Bjerknes Centre for Climate Research

Near-term climate prediction: new opportunities and challenges

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SKD Centre for Climate Dynamics at the Bjerknes Centre

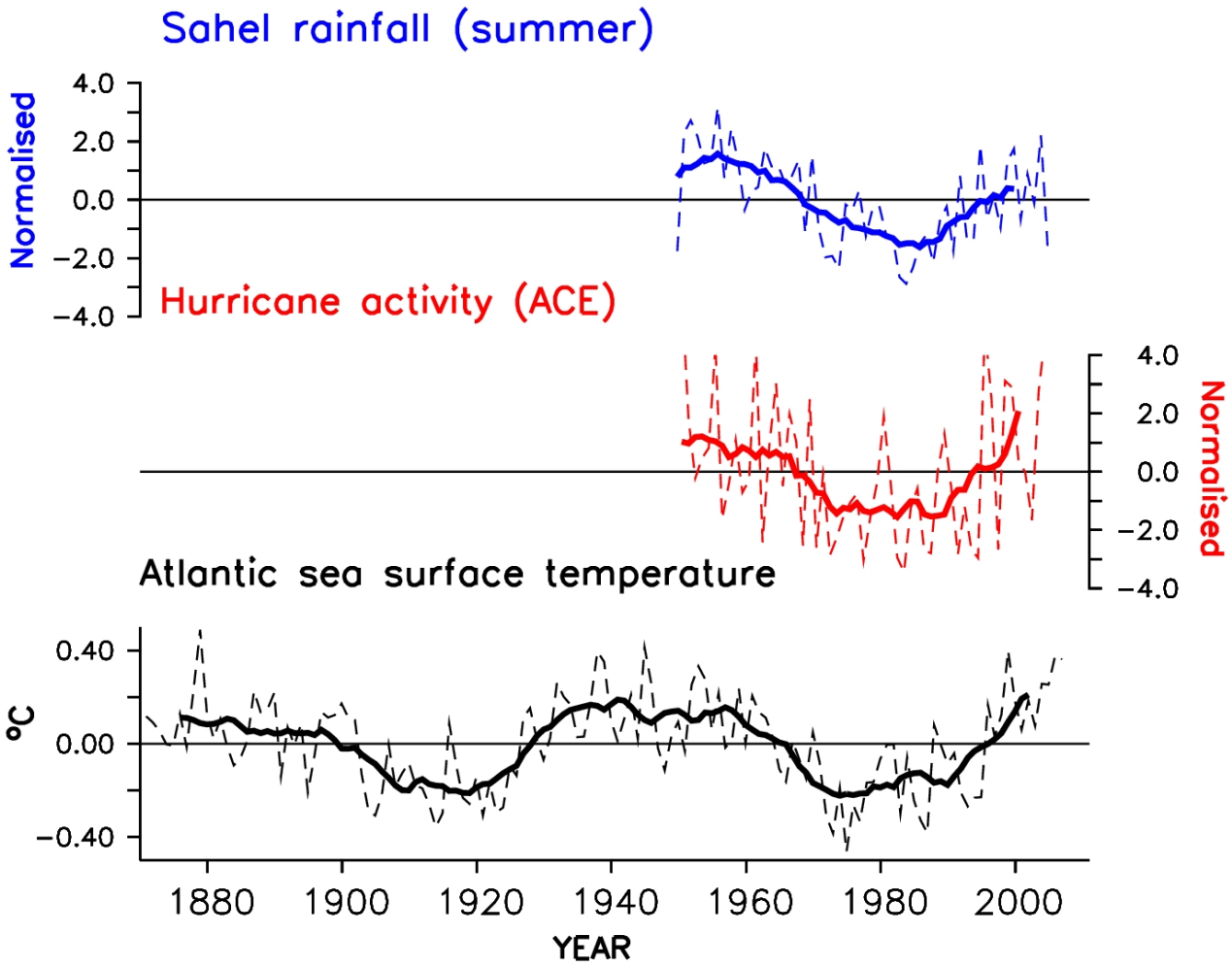
Nansen Center, Bergen

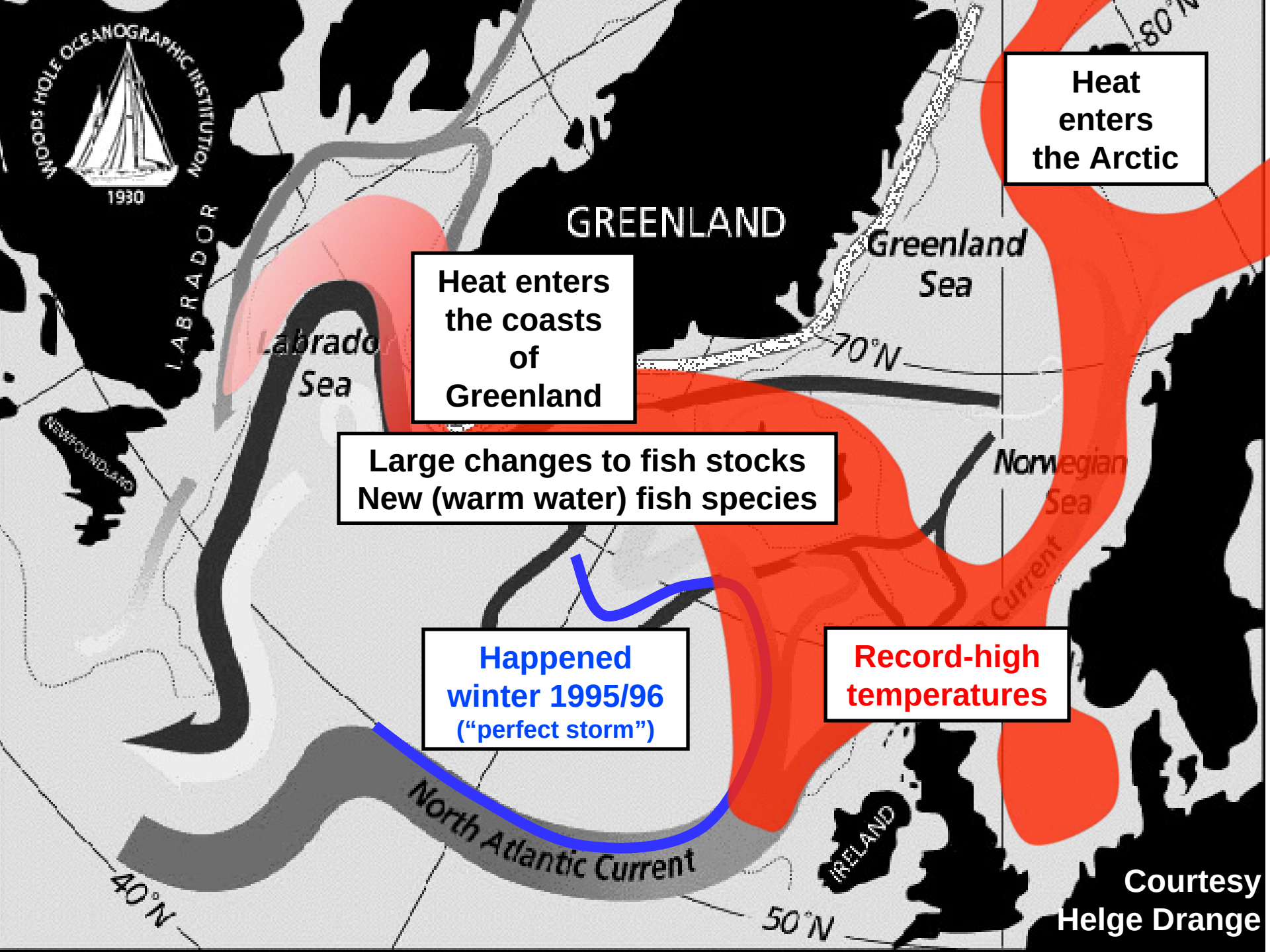
uniResearch

Emmy Noether-Programm
Deutsche Forschungsgemeinschaft DFG

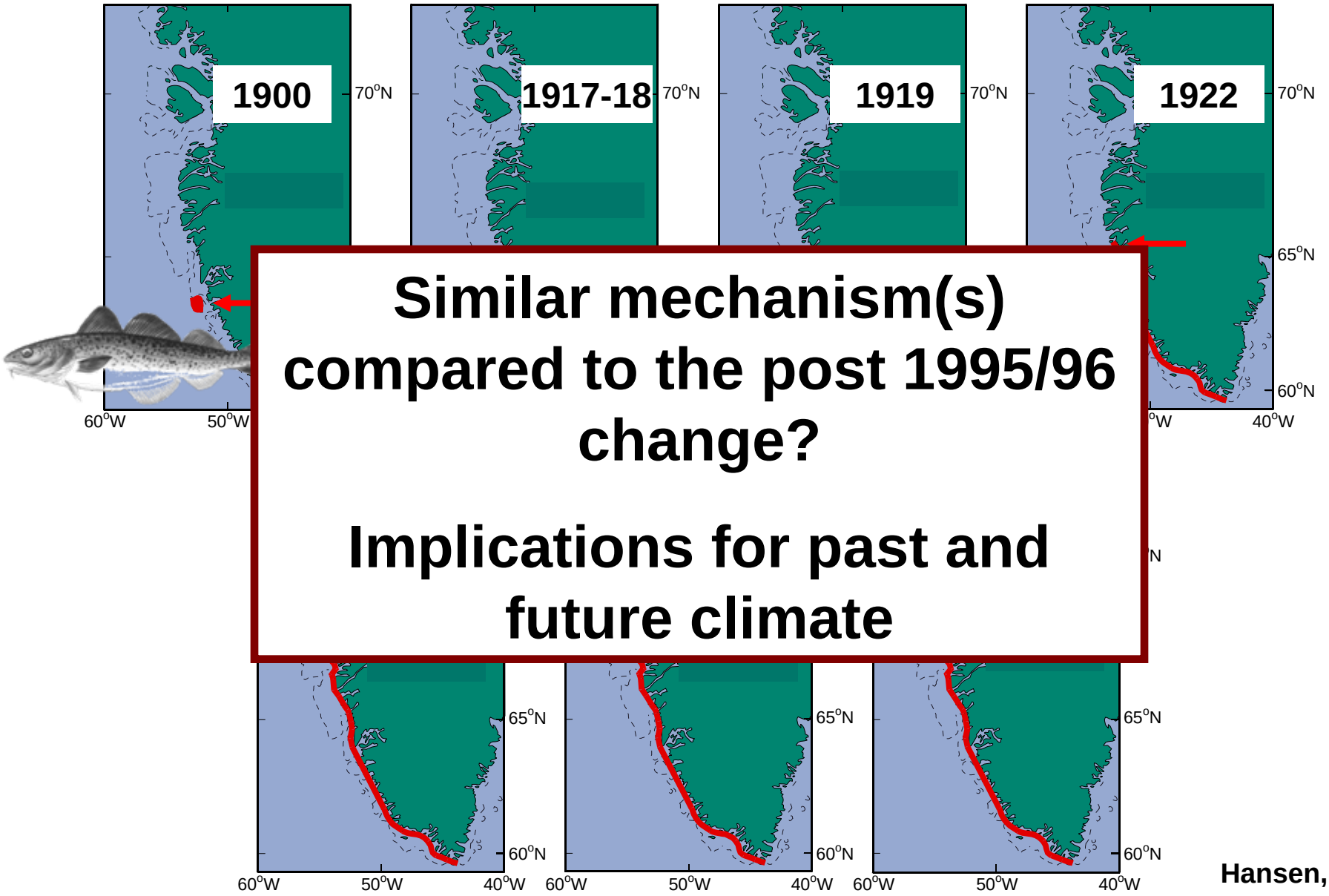
Natural Atlantic multi-decadal variability with strong socio-economic impacts

