

A long-term proxy for sea ice thickness in the Canadian Arctic: 1996-2020

Authors present for the first time a long time series record (25 years), in the Canadian archipelago, for winter sea ice thickness. The thickness proxy is estimated using a neural network approach trained on CS-2, using Ice charts and backscatter information from scatterometers. Thickness are evaluated with in situ measurements within the Beaufort sea and coastal stations as well as with OIB airborne campaigns. This time series is the first one presented for Canadian Arctic, applications of the time series are quite large and the method can be applied for NRT purpose. The study also provides a first overview of sea ice thickness evolution within the Canadian arctic from observation during the past 25 years, where altimetry generally fails at estimating sea ice thickness, especially for long term records.

(I tried to read the data, but the dataset is not as easy readable as I expected, it is not gridded.)

General comment :

The overall study is well presented, clear and the validation convincing. The product is well discussed, especially in the limitation section with CS-2, and limitation of Ice charts for this type of study. I have two main concerns, concerning two points of the methodology.

The first one, relatively minor, concerning the representativity of the dataset, to what extent are the data used to train the NN over the period with CS-2 representative of the whole area you are trying to estimate, in other words, is there a bias in the sampling of the dataset that can lead to a bias in the predicted SIT. For instance, is the backscatter of CS-2 'area' is representative of CS-2+channels area ? A simple plot of the backscatter distribution in the region used for training and the global region would give a good idea, same for the parameters used from ice charts that allow to train the NN (floe width etc)

The second one concerns the data « trending » that is made for MYI thinning correction. To what extent PIOMAS trend for MYI SIT is supposed to represent the real trend especially before 2010 as we usually see higher discrepancies while going back in time with PIOMAS ? This can maybe be discussed a bit more in the conclusion or in a discussion section ? Especially that, as explained by the authors, PIOMAS thick ice (MYI ?) is underestimated, linearly for the past 25 years ?

How confident are the authors by « retrending » using PIOMAS ?

I was also wondering it which extent does it make sense to trend the data and then to explain changes in the trend with the data as we could directly study PIOMAS dataset to get these trends ?

I am a bit confused with the corrected and not corrected trends products. Why the authors detail trends and explain changes for the not corrected sea ice thickness product, as it is supposed not to reflect the trends ? Especially regarding the differences between not corrected and corrected trends for all regions and all months.

Maybe in a way the study of the trends with the corrected dataset will be more relevant if it would have been validated before as the SIT changed, but I am not sure that is the purpose of this study.

What bothers me is probably L 170, and that SIT are consistent but not to estimate trends... so the dataset is not so consistent as correcting the SIT by the trend will change the SIT values.

Same for fig 11 and 12, the not corrected trend values are shown but they are supposed not to be so relevant. Could you make Fig 11/12 (maps) with the trends for corrected SIT ? Are the spatial patterns similar ? (Not necessarily in the manuscript for now.)

I considered major revision because it can lead to some changes in the manuscript but the overall methodology and the manuscript as well as the validation part and the discussion part is very relevant. I am just wondering if the dataset you are validating is the good one. Which dataset would you advise me to use for any application ? I think that this is the one you should validate and I feel the way it is presented a bit confusing.

Specific comments :

L 2/3 : You should be mentioned in the abstract that the estimation is based on Ice chart / scatterometers as it is one of main elements of the thickness estimation.

L 6: 'mean trend' is a bit confusing. If I am not mistaking, this is not the mean trend this is the trend for the non corrected product for all the period and the whole area.

L128 : why to chose the mean of the two product as you have seen that ku seems to be more more uncertain (higher RMSE) ?

L 176 : Just to be sure, are you trending the SIT as following :

$$SIT_{corr_m} = SIT \cdot t \cdot (trend_{MYI_m} \cdot C_{MYI} + trend_{FYI_m} \cdot C_{FYI} (+ trend_{YI_m} \cdot C_{YI}))$$

With SIT the sea ice thickness, m the month you are correcting and C the partial concentration of each category. (Young ice trending is between parentheses as you not correct YI thickness) In other words do you make a weight average of the the SIT with the values of the trends and the partial concentration ?

L 182-184: I would also put this two lines within the conclusion maybe juste clarifying L 375 as you suggest that the proxy SIT need to be trended to take into account MYI thinning.

Figure 7 : I'm not sure that this figure is so convincing and enhance your dataset. The new series is consistent with CS2 which is very good. Altimetry products show big discrepancies with BGEP for the winters 2006/2007 and 2007/2008, so it doesn't surprise me that there are quite big differences for these years in this product too. Nevertheless it might be more meaningful to show a time series (still with CS-2), we would see that the seasonality is well represented too for other winter.

Section 4.3 : Maybe it would be even more readable at some point to put this section as a part of the discussion section as it both discusses the time series and the method and not only the method. But this is more a detail.

L 223: I may have missed this information, but I didn't understood how you estimated the 30-50 cm uncertainties of the product.

L 310-311: RSE characterized how the prediction fits the reference SIT (CS-2). Values are relative to CS-2 SIT not to the trend. Maybe I didn't get the point, why the variability between SIT proxy uncorrected and CS-2 SIT represent the variability to the trend, CS-2 SIT also get a variability to the trend isn't it ?

L 369 : « mean trend » ? This is still a bit confusing, I suppose it is the trend for the SIT for the whole studied area not the mean trend of each region.

L 375 : Which one ? Corrected or not, the not corrected will not provide consistent trends isn't it ?

Which kind of regression are you using to compute trends ?