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Constraining Greenland surface mass balance model parameters using paleoclimate data

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We present an approach to reducing the uncertainty in simulations of the future Greenland Ice Sheet (GIS) contribution to sea level rise, associated with the parameterization of the surface mass balance. Many ice sheet models employ relatively simple, semi-empirical approximations to determine surface mass balance, which may not perform as well for different climates and ice sheet topographies. As an alternative approach, we use the regional energy-moisture balance model REMBO to determine the climate and surface mass balance of the GIS, which is also coupled bi-directionally to the 3D polythermal ice sheet model SICOPOLIS. Calculation of the surface mass balance is performed with two different surface mass balance schemes: the classical positive degree day scheme and a more physically-based approach that, in addition to the temperature dependence of melting, includes shortwave solar radiation in the melt scheme. In both approaches, a daily timestep applies, facilitating the calculation of seasonal albedo changes that can feedback on the climate and affect surface melting. It has already been shown that both approaches can simulate present-day GIS forcing reasonably well, yet they differ in sensitivity to changes in temperature and insolation.

In order to use paleoclimate information to better constrain model parameters, we performed a set of transient simulations over the last few glacial cycles. The REMBO model was driven by output of the CLIMBER2 model and variations in orbital forcing. With a given set of ice sheet model parameters, the mass balance scheme parameters were varied over a wide range. Comparing the results to estimates of the contribution of the GIS to sea level rise during the Eemian interglacial, in combination with present-day GIS topography and mass balance information, allows us to reduce the uncertainty range in model parameters and, therefore, in the sensitivity of the GIS to temperature changes.