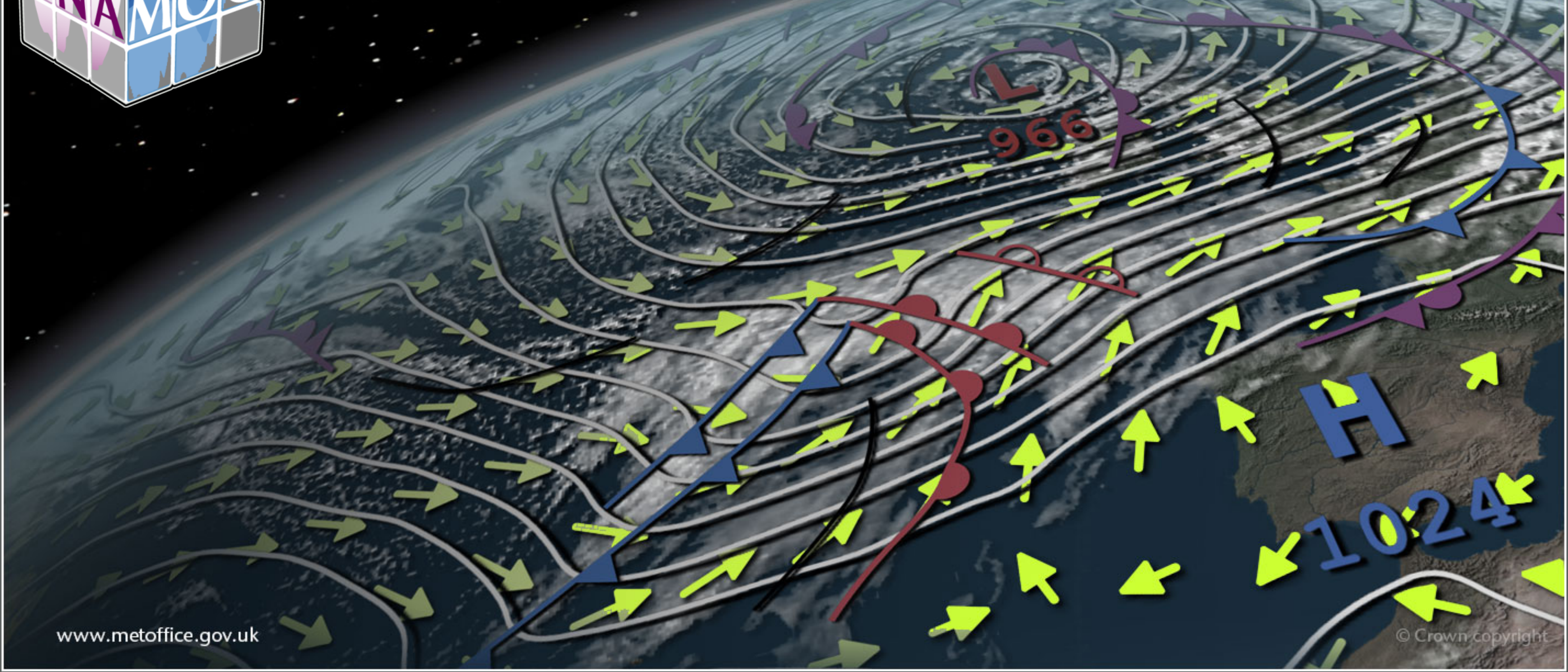
Predicting the high latitude AMOC and its impacts

Leon Hermanson, Nick Dunstone, Doug Smith, Matt Menary

LEFE-IMAGO meeting, 5 May 2017



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Content

- Decadal prediction and the importance of the Atlantic subpolar gyre
- Moving to a high-resolution climate model
- Impacts of the Labrador Sea on decadal prediction
- Impacts of an AMOC slow-down

Benefits of initializing climate predictions

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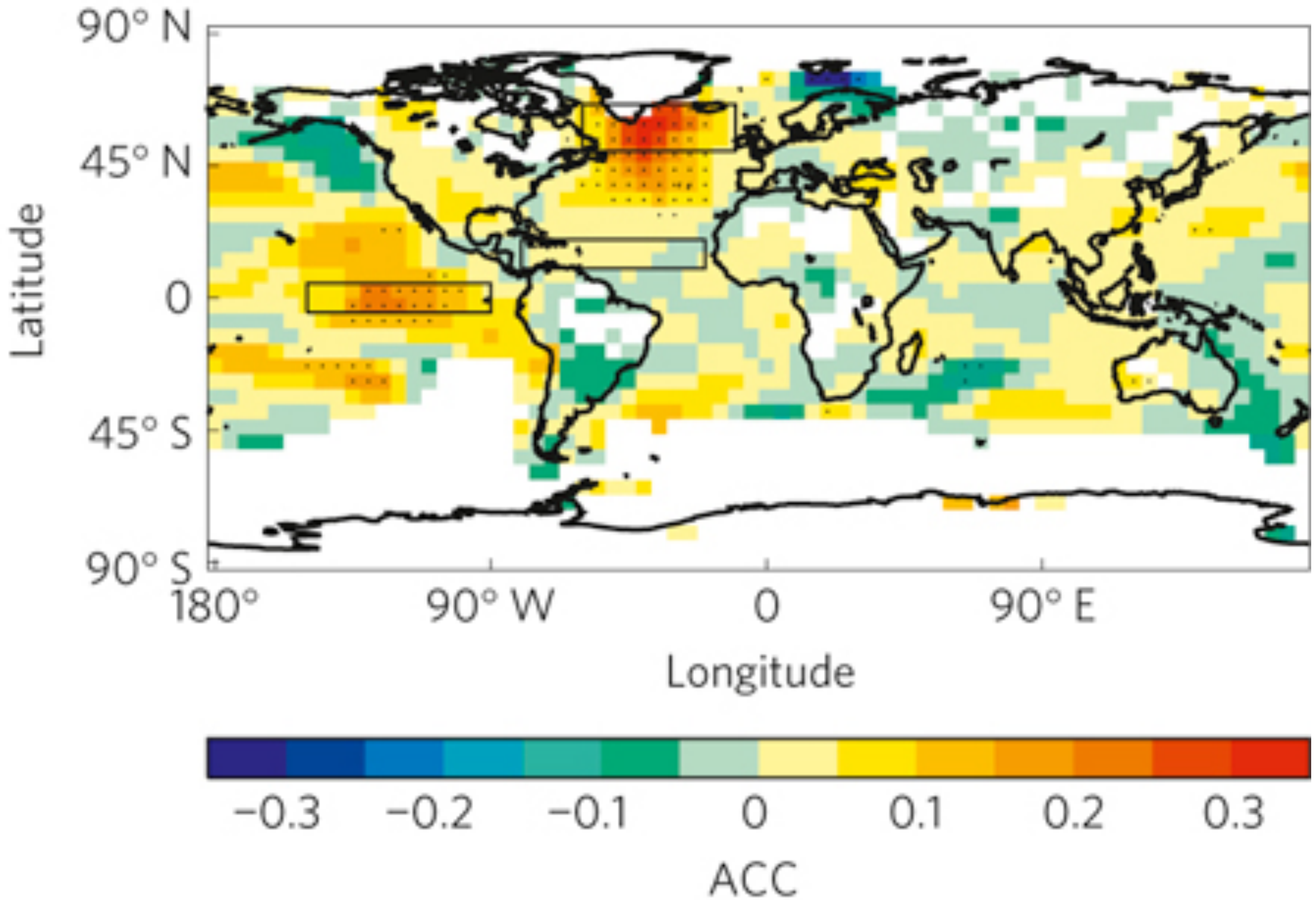
This gives no skill for climate change!



