

Modeling dynamic controls on ice streams: A Bayesian statistical approach

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Abstract

Our main goal is to exemplify the study of ice-stream dynamics via Bayesian statistical analysis that incorporates physical, through imperfectly known, models using data that are both incomplete and noisy. The physical-statistical models we propose account for these uncertainties in a coherent, hierarchical manner. Our basic model begins with a definition of basal shear stress equated to driving stress, as expected under steady-state assumptions, but subsequently includes a random corrector process to account for model error and non-equilibrium behavior. The resulting stochastic equation is incorporated into a simple model for surface velocities. Use of Bayes' Theorem allows us to make inferences on all unknowns given basal-elevation data, surface-elevation data, and surface-velocity data. The result is a posterior distribution of possible values that can be summarized in a number of possible ways. For example, the posterior mean of the stress field indicates average behavior at any location in the field, and the posterior standard deviations describe associated uncertainties. We analyze data from the Northeast Ice Stream in Greenland and illustrate how scientific conclusions may be drawn from our Bayesian analysis.