Model projections of Century-scale change in Extreme Sea-Level for UKCP09 and UKCP18

SL SpaceWatch workshop 2016 03 22

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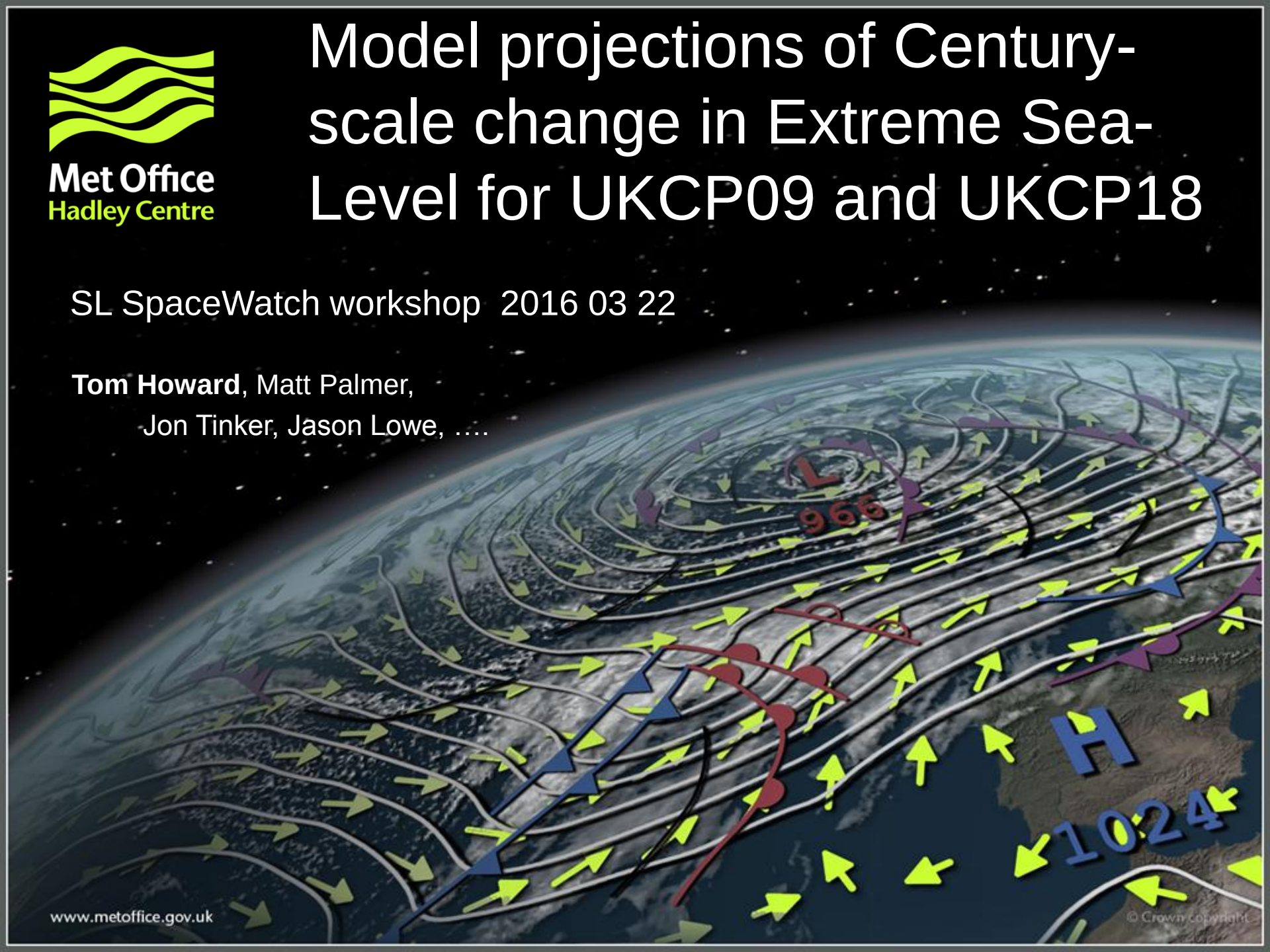
Jon Tinker, Jason Lowe, ….



Contents

- Overview of UKCP18 Marine Projections

- 21st century change in storm surge:
  - UKCP09
  - UKCP18

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Overview of UKCP18 Marine Projections

UKCP18 Marine Strands of science work

Topic 1: Ensemble Projections of large-scale mean sea level change for the 21st century (and beyond?)

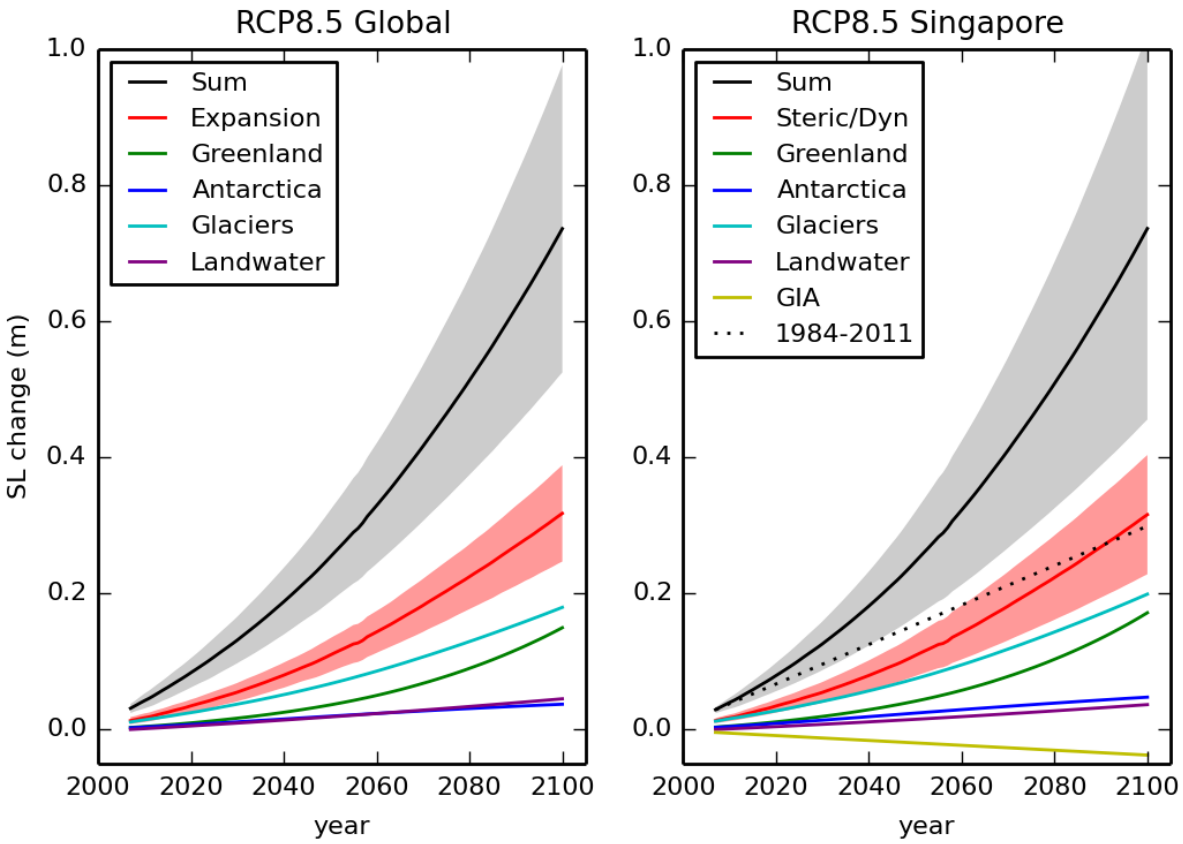
Topic 2: Propagation of sea level signal onto UK shelf

