

## ***Interactive comment on “Multi-model based estimation of sea ice volume variations in the Baffin Bay” by Chao Min et al.***

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This study provides a more thorough assessment of annual sea ice volume changes in and solid ice freshwater flux variations across Baffin Bay than previous work. Combining several state-of-the-art sea ice models, some including data assimilation, enables the authors to estimate an uncertainty envelope around sea volume changes in the absence of in-situ or satellite observations. The amount of sea ice forming thermodynamically in Baffin Bay and the volume of freshwater exported from the bay into the Labrador Sea have critical downstream impacts on deepwater formation and the overturning circulation of the North Atlantic. So, I expect these results will be valued in the climate and physical oceanography communities.

C1

I have made a few comments regarding the choice of datasets and methods used, particularly relating to use of only a single ice motion dataset and rejecting the use of satellite thickness observations. It would also be great to include more context for the calculated solid ice freshwater fluxes. Otherwise the manuscript seems to be in a good state and my remaining comments/edits are all quite minor. Please do get in contact if you have questions regarding these comments. Kind regards, Jack Landy

General comments:

1. Three model ice volume products are used but only one drift product. Alternative drift vectors from OSISAF and/or Kimura et al could also be used to improve the determination of the volume flux uncertainty envelope. Line 62, is OSISAF not available year-round in BB? If other products are not available year-round or have full coverage over BB, can you estimate the uncertainty envelope for the ice motion for the seasons/region where they do overlap and use that in your determination of overall error?
2. L59-60, in my opinion the SIT data from remotely-sensed observations have sufficient validity to compare with the model simulations. If there are clear biases that have been identified in Baffin Bay or in regions with similar sea ice regimes, then please discuss here. Otherwise I suggest to add a short comparison of the winter SIT evolution between the models, SMOS and CS2 or CS2SMOS, with the uncertainties of the observations illustrated, to gauge the validity of the models individually and as a collective. You may be able to discard one model in your ensemble, for instance, if it shows clear deviation from the satellite observations.
3. I recommend adding greater depth to the discussion on Baffin Bay/Labrador Sea freshwater budget. How do your results for the freshwater volume stored in ice within Baffin Bay compare to past estimates? How about the solid ice flux across Davis Strait? More importantly what is the context of the solid ice fluxes within the full freshwater budget? What
4. I would suggest having another careful check through the text, as there are quite a

C2

few minor spelling mistakes and grammatical errors.

Minor comments/edits: Line 23. '. . .largest SIV outflow in spring of 2014' why?

L20. What about the freshwater budget? How much ice meltwater enters the ocean over the melt season? This is the key missing feature of the abstract, with respect to freshwater and deepwater formation.

L23. Draining off what? The Greenland Ice Sheet, liquid freshwater in the ocean proper, both..?

L31. Large errors with respect to what? Other regions or to other model-based thickness estimates?

L34-35. Can you define the directions of these fluxes?

L45-46. This argument requires more detailed explanation.

L50. I am not convinced the satellite based products are inappropriate to be used in this region. Can you provide an argument with supporting evidence why satellite measurements, including SMOS and/or altimetry, cannot be used here? (I do understand the satellite products only capture the winter ice growth season, so cannot be used to determine the full annual ice volume budget, which is in my mind a better reason not to use them than their apparently limiting uncertainties). You also state that the spatial distributions of model SIT are similar to that derived from satellites in Landy et al 2017; so why then are the satellite observations inappropriate to be used?

L53. Spell out the model acronyms.

L54-59. Please list the exact SIC, SIT and SST products used for assimilation into the models, as this clearly affects their interpretation.

L108. Why are the CryoSat-2 or CS2SMOS SIT data inappropriate in Baffin Bay? What does the strong seasonality have to do with it, and what do you mean by that?

### C3

L118. How were the drift observations validated? With in situ measurements?

L153. I do think it is worth including the CS2 or CS2SMOS cycle in your comparisons here.

Fig 2. Can you explain why the CMST simulations show a 'flattening off' of sea ice volume increase at the end of winter, when NAOSIM and PIOMAS are still rising?

L165. 'cycle' rather than 'trend'?

L193. What are the +/- as percentages?

L200. What do you mean by 'reach a maximum in spring/winter with a mean value of...'? Confusing

L205. Can you explain why a constant factor of 0.8 is used and justify it? (It is not sufficient just to include a citation without deeper explanation)

L206. Can you place this value of 271 km<sup>3</sup> yr<sup>-1</sup> in context? What is that in Sv? How does it compare with literature values for the net liquid FW flux across approx. the same southern gate between Baffin Bay and the Labrador Sea from other studies?

L235. It is unclear what you mean by 'We thus speculate that the thick ice is exported from the Arctic since the higher ice velocity is also found in these areas'. What point are you making?

L228-234. How do your results compare with the cited studies? Are the net volume growth/melting terms similar or very different (accounting for disparities in the study area)?

L242. How do you know the drift is underestimated? Have you tried comparing with another product, e.g. OSISAF for at least the months and time period they overlap?

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### C4