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Flow regime of the Joerg Peninsula suture zone, Larsen C Ice Shelf: the role of marine ice

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The flow units making up Antarctic ice shelves are fed primarily by discharge from glaciers. In the lee of peninsulae separating such units the ice is anomalously thin, as there is no or little ice inflow from the promontories itself. In these “gaps” between the flow units, super-cooled water is rising and freezing, leading to accretion of marine ice. Evidence for the existence of marine ice has been found in several Antarctic ice shelves of different geometry and scale.

Marine-ice-rich suture zones are warmer, softer, more permeable than the surrounding flow units coming from tributary glaciers, and thus introduce significant mechanical heterogeneity to the ice shelf. In the first instance suture zones appear to have a stabilizing effect by interrupting rift or crevasse propagation. However, they might equally be regarded as particularly vulnerable, because due to its higher temperature and different structure marine ice is softer than meteoric ice, sustaining elevated velocity gradients across suture zones that could mechanically decouple neighbouring ice units. The amount of marine ice accretion is also subject to oceanic conditions, changes in ocean temperature could lead to less freezing and thinner ice within suture zones. This could weaken the coupling between flow units downstream of peninsulae, and thus impact critically on ice-shelf dynamics and fracturing.

In this study we analyzed the basal mass balance of a suture zone within the Larsen C Shelf, Antarctic Peninsula, which is located downstream of the Joerg Peninsula in the southern part of the ice shelf. We obtained GPR and GPS data of the origin of the suture zone, covering an area of approx. 400 km^2, as well as several GPR profiles across and along the suture zone further towards the calving front. This data set delineates in 3D the boundaries between the meteoric and marine ice bodies, provides meteoric ice thicknesses and densities and supports calculation of marine ice thicknesses assuming hydrostatic equilibrium. Mean accumulation rates for marine ice along the measured GPR profiles are 0.2 m per year (preliminary result). The freezing rates are also discussed in comparison to a basal mass balance derived by numerical modelling of the interaction of ice shelf and ocean.

To quantify the influence of the warmer marine ice bands on the overall stress balance of the surrounding ice shelf area, we used a finite-difference, diagnostic ice-shelf model of which earlier versions have been applied successfully to the Larsen B and C Ice Shelves. Marine ice within suture zones was implemented by modifying appropriately the temperature dependent depth-integrated flow factor A in Glen’s law. The simulated flow regime of the Joerg Peninsula suture zone in its current state could be validated by remotely sensed flow velocities. High lateral velocity gradients across the suture zone in the observed velocity coincide with the high gradients caused by warm suture zone ice in the modelled velocities. Further sensitivity studies have been performed to test how changing freezing rates (i.e. amount of marine ice) and changing inflow velocities of the joining ice units affect their merging process.