Coastal Impacts of WEC arrays – SE England

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Work stream 4: Arrays Wakes and Near Field Effects

Introduction

Energy extraction by long strings of wave energy converters (WEC) will have impacts on the coastline. This study investigates coastline transformations in terms of long term parameters such as cliff erosion and sediment transport rate. The method used is based on a study by Chini et al. (2010) in which the near shore wave height for a site with mobile bed was obtained for a range of conditions. Combined with 140 year forecasts of H_s , T_p , θ_p the sediment transport and cliff erosion rate were estimated. Here a similar analysis is done accounting for energy extraction from a WEC array. To obtain the inshore wave spectrum, a spectral propagation code is modified to accommodate reflections and transmission from long WEC arrays of heaving point absorbers based on linear theory as by Alexandre et al., 2010.

Methodology

The coastal processes are assessed over a long term time series. This process involves 3 steps: 1- Construction of a look-up table with the inshore results (H_{si} , T_{pi} θ_{pi}) for relevant offshore conditions including the WEC array influence. 2 – Using a time series for H_s, T_p, θ_p on a offshore location the correspondent inshore time series is interpolated from the look-up tables. 3 - With the inshore time series defined, a morphological model is used to find the long term shore impacts.

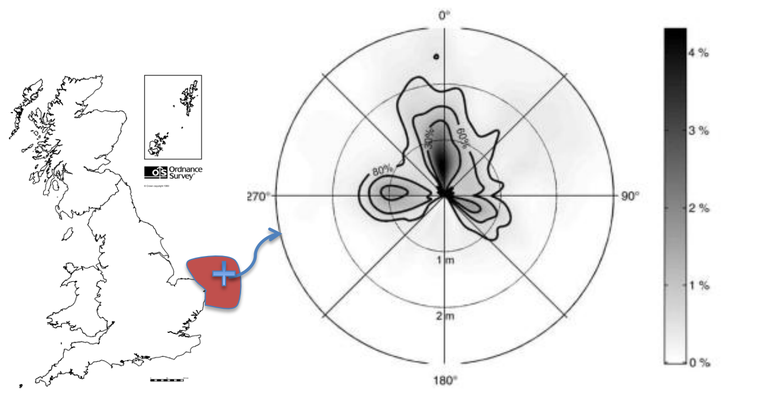

Fig.1 – Area used for the long term coastal modifications in East Anglia, UK, and the occurrence of H_S from Chini et al. (2010) .

Offshore –H_s , T_p θ_p

WEC array - LT ⇩ SWAN

Inshore H_{si} , T_{pi} θ_{pi}

Time series Offshore -140 years

⇩

Look up table

⇩

Inshore $H_{si}(t)$, $T_p(t)$ $\theta_{pi}(t)$

SCAPE[3]

- Cliff recession,
- Sediment transport

Inshore transformations – WEC influences

Linear analysis is conducted in the nearfield using WAMIT to obtain frequency dependent reflection and transmission coefficients: $K_R(\omega)$ and $K_T(\omega)$. The WEC array consists of two long lines of heaving point absorber floats. Each device is optimized to maximize power extraction, here only the orthogonal case is represented. SWAN is used to predict propagation of the modified spectrum across the site bathymetry.

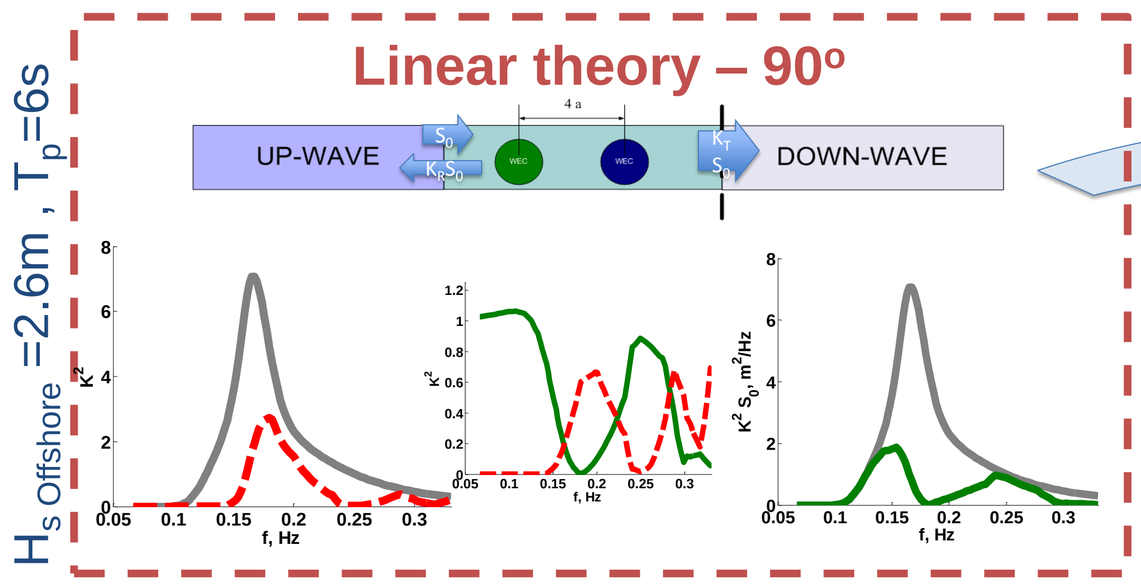

Fig.2 – K_T and K_R from linear theory for orthogonal waves.

