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The Cryosphere Discussions
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Interactive comment on "Evaluation of coastal Antarctic precipitation in MAR3.9 regional and LMDz6 global atmospheric model with ground-based radar observations" *by* Florentin Lemonnier et al.

Anonymous Referee #1

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Summary

The manuscript evaluates the vertical structure of coastal Antarctic precipitation in the region of Dumont D'Urville station, East Antarctica. The authors compare observations from a micro rain radar with model simulations performed using various configurations of two models: the MAR and LMDz models. Sensitivity tests were conducted to evaluate different model resolutions of MAR and the numerical formulation of processes in LMDz. Adjustments to sublimation and sedimentation in the LMDz model had a minimal effect, whereas dissipation had a large, yet indirect, effect on precipitation.

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General comments

This study fits within the aims and scope of The Cryosphere and is of sufficient scientific merit for publication, subject to considerable revision of the text. My main comment is that the text does not currently read like native English, which detracts from the manuscript's quality.

Scientific quality: The authors present a compelling case for the need for improved precipitation modelling in coastal Antarctica and employ relevant scientific methods to evaluate observed and modelled data.

Originality: While the authors do not offer ground-breaking conclusions regarding the scientific understanding of precipitation in coastal East Antarctica, they make a convincing case for adaptations made to optimise the simulation of precipitation with regional and global models, both of which are commonly used in the region because of the scarcity of observational data. For example, MAR is increasingly used to evaluate the surface mass balance in Antarctica – the authors' conclusions show that higher horizontal resolutions and inner domains large enough to resolve meso-scale circulation are essential for accurately simulating precipitation. These are not novel conclusions but add strength to the existing body of knowledge.

Impact: Interestingly, the authors show that numerical dissipation is more important for accurately representing precipitation in East Antarctica using the global model LMDz than physical processes like sublimation and sedimentation, which will be significant for scientists wishing to use this model in the region, but will likely not have broader impact beyond this group.

Presentation: The manuscript is presented in a clear, logical manner with appropriate figures and tables. There are a lot of similar figures (line plots of vertical profiles showing the results of various experiments), and it may be better to think of another way to communicate some of this information. However, my main concern is that the text does not read like native English and can therefore be confusing and distract the reader from

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the scientific content. Specifically, this was evident from the order of sentences, verb tenses and non-standard word choices. I have highlighted some instances in my comments but there are too many to comment on individually. I suggest the authors find a native English speaker to proof-read and edit before re-submission.

Specific comments

[Title] The title could be clearer. Some suggestions: “Evaluation of coastal Antarctic precipitation in a global and regional atmospheric model with ground-based radar observations” or “Evaluation of coastal Antarctic precipitation simulated by the MAR3.9 regional model and LMDz global model using ground-based radar observations”

[Figure & Table captions] References to figures and tables should be capitalised throughout. The relevant part of TC manuscript preparation guidelines states: “The abbreviation "Fig." should be used when it appears in running text and should be followed by a number unless it comes at the beginning of a sentence, e.g.: "The results are depicted in Fig. 5. Figure 9 reveals that..."."

[Figures 3, 5, 6, 8 & 12] – these are all extremely similar plots. To keep the reader engaged, is there any other way you could show the differences between models (e.g. scatter plots of observations v model in different height bins, box and whisker plots etc.)? You could possibly combine plots, but you’d have to consider the trade-off between keeping them simple and easy to read (as they are now) and including more information.

[P2, para beginning L10] – Suggest including additional references regarding model simulation of Antarctic precipitation. For example: 1) issues encountered near the coast as a result of the large accumulation gradients (cf. Agosta et al., 2019 – already cited) and steep topography, which models often struggle to represent at sufficient resolution; 2) the role of cloud parameterisations, which are a notoriously stubborn source of model error in the Antarctic and can be important for accurately simulating precipitation (e.g. van Wessem et al., 2018, https://doi.org/ 10.5194/tc-2017-202); 3)

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the interplay between the representation of cloud, large-scale circulation and topography, which can produce positive accumulation biases near coasts and negative biases inland (e.g. Lenaerts et al., 2018 https://doi.org/10.1017/aog.2017.42); and 4) model difficulties simulating intense precipitation deposition events like 'atmospheric rivers', which can explain some of the biases over the plateau (e.g. Lenaerts et al. 2018, above).

[P2, L28-29] ". . .depending on greenhouse gas emissions exercises." – Please insert citation to Palerme et al. (2017), from which I believe these statistics are taken.

