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Discussions

Interactive comment on "Observation of the 2018 North Greenland polynya with a new merged optical and passive microwave sea ice concentration dataset" *by* Valentin Ludwig et al.

Anonymous Referee #2

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Review of "tc-2019-23" Observation of the 2018 North Greenland polynya with a new merged optical and passive microwave sea ice concentration dataset.

This manuscript presents a new sea-ice concentration methodology, merging an established AMSR2 SIC estimate with thermal-infrared (MODIS) SICs. The new SIC product is then demonstrated in a specific case of the "North Greenland Polynya" event in Feb/March 2018. The polynya event is described with the new SIC data, and additional data (atmosphere reanalysis, ice drift product, coupled ocean/ice model), and the processes leading to re-freeze are described and compared to ground truth (Airborne ElectroMagnetic) data. The event is set in perspective with more typical polynya

events.

It is an interesting paper, that should be published, but both the structure and content of the manuscript must be improved before. I noted several comments (both typos and more general comments) below. I am rather optimistic the authors will -through serious revision work- produce an improved paper, since I found the Discussions were much clearer than the rest of the text. All the material is here, but the text needs are rework.

Title : this paper is really too short on the merging methodology and its evaluation to really consider that we would now have a "new merged optical and passive microwave dataset". I suggest you change your title to underline this is an "introduction" or "initial work" on your product.

Abstract: "20C above the average " → "normal"

Introduction "The recent sea ice retreat ..." : how recent? Also, please add a citation for this sentence. "The 89 GHz sensor..." : change "sensor" with "frequency channels". "3 by 5 km" this is the instantaneous field of view, the effective field of view is closer to "5 by 5 km". "Also, they are insensitive towards the sea ice thickness for thicknesses above 10 cm": this depends strongly on which frequency enters in the algorithms (Ivanova et al. 2015). 10cm might be correct for "near-90GHz" algorithms such as ASI.

About the SAR limitations. Once cloud cover is taken into account, there is much more SAR coverage than thermal infrared. So coverage (swath width and duty cycle) is not a good argument. Automated retrieval of sea-ice from SAR is however a challenging topic, and this might be noted here.

Too many citations of Morales-Maqueda et al. (2004) in 3-4 sentences. Rewrite.

The "oldest and thickest" in the entire Arctic... I would expect sea-ice north of CAA to be older. Change to "one of the oldest and thickest"?

The box used for Figure 1 might be too large, as it includes processes in the East Greenland current. Consider using the same box as Moore et al. (2018) which is

better suited (alternatively, justify your box in the text and note it include processes in the East Greenland Sea).

Section 2.1.1 : here again occurences of "3 by 5 km" should be annotated. You are mixing iFoV, eFoV, sampling in the swath, and sampling on the projected grid.

OSI SAF data; 1) if you use OSI-450, the correct citation is Lavergne et al. (2019). 2) it is unclear if you use the box in polar stereographic coordinates (as shown in Fig 1), or in lat/lon box. Clarify. As noted above, consider using the same lat/lon box as Moore et al. (2018). 3) you are stitching together different products (OSI-450 and OSI-401) and should document that the time-series (of average SIC) are consistent at their transition. 4) the uncertainty are probably not spatially independent (Lavergne et al. 2019) and your approach to error bars seem simplistic. Error bars could rather show the variability (standard deviation) of the SIC in the box, this would also be valid.

Description of OSI-SAF sea-ice drift ; "the single-sensor sea ice drift vectors are merged by an optimal _interpolation_ scheme". Also you could cite Lavergne et al (2010) JGRO rather than the ATBD (grey litterature).

End of 2.2.5: "The results therefore represent the thickness of 5 weeks old first-year ice"... add " ... in those specific environmental conditions".

Move 2.2.5 to section 3 "methods" (since you compute it yourself). However you could add a short subsection to introduce ERA5.

Section 2.2.7, please update your reference to Patilea (now published).

2.2.8 NOASIM: "with the help of an genetic algorithm" change to "a genetic"

Please adopt a more descriptive title for section 4.

Page 10, line 20. If you use OSI-450, the correct reference is Lavergne et al. 2019. Line 21: there are only 30 days in April.

One would expect a nearly 100% average SIC north for Greenland in winter. So it is

either an artefact of the OSI SAF data, or of your box that is too large and includes the East Greenland sea region. Discuss. Also here: you stitched together two SIC products (OSI-450 and OSI-401) and should first comment the temporal consistency of the two, before comparing winter 2017/18 to the climatology.

Avoid "this year's event" and rather refer to the 2017/18 winter season explicitely.

