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Decadal prediction of the North Atlantic subpolar gyre in the HiGEM high-resolution climate model

Jon Robson

(NCAS-Climate, University of Reading)

Thanks to: Irene Polo, Dan Hodson, Len Shaffrey and David Stevens (UEA)

EGU 2017

NERC SCIENCE OF THE ENVIRONMENT

DYNAMOC

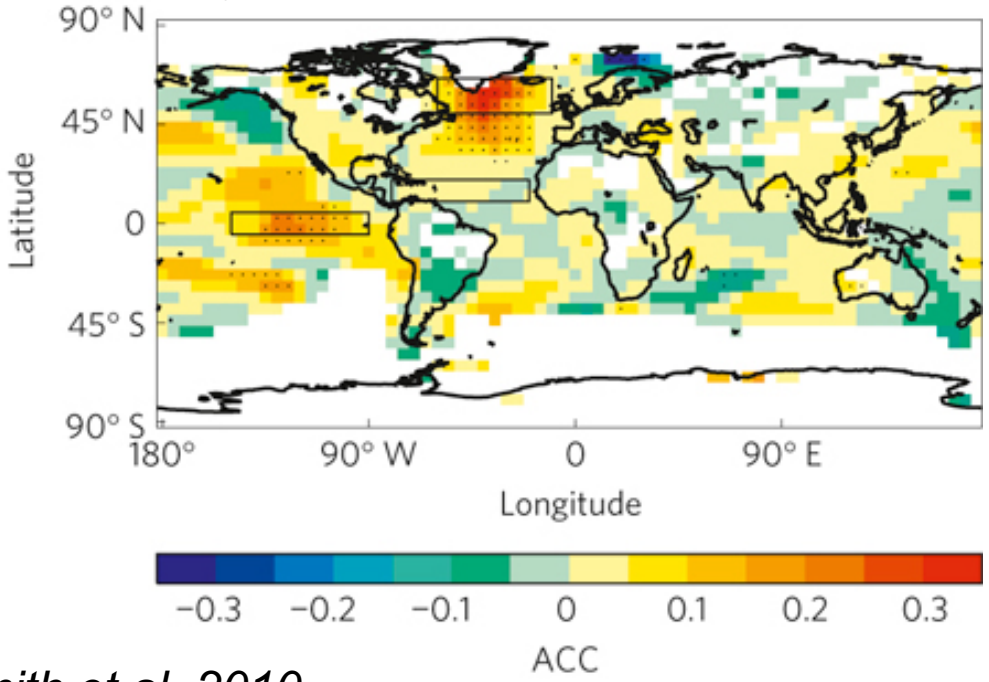
SPECS
Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

ACSIS

Skill in initialised decadal predictions

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Improvement in ACC for year 1-5 JJASON for SAT from DePreSys



Smith et al, 2010

The North Atlantic subpolar gyre is often one of the most improved regions in decadal predictions

Skill is thought to be due to predictable changes in ocean heat content
See ***Yeager and Robson, 2017; Recent Progress in Understanding and Predicting Atlantic Decadal Climate Variability*** for a review

However, thus far, analysis of hindcasts has usually focused on only one case-study or has used low-resolution models.

In this talk we will examine predictions made with a "high-resolution" decadal prediction system to test the sensitivity of the results

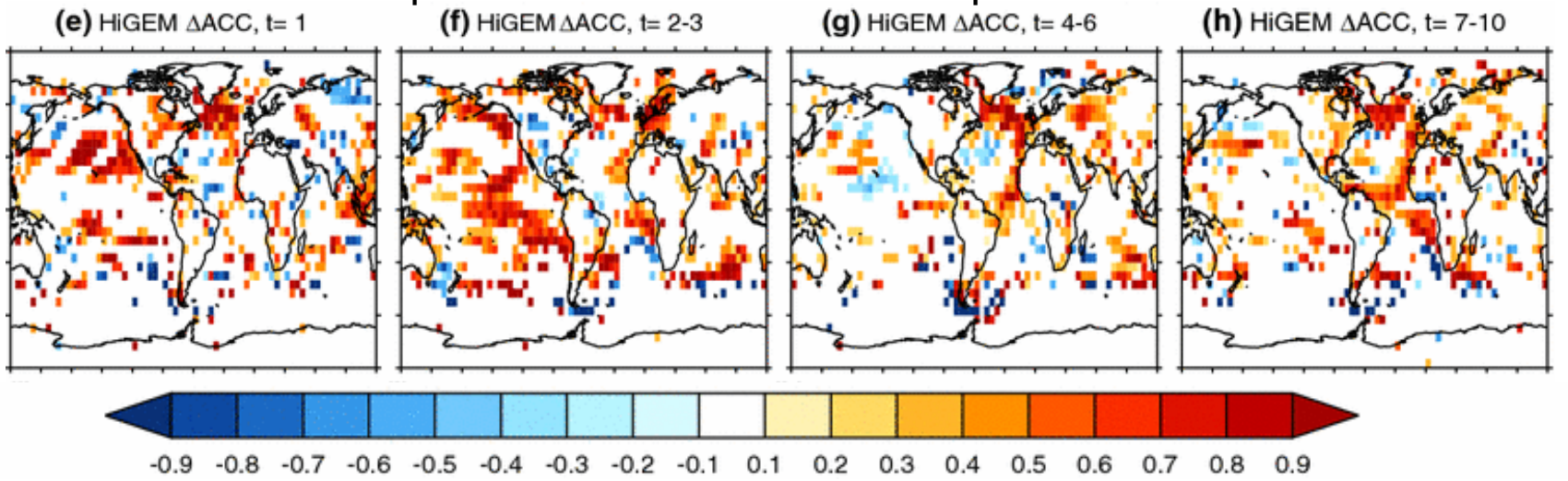
Most of these results will be appearing in Robson et al, 2017, Climate dynamics, accepted

