Projected changes to coastal sedimentation

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Challenge of long term morphological modelling

- Long-term uncertainties in the empirical parameters used in 2-D or 3-D models
- limitations of computer memory

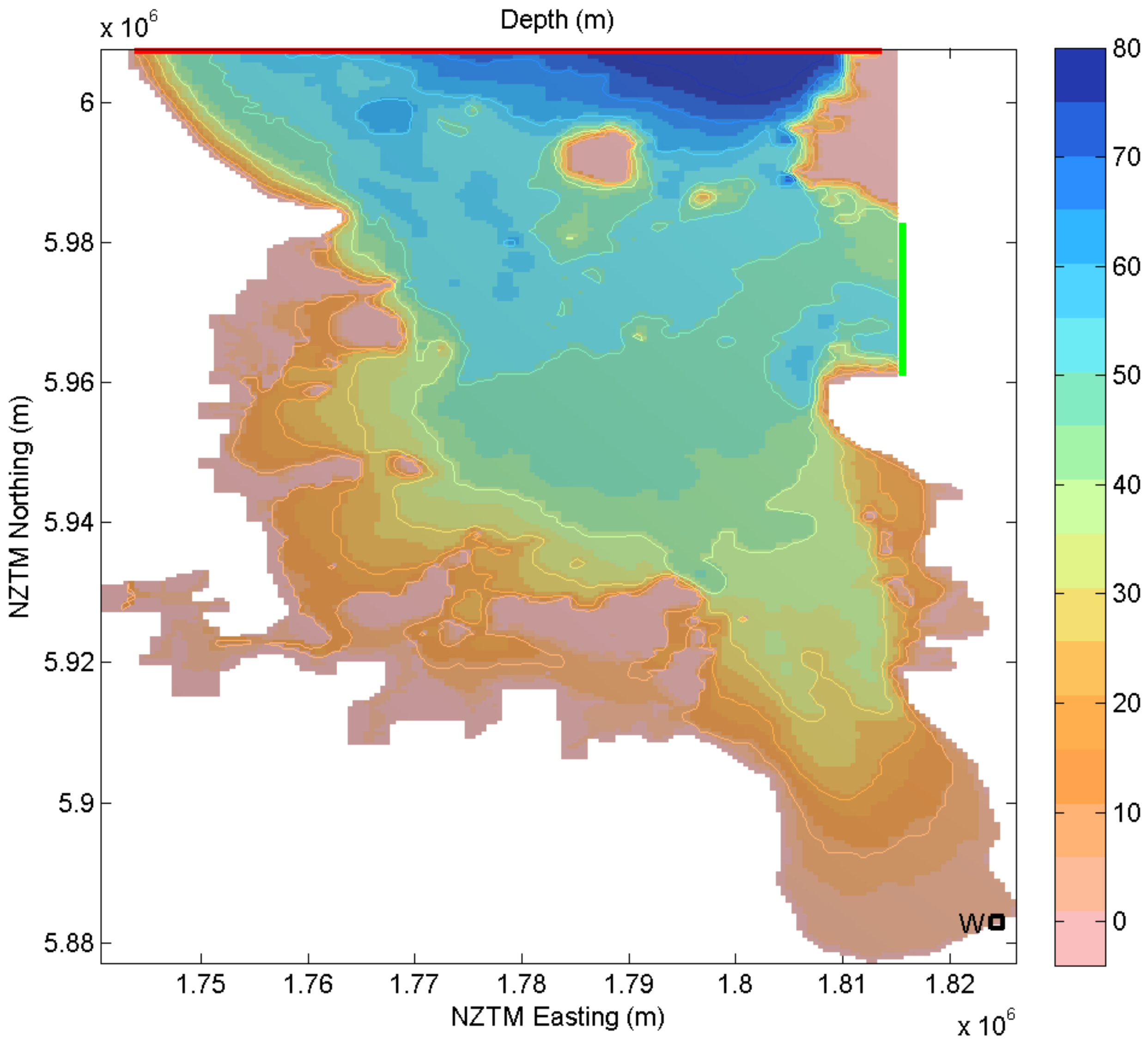
i.e. running complicated models over climate change time scales is not a very practical option

