LONG-TERM BAR DYNAMICS USING SATELLITE IMAGERY: A CASE STUDY AT ANMOK BEACH, SOUTH KOREA

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BACKGROUND

Nearshore sandbar patterns can affect the hydrodynamics and, as a result, the beach morphodynamics in the nearshore zone. Hence, spatial and temporal variability in the sandbars can influence beach accretion and erosion. Understanding the variability of the sandbar system can therefore be crucial for informed coastal zone management. So far, the methods to study sandbar dynamics mainly include datasets of video observations or occasional bathymetric surveys. However, at most locations around the world, these types of data are not or only scarcely available. In this paper we present an alternative method to analyze long-term sandbar variability by means of freely available satellite imagery. These images are globally available since the 1980's and, thus, have the potential to be applicable at any location in the world. Here, we will illustrate the methodology by means of a case study at Anmok beach at the South Korean East coast.

METHOD

Freely available satellite images from the Landsat 4,5,7,8 (U.S Geological Survey) and Sentinel 2 (EU Copernicus Services) missions are used to manually extract the sandbar crest lines (Figure 1) in time. The accuracy of these crest lines is verified with the available bathymetric surveys at the site between 2008 and 2016. The extracted sandbar crest lines allow us to study the sandbar characteristics in terms of wave length, amplitude, cross-shore position and migration rates over a period of 27 years. With the dataset thus obtained we investigated the effects of environmental conditions and human interventions on sandbar characteristics and the correlation between sandbar characteristics and shoreline position.

RESULTS

Although the visual extraction of sandbar patterns from satellite imagery is at times hampered by image quality and the presence of clouds and waves (foam), we were able to obtain 175 additional sandbar positions in the timeframe 1990-2017. A comparison of the manually extracted sandbar positions with the 9 available bathymetric surveys showed fair to good agreement (RMSE=14.6-21.3 m). Figure 2 shows the time series of the extracted sandbar cross-shore position $x_b(y)$ in a time stack image, which illustrates the changes in sandbar characteristics over time. These data allowed us to calculate the statistics of the sandbar characteristics and study the alongshore migration of the patterns. Our analysis indicates that the construction of a port at Anmok beach changed the sandbar characteristics considerably. After the port construction around 2000, both the wave length and the amplitude of the sandbars close to the port decreased. The alongshore bar position is correlated with the shoreline position with correlation coefficients up to -0.8. The negative correlation indicates an out of phase coupling, meaning the sandbar landward perturbations are faced by seaward shoreline perturbations. In-phase coupling was observed scarcely and, when observed, showed much smaller maximum correlation values (r=0.45). Based on our analysis the strength of the correlation seems to be linked to the cross-shore distance between the sandbar and the shoreline, e.g. the smaller this distance, the higher the correlation. This correlation between the bar position and the shoreline position stresses the importance of understanding the bar dynamics for local-scale coastal zone management.

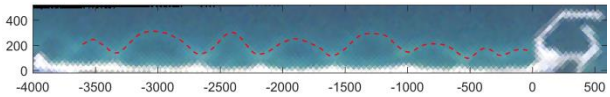

Figure 1 – Sandbar location at Anmok beach detected on a Landsat satellite image

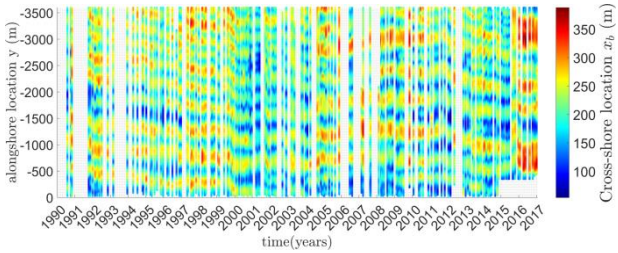

Figure 2 – Timestack image of the sandbar cross-shore location. Red (blue) colors indicate seaward (shoreward) sandbar perturbations with respect to a fixed reference line. The horizontal axis represents time (1990-2017) while the vertical axis represents the alongshore location.

DISCUSSION

The results of this study highlight the potential of using freely available satellite images to analyze long-term sandbar dynamics. Its global availability and (growing) temporal coverage of several decades are advantageous over most of the other available techniques, especially at data scarce locations. The Anmok case study demonstrates that satellite imagery allows analyzing the effects of human interventions on the sandbar characteristics, also in periods where no surveys are available. Future challenges lie in automating the sandbar detection from the satellite imagery and further increasing the temporal resolution and its spatial accuracy, also in the presence of clouds and waves. Nevertheless, even with its present drawbacks, this technique will be useful for analyzing long-term sandbar dynamics at other locations in the world.