3-D rockfall simulation model using terrestrial LiDAR in the active Pajacuaran Fault, Mexico

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Introduction
The town of Pajacuaran, located northwest of the state of Michoacan, experienced an intense rockfall event at the beginning of November 2013 due to an exceptional rainy season. The high precipitation regime, the local seismic activity and the rugged topography, as well as the lack of a proper urban development plan, are only some of the factors that contribute to the rockfall hazard in this area. The purpose of this investigation is to evaluate the potential rockfall threat throughout a portion of the active Pajacuaran Fault.

Fieldwork
Phase 1: Preparation
Review records on historical events [1]
Map - Transit zone (deep-moderate)
 Deposit zone (gentle-flat)
Prepare model input data
Phase 2: Release scenario definition
Define release location, size and shape of blocks
Fig. 5: Rock face at release zone and block diameter > 2 m at deposit zone (from left to right)

Rockyfor3D
Phase 3: Rockfall simulation
Iteratively repeat simulations on Rockyfor3D [3,4]
Fig. 6: 1-meter resolution DEM of a portion of the Pajacuaran Fault, vertical offset of > 500 m.

Phase 4: Plausibility check & validation
Model results converge with real events [3,4]
Fig. 7: Input polygon map for Rockyfor3D [3] parameters.

Hazard Maps
Phase 5: Fixation of model results
Define valid runout zone
Fig. 8: Hazard zone map from Reach_probability.asc output raster.
Phase 6: Transformation into maps
Create spatially distributed datasets
Fig. 9: Rockyfor3D simulation results along slope profile.

Conclusions
- The blocks which release from steep rock faces (e.g. rock faces 1-2) achieved the furthest range and reached maximum velocities of up to 70 m/s, whereas blocks from less steep areas came to a stop relatively soon (e.g. below rock face 1).
- The rockfall paths concentrated in channels (e.g. rock faces 3-4), which is also where most of the blocks and the largest volume of material deposited.
- The maximum kinetic energies of over 110,000 kJ were reached where the slope gradient starts to decrease, near the middle of the rockfall trajectories or below steps in the terrain.
- The forest stand did not have much influence in the rockfall runout or in reducing the kinetic energy values, due to its low stem density and diameter distribution.
- These findings can be helpful to authorities in charge of decision making with regards to disaster prevention and mitigation, as well as to aid in the regulation of future expansion in these hazardous settings.

References

Further Information
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