Local scale groundwater modeling in a landslide. The case of Super-Sauze mudslide (Alpes-de-Haute-Provence, France)

Debieche T.-H., Marc V., Emblanch C., Cognard-Plançon A.-L. & Garel E.
UMR 7114 INRA-UAPV (ESMIAR), Université d’Avignon et des Pays de Vaucluse, Faculté des Sciences Exactes et Naturelles, 33 rue Louis Pasteur, 84000 Avignon, France
Bogaard T.A.
Water Resources Section, Faculty of Civil Engineering and Geosciences, Delft University of Technology, PO Box 5048, 2600 GA Delft, The Netherlands
Malet J.-P.
CRNS UMR 7616, School and Observatory of Earth Sciences, Université Louis Pasteur, Strasbourg, France

Introduction: the Super-Sauze mudslide is a typical complex landslide with huge soil heterogeneity, matrix and preferential flow and spatial differences in landslide dynamics. The quantification and modelling of the hydrological behaviour is challenging as well as very relevant because hydrology determines to a large extent the landslide dynamics and forecasting or planning of mitigation need thorough understanding of underlying physics. To achieve this, we have setup a large scale infiltration (100 m²) and tracing experiment. In this poster we will present the experimental setup and we will discuss preliminary results of the unsaturated-saturated zone modelling of the experiment.

Situation and experimental setup: The Super-Sauze mudslide is located in the South East France. The elevation ranges from 1740 to 2105 m and the area is 17 ha. The geology is mostly Callovo-Oxfordian black marls. Artificial rainfall was applied to a 100 m² plot, where slope averaged 20°. The instrumentation comprised of 6 sprinklers, 15 standard rain gauges, 12 tensiometers located between 0.2 and 0.7 m deep, 7 soil moisture sensors and 38 piezometers for water level measurements, 1 and 3 m deep. Artificial rainfall was applied over a period of 14 days (10/23/2007). KBr was used as tracer during the first week (10/16/2007) whereas KCl was used during the second week (17/23/2007). The mean rainfall intensity was 8.5 mm.h⁻¹ with a mean tracer concentration of 100 mg.l⁻¹ (for both Cl⁻ and Br⁻).

Water level variations and choice of the simulation period: the hydrodynamic monitoring showed different hydrodynamic behaviors (medium and low variation of groundwater levels) in the subsurface piezometers.

Modeling sections: two sections were set up parallel to the flow direction for the model purpose: one on the left side (West) of the plot (apparent fissured part) characterized by several fissures of different length (up to 2 m) and depth (10 to 25 cm) and the other on the right side (East, no apparent fissured part). The features of these sections are: 1) there was no lateral flow (from west to east) and 2) there were several piezometers equipped with automatic recorders of water head.

Characteristics and boundary conditions of the model: the boundary conditions of the section consisted upstream of a constant groundwater flux. The lower boundary at the contact limit with the substratum was set to a no flow boundary condition. An atmospheric boundary condition consisting of rainfall and evaporation and surface runoff at the soil surface was chosen at the surface. The section limits were situated at 50 m upslope and 20 m downslope from the experimental area, so that the boundary conditions had negligible impact on the groundwater flow.

Results: 1) the case of piezometers characterised by large water level variation and "normal" sampling (3 or 6 hours sampling time step): the model simulated fairly well the groundwater level (BI-1 and BI-18). The small difference between measured and simulated values can mainly be attributed to the error in the initial conditions.

2) the case of piezometers characterised by large water level variation, "normal" sampling (3 or 6 hours sampling time step) and macroscopic connection (piezometer BI-C): the model simulated fairly well the normal groundwater level evolution, but was unable to simulate the water table variation due to the macroscopic connection (soil structure variation over the time of the experiment).

3) the case of piezometers characterised by large water level variations and with intensive sampling (1 hours sampling time step): the model fitted well with the observation over the starting and recession periods but not during the sampling period. Most probably this error is due to the uncertainty in sampling discharge. The impact of sampling was not correctly simulated because the nodal discharge was kept constant for all the period whereas water sampling resulted in an intermittent process of water extraction.

4) the case of piezometers with low variations and "normal sampling": the model performed poorly (BI-2 and BI-9). This could be due to the calibration criteria, which was focussed on optimising high dynamic groundwater behaviour and not matrix flow.

Conclusion: the results of the flow simulations indicated that the large water levels variations were well estimated by the model, but the low groundwater variations were overestimated. This is a consequence of the models calibration chosen to simulate fissure flow dynamics rather than matrix flow dynamics. This also resulted in a large difference between the hydraulic conductivities used in the models (10⁻⁴ m.s⁻¹) and measured in the field (10⁻⁷ to 10⁻⁹ m.s⁻¹). In locations where soil macro permeability has been detected (from artificial tracing results), the models performed badly. These results showed the limitations of the traditional groundwater modelling approach in such environment. They showed the need to have a stepwise modeling approach with progressive complexity to fit the system heterogeneity. Assimilation of geotechnics data and information on mudslide movement in the models is also required to improve the simulation of the flow processes.