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Interactive comment on "The Greenland ice sheet: modelling the surface mass balance from GCM output with a new statistical downscaling technique" *by* M. Geyer et al.

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The authors present a simple technique to interpolate SMB from a coarse grid GCM (150 km resolution) to a typical ice-sheet model grid (15 km). Their statistical downscaling technique builds on relationships established between solid precipitation, snowmelt, and sublimation at the one hand, and surface air temperature, at the other hand. These relations are derived from simulations with the snowpack model Crocus, forced both by the underlying GCM and by ERA40 fields.

The resulting sensitivities of snow precipitation, snowmelt, and sublimation to air temperature are not particularly surprising: the total precipitation sensitivity to air temperature follows a Clausius-Clapeyron argument, the snow fraction is approximately a stepwise function of temperature, snowmelt increases non-linearly with temperature

and the relation between total sublimation and surface temperature is somewhat unclear. In fact, similar relations have been obtained in early SMB models based on the PDD method or in outright paramerisations of melt as a function of temperature in older work by Krenke, Oerlemans, Reeh, Huybrechts, and others.

Even though the downscaling technique should be better than simply linearly interpolating a low resolution SMB to a higher grid resolution, I am somewhat puzzled that finally only the SMB vs temperature relation is used for the downscaling technique. One wonders whether it would not have made more sense to downscale the individual components of SMB separately using the statistical correlations established previously and then reassemble SMB on the higher resolution grid as the sum of the downscaled components? As the method stands now, I would expect the downscaling to degrade quickly for elevation differences exceeding some hundred meters. Such elevation differences easily arise near the ice-sheet margin, e.g. in case the ice sheet extent from the ice sheet model differs from the one assumed in the GCM, or when the ice-sheet geometry evolves in a time-dependent experiment.

The method proposed here is clearly less sophisticated than other recent work aiming at using GCM output to force an ice-sheet model (like the work cited by Helsen and Edwards). The largest simplification is the use of a mean annual and spatially uniform SMB vs T correlation, whereas the aforementioned studies at least construct gradients that are spatially variable. In addition, only using surface air temperature as a predictor to interpolate SMB is too simple, and is only expected to work satisfactorily for melting, but much less so for precipitation (as the paper indeed shows).

In view of the above reservations, I doubt whether the downscaling method possesses enough skill to reliably improve total Greenland SMB and sea-level rise estimates compared to the raw GCM data, especially when compared to the more sophisticated methods in other recent work as cited above.

Other comments

p. 3176, l. 5-8: the temperature lapse rate in eq. 9 should be dT/dH, not the inverse. Similarly, the lapse rate is expressed in C/km, not the reverse.

The labelling on the figures is definitely too small for clarity.

Interactive comment on The Cryosphere Discuss., 7, 3163, 2013.