THE APPLICATION OF TERRESTRIAL LASER SCANNING FOR MONITORING NATURAL HAZARDS

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Terrestrial laser scanning is used as a helpful observation method in hazard assessment to collect 3D data from changing landscape surfaces, to obtain information about the current states of natural hazard processes. Three different applications of terrestrial laser scanning for monitoring natural hazard are presented to better understand the method of application, based on the outcome of previous investigations. The three different applications include determination of spatial snow depth distribution on slopes, landslide monitoring, and debris flow experiment observation.

DETERMINATION OF THE SPATIAL SNOW DEPTH DISTRIBUTION

The determination of the spatial snow depth distribution in potentially dangerous avalanche-starting zones is vitally important, both in terms of avalanche-prediction and dimensioning of permanent protection measures. Unfortunately, inaccessibility of the alpine terrain, as well as the acute danger of avalanches complicates snow depth measurements. Therefore, the possibility of measuring the snow pack using a terrestrial laser scanner was tested.
In use was the long-range laser profile measuring system Riegl LPM-i800HA. Without the use of a retroreflector, the scanner calculates the distance to the surface in question, based upon the time-of-flight measurement of a short laser pulse. The measuring range is up to 800 m, but is depending on the weather-situation and the reflecting condition of the snow pack. The wavelength is 0.9 µm (near infrared), the accuracy is typically within 30 mm and the highest resolution is 1mm. For adding global coordinates the registration process was executed using tie point target tapes.
The objectives of the study includes to prove under which meteorological conditions and state of the snow pack and technical circumstances the measurements have to take place to show accurate results. The results of the measurements at test sites in the Austrian Alps (Lech am Arlberg, site area 500 x 500 m, scanning time 2 hours) show that in comparison to alternative methods such as tachymetry and snow probing spatial snow depth maps could be generated within an accuracy range of 15 cm (distance to target: 500 m).

LANDSLIDE MONITORING

Landslides are very complex natural hazard processes and have been investigated in various ways. In the framework of the EU-Alpine Space Interreg III B project ClimChAlp terrestrial laser scanning (TLS) is evaluated, in comparison to other monitoring techniques, for its application in landslide monitoring. The purpose of this research project is to compare data of the TLS measurements with traditionally gained data from tachymetry about the mass movement processes. The research question is to discover to what extent the application of

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TLS is relevant, while still acquiring process able conclusions concerning the movement patterns.
Because a high degree of accuracy is the primary requirement for this application, the RIEGL LMS-Z420i was chosen as the experimental device. The accuracy of the distance measurement is given by the manufacturer of the device to be up to 10 mm, the beam width 0.25 mRad, and the range 1000 m. The combination with a calibrated and oriented high resolution digital camera created a hybrid sensor system, which is needed for the investigation of slope parallel movements (i.e. creation of orthophotos).
The monitored landslide „Galierm“(Vorarlberg, Austria) represents a best practice example including the following site characteristics: the distance between scanner position and the slope monitored is in a range of 120 m (dimensions of test area 100 x 100 m, scanning time 40 min.); the expected movement rate within the test period is > 15 cm; the monitored slope is 70% free of vegetation; the incident angle of the laser beam on the slope is within a reasonable range. Determination of the erosion and deposition behavior of the moving slope was only possible with the laser measurement, tachymetry failed with regard to this particular application. The accuracy of the investigation of height differences between two surface hulls lies within a range of 50 mm (determined by reproducibility tests). Before concluding movement behaviors, the results need to be interpreted concerning the point density of the zones of interest. To measure the difference in position of a single point, the laser measurement lack accuracy in comparison to tachymetry (caused by e.g. larger beam diameter and an imprecise registration process). But still, it was possible to determine a 3D position of a point of interest within an accuracy range of 50 mm (distance to target: 120 m).

DEBRIS FLOW EXPERIMENT OBSERVATION

Debris flows present a serious hazard in alpine regions. The material incorporated in debris flows is inherently complex, varying from clay sized solids to boulders of several meters of diameter.
For geoscientists it is important to predict possible triggering zones and deposition areas or run out lengths. Run out analysis is an especially important component for hazard assessment in alpine watersheds, which includes prediction of potential hazard areas and mapping the distribution of hazard intensity parameters such as the thickness of the deposit.
Terrestrial surveying approaches are difficult due to the fact that information about both before and after debris flow events happen, needs to be collected, which assumes the knowledge of the time and the location such an event occurs. Therefore real scale experiments have been carried out since 2002 in southern Vorarlberg in the area of Schesatobel for investigating different parameters of debris flows.
In 2006 for the first time a detailed survey by TLS was executed for the deposits the experiment causes. For this application the RIEGL LMS-Z420i was chosen as well. While the accuracy of the measurements was not a primary deciding factor for the choice of the RIEGL LMS-Z420i, high scanning speed was required depending on the time-frame of the experiment (30 min.).
The objectives of the TLS survey of the debris flow real scale experiment were to determine the volume of the deposited mass as well as detect zones of erosion and deposition. Spatial erosion and deposition heights could be investigated within an accuracy range of 40 mm (determined by a reproducibility test). Approximately 810 m^3 of material was moved to the deposition zone at a deposition length of 82.5 m, admittedly a rather small debris flow.

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