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Thresholds for irreversible decline of the Greenland ice sheet

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The Greenland ice sheet will decline in volume in a warmer climate. If a sufficiently warm climate is maintained for a few thousand years, the ice sheet will be completely melted. This raises the question of whether the decline would be reversible: would the ice sheet regrow if the climate cooled down? To address this question, we have conducted a number of experiments using the HadCM3 AOGCM fully coupled with a high-resolution 3D ice-sheet model. The experiments are initialised with ice sheet states obtained from various points during its decline as simulated in a high-CO2 scenario, and they are then forced with a climate simulated for pre-industrial greenhouse gas concentrations, to determine the possible trajectories of subsequent ice sheet evolution. These trajectories are not the reverse of the trajectory during decline. They converge on three different steady states. The original ice-sheet volume can be regained only if the volume has not fallen below a threshold of irreversibility, which lies between 80 and 90% of the original value. Depending on the degree of warming and the sensitivity of the climate and the ice-sheet, this point of no return could be reached within a few hundred years, sooner than CO2 and global climate could revert to a pre-industrial state, and in that case global sea level rise of at least 1.3 m would be irreversible. An even larger irreversible change to sea level rise of 5 m may occur if ice sheet volume drops below half of its current size.