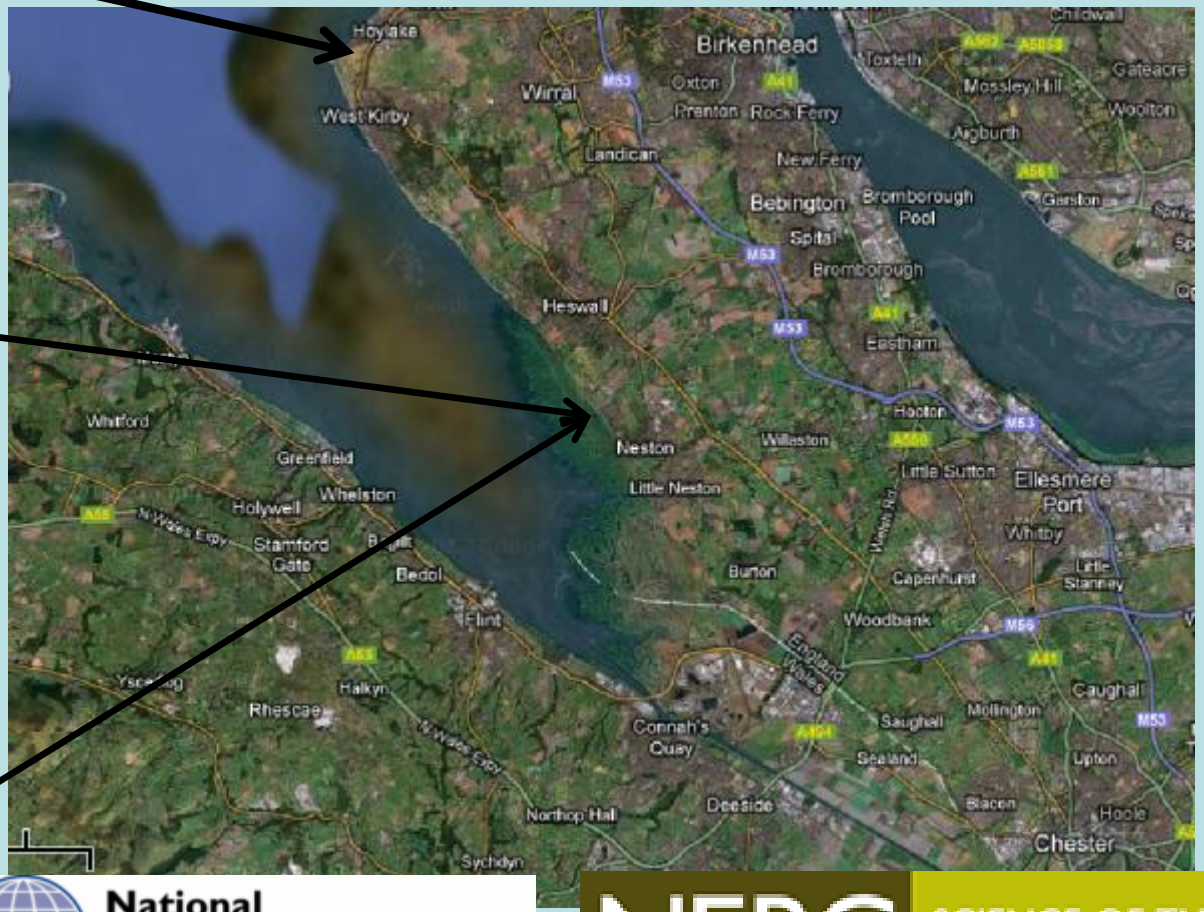
The Dee Estuary: waves, circulation and sediment transport

Work by: **Jenny Brown**, Alejandro Souza, Laurent Amoudry, Rafael Ramírez-Mendoza, Rodolfo Bolaños



National Oceanography Centre
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NERC SCIENCE OF THE ENVIRONMENT

The Dee Estuary

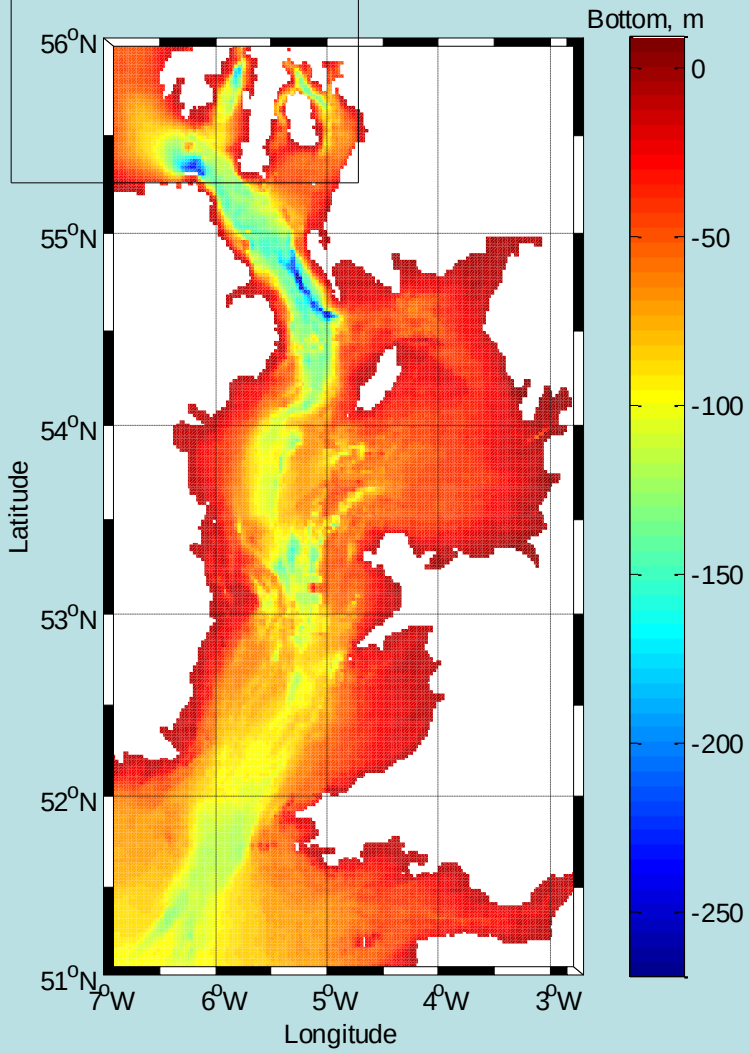
Hilbre Channel

Welsh Channel

- Mixed sediments
- Tidal range <10 m
- Currents <1 m/s
- Ave annual river 31 m^3/s
- Waves < 2 m mouth

Winter Modelling Study (Feb-Mar 08)

Proudman **O**ceanographic **L**aboratory **C**oastal **O**cean **M**odelling **S**ystem – **G**lobal **O**cean **T**urbulence **M**odel – **WA**ve **M**odel



One way nested model

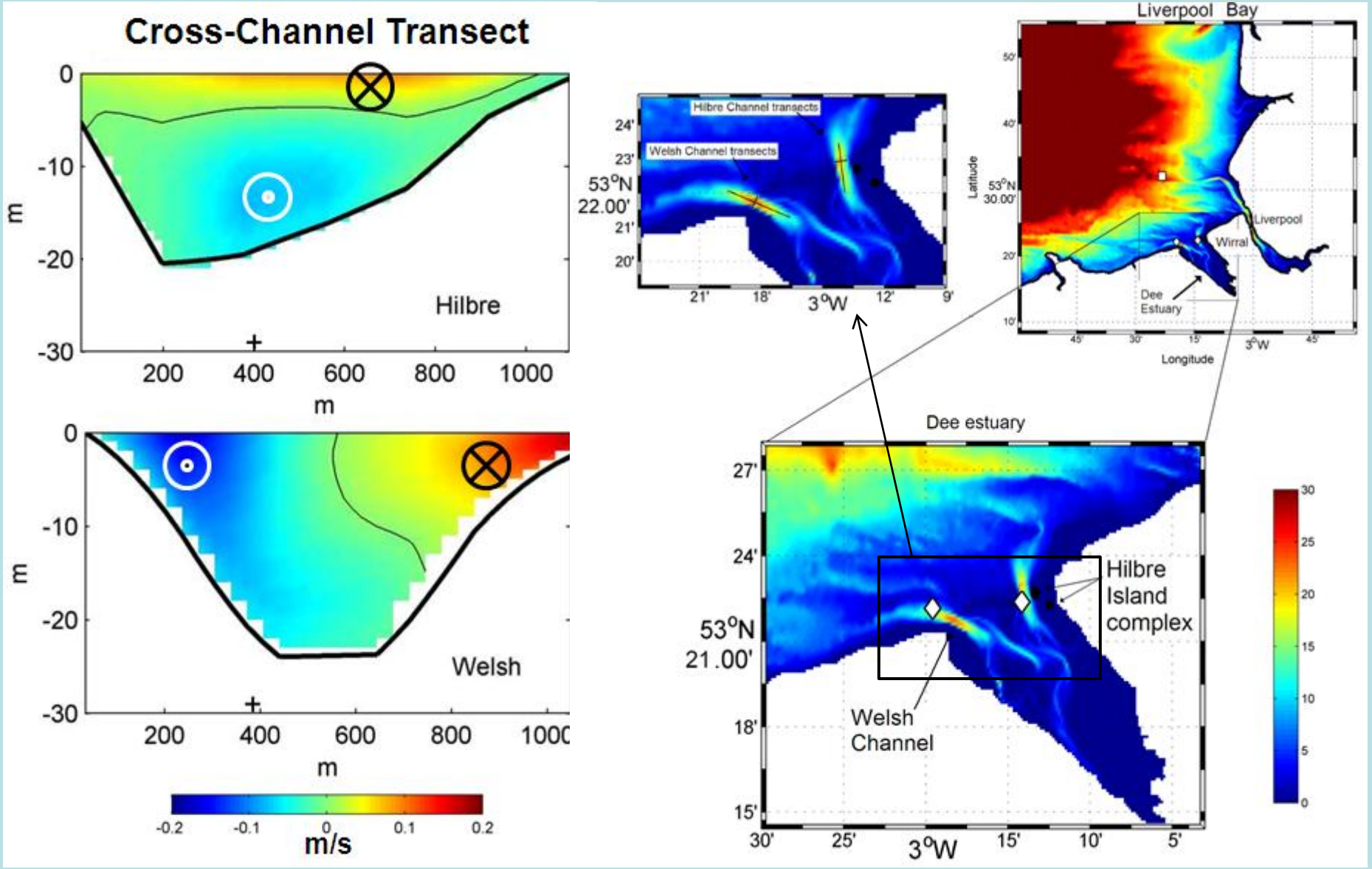
Operational Continental Shelf Surge Model & Operational Atlantic Margin Model

