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Antarctic grounding line retreat enhanced by subglacial freshwater discharge

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Accurate prediction of sea level rise requires detailed understanding of processes contributing to ice sheet mass loss. Antarctica's ice shelves are thinning, resulting in enhanced flow of grounded ice due to weakened ice shelf buttressing. Glaciers feeding ice shelves with the highest melt rates are also experiencing some of the most rapid grounding zone retreat. However, these ice shelf melt rates reach values that cannot be explained by ocean forcing alone and are not reproduced in ocean models. We present subglacial hydrology model outputs for four major Antarctic glaciers (Pine Island, Thwaites, Totten and Denman), which flow through the deepest and most extensive Antarctic marine subglacial basins and feed rapidly thinning ice shelves. We show that the areas of high ice shelf melting rates and grounding line retreat coincide closely with areas of high subglacial discharge. We posit that the subglacial discharge provides the missing component driving the high melt rates, and identify positive feedbacks between ice dynamics, steepening of ice shelf basal slope, and subglacial outflow. If surface temperatures increase as expected in Antarctica over the coming decades, surface meltwater could flow to the ice sheet base, as observed in Greenland. The surface meltwater hydrological cycle could therefore contribute to seasonal variations in subglacial meltwater and ice shelf basal melt, leading to accelerated grounding line retreat into Antarctica's deepest subglacial basins. Invoking these feedbacks could reconcile sea level records and ice sheet model simulations that remain overly stable in warmer periods.