Zen and the art of understanding coastal change

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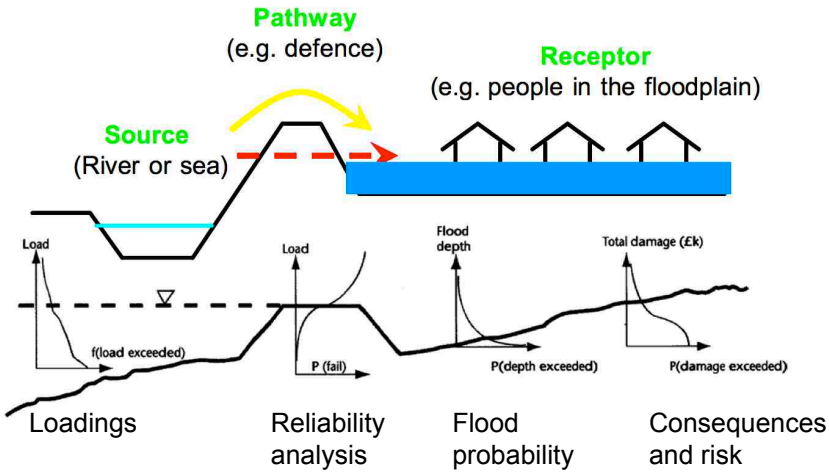
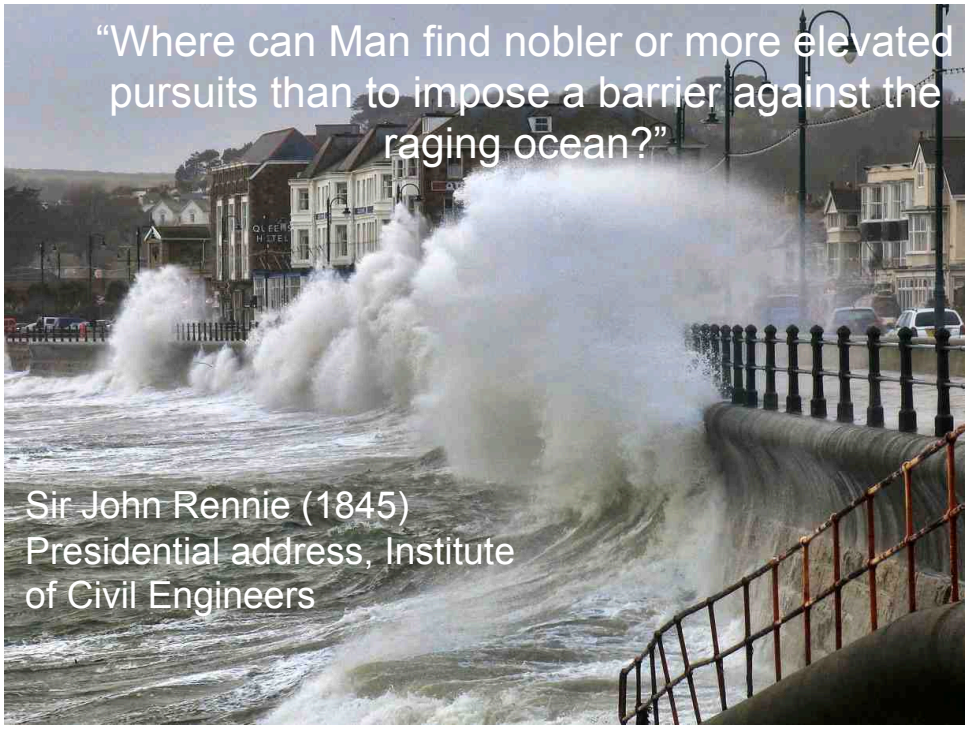
UCL Department of Geography

Morphology as a mediator of risk

Source – pathway – receptor model for coastal flooding (Sayers, 2002)



