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Considering thermal-viscous collapse of the Greenland ice sheet

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We explore potential multi-centurial changes in Greenland ice sheet form and flow associated with increasing ice temperatures, and consequent relaxing effective ice viscosities. We define "thermal-viscous collapse" as a transition from the polythermal ice sheet temperature distribution characteristic of the Holocene epoch to pressure-melting-point ice temperatures and effective viscosities throughout the ice sheet. We present first-order conceptual and numerical models of this mechanism. After conceptualizing three key processes required to initiate thermal collapse, including (i) sufficient energy available in the future meltwater runoff anomaly, (ii) routing of meltwater to the bed of the ice sheet interior, and (iii) efficient energy transfer from meltwater to the ice, it appears thermodynamically plausible to warm the deepest 15 % of the ice sheet, where the majority of deformational shear takes place, to the pressure-melting-point within five centuries. Under an end-member scenario, numerical modelling infers a decrease in ice sheet volume of 5±2 % within five centuries of initiating complete thermal collapse. This is equivalent to a cumulative sea level rise contribution of 33±18 cm due thermal collapse alone. The vast majority of the decreased ice sheet volume associated with thermal collapse, however, would likely be realized over subsequent millennia.