Reply to RC1:

Summary

The submitted article is clearly written and adresses an important topic, adding largely missing detailed insight on how much should Greenland precipitation change in a warming future. Besides suggesting several missing relevant citations and questioning the likely important future model treatment of sea ice decline in Greenland precipitation change, I take issue mainly with the magnitude of the precipitation sensitivity to temperature, arguing that the conclusion of ~5%/K, being considerably lower than theory (~7%/K) appears to me more due to the research design than reality given there exist research finding 7%/K using observation-based approach.

I am a fan of the work that deserves to be published, especially on working with my comments. Upon successful adressing of my comments, I think the work will deserve nomination for a highlight by the EGU (is a question reviewers are asked in this review form).

Thank you for your positive and constructive feedback.

high level critique in no particular order of importance...

Precipitation feedbacks with changing sea ice appear to be a key consideration, deserving perhaps a whole new section in this study. The following is relevant to incorporate in discussion: Stroeve, J. C., Mioduszewski, J. R., Rennermalm, A., Boisvert, L. N., Tedesco, M., and Robinson, D.: Investigating the local scale influence of sea ice on Greenland surface melt, The Cryosphere, 11, 2363–2381, https://doi.org/10.5194/tc-11-2363-2017, 2017.

REPLY: Good point. We will add the following paragraph to the discussion:

"A reduction in Arctic sea ice cover, due to increases in atmospheric CO_2, can enhance transfer of heat and moisture between the ocean and the atmosphere leading to an increase in temperature and precipitation over Greenland (Stroeve et al., 2017; Noel et al., 2014). This increase in temperature will increase the ice melt and thereby decreasing the surface albedo creating a positive feedback loop, resulting in a warmer atmosphere with the capacity to hold more water vapor and thereby intensifying the hydrological cycle (Zeitz et al., 2021)."

Noël, B., Fettweis, X., van de Berg, W. J., van den Broeke, M. R., and Erpicum, M.: Sensitivity of Greenland Ice Sheet surface mass balance to perturbations in sea surface temperature and sea ice cover: a study with the regional climate model MAR, The Cryosphere, 8, 1871–1883, https://doi.org/10.5194/tc-8-1871-2014, 2014.

230 "7% increase per degree warming", the idea of warmer atmosphere, more water vapor appears as a statistically robust feature of observational data, specifically N Atlantic SST and Northern Hemisphere near-surface air temperatures correlation with Greenland snow accumulation, matching theory articulated by Treberth (doi: 10.3354/cr00953), see https://doi.org/10.1175/JCLI-D-12-00373.1 figure 9a, Table 3 and related discussion. The J. Clim. article finds the expected 7%/K sensitivity using observations, in the following Figure 9 comment, I suggest ways to possibly find a more credible result after all the J. Clim. article

has more observation constraint. As is, the conclusion of "4.9%, 5.1% and 4.5% increase in precipitation per Kelvin for HIRHAM, MAR and RACMO," I fear may be misleading...

REPLY: Using the information from the 2013 Box et al. paper, we did an analysis using the northern hemisphere change in tas (using the forcing GCMs) and we still got values around 5% per degree. The Box et al. paper did their analysis for the period 1880–1962 during which the temperature increase was low (less than +1) and during which changes in general circulation or natural variability could have also impacted this precipitation increase vs temperature increase. In the current study, the temperature increase is significantly larger (therefore the trend is likely more robust) and the GCMs do not suggest any general circulation change (Delhasse et al., 2020), therefore it is normal that our rate is different. Moreover, +5%/K is in agreement with other studies based on models over the Greenland ice sheet.

