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Decadal prediction and internal North Atlantic variability

Jon Robson

NERC SCIENCE OF THE ENVIRONMENT

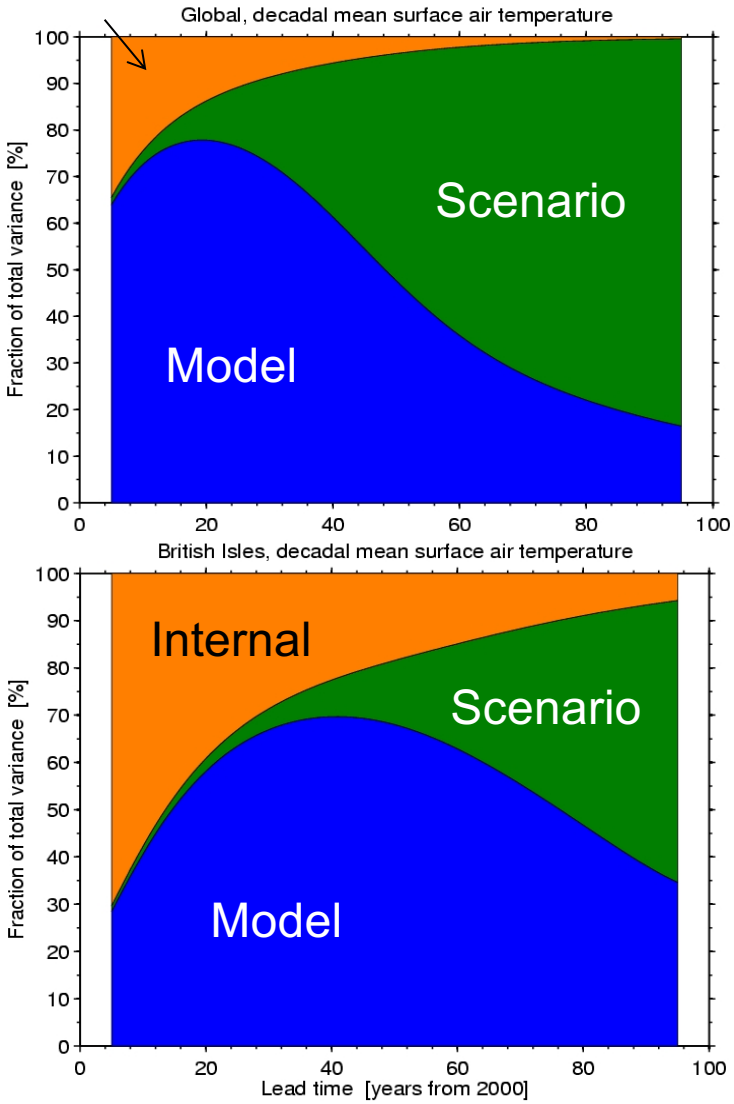
DYNAMOC

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

Why decadal prediction?

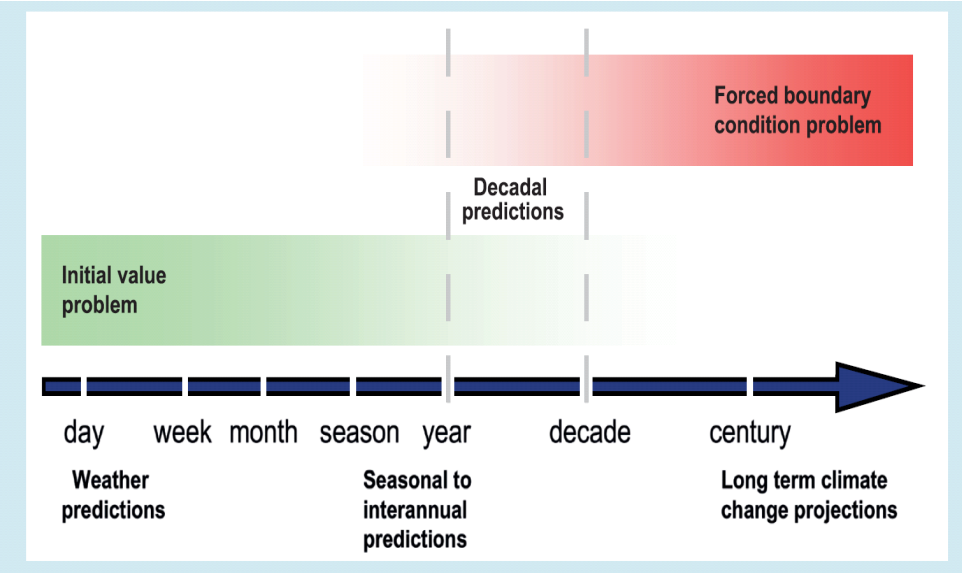
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Internal



