EGUsphere, referee comment RC1
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Comment on egusphere-2022-982

Anonymous Referee #1

Referee comment on "The effects of assimilating a sub-grid-scale sea ice thickness distribution in a new Arctic sea ice data assimilation system" by Nicholas Williams et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-982-RC1, 2022

Cryosphere Review for egusphere-2022-982

The effects of assimilating a sub-grid scale sea ice thickness distribution in a new Arctic sea ice data assimilation system. Williams et al.

Summary

A standalone sea ice model (CICE5.1.2) is used to investigate the impact of incorporating a sub-grid scale sea ice thickness distribution by coupling to the LETKF using the latest version of PDAF. The source of the ice thickness data is from monthly means of CryoSat-2. Multiple experiments are performed consisting of a control run (no assimilation), assimilation of ice concentration only (NASA Bootstrap), assimilation of ice concentration and mean ice thickness, and assimilation of ice concentration, mean ice thickness, and a monthly sea ice thickness distribution. Experiments with 100 ensemble members were performed in which ensemble spread was generated by perturbing the NCEP-2 atmospheric forcing. They find that a forgetting factor of 0.995, amplification factor of 1.5 and localization radius of 100km worked best in these studies. The authors state that this is the first time that a sub-grid scale thickness distribution product has been assimilated. The authors find that the experiment assimilating concentration, mean ice thickness and sub-grid scale thickness distribution performed best in the four thinnest sea ice categories. Comparisons were made against unassimilated CryoSat-2 observations.

I find this to be a well written paper with a thorough description of the techniques and analysis methods used. The graphics and tables are well laid out. I find that this research will be valuable to the community. I recommend publication with minor revisions noted below. General and specific comments are below.

General Comments:

Use CryoSat-2 (not Cryosat-2) throughout the paper.

In the section with lines 55-60; please add these additional references for model forecast systems assimilating sea ice concentration:

Smith GC, Roy F, Rezka M, Surcel Colan D, He Z, Deacu D, Bélanger J-M, Skachko S, Liu Y, Dupont F, Lemieux J-F, Beaudoin C, Tranchant B, Drévillon M, Garric G, Testut C-E, Lellouche J-M, Pellerin P, Ritchie H, Lu Y, Davidson F, Buehner M, Caya A, Lajoie M. 2014. Sea ice forecast verification in the Canadian Global Ice Ocean Prediction System. *Q. J. R. Meteorol. Soc.*, https://doi.org/10.1002/qj.2555

Hebert, D. A., R. A. Allard, E. J. Metzger,P. G. Posey, R. H. Preller, A. J. Wallcraft,M. W. Phelps, and O. M. Smedstad(2015), Short-term sea ice forecasting:An assessment of ice concentrationand ice drift forecasts using the U.S.Navy's Arctic Cap Nowcast/ForecastSystem, J. Geophys. Res. Oceans, 120,8327–8345, doi:10.1002/2015JC011283.

Papers by Massonnet et al. (2011) and Smith et al. (2022) examined the impact of a 15-category ice thickness distribution on seasonal and climate modeling studies. Please speculate on the potential impact of increasing the number of ice categories (ignoring the additional computational cost) in your study.

Massonnet, F., Fichefet, T., Goosse, H., Vancoppenolle, M., Mathiot, P., & K.nig Beatty, C. (2011). On the influence of model physics on simulations of Arctic and Antarctic sea ice. The Cryosphere, 5(3), 687–699. https://doi.org/10.5194/tc-5-687-2011

Smith, M. M., Holland, M. M., Petty, A. A., Light, B., & Bailey, D. A. (2022). Effects of increasing the category resolution of the sea ice thickness distribution in a coupled climate model on Arctic and Antarctic sea ice mean state. Journal of Geophysical Research: Oceans, 127, e2022JC019044. https://doi.org/10.1029/

In lines 365-370 you state that using a forgetting factor of 0.995 (Fig. 1) does not lead to any model crashing. What is the cause of spikes seen in January – May, and Oct-Dec, evident in all runs except for the control?

In lines 430-432 you state: "for the assimilation runs that the decrease in concentration in late August in the Fram Strait leads to a remarkable increase in the sea ice thickness at the same time in these runs." I do not see any "remarkable increase". Please clarify, reword, or delete this sentence.

Lines 537-538: I disagree that all runs with assimilation of sea ice concentration showed very similar results. I agree they are similar to Bootstrap for any given year, but not amongst themselves. Please reword this section or provide additional details to me on what I seem to be missing.

Specific Comments:

Line 26: "rise at roughly twice this" **amount**.

Line 63: A comparison of fourteen ocean-sea ice reanalyzes (provide reference)

Line 95: Somewhere in this section, please provide the horizontal resolution of the CICE model used in this study.

Line 163: (Gaspari and Cohn, 1999) do not appear in references. Please add.

Line 170: Is a reference missing where I see a "?" ?

Line 238: Reword phrase "Grid cells In CICE-PDAF we use…" awkward

Line 333: "and CS2 thickness observations are assimilated monthly". Please clarify as there are not CS2 observations available for May – September.

Figure 2: label on top and bottom for “c” and “h” I assume should be “assim_conc_hi_loc100?

Figure 2 caption should be “Columns show CryoSat-2 and **4** CICE-PDAF runs…”

Figure 3: Legend should be “assim_conc_hi_amp2” The “amp2” is missing.

Line 450: I do not see a gold line in the legend.

Figure 6: With the exception of the control run (green), the 3 other experiments are difficult to see except for the assim_conc_hi_4hd. They must be very similar. Can assim_conc_h1_4hd be drawn first? Maybe assim_conc and assim_conc_hi will be easier to see.

Line 468: Table 2 shows value of “0.62”. Which is correct?

Lines 507-508: The assimilation of only concentration does not show an increase versus the control in the first year. Please modify sentence.

Line 511: I do not see a gold line in Fig 10. Please clarify.

Line 795: Hollinger et al. reference not cited.

Line 878: Zhang and Krishnamurti (1999) not cited.