

Tides and the banks of the Mersey: perspectives on past and future sea levels



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Introduction and aims for today

- Our connection to the sea...what does sea level mean for Liverpool?
- The long-term perspective
 - Measuring sea level
 - Reconstructing past sea-level change from sediment records in the Mersey lowlands
- What challenges does sea-level rise bring and how might we address these?

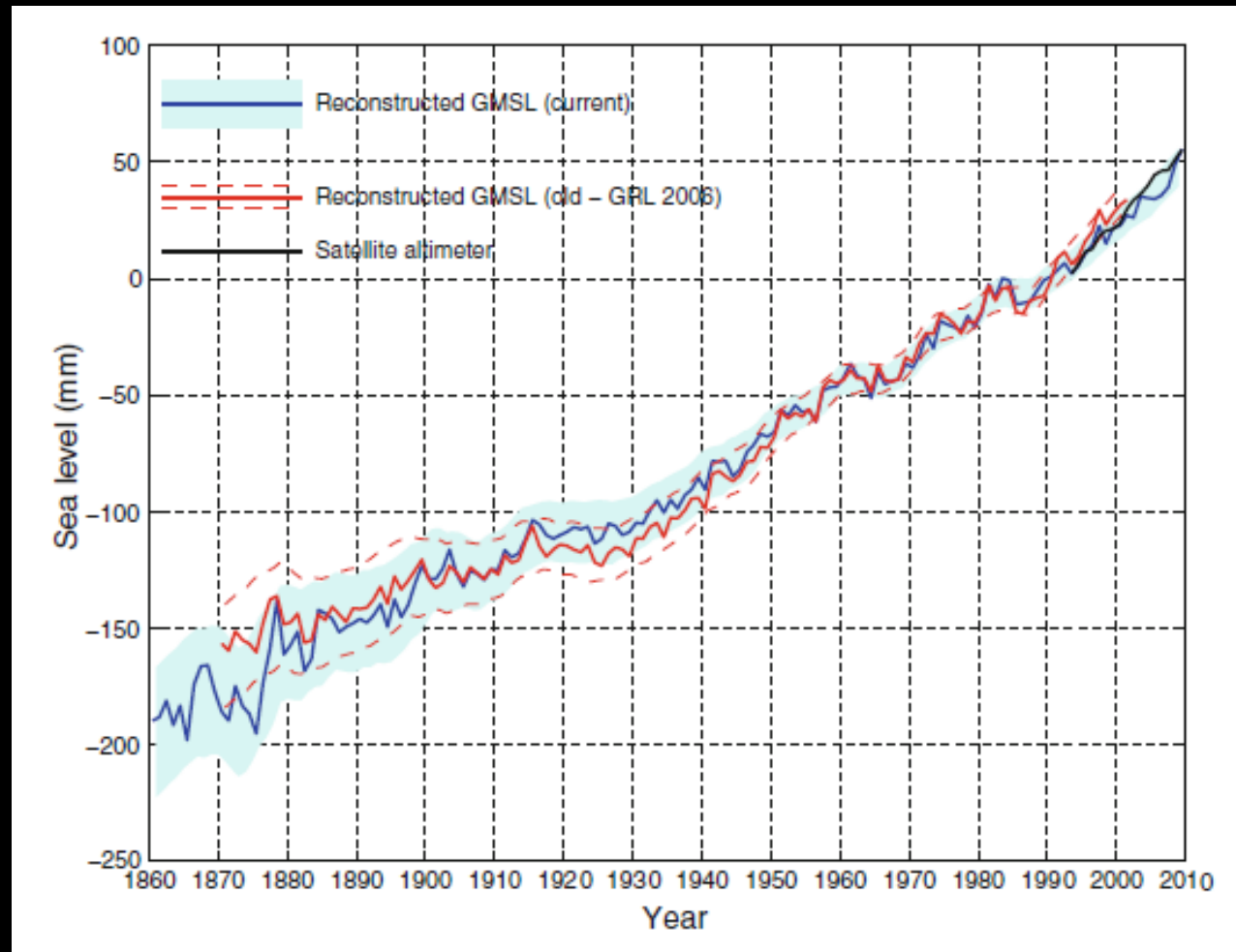
Measuring sea level with tide gauges

Tide gauge record

~1860 onwards

Total amount 210 mm

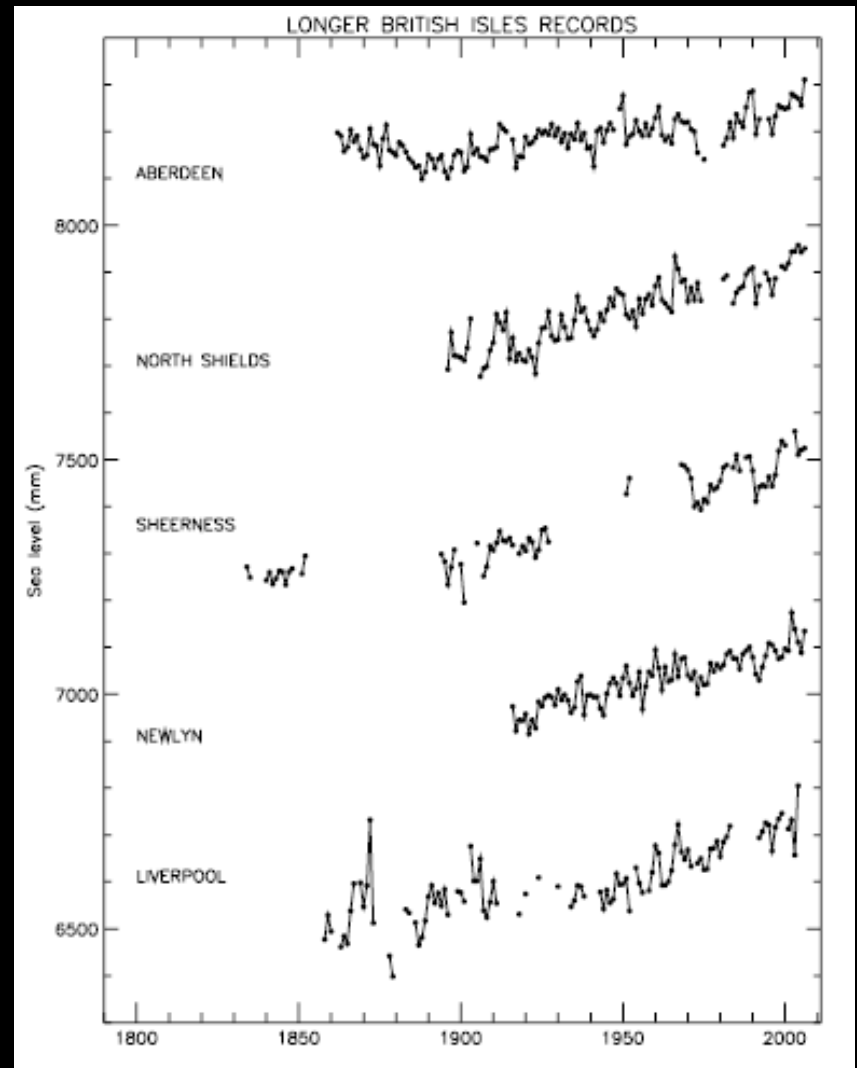
Mean rate 1.7mm/yr



Church & White (2011)

Liverpool's contribution...

