Flow-generated records in the Ross Ice Shelf: evidence for grounding line changes and past shutdown of Whillans Ice Stream

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The complicated patterns of flow-related features on the Ross Ice Shelf contain a wealth of information about the history of ice discharge from the ice streams flowing east off of the WAIS. We have been able to read some of this history from satellite image mosaics using a combination of the geometry of the features, the generation of hypothetical past flow scenarios, and the targeted models used to test the plausibility of those scenarios. We identified a pattern of flow variation due to basal freezing, driven by the influence of longitudinal extension on the basal thermal gradient in the ice, that can explain the observed flow features. Recently, we have recognized that there are other profound records of variation on the shelf; these records, when understood in the proper context, will yield a more complete understanding of ice stream slowdowns and grounding line retreat than is currently available.

These new records of flow come in two “flavors”. The first “flavor” is groups of fracture-related features that serve as kinematic and dynamic tracers, such as sets of grounding-line parallel depressions in the ice-shelf surface. These tracers present a complicated history that we have made some progress in reading. The second “flavor” of record is a detailed picture of ice thickness variation on the Ross Ice Shelf from the IceSAT laser altimeter. The combination of this ice-thickness-related measurement with whole-ice shelf image composites allows us to begin to constrain the volumes of ice involved with the flow history on the ice shelf; this means that we can now approach the variations in flow from the perspective of relative flux between two outlets, and can constrain shutdown and thinning scenarios based on the presence or absence of thinned ice in the shelf.

These datasets lead us to add several additional events to the flow history recorded in shelf ice: 1) a record of sustained grounding line retreat to the north of Crary Ice Rise, and 2) the possible shutdown of Whillans Ice Stream, likely for several hundred years during the last half millennium.