Answer to Referee #2

The manuscript of Merz et al. presents an analysis of reanalysis and model data over different time periods. The aim is to link local accumulation rates on the Greenland ice sheet to large-scale atmospheric patterns in order to determine how well such patterns can be reconstructed from ice core data. This is a very interesting advance on previous work and provides a thorough analysis of all relevant factors. The paper is very well written, engaging and accessible. Some minor grammatical errors could be found (noted below), therefore I would suggest a further careful proofreading of the manuscript. I would recommend the manuscript for publication with only minor revisions.

We thank the referee for the encouraging feedback. As suggested we have thoroughly proofread the manuscript to eliminate some more grammatical errors. The two general and the minor comments have all been addressed and are answered below.

General comments:

1) I find the statistical methods used for the analysis to be appropriate and thorough. However, I think the description of the statistical analysis is rather short and somewhat unclear. Please consider revising and, particularly, separating some sentences to define each concept and method clearly. Also, the phrase "pseudo accumulation records are generated" (p 3833, line 9) is confusing. As far as I finally understood, these are simply the detrended and standardized time series from the model output, but this phrase seems to imply new time series are produced (eg, from atmospheric indices).

Indeed the term "pseudo accumulation record" might be confusing and we have removed this expression throughout the manuscript. We further have adapted the manuscript (P3833 L7) and included a short description of the simple methodology of these accumulation records.

"For each dataset (i.e. ERAi and model runs) and each region we calculate an accumulation time series which averages over all grid points of the corresponding domain. The resulting time series are further detrended and standardized."

2) Finally I wonder why the analysis is limited to the 3 regions originally defined in Hutterli et al. (2005). In particular, it would be very valuable to additionally see the analysis applied to a Northwest region encompassing the NEEM ice core. Would this be possible and worthwhile?

We selected the regions defined in Hutterli et al. (2005) as they are representative for specific Greenland regions but also largely independent of each other (see Fig. 2 in manuscript and Fig. 2 in Hutterli et al. (2005)). However, it is true that no northwestern region has been used. Calculating the correlation of accumulation rates (at every grid point over Greenland) with an accumulation time series generated for a NEEM region (see Fig. B1) we observe a considerable overlap with accumulation in the CW region. Further, the circulation patterns connected with accumulation variability at NEEM are very similar as the CW patterns but shifted slightly northwards in case of NEEM (see Fig. B2). We therefore do not intend to include the NEEM region in the manuscript but we shortly describe the fact that circulation patterns associated with accumulation/precipitation variability at NEEM look similar the CW patterns in the final (outlook) part of the manuscript, P3851 L23.

"As accumulation variability at NEEM is significantly correlated to accumulation in the CW region (see Fig. 2), the atmospheric circulation patterns accounting for inter-annual accumulation/precipitation variability at NEEM are expected to look like the CW patterns. This can be confirmed by applying the analysis to the NEEM region."

We further adapted Fig. 2 in the manuscript to show that accumulation at NEEM is significantly correlated to accumulation in the CW region.

Minor comments:

a) Page 3828, line 29: "time-scales" => "time scales"

done

b) Page 3828, line 29: "annually" => "annual"

done

c) Page 3829, Sect 2.2: The model description is generally very clear, but some model components have been used in a reduced way (ie, ocean from CCSM3, sea ice in thermodynamic mode only). Could you add some sentences discussing the effect, or lack thereof, of these model choices?

We have revised the model description paragraph (P3829 L20-P3830 L2) and addressed these issues.

"We run the CCSM4 with the atmosphere-land-only setup also known as AMIP-type simulation consisting of the Community Atmosphere Model version 4 (Neale et al., 2010) and the Community Land Model version 4 (Oleson et al., 2010) excluding the integrated carbon-nitrogen cycle. This setup has no ocean component so time-varying sea surface temperatures (SST) are prescribed as lower boundary conditions. The sea ice model, the Community Ice CodE version 4 (Hunke and Lipscomb, 2008), is used in its thermodynamic-only mode. This means that sea ice concentration fields are prescribed and sea ice thickness is fixed (e.g., to 2 meters in NH) but surface fluxes are computed taking into account snow depth, albedo, and surface temperature over the ice using one-dimensional thermodynamics. This atmosphere-land-only setup is very cost-efficient compared to fully-coupled runs and allows us to perform a set of time-slice simulations with a fairly high horizontal resolution. As a drawback possible feedbacks with the ocean and sea ice component are excluded."

