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Impact of ice shelf crevasses on Grounding line flux

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Antarctic Ice shelves are fundamentally important components of the cryosphere and key to predictions of global sea level rise. Thinning and fracturing of ice shelf systems can reduce back-stress forces exerted on grounded glaciers upstream, increasing mass flux across their grounding lines (GL). In recent years it has been suggested that a number of ice shelves around Antarctica have rapidly broken apart as a result of hydrofracturing. Hydrofracture is the process whereby surface crevasses are filled up with meltwater and the resulting hydrostatic pressure cause outward propagation of the crevasse fracture.

Recent work assessed the impact of ice shelf thickness change and crevasse hydrofracturing on the vulnerability of ice shelves and on ice drainage. Using a deep convolutional neural network, high-resolution crevasses and fractures were mapped throughout Antarctica, revealing that 60 ± 10 % of ice shelves are vulnerable to fracturing, if inundated with water.

Here we use these crevasse maps to evaluate their impact on the flow of upstream glaciers, quantifying the change in flux at the GL. We employ a finite element ice flow model, Ua, which solves the vertically integrated shallow shelf approximation with an unstructured mesh, that allows refined resolution in complex areas, such as at the GL. In the absence of information on crevasse depth, we make the assumption that crevasses propagate through the entire thickness, meaning our results represent the maximum possible effect that these crevasses may have on ice flow. We present results for many of the most important ice shelves in East and West Antarctica.

We find that incorporating crevasses in the ice shelf always increases the mass flux of upstream glaciers across their GLs, however, there is substantial variability in flux change among ice shelves. Small increases in flux due to crevassing (7-15%) were detected for Fimbul, Shackleton, Pine Island, Larsen C, and Brunt Ice Shelves, with a more considerable increase for the Dotson & Crosson Ice shelves (38%). The increase in flux due to crevassing was extremely large for the Totten Ice Shelf (248%). The large differences in sensitivity between ice shelves may be a result of various factors, most notably the proximity of the features identified as crevasses to important pinning points. More work investigating these factors is needed in order to have a more complete understanding of the effects of crevasse hydrofracturing on inland glaciers.