Long term modelling of a Mediterranean embayed beach: reduced-complexity model vs XBeach model

Albert Falqués, Nil Carrión, Francesca Ribas, Daniel Calvete, Candela Marco-Pereto, Ruth Duran, Angels Fernandez-Mora

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Departament de Física

MOCCA
Coastal Morphodynamics under Climate Change

MOLLY
Improving morphodynamic projections of low-lying coasts

Introduction & Aim

Final objective: Long term morphodynamic modelling (80 yr) of Castell Beach under expected sea level rise

NOT possible with standard process-based 2DH models → Reduced-complexity model: Q2Dmorfo

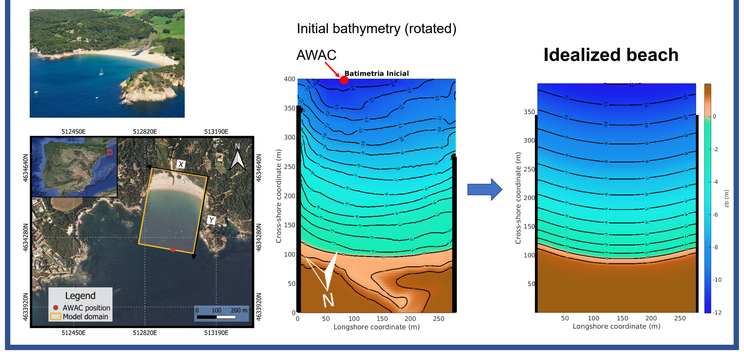
Need validation

Validation of Q2Dmorfo and XBeach at Castell Beach during 6-month period
- Data: initial and final topo-bathymetry + (hourly) waves + (hourly) mean sea level
- After calibration both XBeach and Q2Dmorfo provide a good prediction of coastline position (Brier skill score ≈ 0.8). XBeach provides a reasonable prediction of the bathymetry (skill score ≈ 0.4)

BUT what happens at event time scale? NO bathymetric data

AIM: comparison of Q2Dmorfo with Xbeach at event time scale

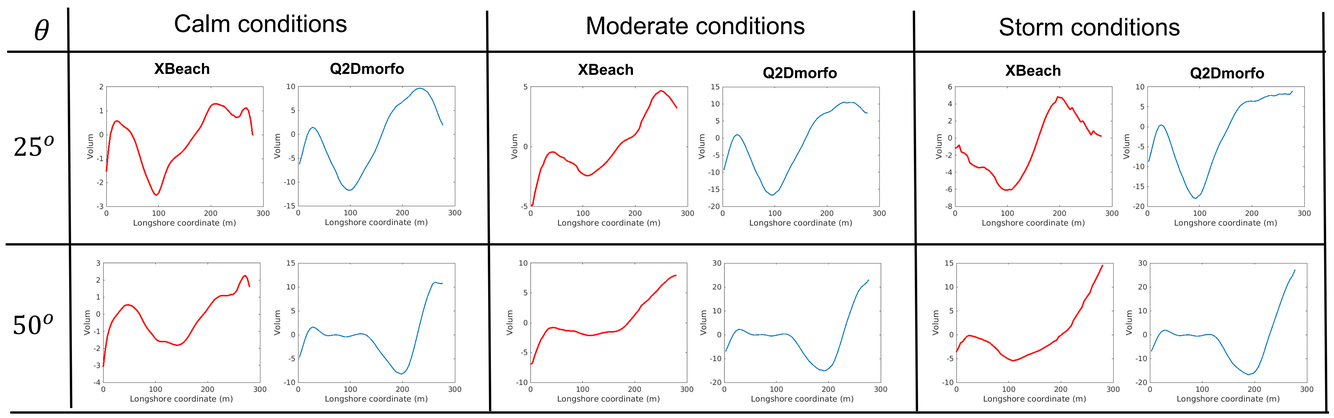
Castell Beach



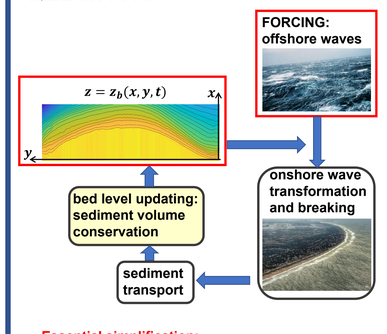
Accumulated sediment volume in each cross-shore section

$$\Delta\left(\frac{\Delta V}{\Delta y}\right)(y) = \int_{x_1}^{x_2} (z_b(x,y,t_F) - z_b(x,y,0))\, dx \qquad m^3/m$$

y = longshore coordinate



Q2Dmorfo



Essential simplification:
Sediment transport is computed parametrically from the waves without resolving the mean hydrodynamics

Approach

Idealized beach approximating the geometry, dimensions and bathymetry of Castell Beach
- Initial shoreline= parabola approximating Castell Beach initial shoreline
- Initial bathymetry= constructed from the shoreline with the Q2Dmorfo equilibrium cross-shore profile
- Lateral boundaries= hard walls representing the rocky headlands

