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The role of pinning-points, marine ice and subglacial channeling in defining the buttressing strength of the Roi Baudouin Ice Shelf, Antarctica

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Within the coastal belt of Dronning Maud Land, many ice shelves, which are freely floating otherwise, reattach to localized highs in the bathymetry on the ice-shelf front. These localized pinning-points exert a buttressing force, which typically slows down the ice shelves farther upstream. Our interest is to quantify this buttressing effect, and to determine as to whether or not, the comparatively small pinning-points can play a decisive role in defining the mass balance of tributary glaciers.

We consider the Roi Baudouin ice shelf, which is laterally confined by two large ice rises, and pinned on the ice-shelf front by a small ice rumple. It buttresses the western Ragnhild glacier. On the ice-shelf surface, satellite imagery reveals a number of elongated surface depressions, which are aligned along-flow and which correspond to a sub-ice shelf channeling system. We present the results of two consecutive field seasons which were geared at unraveling the combined effect of ice rumple and subice-shelf channels on the ice shelf's buttressing strength.

Around 130 km of multi-frequency radar profiles map the channeling as well as the basal interface of the pinning-point. We observe strongly dipping internal layers within the surface depressions and a firmly grounded ice rumple. Data from a 20 x 25 km wide GNSS strain net is extended spatially on a 50 m grid with the help of satellite derived surface velocities. Six wide-angle radar surveys within the research grid show that the depth-averaged density varies spatially on scales that are smaller than the grid size in commonly applied Antarctic-wide firn densification models. The density variations are significant, and need to be taken into account when comparing the hydrostatically inverted GPS thickness with the measured radar thickness.

Notwithstanding the ice-rumple's small extent (1-2 km), the combined strain rates show a shear zone which extends all the way back to the grounding line and emphasizes the importance of pinning points in ice-shelf dynamics. The comparison of GPS heights with radar thickness reveals a marine ice layer, with a variable thickness, particularly in the pinning-point's vicinity. The sub-ice shelf channels extend vertically more than half of the ice thickness, which potentially makes the channels more susceptible to horizontal shearing as they approach the pinning point. The combined data set illustrates that the ice-shelf properties are non-homogeneous, and we hypothesize that this results in a spatially variable effective viscosity which needs to be taken into account in ice-flow modeling.