MODELLING DUNE EROSION OF THE SEFTON COAST, LIVERPOOL BAY, UK

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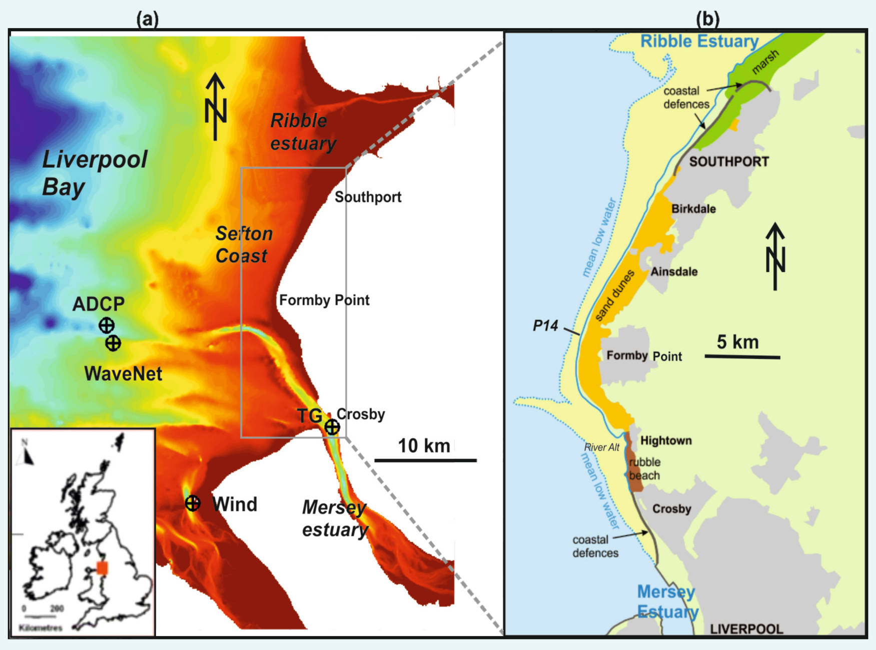
INTRODUCTION

Coastal dune systems provide natural defence against erosion, flooding and important natural habitat to local flora and fauna. Severe storms can cause non-recoverable erosion and dune breaching leading to hinterland flooding. Therefore, this is a major concern of coastal safety and sustainable development in the areas where frontal dune systems are present.

Present study investigates storm impacts on morphological evolution of the Sefton Coast beach/dune system applying process-based numerical models: Delft3D, SWAN and XBeach (Dissanayake et al., under review).

Study area

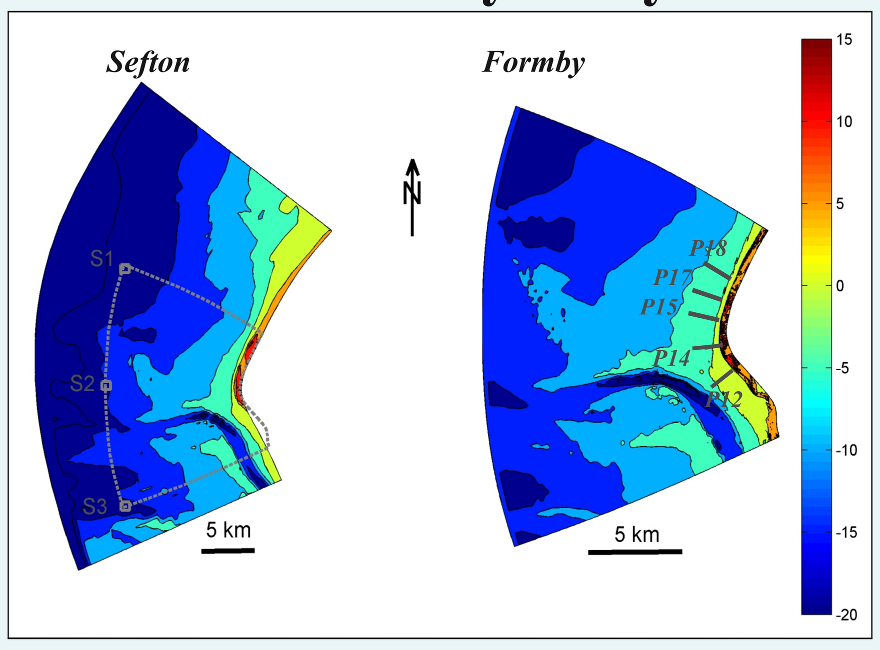


The Sefton Coast represents about 20% of the UK's dune system. It experiences a semi-diurnal macro-tidal regime (spring tidal range ~8.2 m) and extreme wave height ~5 m and it is however susceptible to erosion during storm events where landward retreat occurs leading to dune breach and coastal flooding.

