Projected changes to coastal sedimentation

Mark Pritchard & Graham McBride

NIWA, Hamilton

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

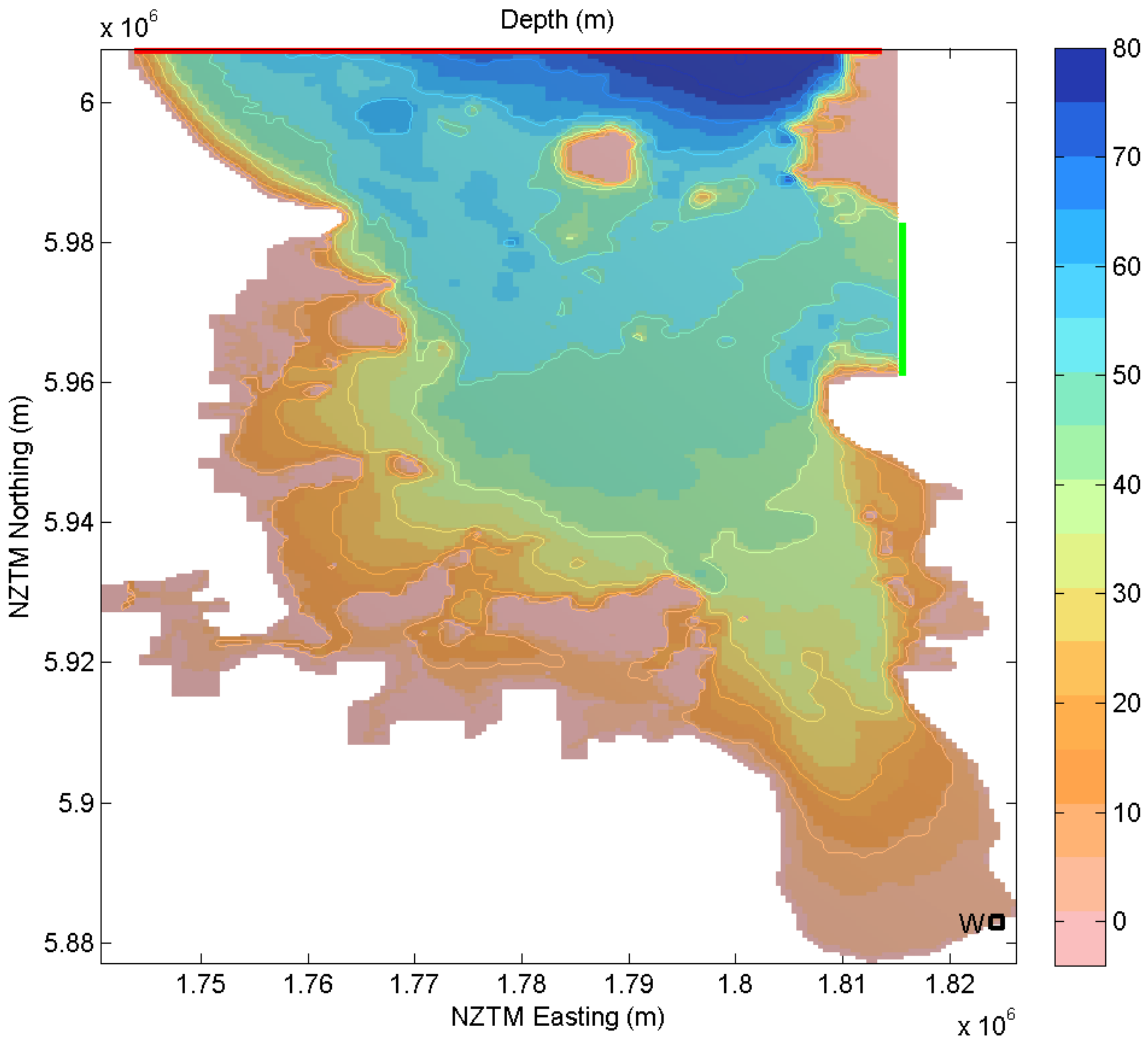
i.e. running complicated models over climate change time scales is not a very practical option

