

Accuracy of satellite-derived waterline extraction methods on sandy beaches

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INTRODUCTION

Satellite-based observations now play a key role in monitoring the morphological evolution of coasts, enabling the extraction of diverse change indicators. The waterline is the indicator that can be extracted the most straightforwardly as it simply represents the strict interface between land and sea and can usually be visually observed. Satellite-derived waterline extraction processes encompass several essential steps, including image preprocessing, pixel indexing (using a water index), thresholding, contouring, and optional post-processing techniques.

While satellite-based methods offer significant advantages for large-scale coastal monitoring, there is a limited body of research that assesses their robustness. Each step in the waterline extraction process introduces potential sources of error, and the diverse characteristics of coastlines, including their nature, tidal range, and wave climate, pose additional challenges that can significantly affect the accuracy of the detection. In this study, we evaluate the performance of a standardized satellite-derived waterline extraction method by validating its results using ground truth data from a dozen of sites around the world. We investigate the impact of pixel indexing on the performances of the process. Additionally, we establish links between beach characteristics and the accuracy of waterline detection.

METHODS

Using various water indexes - e.g., Normalized Difference Water Index (NDWI), Subtractive Coastal Water Index (ScoWI) - and Ostu-based segmentation (Vos *et al.*, 2019; Almeida *et al.*, 2021; Bergsma *et al.*, 2023), we extract waterlines and analyze the performances of the methods by comparing positions of detected waterlines with ground truth data gathered from a dozen of well-monitored sites around the world.

Tide data used to retrieve the corresponding waterline extracted from the beach elevation profiles are computed using the FES 2022 model (Michel Lionel *et al.*, 2023).

Based on the evaluation metrics of the validation, we develop empirical links between the expected accuracy of detected waterline positions with the characteristics of the coasts integrated into dimensionless number such as the beach slope, or the Dean number.

RESULTS AND DISCUSSION

For most of the sites considered, these standardized satellite-derived waterline methods detect accurate waterlines (RMSE around 10m), which could be easily turned into reliable shoreline indicators using tide correction. As pointed out in Vos *et al.* (2023) dissipative beaches (with a high Dean number) are challenging, and detection on such sites generally provide poorer results .

Overall, the ScoWI water index-based waterline extraction method gives the best results and can reliably detect waterlines for some challenging sites (i.e. Truc-Vert, France; $R^2 > 0,5$).

In order to advance the generation of datasets of waterlines/shorelines over large spatial/temporal scales, it is essential to maintain control over the performance of satellite-based coastal indicator methods. We propose working with a 'standardized algorithm,' which, in this context, refers to an algorithm designed in discrete blocks, allowing separate modifications for each component. This modular approach facilitates individual assessment of each component's effectiveness, creating a framework for conducting more rigorous and comprehensive studies on the performance of satellite-derived waterline methods. Such an approach holds the potential for significant improvements in these methods, enabling the generation of reliable waterline/shoreline data on a global scale.



Figure 1 - Location of the validation sites considered in this study.

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