Topic 3: Projected changes in Storm Surge

Topic 4: H++ assessment

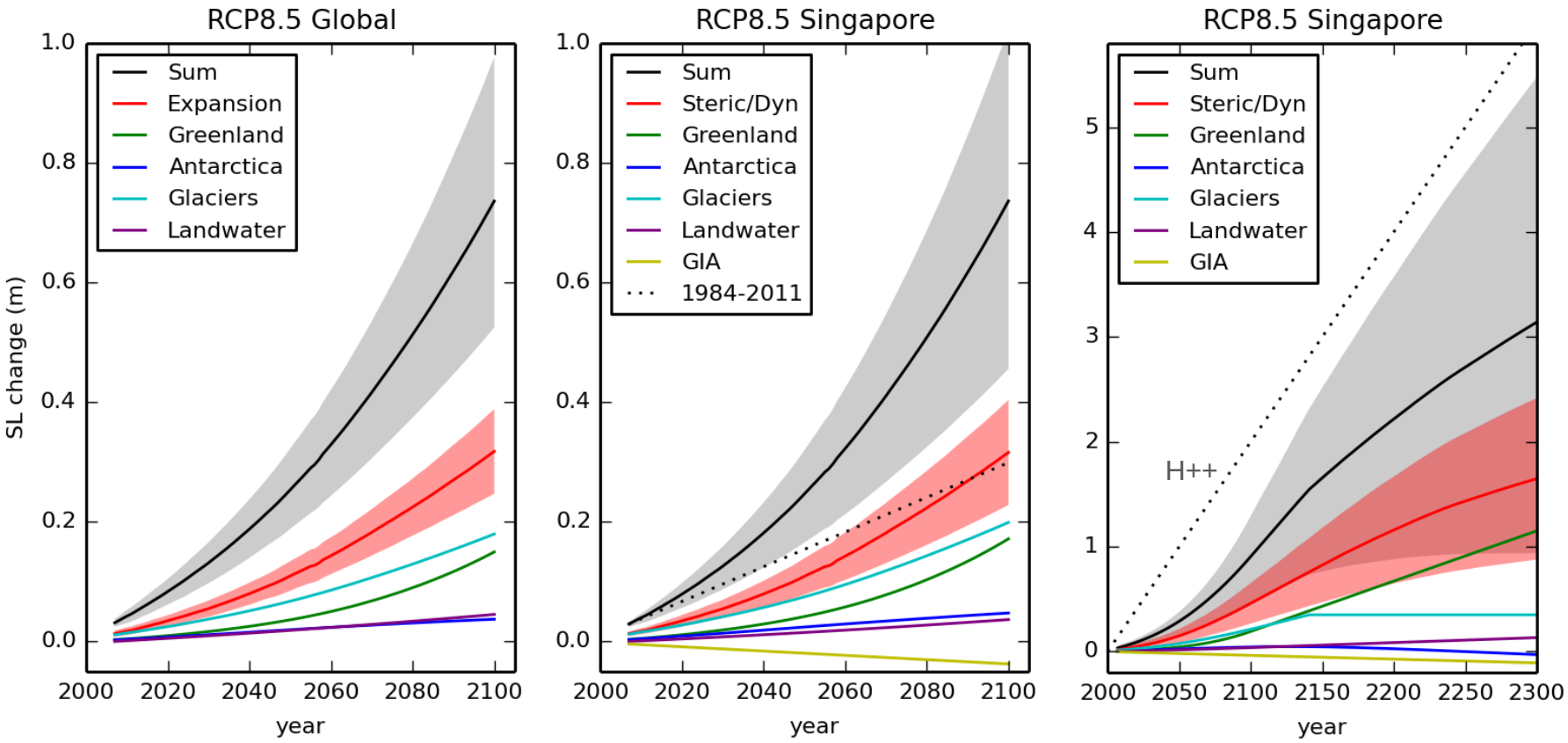
Topic 5: Providing Useful Output (how to combine 1-4?)

Ensemble projections of mean sea level



Based on models and methods presented in IPCC AR5 WG1

Ensemble projections of mean sea level



Based on models and methods presented in IPCC AR5 WG1

Ensemble projections of mean sea level: **what's new?**

- "Pattern scaling" approach to oceanographic sea level
- Multiple estimates of gravitation fingerprints → uncertainty
- Estimate of regional variability (tide gauges + models)
- Consideration of changes beyond 2100..

H++ UKCP09

Je ne regrette rien

- Rohling et al. (2008) *High rates of SLR during the last interglacial period*
- Pfeffer et al. (2008) *Kinematic constraints on glacial contribution to 21st-century SLR*

H++ UKCP09

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H++ UKCP18

Do you feel lucky?