Irish Sea Coupled Model:
1.8km resolution

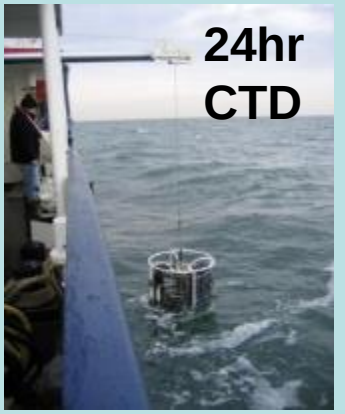
Liverpool Bay coupled wetting & Drying Model:
180m resolution

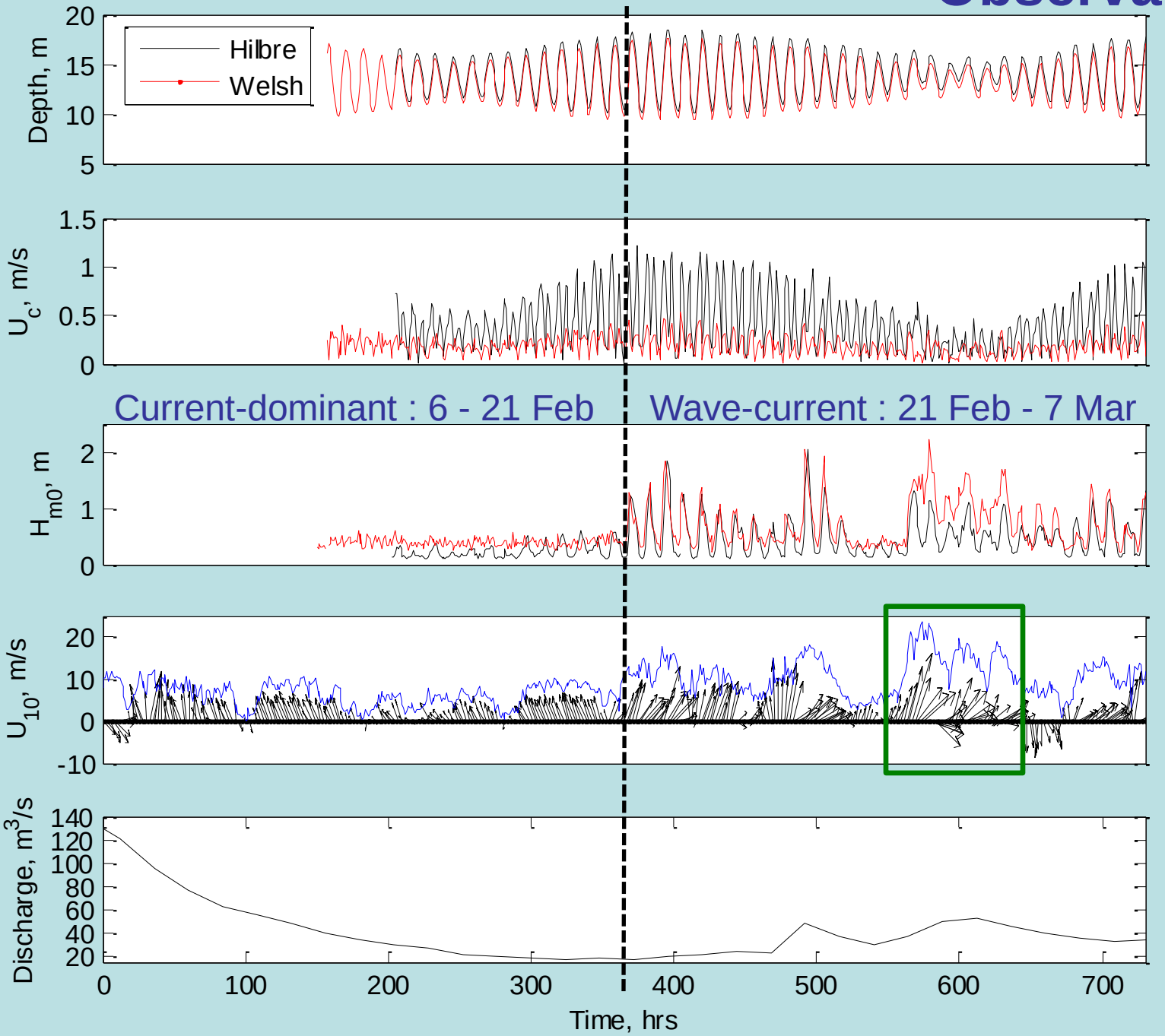
Process selection
to understand what's going on!

