

General comments

GC1: The authors compare how well the NOAA Alaska Sea Ice Program (ASIP) daily ice charts, along with another operational ice extent map and a passive microwave sea ice concentration product, match up with sea ice concentration estimates from visual shipboard observations. I have some concern that a casual reader of the paper will see a statement like “ASIP’s overall accuracy rate of 95.7%...” and use it without reference to the limitations of the validation method that the authors are aware of. The authors will improve the manuscript by tightening and clarifying the presentation, especially when describing the ASIP and MASIE products and how they are “parsed”.

Thank you for your comment and for these helpful suggestions to tighten up the language in the paper. We have changed the terminology and explained in detail how the data are read and converted from SIGRID polygon information to gridded SIC maps (the process we previously referred to as “parsing and gridding”). Furthermore, we have updated the manuscript to be more explicit about the meaning of operational ice products.

To be mindful of the reviewer’s concern that someone might see the accuracy rates/percentages and not consider the limitations of the in situ data used for validation, we have updated the manuscript to present accuracy rates with the caveat: “in situ observations, which do not cover all grid cells and all times, and are thus not comprehensive”, or some variation of that phrasing.

GC2: Sea ice charts are often the best information available to researchers as well as to those operating in polar waters. Yet, charts are underused by the research community, because researchers are often unfamiliar with them and have no way to evaluate their quality. Research papers that attempt to quantify the accuracy of operational products are few. That makes this one especially valuable, if the presentation is improved.

We thank the reviewer for their kind words and for the enthusiasm for our study. We are grateful for their helpful comments, which have strengthened the manuscript.

Specific comments

SC1: In the abstract, the authors write “...we show that the similarity in performance among products is due to the in-situ asset distribution, as most in-situ observations are far from the ice edge in 20 locations where all products agree.” This statement would seem to discount their results. It illustrates why I think the manuscript needs at least a paragraph in section 2.1 describing how analysts make the charts, and a section with at least a few sentences describing how “ice edge” is defined and drawn, if it is drawn, in or using the ASIP, AMSR2, and MASIE products for the purposes of this study.

We have updated the abstract to read: “we show that the similarity in performance among products is partly due to the deficiencies in the in situ asset geographical distribution, as most in situ observations are far from the ice edge in locations where all products agree”.

We have included a description of how analysts draw polygons in section 2.1. A section describing how the ice edge is defined in each product has been included (3.3, in the new Methods subsection recommended by reviewer 1).

SC2: This discussion of how “ice edge” is defined, drawn, and used in the three products should come ahead of the Results section. Section 5 Discussion has some of this, but having the information in a stand-alone section and moving it forward will help readers understand how the differences in where products put an ice edge may arise. As it is, the authors begin using “ice edge” without an explanation. I think of the ice edge as a contour line. Do the authors create a contour line in 0.05° gridded versions of AMSR2 SIC fields, MASIE 1 km binary ice/not ice fields, and ASIP polygons containing ice concentration ranges?

Thank you, we have added a section to the Methods section that describes how the ice edge is defined in each product (section 3.3).

SC3: Each product sets a different-sized area within which SIC is estimated. The AMSR2 grid cell size may be 3.125 km but the SIC algorithm integrates brightness temperature information from frequency channels that have different footprint sizes and shapes. The ASIP analyst looks at satellite imagery and draws a polygon around ice that looks homogenous or ice floes that are fairly evenly distributed, and labels it with an ice concentration range. Each polygon is different. The USNIC analyst that draws the IMS product used by MASIE estimates which 1-km grid cells cover areas with more than about 40% ice and labels them “ice”, using a variety of satellite and other data sources. Finally, the ASSIST observation is for an area within 1 nm of a ship, although visibility may limit this, as the authors note. Describing all this in one place will help the reader have a fuller picture of how differences in ice edge position arise.

Thank you for raising this point. To address the issue of differences in footprint sizes and temporal resolution (also raised by reviewer 1), we have created a section (3.4 Footprint size) where these nuances are presented upfront and together, before the analysis.

SC4: I don't think it would be particularly useful even if it were possible to come up with a rigorous accuracy estimate for these products. I think it's more important to understand how they are made and the strengths and limitations of each. The authors note that the ASIP product puts the ice edge further south than MASIE or AMSR2, and is more accurate when it does so, judging by shipboard obs. If you are a researcher that needs to know how likely it is that ice at any concentration will be present at some location off the coast of Alaska, then the ASIP product is your best choice. A tighter, more carefully written Discussion section up front will help more researchers understand that choice.

We have updated the manuscript to clarify that the accuracy rates are only a function of the in situ observations and are not comprehensive (see response to GC1). Further, we have added a new Methods section (per reviewer 1's request) and included two discussions of how ASIP, AMSR2, and MASIE are different: section 3.3 compares and contrasts how the ice edge is defined in each product, section 3.4 compares and contrasts the footprint size of each product.

