

Interactive comment on “Impact of assimilating sea ice concentration, sea ice thickness and snow depth in a coupled ocean-sea ice modeling system” by Sindre Fritzner et al.

Anonymous Referee #1

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Review on “Impact of assimilating sea ice concentration, sea ice thickness and snow depth in a coupled ocean-sea ice modeling system”, by Fritzner et al., submitted for publication in The Cryosphere Discussion.

General comments :

The paper shows the results of sea ice data assimilation experiments into a coupled ocean and sea ice model using an ensemble Kalman filter (EnKF). Sea ice concentration, sea ice thickness and snow depth are assimilated in different combinations and verifications are performed using assimilated and independent observations. The impact of assimilation is measured on the analysis, 7-day forecasts and 5-month sea-

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sonal forecasts. The paper is generally well written. The assimilation experiments and verifications are well designed. The assimilation of snow depth is particularly original as it has not been done in other studies, as far as I know. However, some aspects could be clarified. For examples, the observation-error used for the assimilation could have been explicitly specified. In some cases it is not clear whether the verification has been done on the ensemble mean or on individual ensemble members (and then calculating and average). Also the error of the ensemble mean and ensemble spread relationship could have been shown, as this is usually considered a requirement for an EnKF.

Specific comments :

1. A couple of sentences at the end of the abstract around line 15 are confusing to me. It seems that the conclusions about the assimilation of snow depth are contradictory: "... while the snow observations have a positive effect on snow thickness and ice concentration. In our study, the seasonal forecast showed that assimilating snow depth lead to a worse estimation of sea-ice extent compared to the other assimilation systems, the other three gave similar results." How come the assimilation of snow depth have a positive effect on ice concentration but lead to a worse estimation of sea-ice extent ?

2. In section 4.1, page 7: First Pb is defined as the background-error covariance matrix. A couple of lines later, it is referred as the model-error covariance matrix. I think you should stick to background-error covariance matrix because model-error covariance matrix is usually reserved for the errors accumulated during model integration.

3. In section 4.3, it is mentioned that there is 5 thickness categories; I assume they are the partial concentrations for each thickness categories and that the total ice concentration can be calculated from them. Later it is mentioned that the assimilation can result into a positive SIC but no volume. Does that mean that the 5 thickness categories and the SIC are all independent analysis variables ? If that is the case, wouldn't

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it be better to only have the 5 partial concentrations as analysis variable and calculate SIC ? It seems that it would avoid the problem of having positive SIC but no volume.

4. In Figure2, what are the observation uncertainty of AMSR-E/2 ice concentration used in the calculation of the RMSE ? Are they included in the product and are they constant values or are they specified for each points ?

5. Figure 5: Over which year(s) ? Is it against IceBridge observations ? Also in the text under section 5.4, please specify what is “observed satellite snow depth”, is this IceBridge ?

6. Page 16, line 5: “This lack of improvement can be an indication of a too simple snow component in our coupled system, only one snow layer is used.” I think that is pure speculation, unless the authors can show evidence to convince the readers. Could the reason be simply that there are large discrepancies between IceBridge and the assimilated snow depth products ? Same comment on page 21, line 25 and on page 22, line 30.

7. Table 3: It is hard to understand from the caption what are the numbers in the table. Is the averaged snow depth over a grid cell compared to the model ensemble mean ? It would help rephrase the caption, maybe removing one of the 3 averages and using “ensemble mean”, if that is appropriate.

8. Figure 8: Are these monthly averages over the 3 years ? The caption is hard to read because the “seven day” and “forecast” are too far apart.

9. Figure 9: Please specify in the caption that (b) is the monthly averaged RMSE over the three years.

10. Figure 10: I think it is unrealistic to use re-analysed forcing for the seasonal forecasts, as the re-analysed forcing would not be available in an operational real time context.

Technical corrections :

Page 5, line 8: Change "...observations where given..." to "...observations were given..."

Caption of Figure 3 : Change "low concentration ice (> 50 %)" to "low concentration ice (< 50 %)"

Caption of Figure 4 : Change "the blue stars the OSISAF" to "the red stars the OSISAF".

Caption of Figure 4 : For ice volume the units are km. Is it the volume per unit area ?

Caption of Figure 4 : It would be easier for the readers to mention that the x-labels are month-year.

Page 14, line : Change "sea-ice extent being too large and the ice is too thick" to "sea-ice extent being too large and the ice being too thick".

Page 18, line 18: "The figures show that that . . ."

Figure 10: Change "The blue line represents a forecast using a climatological forcing made from an over of atmospheric data for 2000-2014 with assimilation" to "The blue line represents a forecast using a climatological forcing made from atmospheric data over 2000-2014 with assimilation"

Page 21, line 31: Change "The main parameters analysed in this study snow depth, SIT and SIC all vary on longer time scales than one week for the spatial resolution in our model" to "The main parameters analysed in this study, snow depth, SIT and SIC, all vary on longer time scales than one week for the spatial resolution in our model"

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