming following the RCP8.5 scenario. They have investigated how permafrost degradation evolves in space and time, with a special focus on how talik formation affects thaw dynamics. Further, the authors have used their model experiment to analyse how future C fluxes in permafrost regions will evolve and when a carbon sink to source transition is likely to occur along different regions of the permafrost domain.

The presented analyses are helpful for increasing our process understanding of how individual factors explain inferred differences in simulated carbon fluxes between cold and warmer permafrost regions. E.g. the authors find that cold permafrost locations become C sources due to altered thaw-season dynamics while transitions of warm permafrost regions are mainly affected by changes in cold season dynamics. Further, the authors discuss how the presented results of this study can help finding an (optimal) design for monitoring the thermal and carbon state and changes in permafrost regions. The paper is well structured and written, and model analyses were performed elaborately. Adding new insights into permafrost degradation and carbon dynamics, this study can be considered of broad interest to the readership of The Cryosphere.

General comments

1) Initial SOC storages The initialized soil C stocks play a key role in affecting simulated future C release and the timing for a sink to source transition. In the study presented, no information is given how these C stocks were initialized for the simulation setting used here (besides referring to two previous CLM4.5 studies). Information should be provided in a sub-section on how SOC stocks were initialized, and on how these stocks compare to observed data (e.g. NCSCD - in terms of total storages and with regard to CLM4.5 inferred high (peaty) SOC storages at northern grid cells). As talik formation down to some meters are analysed in this study, I wonder how deep SOC is initialized in the soil column? Can e.g. soil thaw deeper than 3 meters further increase the pool of thawed carbon available for decomposition? A further key factor not discussed in the manuscript concerns assumptions about SOM lability made in the model. As especially uncertainty in slowly decomposing SOM is very high, I wonder how different settings of a humus timescale parameter (or different partitioning between labile and less labile pools) would affect inferred sink to source transition times? If feasible, this would be worth exploring by an extra sensitivity run, or at least by discussing qualitatively the impact of uncertainty in assumed SOM decomposition timescales on the findings discussed here.

Talik formation

The study focuses on talik formation as a key process which leads to abrupt permafrost degradation. The discussion (and the model simulation) is done for non-lake environments. Talik formation through thermokarst lake initialisation is not considered and mentioned. Yet this process is known to lead to rapid thaw through pronounced sub-lake talik formation, which can strongly affect carbon release from thawed sub-lake sediments. Although it is questionable to which extent future Arctic landscapes will be affected by thermokarst formation, this process should be discussed in the context of future permafrost degradation and permafrost carbon release.

Vegetation distribution

As discussed extensively in the presented paper, the Arctic land carbon balance is determined by changes in the net flux of vegetation carbon uptake and respiration losses. To what extent is CLM4.5 able capturing high latitude vegetation distribution/patterns? Some short discussion on simulated high latitude vegetation in CLM4.5 would be interesting to include.

Cumulated C fluxes

I guess you want to discuss C source numbers as PgC per year? (L387). Please specify in the text and in Fig.7B y-axis label. How does the cumulative C source from 2010-2300 of 11.6 PgC relate to shown C release rates in Fig. 7B? If I interpret numbers shown correctly, these suggest much larger cumulative release. Given published work on total C release from future permafrost degradation under RCP8.5 in other studies (suggesting much larger release), this number (total C release) should be discussed in the context of existing estimates.

Specific comments

Results presented in this study are inferred for the RCP8.5 scenario. This should be made more clear in the text (when discussing future evolution of permafrost and carbon

fluxes), and in some of the figure legends.

Please check for consistent/correct use of NBP sink/source definition (e.g. L410) Fig.8: Did you intend to put the dashed horizontal NBP threshold line at -25 gCm-2yr-1 - in accordance with your definition?

I wonder whether a discussion of a bi-modal distribution (Fig. 7D) seems more likely than a tri-modal distribution.

Maybe a shifting of some figures (e.g. Fig 10., Fig.11) to an appendix section would be good?

L338/339 you mean positive trends?

L 365 and following Given the small (statistically insignificant?) trend at Drughina, probably discussing “unchanged” conditions (instead of discussing a “change in sign”) is more appropriate.

L 362 and following Please check colour specifications (in my printed version lines are yellow instead of orange, “blue” and “cyan” are used to refer to the same line, ...)

L494 define “NF” - or better avoid abbreviation

Fig.12 legend how were error bars inferred / what do they describe?

Spelling

L29 IS -> is

L458 form -> from

L470 = -> -

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