Force balance of Pine Island Glacier and other fast-moving glaciers in Antarctica

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Pine Island Glacier is the most active glacier in Antarctica and its largest discharger of ice. Recent results indicate that this sector of Antarctica is unstable at present, experiences rapid thinning, and is accelerating. In this study, I apply the force budget technique of van der Veen and Whillans to this and other glaciers. This method determines the distribution of resistive forces acting on the glacier to counterbalance the action of gravity. Ice thickness is from BEDMAP, ice velocity is from ERS interferometric synthetic-aperture radar data (InSAR). The results show the interior tributaries of the glacier have the characteristics of ice streams: low driving stress balanced almost entirely by side shearing, as in the case of Whillans ice stream and other ice streams draining Siple Coast. About 100 km from the grounding line, the glacier experiences a higher driving stress at the merging of two tributaries. There, the basal shear stress becomes significant while lateral shearing remains more or less unchanged. The glacier subsequently transitions to a region of much lower basal shear stress before becoming afloat in the Amundsen sea, where, as expected, the basal shear stress drops to zero and the driving stress is again entirely balance by side shear. This complex force balance is unlike that of the lateral-shear dominated Siple Coast Ice Streams, or the basal-shear dominated glaciers of East Antarctica. Yet, model simulations and observations suggest that Pine Island Glacier is behaving more like a shelfy stream than like an outlet glacier. The buttressing force exerted by its ice shelf plays a significant role in its evolution. I contrast this situation with the case of Thwaites Glacier, which no longer experiences an ice shelf buttressing and is retreating, and Rutford Ice Stream, which experiences considerable buttressing and is stable.

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