

# Intercomparison of model predictions of estuarine morphology

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# Outline

- Objectives
- Models × Estuaries
- Evidence for leaflet conclusions



# Objective

- to improve confidence in model predictions of estuary form
- Various models (B-U, T-D, Hybrid)
- eight varied UK estuaries  
→ “ensemble”
- compare model approaches and estuaries



# Models:

Emulator; based on 1-D equations,  $\nabla$  section, uniform tidal ampl

Regime-Shell; described by Adrian Wright

“2.5D”; as used by Andrew Lane

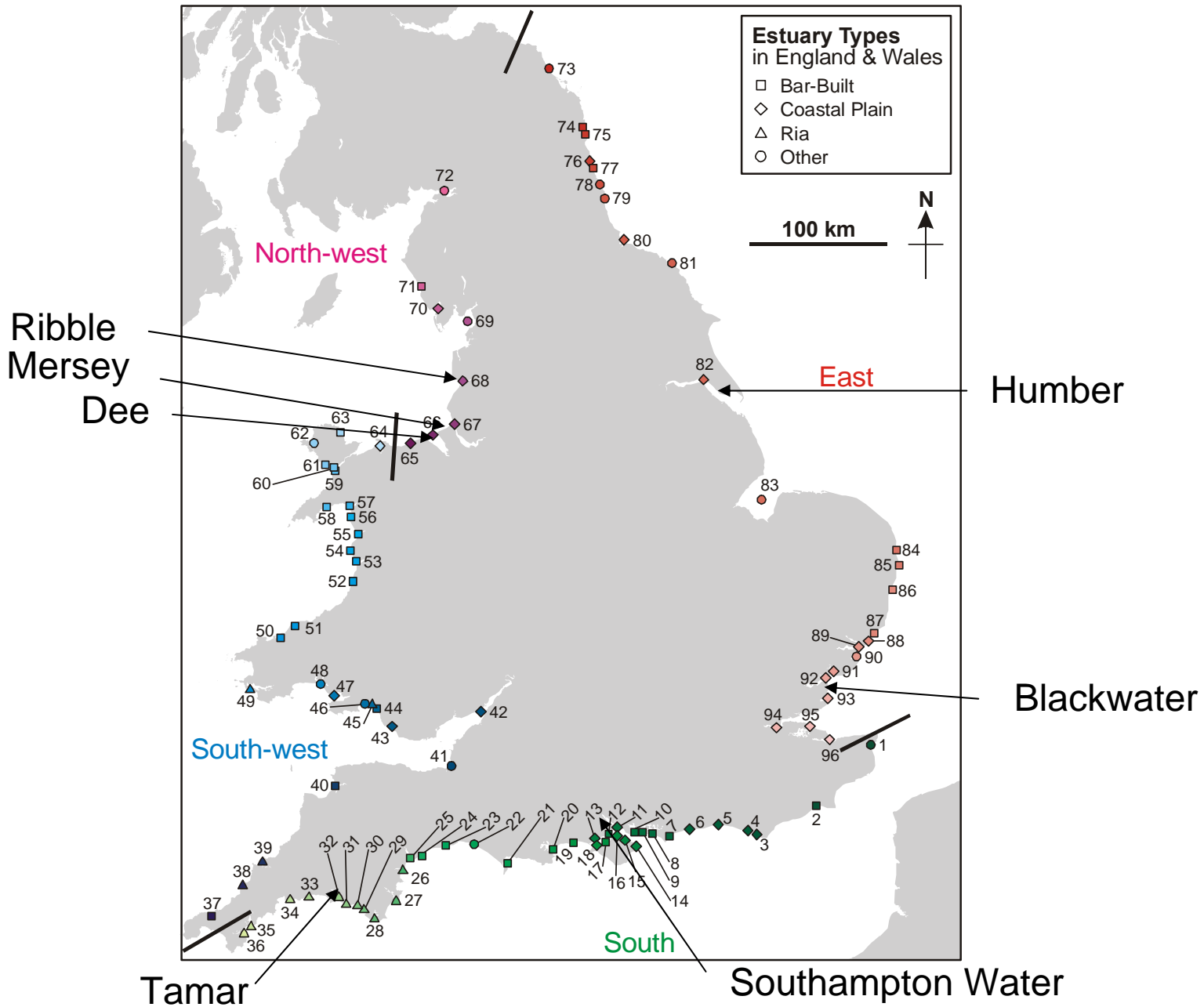
Realignment; described by Richard Soulsby