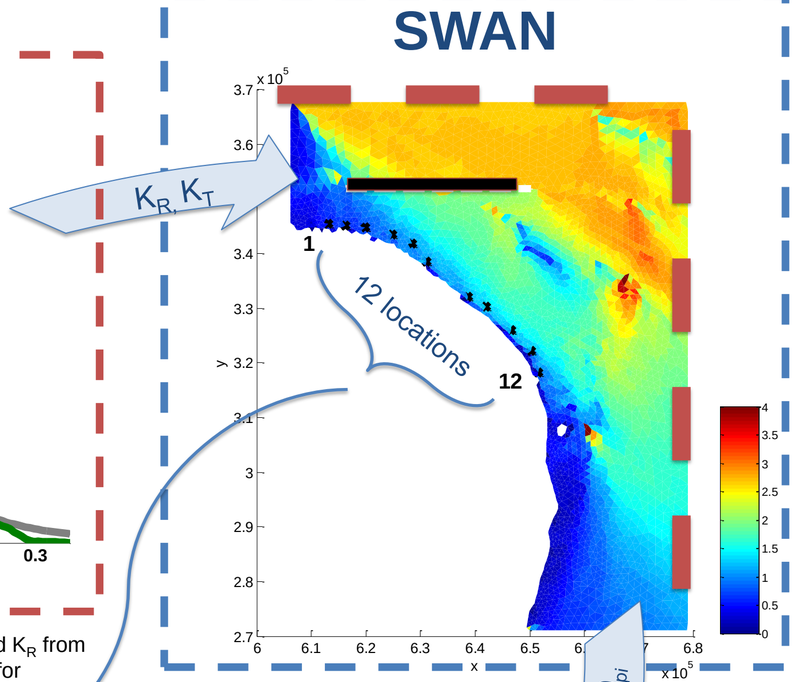

Fig.3 – Hs modification due to WEC array at T_p=6s.

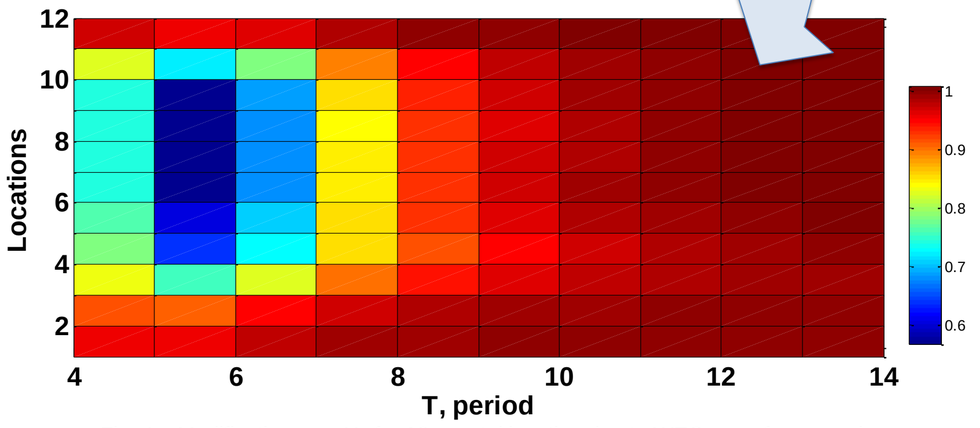

Fig. 4 – Modifications on H_S for 12 coastal location due to WEC array for several T_p for orthogonal waves.

Conclusions

Significant wave height, H_S changes due to the presence of the array on 12 coastal locations are illustrated on Fig. 4, comparing the H_S ratio for the cases with array deployed and without. Depending on the offshore $T_{P,O}$ the transformations on several coastal locations reduce to a maximum of 50% for $T_{P,O}$=6 sec, and very small transformations are registered for $T_{P,O}$ > 10 sec (see Fig. 4). Different results are observed for different coastal locations due to the bathymetry and array size. These results were found for quasi unidirectional with θ_p towards South (Fig.1). Using a time series for offshore conditions (140 years from the predictions from the IPCC), the inshore conditions can be found. Subsequently, the morphological model SCAPE (Walkden et al, 2005) is used for obtaining the cliff recession and sediment transport changes estimations.

References

1. Alexandre, A., T.J. Stallard, and P. K. Stansby. “Wave field modification due to WEC array.” In proceedings of *COASTLAB 10*. Barcelona, 2010.
2. Chini, Nicolas, Peter Stansby, James Leake, Judith Wolf, Jonah Roberts-Jones, and Jason Lowe. “The impact of sea level rise and climate change on inshore wave climate: A case study for East Anglia (UK).” *Coastal Engineering* 57, no. 11-12 (November 2010): 973-984**.**
3. Walkden, M.J.A. and J.W. Hall. 2005. A predictive mesoscale model of the erosion and profile development of soft rock shores, Coastal Engineering, 52, 535–563.

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