Solutions

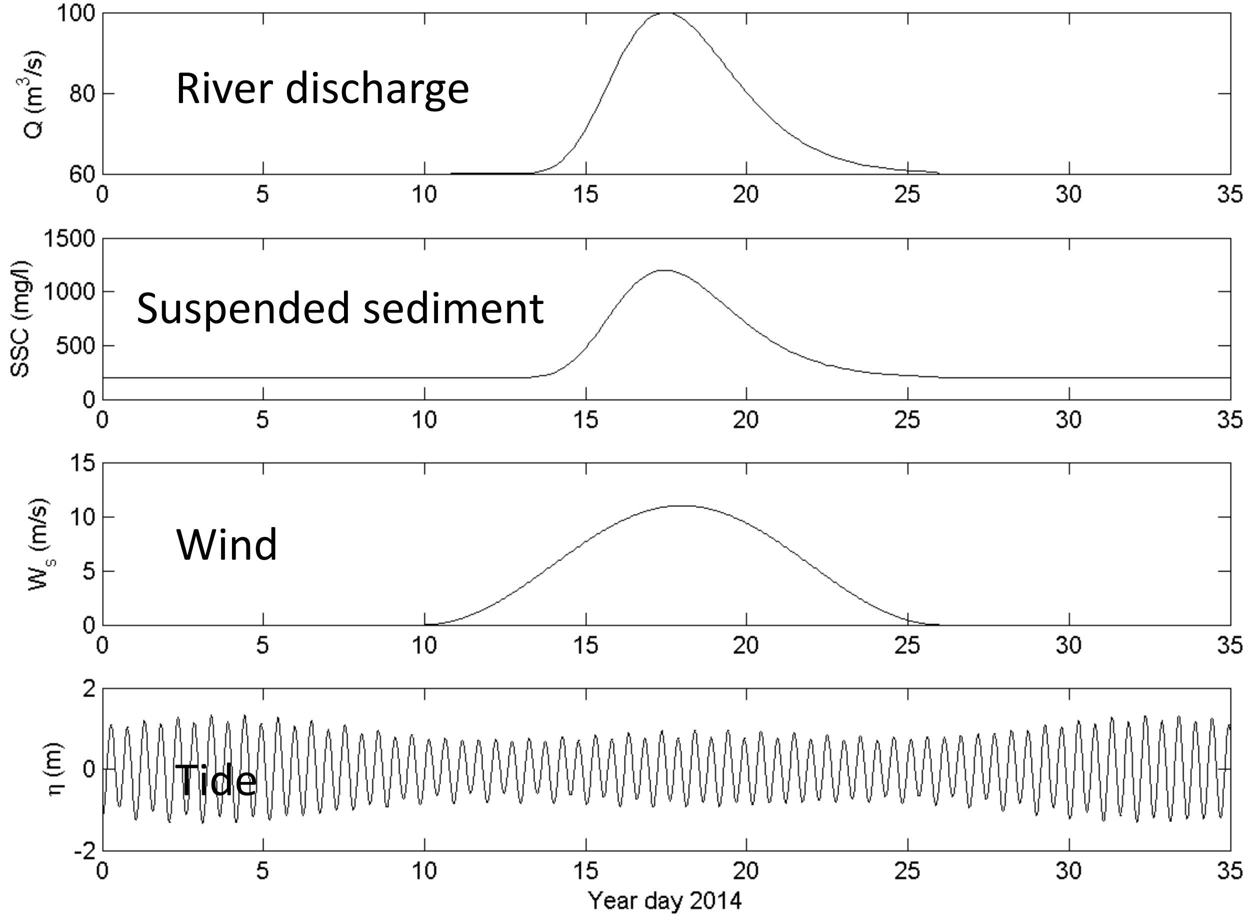
Take a 2-tier modelling approach:

1. 3-D hydrodynamic and sediment transport models (tides, winds and plume dynamics) are used to simulate the event scale (approximately 3-day) buoyant river plumes disperse and deposit in the estuary basin
2. Use the predicted event scale sediment dispersal footprints to locate the intertidal and subtidal sites that will receive a sediment supply.
3. Evolve the morphology at these sites using a simplified water column model forced by output (winds/waves) from different climate models and RCP’s for a period of 100+ years.

3-D model domain of Hauraki Gulf

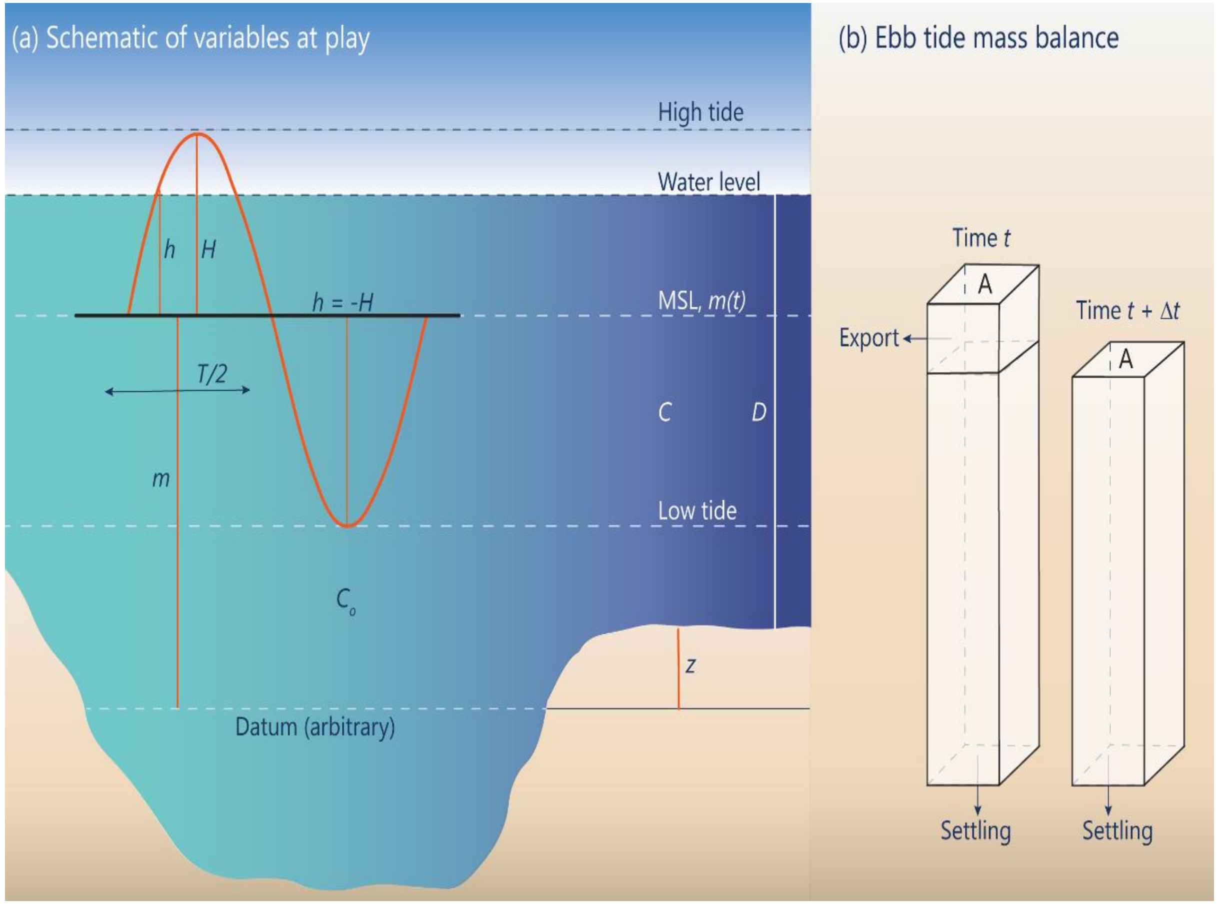


Model idealised boundary conditions



Water column sedimentation model

$$\frac{dz}{dt} = Q_S(z,B) + Q_T(z,B) - E$$



Model setup

- Model predicts the temporal evolution (through sedimentation) of a sea bed or tidal platform height through a single point water column approach