One of the longest tide gauge records in the world

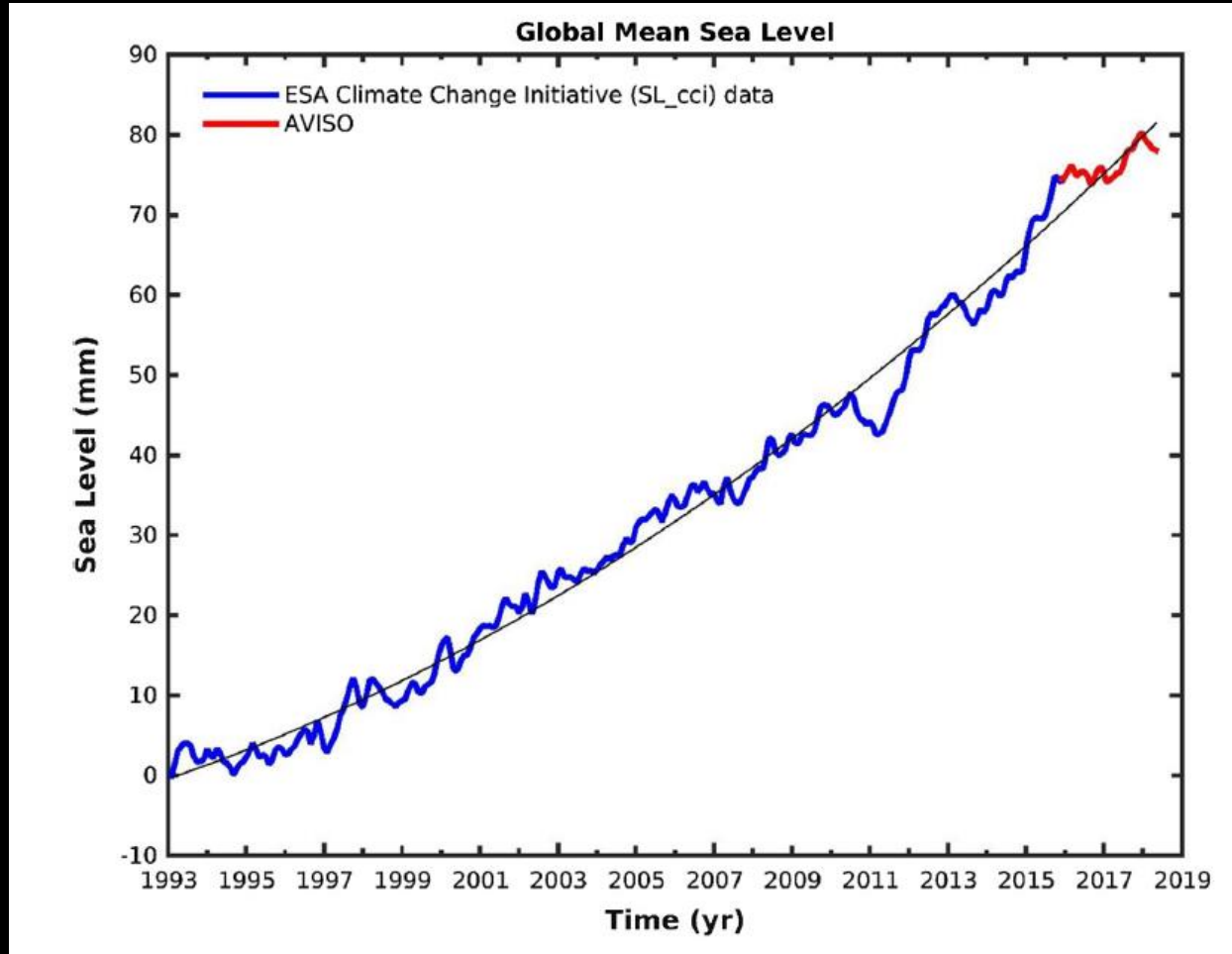


Measuring sea level with satellites

Satellite altimetry

1993 onwards

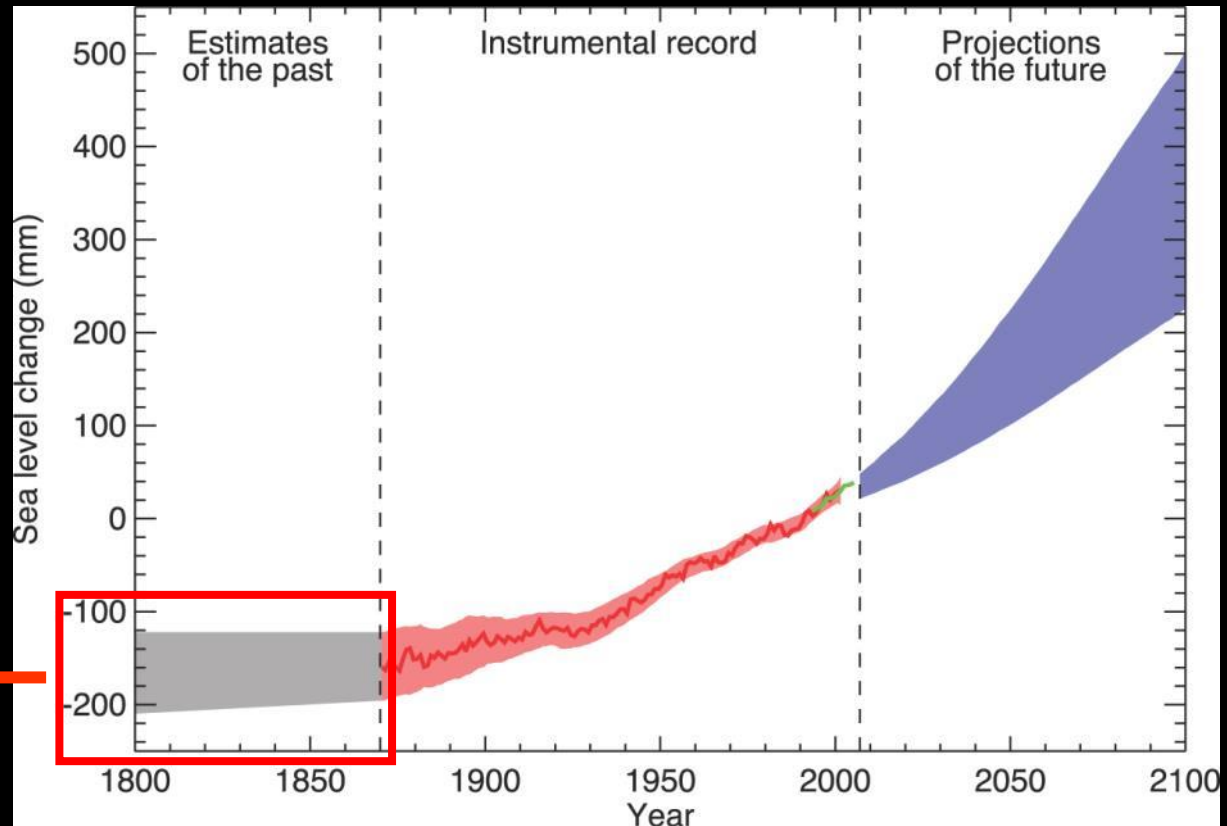
Mean rate 3 mm/yr



Key Questions?

How much has sea level changed in the past?

Is the current rate of sea-level rise unusual?

