

Interactive comment on “Consistent variability but different spatial patterns between observed and reanalysed sea-ice thickness” by Joula Siponen et al.

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We thank you for your comments which we respond below. While revising the manuscript, we will consider all points you raised and try to incorporate them.

1. The manuscript by Siponen and coauthors presents a validation of a recent coupled ice-ocean reanalysis product against a new sea ice thickness satellite climate record joining two altimeters, but only available during the cold season. The validation is rigorous, both the model and observations are at the state of the art, and the manuscript is well-written.

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We thank Referee #1 for these encouraging comments and address the critical ones next.

2. The exercise is unfortunately limited in scope – a monovariate validation – and does not reveal much more than was already known from previous intercomparison articles. The new products compared are certainly of higher quality, but the analysis does not benefit much from this.

In our manuscript we present results based on a sea-ice thickness intercomparison between two datasets: the CCI satellite climate record (CDR) and the ECMWF ORAS5 ocean reanalysis. We think that the scientific results based on this first and rigorous comparison justifies the publication in *The Cryosphere* as they are relevant, original, novel and timely:

- Both the CCI CDR and ORAS5 are new products that have not been compared before, which makes our results original and novel. CCI CDR is the first long observational time series of its kind and agrees well with ORAS5. Because of the novelty of CCI CDR, study on how it compares with modelled estimates of SIT are of interest to the readers of TC. We should point out that at the moment peer-reviewed publications presenting the CCI sea ice thickness CDR do not exist which increases the value of our manuscript.
- There is an urgent need to better understand the decadal-scale variability of the Arctic sea ice in a rapidly warming climate. This makes our topic timely.
- Sea-ice thickness, one of the essential climate variables, aggregates sea-ice evolution due to both thermodynamic and dynamic processes, therefore being an excellent variable for evaluations and intercomparisons. This makes our choice of single variable relevant.
- Moreover, as ORAS5 generates initial conditions for the ECMWF extended- and long-range predictions, its assessment in terms of sea-ice thickness is a sensible



choice to gain a good understanding of its skill in the Arctic. As both CCI and ORAS5 are expected to have many users in the scientific community, it is important to quickly disseminate information on their mutual uncertainties on a suitable forum, such as The Cryosphere. This makes our manuscript timely.

The main new findings of our study are:

- Both CCI and ORAS5 realistically capture Arctic-wide inter-annual variability and decadal trends of sea-ice thickness, so they are suitable for subsequent studies.
- CCI and ORAS5 also agree generally well, revealed by relatively small RMSE, although there are seasons and years when they disagree. This result provides a new focus for elaborative model performance studies.

We are keen to expand the scope of our paper by analysing an ensemble of seven ocean reanalysis which can be calculated from individual product data available at <https://icdc.cen.uni-hamburg.de/1/daten/reanalysis-ocean/oraip.html>. This will address the issue of reanalysis uncertainty and indicate how significantly reanalyses vary from observations. We will also explore the effect of snow on ice on sea-ice volume based on those ocean reanalyses with snow data available. This will address probably the most significant issue of uncertainty due to the large effect of snow thickness on sea-ice volume. We argue that the facts listed above and the additional analysis we propose will expand the paper scope so it is clearly appropriate for the publication in the Cryosphere.

3. This becomes cruelly evident when the authors state the objective of the paper: "Can the ESA CCI sea-ice thickness product be used for the validation of sea ice in the ORAS5 ocean reanalysis during the growth season?", which is not a scientific objective per se.

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True, this is not a scientific objective, but a practical and useful one. We were understanding that it would also be a sufficient one for a research article in *The Cryosphere*. As this may not be the case, it is also possible to state a more scientific objective as “to identify regions, seasons and years where and when the efforts to simulate the observed Arctic sea-ice variability should focus on to improve the realism of modelled ice thickness.” As the significance of physical mechanisms varies seasonally, our results should assist model developers to proceed towards this goal.

4. The results reveal contrasting findings, well summarized in the title, but the analysis is too shallow, only listing non-prioritized factors without pursuing any of them any more than was done in previous literature.

We understood that our main results have been novel, at least to the extent explained above. If Referee 1 disagrees, we would like to invite her/him to provide us with the relevant references, please. This would be very helpful.

5. There are multiple ways the study could evolve into a more informative paper: pursue the ice drift issue by calculating volume fluxes between the different regions, extract the local ice production and melt from the model thermodynamics, the sea ice deformations and the data assimilation increments. The thermodynamics could be further pursued as well by comparing the model snow parameters to the Warren climatology and comparing the full yearly cycle of ice thickness against the Beaufort Gyre Exploration Project <http://www.whoi.edu/beaufortgyre>, these data are freely available. The validation of atmospheric and ocean parameters of relevance for sea ice could be included as well. There are many different directions this paper could evolve to become more informative.

Thank you, these are good and interesting suggestions and we are happy to explore them. However, we need to keep the scope of the manuscript reasonably limited. As mentioned above, we will expand the scope of the paper to explore the uncertainty among the ocean reanalyses, and the satellite data. In terms of ocean reanalysis

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ensemble, we will add results based on its mean and spread enabling statistical significance testing of reanalysis-observational differences.

6. Such additional analysis may represent significant work and I am not confident that this can be done during the review process, I therefore recommend rejection of the paper and resubmission when the analysis has better documented the likely causes for the differences between model and observations.

Fair enough. We need to assess the amount of extra work while completing the manuscript in a reasonable time to provide its main results to the scientific community in a timely manner. We also think that the extra analysis we suggest can be carried out during the review process and will better quantify data uncertainties and explain model-observation differences.

Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2019-272>, 2019.

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