- The model can be set on either an inter-tidal flat or sub-tidal channel/basin of an estuary or coast

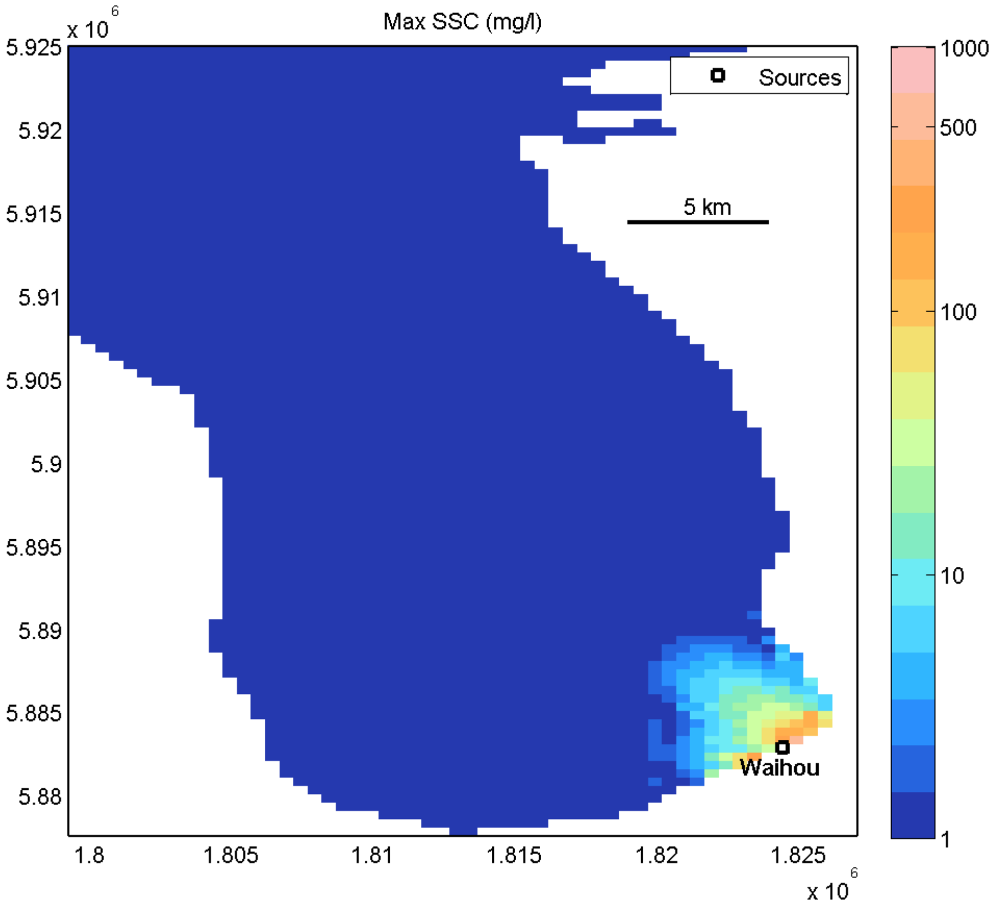
Physical processes included so far in the model are:

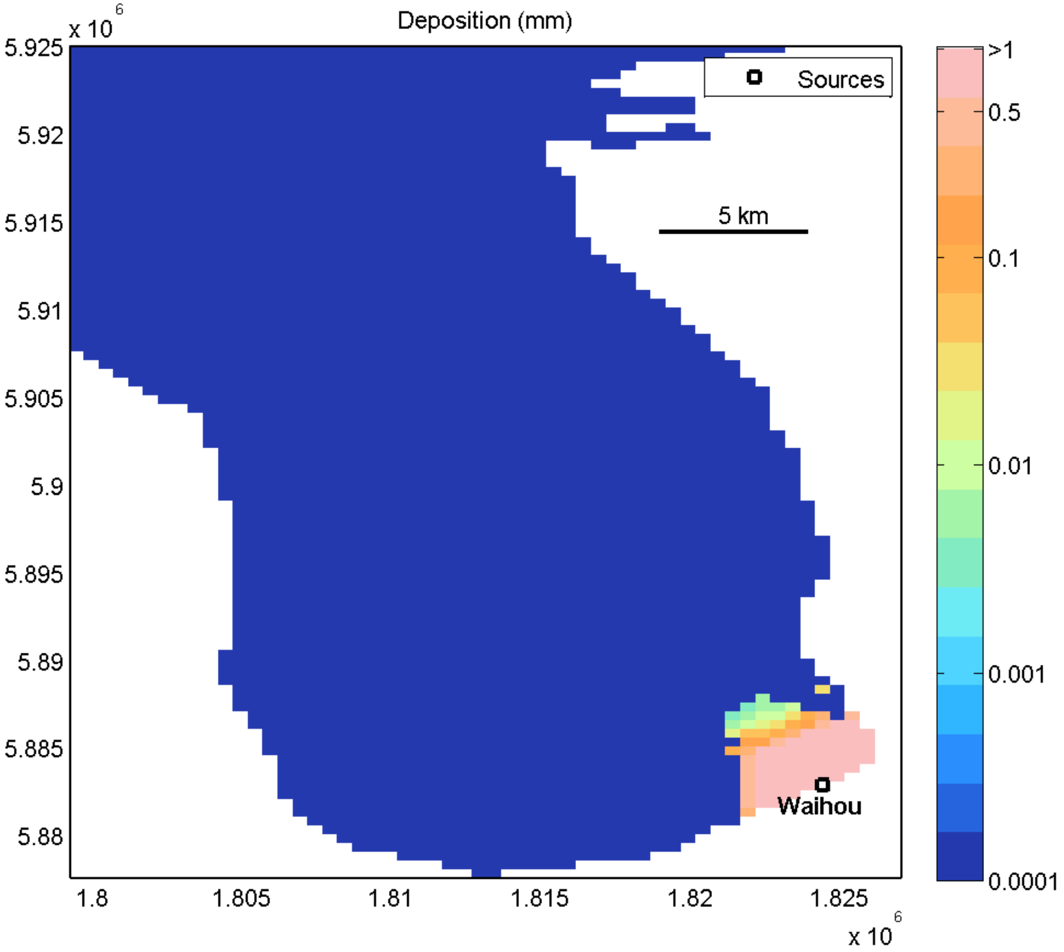
- Tides (wetting and drying)
- Sediment supply from a constant source
- Mean sea-level rise
- Vegetation
- Erosion of the platform by wind waves

