Answers to Reviewer #1:

This manuscript describes the procedures used to create and validate V3.1 of the BEC Arctic surface salinity product: Arctic+ SMOS SSS v3.1. The description is reasonably complete and well written. The following comments are offered in the spirit of improving the description:

Thanks for the detailed and useful review.

Lines 28-29: "L-band frequency is the region of the electromagnetic spectrum offering the most sensitivity to salinity variations". It is optimum from a remote sensing perspective (protected spectrum and reasonable sensitivity), but the maximum sensitivity occurs at lower frequency (500-900 MHz depending on temperature, incidence angle and polarization).

Yes, we agree with the referee. We have added the following sentence to make it more clear.

"The SMOS frequency band (1.43GHz, L-band) is an optimum band to measure salinity, since this electromagnetic region is protected against human electromagnetic emissions, while the sensitivity to salinity is high."

Moreover, we have adapted the sentence in lines 28-29

Line 51: "available [with] prior registration" ?
Yes, corrected.

Line 53: "L1B product contains TB Fourier components": It is not clear in the text whether the starting point is "visibilities" or an image. If starting from the Fourier components, details of the inversion to an image of TB need to be included.

The starting point is the TB Fourier components provided by L1B product. The TB is obtained as the standard procedure does: a Blackman window is used to reduce the Gibbs-like contamination and TB is obtained by an Inverse Fourier Transformation. This text has been included in section 2.1:

"As in the standard procedure [Anterrieu et al., 2002], we apply a Blackman window to the Fourier components in order to reduce the Gibbs-like contamination. The TB is obtained by applying an Inverse Fourier Transformation to the resulting TB coefficients."
[Anterrieu et al., 2002] Anterrieu, E., Waldteufel, P., and Lannes, A. (2002). Apodization func-tions for 2-D hexagonally sampled synthetic aperture imaging radiometers.IEEE Trans.Geosci. Remote Sens., 40(12):2531–2542.

Line 67: A better reference (better than 2018) for corrections to the Meissner-Wentz model for the dielectric constant of sea water is: T. Meissner and F. J. Wentz, "The emissivity of the ocean surface between 6 and 90 GHz over a large range of wind

speeds and Earth incidence angles," IEEE Trans. Geosci. Remote Sens., vol. 50, no. 8, pp. 3004–3026, Aug. 2012.

Yes, the reference has been changed.

Line 117: Why this choice? For example, how does this compare with the model of Yin et al: "Roughness and foam signature on SMOS-MIRAS brightness temperatures: A semi-theoretical approach," Remote Sens. Environ., vol. 180, pp. 221–233, Jul. 2016.

The authors state that the roughness model should be improved to be adapted to cold waters. Nevertheless, the choice of the empirical roughness model has not been considered as a part of the improvement algorithm in this approach. The selection of the roughness model has been purely based on previous works performed by this group.

Line 121: "first Stokes parameter (I = TBx + TBy), parameter used to perform the TB inversion". Details needed. For example, how is the roughness correction (which depends on polarization) made?

The first Stokes parameter is used to avoid ionospheric contribution inaccuracies in the inversion process. The roughness model used is an empirical model based on SMOS measures in which the correction depends on the wind speed and the incidence angle (Guimbard et al 2012). Once all the corrections have been computed (atmospheric, Sun glint, Galactic correction, roughness), we obtain the TB corresponding to the flat sea contribution. The TB is obtained for each latitude/longitude point and antenna position (the antenna position is linked to the incidence angle). The TB inversion is performed minimizing the cost function |I(model)-I(measure)|^2 (a more detailed description is provided in section 2.4 of Martinez et al 2020 -10.13140/RG.2.2.12195.58401)

Line 152: Typo: "starting from"
Done.

Line 183: See comment 4 above.
Reference changed

Line 184: "conductivity equation Debye (1970)" The expression attributed to Debye is for the resonance of the water molecule, not conductivity.

Yes, the correct sentence is *"These dielectric models are based on a Debye relaxation law [Debye, 1929] with a conductivity term."*

The year of the Debye reference has been also modified to refer to the original one and not to a reprint.

Lines 184-185: “Therefore, we have used the MW model to derive the high latitudes SSS.” This certainly is reasonable, but perhaps it should be noted that the MW model has been shown to result in an SST-dependent bias in the retrieved SSS.

Yes, it is true. We have developed a bit more the reason for the MW choice mentioning the SST-dependant bias problem

Line 227: Typo: measured TB
Done

Line 242-243: “Assuming … high radiometric error …” There might be other sources of error in addition to noise in the radiometer.

Yes, of course… for example, RFI is a big problem, however, scenes affected by RFI also have a high radiometric error.

We have added this sentence to the text. ‘*This procedure will help, also, to mitigate the effect of scenes contaminated by RFI.’*

Line 301-302: “It should be noticed the greater coverage and detail of the gradients of Arctic+ v3.1 product to that obtained from the previous BEC Arctic v2.0 product (fig. 5 a-c and 6).” Wording could be improved.

We have modified the sentence as follows: *“Figures 5 and 6 show that Arctic+ v3.1 product has greater coverage and gradient detail than the previous BEC Arctic v2.0 product.”*

Line 318-319: “However, a comparison with punctual measurements can not evaluate the improved data coverage neither spatial resolution.” Something is missing.

Yes, thanks. Modified by: *“However, a comparison with punctual measurements can not be used to evaluate the improved data coverage nor the spatial resolution.”*

Line 365: Typo: extra series: should be "to have a long enough series of ..."

Thanks, changed.

Line 378: “applied the CTC”. Are there limits on the amount of correlation permitted and how it affects the conclusion? This could be important since V2 and V3 are so closely related.

We evaluated the performance of the method as a function of the correlation between the two error-correlated datasets by using synthetic data (see section 3.1 in [Gonzalez-Gambau et al., 2020]). We defined the following metrics: (i) Fraction of valid retrievals (the ratio of the total valid retrievals to the total number of realizations, (ii) Bias, the difference between the average of all valid estimates of the error standard deviations and the value used for the generation of the dataset and (iii) Uncertainty, the standard deviation of the valid estimates of error standard deviations. From these experiments, we saw that the dependence of all metrics on the value of the error correlation is weak in most of the cases. Hence, CTC is very robust independently of the degree of correlation between those errors.

Line 443-445: "As the method extracts the expected natural variability from the common information between the compared products, it means that the fraction of information in the Arctic+ v3.1 product is the largest of the three products." Has this statement about "information" been demonstrated? Perhaps a reference is needed here.

Yes, the explanation was not correct and not clear enough, and in fact the bullet was repetitive. We have changed the previous bullet as follows:

"The introduction of the correlated triple collocation also helps to properly assess the differences existing between the current (in 2021) derived satellite products. The metrics show that Arctic+ v3.1 dataset is the one of the three products with the lowest errors in general except in Hudson Bay, east coast of Greenland, and Kara Sea. In particular, the triple collocation shows that SMAP data yields the largest errors."

Line 449: "at smaller scales than SMAP and BEC v2.0". With the exception of Fig 13a, this does not appear to be true for SMAP.

Yes, this comparison explanation between V3.1 and SMAP is missing. We have added this sentence in the spectral analysis section.

"Moreover, Arctic SSS v3.1 resolves smaller scales than SMAP JPL in Laptev and Bering regions, where SMAP JPL exhibits a flattening in the PDS slope below 50 km wavelength, meaning that the variability contained in SMAP JPL below 50 km wavelength is contaminated by white noise. "