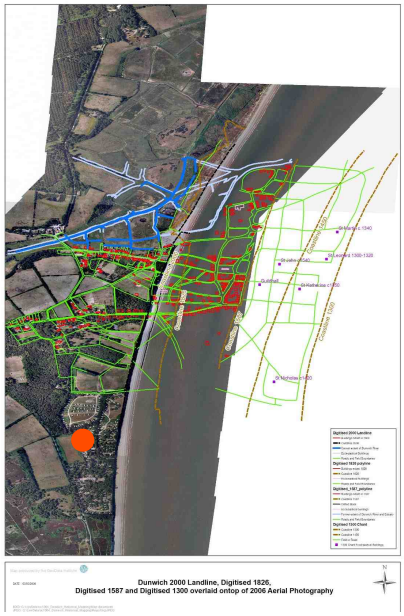
Beach – cliff system as pathway for erosion risk, Happisburgh, Norfolk

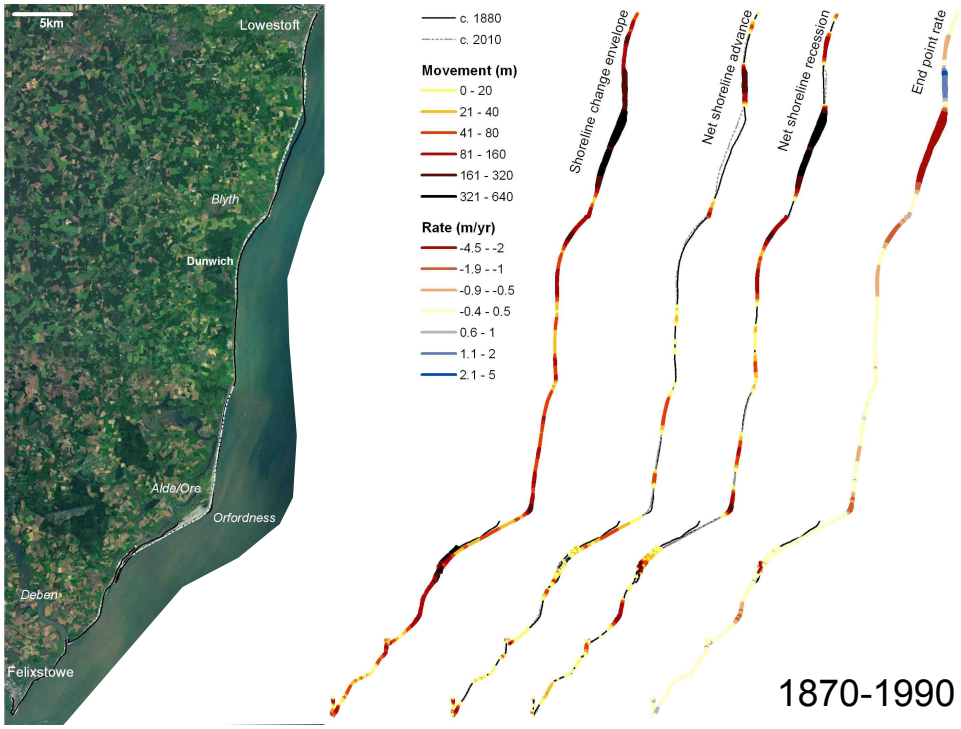


Coastal change in Britain – a bigger picture

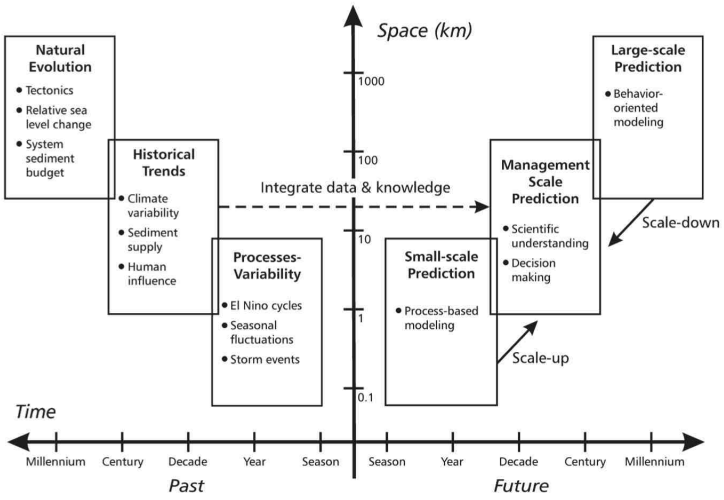
- Formation of North Sea Basin and uplift of British Isles over Cenozoic (> 60Ma).
- Glaciations of past 2- 3 Ma. Devensian, ice extended from Scandinavia across northern North Sea and became contiguous with ice sheets centred in North Wales and Ireland. Sea level 120 - 140 m lower than present and much of continental shelf exposed to sub-aerial processes.
- Approximately 10,000 years ago, southern North Sea, eastern English Channel and eastern Irish Sea still dry.
- Early Holocene sea-level rise too rapid for shorelines to reach erosional equilibrium and coastal change mainly by inundation. By 4500 years BP, coastline has modern gross configuration.
- Subsequent erosion of soft cliffs, marine reworking of submerged Pleistocene sediments, and infilling of estuaries. Rate of change slower in later Holocene as supply of marine and coastal sediment exhausted, partly by engineering works after 18th century.

