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Decadal Predictions using HiGEM, a Higher Resolution Climate Model

Len Shaffrey

Thanks to: Dave Stevens, Ian Stevens, Ed Hawkins, Doug Smith, Pier Luigi Vidale, Rowan Sutton, Dan Hodson, Jon Robson

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Walker INSTITUTE

Outline

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- Quantifying uncertainty in the CMIP3 projections
- Using a higher resolution coupled climate model for decadal prediction

Quantifying Uncertainty

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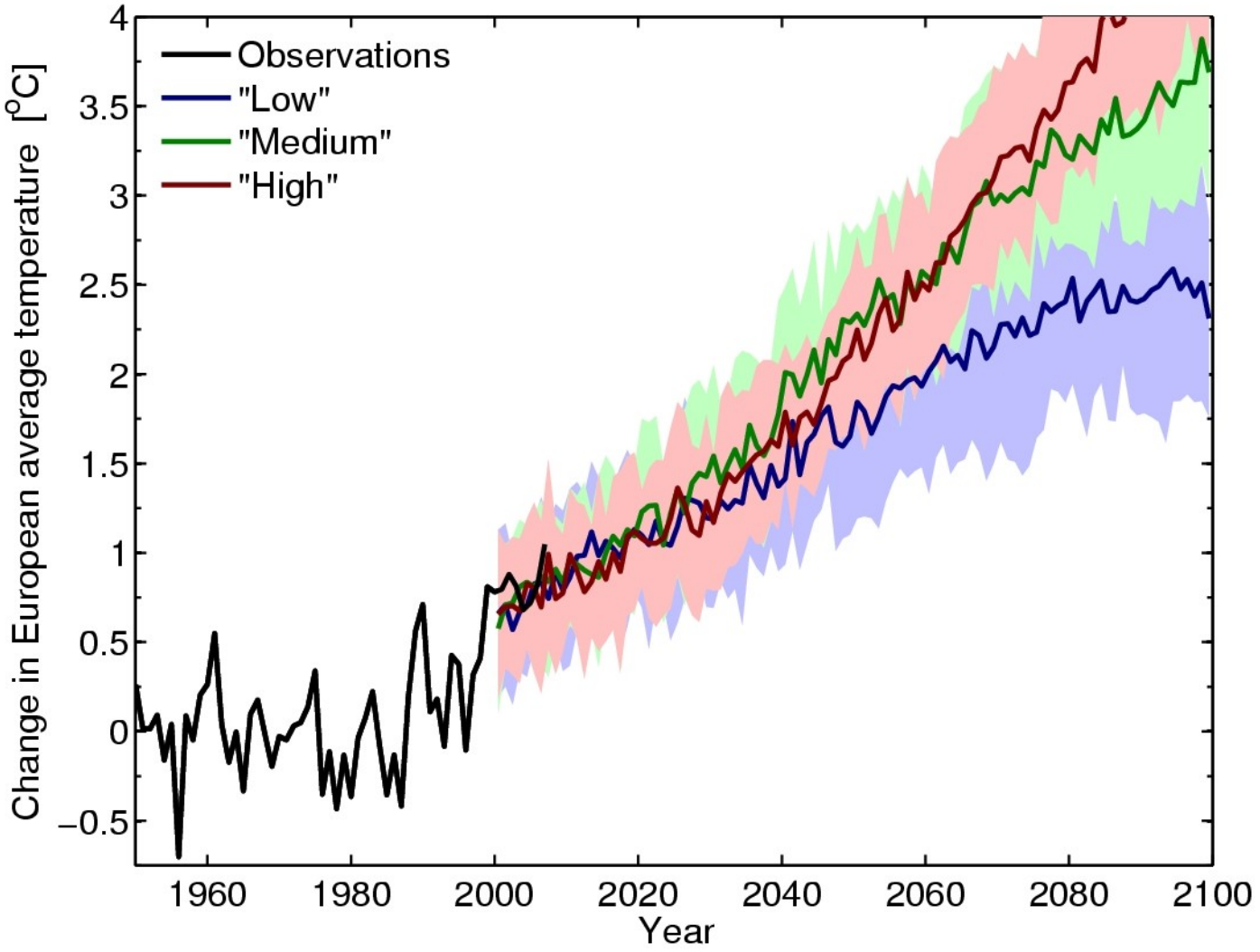

Quantifying Uncertainty

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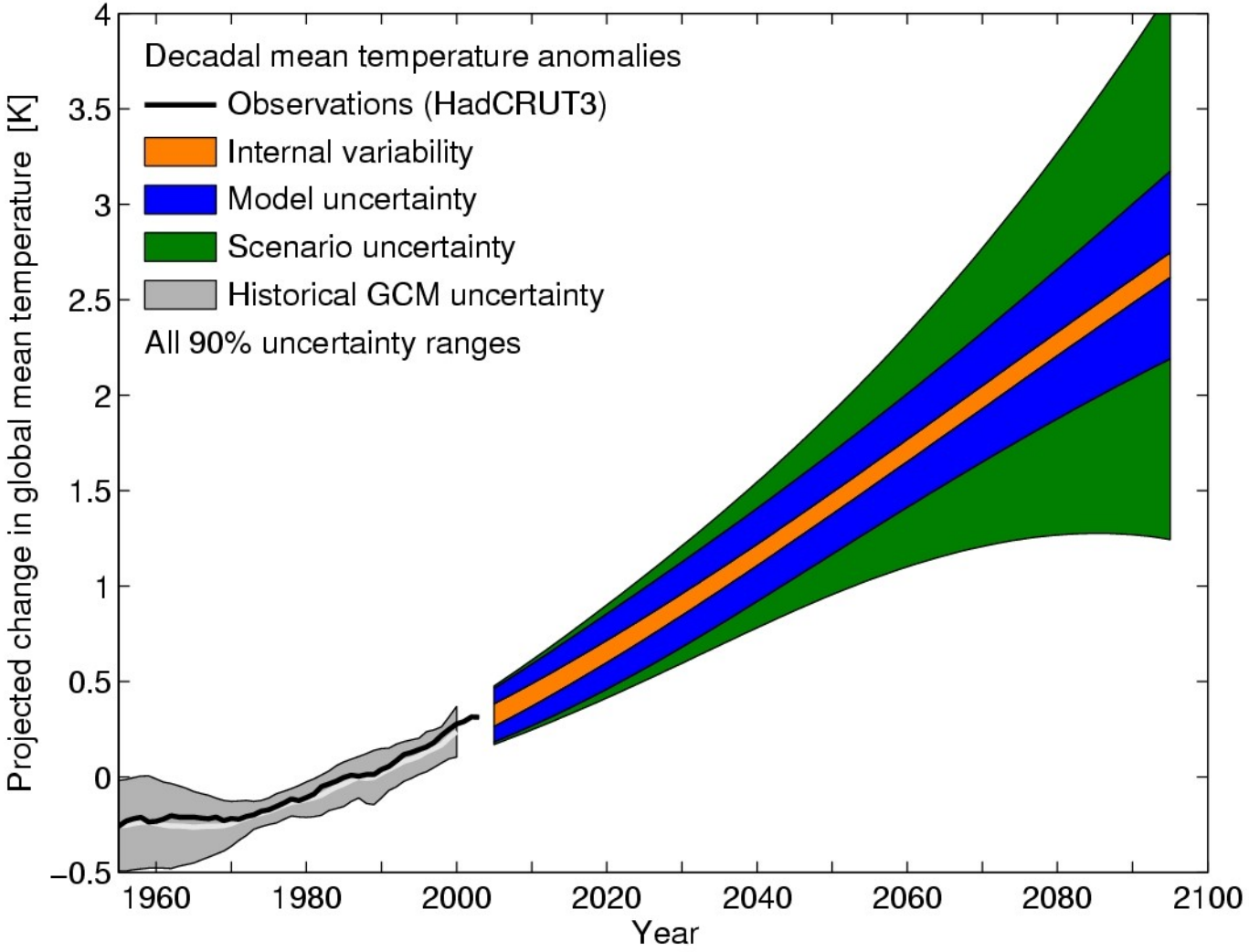

