3D simulation of landslide failure and incipient runout

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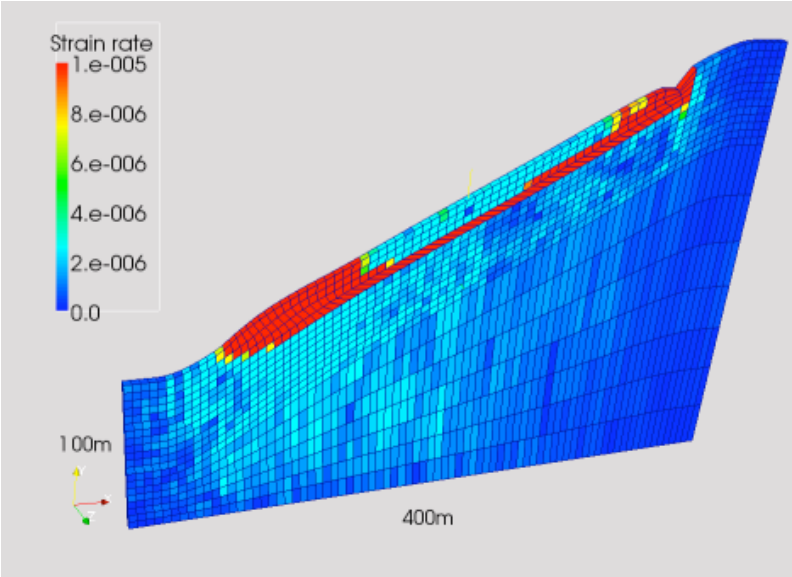
Landslides are a major environmental hazard and a fundamental process in the erosion of mountain landscapes. In both contexts, a major question is this: *when a slope fails, how big will the landslide be?* The question is a challenging one to study in the field or model numerically, because landslide volumes span many orders of magnitude and frequency, and because the mechanisms that control failure geometry are a matter of hot debate. We are conducting a pilot study to see whether this issue can be addressed through the modeling of large ensembles of landslide failures in 3D. We have chosen to use SNAC (Choi et al., 2008) and its ability to simulate the deformation of a heterogeneous Mohr-Coulomb material prone to strain weakening.



Our aim is to generate ~100 realizations of incipient slope failure given stochasticity in the governing physical and topographic properties. Of particular interest are: (1) complexity in the way in which landslide ruptures grow; (2) how strain weakening mechanisms and heterogeneity distributions affect the structure of deformation; (3) the nature of scaling relations between length, depth, area and volume. These results will be compared with observations of landslide structures, variability and scaling to determine the quality of the modeling. Armed with these insights, we will then be able to evaluate the practicality and efficacy of a larger project (>1000 realizations) to study what controls the probability distribution (PDF) of landslide volumes.

Figure: *First successful SNAC simulation of landslide failure. Strain rate @ t-75: snapshot. See http://geomorph.ldeo.columbia.edu/grg/projects/landslides/snac-experiments/snac-expt-hillslope17*

In terms of testing specific hypotheses, we will be able to discriminate between the idea of Katz & Aharonov (2006) that the PDF is a mix of two types of landslide generated in different ways and at two distinct scale ranges, and the model of Stark & Guzzetti (2009) that the PDF and its power-law scaling is the result of a single stochastic process of rupture propagation.

In terms of SNAC/CIG code development, at the time of writing we have built a new SNAC plugin called *hillSlope* to handle model domain geometry, material heterogeneity, and simulation tracking. In addition we have made improvements to post-processing tools. These adaptations are currently undergoing testing on TeraGrid Ranger (project# TG-EAR090034).

References

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