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A MODEL OF WAVE ATTENUATION IN VEGETATED ENVIRONMENTS

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1 INTRODUCTION

Mangrove degradation and rapid coastline erosion have been widely observed at many locations along the Mekong Delta Coast. These locales frequently display narrow mangrove forests, occasionally spanning as few as 100 meters. This phenomenon of the narrower mangrove forests is supposed to be due to the construction of sea dikes in a search to establish room for agricultural purposes and to hinder the salinity intrusion, referred to as "mangrove squeeze". Within the context of monitoring mangrove forest evolution alongside the shoreline's dynamic processes of erosion and accretion, the hypothesis of a "squeeze mangrove forest" was advanced by Phan (2015) and Truong (2017). This conceptual construct underscores the fundamental importance of "mangrove width" as a critical length scale influencing the sustainable growth of a mangrove forest. The physical interpretation of this length scale is intricately tied to the extent of the mixing layer's intrusion into the vegetative domain (Truong et al., 2019). It is important to note that while the mixing dynamics of estuarine mangroves are primarily regulated by lateral flow events induced by large vortex structures moving along the vegetation edge, the characteristics of incoming waves primarily determine the length to which the mixing layer penetrates within coastal mangroves. The latter is the primary focus of this study.

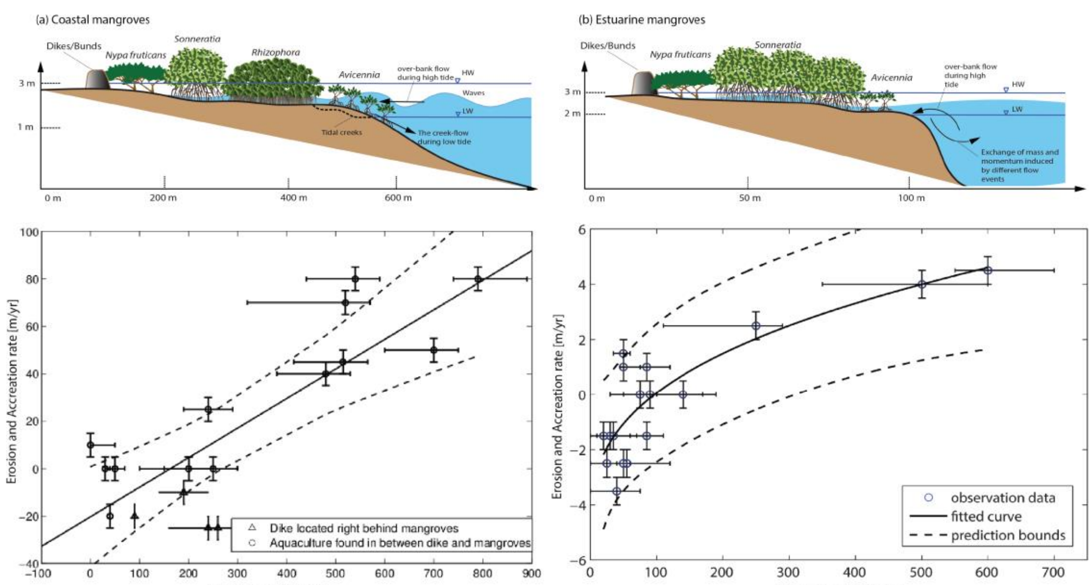

Figure 1. Typical mangrove forest arrangements along the coastline (a) and within estuaries (b). The connection between the width of coastal mangroves and the changes in the shoreline along the eastern coast of the Mekong Delta (left panel), as well as in the estuarine areas of the Mekong Delta (right panel) (Adapted from Phan et al., 2015ss and Truong et al., 2017).

2 METHODOLOGY

In order to obtain more insight into this field, a wave flume experiment was set up to study the impact of the sea dike and the differences between the long waves and short-wave attenuation through the mangrove forest. The experiment of wave attenuation through cylinder arrays, mimicking wave damping through a coastal mangrove forest in the Mekong Delta, was performed within a wave flume at Delft University of Technology. The flume's effective length, height, and width are 40m, 1m, and 0.8m, respectively. A representative cross-section of the experiment can be seen in Figure 2. The second-order wave steering was always active during the experiment. The wave generator with an active wave absorption system was placed at the beginning of the flume to prevent reflected waves from reflecting again into the flume. A steep wooded slope with a combination slope of 1/10 and 1/20 was used to simulate shoaling and breaking waves in the Mekong Delta. This way, the waves shoaling and breaking processes can occur before entering the mangrove forest. Different scenarios were considered, including regular, irregular, broken, and non-broken waves.

Furthermore, a state-of-the-art numerical model mimicking the experiment was constructed in SWASH. The experimental data was employed to calibrate and validate the model. The hydraulic boundary conditions of the numerical model were described based on the experimental configurations. There are about 50–100 grid cells per wavelength. This way, the numerical results can be directly compared with the experimental results.

3 RESULTS & CONCLUSIONS

Results show that short waves are attenuated very quickly, even before they can reach the critical width of the mangrove forest. Infragravity waves, however, penetrate over much larger distances. Therefore, long wave attenuation will significantly determine the maximum length scale of the mixing layer's intrusion into the vegetation region. The results also suggest that the wave attenuation processes inside vegetation strongly depend on the wave characteristics. It is suggested that the SWASH model can capture the transformation processes of the wave attenuation observed and measured in the physical model.

Furthermore, the wave attenuation rate for a specific mangrove density was presented as a function of the number of wavelengths and the Ursell number. The ratio of incoming and damped wave heights reduces when the Ursell number increases, implying that the more non-linear the waves, the more wave dissipation by vegetation.

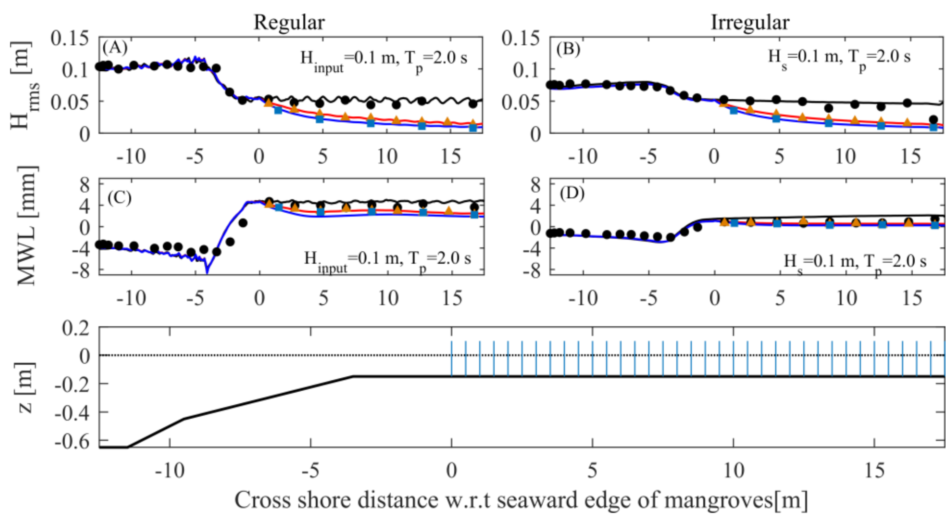

Figure 2. Illustration of wave height transformation comparisons between the physical model: without mangroves (black circles), sparse mangroves (orange triangles), dense mangroves (square blues) and numerical model: without mangroves (black line), sparse mangroves (red line), dense mangroves (blue line).

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