Therefore, we will add the following text to the paragraph beginning at line 280:

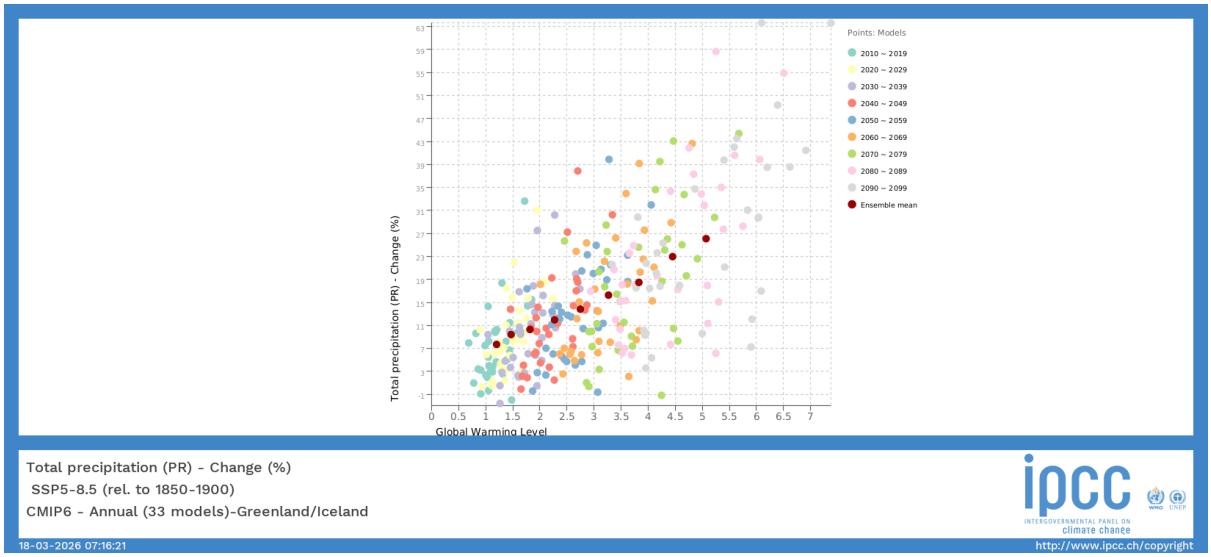
“There are several ways of determining the relationship between temperature and precipitation changes. Frieler et al. (2014) used a wide range of methods for Antarctica and derived a combined sensitivity of 5 ± 1% K^{-1}. The individual forcing models in this study give similar values. However, Box et al. (2013) found the theoretically expected 7% K^{-1} using reconstructions of snow accumulation from ice cores together with the average near-surface air temperature in the Northern Hemisphere for the period 1880–1962 during which the temperature increase was relatively low (less than +1°C) and during which changes in general circulation or natural variability could have also impacted this precipitation increase vs temperature increase.”

Figure 9: Ensemble median... is there a GCM that is arguably more reliable? Groupling ALL models may obscure a more realistic result. I'm wondering which models given 7%/K and if those are of a model class that is arguably more reliable? If so, a new figure could feature that more credible model result. at line 206 you get into the issue "dependency on the choice of GCM."

REPLY: We have investigated the individual models and they all give similar numbers (4-5% per K). Previous studies, using model data (RCMs/GCMs) for different emission scenarios, seem to agree on values close to 5%/K. (see reply above).

...Well ok at line 285 "Bochow 285 et al. (2024) used 32 GCMs within the CMIP6 project and found a mean value of 6% K-1", but I just hope you can build an even more convincing argument why or why not the actually should be drier than theory! If it's something about dynamics, then I think you need to do more sensitivity analysis, i.e. burden of proof on this study.

REPLY: The correct sentence is in fact “Bochow et al. (2024) used 32 GCMs within the CMIP6 project and found a mean value between 3 and 6% K^{-1} following the scenario used”. As we can see over the IPCC AR6 Atlas over Greenland and Iceland (https://interactive-atlas.ipcc.ch/), the ensemble mean changes are close to 5% K-1 (e.g. +26%/+5°C; +23%/+4.5°C) similar to what we found although there are significant differences between models. For example, in a +5°C world precipitation increase varies between +7% and +59%.



...286-299 "A 5% increase in precipitation per degree warming over the GrIS were found by Gregory and Huybrechts (2006) and by Fettweis et al. (2013)." Do they provide a credible explanation why the sensitivity is lower than 'observed' by https://doi.org/10.1175/JCLI-D-12-00373.1 ?

Whatever extent IPCC AR6 examines future Greenland precipitation change warrants treatment here.

REPLY: See our previous response discussing the precipitation increase in Box et al. (2013) vs our rates.