Hawkins & Sutton, BAMS, 2009
Hawkins & Sutton, GRL, sub.

Quantifying Uncertainty

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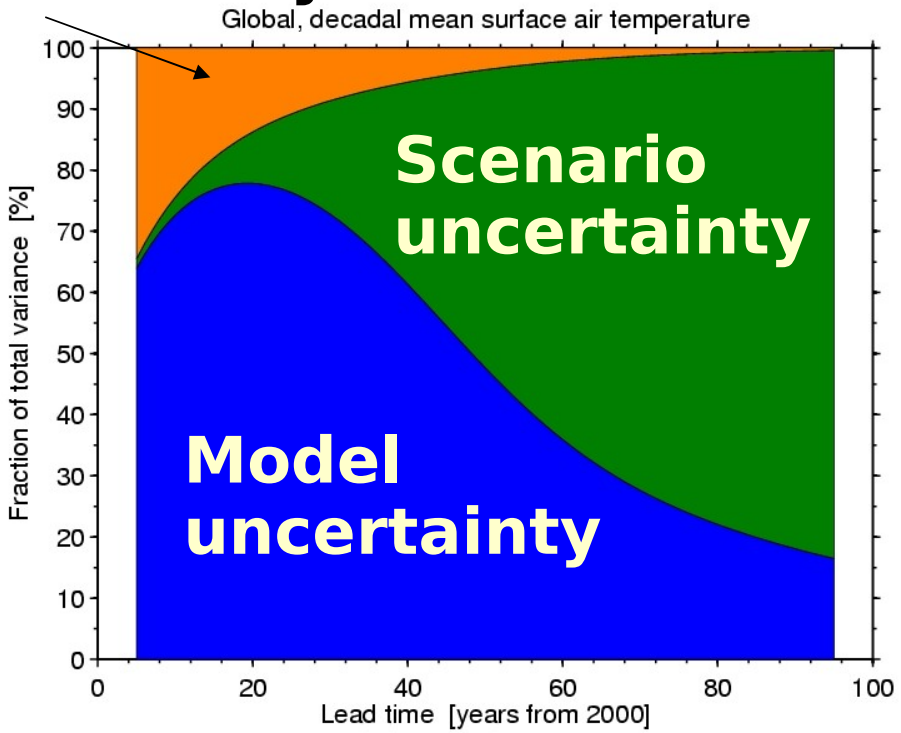
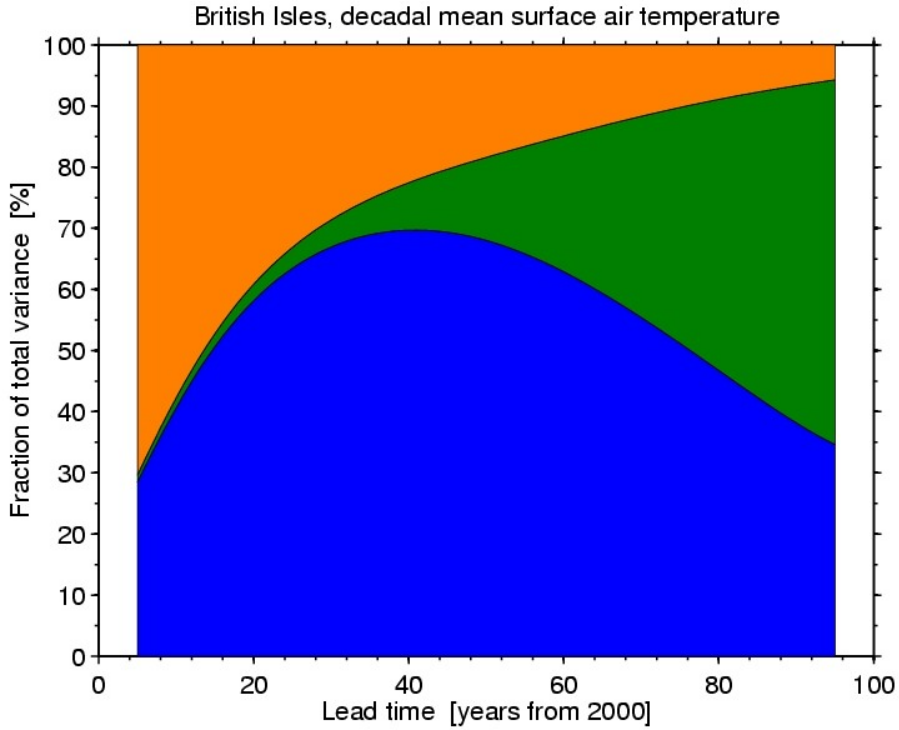
Internal variability





Hawkins & Sutton, BAMS, 2009
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High Resolution Climate Modelling

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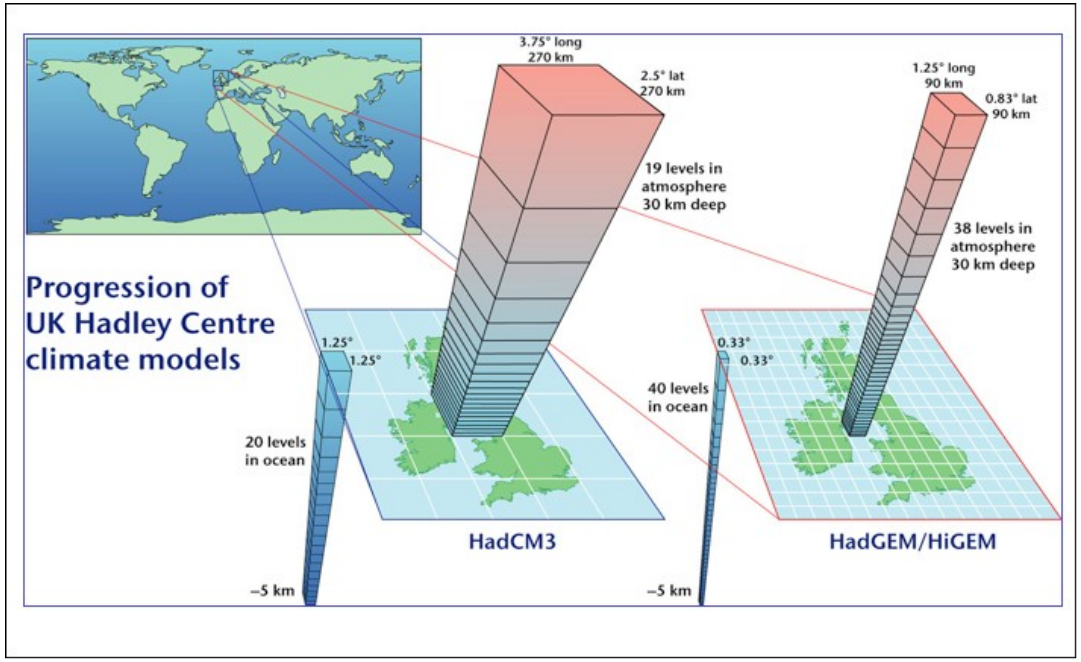
- HiGEM is based on the Met Office Hadley Centre coupled ocean-atmosphere climate model, HadGEM1