Inverse; described by Dominic Reeve

Thames and other models: Jez Spearman

<i>Model</i>	<i>Type</i>	<i>Thames</i>	<i>Blackwater</i>	<i>Humber</i>	<i>Mersey</i>	<i>Dee</i>	<i>Ribble</i>	<i>S'ton Water</i>	<i>Tamar</i>
<i>Emulator</i>	Hybrid	Y	Y	Y	Y	Y	Y	Y	Y
<i>TE2100</i>	Trend	Y							
<i>Regime-Shell</i>	T-D	Y	Y	Y	Y			Y	
<i>“2.5D”</i>	B-U				Y	Y	Y		
<i>ASMITA-type</i>	Hybrid	Y							
<i>Sandtrack</i>	Hybrid	Y							
<i>Realignment</i>	process		Tollesbury						
<i>Inverse</i>	Hybrid			Y					





# Estuary Properties

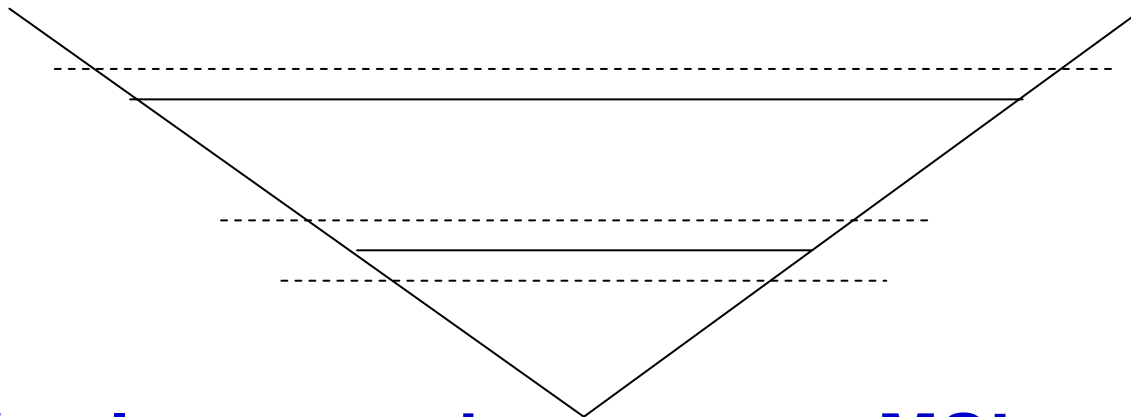
<i>Properties (Future-Coast + ...)</i>	<i>Thames</i>	<i>Black-water</i>	<i>Humber</i>	<i>Mersey</i>	<i>Dee</i>	<i>Ribble</i>	<i>S'ton Water</i>	<i>Tamar</i>
<i>Spring tidal range (m)</i>	5.3	4.6	6.0	8.9	7.6	7.9	4.0	4.7
<i>Mean river flow (m<sup>3</sup>/s)</i>	66	3.8	234	67.1	31.2	33.3	18.1	27
<i>Length (km)</i>	100	21.2	144.7	45.6	37.0	28.4	20.2	34.1
<i>HW Area (km<sup>2</sup> Emulator)</i>	193	46.1	618	194	99	119	38.6	37.7
<i>Intertidal Area (km<sup>2</sup>)</i>	52	27.8	455	118	43	107	13.8	18
<i>Marsh Area (km<sup>2</sup>)</i>	2.1	11.0	14.2	8.5	21	22	3.6	3.6