Period of 70-80 years (detrended timeseries)




WOODS HOLE OCEANOGRAPHIC INSTITUTION
1930
LABRADOR
GREENLAND
Greenland Sea
Labrador Sea
70°N
80°N
NEWFOUNDLAND
Norwegian Sea
Current
IRELAND
North Atlantic Current
40°N
50°N
Heat enters the Arctic
Heat enters the coasts of Greenland
Large changes to fish stocks
New (warm water) fish species
Happened winter 1995/96
(“perfect storm”)
Record-high temperatures
Courtesy Helge Drange

Observed spreading of Atlantic cod along the coast of Greenland, 1900-1940



Similar mechanism(s) compared to the post 1995/96 change?

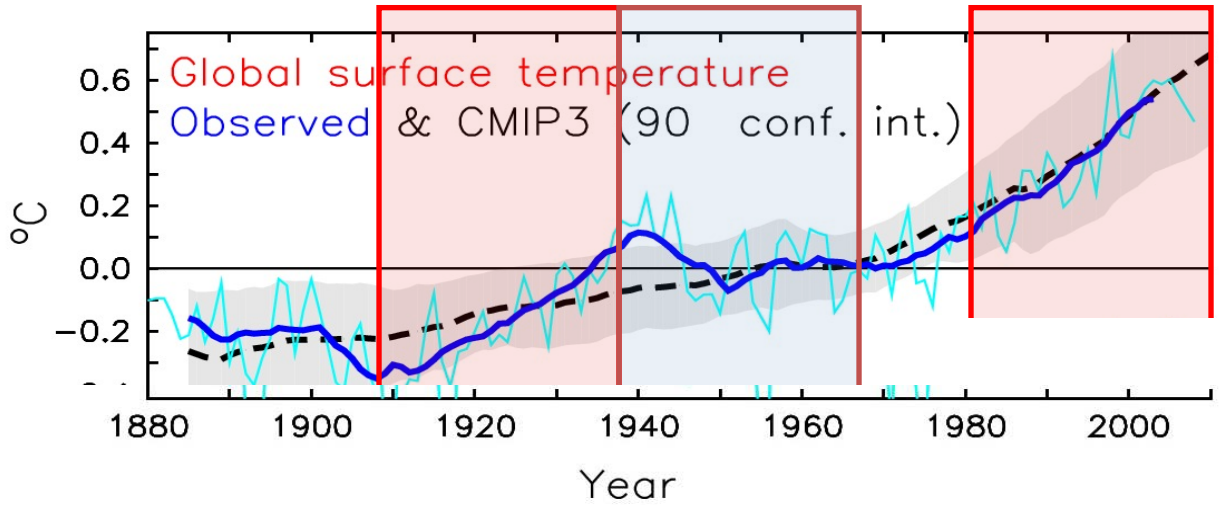
Implications for past and future climate

Hansen, 1940

What is the potential to predict the decadal shifts in the climate system?

- Decadal climate variations – internal versus external
- Near-term prediction – initial/boundary value problem
- Challenges to near-term climate prediction
- We are in a highly experimental stage

Multidecadal temperature fluctuations: Internal versus externally driven?

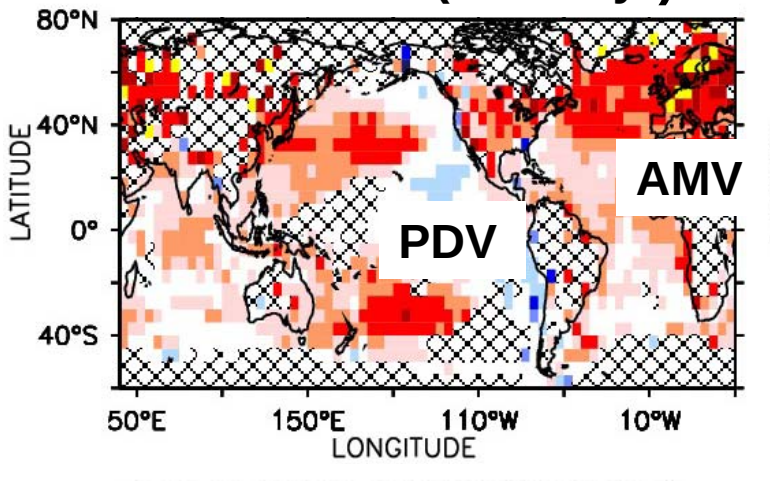


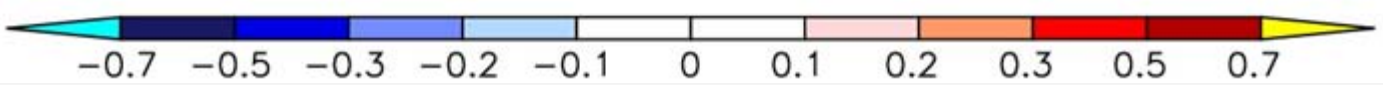
Internal variability large at decadal/regional scales
External dominates on centennial

Surface temperature trends

Observed

1978-2008 (° C/10 yr)

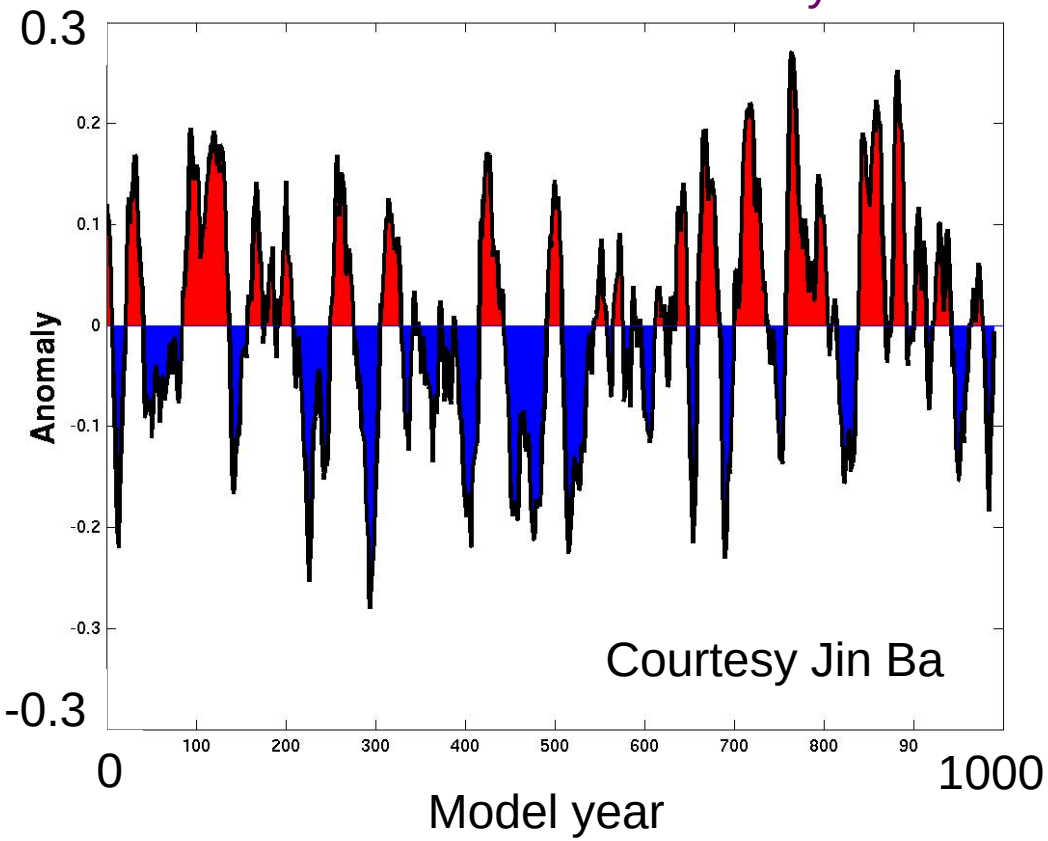




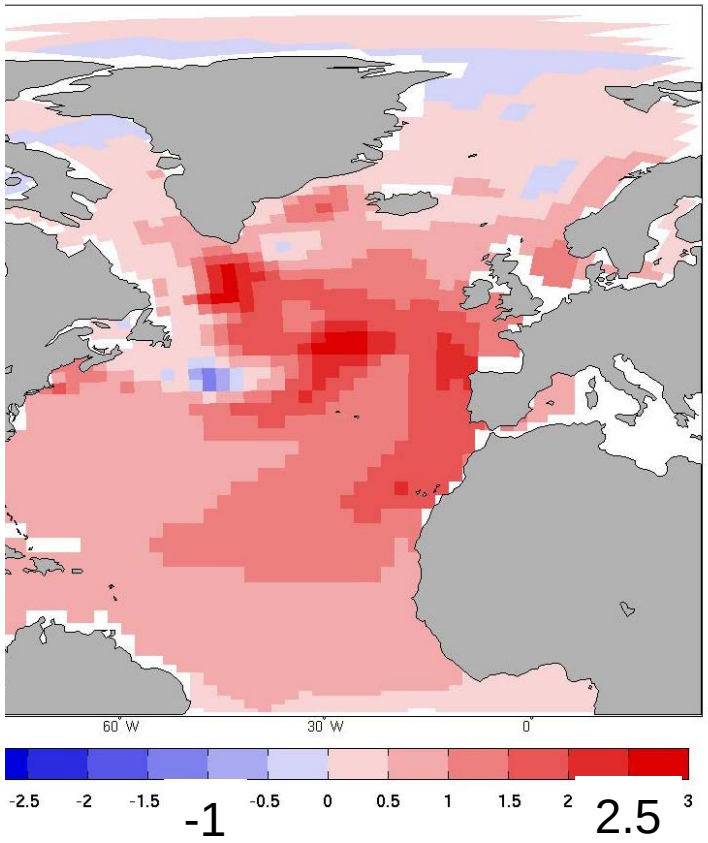
Models simulate similar decadal variability independent of external forces

