The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC2
https://doi.org/10.5194/tc-2021-245-RC2, 2021

Comment on tc-2021-245

Anonymous Referee #2

Referee comment on "Influences of changing sea ice and snow thicknesses on simulated Arctic winter heat fluxes" by Laura L. Landrum and Marika M. Holland, The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-245-RC2, 2021

This study uses an older version of the NCAR climate model to project an increase in wintertime conductive heat flux through the Arctic sea ice of 7-11 W/m2 by mid 21st century due to ice thinning and in spite of surface warming which would favor a reduction in this flux. The implications drawn from this are that atmosphere models, used for climate change, should specify sea ice thickness changes and that a representation of the sub-gridscale sea ice thickness distribution is needed for accurate representation of the effect. The paper is clear and convincing. I have several suggestions for providing additional context and strengthening the conclusions:

1) The increased conductive flux is consistent with the finding from Keen et al (2020) of increased wintertime basal sea ice growth -- the heat produced by this growth being balanced by the conductive flux -- even as the conductive flux is reduced during the rest of the year. Keen et al find a large intermodel spread in the winter basal growth increase encompassing no increase as a possibility. The current study, which uses a single model, may underestimate the uncertainty range on the conductive flux increase. One way to connect the results of the two studies would be to perform the Keen et al basal growth analysis with CESM1 (CESM1 did not participate in the Keen et al study) and compare to the results of that study. This would give some idea of where the CESM1 ensemble fits into the larger multi-model range.

2) Concerning the cautions in the current study about using a single ice thickness to

compute the conductive flux, it is notable that all 7 of the current-generation climate models participating in the Keen et al study employ a sub-gridscale 5-level representation of sea ice thickness categories. Although it is true that the PAMIP protocol allows atmosphere models to employ a fixed sea ice thickness, the use of a variable thickness is encouraged (Smith et al 2019). It could be noted that significant action has already been taken on the main recommendations of this study.

3) The authors note that observed sea ice volume has decreased by about â □ since 1958-1976. This observation should be useful for validating the model. Does CESM1 reproduce this thinning? The effective thickness seems to have decreased much less over this period (Fig. 1c).

4) Since AMIP runs and reanalyses are available over the post-1958 period it should be possible to directly compare the Arctic conductive flux and warming under fixed sea ice thickness with the more sophisticated CESM1 treatment. The authors could directly assess whether variable thickness/thickness distribution leads to increased conductive flux and increased warming. Perhaps there is even a historical AMIP run available with the atmospheric component of CESM1? It would be interesting to plot conductive fluxes and surface temperature from this model alongside the coupled model results in Fig. 1a.

5) Would the underestimation of conductive heat flux with a single thickness representation of ice thickness be, to some degree, self-correcting in an interactive simulation? Since the single thickness ice grows more slowly, it produces less thickness over the winter season than the multiple thickness representation favoring a larger conductive flux, all else equal.