The coast as a place of contemporary erosional change





Conceptual diagram relating time and space scales of past and future coastal change



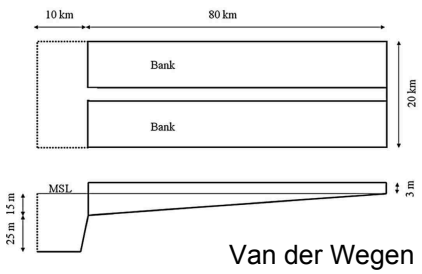
Gelfenbaum & Kaminsky (2010, *Marine Geology*)

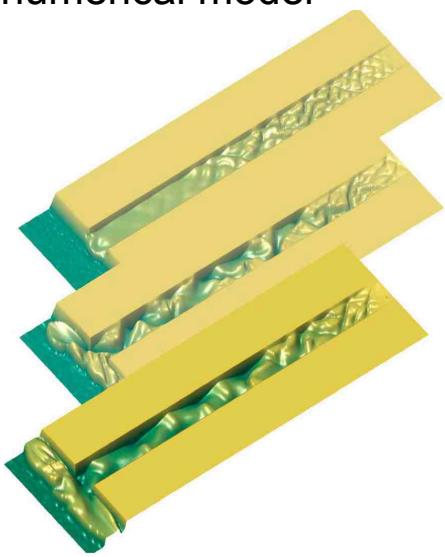
Idealised estuary morphological evolution using a reductionist numerical model

$$\frac{\partial \zeta}{\partial t} + \frac{\partial h\bar{u}}{\partial x} + \frac{\partial h\bar{v}}{\partial y} = 0$$

$$\frac{\partial \bar{u}}{\partial t} + \bar{u}\frac{\partial \bar{u}}{\partial x} + \bar{v}\frac{\partial \bar{u}}{\partial y} + g\frac{\partial \zeta}{\partial x} + c_f\frac{\bar{u}\sqrt{\bar{u}^2+\bar{v}^2}}{h} - \nu_e\left(\frac{\partial^2 \bar{u}}{\partial x^2} + \frac{\partial^2 \bar{u}}{\partial y^2}\right) = 0$$

$$\frac{\partial \bar{v}}{\partial t} + \bar{v}\frac{\partial \bar{v}}{\partial y} + \bar{u}\frac{\partial \bar{v}}{\partial x} + g\frac{\partial \zeta}{\partial y} + c_f\frac{\bar{v}\sqrt{\bar{u}^2+\bar{v}^2}}{h} - \nu_e\left(\frac{\partial^2 \bar{v}}{\partial x^2} + \frac{\partial^2 \bar{v}}{\partial y^2}\right) = 0$$





