J.Karvonen
pdftitle=A sea ice concentration estimation algorithm
pdfauthor=J. Karvonen
title Manuscript prepared for The Cryosphere Discuss.
with version 4.1 of the LaTeX class copernicus_discussions.cls.
Date: 13 June 2014

A sea ice concentration estimation algorithm utilizing radiometer and SAR data

Finnish Meteorological Institute (FMI), Helsinki, PB 503, 00101, Finland

Correspondence to: J. Karvonen (juha.karvonen@fmi.fi)

1 Response for the reviewrs 2 comments

Anonymous Referee 2 Received and published: 31 May 2014 Kavonen (2014) present an improved SAR sea ice concentration algorithm that utilizes radiometer data for improved segmentation. The paper covers scientific questions that are relevant for TC. There are a few revisions needed before publication.

Dear reviewer of my manuscript,

Thank You for the good and constructive comments. I have tried to take the Your comments into account in my revised manuscript. In the following are my reponses for the reviewer (2) comments.

p. 2216 line 13. Why is only the HH channel utilized? This is unclear specially since it is also outlined that the AMSR-2 channels have both H and V polarizations.

In this study only SAR segmentation is utilized in addition to the radiometer data and we have good results of SAR segmentation using only one channel (HH). But classification of the resulting segments to open water and ice based on HH channel only is in many cases very difficult or even impossible even when using texture measures in addition to backscattering. However, in this application we use segment-wise radiometer data and we do not have this problem. The segmentation result can slightly be improved in some cases by using both the SAR channels, e.g. we have studied segmentation of a Principal Component (PC) image consisting of the first PC of the two channels. Bu this does not impprove the results significantly, typically only in some minor details. Have added some text about this, in the section on SAR preprocessing.

p. 2216 lines 15-20. Did the same kind of temperature and wind conditions prevail during the two time periods?

No. The weather conditions during the training period were varying, there was a short cold period (1-2 days), then a warmer period and then colder again. During the test period, there were two warmer periods and one colder period (not as cold as the one short training period cold period). Included this information in the text. In Sections ”Study area, time and data”.

p. 2220 line 14. How many hidden-layer neurons were normally used? What is rather fast?

An optimal number of neurons or units is dependent on the data typically chosen experimantally. We have made selection by increasing the number of neurons and performed training until the training error does not decrease notably any more. Then we have a suitable number of units. Included a sentence on this.

Rather fast means that the classification is available in a reasonable time. In practice this means some seconds on a desktop computer. I have tried to express this more exactly in the revised text.

p. 2221 line 10. How comparable are the sea ice conditions in the Baltic Sea and the Barents and Kara Sea? A description of the study areas "normal" sea ice conditions could perhaps be included in chapter 2?

They differe quite much. Have included some text on these.

p. 2221 line 10. What is a good agreement?

Based on visual inspection the areas of high and low concentration correspond to each other. Edited the sentence.

p. 2222 line 9-18. How do the error and standard deviation estimates presented here compare to previous studies of sea ice concentration? It would be nice to see an expanded discussion on the results from the comparison with the FMI ice charts for the two algorithms (yours and ASI).

There are some comparisons to other EO products, like to concentration from Landsat imagery (Cavalieri et al. 2006), AMSR-E inter-algorithm comparison (Spreen, 2008), and to some visual interpretations from ship (Spreen 2008). Very difficult to make an objective comparison between the results because different things are compared. I included this information in the text.

The new algorithm results are slightly better than the ASI results. This is expectable because we have used FMI ice charts in the training. However, they are quite close to each other. This is also an expected result, because the resolutions are already so close to each other. Have added some sentences on this.

p. 2222 lines 18-21. If possible include a line in the figures indicating where the sea ice edge is so that it is easy for the reader to identify the areas affected by wave conditions.

Ice egde (sketched by hand) added in the SAR mosaic and segmentation images (red line).

p. 2223 line 7-8. Here it is stated that the ASI overestimate the sea ice concentration in the coastal zone. How does this compare to the presented new algorithm results?

Added a sentence on this.

p. 2223 line 11-13. Which Arctic areas? Is it possible to provide an indication in the Figure as to the affected areas? Is this overestimation done by the presented new algorithm or by the ASI concentration estimates?

Tried to describe the location of the area by words.

p. 2223 line 15. Why wasn't a training data set compiled for the Arctic study area as well?

This test was made for the Baltic Sea data, and we had the FMI Baltic Sea high resolution ice charts as our training data set. The arctic test was just made of curiosity on how this method would work in the Arctic with the Baltic Sea training data, and it seemed to work suprisingly well.

p. 2223 line 16. Why were only a visual evaluation made? What does "quite well" imply?

We just wanted to know do the two products look similar (kind of general overview). The idea of the study was to test the new algorithm and to compare to some reference data and we selected the FMI ice charts and ASI radiometer data. "Quite well" means that their generally look the same, but there are different details, because our results are given in a higher resolution with more details (more precise boundaries). Tried to improve text here.

p. 2223 line 23-25. The author indicates that the difference in resolution would affect error estimates. Why wasn't the lower resolution used for such calculations in order to compare the results?

This has also been done now, numbers are given in the text (in section "Evaluation"). However, the basic idea is to improve the location of the area boundaries using the SAR segmentation and SAR resolution. In the radiometer resolution the more precise area boundaries produced by SAR are lost again, so this kind of comparison is not very useful in this case in my opinion.

p. 2223 line 27-29 - p. 2224 line 1. In your opinion what would be the best way to improve the performance, more training data or use the same amount of training data from the Arctic?