Smith et al, Nat Geos, 2010

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Decadal prediction ensemble of opportunity

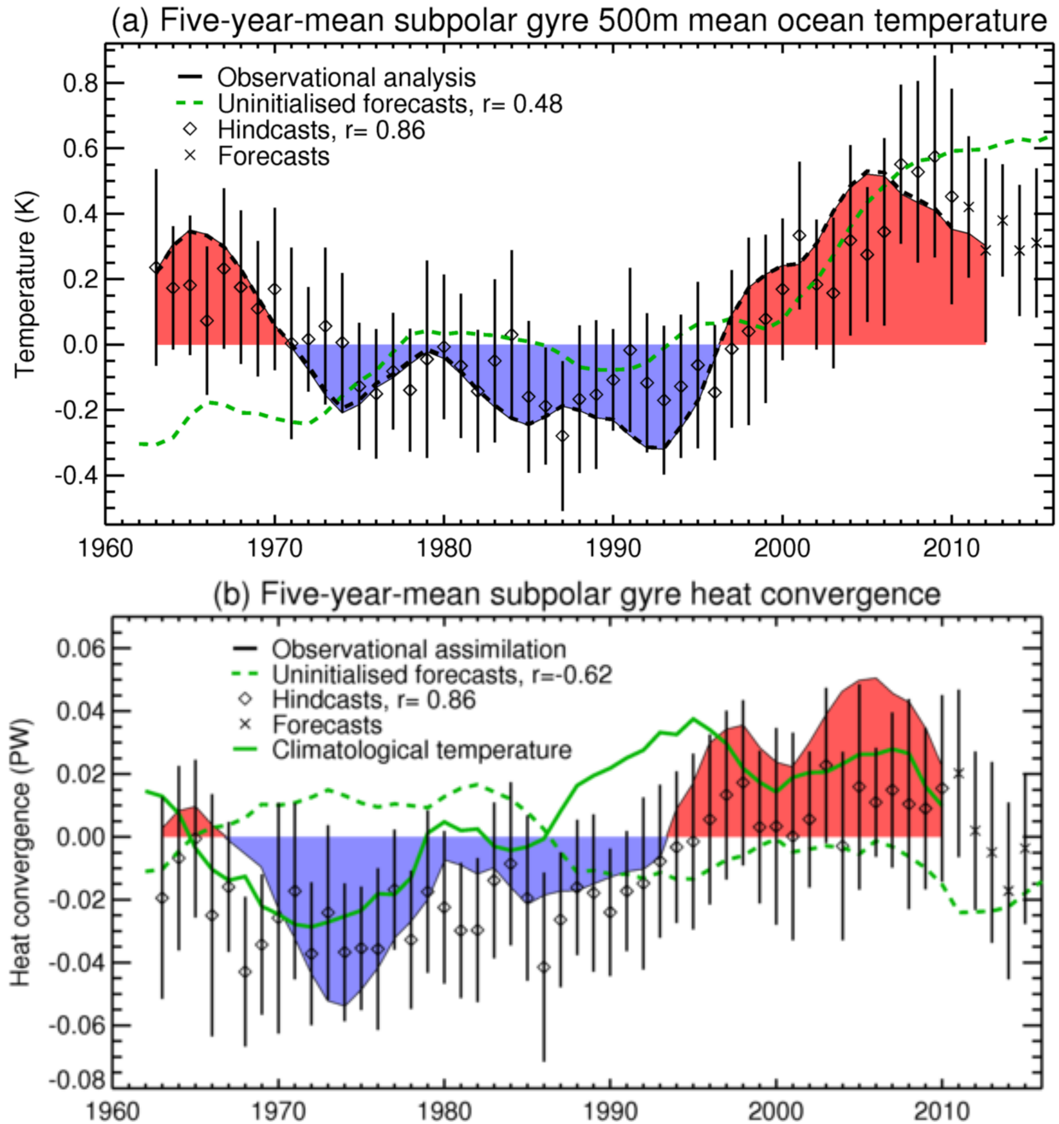
- Three decadal prediction systems
- All anomaly assimilation
- Hindcasts every year 1960-2012

System	Atmosphere	Ocean	Ensemble
DePreSys_CMIP5	2.5°×3.75°	1.25°×1.25°	10
DePreSys_PPE	2.5°×3.75°	1.25°×1.25°	9
DePreSys2	1.25°×1.875°	~1°	4

Hermanson et al, 2014, GRL, 41, 5167–5174

Atlantic subpolar gyre five-year-mean

Initialised forecasts are better at predicting subpolar gyre temperature changes and the dynamics that drive the changes than without initialisation



Hermanson et al, 2014

Density trends 1200-3000m

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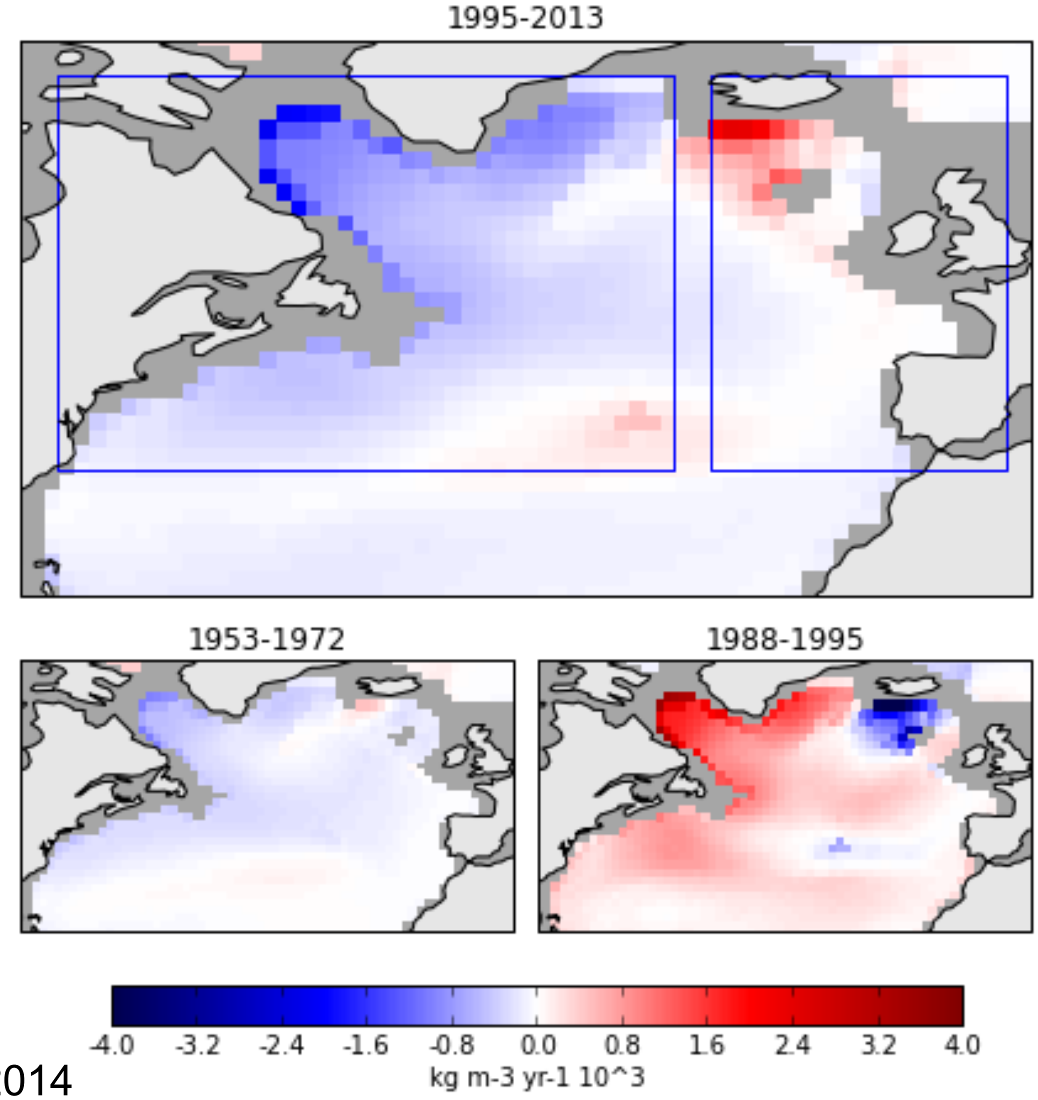
We think the deep density structure in the North Atlantic subpolar gyre region is strongly linked to the Atlantic meridional overturning circulation (AMOC)

