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Interactive comment on "High-resolution mapping of circum-Antarctic landfast sea ice distribution, 2000–2018" *by* Alexander D. Fraser et al.

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(Responses separated into general comments to Reviewer 3, "R3A" through "R3D" as a response to the general comments, then "1)", "2)", etc for specific minor comments)

General comments to Reviewer 3: We thank Reviewer 3 for recognising the importance of this dataset, and for their careful and constructive review which will improve the manuscript. We generally agree with all of Reviewer 3's suggestions and happily note that they reflect many of the same suggestions of the other reviewers!

R3A-D:

R3A) I found the description of the algorithm in the methods section somewhat difficult to follow. I would recommend creating a flow-diagram to better illus-

trate how the algorithm is applied in general This diagram could then refer to Figure 1 to illustrate outputs at various steps in the algorithm. I would also like to see more detail on some aspects of the algorithm. For example, how does the algorithm deal with cases where both thermal and visible imagery are available when generating the 15-day cloud-free composite images? I would also like to see some discussion in the results section on whether there were observed differences between fast ice area products generated from visible and thermal composite images. Further, I would like to see more justification for choosing a 1-km, 15-day epoch for identifying landfast sea ice, and more discussion on how the choice of this epoch influences the generated fast ice extent products.

Similar suggestions were made by Reviewers 1 and 2. The flow chart is a great idea which we will implement.

Regarding your request for more detail, this has also been requested by Reviewers 1 and 2. To specifically answer your questions here:

When visible channel information is available we parallel-process all algorithms for both the Channel 01 (visible) and Channel 31 (thermal IR) cases. Edge guesses are produced for both channels, and combined at the very last step before manual edge completion. We will add this detail to the manuscript. We are also happy to add discussion about the improvements to automation possible when visible channel information is incorporated. The 1 km, 15 day justification has been requested by Reviewer 2 as well – I paste the reply to their comment here for convenience:

As you indicate, our spatial resolution was indeed influenced by the sub-satellite (i.e., nominal) resolution of the thermal infrared channels. Our previous work using fewer swaths per compositing period was limited to a 2 km spatial resolution, but here with more swaths, we were able to get good results with a 1 km spatial resolution.

Regarding the temporal resolution of 15 days, we were driven by a desire to get a finer time-step while still precluding pack ice temporarily advected against the coast from

being counted as fast ice. Another factor limiting a finer time-step is cloud coverage. We find that with a 15 day window we are generally able to build high-quality cloud-free composite imagery. We think this is near the limit though – a finer time-step is likely to result in "holes" in the cloud-free composite imagery corresponding to persistently cloudy regions.

We didn't perform independent retrieval on visible vs thermal IR input data in times of both being available. However we note that the performance of the cloud mask is generally better during times of solar illumination, leading to better quality composite images, so expect that the automation fraction is generally higher during the summer.

R3B) I would also like to see more discussion on the fast ice distributions shown in Figure 2. Antarctic fast ice extent can be temporally variable on a regional scale, and I would argue that this variability is not captured by presenting pan-Antarctic maximum and minimum distributions. For example, the fast ice edge in McMurdo Sound in 2016 was significantly farther from the coast than shown in Figure 2 (see, for exampleMYD02.A2016350.0410.006).

We completely agree with this! However such analysis will appear in our later work, since it is out of scope for ESSD: "Articles in the data section may pertain to the planning, instrumentation, and execution of experiments or collection of data. Any interpretation of data is outside the scope of regular articles." (from https://www.earth-system-science-data.net/about/manuscript$_{t}ypes.html$)

R3C) The authors state that the number of images contributing to the composite was in- creased relative to the Fraser et al. (2019) algorithm (Lines 114 + 115). I would like to see more details on how this was accomplished, particularly since the epoch was reduced from 20 to 15 days. If I understand correctly, the auto-determined fast ice edge moved an average of âĹij 10 km in a 15-day period. How does this compare to previous regional studies?

Happy to elaborate on this. Upon clarifying that statement I discovered that our earlier

work (actually Fraser et al., 2010) did indeed use a slightly smaller input image density (number of images per day). However in our earlier work we considered only half as much coast (10 degrees west to 172 degrees east) so the density was in fact probably higher. However in the present work we rank our relatively fewer images more intelligently to ensure more even coverage in all regions (see response to Reviewer 1, relevant response pasted here in italics). We also use the full swath width here, whereas we trimmed in our previous work (which was more susceptible to cloud-mask inaccuracies). Thus we prefer to rewrite point 1 to state "1) ensuring a more even distribution of cloud-free scenes, thereby increasing the chance of a cloud-free view of the surface".