Wave conditions (different typical conditions at Castell Beach)
- "calm conditions": $H_s = 0.5$ m ; $T_p = 5.5$ s ; $\theta = 0, 25, 50^o$; run time = 26 d
- "moderate conditions": $H_s = 1$ m ; $T_p = 6.5$ s ; $\theta = 0, 25, 50^o$; run time = 6 d
- "storm conditions": $H_s = 1.5$ m ; $T_p = 7.5$ s ; $\theta = 0, 25, 50^o$; run time = 2 d

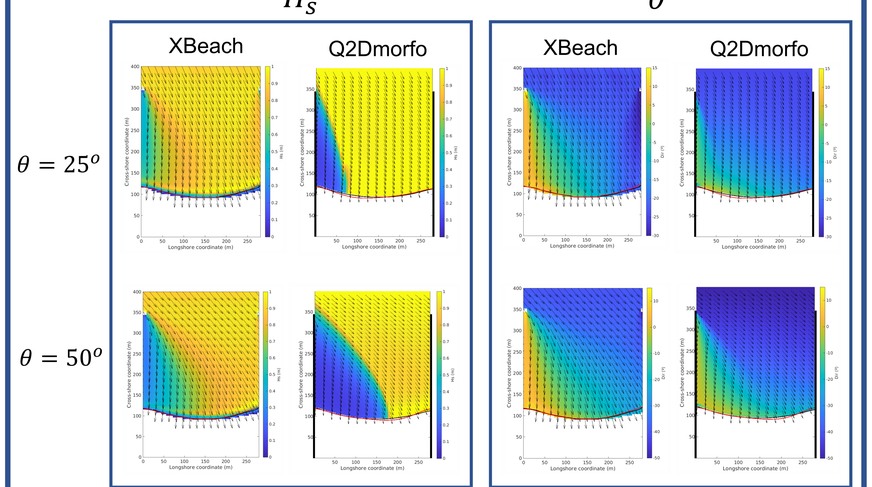
Interplay longshore/cross-shore transport
- Cross-shore transport { XBeach: process-based (waves & currents); Q2Dmorfo: parameterized (relaxation to an assumed equilibrium profile) → **Very different! Hardly comparable**
- Longshore transport { XBeach: process-based (currents); Q2Dmorfo: parameterized (based on the CERC formula) → **Are they similar ?**

Initially, XBeach behaviour is dominated by cross-shore transport since initial profile is of equilibrium for Q2Dmorfo, but NOT for XBeach

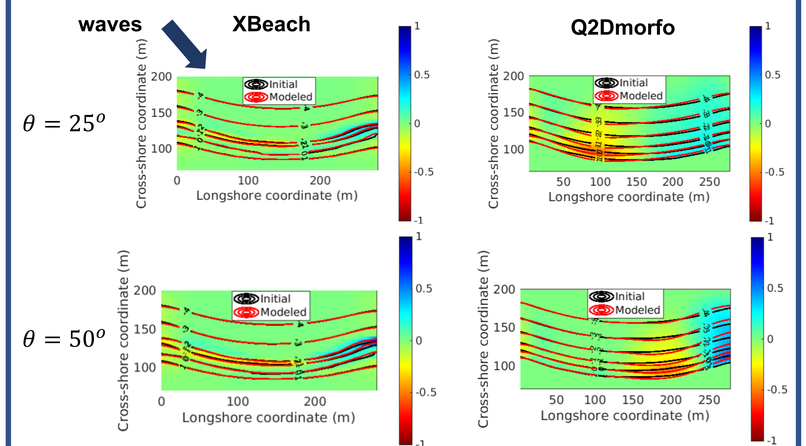
An initial "stabilization run" with shore normal wave incidence is needed for XBeach in order that cross-shore transport becomes small and do not spoil the longshore transport comparison between both models.
Different "stabilization times" have been explored. Finally:
- Calm conditions: $\Delta t = 90$ d
- Moderate conditions: $\Delta t = 50$ d
- Storm conditions: $\Delta t = 35$ d

Model runs for comparison, initial bathymetry:
- Q2Dmorfo: initial idealized
- XBeach: initial idealized after "stabilization" run

Wave height & wave angle: moderate conditions



Bathymetric changes: moderate conditions



See oral presentation by Nil Carrión, session GM6.1

Conclusions

- Alongshore erosion/deposition zones agree quite well, especially for moderate wave incidence angle
  - Althouth Q2Dmorfo tends to overestimate the magnitudes and offshore reaches
- The differences in the alongshore distribution of those zones seem mainly associated to different treatment of the headland wave-shadow, especially for high wave incidence angle. The wave shadow in XBeach is more difuse because of angular spreading.
- Cross-shore transport is quite different in both models with the result that the shorelines can diverge significantly at the event time scale.
- The long term runs of Q2Dmorfo filter out the fast variabilty at event time scale and gives the correct long term tendency of the shoreline as it is seen from the good skill in the 6-month validation.