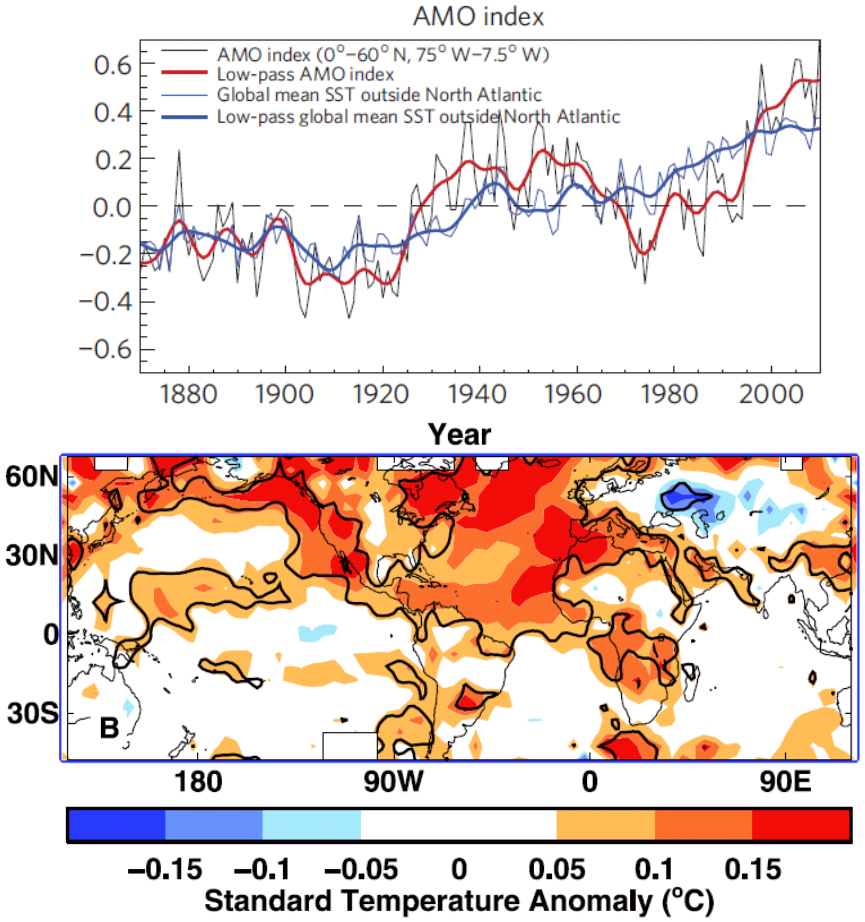
(Hawkins and Sutton, 2009)

- Try to improve climate predictions by initialising the internal variability *as well as* the externally forced response
- It is a mixed initial / boundary condition problem

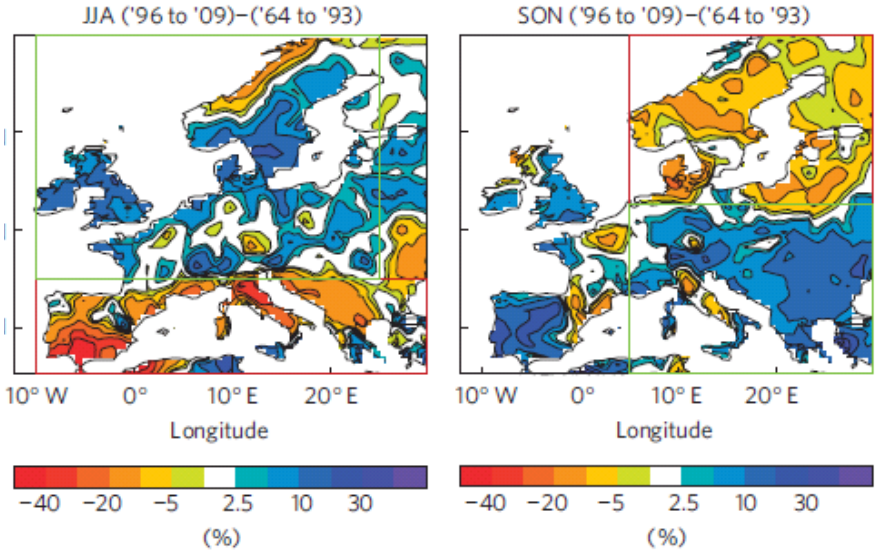


Atlantic Multidecadal Variability (AMV) and its climate impacts

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Knight et al, 2005

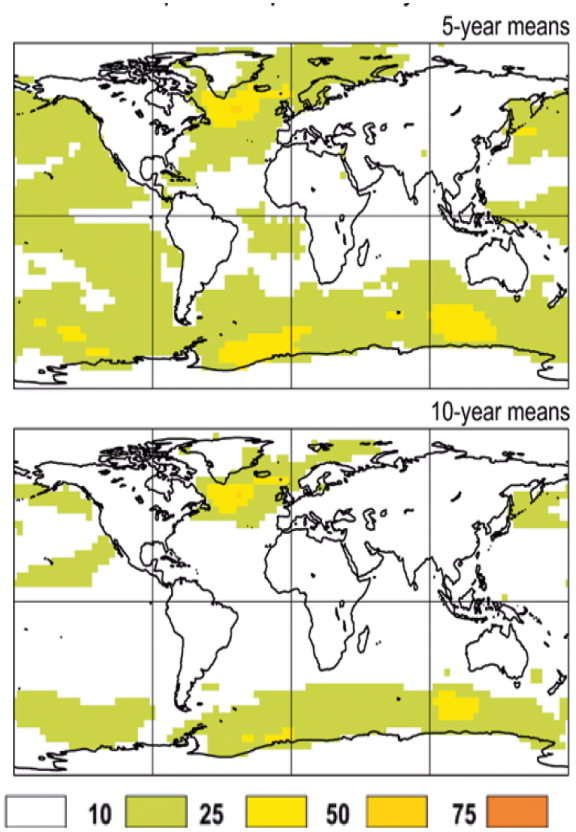


Sutton and Dong, 2012

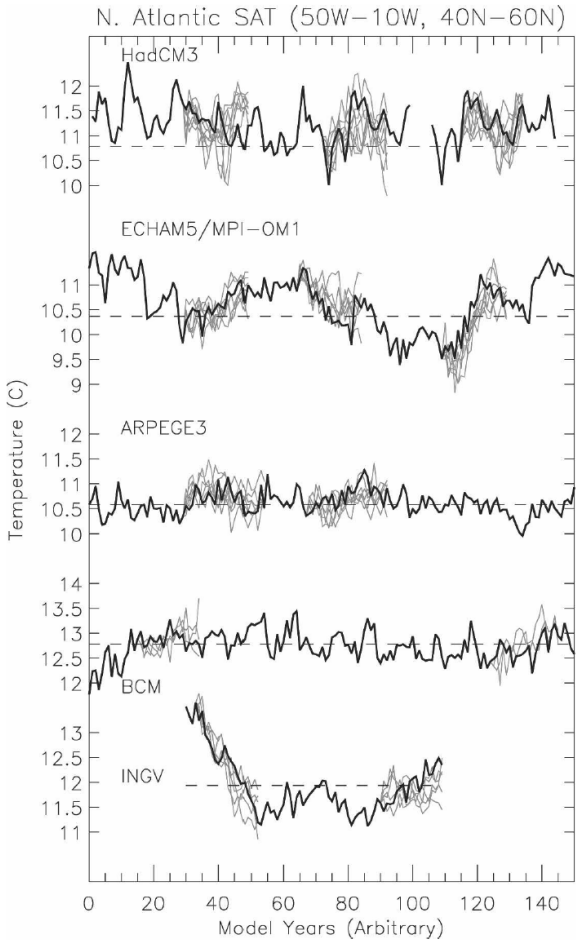
Evidence that North Atlantic SSTs can effect the surface climate across The Americas, Europe and Africa

Why do we think we can do decadal prediction?

