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Review on tc-2021-127

Anonymous Referee #4

Referee comment on "Assimilation of sea ice thickness derived from CryoSat-2 along-track freeboard measurements into the Met Office's Forecast Ocean Assimilation Model (FOAM)" by Emma K. Fiedler et al., The Cryosphere Discuss.,
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Review of „Assimilation of sea ice thickness derived from CryoSat-2 along-track freeboard measurements into the Met Office’s Forecast Ocean Assimilation Model (FOAM)” by Fiedler et al.

Summary

The authors aim to assimilate Cryosat-2 (CS2) winter sea ice thicknesses (SIT) into Met Office’s Forecast Ocean Assimilation Model (FOAM). In contrast to other studies, where mostly gridded monthly or weekly products have been used for assimilation, here, CS2 along track measurements of freeboard are used instead. To convert freeboard into thickness, the snow depth from the model is used instead of a climatology. Validation is carried out with CS2 SIT estimates and a set of independent airborne/moored measurements. The authors conclude that "the assimilation greatly improves the SIT analysis and forecast fields generated by FOAM, particularly in the Canadian Arctic."

General Comments

I find it important to investigate methods for assimilating satellite ice thickness observations into forecast models and therefore I appreciate such work, especially, since it aims to use along track satellite data. However, I have some major concerns, especially with respect to the evaluation of the assimilation results.

It is stated that "the assimilation greatly improves the SIT analysis and forecast fields generated by FOAM, particularly in the Canadian Arctic. Arctic-wide observation-minus-background assimilation statistics show improvements of 0.75 m mean difference and

0.41 m RMSD (root-mean-square difference) in the freeze-up period, and 0.46 m mean difference and 0.33 m RMSD in the ice break-up period, for 2015-2017”.

If I understand correctly, the modelled SIT using assimilation of CS2, and the control run (no assimilation) are compared with CS2 SIT observations that are also used for assimilation? But then it seems somehow clear that the modelled SIT using assimilation of CS2 performs better. Perhaps it would be better to evaluate with a more independent product, e.g. CS2SMOS (at least this is a different product).

I also assume that the modelled snow depth is a very important component here and potentially adds significant uncertainty. A detailed evaluation of the modelled snow depth within FOAM would be important as well for evaluation here, but I understand if this is not within the scope of this paper, and the authors also suggest carrying out such a study in future.

In fact, looking at the validation results using independent SIT measurements, the improvement from the assimilation is not so obvious anymore. Moreover, looking at Fig 7 (at the very beginning of each autumn), it seems that performance significantly decreases through the summer for both the assimilation and control run.

I think this discrepancy in the evaluation needs to be discussed in more detail, so it is clearer to the reader how good this assimilation really works and if it is a benefit using along track data instead of gridded products for assimilation. A comparison using gridded products for assimilation would be beneficial as well. Is it really an advantage to use along-track measurements? This should be discussed in more detail. After all, in view of these points, I recommend major revisions.

Specific Comments:

L 114: It would be interesting to SIT maps also for the summer period. A figure showing SIT maps with and without assimilation throughout one season would be beneficial.

L 152-153: probably also mention dual altimetry, i.e., Ku/Ka band, e.g., Lawrence et al.

L 170: Why median and not mean?

L206: These are not helicopter measurements. PAM-ARCMIP measurements were carried out with a fixed wing aircraft.

L 339-347 and Figure 7: But there is a quite high mean difference/RMS at the beginning of autumn when CS₂ data for assimilation become available again. But that means that the performance decreases significantly within summer months also for the model using assimilation, see also my general comments?

Figures: I recommend having all relevant information included in the figure. Sometimes this information must be searched for in the caption, which slows down the flow, e.g., Figure 6: colorbar label, Figure 7, 11: dashed lines. I think it is easy to provide that information in the legend.