Figure 8: Annual sum of precipitation nonlinearity for rain is striking, deserves highlight in abstract and conclusions and has important implications you get into lines 256-261 that can be further elaborated, more citations, more to the point text... some thoughts, partly redundant...driving snow metamorphic (albedo decline) feedbacks and pontential firn heating at depth (ONLY IF HEAVY RAIN AND LOW TEMPERATURE SNOW https://doi.org/10.1029/2023GL103654), if rain is light, it does not infiltrate and instead the heat radiates away

https://doi.org/10.1029/2021GL097356

REPLY: The second to last sentence in the abstract will be changed to:

“The change in precipitation phase shows a non-linear increase in rainfall with temperature, particularly along the outer edge and the southern part of the ice sheet.”

The second sentence in the Conclusions section will be changed to:

“The fraction of rain relative to the total precipitation increases exponentially with temperature during the 21st century.”

The paragraph on lines 256-261 will be rewritten as:

“The precipitation phase is important because rainfall serves as a crucial climate indicator in polar regions and plays a multifaceted role in cryospheric processes. When heavy rain falls on low temperature snow or ice surfaces, its infiltration not only contributes directly to surface melt, but also initiates a sequence of physical changes in the snowpack (Box et al., 2022). The freezing of rainwater within the firn releases latent heat, which further enhances snowpack collapse by warming the surrounding ice and snow (Harper et al.,

2023). In addition, rainfall events lower the surface albedo making the surface more susceptible to future melting due to increased absorption of solar radiation (Noël et al., 2022; Firn Symposium team, 2024; Gilbert et al., 2025)."

line 260 "rainfall events lower the surface albedo", https://doi.org/10.1029/2021GL097356 cites relevant detail. Another is Colbeck, S.: Theory of metamorphism of wet snow, 1973.

REPLY: The Box et al. paper will be included.

at the first mention of runoff, I was thinking, why? I mean this is a precipitation change study. Then at line 264 "Glaude et al. (2024) however, show from some of the same simulations as we analyse here, that the melt and runoff is projected to increase by a much larger"... again, runoff is beside the point. I recommend you keep the study focused on precip change and not do other mass balance terms and so avoid needing to add yet more (irrelevant) citations.

REPLY: Good point! We will remove the melt/runoff parts in the text (Abstract and Discussion).

PLEASE use "ice sheet" instead of "GrIS" once it's obvious the geographic focus is Greenland. having read though, there are really few places where an abbreviation would be needed. Therefore, clearly it's not.

REPLY: We will change the wording.

** lower level critique **

KEY: "io" means "instead of", NUMEBRS: line numbers

32 "projected increase in snowfall, compensating for increased runoff", consider also https://doi.org/10.1029/2024GL110121

REPLY: The paper will be cited.

40 "higher temperature of rain compared to melt water", surprisingly insignificant for surfaces that are already at melting point, see section 3.6 in https://doi.org/10.1002/met.2134 and supporting citations, the exception being HEAVY rain only LOW TEMPERATURE firn, see Harper et al 2024?

GRL https://doi.org/10.1029/2023GL103654

REPLY: Thanks for pointing this out! We will change the sentence to:

“During the right conditions (heavy rain on low temperature firn), the higher temperature of rain compared to melt water can also transport energy deeper into the firn, warming it and reducing refreezing potential (Harper et al., 2023).”

43-44 "washing away surface debris" shown by what study? citation needed

REPLY: Thanks, we have not found reference about this and we will therefore remove this sentence.

Table 1, CARRA 1971–2000 but CARRA data start in 1991?

REPLY: Yes, CARRA starts in 1991 as stated in the caption. We will add an asterisk to the CARRA value.

105-106 "previously used to evaluate climate models" also https://doi.org/10.1002/met.2134 and https://doi.org/10.1029/2021GL092942

REPLY: We will cite the two papers.

106 and new GEUS AWS data citation https://doi.org/10.5194/essd-2025-687

REPLY: We will add the citation to the text.