Recent trends in density show similarities with the pattern from years linked to past changes in the Atlantic subpolar gyre temperatures



Hermanson et al, 2014

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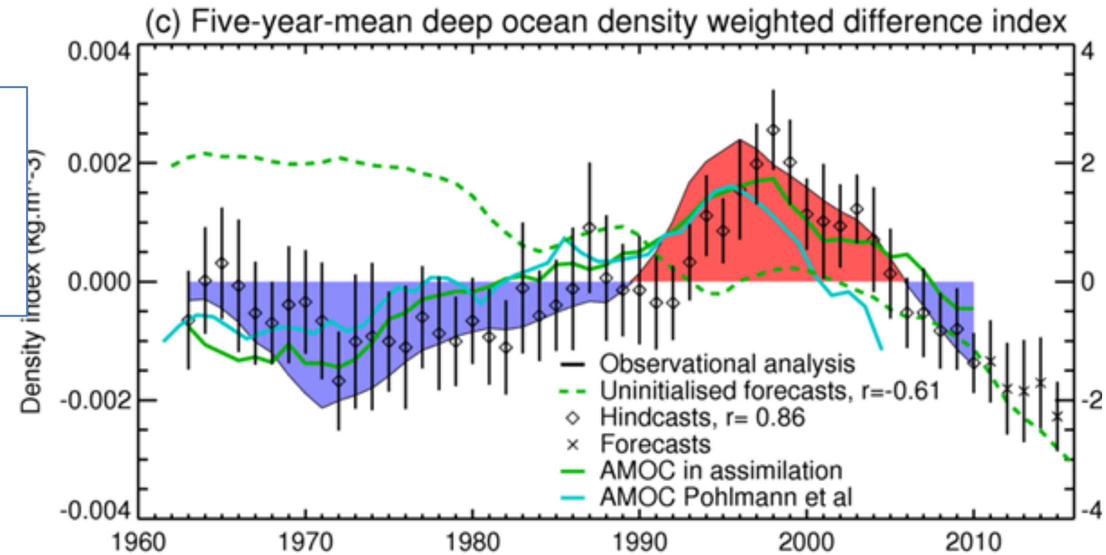
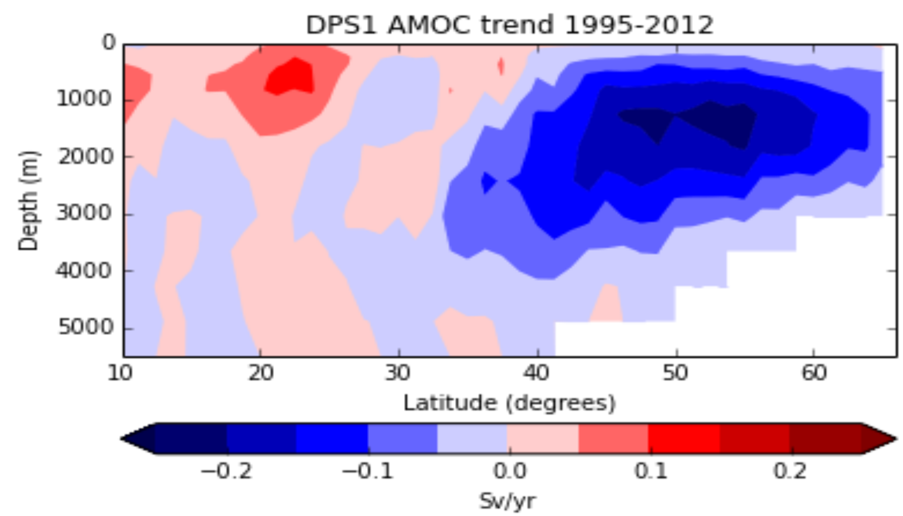
Deep density predictions

The deep density is well predicted and is related to the AMOC at 45°N in many models

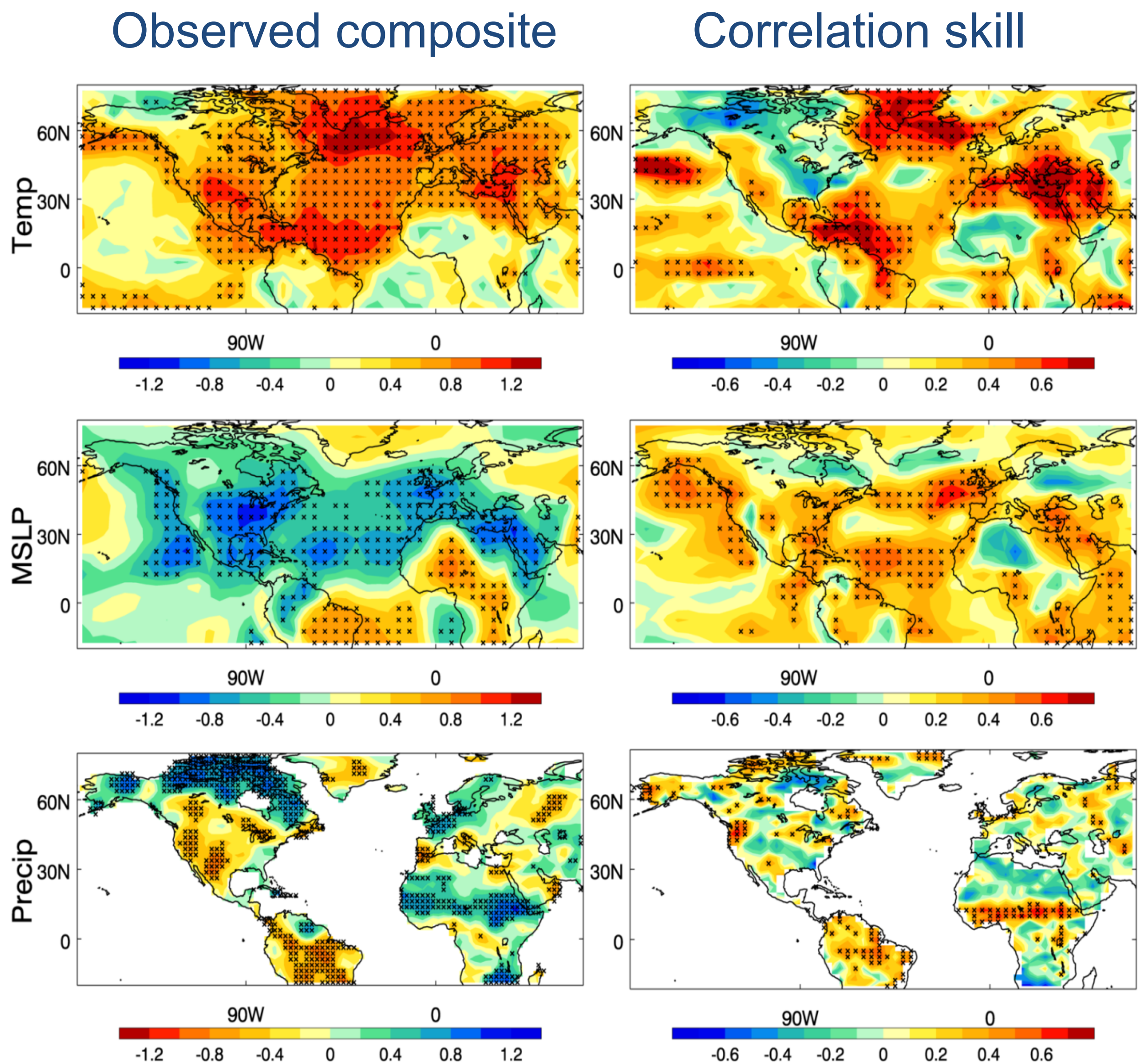


DePreSys_CMIP5 assimilation shows a deep trend signal focussed in the subpolar gyre



