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MODELLING WAVE PROPAGATION OVER VEGETATION FIELDS WITH SWASH

Rui, REIS[1,2]; António A., PIRES-SILVA[1]; Conceição J.E.M., FORTES[2]; Tomohiro, SUZUKI[3]

[1] *CERIS, Instituto Superior Técnico, Universidade de Lisboa. rui.reis@tecnico.ulisboa.pt; antonio.pires.silva@ist.utl.pt*
[2] *DHA, Laboratório Nacional de Engenharia Civil. rreis@lnec.pt; jfortes@lnec.pt*
[3] *Flanders Hydraulics Research. tomohiro.suzuki@mow.vlaanderen.be*

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RESUMO

Aquatic-vegetation has the ability to protect the coasts from erosion and floods by dissipating the energy of waves and currents. The interest in understanding the coastal vegetation capability is growing, since the global warming, and the consequent foreseen sea level rise, would increase the load on the coast. Important losses of vegetation species affecting the coastal environments have occurred due to coastal erosion and human activities. The use of vegetation and the design of vegetation based structures are being increasingly considered for coastal management/protection, since those may lead to efficient and economical solutions with low environmental impact.

Wave propagation over vegetation is a quite complex process that is dependent on both vegetation and hydrodynamic characteristics. Therefore, a comprehensive numerical modelling will be useful in order to estimate waves in and behind the vegetation fields.

Recent studies have focused on the interaction of waves with vegetation. Garzon et al. (2018) numerically modelled the wave propagation across the Chesapeake Bay marshes aiming to evaluate the significance of the drag coefficient in wave attenuation by vegetation at these ecosystems. Chang and Liu (2019) have examined the weakly nonlinear effects of long waves propagating through coastal vegetation. Zhu et al. (2019) have developed a semi-analytical model, including applicability domains, for estimating the depth-integrated drag force in vegetation exposed to Stokes waves.

The SWASH numerical model is an open source time-domain wave model, based on the nonlinear shallow water equations, capable of simulating the wave dissipation by vegetation. It is a non-hydrostatic, phase-resolving, three-dimensional hydrodynamic model for describing unsteady free-surface and rotational flows, adapted to simulate the transformation of surface waves from offshore till shore (Zijlema et al., 2011).

SWASH has been successfully used in a variety of studies with different purposes. Smit et al. (2013) applied SWASH to wave flume laboratory experiments proving the model capacity to resolve the relevant near-shore wave processes including depth-induced wave breaking and wave-driven horizontal circulations in a random short-crested wave-field. Using SWASH for impermeable coastal structures in shallow foreshores, Suzuki et al. (2017) obtained accurate mean wave overtopping discharges, demonstrating the efficiency and robustness of the model. Zhang et al. (2018) showed a good capacity of SWASH to compute the vertical distribution of wave-induced longshore currents, by simulating the results of laboratory

experiments for obliquely incident regular waves on non-barred beaches and for both regular and irregular waves on a barred beach.

There are only few applications of the SWASH model to the propagation of waves over vegetation. Cao et al. (2016) verified the SWASH modelling results of wave height evolution with observed field data obtained in the mangrove forests along the South China Sea coast and analysed the importance of vegetation numerical parameters to the vegetation-induced run-up reduction. Dao et al. (2018) applied the SWASH model to the Mekong Delta Mangrove coasts for better understanding the wave damping provided by wooden fences coastal structures, analysing how transmitted wave height (represented by the transmission coefficient) varied with the nonlinearity (quantified by the Ursell number) of incident waves.

In this work, we apply the SWASH model to reproduce the wave height evolution over vegetation obtained in wave flume experiments (Løvås, 2000) and in field observations (Vo-Luong and Massel, 2008).

Løvås (2000) presented physical model wave flume data of wave propagation over vegetation (kelp *Laminaria hyperborea*) simulating the field conditions along the Jæren coastline, located in the southwestern part of Norway, finding in his study that: the presence of kelp reduces substantially the wave heights and modifies the water velocity profiles; the wave damping over the kelp field reduces the wave breaking phenomena, and the water level is a very important factor to the degree of sand dune erosion, while the presence of kelp has only a minor effect on dune erosion. Vo-Luong and Massel (2008) validated a theoretical predictive model for wave propagation through a non-uniform forest of arbitrary water depth using field measurements from the Nang Hai mixed mangrove forest in Can Gio Mangrove Biosphere Reserve, South Vietnam. They also found that wave breaking and wave interaction with vegetation are the dominant energy dissipation processes in such a forest.

The ultimate goal of applying SWASH in the present work is to compare SWASH wave height results with laboratory results presented in Løvås (2000) and with field observations of Vo-Luong and Massel (2008) as well. Additionally, SWASH results will be also compared to the ones previously obtained by other empirical and numerical models (Mendez and Losada, 2004; Suzuki et al., 2012).

Preliminary SWASH wave height simulations for breaking random waves over vegetation have shown an overall good agreement to the flume data presented in Løvås (2000). The agreement between SWASH and flume results looked worst at the wave breaking zone, which seems to be improved through a better wave breaking parametrization.

Palavras-chave: Wave propagation; Vegetation; SWASH model; Wave dissipation.