Reviewer 2 : Comments and Answers

The paper presents experiments where sea ice concentration and thickness observations are assimilated in a coupled ice-ocean model. The correlation between sea ice concentration and thickness observations is taken into account. The method of Desroziers (2005) is used to better characterize the observation-error statistics. Also the Degrees of Freedom for Signal (DFS) developed by Cardinali et al. (2004) is used to measure the influence of the observations on the analysis.

The results of the experiments are first compared to one of the same sea ice observations dataset that were assimilated. Since only the analyses and not the forecasts are verified, the exercise is more to verify the assimilation methodology than the accuracy of the analyses. Fortunately, the experiments are also verified against independent observations of ice thickness in the Beaufort Sea.

We thank the Reviewer, and we agree that the quality of the Manuscript can increase expanding the validation section. Following a similar comment from the Reviewer 1, we add a second independent comparison against measurements from NASA Operation IceBridge project (http://nsidc.org/data/idcsi4 ; Kurtz et al., 2015) that cover several regions of the Western Arctic for several days in March and April between 2011 and 2013. The results are summarized in the initial answer to the first Reviewer (please see figure S1 and S2) and confirm the conclusions coming from the comparison against BGEP ULS moorings. Winter assimilation of SIT data produces a smaller RMSE in March-April statistics compared to SIC-only or CTRL experiment (no assimilation). Among the different experiments with SIT assimilation, the L4DE1 run (assimilation of CS2SMOS with Desroziers' error) shows the lowest RMSE and reduces the regional BIAS almost everywhere.

Kurtz, N., Studinger, M., Harbeck, J., DePaul Onana, V., and Yi, D.: IceBridge L4 Sea Ice Freeboard, Snow Depth, and Thickness, Version 1, https://doi.org/10.5067/G519SHCKWQV6, 2015.

In the section describing the assimilation method, we see gICE and gSIC that are used interchangeably. I think it would be better to have just one expression throughout, if these point to the same thing.

The difference between gICE and gSIC was not explained, we thank the Reviewer and clarify in the text. While gSIC and gSIT refer specifically to the corresponding gaussian counterpart of SIC and SIT, gICE is used in a more general way, $V_{gICE->ICE}$ points to a generic mapping of the sea-ice variable from Gaussian space to the physical one and can be associated separately to both SIC and SIT.

Figures 10 and 11 seem to be identical. Please remove figure 11 and only refer to figure 10 in the text. Also please revise the caption for this figure. Currently the caption for figure 10 and 11 are slightly different but I am not sure which one is more correct.

Figures 10 and 11 gather results from two different subsets of experiments from Table 1 to highlight different aspects. Fig 10 compares the sole assimilation of SIC with the experiments where both SIC and SIT are used, in particular, L4DE1 experiment (assimilation of the merged L4 product) and its subsampled version (L4DESUB). Fig 11 groups experiments that uses

Specific comments:

Line 20: What about the first CryoSat mission ?

The very first satellite associated with the CryoSat mission was lost due to a failure during its launch in 2008. The second launch was successful, and it is common to refer to the second mission of CryoSat as CryoSat-2.

Line 65: "contest" or "context" ?

Context is the correct word, thank you.

Line 88: 'x' should be called the state vector, and 'x_a' is the final analysis state (the value of 'x' that minimize the cost function).

We rephrase the line, "δx label the increments that correspond to the difference between the final analysis state x_a and the initial ocean state x_b, in the minimum of the cost function." The definition of x as the state vector comes a few lines below.

Line 113: Please define "CVT".

The acronym was indeed not defined, now we added "Control Vector Transformation or CVT", thanks

Line 146: Should "$V_{ICE \rightarrow gICE}$" be "$V^T_{ICE \rightarrow gICE}$" ?

Thank you, gICE was misplaced, we correct the initial "$V_{ICE->gICE}$" to "$V_{gICE \rightarrow ICE}$"

Line 151: I think that "that it has been shown" should be "that has been shown".

 Corrected, Thanks

Technical corrections

Line 122: "31-year-long" should be "31-year long" for consistency with the caption of figure 1.

We uniform text and caption to "31 year-long" that means a single simulation lasting 31 years.

Figure 1: In the caption, "Panel g and f show the same as e,f for September" should be "Panels g and h show the same as e,f for September".

Figure 4: In the caption, "Panels" should be "panels".

Line 203: "Beaufourt" should be "Beaufort".

Line 219: "0.5 * 10^{13}km" should be "0.5 * 10^{13} m^3"

Line 253: "is usual higher" should be "is usually higher".

Line 255: "…contribute to the modify the model…" should be "…contribute to modify the model…".

Line 275: "indestion" should be "ingestion".

We thank you the Reviewer for the corrections. We applied all in the revised version of the manuscript.

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