108 "hard to compare with precipitation in a climate model" true :-) for CARRA data, in addition to the Yang et al citation, pls include

Schyberg, H., Yang, X., Køltzow, M. A. Ø., Amstrup, B., Bakketun, Å., Bazile, E., Bojarova, J., e., B., Dahlgren, P., Hagelin, S., Homleid, M., Horányi, A., Høyer, J., Johansson, Å., Killie, M. A., Körnich, H., Le,Moigne,P., Lindskog, M., Manninen, T., Nielsen,Englyst,P., Nielsen, K. P., Olsson, E., Palmason, B., Peralta,Aros,C., Randriamampianina, R., Samuelsson, P., Stappers, R., Støylen, E., Thorsteinsson, S., Valkonen, T., and Wang, Z. Q.: Arctic regional reanalysis on single levels from 1991 to present, https://doi.org/10.24381/cds.713858f6, 2020.

REPLY: The paper above will be cited.

118 "outperforms ERA5 when comparing the two datasets with in-situ observations", for rainfall using ON-ICE observations, not only CARRA but other models, https://doi.org/10.1002/met.2134

REPLY: We will add a citation to the study.

Figures 3 and7, like the figures!, but the colors need to change, avoid bright yellow and no greens. Orange, magenta and could also be dashed lines, and why not box plots using seaborne or violin plots to make a great plot even better? Instead of 1,2,3... use names like NE, all

REPLY: The figures will be updated with better colors and box plots for figure 7. The numbers 1-7 in Fig.3 refers to the stations in figure 1a.

Figure 4 important results. Comments on sea ice decline effect for change in precipitation needed if not already there.

REPLY: See our 1st reply.

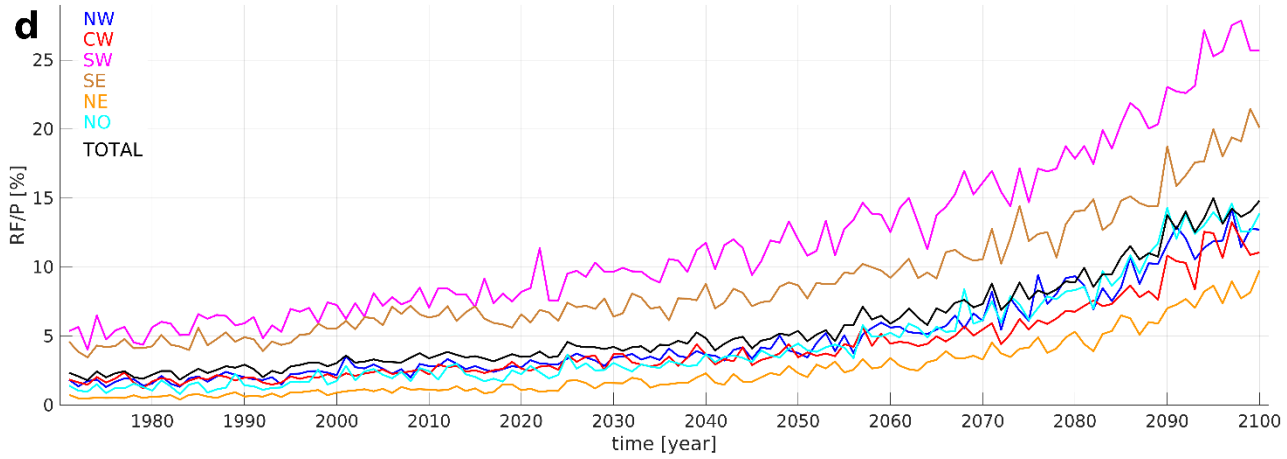
198 "a large fraction", include a quantity

REPLY: (See reply below with the added time-series plot) We will change the text to:

"Figure 6d shows how the rainfall fraction of total precipitation for the six drainage basins changes with time. For the historical period, the mean rainfall fraction is around 5% for basins SW and SE while the other basins show mean values below 2%. At the end of the century for the SSP5-8.5 scenario, we see that a large fraction of the precipitation is rainfall (total ice sheet: around 15%), especially basins SW (above 25%) and SE (around 20%)."