Kiel Climate Model, preindustrial control simulation

Atlantic multi-decadal variability index



Regression pattern



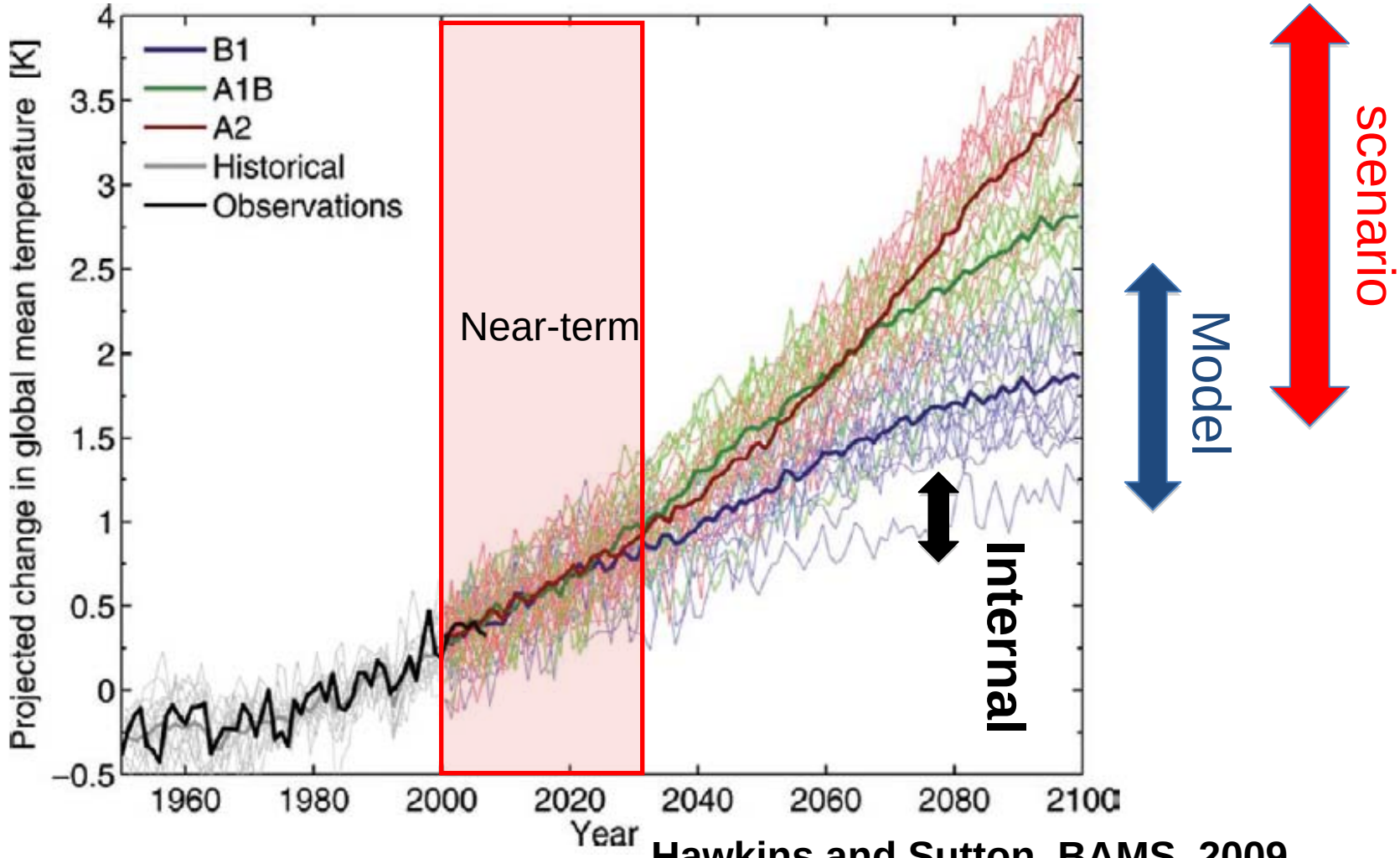
Similarly for PDV, and various other modes

Near-term prediction – initial/boundary value problem

Externally driven climate projections

Prediction uncertainty: scenario, model, and internal

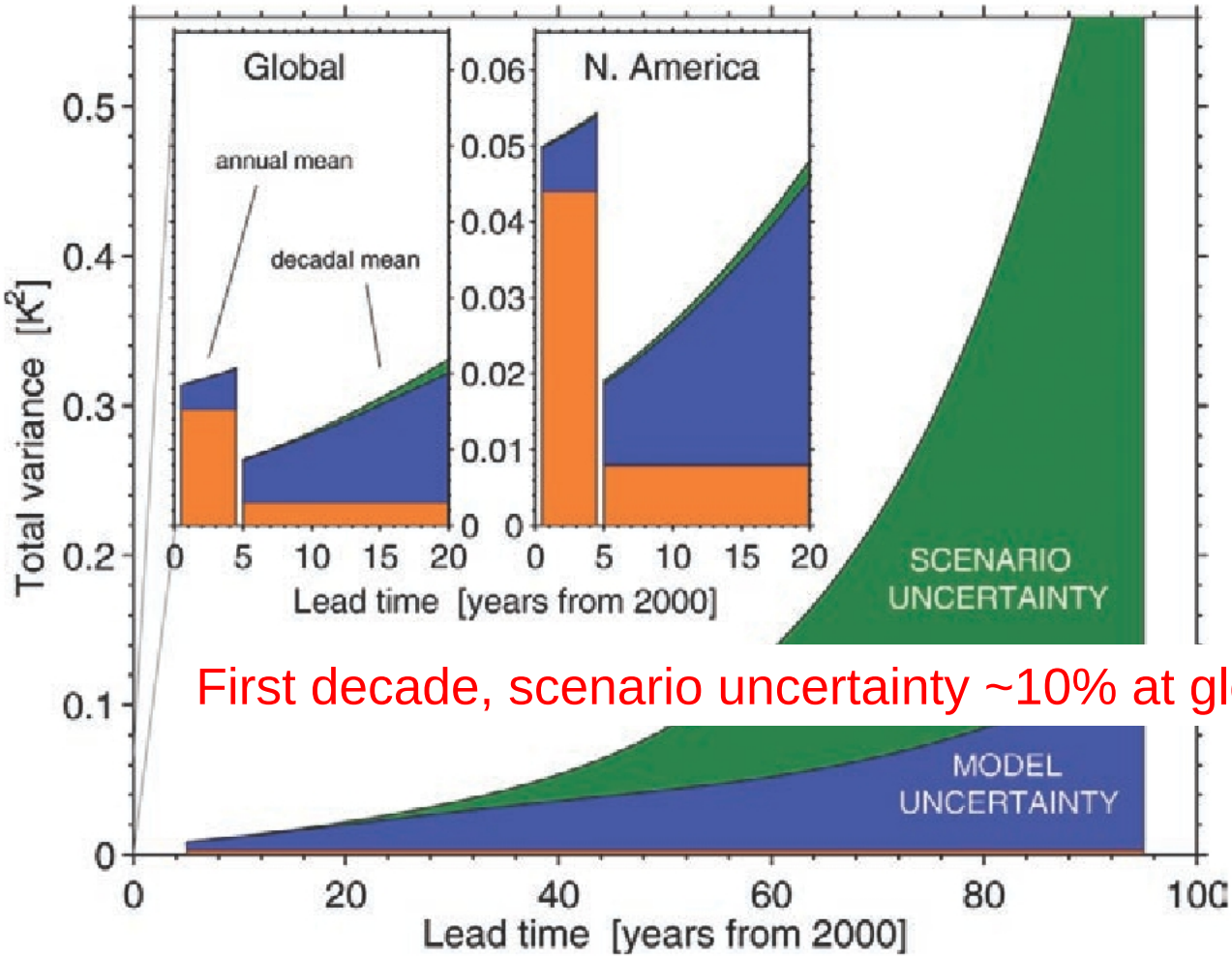
Surface temperature projections from 15 climate models



Hawkins and Sutton, BAMS, 2009

Near-term surface temperature prediction: model and initial condition uncertainty large