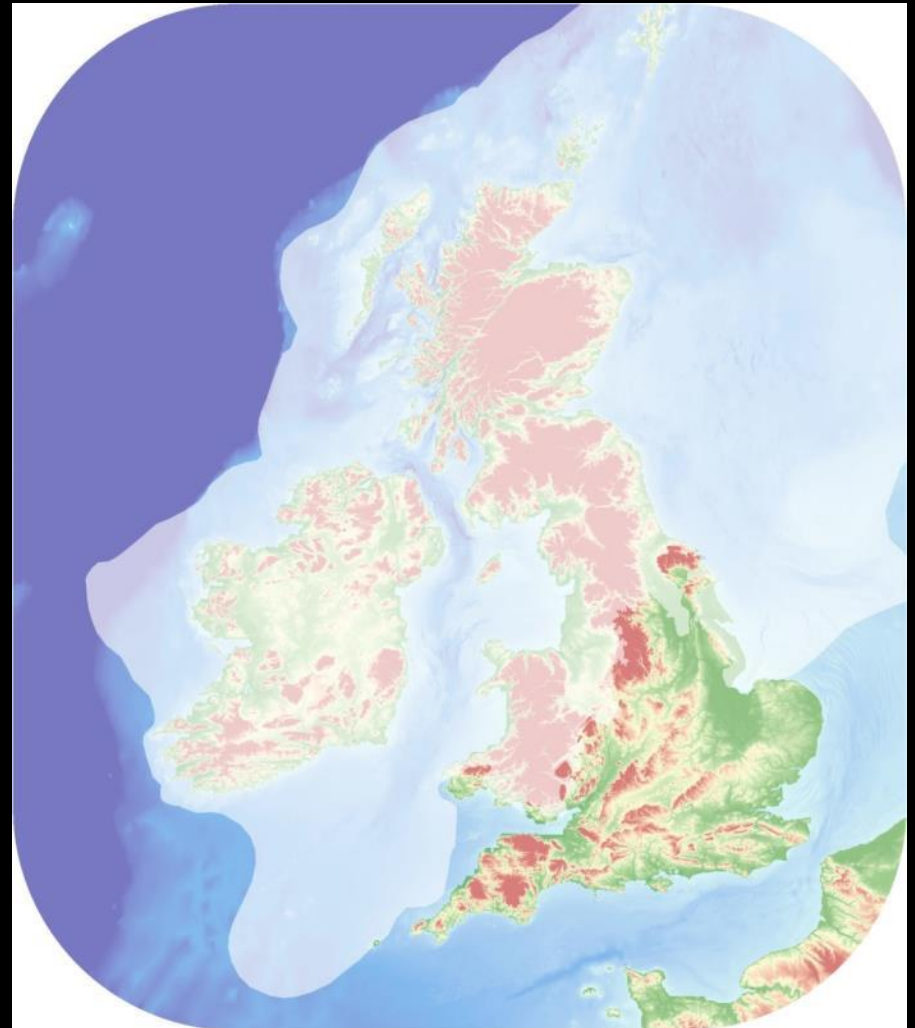


IPCC 5th Assessment Report, Chapter 13

<https://archive.ipcc.ch/report/ar5/wg1/>

Maximum extent of the British-Irish Ice Sheet 24,000 years ago

Liverpool was covered with ice 2-300 m thick



<https://livunigeog.wordpress.com/tag/britice-chrono/>

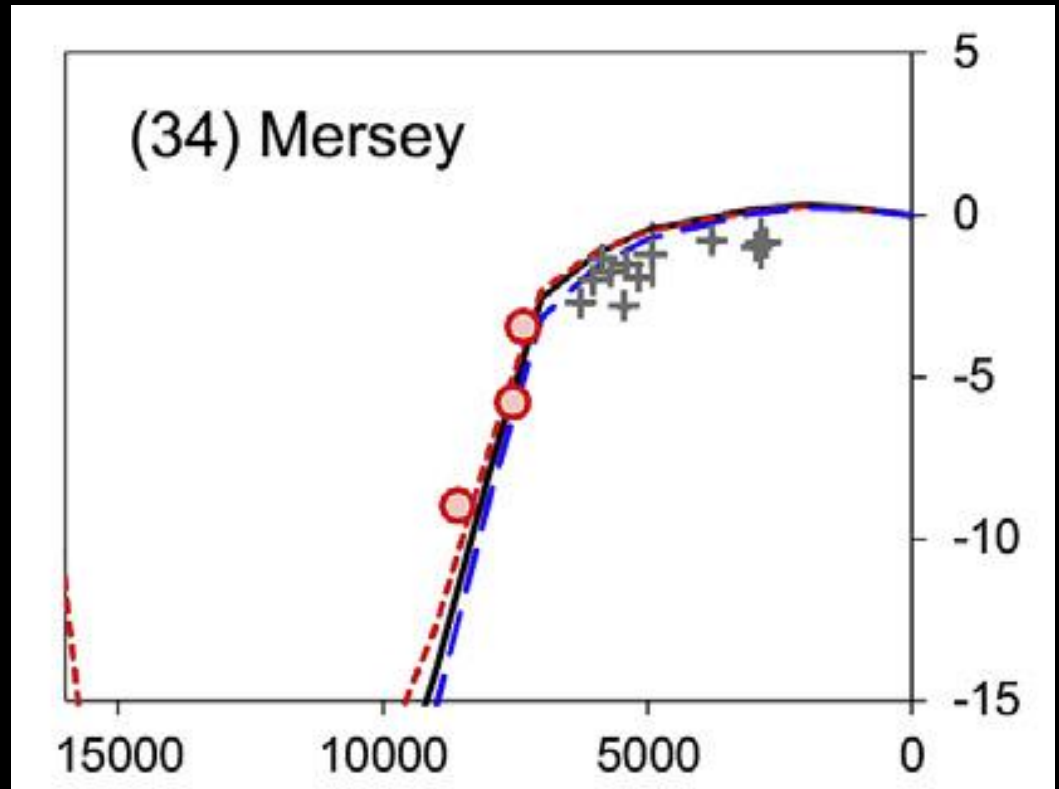
<https://www.sheffield.ac.uk/news/nr/britice-interactive-ice-sheet-map-1.784388>

Long-term sea-level rise in Liverpool

*Relative sea level has risen by
~15m in the last 10,000 years*

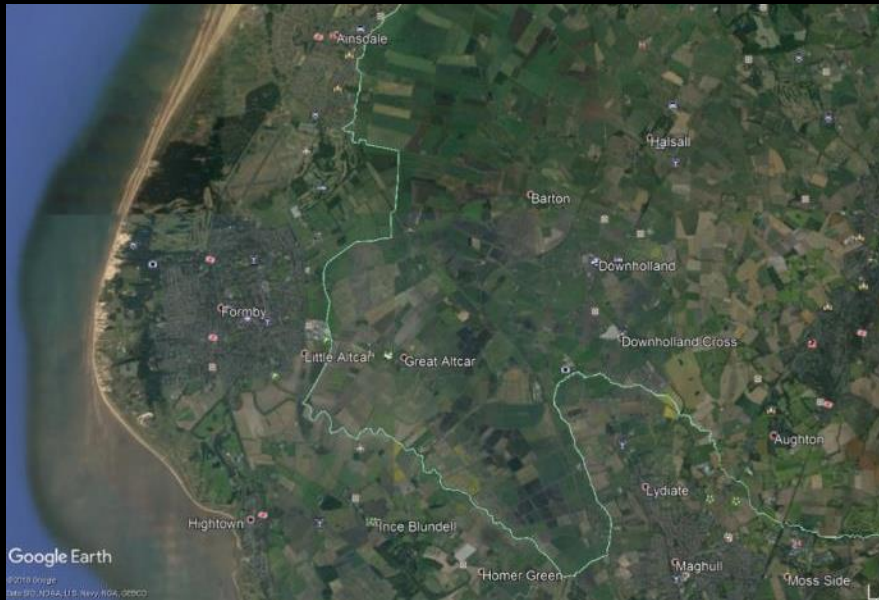
*Melting of ice largely complete
by 6,000 years ago*

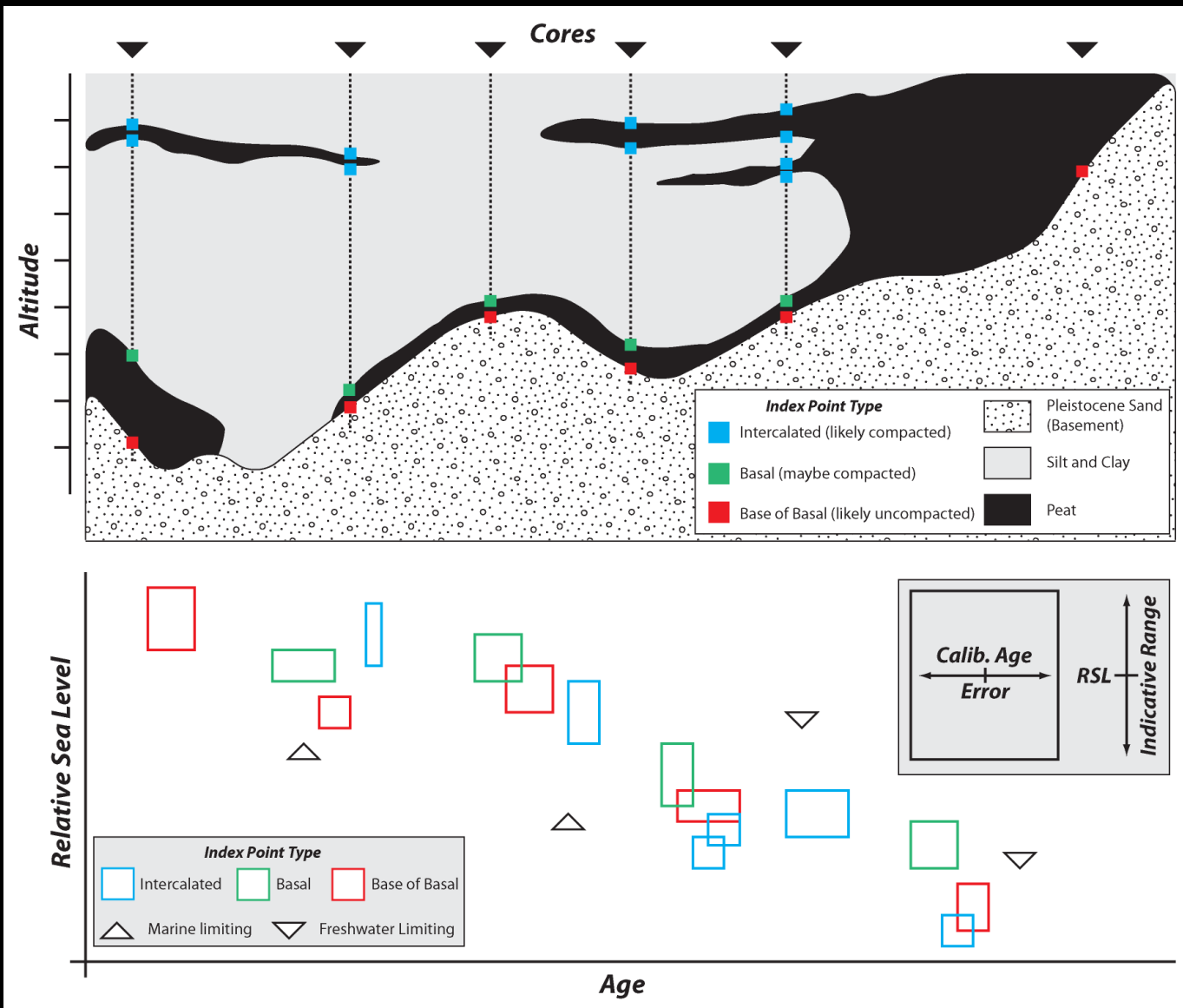
*Where does this information
come from??*



