Quantifying riming from airborne data during HALO-(AC)³
Response to the reviewers

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Original Referee comments are in italic

> manuscript text is indented, with added text underlined and ~~removed text crossed out.~~

We would like to thank the reviewers for their helpful comments. We revised the manuscript and responded to all of the reviewers' comments.

1 Reviewer II

1.1 Summary

The authors have addressed my main concerns and the quality of the manuscript has improved. I list below a few typos and minor corrections to be taken care of (page and line numbers refer to the version with track changes):

1. p.7, l.166: "These functions are then applied to the 89 GHz TB". If "These functions" refers to retrieval mentioned just before, then I do not understand how it can be applied t Tb values... Please clarify.

We apologize that the text was still confusing. We hope, we could clarify and refer to Ruiz-Donoso et al. (2020) for a more detailed explanation:

> ...the liquid water path (LWP) is estimated over open ocean only with a temporal resolution of 1 s as described in Ruiz-Donoso et al. (2020). The retrieval takes profiles of nearby dropsondes to calculate T_B as a function of LWP measurements from simulations with the Passive and Active Microwave radiative TRAnsfer tool (PAMTRA, Mech et al., 2020). ~~These functions are then applied~~ T_B(LWP) is approximated by a third-order regression. The regression is then applied in an inverse scheme to the 89 GHz T_B measurements to derive LWP...

2. p.12, l.299: "the same range AS"

Thank you, now fixed.

3. p.14-15, l.362-364: I do not understand those numbers... And they do not sum up to 100%...

The numbers add up to 100% (and 99% for the in situ method due to rounding) when adding the particle fractions with $M < 0.01$. Here, we want to show that most particles have M between 0.01 and 0.1. The rimed fraction (= fraction of particles that are rimed) results depend on the threshold value we choose to separate "rimed" vs. "unrimed". To better clarify, we changed to:

> Assuming particles with $M < 0.01$ having negligible riming, we derive average rimed fractions of 88 % and 87 % over all collocated flight segments with the combined and the in situ method, respectively. These numbers appear quite high, however, they depend heavily on the rimed vs. unrimed threshold that is chosen; if we assume $M < 0.05$ to be unrimed instead of $M < 0.01$, we get 11 % and 9 % rimed particles, respectively. ~~83~~12 % and ~~83~~13 % ~~fall in range $0.01 \leq M < 0.1$~~ of particles have $M < 0.01$ for the combined and in situ method, respectively, ~~and~~ 83 % and 83 % fall in range $0.01 \leq M < 0.1$, and only 5 % and 3 % have $M \geq 0.1$.

4. p.16, l.414: "larger THAN zero"

Thanks.

5. p.26, l.609: I would use "homogeneous" rather than "continuous".

Yes, we changed to "homogeneous".

6. p. 28, l.664: should it be -10°C?

Yes, thanks for catching that.

7. As an additional point, I would like to mention that I am not sure I understand the response to my specific comment #6 (concerning Eq.3). The loss function defined in

Eq.3 is "mixing" different variables, so their respective magnitudes have an impact on the loss function value... And my point is not about a unique minimum or not, it is about the respective influence of the prior and the forward model.

The different quantities in Eq. 3 are normalized by the covariance matrices S_a and S_y. Selecting S_a and S_y determines whether more weight is put on the observations or the prior information. However, since we use only one observation variable to retrieve one state space variable this is not relevant for our study. For more in depth information about the Optimal Estimation theory see Rodgers (2000).