# Emulator – basic comparator

- No morphological change except

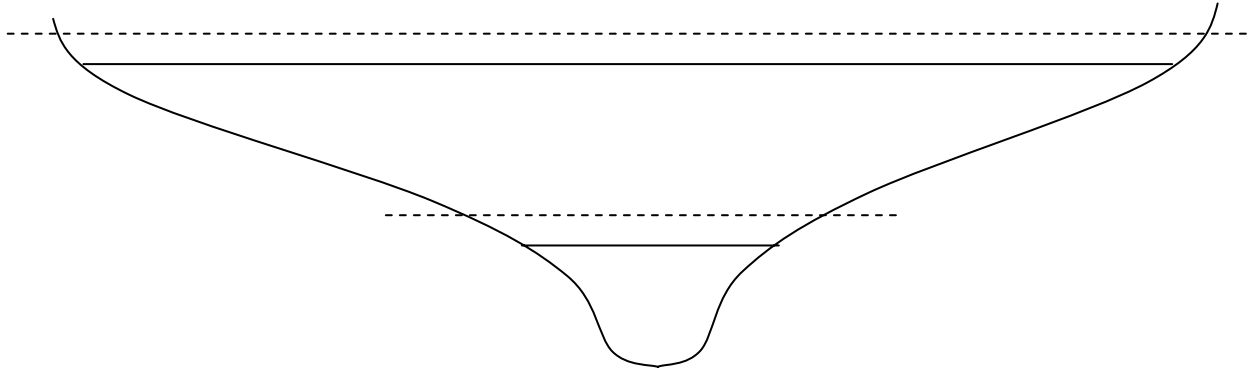
$$\text{Depth} \sim (\text{river flow})^{0.4}$$



**LW, HW volumes and areas  $\uparrow$  as MSL  $\uparrow$**   
**Intertidal area unchanged, because fixed slope**  
**but  $\sim$  tidal range**



# “Convexity”

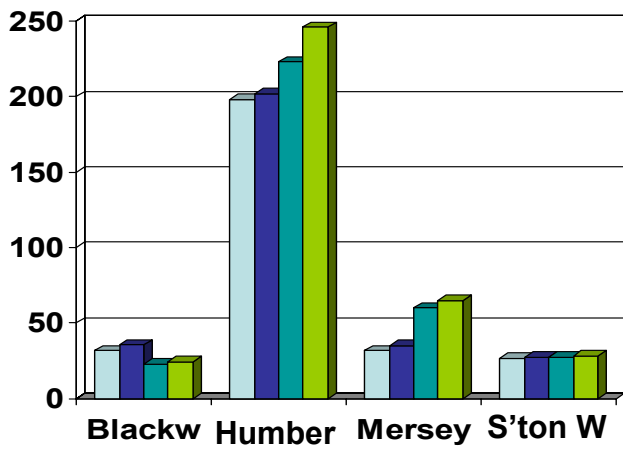


- **Maybe less sensitive LW, HW area, volume**
- **Tendency for intertidal area loss**

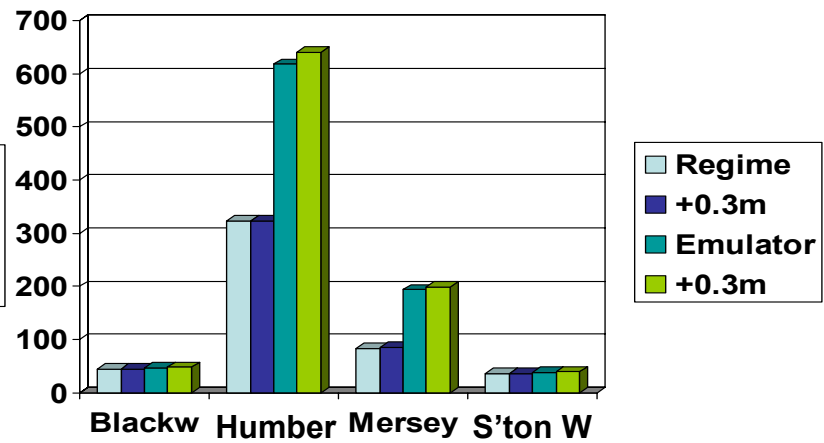
**Analytical Emulator difficulty representing intertidal consistent with high and low water areas.**

