Review of the paper "Operational algorithm for ice/water classification on dual-polarized RADARSAT-2 images" by N. Zakhvatkina and 4 co-authors

General comment

Currently not many SAR based products are in operational use in the sea ice monitoring although a large amount of case studies utilizing just a few SAR scenes have been carried out. In the present paper one such operational product is introduced and tested. The proposed approach produces an ice/open water chart in the Arctic and it can be used around the year. It uses C -band dual-polarized SAR imagery acquired by the SAR sensor in the RADARSAT-2 satellite. The approach is applicable also for Sentinel-1 data.

The major strength of the present paper is that the presented classification scheme is applied to over 2700 RS2 SAR scenes covering a time period of almost three years from 2013 to 2015. The classification results are validated against manually derived ice charts provided by the Norwegian Meteorological Institute. According to the validation procedure the accuracy of the results is high (about 91 %). Even during the summer months the accuracy remains high which is a remarkable achievement. It is well-known that ice conditions during the summer are difficult to analyze using SAR data. The article follows the traditional structure of a scientific research paper. However, the language needs editing.

There are several issues that the authors must address before the publication. I think that the main problem of the paper is that the authors often support their claims with words instead of calculations. The texture features have a central role in the classification. Despite this the authors have not demonstrated their importance quantitatively. For a reader it remains unclear how much the addition of these features increases the classification accuracy. I am more specific in my detailed comments.

When I wrote my review I had an access to the review of the Referee 1. This helped me a lot because my colleague raised several important points and questions which were also in my mind. I have focused in my comments mostly on questions not discussed in the first review.

I recommend accepting this paper after major revisions.

Detailed comments

1. P2L26- Dual-polarization has several ..

   C: The major advantage offered by the HH and HV polarizations is that they are results from different backscattering mechanisms. σ^o_{HH} is dominated by first-order scattering (direct backscatter with no multiple reflections), whereas σ^o_{HV} is a result of multiple scattering (two or more reflections involving two or more scatterers)). Hence it easy to understand that the magnitude of σ^o_{HV} is usually smaller than the magnitude σ^o_{HH}. The energy radiated towards the radar decreases significantly with each reflection. Rewrite also the text in P4 L11-14 keeping in mind the above explanation and the comment (9) by Referee 1. E.g. increased ice deformation increases also the amount of the multiple scattering as does the large volume scattering component from MYI.

2. P3L20-23. C: Here the authors could also comment why they have not targeted to produce a sea ice concentration chart which would provide to the users and modelers more information than a binary open water/sea ice chart. As we can see from Fig. 8 the presented classification chart (8d) is not a good approximation for an ice concentration chart (8b).

3. P4L5-8. C: Here you could add a remark that the classifier trained in the winter conditions is not ideal for the summer conditions.

4. P5 Sect. 3.1. and P8 Sect. 4.1. C: I strongly support the suggestion (14) of Referee 1. Otherwise the statistical incidence angle compensation that you use is left unclear. In Sect. 4.1 you give just number (0.298) without units and with wrong sign. I assume that you mean the slope coefficient $-0.298\text{dB}/1^o$. I wonder why the magnitude of the coefficient is much larger than $-0.196\text{dB}/1^o$ given in your 2013 paper for MYI or the coefficient $-0.23\text{dB}/1^o$ estimated in Mäkynen et al. (2002) for FYI. It should

be noted that in Mäkynen et al. (2002) the same targets in different images with different incidence angles are examined. If I have understood correctly, in your 2013 paper you have studied targets which looked similar but appeared in different incidence angle ranges in the same image. What kind of procedure have you followed here? Is the steeper slope due only to a different sensor or do some geophysical factors contribute, like sometimes less than 100 % ice concentration in the test images?

5. P6L2-7. C: The referee 1 already commented this passage in the comments (16) and (17) which comments I support. My additional question is that what is the role of these subclasses in the classification scheme. Does SVM use them? If so, how have you selected all these subclasses as input to the classifier. Clarify the text please.

