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Partitioning the geothermal component of basal melting beneath the Greenland Ice Sheet: a combined ice sheet model and radar sounding approach

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Geothermal heat flux impacts basal meltwater production and thus ice motion along the base of ice sheets. Recent studies of the Greenland Ice Sheet indicate that geothermal heating related to ancient hotspot activities can modify the distribution of present-day subglacial hydrology. Despite its importance in the basal energy budget, it is currently unclear how much of the observed basal water in Greenland is produced by geothermal heating and how much is actually caused by strain or frictional heating.

To address this challenge, we combine ice-sheet modeling, new basal water predictions from radar sounding analysis, and the latest, magnetic-derived geothermal heat flux distribution to assess the role of geothermal heat fluxes on basal water production. We examine the sensitivity of basal melting to variations in geothermal heat flux using a thermal enthalpy scheme in the JPL Ice Sheet System Model (ISSM). By coupling the thermal and stress balance modeling components, we partition the relative contribution of geothermal, frictional, and deformational heating on basal melting for different regions across Greenland. In parallel, we use the new, ice-sheet-wide basal water distribution derived from radar bed echoes as an independent constraint to examine the model capabilities to produce basal melting.

Together, our results reveal that vast regions of basal melting underneath the Northern and Eastern sectors of the ice sheet interior are related to the spatial variations of geothermal heat fluxes. In contrast, geothermal heat flux exerts a more minor role along the Northwestern coast, where the spatial distribution of elevated geothermal heat flux can explain the observed meltwater underneath vast regions of the Northern and Eastern ice-sheet interior. We will discuss the implications of the presence of a stable melt production related to geothermal heating on the long-term dynamics and mass balance of the Greenland ice sheet.