Runtime

The model is ran for 100 years at 2 cycles per day which is a total of 73000 tides. Run time for 100 years is approximately 15 minutes in Matlab

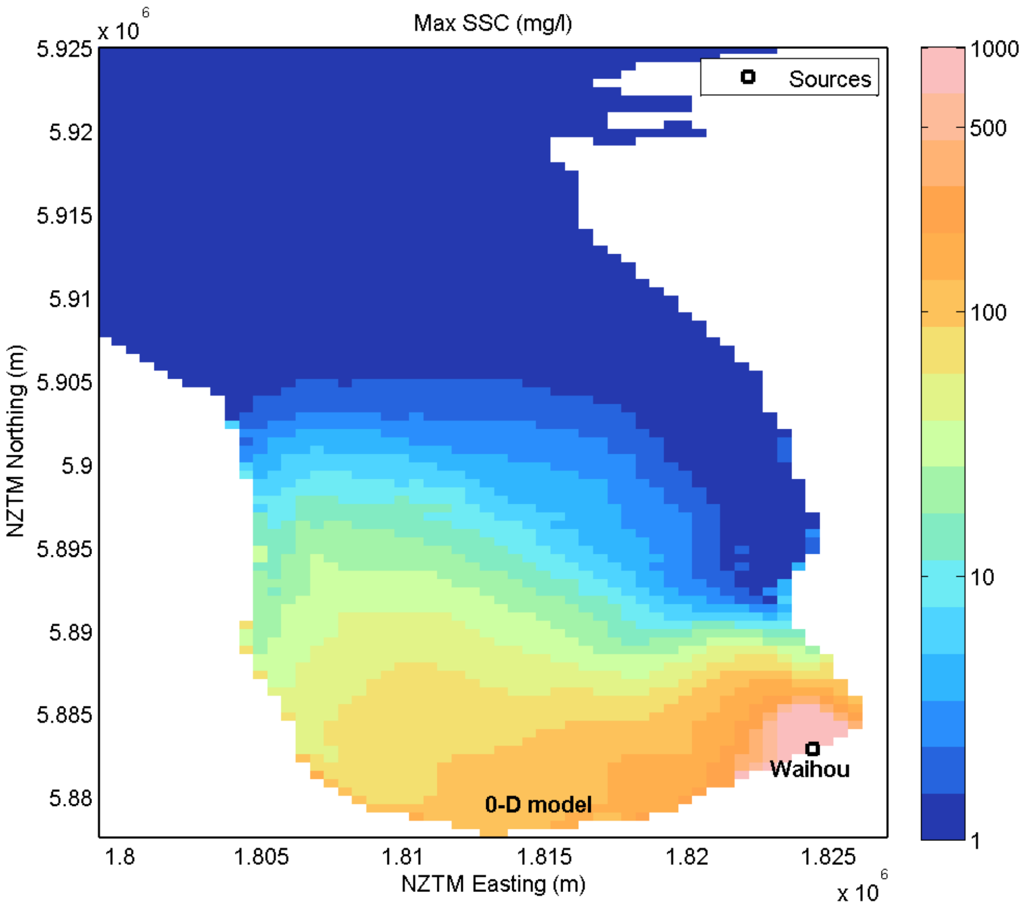
3-D modelling
Calm – Sediment plume dispersal and deposition zone

