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# Landslide early warning models - five applications within the ILEWS project

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Landslide early warning systems are a good choice if hazards cannot be avoided or if remedial actions are too costly or impossible. Landslide early warning systems are often site-specific and cannot easily be transferred to other regions or even to other landslide processes. One of the main goals of the ILEWS project is the development of transferable early warning concepts starting by the sensor in field and modelling early warning, and ending with user-optimized action advises embedded in a holistic risk management strategy.

In our presentation we discuss five landslide early warning models applied in the ILEWS project of which four are aiming at the local scale and single slopes and one at the regional scale.

The local study area is located on an extremely slow moving complex rotational landslide in the Swabian Alb, southwest Germany. A slow moving landslide was chosen to ensure that monitoring equipment does not get destroyed before the developed models can be tested extensively. A monitoring system with inclinometers, geoelectric profiles, TDR sensors and tensiometers, a geodetic network and a weather station was installed on the slope and data is utilized in the consequent early warning modelling. The regional model was applied to the Swabian Alb and to the region of South Tyrol, Northern Italy.

The first local model is based the physically-based slope stability program CHASM (Combined Hydrology and Stability Model). Slope stability is continuously calculated on a web-processing service. Further on, registered users can create their personal simulations by selecting individual profiles by clicking on a map, and choosing scenarios for rainfall and slope moisture.

A second model applies the concept of progressive failure to the slope. Warning is issued when a sudden increase in movement speed is reported by a stationary inclinometer chain.

The third model utilizes the analysis of critical thresholds initiating movements. Definition of these thresholds is based on the empirical analysis of data from the monitoring system.

A fourth model uses geodetic adjustments and dynamical deformation analysis to model surface and subsurface movements as a consequence of slope hydrological processes. Threshold values are determined considering the forms and characteristics of landslides velocities which correspond to specific precipitation events.

On the regional scale rainfall thresholds are implemented in a Web-GIS and connected to weather forecasts to define situations favouring the initiation of landslides and debris flows.

In the presentation, all early warning models are compared in their character and methods. Further on, technical demands, strengths and limitations as well as their applicability to other areas are discussed.