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Assessment of WEC Array Effects of a realistic WEC Farm with a hydraulic PTO System Utilizing a Coupled Model Suite

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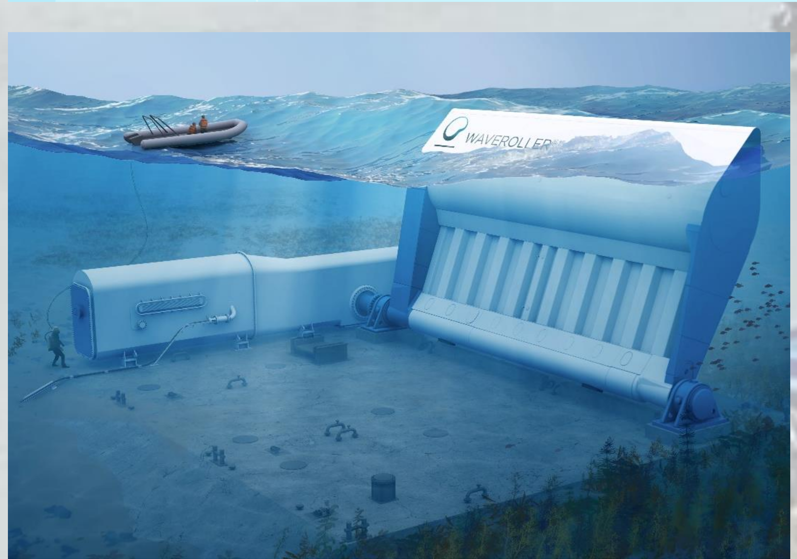
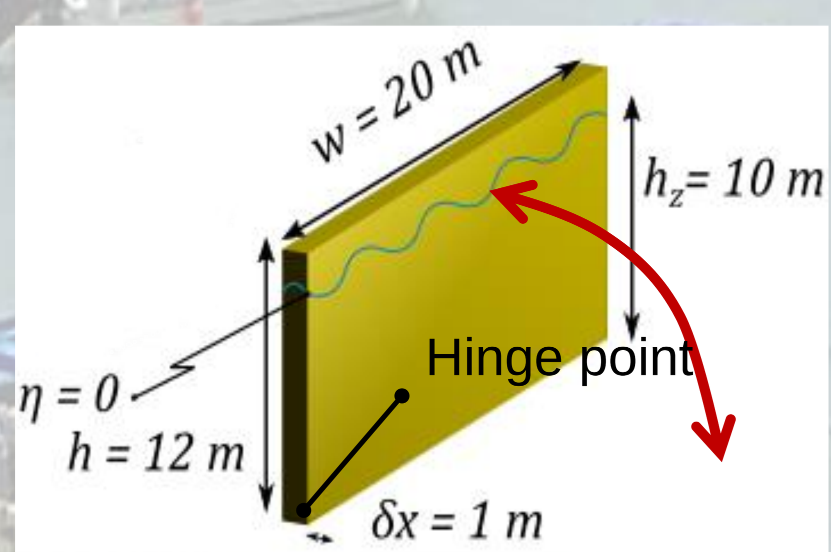
A WEC farm composed of 10 5-WEC arrays of Oscillating Surging Wave Energy Converters (OSWECs) is modelled using a new wave-to-wire (W2W) model. The WEC farm is modelled for a real wave climate derived from 10 years of buoy data and a sloping bathymetry based on a proposed OSWEC project off the W. coast of Bretagne, France.

