Geophysical Research Abstracts
Vol. 19, EGU2017-9130, 2017
EGU General Assembly 2017

Detectability and geomorphometry of tufa barrages in a small forested karstic river using airborne LiDAR topo-bathymetry

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Tufas are secondary carbonate precipitations which occur ubiquitously in karstic environments. Thus, freshwater tufas are increasingly noticed as a high-resolution terrestrial paleoclimate archive. However, complex interactions between climate, hydrology and geomorphology drive tufa landscapes as a self-organizing system that creates a patchy transition zone between land and water at the decimeter scale. These feedbacks challenge the modern analogue technique to understand paleo-tufa evolution and require a detailed 3D characterization of tufa geomorphometry to better understand their shaping processes in relation to channel bed morphology.

Due to the complex geometric nature of tufa landscapes and predominant land-water transition zones, new remote sensing techniques such as airborne sub-meter footprint LiDAR topo-bathymetry (ALTB) are necessary to enable a detailed 3D description. Using the Riegl VQ-820-G at the Kaisinger Brunnenbach, Germany, we successfully detected submerged and subaerial tufas with maximum total dam heights from 0.3 m up to 1.6 m (cf. Profe et al. 2016). In addition, slope and openness derived from a high-resolution digital terrain model (DTM) with 0.2 m spatial resolution provide insights into barrage morphology and orientation. We found that longitudinal slope analysis along the river course relates tufa morphology to channel bed morphology. Raster-based data quality control of the LiDAR topo-bathymetric DTM reveals an overall vertical data precision of 3 cm and an overall vertical data accuracy of 15.4 cm (1σ) (Profe et al. 2016).

The 3D characterization of tufa landscapes facilitates the identification of monitoring and drilling sites for subsequent hydrological and geochemical studies that deepen our knowledge about the complex barrage formation processes. In the advent of UAV-borne LiDAR platforms, we are convinced that it becomes possible to reduce data uncertainty and to better represent e.g. tufa overhangs, vegetation cover and incorporated plant material. Furthermore, our findings may foster research in other disciplines that work on small-scale land-water transition zones and are interested in a detailed 3D geomorphometric description derived from 3D point clouds directly.

Reference:

Profe, J., Höfle, B., Hämmerle, M., Steinbacher, F., Yang, M.-S., Schröder-Ritzrau, A., Frank, N., 2016. Characterizing tufa barrages in relation to channel bed morphology in a small karstic river by airborne LiDAR topo-bathymetry. Proceedings of the Geologists' Association 127: 664-675. doi:10.1016/j.pgeola.2016.10.004