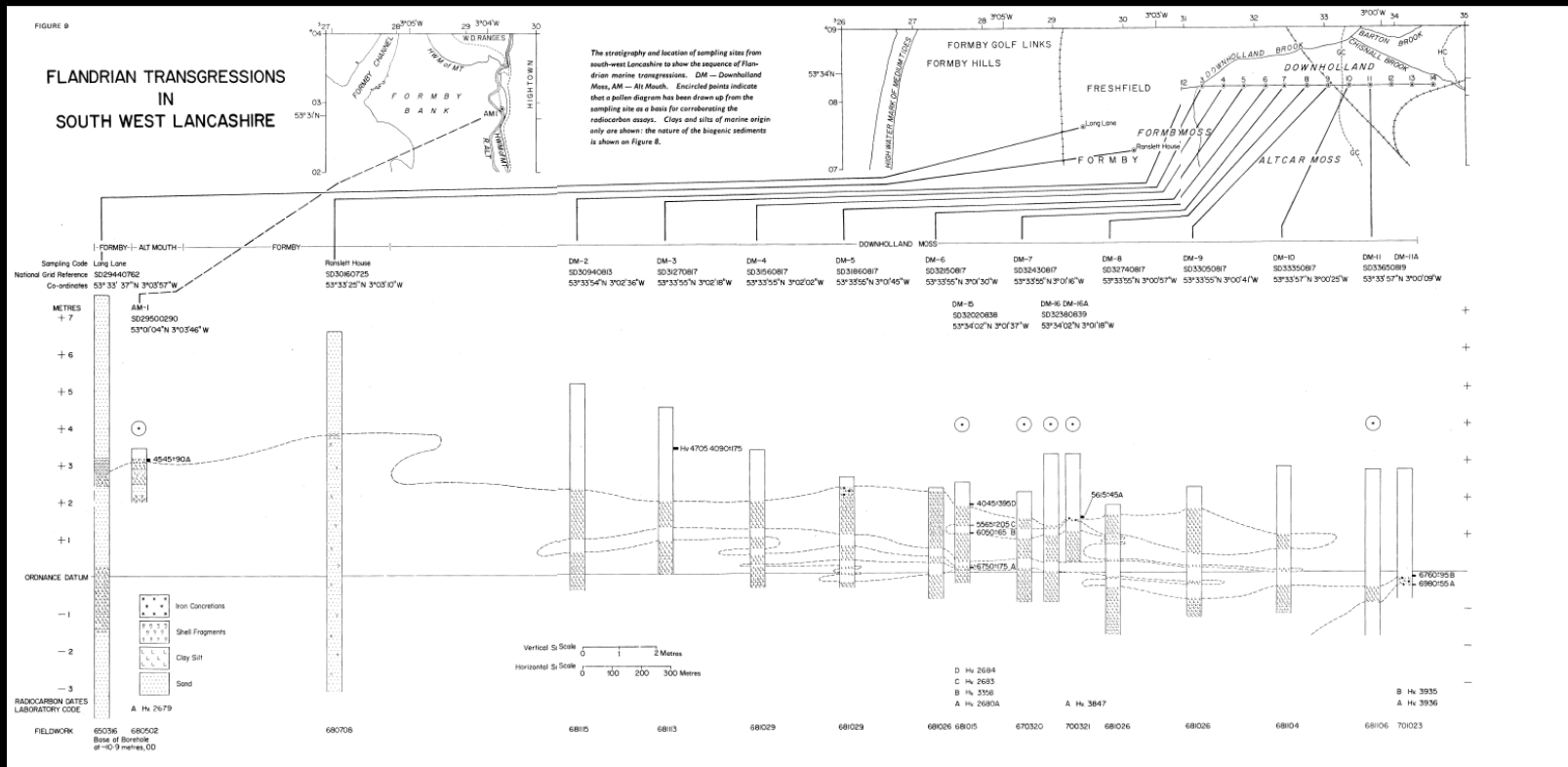
From: Shennan et al. (2018)

Marine sediments buried in Sefton coastal lowlands





Graphic reproduced with kind permission of Dr Andy Kemp

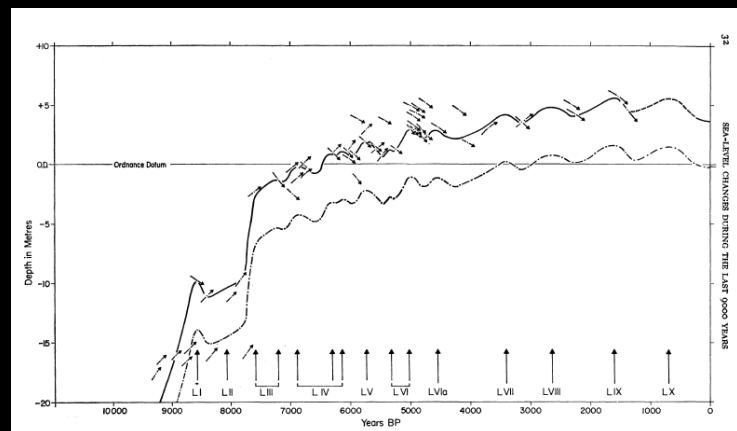


Tooley, M.J., 1974. Sea-level changes during the last 9000 years in northwest England. The Geographical Journal 140, 18-42.

Snapshots in time

Issues with compaction

Data lacking for last 2000 years

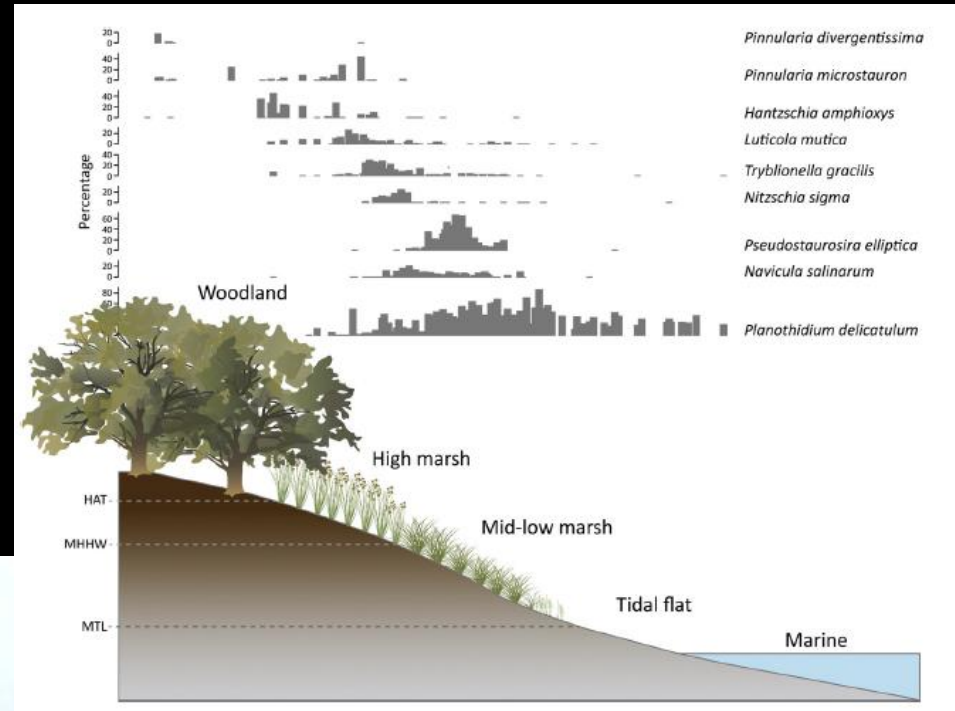


Sea level data from salt-marshes

The present is the key to the past

Improved precision of reconstruction

Sediments span instrumental and geological eras



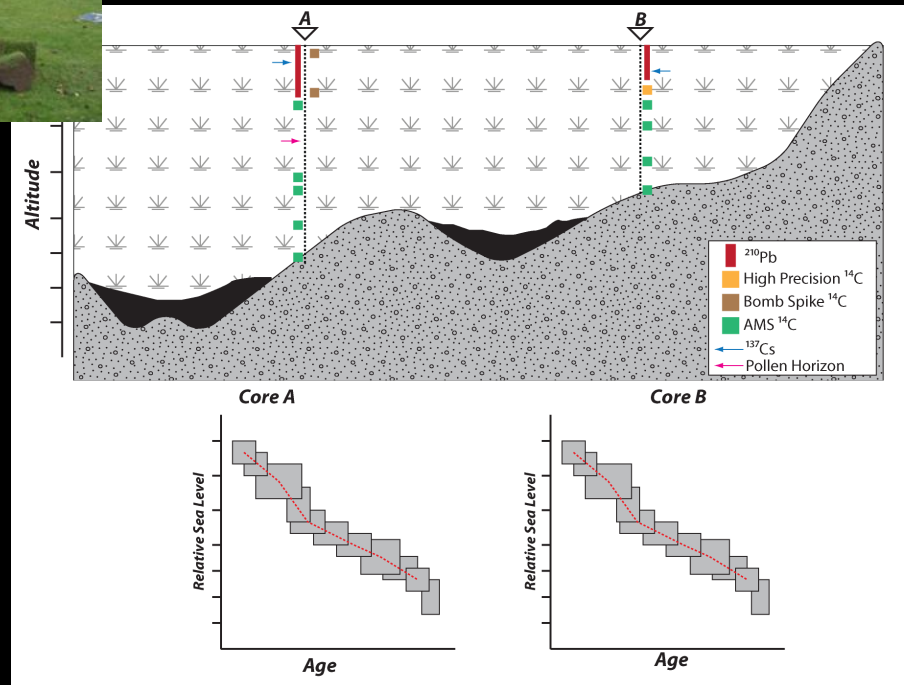
Altitude (m OD)



Distance (m)

