

The Cryosphere Discuss., referee comment RC2
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Comment on tc-2021-231

Anonymous Referee #2

Referee comment on "Strong increase in thawing of subsea permafrost in the 22nd century caused by anthropogenic climate change" by Stig Wilkenskjeld et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-231-RC2>, 2021

Over all, the manuscript by Wilkenskjeld et al. is an interesting one describing a first attempt to include benthic sediment temperatures within the framework of an Earth system model across the entire Arctic benthic environment. The primary result is that the loss of pore ice is expected to be large under high emissions and long-term warming, and less so under more highly-mitigated scenarios. My main comments are (1) to try to focus a bit more on the clearly reporting of the results, to show what the model is projecting for each of the scenarios; and (2) to discuss what the initial trend in the benthic temperatures are, and how confident we are in those given the smodel initialization protocol.

While some sensitivity tests were carried out for some of the modeling assumptions made, I am curious whether there are other parameters in the model that could give very different results. For example, how was the thermal conductivity and porosity of these sediments calculated, and how well constrained are those estimates? Are the timing of results robust with respect to this uncertainty? Also, given the importance of freeze/thaw processes in the manuscript, I'd like to see a bit more description of how the temperature diffusion and latent heat effects were calculated in the model.

p. 2, section 2.1: Some more info is needed on how MPI-OM calculates the benthic temperature. What is the depth distribution of ocean model layers? Are the heat flux assumptions made in the benthic model consistent with those used in the land model? How well does the model represent the observed benthic climate? Also what are the nominal resolutions of the GR30 and T63 grids? Also what aspects of the CLIMBER output were used to force MPI-ESM, just CO₂ and other GHGs?

p. 3 l. 70-79. These two paragraphs seem in conflict with each other. Either salt diffusion is slow and unimportant, or it is fast and important. Why didn't the authors just set an observed salt gradient rather than disallowing the porewaters to freeze? Also, what about pressure effects on freezing point depression, it seems like those are relevant to this system? I see that there is some discussion of the effects of this assumption in section

4.2, but I think some clearer discussion of this here would help.

p. 5, l. 136 Is this thawing under preindustrial forcing to be interpreted as lagged thaw following LGM, or is it an artifact of the imposed initial conditions?

figs. 1, 5, &6: Is 'depth' the depth below the benthic surface or the depth below the sea surface?

fig. 3: Is the ratio of melt rate to the preindustrial melt rate a meaningful metric, and if so why? It seems like the absolute loss rate is a more fundamental measure than the relative rate. But if the relative rate is more meaningful, then some background and explanation would be helpful.

fig. 4: It would be helpful to see some time progression here. For example how much ice will have melted by 2100, 2200, 2300, 2500, and 3000 under each of the scenarios?

fig. 7: Why the break in slope at 70% sea ice concentration? Are these annual mean values, and if so, should these be thought of as the spatial area with no ice, or the fraction of the year with no ice? Would the plot look different if other explanatory variables (e.g. surface ocean temperature or surface air temperature) were used?

p. 8, Line 244: does this loss also occur under a steady-state preindustrial climate, or is it a forced response to the historical warming?

fig. S1 What are the units?

fig. S6 Is helpful in interpreting the results, I suggest moving to the main manuscript document.

fig. S11, the right hand side panel isn't interpretable, I think you'd need to show the amplitude for each scenario separately, and using the same color scale for both the historical and future panels.