Solutions

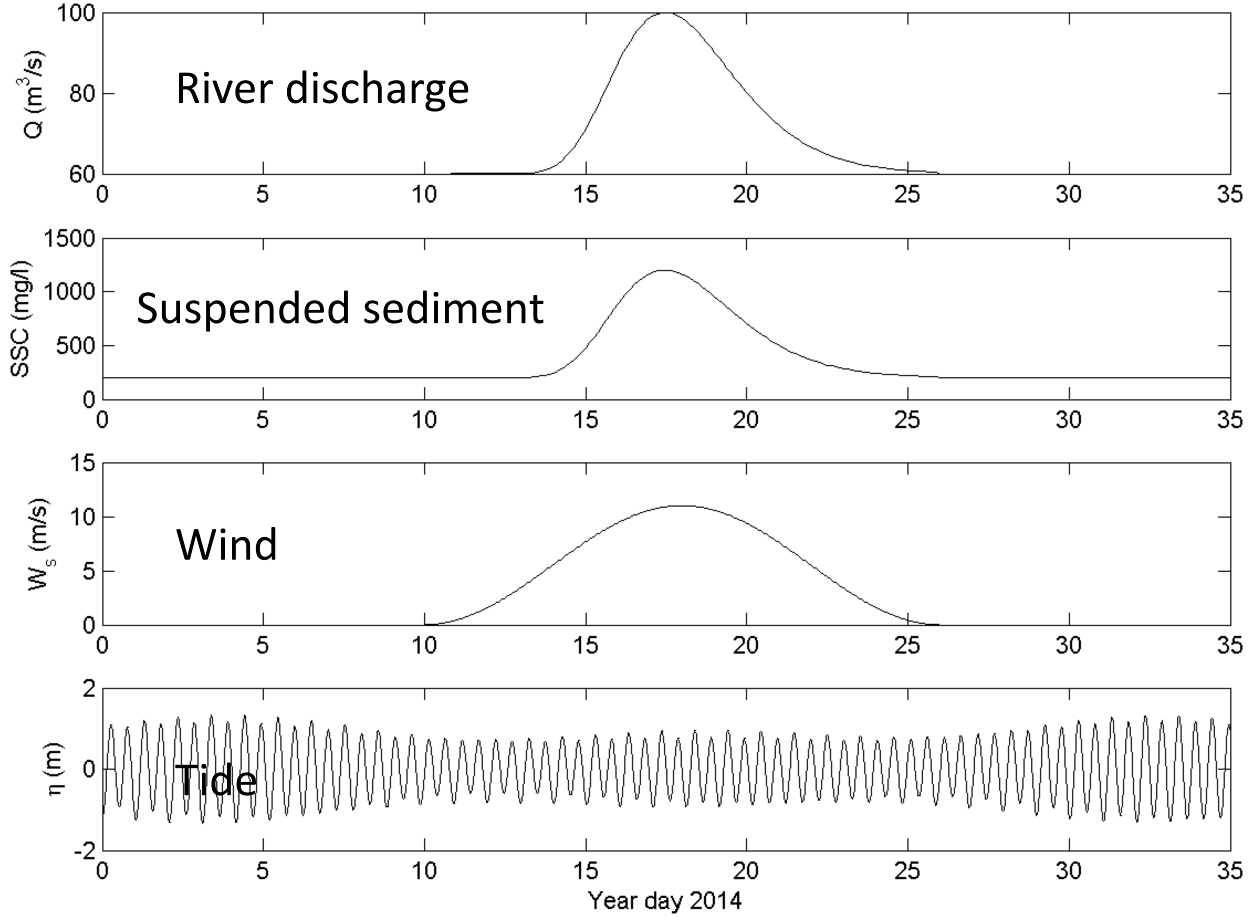
Take a 2-tier modelling approach:

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

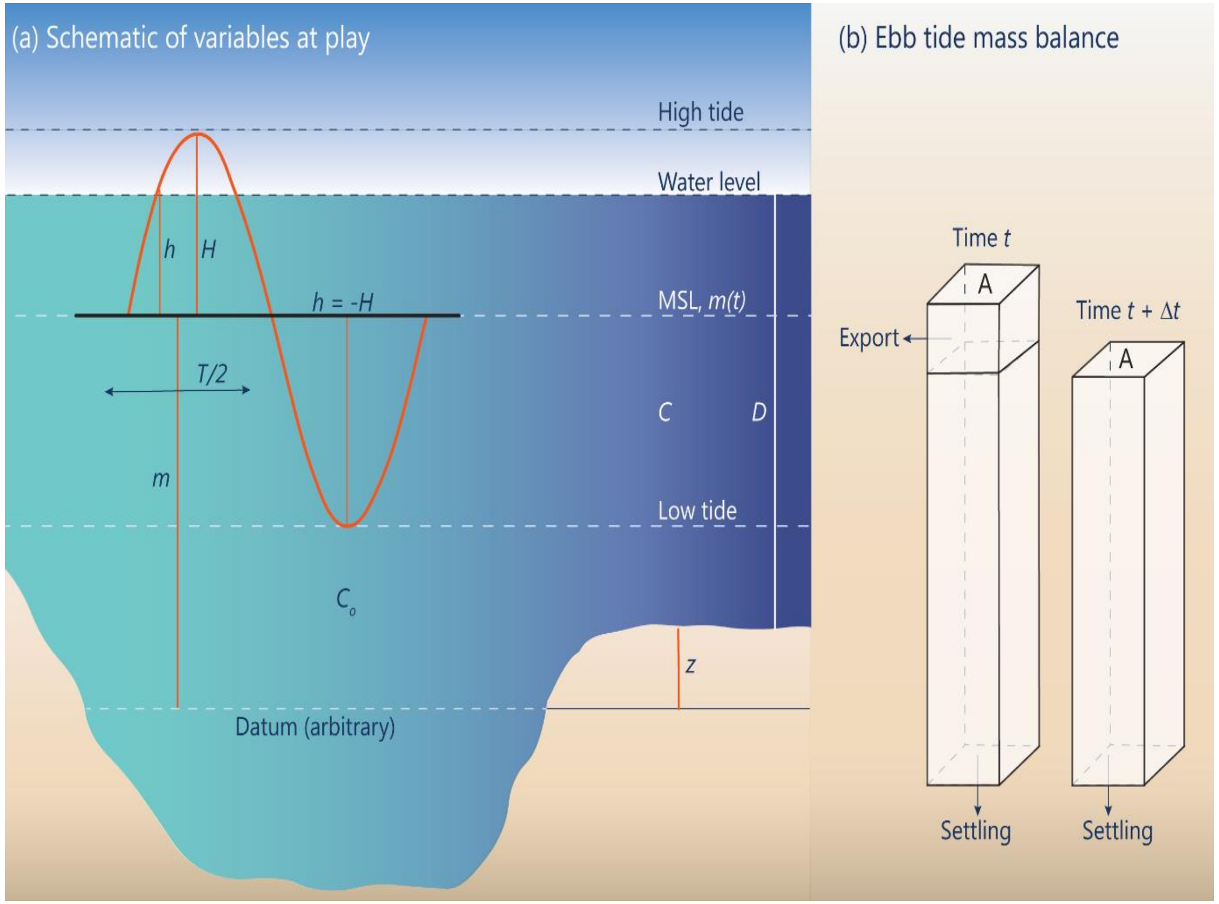


Model idealised boundary conditions



Water column sedimentation model

$$\frac{\mathrm{d}z}{\mathrm{d}t} = Q_S(z,B) + Q_T(z,B) - E$$



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

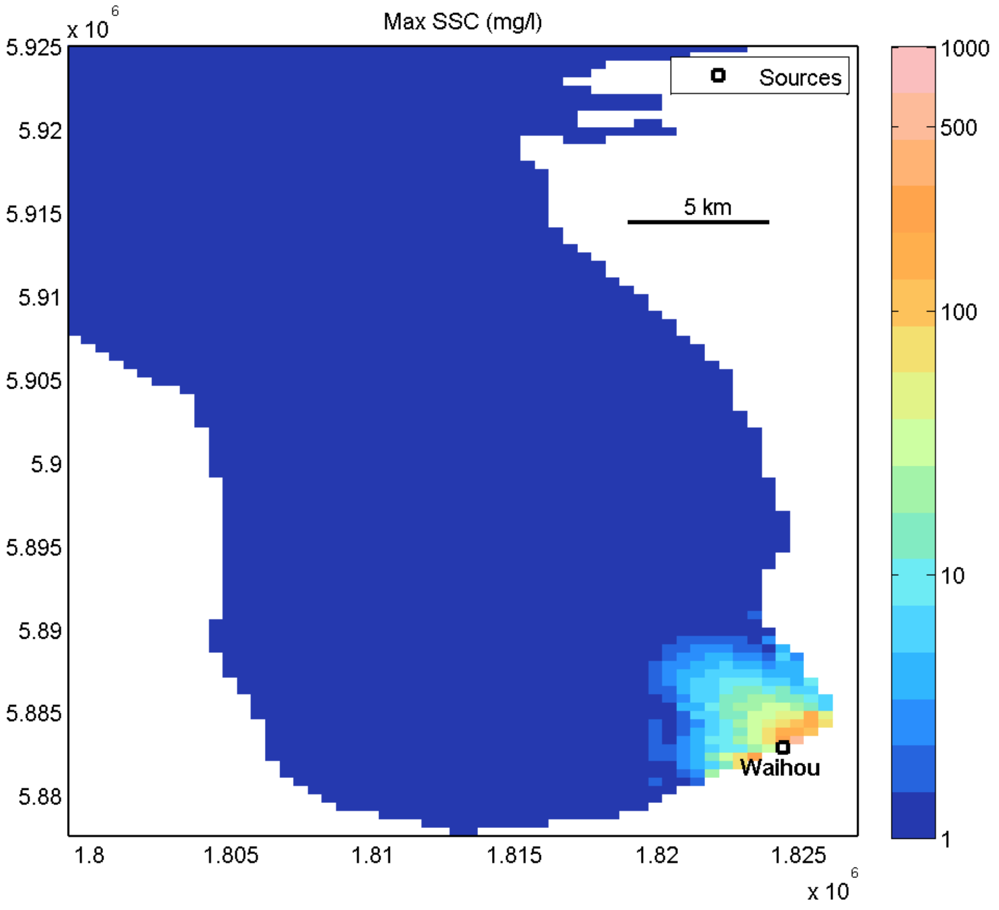
Physical processes included so far in the model are:

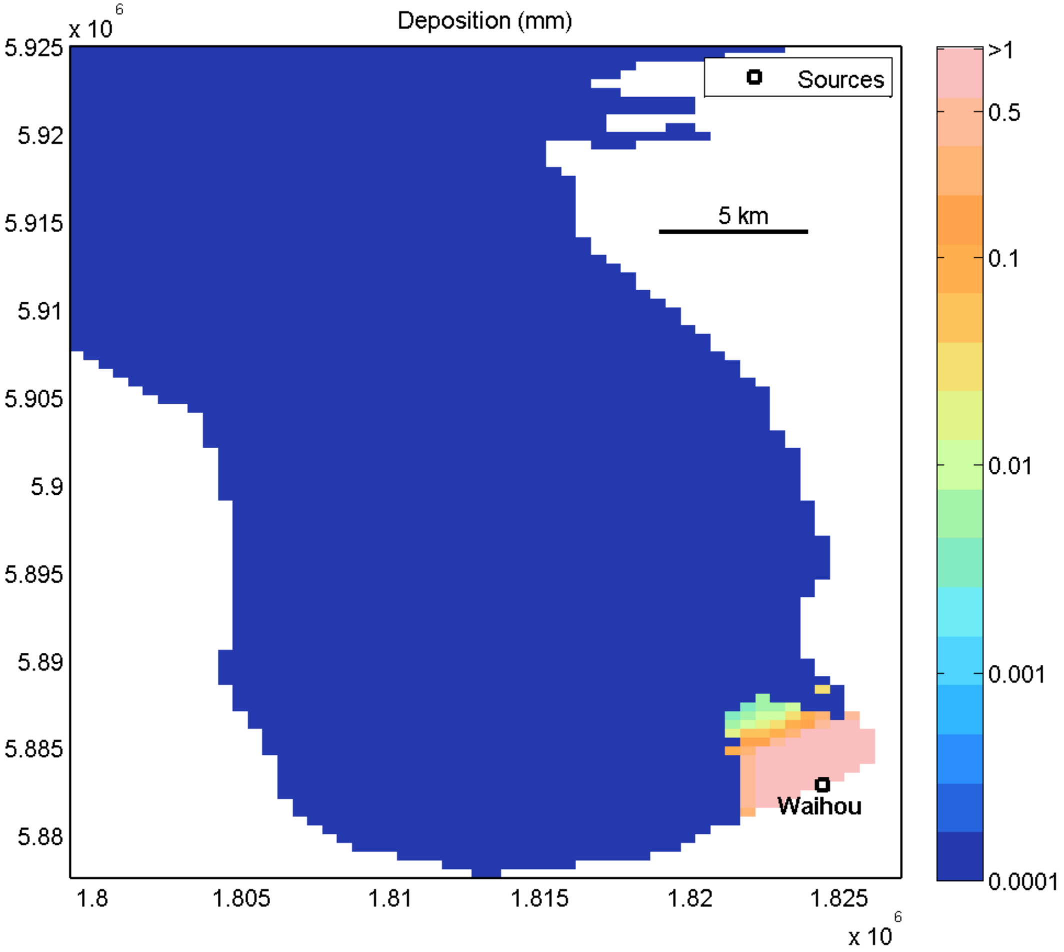
- Tides (wetting and drying)
- Sediment supply from a constant source
- Mean sea-level rise
- Vegetation
- Erosion of the platform by wind waves