The Discussion section has been updated to say that ASIP's ice edge is generally further south, and is generally more accurate as judged by in situ observations. Thus, we recommend the data for scientific and operational stakeholders alike.

SC5: The Discussion section also needs something on why MASIE and the hi-res AMSR2 from Bremen were chosen. Note that MASIE is not itself an operational product but is a reformatting of the USNIC IMS operational product. I assume MASIE was chosen because it is easier to work with than IMS and offers a unique daily high-resolution map of ice extent.

We have added a discussion of why we selected these two products. We chose to put this earlier in the manuscript, in the Data section, so that readers understand upfront why these products were chosen. Now the text reads: "MASIE was chosen, instead of the USNIC IMS operational product, for example, because it offers a unique daily high-resolution map of ice extent, is provided in an easy-to-use gridded format, and represents a product commonly used in the scientific literature that is generated following similar methodology to the grASIP dataset."

SC6: The USNIC MIZ product (U.S. National Ice Center, 2020) is another daily product that shows a 10% and 80% SIC contour. The authors could consider working with it as an alternative or in addition to MASIE.

U.S. National Ice Center (2020). U.S. National Ice Center Daily Marginal Ice Zone Products, Version 1 [Data Set]. Boulder, Colorado USA. National Snow and Ice Data Center.
<https://doi.org/10.7265/ggcq-1m67>.

Thank you for suggesting this analysis. While it would be interesting to include the USNIC MIZ product in this study, our goal was not to provide a comprehensive comparison between all or many SIC products and instead present a comparison between a few representative datasets. Thus it is outside the scope of this manuscript. This is because we aim to show the reader three types of data and (a) how they compare and contrast and (b) how someone could repeat this analysis for a different selection of datasets.

SC7: It would be helpful to mention that USNIC charts also cover the region covered by the ASIP charts, and have some words about how they compare, as RC1 noted.

Done.

SC8: After years of working with ice chart products along with satellite data, I strongly agree with the authors concluding statements about the value of ASIP products for scientific studies.

Thank you for your enthusiasm!

More specific comments follow.

L9: "...we present a new SIC product..." Please clarify exactly what the new product is and how it differs from the ice charts that are available on <https://www.weather.gov/afc/ice>. The text isn't clear on this.

We have now updated the abstract to specify that “we present a newly-gridded SIC product generated from data from the...”. We have also clarified that these data are different (source vs. gridded fields) in Section 2.1.

This raises an interesting point that we had not previously considered. We fundamentally modify the ASIP source data when we grid it and convert the concentration ranges into SIC values. For this reason, it seems appropriate to use a different name to distinguish the data from their source data stream, as MASIE did. For this reason, we have updated the text to refer to grASIP (Gridded ASIP), instead of ASIP.

L11: Does EGU prefer “in-situ” to “in situ”?

Thank you for pointing this out. According to the submission policies, they ask that Latin phrases not be hyphenated. We have updated the manuscript accordingly.

L16: Consider rewriting as “ ... and (iii) a product available from the National Snow and Ice Data Center (MASIE) that originates with the US National Ice Center (USNIC) operational IMS product.”

NSIDC archives both products, and both should be cited correctly, and listed in the References section. Here are the MASIE and IMS citations in APA style:

U.S. National Ice Center, Fetterer, F., Savoie, M., Helfrich, S. & Clemente-Colón, P. (2010). Multisensor Analyzed Sea Ice Extent - Northern Hemisphere (MASIE-NH), Version 1 [Data Set]. Boulder, Colorado USA. National Snow and Ice Data Center. <https://doi.org/10.7265/N5GT5K3K>.

U.S. National Ice Center (2008). IMS Daily Northern Hemisphere Snow and Ice Analysis at 1 km, 4 km, and 24 km Resolutions, Version 1 [Data Set]. Boulder, Colorado USA. National Snow and Ice Data Center. <https://doi.org/10.7265/N52R3PMC>.

Done.

It’s important that readers understand that NSIDC is not an operational center, and MASIE is not an operational product, in contrast to USNIC and IMS. It would be helpful to say what is meant by the term “operational” as used in this paper.

The fact that MASIE is not an operational product is now stated explicitly in Section 2.3.2. We now provide an explicit definition for operational ice products in the Introduction.

L31: “MASIE has by definition no information at SIC < 40%.” That’s not entirely true. One could regrid MASIE to some larger grid-cell size, and end up with larger grid cells with less than 40% SIC.

Thank you for this point. While we agree that one can always blur out an ice edge by moving to larger and larger grid cells, the product itself does not provide information beyond a 40% cutoff.