**Regime-Shell overcomes these limitations.**





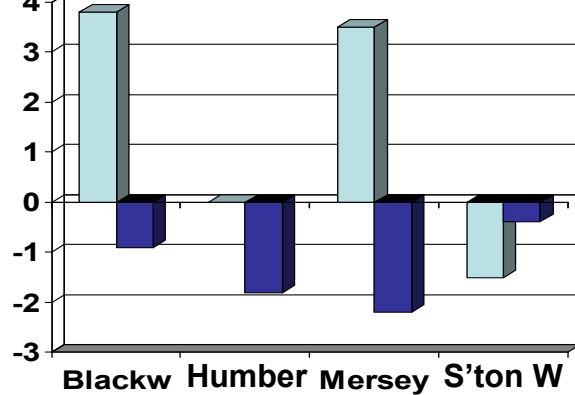
**LW area**



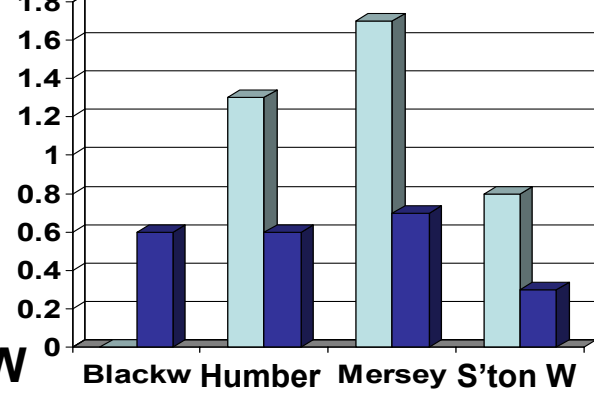
**HW area**

- LW volumes and areas invariably increase for raised MSL.
- HW volumes and areas generally increase, but less so (Blackwater HW area unchanged in Regime-Shell model).
- Inter-tidal area decreases (especially Blackwater).
- Regime-Shell results do not suggest infill keeping pace with sea-level rise, except for the Mersey.

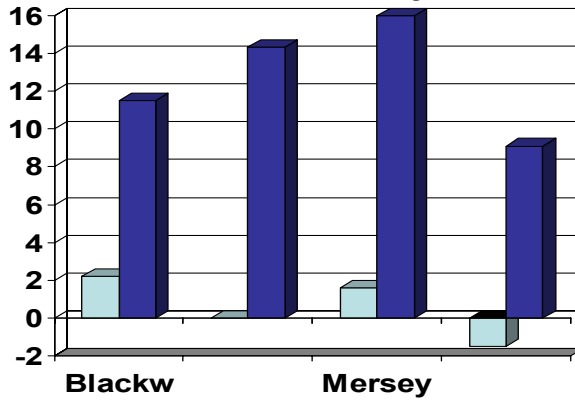




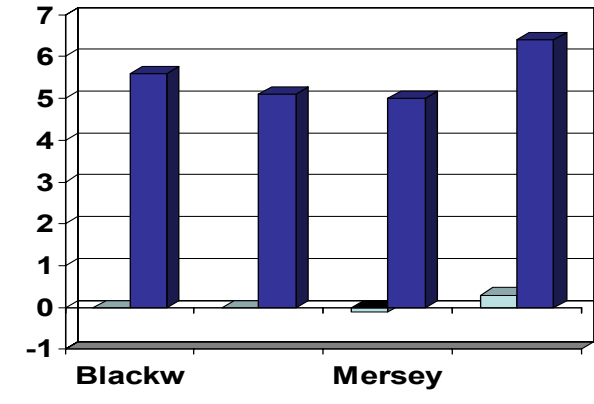
**Tide +2%**  
 % change LW Area



Regime  
Emulator



**River +20%**



Regime  
Emulator

- **Realistic changes in tidal range (e.g. +2%)**

- Likely effects of are relatively modest.

