Dynamics of gravitational instabilities on Earth and on Mars

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Gravitational instabilities such as debris flows, landslides or avalanches play a key role in erosion processes on the Earth's surface and represent one of the major natural hazards threatening life and property in mountainous, volcanic, seismic and coastal areas. A great amount of experimental, numerical and field studies have been devoted to analyze the physical processes involved in gravitational flows and to propose rheological models describing their behavior. Even though recent rheological models for granular materials are able to reproduce some basic features of granular flows in laboratory, they fail in simulating real landslides with realistic rheological parameters. As a result, the physical processes at work during debris flows or landslides are still an open question. In particular, there is no consensus to explain the high mobility of natural avalanches.

A new model able to describe natural debris flows over complex topography is presented here (see [1], [2] and [4]). At the same time, the models currently used for avalanche modeling and their predictive power will be discussed, in the light of laboratory experiments on granular flows and of application to real cases on Earth and on Mars. Finally, a new methodology for measuring the dynamics of natural landslides will be proposed based on the study of seismic waves generated by these gravitational flows. This approach consists of solving two systems of hyperbolic equations: the equations for granular flow dynamics and those for seismic wave propagation. We show that simulation of the seismic signal generated by landslides makes it possible to discriminate between possible alternative scenarios for flow dynamics and to provide first estimates of the rheological parameters (see [3]). As landslide generated seismic waves are continuously recorded by seismic networks, our results provide a new way to collect data on the dynamics and rheology of natural flows.

Références

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