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Configuration of Subglacial Water and Sediments Beneath Thwaites Glacier, West Antarctica: Context for a Potential Melt-Water-Intensive Grounding-Line-Retreat

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Thwaites Glacier, in the Amundsen Sea Embayment of the marine West Antarctic Ice Sheet (WAIS) is one of the largest and most rapidly changing glaciers on earth. Thwaites Glacier has a sloping bed that reaches deep into the WAIS interior, so a retreat started at its grounding-line has the potential to spread to the rest of the ice sheet, making its behavior and stability the subject of significant interest and study. Although sub-ice-shelf melting by warm ocean water is a leading hypothesis for the observed changes in Thwaites Glacier, its dynamic subglacial water system offers an alternative or complementary trigger for potential ice sheet acceleration and grounding line retreat. Subglacial water systems have been observed to cause significant accelerations in large Antarctic outlet glaciers and marine bathymetry of collapsed paleo-ice-streams show evidence of large volumes of melt-water and outbursts. However, the observational challenges in characterizing catchment-scale subglacial water systems have prevented the assessment of basal water as a potential trigger of unstable retreat for Thwaites Glacier. Using recent advances in focused coherent radar sounding data analysis, we show that the subglacial hydrology of Thwaites Glacier contains significant volumes of water ponding behind a damming bedrock ridge in a distributed canal system that is feeding a system of concentrated channels downstream. We show that the hydrologic dynamic state of these water systems is coupled to ice flow with the transition from a distributed to a concentrated water system co-located with an increase in basal shear stress. We also use the anisotropy of the radar echo specularity to identify flow-aligned sedimentary bedforms consistent with mega-scale glacial lineations underlying most of the glacier tributaries and a transition from sediment to crystalline bedrock in the trunk upstream of the grounding line. We compare the configuration of sedimentary bedforms beneath Thwaites Glacier with marine bathymetric observations of paleo-ice-streams and conclude that its configuration is consistent with the large melt water volumes and outbursts associated with the collapses of those ice streams. Finally, we offer a mechanism by which the configuration of subglacial water and sediments beneath Thwaites Glacier could facilitate a basal-water-triggered grounding-line-retreat.

Keywords: Thwaites Glacier, glacier, ice sheet, subglacial, melt water