Assimilation of sea surface salinities from SMOS in an Arctic coupled ocean and sea ice reanalysis

Jiping Xie, Roshin P. Raj, Laurent Bertino, Justino Martínez, Carolina Gabarró and Rafael Catany

This article presents the impact of satellite sea surface salinity assimilation on an Artic coupled ocean and ice system. Different version of SSS maps derived from SMOS observations in the Arctic are tested. Results show significant impact depending on the region and the product version. In situ observations from different campaigns are used to assess if those changes correspond to improvement or degradation toward the real state of the ocean. They allow to demonstrate the globally positive impact of the assimilation of the latest version compared to the previous one and the simulation without SSS data assimilation. The impact of SMOS SSS data assimilation is also assessed on a more climate-oriented diagnostic, the Fresh Water Content north of 70°N.

This article is well introduced with a clear description of the data and assimilation system used. The results are clearly and rigorously analyzed. The article is original since it shows the benefit of assimilating very recent satellite Sea Surface Salinity product dedicated to the Arctic to constrain a coupled ocean and ice system. Few satellite SSS impact studies were conducted in other regions but not in the Arctic, at my knowledge. I addition, until very recently, the accuracy of such satellite product did not allow their assimilation into ocean forecasting system in the Artic. The perspectives from this study are important. It shows that today Arctic satellite SSS product can be used to monitor and constrain operational system toward more realistic representation of the SSS in the Artic, where in situ salinity observations are sparse.

I would recommend the publication of this article after minor revisions.

General comments

I would suggest showing maps of the different SSS satellite products for August and September to complement figure 3 (model fields). This will highlight differences between the product versions and between the different experiments presented in figure 3. It may also help to understand the differences in the increments in the ESS, LS and KS regions shown in figure 8. Since the increments (figure 8) are quite different in regions where no in situ data allows to evaluate their realism, it may be interesting to compare them to the mean SMOS innovations to see if it can explain the increment differences in expv2 and expv3. As it is difficult to see the SSS differences between the different experiments and the observations when looking at the absolute fields, showing maps of differences may be more efficient to illustrate the results.

In many regions, the model salinity shows less variation than the in situ observations (scatterplots), even if it is still improved with assimilation. For the Chukchi Sea, it is attributed to the climatology relaxation, but do you have any possible explanations for the other regions?

In few places in the article, regions are referred with "S number" that may be removed completely with just the use of the acronyms presented in figure 1.

Line by line comments

l.21: Sea ice melt contributes freshwater: missing words?

l.119: Can you confirm that “the relaxation is turned off wherever the difference from climatology exceeds 0.5 psu.” And not the opposite?

L160: “observation” error: can you give a range for the errors attributed to the different versions?

l.230: the root is missing.

l.239: The beginning of the sentence is in italic letters.

L.257: Adding the SMOS “equivalent maps” may help to interpret the differences between the different experiments. Does those differences follow the product differences or “remote differences” exist?

l.267: “On the European side of the Arctic, the characteristics of the saline Atlantic water are very similar in all the three runs. This is an indication that the model ensemble has a lower standard deviation of SSS.” Could it be also due to smaller innovations/higher observation error in those regions?

l.408: the acronym FWCL is not defined.

l.476: S5 and S6 regions are mentioned but only appear in table 2 and not in figure 7.

l.492: S1 is mentioned for Figure 1 but do not appear on it.

l.496: though DA -> through DA?

l.510: I suggest to replace S6 with BB.

L.532: Space to remove between copernicus. and eu.

L.540: Space to add between Competing and interests.

l.544: The “link” to PO.DAAC does not work in the pdf, or it appears in blue as a link but is not.

l.594: the correct link is: https://doi.org/10.5670/oceanog.2016.100