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Documentation of dislocated boulders and monitoring of coastal sites in western Greece by terrestrial laser scanning and dense image matching

Dirk Hoffmeister (1), Constanze Curdt (1), Björn Röbke (2), Andreas Vött (2), and Georg Bareth (1)

(1) Institute of Geography, GIS & RS group, University of Cologne, Germany (dirk.hoffmeister@uni-koeln.de), (2) Institute of Geography, Johannes Gutenberg University, Mainz, Germany

Dislocated boulders are one evidence of high-energy coastal inundation by tsunamis and storms. The accurate determination of the mass and the lateral areas of these boulders are important input parameters for wave transport equations, which calculate the necessary wave height and velocity for dislocation. Several studies have revealed that these boulder parameters are not easy to estimate by simply measuring the axes of a boulder, as their morphology is mostly complex. In addition, there is an ongoing debate, how tsunami and storm impacts are distinguishable by wave transport equations.

Therefore, terrestrial laser scanning (TLS), as well as dense image matching from the ground and by an unmanned aerial system (UAS) have been used to accurately document dislocated boulders. In addition, several different coastal sites in western Greece were monitored since 2009 in order to distinguish gradual changes. This specific region is characterized by a high seismic and tsunami hazard risk, due to the nearby plate boundaries. In addition, severe storms during winter time can considerably alter the coasts.

The 3D data, gathered by the different methods, was used to derive 3D models of the boulders and enabled the calculation of the volume of each boulder and the corresponding lateral areas as well. The mass of the boulders was achieved by the incorporation of density values. Likewise, the accurate position, orientation and distance to the sea were measured. High-resolution digital elevation models (2.5D) of each site were compared to each other in order to determine changes. For all measurements, marked base points were used for RTK-GPS and tachymetric measurements. Thus, all data is georeferenced and comparable over the observed years.

The results of the field campaigns show that the dislocated boulders can be accurately documented and monitored. Their volume and the lateral areas are considerably smaller than estimations by axes measurements. The new data shows reduced wave heights and velocities of about 40%. All regarded boulders showed no movement during the observation time. Only small changes have occurred on the observed elevated areas. Bigger changes were detectable on monitored beach areas.

TLS and dense image matching are both feasible and accurate methods for this study. In order to accurately monitor coastal sites and document dislocated boulders, a combination of both applied methods achieves the best result. Overall, this accurate determination of parameters is important to increase the accuracy of studies, which apply wave transport equations, as well as to determine the different effects on coastal areas in western Greece.