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Frictional Weakening of Landslides: Towards a generalized mechanism?

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Ultimately, landslide science aims to assess risk area by predicting the maximum distance travelled as well as the maximum velocity reached in order to quantify the destruction power of these events. Observations show that some landslides may travel over unexpectedly long distances, suggesting a very low mean dissipation during their flow. On the other hand, numerical simulation of real landslides commonly requires the assumption of very small friction coefficient to reproduce the deposits extension.

Despite the great amount of work (field, experimental and numerical studies) physical processes at work in these granular flows at the natural scale still need to be explained. Field observations show that the so-called Heim's ratio (i.e. the ratio between the difference of the height of the initial mass and that of the deposit, and the traveling distance) decreases with increasing volume, for landslides observed on Earth but also on the other planets like Mars or Iapetus. Whether this coefficient is a good representation of the effective friction during the flow is still a controversial issue. We show here, using both analytical and numerical solutions of granular flows over sloping beds as well as field observations, that the Heim's ratio is not equivalent to the effective friction coefficient.

We propose another way to estimate this coefficient from field data and show that whatever the environment, material involved or planet (including icy moons of giant planets), the effective friction indeed decreases when the volume involved increases, but in a different way than the Heim's ratio. Numerical simulation of natural landslides on real topography corroborates the volume dependence of the effective friction coefficient. Friction weakening is here investigated numerically in order to explain the volume dependence of the effective friction. While different processes may be invoked, we show that flash heating is quantitatively compatible with the observations. Resolving the issue of the observed small dissipation in real landslides will require detailed quantitative comparison of the possible processes with observations at the natural scale.