Van der Wegen (2013; Journal of Geophysical Research)

Integrated Coastal Sediment Systems (iCOASST)

Meso-scale *O*(10^1 – 10^2 yr, km) coastal morphological change

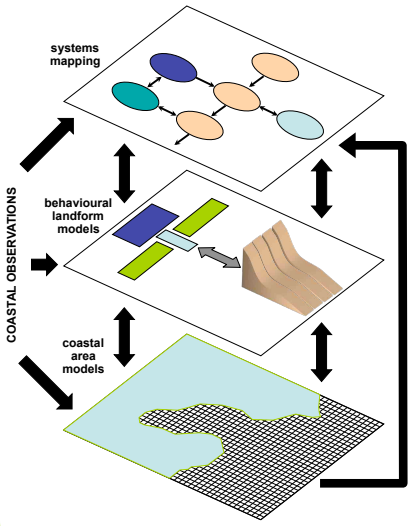
Landform behaviour models nested in shelf-scale coastal area models

New conceptual framework to:

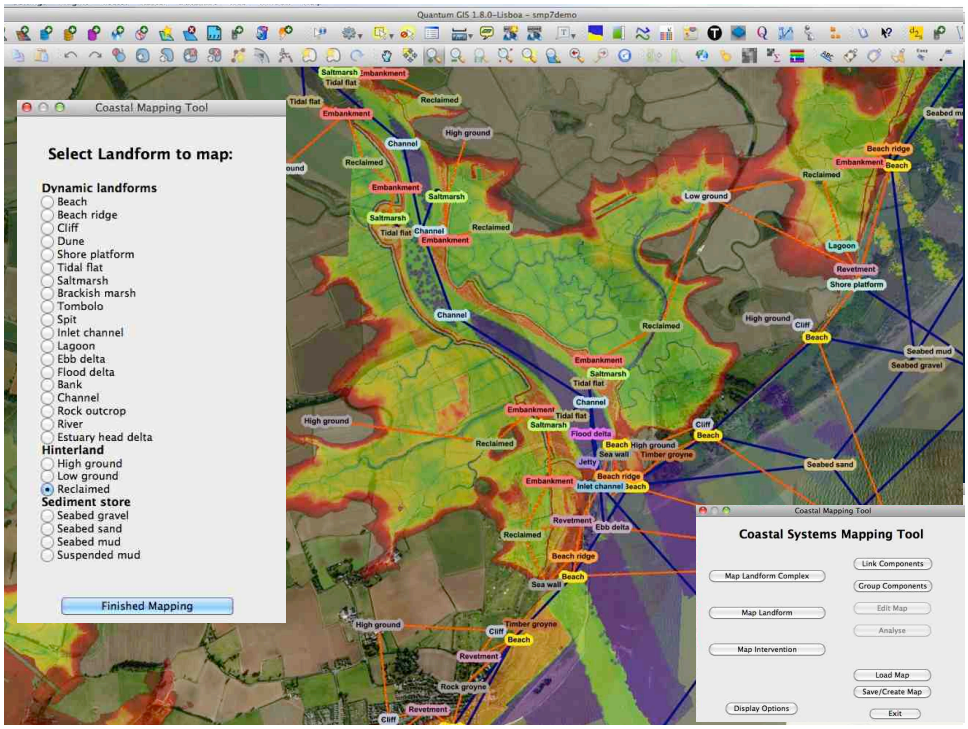
i) integrate estuary, coast and shelf

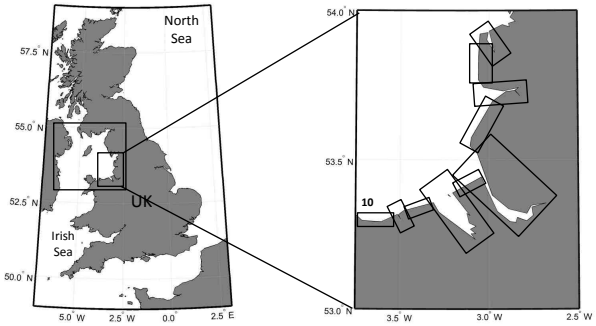
ii) formalise knowledge of interactions and multi-scale transport pathways

