

SIMULTANEOUS 3D TOPOGRAPHY AND BATHYMETRY ESTIMATION FROM SPACEBORNE VIDEO OPTICAL IMAGERY

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INTRODUCTION

Our coasts are the buffer between us and the ocean, it protects us from the ocean elements. Observing the coastal zone is paramount to understand their natural behavior and risks that human coastal settlements are exposed to. While the need seem imminent, coastal observations are relatively rare and if existing is often clustered around high-latitudes or outdated (decades old) due to the expensive and labor-intensive nature of these measurements. Emerging techniques using Earth Observation satellites such as shoreline detections are providing new insights but deliver only a partial, indicative image. For full comprehension, regular measurements of the emerged topography and submerged bathymetry are essential. Here we present ongoing work on the estimation of the coastal topography and bathymetry using spaceborne video imagery.

METHODS

As has been shown before, instantaneous, and simultaneous topography and bathymetry estimations from space are attainable using agile satellites (Bergsma et al., 2021). This suite of satellites typically acquires satellite imagery of the same scene/location with different view-angles consecutively. Perhaps not surprisingly, but the more consecutive images can be obtained the better for the local precision of the bathymetry estimation and often topography. Here, we present the workflow and after the results using a video from space at 5 Hz over 175 frames acquired using the JILIN-1 platform.

Spaceborne videos from JILIN-1 are rather instable when one directly projects the image on the ground using the geometrical model as provide with the imagery. Therefore, a correction and alignment approach are developed in-house at the French Space Agency CNES using very high-resolution Pleiades imagery as a reference for the JILIN imagery. After all geometrical models for each frame of the video are well corrected the topography can directly be calculated using a N-stereo photogrammetry approach, in our case through CARS software (in which N is the number of total frames that are used for the topography estimation). Notably, images are not projected on the ground to enable a 3D reconstruction of the topography, in contrast to the bathymetry estimation.

For the bathymetry estimation, all frames are projected on the ground, now perfectly collocated, and a single TIFF file is generated. From this data cube (x,y,t) through a spatiotemporal correlation technique wave

displacement, resulting in a wave celerity, and the wave length are deducted. Once the wave characteristics are found, the local depth is inverted using the linear dispersion relation for free surface waves. The bathymetry is then referenced to the Mean Sea Level using the FES2022 tidal model.

RESULTS

The geometrical processing of the raw imagery is absolute key for both the topography as the bathymetry estimation. As images from the JILIN-1 platform float 100s of meters, the estimation of the bathymetry and topography would be impossible. Figure 1 illustrates the effect of the geometrical correction; after which each individual frame is correctly aligned with the reference image.



Figure 1 - Example of the geometric correction. On the left an uncorrected single frame and on the right we see a perfect match of the reference image.

Now the images are well collocated, the bathymetry and topography are estimated. The bathymetry estimation method, given the video image time-series is adapted from Almar et al, 2019, which enables the estimation of nearshore sand-bars with an accuracy between 5-10 % of the water depth

REFERENCES

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