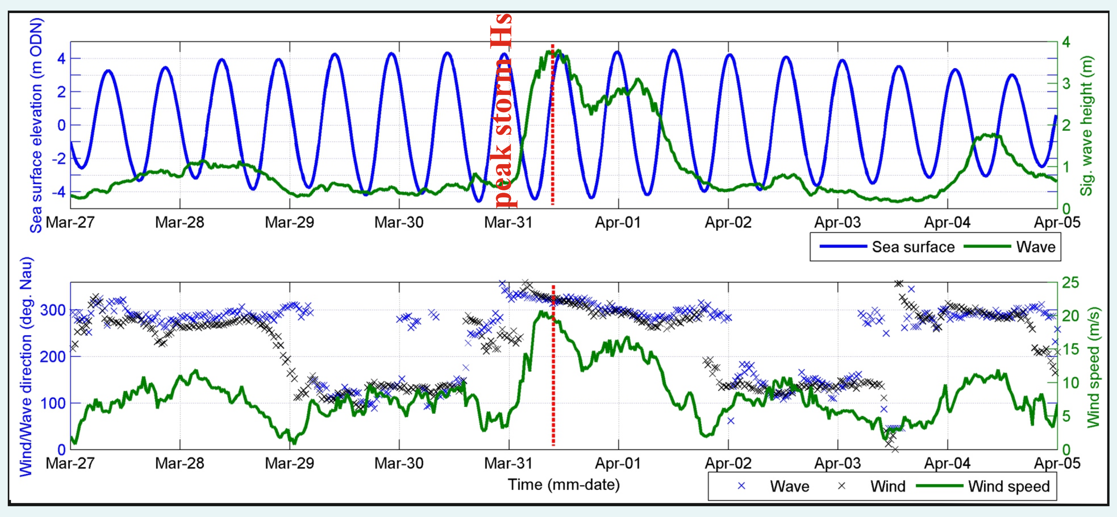
APPROACH

Our cascade modelling approach uses the ***Sefton*** domain, in **Delft3D** to generate spatial and time varying hydrodynamics and then in **SWAN** to transform offshore waves (WaveNet) up to the offshore boundary of the ***Formby*** domain in which **XBeach** is used to simulate the beach/dune system evolution during the storm period from ***27th March to 05th April 2010***.

Model bathymetry



Storm event - offshore conditions



The ***Sefton*** domain encloses entire Sefton coast with a coarse grid setup while the ***Formby*** domain covers the highly dynamic Formby beach/dune system with a finer grid resolution. Offshore bathymetry is based on the existing POLCOMS model (Brown et al, 2010) and the beach/dune system is constructed using the observed LiDAR data before the storm event.

