

# Laboratory experiments application in a 2DV numerical cross-shore sediment transport model, pros and challenges

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**Abstract:** Laboratory experiments are notable in enabling understanding of the processes behind key cross-shore morphological developments [1, 3], such as berm erosion, undertow, and breaker bar formation under stormy conditions, which are otherwise difficult to observe during a storm event in the field. IH2VOF-SED is a one-phase RANS-based two-dimensional vertical sediment transport model [2] developed to provide accurate morphological predictions for a given storm condition. Figure (1) provides a numerical replication of a case of breaker bar formation and foreshore erosion from a flat beach driven by bichromatic waves from large-scale experiments [3] conducted in the LIM wave flume, UPC, Barcelona. The wave conditions used for this case consist of two primary frequencies of 0.3041 Hz and 0.2365 Hz with a wave height of 0.32 m and a peak period of 3.7 s. The input wave condition for the model is the data recorded in the laboratory at 54.69 m from the wave maker. The experiment was carried out using waves of 1<sup>st</sup> order and without active-wave absorption. Two cases of input wave conditions were considered to force the model, one using directly the wave gauge data and another one removing low-frequency waves from the lab signal and complementing it with theoretical 2<sup>nd</sup> order waves. The model was able to provide an accurate representation of the primary breaking point and the breaker bar in both cases, while forcing with theoretical 2<sup>nd</sup> order also provided an analogous secondary bar. The model effectively represents the morphodynamic processes of foreshore erosion and

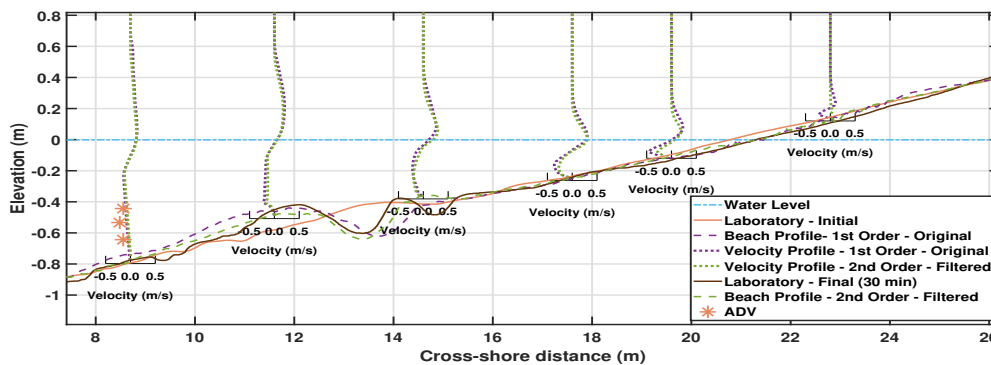


Figure 1: Figure represents the evolution of the beach profiles from the initial state to 30 minutes of morphological time and the comparison to the profile measured in the laboratory. Averaged velocity profiles show the hydrodynamic processes driving the morphological change

deposition in the breaking zone, leading to the formation and shaping of the breaker bar. The velocity profiles show undertow dominance from the swash towards the breaking point where it detaches leading to the formation of the breaker bar and matches with the experimental data. The differences arise in the foreshore deposition which is common in experiments with the presence of free long waves [1].

and the no definitive formation of the secondary breaker bar. The results from Figure (2) show that the phase-lag between the long-wave and short-wave groups is different between the model and experiments. In the case of 2<sup>nd</sup> order waves, the phase is closer at the breaking zone, which leads to a better representation of the bar. This difference in phase of the long wave compared to the laboratory arises for specific reasons: (i) the model does not account for the entire length of the flume due to the lack of input information, and (ii) even considering the entire length of the flume leads to discrepancies in capturing the free waves as the numerical setup is more controlled due to active wave absorption. Prior studies have shown that the energy transfer from short-wave to long-wave components occurs during the shoaling, and the potential presence of the spurious components could affect the key processes leading to different morphological responses. However, laboratory experiments provide crucial insight into the development of the understanding of these processes. The presented numerical model has shown that accurate morphological predictions can be done for the given wave condition, even with the limitation of replicating whole laboratory conditions.

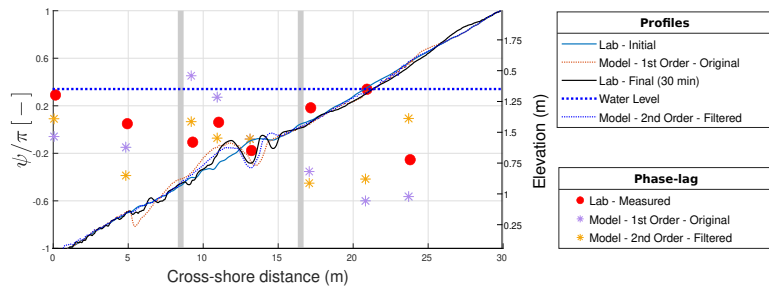


Figure 2: Right y-axis represents the elevation of beach profiles (lines), and left y-axis represents the normalized phase lag between the long and short wave components (points). Grey lines are the two distinct breaking points.

The predictions of the model depend on having accurate information from the laboratory to feed it, the lack of active wave absorption could lead to less reliable results, and the processes become difficult to replicate in the model. When field observations are lacking, data from laboratory experiments help improve numerical models, opening the potential for new avenues of application. However, it is important to consider that active wave absorption, higher-order wave generation, proper scaling, and advanced measurement techniques would reduce the bottlenecks faced by numerical models in replicating laboratory processes.

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## References:

- [1] Baldock T.E. et.al. Large-scale experiments on beach profile evolution and surf and swash zone sediment transport. *Coastal Engineering*, 58(2):214–227, February 2011.
- [2] García-Maribona J. et.al. An efficient RANS numerical model for cross-shore beach processes under erosive conditions. *Coastal Engineering*, 170, December 2021.
- [3] Grossmann F. et.al. Near-bed sediment transport during offshore bar migration in large-scale experiments. *Journal of Geophysical Research: Oceans*, 127(5), May 2022.