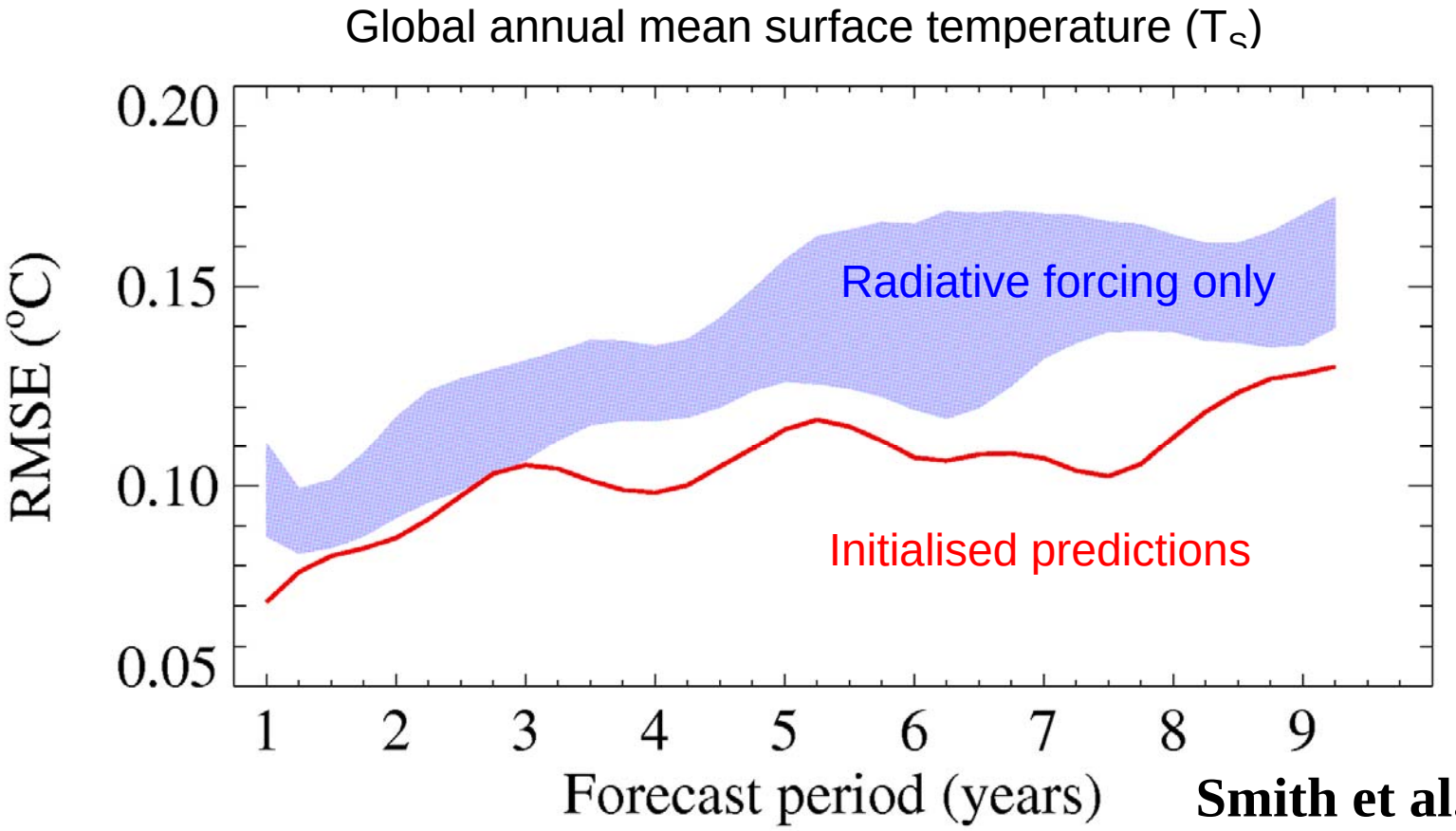
Relative importance computed from CMIP3 models



First decade, scenario uncertainty ~10% at global scale

Hawkins and Sutton, BAMS, 2009

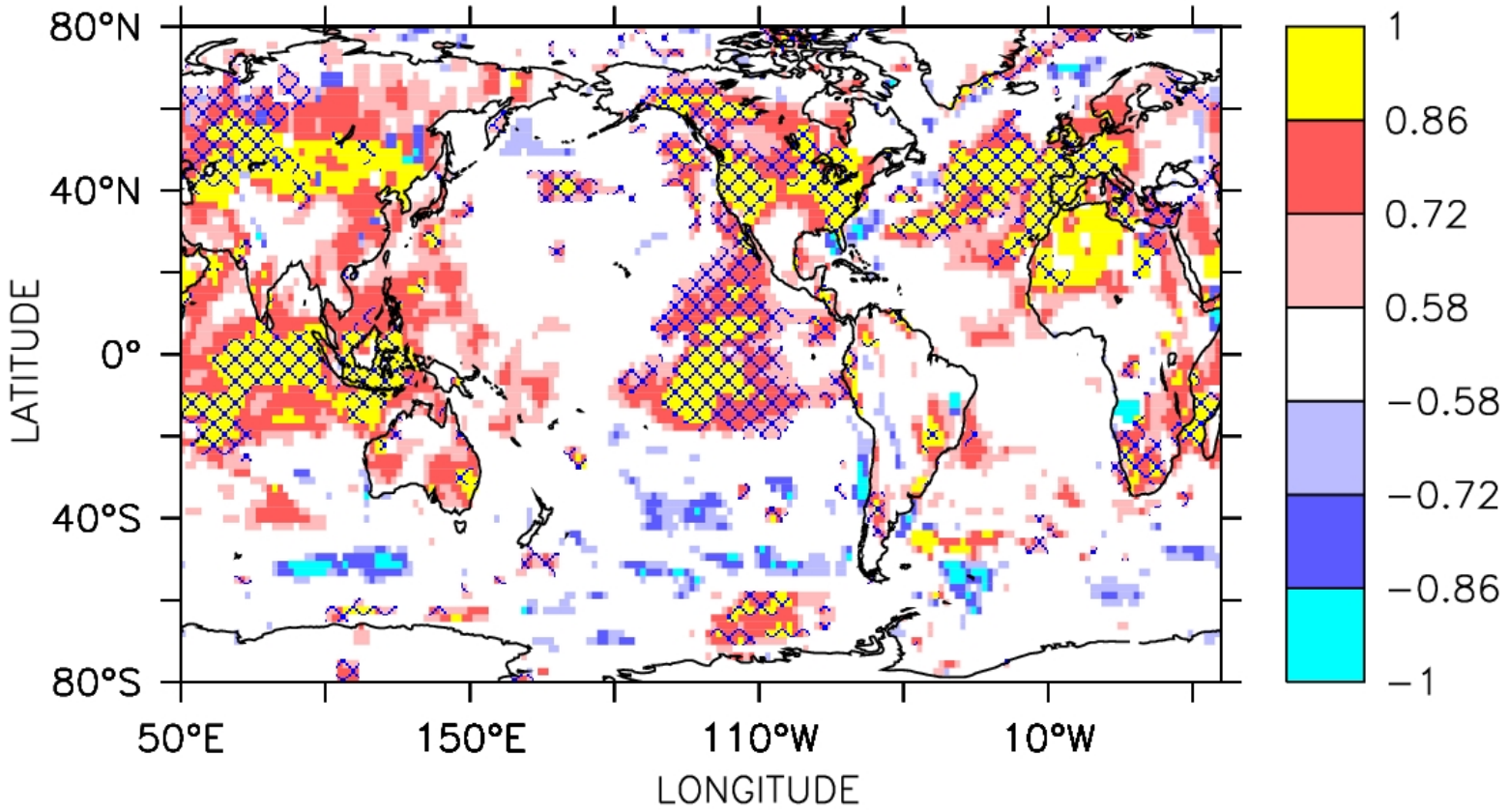
Predicting global temperature for next decade: Initialising with ocean reanalysis



Smith et al. 2007

Decadal prediction skill - Initialised hindcasts with ECHAM5/MPIOM

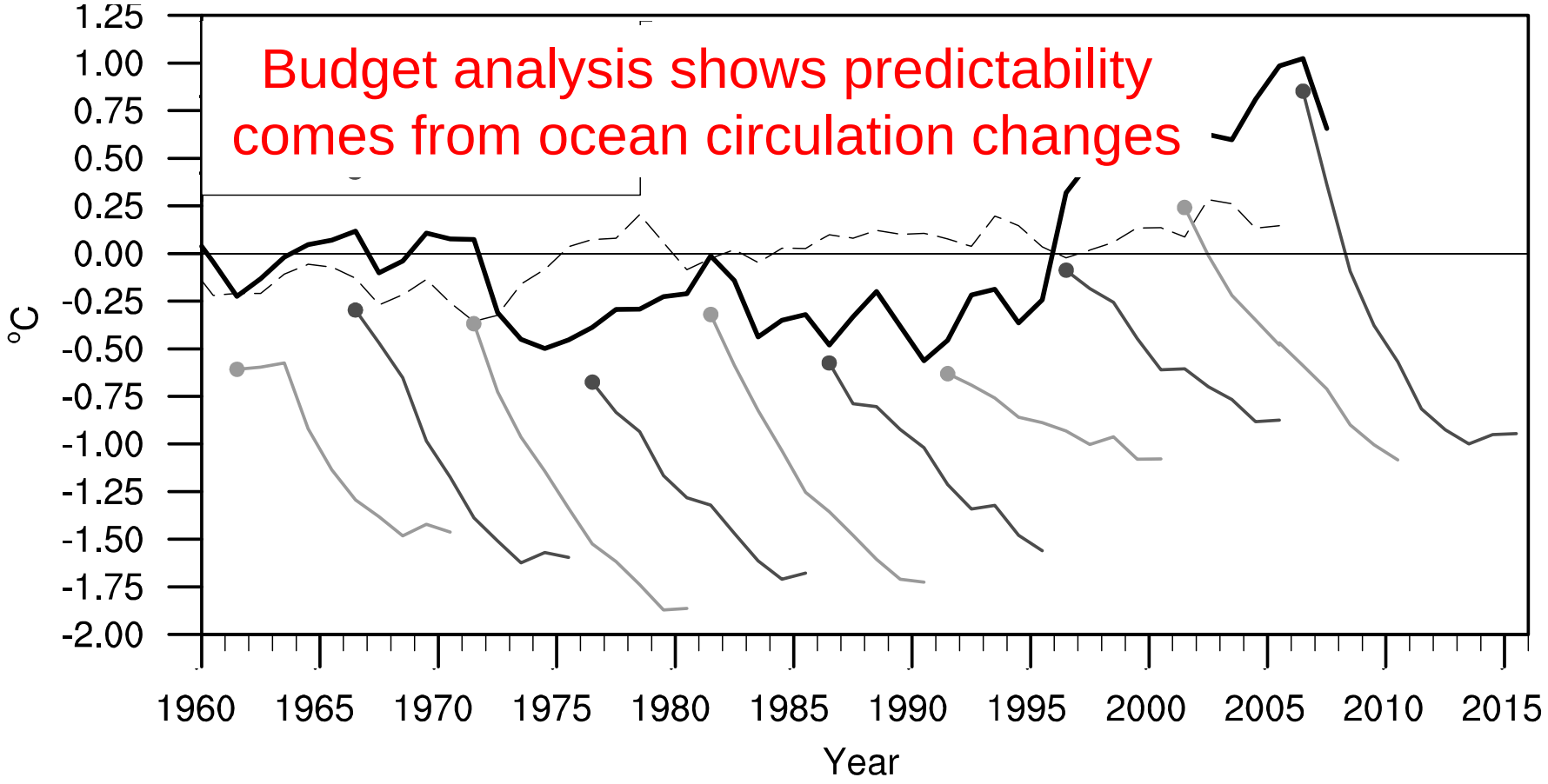
Correlation with observed surface temperature anomalies
years 1-10; 9 hindcasts, 1955-2005



