Reviewer : Charlie Zender

We would like to thank the reviewer for his constructive comments that will improve the paper. We have responded to all of them and modified our paper accordingly. The reviewer was invited to judge the revised paper, not the original one. The reviewer explains that after the major revision, the paper has been greatly clarified and focused but a few more scientific and writing point still remains to be addressed. Our point-by-point answers (in blue) follow as a supplement.

Specific comments:

1. *The methodology used to assimilate the RS data is impressive. Nice work!*
   Thank you, the methodology has been studied to maximize the utilization of remote sensing data while avoiding over-reliance on them for the model.

2. *L206: "as very little [sic] melting events are expected". Winter-season melt is not uncommon on Larsen C during Foehn events. More than 20% of annual melt at AWS18 in Cabinet Inlet on Larsen C has occurred due to sensible heating by foehns during polar night (Kuipers Munneke et al., 2018). Laffin et al. (2021) and Laffin et al. (2022) quantify seasonal and regional behavior of such foehn-induced melt on the eastern AP.*
   Indeed melt events can occur during winter on Larsen C during winter. The sentence in line 206 is too brief to provide a complete explanation of why assimilation is not carried out during winter. The complete reason is based on two points.
   First, there is a computational reason. The assimilation increases the computation time of MAR by a factor of 2 when the routine is on. As the Assimilation was planned to be performed over the entire Antarctic ice sheet and for a longer period, we disable it during winter as fewer melt events would occur on average (Figure 6).
   Second, it would be very interesting to study those melt events during winter. But as they are caused by specific events (mostly foehn-induced melt), we choose not to include them in the study of the general sensitivity of the model to the parameter of the assimilation.
   To clarify the situation, the sentence will be rewritten to: "*Outside of this timeframe, no assimilation is performed for computational constraints and the likely prevalence of shorter melting events during winter. These events are commonly related to Foehn effects near the grounding line (Munneke et al., 2018) where the effectiveness of passive sensors decreases*".

3. *Lines 231–239 repeat lines 221–229 verbatim. Oops :)*

We are deeply sorry for this mistake. Lines 221-229 have been removed in the revised version of the paper. An error in the LaTeX code includes the lines in the text instead of including them in the track change.

4. *Large portions of lines 280–292 repeat lines 272–279 verbatim.*
   Same as for comment number 3, we are deeply sorry for this mistake. Lines 272-279 have been removed in the revised version of the paper. An error in the LaTeX code includes the lines in the text instead of including them in the track change.

5. *Where is the exact region of the Antarctic Peninsula (AP) simulated by MAR defined? Tables 4 and 5 and Figures 7–9 appear to tabulate the entire AP, and then some. Where is the region for which the mass budgets are computed defined? The present results cannot be reproduced without a clear definition of the boundaries.*
   The exact MAR domain is a bit larger than Figure 1. After removing the edges of the domain, its extent was reduced to the same extent as in Figure 1. For the ice shelves, the extent used is the same as the extent highlighted in Figure 1. The revised version of the paper will include :
   - In line 191: "*The spatial extent of the simulations corresponds to the extent of Figure 1.*"
   - The caption of Figure 1 will be updated with "*The red square around the AP corresponds to the MAR spatial extent.*"
   - Captions of Tables 4 and 5 will be updated with "*[...] over the 2019-2020 melt season for the whole MAR spatial extent.*"
   - The caption of Figures 7-8-10-11-13 will be updated with "*[...] over the whole MAR domain for the 2019-2020 melt season as modeled by MAR [...]*"
   - Captions of Tables 6 and 7 will be updated with "*[...] over the three highlighted ice shelves in 2019-2020 using the delimitation shown in Figure 1.*"

6. *Line 355 defines the accumulation portion of SMB as comprising snowfall and rainfall. However, the ablation portion only mentions runoff and sublimation, not evaporation. This seems inconsistent, as evaporation from the liquid phase does reduce SMB during melt (or rainfall) events just as sublimation reduces SMB during dry weather.*
   Here, "sublimation" is used to refer to all water fluxes, i.e. the condensation, evaporation, and sublimation balance. Evaporation will be added in the ablation term in line 356.

7. *Line 355: In accord with Reviewer 1's suggestion, the revised manuscript should explicitly state that MAR is configured not to represent snow drift, so it is not included in the SMB.*

   The received version of the manuscript will include at the end of line 190: "The blowing snow module of MAR is not used in this study causing no representation for snow drift.".

8. *The relative roles of the three assimilation parameters studied in influencing densification, runoff, and SMB is interesting. The manuscript reaches conclusions that will be helpful in advancing assimilation methods and reducing biases in RCMs.*

   Thank you. Your recognition of the importance of our study is deeply encouraging and truly motivating.

9. *The maximum volumetric liquid water content of firn prior to percolation adopted by MAR and used in this study is 5%. Where does the experimental support for this limit described? Please comment on the expected sensitivity the assimilation to the value chosen for this parameter within its uncertainty range. Please cite or describe the original source/justification for this limit the first time it appears in the manuscript.*

   Regarding the maximum volumetric liquid water content of firn prior to percolation as adopted by MAR and utilized in our study, we acknowledge the valid question raised. While the order of magnitude of the irreducible water saturation in MAR is based on Coléou & Lesaffre (1998), the specific choice for this limit is not currently described in existing publications (at least, for simulation in Antarctica (Reijmer et al., 2012)), the choice of this value is based on considerations that align with the MAR model's development context. Regarding assimilation, this parameter can indeed impact the outcomes, yet no sensitivity analyses were conducted. By retaining increased liquid water content in the initial layers, it could potentially necessitate reduced nudging to align with RS datasets during extended periods of wet snow without inducing excessive melting but it may induce more refreeze as explained in Fettweis et al. (2011).

   In a matter of clarity, we will reword lines 186-188 to: "*Each layer has a maximum liquid water content (LWC) of 5 % of its air content beyond which the water freely percolates to the deeper layer or runoffs above impermeable layers (bare ice or ice lenses) (Coléou & Lesaffre, 1998).*" in the revised version of the manuscript. We will also discuss the effect of this choice by rewording lines 398-399 to "*If the model were to retain liquid water in its top snow layers for a longer duration, it would require less nudging to match the RS datasets. Achieving this could involve increasing the maximum liquid water content of the snow layers. However, enhancing water retention in the initial snowpack layers might lead to increased refreezing and* *consequently, densification, depending on the snowpack temperature (Fettweis et al. 2011)."*

Technical Corrections:

The revised manuscript contains fewer, though still many, instances of poor English syntax, verb use, spelling, and adjective placement. A fluent English speaker could catch those remaining instances.

We acknowledge that the paper still contains poorly written sentences. The paper is currently undergoing revisions by a native English speaker. Among other minor syntax and grammar corrections, technical corrections 1 to 10 have been duly incorporated in the revised version.

References:

Coléou, C. & Lesaffre, B. (1998). Irreducible water saturation in snow: Experimental results in a cold laboratory. Annals of Glaciology. 26. https://doi.org/10.1017/S0260305500014579

Reijmer, C. H., van den Broeke, M. R., Fettweis, X., Ettema, J., and Stap, L. B. (2012). Refreezing on the Greenland ice sheet: a comparison of parameterizations. The Cryosphere, 6, 743–762, https://doi.org/10.5194/tc-6-743-2012

Fettweis, X., Tedesco, M., van den Broeke, M., and Ettema, J. (2011). Melting trends over the Greenland ice sheet (1958–2009) from spaceborne microwave data and regional climate models. The Cryosphere, 5, 359–375, https://doi.org/10.5194/tc-5-359-2011

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