COVE: Coastal One-line Vector Evolution model.

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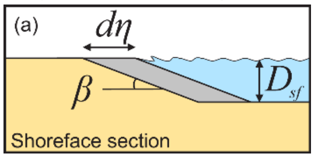
SUMMARY

- COVE is a ‘one-line’ type shoreline evolution model.
- Application at spatial scales of kms to tens of kms, over decadal to millennial timescales.
- Coastal change is driven by gradients in wave-generated alongshore sediment transport.
- Alongshore sediment transport driven by the height and angle of breaking waves.
- Include emergent landforms (capes) and emergent processes (wave shadowing)
- Retreat of cliffs governed by beach interaction (abrasive tools vs cliff protection).

Fig. 1: Constant shore profile

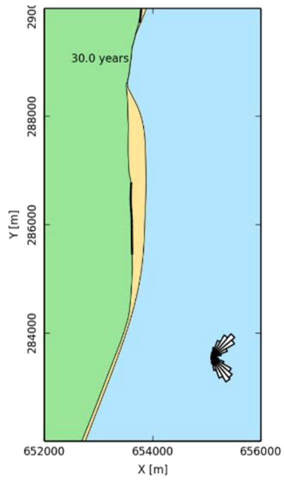


The COVE model is a special case of a ‘one-line’ model designed to handle complex coastline geometries, with high planform curvature shorelines (Hurst et al., 2015). The shoreline is represented by a single line (or contour) that advances or retreats depending on the gradient of the alongshore sediment flux. COVE is now actually a two-line model because a second line represents the coastal cliffs top, which interacts with the shoreline, eroding to provide beach sediment which then offers protection to the cliff against further erosion. One-line models make a number of simplifying assumptions to conceptualise the coastline allowing the ‘one-line’ representation of the coastline:

ASSUMPTIONS

- Short-term cross-shore variations due to storms or rip currents are considered temporary perturbations to the long-term trajectory of coastal change (i.e. the shoreface recovers rapidly from storm-driven cross-shore transport).
- The beach profile is thus assumed to maintain a constant time-averaged form (Fig. 1), implying that depth contours are shore-parallel and therefore allows the coast to be represented by a single contour line.
- Alongshore sediment transport occurs primarily in the surf zone, and cross-shore sediment transport acts to maintain the equilibrium shoreface as it advances /retreats.
- Alongshore sediment flux occurs due to wave action in the surf zone, parameterized by the height and angle of incidence of breaking waves. Gradients in alongshore transport dictate whether the shoreline advances or retreats, and depositional landforms diffuse, migrate or grow (Fig. 2 shows an example of migrating landform).

Fig. 2: Benacre Ness simulation

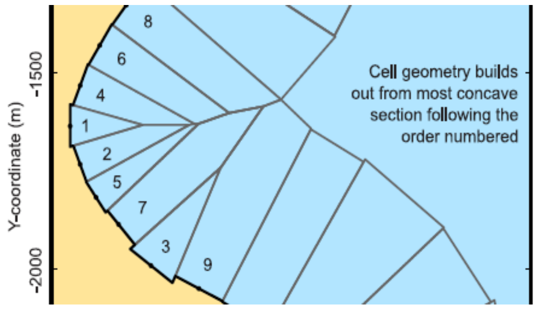


The **conservation equation** for beach sediment expressed in terms of local coordinates states that the change in position of the shoreline ($d\eta$), perpendicular to the local shoreline orientation (s) through time (t) is a function of the divergence of alongshore sediment flux (Q).

$$\frac{d\eta}{dt} = f\left(\frac{dQ}{ds}\right)$$

A *key novelty* of COVE is that it uses a local coordinate scheme (rather than global), requiring that coastal cells take on a variety of polygonal shapes (e.g. triangles and trapezoids). The coastline is represented as a series of nodes, each of which have a corresponding cell. The cells are meshed by projecting cell boundaries perpendicular to the local shoreline orientation (Fig. 3).

Fig. 3: Example of meshed shoreline cells



Sediment flux is driven by breaking waves. Offshore waves are transformed according to linear wave threory, assumping shore-parallel depth contours. Typically in bulk alongshore transport laws, flux depends on the height (H_b) and angle (α_b) of breaking waves, e.g. CERC equation:

$$Q_{ls} = K_{ls} H_b^{5/2} \sin 2\alpha_b$$

DATA

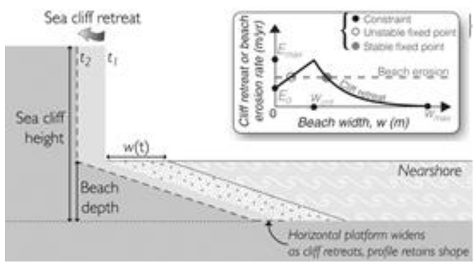
- The model requires an offshore (~unaffected by refraction, shoaling and shadowing) wave data. This can be obtained either from a wave buoy or preferably from distributed coastal area modelling predictions of wave conditions
- The transport coefficient K_{ls} may be modified to account for the size of beach material (D_{50}). Calibration of this coefficient can be made from estimates of bulk alongshore transport or by calibration against a historical record of coastal change.
- Historical shoreline positions and legacy wave data allow training of the model to reproduce past geomorphic changes.

The cliffline and coastline interact to determine how wide the beach is locally. Eroded cliff material is provided to the adjacent beach and causes the shoreface to advance. Cliff erosion is controlled by beach width since a wider beach provide energy dissipation and protection from breaking waves (Fig 3). The result is that we can run simulations at decadal timescales to explore the interactions between coastal erosion and alongshore sediment dynamics.

Human interaction with the coast

- Nourishment can be provided to build out the shoreface
- Hard defences represented as immovable, cliffed shoreline
- Groin fields simulated by prescribing a minimum beach width

Fig. 3: Cliffs model (after Limber et al., 2014)



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