21st century sea level rise	Evidence types	Comment
Up to 1m	Process based models, palaeo studies of last interglacial, semi-empirical methods, kinematic constraints, expert narratives, amount of land ice available	
Up to 1.5m	A limited number of process based models, palaeo studies of last interglacial, semi-empirical methods, kinematic constraints, expert narratives, amount of land ice available	Katsman et al. (2008) expert narratives in this range.
Up to 2m	Some process based models estimates from perturbed parameter type experiments, palaeo studies of the last interglacial, a minority of the semi-empirical methods, kinematic constraints, expert narratives.	Pfeffer et al. (2008); Bamber and Aspinal (2013); and Jevrejeva et al (2014) reach this range.
Up to 2.5m	Upper estimate of last interglacial palaeo estimates, a small minority of very extreme semi-empirical methods.	
Above 3m	Simple calculation of amount of land ice. Evidence from palaeo but for periods that are a poor analogue to present day	

H++ UKCP18

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UKCP09: change in storm surge

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Storminess/Surge

CS3 nested

Driven by MOHC Regional Ensemble

Wind

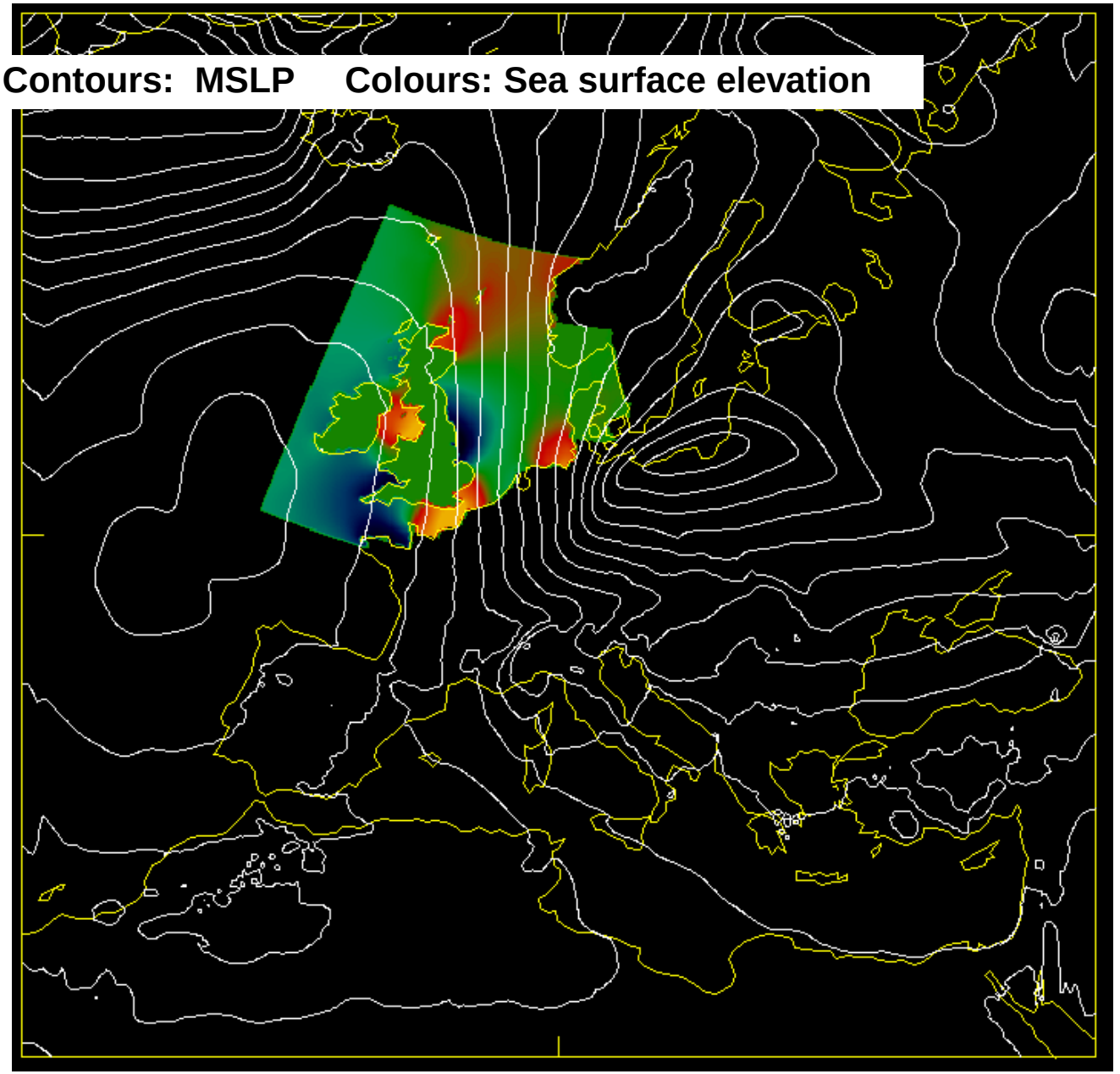
MSLP

Bottom friction

Gravitational forcing

(Rotation)

Lateral BCs: harmonic + inv. barom.