More training data both from the Arctic and the Baltic to include different weather and ice conditions, a really replresentative training data set.

p. 2224 line 6. How large were the standard deviations?

There were only two images, very little data also, these were inlcuded in the table now, but I also included a word of warning that the data set was small.

p. 2224 line 11. How does the thickness estimates contribute to the sea ice concentration estimates? This is not clear at present. Changed the text, hopefully it is more clear now.

This just refers to the methodology used for ice thickness, a similar approach could be used for ice concentration.

p. 2225 line 11-15. Would it have been possible to use another data source for the comparison than the FMI sea ice charts as they are based on SAR data?

They are not based solely on SAR data, they are based on other sources also, such as MODIS imagery, and also ice models are used. I think they are the best available information source in the Baltic in a good resolution. We could possibly have used for example the ASI concentrations in the training phase, but at this point we do not have resources to perform this work again with other data sets. Probably we are going to use e.g. radiometer data for training in the Arctic in the future, but we first need resources for this work. With MODIS there is the problem of clouds and cloud masking.

p. 2226 line 11-12. Which areas?

Included one reference to one of the images as an example.

The evaluation would benefit from an indication if certain ranges in sea ice concentration are easier to identify with the different sea ice concentration algorithms. E.g. is the presented new algorithm better in distinguishing high concentration sea ice than low concentration sea ice? Or similar?

The performance is quite similar, no special concentration ranges where the new algorithm can be said to perform better with this data set. The main advantage of the new algorithm is its ability to locate the boundaries of different ice concentration areas more precisely, because the result is in a high resolution defined by ther SAR mosaic. The new algorithm should sharpen the areal boundaries of different concentration areas. This lead to that the concentration distributions of our algorithm have less mid-range concentrations than the other algorithms (especially bootstrap with the lowest resolution), because the blurring at the edges is reduced by our high-

reolution algorithm. In the Arctic test area our algorithm overestimated the concentration in some open water areas compared to the other algorithms. This was probably due to weather and can be improved by training the MLP with a representative training data set (including Arctic data of different weather conditions).

Figures. The figures are generally quite small and it is difficult to see all the details described in the text. Maybe some kind of indication in the figures as to what the author is talking about could be included, maybe a reference to a position in Lat/Long or similar.

I have tried to describe the locations in the figures better in the text. Because this will be a digital publication, the reader can zoom in the figures to see details.

Generally some subjective words such as; little, worse and some could be changed into more precise indications.

Have tried to improve these.

Minor revision; p. 2219 line 4-5. ”The boundaries of different...” This is not clear.

Just meaning that the new algorithm will produce sharper boundaries based on the SAR segmentation. Tried to improve this sentence.

p. 2219 line 9. The abbreviation MLP is explained already on page 2216 line 5.

Removed the second explanation.

p. 2219 line 11. What is the resolution of the FMI gridded ice charts?

The nominal resolution is about 1000m. Included.

p. 2221 line 6. What is the resolution of the AMSR-2 bootstrap algorithm?

The resolution is about 10 km. Included.

p. 2221 line 6. Bootsrap needs to be changed to bootstrap.

Changed.

p. 2221 line 12. Figure 5 is referred to before Figure 3 and 4.

Moved the reference later.

p. 2221 line 12. Should the reference to Figure 5 be changed into Figure 7?

Yes, it should be Figure 7.

p. 2222 line 18. Figure 5 is again reference before Figure 4. Order of Figures needs to be changed.

Order of figures changed.

p. 2222 line 23. ”In these gures...” Which gures, gure 3 and 5?

Yes, 3 and 5, in the updated version 3 and 4.

p. 2222 line 28. Does ”...the bootstrap algorithm result in both cases.” Refer to the Gulf or Riga and the Gulf of Finland?

Refering to both the images and Gulf of Riga. Changed ”both cases” to ”both cases of February 2, and February 11”.

p. 2222 last sentence - p. 2223 first sentence. This is not clear.

Rephrased this.

p. 2224 line 16-18. ”...the MLP convergence was slower and estimation results worse...” How much slower and how much worse?

We did not get reasonable results for our test data set with this training data set. The L1 errors were 30-40 percentage points. Also the algorithm did not converge to a a reasonable error level with even 100000 epochs. Added some text about this.

p. 2225 line 19. How much is a ”little multi-year”?

Less than 1 percent of the whole area. Small portion in the northeastern part of the image. Included this rough number in the manuscript.

Tables. The tables would benefit from a more comprehensive table captions. E.g. indication to test areas, datum for the different data sets, and an indication if the results are presented for the algorithm results compared to the FMI ice charts etc.

Have improved the captions, more detailed information on the projections have been included in the section describing the data.

Figure 1 and 3-8. Inclusion of the coordinates would be beneficial, e.g. lat long or similar on the axis.

Have included scales in the images and their explanations. Unfortunately I do not have good tools to include numbers in a suitable scale into the imagery automatically, so the scales are described in the image captions.

Figure 7. Which areas are not covered by the SAR mosaic?

The black areas are either land areas or not covered by the SAR mosaic.

Figure 8. Here the proposed algorithm is referred to as the FMI algorithm. This is the only instance where that happens.

Changed ”FMI” to ”our”.