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Interactive comment on "Classification of Sea Ice Types in Sentinel-1 SAR images" *by* Jeong-Won Park et al.

Anonymous Referee #1

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The manuscript by Park et al presents a machine learning technique to provide operational sea ice charts. The use of machine learning is interesting from the operational side as it enables processing of large volumes of data in a consistent manner. Such sea ice charts are of significant use for the both scientific community as well as the general community.

The manuscript is well structured, though would benefit from a spell and grammar check, e.g. Sentinel is misspelled several times. The authors claim that the method is free from subjective judgements though it requires the input of manually derived open water vs sea ice charts.

Specific comments

The authors claim that by using operationally provide sea ice charts they are avoiding

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subjective decisions in the sea ice classification training data. To my knowledge the sea ice charts provided by the US National Ice Center are based on exactly such subjective decisions and are made to the best ability of the excellent sea ice experts working there. Please clarify how the training and validation data used here are not subjected to such decisions. The manually derived open water vs sea ice maps used as input training data could also be viewed as subjectively derived data.

It is unclear if only the sea ice parts of the images were incidence angle corrected using the sea ice estimated slope or if the whole image was corrected using the slopes derived for the sea ice part of the images. Please clarify. If the incidence angle slope derived for the sea ice were used over the entire image how would this affect the open water areas of the image? How are the slopes presented here derived? Mahmud et al 2018 showed that different sea ice types have different incidence angle dependent slopes. Have you considered using a sea ice type dependent slope factor? Moreover, how does the work by Mahmud et al 2018 fit in with the incidence angle dependencies presented here?

How do you define “good match” (P7 R3)? Temporal overlap? Spatial overlap? How was this manual selection of images performed? How were the open water vs sea ice charts, that are used as initial input into the classifier, derived? Are the open water areas separated from the sea ice areas at this stage of the classification process? Or are they classified at the same time as the sea ice types?

Given that one possible reason for the low accuracy in 2019 were stated to be insufficient training data (P9 R9-11), have you tested how the classification improves/remains the same if additional training data is added? Such an assessment would add strength to the accuracy of the method presented here.

Daily ice charts using Sentinel-1 data covering at least part of the study areas used here are provided by the Norway Ice Service. A comparison with their ice charts when they overlap, spatially and temporally, would have been beneficial and added strength

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to the accuracy assessment. Partially as it would have provided daily instead of weekly ice charts to compare to.

Would your method work also outside the winter season? Has it been tested for other seasons? A majority of the shipping industry is dependent on sea ice charts year-round and a consistent method employed year-round is therefore beneficial.

Day of year might not correspond to the same temperature, fluxes and weather regimes. Have you considered using a weather variant input parameter instead of day of year? Such a parameter might be more suitable to capture the seasonality within the scenes.

How is the general accuracy derived? Is it a normalised average and does it account for the varying amounts of the different sea ice types? The overall accuracy of the sea ice classifier is only provided in the abstract and the conclusion. Please also provide it with the general results and discussion.

Is all level sea ice considered to have low backscatter? (P4 R7.)

How does the spatial resolution of 1 km affect the results? Have you tested using different spatial resolution sizes?

How was the value of 3 km set? (P7 R14)

Sea ice does not form bergy bits, the terminology used in Figure 3 of bergy water may therefore be misleading. Please change to a more appropriate term.

Visual inspection of Figure 7 seems to indicate that the method struggles with SAR image edges and that the same sea ice on different side of an image edge is classified differently, e.g. top right corner where one size of the edge is young ice and on the other side there is first-year ice. Please comment. Is the First-year ice observed in Figure 8 to the east of the old ice an artefact of a beam problem for the method?

What is your definition of New ice? For the ice types used here are you using the WMO

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definitions? In Figure 9 the sea ice type FYI thin is include in the sea ice classification results. Please clarify what thin FYI means. Why is this class not used throughout?

Consider adding something indicating the semi-automatic aspect of the manuscript in the title. And also indicate that the Sentinel-1 scenes used here only reflect the winter season.

Technical comments

In many places references to the appropriate work is missing, e.g. P1, R27, P4 R15-16 and P6 R9-10. Please carefully revise the manuscript to include references to earlier work.

The method is claimed to be semi-automatic in the body of the manuscript though the word semi- is left out of the abstract of the manuscript. Please correct.

P1 R22-24. Unclear sentence, consider rewriting.

P.1, R.14-15. Unclear sentence, consider rewriting.

Minor grammatical errors are present throughout the manuscript, e.g. P2 R5 ... particularly in the cross-polarization... P2 R7 ... considering the relative... p2 R31 ...to train the classifier... P3 R15 To take advantage of the objective... Please carefully revise the English language throughout and pay particular attention to "the"

P2 R24 Region of interest -> region of study

P2 R25 coexit -> are found

P3 R2 National Ice Center (NIC) -> US National Ice Center

P3 R29. What does the precision of decimals mean here? That e.g. that the sea ice concentration can be 10.1%?

P4 R5. What is strong noise?

Consider using the commonly used term "open water" instead of "ocean" throughout. The same goes for ice free (IF) please use the much more commonly used open water (OW). MFYI could easily be confused with Multi-first-year ice. If MFYI is meant to indicate Mixed First Year Ice please change this or at least include this information in the header of the tables 4 and 5. In Table 4 and 5 are the MFYI meant to be used also

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on the predicted header?
P4 R12. Senitnel -> Sentinel
P5 R9 “Furthermore, further. . .” consider changing this.
P6 R10-12 you argue that when training dataset are prepared manually the sample size is usually less then 20 images. Please provide several references to support this statement.
P7 R6. Unclear sentence please revise.
P7 R19-21 appears to be a description of the method please move them to the methods section.
P8 R13-14. Substantial work studying young ice type has been carried out by e.g. Dierking 2010. Consider referencing such works. The young sea ice has a large range in backscatter values from very low to high and are also often subjected to frost flowers, see e.g. excellent work by Isleifson. Stating that young ice “typically just look dark in the SAR images” may therefore not be strictly true.
P9 R13-15. Unclear sentence, please revise.
P9 R16. What does “charted in” mean?
P9 R17. What does “included wrong samples” mean? What makes a sample wrong?
P9 R19. When mentioning previous studies please provide references to these studies.
P9 R31-32. Daily ice charts building on Sentinel-1 are provided by the Ice service at the Meteorological office in Norway, so it is certainly true that this can be done.
Figure 4. What does the colorbar represent?
Figure 8. In Figure 3 and 7 the ice chart from 3 days later is used yet in Figure 8 the image from the same day is used. Please be consistent in which time interval is used for these weekly ice charts.

References

Mahmud, M.S., T. Geldsetzer, S. E. L. Howell, J. J. Yackel, V. Nandan, and R. K. Scharien, Incidence Angle Dependence of HH-Polarized C and L-Band Wintertime

Backscatter over Arctic Sea Ice, EEE Transactions on Geoscience and Remote Sensing, 2018.

W. Dierking, Mapping of Different Sea Ice Regimes Using Images from Sentinel-1 and ALOS Synthetic Aperture Radar, IEEE Transactions on Geoscience and Remote Sensing, vol. 48, no. 3, pp. 1045–1058, March 2010.

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