Jaime Ascencio

Spectral Wave Dissipation by Vegetation

Graduation Date and Time:

15:00h on the 17th of July, 2020

Report:

http://repository.tudelft.nl/

Abstract:

Large-scale modeling of waves with spectral wave models such as SWAN is indispensable for the design of coastal structures and the assessment of flood risk. Wave dissipation due to vegetation can be modeled in SWAN as increased bottom friction (implicit modeling) or as an additional dissipation function (explicit modeling). The second assumes that vegetation can be represented as rigid cylinders or plates (canopies) with different properties. While some studies concluded that implicit modeling reproduces the spectral evolution of field measurements more closely, others concluded the opposite.

Within the BE-SAFE project, field campaigns measured the spectral energy distribution over salt marshes in the Dutch Wadden Sea during several winter storms. The vegetated foreshore in front of the coastal dike got submerged over 2mof water during high tide and stormsurge. The measurements deployed wave gauges over the study transect, which was defined between the pioneer zone marsh edge and the near-dike location
(300 m behind the salt marsh). Calibrating the implicit and explicit models in SWAN brought the modeled total wave energy decay closer to the measurement. Nevertheless, the spectral shape, which describes the energy distribution over frequencies, still showed significant and not yet understood differences near the dike.

A methodology was executed to investigate the mechanisms that could reduce the spectral mismatch between the SWAN wave model and measurements over vegetation. First, the literature highlighted possible mechanisms that could be incorporated for this purpose. Next, a new frequency-distributed explicit dissipation model of Jacobsen et al. [2019] was implemented in SWAN and compared to implicit and explicit models
using lab and field measurements.

The results showed that the newly implemented model accurately captures the physics and the change of spectral shapes for all experimentally tested wave conditions and submergences. In contrast, the existing implicit and explicit dissipation models in SWAN reproduce the spectral evolution only under certain circumstances. In the validation and comparison to the field measurements with a much larger water depth than the vegetation height, the model of Jacobsen et al. [2019] correctly captured the vegetation's physical representation and the dissipation on the wind-sea frequencies. Nevertheless, the amount of energy on low frequencies was largely underpredicted by all frequency-distributed models. Therefore, the model of Jacobsen et al. [2019] was modified to include flexibility in a frequency-dependent reduction factor that reproduced
the energy decay of the measurements in all frequency regions. Other mechanisms that could be responsible for the mismatch before and over the marsh are the redistribution of energy by non-linear triad interactions,
generation of infra-gravity waves, and near-shore currents caused by horizontal variations on the vegetation properties.

The present research provides the range of conditions in which the tested explicit and implicit energy dissipation functions in SWAN are able to simulate the spectral evolution over rigid canopies and flexible salt-marsh vegetation. A new version of SWAN includes a new frequency-distributed explicit model that performed more accurately than existing models for rigid canopies. The physical insights from the research contributed to developing additional versions of SWAN, which performed closely to the energy distribution of the measurements over deeply submerged and flexible salt marsh vegetation species.

Reference: Jacobsen, McFall, Van der A (2019). A frequency distributed dissipation model for canopies. Coastal Engineering, 150,135-146

https://www.sciencedirect.com/science/article/abs/pii/S0378383918303892

Info:

The main objectives of the thesis project are:

1) Understand the processes related to spectral wave dissipation for submerged vegetation

2) Improve the wave vegetation module of SWAN to provide better results on the wave energy spectra for projects.

<image>