6. P7L5-8. C: An addition to the comment (19) of the Referee 1. Yu et al. 2012 (in your reference list) have applied to the feature selection problem "a forward feature search" which is identical to the forward stepwise selection in the regression analysis. The only difference is that in the feature selection the criterion is the classification accuracy instead of the criteria like AIC, BIC and many others used in the selection of the variables in the regression model.

7. P7: Section 3.5. The description of the SVM is given in a very general level and the text is not well organized. The presentation should be more informative. You have many alternatives to detail your presentation. One is that you formulate the SVM as a solution to an optimization problem (e.g. Hastie et al, The Elements of Statistical Learning, available as a PDF file in the internet) and comment its properties from this point of view. Another approach is to treat the problem as Yu et al. 2012 (mentioned above) have done. In any case you must estimate some parameters when fitting the SVM in your data. Give the estimation method. When someone reads your text, he/she should get an idea what the SVM is and why you have chosen it. The equations are in this context necessary. The SVM gives only a binary classification result. Explain how you have generalized it into the case of three classes (like in Fig. 8c).

8. P8L11. C: Is the radar look direction in Fig. from right to left?

9. P9L3-5. C: I agree with Referee 1 (comment (25)) that Fig. 4 shows no increased discrimination ability with the texture features when compared to the (σ^o_{HH},σ^o_{HV}) pair. When looking at Fig. 5 my subjective opinion is that Figs. 5a and 5h (corresponding to the HH and HV channels) provide the two best features. Show how the classification accuracy improves when you add texture features to the (σ^o_{HH},σ^o_{HV}) pair. The sentence in P9L1-2 is not an argument.

10. P9L2. ... methodology description... C: What did you mean by this? In the 2013 paper you selected all the features. Please clarify.

11. Sect. 4.2. and Fig.4. C: How have you normalized the features? As Fig. 4 shows the ranges of different textural features are highly variable. It would also be better if the normalized values of the textures (as in Fig. 5) would be used in Fig. 4. In any case the SVM requires that normalized feature values are used or the distance concept in the radial basis function is arbitrary.

12. Fig. 8. In the figure caption: ...open water (ice concentration from 0 to 15%)... C: How have you identified such areas? The manual ice charts has the ice concentration classes: 0/10 -1/10, 1/10 -4/10 and so on. The class 0/10 -1.5/10 is missing.

13. P9L28-30. C: I disagree with your conclusion that the SVM classification gives a more detailed ice cover map than the manual ice chart. If we inspect Fig. 8b we see how the sea area is divided into subareas with different ice concentrations. In Fig. 8e you have thrown away all this valuable information and forced the manual ice chart to a binary map. The comparison between the automated and manual chart that you have presented in the text is not fair. Please modify your text and assessment.

14. Sect. 5.2. C: An addition to the comment (32) by the Referee 1. Do yo have considered the principal components as a way to deal with the intercorrelation of the features and simultaneously reduce the dimensionality? If you have, why did you reject the principal component analysis.

15. Sect. 5.3. C: As the Referee 1 (the comment (33)) I struggled and often failed to understand your interpretations of the texture measures. This section had to be rewritten, e.g. following the guidelines given by the Referee 1. Just one addition. As far as I know, the only scattering mechanism one is able to measure from the dual-polarized HH +HV image is the depolarization ratio. In the decibel scale the depolarization ratio is simply the difference σ^o_{HV} -σ^o_{HH}.

16. P12L4-5. C: I disagree with you due to the same reason as earlier. I think that for the models a sea ice concentration estimate at coarser resolution is a better option than knowledge of locations of small open water patches or leads.

17. P12L6-8. C: It is possible to derive a land mask from the MODIS data at resolution of 250 m. So the difference is not big compared to RS2 data, especially when we take into account that the resolution of the final product is 1.6 km (P5L6). Why do a MODIS based land mask underestimate the land area? I would expect that it might slightly overestimate it.

18. P12L15. ...different structures on the water affected by wind and .. C: Eddies are not caused by winds. They are results of ocean currents. Write ...affected by wind and currents ..