Modelling nutrient distributions in a large-scale river plume

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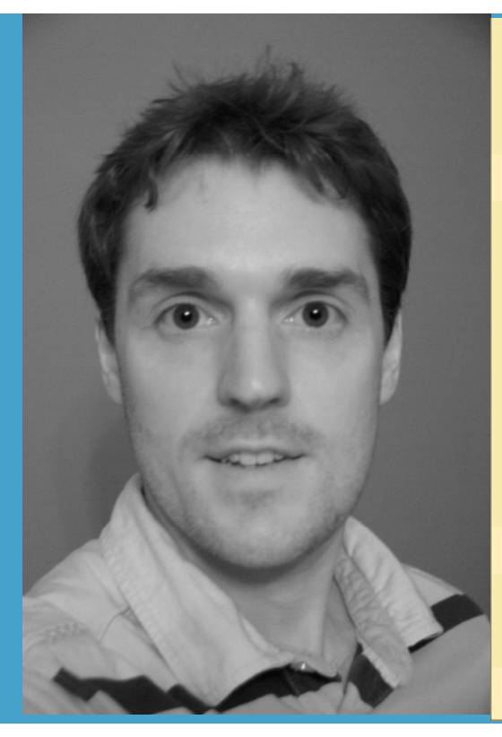

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Introduction & Methods

- Nutrients transported into the marine environment have significant effects on the ecology of coastal regions. The Columbia River is the largest input of fresh water to the Eastern Pacific Ocean. Numerical modelling allows detailed investigations of the physical processes controlling nutrient distributions.
- The non-hydrostatic 3D MIT general circulation model was used to simulate the Columbia River Plume and is compared with data collected during the **R**iver **I**nfluences on **S**helf **E**cosystems project (RISE). ***Figure 1* → shows the model domain and detailed bathymetry.**
- Horizontal resolution was 500m with variable vertical resolution. Orlanski boundaries were used in the north, south and west, whilst prescribed boundary conditions were used at the eastern boundary.
- ***Figure 2* ↓ shows wind, tide and river discharge forcing obtained from observations and the TPXO7.1: Global Inverse Tide Model for the period 27th July to 27th August 2005.**

