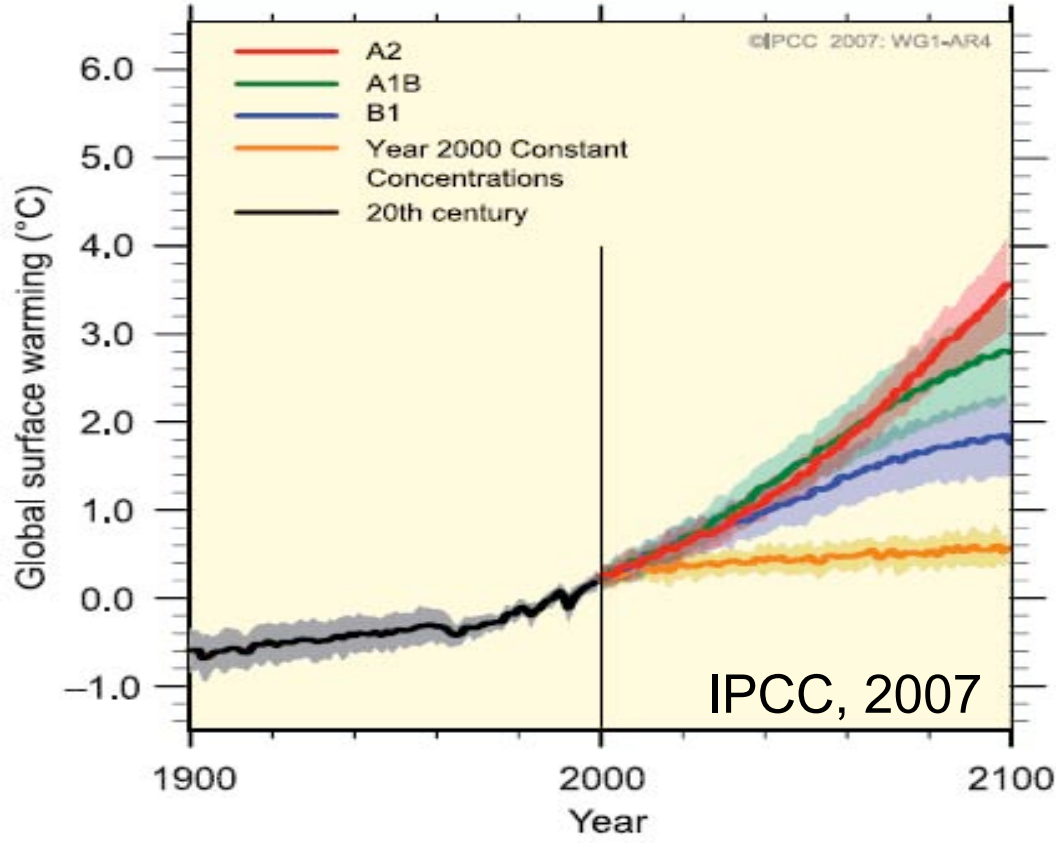
Advancing decadal-scale climate prediction in the North Atlantic Sector

Noel Keenlyside

M. Latif, J. Jungclaus, L. Kornblueh, E. Roeckner, V. Semenov & W. Park



How warm will be the next decade?

