VALIDATION OF INTEGRATED COASTAL PROCESS MODEL FOR SIMULATING WAVE-CURRENT-VEGETATION INTERACTION

Yan Ding, ERDC's CHL, U.S. Army Corps of Engineers, Yan.Ding@usace.army.mil
Julie D. Rosati, U.S. Army Corps of Engineers, Julie.D.Rosati@usace.army.mil

INTRODUCTION

Vegetation plays an important role in reducing wetland and coastal erosion. It is well-known that vegetation in coastal regions acts as a buffer to reduce wave impact and wave setup, as waves are deformed and energy of waves is attenuated through vegetation zones. Modeling wave deformation and transformation through vegetation zones can quantify wave attenuation effects as a function of vegetation properties, improve our understanding of physical processes, and eventually provide an effective assessment tool for management, control, and design of vegetation zones and wetlands. Wave attenuation effects have been studied for several decades. In addition to physical modeling and field observation, two types of mathematical approaches for modeling effects of vegetation on waves can be identified, i.e., phase-resolving wave model and phase-averaged wave model. The former directly simulates dynamic wave shape deformations through a vegetation field by solving the time-dependent fluid flow governing equations. The latter directly computes wave spectral variations in space and time by using a time-averaged wave energy equation. Although a phase-resolving model can give detailed wave phase information as waves propagate through vegetation zones, it needs extensive computing efforts to solve dynamic fluid flow problems.

METHOD

This study aims to validate an integrated coastal processes model (Ding et al. 2013) by simulating waves and currents through a vegetation zone. The energy loss due to vegetation resistance is modeled by a vegetation drag model proposed by Dalrymple et al. (1984) and modified by Mendez and Losada (2004) for random wave conditions. Based on a directional wave-action balance equation, the wave dissipation effect is implemented into this integrated coastal process model, in which a wave module is capable of computing various random wave processes such as refraction, diffraction, breaking, wave-current interaction, bottom friction, etc. In order to compute currents and wave setup on a sloped beach with vegetation, this wave-action model is coupled with a hydrodynamic model which includes the radiation stresses and drag forcing due to vegetation resistance.

RESULTS

The capability for simulation of wave attenuation effect including vegetation resistance is validated by comparing to laboratory experiment data in a wave flume with planted artificial vegetation. The experiments were done in a laboratory beach with a slope of 1:30 in which artificial vegetation were planted within the wave breaking zone (Wu et al. 2011). The laboratory experiments have provided a set of runs with the vegetation covered and no vegetation planted. Therefore, the vegetation model and the wave breaking model can be validated separately

Figure 1 presents comparisons of significant wave heights with and without vegetation. Without vegetation, the wave was reduced in the sloped beach due to wave breaking. The wave action model correctly produced the wave attenuation effect when the waves propagated through the vegetation zone. The wave setup was computed by the hydrodynamic model in which wave radiation forcing and drag forcing due to vegetation resistance are included. Figure 2 shows comparisons of mean water surface elevations in the cases of vegetation and no vegetation. The simulation results accurately produced the wave setup in both cases. It shows that due to vegetation resistance wave setup was reduced drastically. Model validation shows that an integrated coastal process model is capable of simulating energy dissipation and wave setup due to vegetation resistance and wave breaking.

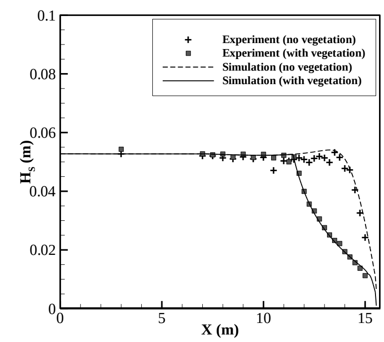

Figure 1. Comparisons of significant wave heights

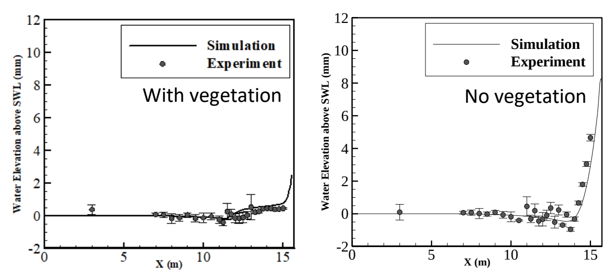

Figure 2. Comparisons of mean water surface elevations with and without vegetation

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