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Boer, 2001



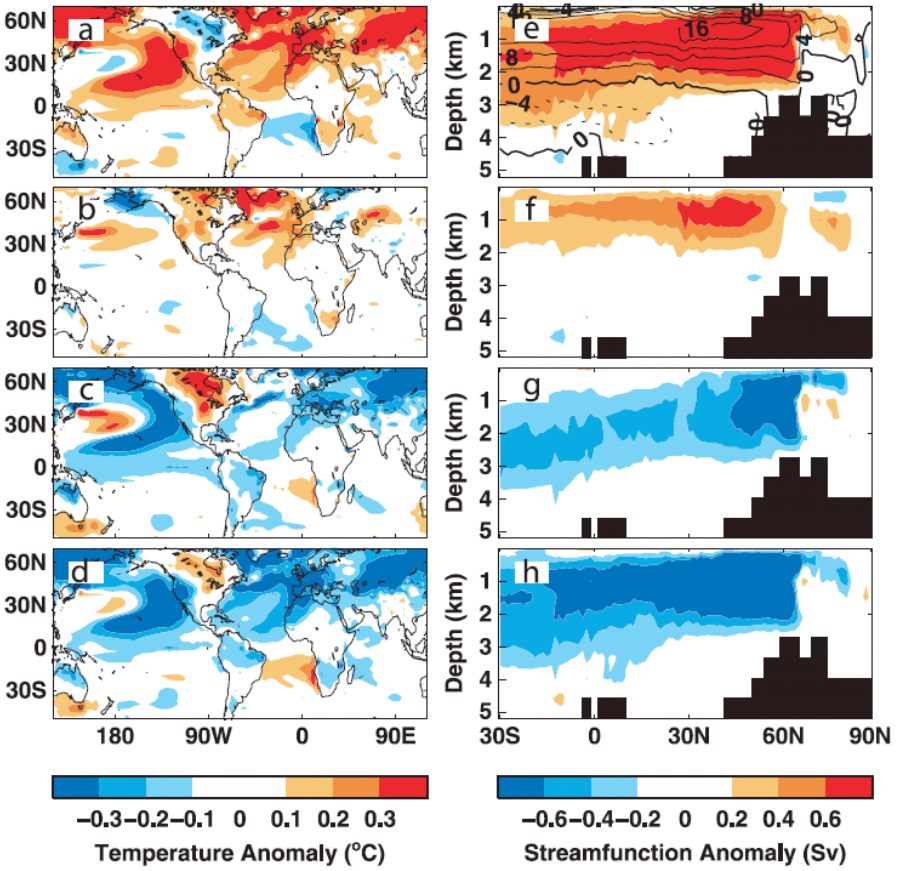
Collins et al, 2006

- decadal time-scale *Internal* variability exists in the North Atlantic in models
- The variability could be predicted for years-to-decades ahead, *depending on model, region and variable*
- *AMOC predictable for up to 10 years?*
- *NAO not predictable....*
- *Fits with the idea that AMV was not a coupled mode....*

Can we predict the low frequency variability?

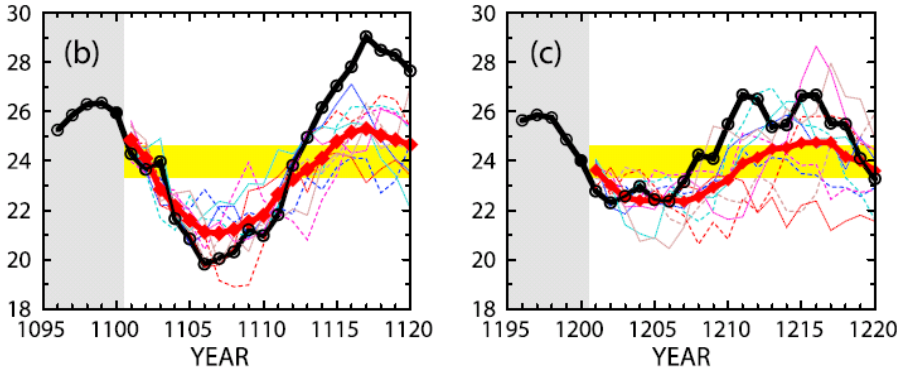
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AMV in many models is associated with changes in ocean circulation and heat transport