AGCI meeting, Aspen, 24.06.08

ENSEMBLES

Emmy Noether-Programm
Deutsche Forschungsgemeinschaft DFG

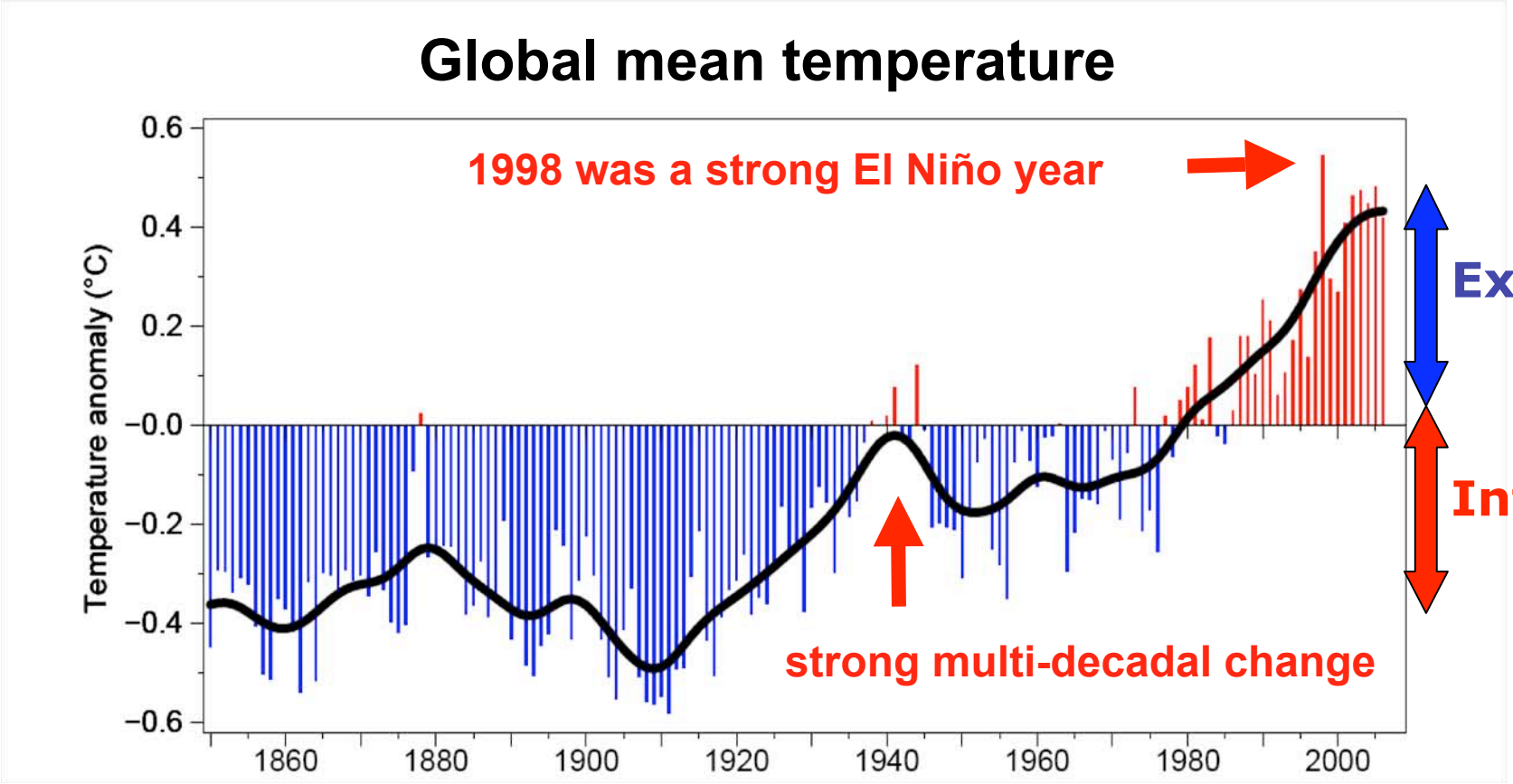
IFM-GEOMAR

Outline

1. **Motivation and background**
   - **Predictability of the first kind: arises from the initial conditions**
   - **Predictability of the second kind: arises from the boundary conditions**
2. **Results using SST initialisation**
3. **Summary and future activities**

