Geophysical Research Abstracts
Vol. 18, EGU2016-11763, 2016
EGU General Assembly 2016

The relevance of buttressing for Filchner-Ronne and Ross Ice Shelf

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Sub-shelf melting is an important component of Antarctica's mass budget. Although thinning of ice shelves does not directly contribute to sea-level rise, it may have a significant indirect impact through the potential of ice shelves to buttress their adjacent ice sheet. This is clearly seen in recent observations, e.g. in the Amundsen region (Pritchard et al., 2012) or at the Southern Antarctic Peninsula (Wouters et al, 2015) where increased ice loss of the adjacent upstream drainage basins is attributed to enhanced sub-shelf melting. In the extreme case, the complete disintegration of an ice shelf, e.g. during the calving events of Larsen A and B in 1995 and 2002, respectively, the adjacent ice streams subsequently accelerated significantly (Scambos et al., 2014).

Here, we investigate the importance of buttressing using the finite-element, shallow-stream approximation numerical model Úa. We derive transfer functions for an idealized setup (Gudmundsson et al. 2012) and the Filchner-Ronne and Ross Ice Shelf. They allow for the computation of instantaneous changes in velocities to thickness perturbation patterns. Based on the transfer functions, we calculate the sensitivity of flux across the grounding line to regional varying melting patterns for the idealized setup and for Filchner-Ronne and Ross Ice Shelf.

We find that the immediate response of velocities in the ice shelf-ice sheet system to changes in sub-shelf melting can be understood as the interaction of two effects: On the one hand, the spreading rate is a function of local ice thickness, indicating that a thinning of the ice shelf reduces velocities. On the other hand, ice shelf thinning weakens its ability to buttress, and thus enhances velocities. These two processes compete, leading to a complex pattern of velocity changes within the ice shelf. We find - both in the idealized setup and for Ross and Filchner-Ronne Ice Shelves - that the reduction in buttressing is dominating the velocity changes in the vicinity of the grounding line while the reduction in spreading rate is more dominant towards the calving front. The flux across the grounding line is (instantaneously) most sensitive to sub-shelf melting in the vicinity of the grounding line – this is true for the idealized setup and for the real-world Ross and Filchner-Ronne Ice Shelf.