Figure 6 using a colorblind sensitive color palette? Seems not. I'm not color blind (at least I don't think so), but it's the norm anyway to not combine green and red-sh colors. And thin rain fraction of total precip is more standard than snow fraction of total precip. Really want a number for the whole ice sheet within the ice mask, and a time series graphic

REPLY: We are using the IPCC color palette for all of our map plots and we would like to stick to this if ok. We will change to showing rainfall fraction, add numbers to the text and add the panel below showing a time series (ensemble median):



249 "robust across most models." or "consistent across all models"... is there a statistical test to help here?

REPLY: The sentence will be changed to:

“Results from the GCM ensemble from CMIP6 (cf. Figure 5) show that the north east signal is robust across all models while the south east signal is positive for 28 out of the 34 models for the end of the century (cf. Figure 5f).”

254 "we find increases" io "we see positive changes"

REPLY: Text will be changed.

274 "CARRA has shown clear advantages to other reanalysis products (Køltzow et al., 2022)" include the Greenland specific study reaching this conclusion https://doi.org/10.1002/met.2134

REPLY: We will cite this study as well.

275 "performs better in other regions." better than ___?, could be something like "has smaller differences relative to observations in other regions."

REPLY: We will change the first part of the paragraph to

“CARRA has shown clear advantages to other reanalysis products (Køltzow et al., 2022; Box et al., 2023) and CARRA performs well when compared with station observations outside the GrIS (cf. Figure 3). Compared with our RCM ensemble (cf. Figure 7) over the ice sheet, CARRA overestimate precipitation for all basins except NO and NW.”

276 "located in or near" io "located in"

REPLY: We will change the wording.

283 "However,", see the %/K points above in this review.

REPLY: see our previous replies about this issue.

293 "(Doyle et al., 2015)"? io "(Doyle et al., 2014)"

REPLY: Indeed, it is Doyle et al. (2015): Doyle, S., Hubbard, A., van de Wal, R. et al. Amplified melt and flow of the Greenland ice sheet driven by late-summer cyclonic rainfall. Nature Geosci 8, 647–653 (2015). https://doi.org/10.1038/ngeo2482

299 something like "Our work, consistent with theory, finds that the GrIS faces a wetter future in all regions," io "The GrIS faces a wetter future in all regions,"

REPLY: Text will be changed.

301 avoid/spell out abbreviations in conclusions, "SSP".

REPLY: Text will be changed to “shared socioeconomic pathway (SSP)”.

Reply to RC2:

Review of manuscript “21st century change in precipitation on the Greenland Ice Sheet using high resolution regional climate models” by Boberg et al.

General overview of the manuscript

The manuscript looks at changes in solid and liquid precipitation over the Greenland ice sheet (GrIS) in an ensemble of high resolution future projections compared with those obtained with 34 CMIP6 global climate model in three different SSP scenarios (SSP1-2.6/SSP2-4.5/SSP5-8.5) and observations/reanalysis datasets. High resolution ensemble members are obtained in three different ways: (i) with the regional climate model (RCM HIRHAM, forced with EC-Earth3; (ii) with a set of # CMIP6 models downscaled with MAR and (iii) with the RCM RAMCO forced by CESM2-L. Total precipitation over GrIS is projected to increase up to 24% in the 2071-2100 period for the most extreme SSP scenario. The model spread and changes in precipitation characteristics (e.g. total precipitation versus snowfall/rainfall fraction) are analysed over the entire GrIS and over six different catchments. Overall, all models tend to underestimate the total amount of precipitation over the most part of GrIS during the validation period, with the exception of coastal areas. In general, I find that the manuscript is well written, although a few points need further clarification to ensure that the paper can be accessible to a broader spectrum in the scientific community. The research topic is relevant to the broad scientific community and the manuscript represents a good fit for Copernicus journal “The Cryosphere”. Most comments mainly aim to improve the readability and accessibility of the paper, and to better describe Figures. I would recommend publication in TC after current concerns have been successfully addressed.

Thank you for your positive and constructive comments.