Knight et al, 2005

Msadek et al, 2010

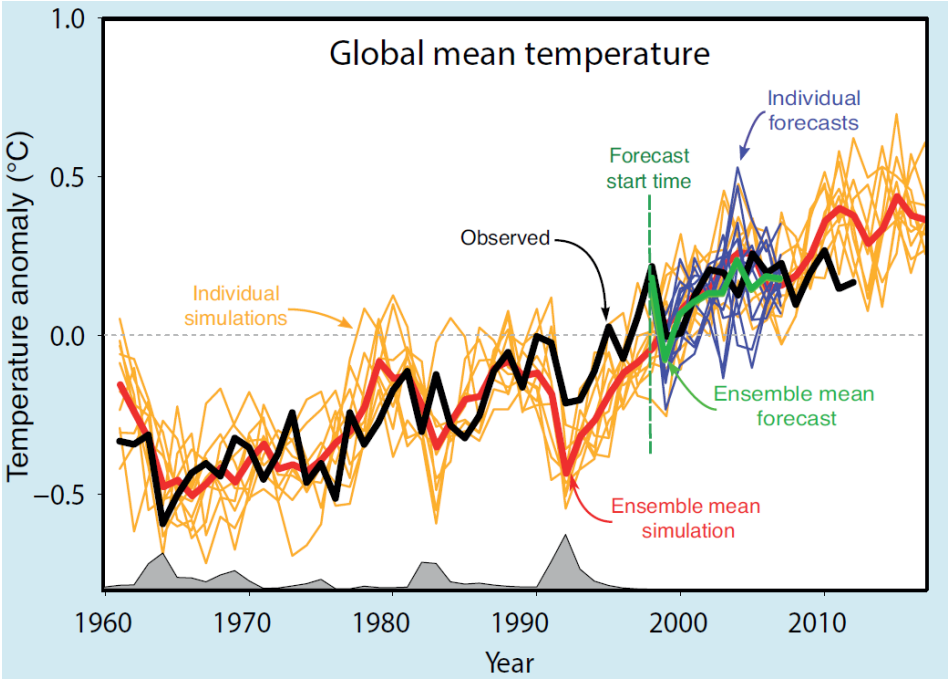


- *Models* suggest that AMV is largely associated with slow changes in ocean circulation and heat transport
- Ocean evolves slower than atmosphere → could be predictable for much longer

What are decadal predictions?

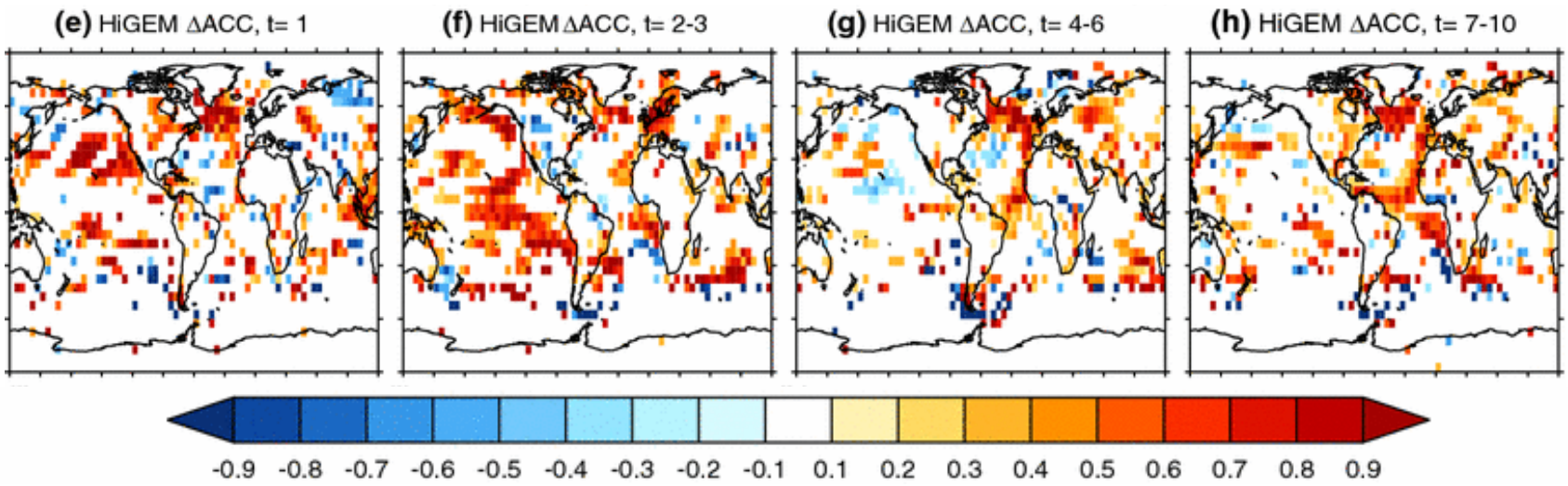
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- Coupled model predictions
  - CMIP5 decadal predictions typically made with low-res models (i.e. HadCM3)
  - The observations are introduced into the model, usually from a pre-analysed data set
  - Hindcasts usually initialised between 1960--present
  - External forcings are prescribed, including *volcanic forcing*
  - Met O will use HadGEM3-GC3.1 for DCPP
  - *Forecast drift still remains a major problem... (Menary et al, 2016)*