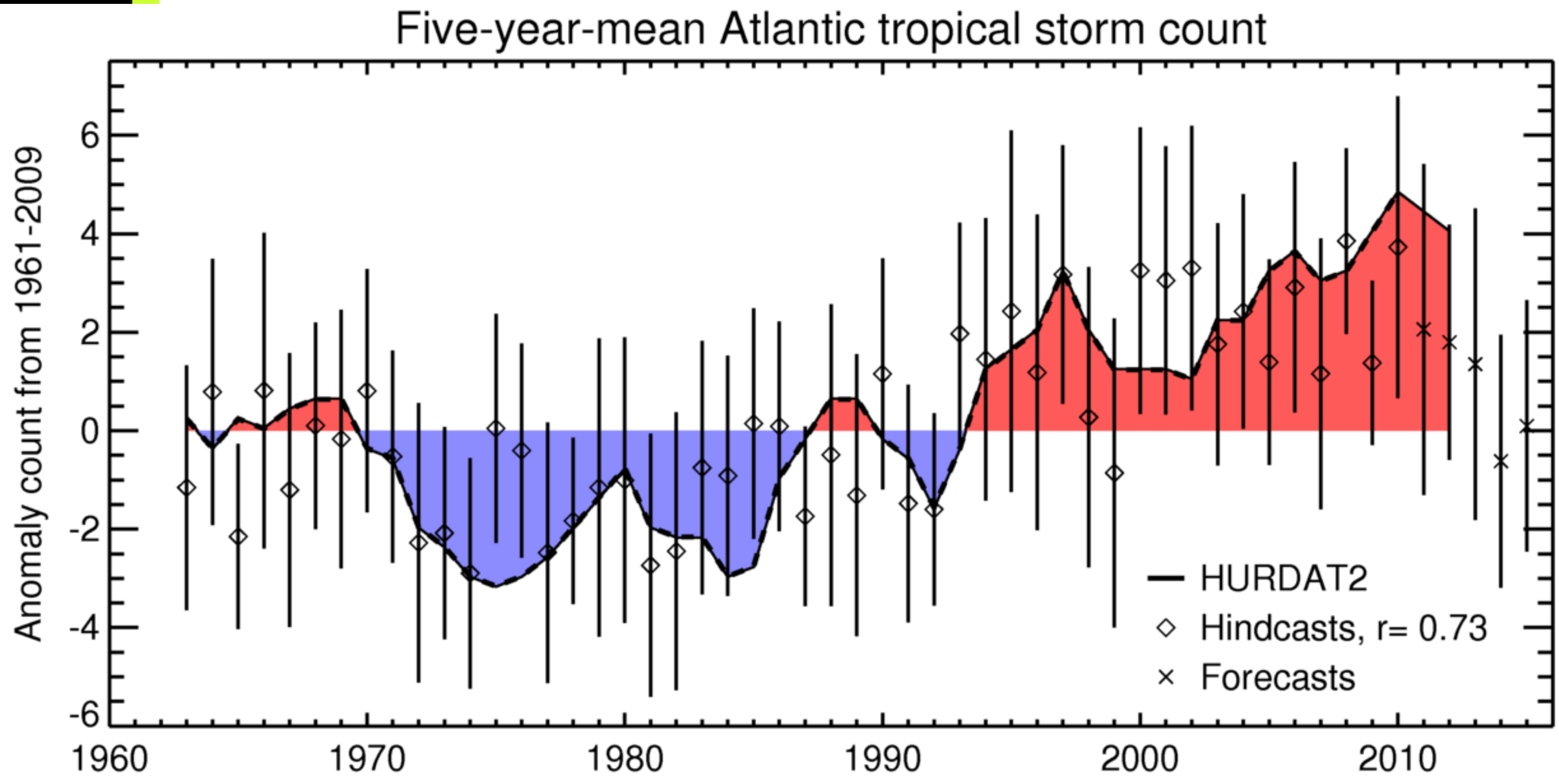
Hermanson et al, 2014

Surface impacts JJA of North Atlantic



Three versions of the Met Office Decadal Prediction System (DePreSys1/2) are combined into a grand ensemble

Impact on Atlantic tropical storm count



Hermanson et al, 2014

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High(er) resolution decadal prediction

- Same model as seasonal predictions
- Full-field assimilation
- Hindcasts every 2/3 years 1960-2014

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DePreSys_PPE	2.5°×3.75°	1.25°×1.25°	9
DePreSys2	1.25°×1.875°	~1°	4
DePreSys3	0.55°×0.833°	~0.25°	10

