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UAS-SfM as a Cost-Effective Tool for Coastal Monitoring and Management

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INTRODUCTION

Coastal zone monitoring of river deltas is essential in order to understand their evolution and incorporate sustainable coastal management practices. Frequent data collection is essential but often surveys can be costly and time-consuming. This often leads to increase the time lag between successive monitoring campaigns to reduce survey costs, with the consequence of fragmenting the data available for coastal zone management. In this study we present the ability of off-the-shelf Unmanned Aerial Systems (UAS) coupled with Structure-from-Motion (SfM) photogrammetry to map and measure coastal features (e.g. shorelines).

MATERIALS AND METHODS

Study Area: For the purposes of the study three beaches at Stomio, Alexandrini and Nea Mesagkala settlements were selected in the deltaic coast of Pinios River. The residential use (e.g. hotels, vacation residences) along the coastline have increased significantly over the recent decades. Thus, often during winter period coastal buildings, especially at Nea Mesagkala, are severely affected by the storm surges originating from the less frequent east and southeast waves.

Field Data Collection: A rotor-wing UAS (DJI Phantom 4) has used to collect the high resolution natural colour aerial images of the three coastal areas over three campaigns in Autumn 2017 (24/11/17), Spring 2018 (11/03/18) and Autumn 2018 (02/10/18). Each flight was at approximately 90 m altitude and image footprints have 75% overlap with 3.7 cm pixel resolution. The approximate camera position at the time of each photograph was measured by an on-board GNSS receiver which provides a level of precision that is considered adequate for the horizontal axis.

Structure-from-Motion: Visual-topographic point clouds and an orthomosaic were produced using SfM algorithms in Agisoft Metashape Professional software. The SfM workflow to generate a point cloud includes photo alignment and tie point generation, camera optimization, and finally dense point cloud construction. Since fine topographic details were available, the workflow continued with meshing the original images. Texturing was also applied to the resulted mesh in a future step and a high quality orthophoto was generated.

Shoreline change analysis: Finally, an extension of the ESRI ArcGIS v.10 software (DSAS v.4.3) was employed to analyze the seasonal shoreline change. It computes rate-of-change statistics for a time series of shoreline vector data using a measurement baseline method.

RESULTS AND DISCUSION

High spatial resolution of the UAS-SfM product (Fig. 1) enhanced the ability of detecting coastal features. Thus, the extraction of the shoreline position was very precise (e.g. clearly visible berm, swash zone, beach step) and the resulted statistics characterized by very low uncertainty. Additionally, beach cusps were detected and recorded at different sites and dates; their size and position could potentially provide valuable information about the state of the beach (accretion/erosion) and the related wave regime.

Figure 1. Orthophotos from UAS flight (02/10/18) and SfM workflow in the three study sites

Among the three studied beaches, the greatest maximum total change in shoreline movement for all available shoreline positions is observed at Stomio (34 m) and the lowest at Nea Mesagkala (13 m). In terms of seasonal change (winter-summer profile) the beach segment at Nea Mesagkala is characterized by the lowest value (6 m) again; however, this part of deltaic coast is the most vulnerable and susceptible to increases in sea level, storms and inundation because of its physical attributes (e.g. gentle slope, small width).

UAS-SfM produces remote sensing data with great spatial resolution which could be used to visually identify important parameters for coastal research and management at a fraction of the cost of other available techniques and means (e.g. topographic surveys, airborne lidar and high-resolution satellite images). Even an off-the-shelf UAS is suitable for repeat surveys to assess spatial and temporal changes at small spatial extents and to better comprehend how these may be related with site-specific natural processes along the coast.