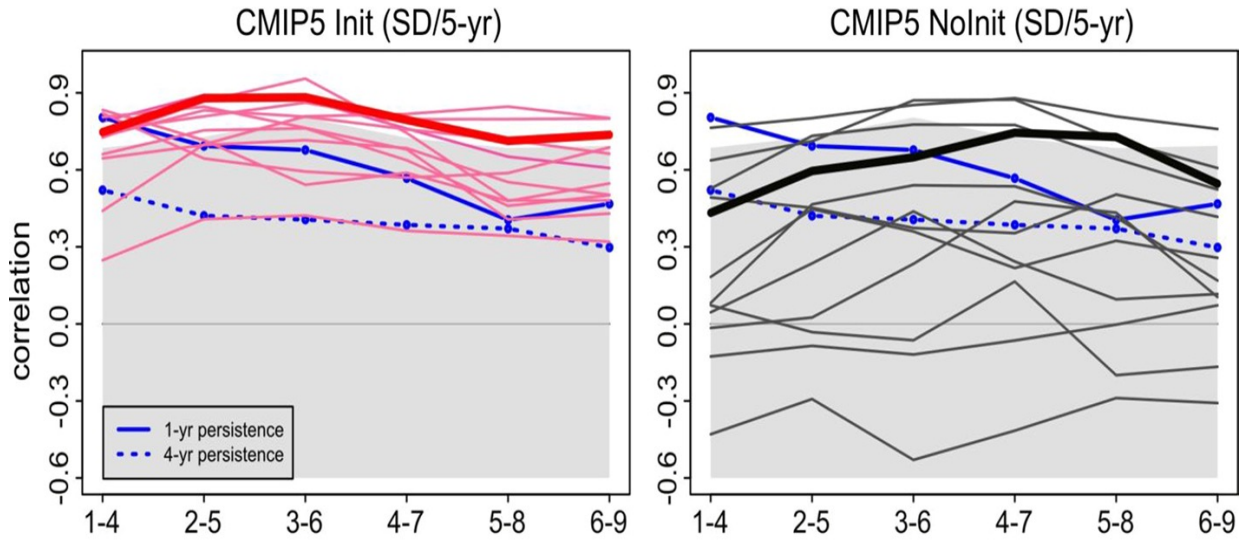


The North Atlantic is consistently improved in decadal predictions

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Shaffrey et al, 2017

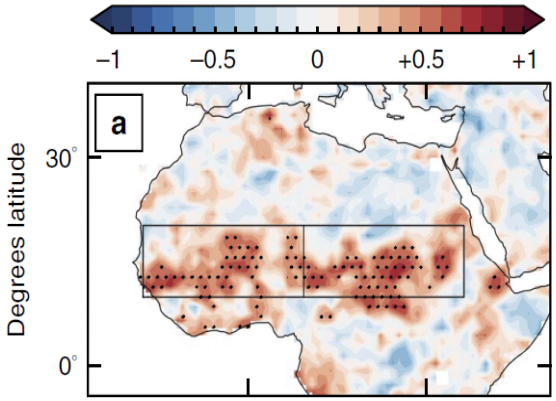


Garcia-Serrano, et al 2014

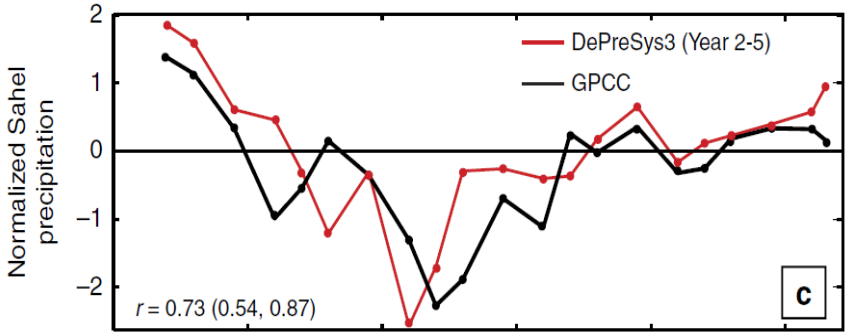
Surface climate Skill in real predictions

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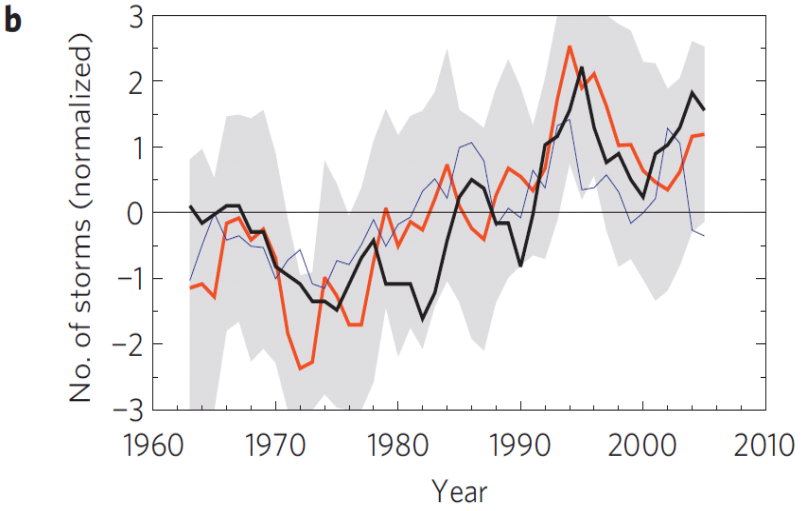
Skill in Sahel rainfall



