Influence of nonlinear waves on sandbar migrations using Monte Carlo simulations

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Objectives

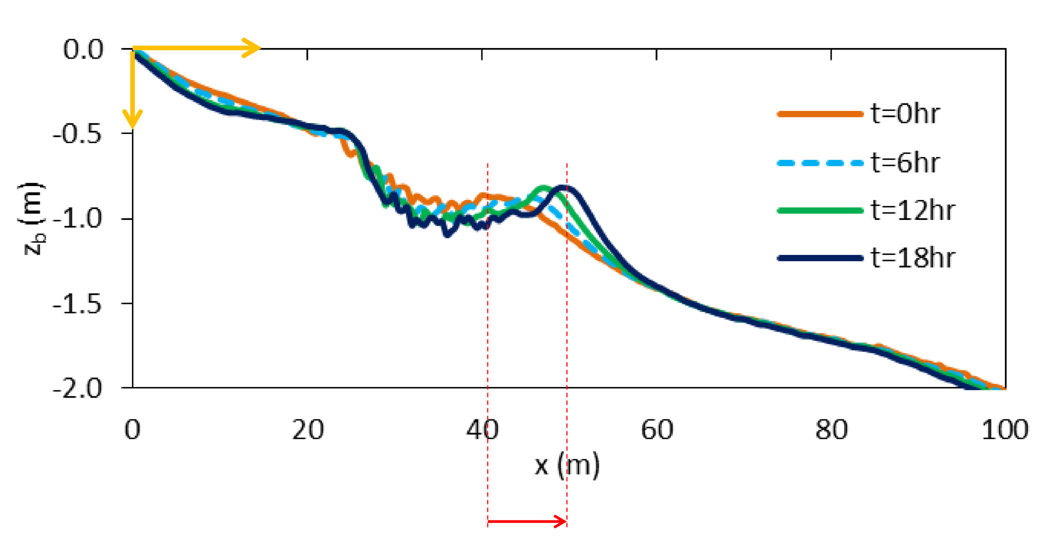
- Increase the understanding of cross-shore sediment transport processes under combined nonlinear waves and currents;
- Assess the ability of (practical) sediment transport models to predict beach profile evolutions;
- Validate a morphodynamic model, using observed beach profile evolutions of the European project "Large Installations Plan - LIP" (Arcilla et al., 1994);
- Investigate the influence of the wave asymmetry and skewness on the beach profile evolution using Monte Carlo simulations;

LIP Experiments

LIP 1B

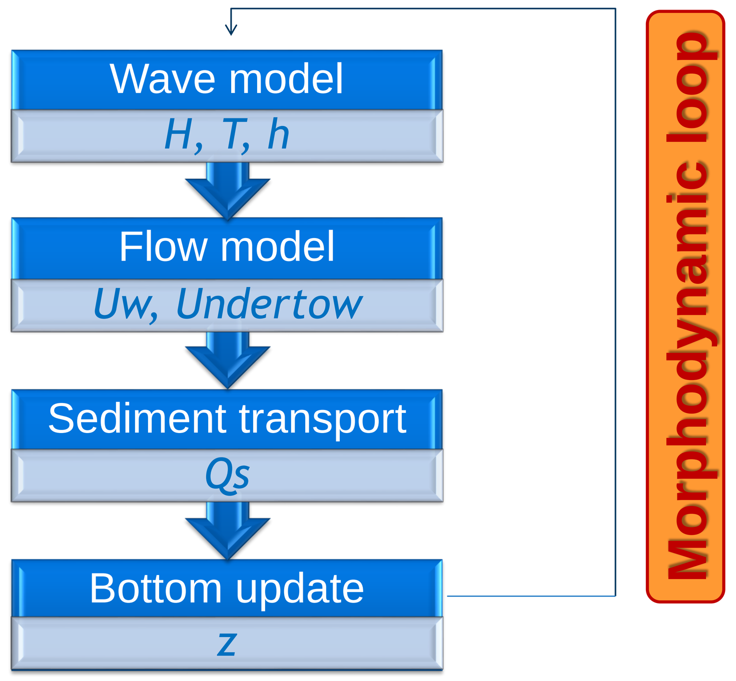
Irregular waves:
H_s=1.4 m,
T_p=5 s
→ **Erosive conditions**

d_{50}=0.22mm



Breaker bar in the surf zone grows and migrates offshore (18h simulation).