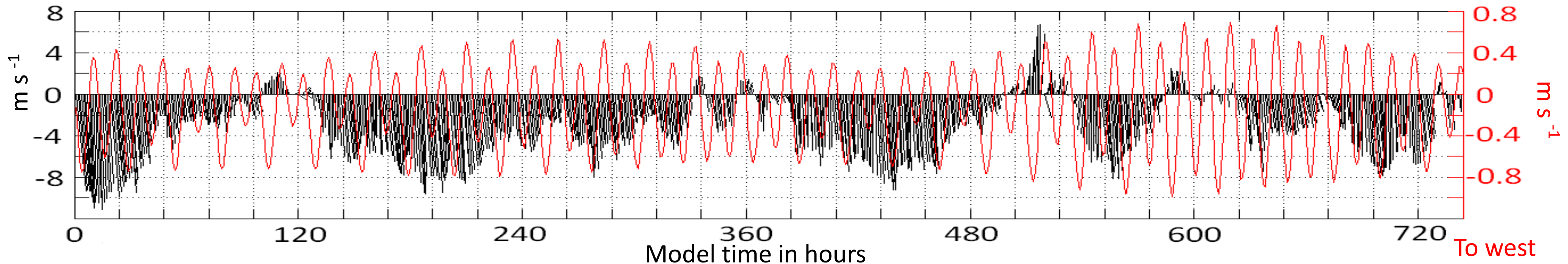

Figure 2. Wind velocity River discharge velocity

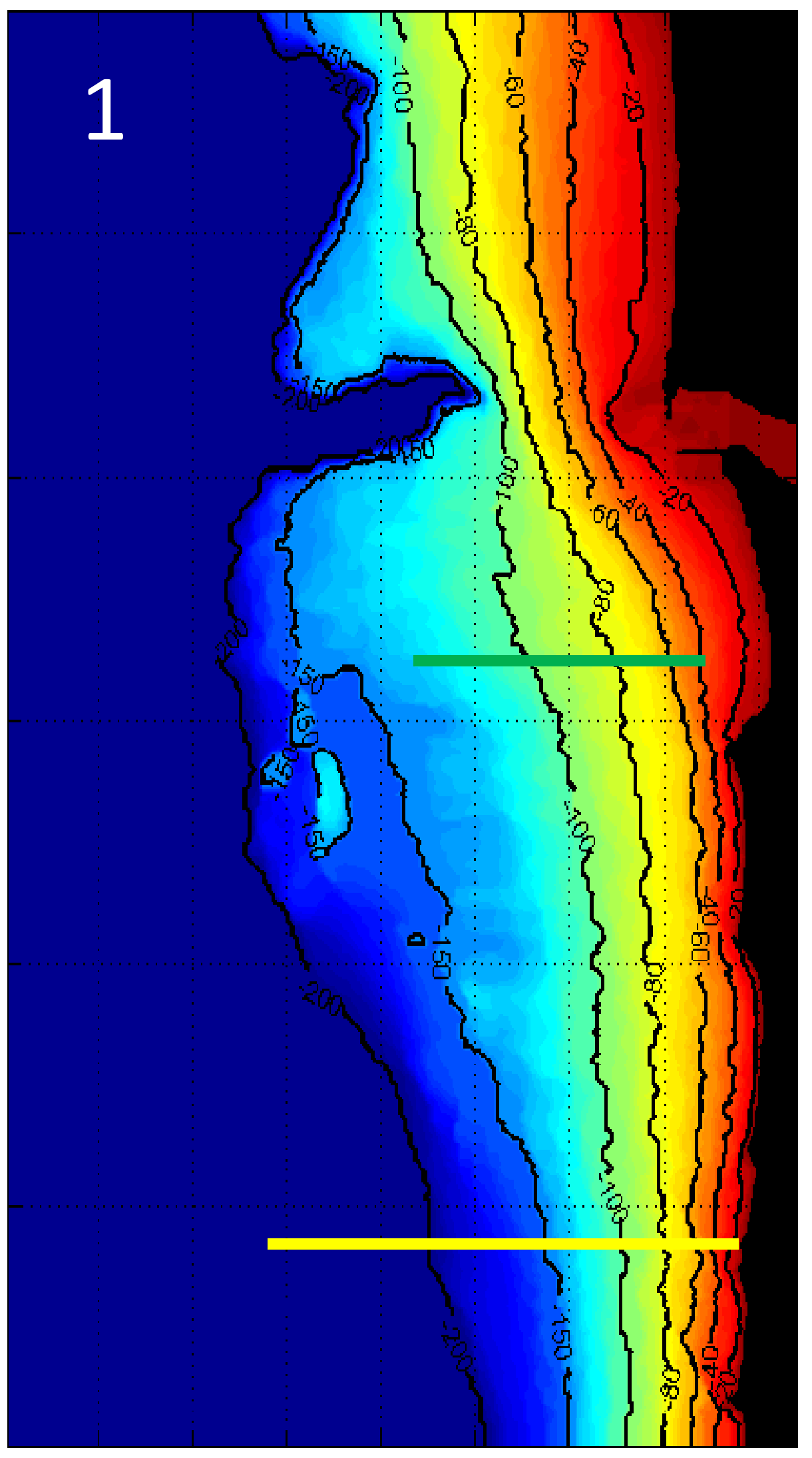

Figure 1 Bathymetry of model domain

Sensitivity studies

- To determine the appropriate diffusion and viscosity values for the model to reproduce an accurate and stable spatial distribution of the plume a series of sensitivity runs were carried out.
- ***Figures 3 a, b & c* → show the effect of varying horizontal diffusion on sea surface salinity.**
- A value of 0.5x10^{-4} was chosen as an appropriate value for further investigations as it resulted in values that best matched the collected data.
- Viscosity values were also adjusted in order to obtain representative vertical mixing.
- ***Figures 4 a & b* ↓ show the difference in plume spreading and vertical mixing when viscosity is varied.** Viscosity is 0.01 in 4a and 0.05 in 4b. The increased viscosity gives a better representation of the mixing but also produces a good approximation of upwelling, an important feature of the region.