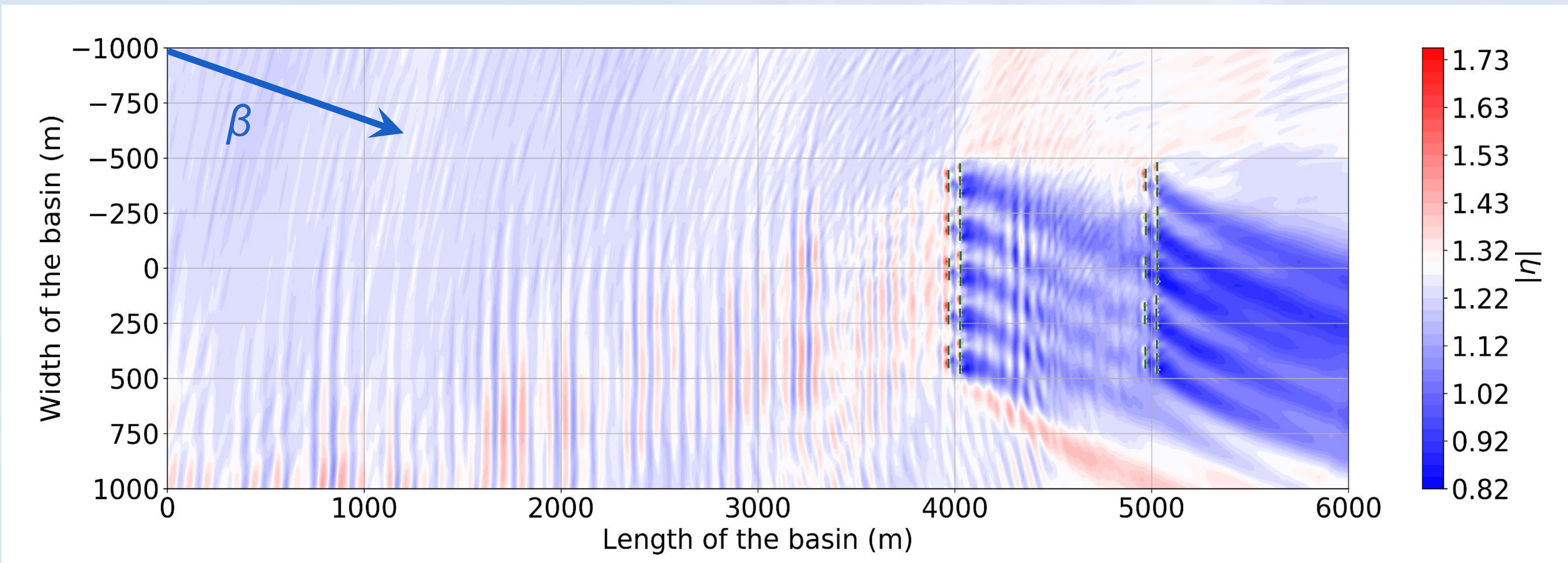
The W2W model links a Boundary Element Method (BEM) solver to a Wave Energy Converter (WEC) motion solver that are in turn coupled to a wave propagation model. The hydrodynamics of the WECs are resolved in the wave structure interaction solver NEMOH, the Power Take-off (PTO) is simulated in the WEC simulation tool WEC-Sim, and the resulting perturbed wave field is coupled to the mild-slope propagation model MILDwave. The WEC farm power output and the near and far-field effects are simulated for irregular waves with various significant wave heights wave peak periods and mean wave incidence directions β based on the modelled site wave climatology The PTO system of each WEC in each farm is modelled as a closed-circuit hydraulic PTO system optimized for each set of incident wave conditions, mimicking the proposed site technology. The WEC dimensions are based on the dimensions given by the WEC developer AW Energy.