iii) provide framework for specifying and coupling landform behaviour models



UCL NERC SCIENCE OF THE ENVIRONMENT iCOASST integrating coastal sediment systems



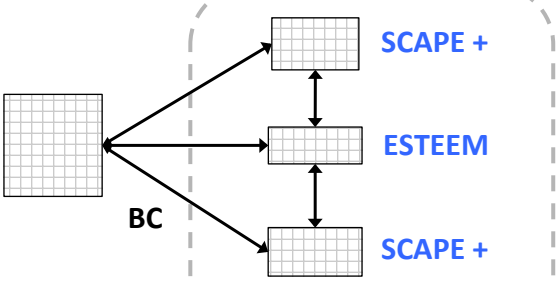


Landform complexes provide template for model ‘compositions’

Landform models:

Coastal area models:

Telemac
FVCOM
POLCOMMS



‘Synthesist’ model of coastal platform and soft rock cliff evolution (SCAPE; Walkden & Hall, 2011))

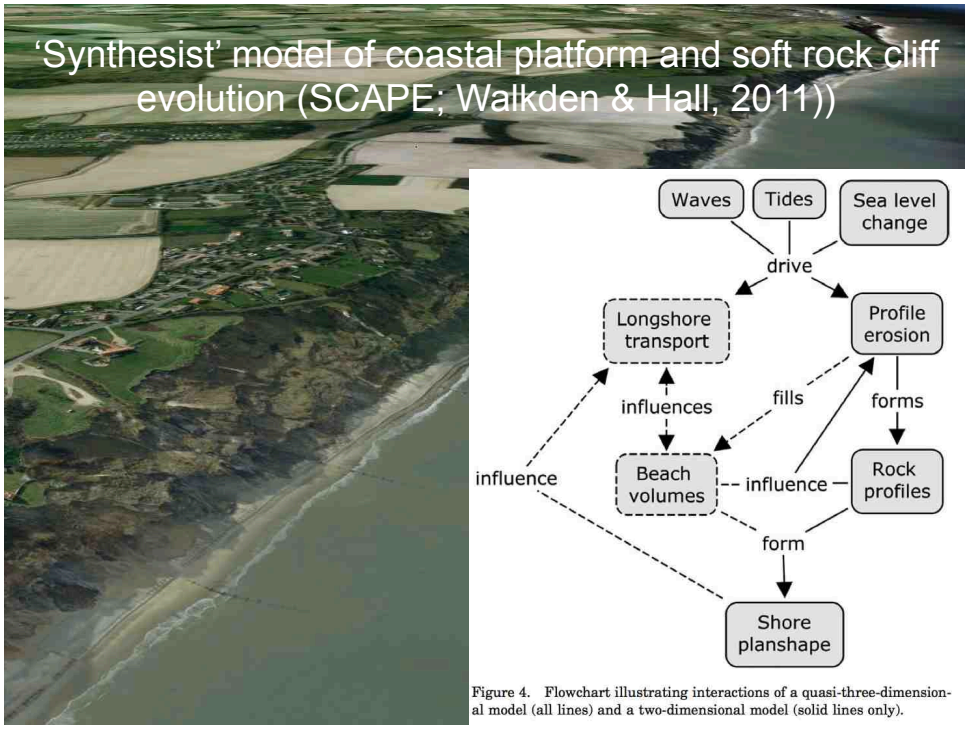
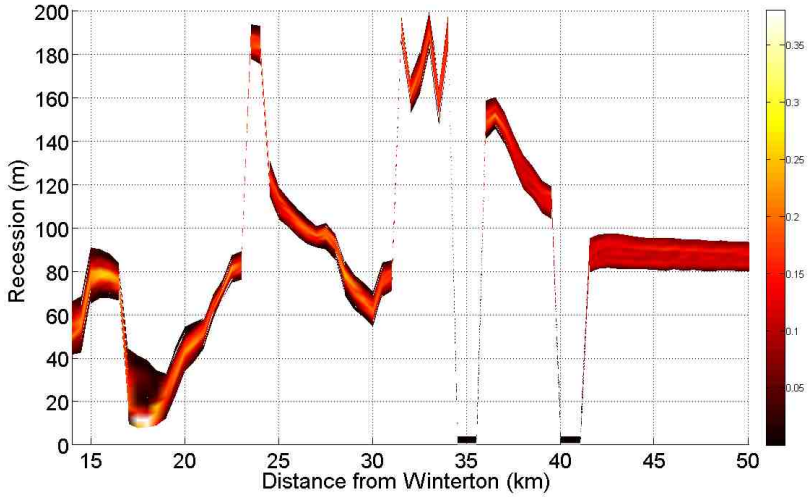
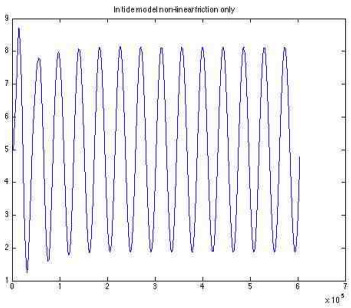


