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Evaluating synergy effects of combined close-range and remote sensing techniques for the monitoring of a deep-seated landslide (Schmirn, Austria)

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In the recent past, studies on the monitoring of deep-seated landslides included a multitude of measuring techniques. Direct and indirect methods are applied for displacement measurements at points, along lines or area-wide. In particular close-range and remote sensing has proven to be feasible for the detection of displacements featuring a high accuracy (range of cm to dm) while covering the whole area of interest. However, a combination of supplementing methods is preferable to confirm the observations and to overcome their individual drawbacks and limitations. In the present study, displacements of a deep-seated landslide situated in the Schmirn valley (Tyrol, Austria) are assessed by (i) image correlation of existing orthophoto series, (ii) multi-temporal data acquisitions using a terrestrial laser scanner (TLS) and (iii) repeated measurements with the help of a differential global positioning system (DGPS). The study focusses on evaluating the synergy effects of the tested methods in quantifying the landslide's movement. Limitations concerning their spatial resolution and accuracy are addressed in specific detail. The landslide's activity is likely controlled by hillslope hydrology and its seasonality. Phases of enhanced movement are expected in the course of snowmelt and after exceptional rainfall events. Preliminary results of the image correlation reveal mean annual horizontal displacement rates of 0.75 m ($\pm$0.45 m; one standard deviation), which is confirmed by the DGPS measurements. The first results also suggest constant annual displacement rates for the period of 2004 to 2015. Further comparisons with the multi-temporal TLS data will reveal detailed spatial patterns of displacement rates and deepen the understanding of the landslide's kinematics.

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