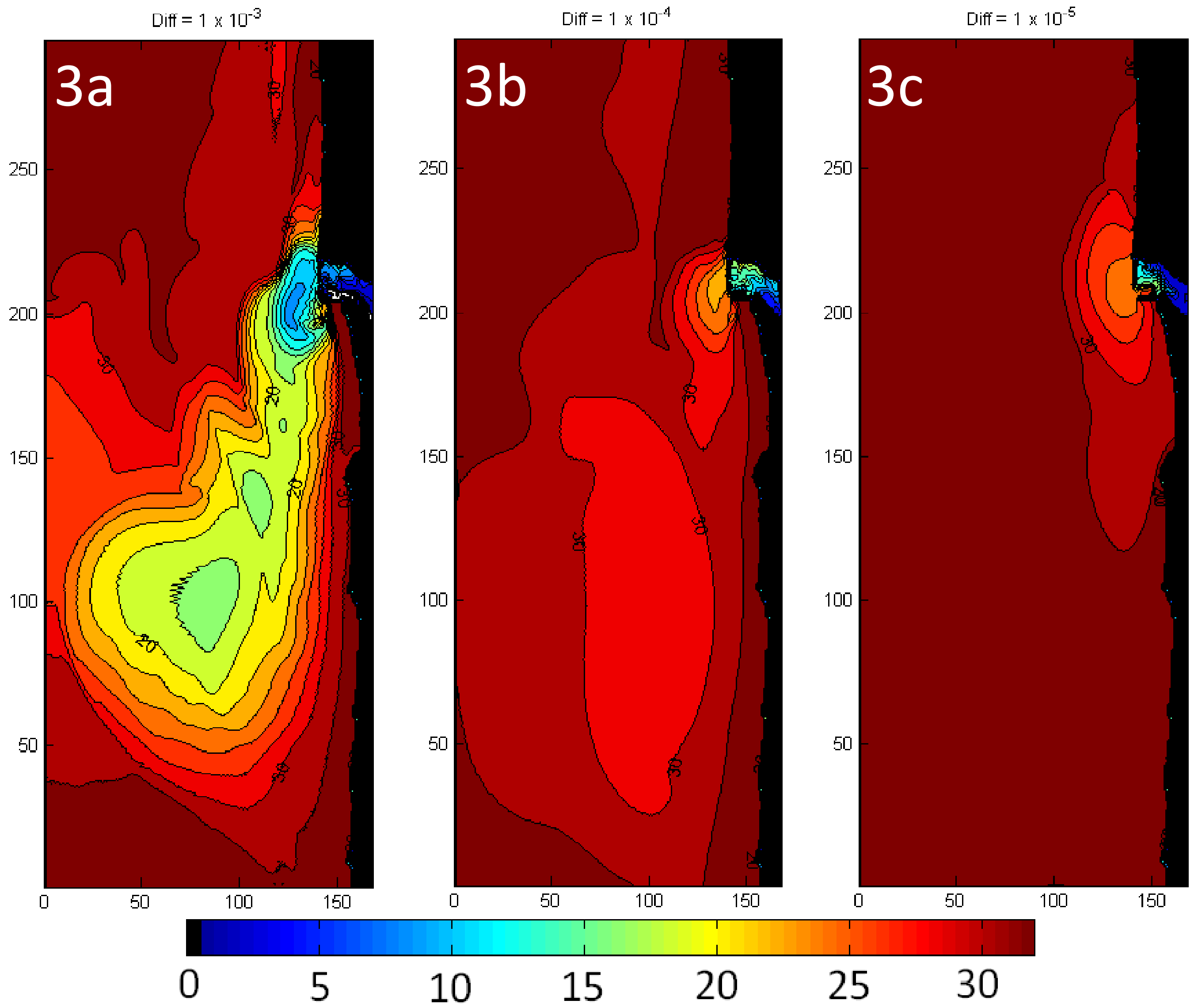

Figure 3 Model surface salinity after 286 hours

- Further improvements may come from introducing sources of deep water at the bottom or increasing the total depth of the model domain, although this may be a less economic approach.

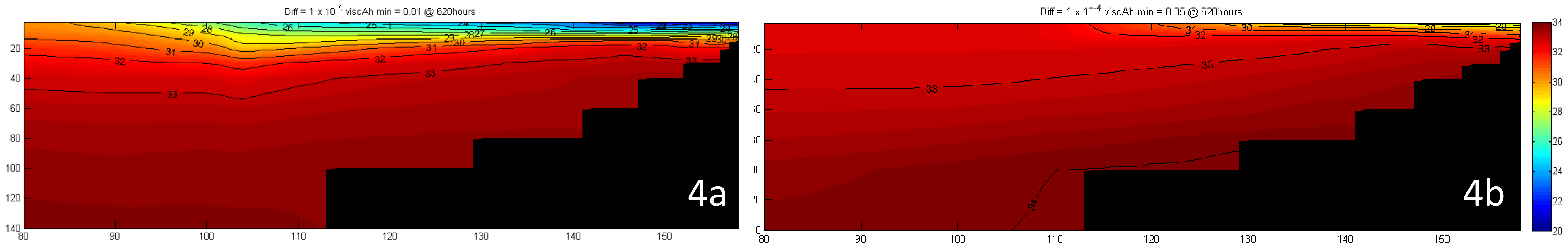

Figure 4 Model Salinity cross-section after 620 hours at the transect indicated by the green line in Figure 1

Silicate

- The Columbia River has high silicate concentrations compared with many major rivers. Despite being an area of strong upwelling the silicate supply from the Columbia River represents a significant source for diatom productivity in the surrounding depleted surface shelf waters.
- The models initial silicate fields were set to representative depth varying concentrations whilst river water had a constant concentration of 140 micro molar as seen in measurements.
- ***Figure 5* → shows data from 41 profiles collected during the cruise (black) compared to corresponding model data (red).**
- The data shows good agreement although the model has not fully reproduced the effects of upwelling in shallower waters.
- This is partly due to the horizontal uniformity of the initial field which doesn't fully represent the extent of upwelling at the coast present at the beginning of the time series.
- A longer spin up period would increase the extent of upwelling but at greater computational expense.