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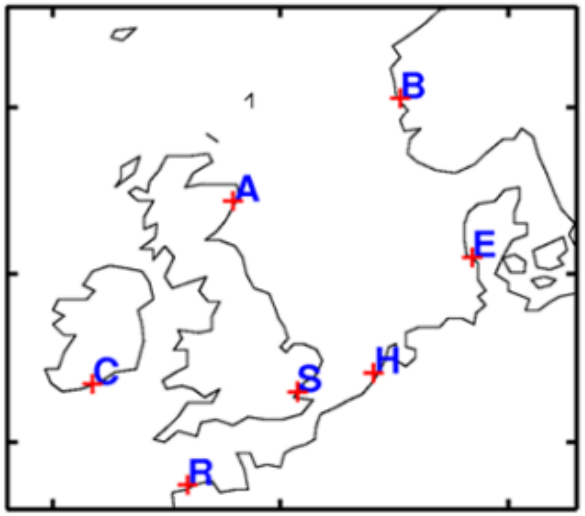
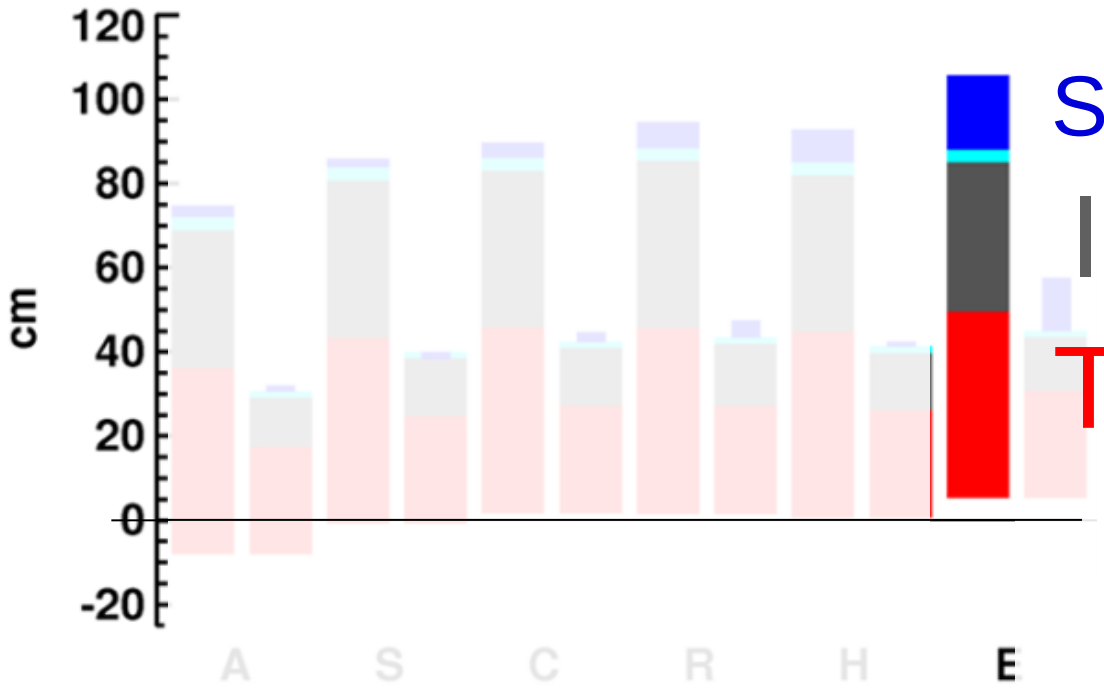
Howard et al. Sources of 21st century sea-level rise along the coast of northwest Europe, Ocean Science 2104

Combined high-end and mid-range estima
of 21st-century change in extreme sea leve



Storm surge climate
Ice-induced DSL
Ice melt incl elastic fingerprint
Thermal exp and non-ice DSL