In line 132 we state that 600 images are incorporated into the composite images for each 15 day period, but we are happy to elaborate on this in the text by saying that these 600 images are separated into 6 regions of 100 images. Without this regional consideration, we found that there is a concentration of images in one or more particular regions based on cloud conditions, since we rank and select the 600 least cloudy granules.

Yes, we found the auto-determined fast ice edge moves around 10 km in a 15 day period. We aren't aware of any previous regional, automated, long-term datasets but are interested in performing this kind of comparison in future work. Automated SAR products exist but are sporadic in coverage and temporal baseline, so are likely to have a confounded statistic in this regard.

R3D) The authors state that four adaptive thresholds are set when computing fast ice edge confidence, but then do not describe how these thresholds are utilised in the algorithm. Please provide this detail.

Apologies for this oversight! These thresholds are used to assign four levels of edge confidence in the automatically-determined edge map. This is the main input to the manual processing step. The manual processing links automatically-determined

edges. This map showing four levels of confidence (as a grey-scale) are particularly helpful in guiding edge completion. This detail will be added to the text at around L150.

1) Line 7: visible-thermal infrared imagery – change to "compositing visible and thermal infrared imagery".

OK

2) Line 38: change ", but at a poorer spatial resolution of 6.25 km (Nihashi and Ohshima, 2015) to limit its" to ", but a poorer spatial resolution of 6.25 km (Nihashi and Ohshima, 2015) limits its"

Good suggestion, thank you.

3) Lines 65 – 75: this would fit better in the results section.

Reviewer 1 also suggested to move it, but to discussion. We will move it to one of these sections.

4) Line 66: suggest re-order "It also has a multitude of potential scientific and operational uses, given the wide-ranging importance of fast ice" to "Given the wide-ranging importance of fast ice, it also has a multitude of potential scientific and operational uses."

Good suggestion, we will amend it.

5) Line 68: remove "developed"

Agreed.

6) Line 95: Can you estimate how time intensive it is to update the coastlines and ice shelf edge positions on an annual basis?

Also a suggestion of Reviewer 2. This update (conducted once per year, or 18 times) was trivial in comparison to edge completion of the 432 fast ice maps. Detail will be added.

7) Line 96: it is not clear what is meant by "change in".

Also suggested by Reviewer 2. Will be amended.

8) Line 104: where are the data provided?

This is detailed in the abstract, the data availability section and in the reference list, and all three places are mandated by ESSD. I'm hesitant to include the URL again but am happy to if the editor agrees.

9) Line 139: what is meant by "successive"?

A mistake by me – also picked up by reviewer 2! This will be amended.

10) Line 139 + 140: provide more detail by what is meant by "sum over".

As above – this mistake will be rectified.

11) Line 142: Provide more detail on how the absolute value of the gradient for the composite image was calculated.

OK. For each pixel in each composite image (i.e., for the visible composite and the thermal IR composite images separately) the median pixel value was calculated from a 7*7 pixel neighbourhood. Then for each pixel in the median-filtered composite, the magnitude of the gradient vector was obtained. More detail will be added to the text.

12) Line 149: remove "are set".

Thank you – will do.

13) Lines 154 – 158: how time intensive is it (on average) to undertake manual processing of fast ice edges? How are the lead-detection images used in the manual processing?

Reviewer 1 also requested this detail. It is the most time-intensive part of the work. One year of manual processing (i.e., 24 maps) can be completed in about one week of approximately full-time work. The aim for the manual processing is to complete

the auto-determined edges, so as to provide a contiguous fast ice edge which can be "bucket-filled" to represent fast ice. This detail will be added to the text.

14) Line 178: replace "Here and" with "Here, "

OK

15) Lines 195 + 197: provide more detail on how the mean fast ice edge separation between composite subsequent images is calculated, e.g. how do you determine which pixel in the second image to "match" with the pixel in the first image?

We find the nearest edge of similar type (manually- or automatically-determined). Cross-type edges are ignored (i.e., auto to manual, or manual to auto) to avoid confounding results. A cutoff of +/- 50 px (i.e., a 100 km window) is used as an extremely conservative upper bound to avoid the rare case of pixels matching with distant pixels. This detail will be added to the text.

16) Line 202: explain what is meant by ". . . all remaining manually-determined pixels . . ."

"Remaining" was a poor choice of word. Sentence changed to "weighting all skeletonised manually-determined pixels by their respective area".

17) Line 223: replace "journal" with "manuscript".

We did actually mean "journal" here – ESSD is only for presentation of datasets, not their scientific analysis – but agree that "manuscript" would fit equally well in this case.

18) Line 248: confirm whether the time period over which these variations have been calculated is 15-days.

You're right. This clarification will be added.

Comments on the data set

19) In the data set's README file, it states that the latitude of true scale is 70 N. This should read 70 S.

Thank you for picking up on this error. I have already amended it at the data centre.

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