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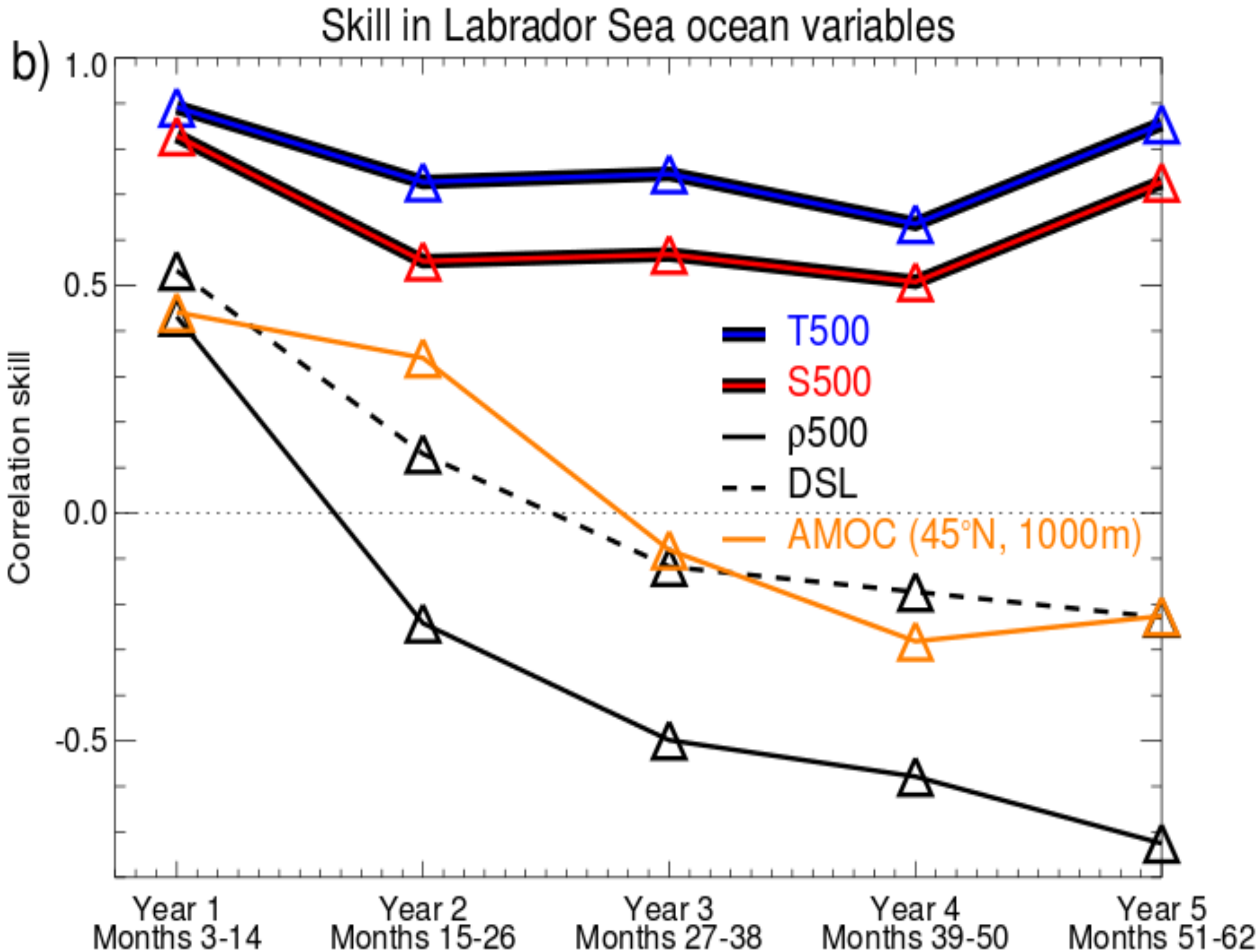
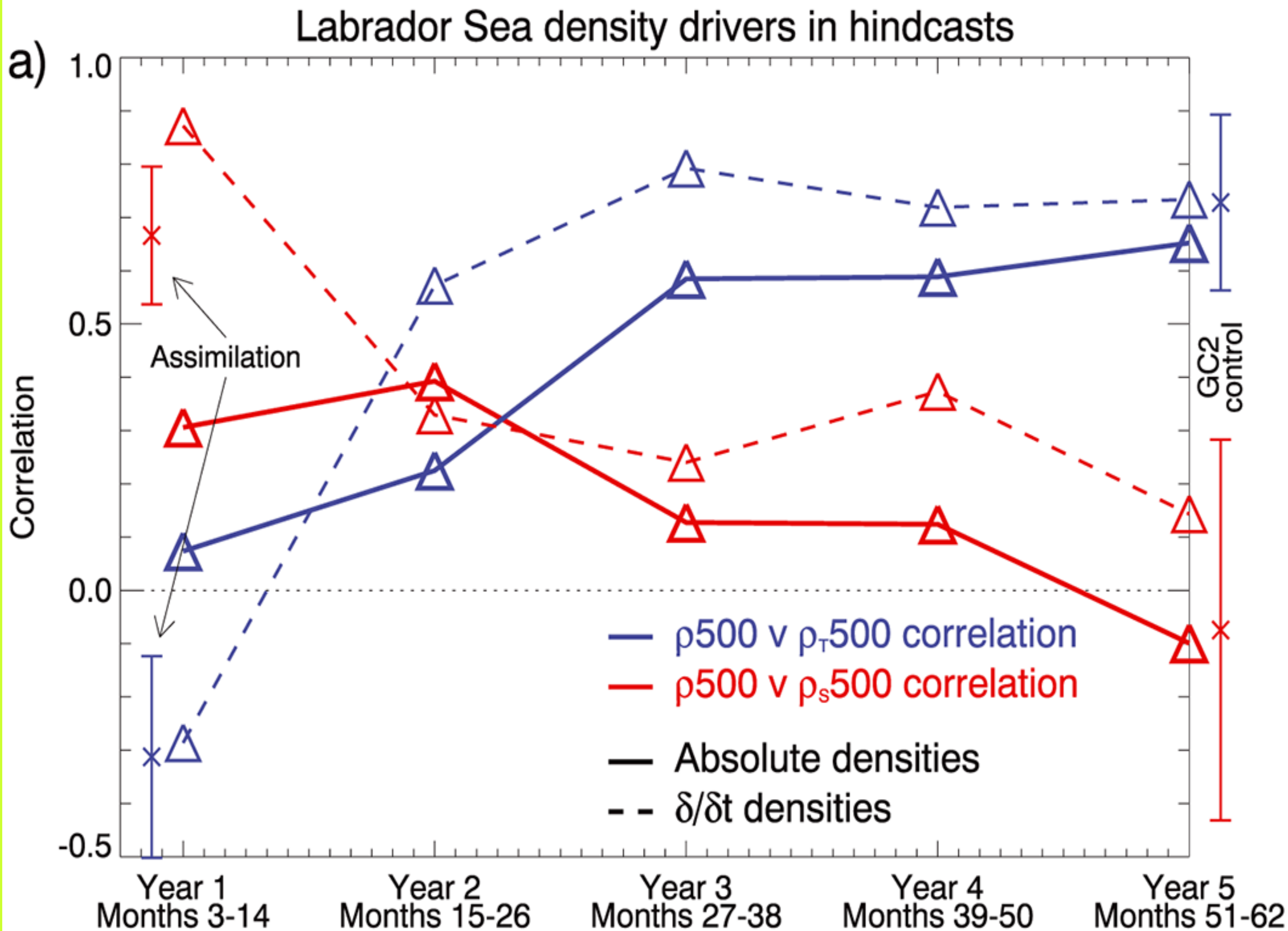


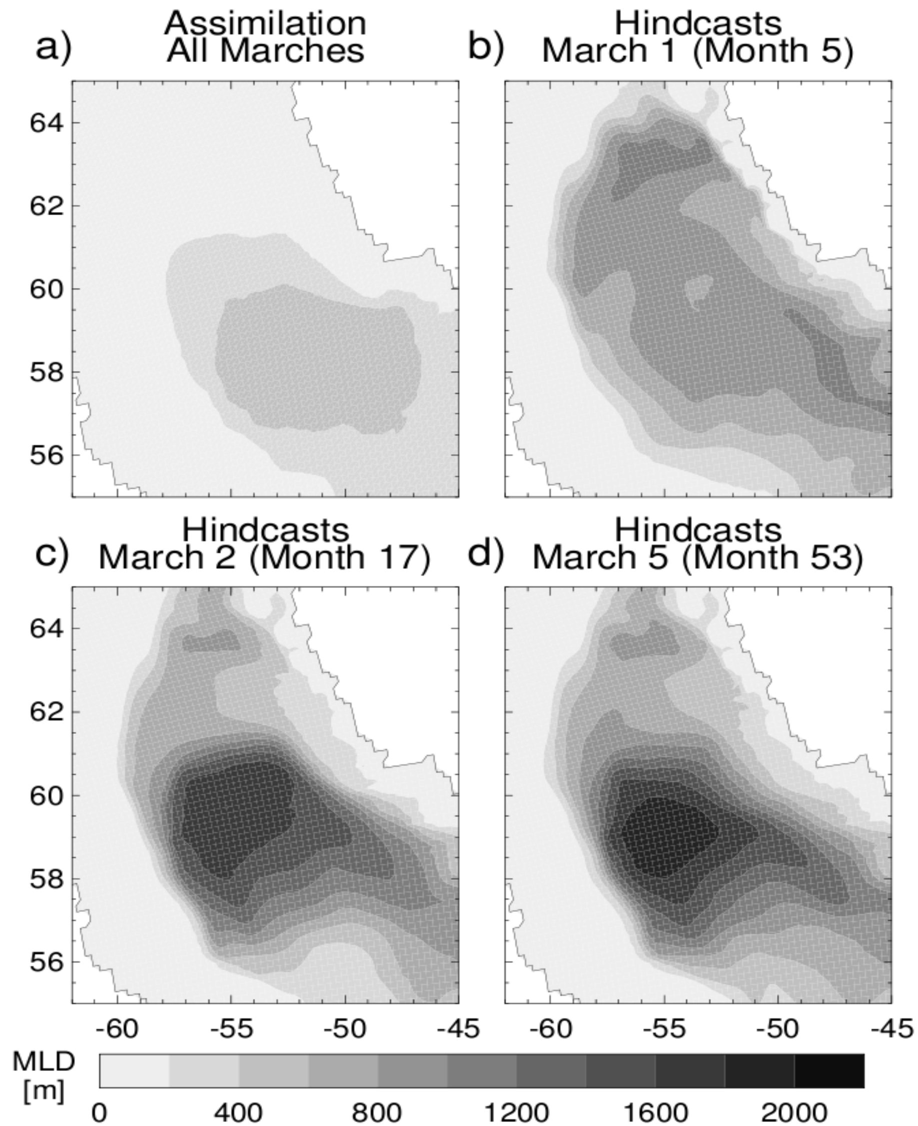
Menary et al
(2016, GRL)

www.metoffice.gov.uk



Menary et al (2016, GRL)