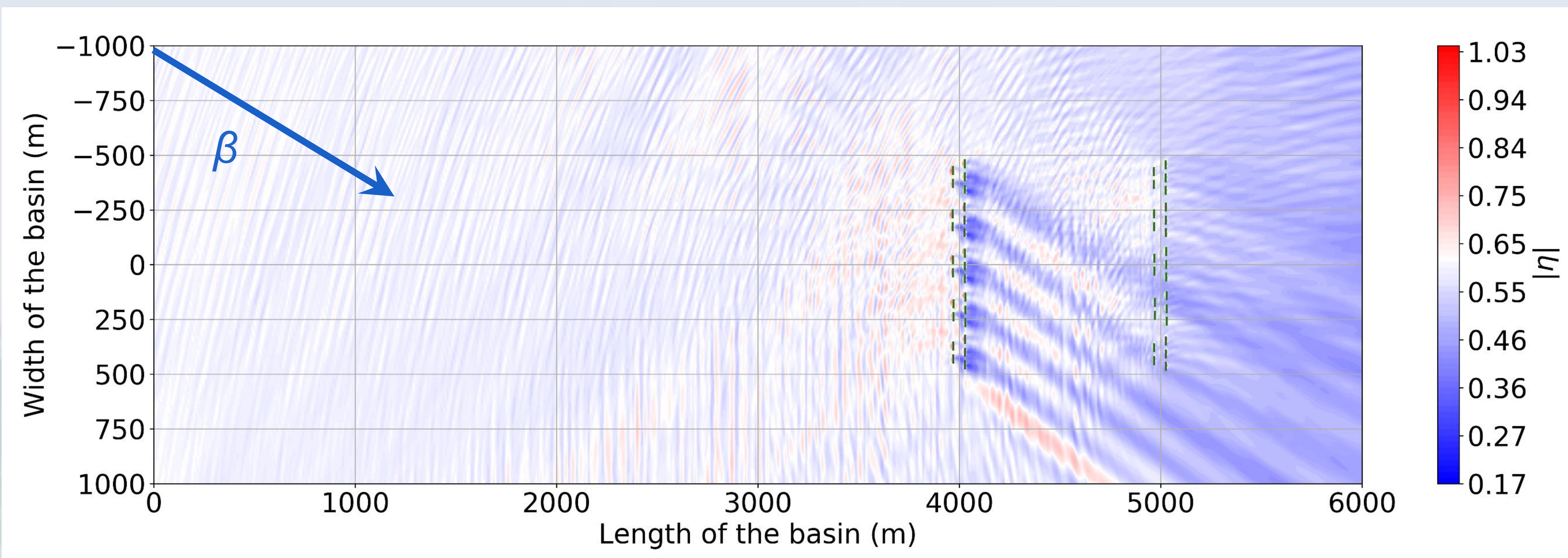


The wave field modification is displayed in terms of the absolute value of the complex wave amplitude |η| demonstrates a significant shadowing effect down-wave of the WEC farm of up to a 20 % reduction. Some enhancement in |η| is observed lateral of the front WEC array row. The power output of the WECs in the back array row is strongly influenced by the wave incidence angle β. The coupled W2W model allows for the fast (several hours) calculation of a large number of WECs simultaneously.

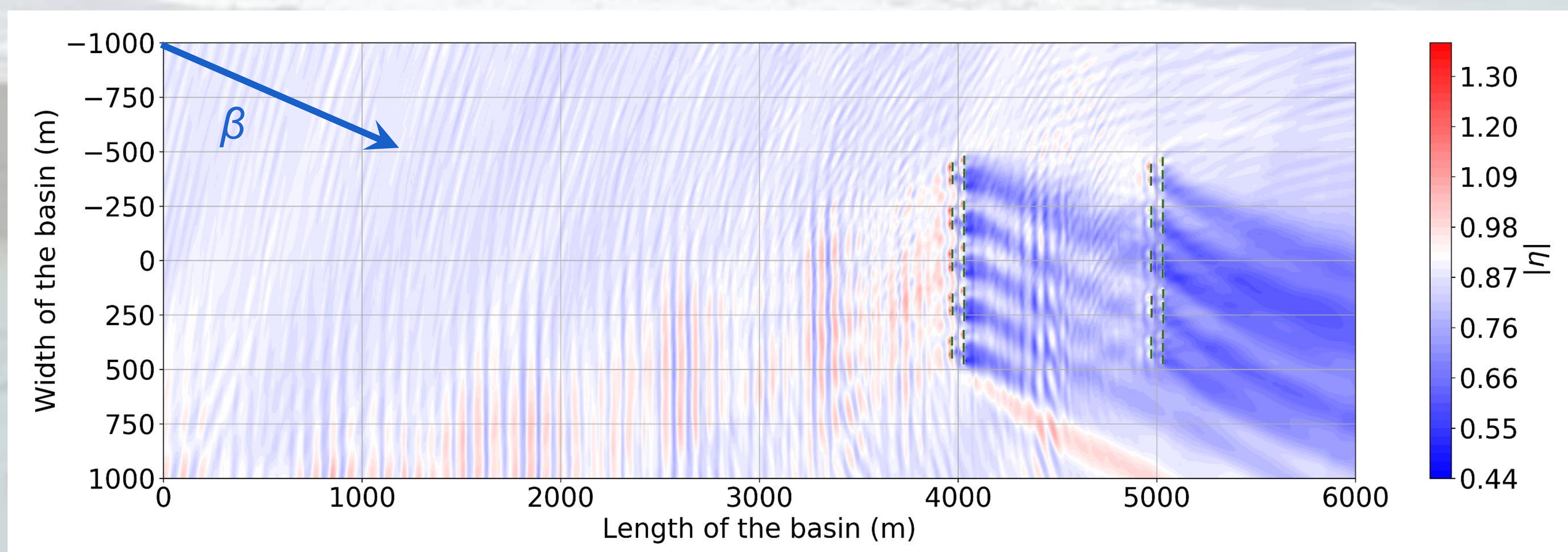
Winter wave climate H_{m0} = 2.55 m T_p = 11.71 s incident wave angle β = -20°]



Summer wave climate H_{m0} = 2.55 m T_p = 11.71 s incident wave angle β = -30°]



Autumn wave climate H_{m0} = 2.55 m T_p = 11.71 s incident wave angle β = -22°]



The closed-circuit hydraulic PTO is modelled in the time domain in WEC-Sim. The average absorbed power of the OSWEC over one wave period is expressed as:

$$P_h = -\frac{1}{T} f_{\text{PTO}} t \cdot \dot{z}(t) dt$$

The difference in power output of the WECs between the seasons is lessened by the increased relative efficiency of the WEC farm configuration for the summer climate and to a lesser extent the autumn. The power output difference between the front and back row is magnified in the winter due to the significant shadowing imparted by the front row via absorption and some reflection as seen in the |η|.