Physical-statistical modeling of ice-stream dynamics

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Abstract

Our main goal is to exemplify the study of ice-stream dynamics via fully Bayesian statistical analysis that incorporates physical models that are not perfectly known, using data that are both incomplete and noisy. The physical-statistical models we propose account for these uncertainties in a coherent, hierarchical manner. Use of Bayes' Theorem allows us to make inference on all unknowns given the data. The result of that inference 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 gives average behavior at any location in the field, and the posterior standard deviation associated with a posterior mean value shows how variable the possible values are. There are no direct measurements on stress; we infer it from basal-elevation data, surface-elevation data, and velocity data. Forward smoothing methods could also be used, but they lack a coherent accounting of uncertainties. We analyze data from the Northeast Ice Stream in Greenland and indicate how scientific conclusions may be drawn from Bayesian analyses.