Labrador Sea March MLD



Menary et al (2016, GRL)

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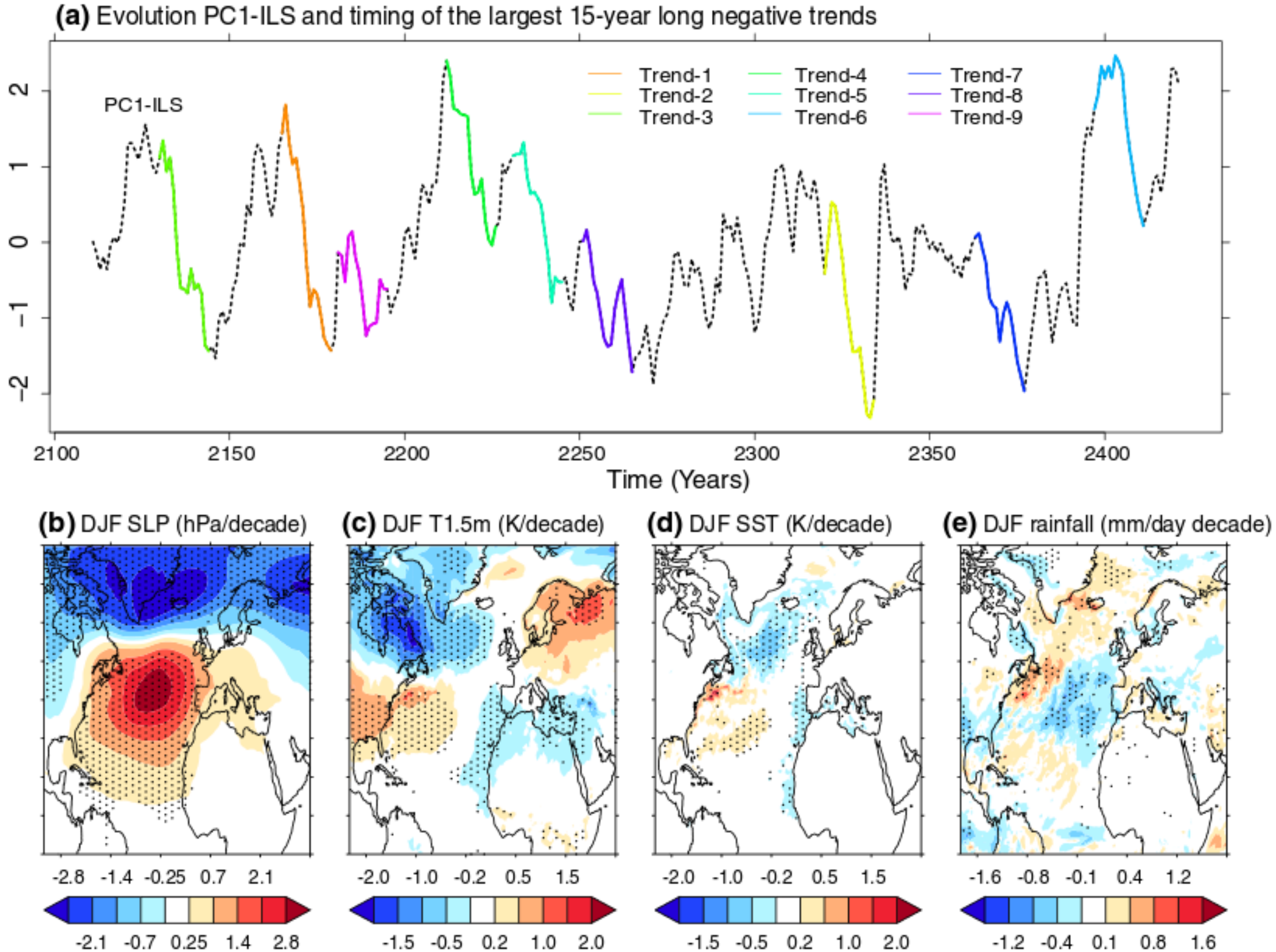
Impacts of density decreases in the Labrador Sea in a **control run**



Ortega et al, 2016, Clim Dyn

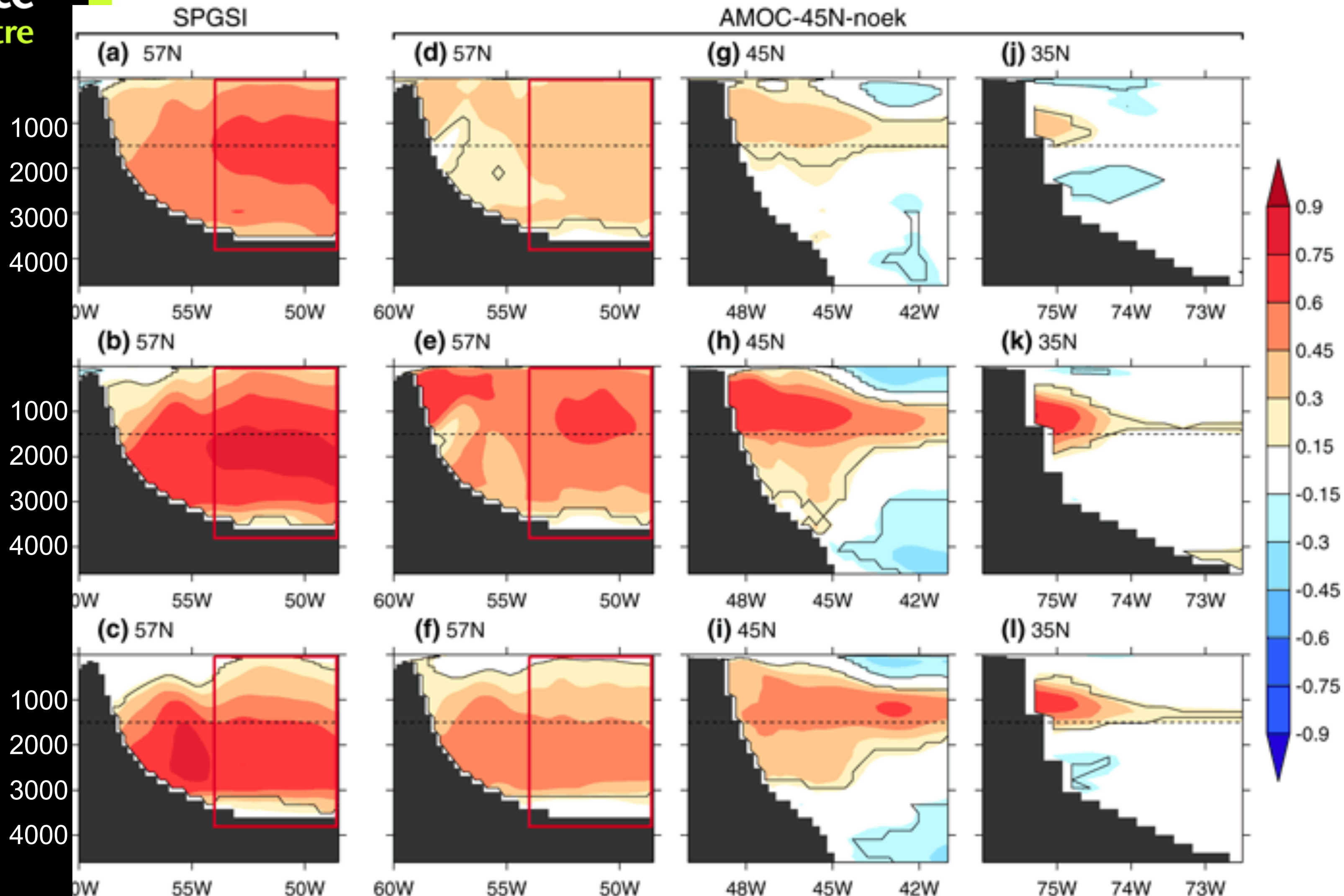
Density-AMOC correlations in coupled control