- HiGEM has an atmospheric resolution of 1.25°x0.83° longitude by latitude, and 38 levels in the vertical

- The ocean resolution is 1/3°x1/3°, which allows the model to begin resolve ocean eddies (an *eddy-permitting* resolution). The ocean model has 40 levels in the vertical
- Centennial length runs have been integrated
- Does increasing the resolution improve the representation of regional climate and weather?

ENSO in HiGEM

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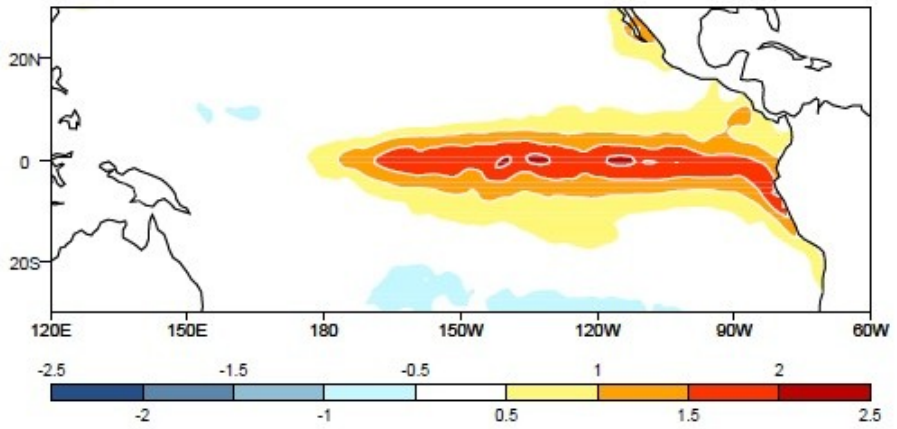
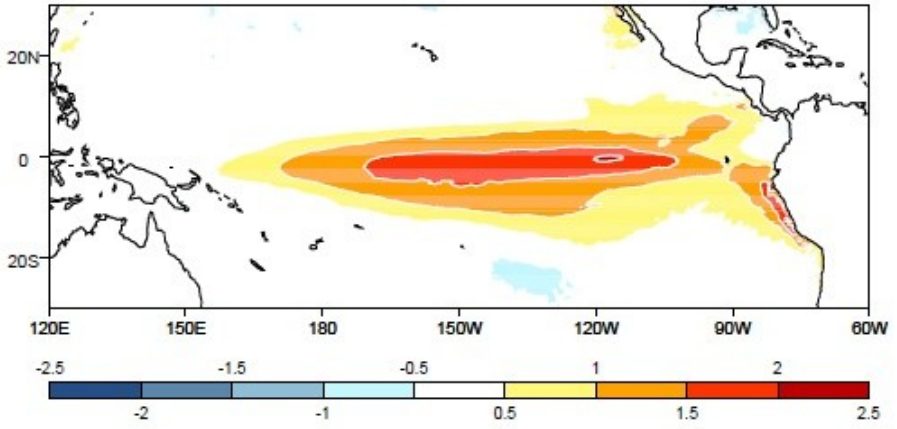
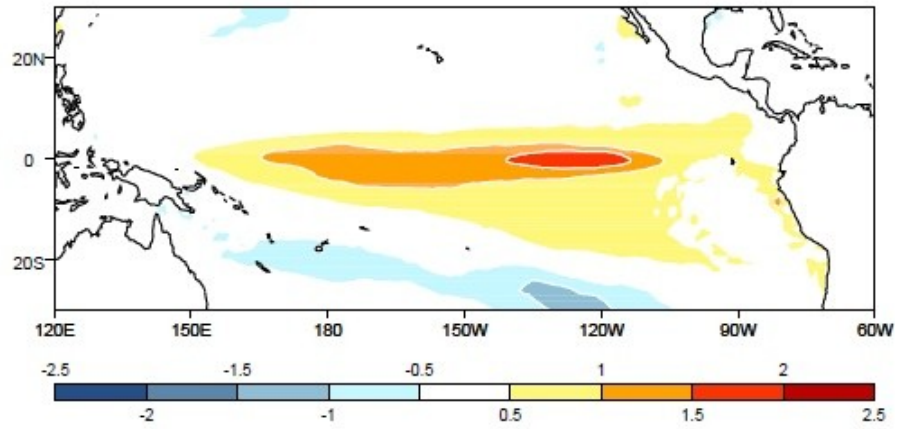
DJF El Nino SST Composites



Observations



HiGEM



HadGEM

Shaffrey et al. 2009, J. Clim.

