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r.avaflow: An advanced open source computational framework for the GIS-based simulation of two-phase mass flows and process chains

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Geophysical mass flows stand for a broad range of processes and process chains such as flows and avalanches of snow, soil, debris or rock, and their interactions with water bodies resulting in flood waves. Despite considerable efforts put in model development, the simulation, and therefore the appropriate prediction of these types of events still remains a major challenge in terms of the complex material behaviour, strong phase interactions, process transformations and the complex mountain topography. Sophisticated theories exist, but they have hardly been brought to practice yet.

We fill this gap by developing a novel and unified high-resolution computational tool, r.avaflow, representing a comprehensive and advanced open source GIS simulation environment for geophysical mass flows. Based on the latest and most advanced two-phase physical-mathematical models, r.avaflow includes the following features: (i) it is suitable for a broad spectrum of mass flows such as rock, rock-ice and snow avalanches, glacial lake outburst floods, debris and hyperconcentrated flows, and even landslide-induced tsunamis and submarine landslides, as well as process chains involving more than one of these phenomena; (ii) it accounts for the real two-phase nature of many flow types: viscous fluids and solid particles are considered separately with advanced mechanics and strong phase interactions; (iii) it is freely available and adoptable along with the GRASS GIS software. In the future, it will include the intrinsic topographic influences on the flow dynamics and morphology as well as an advanced approach to simulate the entrainment and deposition of solid and fluid material. As input r.avaflow needs information on (a) the mountain topography, (b) the material properties and (c) the spatial distribution of the solid and fluid release masses or one or more hydrographs of fluid and solid material.

We demonstrate the functionalities and performance of r.avaflow by using some generic and real-world examples including a channelized debris flow with hydrograph input, and a rock avalanche impacting a reservoir, triggering a flood wave overtopping and eroding the dam.

Project web site: http://www.avaflow.org/