HiGEM decadal predictions

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- Decadal prediction system, based on *HiGEM model*
  - 1/3° ocean (eddy-permitting) and 90km atmosphere
  - 4 Member ensembles generated following the CMIP5 protocol. I.e. hindcasts every 5 years from 1960 – 2005. Additional hindcasts in 1991, 1992, 1993 and 1994
- 3D T and S **anomalies** are assimilated into the ocean by relaxing to the model climate *plus* the observed anomalies.

Improvement in surface air temperature skill



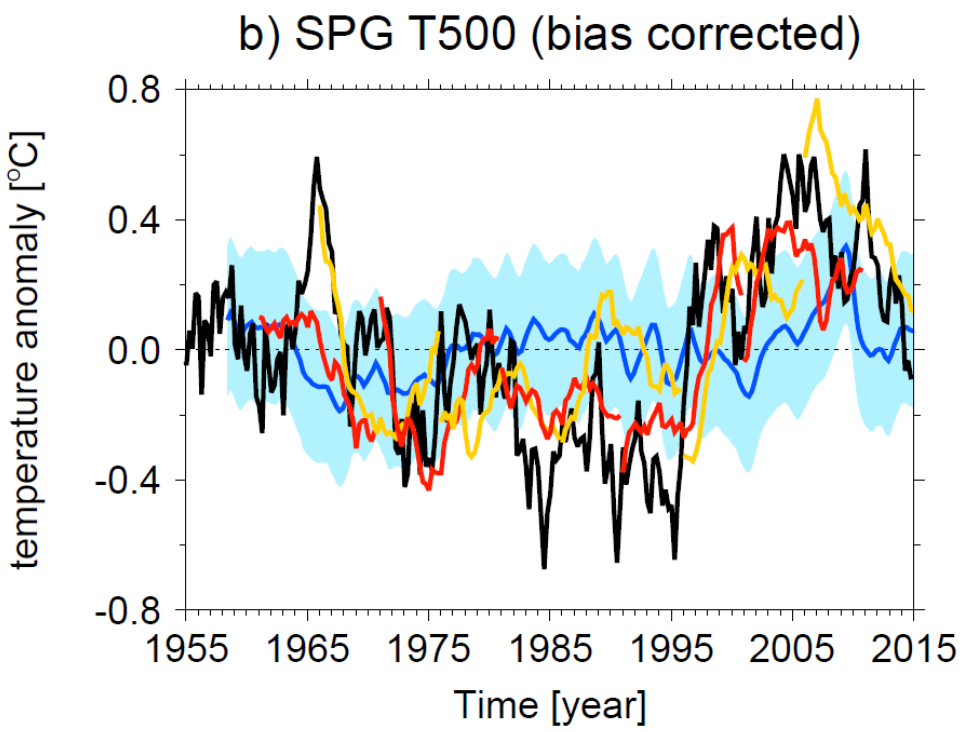
Is the improved skill in surface temperature related to predictions of the SPG heat content?

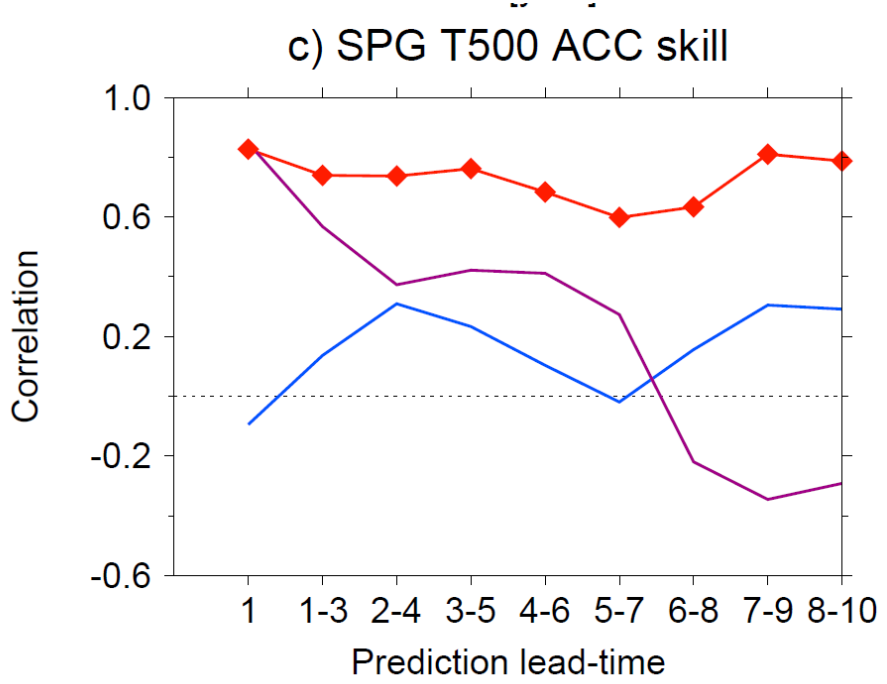
Find out more in ***Shaffrey et al, 2016; Climate Dynamics***