Barlow et al. 2013

Salt-marshes in the Mersey



Graphic reproduced with kind permission of Dr Andy Kemp

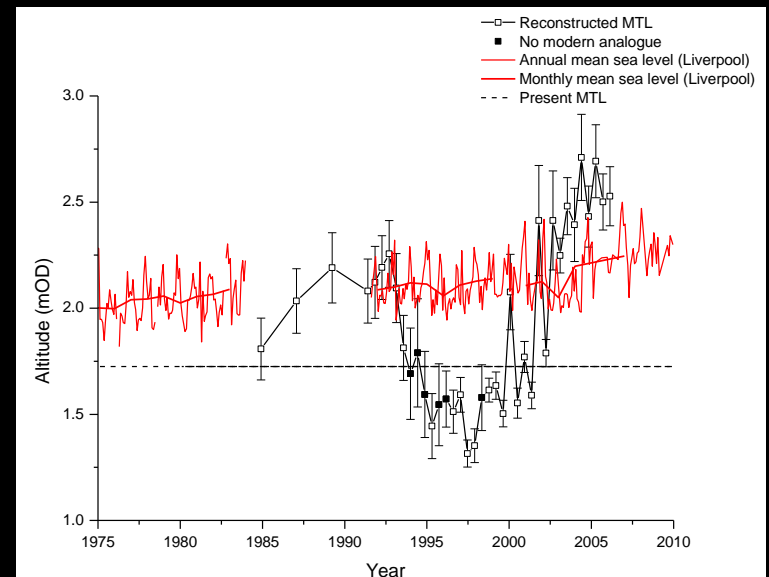
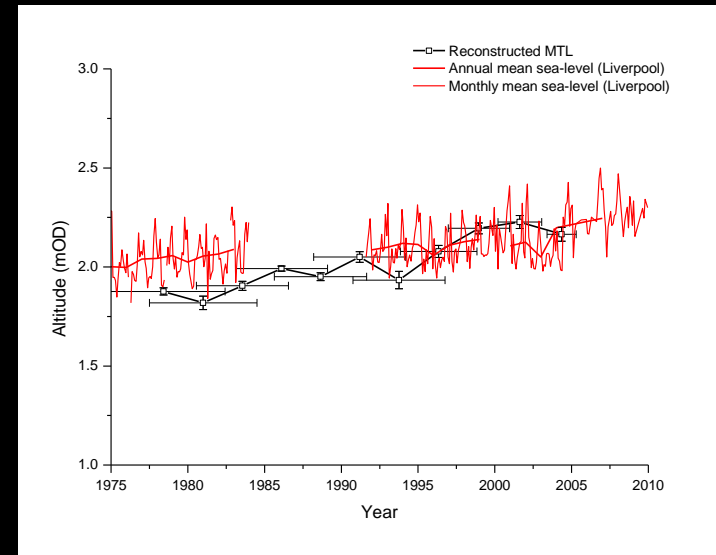
Mersey salt-marsh sea-level record

Mixed success

Heavily modified/human impacted estuary

Morphological changes (e.g. intertidal banks, channel migration) affect signal

Mills (2011)



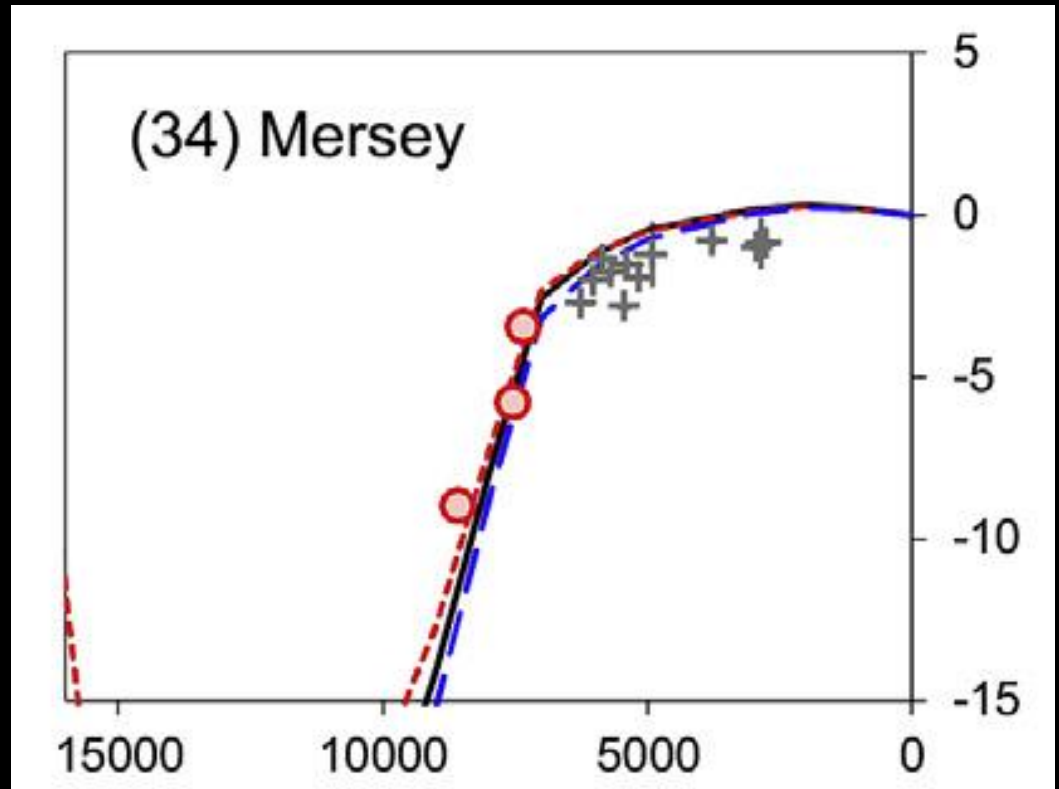
Sea-level rise is not new to Liverpool

However...

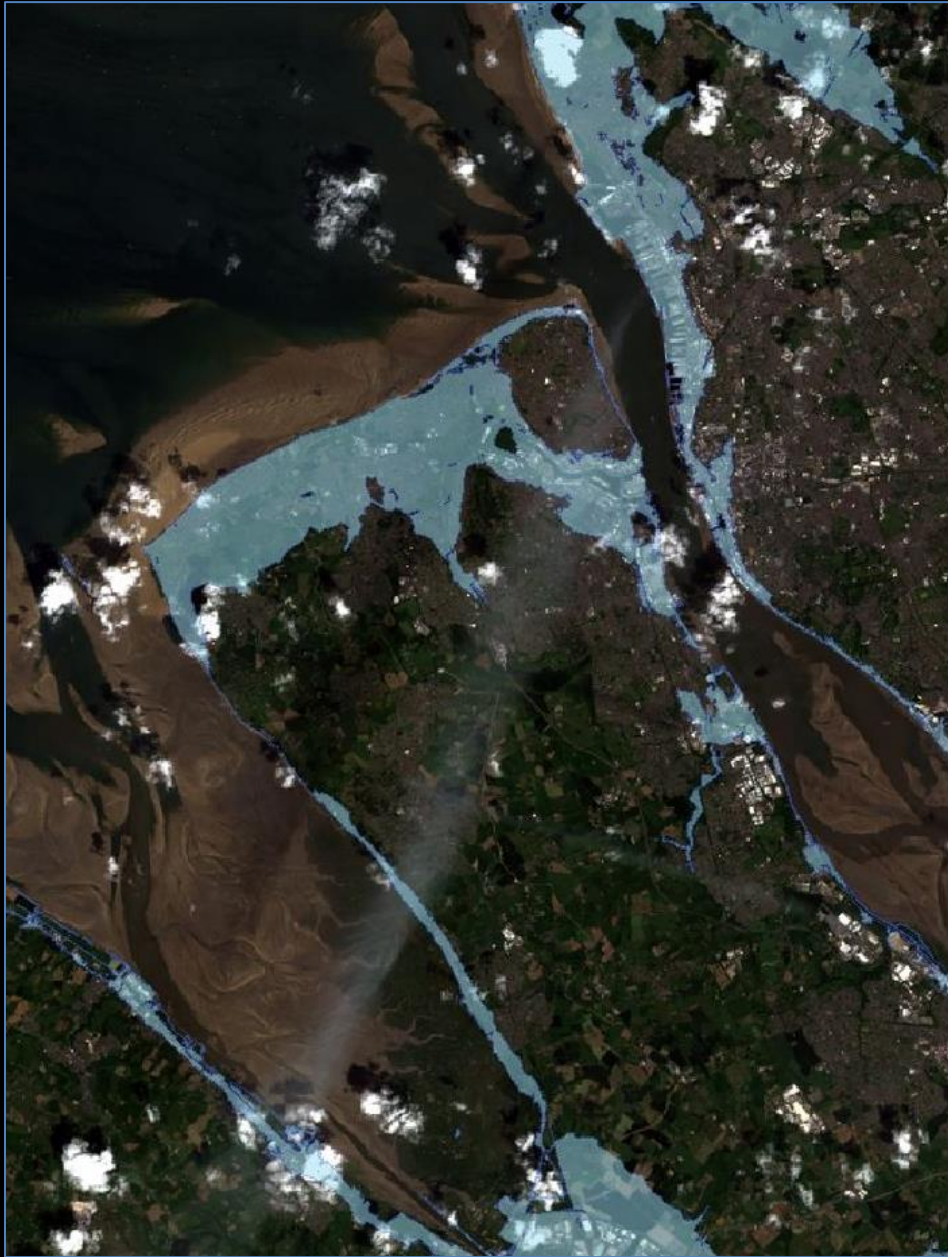
Rates of rise before 6,000 years ago 5-10 mm/yr

Rate of rise after 6,000 years ago <1mm/yr

Contemporary rates have serious implications for coastal population and infrastructure



Shennan et al. (2018)



What does the future hold for Merseyside?

