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Change Detection of Geological Surfaces by Image-Based Sensor Systems

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While long term erosion rates may be estimated by dating methods, current day erosion rates are – if at all available – based on rough estimates or on point measurements. Precise quantification of short term erosion rates are required to improve our understanding of short term processes, for input in landscape evolution models, as well as for studying the mechanics and efficiency of different erosion processes in varying geomorphological settings.

Typical current day erosion rates in the European Alps range from sub-millimetre to several millimetres per year depending on the dominant erosion processes. The level of surveying accuracy required for recurring sub-millimetre to millimetre measurements in the field is demanding.

Our project is focused on the development and installation of new techniques for detecting "surface changes" with the accuracy needed. The experimental part has been divided into two steps. A) Tests in the laboratory under well constrained conditions, and B) tests in the field. For field tests three bedrock samples of different lithology were installed in a debris flow channel (Illgraben in Switzerland). Samples were placed in a bed of concrete and fixed to a check dam already present in the flow channel. The expected erosion rate in this channel was assumed to allow for recurrent measurements after single debris flow events.

A twofold measurement approach was chosen. For the first setup control points providing an absolute reference frame for recurrent measurements were embedded in the concrete next to the bedrock samples. A photogrammetric technique was developed to measure surface changes on the bedrock samples. Comparison of two measurement epochs revealed very little erosion, but also allowed to calculate the precision of the technique. The reference frame was recovered in the second epoch with a precision of 0.025 mm. Mass point measurement on the bedrock samples was performed by automated image correlation techniques. Assuming no erosion, the precision of the matching results, comparing both epochs, was 0.050 mm and better for the three rock samples. Images of the surfaces were covering approximately 1 m^2, and the whole workflow may be extended to cover even larger areas. Fixing the reference points next to the bedrock samples is straight forward, but may disturb the vicinity of the samples or the point may be eroded themselves.

Therefore a second approach was followed as well. In this case the measurements were taken with an image assisted total station. The setup of the total station is calculated on a network of control points in the surroundings of the debris flow channel. Images of the area of interest were taken with the digital sensor in the focal plane of the total station. Stereo photogrammetry and automated image correlation techniques were used to generate elevation models from the bedrock surfaces.

Comparative measurements of both techniques are only available for laboratory experiments simulating field conditions. Measurements with both techniques will continue for another summer debris flow season.