

The Cryosphere Discuss., author comment AC1
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Reply on RC1

Wenkai Guo et al.

Author comment on "Sea ice classification of TerraSAR-X ScanSAR images for the MOSAiC expedition incorporating per-class incidence angle dependency of image texture" by Wenkai Guo et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2022-86-AC1>, 2022

The manuscript "Sea ice classification of TerraSAR-X ScanSAR images for the MOSAiC expedition incorporating per-class incidence angle dependency of image texture" presents methodology and results of sea ice type classification of TerraSAR-X imagery obtained during the MOSAiC expedition. Despite very interesting findings, due to large diversity of methods, results and analysis and a large size of the manuscript, it is recommended to split the manuscript in two parts, improve the order of the presentation and resubmit the manuscript(s) after a major revision.

Major comments

- **Although only two objectives are formulated in the introduction, the impression is that the manuscript attempts to fulfil at least four: 1. Investigate per-class AI dependence; 2. Optimize parameters of texture features; 3. Train and evaluate classifier; 4. Analyse time series. In my opinion such variety of objectives does not allow to focus well. That makes the manuscript too long to read and the story too difficult to follow. I would suggest to completely remove section 3.3 and correspondingly reduce section 3.4. I'm confident that results shown in these sections deserve a separate paper. I will therefore focus my review on the first, methodological part.**

We think it's reasonable to maintain the current manuscript structure, while streamlining the text for better clarity and readability. As suggested by the manuscript title, this paper mainly serves as an introduction to a classified time series which can potentially be a useful dataset for MOSAiC-related research. Quantitative evaluation of the classification, the comparison to ice roughness transects, and the comparison to ice opening records in other studies have shown the reliability of the classified time series. Method development was not central, having used an established classifier and commonly used GLCM textures to aid the classification. The demonstration of IA dependencies of TSX intensities/textures,

which is another major finding of the paper, is also based on the time series itself. This clarification will also be reflected in the introduction section of the text.

- **What is GIA classifier? Authors refer to that term in many places, but it is never defined or explained. I guess, that's one of the central blocks in the classification algorithm: apparently, the backscatter, the texture features, the IA are passed into the mysterious "GIA classifier" for doing the actual classification. But how?! I'm very curious to know. GIA classifier needs to be clearly explained.**

As stated in the text, the GIA classifier was developed and published in Lohse et al., 2020. The investigation of IA dependencies of sea ice types on TSX SC is central to this study, hence the choice of the GIA classifier which specifically incorporates this phenomenon well. This is explained by the most part of the 3rd paragraph in the Introduction. We think that this length is suitable for the manuscript which is currently already lengthy.

- **Order of presentation needs to be revised in order to correspond to the selected logic (Intro, Data and methods, Results and Discussion): Lines 133 – 144 and Fig. 4 should come in Section 2.1 Data; Lines 151 – 164 with Table 1 and lines 271 – 275 with Table 2 belong to Introduction as they describe state-of-the-art; Section 2.3.2 belongs to Results as it describes WHAT is achieved and not HOW it is achieved.**

Edited.

Exceptions:

a. Table 1 is specific to this study, and is introduced by line 165. Therefore, we think it's best to keep it in its current position.

b. Lines 271-275 and Table 2 are meant to summarize our parameterization while placing it into the bigger picture of previous finds. The same is done for IA dependencies in this section. Therefore, we also think it's best to be kept in its current position.

- **Analysis of IA dependence for various ice types need to be increased as it is an important result of this work. What is error-bars of the slopes (it can be computed, e.g. by bootstrapping) and what is significance? What is the reason for large positive bias of the slopes – speculation on stronger volume scattering needs to be expanded. What is physical reasoning behind positive slope for leads? The suggested method and parametrisations seem to be**

difficult to use in other conditions (C-band, other IA, other ice types, summer). Although it is mentioned as a limitation in the end, I believe it is important to also underline in the Introduction – the goal is to study a specific TSX SC timeseries and for analysis of another dataset a similar full-scale analysis needs to be performed.

In fig.5, IA slope values in bold fonts indicate statistical significance of the linear regression model, while regular fonts indicate otherwise. All slope values are significant except for the leads class, which is expected as all leads pixels are under the noise floor of the sensor, leading to a wide distribution of pixel values that does not exhibit a significant linear dependency to IA (mentioned in the text). The positive slope is therefore not significant and has no physical meaning (visually, a slight negative slope can be observed). Errors can be computed for the linear models but is of less interest to our study, but can be included in the appendix if desired.

Yes, an explanation is added to the introduction to clarify the limited setting of this study: 'In summary, the objectives of this study are: 1. to investigate and demonstrate per-class IA dependencies of TSX SC HH intensity and GLCM textures **specifically for the above mentioned study area and period...**'

- **Image size and number of texture features are undoubtedly important hyperparameters of the Haralick algorithm. However, neglecting quantisation level and distance to neighbour pixels can lead to significantly worse results. Sensitivity to these two parameters should also be studied, for example in this respect: how does despeckling boxcar filter impact the GLCM? In theory, if a 3x3 filter is applied and then GLCM is computed with 2 pix distance, there should be almost no elements in GLCM off the main diagonal. On another note, Haralick (1973) suggested using adjacent pixels (d=1) so the choice of authors d=2 should be tested and explained better.**

The number of quantization levels directly impacts the precision of the converted integer values used for GLCM calculation in representing the actual pixel values. Therefore, within reasonable computational loads, more levels are desirable. A level of 64 is thus chosen, and the reasoning is included in the text.