- **20% increase in river flow**

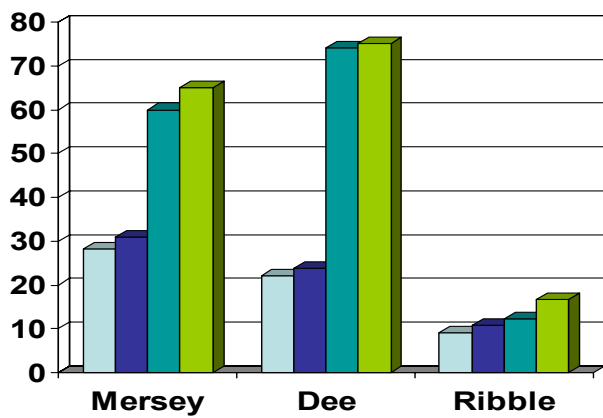
- small changes in LW and HW areas and volumes

- Mersey and sensitive Blackwater lose inter-tidal

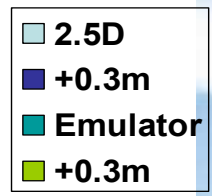
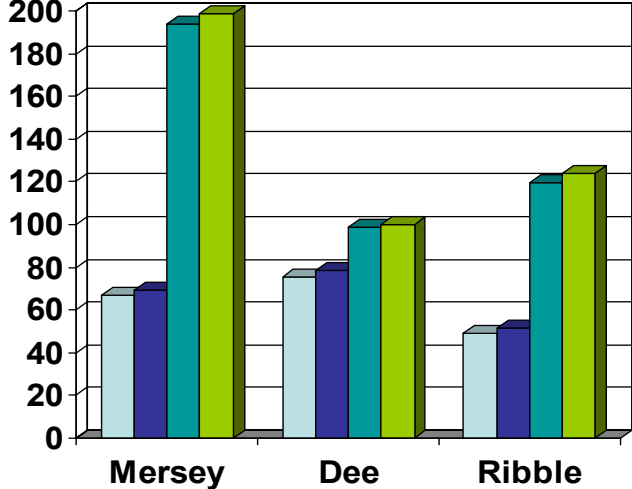
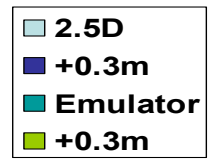
- Emulator is sensitive



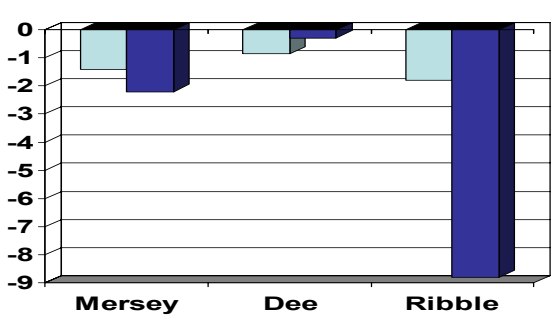
# Emulator and "2.5-D" model:



LW HW  
Area, km<sup>2</sup>



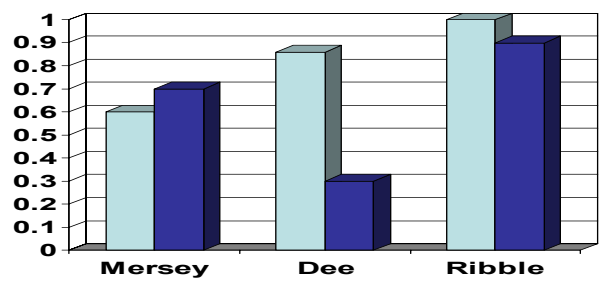
## Discrepant representations but changes similar for raised MSL



Tide + 2%:  
% change

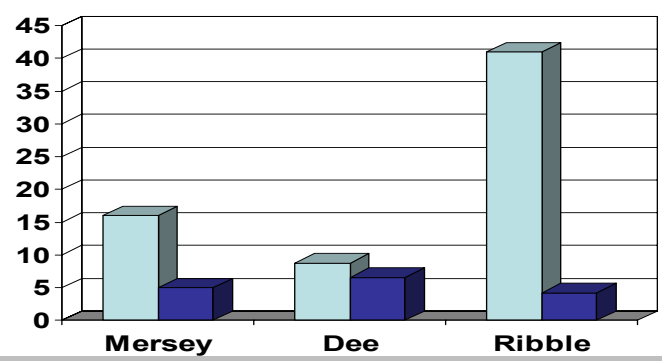


LW Area HW



## Emulator LW area is small so sensitive to lower LW, river flow

River flow + 20%:  
% change of area  
(Emulator only)