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

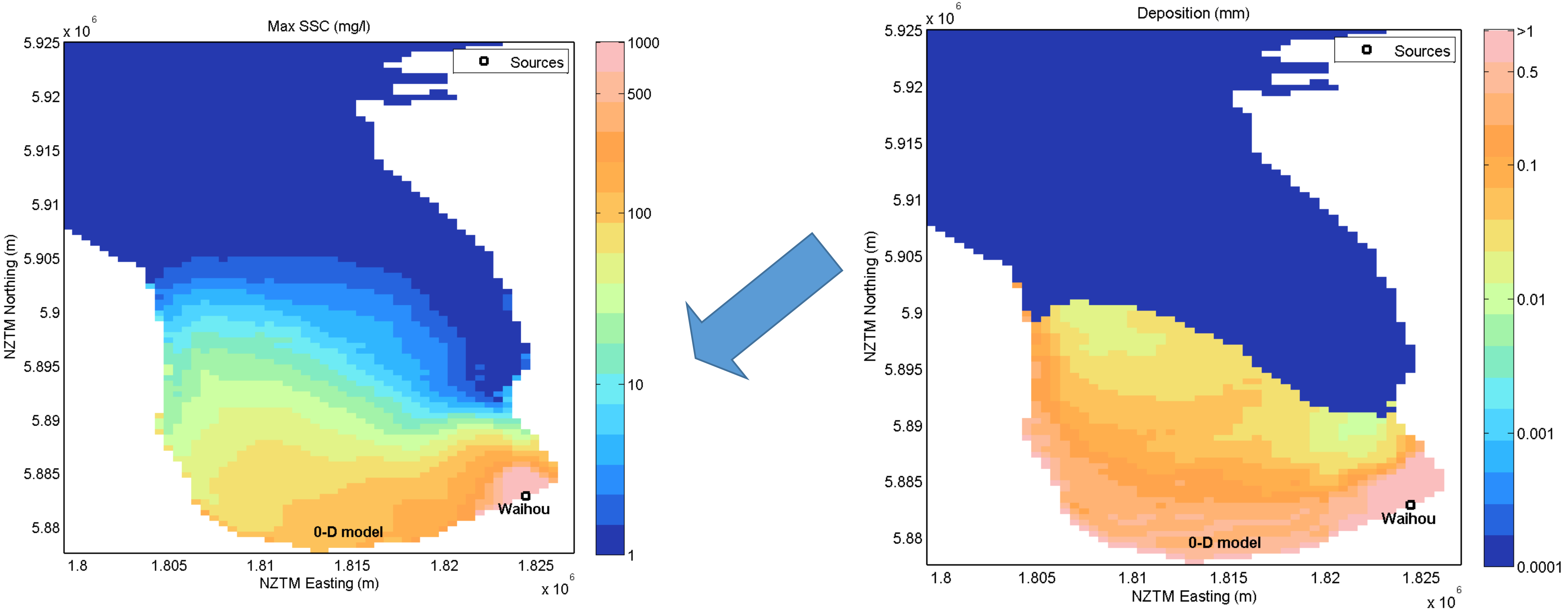
3-D modelling
Calm – Sediment plume dispersal and deposition zone



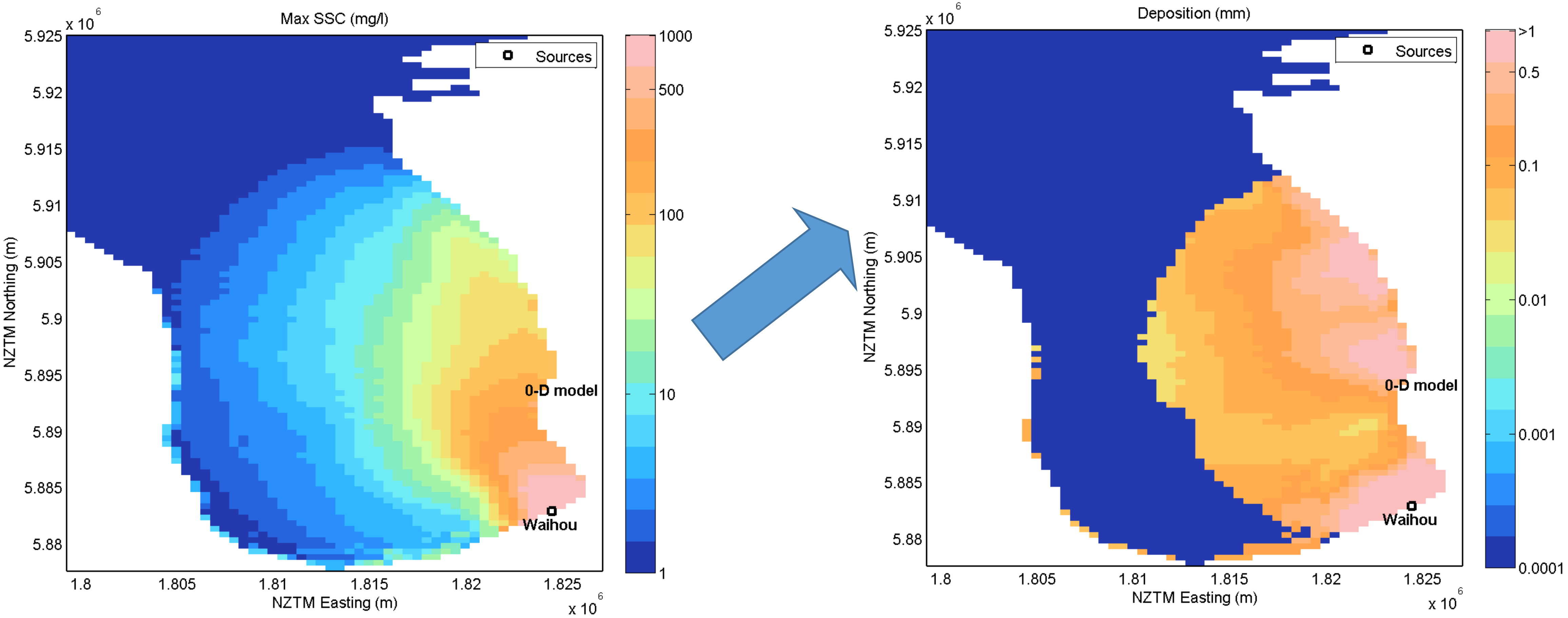


Pritchard et al (2015)

