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Mass movement monitoring by Terrestrial Laser Scanning on Madeira Island (Portugal)

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The terrestrial laser scanning (TLS) is an effective remote sensing technology for reconstruction and observation of mass movement phenomena and related hazards as it is well founded of high spatial and temporal resolution. TLS has been used for the investigation of landslides (slides, rock falls, and flows) at different sites on the volcanic island of Madeira, Portugal. These mass movements provide a potential hazard for population and infrastructure and led to fatalities and serious damages in the past. First measurements have been conducted in spring 2008 and a second campaign took place in fall 2008. In the future, semi-annual laser scanning will provide the possibility to establish a monitoring and to identify the mechanisms of mass movements in detail. The data acquisition with the TLS method and high-resolution spatial surface analysis can help to improve data quality and density for a higher accurate monitoring and subsequently better prediction of the mass movements. Major aims of our investigation are to find quantitative and qualitative data for the engineering geology. In this context the detailed structural analysis of rock surfaces and the slope stability analysis are fundamental. Other scientific goals are the analysis of rock surface roughness in different scales and types, which is of interest to determine relative age and exposure of rock faces and is of importance for engineering geological stability analysis. Besides this small scale roughness analysis (mm – dm), investigation of terrain roughness from high resolution digital elevation models (HRDEM) for rock fall modelling, but also geomorphologic studies for hazard analysis is important. HRDEM can help to describe terrace developments, debris cones or ancient landslides and their interactions in terrain evolution. Especially these hidden elements are important to quantify processes for historical landslide analysis in the course of a hazard analysis. Furthermore the intensity of reflexivity of diverse rocks can help to identify semi-automatically different rock types and weathering stages, e.g. in large rock faces. TLS provides an excellent method for not accessible and especially unstable areas by joint analysis in terms of orientation, extent, distribution and density of joints, which are important input parameters for stability analysis. In the areas with debris flow hazard the monitoring of source areas and mass balances in deposition areas are possible to quantify the potential of debris flow material. In the future course of our research the process knowledge of the monitored mass movements will be used for the mapping, verification and validation of hazard zones. Additionally, geodetic measurements with compass and GPS are carried out to cross-validate the quality of the TLS point cloud data. Coevally, mineralogical and geotechnical investigations in areas with high active clays and different types of volcanic rocks will be used to determine the mechanical properties of the materials, which are subject under the Madeira climate to fast erosion and weathering, driven by very high precipitation and silicate alteration.