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Empirical and numerical investigation of mass movements - data fusion and analysis

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Increasing settlement activities of people in mountanious regions and the appearance of extreme climatic conditions motivate the investigation of landslides. Within the last few years a significant rising of disastrous slides could be registered which generated a broad public interest and the request for security measures.
The FWF (Austrian Science Fund) funded project ‘KASIP’ (Knowledge-based Alarm System with Identified Deformation Predictor) deals with the development of a new type of alarm system based on calibrated numerical slope models for the realistic calculation of failure scenarios. In KASIP, calibration is the optimal adaptation of a numerical model to available monitoring data by least-squares techniques (e.g. adaptive Kalman-filtering). Adaptation means the determination of a priori uncertain physical parameters like the strength of the geological structure.
The object of our studies in KASIP is the landslide ‘Steinlehnen’ near Innsbruck (Northern Tyrol, Austria). The first part of the presentation is focussed on the determination of geometrical surface-information. This also includes the description of the monitoring system for the collection of the displacement data and filter approaches for the estimation of the slopes kinematic behaviour. The necessity of continous monitoring and the effect of data gaps for reliable filter results and the prediction of the future state is discussed.
The second part of the presentation is more focussed on the numerical modelling of the slope by FD- (Finite Difference-) methods and the development of the adaptive Kalman-filter. The realisation of the numerical slope model is developed by FLAC3D (software company HCItasca Ltd.). The model contains different geomechanical approaches (like Mohr-Coulomb) and enables the calculation of great deformations and the failure of the slope. Stability parameters (like the factor-of-safety FS) allow the evaluation of the current state of the slope. Until now, the adaptation of relevant material parameters is often performed by trial and error methods. This common method shall be improved by adaptive Kalman-filtering methods. In contrast to trial and error, Kalman-filtering also considers stochastical information of the input data. Especially the estimation of strength parameters (cohesion c, angle of internal friction phi) in a dynamic consideration of the slope is discussed. Problems with conditioning and numerical stability of the filter matrices, memory overflow and computing time are outlined. It is shown that the Kalman-filter is in principle suitable for an semi-automated adaptation process and obtains realistic values for the unknown material parameters.