A Permafrost Implementation in the Simple Carbon-Climate Model Hector

This paper discusses the implementation of a simple permafrost carbon module within the Hector simple climate model. The authors talk about uncertainties but the results have very few details of their impact. In particular, the model results have a high permafrost carbon feedback temperature compared to other results in the literature. I think this is fine if the uncertainties are made more high profile throughout the whole document particularly plumes in Figure 3 but also maybe table 3. Q quick thought - do the authors think this high feedback temperature is caused by a relatively large methane contribution?

I think more details and discussion are required about the physical permafrost change parametrisation. This is a key addition to the model and not explored in much detail. I see it is discussed more in Figure 2 but I think it needs to be compared to something other than Kessler. **Why is a volume fraction not used when considering physical permafrost change?** This is much more relate-able to carbon amount.

Please check the signs/definition of fluxes in the equations and their text.
It would be good to have units included for all variables. Also check all acronyms are defined.

In general the paper contains most of the required information but sometimes later than I would like it.

Minor comments:

Line 3 - permafrost C feedback is hardly ever estimated using ESMs currently.
Line 6 - ?? ESM permafrost estimate
Line 10 - 0.5 degree feedback temperature is relatively high.
Line 20 - add Biskaborn reference (https://www.nature.com/articles/s41467-018-08240-4)
Line 27/29 - Burke et al., 2017 (https://bg.copernicus.org/articles/14/3051/2017/bg-14-3051-2017.pdf)
Line 30 - JULES - Joint UK Land Environment Simulator
Line 31 - remove both 'can' s
Line 35 - these more complex models still have missing/incorrectly parametrised processes and would definitely benefit from uncertainty quantification.
Line 39 - remove 'models'
Line 45 - remove 'and'
Line 48 - The paragraph above suggests that these simple climate models do not have good spatio-temporal resolution but then this line suggests that Hector will be used to evaluate regional impacts.
Line 71 - Equation 1 defines a land-to-atmosphere flux but Equation 3 suggests an atmosphere-to-land flux.
Line 71 - I think the last sign in Equation 1 should be + and the definition of FL shoudl specifically state that NPP and Respiration act in opposite directions
Line 73 - FL is the difference between NPP (uptake) and respiration (loss).
Line 78/79 - what are the 1/4 and 1/50 factors for?
Equation 4 has an air temperature change as a power and Equation 5 - has a running mean air temperature as a power? That looks a bit odd?
Line 85 - Where does the 200 years come from? Can this be justified further?
Line 99 - Equation 6/7 - DCperm is added to both Cperm and Cthawed? Surely it should be subtracted from one and added to the other?
Line 99 - What is Fthawed-atm? Is the sign correct?
Line 103 - shouldn't PHI be a volume fraction?
Line 109 - Please give more details on Equation 9 and explore its validity.

Line 139 - please state earlier that the 308 Pg C soil carbon is 'non-permafrost' carbon
Table 1 caption - it says mu and sigma are from Koven et al, but in the Tabel it says they are from Kessler.
Table 1 - no range for Cosoil or Cveg - have the authours checked if the model is snesitive to these?
Table 1/Line 144 - what is the wf used for? I cant see it in any equation? How does this compare to the value in Chadburn et al. 2017 (https://www.nature.com/articles/nclimate3262)
Table 1 - f_RH_CH4 does not match the name in equation 11/12
Line 150 - cite Burke et al. 2020 (https://tc.copernicus.org/articles/14/3155/2020/tc-14-3155-2020.pdf) which shows CMIP6 and CMIP5 are very similar.
Table 2 - how dies this compare to Burke et al. 2020?
Line 155 - why do we expect mu/sigma to fall within the range of Kessler 2017?
Line 159 - this 70 % was not included in the uncertainty range. Any reason?
Line 161 - uncertainty ranges in Table 1 do not reach the 4.3 % suggested in the text. Why not?
Line 178 - check name f_RH_CH4
Line 179 - how were the parameters sampled from prior distribution? Latin Hypercube?
Line 181-184 - please give more details on what these parameters mean and what the apprach of LeBauer is.
Line 188 - these 300-400 Pg C are not yet decomposed so comprise the Cthawed pool?
Line 195 - is there any evidence that the ~3 Pg C /year has been found in other models. This is quie high.
Figure 3 - Again I think the feedback temperature is generally quite high compared with other simulations. It would be good to see the spread introduced by including the parameter uncertainties.
Figure 3 - Please look up the standard colours for the RCP scenarios and use them. It is a littel confusing to have RCP2.6 as red.
Line 221 - Quite a lot of this carbon remains in the atmosphere (expect ~50 %, ~25% to land/~25% to ocean). Is this a function of the model structure?
Figure 5 looks interesting but is not immediately clear. Please include equation symbols in the names. I am not familiar with all of these statistics so a way to highlight the interesting ones and link them to the text would be great.
Line 235 – the 30-45% is ‘partial variance’?
Line 266 – Walter-Anthony, 2018
Line 275 – this should be encompassed by the parameter uncertainty.
Line 275 – 280 – this relates to the abrupt thaw processes discussed above and the two discussed together.
Line 304 – Chadburn et al assumed the soil and air temperatures were in equilibrium in their analysis.
How well does the 200 year temperature term represent the thermal inertia of the permafrost?
Section 4.1 probably need to mention nutrient limitation.
Table 4 – add the results of the temperature effect here. I am not sure why some comparisons are in the table and some are in the text.
Line 334 – please define/reference GCAM.