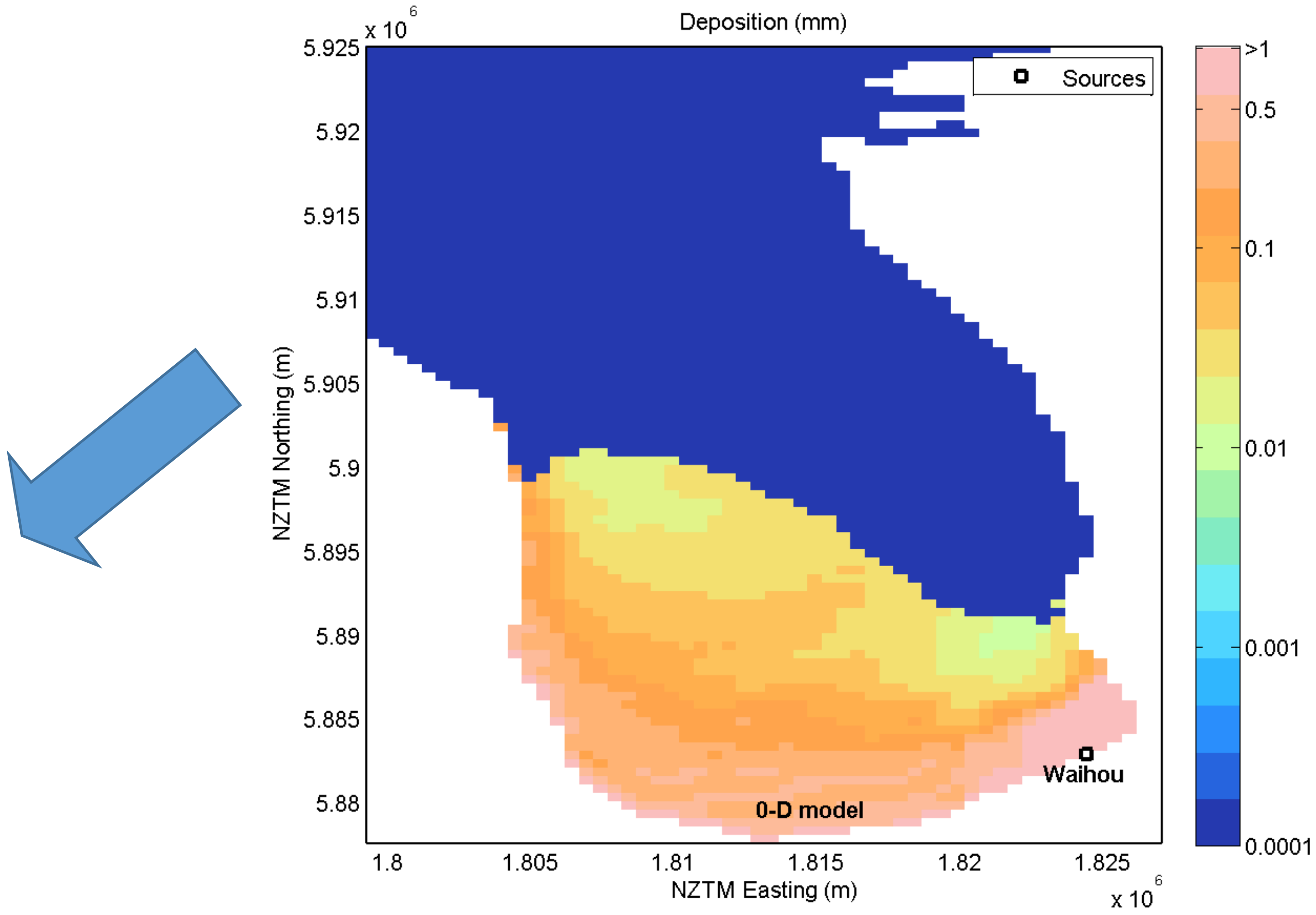




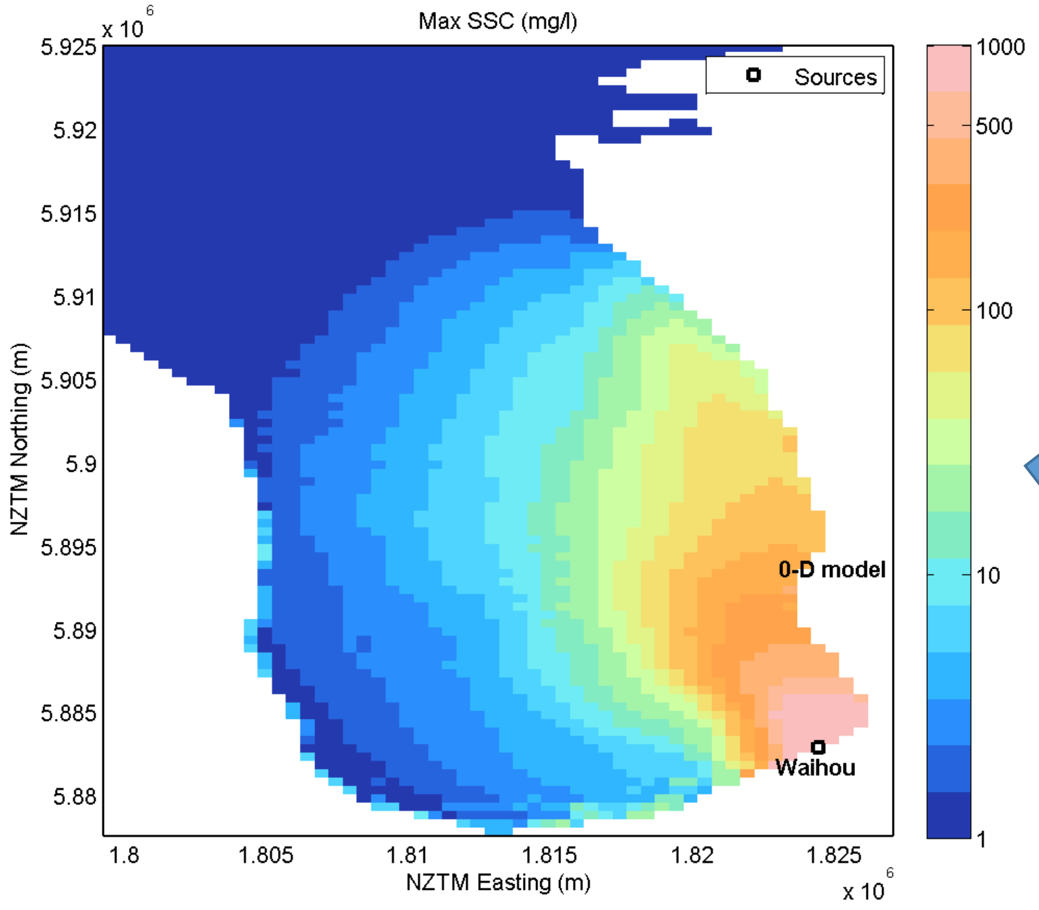
Pritchard et al (2015)

