グリーンランド北西部カナック地域ボードイン氷河の流動に関する数値実験

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Modeling the flow dynamics of Bowdoin Glacier, Qaanaaq region, northwestern Greenland

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The Greenland ice sheet is losing mass at a rate increasing over the last decades. In this mass loss a predominant role is played by surface melt and ice discharge from accelerating marine-terminating outlet glaciers. It is thus essential to better understand the dynamics of these outlet glaciers. Located 30 km northeast of Qaanaaq in northwestern Greenland, Bowdoin Glacier (77º41'N, 68º35'W) is a fjord-terminating glacier which was intensively surveyed in the GRENE field campaigns in summer 2013, 2014 and 2015. Complementary to this work, we used the three-dimensional, full Stokes model Elmer/Ice (Gagliardini and others, 2013; elmerice.elmerfem.org) to investigate the flow dynamics of Bowdoin Glacier. Bowdoin Glacier was relatively stable for more than 20 years before 2008. Since then it has been retreating rapidly and its speed has fluctuated frequently. Using the available observational data, we modeled the glacier flow and investigated its sensitivity to external forcing. We applied a control inverse method to infer the present-day spatial distribution of the basal friction coefficient from the measured surface velocities (Sugiyama and others, 2015). We performed sensitivity experiments by applying basal perturbations, i.e., increased basal lubrication, and by changing the sea level at the glacier front. Glacier ice flow was sensitive to moderate basal perturbations (10% decrease in the basal friction coefficient). This suggests that ice flow is affected by rapid short-term variations in air temperature and precipitation. More interestingly, glacier ice flow near the glacier front varies significantly with sea tides. Flow accelerates with falling tides and slows with rising tides. Investigation of the stress regime driving ice deformation revealed a complex combination of lateral shearing that supports the glacier and longitudinal stress (glacier ice extension) that interacts with the hydrostatic pressure acting on the calving front. We therefore demonstrated that the dynamics of Bowdoin Glacier is sensitive to small perturbations occurring at the glacier base and at the calving front.

References

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