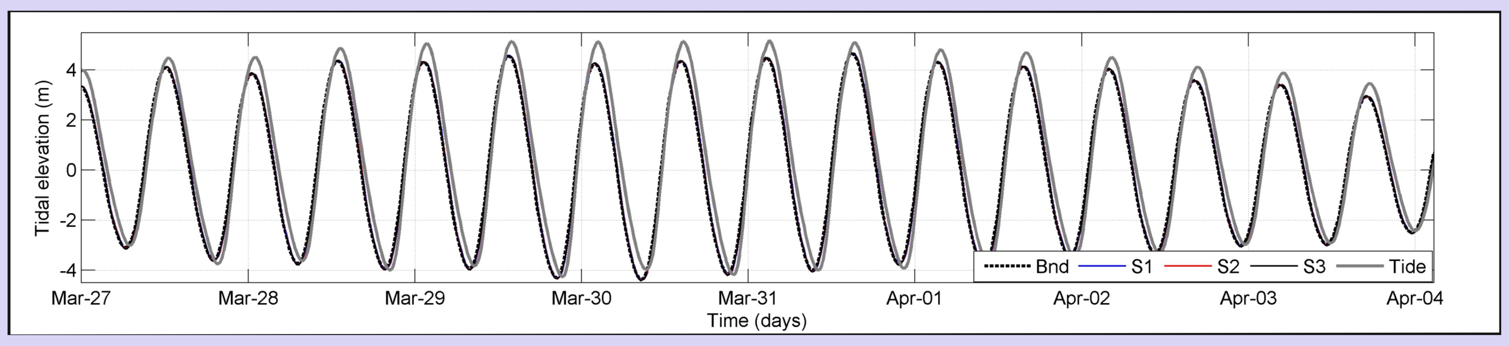
Northwesterly (NW) peak storm wave height (H_s = 3.8 m) at *WaveNet* (~ 24 m ODN depth) occurred at high tide (3.3 m ODN at *ADCP*) and strong NW wind (20 m/s). This combination of forcings makes the beach/dune system more vulnerable to storm attack.

RESULTS

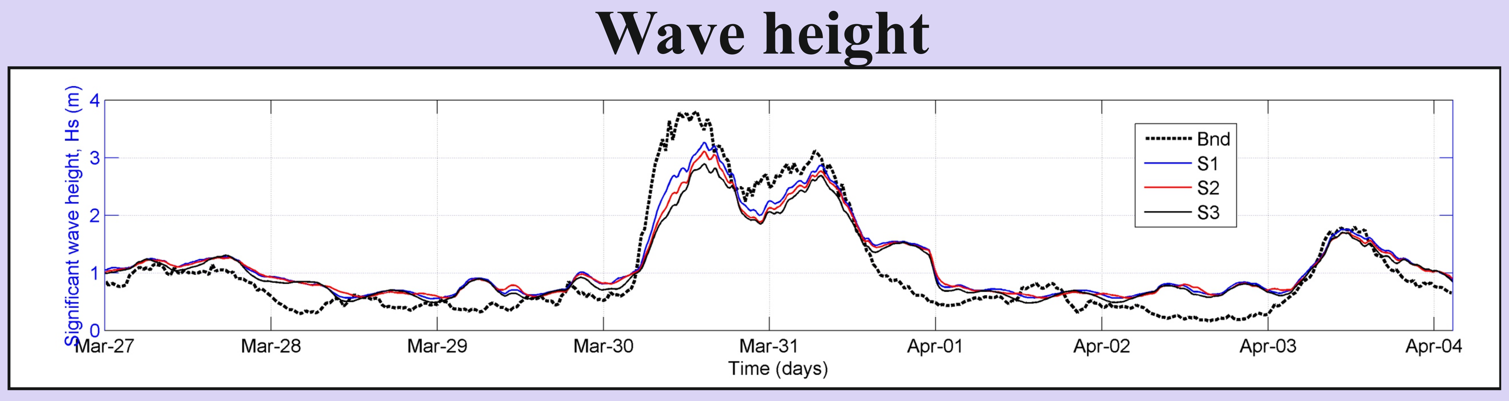
● *Hydrodynamics*

Hydrodynamics of the ***Sefton*** domain are compared with transformed water levels and wave heights at *S1*, *S2* and *S3* locations at the offshore boundary of the ***Formby*** domain.