Methodology



Wave model

Parameterization of wave skewness and asymmetry (Ruessink et al.,2012):

- Input: H, T, h ⟹ r – index of skewness or nonlinearity; ϕ – waveform parameter
- Determine:
  - Ursel Number, non-linearity parameter.

$$U_r = \frac{3}{8}\frac{Hk}{(kh)^3}$$

$$B = p_1 + \frac{p_2 - p_1}{1+\exp\left(\frac{p_3 - \log U_r}{p_4}\right)}$$

Parameter	Proposed value	95% confidence interval
p_1	0	–
p_2	0.857	±0.016
p_3	−0.471	±0.025
p_4	0.297	±0.021
p_5	0.815	±0.055
p_6	0.672	±0.073

Nonlinear free stream velocity, $u_\infty(t)$, parameterized by (Abreu et al., 2010):

U_r, B → r,ϕ →

$$u(t) = U_w f\frac{\left[\sin(\omega t) + \frac{r\sin\phi}{1+\sqrt{1-r^2}}\right]}{\left[1 - r\cos(\omega t + \phi)\right]}$$

Sediment transport

Meyer-Peter Müller type formula (Nielsen, 2006)

$$q_s = 12\sqrt{(s-1)gd^3}\left(\theta(t) - \theta_{cr}\right)\sqrt{\theta(t)}\,u_*/|u_*|$$

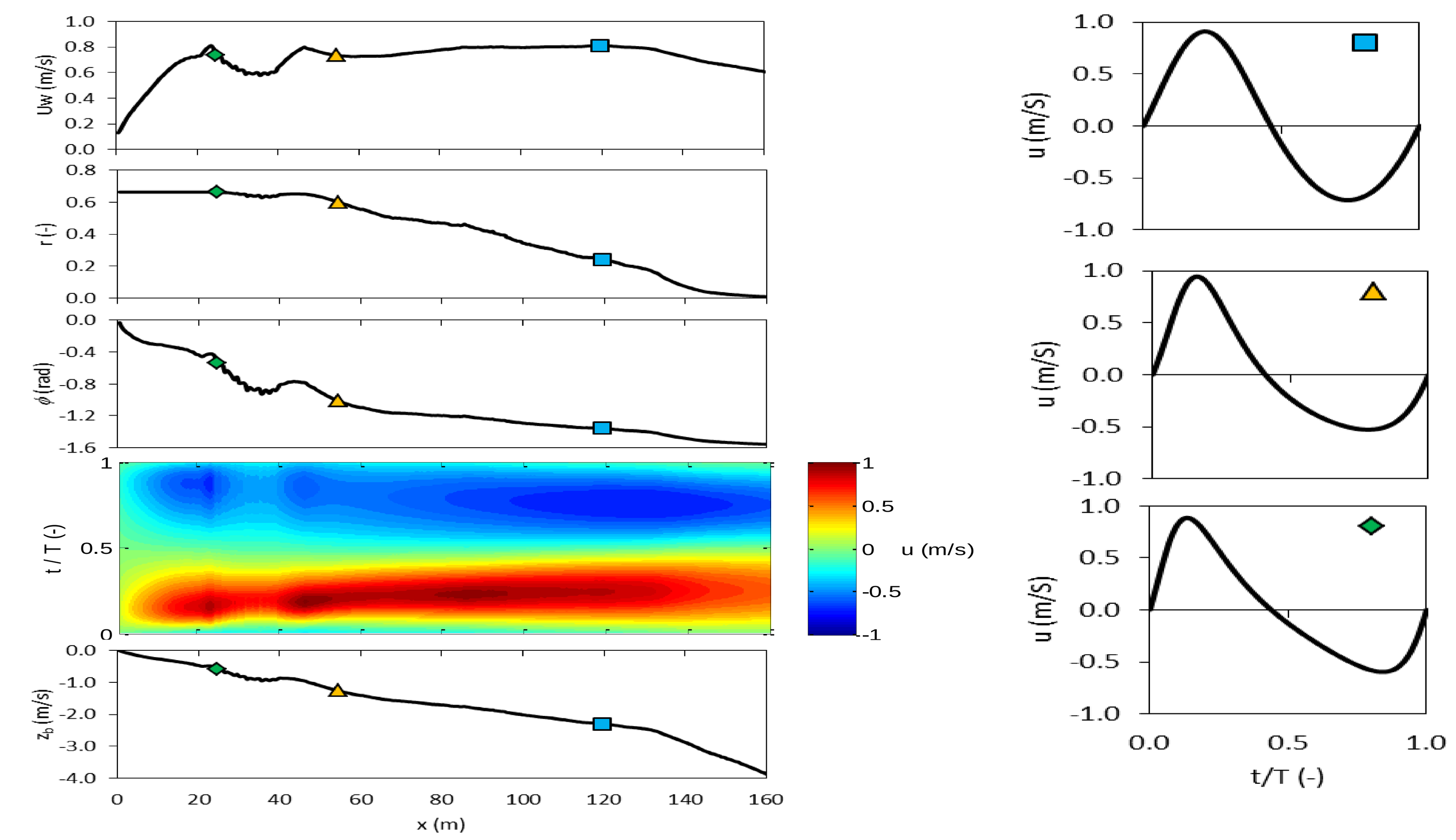
bed shear stress predictor (Abreu et al., 2013):

$$u_*(t) = \sqrt{\frac{f_w}{2}}\left(\cos(\varphi)\,u(t) - \sin(\varphi)\,\mathcal{H}\left(u(t)\right)\right)$$