Predictions of the North Atlantic subpolar gyre

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HiGEM-DP
Transients
Obs





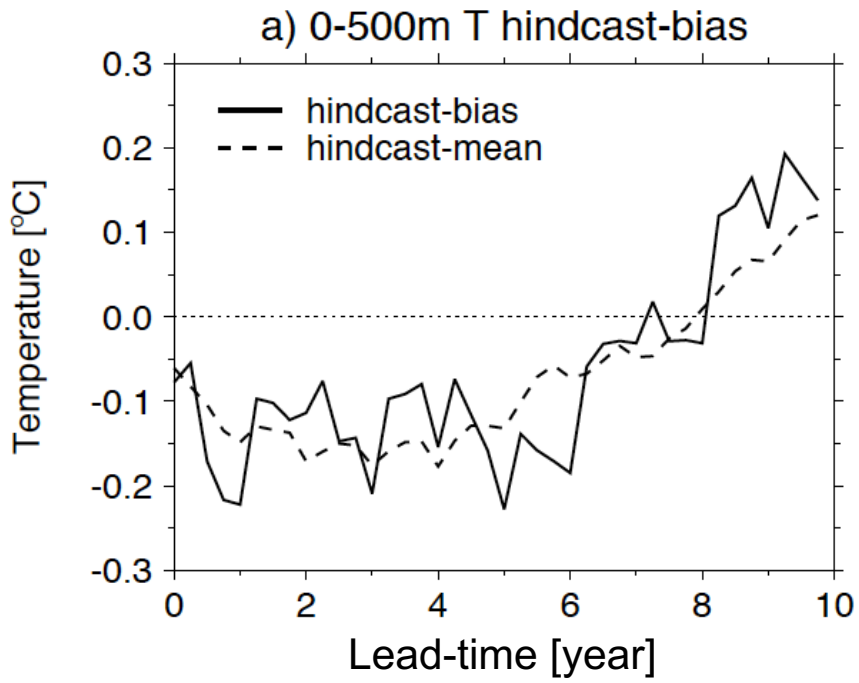
HiGEM-DP
Transients
Persistence

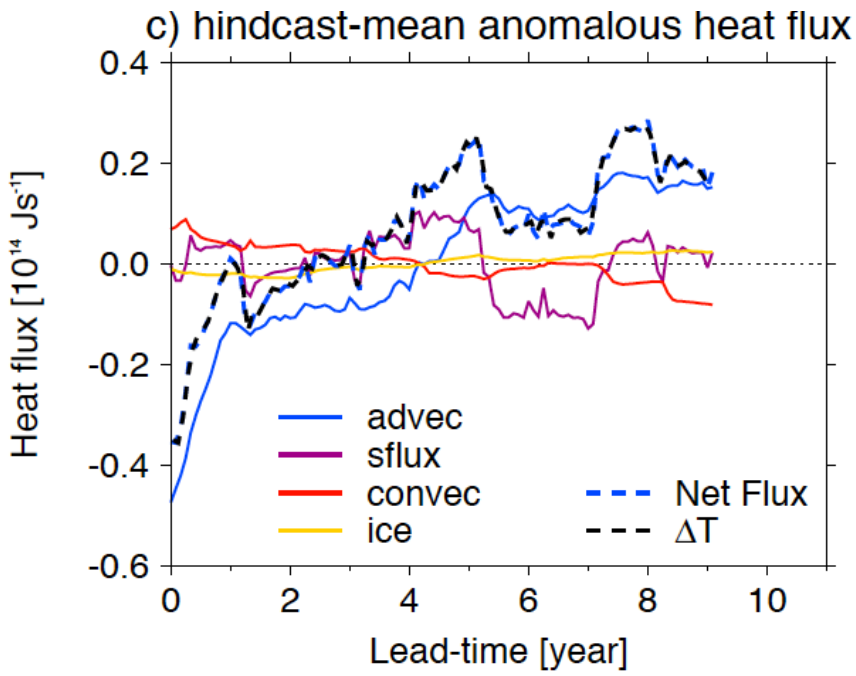
Subpolar gyre mean (60-10W:50N-65N)
0-500m heat content

HiGEM-DP is able to capture the skill in the SPG heat content, and improves significantly on the HiGEM transient runs and persistence.