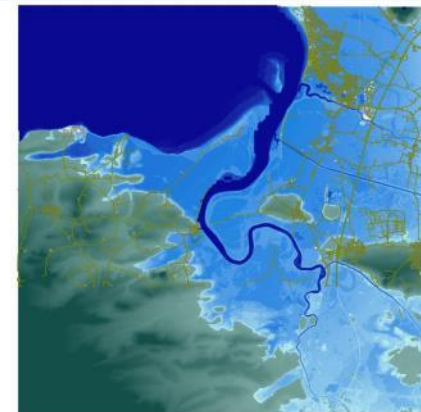
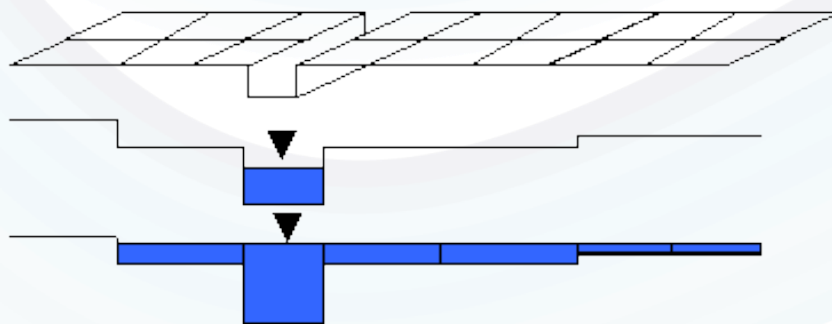
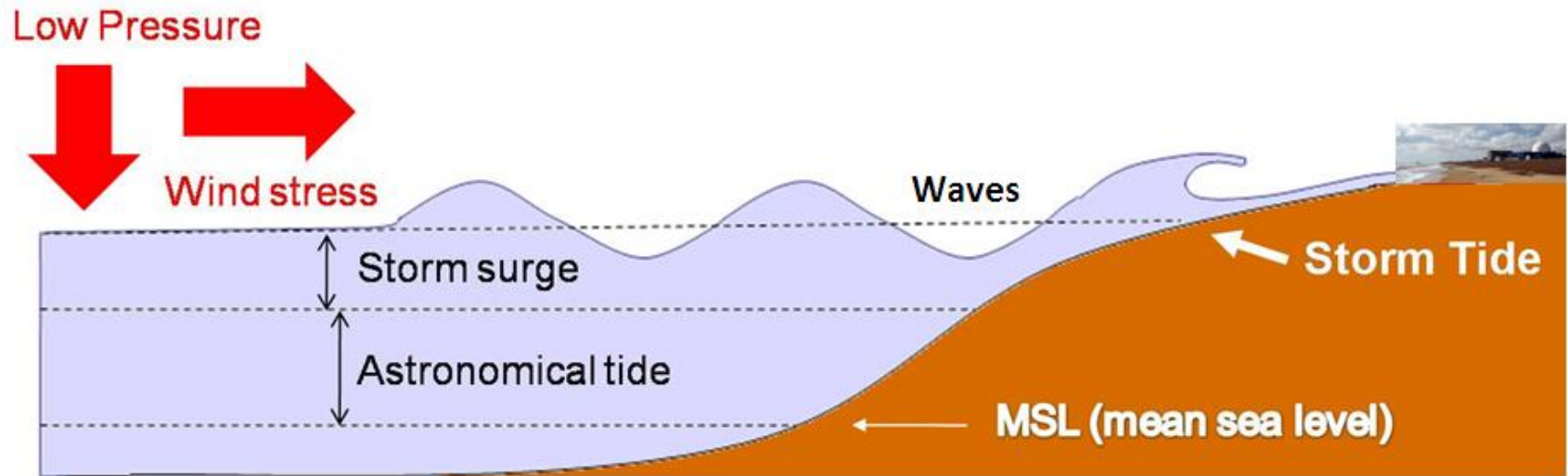
The Last Interglacial

Potential impact of a 7m sea-level rise on Merseyside



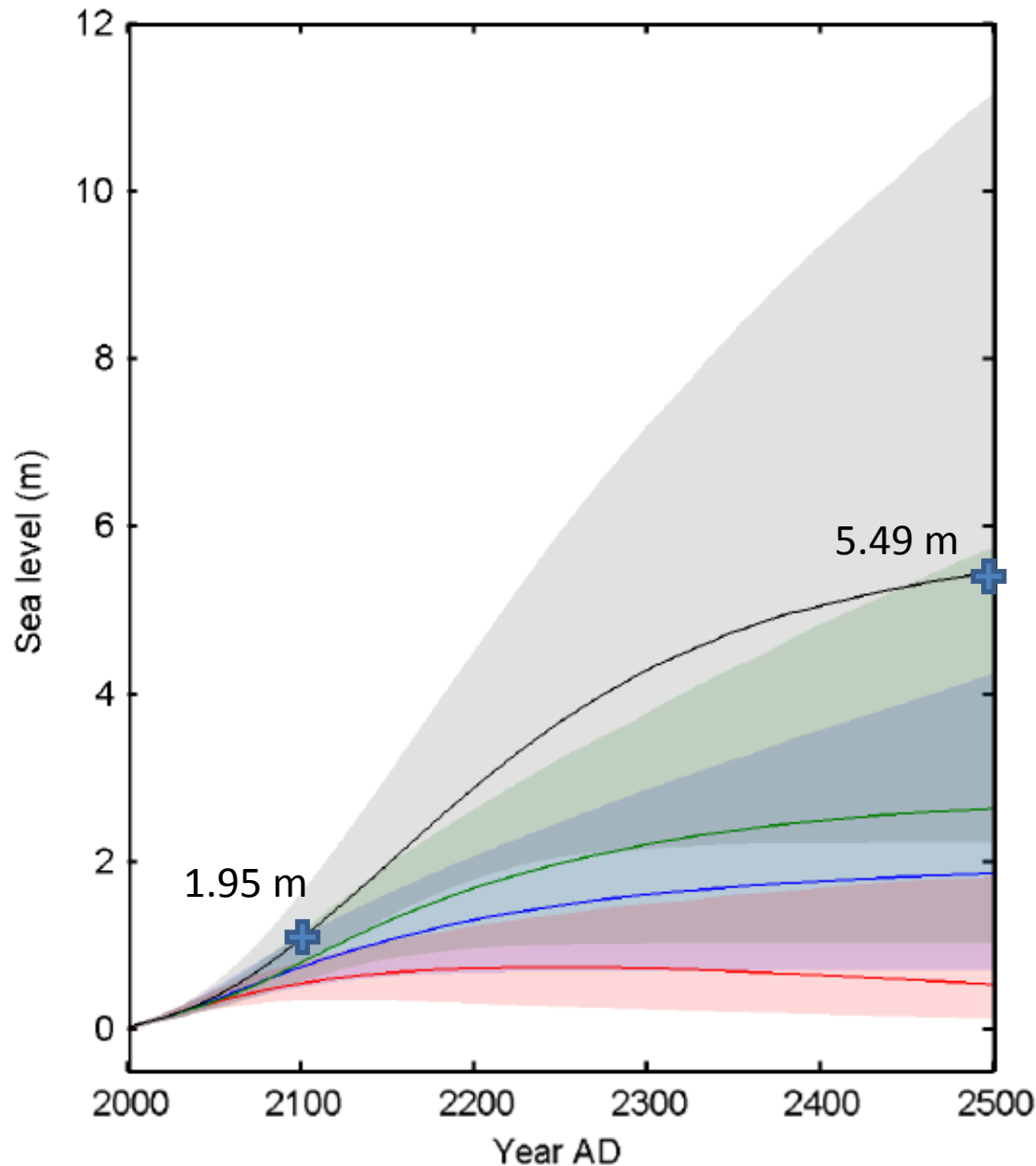
Vulnerable Coastal Infrastructure and Resources





Sea-level Rise: Plausible High-end Projections to 2500 AD

(Jevrejeva et al., 2012)