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

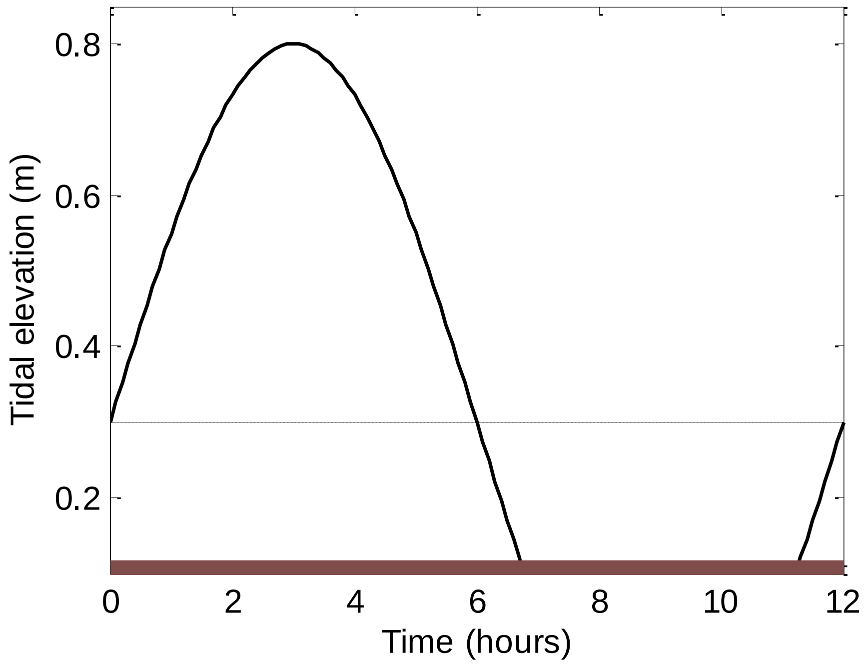


3-D modelling
SW wind – Sediment plume dispersal and deposition zone

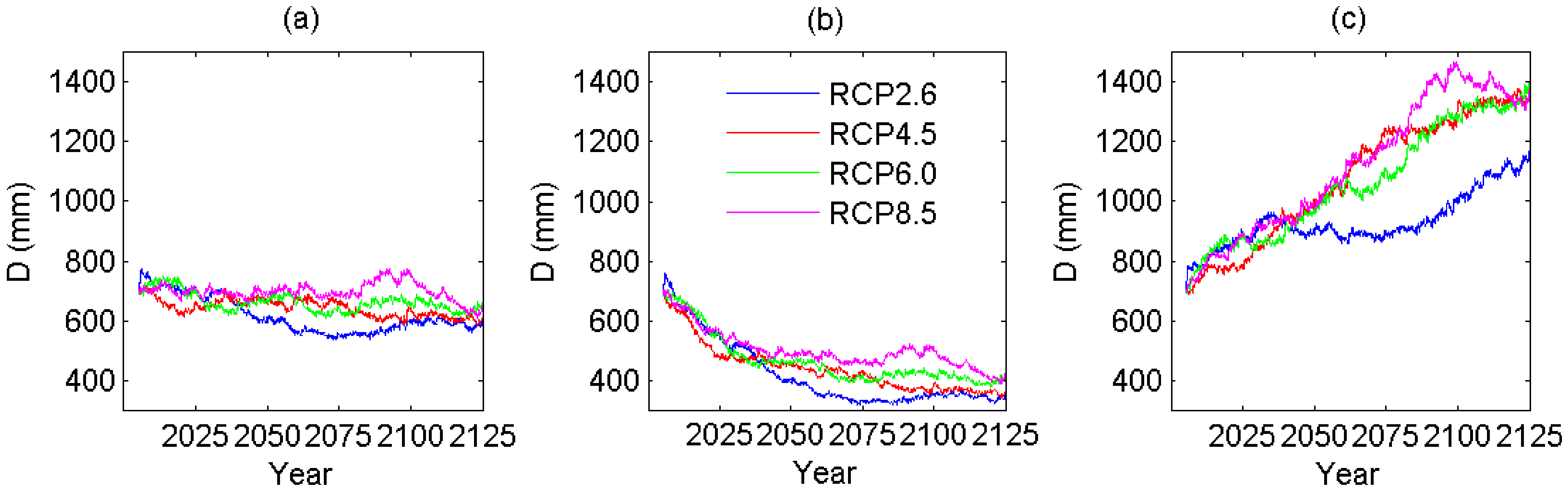


Intertidal – (initial drying case)

