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Paleo response of the Northeast Greenland ice stream to changes in ice geometry and anomalously high geothermal flux

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The Northeast Greenland ice stream (NEGIS) extends more than 600 km into the interior of the Greenland Ice Sheet, and the observed recent increase in surface melting and dynamic thinning have raised questions about its future stability. Most numerical modelling studies have focused on understanding ice dynamics and processes occurring at the terminus, and a higher-dimension modelling characterization of the ice stream, especially 100-600 km upstream glacier, is still missing.

Using the Parallel Ice Sheet Model we investigate the sensitivity of the NEGIS ice flow to past changes in ice geometry, anomalously high geothermal flux and subglacial hydrology routing. We use two subglacial hydrology models. In the first model, the water in the subglacial layer is not conserved and it is only stored locally in a layer of subglacial till up to 2 m. In the second model, the water is conserved in the map-plane and the excess water is transported downstream glacier horizontally. On millennial time scales (here 120 ka), the basal topography influences the spatial pattern of the ice flow by changing the longitudinal stress gradients in the ice, while the thermal boundary conditions at the base of the ice sheet influence the ice flow through changes in basal melt rates and subsequent basal sliding. Field observations interpreted together with numerical simulations suggest that a combination of anomalously high geothermal flux and subglacial hydrology routing, bed topography and time-evolved ice geometry could explain the observed speed and shape of the NEGIS. The model performance is assessed against observed ice flow velocities, surface elevation change from satellite and airborne laser and radar altimetry, and reconstructed terminus retreat.