Sheen et al, 2017

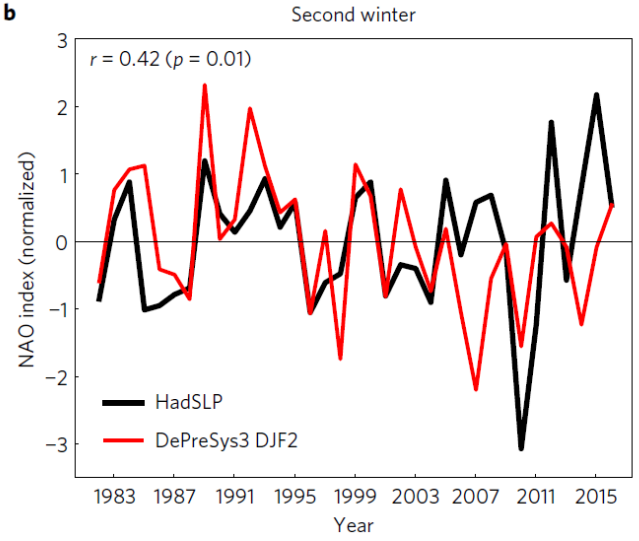


Hurricane Frequency



Smith et al, 2010

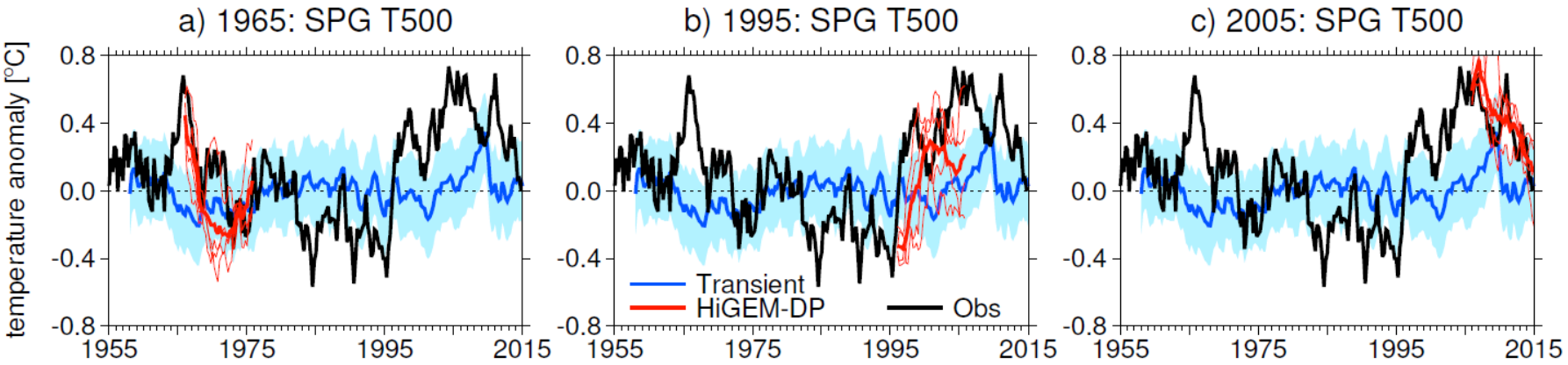
NAO skill



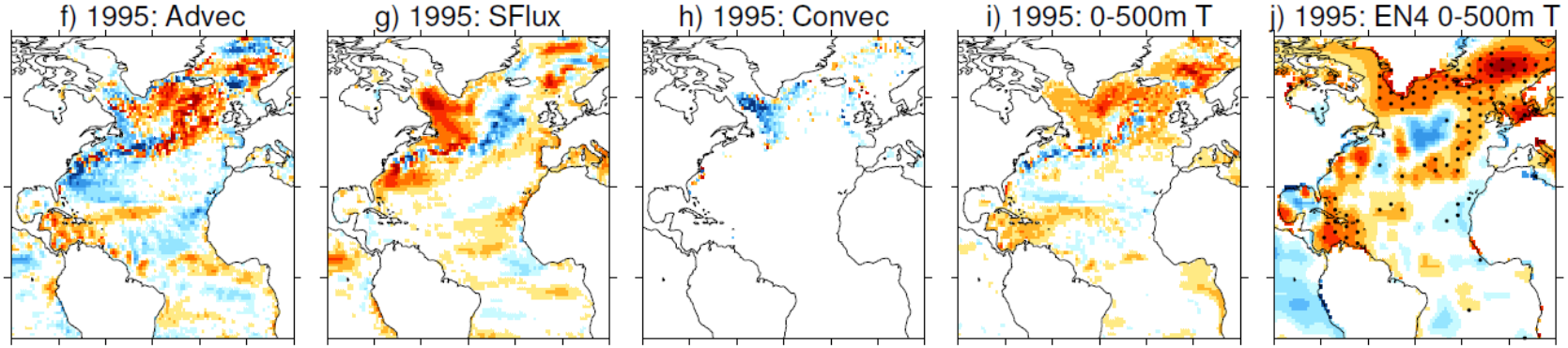
Dunstone et al, 2016

Why the improved skill in the North Atlantic?

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Success in capturing large shifts in subpolar gyre heat content shown to plays a large role in improved skill in a couple of models. (Robson et al, 2012;2014; Yeager et al, 2012;2015; Msadek et al, 2014; Hermanson et al, 2014)



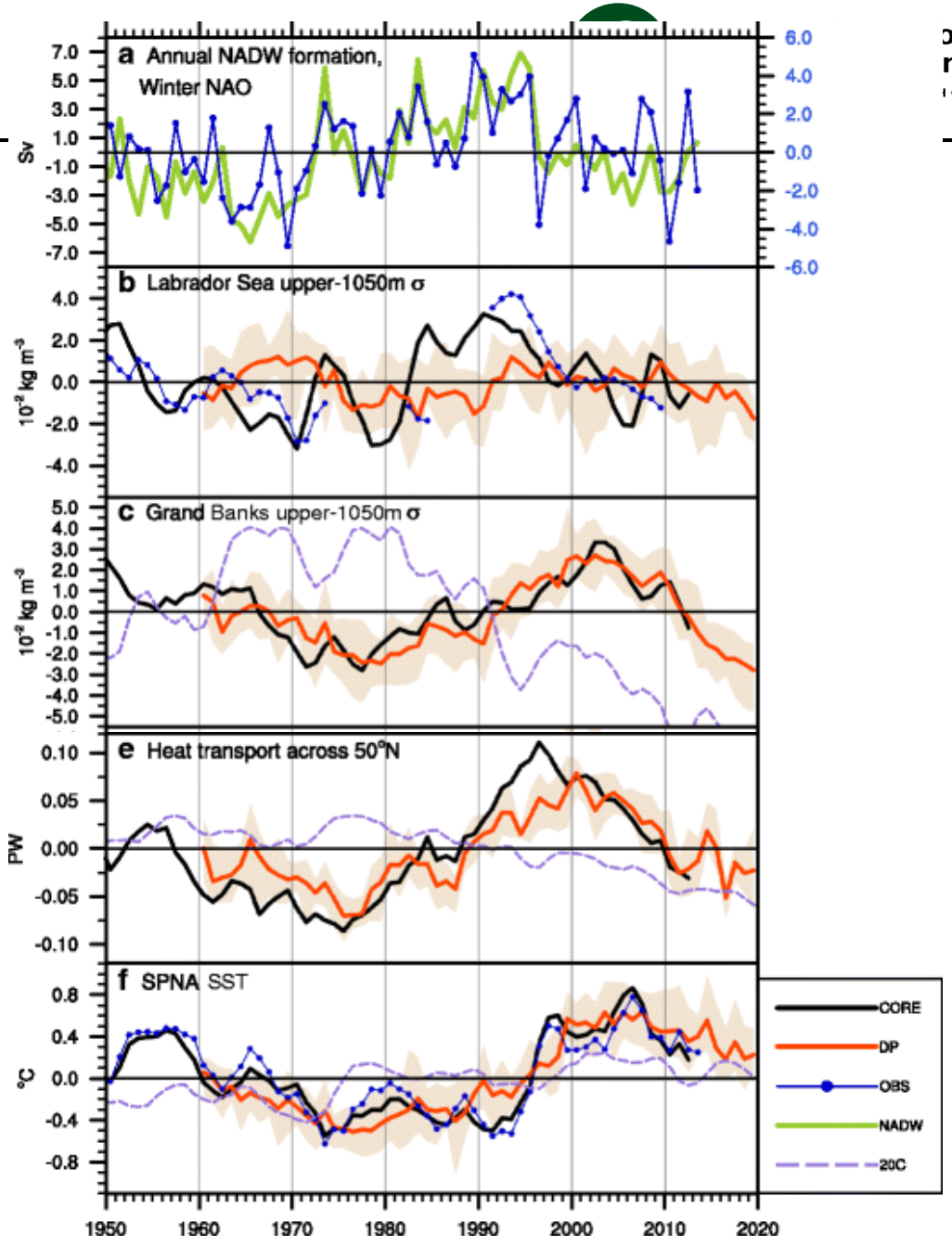
Initialising changes in ocean heat transports important

