

Interactive comment on “Assimilating high horizontal resolution sea ice concentration data into the US Navy’s ice forecast systems: Arctic Cap Nowcast/Forecast System (ACNFS) and the Global Ocean Forecast System (GOFS 3.1)” by P. G. Posey et al.

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Addressing the revisions recommended by the Reviewer #2 (author’s response follow "AR:" in text):

Anonymous Referee #2 This paper introduces an interesting approach to blending ob-

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servations from different sources and resolutions to initialize coupled sea ice-ocean forecast models. The improvements made to ice edge forecasts is impressive and it would be good to see ongoing improvements of this magnitude.

The paper could be improved/made more useful by providing additional information about the observation data handling,

AR: Section 2.2 describes the passive microwave data sources. These ice concentration products are simply used as gridded input into NCODA. In section 2.4 these ice concentration products are used as gridded input to NCODA. In section 3.2 we briefly describe the real time data handling.

the assimilation methodology

AR: Text was added in the manuscript (section 2.4) describing the assimilation technique in more detail. It’s a 2 step process: 1) reading in ice concentration observations (AMSR2/blended product) into NCODA (3DVAR) that produces an ice analysis, and 2) which then gets read into CICE where the concentration is blended with the model ice concentration along the ice edge. This simple methodology has been used in the past forecast systems and is continued here.

AR: We will soon be developing a more advanced technique for assimilating the IMS sea ice mask (along with new data sources, i.e. VIIRS) within NCODA. During this time, the blending that is currently implemented within CICE will be moved into NCODA. Adjustments to other ice variables will also be investigated in this work.

and the ice edge verification.

AR: The ice edge verification is described in the second paragraph in section 3.1.

A clear understanding of these would allow the reader to better understand the results presented.

In addition, the term resolution is used rather loosely to describe the various observa-

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tions and greater rigour is advised.

AR: Text has been added in the second paragraph in the Introduction to more precisely describe the resolution of the satellite data. In addition, text has been added in the second paragraph of section 2.2 to discuss the resolution of SSMIS, AMSR-E and AMSR2.

Lastly, the results are presented without significant discussion about the sources of error or how these might be overcome in future.

AR: The issues with passive microwave data are described in section 2.2. This is the reason we added IMS/MASIE into the assimilation scheme. This paper focused on ice edge error and, unfortunately, there are no uncertainty estimates of the independent NIC ice edge at this time.

P 2 L 20 and 21: numbers or references should be provided to clarify 'high year-to-year variability' and 'rapidly changing Arctic environment'

AR: References have been added in paragraph 1 in the Introduction.

P 3 L 10: the term 'determined' is vague and should be replaced by observed or analyzed as appropriate –

AR: Changed 'determined' to 'analyzed' in the last paragraph of section 2.1.

P 3 L 24: the resolution of SSMIS is frequency dependent so it would be helpful to indicate which channel has a resolution of 25 km and this should be relevant to the sensor's use for this application –

AR: This has been addressed in the 2nd paragraph of the introduction.

P 3 L 28: the IMS acronym and reference should be indicated here and not repeated on page 5 lines 21-22

AR: This specific text has been re-arranged and we have taken care to properly define

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all acronyms.

P 4 L 1: 'into the both' should be 'into both'

AR: Done.

P 4 L 17-19: higher gridding resolution is not equivalent to higher resolution observations. The ice concentration retrieval algorithm that is being used should be identified and the resolution of the channels used should be provided

AR: Text has been added in the second paragraph in the Introduction to more precisely describe the resolution of the satellite data. In addition, text has been added in the second paragraph of section 2.2 to discuss the resolution of SSMIS, AMSR-E and AMSR2.

P 5 L 6-7: it would be helpful to identify the 'human-analysis-based product' here

AR: Identified this product as MASIE/IMS in the last paragraph of section 2.2.

P 5 L 21: insert 'using' before the Interactive

AR: This sentence has been reworded.

P 5 L 22: should indicate the valid time of the IMS product or indicate if it is a daily average product. This has significance to the later results.

AR: A statement has been added concerning the valid time of the IMS product.

P 5 L 25: insert satellite before imagery

AR: Done

P 5 L 26-27: suggest removing the remainder of the sentence beginning with 'with a 40% ..'

AR: This has been removed.

P 6 L 12: should indicate the source of the AMSR2 ice product

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AR: AMSR2 website information has been added in the first paragraph of section 2.4.

P 6 L 15: the term 'modeled forecast' seems redundant –

AR: Done

P 7 L 16-26: further details on the assimilation methodology would be helpful such as whether the ocean is adjusted according to the initial ice concentration, how the ice thickness is specified and how the weighting works.

