Geophysical Research Abstracts
Vol. 20, EGU2018-15780, 2018
EGU General Assembly 2018

Landslide Early Warning Systems – challenges from local monitoring to regional risk governance

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Landslides change our environment continuously as an on-going process and are a crucial part within landscape evolution. Hereby, the "landslide" processes range from rock slides and falls to shallow and deep-seated translational and rotational slides to debris flows, including also complex movements. These operate at a variety of magnitudes and at completely different frequencies and are initiated or remobilized by a range of natural or human related triggers. At the same time, human spread also into landslide prone regions exposes the society towards these natural process. Landslide have direct impacts, but their occurrence may also influence settings far away. Furthermore, impacts range from short-term effects to long-lasting consequences, for both the environment and/or the society. Consequently, there is an increasing societal demand to receive early warnings for landslide movements as well as for potential consequences.

This paper will explore the different settings and conditions of landslide instrumentations required for local, object based and for spatial, regional early warnings. Based on a variety of examples, common solutions and implementations of implementing landslide early warnings systems are presented and related to the demands on such systems. In addition, the societal expectations are outlined requiring "protection" and "security". These will be explored based on the risk cycle, which is a supportive concept to be applied to landslide early warning. Furthermore, the innovations required to link local information to spatial assessments are addressed.

Finally, challenges will be delineated from both a review of existing landslide early warning systems and own experiences from a local monitoring system. These will include some advances on measurement equipment including surface and subsurface sensors, but also on risk governance principles and the respective consequences.