Geophysical Research Abstracts, Vol. 8, 09546, 2006
SRef-ID: 1607-7962/gra/EGU06-A-09546

Comparison of two codes for modeling potential lahars at Cotopaxi volcano

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Cotopaxi volcano, with an elevation of 5897 m a.s.l., a near perfect cone and relief of well over 2000 m is one of the world's most beautiful, active and dangerous volcanoes. Located in the Interandean valley south of Quito, Ecuador's capital, Cotopaxi has long been known to the local population for the damage caused to the area: in the native Quichua language Cotopaxi means "King of Death". The combination of numerous factors such as high relief, elevation, the presence of an ice cap, the eruptive frequency and the distribution of the elements at risk all make this volcano extremely dangerous: in the last ca. 500 years the volcano has averaged roughly one eruption every century. The most recent eruption occurred in 1877 and had a severe impact on the surrounding area, particularly along the southern drainages of the volcano, due to a large lahar that flowed through the towns of Latacunga and Salcedo and numerous other small villages located along the Rio Cutuchi and its tributaries. In the present work we simulate potential lahars in the southern drainages of the Cotopaxi with the main aim of forecasting the extent of areas exposed to inundation hazard. The simulations are performed with two different codes in order to assess and compare model performance. Model calibration and validation are carried out with data collected in the field, including the volume of past lahars, flow velocities, grain size distribution and channel geometry. In addition to lahar inundation areas, mean and peak flow depths and velocities, model evaluation also regarded input data requirements, simulation setup complexity and output data format. Titan2D, developed by the Geophysical Mass Flow Group at the University at Buffalo and freely available, is a code that adopts a depth-averaged, shallow-water granular flow model for incompressible Coulomb continuums. It incorporates several innovative features such as adaptive gridding and the capability of running on multiple processors. FLO-2D is a commercially available flood routing code that uses a quadratic rheological model to represent viscous stress, yield stress, turbu-

lence and dispersive stress terms as a function of sediment concentration. The model routes a flood hydrograph over a DEM using the full dynamic wave momentum equation and a central finite difference routing scheme to distribute flow. Titan2D provides sound results on the flanks of the volcano but tends to underestimate lahar travel distances in the lower gradient floodplains. This shortcoming will likely be solved in a future release of the model in which the constitutive equations will be modified to simulate a two-phase medium. FLO-2D, on the other hand, encounters more difficulties in rugged steep terrain but improves performance in low gradient areas. An optimal solution could therefore be represented by the combined use of the two models. However, as for both models simulation preparation can be complex and time consuming, this solution would not be viable during a volcanic crisis.