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Hydrology and slope mobility at the Heumöser landslide in the Austrian Alps (Vorarlberg)

Jan Wienhöfer (1,2), Falk Lindenmaier (3), and Erwin Zehe (1)

(1) Technische Universität München, Institute of Water and Environment, Hydrology and River Basin Management, München, Germany (j.wienhoefer@bv.tum.de), (2) University of Potsdam, Earth and Environmental Sciences, Potsdam, Germany, (3) Federal Institute for Geosciences and Natural Resources (BGR), Hannover, Germany

Extreme precipitation events are often crucial for the occurrence of landslides, but are by no means sufficient to explain the failure of large hillslopes. The Heumöser landslide near Dornbirn (Vorarlberg, Austria) experiences continuous, but slow deformations. Extreme precipitation events with over 200 mm rain per day, e.g. in 2005, caused failure of other slopes in Vorarlberg, but no catastrophic acceleration of the Heumöser landslide.

The interdisciplinary research unit "Grosshang" is working at Heumöser since 2006, combining experimental and modelling approaches to shed light on the factors that govern the movement dynamics of the large and heterogeneous landslide. This contribution focusses on parts of the field data from the Heumöser landslide which allow to characterise hydrology and movement dynamics. We present a synopsis of field experiments including tracer tests and three years of monitoring data including stationary inclinometers and pore-pressure sensors at three boreholes, monitoring of surface and subsurface waters, and a meteorological station at Heumöser. Hydrometric monitoring and tracer tests showed fast preferential infiltration and subsurface flow in the forested side slopes of the catchment, while the landslide body is mostly impervious with fine-tesxtured, stagnic soils. The inclinometers revealed deformations of the landslide body of about 0.1 m per year, mainly along a shear zone in about 10 m depth, while the continuous monitoring showed that the movement rate has a quite high intra- and inter-annual variability.

Statistical analyses of the movement dynamics show that these are not directly correlated with measured pore-pressure fluctuations, but with additionally modulation by subsurface flow near to the landslide body, antecedent precipitation, snow cover and/or fluvial processes at the hillslope toe. Furthermore, different combinations of predictors are found to have the most predictive value for various subsets when splitting the data set into smaller periods. These findings challenge attempts to model such systems.

Traditional top-down approaches as the Infinite Slope Model basically are linear models comparable to these statistical linear models, which means that parameters of the model would have to be non-stationary. To incorporate addional influences and feedbacks to mimic the observed dynamics, other modelling approaches are needed. Traditional bottom-up approaches, however, are still highly data-intensive and computationally demanding, and thus do not offer a straightforward solution. To overcome this problem, the Grosshang project follows the strategy of combining different sources of data and types of models to develop tools to simulate the interactions of flow and deformation processes at an appropriate level of complexity.

The monitoring data presented here are used within the group for parameterization or validation of numerical models. We further use the field experiments and hydrometric monitoring for process-based hydrological modelling of selected areas, where preferential flow processes have been observed. The idea is to use the larger scale hydrological models, which mimic observed hydrological surface and subsurface behavior, to generate initial and boundary conditions for the smaller scale complex models, which predict the location of the shear surface and accumulated deformations. Although the project is still ongoing, our results are promising up to now and make the Heumöser landslide an interesting case study.

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