NUMERICAL SIMULATION OF WAVE-DRIVEN FLOWS ON A MORPHOLOGICALLY EVOLVING BEACH

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INTRODUCTION

Wave-driven flows in the nearshore zone are responsible for the erosion and transport of beach sediments, causing a continuous cycle of bathymetric change that is linked with changes to wave transformation and nearshore hydrodynamics. Numerical models have been used to investigate the evolving nearshore wave field corresponding to beach morphology change in field studies (e.g., Ruiz de Alegría-Arzaburu et al., 2013). In the present study, the non-hydrostatic wave-flow SWASH model (Zijlema et al., 2011) is applied to five laboratory cases to investigate the change in wave and flow fields corresponding to evolving beach morphology during a simulated storm event.

PHYSICAL MODEL

A three-dimensional physical model is implemented in a wave basin with a 20.0 m long sandy beach and a continuous steep slope of 1:5. The hydrodynamics are forced with a variation in wave energy over time and along the beach using a 10.7 m long wave paddle at the offshore boundary to simulate a passing storm along the coast. The beach morphology is surveyed using a 3D laser scanner (Smith et al., 2017) with high resolution of 0.3 mm that provides a contour map of the beach corresponding to wave energy change during the storm event. Nearshore wave and current observations are collected using pressure and acoustic velocity sensors.

NUMERICAL MODEL

SWASH is used to simulate the hydrodynamics in the physical model domain. The model grid has 2.5 cm computational horizontal cell size and two vertical layers. Waves are generated over a simulation time of 360 s to ensure that a large number of waves are included and that steady-state nearshore hydrodynamics are achieved. The model results are validated with laboratory observations of wave and velocity collected at different locations across the beach. The model results indicate the ability to predict wave shoaling, breaking and generation of the alongshore current. The spatial distribution of the significant wave height (H_s) and the root-mean-square velocity (u_{rms}) are shown in Figure 1 for the case with the largest offshore waves (H_s = 0.13 m).

DISCUSSION

The model results indicate an alongshore current is generated with a maximum speed of 0.3 m/s near the shoreline, and the surf zone is approximately 2.0 m wide for the low wave energy case. When the storm wave energy increased, a similar nearshore flow pattern is observed, however, the surf zone extends to 2.7 m in width due to the retreating shoreline and larger waves at the outer edge of the surf zone. For the largest waves at the peak of the storm, the surf zone extends in both directions (shoreward and seaward) to a width of 3.7 m and has a more uniformly distributed current speed of up to 0.45 m/s across the surf zone.

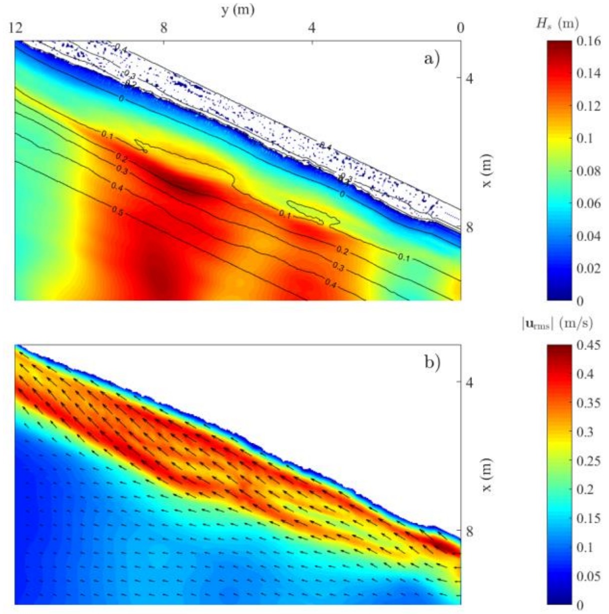

Figure 1 - Time average model output: a) significant wave height (H_s); and b) root mean square velocity magnitude (u_{rms}) for the case with largest offshore waves.

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