Reviewer #2

The manuscript presents a comparison between precipitation frequency as observed by CloudSat and as modeled by the Community Earth System Model for the last 15 years (2006-2020) and once determined that the model can simulate fairly well the pattern and the seasonal variability of precipitation, it extends the simulation to the last 15 years of the 21st Century. The results show a general decrease on snowfall frequency over the Greenland Ice Sheet except for the inner most elevated region where the snowfall frequency actually increases by 10%. Rainfall frequency is supposed to increase over the entire Greenland and will extend over higher elevation compared to present-days. These changes will affect climate and mass balance of the Greenland Ice Sheet with dramatic consequences on the snowpack. The paper follows a pretty straightforward line of reasoning, clearly describing data, methodology and results. Here are few suggestions to clarify few points:

We thank the reviewer for their positive feedback. We provide a response to all items below.

The whole paper is about precipitation frequency so I suggest to explicitly describe what you mean with it (#precipitating pixels/#total pixels I suppose), especially because you also partition snow and rain and there could be confusion between the snow (rain) frequency over all pixels or over only precipitating pixels for example.

Good point, we added to the first paragraph of the data and methods section: "We define precipitation frequency as the ratio between the number of time steps with precipitation and the total number of time steps. If averaged across an area, such as the ice sheet or elevation bin, frequency is defined as the average frequency of all grid cells contained within that area."

P4 L2: add a sentence to tell what RCP is (a forecast model? A future scenario? . . .)

We added: "using the worst-case Representative Concentration Pathway (RCP) 8.5 greenhouse gas emissions scenario."

Section 3.1: describing present-day precipitation from CloudSat it is worth mentioning that there could be some biases due to the daylight operational mode CloudSat is operating on since 2011. The winter descending orbits over Southern Greenland for example do not provide any data. There are ongoing studies that will eventually quantify

the biases but nothing has been published yet. I would suggest to mention the issue and just advice that no bias correction have been applied in the present study.

Thanks for pointing that out. We have added this to the Data and methods section:" Since CloudSat has been operating on daytime only mode since 2011, which might potentially introduce biases that are not considered in this study."

P5 L10-11: does the fact that areas below 2000m are actually a low percentage compared to other eleva- tions affect precipitation frequencies? Describe a bit more how those variables are connected in your study.

Yes, it does, and this sentence aims to address exactly that: "This implies that, although all areas below 2000 m a.s.l. experience rain, all these elevation bands combined only occupy ≈ 38% of the ice sheet area."

P5 L19 and following: it is not really clear from your wording that you are calculating the difference between CESM and CloudSat frequencies. I would suggest to make this more explicit both here and on fig.5 caption.

Good point, we added a sentence to start the paragraph: "We first present the CESM precipitation frequencies (Figure 4), and then compare them directly to CloudSat (Figure 5)." In the caption of Figure 5, we more explicitly state that these map shows CESM-CloudSat: "Present-day, annual (left) and seasonal (DJF, MAM, JJA, SON, from left to right) mean snowfall (top) and rainfall (bottom) frequency difference between CESM (2006--2020) and CloudSat 2CPC (2006--2016). Positive values indicate that CESM overestimates precipitation frequency relative to CloudSat."

Figure 3 caption: the "grid-cell" area concept is not really clear, is it the total area of the GrIS for each elevation bin? I feel like this "grid-cell" is a bit misleading.

We acknowledge that 'grid cell area' is confusing; this is simply the total area in each bin. We have changed this to 'Area' instead and divided the number by 10^5 to improve readability of the labels.

P9 L1-4: as a curiosity, have you tried to compare different intervals like only 10 years or for example 15 years around 2050? Just to see if there is a dependence on the actual interval of years used for the comparison or if we can extend the results independently on that.

We have not done that. The 15 years is chosen because it is a compromise between having sufficient number of years to filter out much of the internal variability, and to stay as close to the end of the 21st century to see the largest signal.

In general I feel like the conclusion section is a bit weak, some more information could be added about the mass balance and what to expect for future satellite missions here. Better describing the consequences of your results would absolutely help making the paper stronger.

We agree, and have added new text to discuss the relevance for future satellite missions.

Minor comments:

In the abstract you mention RCP8.5, I suggest to explicitly write "Representative Concentration Pathway 8.5 Scenario" as you did for CESM earlier.

Done.

P2 L8: why the snow layer "needs" to be melted away?

Changed to 'is melted away'

P2 L29: remove the first "the" from "CloudSat is the currently the. . ."

Done.

P2 L30: there aren't so many papers about the observational assess- ment of Antarctic Ice Sheet precipitation rates, so I would mention all of them, including Milani et al 2018 that considered also the surrounding oceans and the ground clutter corrections.

Thanks, added Milani et al., 2018 and Lemonnier et al., 2020 references to revised paper.

Milani, L., Kulie, M. S., Casella, D., Dietrich, S., L'Ecuyer, T. S., Panegrossi, G., et al. (2018). CloudSat snowfall estimates over Antarctica and the Southern Ocean: An assessment of independent retrieval methodologies and multi-year snowfall analysis. *Atmospheric Research*, *213*, 121–135. https://doi.org/10.1016/j.atmosres.2018.05.015

Lemonnier, F., Madeleine, J.-B., Claud, C., Palerme, C., Genthon, C., L'Ecuyer, T., & Wood, N. B. (2020). CloudSat-Inferred Vertical Structure of Snowfall Over the Antarctic Continent. *Journal of Geophysical Research: Atmospheres*, *125*(2), e2019JD031399. https://doi.org/10.1029/2019JD031399

P3 L21: "gridded observations", can you give some details about the grid you used for this work?

This grid is a 1x1 degree grid in which all CloudSat 2C-PRECIPITATION-COLUMN are aggregated. This is added to the text.

P3 L21: "2CPC", for a reader not familiar with CloudSat this acronym does not make much sense, explicitly mention 2C-PRECIPITATION-COLUMN product so they know what to look for.

Done.

P6 L4: you probably forgot to say "in winter".

We are unclear as to what the reviewer refers to, since the sentence includes 'in winter'.

P8 L5: Is Figure A1 an appendix figure? It is not clear at the end of the manuscript that there is an appendix, shouldn't this figure just be included as a regular figure since there is no in-depth description in a real supplemental section?

We added this figure as a separate regular figure in the revised manuscript.
P8 L7: what is GIMP and what is its grid? The full name is provided in fig. 3 caption, I would suggest to include it in the text as well.

Done.

P9 L14-21: I guess you are referring to figure 9, please cite it.

Done.

P10 L2: "the increase of light frequency", add "light rain frequency".

Done.