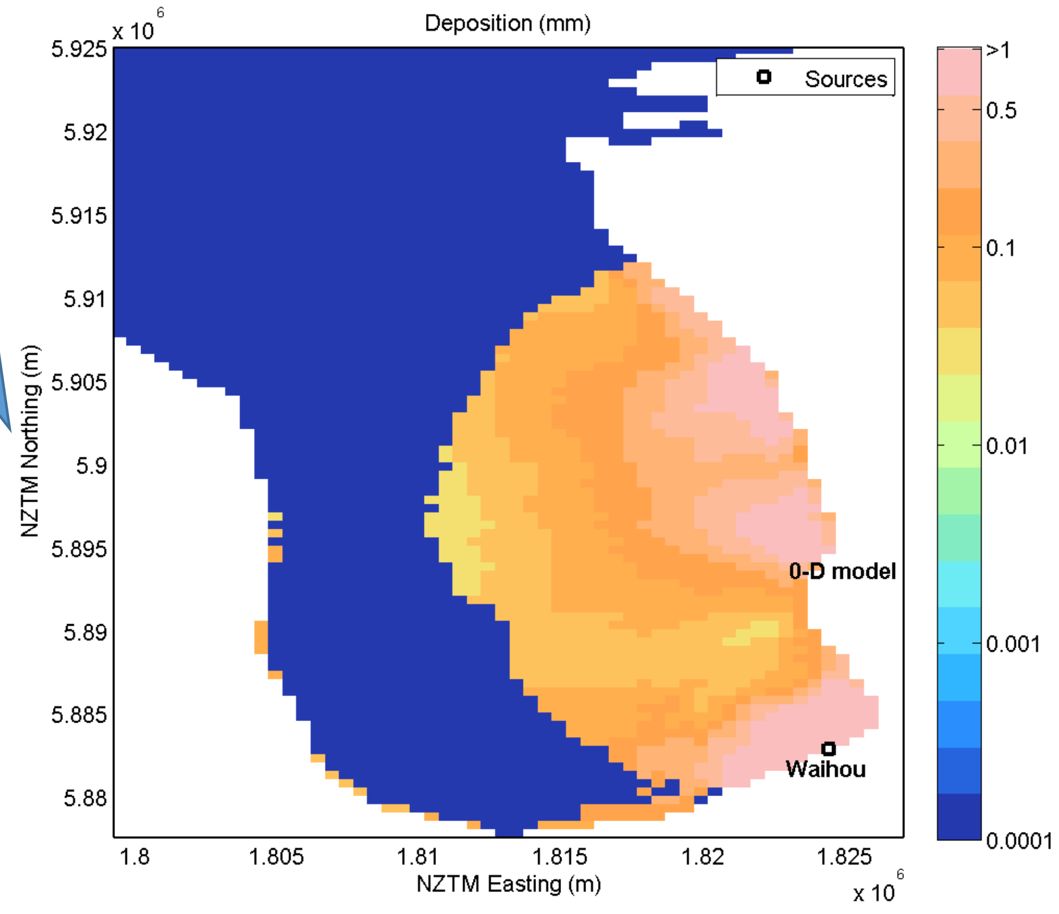
3-D modelling
NE wind – Sediment plume and deposition zone





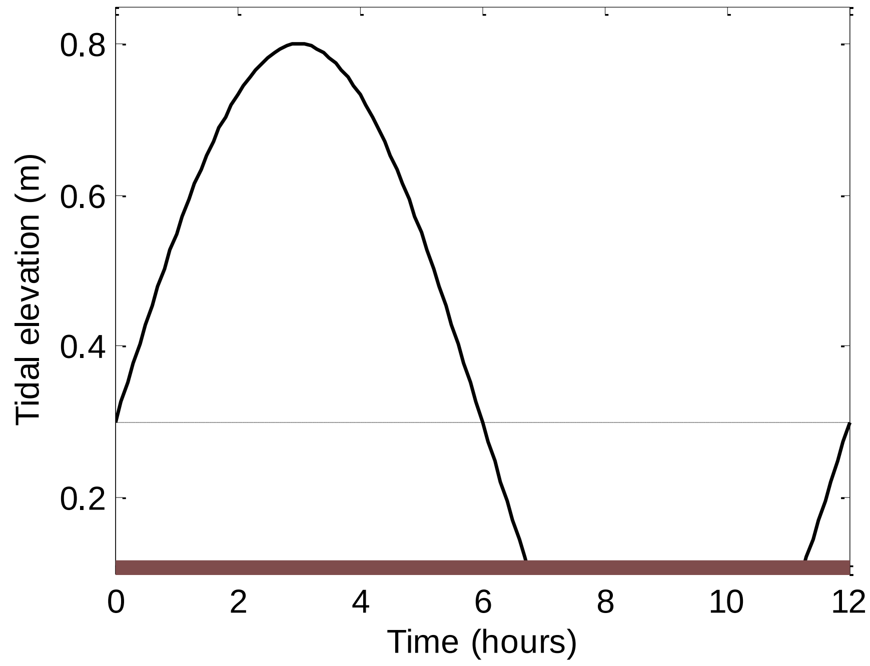
3-D modelling
SW wind – Sediment plume dispersal and deposition zone