Major comments

Line(s) 95, table 1. The table caption reads “Numbers in blue/green/red are for the SSP1-2.6/SSP2-4.5/SSP5-8.5 scenario”, however all tables are in black and white in the pdf. Also I am not sure why some values are set to N/A, does it mean that for that model the scenario is not available? Please clarify. Moreover, at first glance it seems like the bias between the ensemble and CARRA over the 1971-2000 period is -142 Gt, and that for the 1991-2022 period the bias is -307 Gt. Again, it takes a while to understand that the last two columns represent the bias between the 7 chosen observation stations and the models (CARRA). Why is a small set of 7 weather station used to calculate the bias when the most of the anaylsis afterwards shows the comparison with CARRA? I would suggest to show in the table the bias with CARRA instead, or show both and remove the RMSE. Also that the CARRA value in the second column to the left is for a different period: this is misleading and I would at least mark the value with an asterisk, although I would suggest to re-think the table.

REPLY: Thank you for this valid comment. The original table had colors but these were replaced by different lines for different scenarios in the submission process. We subsequently forgot to update the table caption. This will be done in the revised text. Yes, the N/A refers to data not available, either missing scenario simulations (RCM) or time period not covered by the data (CARRA). This will be clarified in the new caption. An asterisk is added for the CARRA values. We do an undercatch correction of the observations and we only have data available for 7 stations for this correction as this requires wind observations as well as temperature. CARRA is treated as a model simulation and not a reference for the true precipitation. The models (RCMs and CARRA) are validated against observations. This will be clarified in the revised text.

Line(s) 129-130. Figure 2 is described in too little detail. First, it is difficult in the figure to distinguish different colours from the colour scale: I suggest adding isolines on the plot and highlight one level every two or three, e.g. 15%, 45%, 75%. This way it would be easier to notice differences among different plots. Second, 12 different maps are described in two short sentences, with only a very general statement on where "positive" or "negative" biases are found, entirely leaving to the reader the task of trying to catch and interpret the values on the maps. Please revise the figure description adding values to the description of panels (b)-(l). See below a suggestion on how to improve the paragraph:

"We see similar patterns for all models with large areas with a negative bias of about -15-30% in the central parts of the GrIS and smaller areas with a positive bias up to +40-50% along the Greenland coastline. The model with the highest bias are (add models), which show a deviation from the climatology up to -50%. Four of the MAR models (Figure 2f to 2i) show a large positive bias from the climatology, with values of about +40-50% in region NW and NO, which correspond to an increase in precipitation of about (add number) mm". Note that the numbers provided above may be incorrect but this is currently what I can gather from the figure.

REPLY: We tried using contour lines but it made the figure very busy. We will reduce the number of colours instead, making it easier to distinguish the different regions. The following text is added to more clearly describing the differences between CARRA and the RCMs:

"We see similar patterns for all models with large areas with a negative difference of about -10 to -30% in the central parts of the ice sheet and smaller areas with a positive difference up to 50% along the Greenland coastline. The model with the largest positive difference (in regions NW and NO with values in the range 10-50%) over the ice sheet are MAR driven by CNRM-CM6, CNRM-ESM2 and MPI-ESM1.2 while the two HIRHAM simulations and the RACMO simulation have the largest positive differences outside the ice sheet with values in the range 30-70% with peaks in excess of 70%."

Note that we do not consider CARRA as the truth. In figure 2 we only compare CARRA to RCMs and look at differences.

Line(s) 143-149. Figure 3. Same comment as for Figure 2. Please add values to the text and explain their meaning in the context of your analysis.

REPLY: We will update the paragraph to the following:

"For station 1 all model simulations agree with observations except MAR, driven by IPSL, showing a dry bias while RACMO shows a clear wet bias of about 60% (130 mm). For station 2 all MAR simulations show a dry bias of about -25% (-250 mm) while the other simulations are closer to observations. For station 3, CARRA is close to observations while the two HIRHAM simulations have a wet bias in the range 35 to 70% (250 to 500

mm), RACMO show a wet bias of about 110% (800 mm) and five of the MAR simulations have a dry bias of about -35% (-250 mm). The two HIRHAM simulations are close to observations for station 4 while CARRA and RACMO show a dry bias close to -20% (-350 mm) while all eight MAR simulations have a clear dry bias close to -65% (-1300 mm). For station 5, CARRA and one HIRHAM simulation are close to observations while the other HIRHAM simulation together with two MAR simulations and RACMO have a dry bias of about -20% (-180 mm). The other MAR simulations have a clearer dry bias in the range -30 to -60% (-330 to -530 mm). A similar pattern is seen for station 6 with the exception for RACMO here showing a wet bias of about 25% (90 mm). Finally, for station 7 one HIRHAM simulation is close to observations while the other HIRHAM simulation together with RACMO have a wet bias of about 15% (80 mm) while CARRA has a dry bias of -15% (70 mm) and all eight MAR simulations have a dry bias in the range -15 to -45% (-60 to -210 mm).