Liverpool Bay Model

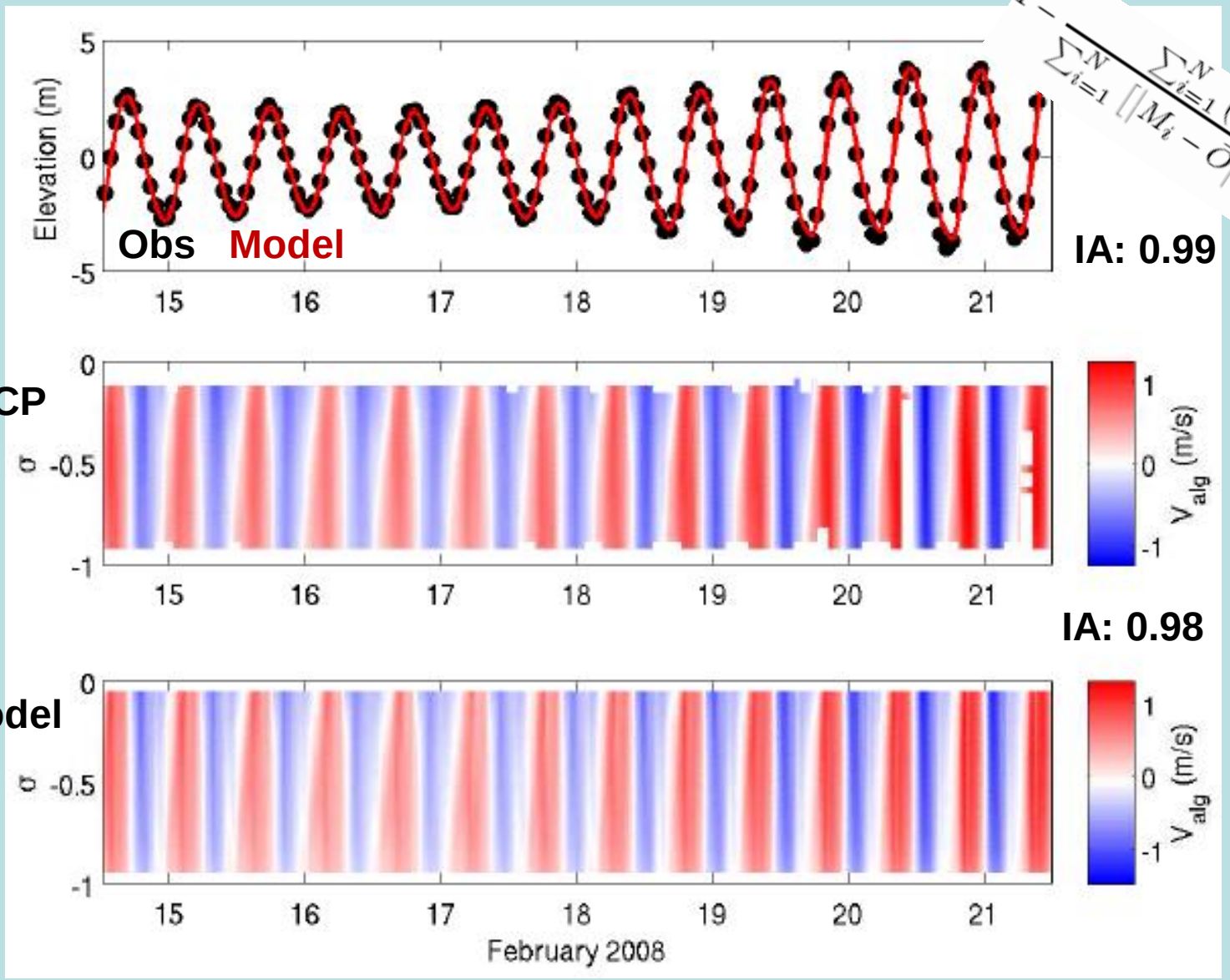


Observations



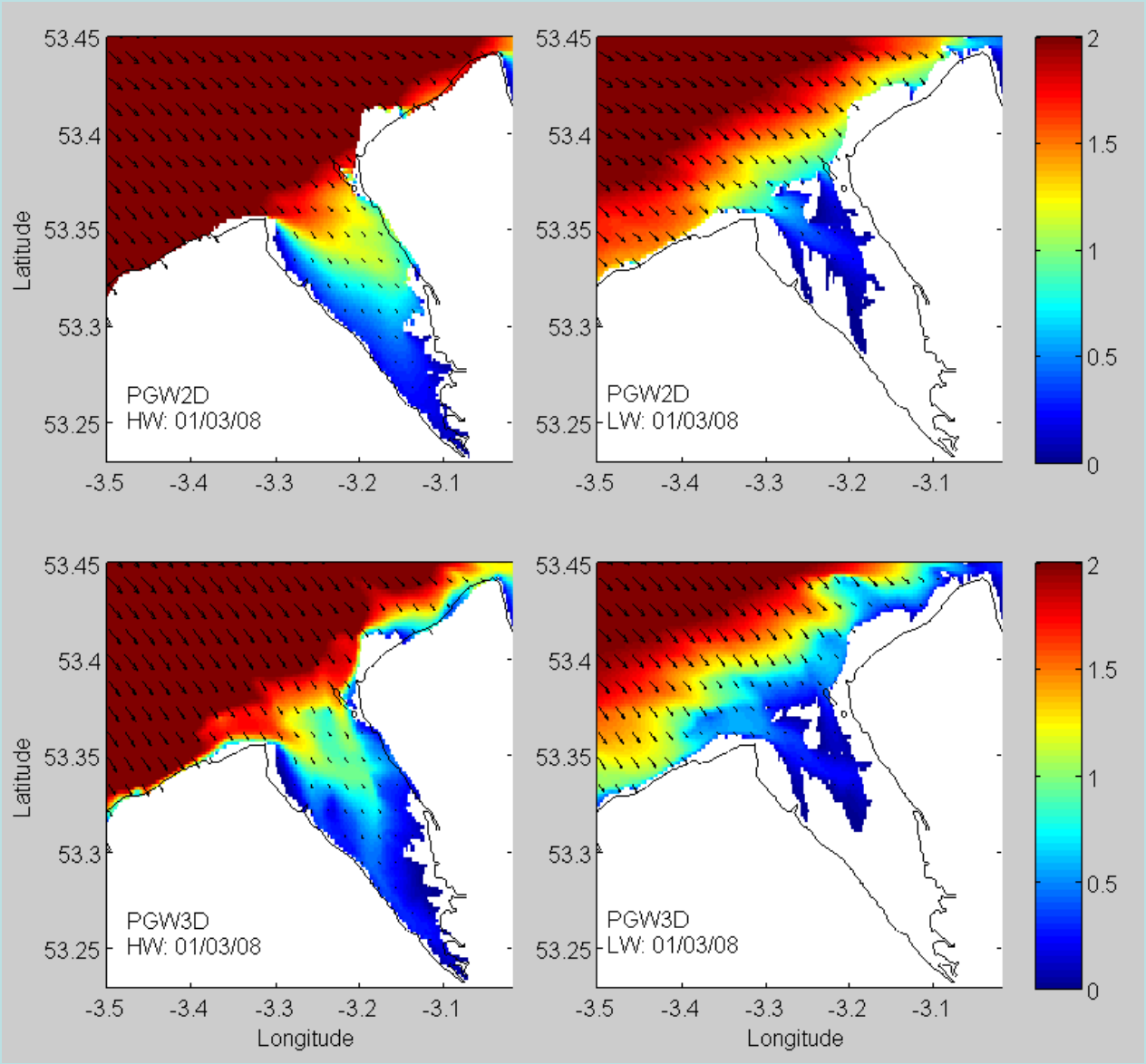


Dee Validation: Hilbre Calm Period



$$1 - \frac{\sum_{i=1}^{N}(M_i - O_i)}{\sum_{i=1}^{N}\left[|M_i - \bar{O}| + |O_i - \bar{O}|\right]^2}$$

2D v. 3D Wave Coupling



2D

- Depth-Ave current
  (refraction & Doppler shift)
- 2D radiation stress
  (vertically uniform)

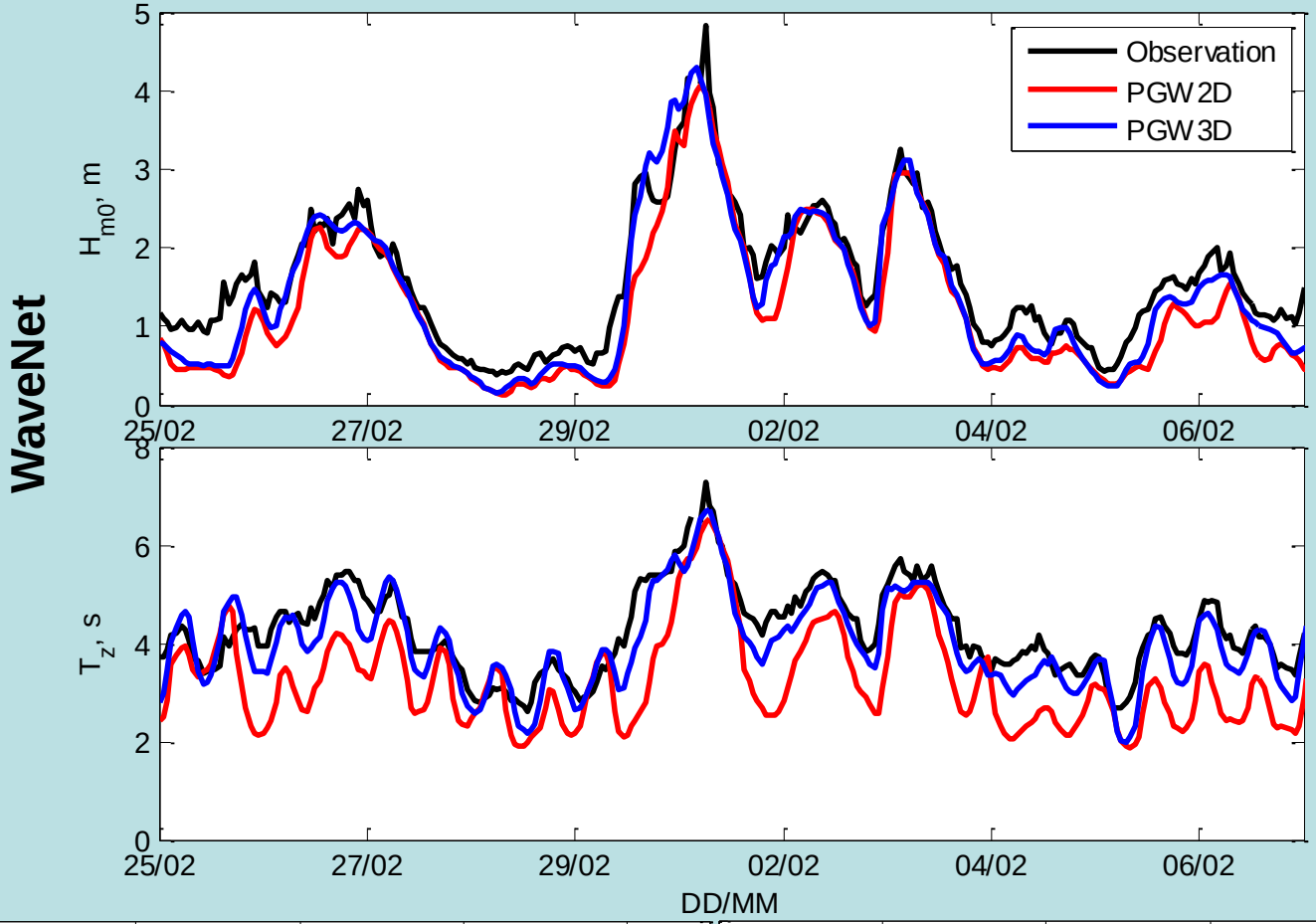
3D

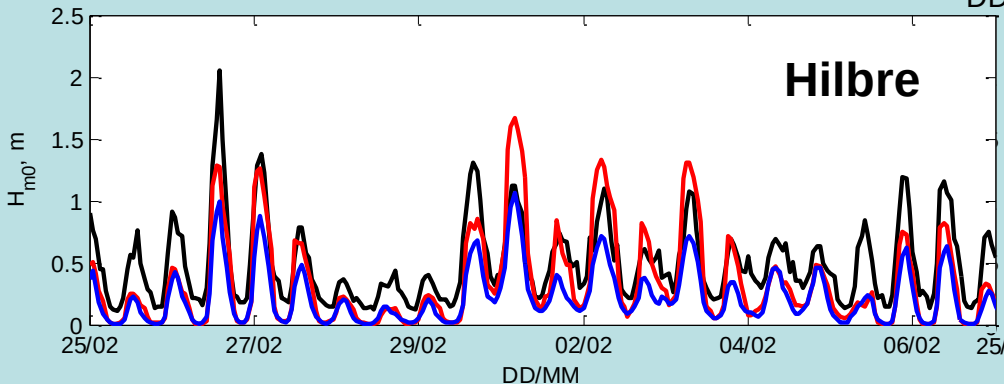
- Depth-integrated current
  (refraction & Doppler shift)
- 3D radiation stress
  (vertical profile)
- Stokes drift
  (Vertical profile)