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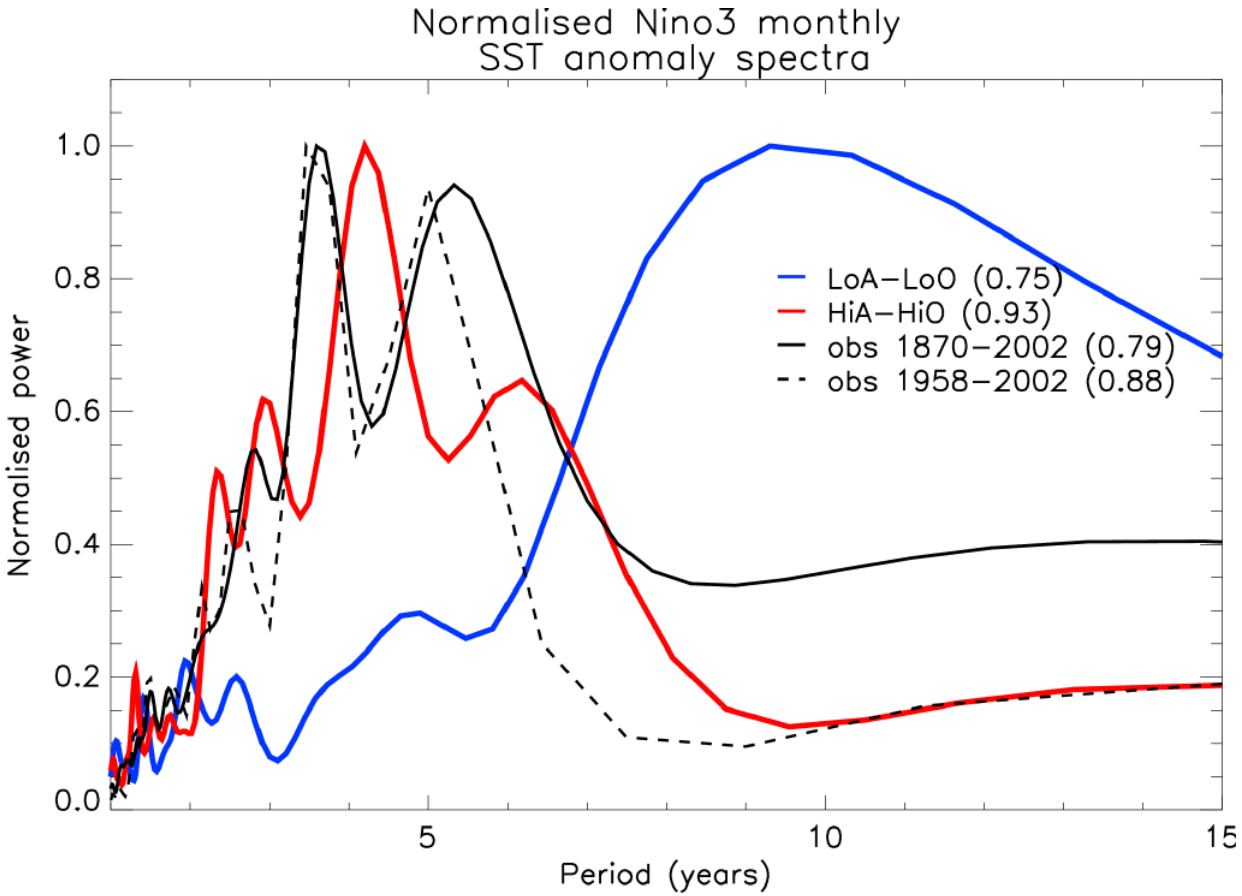
Nino3 SST Normalised Power Spectra



Tropical Instability Waves

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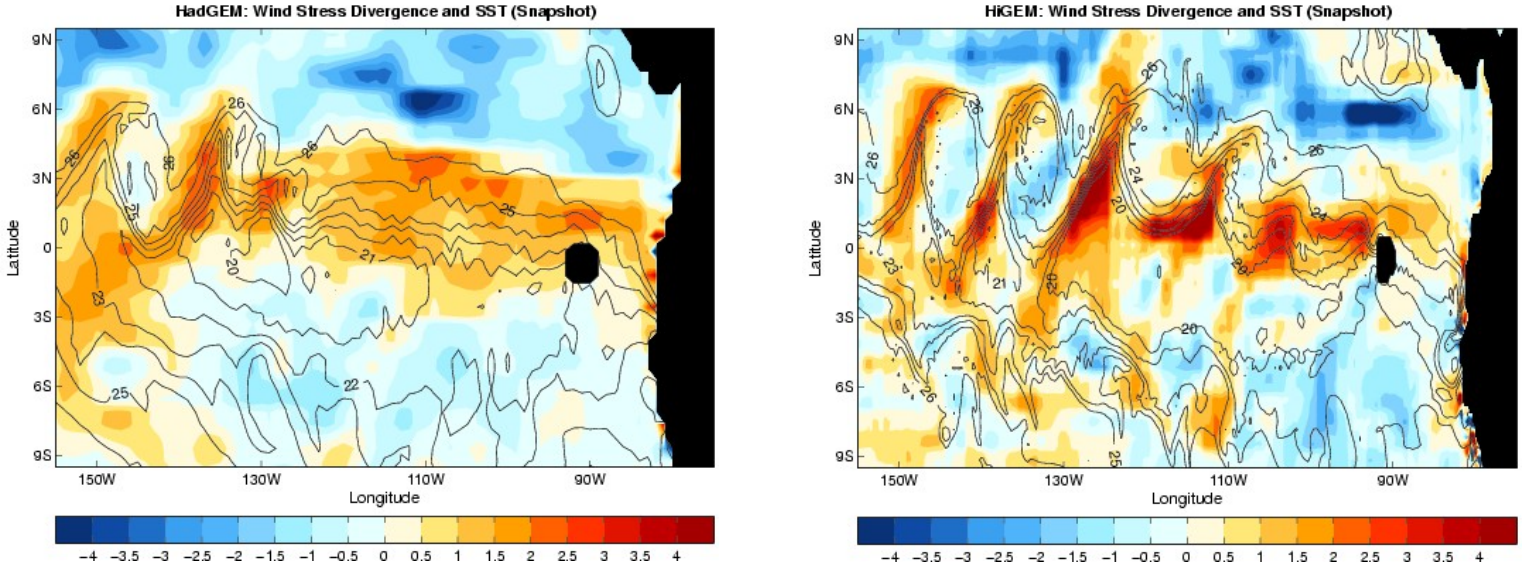
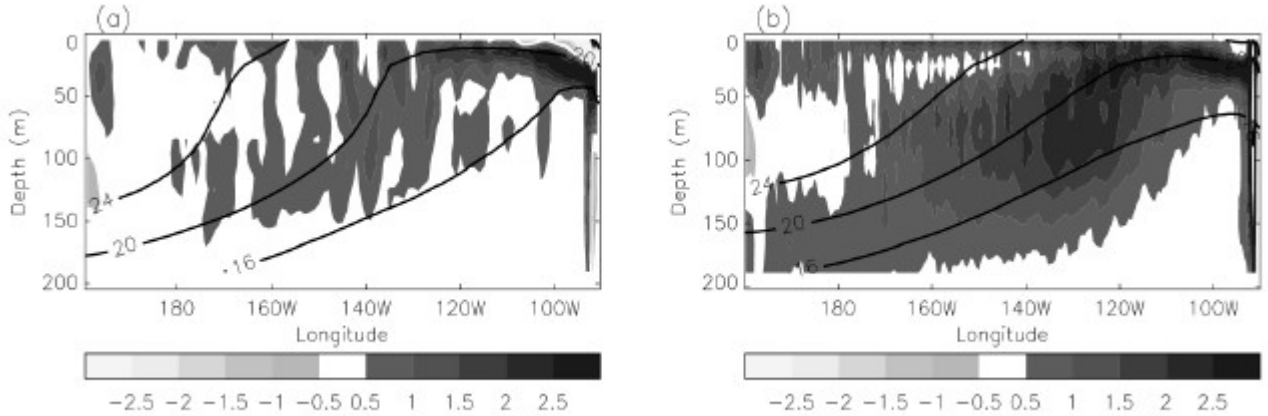


Instantaneous SSTs (lines) and surface windstress divergence (colours) from HadGEM1 (left) and from HiGEM (right) in the Tropical Pacific. Shaffrey et al. (2009)



The eddy heat transport convergence from Tropical Instability Waves warm the Tropical Pacific cold tongue, improving the mean state, Roberts et al. (2009).