AR: More details on the assimilation methodology were added in section 2.4.

P 7 L 19: 'near the ice edge' refers to the model ice edge?

AR: This text has been removed from the manuscript.

P 7 L 25-26: what is the NCODA ice analysis and is there a reference?

AR: This text has been removed from the manuscript. The NCODA reference is Cummings and Smedstad (2014) which is indicated in the first paragraph of section 2.1.

P 8 L 1: why is such a short forecast period used? It would be more instructive to see how the forecast error changes with forecast duration.

AR: The results discussed in the paper were from a hindcast that stepped forward a single day at a time. Longer forecasts were not performed. In the GOF3.1 Validation Test Report (Metzger et al, 2015), ice edge error as a function of forecast length (out to 5 days) was examined. Ice edge error growth as a function of forecast length in GOF3.1 was small. Average ice edge error at the 12-hr forecast was 32.6 km and 36.6 km at the 132 hr forecasts. This 4 km difference is approximately equivalent to a single model grid point.

P 8 L 3: is there a reference for the NIC ice edge product?

AR: There is no reference for the ASCII ice edge location.

How is the ice edge defined?

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AR; Text has been added in the first paragraph of section 3.1 that defines the NIC ice edge as the 10% isoline.

What is its valid time and is it an analyzed edge or a nowcast edge?

AR: Text has been added in the first paragraph of section 3.1 that defines the valid time at 00Z and we also indicate that it is an analyzed product.

P 8 L 6: what is meant by 'conservative edge location'?

AR: This statement has been reworded.

P 8 L 8: what is meant by 'buffer'?

AR: This sentence has been reworded.

P 8 L 10-11: it seems odd that the NIC ice edge product and NIC IMS product use different data sources and that they are independent

AR: The two NIC products are derived using different data sources and define different ice edges. While some of the data sources are the same, the NIC has maintained that these two products are independent.

AR: The daily ice edge product is used to warn navigators and others in arctic sea where ice exists or is likely to form at any concentration. The daily ice edge product edge is always outboard of the IMS/MASIE edge. The NIC's weekly ice charts and ice edge products have marine transportation interest as primary users, while the IMS product is designed primarily for modelers.

P 8 L 19: 'observed' should be replaced with analyzed or nowcast

AR: Done.

P 8 L 23: how sensitive is the choice of a 5% threshold and is this consistent with the verifying data? It has been indicated that the model is never initialized with ice concentrations between 0 and 70%

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AR: Previous research has shown that using the 5% isoline produced lower ice edge error than using isolines of higher concentration, thus we continue to use this value. Sensitivity studies were not performed varying this threshold.

P 8 L 23-25: more detail and a reference would be helpful here. For instance, how closely spaced are the 'NIC observed points' and is this consistent along the edge?

AR: There is no reference for the NIC ice edge ASCII product. We added text in the first paragraph of section 3.1 to indicate the data sources used to produce this product. As indicated in the inset of figure 6, the spacing varies along the NIC ice edge.

How are potential problems related to shore leads and patchy ice dealt with?

AR: This was not considered in this study.

Are the results the same if you measure the distance from the model edge to the NIC ice edge?

AR: This is how we determine the ice edge errors.

P 8 L 25: the results for the 6 regions are never discussed.

AR: These results are not discussed in the text but are shown in the tables for completeness.

P 8 L 30 and onward: while these improvements are impressive, the actual error seems incredibly large especially for a 6 hour forecast. To better understand this error, it would be helpful to quantify the error or difference in the IMS and the NIC ice edge.

AR: Quantifying the error between the IMS and NIC ice edges has not been determined by the NIC, but they have plans to do so in the future.

Presumably the difference between this and the reported errors are due to the model adjusting to the imposed ice field, i.e. melting ice or forming ice according to its internal SST/upper ocean heat content.

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Also, is it possible to quantify whether the model under or overestimates the ice extent?

AR: This is work in progress.

P 9 L 5-10: it would be helpful to include this information in a table.

AR: A new table (now Table 2) has been added to show seasonal errors.

P 9 L 20-25: it would be helpful to provide more and clearer detail here

AR: This text has been re-worded in the first paragraph section 3.2.

P 9 L 19-23: it's not immediately clear why the results found by including SSMIS are identical to those without it. In fact it's not clear how the SSMIS and AMSR2 ice concentrations are used in combination

AR: NCODA can accept multiple data sources, but since AMSR2 has a much higher resolution it will dominate. We think the main reason why the results are similar, is due to the IMS assimilation. IMS will dominate what is going on close to the ice edge.

Interactive comment on The Cryosphere Discuss., 9, 2339, 2015.

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