IFM-GEOMAR

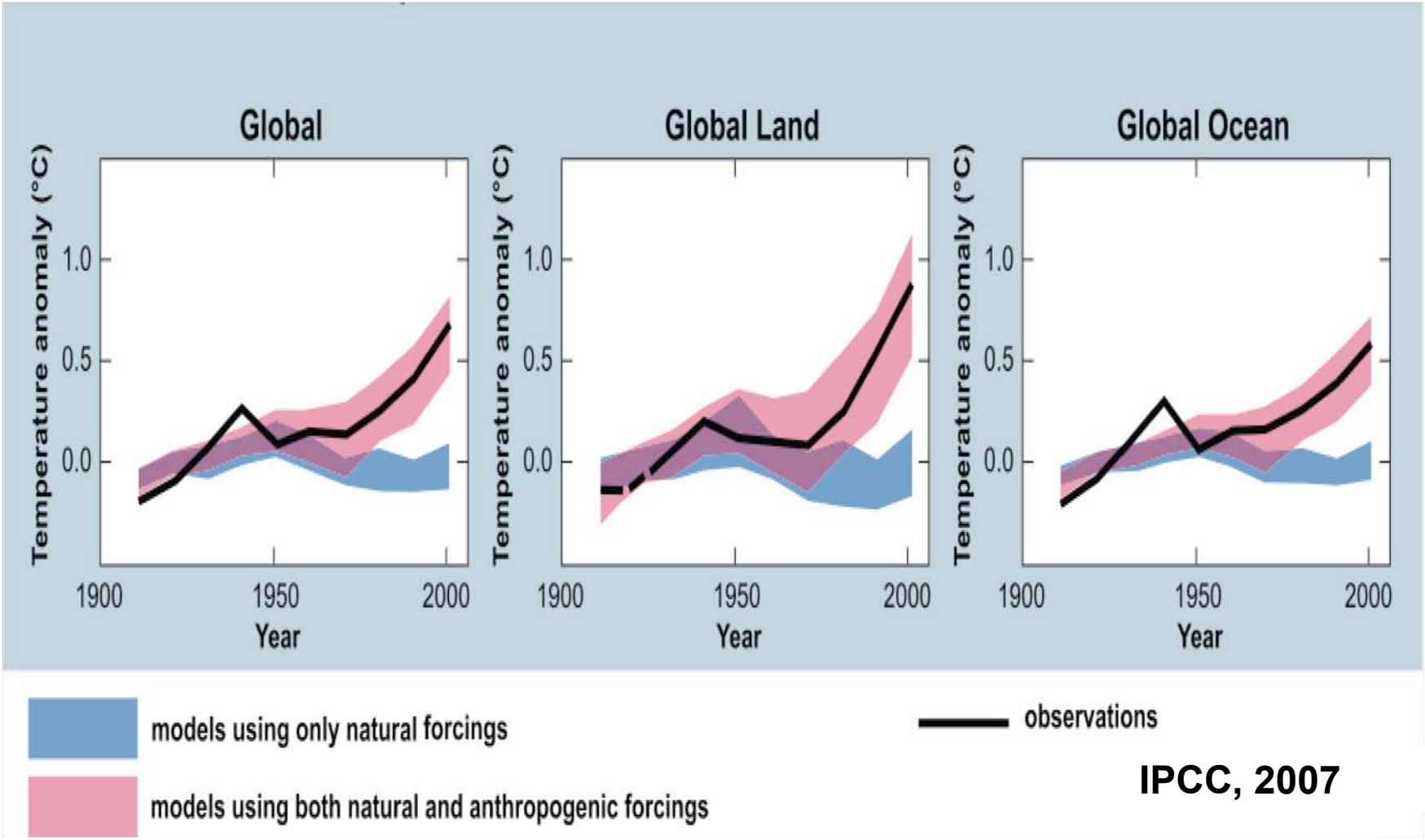
Twentieth century climate variability: Natural and anthropogenic



What is the contribution