Grounding line migration on unstable bedrock slopes: The example of Thwaites Glacier, Antarctica

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Recent satellite observations of the Antarctic and Greenland ice sheets show accelerated ice flow and associated ice sheet thinning along coastal outlet glaciers in contact with the ocean. However, many uncertainties exist with respect to the behaviour of these ice sheets, especially the marine ice sheets, which rest on bedrock below sea level. This could imply significant errors in estimating sea level rise due to ice sheet melting. Marine ice sheet stability is mostly controlled by the dynamics of the grounding line, i.e. the junction between the grounded ice sheet and the floating ice shelf. While the grounded ice is dominated by vertical shear and basal friction, the ice shelf is dominated by longitudinal stretching and lateral shearing. Stress coupling is then essential at the grounding line.

Here we report on the state-of-the art of grounding line migration in marine ice sheets and address different ways in which grounding line migration can be attributed and represented in ice sheet models. Using flowline and three-dimensional ice sheet models we performed a number of sensitivity experiments (i.e. changes in sea level, sub-ice shelf melt rate, and buttressing effect) with different spatial resolutions and stress approximations. The models are tested using simple geometries (linearly downward-sloping and overdeepened bedrocks) on one hand and they are applied to Thwaites Glacier on the other hand. This last glacier is one of the fastest and largest ice streams in Antarctica and is a major contributor to the current sea level rise. A discussion is given on the stability of marine ice sheets on upward-sloping bedrocks, as well as on the robustness of numerical schemes to capture grounding line migration within short (centennial) time scales.

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