Use of Shallow Ice Radar Reflections of Kamb Ice Stream within the Ross Ice Shelf to Evaluate Thickness Change due to Basal Processes

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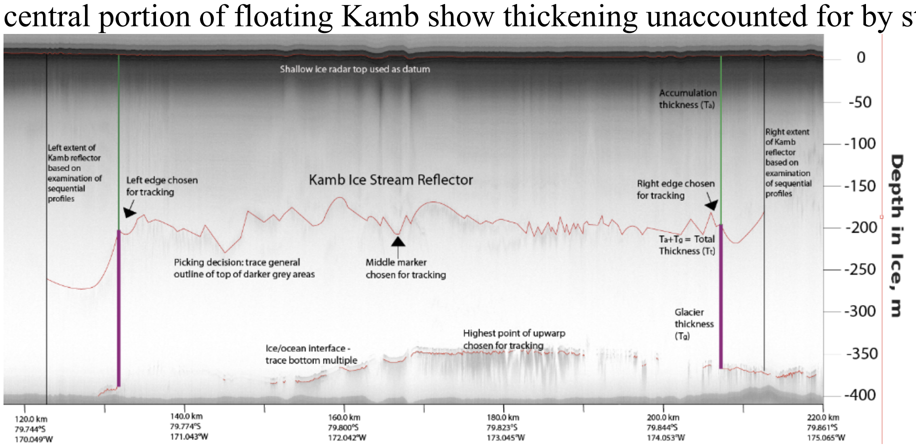
The ROSETTA-Ice Project uses the ICEPOD instrument suite to collect shallow ice radar profiles of the Ross Ice Shelf that reveal the extent of ice stream and glacier-ice constituents of the floating ice sheet. To date, flight lines are spaced at 10 to 30 km and numbered L20 (south) to L910 (north). The survey is 2/3 complete. Ice flowing from Kamb Ice Stream can be identified in the shallow ice radar images by a jagged reflection, taken to be the top of continental glacier ice, at a depth of 149 meters close to the grounding line and 221 meters near the calving front. The thickness of glacier-ice, T_g, beneath the reflector decreases from 215 m to 74 m over this distance. Distinct repeated features in the reflectors at the top and base of the glacier ice volume can be tracked from line to line and across the length of the glacier-ice within the ice sheet.

The value of glacier ice reflectors such as Kamb's is that they provide markers for strain, depth variation, and thickness change between flight line profiles. By determining thickness change using the packet of ice beneath the internal reflection, uncertainties of thickness changes due to accumulation and firn densification are excluded. Once mapped, depth, width, and thickness variations in the glacier ice volumes can be used to assess the processes responsible for thinning. Strain is the dominant process verified by prior studies. Our work seeks to isolate and quantify change resulting from basal processes such as melting and freeze-on that could reveal areas of importance for study of ocean-ice interactions in the marine cavity.

Using geospatial and graphics software, we measured the thickness of accumulation above the reflection, T_a, and total glacier thickness below the reflector, T_g, at four points on each profile. The four positions are left and right margins, one distinct upper feature and one lower feature that is repeated in the reflector pattern in 18 sequential lines. For each point, we tabulated ice velocity (Rignot 2017), RIGGS vertical strain rate (Thomas et al. 1984), thickness change between lines, and time elapsed from grounding line (Moholdt, unpub.). After accounting for thinning caused by strain, the remainder is attributable to basal melting, freeze-on, or other processes to be determined. For Kamb glacier-ice, thinning due to strain is 1 to 6 m over each 10-km increment (Thomas et al., 1984). The amount of thinning unaccounted for by strain is 0.2 to 1.3 m/yr per increment, which may be attributable to basal melting. A few increments in the central portion of floating Kamb show thickening unaccounted for by strain, at 0.1 to 0.6 m/yr .



Annotated L660 radargram for Kamb Glacier, illustrating measurement method.