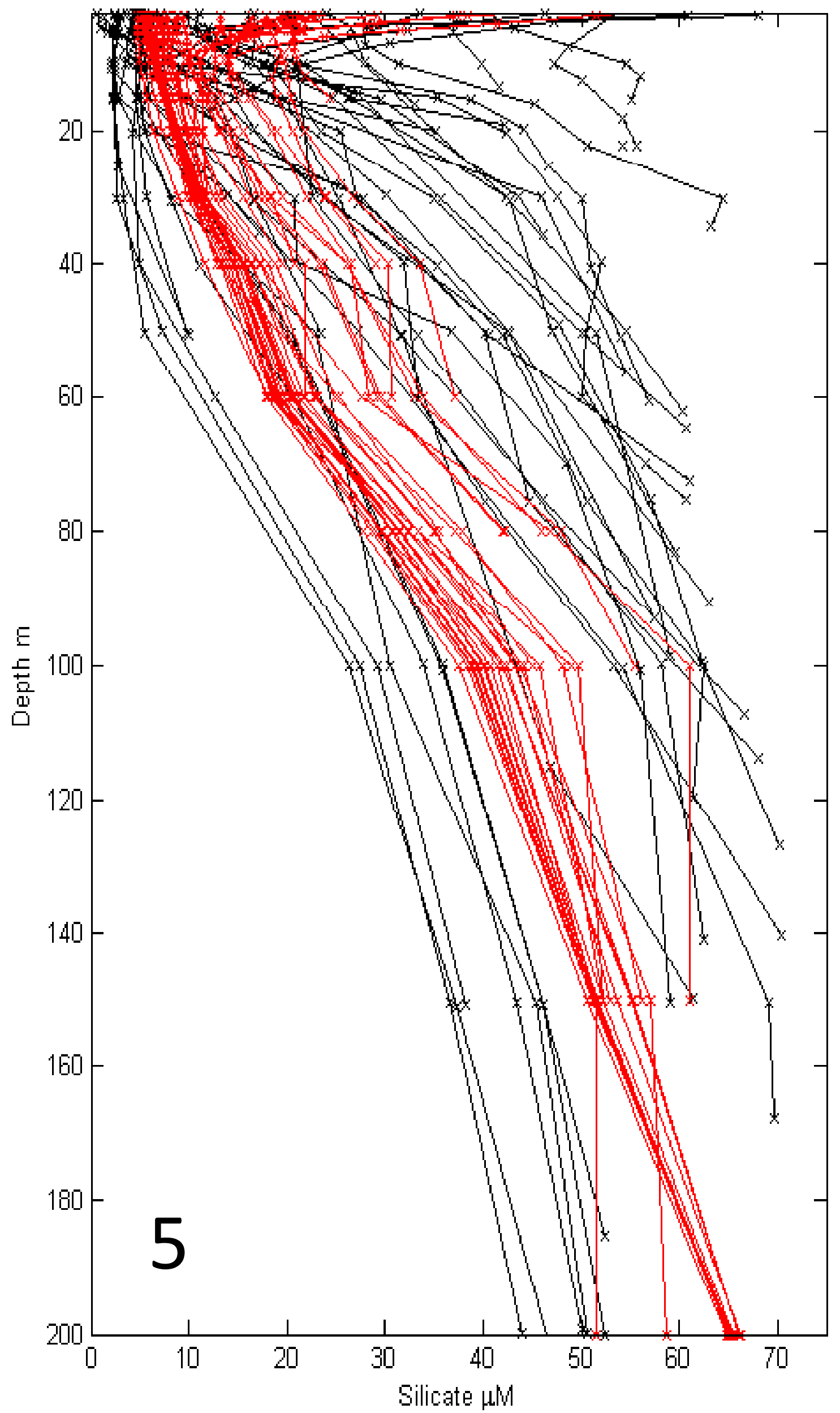

Figure 5 Silicate profiles. Field data and Model data

- ***Figure 6 a & c* ↘ show cross sections constructed from profiles collected during the cruise along transects** (indicated in *Figure 1* ↖ by the green and yellow lines) **and the corresponding model data in 6 b & d.**
- There is a clear difference in the extent to which the model has up-welled silicate rich water after 26 days (6b) compared with the field data (6a) showing a greater maximum concentration on the shelf. Also the position of the plume water lens is found further offshore in the field data possibly due to silicate utilisation at the coast.
- Better agreement is seen in the southern transects (6c, 6d) with upwelling reproduced well and little sign of the plume waters in the surface layer. The data was limited in that there are no measurements within the surface 2.4 metres which may have identified the far field plume.

Summary

- Realistic variable forcing works well within the model setup.
- The models sensitivity to variations in diffusion and viscosity have been identified and appropriate values for the current set up attained.
- The importance of horizontally variable initial fields is shown
- Future improvements will include deep water sources and as well as biological representation in the form of surface sinks.

