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# A Comparison of 2-D and 3-D Models for the M. Salta rock fall, Vajont Valley, northern Italy

F. Tagliavini (1), P. Reichenbach (2), D. Maragna (3), F. Guzzetti (2), and A. Pasuto (1)

(1) CNR-IRPI, Corso Stati Uniti 4, 35127 Padova, Italy, (tagliavini@irpi.cnr.it) (2) CNR-IRPI, Via della Madonna Alta 126, 06128 Perugia, Italy, (3) Università degli Studi di Ferrara, Via Saragat, 1, 44100 Ferrara, Italy

Rock falls are very fast mass movements that occur when a fragment of rock (a block) is detached from a nearly vertical cliff, and travels down-slope by bouncing, flying and rolling. Rock falls represent a constant hazard in mountain regions worldwide, and pose a severe threat to the structures, the infrastructure, and the population. Investigators have long attempted empirical and mathematical modelling of rock falls, estimates of rock fall hazards and of the associated risk.

Software is available to simulate the behaviour of rock falls in 1-, 2- and 3-dimensions. Here, we compare the results obtained using STONE, a research software for the 3-D kinematic or simplified dynamic modelling of rock falls, and RocFall®, a commercial software for the 2-D dynamic modelling of rock falls developed by Rocscience Inc. The analysis is carried out in the Monte Salta Landslide, a complex rock fall – rock slide detached from the northern slope of the Vajont valley, in north-eastern Italy. The landslide has an estimated total volume of 2.5 million cubic meters, and is the result of multiple failure events. The landslide source area is located in the upper part of Monte Salta, and is controlled by the presence of the Monte Borgà thrust, which has superimposed the Vajont limestone, Jurassic in age, on the Scaglia Rossa marly limestone, Cretaceous in age. The thrust produced a highly fractured rock mass prone to rock falls and rock slides.

We determined different landslide hazard scenarios using STONE. The software was used to compute 3-dimensional rock fall trajectories starting from: (i) a digital terrain model with a ground resolution of 5 m $\times$ 5 m prepared by interpolating the contour lines obtained from topographic maps at 1:10,000 scale, (ii) a detailed map of the location of rock fall release points (the rock fall source areas), obtained through extensive field surveys – including GPS measurements – and the interpretation of stereoscopic aerial photographs, and (iii) maps of the dynamic rolling coefficient and of the coefficients of normal and tangential energy restitution, prepared in a GIS exploiting existing topographic, lithological and geomorphological maps, supplemented by field surveys. Field information on historical rock fall deposits, and rock fall trajectories, allowed calibration of the modelling parameters, and validation of the 3-D model results. Along the rock fall trajectories identified by STONE as those with a larger number of possible rock falls (i.e., most likely rock fall paths), we performed simulations using RocFall®. The latter software does not use a digital elevation model to represent the topographic surface, and the rock fall simulation is performed along topographic profiles defined a-priori by the investigator.

STONE and RocFall® provide similar (or at least comparable) outputs, including estimates of the rock fall energy, instant velocity, and distance to the ground (rock fall flying height, or rock fall bounce height). We examined the differences between the two modelling software by comparing the rock fall energy, velocity, and distance to the ground on a pixel by pixel basis. Results indicate that the two models provide reasonable similar results.