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

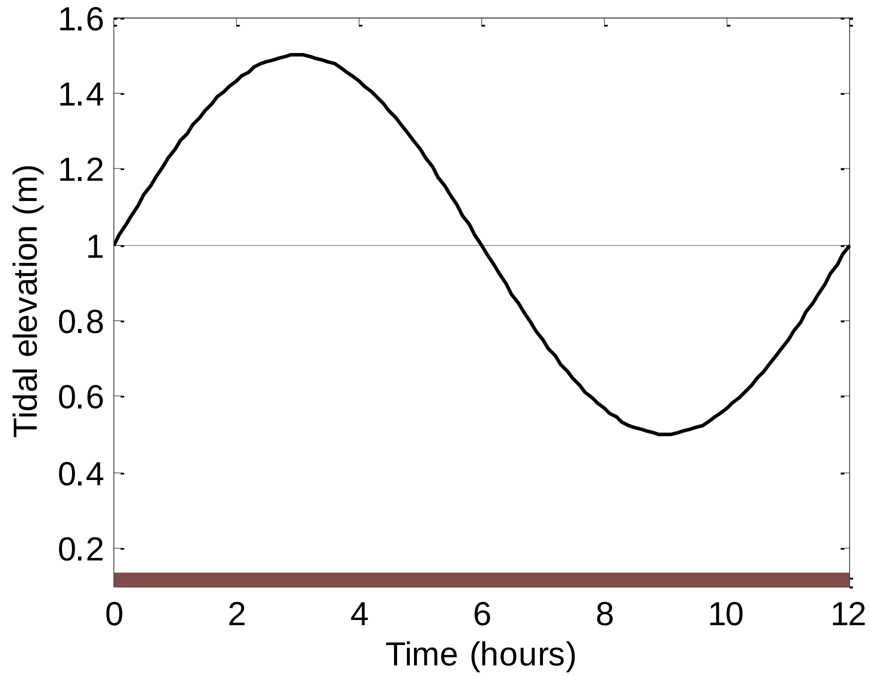


Water depth (high water) above platform

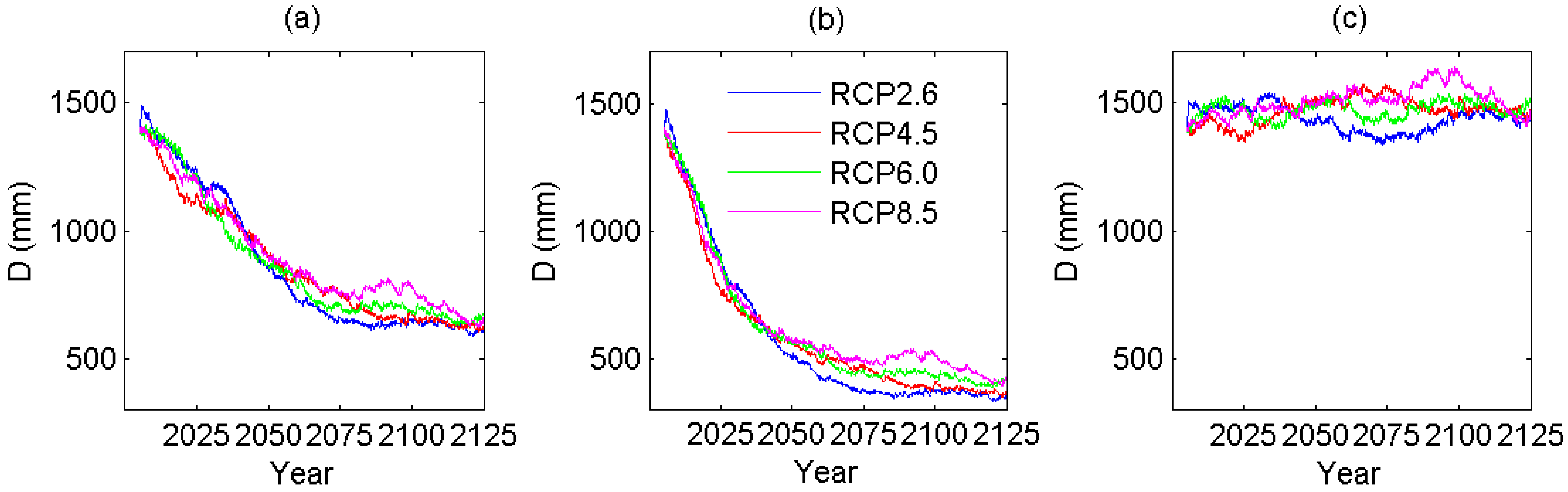


Shallow sub-tidal

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

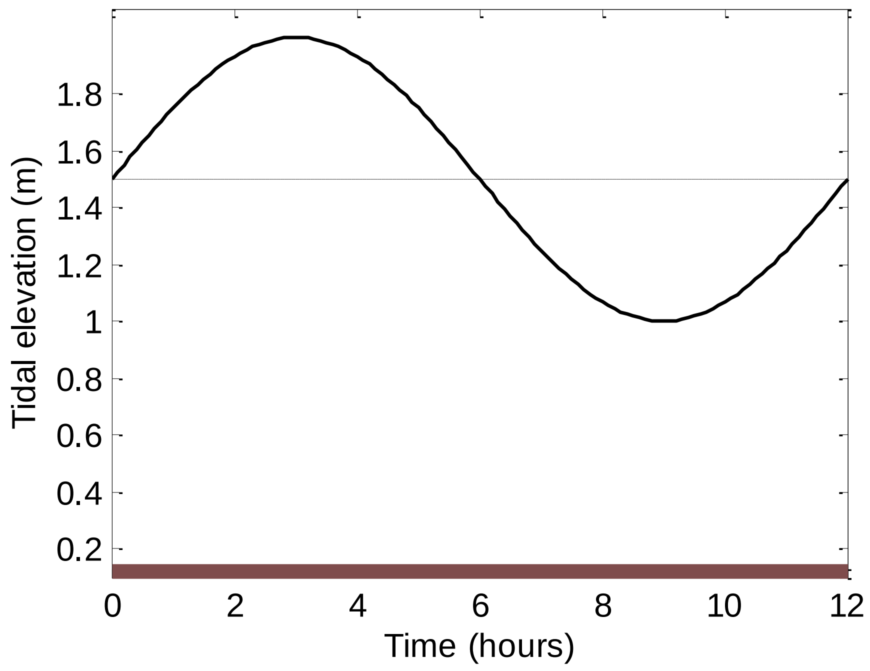


Water depth (high water) above platform

