Reviewer #3

The authors provide an overview of the driving forces of surface melt over the ice shelves over Antarctica. Although the work is mainly confirming the results of other studies, it is one of the first to provide a quantitative assessment of these driving forces towards the future, which is a step forward in the scientific understanding of how models interact with the surface.

We would like to thank the reviewer #3 for reading the manuscript and the interesting comments which helped us to improve our manuscript. Please find our responses in blue below your comments. Italic text represents unchanged text from our manuscript while bold text highlights our suggested changes.

Main comments:

- The paper is well structured & contains a lot of interesting information regarding the representation of melt in future simulations. One aspect that is not discussed however is the effect of precipitation on surface melt. A higher number of clouds would possibly also result in higher precipitation numbers, which would increase the surface albedo. This counteracts part of the warming induced by the increase in liquid clouds and LWD. It would be nice to see the contribution of precipitation and surface albedo in the results.

See our response to #R1 that includes theoretical approaches and sensitivity experiments to discuss the influence of the amount of snow and rainfall compared to melt.

- The paper mainly discusses average changes towards the future. However, most of the large melting occurs during 'events' nowadays. With the increase in general surface temperatures towards the future, I am wondering if these individual melt events become of lesser / higher importance & that individual events will still be the driver of most melt or that temperatures will increase to such a level that melt will occur during the whole summer.

Since we mostly aim to discuss the physical reasons behind melt differences over the century, we indeed focus our analyses on average changes (or climate changes). However, we acknowledge that changes in the influence of individual events could also contribute to differences and then improve our analysis. We compared the amount of mean melt produced during the strongest events (daily melt above the p95 of the climate period) to the mean total amount of melt for the present period (1981-2010) and the future period (2071-2100).

$$Ratio = \frac{\sum_{dailymelt>P95}^{summer} \frac{melt}{\sum_{allday}^{summer} melt}}{}$$

As expressed by Eq. R1, high values (~1) of the ratio suggest that total summer surface melt is mainly produced during strong events, while lower values highlight the contribution of more numerous "smaller" events in the total production. As mentioned by #R3, the ratio is close to 1 (and generally over 0.8) over most of the Antarctic ice shelves over the present period, the peninsula excepted (Fig. R14). This underlines that in the current climate over most of the ice shelves, melt is associated with events (e.g, Atmospheric Rivers or Foehn).

On the contrary, our experiments all suggest a decrease in the contribution of strong events to the total summer melt in the future and that melt could occur during more days in the whole summer (Fig. R15.) This would also have consequences in terms of modelling: properties during very isolated events (AR or at least maritime intrusions) while it could be different for future climates.

We suggest to add in S3.1:
The contribution of a few specific events to produce melt over the Antarctic ice shelves is projected to change. We compared the amount of mean melt produced during the strongest summer events (daily melt above the p95 of the climate period) to the mean total summer amount of melt for the present period (1981-2010) and the future period (2071-2100). Over present-day conditions (Fig.~S5), this ratio is high (higher than 80\%, the peninsula excepted) suggesting that melt mainly occurs during specific events such as atmospheric rivers \citep{Wille2019}. On the contrary, all the MAR experiments project a much lower contribution of these specific events in the total summer melt (Fig.~S6). This suggests that melt will occur during more days in the whole summer.

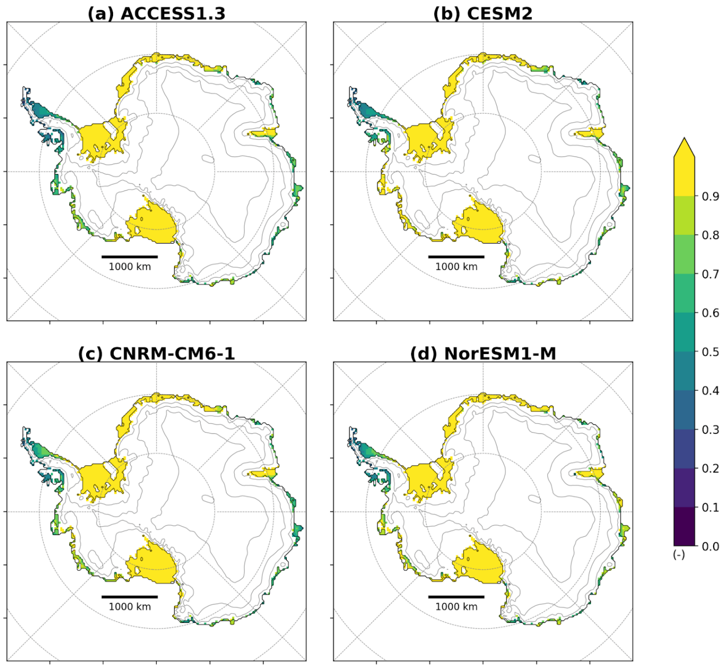

Fig R14: Mean ratio of the melt produced during melt days stronger than P95 to the total surface melt in summer over 1981-2010 as simulated by MAR forced by ACCESS1.3 (a), CESM2 (b), CNRM-CM6-1 (c), NorESM1-M(d).