Water level



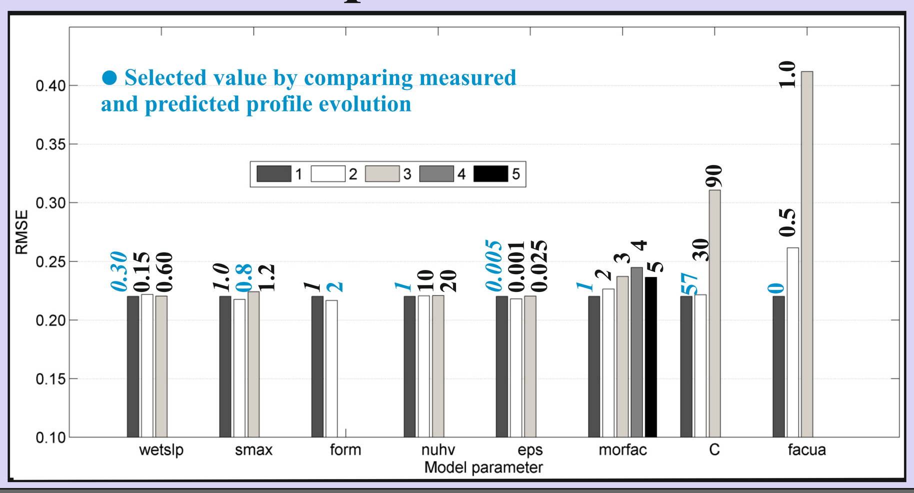
Wave height



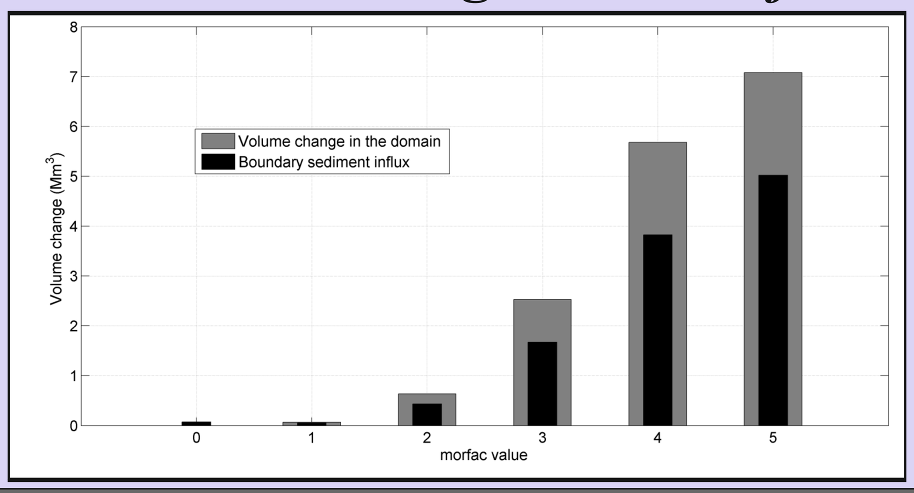
● *Sensitivity analysis*

Morphological evolution from XBeach model is known to be very sensitive to some model parameters; slope for avalanching (*wetslp*), maximum Shield value for overwash (*smax*), transport formula (*form*), additional shear dispersion factor (*nuhv*), threshold depth for drying/flooding (*eps*), morphological scale factor (*morfac*), Chézy coefficient (*C*) and calibration factor for wave asymmetry (*facua*). Optimised values are selected by sensitivity model runs.

