



## **Process dynamics and early warning strategies for a preparing high-magnitude rock slope failure at the Hochvogel (Allgäu Alps)**

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Alpine hazards are a significant threat to alpine communities, infrastructure and economics and are expected to increase in the future. Climatic changes and population growth will enhance the risk caused by alpine mass movements requiring a precise understanding of the underlying processes. Due to high costs for maintenance and reinstallation of protective structures, clever early warning and anticipation strategies based on the process dynamics are agreed to be a key strategy for alpine societies in the near future.

As part of the AlpSense-Project ([www.landslides.geo.tum.de/alpsensebench](http://www.landslides.geo.tum.de/alpsensebench)) we observe a large preparing rock slide at the Hochvogel summit (2592 m a.s.l., Allgäu Alps). The Hochvogel is currently a benchmark site to gain insights into slope failure dynamics and for developing an effective early warning system.

The main crack is two to eight metres wide and boulders are blocked in the crack in almost ten metres depth. The sliding mass has moved downward by about three metres compared to the back scarp edge. Analysis of historical ortho- and aerial images yield an elongation of the main crack length from 10 to 35 m from 1960 until now. In addition, almost 1.500 UAV photos have been used to generate a 3D model of the extended summit area which we used for tracing geomechanically relevant structures. After deviating a kinematic model, the volume of the potentially failing mass has been calculated. In total, geomechanically relevant cracks and weak layers are delimiting six separated subunits of 8.000 to 148.000 m<sup>3</sup> which account for 260.000 m<sup>3</sup> in total. The pre-deformation is yet not pronounced enough to decide on the expected volume.

Since 2014 discontinuous extensometer measurements in the main crack were carried out to determine movement rates of the instable mass. The crack opened over 30 cm between 2014 and 2018 with movement rates of up to 1 cm/month. To improve the temporal resolution and in preparation of an early warning system eight vibrating wire gauges have been installed in July 2018 in the main and lateral cracks. Once a minute data are transmitted wireless to a safe server together with temperature and rain measurements from site.

Here we demonstrate first results from a preparing alpine rock slope failure including a high-resolution movement record and corresponding geodetic, photogrammetric, seismic and gravimetric measurements. The comprehensive measurement design at the Hochvogel fosters our understanding of the process dynamics initiating alpine rock slope failures and will help to better predict events in future.