d) Page 3844, line 16: "patterns" => "pattern"
done

e) Page 3844, line 29: "lead" => "leads"
done

f) Page 3845, line 1: "expense rain" => "expense of rain"
done

g) Page 3850, line 18: "Both changes in" => "Changes in both"
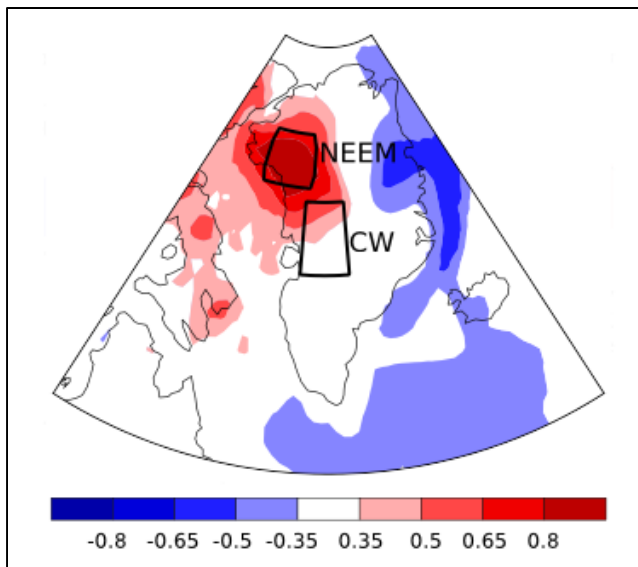done

Figures

Fig. B1: Correlation of ERA-interim annual accumulation rates with the accumulation record at NEEM (top framed area). Note that only significant correlation coefficients are shaded.
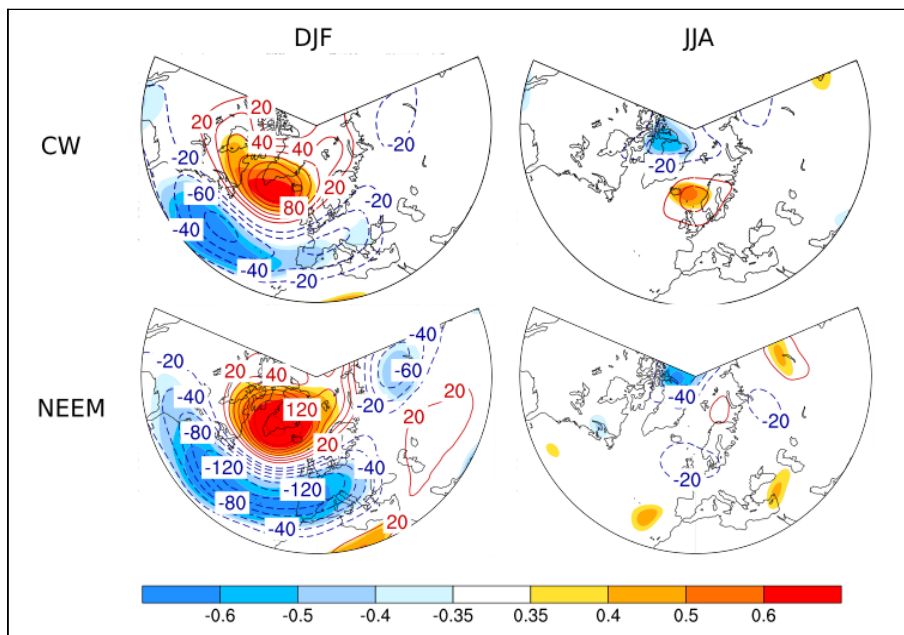

Fig. B2: ERA-interim z500 correlation and plus-minus composite patterns associated with seasonal mean accumulation in CW (top) and NEEM (bottom) for winter (DJF) and summer (JJA). Shading illustrates the correlation pattern significant at the 5% level (t-test statistics) and contour lines illustrate the z500 plus-minus composite (in geopotential height meters). The plus-minus composite corresponds to the difference pattern of the ±1 standard deviation samples of seasonal mean accumulation.
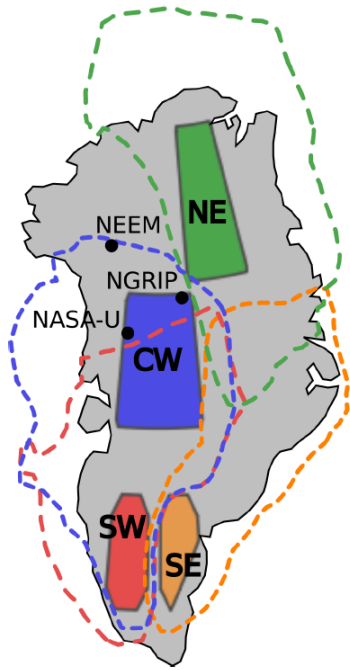
New Fig. 2 in manuscript: Overview of the Greenland accumulation regions (shaded) as defined in Hutterli et al. (2005). The dashed contour lines denote regions which show a coherent accumulation behavior as the record of the corresponding region (significant correlation at 5% level based on t-test statistics in ERAi). The three dots indicate the locations of the NASA-U, NGRIP and NEEM ice cores.