RMSE **of profile evolution**



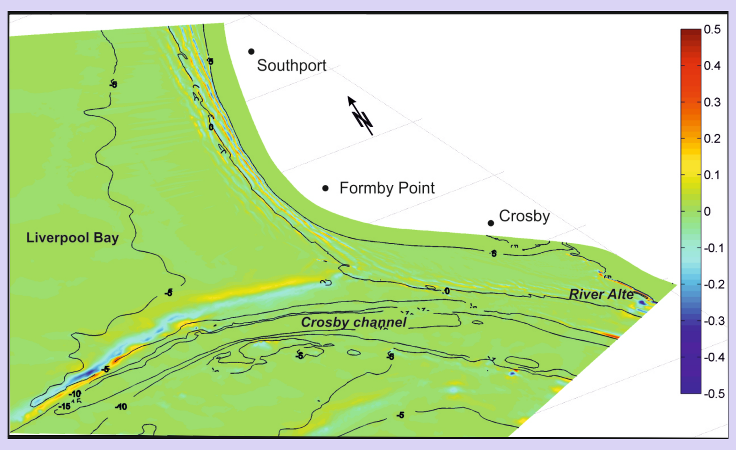
Volume change with ***morfac***



● *Storm impacts on beach/dune evolution*

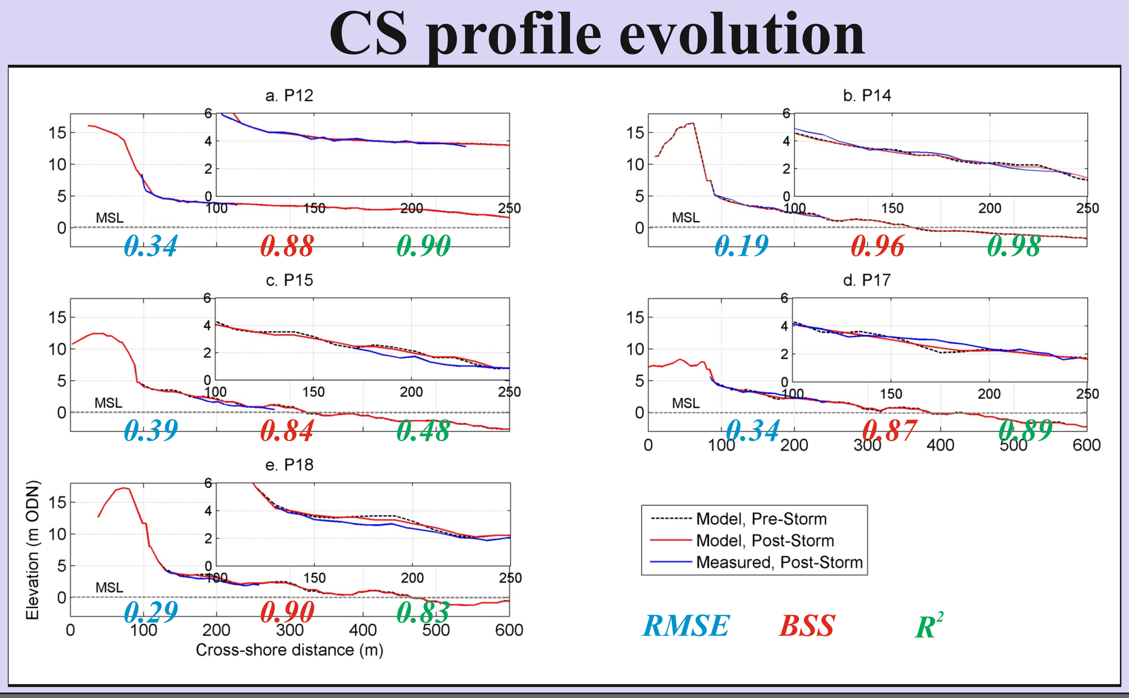
Bed evolution indicates alternate areas of erosion and sedimentation as typically found after a storm attack on a sandy beach system (Roelvink et al., 2009). Area above MWL within the inter-tidal region incurs the greatest bed change due to strong erosion on the dune front.

Erosion/Sedimentation



Bed level evolution increases from *P12* to *P17*. Statistical values indicate reasonable agreement between predicted and measured final profiles of which *P14* has the highest similarity.

CS profile evolution



CONCLUSIONS

● Morphological updating facility *morfac* available in the XBeach model (*morfac* > 1 approach) was not suitable to the prevailing environmental conditions of the Sefton coast (i.e. macro-tidal region). Therefore, simulations presented in this study used ***morfac* = 1**.

● Strong morphological changes occurred within the **inter-tidal region** due to severe erosion of the dune front which was aggressive during NW peak storm wave height (3.8 m) in combination with high tide (3.3 m) and NW strong wind (20 m/s).

● Statistical comparison indicated reasonable agreement between predicted and measured profiles. Present study provides preliminary insights of storm attack on the Sefton coast. On going work focuses the dune system response to **storm clustering** and **climate change**.

REFERENCES

Dissanayake, P., Brown, J. Karunarathna, H., *under review*. Modelling storm-induced beach/dune evolution: Sefton coast, Liverpool Bay, UK. *Marine Geology*.

Brown, J.M., Souza, A.J., Wolf, J., 2010a. An investigation of recent decadal-scale storm events in the eastern Irish Sea, Journal of Geophysical Research 115, C05018, doi: 10.1029/2009JC005662.

Roelvink, D., Reniers, A., van Dongeren, A., Van Thiel de Vries, J., McCall, R., Lescinski, J., 2009. Modelling storm impacts on beaches, dunes and barrier islands.