Observing Glacier Variability: Progress and Remaining Challenges

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Retreat, acceleration, and thinning have been observed on numerous outlet glaciers around the Greenland Ice Sheet over the last two decades, doubling the ice sheet's contribution to global mean sea level rise. The widespread response of marine-terminating outlet glaciers, and the coincidence with a period of oceanic and atmospheric warming, points toward a common climate driver. Recent studies generally agree that the change initiated at the marine margin of these glaciers but details of both the forcing mechanism(s) and the response in glacier dynamics are not fully understood. In fact, many of the largest unknowns concerning glacier dynamics culminate at tidewater glacier margins: variability in glacier flow, calving mechanisms, and submarine melt.

Processes occurring at the ice-ocean margin – mainly submarine melting and iceberg calving – are inherently intertwined with ocean variability. Differentiating fresh-water originating up-glacier from fresh-water originating at the ice-ocean interface remains an over-arching goal for glaciologists and oceanographers. Submarine melt rates are also intrinsically linked to calving rates, as is the complex interaction of ice velocity and fracture mechanics. It is still unclear whether flow acceleration causes glacier retreat, or whether a loss of buttressing at the glacier terminus (from iceberg calving or mélange breakup) causes flow acceleration. Achieving the level of physically-based understanding needed to improve current ice sheet models requires that detailed measurements be made at high temporal and spatial scales. Only after these processes are better understood can we simplify our observational platforms and build process-oriented ice flow models that realistically incorporate ocean dynamics.