Keenlyside et al. 2008

North Atlantic subpolar gyre – very predictable

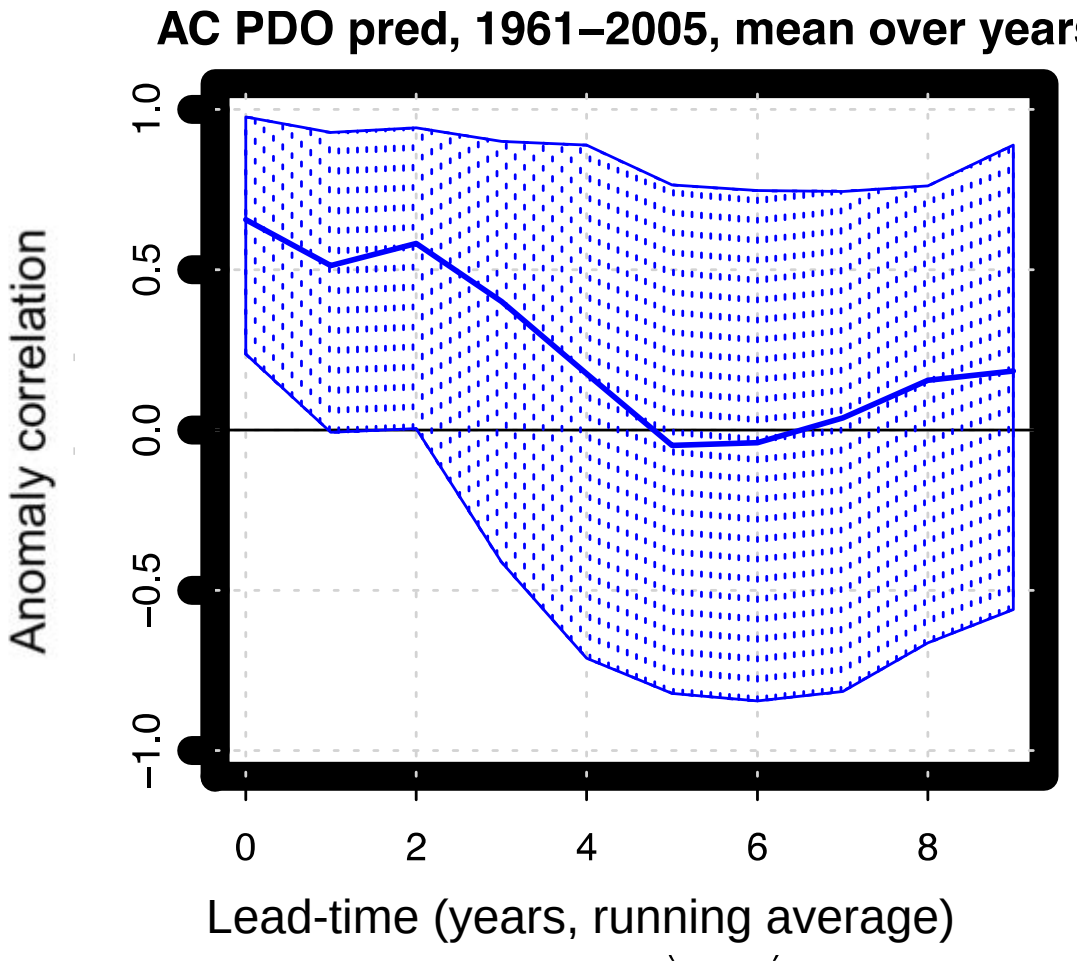
Raw CCSM4 predictions of SPG heat content anomalies
10 year long; 10 members



Yeager et al. 2012

Prediction of Pacific Decadal Variability possible a few years in advance

CCCma predictions of PDO index
Every five years from 1961, 10 year long; 10 members



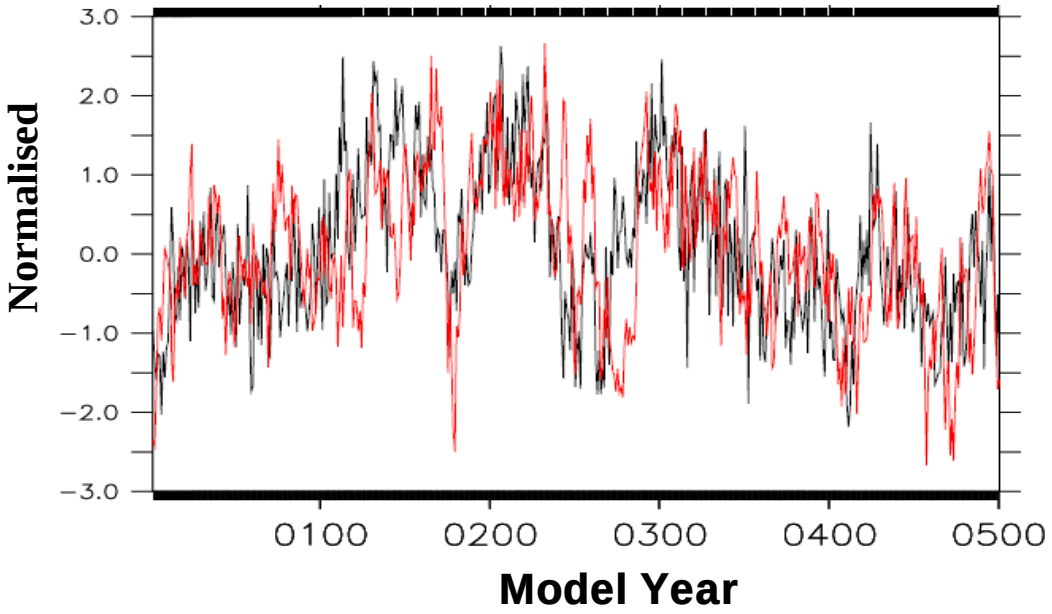
Fabian Leinert
PhD thesis

Challenges to near-term climate prediction: an illustration from the Atlantic

- Model ‘response’ uncertainty
- Model ‘mechanism’ uncertain
- Ocean initial conditions uncertain

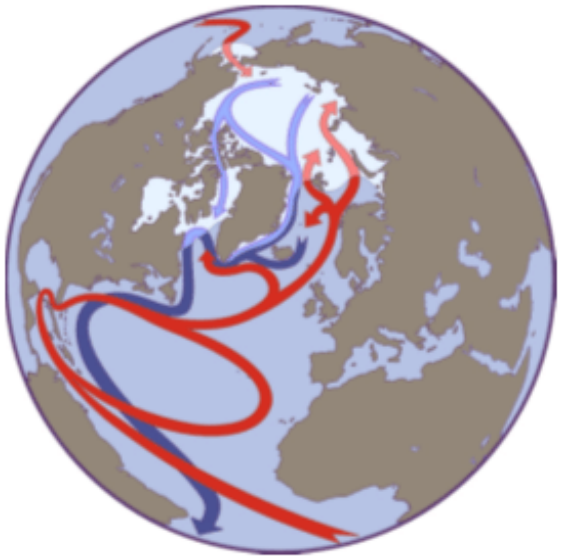
Poleward heat transport and role of Meridional Overturning Circulation

Kiel Climate Model – MOC (black), Atlantic sea surface temperature (red)



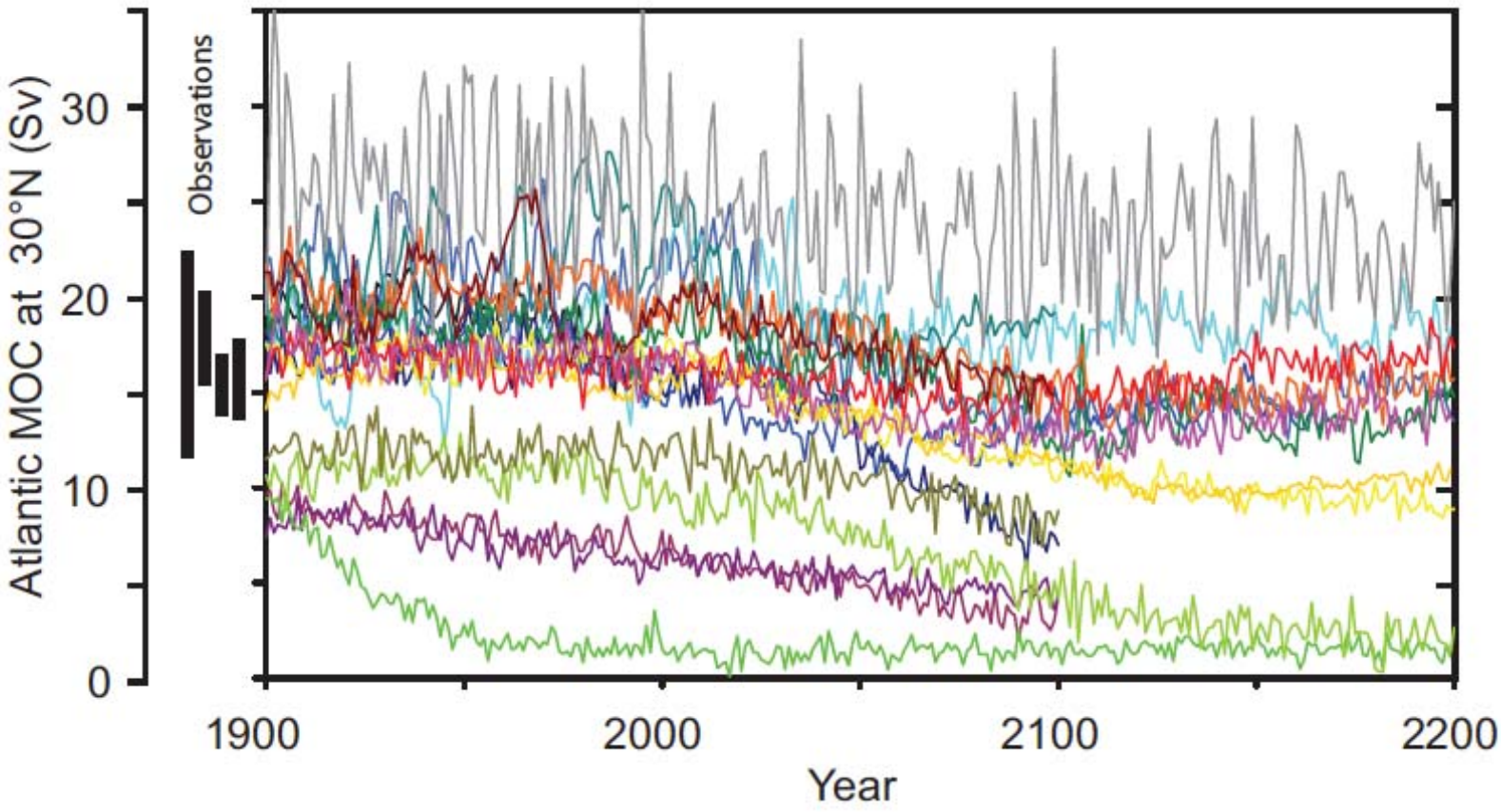
[Latif et al. 2009]

