Ice flow over plastic beds

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Portions of WAIS are underlain by plastically deforming beds but the influence of basal plasticity on ice flow is not completely understood. Here we consider the dynamics of Hofsjökull, a soft-bedded ice cap in central Iceland, using surface velocity observations taken before and at different times during the melt season. Hofsjökull serves as an ideal natural experiment in which basal processes are isolated from oceanic forcings. This isolation helps to illuminate the salient mechanics of plastic-bedded glaciers. We first infer the existence of a plastically deforming bed beneath the ice cap by constraining numerical ice flow models with surface velocity measurements derived from airborne radar interferometry and inverting for the optimal basal shear stress and basal slip rate fields. Basal plasticity is evident from the independence of basal shear stress and basal slip rate. By comparing velocity fields collected at different times of year, we highlight the response of ice flow to surface melt in various outlet glaciers. We assume that ice flow accelerations are caused by variations in basal water pressure, which are driven by fluctuations in surface meltwater flux and modulated by the characteristics of the hydrological systems beneath each outlet glacier. Our data clearly show that different outlet glaciers respond in different ways to similar environmental forcing. Most outlet glaciers accelerate following the onset of melt, but the characteristics of slowdown vary significantly between different outlet glaciers. Some outlet glaciers slow completely to wintertime velocities, some slow partially, and some do not slow at all over the same time period and under roughly the same melt conditions in the early melt season. This heterogeneity in response, which can be at least partially accounted for by differential evolution of the basal hydrological systems, motivates an idealized physical model of ice flow over plastic beds. Our data and our associated model indicate that the sensitivity of ice flow to changes in basal water pressure scales as the inverse of the ice surface slope. This finding has implications for ice flow in WAIS, where surface slopes are relatively shallow, subglacial lake drainage events are known to occur, and basal hydrological systems may be linked to the ocean.

Theme: Modeling of ice and polar ocean (*California Dreamin'*)