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The response of the Greenland ice sheet to Last Interglacial climate

Petra M. Langebroek (1) and Kerim H. Nisancioglu (2)

(1) Uni Climate, Research AS & Bjerknes Centre for Climate Research, Bergen, Norway (petra.langebroek@uni.no), (2) Dept. of Earth Science and Bjerknes Centre for Climate Research, University of Bergen, Bergen, Norway (kerim@bjerknes.uib.no)

Predicting the long-term response of the Greenland ice sheet (GIS) to present-day warming is challenging, especially as only a limited number of years of data exists for the surface mass balance. Investigating the response of the GIS to warm periods of the past might help us better understand its response to the current changes in climate. Based on proxy data we know that a significant part of the GIS melted during the last interglacial (LIG) period. Recent modelling studies confirm the existence of a smaller GIS during the LIG, although a discussion remains on the spatial distribution of the ice. Most of these recent studies apply forcing fields from General Circulation Models to models of the Greenland ice sheet, using reconstructed atmospheric greenhouse gas concentrations and orbital configurations for the LIG.

Here we examine the response of the GIS to a range of LIG climate conditions. These climates are computed using the Norwegian Earth System Model (NorESM) under a set of different orbital configurations and different levels of greenhouse gasses, thus isolating the relative effect of changes in greenhouse gasses and insolation during different stages of the LIG. The simulated LIG climates are validated using available proxy reconstructions, and the most realistic climate forcing is used as input for an ice sheet model.

Equilibrium simulations (constant climate forcing) show a large dependence of the GIS to the different LIG climates, with a rapid melting for the early LIG ($\sim$125 and 130 ka) and a small ice volume increase for the late LIG climates ($\sim$115 and 120 ka). The equilibrium ice sheet response does not depend much on the initial ice sheet size. In contrast, the initial ice sheet size is important for transient simulations covering the entire LIG. This is due to the fact that equilibrium is not reached before the forcing changes through the LIG. We compute the timing of minimum ice volume similar to other studies ($\sim$122 ka), but the simulated minimum GIS volume is smaller than found in other recent studies, and no ice remains at the locations of Cape Century and Dye-3 during the warmest part of the LIG. However, there is a large spread in published simulations of LIG GIS extent, illustrating the fact that additional research on this topic is required.