

Interactive comment on “Estimating Snow Depth on Arctic Sea Ice using Satellite Microwave Radiometry and a Neural Network” by Anne Braakmann-Folgmann and Craig Donlon

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We thank Sara Fleury for her contribution to the discussion, adding further suggestions and arguments.

This paper presents and compares some very interesting and promising methods to retrieve the Snow Depth (SD) with AMSR-2. Such studies are very important because the Snow Depth over sea ice remains largely unknown whereas it plays an important role in the climate (albedo), the sea ice dynamics (thermal insulation, melt pounds), the biochemical (UV insulation), etc. But the validation of the emerging solutions is a very difficult task due to the snow diversity and the lack of in-situ data. Also we must be

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very careful in our conclusions and clearly stated the uncertainties and the conditions of applicability.

My remarks and questions are the following :

1/ Could you indicate if the presented SD-AMSR-2 products are available and where we could get them in order to make alternative tests ?

The neural networks have been uploaded and are publicly available together with sample Python code to read and apply them as mentioned under code availability.

2/ Did you evaluate the product that is freely distributed by NSIDC (https://nsidc.org/data/AU_S112/versions/1) ?

We did not explicitly evaluate this product, because it is based on the algorithm by Markus and Cavalieri. We would expect the same result as shown for Markus and Cavalieri with the difference that in the NSIDC product snow depth over MYI are filtered out. We did not filter these parts in our paper to compare all algorithms over the same (and a larger) dataset.

3/ How do you manage the impacts of the fog and clouds ? For instance within the NSIDC product some large parts are missing because of the presence of clouds, which is not the case for the 5 solutions you present. More generally, do they work all along the year over the full Arctic basin ?

All snow depth on sea ice algorithms relying on passive microwave measurements are restricted to dry snow conditions and therefore the winter season (approx. mid Oct to mid May). Clouds and fog should not pose a problem, though, especially when lower frequencies are used. The large gaps in the NSIDC product are due to the fact that the Markus and Cavalieri approach does not work well over MYI (as mentioned above). Given the fact, that both our neural networks and the algorithm from Rostosky et al. are trained with OIB data, which are only

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available for the Western Arctic, we cannot guarantee that the same functional relationships hold for the full Arctic basin. To see how the different algorithms behave outside the training area and period, we applied them for a whole season and across the whole Arctic (pages 15-18). We cannot really evaluate if the results are correct due to a lack of in situ data, but we do observe a generally good consistency between the algorithms and to the Warren climatology.

4/ For the sea ice thickness comparisons, it seems that you are using the CryoSat-2 Baseline-C freeboard (FB), which is known to over estimate the sea ice freeboard by more than 10cm (ie, 1m on the thickness). This bias will be corrected in the next baseline-D. In the meantime, you should use other FB products (AWI, LEGOS, CPOM, NASA, JPL, ...).

The SIT part is meant to be only a minor part in the paper and may also be understood as an outlook. You are more than welcome to use our neural networks, which are publicly available, to investigate their use with other freeboard data. We believe, that in the spirit of science an independent evaluation would be best anyway.

5/ Due to the dramatic lack of SD data over the polar regions, all study tracks have to be investigated and the solution will most probably come from the synergy between several solutions to cover the different needs. Nevertheless, in order to improve the Sea Ice Thickness (SIT) retrieval from altimetry, it is really important to measure the SD synchronously and coherently with the FB, ie, from the same platform and the same instruments, as proposed by CRISTAL Copernicus candidate mission.

We agree on that. However, sea ice thickness is not the only application where snow depth estimates are needed. Models and Forecasts for example might need (sub-) daily maps covering the whole Arctic, which CIMR would offer. Furthermore both satellites should be used in synergy and for inter-calibration of the snow depth products.

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On the other hand the synergy between CRISTAL and CIMR could aim to daily pan-Arctic SD observations, which would be a major step forward to better model the dynamics of the ice pack and its snow cover, and their impact on the climate. This kind of study could definitively participate to reach such an achievement.

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