The Cryosphere
Discussions

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Interactive comment on "Snow depth uncertainty and its implications on satellite derived Antarctic sea ice thickness" *by* Daniel Price et al.

Anonymous Referee #1

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Review of "Snow depth uncertainty and its implications on satellite derived Antarctic sea ice thickness " by Price et al

In this paper, Price et al. use in situ snow depth and ice thickness data from a McMurdo Sound sea ice survey in 2011 to evaluate different snow depth estimates and ice thicknesses derived from CryoSat-2 radar freeboard estimates. Snow depth and sea ice thickness around Antarctica are highly uncertain, so studies exploring these ideas are clearly needed. However, I found the analysis presented in this study to be lacking the rigor and quality expected for a paper published in The Cryosphere. I list my various concerns below, but also generally felt that the analysis was just not presented well enough to provide a useful resource for the ideas the paper was aiming to highlight (i.e. issues of uncertain snow depths, radar penetration, ice thickness estimates etc.)

C1

I leave the publication decision up to the editor, and provide my review of the paper below.

General comments

The presentation of the different snow depths was pretty bad. I'm very surprised you didn't even show maps of the evolution of the snow depth in SnowModel, AMSRE and the ERA-I precip. I really struggled to get a sense of what they were all doing through this accumulation season.

You use passive microwave snow depths, snow depths converted from ERA-I precip, and snow depths from SnowModel. I was pleased to see such a comparison of different approaches, but the use of SnowModel seemed not well justified considering the uncertainty in precipitation over this study region. In the discussion you mention the benefits of having this sophisticated SnowModel framework, but then also highlight that actually just converting ERA-I precip to snow depth gives arguably better results (through comparisons of the means), so how do you reconcile that? I think you needed to do a lot more comparison of available precipitation/snowfall datasets to get a better idea of what the model is actually doing. How do the PWRF and ERA-I precip/snowfall data differ? It also wasn't clear to me if you were using precip or snowfall in SnowModel and ERA-I..

I was also very confused by the SnowModel configuration and components needed to produce snow depths from this model. What is the Noah-LSM and why is this needed? Seems like this is maybe running an entire atmospheric regional model without any real validation, so why not keep it simple and force this model with a reanalysis like ASR, which is based on Polar WRF?

The use of Pd in this study seemed odd to me, and I think is the wrong way of thinking about this problem. The main issue here is that we have a distribution of returns across the snow layer, including likely some return from no penetration (the snow-air interface) to returns from various penetration depths into the snow layer. What you are showing

C2

is a simplification of this high complexity. I get that you need to do something, but how you've presented this was overly simplistic (a fixed value) in my view and needs to be better explained.

I think you need to provide more context for the survey and the snow data that exists around Antarctica. You say snow depth data are lacking but then present this nice in-situ snow depth dataset. Are similar datasets available elsewhere to see how consistent these ideas are in other areas?

Your title needs changing as I don't really think the results here can help us say anything about snow depth uncertainty and satellite derived Antarctic sea ice other than it being a challenging topic!

The satellite data are described and introduced very crudely throughout. You need to provide better a description of these datasets, especially the Envisat data section.

You mention in the discussion (finally!) the issue of initial conditions, but say are hindered by the fact you don't have good freeze-up info at high resolution, but I would think the passive microwave data is fine for this purpose, especially with the ERA-I analysis? You must have some idea of the bias you introduce if you don't start accumulating until the ice fastens, instead of simply forming.. Is the idea that the ice that forms before fastening is all transported northwards and away from the region? Are there no drift products available to understand that?

I think you should compare using meters, not SWE, as that is what is going into the thickness model. You also didn't even say what the in-situ snow density was.

Specific comments

L27 Not sure I agree with the first line of the introduction!

L42 Decadal trends is pushing it considering we have data from 2003. I think you could be more specific here about the relevant altimetry missions from which thickness data is still lacking.

L43 Completed is strange language to use here.

L54 I think what you want to say here is that there is a long, but old, record of in-situ data of Arctic snow depth from which a climatology has been produced.

L58-59 Reword. Passive microwave data of snow depth available over both poles (where we have FYI).

L73 This terminology doesn't make much sense to me. What is sea ice fast-day-zero?!

L78 Maybe say you compare against in-situ data. Assess uncertainty sounds odd.

L99 Virtual weather station?! Is this not simply the location of an overlapping ERA-I grid cell?

L114 I don't get this gridding discussion. Is this true? It's produced at 25 km then down sampled??

L116 You don't need to state the flag number here..

L133 You need to reword this! Strange sentence structure at the start.

L135 Provide a citation to the CS2 L2 data.

L143 Is this max freeboard based on anything? Surprised this is so low..

L155 Reword Beyond Wingham etc..

L172 Which investigations? Are these the same as other altimetry studies?

L173 Need to reword this. What do you mean by when required? When is this required?!

L191 Has it ever been used for Antarctic snow on sea ice?

L241 Are you using snowfall, not precip? Why can't you also comapre this with the precip from pWRF (or ASR as suggested).

L244-245 So this is the location of the only ERA-I grid-cell in the study area?

Figure 2 Pretty unclear figure with no legend and lines that are hard to distinguish.

L315-318 Ok so two provide snow depth and ERA-I is converted using in-situ density. Reword.

Figure 4 I can't even work out what is being shown here.

L424 I'm not sure what you mean here.

L480 Good point, was ice density not measured directly in this study?!

L485 Unclear how these results indicate accurate snow depths. Figure 3 and 4 showed big differences (especially as a percentage), and ERA-I perhaps performing better..?

It would be clearer if you used centimeter units for the snow depth results throughout!