Overturning circulation in HiGEM

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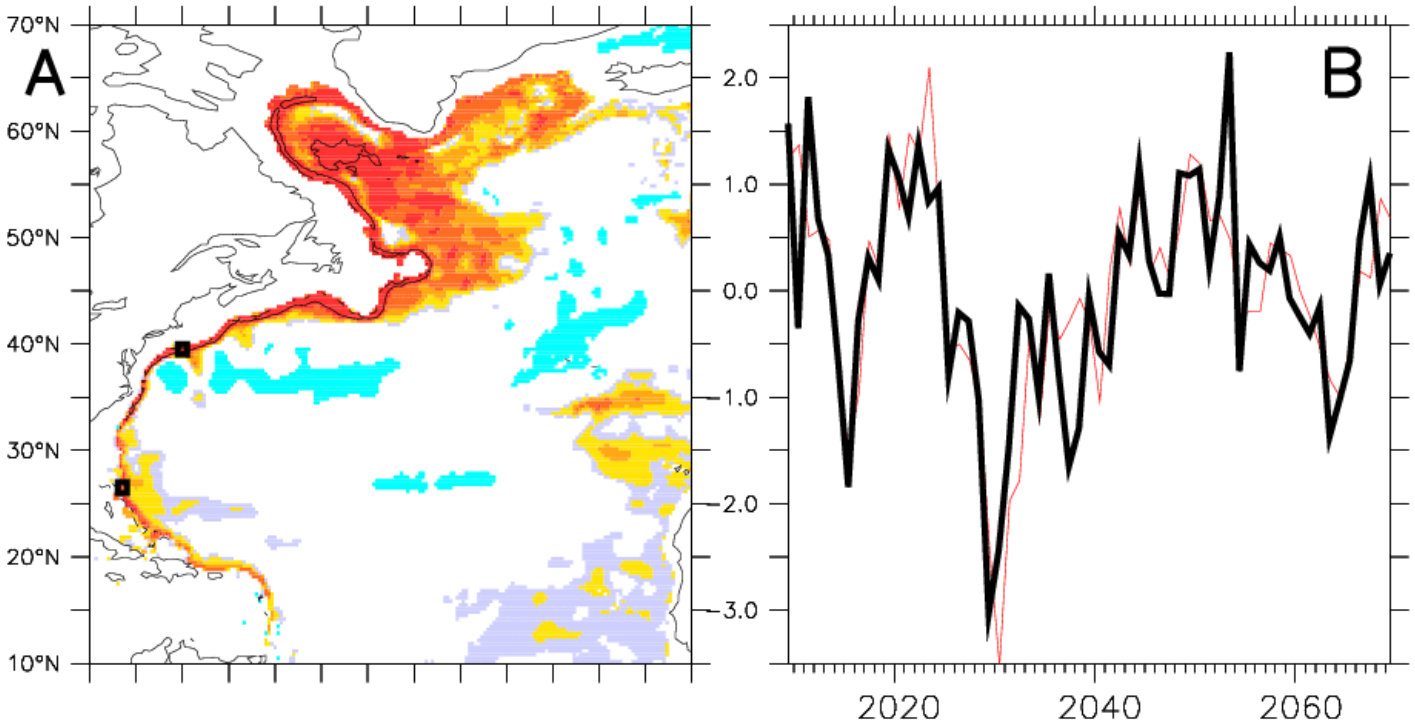
Atlantic meridional overturning at 40N



Density (800-3000m), correlated with boundary density @ 40N

Overturning – black
Density index – red

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HiGEM decadal variability

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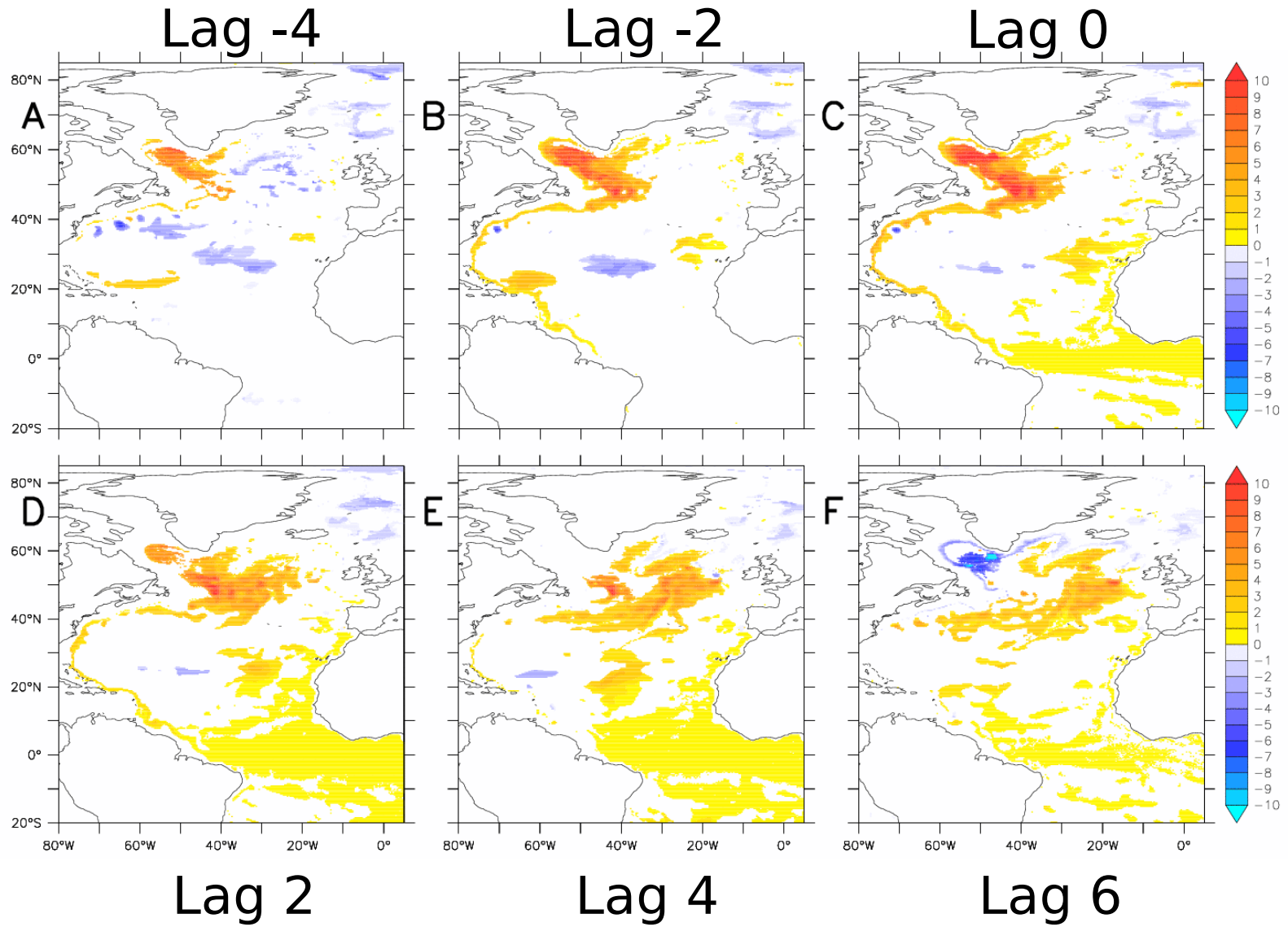
Ocean density regressed onto the MOC