of internal variability?

IFM-GEOMAR

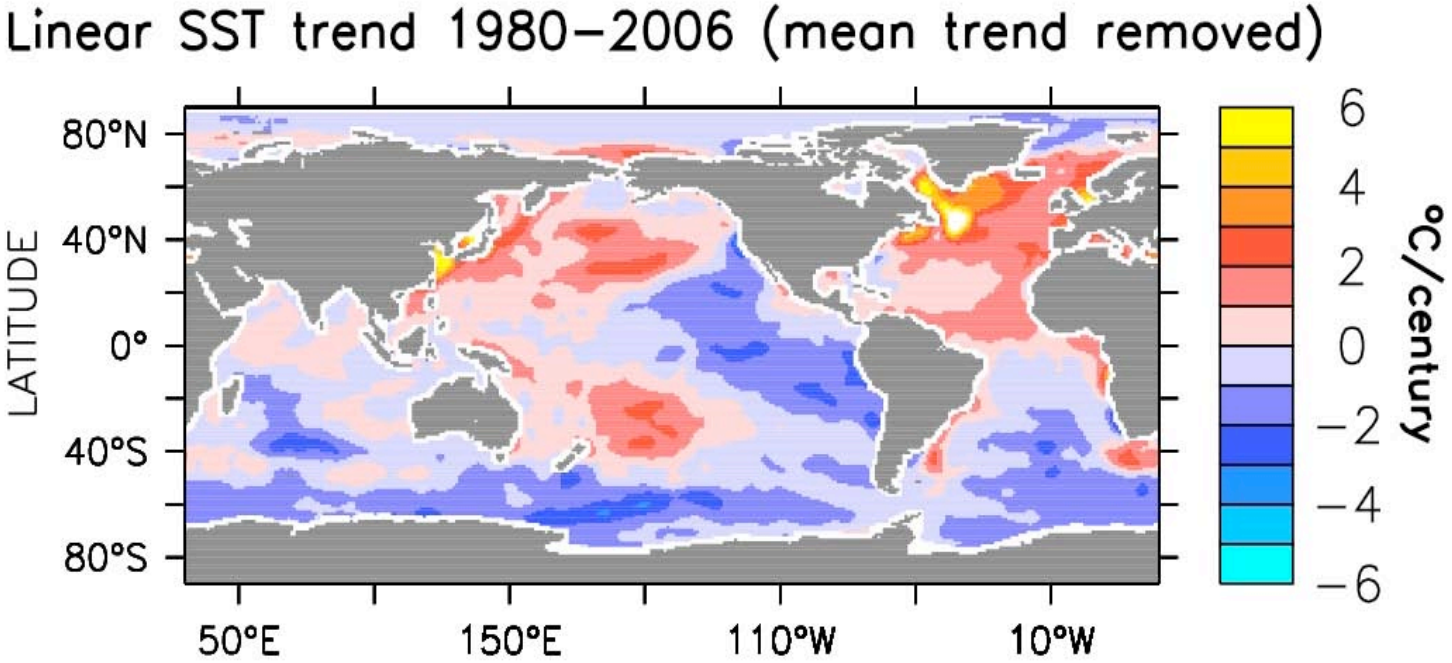
Decadal temperature fluctuations: Can radiative forcing explain all?

