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Washington, D.C. | 10–14 Dec 2018

GC13D-1046: Climatic Thresholds for Widespread Ice Shelf Hydrofracturing and Ice Cliff Calving In Antarctica: Implications for Future Sea Level Rise

Monday, 10 December 2018
13:40 - 18:00
Walter E Washington Convention Center - Hall A-C (Poster Hall)

The loss or thinning of buttressing ice shelves and accompanying changes in grounding-zone stress balance are commonly implicated as the primary trigger for grounding-line retreat, such as that observed in Amundsen Sea outlet glaciers today. Ice-shelf thinning is mostly attributed to the presence of warm ocean waters beneath the shelves. However, climate model projections show that summer air temperatures could soon exceed the threshold for widespread meltwater production on ice-shelf surfaces. This has serious implications for their future stability, because they are vulnerable to water-induced flexural stresses and water-aided crevasse penetration, termed ‘hydrofracturing’. Once initiated, the rate of shelf loss through hydrofracturing can far exceed that caused by sub-surface melting, and could result in the complete loss of some buttressing ice shelves, with marine grounding lines suddenly becoming calving ice fronts. In places where those exposed ice fronts are thick (>900m) and crevassed, deviatoric stresses can exceed the strength of the ice and the cliff face will fail mechanically, leading to rapid calving like that seen in analogous settings such as Jakobshavn on Greenland.

Here we explore the implications of hydrofacturing and subsequent ice-cliff collapse in a warming climate, by parameterizing these processes in a hybrid ice sheet-shelf model. Model sensitivities to meltwater production and to ice-cliff calving rate (a function of cliff height above the stress balance threshold triggering brittle failure) are calibrated to match modern observations of calving and thinning. We find the potential for major ice-sheet retreat if global mean temperature rises more than ~2ºC above preindustrial. In the model, Antarctic calving rates at thick ice fronts are not allowed to exceed those observed in Greenland today. This may be a conservative assumption, considering the very different spatial scales of Antarctic outlets, such as Thwaites. Nonetheless, simulations following a ‘worst case’ RCP8.5 scenario produce rates of sea-level rise measured in cm per year by the end of this century. Clearly, the potential for brittle processes to deliver ice to the ocean, in addition to viscous and basal processes, needs to be better constrained through more complete, physically based representations of calving.

Authors

Robert M Deconto
University of Massachusetts Amherst

David Pollard
Pennsylvania State University

Knut A Christianson
University of Washington

Richard B Alley
Pennsylvania State University

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