Zero offset: vertical land movement = viscous fingerprint

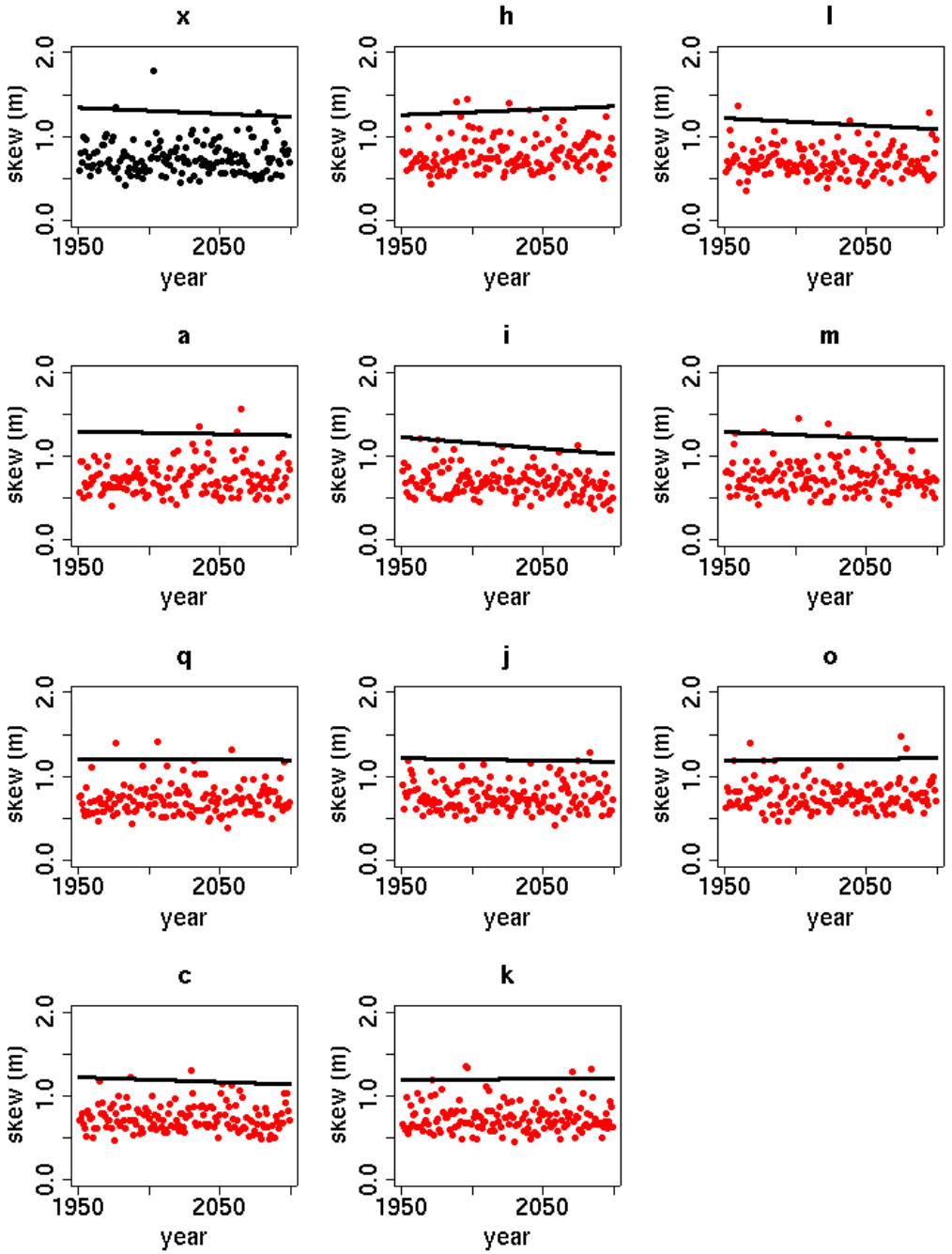


Surge change
Ice Melt
TE + DSL

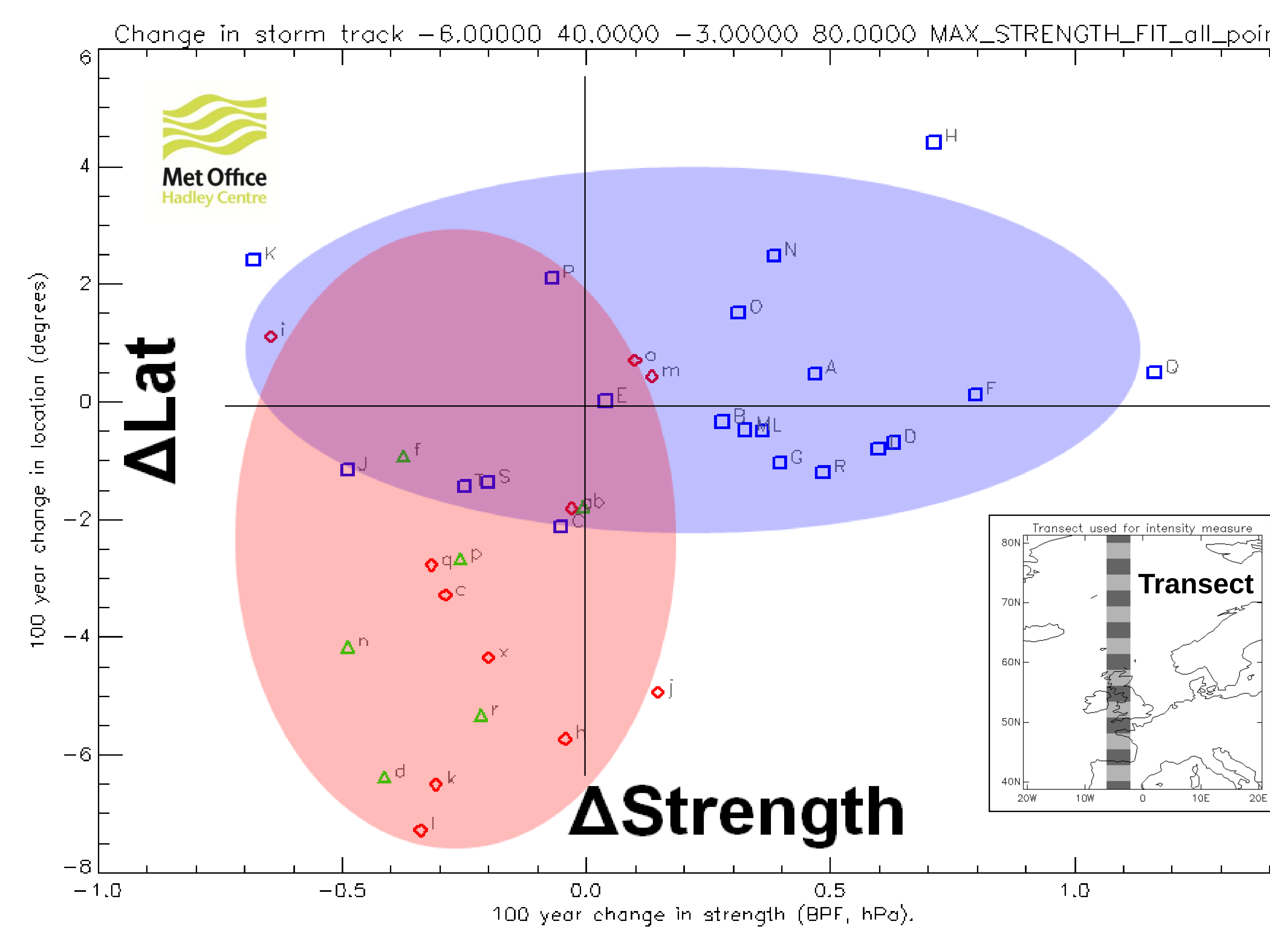
Thames

However, *trends* in storminess-driven component of extreme sea level at Thames mouth are not significant when driven by MOHC ensemble

Plot shows time series of annual max skew surge and a fitted trend line based on the annual 5 largest.



UKCP18: change in storm surge



Change in storm track -6.00000 40.0000 -3.00000 80.0000 MAX_STRENGTH_FIT_all_poi
Met Office
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ΔLat
ΔStrength
100 year change in location (degrees)
100 year change in strength (BPF, hPa).
Transect used for intensity measure
Transect

UKCP18 changes in storm surges

Simulations with CS3 using Euro-CORDEX data:

•

•Select small number of models that span storm track response

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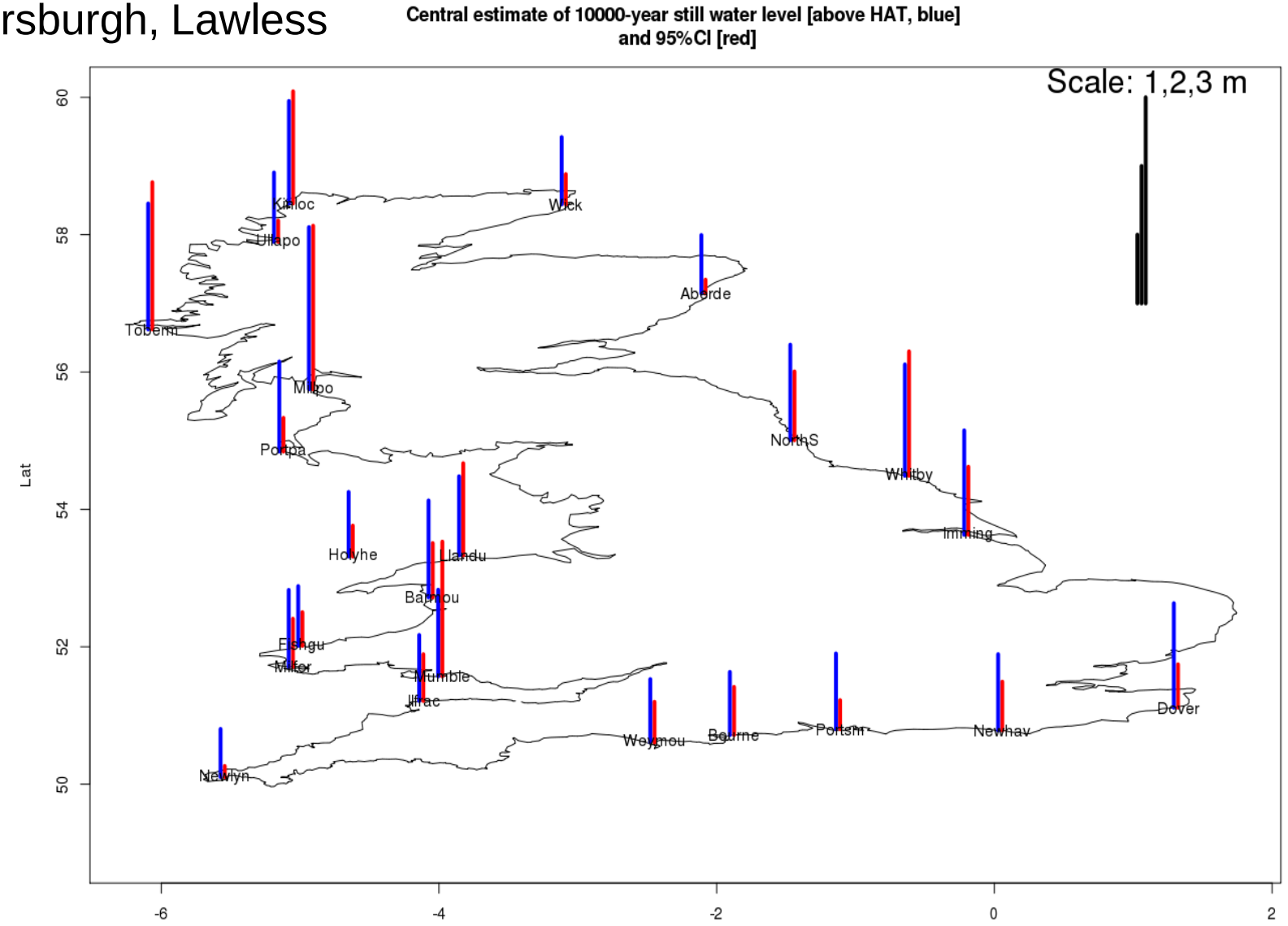
Providing useful output