That said, this is important when we re-grid MASIE to grASIP grid for the analysis in section 4.3 and introduce non-binary values along the ice edge. We now explain that the SIC = 0.5 contour from this gridding is used, to be as true to the source data as possible.

L35-131 The Introduction section could be shortened and tightened up a lot. Omit needless words.

We have tightened up the wording in the introduction section. However, given the suggestions for this section from both reviewers, we have slightly increased the length of the introduction, as opposed to shortened it.

L58: Lohanick is misspelled.

Thank you for catching this, it is fixed.

L59: It would help users understand better if written “This leads to an underestimation of sea ice concentration, which in turn results in an underestimation of sea ice extent...”

Done.

L63-67: While the first method describes using a processing algorithm on satellite data, the second method describes how a human might draw a chart. Different word choices might better get across the manual nature of drawing operational charts, e.g “an analyst manually synthesizes the information in satellite imagery ...” ; ”Operational maps as drawn...”

We have modified the word choice to emphasize the manual nature of this second class of ice products. We also take this opportunity to define what we mean by operational ice products.

L77: Consider citing the CIS data so that others can easily find it:

Done.

Canadian Ice Service (2009). Canadian Ice Service Arctic Regional Sea Ice Charts in SIGRID-3 Format, Version 1 [Data Set]. Boulder, Colorado USA. National Snow and Ice Data Center. <https://doi.org/10.7265/N51V5BW9>.

Done.

L80-81: here, please make the clarifications and add the citations that I noted with respect to the abstract. Also, I hear that USNIC prefers USNIC to NIC these days.

Done. We also have updated the manuscript to use USNIC, instead of NIC.

L87-88: This is the first mention of color code, egg code, and WMO standards. A few things are incorrect. “Egg code” is not a WMO standard, rather, it is a shorthand way, taken from the egg shape of the labeling symbol, that analysts use to refer to how a polygon in an ice chart is

labeled. The ice information inside the egg symbol would be in SIGRID, which is a WMO format. While SIGRID is used by ASIP, USNIC, and other ice services to describe the ice within each polygon, egg codes are not used much anymore. (Danish Meteorological Institute charts are an exception. See <https://www.bsis-ice.de/IcePortal/>)

I would avoid using “egg code” entirely. Instead, just briefly mention that you are following ASIP and international ice chart convention in using the WMO color code and descriptors for characterizing ice concentration ranges in your presentation of AMSR2 and MASIE sea ice concentration as well as for ASIP. You can cite WMO Sea-Ice Nomenclature (WMO, 2014):

World Meteorological Organization (WMO). 2014. WMO Sea-Ice Nomenclature. Volume 1 - Terminology and Codes, Volume II - Illustrated Glossary, Volume III - International System of Sea-Ice Symbols. Fifth Session of Joint Commission on Marine Meteorology (JCOMM) Expert Team on Sea Ice. WMO Publication No. 259.

and perhaps Manual of Standard Procedures for Observing and Reporting Ice Conditions (MANICE) (Env. Canada, 2005)

Environment Canada. 2005. Manual of Standard Procedures for Observing and Reporting Ice Conditions (MANICE). Issuing authority: Assistant Deputy Minister, Meteorological Service of Canada.

Thank you for the clarification on the origins of the term “egg code”. We have updated the text to avoid using the terminology “egg code” and instead do as suggested by the reviewer, by explaining that we are using WMO convention for color codes and ice descriptors. The reader is then referenced to both the citations listed here, as well as section 2.1, which has been updated following this comment.

L89: Include acronym here (SASSIE) if correct to do so.

Done.

L120: Remove “operational” here.

Done.

L123-131 and Figure 1: The images here need to be MUCH bigger. Delete the photo (e) if necessary in order to enlarge the rest of the figure. Also please clean up the text about WMO and eggs, and provide the information on how AMSR2 data are binned somewhere in the main text, not the caption.

We have shifted panel (e) below the SIC maps (a-d), in order to enlarge panels a-d, and we have removed the mention of egg code. The AMSR2 SIC binning information has been moved to the text.

L143-144: Suggest you include just one WMO reference, this one, at the end of the second sentence:

World Meteorological Organization (WMO). 2010. SIGRID-3 : A Vector Archive Format for Sea Ice Charts. Intergovernmental Oceanographic Commission. First edition: 2004. JCOMM Technical Report No. 23, WMO/TD-No. 1214: <https://library.wmo.int/index.php>

Done.

L148: Suggest changing “but is analyzed from imagery over the preceding 24 hours.” To “based on imagery acquired over the preceding 24 hours.”

Done.

L154-180: Please consider my general comments when editing this section, and describe how a person draws polygons. The word “implement” is misleading. Also, it’s not always clear what is meant when the word “parse” is used. Consider choosing other words to describe the process of gridding the ASIP polygon SIC information onto a grid in some projection.

