Title
Characterization of Geomorphological Surface Activities Using Near-Continuous Terrestrial LiDAR Time Series: The classification of 4D objects-by-change

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Abstract

The Earth's landscapes are shaped by processes eroding, transporting, and depositing material over various timespans and spatial scales. To understand these surface activities and mitigate potential hazards they inflict, knowledge is needed of their occurrences and properties. Near-continuous terrestrial laser scanning (TLS) enables the acquisition of point cloud time series, constituting up to thousands of three-dimensional surface morphology representations. Exploiting the full potential of this large amount of data by extracting and characterizing different types of surface activities inside these point cloud time series is, however, challenging.

This thesis addresses this challenge by developing an automated and unsupervised method for classifying 4D objects-by-change (4D-OBCs). These 4D-OBCs represent the spatiotemporal extent of individual surface activities in a point cloud time series. They are classified using a Self-organizing Map (SOM) and hierarchical clustering, grouping them into different levels of surface activity types. The workflow is tested on its ability to characterize surface activities in two study areas, a sandy beach and a snow-covered Alpine area.

Application of an optimized SOM configuration on the sandy beach results in groups of 4D-OBCs physically interpretable as different types of surface activities. A validation dataset containing 51 manually labeled 4D-OBCs of various surface activity types (e.g., intertidal bar depositions, anthropogenic bulldozer depositions) is distributed over the SOM generally according to the labels provided. The SOM thus enables the identification of 4D-OBCs displaying a particular type of surface activity, as well as subtle differences between events of one surface activity. Hierarchical clustering allows us to find and characterize broader groups of surface activities, even if the same type occurs at different points in space or time. For example, the varying spatial redistribution of sand through the initiation of different types of surface activities after the destruction of an intertidal bar system under different environmental conditions is successfully studied.

A nearly identical workflow configuration applied on the snow cover 4D-OBC set does not result in equal performance. Several groups of surface activity in the SOM contain a combination of 4D-OBCs representing different surface activity types. These results highlight the necessity of a study area specific workflow optimization by selecting specific features and SOM configurations. However, if optimized for the specific environment, the workflow has the potential to be used in long-term automated monitoring of surface activity in systems with complex morphological interactions, increasing the applicability of TLS for studying geomorphological change.