Authors' Response to Reviews of

Cloud liquid water path detectability and retrieval accuracy from airborne passive microwave observations over Arctic sea ice

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Atmospheric Measurement Techniques,

RC: ***Reviewers' Comment***, AR: Authors' Response, □ Manuscript Text

1. RC1

1.1. Comments

AR: The authors would like to thank the reviewer for their constructive and valuable feedback on this manuscript. We have carefully considered all the comments and provided responses below.

RC: ***The discussion in Sec 4.1 regarding the mis-match between the observed and retrieved brightness temperatures in clear-sky cases is still not satisfactory. The large tail of positive observation-simulation differences at 118 and 183 GHz is not fully explained, and related analysis is only in the author response and not included in the revised text. Although fig Rev1 in the author response shows that the agreement in the central arctic region is generally good, there are still a large number of significant differences which do not correspond to thin sea ice as detected by VELOX. Perhaps I could infer from the later discussion in Sec 4.2. that this could be caused by thin ice which VELOX misses, but I would prefer it if the authors discussed this properly in Sec 4.1.1. I do not think that Fig Rev1 is consistent with the L323: "These cases occur mainly over young sea ice as identified from VELOX...". However, the figure is not included in the revised text so the reader is not able to draw their own conclusions about the validity of this statement and may get a misleading impression.***

AR: We have updated the discussion of the large positive observation-minus-simulation differences at 118 and 183 GHz in Sect. 4.1.1. The updates reflect that not all of the positive outliers in R1 correspond to thin sea ice detected by VELOX. Instead, the paragraph now mentions that the distribution is the same as for thin sea ice detected by VELOX. Additionally, we argue that the absence of these positive outliers in the Central Arctic (200 km from the ice edge), where ice is more compact, is a strong indication that they are linked to young sea ice, which covers large parts of the marginal ice zone. After careful consideration, we decided not to include histograms from the previous review response for the Central Arctic and young ice in the manuscript, as this information is already contained in Fig. 7: positive R1 departures correspond to falsely-detected CLWP in R2, as mentioned in Sect. 4.1.1. For an extended discussion, we refer to the analysis in Sect. 4.2, which also includes the SMRT simulation for thin ice to support the hypothesis.

RC: ***The sensitivity of the retrieval to the a-priori CLWP, as shown by figure Rev4 in the response, is a significant result, but is only very briefly discussed in the revised text and the results are not shown. It is a further indication that the CLWP is not strongly constrained by the retrieval, presumably due to the ambiguity with the other parameters. For me, a key conclusion of this paper is that to accurately retrieve CLWP from passive microwave observations over sea ice, it is necessary to provide stronger a-priori constraints on the surface parameters.***

AR: The sensitivity test regarding the a priori CLWP assumptions has been conducted to confirm that the CLWP bias for high CLWP is related to the cloud-free a priori mean. We believe that this is a rather general finding regarding optimal estimation methodology (e.g., Maahn et al., 2020), and we therefore did not include an extended discussion in the manuscript. We agree that improving the a priori estimate for surface parameters, ideally those with a spectral signature similar to CLWP, will improve the CLWP retrieval skill. Therefore, the final sentence of our conclusions section mentions the potential of using thermodynamic sea ice and snow models to describe the surface, rather than the static surface approach. We slightly adjusted this sentence.

RC: ***L376: I still think this is too positive a statement regarding the performance of a retrieval with such significant biases. Perhaps replace "the retrieval approximates the true CLWP" with "the retrieved CLWP is correlated with the true CLWP".***

AR: We modified the sentence accordingly.