Review of Assessment of Contemporary Satellite Sea Ice Thickness Products for Arctic Sea Ice by Sallila et al.

Summary

The paper “Assessment of Contemporary Satellite Sea Ice Thickness Products for Arctic Sea Ice” evaluates and compares 6 different sea ice thickness data products that are publicly available, including data from CryoSat-2 (CS2), SMOS and the Advanced Very-High-Resolution Radiometer (AVHRR). For the evaluation, they use independent ice draft and thickness measurements obtained from the Beaufort Gyre Exploration Project (BGEP) upward looking sonars (ULS) and Operation IceBridge. The authors find that products utilizing CS2-only measurements are reliable for sea ice thickness between ~0.5 m and 4 m, while the merged CS2-SMOS product was the most reliable for thin ice. In contrast to the other products, the AVHRR dataset does not seem to represent a reliable ice thickness distribution at the end of the winter season.

I think this study is potentially very useful for the user community of those sea ice thickness data sets, since so far, such a review of current sea-ice thickness data sets is not existing to my knowledge. It is well written, has a clear structure and generally is easy to follow. It presents useful information bundled in one paper. Table 1, for example, is great as an overview. However, I also find that the paper lacks some crucial information regarding the products and the way the data are analyzed. I also have the feeling that there are some inconsistencies in the data analysis. My 3 major concerns are:

1. I find that the description of the sea-ice thickness data sets in section 2.1 is incomplete. The AWI and the CPOM processing is quite different in some aspects, e.g. retracking of ice and lead waveforms. I think this should be described in more detail. See therefore also my comments below.

2. I am not really sure about the way the original data are re-gridded for the comparison. The paper lacks motivation regarding the chosen values for the re-gridding resolution of 5 km and the search radius of 50 km. I am also not sure if this is really the best way to do it, see detailed comments below. In any case, I suggest to revise section 3.1 in order to motivate your chosen method.

3. It also seems strange that CS2SMOS underestimates ice thickness in the MYI zone compared to the AWI product. CS2SMOS uses the AWI product for merging with SMOS, but in MYI areas, SMOS should not have a significant impact. See also my detailed comments below.

Detailed Comments

P1 L18-19: “… are reliable for sea ice [thickness] between ~0.5 m and 4 m” - it should be mentioned that you are talking about thickness.

P2 L26: „One of the most widely used thickness data sets derives from the radar altimeter flown on CryoSat-2 …“ - this sentence sounds a bit odd to me.

P4 L11-12: Please mention the version of the CS2SMOS weekly ice thickness product.

P5 L8-9: I don’t think that the CPOM processor uses the TFMRA algorithm (AWI). They also use a different retracking method for lead returns: a gaussian function is fitted to the waveform, as far as I know. See therefore, Tilling et al. (2017) - „Estimating Arctic sea ice thickness and volume using CryoSat-2 radar altimeter data“.