Lag (years)

-2

0

+2



Ortega et al, 2016

Fresh water hosing in the North Atlantic of a high resolution coupled model

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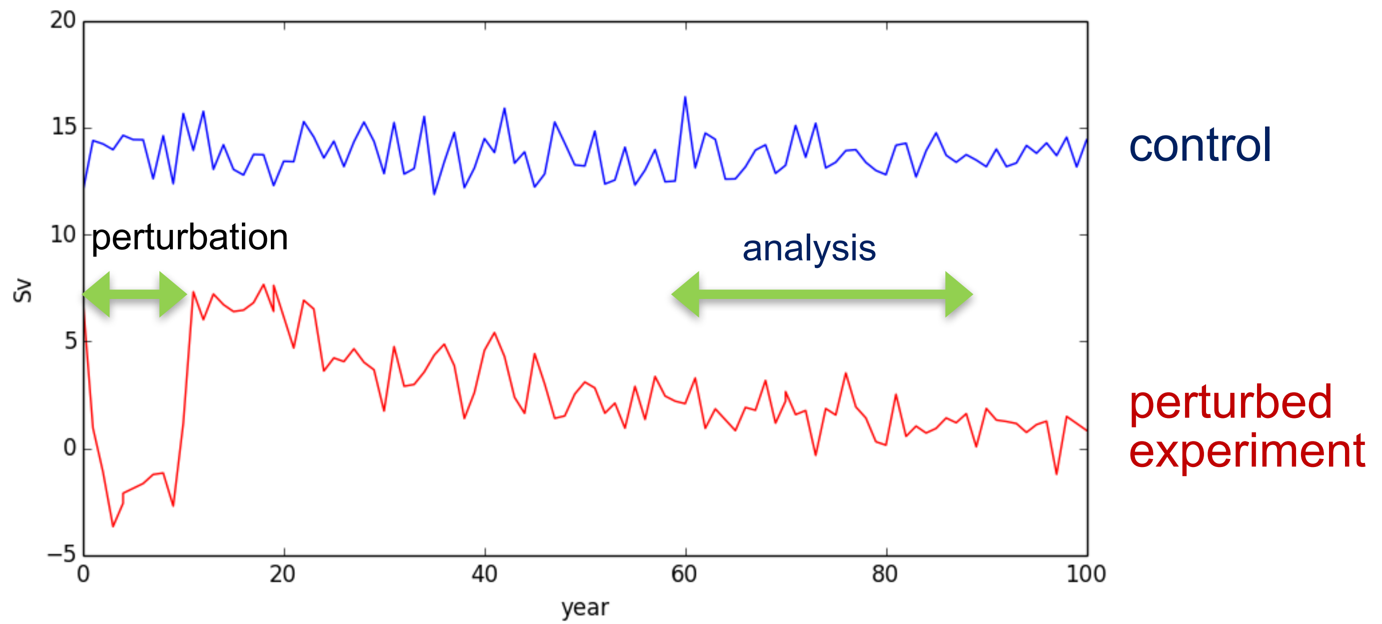
AMOC
26° N



Used idealised forcing (salinity perturbation over first 10 years – equivalent to 100 Sv yrs of fresh water) to weaken AMOC.

The MOC weakens from 14Sv to ~ 2Sv and stays in this weak state for at least 100 years

Impacts are assessed from years 60-90

Jackson et al, 2015, Clim Dyn

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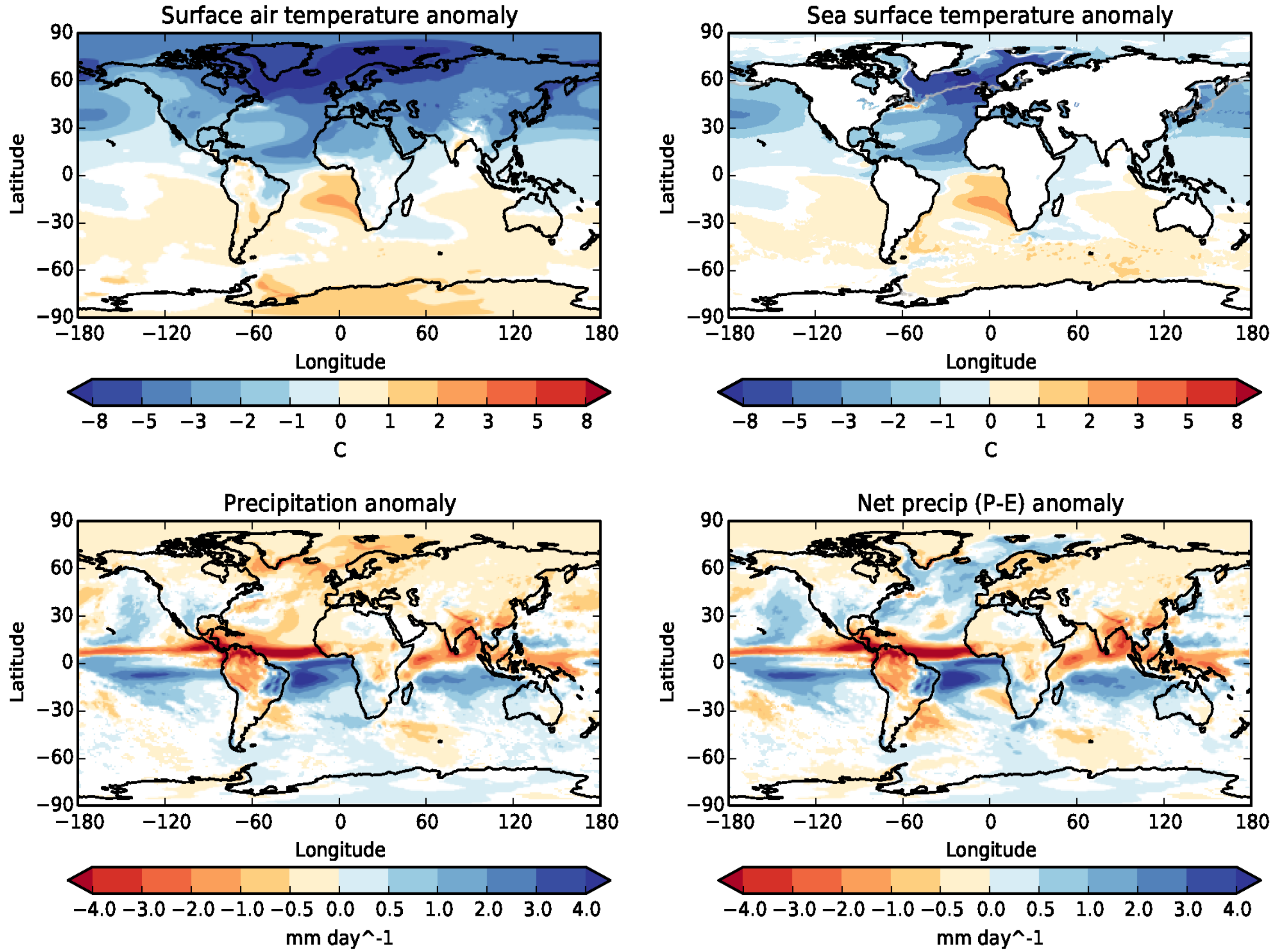
Global impacts of AMOC collapse