upper 95% and low 5%
confidence level

RCP8.5

RCP6

RCP4.5

RCP3PD

Providing context: Sea-level Rise Scenarios

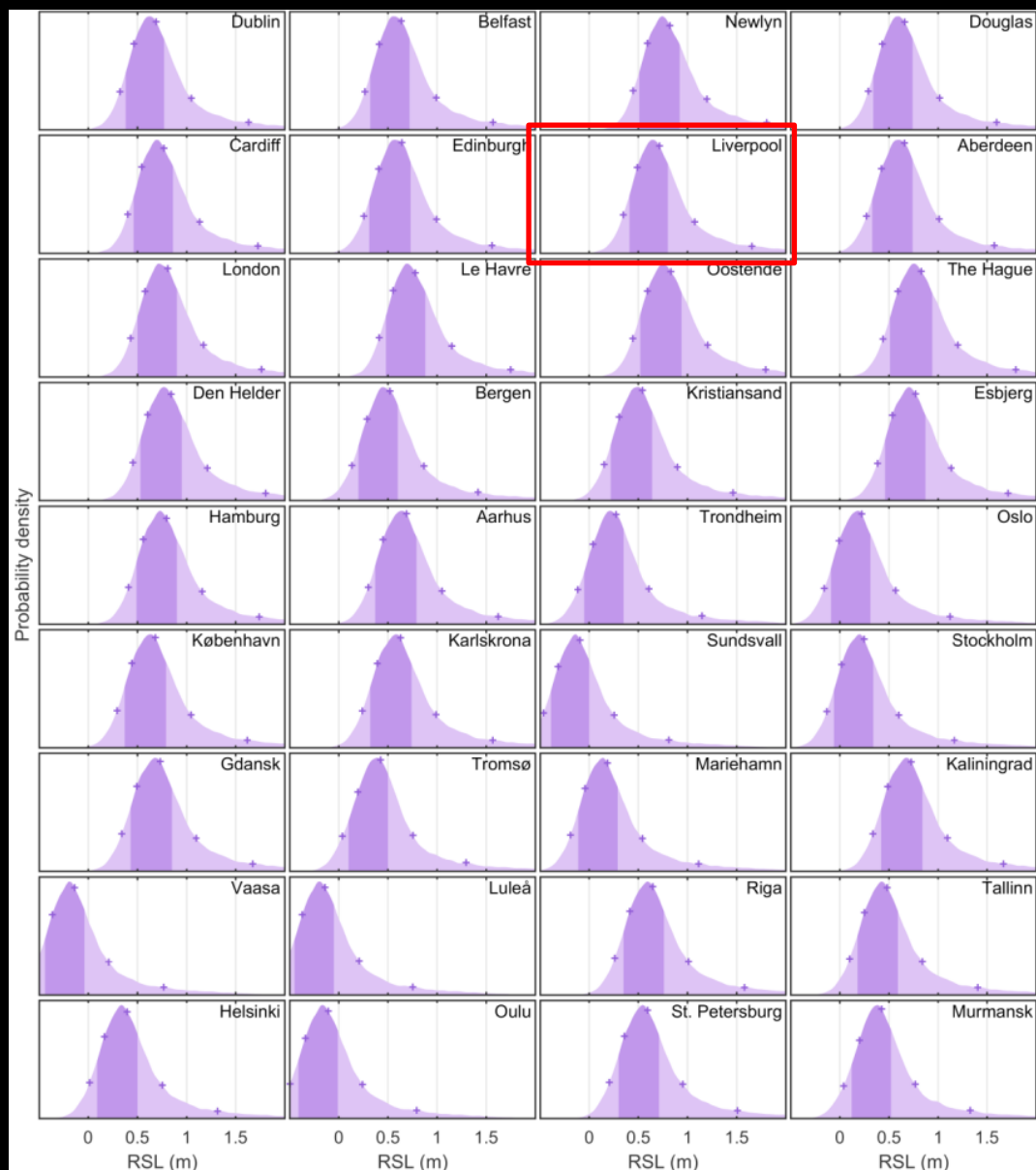
Regional sea level rise projections for cities.

Figure S4:

Projected regional sea level rise over the 21st century and uncertainty distributions for cities in Northern Europe under RCP8.5.

Darker shading: 17-83% range.

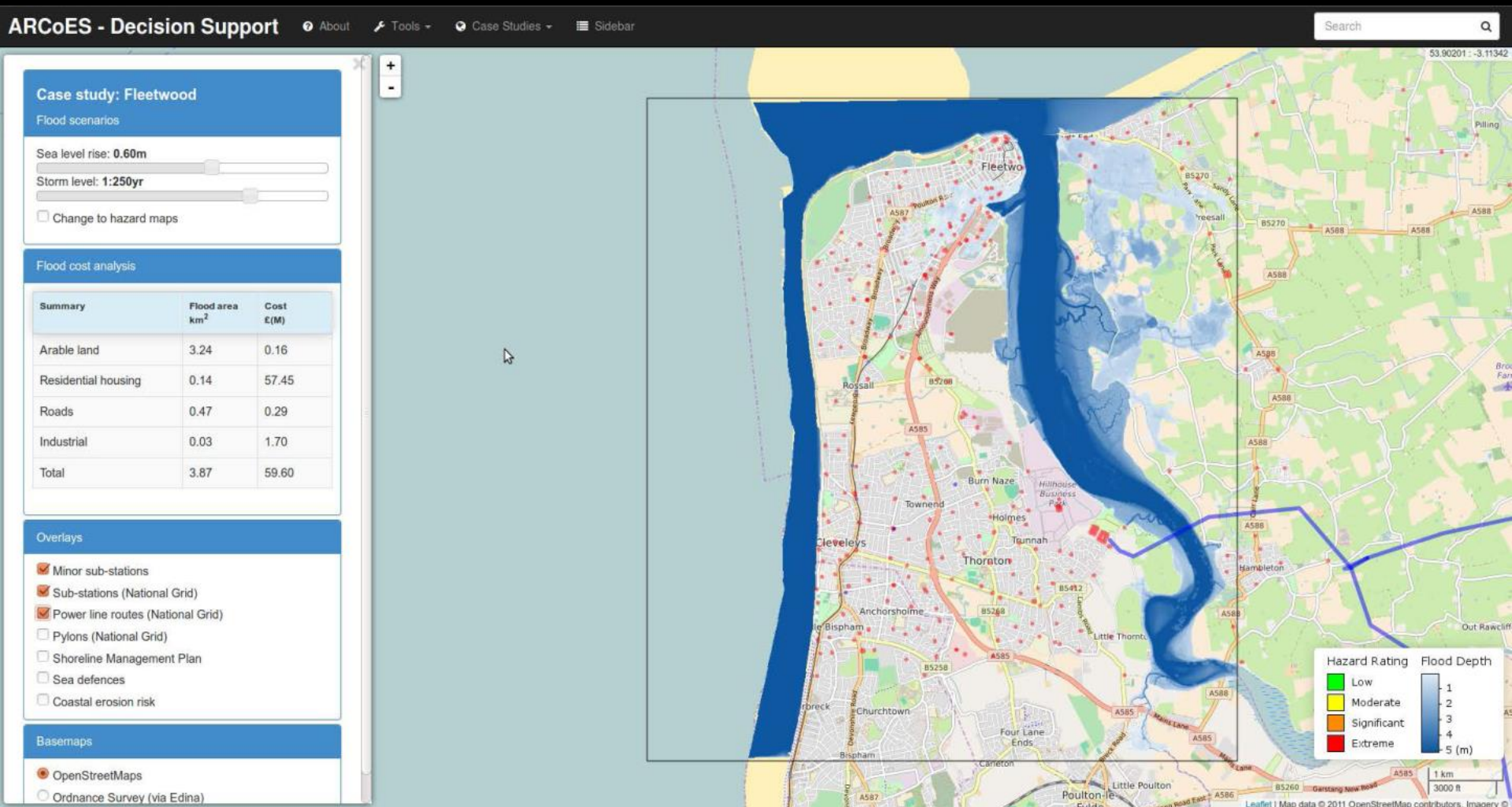
Grinsted et al. (2015) Climate Research, Vol. 64: 15–23, doi: 10.3354/cr01309



liverpool acceleration



Potential Flood Depth: Sea Level & Storms



<http://arcoes-dst.liverpool.ac.uk/>

ARCoES Impact

Living With Environmental Change

Policy and Practice Notes

Note No.30

May 20th 2016

Letter from Peter Aldous, MP
from Waveney, feedback on
PPN No.30:

“This research will be helpful to me in ensuring that the risks that Waveney and other constituencies face are addressed in the most practical way.”

Building coastal resilience to sea-level rise and storms in the UK

What steps can decision makers both locally and nationally take to make coastal populations and businesses more resilient to sea-level rise and climate change?



Living With Environmental Change
Policy and Practice Notes

Note No.30
May 2016

The Living With Environmental Change Partnership brings together 22 public sector organisations that fund, carry out and use environmental research and observations. They include the UK research councils, government departments with environmental responsibilities, devolved administrations and government agencies. The private sector is represented by a Business Advisory Board.

Planning Interventions that Work with Natural Processes (WWNP): e.g. Sand Engine e.g. Coastal Wetlands



Brown et al. (2016) *Journal of Environmental Management* 184, 400-408
[10.1016/j.jenvman.2016.09.090](https://doi.org/10.1016/j.jenvman.2016.09.090)

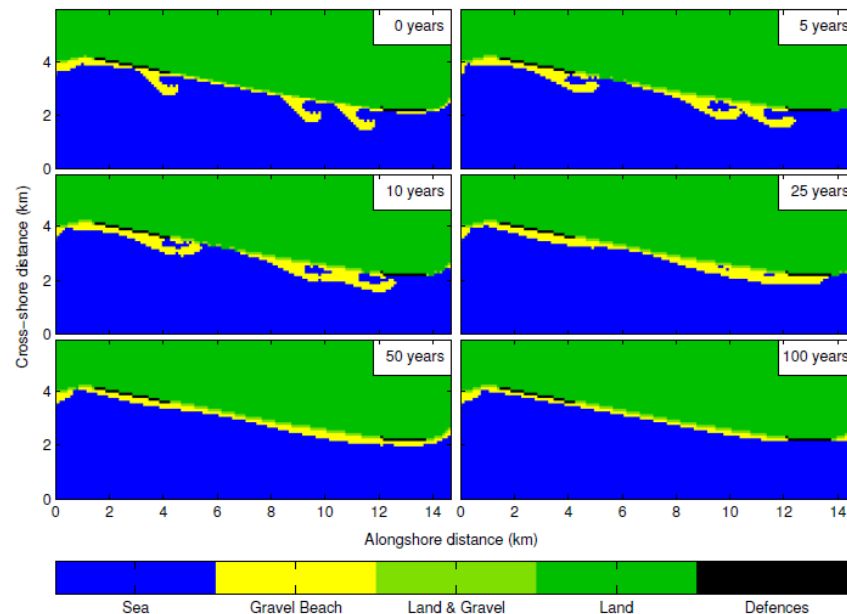


Figure 14: As figure 11 but for the SS scenario.