Figure 3 : in what respect is your merged MODIS+AMSR2 SIC much better than the OSISAF SIC (Figure 1)? The OSI-SAF curve on Figure 1 also reaches 0.7 mean SIC. Maybe Mean SIC is not the most appropriate metric here, did you try "open water extent" (1 – sea-ice-extent)? And -again- your box seems very large wrt to the polynya (extending to the East Greenland Sea). Bring the OSI SAF curve from Figure 1 onto Figure 3, and discuss.

Page 15, line 11-13: "Note that the area of the opening is still visible as dark/new ice in the Sentinel-1 mosaic. This shows the limitations of AMSR2 data for the observation of polynya events". I do not understand. If a uniform cover of new-ice is seen in the Sentinel-1 mosaic, then it is correct for AMSR2 SIC to show 100% SIC (irrespective of its thickness if > 10cm). If one is interested in SIC, the SAR image might be hard to turn into 100% SIC, so I would see this as a limitation of the SAR technique. Explain further what you mean, or remove.

Figure 4: lower panel: it would be good to align the design (e.g. yticklabels, gridlines, with that of Figure 5).

You could consider merging together section 4 and 5 because section 4 is quite short.

Section 5: "Given the time of year and the location, only anomalous sea ice drift can be the driver. Nevertheless, a warm-air intrusion (Fig. 5 and 6) contributed to maintaining the polynya open." here you are stating the conclusions of your analysis. Move them to the end of this section, after the presentation of the results.

"We conclude that the sea ice must have been broken up by sea ice drift." Since Moore

et al (2018) exists, you should acknowledge them here, e.g. by stating that you confirm (or not) their conclusions.

Figure 5: fix unit of y-axis for lower panel (should be km^2)

Figure 6 and 7 (d) and (e): please regrid the winds to a polar grid before plotting. Here the lat/lon original sampling is evident and disturb the interpretation (e.g. no vectors in the central Arctic Ocean).

Table 1 and Figure 8: consider re-stating the source of sea-ice drift information (OSI SAF) in the legend, like done in Figure 6 and 7 (ERA5).

Section 6:

We need more details on how the NAOSIM, FDD, and SMOS/SMAP products are compared. The sentence "For consistency, only grid cells with a SIC minimum beneath 50 % during the polynya on the respective grid are considered for the calculation. " in the caption to Figure 9 should be re-written (I did not understand what you mean), and this should be in the text of section 6 (not in the caption). The SMOS/SMAP curve is unsettling because it first drops while the two others grow steadily. Yet, you write "The SMOS/SMAP sea ice thickness evolved synchronously to the accumulated thermodynamic sea ice growth" which is maybe correct after the re-freeze has started, but not before. We need more details on how you extracted the SMOS/SMAP curve (average over the same box)? What you probably want is to show SMOS/SMAP only there there is newly forming ice (not where there is still old sea-ice). Also, the SMOS/SMAP algorithm uses the hypothesis of 100% sea-ice cover (this is not the case during the whole event). And L-band radiometry might (or not, discuss) be affected by the warm air intrusion if there is surface melt. Please re-work this section.

Sea-ice volume computations and Fig 9 (b): first, methodology: "by multiplying the accumulated growth rates from Fig. 9 with the area covered by the polynya"... where do you find the area of the polynya? Is it from Figure 4 and 5 (lower panels)? If the

C5

case, then after March 8th the area is 0 (according to the merged product), so we would expect the volume curves to not grow anymore? Looking again at Figure 9 (b) it almost seems it is a scaling from Figure 9 (b). So did you use a fixed polynya area? If a fixed polynya area, the plot does not bring information compared to your sentence "The freezing degree day parameterisation yields a sea ice volume of 33 km3 , NAOSIM yields a sea ice volume of 15 km3 ." Please rework the description of your "new ice volume" computation.

Page 23 line 6: This would be Figure 9(c).

Figure 10: panels to the right with AEM. Interesting, but difficult to know where we are. Suggestion to plot a larger area or add a larger map as inlet to show where the sampled region is. Also, merge the two maps and use a different symbol (or a label) to show the difference of date. The AEM frequency distribution has a first peak around 0.1m. What is this, an artefact? Describe and comment.

Section 7, discussions: "extraordinary" is often (always?) used in a very positive sense, while you mean here this is a first-time event.

Again, Moore et al. (2018) already compared with the 1978-2017 climatology, so your should put your findings in perspective of their study.

Otherwise, I found the discussion much much clearer than the text in Section 6 (e.g. on the volume computation, the meaning of the heat exchange, etc...).

Page 29, line 30: "European Copernicus Sentinel-2" add "Union".

Acknowledgements: since you use both SIC and SIDrift from EUMETSAT OSI SAF, you could add them in this section. Also, you could credit DMI for running (and sharing data from) the weather station.

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