**Title:** A Physics-based emulator for the simulation of geophysical mass flows

Asif Mahmood
Penn State Univ. at York
aum54@psu.edu

**Abstract:**
Rare natural hazards such as large volcanic eruptions can cause loss of life and damage to property. With sufficient information, those charged with public safety may issue warnings of impending hazards, to mitigate the hazard impact. Recent developments in modeling and simulating large geophysical mass flows can provide useful information in assessing hazard risk. In particular, computer simulations of a model system of partial differential equations, which determines flow depth and runout, are expensive to run. On the other hand, analysis based on but a few simulations is not sufficiently accurate for hazard analysis. Computational costs can be reduced by constructing a statistical emulator - a regression surface for selected output variables derived from several full simulator runs. Whenever the result from a simulation is required in an analysis, the emulator can be queried quickly. A key feature of the emulator is that an estimate of the prediction uncertainty, or error, is defined together with the regression estimate. A popular emulator is the Gaussian Seperable Process emulator, or GaSP, which is constructed as the mean of a Bayesian posterior distribution over outputs. In this work, we propose an alternative procedure for constructing emulators, one that uses knowledge about the model physics. We model the mass flow as an Ornstein-Uhlenbeck (OU)process for sliding blocks over the topography. We demonstrate how the OU results can be used to predict simulator results. A fit to the OU process is made, together with an error approximation, by classical statistical techniques, to provide an emulator of the runout computed by the computer simulator.

Key words: Computer model, Emulator, Ornstein-Uhlenbeck process, Uncertainty analysis, Gaussian process, Geophysical Mass Flows