Geophysical Research Abstracts
Vol. 13, EGU2011-4202, 2011
EGU General Assembly 2011

The Hypermobility of Huge Landslides and Avalanches

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We propose a new rheological model for the basal shear stress and the hypermobility of huge rockfalls, landslides and debris avalanches. This new model addresses the long standing problem of explaining the observed hypermobility of the gigantic, catastrophic and the ultra rapid geophysical events in terms of the involved volume or the inundation area. We show that the hypermobility is the reciprocal of the effective Coulomb friction coefficient, which in our new approach is described analytically as a function of the mechanical, volumetric and topographical parameters of the flow. Contrary to the standing hypotheses, we show that the new mass-dependent effective Coulomb friction induced basal shear stress, and the new effective hypermobility function, adequately describes long run-out distances and compares very well with a large data set of huge terrestrial and extraterrestrial events. The new hypermobility model is general in several aspects, including the most dominant mobility parameters in the description of the long run-out lengths. It does not assume any specific form of debris avalanche overrun area, and the physical parameters are the material friction and the volume fraction of the fluid, while the volumetric parameters are the flow volume, the mean flow depth, and the actual overrun area. The topographic parameters are the mean slope and its curvature. We provide new and independent scaling arguments between the inundation area and the volume based on the arbitrary shape of the inundation area and the mean basal shear stress. The new effective Coulomb friction coefficient systematically explains the hypermobility of long run-out avalanches. The local dynamic shear stress is height-dependent, while for a given event the mean basal shear stress is uniformly distributed over the domain of the flow. This provides a physical explanation for efficient flows of very large events. Dynamic modelling of exceptional mobility of large avalanches must employ physically based flow rheology. We present one such flow rheology that has been successfully validated with a large data set. Validation of the new hypermobility function provides the opportunity to simulate past and/or potential huge landslide and debris avalanche events, their run-out distances, destructive impact, risk assessments, etc. In most cases, mobility is known but volumes and the overrun areas are unknown. Our new model can be used to estimate the overrun area and volume in terms of the known mobility data.