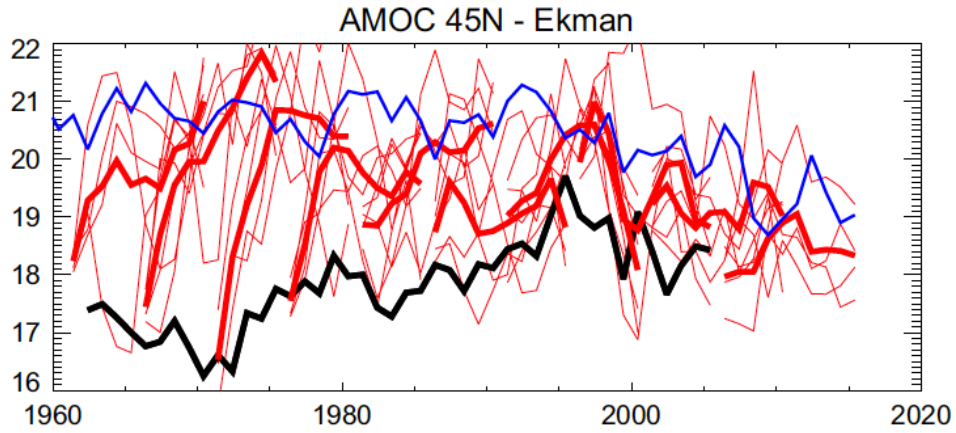
Heat budget analysis and SPG drift

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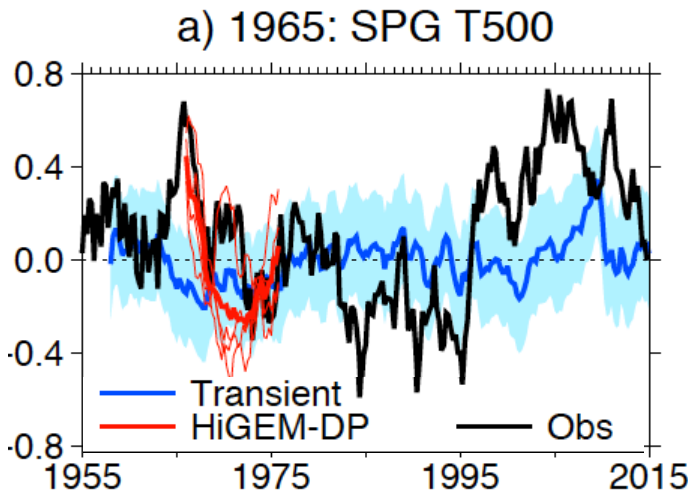


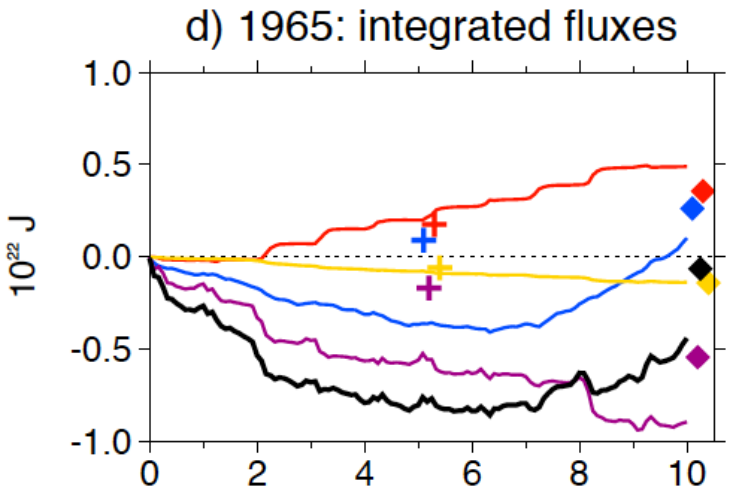
- HiGEM-DP does still have a significant model drift. Cooling initially before warming.
- Drift is primarily related to the initialization of an erroneous weak AMOC which subsequently spins up



1960s cooling

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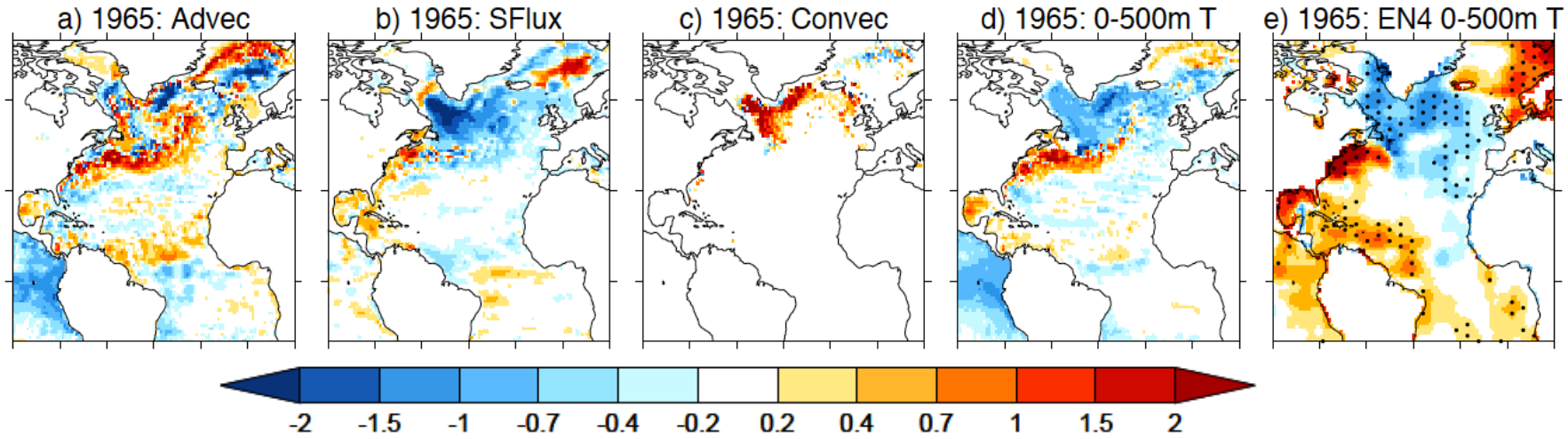