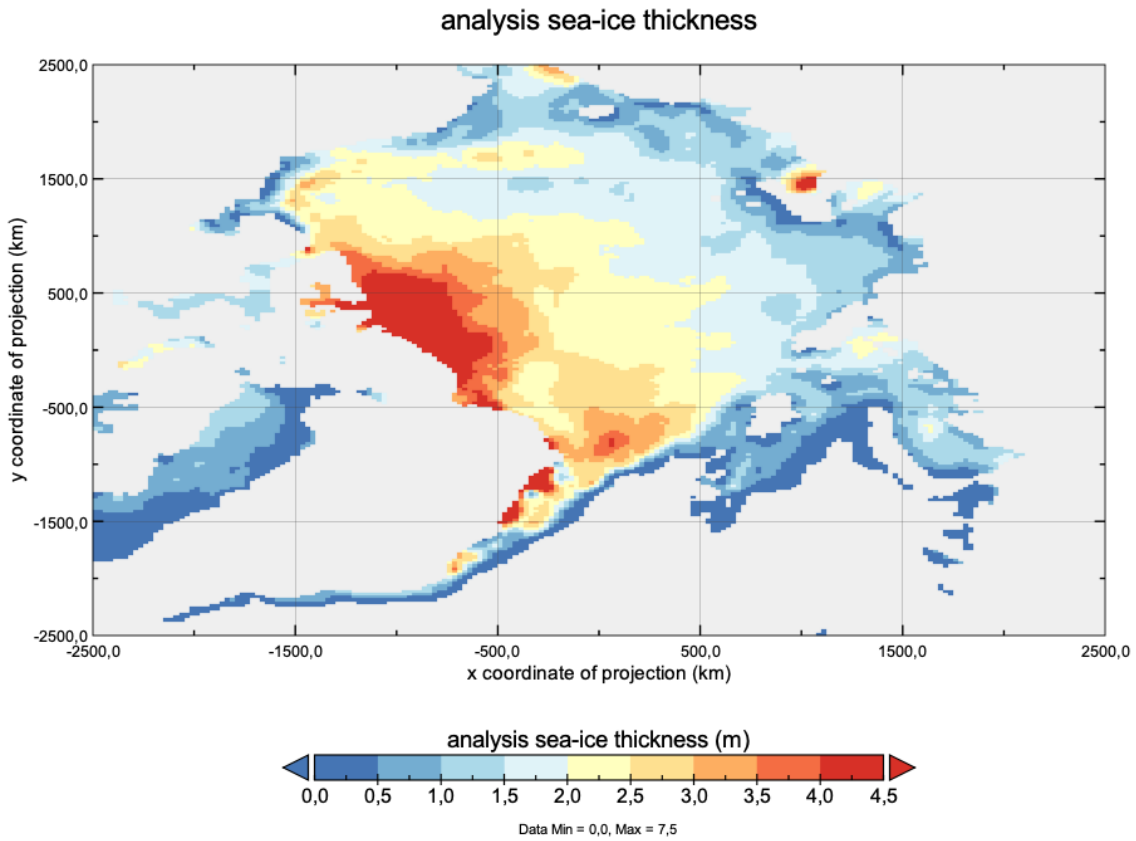

Figure R1: CS2SMOS Analysis Thickness from 20150323-20150329, version 1.3.

P5 L18: Please provide the version number of the AWI product. Is it 1.2?

P5 L18-28: Here it should be mentioned that the TFMRA is used. Moreover, I do not agree with the statement „The algorithm employed by AWI does not differ significantly from that used in the derivation of the CPOM product“. While I agree that there are some similarities in the processing and also the derived ice thickness distributions look similar, some signifiant differences exist. For example, AWI uses the same retracking for lead and sea ice echoes, while CPOM does not (see above). Moreover, the surface type classification is different. CPOM also applies a retracker bias correction (Tilling et al. (2017).

P7 L16: What is the reason to include the APP-x data here? They do not seem to represent the entire Arctic sea ice thickness distribution and ice growth during the season (see Figure 2 a,b). Then, one could argue to also include the SMOS sea ice thickness product.

P9 L9-11: Why do you choose a 5 km grid and a 50 km search radius? What happens at the ice edges or at the coasts. For example, areas, where the original grid contains NaN's in case of open water. Does this mean that you obtain ice thickness estimates on your new grid, where there were NaN's before, if valid ice thickness grid cells are found within the 50 km search radius? Wouldn't that erroneously enlarge the ice area?
If there are more than one grid cell found within the search radius, are you only considering the closest one? Or is there some weighting applied?

P10 L3: Why do you choose such a large radius (200 km)? Especially in the Beaufort Sea, where those moorings are deployed, you may have very mixed ice regimes with some chunks of MYI surrounded by FYI. Wouldn't it be better to only choose the nearest one or at least a smaller radius?

P10 L16: Why are the IceBridge data interpolated on a 50 km grid? Why not 5 km as the re-gridded satellite products?

P11L15-16: I am a bit confused about the CS2SMOS ice thickness maps. Here, it seems that they consequently underestimate ice thickness. Especially in MYI areas, the thickness should be very similar to the AWI CS-2 Product, since this is used for the data merging, and SMOS data should have almost no impact in the MYI zones. When I plot the CS2SMOS thickness for the week 2015-03-23 - 2015-03-29 (see **Figure R1,** data from Meereisportal, version 1.3), using a similar color scale with the switch from light blue to yellow at 2m, the MYI tail in the Beaufort Sea appears yellow, indicating thickness above 2 m. In your map it seems to be below 2m. Of course, your map shows the average from March - April, but I would assume that this is not much different.

Figure 2: I really would recommend to use a different color scale with a linear color gradient, starting at 0.0 m. Moreover I would also suggest to use a finer resolution, e.g. 0.25 m. 0.5 m is too coarse from my point of view.

P12 L12-14: As mentioned above, it seems a bit strange that CS2SMOS is significantly thinner than AWI CS-2 in the MYI regions, since it uses the AWI CS-2 data, while the SMOS ice thickness estimates are not valid in MYI areas.

P17 L2-3: See above.

Figures 5: The CS2SMOS data seem very noisy and show some strange behavior, e.g. strong decreases in mean ice thickness in some months. This should be checked. It does not seem to occur in Ricker et al (2017): “Satellite−observed drop of Arctic sea ice growth in winter 2015–2016”. Although they show sea-ice volume, I would expect similar behavior.

Figure 5 and 6: Over which area are these averages calculated? Regions 1-6 as indicated in Figure 1?

Figure 6: “a)” and “b)” are missing in the figure.