Figure 4. Flowchart illustrating interactions of a quasi-three-dimensional model (all lines) and a two-dimensional model (solid lines only).

SCAPE: Probabilistic cliff recession
(over 100 years)



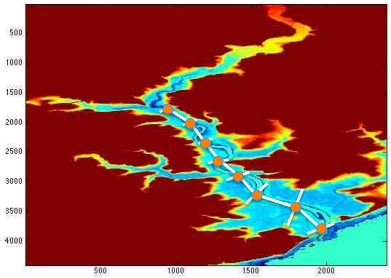
Hybrid ESTEEM model under development at UCL



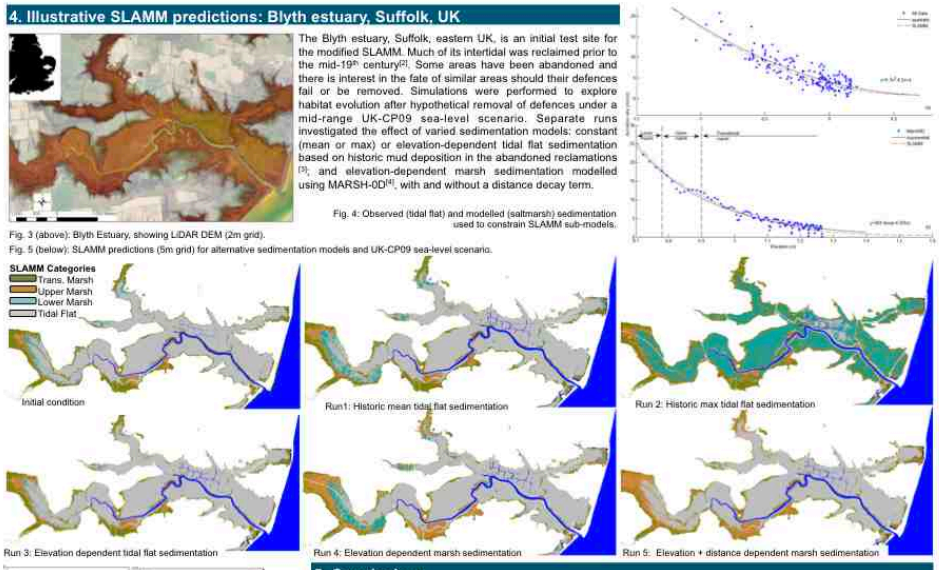
Prototype hydrodynamic code:

- tidal amplitudes determine landform zonation
- currents drive sediment exchange