The two rightmost columns of Table 1 give the RMSE and mean bias for CARRA and the eleven RCM simulations, showing low RMSE values and low mean bias for the two HIRHAM simulations and CARRA while the MAR simulations have a relatively high RMSE and negative bias."

Line(s) 163-167. Figure 4. Same comment as for Figure 2. Please add values to the text and explain their meaning in the context of your analysis. I would also recommend shifting the panels from a 6 by 3 grid to a 3 by 6 to better suit the page format.

REPLY: We will change to a 3 by 6 matrix with one row per SSP and update the text to the following (note that the panel letters below match the new figure layout with a 3 by 6 grid):

"Figure 4 shows the model spread of the relative change in precipitation for a mid-century and an end of century period relative to 1971–2000 using the RCM ensemble for all three SSP scenarios. For the mid-century median for all three scenarios (Figure 4b, 4h and 4n) we see a positive change between 10 and 50% for most of Greenland except region SE with no clear change. For the mid-century 25th percentile (Figure 4a, 4g and 4m) we mostly see a positive change (10 to 30%) for regions NE and NO and a negative change (-10 to -30%) in region SE. For the mid-century 75th percentile (Figure 4c, 4i and 4o) all of Greenland shows a positive change that is most pronounced in regions NE and NO with values in the range 30 to 70%.

Towards the end of the century, we see an overall amplification of the mid-century signal. The ensemble median shows a reduction in precipitation compared with the mid-century values for the SSP1-2.6 scenario (Figure 4e) while SSP2-4.5 (Figure 4k) and SSP5-8.5 (Figure 4q) show an increase (except region SE) with values reaching 100% for region NE for SSP5-8.5. For the end of century 25th percentile (Figure 4d, 4j and 4p), we see similar patterns except for region SE with a -10 to -30% change along the outer edge. For the end of century 75th percentile (Figure 4f, 4l and 4r) we see a positive change for most of Greenland with values in the range 30 to 70% in region NE for SSP2-4.5 and values in the range 70 to 110% for SSP5-8.5."

Line(s) 187-194. Figure 5. Same comment as for Figure 2. Please add values to the text and explain their meaning in the context of your analysis. I would also suggest to add in each plot the period/SSP scenario as done in Fig. 4.

REPLY: We will put info into the panels as done for Fig. 4. The paragraph will be updated to the following text:

"Figure 5a and 5d show the ensemble mean relative change, using the eight CMIP6 GCMs dynamically downscaled by the RCMs (cf. Table 2), for the SSP5-8.5 scenario for 2031–2060 and 2071–2100 relative 1971–2000, respectively. The mid-century relative change is between 10 and 30% for regions SW, NO and NE with areas reaching 50% for region NE. For the end of the century, all regions except SE show positive change with areas reaching 90% in NO and NE. Figure 5b and 5e give the corresponding maps when using

the full 34 CMIP6 GCMs for the SSP5-8.5 scenario. Compared with the eight-model ensemble, the full model ensemble has larger changes for all six subregions but most pronounced for region SE where we now see a positive change in the range 10 to 30%. Figure 5c and 5f show the number of CMIP6 models that give positive changes in precipitation for the mid-century and end of century, pixel by pixel. The CMIP6 ensemble show good agreement for all drainage basins except for region SE where about 6 of the 34 members show a negative change for the end of century, in line with Huai et al. (2025)."

Line(s) 196-203. Figure 6. Here I would say the colour shading is clear enough and values of the snowfall/precipitation fraction are reported in the text. However, I would explicitly include at the beginning of the paragraph the definition of the snowfall fraction (snowfall/total precipitation) and include an example to show what a certain value means.

REPLY: On suggestion from another reviewer, we will change to showing rainfall fraction instead of snowfall fraction. We will add context to the paragraph, e.g. that a value of 50% means that rainfall and snowfall contribute equal amounts to the total precipitation.