Based on: Coastal flood boundary conditions for UK mainland and islands. McMillan, Batstone, Worth, Tawn, Horsburgh, Lawless



(This illustration shows present-day data)

HAT = Highest Astronomical Tide

The only coastal-flood RL plot in UKCP09

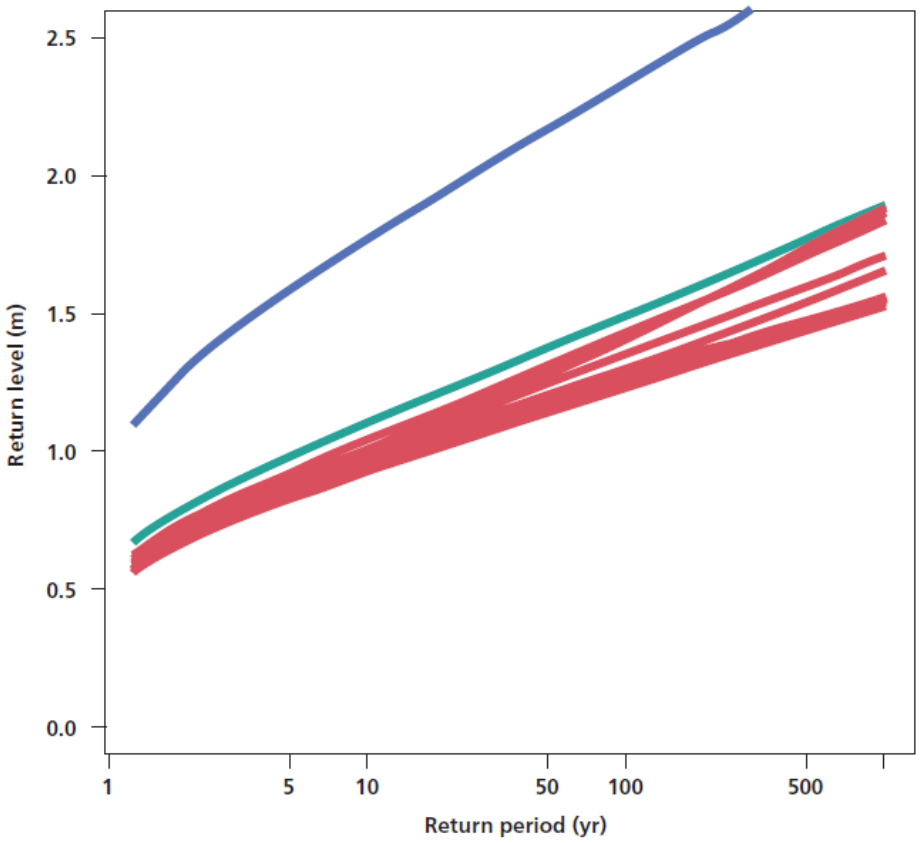
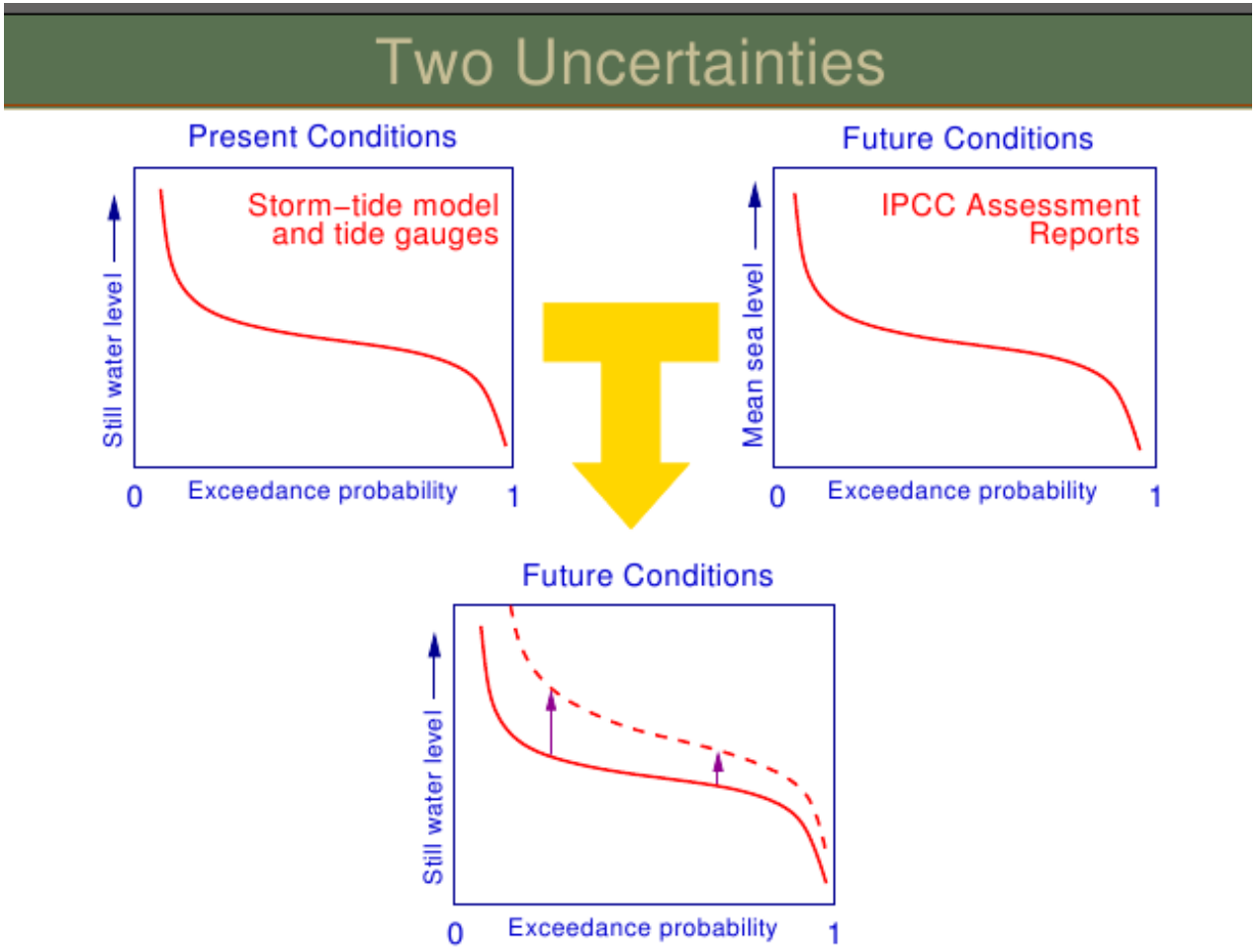