Results

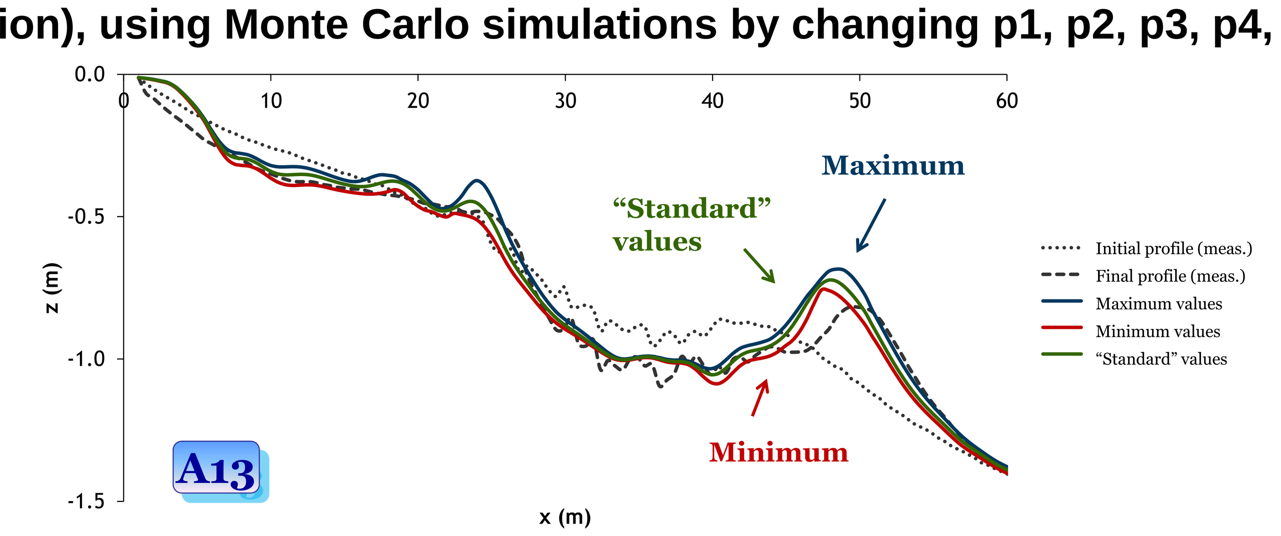
Hydrodynamics

Spatial variation of U_w, r, ϕ, $u(t)$:



Computed profiles

Influence of the variations of non-linear parameters (wave asymmetry and skewness) in the sandbar evolution (18h simulation), using Monte Carlo simulations by changing p1, p2, p3, p4, p5, p6.



Conclusions

- The numerical results of a morphodynamic model are compared against the observed beach profile evolutions of the experiment LIP1B.
- The parameterizations of Abreu et al. (2010) and Ruessink et al. (2012) provide a good characterization of the flow characteristics.
- The ability of a simple practical sand transport model is examined to reproduce the seaward migration of the sand bar.
- Using variations in the parameters proposed by Ruessink et al. (2012) through Monte Carlo method does not lead to significant changes in the sandbar evolution.

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References

- Abreu, T., Silva, P.A., Sancho, F. and A. Temperville. 2010. Analytical approximate wave form for asymmetric waves, Coastal Engineering, 57, 656-667.
- Abreu, T., Michallet, H., Silva, P.A., Sancho, F., van der A, D.A. and Ruessink, B.G., 2013. Bed shear stress under skewed and asymmetric oscillatory flows. Coastal Engineering, 73: 1-10.
- Arcilla, A. Roelvink, J., O'Conner, B., Reniers, A. and Jiménez, J., 1994. The delta flume '93 experiment. Coastal Dynamics'94, ASCE: 488-502.
- Nielsen, P. 2006. Sheet flow sediment transport under waves with acceleration skewness and boundary layer streaming. Coastal Engineering, 53(9): 749-758.
- Ruessink, B.G., Ramaekers, G. and L.C. van Rijn. 2012. On the parameterization of the free-stream non-linear wave orbital motion in nearshore morphodynamic models. Coastal Engineering, 65: 56–63..