A probabilistic framework for attribution of rapid outlet glacier retreat

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Abstract

Many marine-terminating outlet glaciers in Greenland and Antarctica have retreated dramatically in recent decades. Retreat onset has been tied to local atmospheric and ocean forcing, but strong regional climate variability makes the role of anthropogenic climate change uncertain. An additional attribution challenge specific to outlet glaciers is the potential for instabilities in ice sheet dynamics associated with subglacial topography. If sufficiently perturbed, termini may retreat rapidly between topographic highs due to a positive feedback between ice flux and bed slope. Any attempt to attribute outlet glacier retreat must therefore explicitly include the possibility that climate variability alone could push termini past topographic thresholds. We propose an attribution framework for outlet-glacier retreat using a model forced with many realizations of stochastic climate variability. Experiments with synthetic bed topography show that the probability of retreat is highly sensitive to topography near the terminus, and the glacier's preindustrial position. However, we generally find that persistent external climate forcing can significantly increase the probability of retreat, even if the trend is small compared to the magnitude of climate variability. This is a consequence of the timescales over which glacier dynamics integrate forcing, and suggests that the long-term history of forcing is important for outlet glacier attribution, even for recently initiated retreats.

Keywords: glaciers, climate variability, ensembles

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