I suggest you reference the following data set somewhere in Section 2.1. As with the ASIP product, when we made it, we needed to convert SIC information in shapefile polygons to gridded fields of SIC. The User Guide for the product describes the process we used. There are so few products of this kind that it would be helpful for readers to know about this one as well:

U.S. National Ice Center. 2020. U.S. National Ice Center Arctic and Antarctic Sea Ice Concentration and Climatologies in Gridded Format, Version 1. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. <https://doi.org/10.7265/46cc-3952>.

Thank you for the helpful comments to tighten up word choice. We have added an explanation for how an analyst draws a polygon. The word implemented has been replaced with drawn. Instead of using the word parse, we now explain that the data are read, projected, and the alphanumeric string corresponding to ice concentration and form are converted to numerical information. Then the data are gridded and SIC is computed. We also now refer to the above citation to demonstrate that this has been done similarly for other datasets.

Figure 2 (c) and (f): Suggest using a step color bar.

Done.

L255: Remove “operational”.

Done.

L260: Clarify what “it” refers to.

Done. Please note, we have expanded on this section at reviewer 1’s request.

L267-276: Please edit, taking my general comments and other specific suggestions into account.

Done.

L278: “We compare satellite SIC to in-situ observations...” What does “satellite SIC” refer to? Is it just the AMSR2 25km and 3.125 km products? Please specify. MASIE and the ASIP products should not be referred to simply as “satellite SIC”. Perhaps “gridded SIC fields” is a better choice?

This has been clarified.

L279: Further confusion about satellite products here. Line 280 refers to the “nearest satellite pass”, but earlier, AMSR data were described as a daily field and not as swath data. Is the time of the nearest satellite pass known? “Satellite grid cell”: does this mean the AMSR2 SIC grid cell?

Thank you for identifying this confusion. We have clarified the text to refer to SIC products/maps. While we do not know the specific time of the nearest pass, we take the timestamp from the daily gridded field in the SIC product. The reason this still matters is because there are cases when an in situ observation is > 12 hours from a SIC map (this is especially true for ASIP matchups, as ASIP does not have daily maps for the entire record).

L285: Here, “three satellite products” implies that “satellite products” is being used to refer to the MASIE and ASIP fields and not just the AMSR2 data. Please choose words other than “satellite products” and clarify the reference to “nearest satellite pass”.

Done. We now refer to the datasets as “SIC products/map”.

L292: Section 3.1 is titled “Satellite products compared with in-situ observations”. Change “satellite products”.

Done. This now reads “Ice maps compared with in situ observations”.

L295: Suggest addition to read “...defining the ice edge in passive microwave products...”

Done. Note, this sentence has been moved to earlier in the manuscript to the methods section (3.3 Defining the ice edge).

L340 and section 3.1.2: It’s not surprising that AMSR2 under-predicts the presence of sea ice, and it’s helpful to see it demonstrated by the comparison with shipboard obs and with the ASIP operational charts here.

Agreed, thank you.

Figure 7: I agree with RC1 that these figures can be much smaller and font bigger.

Done.

Figure 8: Suggest including only one (bigger) legend and making the MASIE edge a different color.

Done. Thank you for pointing out the red/green issue. We have updated the AMSR2 to a dark red and MASIE to a yellow/orange. The figure has been updated to have one large legend. Note, to maintain consistency throughout the manuscript, we have also updated Fig. 6 and Table 3 to use this color scheme.

L434: Does the word “difference” belong after “distance”?

We have clarified the meaning by re-wording the text to read “ice edge distance between products”.

Figure 10: the Y axis needs units.

Done.

L468: The phrase “lowest common denominator” doesn’t work well here.

We have removed this section and instead describe how the comparisons are made in the new methods section (3.1 Parity analysis, paragraph 3).

L479-486: This is important information that should come earlier.

This has been shortened and moved earlier in the manuscript, to section 4.3.

L 485: Suggest addition to read “...ASIP product is a vector shapefile that is not provided...”

Per reviewer 1’s comments, we have removed this statement.

L494: “grid cell” would be better than “pixel”

Done.

L496: Suggest instead of “the broader pixel” using “are reflected in the SIC grid cell”

Done.

L520: IMPORTANT- Should read “...grateful to all the analysts at ASIP and at USNIC”.

Thank you, done.

L558: This should read:

U.S. National Ice Center, Fetterer, F., Savoie, M., Helfrich, S. & Clemente-Colón, P. (2010). Multisensor Analyzed Sea Ice Extent - Northern Hemisphere (MASIE-NH), Version 1 [Data

Set]. Boulder, Colorado USA. National Snow and Ice Data Center.
<https://doi.org/10.7265/N5GT5K3K>.

Done.

L585: Please include DOI or link for this report.

Done.

L598: Please include DOI or link for this report.

Done.

L602: Please include DOI or link for this report.

Done.