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Labrador Sea Water trajectories

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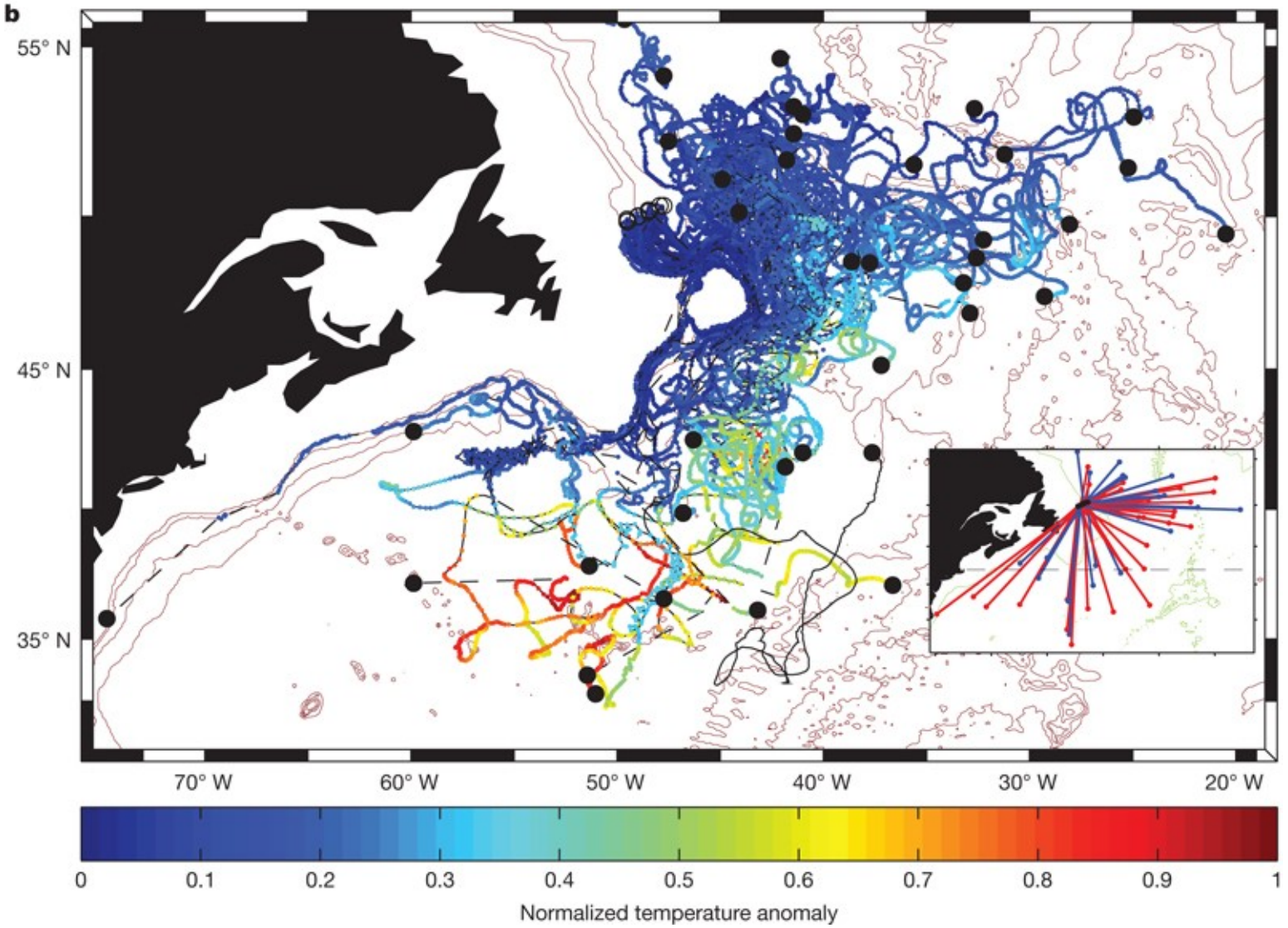
RAFOS floats released in Labrador Sea tend to migrate towards the interior



Bower et al. 2009

Decadal Predictions for CMIP5

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Increasing resolution reduces some biases, and improves the representation of ENSO, blocking, NH stationary wave patterns and stratocumulus decks (Toniazzo et al., 2009)

Start to resolve structures in weather systems, for example extratropical cyclones (Catto et al., J. Clim submitted)

Increasing resolution is **not** a panacea. Major biases remain, e.g. both HadGEM1 and HiGEM poorly represent the distribution of Indian summer monsoon rainfall

Decadal predictions using HiGEM for the CMIP5 near-term experiment are planned and will start when the RCP forcing scenarios are finalised. Focus on the 10 year hindcast set (1960, 1965, 1970...2000, 2005)

The initialisation is based on the Met Office DePreSys anomaly assimilation for T and S through the ocean depth