Initialisation of deep density important

models do not currently predict changes in an onset of deep water formation or changes in circulation ahead of time.

But, the impact of the atmosphere on the deep ocean is initialised

The resultant changes at depth *does appear* predictable, and leads to improved predictions at the surface

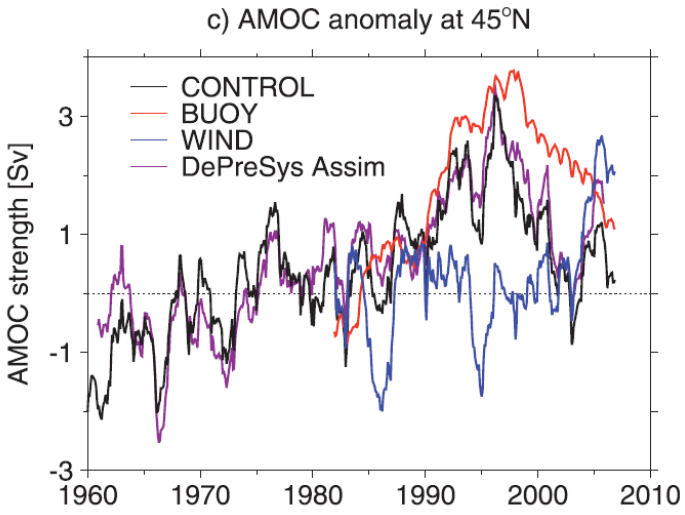


Yeager and Robson, 2017

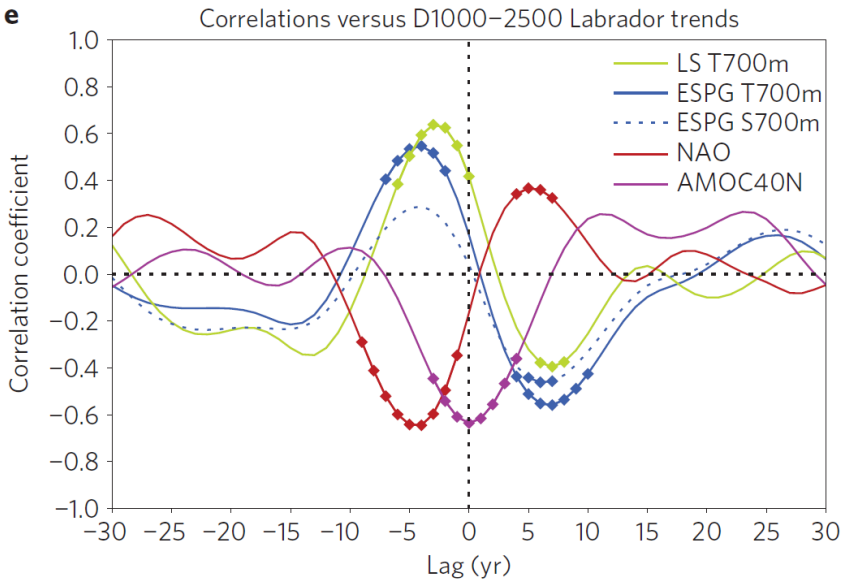
Predictions of 1990s warming similarity with internal variability?

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- Mid-1990s warming came after a sustained trend towards more positive NAO.
- Lagged increase in the buoyancy forced ocean circulation (AMOC and Gyre), and northward heat transport
- Similar to coupled model *internal variability*, including HiGEM and HadGEM3-GC2 (*i.e. Hodson et al, 2012; Menary et al, 2015; Robson et al, 2016; Ortega et al, 2017*)