30 year analysis period compared to control



Jackson et al, 2015, Clim Dyn

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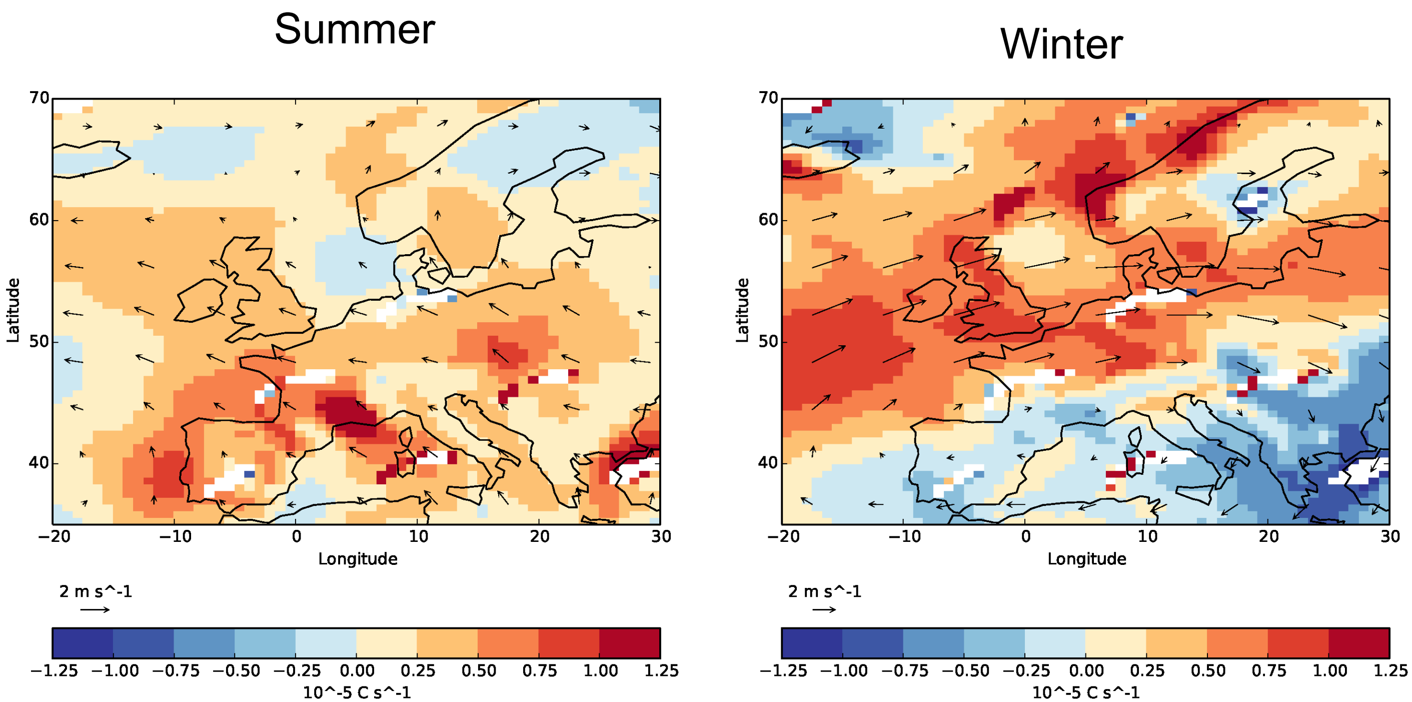
Thermal advection anomaly

Mitigating circulation effects



In summer the westerlies weaken, reducing the cooling effect of the onshore wind → relative warming on land

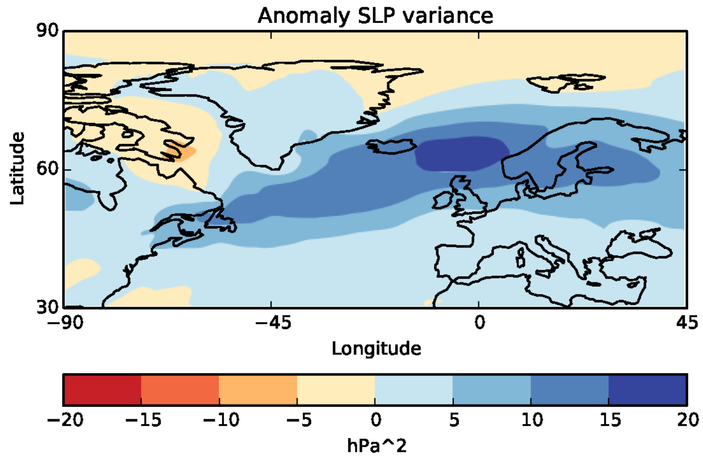
In winter the westerlies strengthen, increasing the warming effect of the onshore wind → relative warming on land

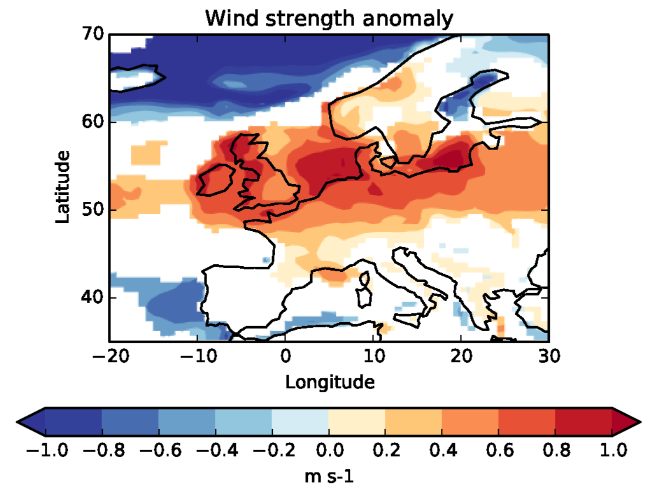
Circulation changes contribute to less cooling on land

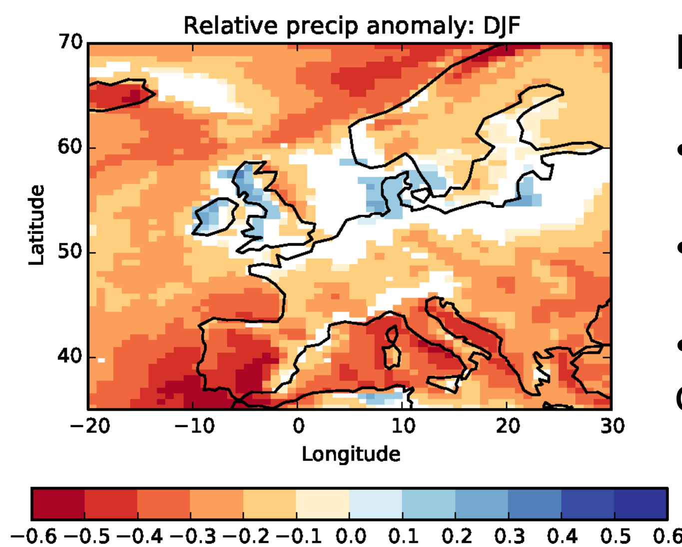
Jackson et al, 2015, Clim Dyn

European precip - winter

Increasing storm track







More positive winter NAO →

- Stronger winds over N Europe
- More winter storms
- More precipitation from storms on western coasts of N Europe

Jackson et al, 2015, Clim Dyn

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Summary

- Decadal prediction derives important skill from the AMOC and its impacts on the land masses surrounding the Atlantic
- Moving to a high-resolution ocean model means we may have to rethink our AMOC mechanisms (climate scientists at least!)
- Decadal prediction skill can be severely reduced by drifts in the Labrador Sea
- Impacts of an AMOC slow-down:
  - wide spread cooling
  - reduced precipitation
  - strengthened storm track
  - higher resolution models have allowed a better understanding of how changes in circulation can counteract some changes over Europe