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Ice shelf internal reflection horizons reveal ice provenance, dynamics, surface accumulation and oceanic melt

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Ice shelves are widely known to slow the transfer of Antarctic grounded ice to the ocean, especially if their flow is decelerated by local pinning points. Their longevity is influenced by variations in ice dynamics, surface accumulation and oceanic conditions in the ice shelf cavity. This is reflected in the ice shelf structure, which can be characterized by the shape of internal radar reflection horizons.

We aim to map the internal ice shelf stratigraphy of ice shelves, starting with the narrow belt of ice-shelves in the Dronning Maud Land area. The final goal will be to evaluate these as a spatiotemporal archive of ice provenance and ice dynamics. The bulk of the data presented here were collected with AWI's airborne multi frequency ultra-wideband radar and we combine these new observations with airborne and ground-based radar surveys from previous years. We present a consistent set of internal radar isochrones on a catchment scale for the Roi Baudoin area including the Ragnhild ice streams, the grounding-zone, the iceshelf and multiple ice rises. Using pattern matching technique we can link isochrones across different ice rises in the area, and hence provide first observational constraints on how ice rises jointly react to changes in atmospheric and oceanographic forcings. We also find a number of interesting features including dynamically induced dips in shear zones, truncating layers at the ice-shelf base, and the development of a meteoric ice layer distinguishing advected from newly accumulated ice in the iceshelf. The time series provided by radar observations over the last 10 years also offers the potential to map temporal changes. We use ice-flow modelling to provide age constraints for some internal layers and delineate portions within the shelf as a function of their advection history, hence marking areas of differing rheologies within the shelf. Taken together, this case study on a catchment scale is a primer to unravel the information stored in the isochronal stratigraphy of coastal Antarctica and contributes to international efforts (e.g., SCAR AntArchitecture) of mapping stratigraphy on ice sheet scales.