Robson et al, 2012

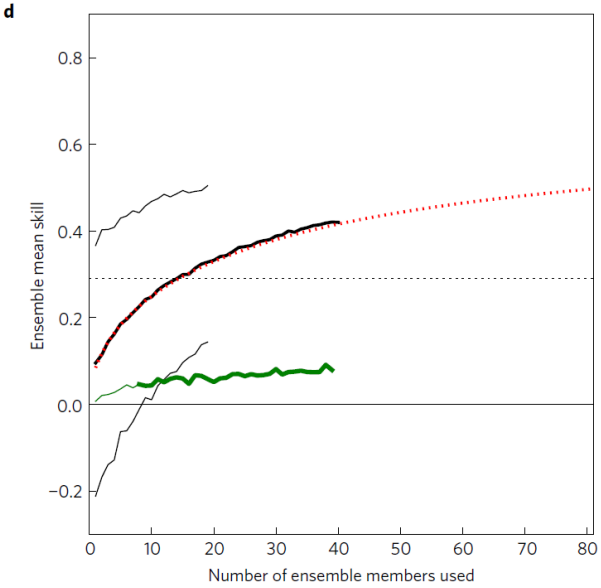


Robson et al, 2016

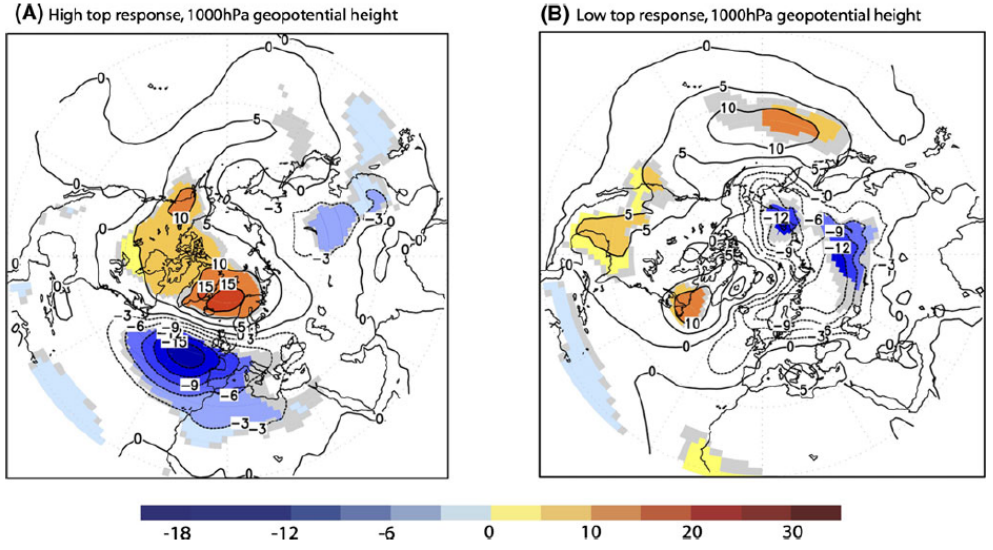
Is the AMV more coupled than we currently expect?

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- "high-resolution" prediction systems capture the NAO at seasonal to interannual time-scales
- Signal to noise paradox – more coupled in the North Atlantic??
- Improved resolution and improved model physics important?
- Could lead to improved predictions?



Dunstone et al, 2016

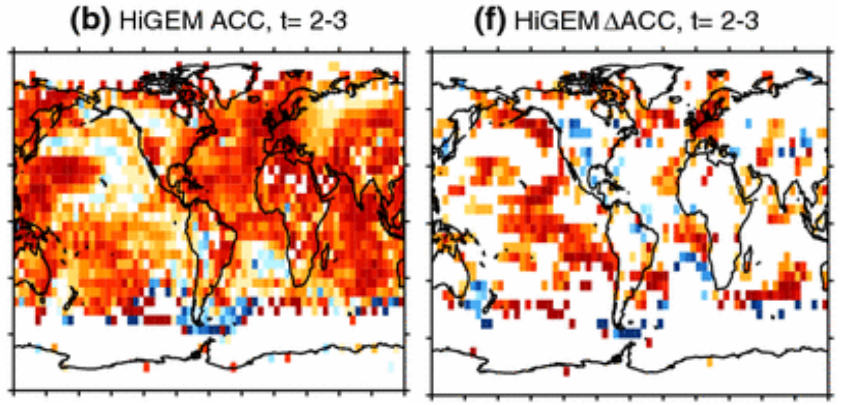


Omrani et al, 2014

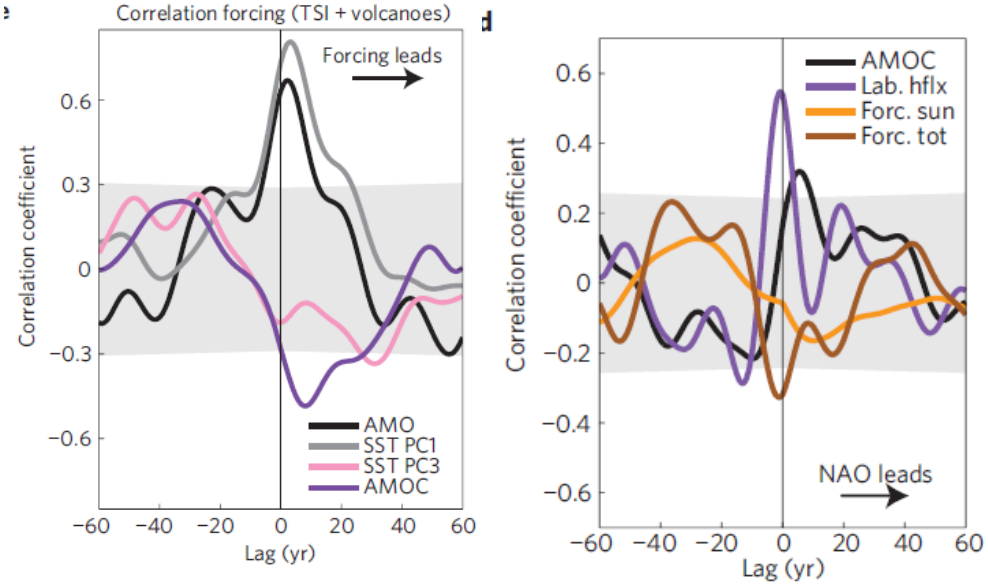
But is it this simple?

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- Probably not....
  - forcing is important for skill – but we don't know why (GHG, volcanoes, Aerosols?)
  - Do external forcings project onto the internal variability?
  - Initialisation can also correcting for an imperfect forced response?
  - Within the confines of a very short observed record, how do we tell?



Shaffrey et al, 2017



Ottera et al, 2010

Conclusions

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- The North Atlantic is one of the most improved regions in initialised climate predictions
  - Improved skill is routinely found in heat content / skill beyond 5 years
  - Improved skill in Atlantic linked to improved predictions of hurricanes, Sahel Rainfall and NAO
- Improved skill is largely due to improved predictions of the subpolar North Atlantic,
  - particular the mid-1990s which is generally consistent with modes of internal variability in models that are forced by the NAO
  - Could improved prediction in the NAO lead to improved prediction of Atlantic at long leads?
- However,
  - role of external forcing in decadal variability and prediction is *extremely* uncertain
  - Modes of internal variability are very sensitive to the model used