

The Cryosphere Discuss., referee comment RC2  
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## Comment on tc-2021-263

Rajashree Datta (Referee)

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Referee comment on "Clouds drive differences in future surface melt over the Antarctic ice shelves" by Christoph Kittel et al., The Cryosphere Discuss.,  
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This manuscript presents an analysis of the importance of cloud properties in driving surface melt over Antarctic ice shelves in the future (to 2100), comparing these to a 1981-2010 reference period. This uses the MAR model forced at the boundaries with 4 ESMs (ACCESS1.3, NorESM-1-M, CRNM-CM6-1 and CESM2) in the RCP8.5 (for CMIP5 models) and SSP585 (for CMIP6 models). The authors examine potential drivers for surface melt beginning with energy balance components, identify the importance of clouds, and present a strong analysis of properties which contribute most to differences in melt produced by each ESM-forced-version of MAR. I commend the authors on a very well-organized argument and believe that this will eventually be a strong contribution to the understanding of future surface melt in Antarctica, although several important aspects are currently missing, which could be addressed with additional figures and analysis.

Specific Comments:

1) The integration of all ice shelves may be hiding processes which vary spatially

As an example, the authors specifically admit that the SEB is impacted by SHF values only in certain regions. We note that one such region is the Larsen C ice shelf, where a substantial amount of total surface melt occurs. At the 35 km spatial resolution, surface melt would necessarily be poorly-represented over the Larsen C ice shelf in this version of MAR. A more meaningful analysis (making this manuscript an excellent companion to Gilbert and Kittel, 2021) would be to essentially conduct the organisation of this study, but with ice shelves divided regionally.

For plots (i.e. Figures 2,4, 6, S1, S2) these would benefit from a map showing differences ( as in Fig. S3). We note that on line 164, the authors mention the thickening of the future planetary boundary layer over ice shelves of West Antarctica – it would be relevant to show whether this was demonstrated in East Antarctica as well independently.

Additionally, it would be beneficial to see similar maps of averaged values for forcing fields (in Supplemental Figures) to illustrate the spatial characteristic of the differences in forcing. By integrating, we have no picture on the spatial characteristics which are driving this (i.e. are the differences in moisture at lower altitudes vs higher altitudes dominant in West Antarctica but not East Antarctica)

## 2) A more rigorous account of changes in albedo

The differences in albedo are mentioned briefly, but this seems to be a major driver in the overall differences shown, and there is no discussion about how this impacted by snowfall events. While I think that a thorough examination of precipitation trends is outside the scope of this manuscript, an analysis of albedo differences (in a map) as well as snowfall differences (in a map) would strengthen the manuscript significantly.

## 3) A greater discussion of biases in cloud properties that are present in historical runs of MAR

To my knowledge, none of the evaluations of MAR present a comparison of biases in cloud properties (as compared to observations, i.e. CALIPSO). If I've missed something, a reference and a short discussion would be relevant. If not, then some level of validation of MAR's representation of cloud properties in the historical record would be directly germane to this study.

## Technical Corrections:

L 42: I could not find the reference to lower future melt changes in ESMS in Kittel et al., 2021. Could the authors clarify (identify a figure/section)?

L 61: Use of the word "correct" twice in proximity. Additionally. I would suggest, "presents well" as opposed to "correctly". Additionally, Kittel et al., 2021 refers to future runs, rather than an evaluation of a historical run. Perhaps referencing Agosta et al., 2019 would be more accurate.

L 64: "difficult to assess". This is a good way to declare this complexity without making dishonest claims. Thanks for that.

L 110: Make clearer exactly how these melt projections used climate models.

L 171: Awkward sentence. Suggestion: "This could be explained by accounting for the ECS capturing the greater warming over the Antarctic region simulated by CNRM-CM6-1 (+8.5°C vs 7.7°C for CESM2 in 2100 compared to 1981-2010).

L 173: replace "this ESM" with "CRNM-CM6-1" for clarity

L 176: relatively – (remove dash)

L 182: "suggests a low influence on LWD". Clarify the discrepancy by comparing the quantity

L 206: "southern" == "austral"

L 210: Why are clear and cloud sky conditions treated separately? Could you clarify the reason or separate the analysis accordingly?

L 220: Could you demonstrate the saturation of LWD for large COD increases in supplemental?

Sincerely,

R. Tri Datta