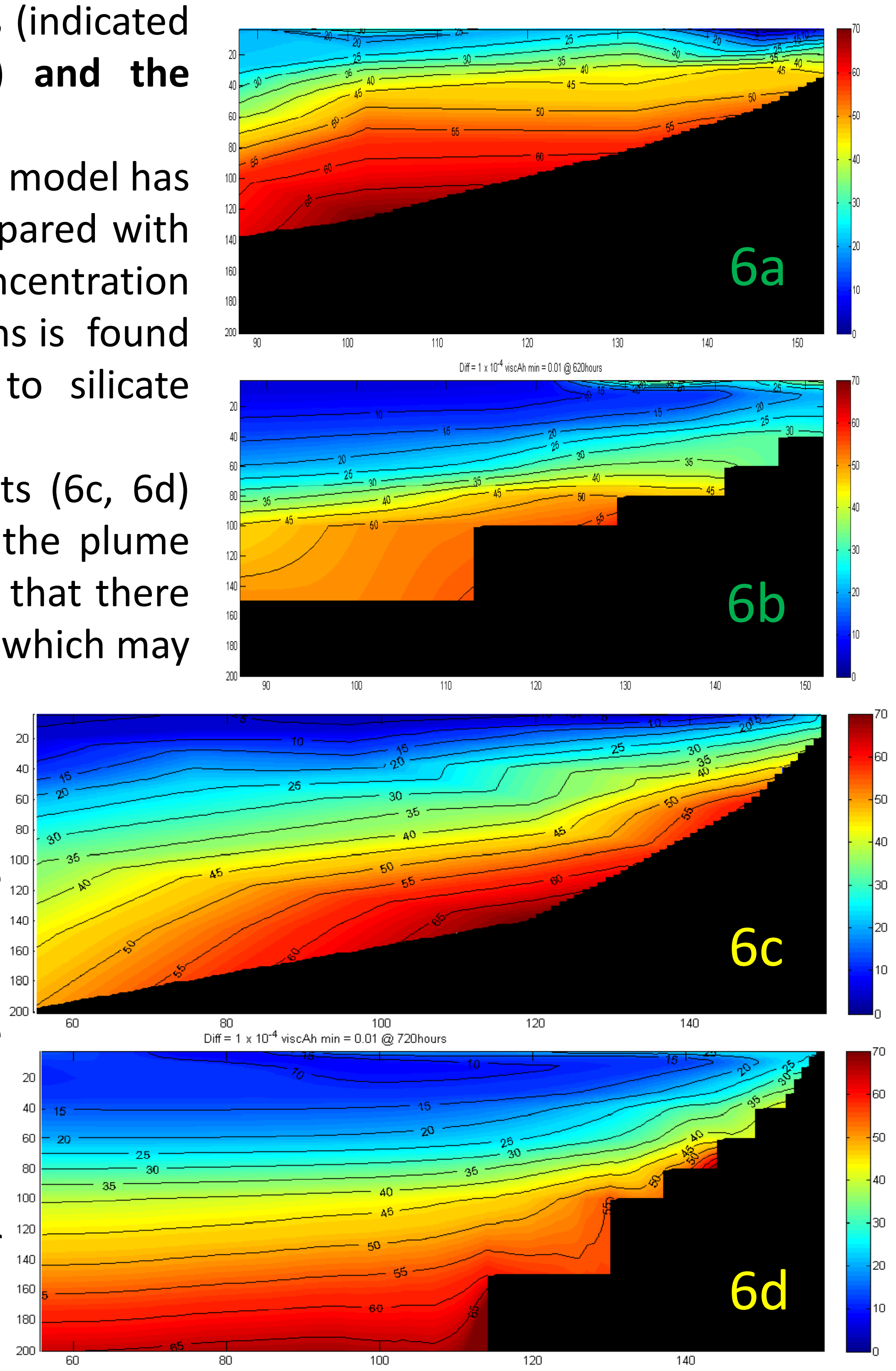

Figure 6 Silicate conc. cross-sections. Field data a and c, model data b and d

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