Response to the comments from the anonymous Referee #1

The paper shows an intercomparison among 6 arctic salinity products (2 based on SMOS acquisitions, 2 climatologies and 2 reanalysis products). All products are also compared with in-situ data CORA 5.1. In addition to the intercomparison by itself, the aim of the paper is to evaluate the best SMOS product to be assimilated by TOPAZ4 reanalysis product. -We thank the referee for the detailed evaluation of our manuscript and constructive suggestions. We appreciated this very much, the comments will all be taken into account in the revised version of the manuscript. Below, we answer point-by-point all specific and technical comments.

General Comments

The paper needs a general improvement of the writing. In some cases the concepts are no clear and English should be improved.

-We thank the reviewer for pointing to this weakness in the manuscript. We will improve the manuscript.

Other general comment refers to the version of the BEC SMOS product included in the comparison. The version of the SMOS BEC product is only clearly defined at the end of the conclusions (lines 543-546). This should be explained in section 2. According to the expressed in conclusions, the version of the BEC SMOS product used in this paper is version 1.0. This version is not accessible now because it has been superseded by version 2.0. Why authors have not included v2.0 instead v1.0 in this study?

-Thank you for this comment. We agree with the reviewer. Note that BEC product was released just before the deadline for the submission of the manuscript. The SMOS BEC product will be defined in Section 2.1. We will update all figures and results using version 2.0 in the revised manuscript.

This reviewer knows the effort that implies to redo this validation using the new BEC product, but taking into account that v1.0 is not available, the inclusion of this product in the study is not interesting and v2.0 should be used. It is not necessary to proceed with all the period of the current v2.0, only the studied period (2011-2013) will be enough. Please, use v2.0 of 2011-2013 period instead v1.0. Change "BEC product" section accordingly. -Agreed. The revision will replace the previous BEC product with version 2.0 and the concerned figures and analysis will be updated.

Specific Comments

Lines 142-145: The BEC Arctic product 1.0 is not created as is described here. Systematic bias of the retrieved salinity data is corrected computing the so-called SMOS climatology (the most probable value for a given lat-lon, incidence angle and across swath distance) and substituting this one by a reference. The used reference is the annual WOA13 (the same reference for all maps) and not Argo float extrapolated at 7.5km. The second correction (the temporal bias correction) was computed for version 1.0 of the Arctic product in the same way as in the global one: assuming that the quantity of salt is constant in the surface. This coarse approach has been refined in version 2.0 (the current one) using Argo to compute the mean value of salinity for each Arctic map.

-Thank you for this informative and constructive comment. The text will be changed to "The BEC SSS product was generated from ESA L1B (v620) products (SMOS-BEC Team, 2016), and accumulates salinity data over 9 days with a spatial grid

resolution of 25 km. To characterize the SMOS SSS bias and generate a timedependent bias correction, they use Argo salinity which is taken from the Argo profiles cut off at 10 m. Referred to the climatology of WOA13, the Argo profiles with anomalies larger than 5 psu in salinity or 10 in temperature were discarded (Olmedo et al., 2018)."

Line 147: The anomaly is referenced to WOA13 (not WOA09) -Thank you. It is corrected.

Section 3: Many comparisons are made involving different regions and products. A table similar to table 1 but for intercomparisons would help to the reader. -It is a good suggestion. A new table is added to clearly explain the reference data.

Line 466: Beware both SMOS products do not use different BT filtering flags. The main difference between both is that they are applying a completely different salinity retrieval method.

-Thanks for this point. It is corrected as "... show the two SMOS products have obviously different coverage in summer months due to the application of different methods of salinity retrieval."

Lines 5-9: Suppress "respectively". This long sentence probably sounds better as "Recently, two independent gridded SSS products have been derived from mission: the developed by the Barcelona... and the one developed by Ocean...." Here a mention about the regional or global character of both products will help to the reader to know about the general characteristics of each product (one can expect that a product specifically developed for Arctic will provide better results)

-Thank you for this suggestion. Here is the revised text: "Recently, two gridded SSS products have been derived from the European Space Agency's (ESA) Soil Moisture and Ocean Salinity (SMOS) mission: the one developed by the Barcelona Expert Centre (BEC) in Spain and another one developed by the Ocean Salinity Expertise Center (CECOS) of the Centre Aval de Traitemenent des Donnees SMOS (CATDS) in France. Except of their independent SSS retrieval algorithms, the former also developed a new version of regional grid products with respect to the Arctic Ocean, although both of them can cover global ocean."

Line 42: "northern North Atlantic". Authors are referring to the north of the North Sea (a relative mall region) or the authors are referring to the thermohaline circulation between Arctic Ocean and North Atlantic? (probably is this second option but "northern North Atlantic" sounds strange to me)

-Thank you for this comment. Here it means the thermohaline circulation between Arctic Ocean and North Atlantic. And this sentence will be changed as "the SSS further affects the decadal variability of hydrography in the upper North Atlantic (Reverdin et al., 1997)".

Lines 47-50. This sentence is difficult to read. "a significant change in the global warming scenario" should be "or a significant"? Probably no, but I do not clearly understand what is the meaning of this sentence.

