IMPROVING WAVE TRANSFORMATIONS ON ROUGH BOTTOM IN A 3D PHASE RESOLVED MODEL WITH LABORATORY AND FIELD CAMPAIGNS

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INTRODUCTION

Despite their global importance, the understanding of wave transformation processes and marine flooding has been much less studied on rocky beaches than on sandy beaches. Thus, the representation of bottom dissipation on this type of environment is generally based on site-specific parameterization in operational wave models, with mixed performance. The main aim of this study is to improve wave propagation and transformation on rough bottoms in the phase-resolved 3D non-hydrostatic model Symphonie (Marsaleix et al., 2019), using comparative confrontations with wave channel experiments and in situ data on the rocky beach of Ars-en-Ré, France. Different types of parameterization are implemented and evaluated against controlled laboratory experiments and in situ observations. The second main objective is to improve the existing representation of frictional dissipation, targeting the establishment of more generic parameterization based on the actual statistical properties of the seabed structure. To date, most parameterizations are entirely or semi-empirical, site-specific and almost never include appropriate measurements of roughness topography.

3D NH MODEL

The representation of roughness-induced dissipation in the phase-resolved wave model Symphonie is implemented with two different approaches depending on the ratio between the thickness of the bottom layer in the model and a roughness influence height: a bottom stress approach (a classic bottom drag coefficient, obtained from hydraulic roughness logarithmic profile and only applied to bottom layer) and a volume drag approach (an added volumetric drag force inspired from canopy hydrodynamics, uniformly applied to layers crossed by roughness influence height and made up of a combination of laminar, turbulent and inertial expressions, with a porous bottom taken into account).

FLUME EXPERIMENT

We reproduce the laboratory experiments of Dealbera et al. (2023), conducted in the 6m long CASH wave flume MIO/SEATECH). Different incident irregular waves are tested on sloping seabeds with varying levels and configurations of bottom roughness using 27 different Lego® assemblies. After setting the wave generation and breaking in the model, the bottom friction parameterizations as a function of the micro-topography are studied and fitted to the model in order to reproduce the experiments.

FIELD CAMPAIGN

Second, we focus on the measurements obtained during the RicoRe campaign, during winter 2020-2021, on the north-west coast of Ré Island. About 65 instruments, including current profilers and velocimeters, tide gauges, offshore wave buoys and pressure sensors, were deployed on three cross-shore transects. A numerical configuration is set up over the area of about 10 km by 5 km with varying horizontal resolution and 10 vertical levels covered by the observations. Forcing conditions for the initial state and for the lateral open boundary are given by a hydrostatic model and directional wave spectra from a spectral model. Wave breaking and nonlinear wave interactions are assessed both in numerical and experimental data, in order to correctly work on bottom dissipation.

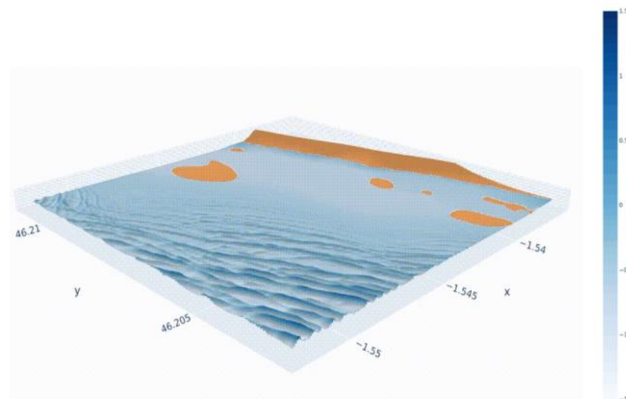

Figure 1 – Simulated elevation (m) during a rising tide at the instrumented transect

RESULTS

In the laboratory experiment, both bottom stress and canopy approaches are assessed. The bottom stress approach, widely used for sandy bottoms, showed its limitations when roughness exceeded vertical resolution, particularly in shallow water. The volume drag approach, on the other hand, produced results closer to channel measurements, consistent with the results obtained with the spatially resolved approach, and better representing the 3D dissipation induced by the influence of macro-roughness within the water column. Inclusion of a porous bottom also enabled a slight improvement in the representation of the impact of porous macro-roughness on flow.

In the field experiment, comparison of numerical results with in-situ wave spectra, vertical profile of currents and water level are made. The different types of parameterizations are assessed as well as their connectivity with roughness statistical properties.

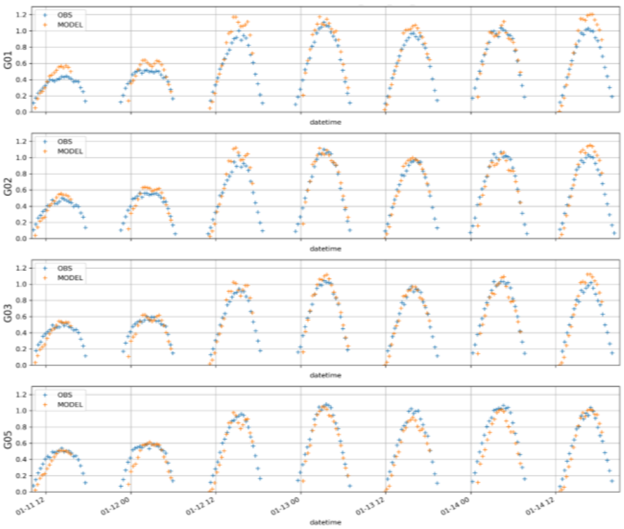

Figure 2 – Comparison of simulated and measured significant wave height at different locations

CONCLUSION AND PERSPECTIVES

The present study aimed to improve the representation of the wave dissipation on rough bottom in a 3D phase-resolved model, at laboratory and in situ scales. Different parameterizations are tested. Further efforts must be made in order to improve the link between the parameterizations and the roughness statistical properties, in order to obtain robust and reliable bottom dissipation laws.

The work carried out will enable an extension of the bottom friction parameterization of barotropic NH (Tolosa LCT) and spectral (Wavewatch III) models used for operational wave and storm surge forecasting.

REFERENCES

Dealbera, Sous, Morichon and Michaud (2023): The role of roughness geometry in wave frictional dissipation. Submitted to Coastal Engineering

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