# Emulator-estimated in-fill times

149-765 years

	<i>Thames</i>	<i>Blackwater</i>	<i>Humber</i>	<i>Mersey</i>	<i>Dee</i>	<i>Ribble</i>	<i>S'ton Water</i>	<i>Tamar</i>
<i>flushing time, days</i>	7	9	6.3	7.5	21.3	4.7	14.9	11.5
<i>mean SPM, mg/l</i>	127	69	112	164	214	125	77	74
<i>in-fill time, years</i>	218	516	223	182	395	149	765	619

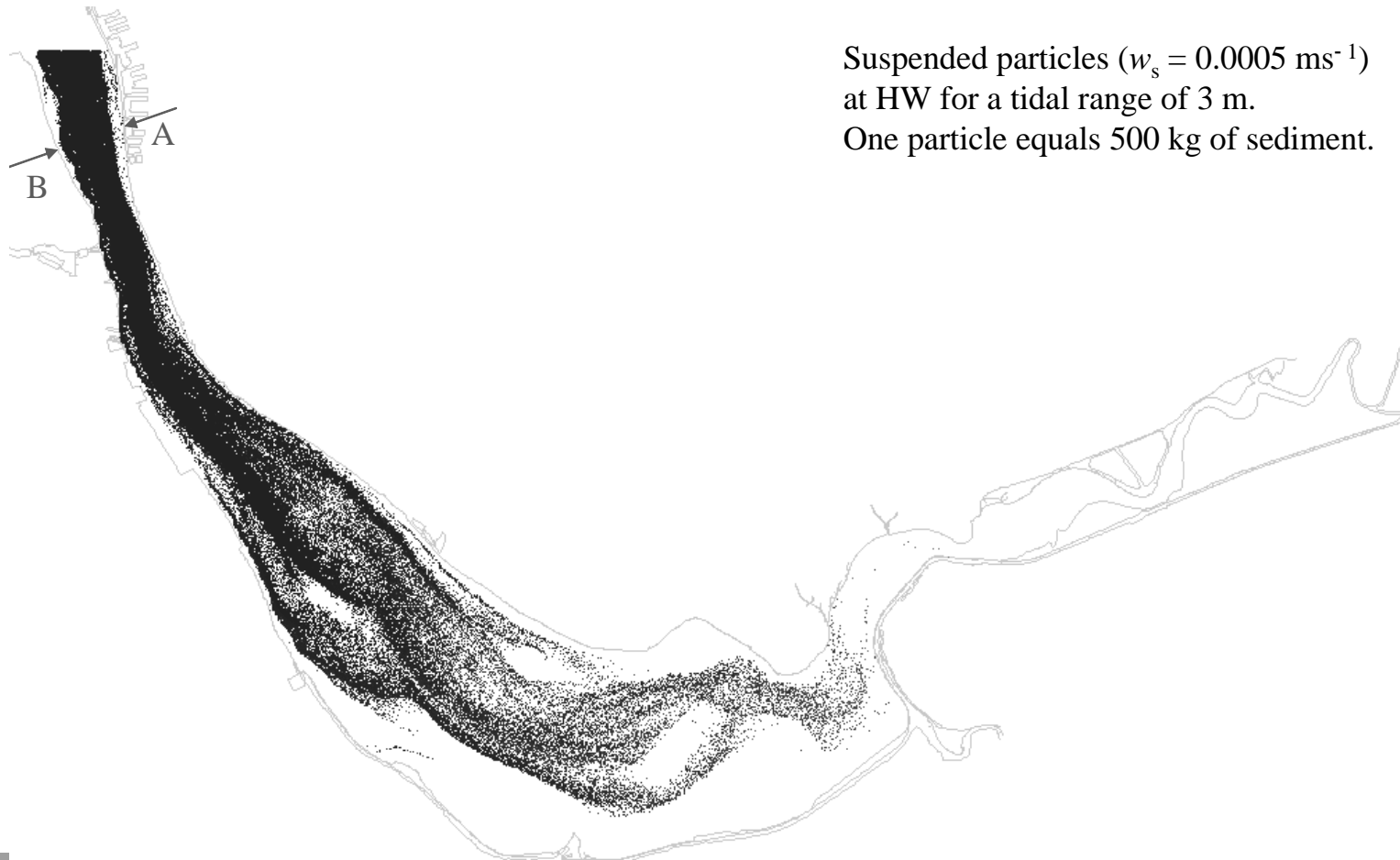
Most  $\leq$  time scale for volume change with MSL

Just implies enough sediment, not actual infill  
- Role of dynamics!