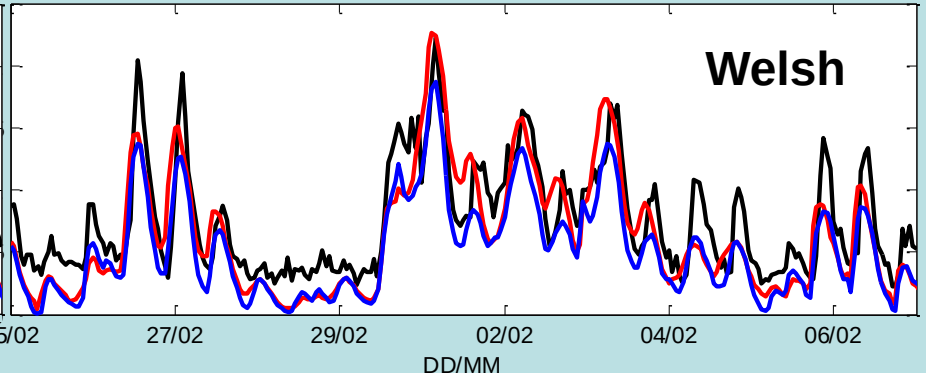
Both

- Surface & Bottom roughness enhanced

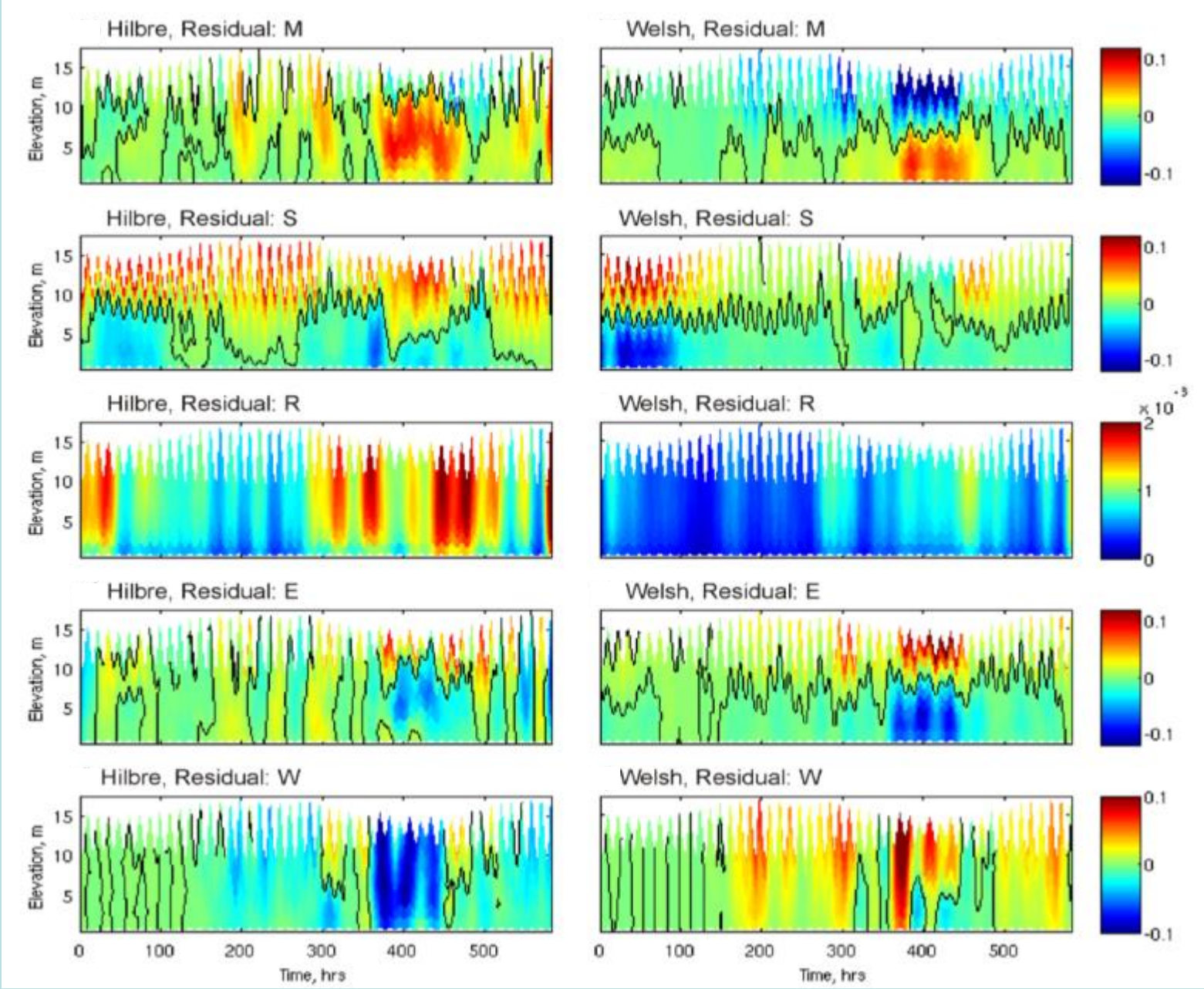
Wave Validation



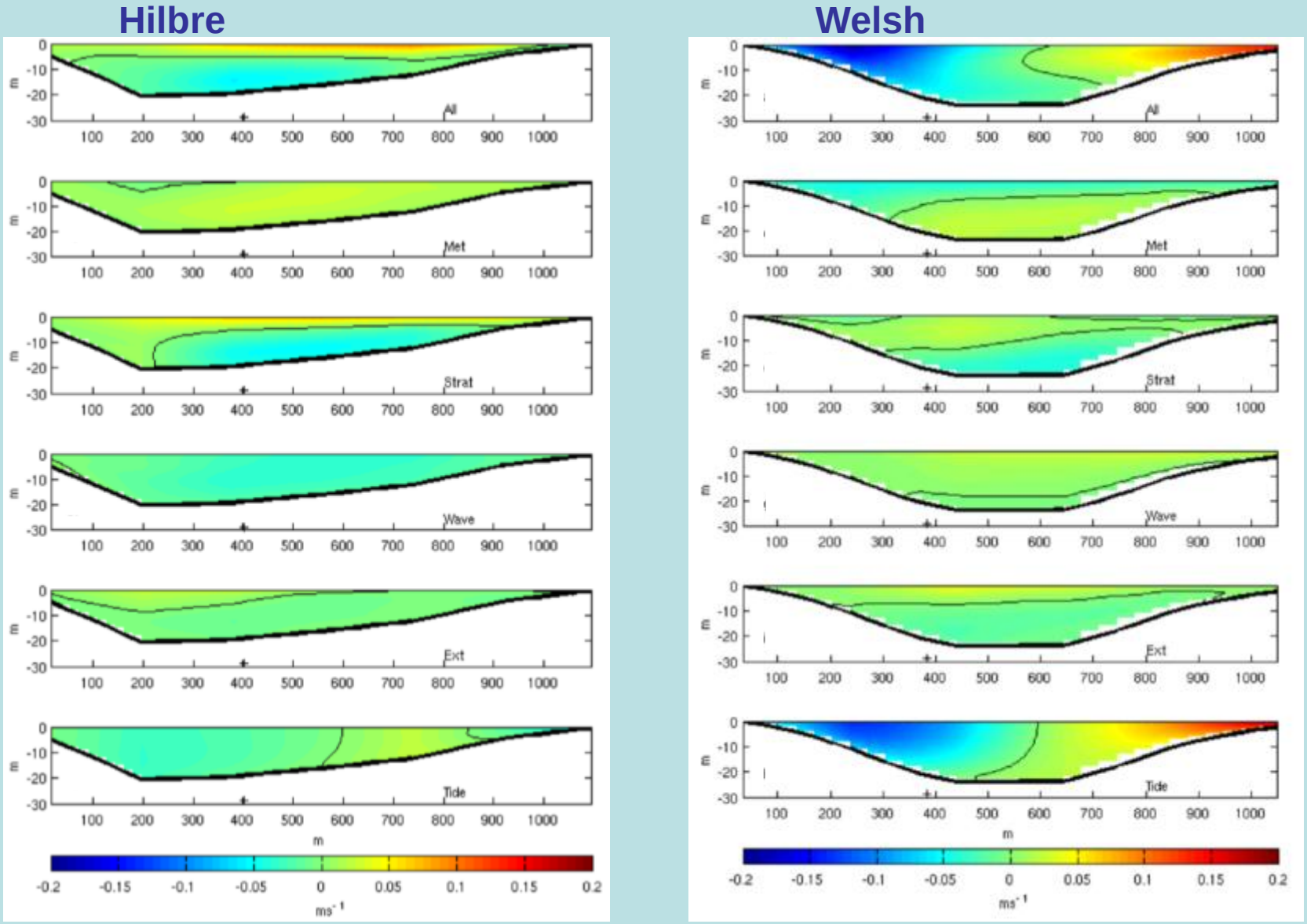




Time-Varying Non-Tidal Processes

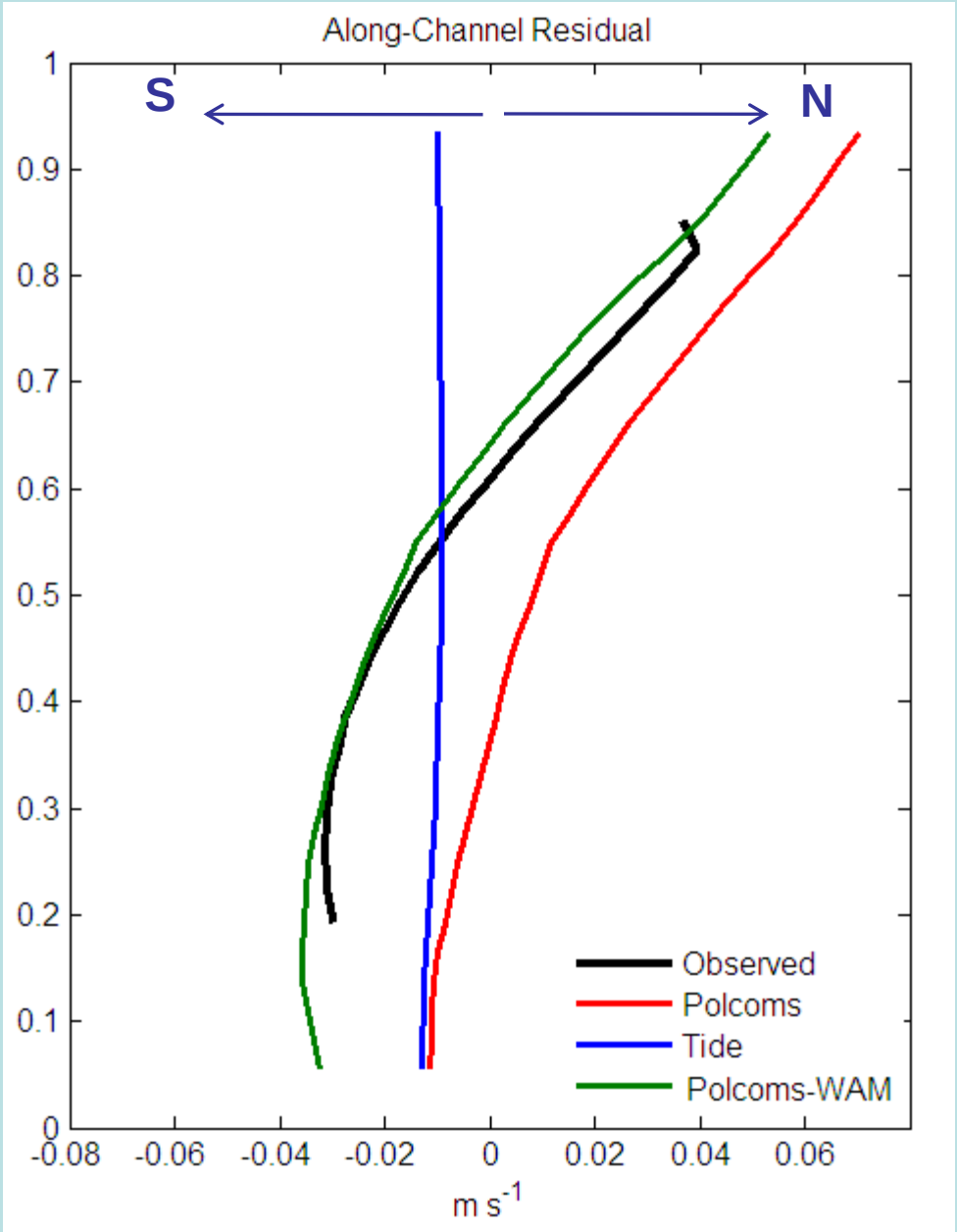


Wave-Current Along-channel Residual Circulation

