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Long-term future Greenland ice loss determined by peak global warming

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The Greenland ice sheet (GrIS) is recognised as highly sensitive to climate change, with palaeoclimate evidence and modellingstudies suggesting that sustained global warming only marginally above present-day levels could trigger its complete deglaciation over multi-millennial timescales. Despite growing understanding of threshold behaviour in the GrIS, the implications of a temporal crossing of this temperature threshold, particularly the duration and magnitude of temperature overshoots, for the future GrIS mass loss trajectory remain poorly constrained. Here we present simulations of the next 10,000 years under a range of future anthropogenic emissions scenarios, performed using a fully coupled Earth system model with a dynamic GrIS and interactive atmospheric CO_2 and CH_4. Our model experiments span scenarios from strong mitigation to high emissions SSP pathways, allowing systematic exploration of the relationship between warming trajectories and ice sheet response.
We find that the long-term ice loss on Greenland is predominantly determined by the peak global temperature increase relative to pre-industrial levels, which generally occurs within the next few centuries depending on the emissions pathway. The GrIS contribution to global mean sea-level rise after 10,000 years increases by approximately 2 metres for each degree of warming above a critical peak global warming threshold of approximately 2°C above pre-industrial temperatures, which is close to the GrIS equilibrium tipping point. This finding is robust for different equilibrium climate sensitivities and across different scenarios. Furthermore, when accounting for variations in the Earth's orbital parameters over the next 10,000 years, the sensitivity of the GrIS mass loss to anthropogenic warming substantially increases, as future orbital configurations lead to higher summer insolation over Greenland.
Overall, our results demonstrate how 21st century climate policy will largely determine the fate of the GrIS for millennia to come.