EGU22-5794
https://doi.org/10.5194/egusphere-egu22-5794
EGU General Assembly 2022

Monitoring beachrock and low-altitude aerial photogrammetry-UAV in the northern coast of the Sea of Marmara, Turkey: A tool for coastal evolution and relative sea level change

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Coastal landscapes are dynamic sites, with their evolution strongly linked with sea level variations and tectonic activity produced intense faulting at different temporal and spatial scales. Geomorphological features in the coastal area, such as beachrock formations, can function as indicators of the coastal landscape evolution through time. However, mapping beachrocks on coastal areas is fundamental to study beach evolution and the vulnerability of low-lying coasts to erosion and waves. Also, high resolution coastal maps are going to be obtained by using air photogrammetry (Unmanned Aerial Vehicle-UAV) to construct the changing dynamics of the coastal geomorphology of the region in recent years. Moreover, the existence of beachrocks and monitoring them in far-field sites provide a good potential indicator of former sea level position. Such a case is the northern coast of the Sea of Marmara (Tekirdag-Altinova coastal area), hosting submerged beachrocks bordering low-lying coasts. However, our knowledge of the submerged beachrocks in the Sea of Marmara coasts is limited and scarce.

The Tekirdag-Altinova coastal area lies in the western Marmara Region, being part of the Sea of Marmara. The western coasts of the Marmara Region include a number of natural features inherited from their coastal evolution. Typically, the western coasts of the Marmara Region are composed of a sandy beach, bordered by a low lying beachrock, a coastal lagoon and an alluvial plain. Furthermore, in this region relative sea level (RSL) changes during late Quaternary and its vicinity are generally not homogeneous as a result of the tectonic activity controlled by the North Anatolian Fault Zone (NAFZ) that played a crucial role in the coastal evolution at different periods of the region.

The aim of the study is to define spatial extent of the beachrocks, and to collect high-resolution aerial photos of the coastline in the study area. For this purpose, we performed coupled detailed aerial surveys with UAV, analysis of aerial photogrammetry and morphometric analysis to study beachrock outcrops found down to 2 m below the present sea level with a ~5 km coastal extend. In particular, it was used to generate a dense point cloud and successively a high resolution Digital

Surface Model (DSM) of submerged beachrocks. Hereby, Structure from Motion (SfM) photogrammetry technique was exploited to a low-cost and effective UAV derived imagery to achieve monitoring submerged beachrocks. Then, we further carried out one or more underwater transects to measure width and depth of the beachrock slabs and sampled seaward and landward parts of each beachrock slab. As a result of our analysis, we aim to better elucidate monitoring the submerged beachrocks in the nearshore of the Tekirdag-Altinova coastal area and provide new insight to the RSL evolution.