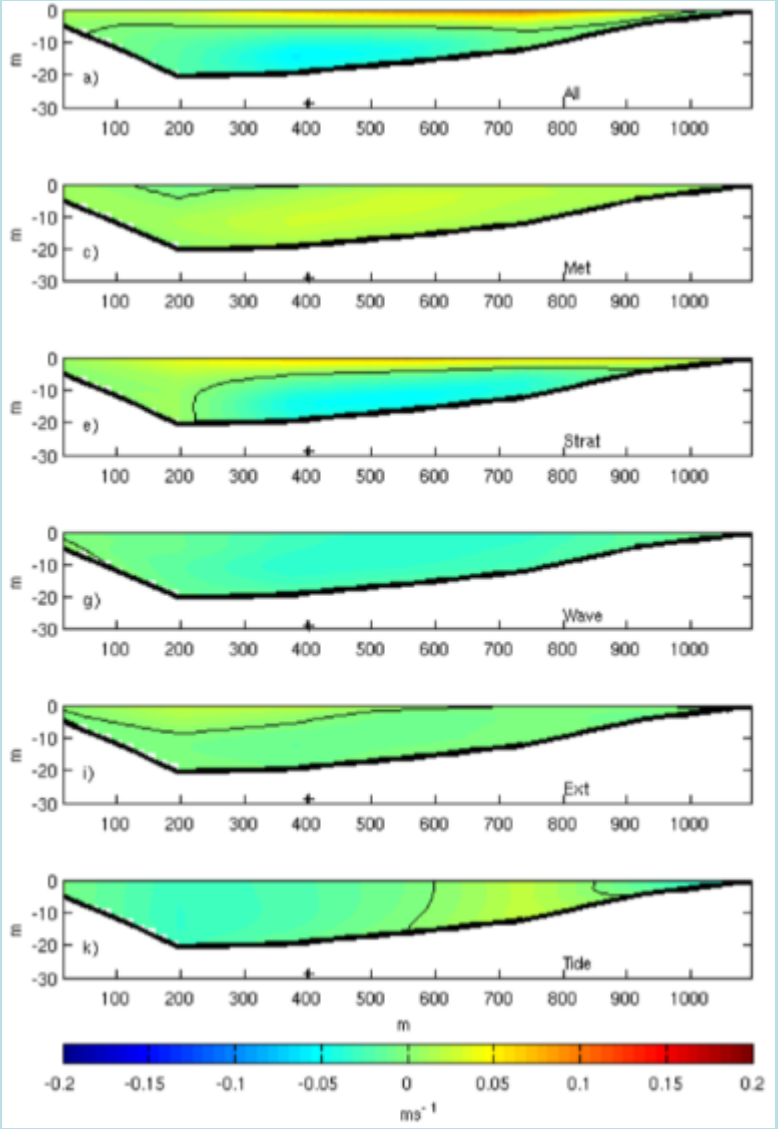


Cross-channel profile

Hilbre Channel Residual Circulation

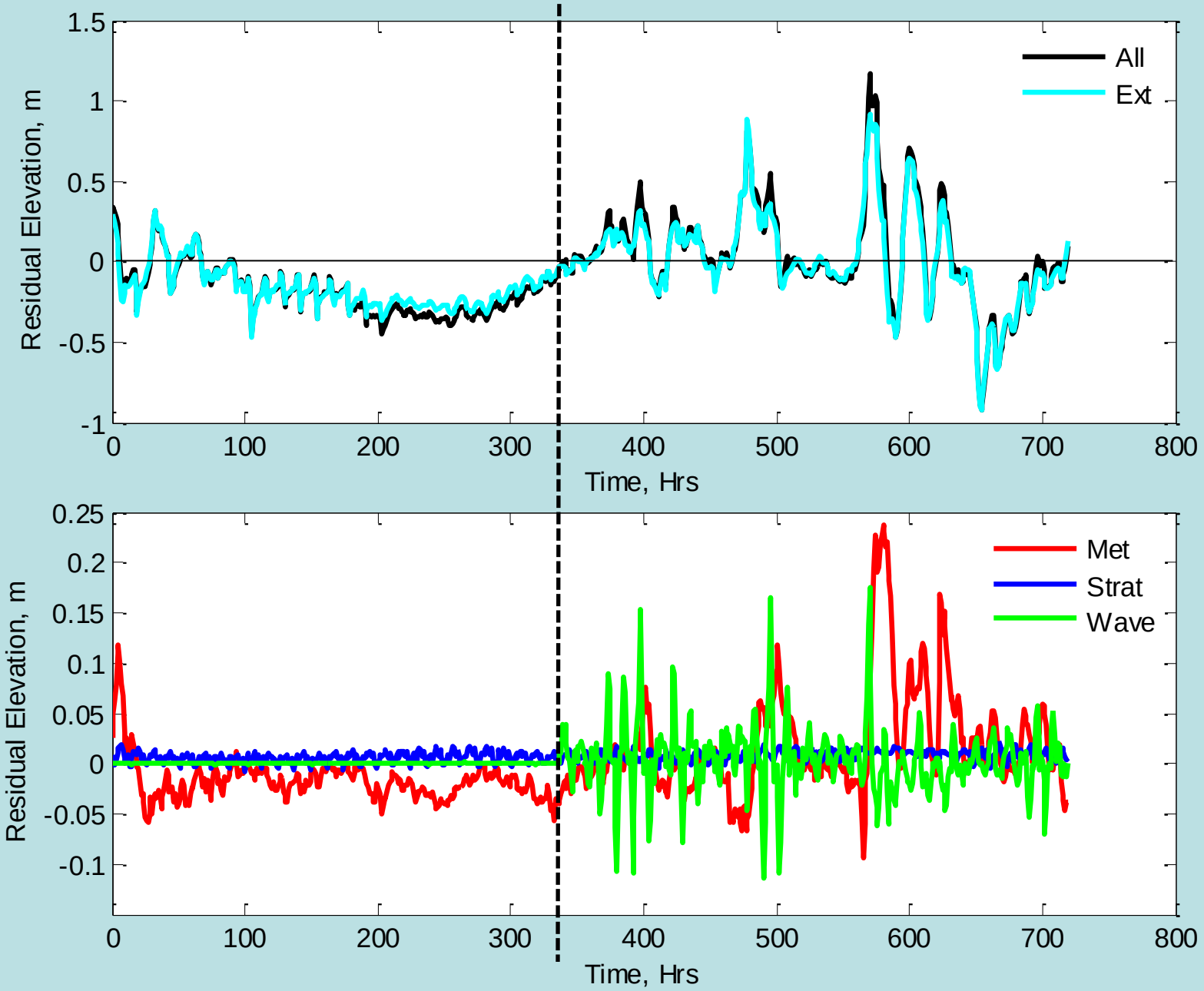


Along-channel residual



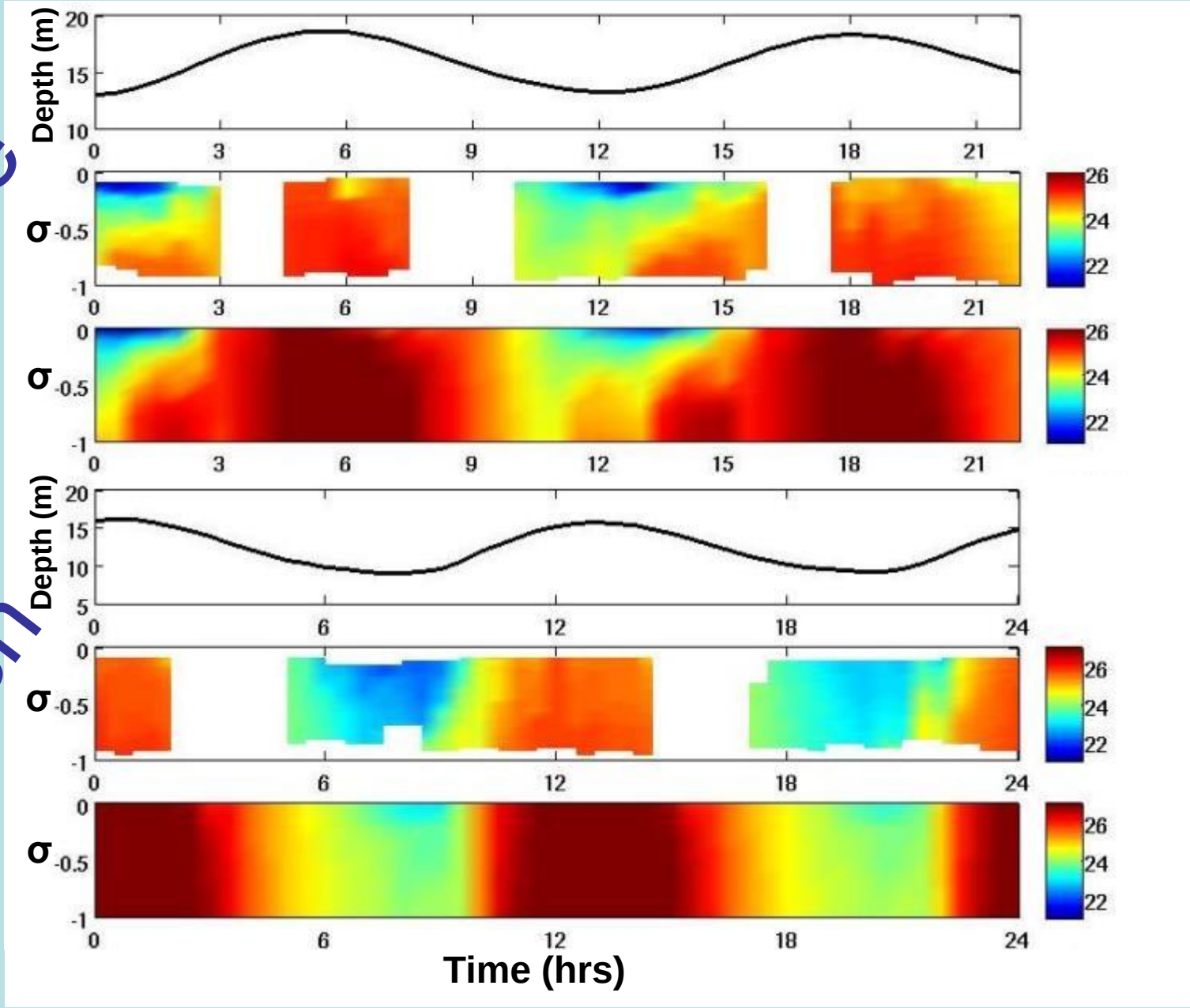
Cross-channel profile

Hilbre Channel Residual Elevation



Hilbre

