Examination of Coupling Between Bed and Surface Strain on Thwaites Glacier using Nodal Seismic Data

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Abstract

The International Thwaites Glacier Collaboration (ITGC) has supported multiple projects over the past 7 years, all of which are dedicated to investigating various components of one of the most unstable glaciers in Antarctica, Thwaites glacier. Thwaites is the size of Florida and drains into the Amundsen Sea embayment in west Antarctica. It is currently of interest due to risks and rapid changes that are compromising its own stability, as well as the importance it has on the stability of the rest of the west Antarctic ice shelf, which holds enough water to raise sea level by at least 10 feet. A dominant mechanism governing glaciers' stability and the migration of ice from land into oceans is how they slide over their underlying bed. Despite this mechanism being a primary contributing factor of ice mass loss in Antarctica, it remains poorly understood and observational constraints are sparse. The GHOST team, which is a part of the ITGC, studies the geophysical habitat of subglacial Thwaites and has spent the austral summers of 2022/2023 and 2023/2024 traveling to this remote glacier doing seismic and radar experiments to try and close this gap. The data collected will be integrated into models to determine controlling interactions between glaciers and beds, thereby improving projections of Thwaites' evolution and its potential contribution to global sea level rise. Components of the GHOST project have been supported by both IRIS and UNAVCO, whose instruments successfully collected the data presented in this study under sometimes extreme field conditions. Like earthquakes, glaciers sliding over their beds or cracking at the surface release energy that can be recorded by seismometers, giving us important insights on sticky spots at the bed and how damage is being generated at the surface. As important as ice-bed interactions are, so too is understanding how glaciers are damaged at the surface, which eventually leads to ice breaking off the front of glaciers (and generates crevasses that can greatly complicate on-ice field research!). Over the course of two seasons (6 months total by the lead author, including extended on-ice deep-field traversing) an array of 164 Magseis Fairfield ZLand 3C nodal seismometers were deployed, collecting data over 288 km^2 of Thwaites; most of the data were just returned from the field in February 2024. The first analyses of these data focus on 16 seismometers selected for optimal study of events at the bed and surface by enveloping a nearby crevasse and overlaying a subglacial ridge where the average speed is high (up to 400 m a^{-1}), generating high basal drag. Jointly studying surface and basal processes and their coupling offers a unique opportunity to gain further insights on each independent mechanism, as well as their interactions. A preliminary exploration of the data using QuakeMigrate shows an abundance of bed and surface events available for further analysis and highlights the importance of traveling to remote locations to collect novel data sets.