-This sentence will be corrected by "On the other hand, the increased melting of glaciers and sea-ice in the Arctic (McPhee et al., 1998; Macdonald et al., 1999) leads

to significant changes in the salinity distribution and fresh water pathways (Steele and Ermold, 2004; Morison et al., 2012)."

- Macdonald, R. W., Carmack, E. C., McLaughlin, F. A., Falkner, K. K., and Swift, J. H.: Connections among ice, runoff and atmospheric forcing in the Beaufort Gyre. Geophys. Res. Lett., 26, 2223–2226, 1999
- McPhee, M. G., Stanton, T. P., Morison, J. H. and Martinson, D. G.: Freshening of the upper ocean in the Arctic: is perennial sea ice disappearing? Geophys. Res. Lett. 25, 1729–1732, 1998.
- Morison, J., Kwok, R., Peralta-Ferriz, C., Alkire, M., Rigor, I., Andersen, R., and Steele, M.: Changing arctic ocean freshwater pathways. Nature, 481:66–70, 2012.
- Steele, M. and W. Ermold (2004) Salinity Trends on the East Siberian Shelves, Geophysical Research Letters, Vol. 31, L24308, doi:10.1029/2004GL021302, 2004.

Line 112: There exist, at least, two different versions of WOA13 (1.0 and 2.0) with significant differences between them in the Arctic data. Please, indicate the one used in this study. -Thanks for this point. It is the WOA13 version 2.0, and will be clearly stated in the revision.

Line 130: "non geophysical sources" should be better than "unphysical contaminations" -Thank you for this suggestion. It is corrected.

Line 131: ice-sea contamination should be mentioned because is an important source of biases in the Arctic.

-Thank you for this suggestion. Add a more statement like "Especially in Arctic, resolving the edge between sea-ice and sea water still is a challenge. Ice-sea contamination same as land-sea contamination (Martín-Neira et al., 2016), in which the brightness temperature bias appears around the area covered sea-ice, may also be an important source of biases for the salinity retrieval in the Arctic Ocean."

Line 193: Acronyms EnKF (Ensemble Kalman Filter) and DEnKF have not been defined in the text

-It is corrected.

Line 268: "Marches" should be "matches"? -It is corrected.

Lines 281-282: Have in mind that comparison of BEC product and WOA is not recommended because BEC product incorporates as reference WOA13. -Thank you for pointing out this issue. In fact, even the BEC product has been incorporated as reference WOA13, the updated evaluation of the BEC version 2.0

still shows a bit far from the referred climatology as shown in Fig. A1



Fig. A1 Monthly SSS (unit: psu) in March from satellite products (BEC and CEC, *left column*), reanalyzes (TP4 and MOI, *middle column*), and climatology (PHC and WOA, *right column*). The black shaded isoline represents the salinity of 35 psu near surface regarding to the product self.

In the Barents Sea, the salinity bias of BEC is rather clear even this product has been referred to WOA13.

The statement is changed to "In comparison to the climatologies, the SSS products from BEC and CEC are all fresher in summer in the Nordic Sea, as shown by the isoline of 35 psu in Fig.3. But in winter (as Fig. 2), only the BEC shows a large salinity deviation in the Barents Sea."

Lines 285-286: For this reviewer is not clear what do you mean with "over the sea-ice conver" and "under the sea-ice cover"... Under sea-ice cover means "below the ice"? Probably the meanin is related with latitudes not covered by ice?

-Thank you for this point. It is corrected as "However, the discrepancies among them collectively emerge near the sea-ice cover area in the Arctic. Below the ice or inside of the sea-ice edge denoted by the brown thick line in Fig. 2 and 3, the TP4 and the PHC become rather similar spatial patterns."

Line 294: This sentence refers to figure 6? This figure is only referred in conclusions (line 487)

-No, it refers to Fig. 4 and Fig.6, this will be clarified in the text.

Line 413: The mentioned four observations, are outliers?

-Yes, more explanations are included as "Regarding the four salinity observations (~26.8 psu) collected at (136.4°W, 70.5°N) on 15th August 2011, marked by anti-triangles near the estuary of Mackenzie River, the TP4 simulation have a significant

negative salinity deviation (~-4.4 psu) as the outliers above the dashed-blue line in Fig. 9a. This occurs near the continental shelf where the product uncertainty like in TP4 originates from high fresh water spatio-temperal variability."

Line 536: In my opinion this is not a validation. Is a comparison. -Right, validation it is changed to evaluation.

Line 61. Typo: MIRIAS should be MIRAS -It is corrected.

Technical corrections (Typos) Line 122: Typo: "in in Section" ("in" written twice) -It is corrected.

Line 133: Typo: "march-up" should be "match-up"? -Thanks for this point. It is corrected

Line 139: Correct address is http://bec.icm.csic.es **-lt is corrected**.

Line 163: Typo: should be EASE instead of EASA -Here, it means an Equal-Area Scalable Earth Grid (EASE-Grid), and also changed in the revision.

Line 281: Typo: then should be than. The correct ending for the sentence should be "than the provided by BEC product" -Thank you for this point. It is corrected

Line 317: Word SMOS is used twice. **-It is corrected**.

Line 552: The correct URL is bec.icm.csic.es **-Thanks, it is corrected**.