Figure 4.10: Skew surge return level curves (not including mean sea level change) at the Thames Estuary for raw PPE ensemble (red lines) and simulated results for MME model Q for the end of the 21st century (approx 2080–2099) using two different scaling approaches (blue and green lines). The green curve contains little evidence of a climate signal. The dark blue curve has a significant climate change signal.

Canute (Australia)

canute.sealevelrise.info



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Thank you for listening

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Questions/comments...

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Additional Slides...

When to use H++ ?

AR5 statement: 'GMSL rise during the 21st century for each RCP scenario is *likely (medium confidence)* to lie within the 5 to 95% range given by the process-based projections'

i.e. P(GMSL rise < z95 over next 85 years) > 0.66

If MSL were held constant at present level,

P(extreme SL does not exceed the 200-year RL over the next 85 years)=(199/200)^85 = 0.65

So in combining the two we can give useful guidance from the process-based projections up to ~100 year RL. Above that, need to consider H++.

For users interested in an asset period of, say, 2016-2050, H++ less relevant. But for e.g. 2016-2030, where we are in the 18.6 year nodal cycle is important.

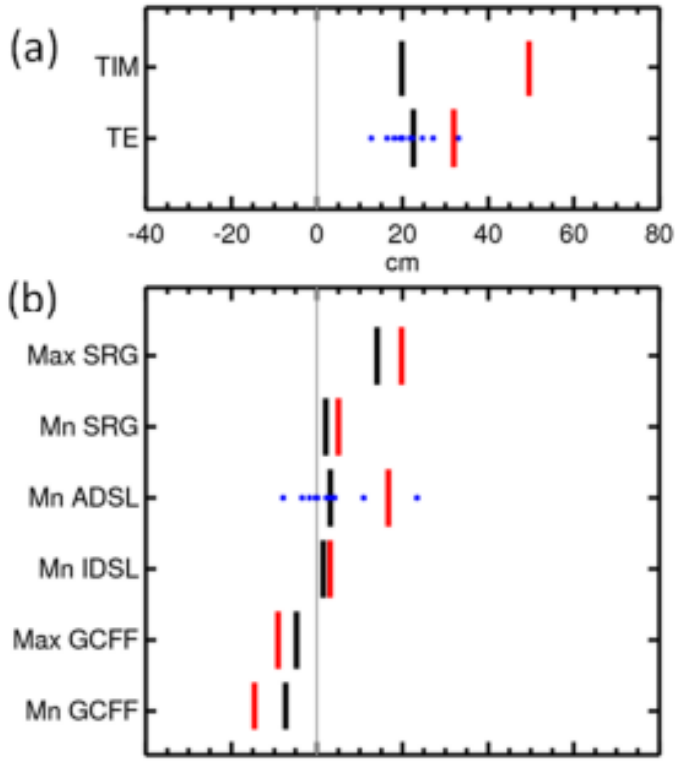


Figure 4. Comparison of contributions to the 21st century change in 50-year storm surge height around NW Europe (centimetres). **(a)** Global mean contributions, **(b)** local contributions. Black bars indicate the representative mid-range, and red, the illustrative high-end contributions. Blue dots show the individual ensemble members where these are available. The abbreviations used in the figure are those given in Tables 1 and 2.