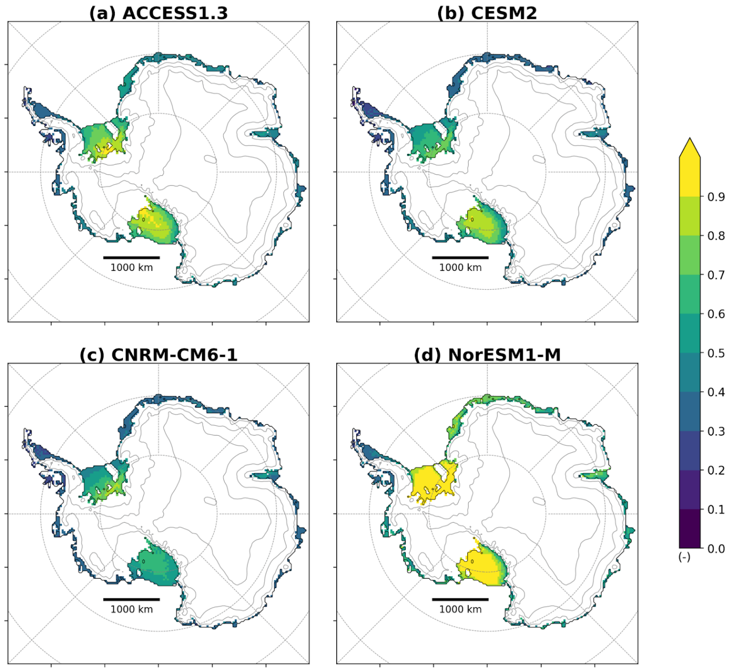

Fig R15: Mean ratio of the melt produced during melt days stronger than P95 to the total surface melt in summer over 2071-2100 as simulated by MAR forced by ACCESS1.3 (a), CESM2 (b), CNRM-CM6-1 (c), NorESM1-M(d).

The paper is clear and well written, i only have a few **specific comments**:

- When first reading the title of the paper, I immediately thought of the paper of Van Tricht (https://doi.org/10.1038/ncomms10266). Despite dealing about a similar subject (although another ice sheet), I think a reference to this work is valid somewhere in the introduction. A same set of techniques is also used in the methodology & results section and in the discussion, one could relate to the differences between the Greenland & Antarctic Ice Sheet
We added a reference to Van Tricht et al (2016) in the introduction:

*The net cloud radiative effect - the balance between these opposite contributions - is notably determined by the surface albedo \citep{bintanja1996,hofer2017}, and cloud properties, i.e their temperature \citep{stephens1984}, structure \citep{barrett2017, gilbert2020}, and water phase (ice or liquid) \citep{lachlan2010,**van2tricht2016**,hines2019,gilbert2020}.*

and

Clouds currently warm the Antarctic Ice Sheet (AIS) surface \citep{pavolonis2003,van2006}. While the highly-reflective snow already prevents significant absorption of solar downwelling radiation (SWD) in summer, clouds act as another source of incoming energy in the infrared spectrum, which can heat and melt snow \citep{bintanja1996,van2006} ***similarly as over bright surfaces of the Greenland Ice Sheet \citep{van2tricht2016}.***

- Specify on line 134 that NorEsm is the lowest range model & CNRM is the upper range (instead of line 140)

Change as requested:

from

MAR driven by NorESM1-M simulates a cumulated melt increase of $\sim$8000 \unit{Gt} during the 21st century, while the increase reaches $\sim$31400 \unit{Gt} when MAR is driven by CNRM-CM6-1.

to

MAR driven by NorESM1-M simulates a cumulated melt increase of $\sim$8000 \unit{Gt} during the 21st century ***(i.e the lowest melt increase)****, while the increase reaches $\sim$31400 \unit{Gt} when MAR is driven by CNRM-CM6-1* ***(i.e the highest melt projection).***