Hydrology and
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Sciences

Discussions

Interactive comment on "The influence of albedo parameterization for improved lake ice simulation" *by* Alexis L. Robinson et al.

Anonymous Referee #2

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This paper describes the 1-D lake ice model simulations for the two northern lakes and temperate lakes in Canada with sensitivity studies by changing ice and snow albedo parameterizations. The paper also documents the recent observations of lake ice and snow properties in the two northern lakes and two mid-latitude lakes in Canada. This paper can potentially be a significant contribution to lake ice modeling in general. In particular, the observations on ice thickness, snow properties, and albedo are rare and valuable for model improvements. On the other hand, the paper appears to have issues with presenting their findings in a way that can contribute to the model's improvements, model description, and organization.

1) The manuscript does not feedback their findings well to the original albedo parameterization, which appears to fail to reproduce ice thickness and ice off dates in the

temperate lakes, but instead, it appears that the albedos were simply tuned to match the observed ice off dates and ice thickness in the temperate lakes. In addition, further tuning is done just for a specific season (2015-2016). The needs for these tunings indicate the opportunity of improvements in the original model but this has not been achieved in the way the work is presented.

Surprisingly, the fixed albedo values 0.75 (pre-melt) is equivalent for the albedo with 4.5m thick ice in eq. (3), and 0.56 (melting) is about the upper bound in eq. (4). The authors attribute the failure of the original parameterization to white ice in temperate lakes not taken into account by the model. This might be the case, but if so, this is a shortfall of the parameterization, which should actually be latitude-dependent, or include white ice. The model by Duguay (2003) appears to include snow ice (white ice) so including white ice in the albedo parameterization appears to be straight forward. The authors increased snow albedo just for the 2015-2016 season because of the massive snowfall earlier in the season, but doesn't this mean α_s in eq. (5) should be snow-depth dependent rather than altering α_s from year to year?

First, I suggest the authors provide a figure illustrating the relation among ice thickness, snow depth, surface temperature and bulk albedo for the original parameterization (yes it's multi-dimension but there can be a few ways for this, such as Figure 4 in Icepack Documentation, https://media.readthedocs.org/pdf/cice-consortium-icepack/icepack1.2.2/cice-consortium-icepack.pdf). Next, I suggest that the authors add data points of their observed albedos, as they have synchronized observations for snow depth, ice thickness, and albedos.

Finally, I suggest that the authors propose a new set of equations which includes white ice (ideally), or is latitude dependent (this could simply be another if branch). The improved parameterization would be a valuable contribution to lake ice modeling.

2) More details for the model description are needed. 'Mixing depth' appeared in section 3.5 but there is no description for what this does with the model. If the model

includes 'snow-ice' (or white ice) parameterization, this should be stated in section 3.4. How many layers are defined? Clarify that 'the vertical coordinate 0' means the interface between the air and the snow or ice? Is there any heat flux from water to the bottom of ice? I understand that many of them are described in Duguay et al (2003) but this paper should provide at least minimum of the key information.

3) The organization should be carefully reviewed. Multiple descriptions are mis-placed. For example, section 2 should be about geography and relevant background knowledge for the study areas but it extends to descriptions on CID and Snow CD (data used in this study), which should belong to section 3 "Data and Methodology". Adjustments to albedo in page 9 (section 3.5, simulation) should belong to section 3.4.1 (albedo parameterization).

Other points:

Page 1, L15: "the High Arctic ice cover" should be "ice cover in the High Arctic lakes"

Page 1, L17: The meaning of "underestimation" of "ice-off timing" is not clear.

Page 7, eq. (3): Please define 'h'.

Page 8, L211: Does 'the vertical coordinate 0' mean the air-ice/snow interface? How many layers were defined?

Page 9, L265: "However, for the study year 2015-2016 the snow albedo was increased to 0.88 to better predict ice-off dates as this season had more early-season snow on the ice". I don't understand this reasoning. Doesn't this simply mean the parameterization should include the increase of snow albedo with snow depth?

Page 11, L312: Please define 'Ia'.

Figure 1: It'd be helpful if bathymetry information for the lakes are added. No mean depth info for the High Arctic lakes? I see that they are provided for the temperate lakes in section 2.2.

Figure 6: I'd like to see thickness timeseries for the simulations in the High Arctic lakes as well. Do they capture the feature in the historical observations described in section 2.1?

More information on forcing (air temperature, wind, snowfall) would be appreciated. Maybe timeseries graphic or providing mean values for each season.