Meridional overturning circulation (MOC)



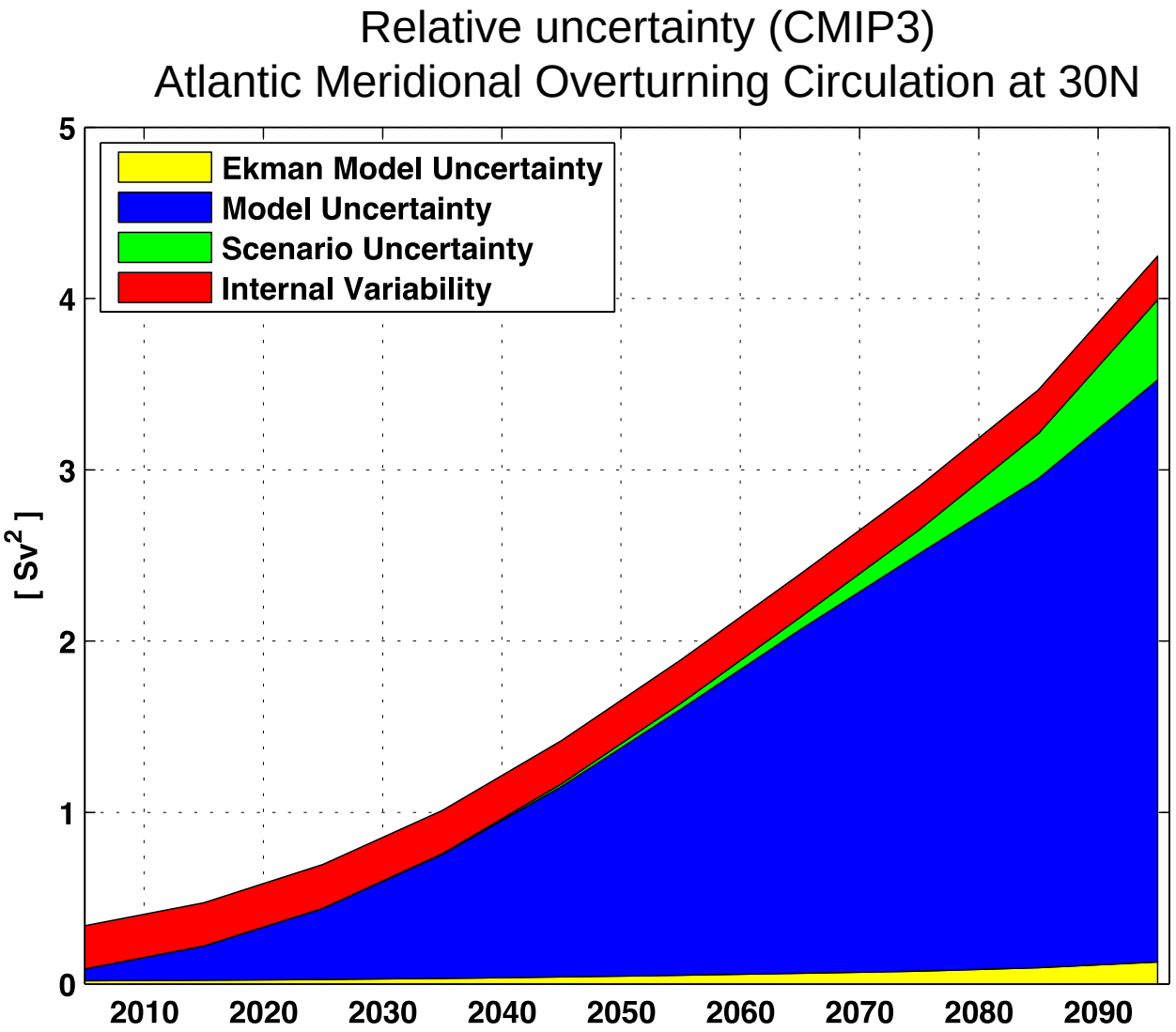
Large uncertainty – model projections of AMOC

AMOC at 30N, CMIP3 models, 20C/A1B



Schmittner et al. (2005)

