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Applications of terrestrial laser scanning in natural hazard sciences

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Application of terrestrial laser scanning (TLS) is more and more common in environmental studies. In fact, the TLS is the computer tomograph or microspope for landscape research. However, often there are only few thoughts about possible measurement errors, achievable precision and limitations for certain applications. This contribution reviews the use of TLS within different applications in the field, achievable results and limitations to consider.

(i) In rockfall research laser scanners are used for analysing the volumetric shapes of fallen rocks or endangered rock faces to estimate rockfall energies and boulder details for trajectory simulations. In this case, the typical distance to the object measured stays rather small with 0 to 30 m. Precision is sufficient in the millimetre range and resolution should deliver 0.5 - 2 points per cm.
A rockfall slope analysis usually covers a larger area that has to be scanned from several positions, and - if possible – from the other valley side. In the first case mid-range scanners are fine with a scan distance of up 300 m, the latter requires often long range equipment. The resolution usually requires not more than a few point per metre.

(ii) Shallow landslides can be quantified, i.e., their release and deposit volume can be measured through TLS. For this mid-range devices up to a couple of hundreds meters with a resolution of 5 to 10 points per metre are practical.

(iii) River beds exhibit continuous change. Here the scan range has not to be very large, since, the amount of shading sediments in the river bed require the combination of many scan positions. Precision and resolution strongly depend on sediment dimensions and the research interests and may therefore vary between single points every cm and one point every m. Detecting erosion however will require accuracies below 1cm and therefore application of a short range scanner.

(iv) Scanning snow surfaces show special requirements according to the high reflectivity and the usage temperature. Precision varies between 1 cm and 10 cm. Usually, long range scanners are used to characterize dimensions and entrainment of avalanches to validate and improve dynamic avalanche models. This technology also allows accurately monitoring and modeling the seasonal evolution of the spatial distribution of the snow pack, which is relevant to estimate the total amount of snow water equivalent within a small catchment during wintertime and its melt water release in early summer.

(v) Monitoring of mountain faces, too, usually requires long range scanners. However, if weather conditions are bad (typical for rockfall situations) there will not be satisfying results. For these applications RADAR might produce better results.

(vi) Investigations of protection systems can be done very efficiently using laser scanners for deformation analyses, impact volumes, retention capacity etc. The requirement on precision varies between mm and cm and the resolution between 5mm (net systems) and 50cm (dam constructions).