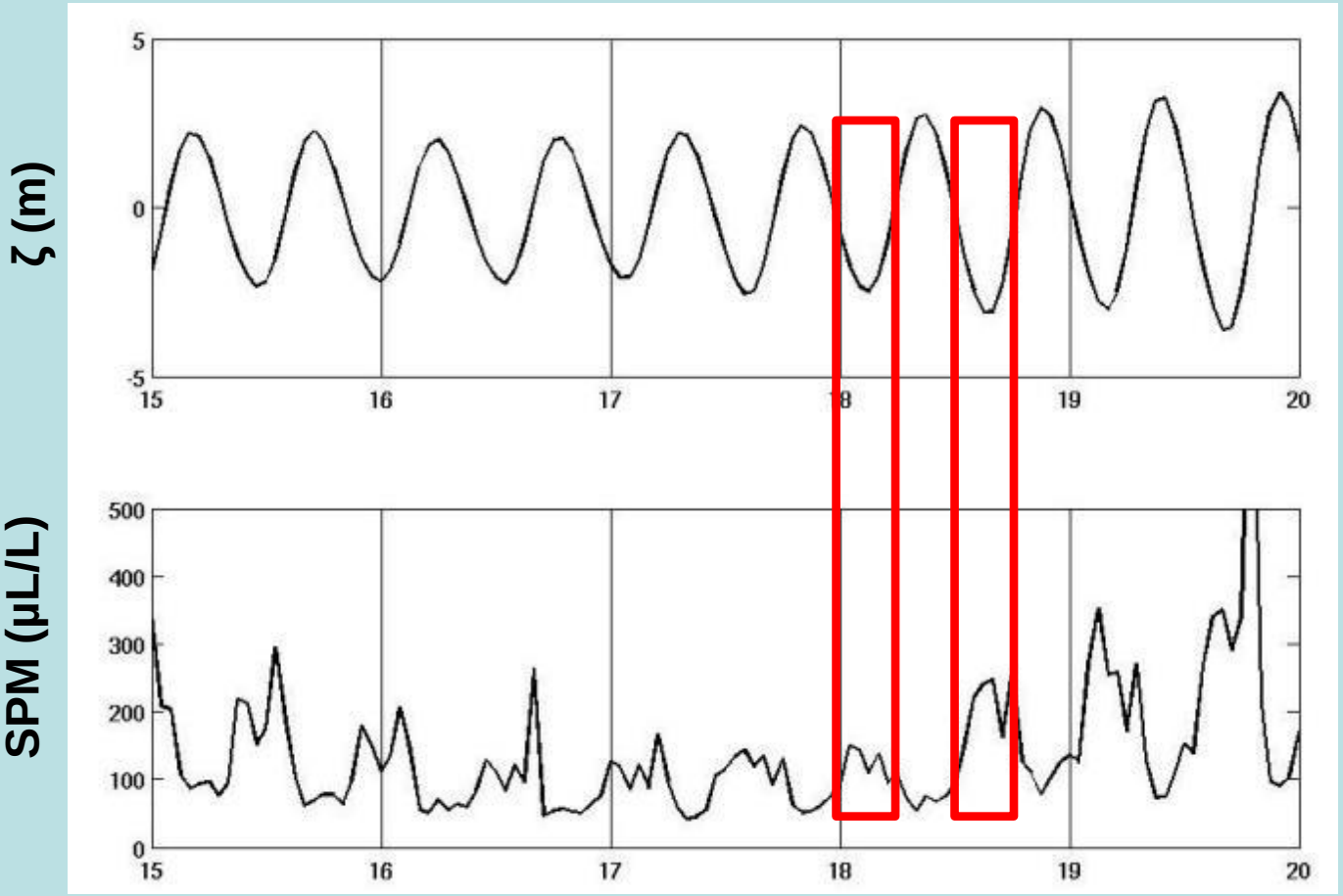
Welsh



Density anomaly (kg/m³)

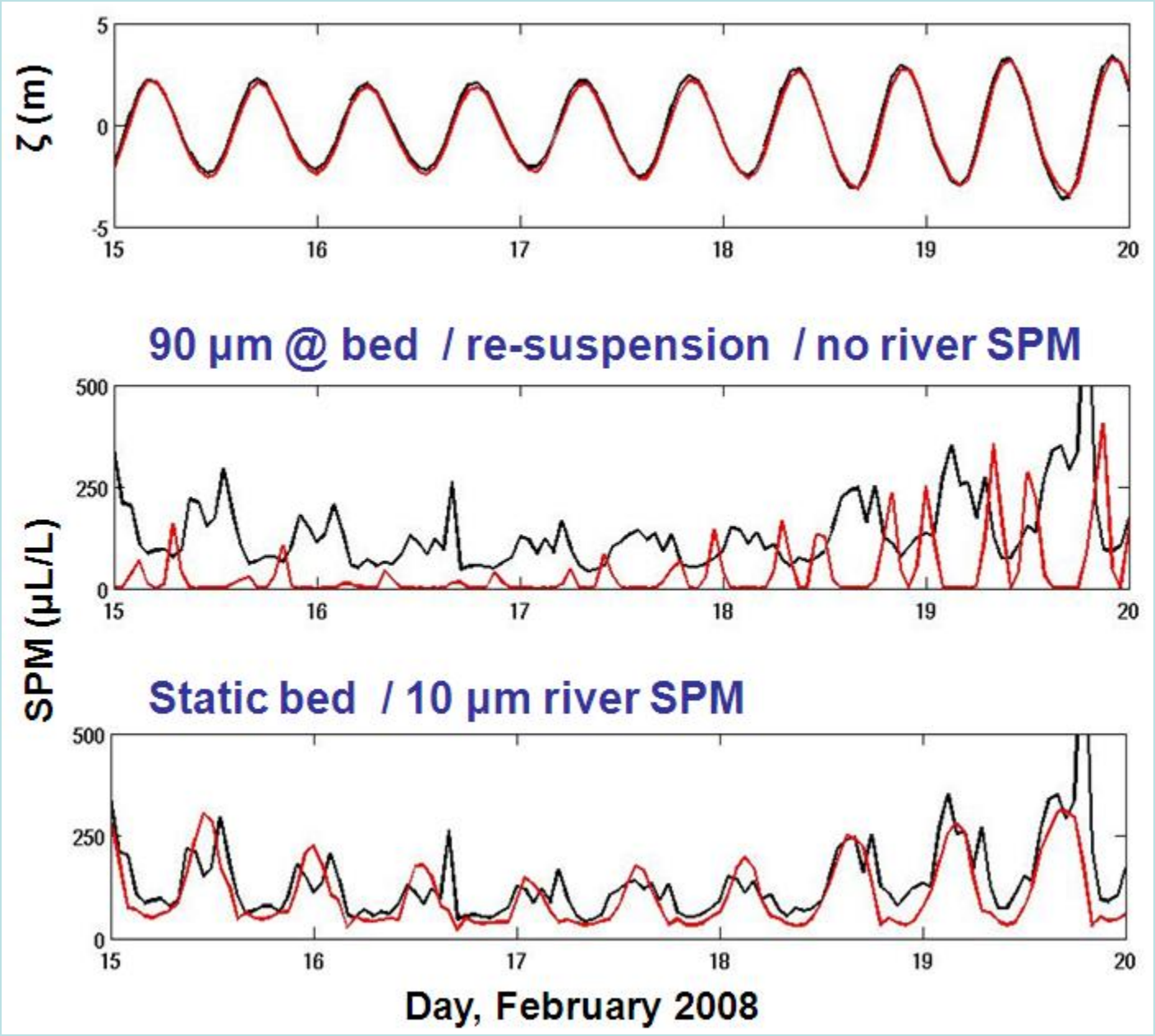
Hilbre LISST Observations Calm Period

Installed on bottom tripod, 1.8 m above bed



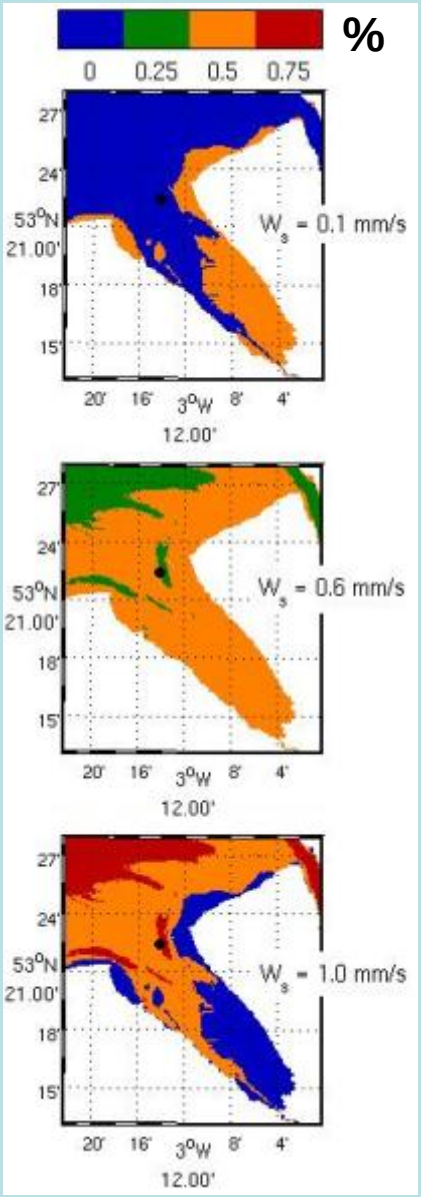
Concentration peaks with semi-diurnal period coinciding with low water.