A test: The 97/98 El Nino

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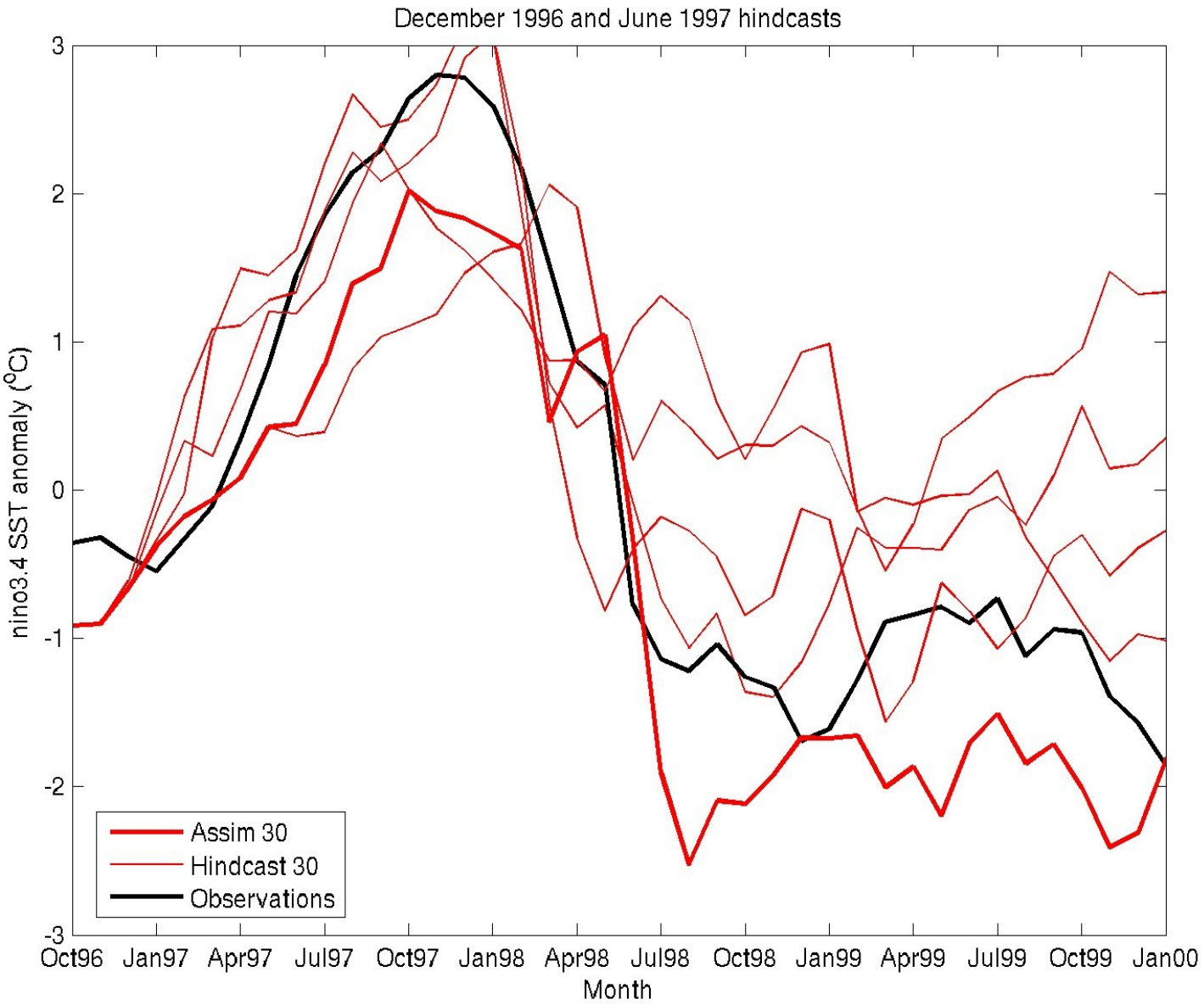
A test of the system, forecasting the 1997/1998 ENSO from Dec 1996.

Timeseries of Nino3.4 SST anomalies from observations (black), the assimilation run (thick red) and three hindcasts (thin red).



Decadal prediction case study

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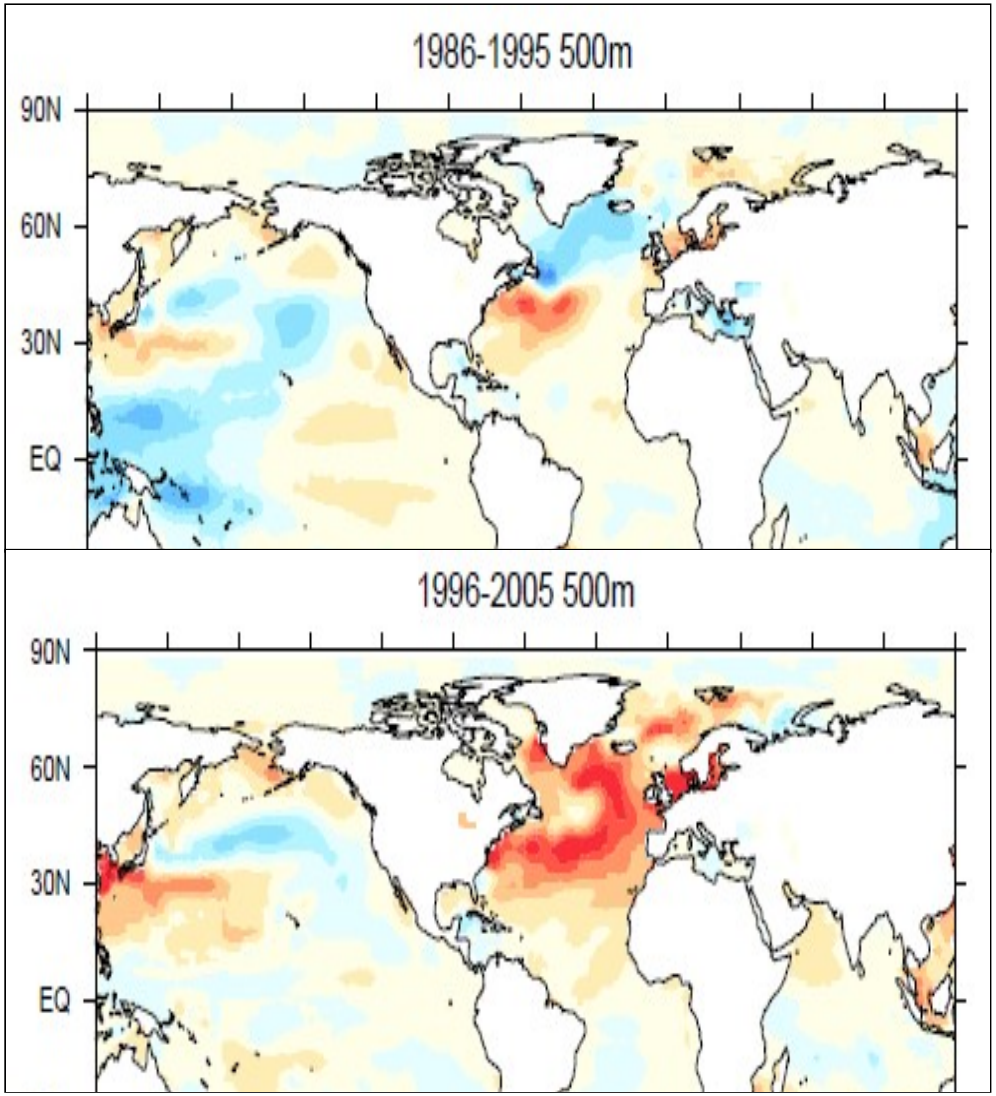
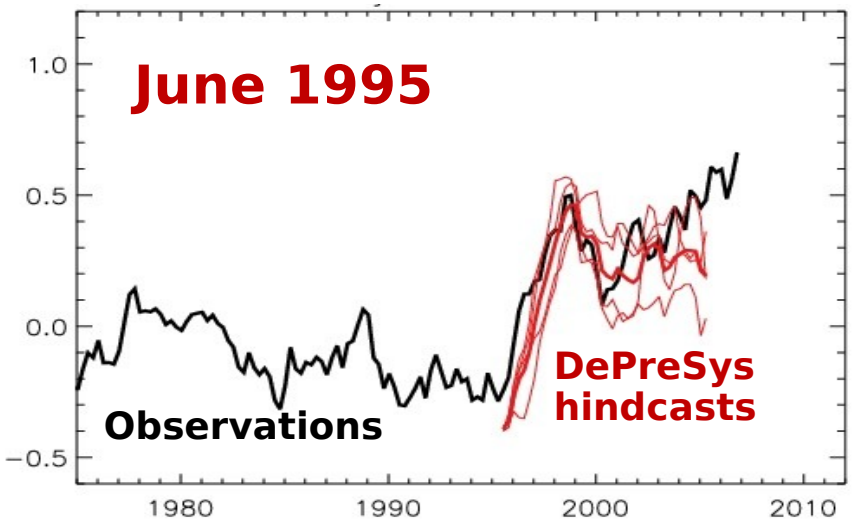
North Atlantic upper ocean heat content