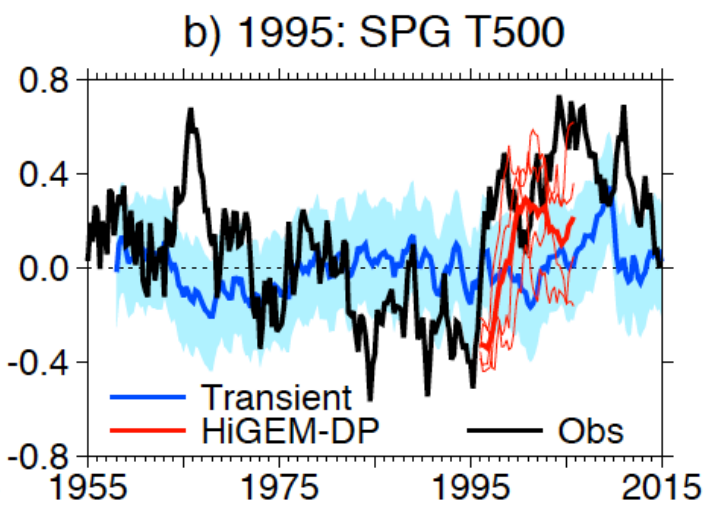
Advection
Surface flux
Convection
Ice
total

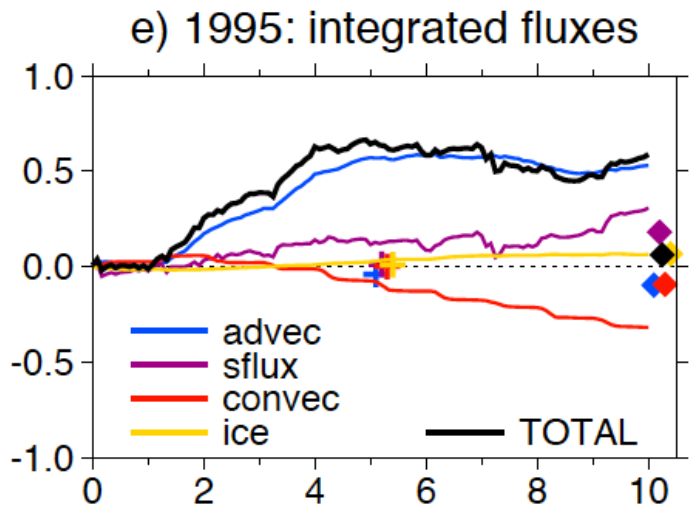
Surface heat fluxes and weak ocean advection dominates initial cooling.