Quantifying uncertainties in decadal AMOC change

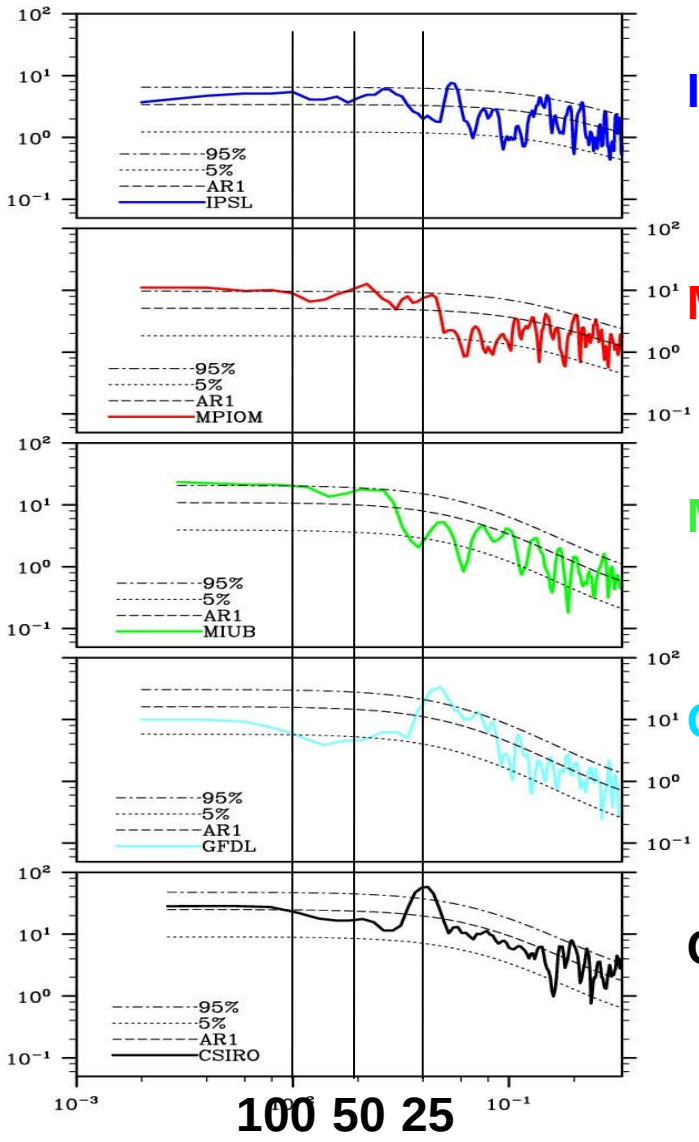


Courtesy Annika Reintges

Uncertainties in internal variability

Spectra of AMOC 30N

CMIP3 Pre-industrial Runs



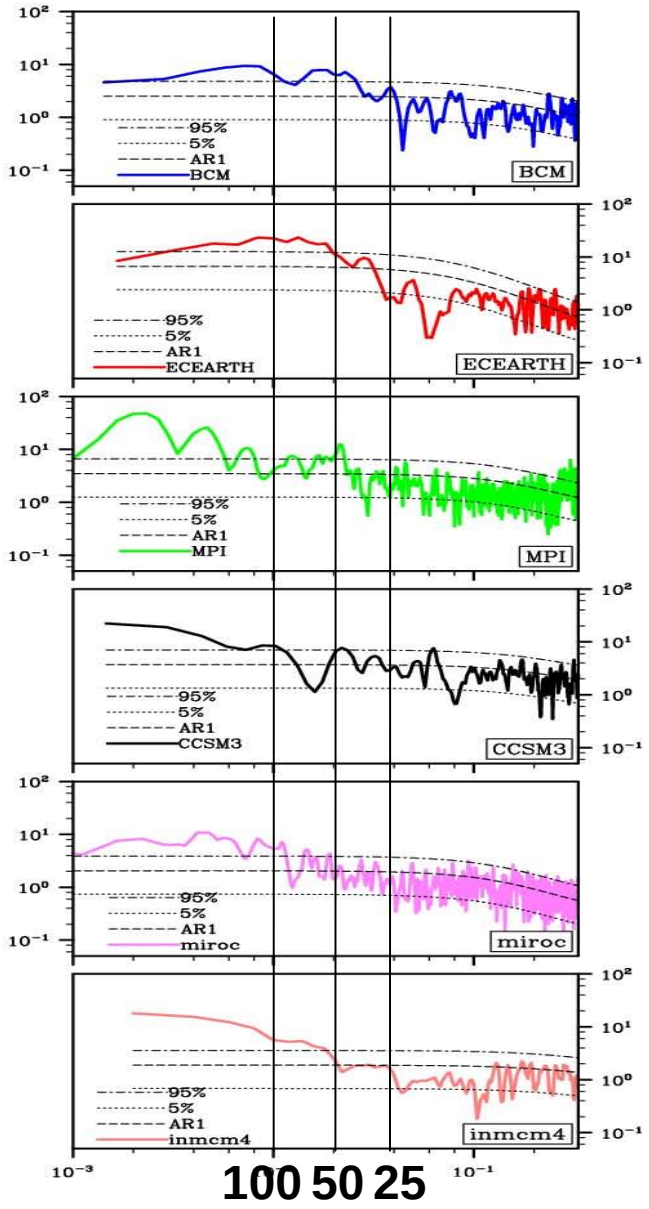
IPSL

MPIOM

MIUB

GFDL

CSIRO



BCM

ECEARTH

MPI

CCSM3

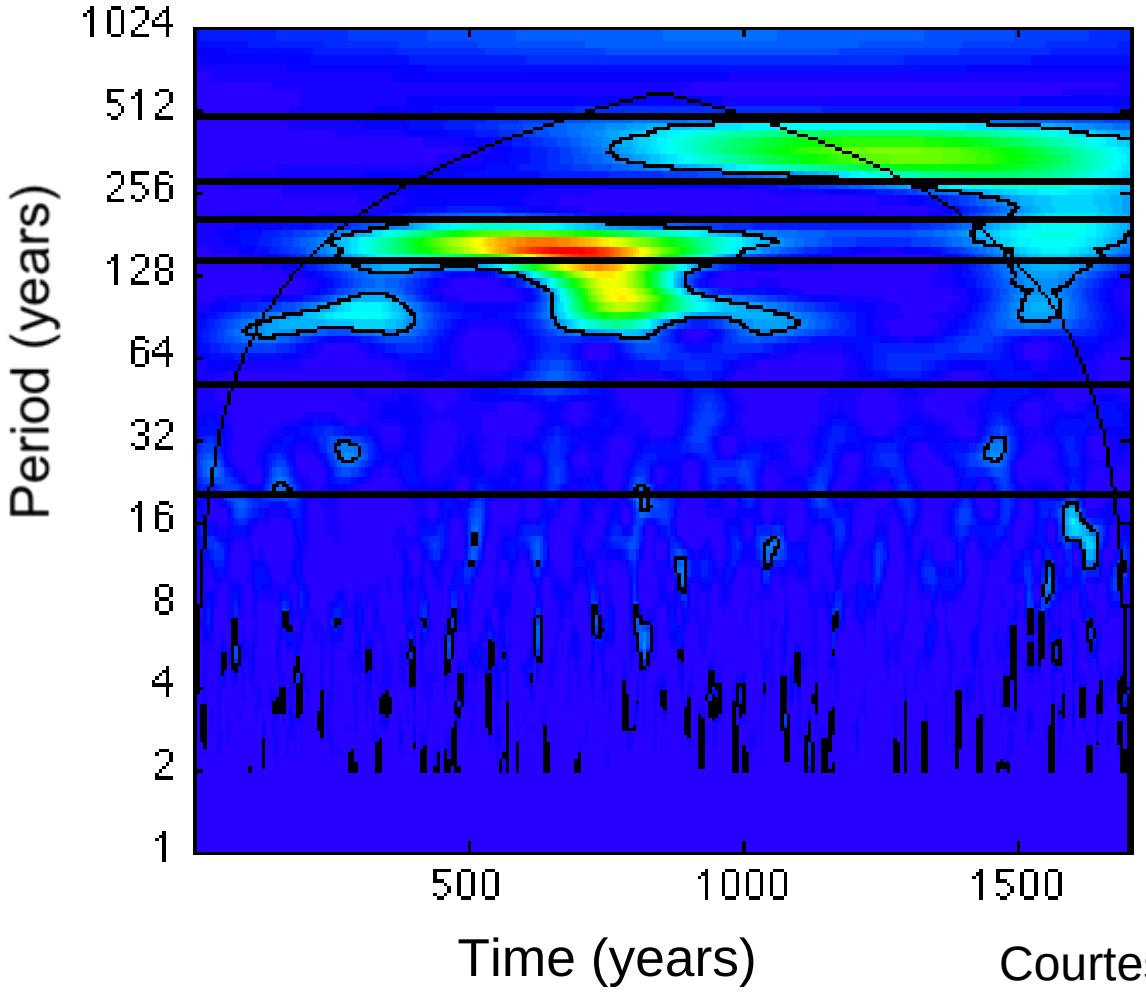
MIROC

INMCM4

Ocean driven by stochastic atmospheric variability

Ocean model simulation driven by stochastic NAO forcing

Wavelet spectrum: AMV : North Atlantic average SST



Courtesy: Jenny Mecking

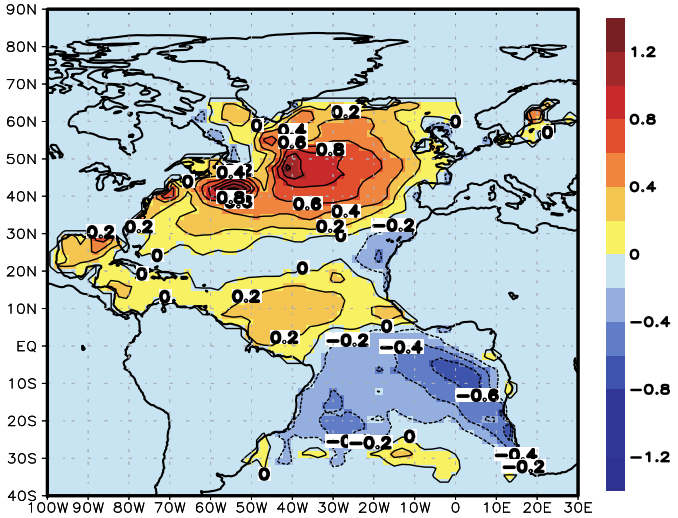
Ocean-atmosphere coupling: Potential role of stratosphere

Observed 1951-1960 anomalies

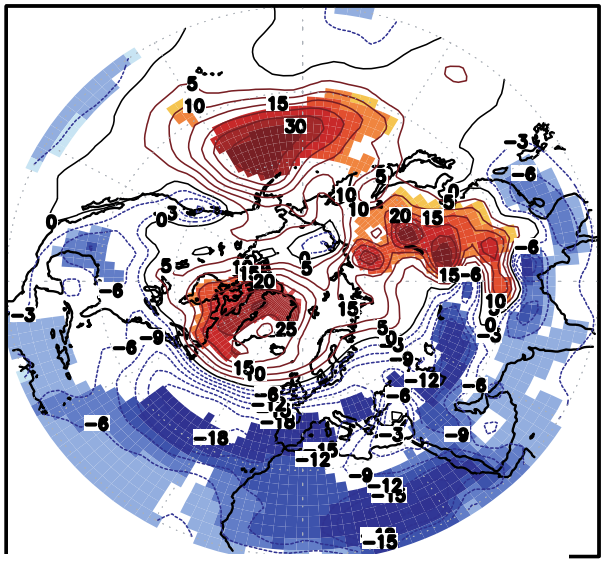
Simulated (ECHAM5)response to Atlantic SST 1951-1960

