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Numerical modeling of debris flows – Case study at Dorfbach, Randa (Valais, Switzerland)

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Debris flow occurrence in mountain torrents seems to have increased over the last few years - most likely due to glacier retreat and permafrost melting in high Alpine regions. Additional debris material is available, which serves as starting material for catastrophic debris flow events after heavy rainfalls or snow melting. As a result, it is increasingly important to better understand the physical mechanisms governing initiation, motion and settlement of debris flows. Numerical models, such as RAMMS (RApid Mass MovementS (Christen et al., 2010)) are used to study the dynamics and are valuable tools for hazard assessment and the design of mitigation measures in inhabited Alpine regions.

For the applied project “Hazard mapping in Mattertal (Valais, Switzerland): Data acquisition and numerical modeling of debris flows” we placed monitoring instruments in one of the mountain torrents (Dorfbach, Randa, Valais, Switzerland) including devices to measure front velocity and flow depths and a video camera providing visual information of an debris flow event. The newly gained data from Dorfbach combined with existing data from Illgraben (Valais, Switzerland) and other locations in the Alps can be used to investigate entrainment and deposition processes along the channel. The new knowledge on the dynamics helps to optimize the existing numerical debris flow model. Modeling results serve as a basis for hazard mapping and planning of mitigation measures.

We present 2D numerical simulations in a 3D terrain using RAMMS. The model is based on the 2D shallow water equations and incorporates the Voellmy friction relation. We performed simulations for different scenarios in order to asses different flow paths and deposition areas, which may have disastrous consequences for the population in the Mattertal. The ability to incorporate mitigation structures helps to evaluate the dimensions and the position of such structures in order to protect the populated areas.

On the basis of these results, we show weaknesses of the used Voellmy friction model. Comparison with natural events show that the reproduction of flow heights, runout distances as well as local deposition of material causing channel blockage are generally good but could be improved. Therefore, we are currently testing a modified version of the Voellmy friction model, where the friction is a function of the internal random kinetic energy of the flow (random kinetic energy model). Such a model generally allows a better description of the entrainment and deposition processes.

REFERENCES

Christen, M., Kowalski, J. and Bartelt, P. RAMMS: Numerical simulation of dense snow avalanches in three-dimensional terrain. Cold Regions Science and Technology 63 (2010) 1–14.