Deben estuary

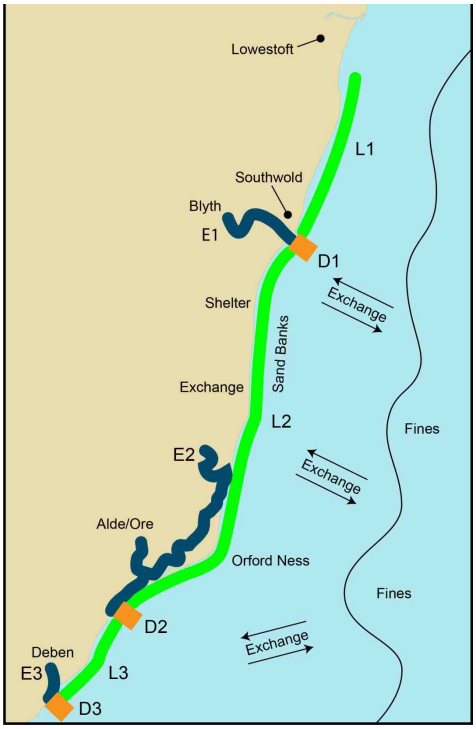


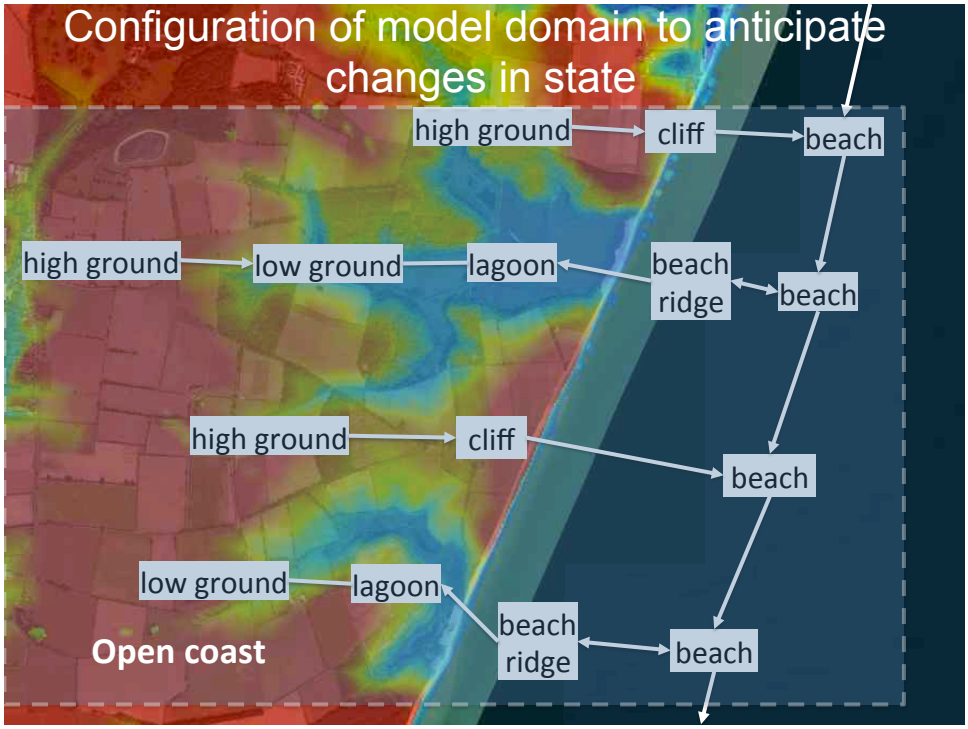
1D tidal channel scheme embedded in raster DEM