1000hPa GPH

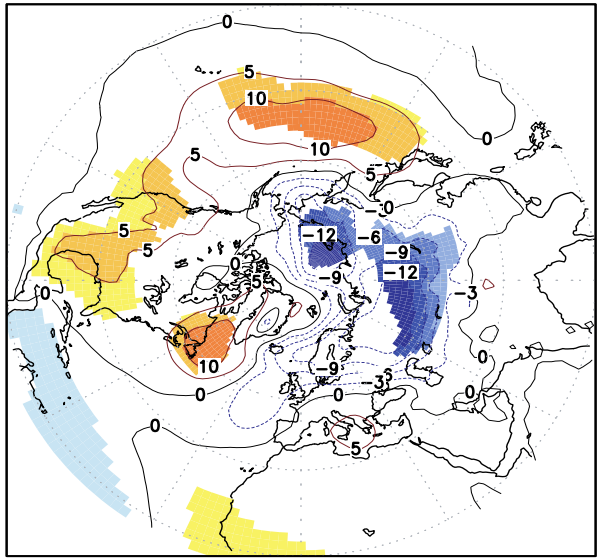
Observed SST anomaly



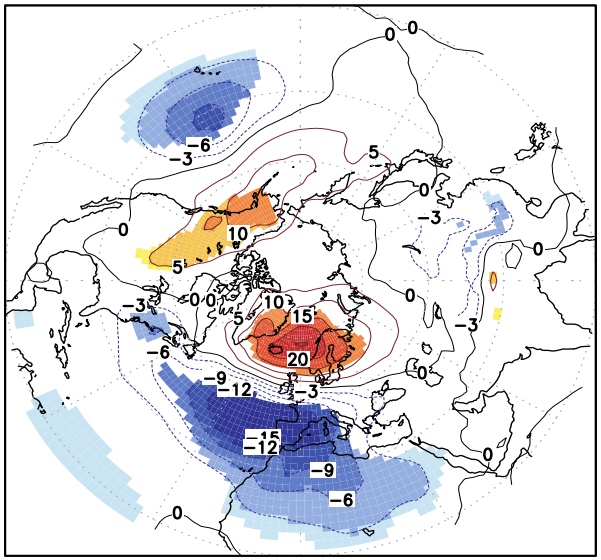
NCEP/NCAR 1000hPa GPH anomaly



Lower stratosphere resolving

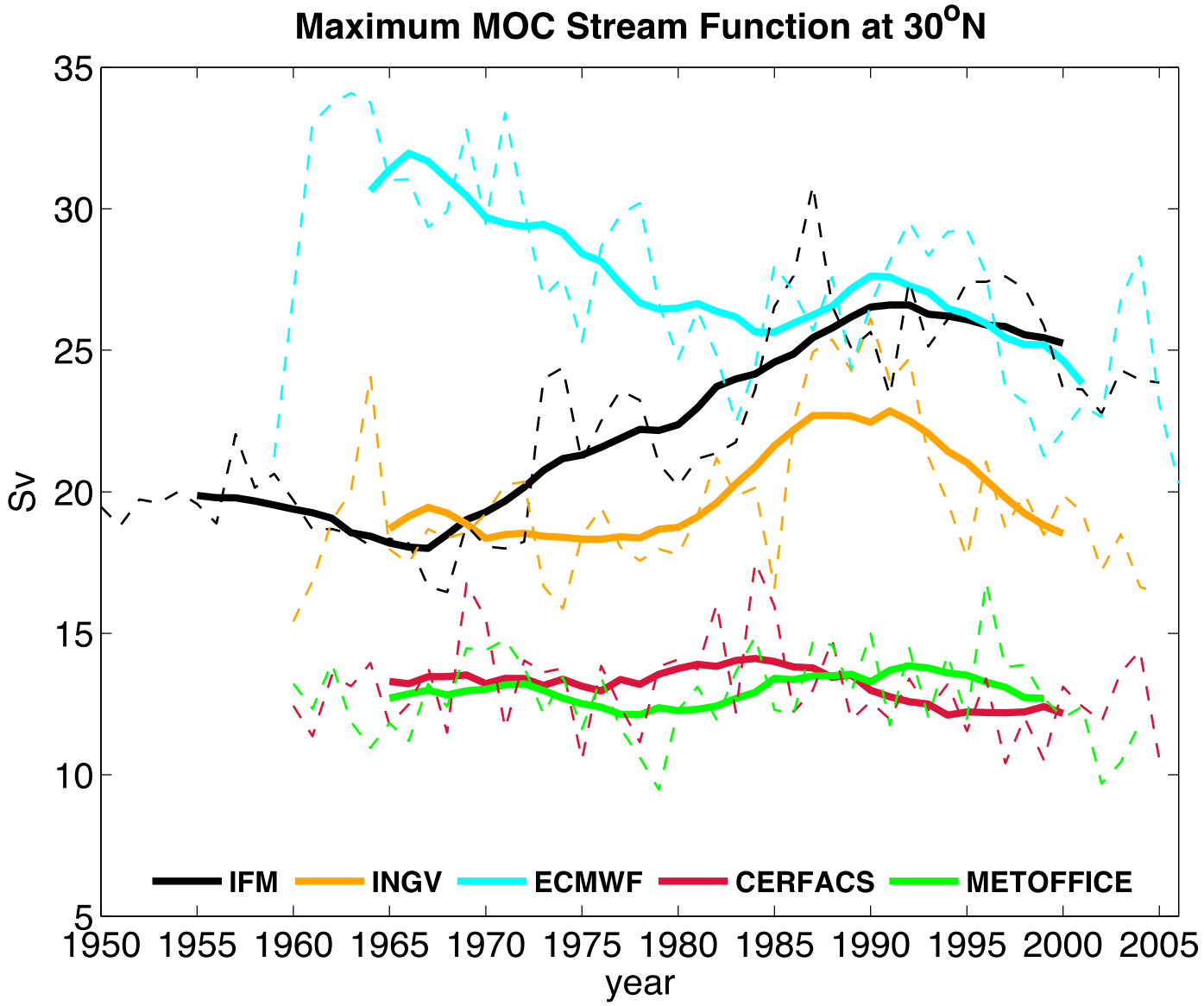


Entire stratosphere resolving



Omrani et al., submitted

Uncertainties in initial conditions



Keenlyside & Ba (2010)

We are in a highly experimental stage

IPCC AR5 near-term predictions: what to expect, how reliable?

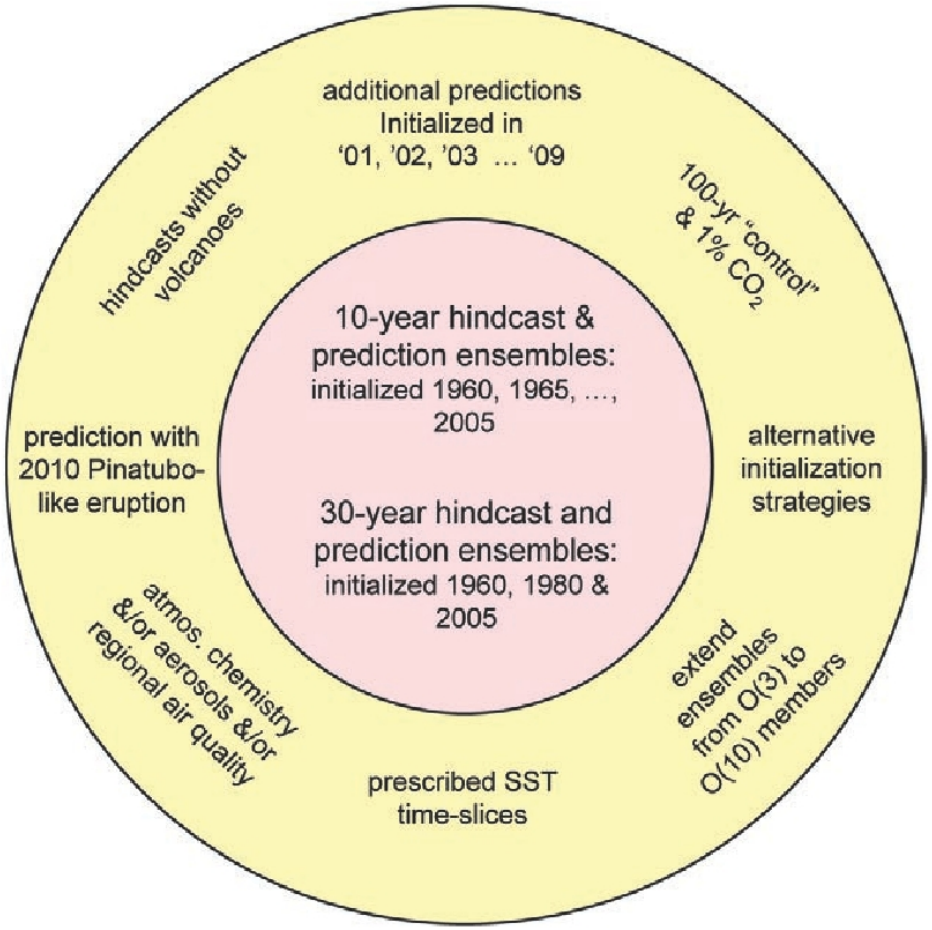


FIG. 9. Schmatic of decadal predictability/prediction experiments as part of CMIP5 (from Taylor et al. 2008).

Decadal Forecast Exchange

Doug Smith, UKMO-Hadley

Uni. Tokyo – *Kimoto Masahide*

MRI – Masayoshi Ishii

SMHI – *Klaus Wyser,Colin Jones*

KNMI – *Wilco Hazeleger, Bert Wouters*

IC3 – *Francisco Doblas-Reyes, Virginie Guemas*

MPI – *Daniela Matei, Wolfgang Muller*

RSMAS – *Ben Kirtman*

CCCMA – *George Boer, Bill Merryfield*

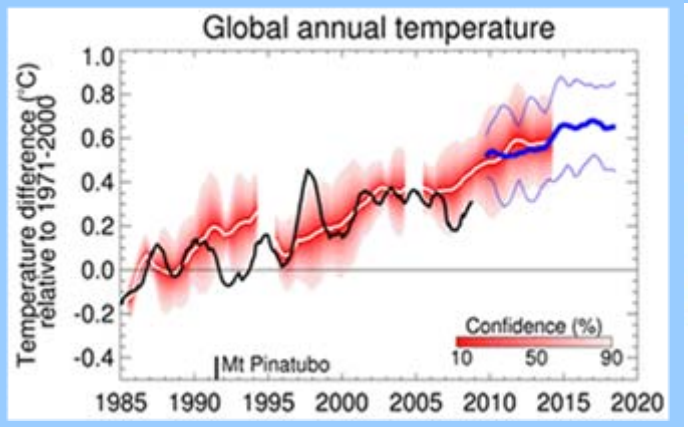
UKMO-Hadley – *Doug Smith, Adam Scaife*

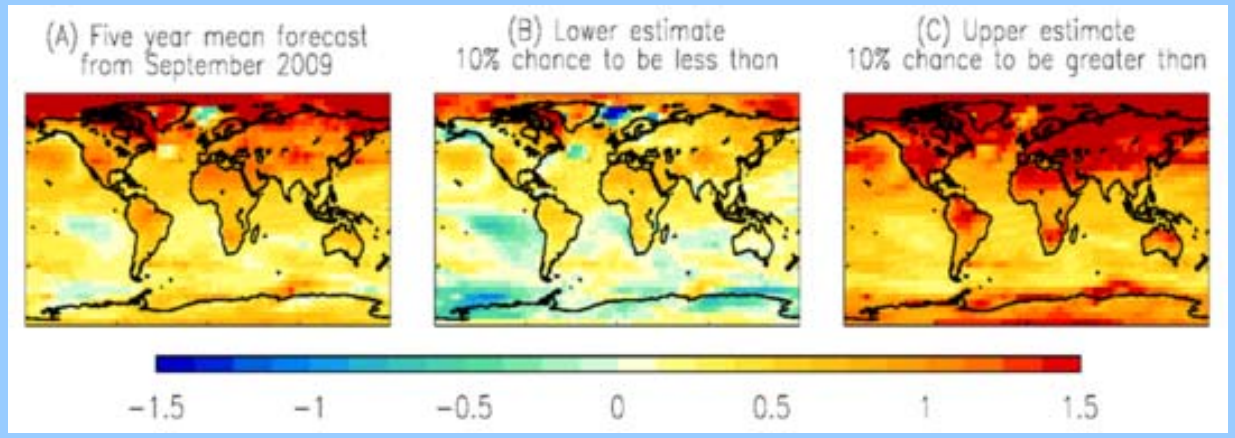
NRL *– Judith Lean, David Rind*

NOAA *– Arun Kumar*

Please contact: doug.smith@metoffice.gov.uk

to contribute your forecasts…





What is the potential to predict the decadal shifts in the climate system?

- Some initial success, especially in the N. Atlantic
- Major challenges exist:
  - Model and initial conditions uncertain large
- We are in a highly experimental stage