Note: Erroneous drift in AMOC causes warming at long lead-times



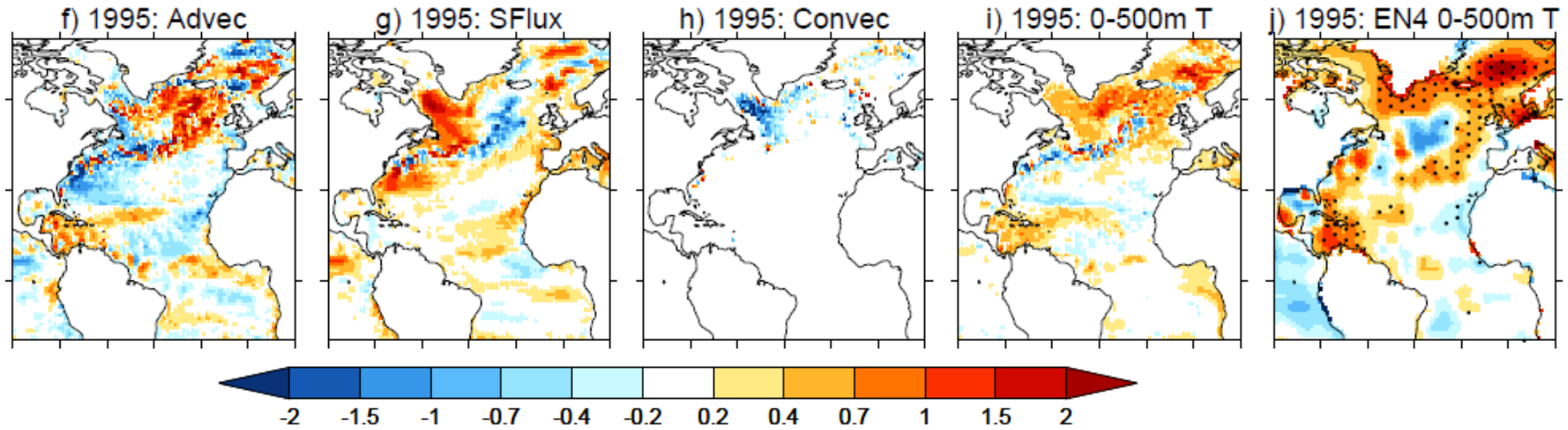
1990s warming



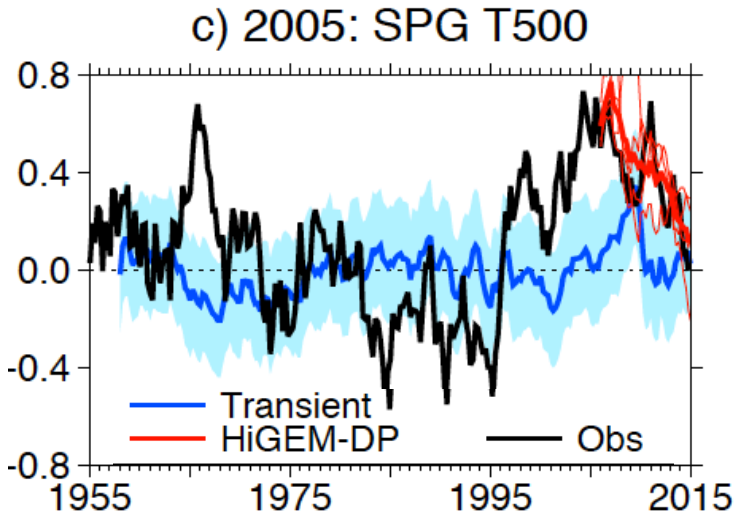


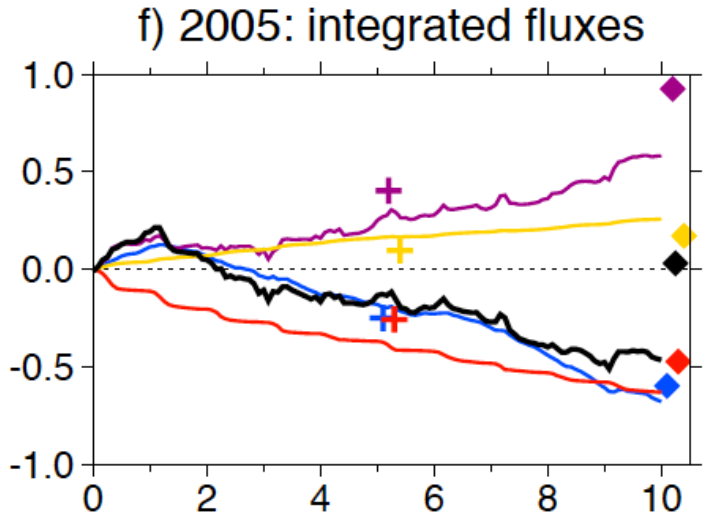
Ocean heat transport convergence in the SPG dominates the mid 1990s warming, similar to previous studies. I.e. *Robson et al, 2012*