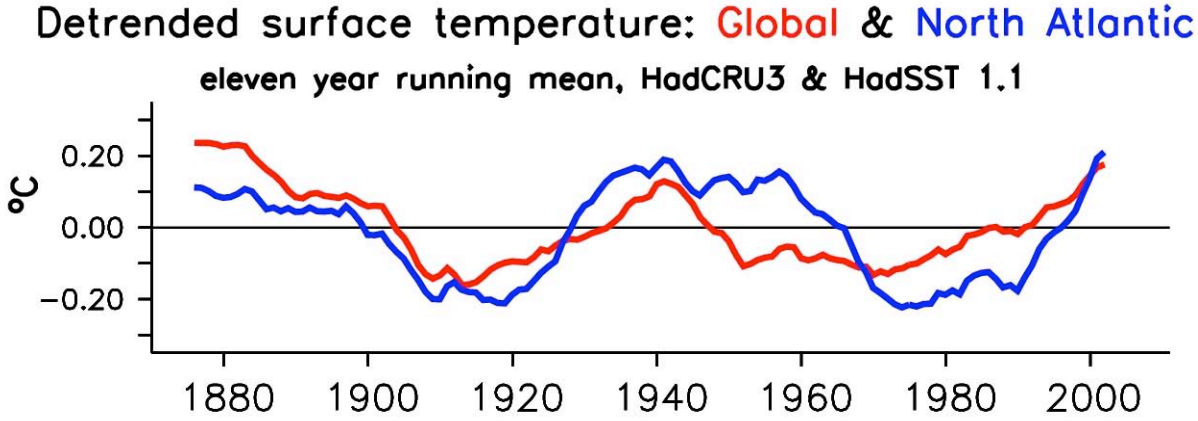


IPCC, 2007

IFM-GEOMAR

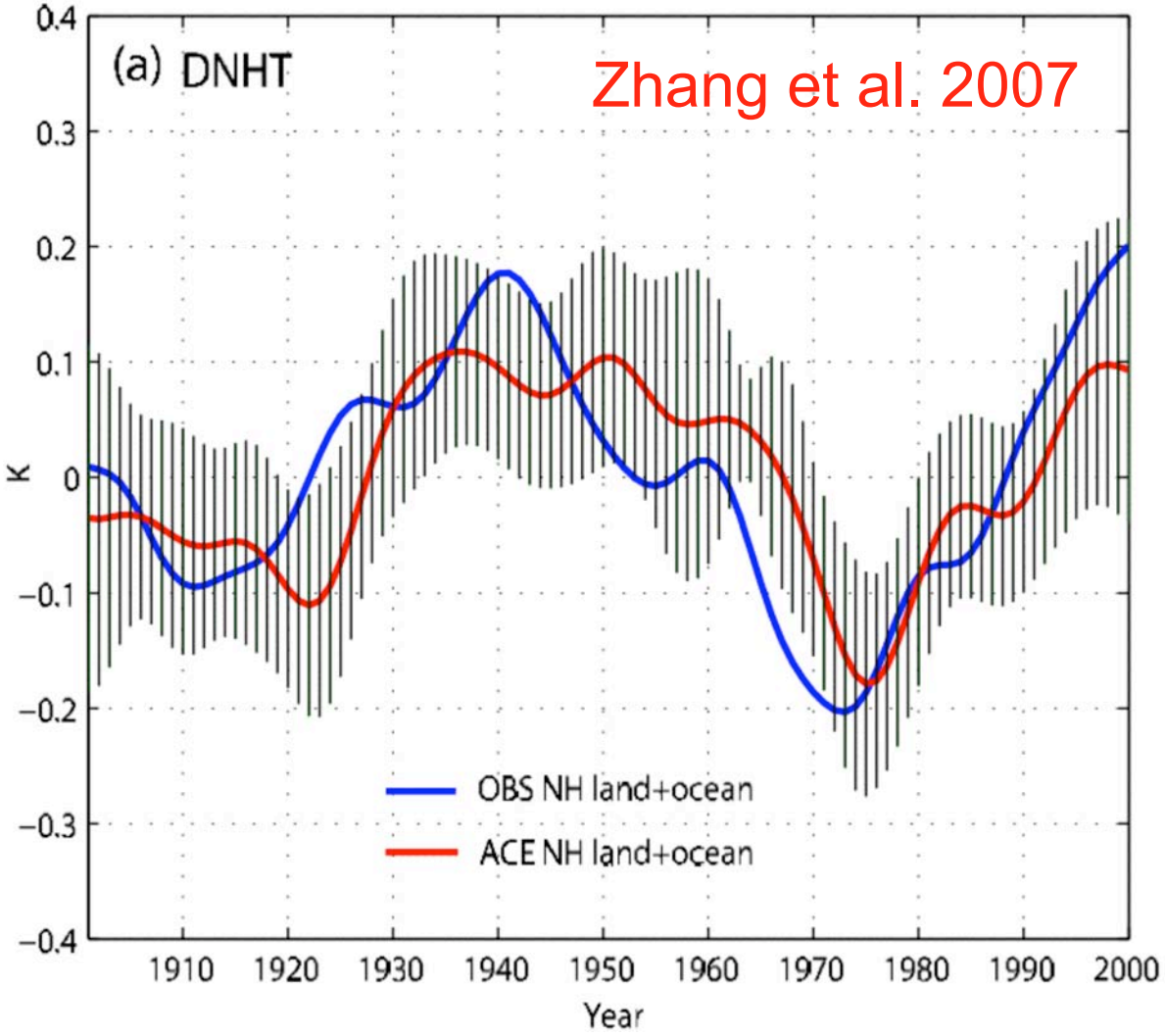
Signs of natural variability: North Atlantic