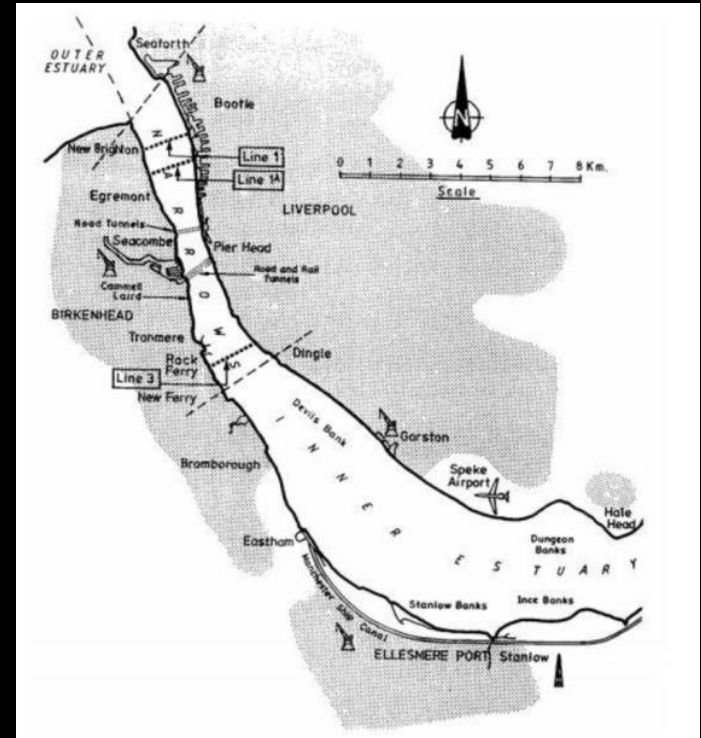
Tidal Barrage: Multiple Benefits



Liverpool ECHO:

<https://www.liverpoolecho.co.uk/news/liverpool-news/liverpool-university-students-design-mersey-9686526>

Tidal Barrage Locations

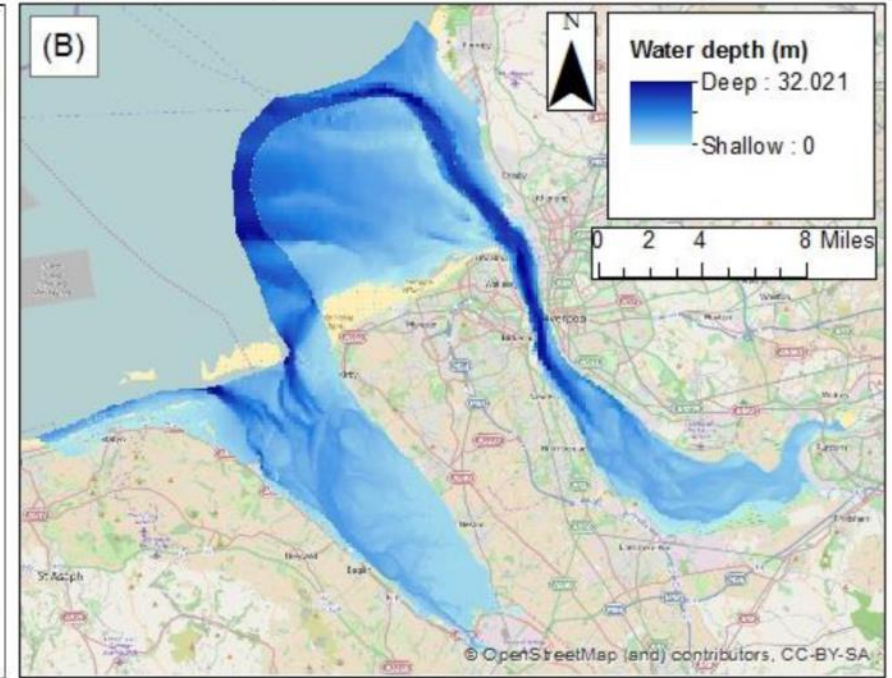
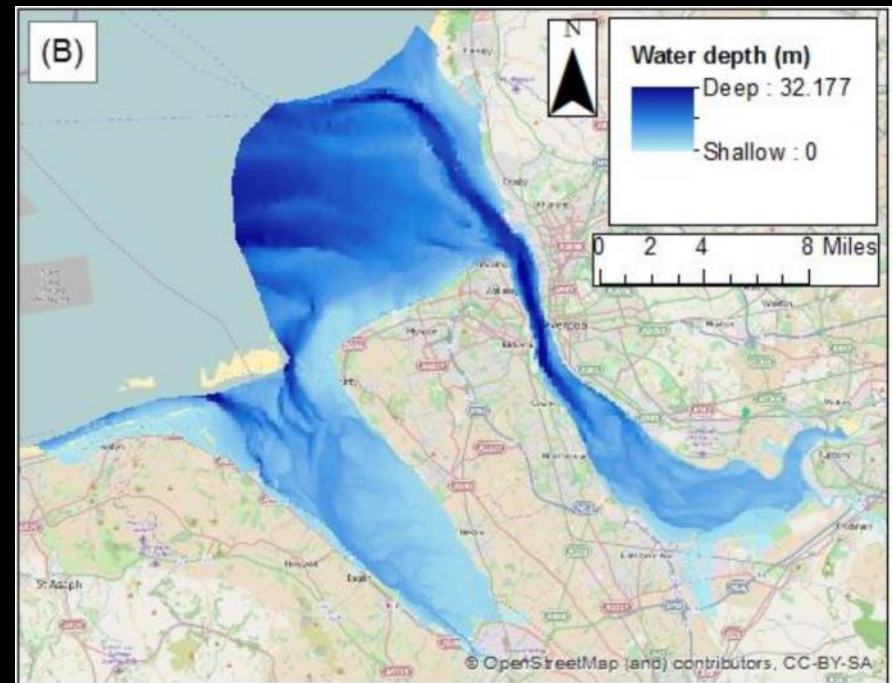
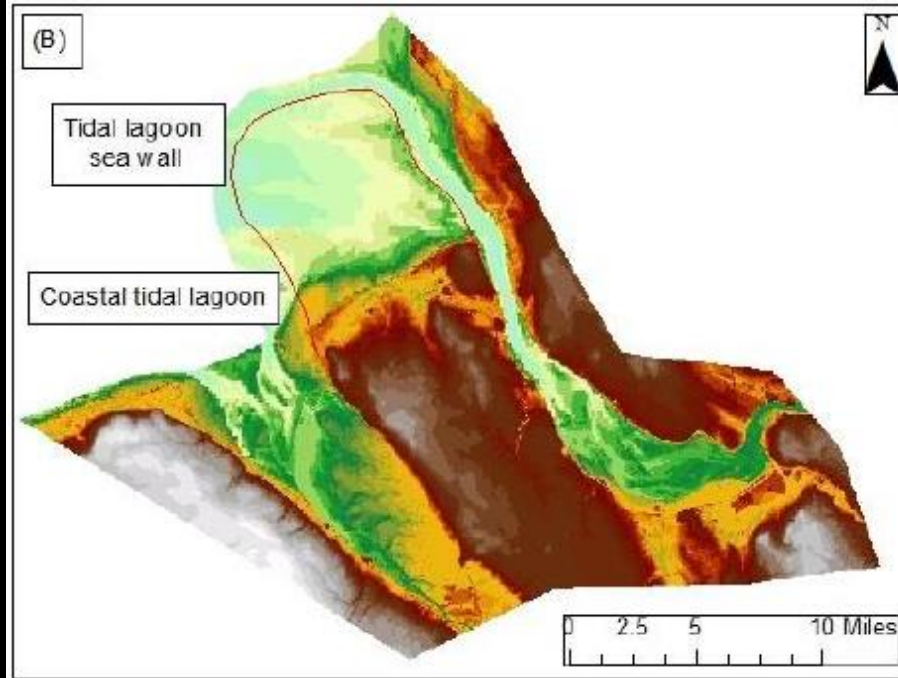


Reilly and Jones, 1990
Progress on civil engineering and
planning of the Mersey tidal
project. Thomas Telford Publishing

Tidal Lagoons: Multiple Benefits

RCP4.5 SLR Potential flooding (HAT +0.72 m by 2100)

Lyddon et al. (2015). The impact of tidal lagoons on future flood risk on the North Wirral and Conwy coastline, UK. (NOC Internal Document No.16).



Conclusions

- Past sea-level trends provide an important context for future planning scenarios
- Future sea-level rise increases risk of flooding – needs to be considered in concert with storm surges: *Tipping Points*
- Maintenance of our natural habitats and beaches offers important protection - threat/opportunity
- Potential to align future Mayoral vision for carbon neutral energy by 2040 with flood protection