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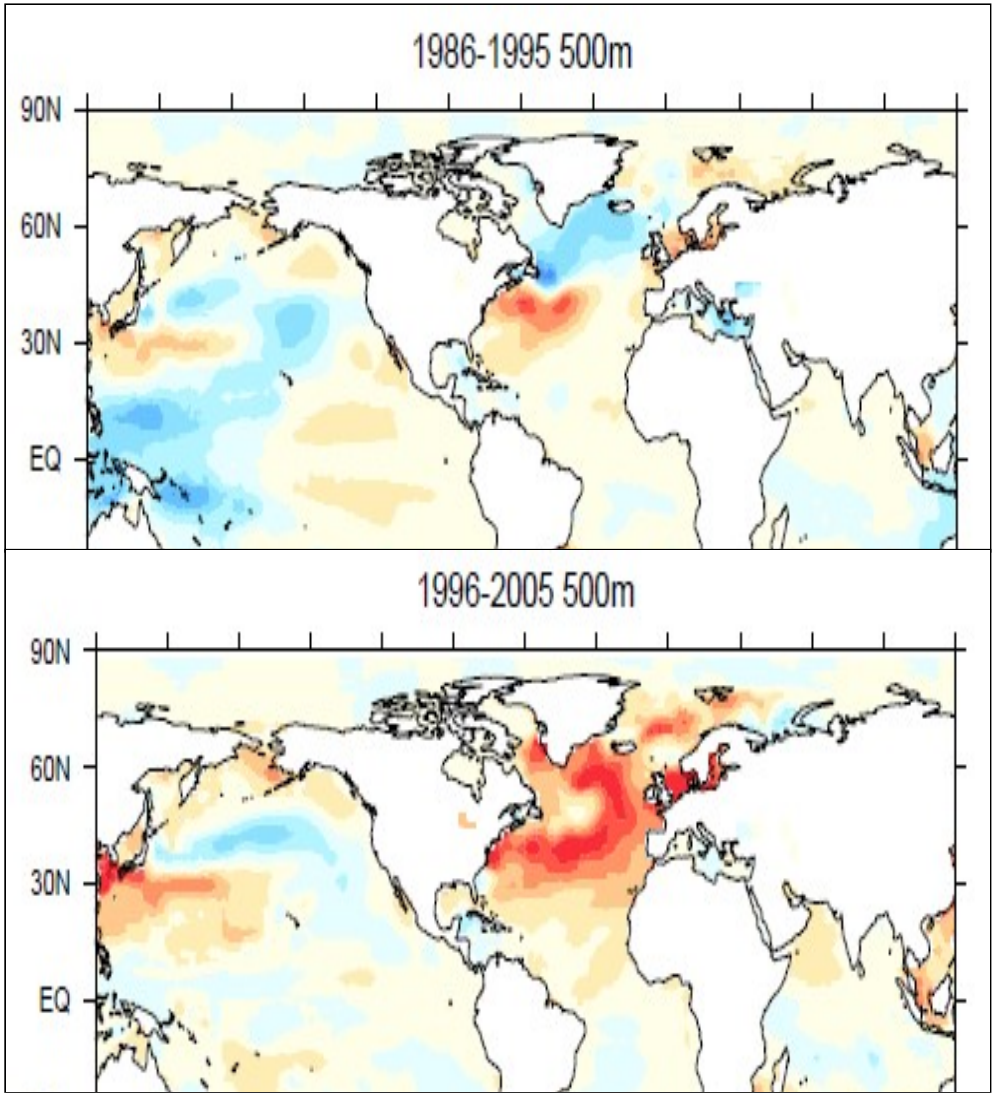

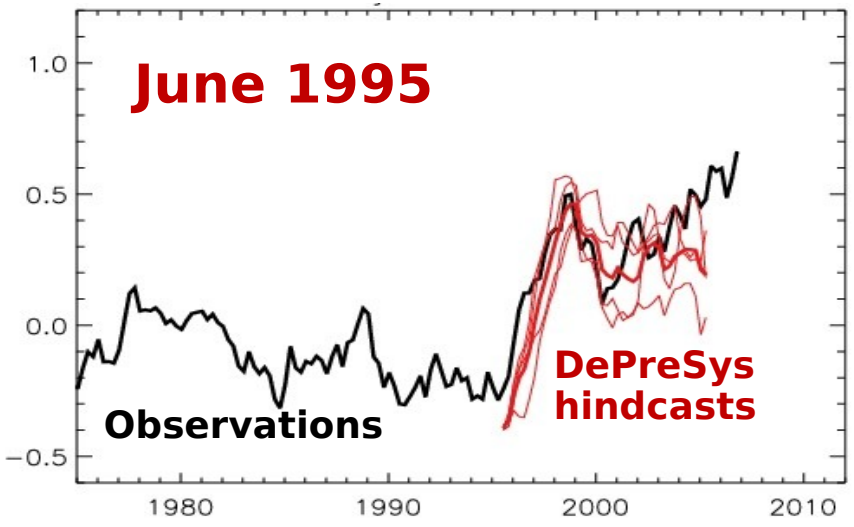

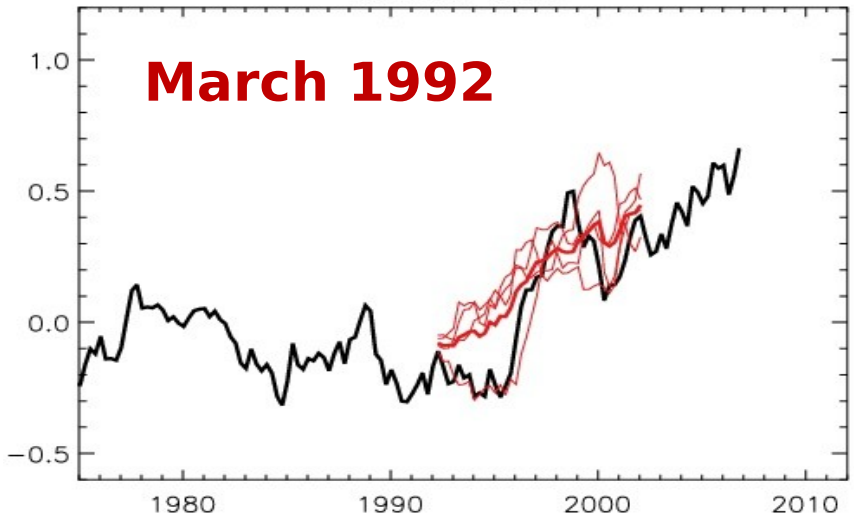

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Summary

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- On decadal and regional scales, the uncertainty from internal variability is large – a case for initialised predictions

- Higher resolution can improve the representation of climate variability and reduce biases. What will this do for forecast skill?

- Examining case studies could be an important method for identifying error growth and evaluating processes in climate models

- Improving models and reducing biases is essential, through both higher resolution and improved parameterisations