A Bedrock GNSS Network for Continuous Measurement of Glacial Discharge

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Ice and water discharge from Greenland outlet glaciers results from complicated processes occurring within the ice sheet and its interfaces with the atmosphere, bedrock, and the oceans. Unfortunately, the existing methods cannot measure glacier discharge directly. The Gravity Recovery and Climate Experiment (GRACE) and its follow-on (GRACE-FO) missions lack the required spatial resolution to measure discharge at individual glaciers. Other methods that rely upon satellite altimetry, interferometry, and optical imagery need ancillary models (e.g., firn-air compaction) and a priori knowledge (e.g., bedrock topography) to derive the glacier discharge, resulting in estimates with relatively high uncertainties. We propose a novel adjoint-based technique that relies on the solid Earth as a natural filter for determining glacier mass changes year-round. In particular, we hypothesize that Global Navigation Satellite Systems (GNSS) stations placed on the bedrock next to a glacier can be used to infer glacier discharge with minimal ambiguity. The granularity of these observations may unmask competing processes that control ice/water dynamics over seasonal to interannual time scales. Estimating glacier discharge from the network of bedrock GNSS stations requires separating the glacial isostatic adjustment (GIA) signals. To this end, we exploit the differential sensitivity gradients of multiple GNSS stations. Thus inferred basin-scale GIA signals would be invaluable to constraining the rheology and spatial structure of the solid Earth.