



A Century of Stability of Avannarleq and Kujalleq Glaciers, West Greenland, Explained Using High-resolution Airborne Gravity and Other Data

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Marine-terminating glaciers dominate the evolution of the Greenland Ice Sheet (GrIS) mass balance as they control 88% of the ice discharge into the ocean. The evolution of Greenland glaciers in a warming climate depends on their depth below sea level, flow speed, surface melt, and ocean-induced ice melt at the calving front. To interpret the recent and future evolution of two outlet glaciers, Sermeq Avannarleq (AVA) and Sermeq Kujalleq (KUJ) in central West Greenland, flowing into the ice-choked Torssukatak fjord (TOR), we need to know their ice thickness and bed topography and the fjord bathymetry. Here, we present a novel mapping of the glacier bed topography, ice thickness and sea floor bathymetry near the grounding line using high resolution airborne gravity data from AIRGrav collected in August 2012 with a helicopter platform, at 500 m spacing grid, 50 knots ground speed, 80 m ground clearance, with submilligal accuracy, i.e. higher than NASA Operation IceBridge (OIB)'s 5.2 km resolution, 290 knots, and 450 m clearance. We also employ MultiBeam Echo Sounding data (MBES) collected in the fjord since 2009. We had to wait until the summer of 2016, during Ocean Melting Greenland (OMG), to map the fjord bathymetry near the ice fronts for the first time. We constrain the 3D inversion of the gravity data with MBES in the fjord and a reconstruction of the glacier bed topography using mass conservation (BedMachine) on land ice. We obtain a reliable, precision (± 40 m) solution of bed topography across the ice-ocean boundary. The results reveal a deep fjord (700 m) that abruptly shallows to a 100-300 m deep sill at the calving fronts. The shallow sills explain the presence of stranded icebergs, the resilience of the glaciers to ocean-induced ice melt, and their remarkable stability over the past century. This work was funded by NASA Cryosphere Program and from a grant by the Gordon and Betty Moore Foundation.