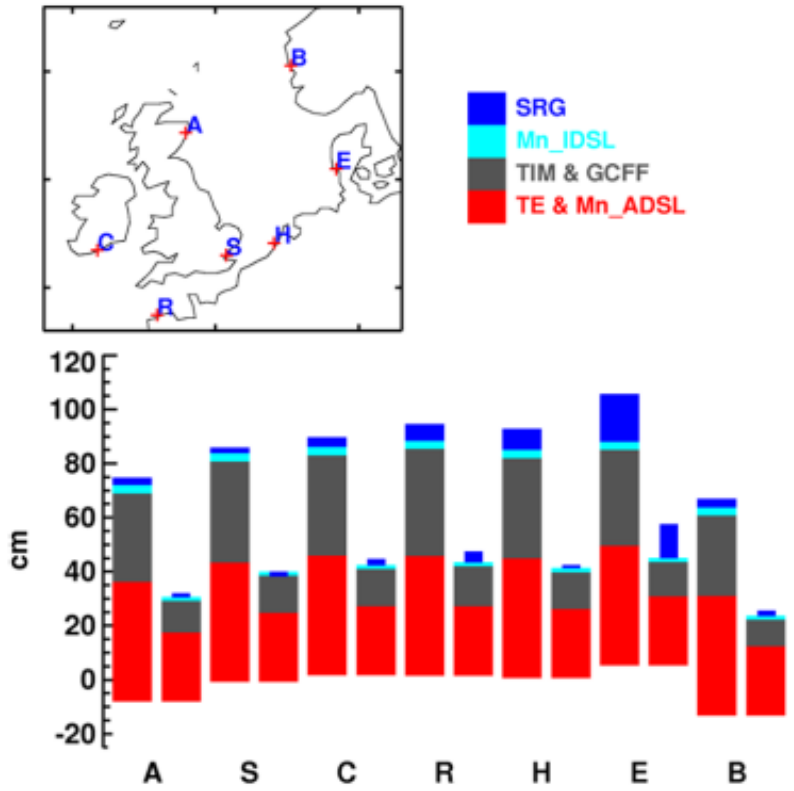
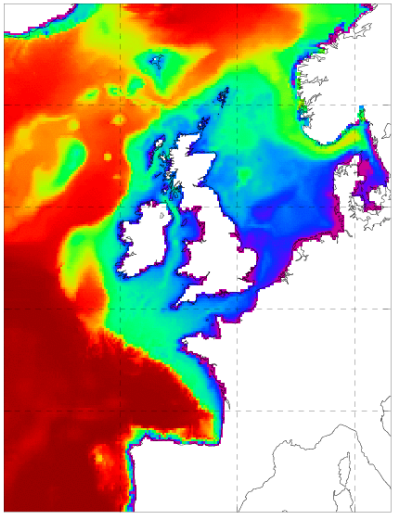


Figure 5. Addition of illustrative high-end (and representative mid-range) projections of contributions to 21st century change in the height of the 50-year storm surge for seven locations around NW Europe. The locations are Aberdeen, (A); Sheerness, (S); Cork Harbour (C); Roscoff, (R); The Hague, (H); Esbjerg (E) and Bergen (B). For each location, the larger (left-hand) bar shows the high-end estimate, and the smaller (right-hand) bar shows the mid-range estimate. The projected contribution from *GIA* is shown as an offset to the zero of each bar. The mid-range *SRG* projection at Sheerness is negative, and so that this can be seen, the mid-range *SRG* projections are shown as half-width bars. Further details are given in the main text.

Propagation of sea level onto UK shelf

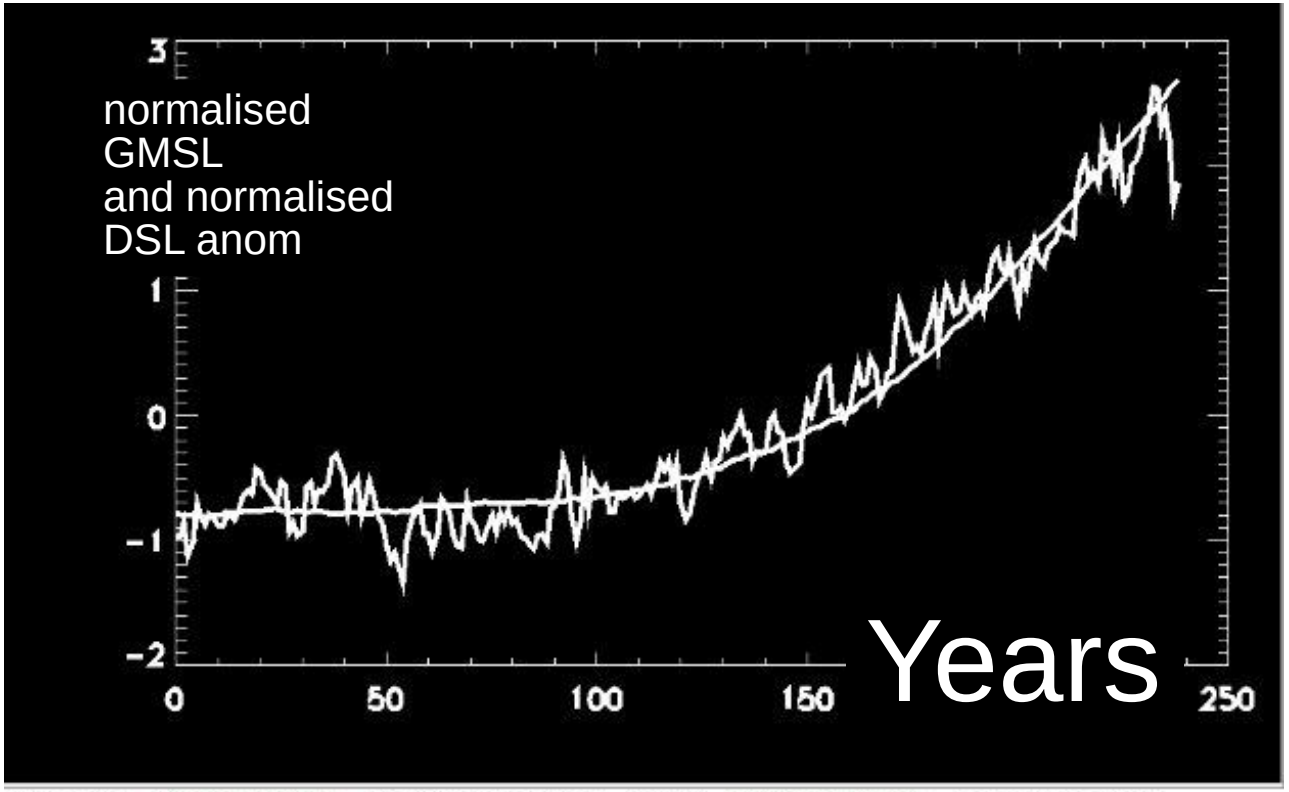


New experiments with NEMO-Shelf:

- Repeat 1 member of UKCP09 with NEMO-Shelf
- Downscale a pair of CMIP5 models (model uncertainty)
- Long piControl run to assess sea level variability

DSL regression against MSL

c/f Roberto Bilbao, Jonathan Gregory, @Reading



OHC and timeseries of first EOF, both normalised, global but resolution reduced from 288x143 to 144x71 for tractability.

→ Cast net wider using simple models

...&
? MSL better predictor (than time) of surge change

this example:
Ice2Sea
A1B
HadCM3