Hilbre Model-LISST Comparison Calm Period

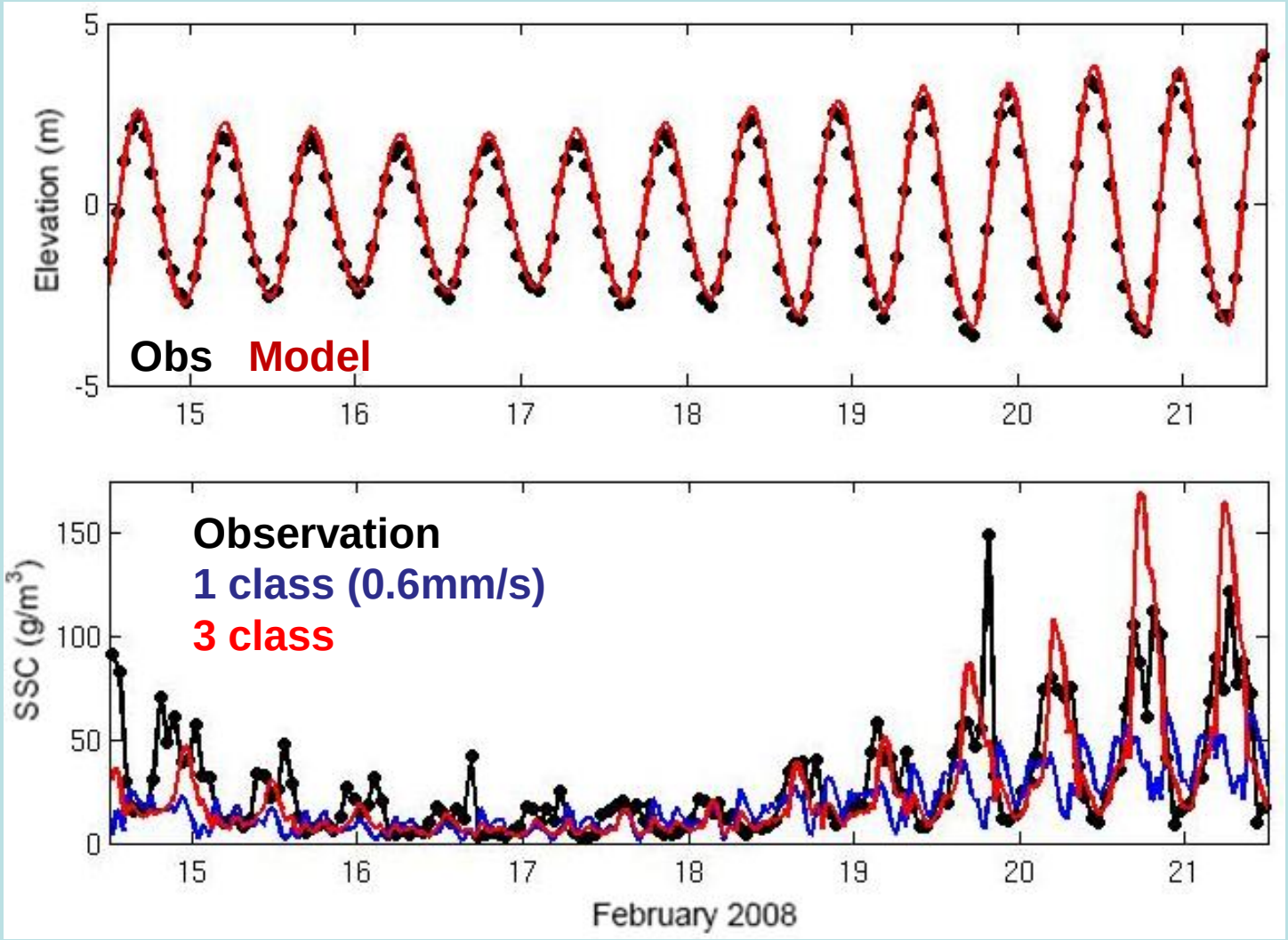


LISST
Model

Varying Bed Composition

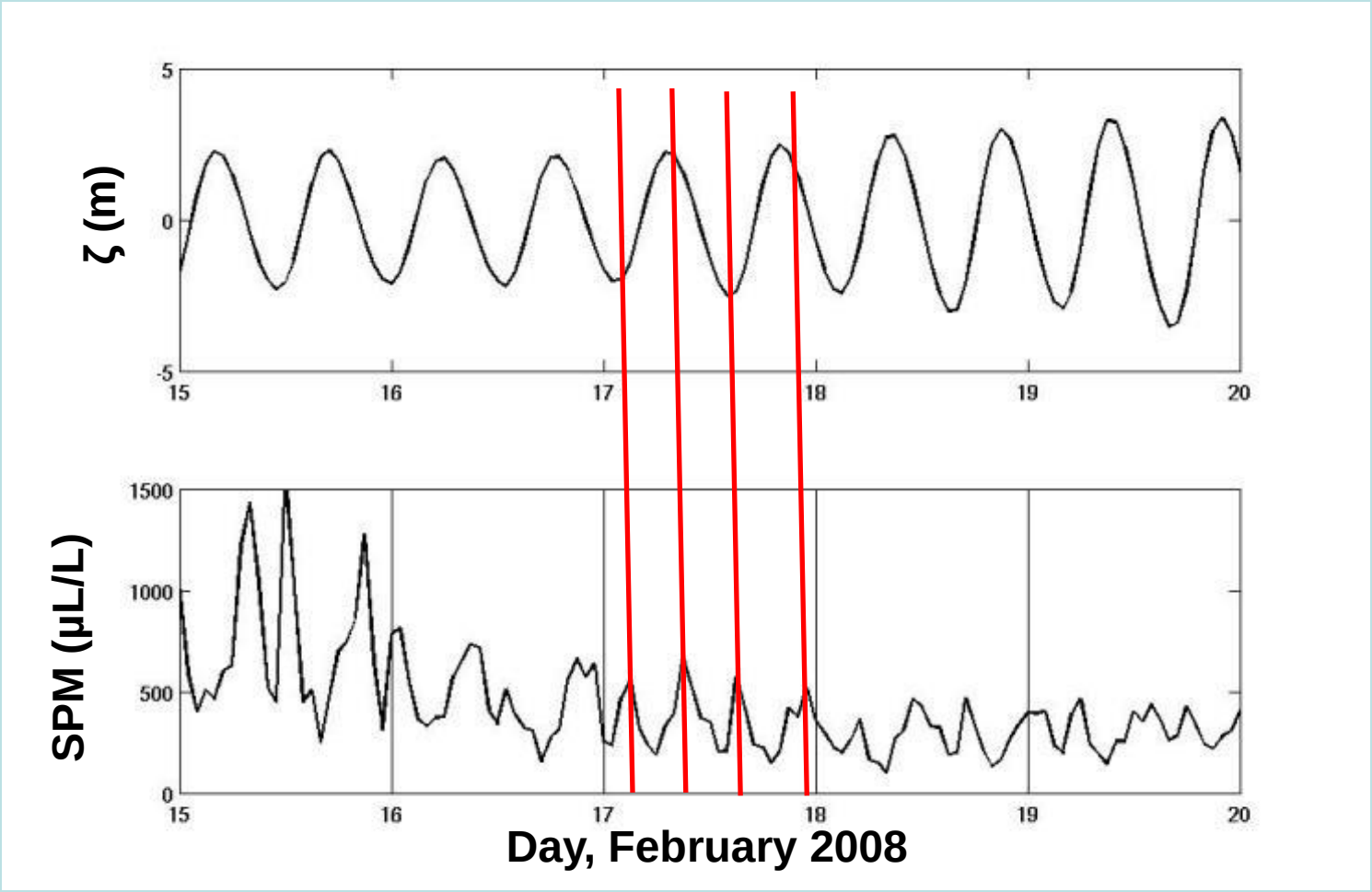


Hilbre Chanel Calm Period



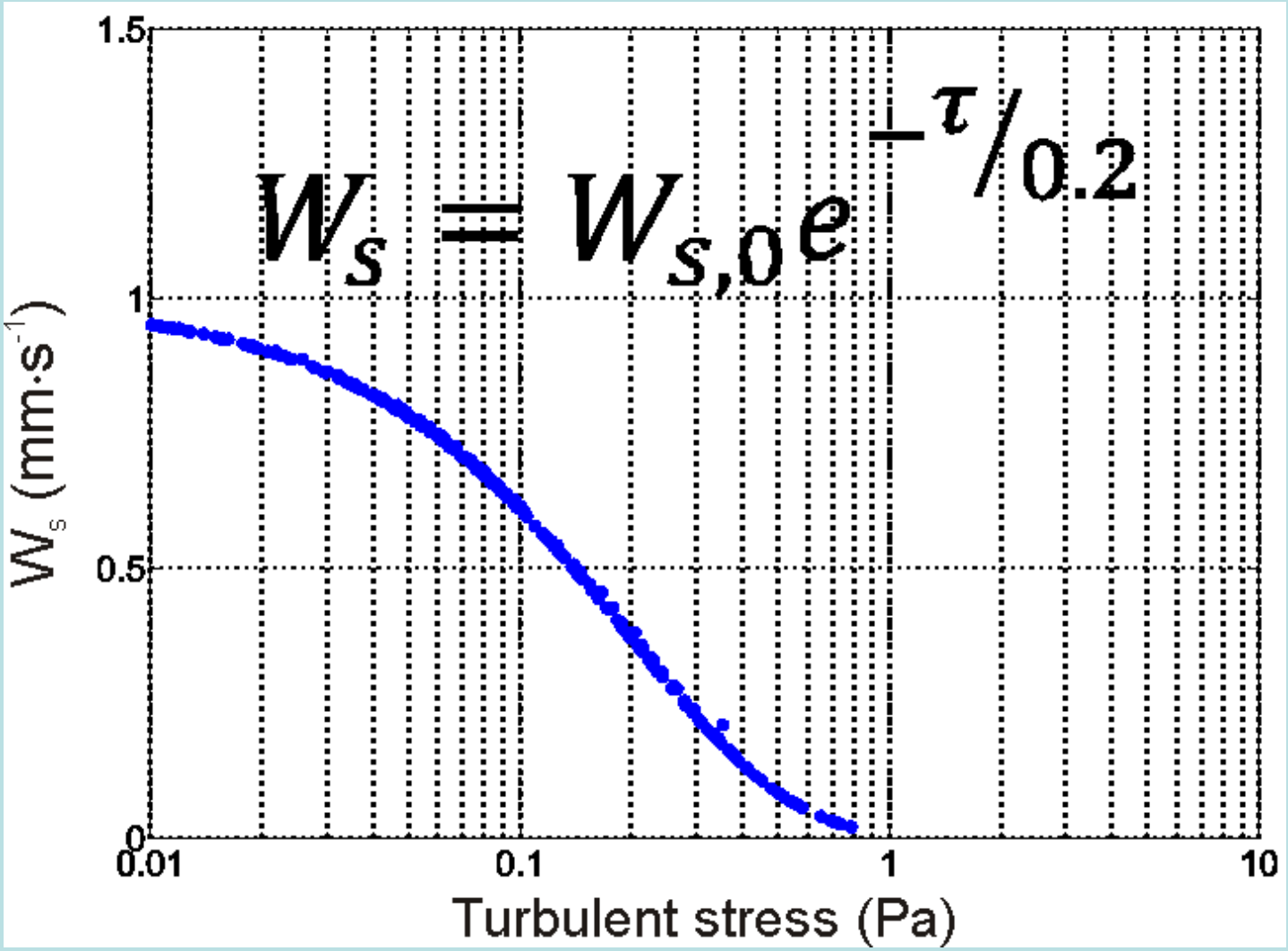
Welsh LISST Observations Calm Period

Installed on bottom tripod, 1.5 m above bed



Concentration peaks with quarter-diurnal period coinciding with flood & ebb.