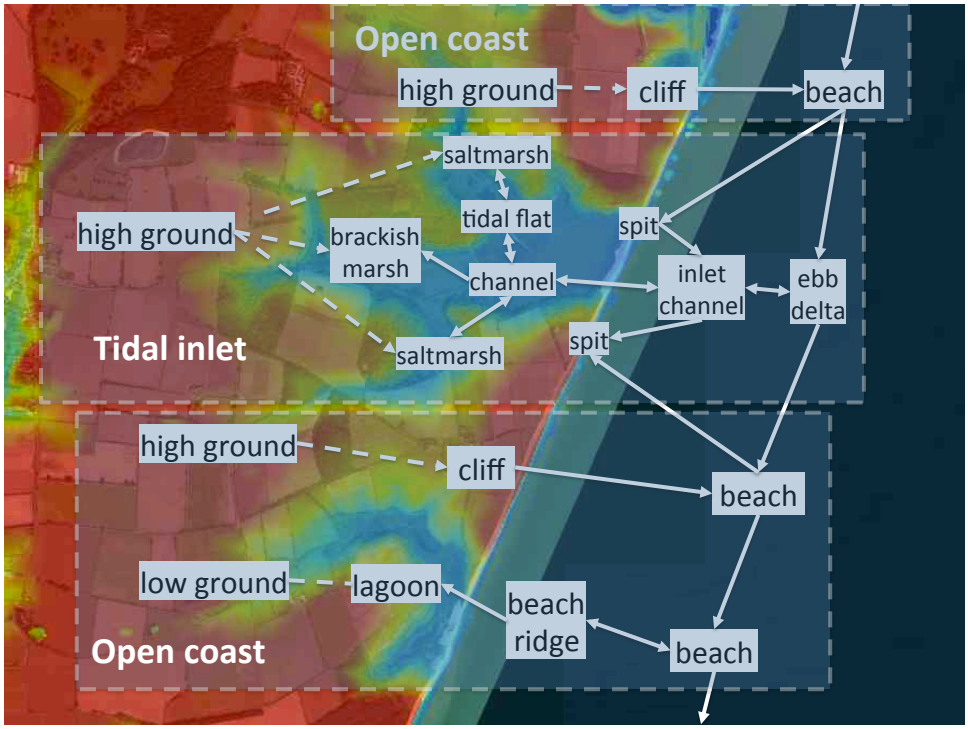


iCOASST Suffolk model 'composition' idea

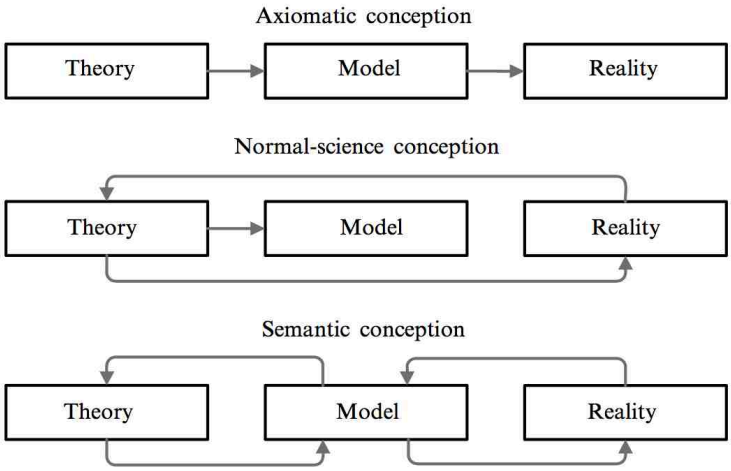
- L = longshore drift model;
- D = estuary / coast / shelf sea exchange (delta) model;
- E = estuary model;
- Sand banks exchange material with beach and shelter it;
- Exchanges of fines between coast and sea to be defined




Configuration of model domain to anticipate changes in state
high ground
cliff
beach
high ground
low ground
lagoon
beach ridge
beach
high ground
cliff
beach
low ground
lagoon
beach ridge
beach
Open coast


Open coast
high ground
cliff
beach
saltmarsh
tidal flat
spit
high ground
brackish marsh
channel
inlet channel
ebb delta
spit
saltmarsh
Tidal inlet
high ground
cliff
beach
low ground
lagoon
beach ridge
beach
Open coast

Changing role of models in science .. and society?



Axiomatic, normal-science, and semantic conceptions of the relationship between theory, models, and reality (Manson, 2007).

And Zen?

Rjoan-ji, Kyoto