[P3, L1-4] Regional models tend to produce more minimal biases. As your study also employs an RCM, could you perhaps include reference to some studies that use higher resolution models over the historical period? E.g. Mottram et al. (2020) https://doi.org/10.5194/tc-2019-333

[P4, L12] Unclear exactly what you mean by "refinement in the boundary layer and troposphere". Please revise.

[P4, 12-13] Without context, it is unclear what you mean by "The vertical precipitation profile studied at Dumont d'Urville in the LMDz model is selected over continental surface." – presumably you mean that model profiles corresponding to the observations are extracted from continental, rather than ocean or ice shelf gridboxes? Please refine for improved clarity. (The same comment also applies to L29-30 regarding the profile selected in MAR)

[P4, L28-29] "MAR is accurate on the surface and in the boundary layer" – do you have a citation to substantiate this? Which parameters are accurately simulated on the surface/in the boundary layer? Further evidence would be helpful to support this claim.

[P5, L15] Explaining your reasoning for focusing on accumulated precipitation instead of a specific event may help the reader.

[Figure 2] Axis and colourbar labels are quite small and difficult to read. Suggest

enlarging the labels (and perhaps labelling only alternate intervals).

[P6, L14-16] How does the representation of topography compare between MAR and LMDz in the SMALL and BIG domains?

[P7, L14-15] "To do this, several orders of magnitude have been fixed to β tunable parameter value" – this could be phrased more clearly. For example something like: "Several values of the β tunable parameter are chosen that vary across several orders of magnitude"

[Tables 7 & 8] Slightly more detail in the table captions would be helpful. The word ordering is also quite difficult to understand, e.g. "...experiments on LMDz precipitation evaporation" – are these experiments testing the change in precipitation only, evaporation only, or both?

[P8, L6-7] Here is an example of a sentence that would benefit from editing by a native English speaker: "Green dashed line corresponds to best MAR configuration with a 5 km horizontal resolution and a BIG domain is in good agreement with MRR vertical observed profile". This could be revised to (for instance): "The green dashed line shows that the best MAR configuration - with a 5 km horizontal resolution and a BIG domain - is in good agreement with the MRR observed vertical profile"

[P8, L13] The word 'petite' isn't usually used to describe precipitation (although I like the idea of petite precipitation..!) – suggest revising to e.g. 'under-estimated' or 'too small'.

[Figure 3] Please include description of the red line and shaded region (MRR obs + 95% confidence interval) in the caption

[Figure 4] Please include description of what the vectors show in the caption. Again, axis and colourbar labels are quite small and would benefit from being larger. Another small point: as far as I can tell, the 0.5 g kg-1 contour is blue, not white. An inset panel showing the location of the transect may also benefit the reader.

[P12, L4] For clarity, make sure you specifically refer to “potential temperature” rather than temperature.

[P12, L11-12] Another example of where proof-reading by a native English speaker may help with the sentence construction: “In addition, the amount of simulated precipitation overestimates by approximately 50% the amount of precipitation observed along the vertical profile at Dumont d’Urville” could be revised to “In addition, LMDz overestimates the amount of simulated precipitation by approximately 50% throughout the vertical profile at Dumont d’Urville”

[P12, L14] What does this say about the formulation of the microphysics in LMDz? Is it therefore suitable for use in the Antarctic region if changing variables such as sublimation and sedimentation has limited effect? Is further development required to improve the representation of meso-scale processes needed before it can be widely deployed?

[P14, L13] Unclear what you mean “designed by” (do you mean “designated”?) - could you revise your word choice?

[Figure 9] Axis and colourbar labels are again too small to read clearly – please enlarge them. I also think “differential” may not be exactly what you mean here, perhaps revise this part of the captions to “c) Time series of temperature difference between control and D09 simulations” (this also applies to the caption of Figure 10)

[P17, L5] It may aid the reader’s understanding to include a brief description of what Fig. 11 shows.

[P17, L9-16] This is indeed an interesting result! Are you able to speculate about why this might be?

[Figure 12] Nice summary figure. You could sign-post the reader to this figure more to emphasise your most important take-home results, for instance by including a brief sentence summarising what it shows.

[P19, L23-25] Did you examine the effect of tuning the dissipation variables on any other fields? Does tuning the model to better represent one or two variables in one geographical area have knock-on effects on other variables, for instance introducing competing biases and errors elsewhere in the model? Can you conclusively say that amending the representation of dissipation does not produce other cancelling errors (i.e. that the model gets the 'right results for the wrong reasons')?

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