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On the effect of grounding-line retreat on the ice flow of Pine Island Glacier, West Antarctica.

Pine Island Glacier is a fast-moving outlet that flows into the Amundsen sea at more than 2.5 km/a. Satellite radar interferometry revealed a retreat of the glacier grounding line averaging about 1 km per year between 1992 and 2000. During that same time period, the flow velocity of the glacier has changed significantly, with irregular accelerations. A large change in velocity took place between 1996 and 2000. A smaller change took place between the 1992-1996 time period. The velocity remained steady between 2000 and 2002, but is known to have been increasing already prior to 1992.

We use a finite-element model of ice-stream/ice-shelf flow to match the velocity observations obtained in 1996, over nearly the entire glacier drainage. Model fitting is done by adjusting a basal friction coefficient on grounded ice, and a softening coefficient along the glacier and ice-shelf margins, using a control method. The model is then employed to calculate the flow velocity of the glacier, with a different grounding-line position, but the same selection of basal friction and ice softening parameters. Similarly, we calculate the flow velocity resulting from a reduced ice-shelf area consecutive to rifting along the northern margin, as suggested by observations. Results indicate that both flow perturbations propagate far inland, consistent with insar observations, yet the model is not able to replicate flow changes more than 50 km upstream of the grounding line. The calculated velocity changes are of the same order magnitude as the observations, but a detailed comparison of the results suggest a delayed response of the glacier to perturbations. This would explain why the glacier acceleration was most pronounced in 1996-2000, whereas the largest grounding-line retreat took place in 1992-1994. Similarly the grounding line retreated in 1996-2000 yet no flow change was observed in 2000-2002. In the model, most of the flow adjustment takes place in a 30-km long region above the grounding line, which is slightly grounded, and has been referred to as an ice plain. This region is probably key to the flow stability of the glacier. The erratic retreat of the grounding line in that region is probably caused by the presence of a rough bed, with numerous glacier pinning points, which progressively get unpinned as the grounding line retreats from enhanced bottom melting of the ice shelf. If the retreat continues at this rate, and the ice shelf in front of the glacier continues to weaken and rift, the model predicts that the flow velocity will continue to increase, up to 90% if the entire ice shelf collapses and the grounding line retreats all the way along the ice plain.

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Topics :

Ice-sheet dynamics, remote sensing