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The impact of inter-annual variability on the surface mass balance of Greenland

Tobias Zolles[1,2] and Andreas Born[1,2]
[1]University of Bergen, Department for Earth sciences, Bergen, Norway (tobias.zolles@uib.no)
[2]Bjerknes Centre for Climate Research, Bergen, Norway

Surface mass balance models that are run over longer timescales are commonly forced with climatological forcing, disregarding natural climate variability. Here we investigate the impact of inter-annual variability of the present day climate using the energy balance model BESSI. The model is forced with daily data of precipitation, temperature, long and short wave radiation and humidity. We create synthetic time series of realistic climate forcing with different time scales of variability by re-ordering the years of present day reanalysis as well as using the climatology.

We find that the model significantly overestimates the Greenland SMB in case of climatological forcing when compared to the original daily reanalysis (40%). The effect of changing inter-annual variability by the re-ordering of forcing years has a relatively minor effect on the Greenland-wide mass balance (<5%), but is more important around the equilibrium line where positive feedback increase its impact over time. The averaging of precipitation is the key factor. It leads to a surface albedo increase as the nature of snowfall changes from event-based to continuous. To reduce this effect we use monthly climatologies in combination with a sub-monthly variability instead of daily climatologies, to retain the event (storm) based nature of precipitation.

Finally, we characterize the errors in cases of using climatology where interannual variability is unknown, such as simulations of the deep past and future and propose a solution.