(Time scales not correlated with size)



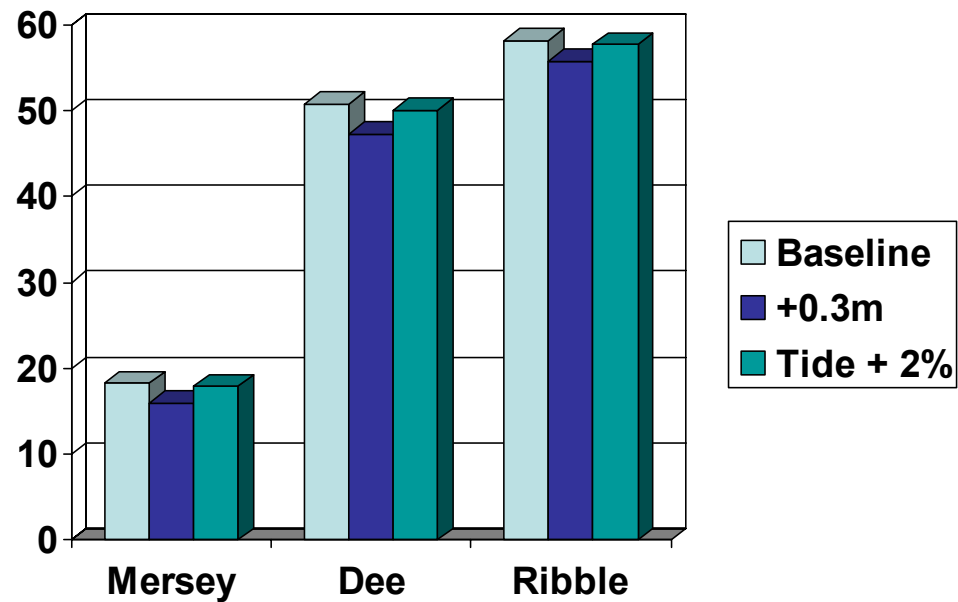
**2-D and 3-D particle-tracking models can represent LW and HW areas and volumes; resolution is only limit.  
They predict sediment transport and deposition.  
They have to repeat flow model runs as bathymetry evolves (computing cost).**



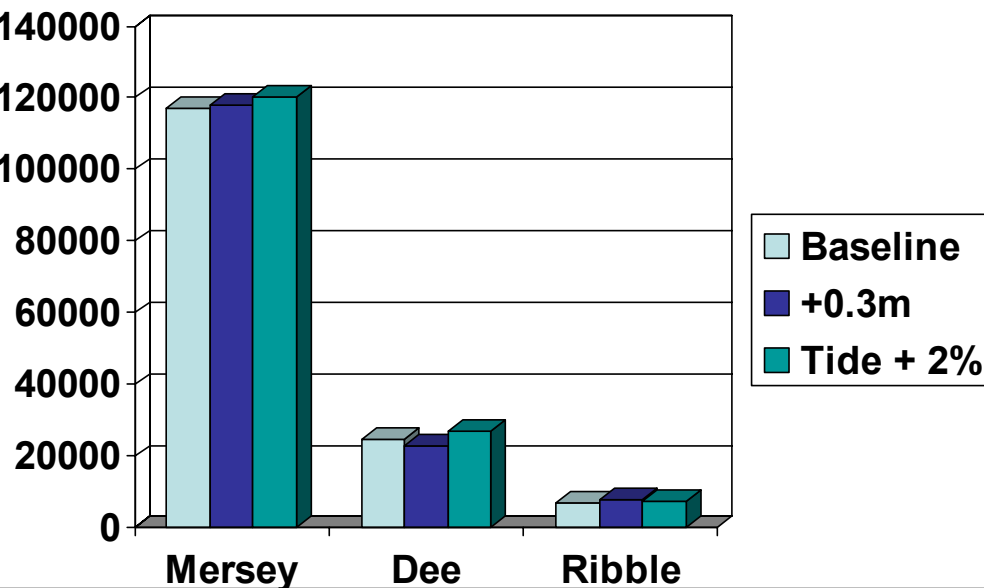
Suspended particles ( $w_s = 0.0005 \text{ ms}^{-1}$ )  
at HW for a tidal range of 3 m.  
One particle equals 500 kg of sediment.