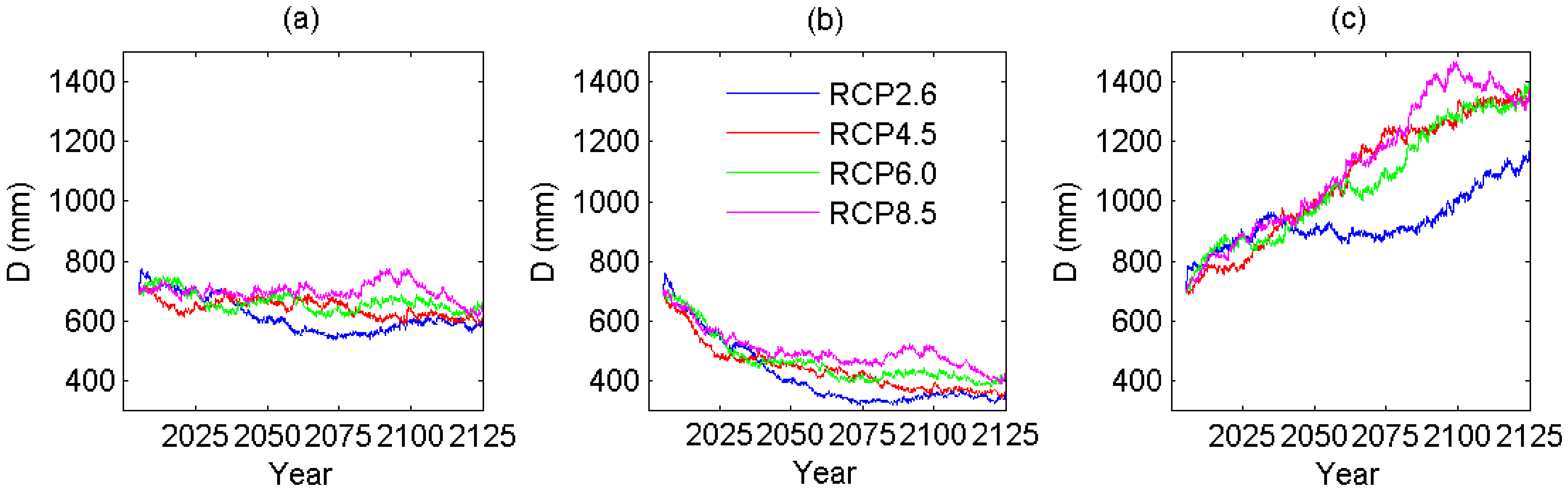


Intertidal – (initial drying case)

