Geophysical Research Abstracts
Vol. 14, EGU2012-11485, 2012
EGU General Assembly 2012

High-resolution Terrestrial Laser Scanning (TLS) on cushion peatlands – a case study from the Peruvian Andes

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So-called cushion peatlands located in the high mountain areas of the Peruvian Andes are unique ecotopes, which are of major importance for both palaeoenvironmental reconstructions and permanent water supply of the valley oases in the presently hyperarid Peruvian desert. In this context, a case study was performed on the Cerro Llamoca peatland (southern Peru, province Lucanas, 14° S) in the uppermost reaches of the Rió Grande catchment area (4000-4450 m a.s.l.) within the framework of the BMBF-funded project 'Andean Transect – Climate Sensitivity of pre-Columbian Man-Environment-Systems' and serves as a basis for a long-term, multitemporal observation study.

As small-scale geomorphologic investigations require high-resolution elevation data, which is still not available for this remote study site, and local microrelief is characterised by features not visible from aerial view (e.g. channel cuttings within the peatland), terrestrial laser scanning (TLS) was applied. Data acquisition was carried out with one of the latest 'time-of-flight'-scanners (Riegl VZ-400). A total of 46 positions was recorded to capture the whole area of interest leading to more 370 million single laser points within an area of approximately 1,8 km^2. Registration of scan positions was performed by means of GPS measurements, coarse registration and the iterative closest point (ICP) algorithm provided by the plugin Multi-Station Adjustment within the RiSCAN PRO software (Riegl). The large amount of output data required the use of special LiDAR software for further processing and digital elevation raster generation (OPALS software).

The defined target raster resolution was set to values between 0.1 and 2 m depending on the average point density. It is important to have access to the original point cloud including additional laser point attributes (e.g. signal amplitude and echo width) for digital terrain model generation (i.e. terrain point filtering) and geomorphologic mapping by means of segmentation and object-based classification. Furthermore, multitemporal investigation of the study area requires co-registration of the datasets of the different epochs to each other, which is best performed using the original point cloud. This guarantees high accuracy of elevation change estimation and, thus, volume change assessment. Geomorphologic microscale features can be analyzed in, by now, inaccessible details and therefore also short term events with only little impact can be investigated.

The outcomes demonstrate the great suitability of terrestrial laser scanning for fast and high-precision mapping, particularly in isolated terrains at high altitudes like the Peruvian Altiplano. Future investigations will focus on data fusion of surface and subsurface data derived from geophysical measurements. In combination with vibra coring, chronometric dating and geochemical analysis palaeoenvironmental 3D reconstructions over time are possible. With regard to recent water storage capacity, new approximations can be carried out. Additionally, the determination of erosion and degradation rates will be possible at high resolutions.