Report Antarctic Science Bursary

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Introduction

A major finding over the last two decades of research in glaciology is the recognition that marine ice sheets, and sea-level rise associated with their melting, are acutely sensitive to their interaction with ocean water (e.g. IPPC AR5, ch. 4, p. 357). Floating ice shelves dampen the susceptibility of the upstream ice sheet to the catastrophic marine ice-sheet instability. Ice-shelf disintegration, on the other hand, causes the grounding line (i.e. to junction between grounded and floating ice) to retreat and the ice-sheet to collapse. Despite the recognized importance of ice shelves, one of the biggest unknowns today is how ocean-induced melting at the ice-shelf base impacts ice-shelf integrity and thus grounding-line migration. Our lack of knowledge is rooted in the nature of basal melting that varies spatially from meters to hundreds of kilometers, and temporally from tidal, seasonal to centennial (and longer) time scales.

Scientific Questions Addressed

The floating ice shelves surrounding the Antarctic perimeter decelerate ice from tributary glaciers and thus exhibit a stabilizing control on the entire ice sheet. Here we investigate Ice-shelf channels which are curvilinear tracts of thin ice occurring in many Antarctic and Greenlandic ice shelves. They are narrow in the across-flow direction (typically 1-5 km), but may extend for hundreds of kilometers in the along-flow direction. Ice thickness can locally be reduced by more than half and both stabilizing and destabilizing effects have been proposed as a result of this. Ice-shelf channels develop an interesting morphology, including meandering and junctions where ice-shelf channels split and merge. It has been suggested, that these patterns are caused by spatio-temporal variability of subglacial water outlets at the grounding line, and also by preferential basal melting at one of the channels' flanks causing deviations from ice-shelf flowlines. However, no direct evidence is so far available to conclusively demonstrate either of these hypotheses. The spatial dimensions of ice-shelf channels (especially in the across-flow direction) are at the limit of what today's satellites can resolve in terms of topography and flow velocities. The scientific questions that we addressed are:

- Can we detect spatial variability of the ice-shelf mass balance across and along ice-shelf channels from space?
- If so, can we use the observed patterns to determine how much basal melting is determined by ice-shelf draft (as opposed to, e.g., the bathymetry)?

Support through the Antarctic Science Bursary

In order to answer these questions, we determined the basal mass balance by using a mass conservation scheme in a Lagrangian Framework. The basal mass balance is found as a residual from the individual terms in the mass budget including transient changes in ice thickness, the ice flux divergence, and the surface mass balance. The first two terms require to derive the ice

thickness, and the ice velocity at a spatial resolution much smaller than ice-shelf channels. For this, we have used satellite data that is freely available to us (such as acquisitions from ERS ½, TerraSAR-X, ALOS PALSAR). However, in order to overcome the limited spatial and temporal coverage of these satellites, we also turned to commercial satellites, in particular to the Cosmo Skymed (CSK) SAR satellites operated by the Italian Space Agency. **Using funds from the Antarctic Science Bursary, we bought multiple CSK satellite acquisition from the Roi Baudouin Ice Shelf**, closing an important data gap in our existing data. Unfortunately, a major challenge in communicating with the Italian Space Agency was that we were not able to infer the spatial baseline of the interferometric SAR pairs prior to ordering. Other researchers that we contacted have confirmed this somewhat inexplicable administrative bottleneck. We hence ordered scenes in explorative mode, with the expected result that many pairs were unsuitable for interferometric processing. Nevertheless, the high-resolution and up-to date SAR images were a valuable resource for guiding field work on the Roi Baudouin Ice Shelf, providing sorely needed ground-truth data for our analysis from which two peer reviewed publications emerged (Berger et al., Journal of Glaciology, 2015; Berger et al., The Cryosphere, 2016).

Fig 1: (left) interferogram (right) coherence of a Cosmo-Skymed SAR pair covering a pinning point and ice-shelf channels at the Roi Baudouin Ice Shelf

Support of Young Scientists by the Antarctic Science Bursary

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https://dipot.ulb.ac.be/dspace/bitstream/2013/258789/4/Berger2017_PhD_final.pdf

We thank the Antarctic Science Bursary for this opportunity to support young researchers in the field.