Ocean advection is particularly important for the eastern SPG

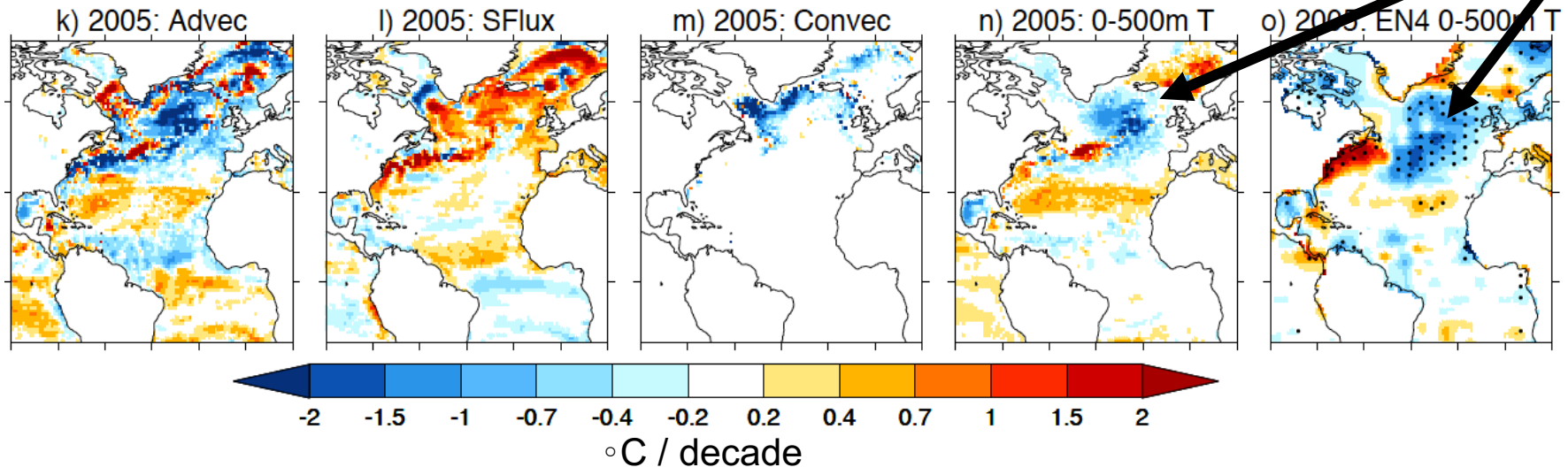


2000s cooling





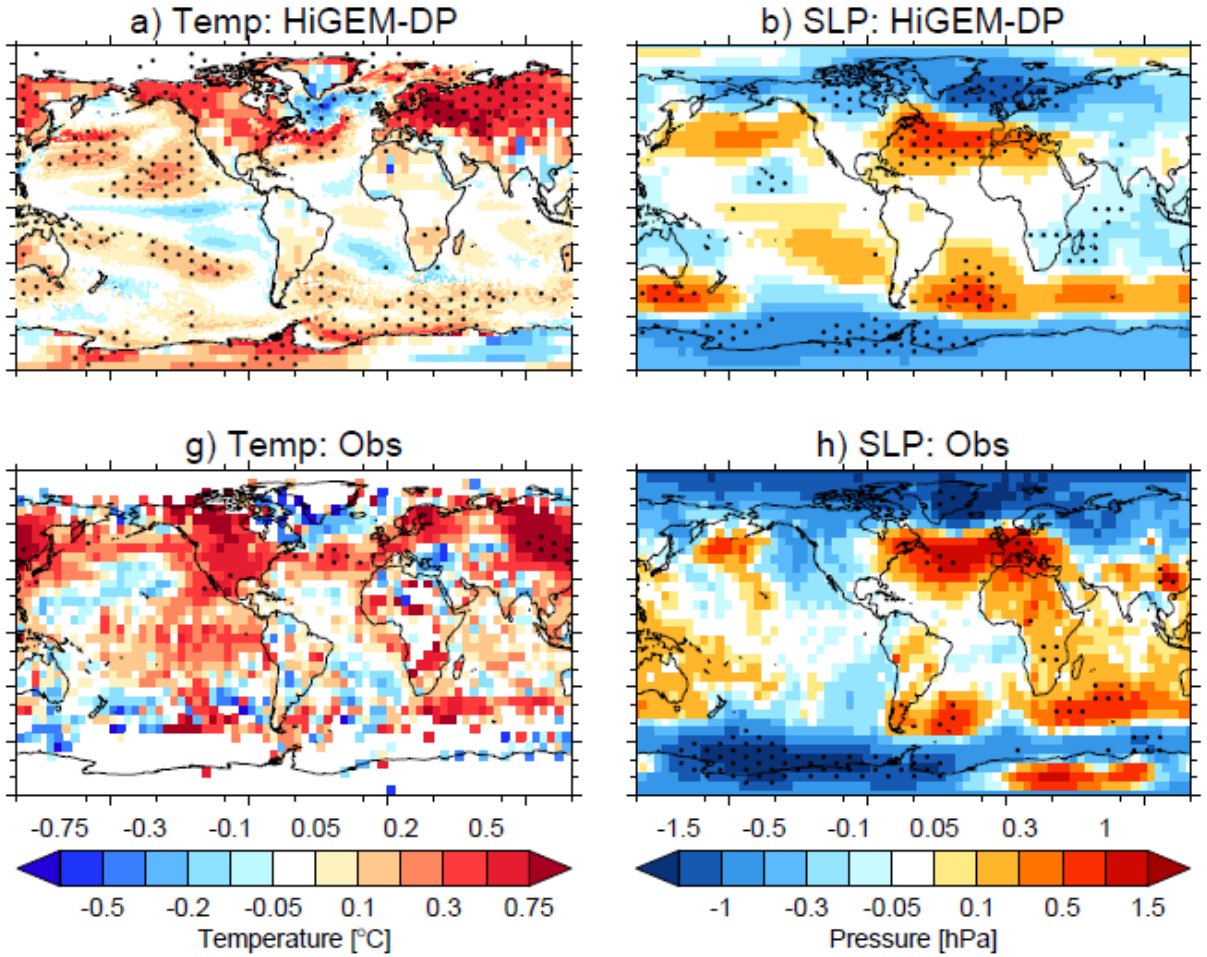
Advection
Surface flux
Convection
Ice
total



- Predicted cooling agrees with observational analysis **Robson et al, 2016, Nat Geosci**

