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Simulating Antarctic subglacial hydrology processes underneath Pine Island Glacier, West Antarctica, using GlaDS model in Elmer/Ice

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Abstract: Very little is known about the subglacial hydrologic system under the Antarctic Ice Sheet due to the difficulty of directly observing the bottom of the ice sheet. Hydrology modeling is a powerful tool to simulate the spatial distribution of crucial hydrologic properties under the ice sheet. Here, we use the state-of-art two-dimensional Glacier Drainage System model (GlaDS) to simulate both distributed sheet flow and continuous channels under Pine Island Glacier (PIG), West Antarctica, one of the largest contributors to sea level rise in Antarctica.

We adopt an unstructured triangular mesh which enables channels to form along element edges. We drive the model with meltwater computed from an inversion and steady temperature simulation of PIG using a Stokes flow ice dynamic model. Our domain comprises the full PIG catchment. We aim to study the pattern and development of water pressure, hydraulic potential, water sheet thickness and discharge, as well as channel area and flux, which together describe the state of the basal system.

Our results for hydraulic potential correctly route water towards the grounding line, while we find near-zero effective pressure underneath the main trunk of PIG, consistent with the low basal drag and low driving stress there. This has implications for the representation of sliding in ice dynamic models: typical assumptions about hydrology connectivity to the ocean will overestimate effective pressure. When run forward in time, efficient channels evolve near the grounding line indicating an efficient drainage system where water fluxes are high in the downstream part of the PIG.

By applying GlaDS to a real marine ice sheet catchment we can better understand how basal hydrology modulates ice dynamics through basal sliding. We plan to compare our model predictions of effective pressure and drainage system with driving stress and inversions of basal drag. This will allow us to see the relationship between basal hydrology and basal sliding under PIG, and provide us better tools to predict the evolution of the region in view of future climate scenarios. Moving forward, we plan to couple the hydrology model with the ice dynamics model to make more accurate projections of sea level rise from PIG.

Key Words: West Antarctica, subglacial hydrology, drainage system, GlaDS, Elmer/Ice, Pine Island

Glacier