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Morphodynamic Analysis and Statistical Synthesis of Geomorphic Data

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Many Earth-surface processes are studied using field, experimental, or numerical modeling datasets that, although realistic, only represent a small subset of possible outcomes observed in nature. Acquiring statistically significant quantities of data is often time- and/or cost intensive. Therefore it is not uncommon that a quantitative statement of uncertainty is missing in predictions made from geomorphic datasets. To access such uncertainty for partially or unobserved states of a system, a stochastic model is needed that can mimic spatial as well as temporal variability. In this paper, we propose such a stochastic model for morphodynamic datasets. One component of the model represents long time-scale behavior using extreme value statistics that describe large but infrequent morphological changes; a second component models short time-scale behavior by means of multiple-point geostatistics. We propose a Bayesian protocol to first falsify the stochastic model based on the statistical similarity to the dataset thereby improving physical plausibility. Then, we use approximate Bayesian computation to infer the stochastic model parameters from the temporally limited geomorphic data. We apply the model to a single flume experiment of braided river channels evolving under steady water and sediment flux. Realizations of the stochastic model allow quantifying uncertainty on the movement of channels in the flume and on the occurrence of rare extreme events.