**Text S1. Mechanism, practical workflow and data processing code of the HU method**

**Introduction**

The *HU* method is designed as an easy-to-use tool for coastal practitioners to assess wave dissipation capacity of coastal and estuarine forested wetlands. This method makes use of wave measurements obtained from calm wave conditions to determine wave attenuation during storm events. It is based on data analysis of existing data of wave height evolution along forests, and does not require numerical modelling. Thus, it is suitable for many practitioners who do not have modelling expertise.

**Mechanism**

The *HU* method is based on the *HLn-Ur* relations, where *HLn* is the ratio of significant wave height after *n* of wavelengths over the incident significant wave height at forest seaward edge. Ur is the Ursell number, which is typically an index for wave nonlinearity. Ur is defined as Hs0\*L2/h3, where Hs0 is the incident significant wave height, L is the wavelength, and h is the water depth. L and h are measured at forest seaward edge.

To further explore and understand the *HLn-Ur* relations, we conducted a model experiment based on the bathymetry and forest canopy of Cù Lao Dung Island site, Mekong Delta1. We used SWASH to conduct the experiment, as it can not only provide results of wave height but also (nonlinear) wave orbital velocity. Two vegetation densities were tested, which was the original density and high density, set as 5 times of the original density. The tested hydrodynamic conditions are as follows: h=0.8-2.4 m, T=3-5 s and Hs0=0.1-0.4 s. These experiments show that higher vegetation density leads to greater damping, i.e., lower *HLn* (Fig. S3). Data of each density fit onto their corresponding *HLn*-Ur relations (within the 95% confidence intervals). Thus, the derived *HLn*-Ur relations are bind to the specific coastal forest density and structure.

To explain the role of *HLn-Ur* relations, we quantify total wave energy (*εt*), energy dissipation by vegetation drag (*εD*), and skewness in waves orbital velocity (). The total wave energy (*εt*) is quantified as:

(S1)

where is water density, g is acceleration of gravity, and is root-mean-square wave amplitude. is quantified as:

(S2)

where *N* is the number of vegetation stems, is canopy height, is the instantaneous orbital flow velocity, and *t* is time. In the experiment, we used CD relation 8 since it provides the best prediction for the Cù Lao Dung Island site.

If linear wave orbital velocity applies, the ratio of damped wave energy over total wave energy (*εD/εt*) ratio increases with *Ur* (Fig. S4). However, the ratio obtained from linear wave theory is in the range of [0.03 0.12], which is significantly less than that derived from the wave height reduction ([0.2 0.6]). This indicates that other factors such as wave nonlinearity should be considered. When nonlinear wave orbital velocity is considered, the estimated *εD*/*εt* ratio increases dramatically with *Ur* (Fig. S4), and a good agreement is obtained between the estimated *εD*/*εt* ratio and that derived from wave height reduction (Fig. S5).

To demonstrate how wave nonlinearity contributes to higher wave damping, we show that over the course of 20 seconds the nonlinear wave orbital velocities can lead to 80% higher energy dissipation (*εD*) compared to linear wave orbital velocities of similar magnitude (Fig. S6). This is induced by the fact that most wave energy damping occurs with the peak velocities over a wave period. Thus, higher skewness in wave orbital velocity (i.e., , Eq. S3) means higher velocity peaks, i.e., greater wave dissipation. Skewness in wave orbital velocity is strongly linked to the *Ur* number (Fig. S7).

The skewness parameter for waves orbital velocity is2:

(S3)

where is the orbital wave velocity with maximum amplitude, is the peak orbital wave velocity in opposite direction of . Overall, this experiment reveals the importance of wave nonlinearity and confirms the predictive function of Ur in wave damping by coastal forested wetlands, since the wave damping process is highly nonlinear.

**Practical workflow of the *HU* method**

1. **Field measurements**

Since the *HU* method is an empirical method, it requires in-situ wave data to assess the wave dissipation capacity of a forest wetlands. The *HU* method requires a wave measuring transect across the seaward edge into the mature forest wetland (Fig. 1). The measuring transect should be composed of 2 and preferably more measuring stations. The landward end of the transect is typically 5-10 wavelength away from the seaward forest edge, to ensure sufficient distance for wave dissipation measurements. Note that the landward station should not be placed too far from the seaward forest edge, to avoid too high in the tidal frame and too little time for measurements.

The common instrument for field wave measurements is pressure sensors, which are robust and easy to install in forest wetlands. They can be placed on the mangrove stems or metal poles, and 5-10 cm above the bed. The measuring frequency is at least 4 Hz and the measuring interval can be set as 10-20 mins. In each interval the measured pressure number of data points is often 2048 or 4096. The obtained pressure data can be processed to obtain water depth, significant wave height and peak wave period at each measuring station3. Processing procedure of the pressure sensors can be found at <http://neumeier.perso.ch/matlab/waves.html>.

1. **Data processing**

**2.1 Overall procedure of data processing**

Since the *HU* method based on the *HLn-Ur* relations, we first need to derive *HLn* and *Ur* from the measured data. *Ur* = Hs0\*L2/h3 can be derived from the data at the seaward edge of the forest wetland.

*HLn* of the measured cases need to be determined based on a fitting relation, as we need *HLn* at each wavelength, which is not directly available from the measurement. *HLn* is obtained as4 (see also Fig. S8):

(S4)

where is an empirical dissipation rate that can be obtained by fitting the measured data of relative wave height change, using *Hsn*=1/(1+β*Dn*), where *Hsn* is the relative wave height at the nth measuring station, *Dn* is the distance of the wave propagation in the vegetation canopy.



**Fig. S8** Workflow to obtain *HLn* of each case. *Hs0*, *Hs1*, *Hs2*, *Hs3* are the measured significant wave heights at measuring stations. , .. are fitted dissipation rate of each case, which is obtained based on measured significant wave heights. Subsequently, *HLn* of each case can be derived from Eq. S4.

When *HLn* of the measured cases have been derived, we can plot for example, *HL1* of all the measured cases against the corresponding *Ur* values.

Then the relation between *HL1* and *Ur* values can be obtained following the general form:

(S5)

where *a1* and *b1* are fitting parameters for wavelength number 1. Subsequently, similar relations for *HL2* to*HLn* can be obtained, in which *a1* and *b1* will be changed to *an* and *bn* accordingly (Fig. S9).

When all the *HLn* and *Ur* relations are known, we can derive the reduction of relative wave height (*HLn’*)with increasing number of wavelengths for a given *Ur* number (see Fig. S9).

**Fig. S9** Workflow to obtain the predicted relative wave height at each wavelenght: *HL1’*, *HL2’*, …, *HLn’* for a given *Ur’*. Firstly, collect *HL1* of all the measured cases and their corresponding *Ur* number to derive Eq. S5. Then repeat the procedure to obtain all the relations of *HLn*. Subsequently, for a given *Ur’*, the resulting *HL1’*, *HL2’*, …, *HLn’* can be derived.

The absolute wave height reduction [m] at wavelength *n* can be determined as:

(S6)

Thus, for a given stormy incident wave condition, we can firstly obtain the *Ur* number based on the data at the seaward edge of the forest wetland, and then derive the wave dynamic based on the workflow shown in Fig. S8 and S9. Notably, wave height in between two wavelengths can be derived by interpolation.

**2.2 MATLAB data processing code**

The data processing procedure can be done with three simple MATLAB scripts. Before using the scripts, the users need to prepare measured data of significant wave height, water depth and peak wave period at each station. The distance between each station should also be prepared. The scripts and an example can be found via the following link: **10.4121/bbb3cf31-043a-40a4-9bbc-42c599874db3**