Geophysical Research Abstracts
Vol. 18, EGU2016-14842, 2016
EGU General Assembly 2016

Observing ice-shelf channels and basal melting from space

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Ice-shelf channels (along-flow lineations in which ice is thinner) are ubiquitous in Antarctic ice shelves. Although these features are readily visible in satellite imagery, ice-thickness and ice-velocity variations in their surrounding are typically heavily undersampled. Ice-shelf channels focus channelized melting and significantly alter the basal mass balance (and hence ice-shelf stability) on short horizontal scales.
Here we use interferometrically-derived TandDEM-X digital elevation models and ice-flow velocities with a horizontal gridding of 125 m illustrating the ice-shelf dynamics of the Roi Baudouin Ice Shelf, Dronning Maud Land (East Antarctica) in unprecedented detail. Using ground-based GPS surface elevation, we demonstrate that TanDEM-X is an ideal sensor to map the channel morphology at the ice-shelf surface. We find velocity anomalies surrounding the channels along the entire ice shelf potentially indicating the presence of locally elevated basal melt rates.
Using mass conservation in a Lagrangian framework, we find basal melt rates averaging 0.4 m/a in the middle of the ice shelf and peaking at 12 m/a inside some channels. We illustrate the sensitivity of the method with respect to systematic biases in elevation/velocity and also with respect to lateral variations of the depth-density relationship.

With the increased availability of high-resolution radar satellites (such as Sentinel1), the techniques presented here could be applied on an pan-Antarctic scale to map basal melting both in space and time at high-resolution.