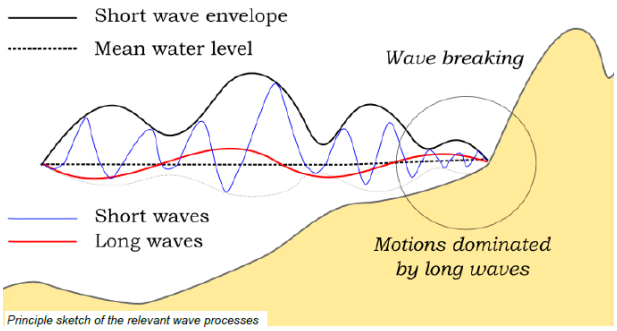
XBeach – an open-source model to simulate hydrodynamic and morphodynamic processes and storm impacts

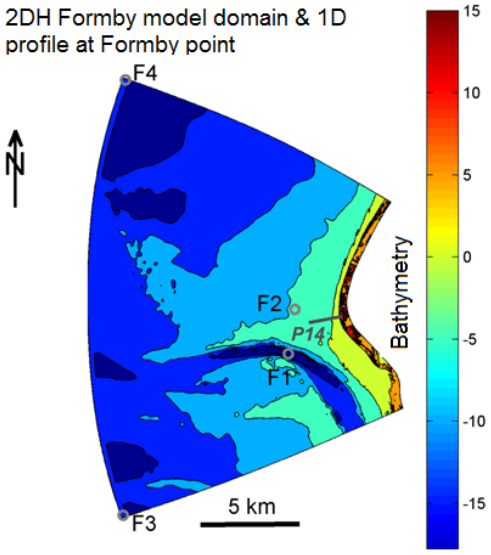
General features of hydrodynamics:

- XBeach, originally developed for sandy coast.
- Includes: short wave transformation (refraction, shoaling and breaking), long wave (infragravity wave) transformation (generation, propagation and dissipation), wave-induced setup and runup, time-varying depth-averaged currents, wave-current interaction, roller momentum exchange, overwash, inundation, vegetation and hard structures.
- The domain can be 1D cross-shore (the longshore gradients are ignored) or in XBeach only 2DH area (solved on a curvilinear grid).



Principle sketch of the relevant wave processes

- The time scales in XBeach can be set to resolve: wave-averaged, wave group or the non-linear shallow water equations.
- The non-linear shallow water equations are solved as depth-averaged Generalized Lagrangian Mean formulations with a non-hydrostatic pressure term to solve short waves. The momentum and continuity equations are formulated in terms of the Lagrangian velocity and take into account wind stress, bed shear, wave-induced stress, vegetation-induced stress, horizontal viscosity and the Coriolis effect.
- Ground water is considered using the principle of Darcy flow for laminar flow and a parameterization of the Forchheimer equations for turbulent flow.



Sediment transport:

- Processes in XBeach include bed load and suspended sediment transport, dune face avalanching, bed evolution and breaching.
- In XBeach depth-averaged sediment concentrations in the water column are modelled using a depth-averaged advection-diffusion scheme with a source-sink term based on equilibrium sediment concentrations (Galappatti and Vreugdenhil, 1985).
- The 2 sand transport options in XBeach are the Soulsby-Van Rijn equations (Soulsby, 1997; van Rijn, 1984) or the Van Thiel-Van Rijn transport equations (van Rijn, 2007; van Thiel de Vries, 2009).
- Variable bed composition can be included to account for different sediment fractions, sorting and armouring.
- Morphological evolution can run in 'real time' or with a morphological factor to simulate longer term changes.
- Bed shear stress is calculated using the approach of Ruessink et al. (2001) and enhanced near-bed turbulence due to wave breaking can be accounted for using wave-averaged or bore-averaged exponential decay models.

Improvements to the sediment transport model: Incorporation of a new physical parameterisation of Aeolian transport to enable dune growth within XBeach.

XBeach use and linkages within BLUEcoast

- Applied in WP1 (Perranporth) & WP4 (Minsmere) to assess sensitivity in beach response to boundary forcing from FVCOM (WP3), Delft 3D (WP1, WP4) & the Met office products (WP1, WP4).
- Applied in WP1 (Perranporth) to investigate cross-shore and along-shore sediment exchange.
- Applied in WP4 (Minsmere) to investigate future resilience of the coastal system with consideration of plausible human intervention.
- Applied in WP1 & WP4 to determine changes in flood and erosion risk under future shoreline projections by COVE, developed in WP2.