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Greenland Ice Sheet Response to Transient Climate Change: Consensus between two CGCMs

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Possible accelerated melting of the Greenland ice sheet in the 21st century has profound implications for sea-level rise and for climate change feedback. This study quantifies the potential melting of the Greenland ice sheet under a realistic 21st century greenhouse gas emission scenario. To this end, an extended integration is carried out of a new multi-phase, multiple-rheology, scalable and extensible geofluid model of the Greenland ice sheet, using 200-year long monthly atmospheric forcing from two high-resolution climate models. The ice sheet model versatility allows an investigation of detailed features such as seasonal melt area extent. Applied to Greenland, the warming- enhanced low altitude surface melting is found to dominate snow precipitation increase, causing a steady ice loss. By 2060, the ice surface topography has changed little over inland Greenland. However, the surface flow patterns change significantly over the entire Greenland ice sheet, due to the temperature dependence of ice viscosity. With increased surface flow speed, strain-heating becomes a mechanism for rapid heating of the ice to a far greater depth than diffusion alone. Basal sliding, especially involving granular sediments, is shown to be an efficient mechanism for fast-glacier acceleration and enhanced mass loss. This significant source of rapid dynamic responses to climate change is absent from previous models. The net mass loss estimates from the model are $\sim$50 km^3 of ice per year for the first 50 years of the 21st century, reaching 220 km^3 per year for the second half. By 2100, the perennial frozen surface area decreases by as much as 60%, to $\sim 7\times10^5$ km^2, indicative of a massive expansion of the ablation zone.