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Interactive comment on "Glacial cycles simulation of the Antarctic Ice Sheet with PISM – Part 1: Boundary conditions and climatic forcing" *by* Torsten Albrecht et al.

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Thank you for your comment and the reference to your very informative study. You are addressing an interesting aspect of the climatic forcing, we have not considered yet.

The orange and grey line in Fig. 19 top left, you were referring to, are actually combined timeseries of EDC and WDC with different properties. As the WDC temperature reconstruction with about 1-year sampling rate and comparably low variability goes back to around 67kyr BP, we concatenated it with the much longer EDC temperature reconstruction, which comes with about 10 year sampling rate and higher variability. In the same figure we have compared the combined WDC+EDC timeseries to the continuous

EDC reconstruction (blue), which shows also higher variability than WDC in the last 67kyr. In warmer than present periods around 10kyr BP the EDC forcing may induce slightly earlier deglaciation, while the modern ice volume varies by only 1m SLE.

In order to have a first sensitivity check on the effect of variability on ice volume we tested for a modified WDC+EDC forcing timeseries with

a) 500-year moving average with low variability (smoothed - green) and

b) with added white noise of high variance 1.54 K^2 as in your AR(1) fit for Greenland (noise - reddish).

The difference in ice volume response seems comparably small with about 1m SLE variance and slightly earlier retreat for lower variability (a). Also for higher variability (b) differences in ice volume response are rather small through most of the glacial climate period. For Holocene climate, however, we find slightly later deglaciation and considerable difference in ice volume of up to 5 m SLE. In our simulation the difference can be attributed to glacial ice in the Weddell Sea and Amery basins that does not retreat (to its modern extent) or become afloat and one could speculate about the dominant process(es).

In your study (Mikkelsen et al., 2018) you found lower modern ice volume in Greenland for high forcing variability and explain this effect with the nonlinear dependence of surface mass balance on temperature. In Antarctica, however, other feedback mechanisms seem relevant for the ice volume response. In our study we do not include hydrofracturing and cliff-calving mechanisms as in Pollard et al., 2015. Surface temperature forcing enters in our simulations the enthalpy scheme as boundary condition and hence affects the nonlinear ice viscosity. Also the surface runoff (via the positive-degree-day model) and precipitation change (scaling) is estimated from temperature forcing. In this complex interplay of processes, deglacial retreat reveals threshold behavior in the different sectors of the Antarctic continent. For the last interglacial (around 120 kyr BP) interannual variability does not seem to have a significant impact on the simulated ice volume, while through the Holocene variability tends to maintain the extended glacial state in some sectors. But these are first sensitivity tests and no general conclusions should be drawn from them at this point.

References:

Mikkelsen, T. B., Grinsted, A., and Ditlevsen, P.: Influence of temperature fluctuations on equilibrium ice sheet volume, The Cryosphere, 12, 39-47, https://doi.org/10.5194/tc-12-39-2018, 2018.

Pollard, D., DeConto, R. M., and Alley, R. B.: Potential Antarctic Ice Sheet retreat driven by hydrofracturing and ice cliff failure, Earth Planet. Sc. Lett., 412, 112–121, https://doi.org/10.1016/j.epsl.2014.12.035, 2015.

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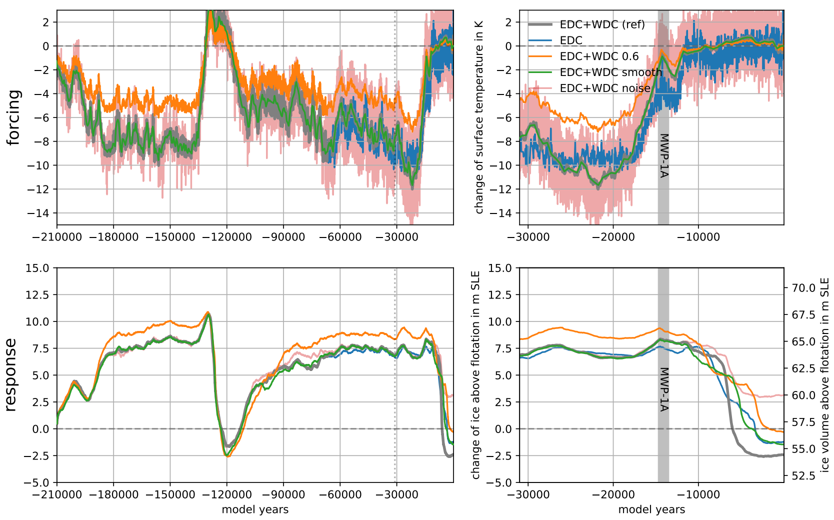

Fig. 1. Timeseries of PISM-simulated ice volume above flotation relative to observations over last 210 kyr forced with five different surface temperature reconstructions (added to Figure 19).