Developing a Wave Attenuation Model with Parameterized Drag Coefficients for Philippine Mangroves: Constraints and Lessons

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Abstract

Mangrove forests are seen to mitigate the potentially disastrous effects of typhoons and storm surges, improving the resiliency of coastal areas. Some hydrodynamic models have attempted to quantitatively assess the wave attenuation properties of mangrove forests. These models rely on a drag coefficient that is usually calibrated by simulating the dragging capacity of the vegetation through lab experiments. In this study, we considered a computer implementation of a hydrodynamic model through SWAN-VEG where the drag coefficient is instead parameterized using plant characteristics. This implementation attempts to incorporate the use of actual mangrove monitoring data gathered from selected sampling sites in the country. Simulations using this model provide a preliminary analysis of the water wave attenuation caused by the mangroves. The results may also be used to motivate and streamline further study on the capacity of mangrove forests to adapt or mitigate against the impacts of typhoons and storm surges.

Introduction

The Philippines is frequently visited by tropical cyclones or storms, with around 17-19 entering the Philippine area of responsibility (PAR). Of these, around 6-9 make landfall. These typhoons can cause immense damage to lives and infrastructure. For instance, typhoon-enhanced coastal waves such as tsunamis and storm surges are one of the primary causes of structural damage along coastal areas. Thus, there is a need to simulate these waves across multiple scenarios to assess impact and design measures to mitigate their adverse effects. The presence of mangrove forests along coastlines has been viewed, both by anecdotal experience and in some studies, in a positive light due to a number of factors. Mangroves are seen to provide a natural and resilient barrier from severe waves such as storm surges and help in ecosystem maintenance. However, improper or excessive planting of mangroves may not yield any significant wave reduction effect. At its worst, the forced mangrove forest implementation may ultimately prove to be detrimental to the ecosystem. Thus, there is a need to quantify the effect of mangrove forests on coastlines. Specifically, one would like to quantify the wave reduction properties and ecosystem effects of mangrove forests while taking into consideration the different types of mangroves species that could be planted.

Materials and Methods

This paper utilizes a numerical implementation by Suzuki et al. (2012) through the computer software SWAN of a wave attenuation model suggested by Mendez and Losada (2004), verified using an independent SciLab implementation by Antonio (2015). Using the parameterized drag coefficient suggested by Hendriks (2014), the model is applied to a mangrove forest in the Philippines using the measurements obtained by Salmo et al (2013). The paper concludes with some insights regarding the results yielded by the model, along with some suggestions regarding model development for mangrove forests in the Philippines. In SWAN-VEG, the bathymetry input simulates a reef flat with a gradual slope that is 0.2m deep at around 1km from the shoreline and with a vegetation field equivalent to the characteristics of a replanted 6 year old, replanted 18 year old, and natural mangrove. Different drag coefficients are estimated to see the effect, where it is seen that the presence of the mangroves has a dissipating effect on the wave, and the maturity of the mangrove forest affects this wave attenuating capacity.

Summary and Implications

Based on the results, we see the importance of accurate bathymetry both for the vegetation field and the reef flat itself (Fig. 1). Also, we see the importance of the wave profile in simulating real-time coastal conditions. Finally, we see the promising viability of this model as a predictor for the effect of mangrove forests on coastal wave behavior.

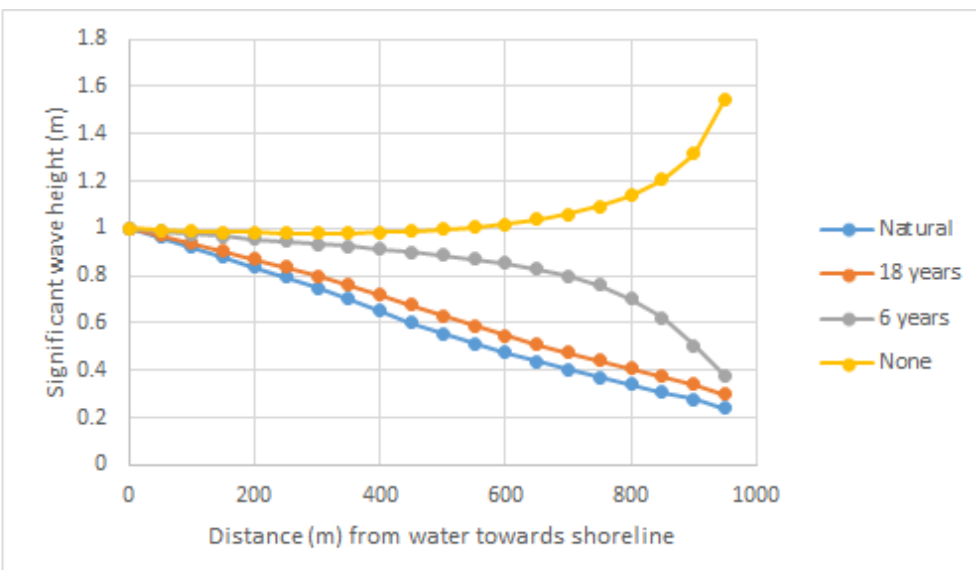

Fig. 1. Dissipation seen through wave height decrease as wave travels towards the shoreline for drag coefficient $C_D = 1$.

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