The speckle filter is no longer used to further preserve spatial details.

The displacement value is now directly added to the parameter optimization process (section 2.3.3), i.e., an optimal set of displacement size, window size and texture combination is selected together.

Minor comments

L7. Phrases in parenthesis make the sentence very unclear. Please split into two sentences.

All instances in manuscript are adjusted accordingly, except for very short clarifications and acronyms.

L12. Unfortunately the GIA classifier and class probabilities are never explained in the manuscript.

See reply to major comment 2.

L24. Please provide reference to prove the "largest expedition in history"?

Reference added.

L71. Objective 1 is actually two objectives: 1 . to investigate and demonstrate per-class IA dependencies of TSX SC HH intensity and GLCM textures; 2. to determine the feasibility and optimal parameterization of including texture measures as input features to the GIA classifier.

Edited.

Figure 1 shall be removed as it does not explain anything.

Edited.

L96. "and shown in details in " -> ", dates shown in"

Edited.

L107. Why were these ice categories chosen? It should be written that other categories were not

present in the dataset and the method cannot be extrapolated.

'Based on the ice conditions in the study area and period' is added to show that the choice is made considering the specific conditions of this study.

L129. Polygons == rectangles? This is unclear.

The first instance has been edited to 'polygons in rectangles,' and 'polygons' are used subsequently.

L133. Maybe "evolution of young ice" ?

Edited.

L135. Please rewrite "wide-spread lead openings of open water or nilas" as "wide opening of leads

with water or nilas"

This is meant to emphasize the spatial abundance of leads within the area, instead of the physical widths of the leads. It has been edited to ' wide-spread opening of leads with water or nilas.'

Figure 3. The smallest sub-images seem to be very blurred. Is it the effect of the despeckling filter or just visualisation?

The smallest sub-images are zoomed in to a level where individual pixels are visible, in order to give a (example) visual impression of textures of each class at this scale. I would not say they are 'blurred,' as this visual effect is natural at this zoom scale, and also it can be seen that different classes have different 'blurriness' which are related to how their textures differ from each other. Of course, as we now do not use a speckle filter, visually these subsets are now less 'blurred.'

L208. Cannot agree here. Other authors also studied distance and number of grey levels (e.g. Clausi 2002). Sensitivity to these two parameters need also to

be studied (see major comments).

See reply to the corresponding major comment.

L221. "...and thus is a relatively..."

Edited.

L236 and 237. Is that already results of parameter optimization? Then it is better to move to the Results section.

Edited.

L268. Why volume scattering is presumed to be stronger?

In this sentence, 'stronger volume scattering' refers to MYI, and 'added randomness in backscatter caused by deformation features' refers to deformed FYI. 'Respectively' is now added at the end of the sentence to avoid confusion.

Figure 6. Is positive slope for leads even physical? How the strong positive bias of the slopes can be

explained?

All of these pixels are under the noise floor of the sensor, resulting in unreliable IA dependencies. Explanation is added to the text.

L274. "This is given that" can be removed.

Edited.

L276 – 280. This seems to be logical after the results, in the Conclusions section.

As this relates to the limitations of this study, these sentences have been moved to the 'Limitations and future steps' section, which also avoids lengthy conclusions.

L321. A reference to unpublished work just supports my concern that it is too early to include this section in the manuscript.

This sentence only refers to the method of classifying the sea ice roughness transects that happens to be also used in another study. These roughness transects are analyzed specifically for this study.

Figure 10. It is impossible to see shades of blue on the roughness transects.

The symbology is adjusted for better visualization with thicker transects.

Figure 11 and Lines 389 - 392. Why the 10% sudden drop of the polygon area on ~15 December is not reflected in a similar change of MY or young ice? Why does the lead ice increases ~3 times on 1 March and this is not reflected in the polygon area? Where are the plots of "other mosaic studies" that are easy to compare with fractions of different ice types? I'm afraid it is too early to write "that the classified time series is valuable as indicator of ice openings" as I cannot see a proof of that. Instead, the variations of ice fractions seem to be rather spontaneous and connected to uncertainty of the algorithm.

As mentioned in the text, the polygon formed by the buoys is a small, variable area around the ship, which is much smaller than the parts of TSX scenes used for classification. Therefore, not all variations are synchronized between these time series. We'll consider putting results from other papers directly within the plots for easier comparison.

L396. "The leads class are mostly fully represented in the classification map" is it really a limitation? Can be removed from that section.

This is added in comparison to the sentence before (incomplete representation of thin young ice areas). 'Comparatively' is now added to clarify.

L425. Convolutional neural networks also deserve being mentioned as a potential tool.

Deep learning-related methods are definitely important tools for sea ice classification, but this sentence only talks about potential utilization of different forms of image texture. A sentence is added to the end of this section to mention the future use of CNN in the classification.