Line(s) 222-227. Figure 7. It took me a while to understand why the total precipitation doesn't seem to match the basin values. Please write explicitly in the text that this is the sum of the other values and the y-axis of reference is the right one. Also see previous comment for Figure 2. Please add values to the text and explain their meaning in the context of your analysis.

REPLY: We will add a clarification that the numbers for the full ice sheet refers to the right y-axis. Also, from a comment by another reviewer we have changed the bars into boxplots and also changed the color scheme. The paragraph will be updated to:

"Figure 7 shows the annual total precipitation for the six drainage basins as well as for the total ice sheet for CARRA and the RCM simulations. The vertical extent of each line represents the model spread for each basin while the boxes show the 25th and the 75th percentiles of the ensemble. For the two scenario periods the bar is split into three segments to show the difference between the three SSPs. The largest uncertainties are, as expected, found in region SE. There is no clear difference between the SSPs for the 2031–2060 period while the 2071–2100 period has a clear difference in the ensemble median. The CARRA values match the higher end of the model spread for each basin, giving an annual amount for the total ice sheet that is significantly higher than any of the other models."

Line(s) 244-297. In general, the discussion is missing a paragraph outlining the limitations of this study and of the used datasets.

REPLY: Good point! We will add the following paragraph about limitations of this study:

"A clear limitation of this study is that RCMs often exhibit large biases in simulating point-wise precipitation, while the observations also have large uncertainties, especially when undercatch is prominent. The large-scale circulation and sea surface temperatures from forcing GCMs often have errors that are subsequently inherited by the RCMs. Furthermore, small-scale convective processes are not (fully) resolved by the RCMs used in this study. Also, the lack of a gridded observational product for Greenland makes it difficult to perform bias adjustment of the modeled precipitation. These limitations are, to some degree, compensated when looking at relative changes and not absolute values and the use of an RCM ensemble instead of looking at a single RCM."

Line(s) 264-267. The importance of the discrepancy between the runoff and the increase in precipitation is prominently present in the abstract, however only two brief sentences on the topic are present in the discussion with no explanation on what could cause the increase in runoff. Runoff ultimately contributes to sea level rise and is therefore a key element of Greenland research. While I understand that the scope of this study is to analyse precipitation changes, it is important to elaborate a bit more the implications of these findings for GrIS runoff in the discussion, and explore potential reasons why this discrepancy is present in the first place. My uninformed assumption would be that surface temperature increase and surface melting may play a big role into explaining the runoff, but I suppose other explanations like model parametrisation or fixed ice sheet characteristics may play a role as well.

REPLY: We have decided to remove all text about runoff/melt etc, based on a comment by another reviewer, and only present numbers on precipitation. We hope this is acceptable.

Minor comments

Line(s) 110-111. Could you please add one sentence to clarify what "undercatch corrected" means. This seems a quite specific/technical term that many readers may not be familiar with.

REPLY: We will add a clarification to the sentence:

"The station data are undercatch-corrected (i.e. positive correction of the amount of water caught by the rain gauge due to winds) using the mean correction factors and mean rainfall fractions from Huai et al. (2021)."

Line(s) 249-254. Figure 9. I would suggest to move the description of this figure to the results section and focus on the interpretation/comparison with other literature in the discussion.

REPLY: We will move Fig. 9 to the Results section together with the text on lines 250-254.

Line(s) 269-271. What about Greenland blocking? Please see

Davini, P.,Weisheimer, A., Balmaseda, M., Johnson, S. J., Molteni, F., Roberts, C. D., Senan, R., and Stockdale, T. N.: The representation of winter Northern Hemisphere atmospheric blocking in ECMWF seasonal prediction systems, Q. J. Roy. Meteor. Soc., 147, 1344–1363, https://doi.org/10.1002/qj.3974, 2021.

REPLY: Good point! We will add the following sentence on the Greenland blocking at the end of the paragraph on lines 269-272 (and add the Davini et al paper to the References list):

"Furthermore, Greenland blocking events are difficult to estimate by climate models (Davini et al. 2021) and can have a large impact on precipitation, especially during winter."

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