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The Cryosphere Discussions

Interactive comment on "An inter-comparison of the mass budget of the Arctic sea ice in CMIP6 models" *by* Ann Keen et al.

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In this manuscript, the authors compare the individual terms of the Arctic sea ice mass budget (predominantly surface and bottom melt, basal growth and frazil ice formation, and advection) from 14 CMIP6 models. This type of in-depth analysis had not been possible for previous CMIPs, as individual mass budget terms were not routinely reported.

The paper is very well written and structured, clearly illustrated, and the subject matter is a good fit for The Cryosphere. It presents an interesting result in that ∼half of the simulated annual ice loss is due to basal melt, and ∼one quarter each due to surface melt and advection out of the Arctic. Another central result is that ice formation oc-

curs predominantly as basal growth, with frazil ice formation playing a substantial role depending on a model's minimum frazil ice thickness. Finally, it is striking to see how consistent the partitioning of the individual mass budget terms is between models.

In light of this I recommend the paper for publication after minor revisions.

I agree with the other reviewer with regard to two general comments:

1) I found the paper could do with some more focus, and investigate model differences in more detail. In particular highlighting which differences are due to different physics (e.g., meltpond or radiation schemes) and which are due to different parameter values (such as minimum frazil ice thickness) would be of interest.

This brings me to my main comment. Many of the models share the same sea ice model components (CICE, LIM, SIS) and I believe it would be of interest what the differences are between models with the same sea ice component vs between models with different sea ice components. In the case this is not insightful, it would nevertheless be helpful to discuss the role of having shared sea ice components or not (e.g., for a reader like me who is keenly interested but no expert in the differences between sea ice model components).

2) In line with the other reviewer's comment, I found the section on the forced model runs somewhat vague and only tangentially related to central message of the paper. I would also suggest that this section be either incorporated more carefully or cut (which would further help focusing the main story).

Specific Comments:

l.65 "uncertainty" (not uncertainly)

l.68 " models' " (not model's)

l.74 maybe "emerging consensus" rather than "increasing appreciation"

l.135 what time periods are covered by the 3 observational products?

l.263 Is this a linear relationship? Would it be insightful to plot "% of frazil ice formation" vs "min frazil ice thickness"

l.309 period at end of sentence

l.350 "amount" (not about)

Fig 4 would it make sense to add the observations?

Fig 5b add legend

Fig 6 It is difficult to see the differences between the models. Is there a more concise way to present this data? In line with my major comment above, maybe it would be worth grouping the models by sea ice model component? e.g., instead of the bar plots have one subplot for all CICE models, one for all LIM models, etc, with each model's basal growth value indicated by a marker and the same for the other terms?

Fig 7 As for Fig 6 it is difficult to see differences between models.

Fig 9 and 10 are cropped on the left edge.

Fig 9 doesn't show units on vertical axis, Fig 10 does.

Fig 9b is "surface melt", Fig 10b is "top melt".

Fig 9a is "basal growth", Fig 10a is "frazil ice formation". Why are the different quantities shown, why not all 4 main terms for each Figure?

Fig 11 are the units on the vertical axis Gt yearˆ-1 rather than kg yearˆ-1?

Fig 12 maybe leave out the lines for lateral melt, snowice, evapsubl, since they are mostly negligible and make the figure harder to read?

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