Geophysical Research Abstracts
Vol. 15, EGU2013-2039, 2013
EGU General Assembly 2013

Will Antarctic ice shelves survive atmospheric warming in the next two centuries?

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Since the 1970s, the sudden, rapid collapse of approximately 20% of ice shelves along the Antarctic Peninsula has led to large-scale thinning and acceleration of its tributary glaciers. Their collapse is explained by the process of hydrofracturing, whereby a water-filled crevasse is opened, sometimes all the way to the ice-shelf base, by the hydrostatic pressure acting at the crevasse tip. This process has been linked to observed atmospheric warming through the increased supply of meltwater. With projected future warming in many parts of coastal Antarctica, what will be the fate of the Antarctic ice shelves, which lend stability to the Antarctic ice sheet by buttressing its grounded ice? To answer this question, we examine the low-density firn layer near the ice-shelf surface, which provides a porous medium in which meltwater can percolate and refreeze. It has to be filled with refrozen meltwater before hydrofracturing can take place. A firn layer with a depleted pore space is therefore susceptible to collapse by hydrofracturing.

In this presentation, we use a firn model embedded in a regional climate model, to show that pore space was depleted in the firn layer on ice shelves that have now collapsed. The depletion or firn air enabled the development of connections between surface ponds and crevasses, and subsequent ice-shelf collapse. To see what the future may have in store, a climate scenario run with the same model indicates that during the 21st century most Antarctic Peninsula ice shelves, and some minor ice shelves elsewhere, will become susceptible to collapse following firn air depletion. If warming continues into the 22nd century, similar depletion will become widespread on ice shelves around East Antarctica. But there is good news too: the firn air content of the large Filchner-Ronne and Ross ice shelves is projected to increase due to increased snowfall, keeping them safe from hydrofracturing for a long time to come.