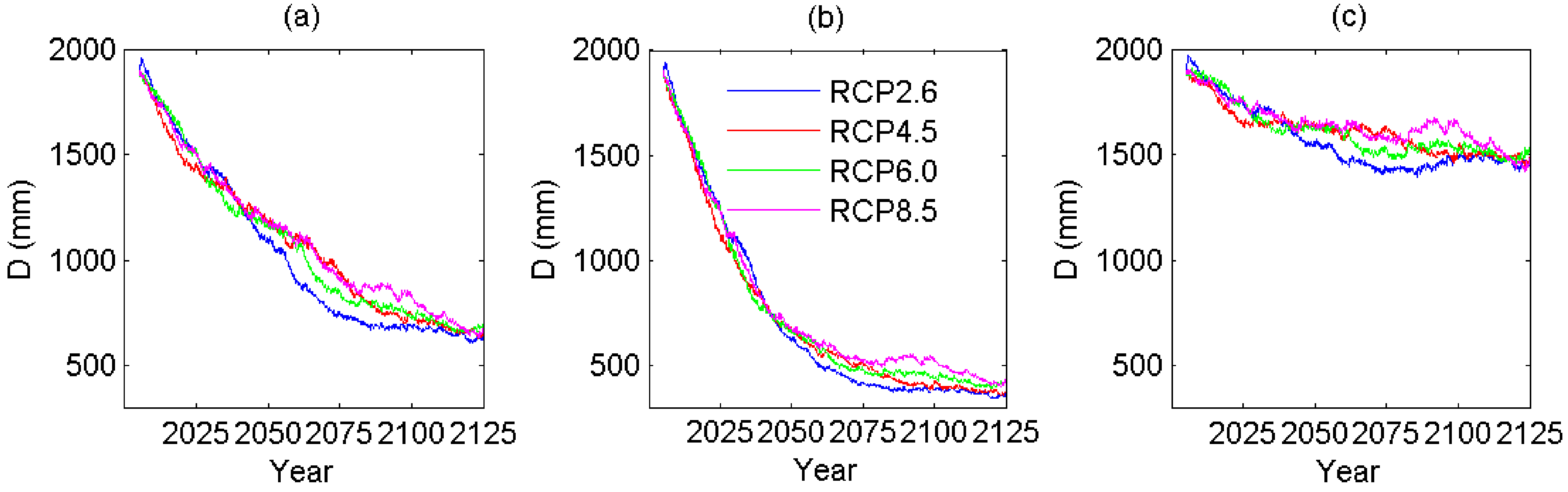


Deeper sub-tidal

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

<u>Intertidal site (0.8 m deep)</u>

- 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

<u>Sub-tidal sites (1.5 and 2 m deep)</u>

- 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