Response to the comments from the anonymous Referee #2

The paper aims to quantify uncertainties of Arctic observation-based sea surface salinity to be included in the TOPAZ reanalysis. Two SMOS products are considered and compared against climatologies, observed data sets and reanalysis. This is an important problem in advancing in the data assimilation technics and improving the quality of CMEMS reanalyses. Anyway this study is not a significant step along that path. The paper has some unclear or incomplete reasoning. I do not feel that this research is ready to be published in OS. I do encourage resubmission after a much more detailed and careful investigation.
-We thank the referee for the time spent and for the detailed revision of our manuscript. We appreciated very much for the comments which will be all taken into account in the revised version of the manuscript. Below, we answer point-by-point for all comments.

My primary concerns are i) the research is poorly presented, with vital details missing
-Thank you for this comment. We will improve the presentation of the work to help the reader understand. This evaluation has two parts: the first part is an intercomparison with reference to the TP4 reanalysis, the second part is an evaluation with respect to two in situ datasets which are involved in the TOPAZ system and independent respectively. In the revision, the observed SSS by in situ near surface will be extended from no deeper than 5 m depth to 8 m depth, which will involve more observation samples for this evaluation.

ii) the BEC SMOS product selected from this study should actually be updated to version 2.
-Yes. In the revision, we will use the version 2.0 of BEC product to replace all the figure and the concerned analysis (also see the response to the same comment of Referee #1).

iii) the PHC data set is old, is included in WOA13 and assimilated in TOPAZ. It does not add much to the analysis
-Thank you for this suggestion. The PHC dataset is one of the most important climatology in the Arctic Ocean, and still implemented widely in quantitative evaluation works (Carton et al., 2018, 2019). The PHC is based on the archive of observations primarily from the 1950s through the 1980s and so may have a somewhat cool climatology. In the current version of TOPAZ, the combined climatology of PHC and WOA13 are used as relaxation so that the quantitative comparison of two climatologies still could be helpful to reasonably reject this or not for the improving of the model relaxation process.

Carton, J.A., G.A. Chepurin, and L. Chen, 2018: SODA3: a new ocean climate reanalysis, *J. Clim.*, **31**, 6967-6983, doi:10.1175/JCLI-D-18-0149.1.

Carton, J.A., S.G. Penny, and E. Kalnay, 2019: Temperature and salinity variability in soda3, ECCO4r3, and ORAS5 ocean reanalyses, 1993-2015, *J. Clim.*, 32, 2277-2293, doi:10.1175/JCLI-D-18-0605.1.

iv) MOI is not a reanalysis. The CMEMS product MULTIOBS_GLO_PHY_REP_015_002 is a combination of four data set. I do define a reanalysis as a combination of ocean modeling,

data assimilation scheme and observed data sets. I would rather include in this study a global CMEMS ocean/sea ice reanalysis to be compared with TOPAZ4.
-Thank you for this comment. We agree that evaluating more global reanalysis products in CMEMS would be very interesting, and give more knowledge of the uncertainties in the different model systems, but it would go beyond the initial aim of directing our next assimilation work.
As an objective analysis product MOI uses the multivariable optimal interpolation method and can be used as a special representative in reanalysis products just like Simple Ocean Data Assimilation (SODA, Carton et al., 2018) is often used for comparative analysis with respect to other traditional reanalysis products (Uotila et al., 2018).
So in this study, we choose to use these two representative types of reanalysis products in CMEMS to evaluate the new satellite SSS products.

v) The region of interested is the Arctic Ocean, but results are mostly related to the North Atlantic/Nordic Seas area.
-Thank you for this comment. In the current evaluation, the comparison in the Beaufort Sea is presented in Fig. 9 and 10, referred to the independent SSS from BGEP and CLIVAR, which is directly linked to one of the main conclusions to support the BEC product. In addition, our forecast products more focus on the region north of 62N, where our general interest is and discussed in this study.

In this study, the in situ SSS from CORA5.1 were used by the TOPAZ system either assimilated or filtered during pre-processing for QC. It results these dependent SSS from CORA5.1 primarily are distributed in the Nordic Sea as shown in that figure. There are in general few observations in Arctic, the additional reason is a strictly used limit for the SSS observations - near the surface no deeper than 5 m depth. In fact, if extending the limit to 8 m depth, more SSS observations extracted from Ice-Tethered Profiler (ITP) will be involved. The Fig. A shows the locations of the SSS from ITP in the three years. Clearly, the evaluation referred to this dataset would enrich our knowledge of the Arctic SSS uncertainty.

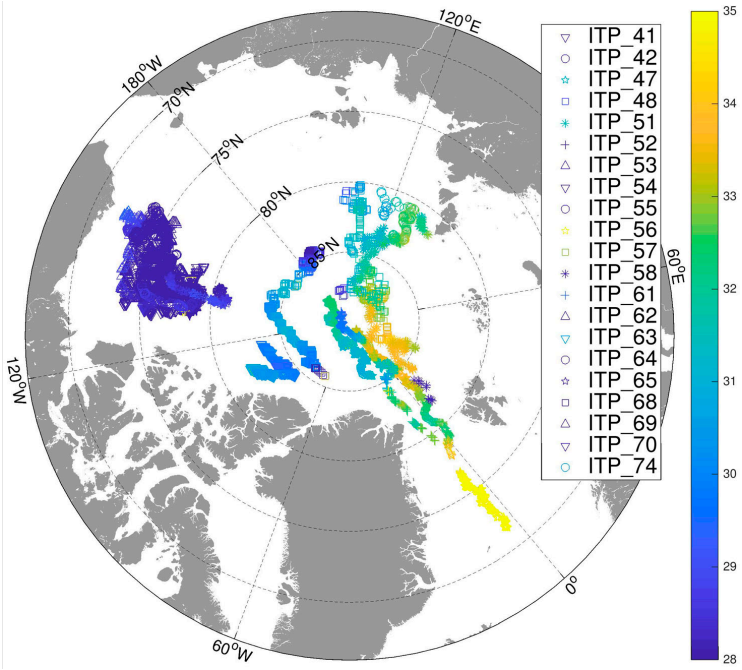

Fig. A The locations of the SSS observations extracted at the 8m depth from the ITP living more than 30 days during the years of 2011-2013.

vi) Section 5 summarizes main results but a proper discussion to support the BEC SMOS and the "certain benefit (line 537) is missing. These points significantly detract from the conclusions of the study, make the conclusions much weaker than the present manuscript states.

-Thank you for this comment. The revision will add more discussions about this issue, with more consistence to the present results.

English need to be generally improved.

-Thanks for your comments. We will further improve the concerned parts.