Surface climate impacts

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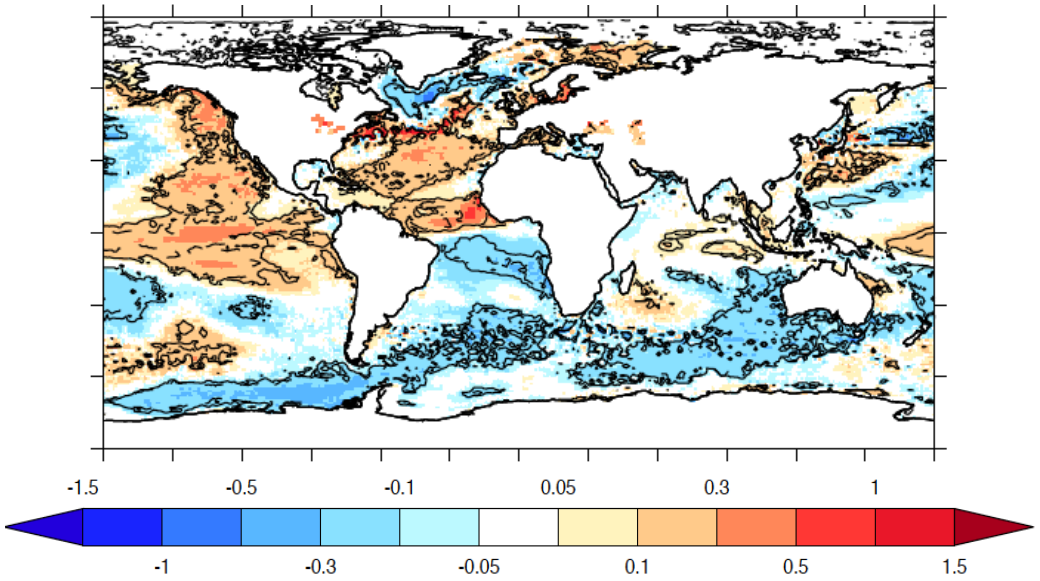


- Average of hindcasts initialised every year between 1990-1995 [NDJFM]
- Similar to pattern which leading AMOC increase in the HiGEM control
- Important to highlight that there is no mean skill for NAO
- Did the initialisation of the ocean help to maintain the positive NAO in the early-1990s?

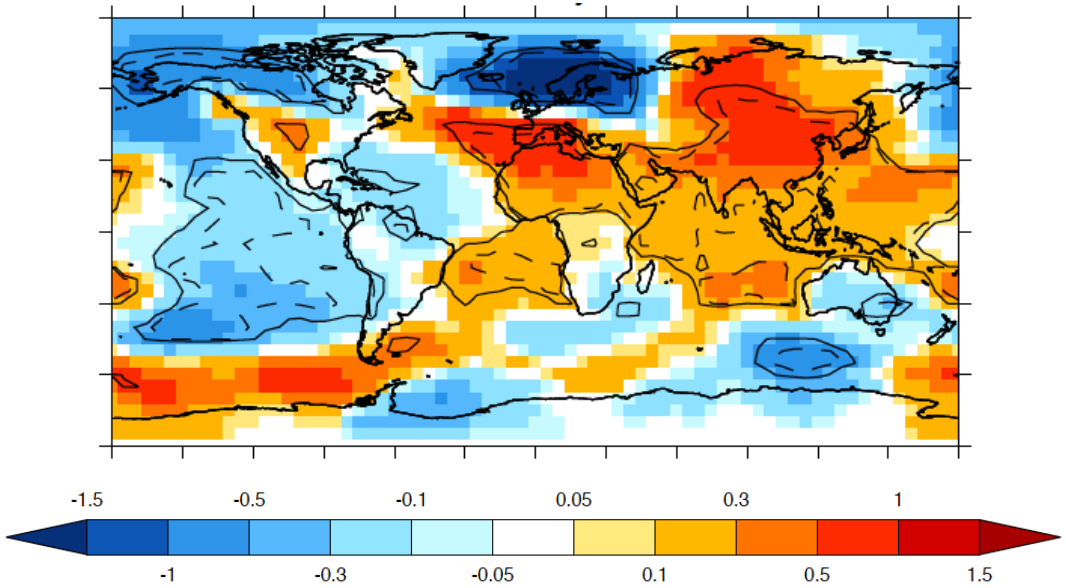
The impact of the SPG

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SST Difference, years 1-5



SLP Difference, years 1-5



- HiGEM-DP hindcasts for 1994 and 1995 have been re-run, ***but*** now with the SPG initialized from climatology
  - cf Dunstone et al, 2013 and DCPP C
- Suggests initialization of SPG important for NAO prediction?
- <u>Analysis is ongoing and so these are preliminary results</u>

Conclusions

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- HiGEM-DP successfully captures the observed shifts in the North Atlantic SPG heat content, consistent with previous studies.
- These results are supportive of previous studies conclusions, i.e. that the initialization ocean heat transport is key to capture the shifts in the SPG
  - This is especially true for the Eastern SPG, but changes in surface heat fluxes are more important in the west.
  - However, surface fluxes are more important for 1960s cooling, and the role of ocean circulation anomalies at the latitude of the SPG is smaller in HiGEM.
- HiGEM-DP appears to capture a tendency for strong positive NAO in the early 1990s
  - Sensitivity experiments suggest that the initialization of the SPG may have played an important role in the predictions of the NAO, but analysis is still ongoing