a. C = 300 mg/l
b. C = 360 mg/l
c. C = 240 mg/l

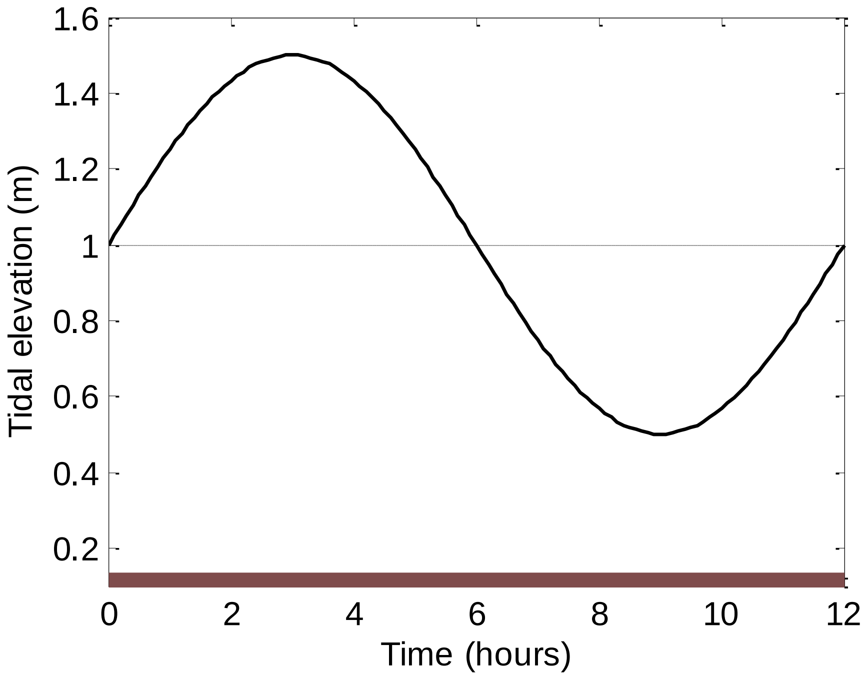


Water depth (high water) above platform

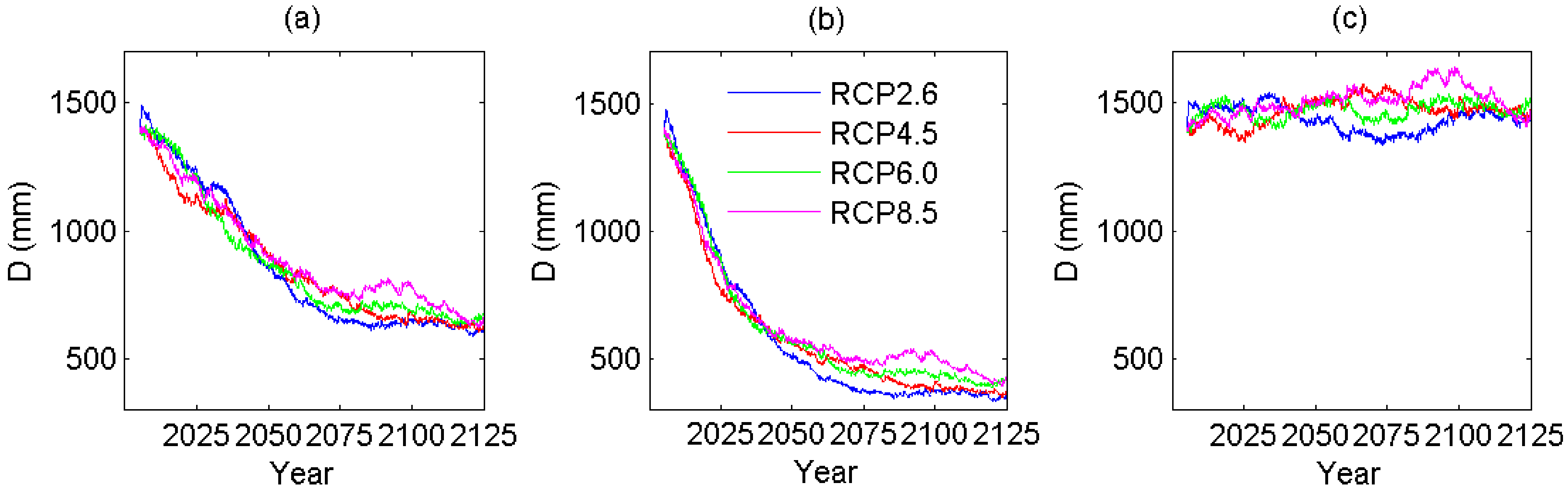


Shallow sub-tidal

a. C = 300 mg/l
b. C = 360 mg/l
c. C = 240 mg/l

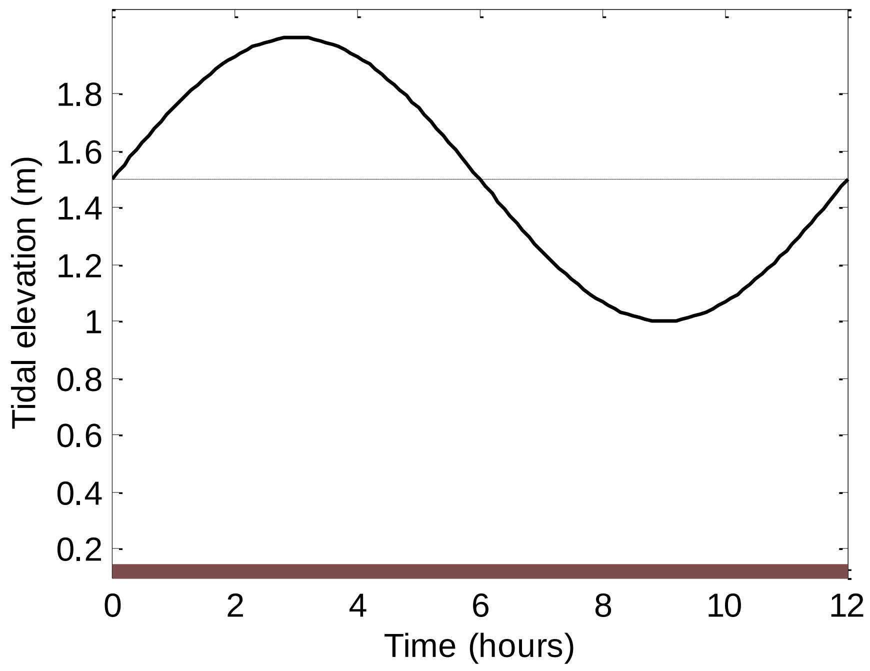


Water depth (high water) above platform

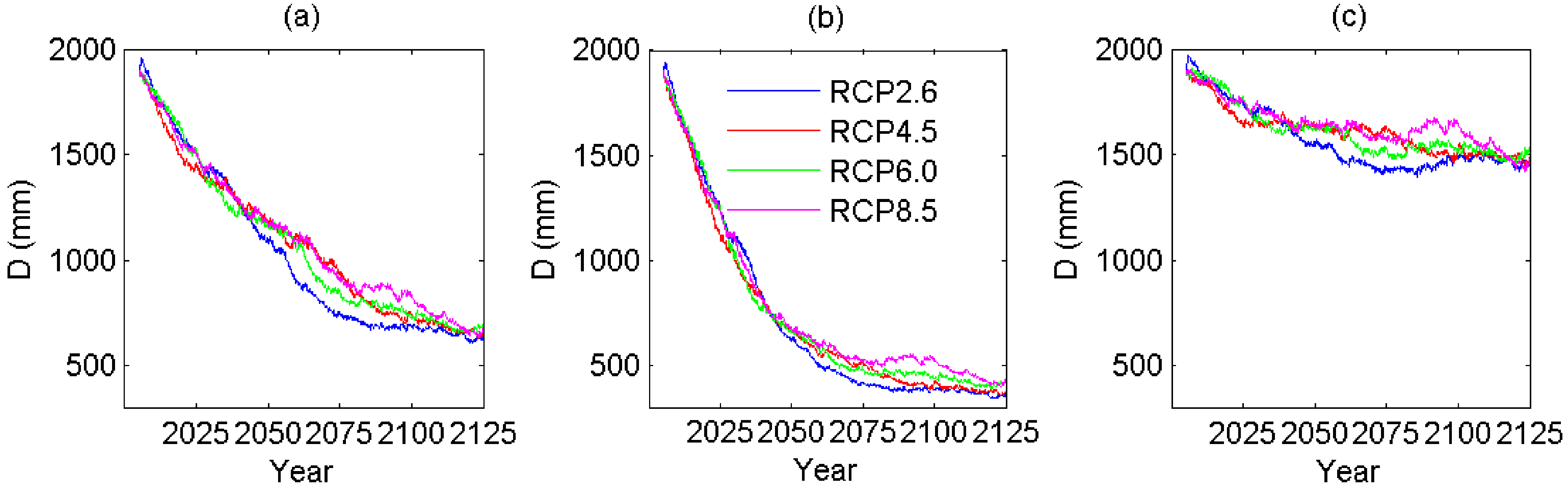


Deeper sub-tidal

a. C = 300 mg/l
b. C = 360 mg/l
c. C = 240 mg/l



Water depth (high water) above platform



Results from water column model

Intertidal site (0.8 m deep)

- Water depths over time are relatively independent of the RCP values i.e. as the sea level rises the bed level tends to rise
- Reason - Equilibrium in high-tide depth (shallow water and drying) , sediment resuspension (waves) and transport and sediment delivery rate.
- More sediment increases accretion and less sediment decreases accretion. Maximum water depth is reached when MSL, the effect of waves (water depth and wind) and sediment supply reach an equilibrium

Sub-tidal sites (1.5 and 2 m deep)

- Reduction in water depth (sediment settles and accretes) until water depth reaches an equilibrium with waves, MSL and sediment supply rate.
- Increase/decrease in sediment supply speeds up/slows down sedimentation.

Main conclusion

Firth of Thames water depth distribution depends more on sediment supply from rivers than RCP-related sea-level rise and climatic changes in wind