Abstract Submitted
for the DFD19 Meeting of
The American Physical Society

Relaxation of ice-sheet uplift on a porous bed CHING-YAO LAI, Columbia University, DANIELLE L. CHASE, Princeton University, LAURA A. STEVENS, TIMOTHY T. CREYTS, Columbia University, HOWARD A. STONE, Princeton University — When surface meltwater reaches the base of an ice-sheet with high flow rate, it peels apart the interface between the ice and bed, forming a water-filled blister and inducing ice-sheet uplift. The uplift relaxes after water injection, with a wide range of relaxation times (Geodetic observations show relaxation occurs over hours to days). Improved characterization of water flow at the base of ice sheets is vital for predicting ice-sheet dynamics and mass loss when the bed is lubricated. Although properties of the lubricated porous sheet beneath the ice impact ice sliding, the permeability of the porous sheet has not been measured directly and remains unknown. Here, we show that the elastic relaxation of a water-filled blister above a porous substrate can be used to probe permeability. Combining field data, a mathematical model, and laboratory experiments, we show that the blister height decreases exponentially with time as the water in the blister permeates through the porous sheet. We find that the relaxation dynamics obeys a universal law with a time scale involving the thickness and permeability of the porous sheet, water viscosity, and the Young's modulus of ice. We show that the range of observed relaxation times can be explained by the evolving permeability of the porous sheet. Our reduced-order model better characterizes the evolution of bed permeability based on surface observations.

Ching-Yao Lai
Columbia University

Date submitted: 30 Jul 2019 Electronic form version 1.4