Parameterising Flocculation



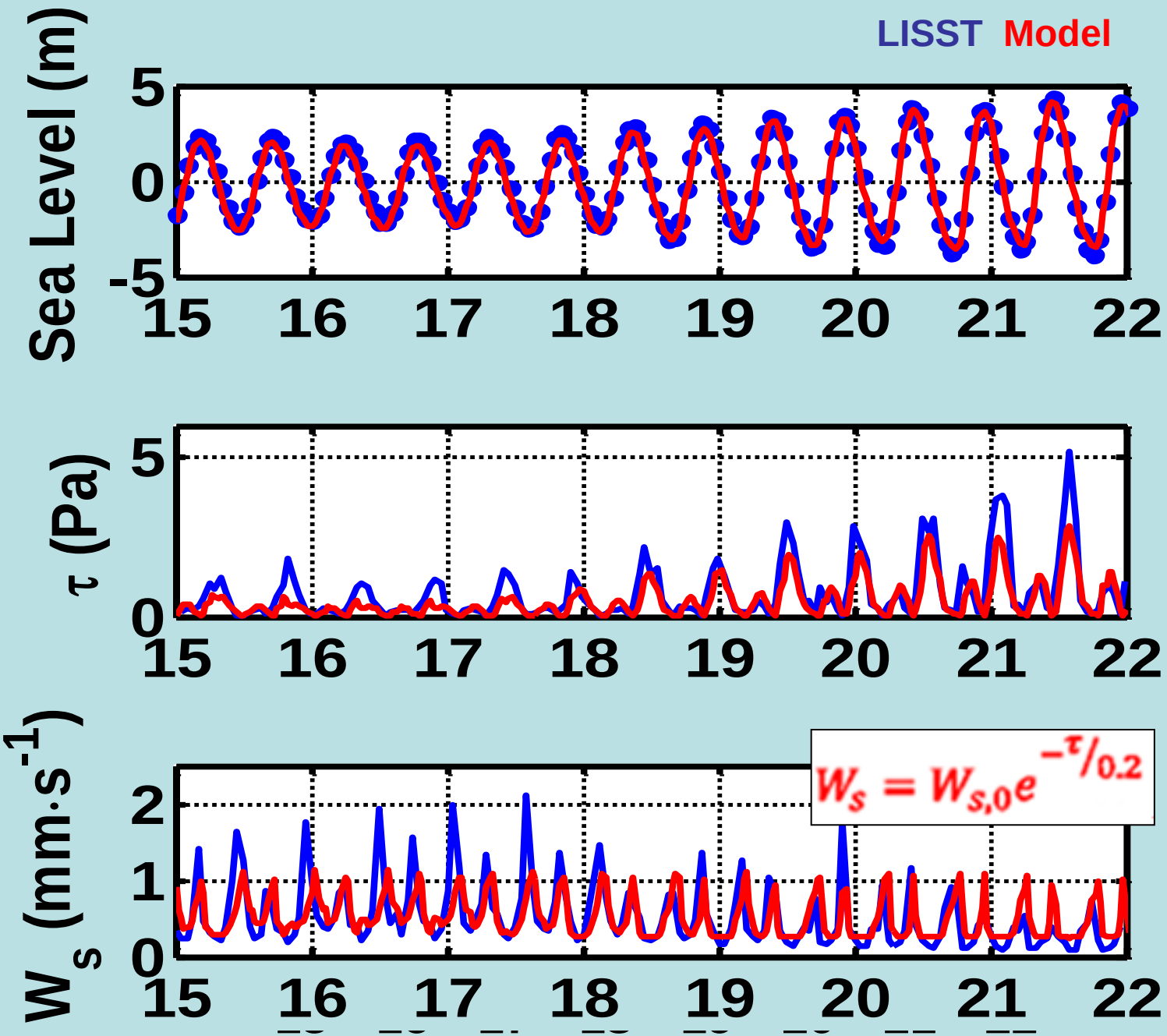
Large flocs

Small flocs

Weak currents
Aggregation

Strong currents
Breakup

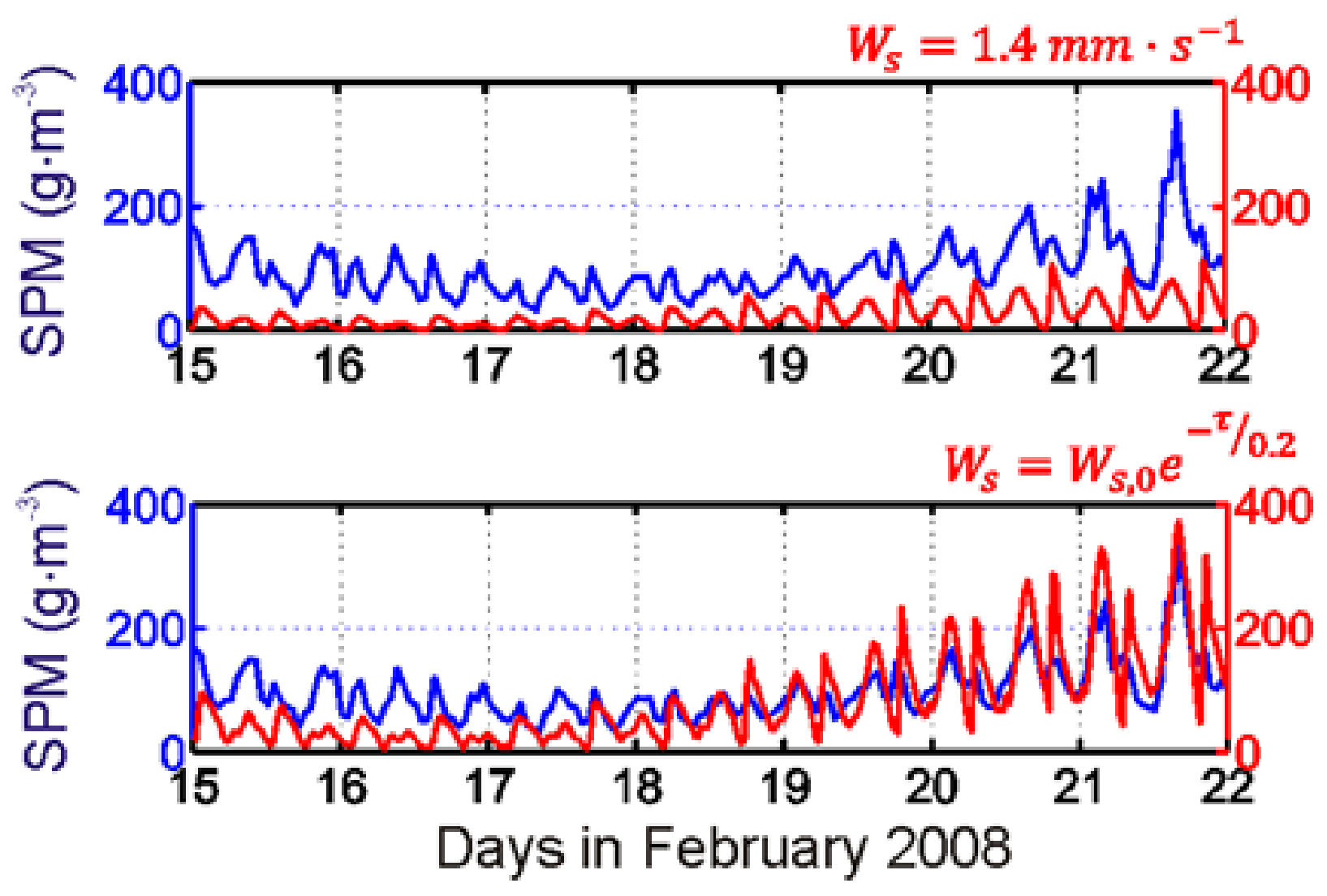
Welsh Channel Validation
Calm Period



Welsh Model-LISST Comparison Calm Period

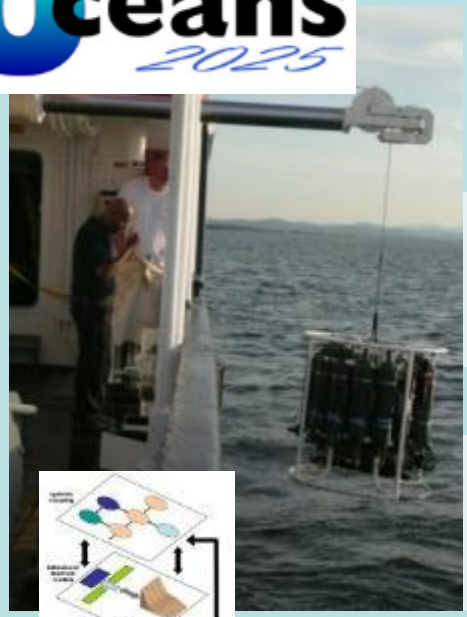
LISST Model

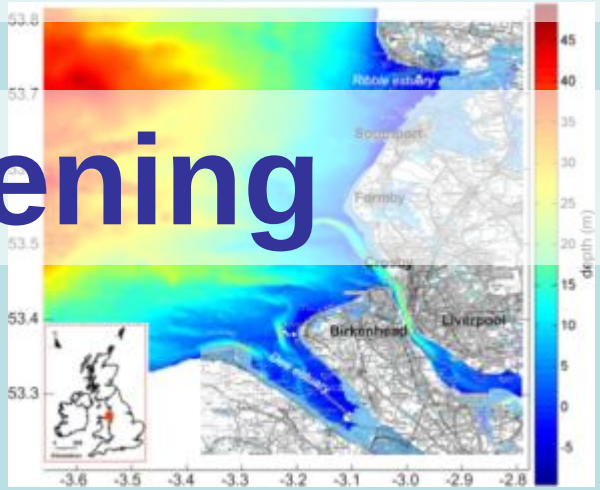
90 µm @ bed / re-suspension / no river SPM



Conclusions

- Although Hypertidal the Dee has a barotropic and baroclinic dominant channel. Co-existance of different regimes within a system.
- At the event scale metrological, wave and riverine processes have impact, but over monthly time scales tides and river influence dominate.
- Waves may seem to be of low importance, but the landward wave driven flow does influence the magnitude of the residual circulation.
- The horizontal gradient in estuarine bed composition is important for accurate sediment modelling, as shown in the Hilbre Channel.
- Tidal re-suspension and turbulent influence on flocculation are the important, as shown in the Welsh channel.
- Waves-Current sediment dynamics & Morphology to come!





Thanks for listening