# “2.5-D” model (continued)

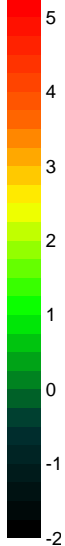
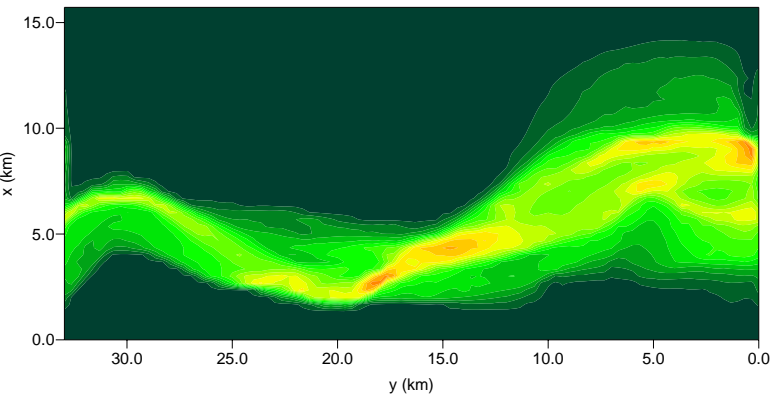


“2.5-D” salt-marsh area  
↓ for MSL ↑, tide ↑  
(concave profile)



SPM “in” (tonnes/tide)  
↑ for tide ↑  
variable ↔ MSL

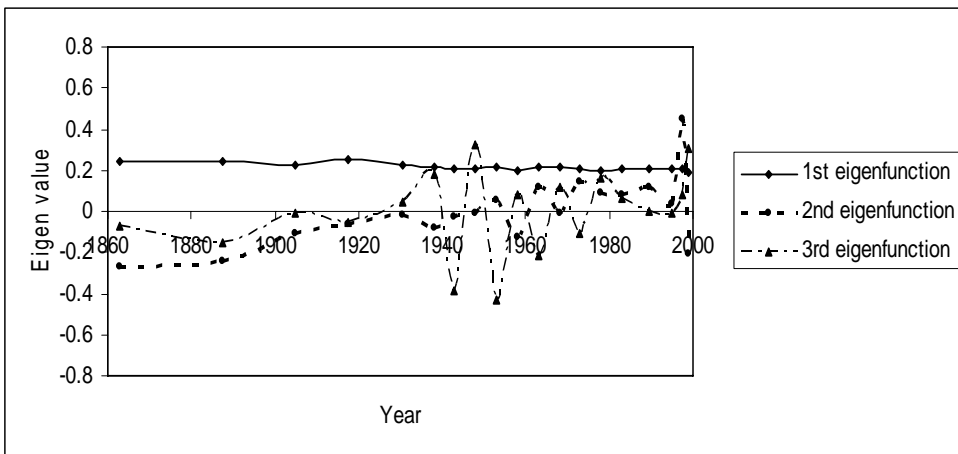




- Trend analysis can guide predications if applied within the range of experience.

- Inverse model uses previous changes, with reference to dynamics (bed-evolution equation)

**92% of Inverse model “source function” (with 1<sup>st</sup> time series ↓)**



**Predictions depend on relatively frequent surveys.**



# General Conclusions

- **Best practice: validate against historic change**
  - some confidence that model predicts key processes
  - Needs validation data!
- **Otherwise, generate ensemble of possible outcomes**
- **Need care interpreting results from any one model**
  - limitations of routines updating bed-morphology
  - inherent unpredictability
- **Ideally compare model results with alternatives**
  - to help establish the validity
- **Predicted trends should be broadly consistent with results of bottom-up models.**
- **The results show sensitivities of different estuaries to a range of climate change scenarios**
- **Not all estuaries respond in the same manner!**

