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Site-specific landslide assessment in Alpine area using a reliable integrated monitoring system

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Rockfalls are one of major cause of landslide fatalities around the world. The present work discusses the reliability of integrated monitoring of displacements in a rockfall within the Alpine region (Salzburg Land – Austria), taking into account also the effect of the ongoing climate change. Due to the unpredictability of the frequency and magnitude, that threatens human lives and infrastructure, frequently it is necessary to implement an efficient monitoring system. For this reason, during the last decades, integrated monitoring systems of unstable slopes were widely developed and used (e.g., extensometers, cameras, remote sensing, etc.). In this framework, Remote Sensing techniques, such as GBInSAR technique (Groung-Based Interferometric Synthetic Aperture Radar), have emerged as efficient and powerful tools for deformation monitoring. GBInSAR measurements can be useful to achieve an early warning system using surface deformation parameters as ground displacement or inverse velocity (for semi-empirical forecasting methods). In order to check the reliability of GBInSAR and to monitor the evolution of landslide, it is very important to integrate different techniques. Indeed, a multi-instrumental approach is essential to investigate movements both in surface and in depth and the use of different monitoring techniques allows to perform a cross analysis of the data and to minimize errors, to check the data quality and to improve the monitoring system.
During 2013, an intense and complete monitoring campaign has been conducted on the Ingelsberg landslide. By analyzing both historical temperature series (HISTALP) recorded during the last century and those from local weather stations, temperature values (Autumn-Winter, Winter and Spring) are clearly increased in Bad Hofgastein area as well as in Alpine region. As consequence, in the last decades the rockfall events have been shifted from spring to summer due to warmer winters. It is interesting to point out that temperature values recorded in the valley and on the slope show a good relationship indicating that the climatic monitoring is reliable. In addition, the landslide displacement monitoring is reliable as well: the comparison between displacements in depth by extensometers and in surface by GBInSAR - referred to March-December 2013 - shows ad high reliability as confirmed by the inter-rater reliability analysis (Pearson correlation coefficient higher than 0.9). In conclusion, the reliability of the monitoring system confirms that data can be useful to improve the knowledge on rockfall kinematic and to develop an accurate early warning system useful for civil protection issues.