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Long term real-time monitoring of large alpine rockslides by GB-InSAR: mechanisms, triggers, scenario assessment and Early Warning

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Large rockslides in alpine valleys can undergo catastrophic evolution, posing extraordinary risks to settlements, lives and critical infrastructures. These phenomena are controlled by a complex interplay of lithological, structural, hydrological and meteo-climatic factors, which eventually result in: complex triggering mechanisms and kinematics, highly variable activity, regressive to progressive trends with superimposed acceleration and deceleration periods related to rainfall and snowmelt. Managing large rockslide risk remains challenging, due the high uncertainty related to their geological model and dynamics. In this context, the most promising approach to constrain rockslide kinematics, establish correlations with triggering factors, and predict future displacements, velocity and acceleration, and eventually possible final collapse is based on the analysis and modelling of long-term series of monitoring data. More than traditional monitoring activities, remote sensing represents an important tool aimed at describing local rockslide displacements and kinematics, at distinguishing rates of activity, and providing real time data suitable for early warning.

We analyze a long term monitoring dataset collected for a deep-seated rockslide (Ruinon, Lombardy, Italy), actively monitored since 1997 through an in situ monitoring network (topographic and GPS, wire extensometers and distometer baselines) and since 2006 by a ground based radar (GB-InSAR). Monitoring allowed to set-up and update the geological model, identify rockslide extent and geometry, analyze its sensitivity to seasonal changes and their impact on the reliability and EW potential of monitoring data. GB-InSAR data allowed to identify sub-areas with different behaviors associated to outcropping bedrock and thick debris cover, and to set-up a “virtual monitoring network” by a posteriori selection of critical locations. Resulting displacement time series provide a large amount of information even in debris-covered areas, where traditional monitoring fails. Such spatially-distributed, improved information, validated by selected ground-based measurements, allowed to establish new velocity thresholds for EW purposes. Relationships between rainfall and displacement rates allowed to identify different possible failure mechanisms and to constrain the applicability of rainfall EW thresholds. Comparison with temperature and snow melting time series allowed to clarify the sensitivity of the rockslide movement to these controlling factors. Finally, the recognition of the sensitivity to all these factors allowed us to accomplish a more complete hazard assessment by defining different failure scenarios and the associated triggering thresholds.