IFM-GEOMAR

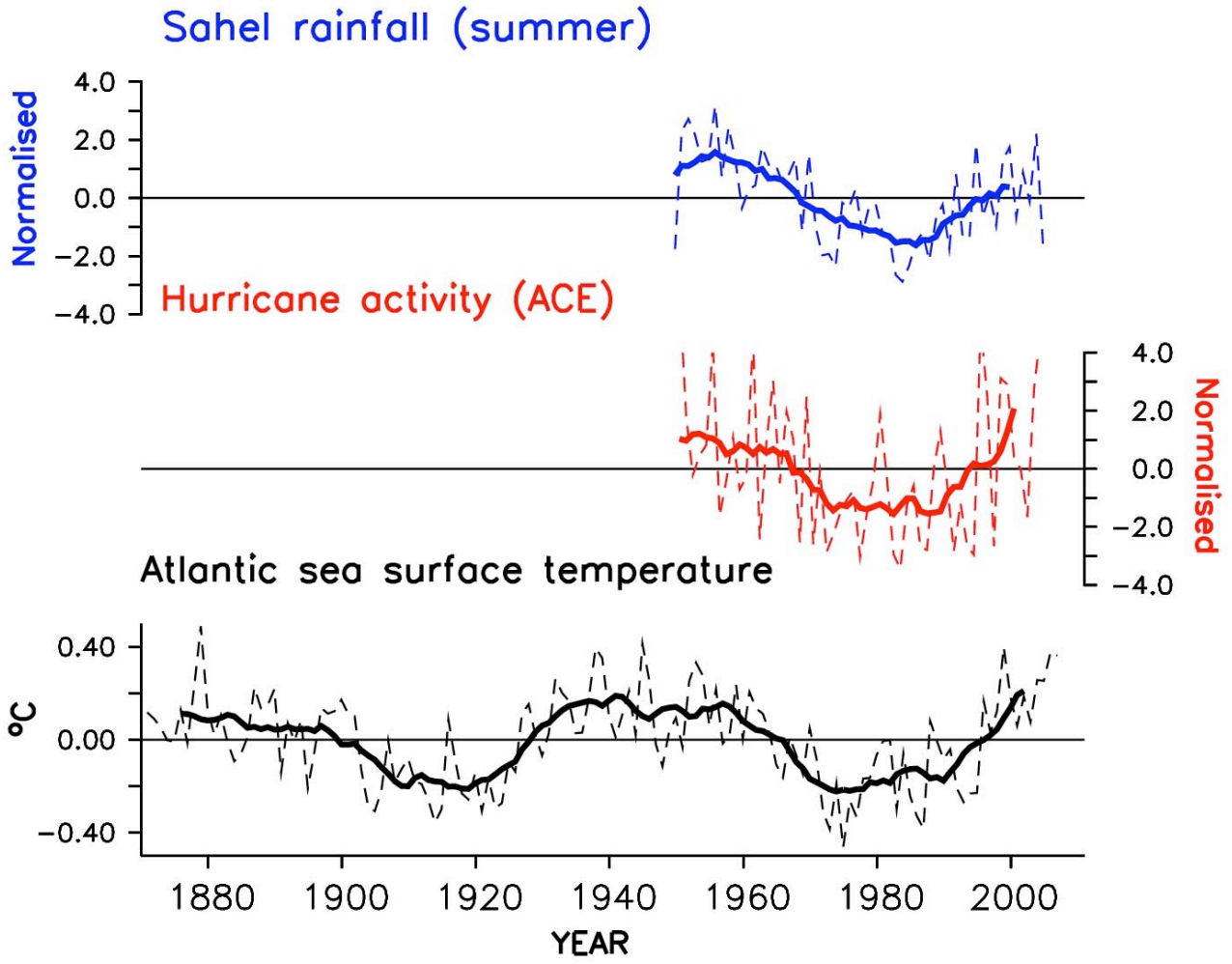
Can the Atlantic drive multi-decadal Northern Hemisphere (& global) surface temperature variations?



IFM-GEOMAR

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

Period of 70-80 years (detrended timeseries)



IFM-GEOMAR

Outline

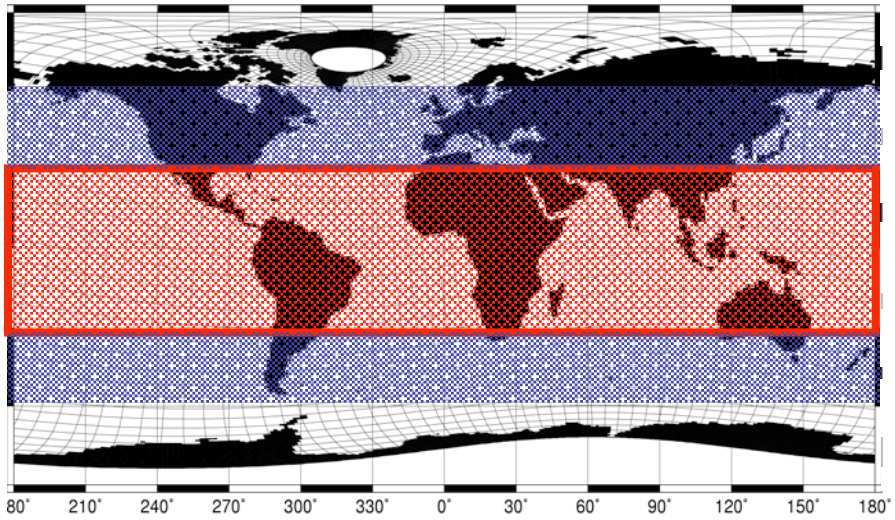
1. Motivation and background
   - Predictability of the first kind: arises from the initial conditions
   - Predictability of the second kind: arises from the boundary conditions
2. **Results using SST initialisation**

IFM-GEOMAR

Decadal hindcast/forecast strategy

- Model: ECHAM5/MPIOM Climate model (IPCC AR4 version)
- Initial conditions: Coupled model SST anomalies restored to observations
- Boundary conditions: 20th century/A1B radiative forcing

Nudging constant varies with latitude



0 days^{-1} (fully coupled)

Linear transition

0.25 days^{-1}

Linear transition

0 days^{-1} (fully coupled)

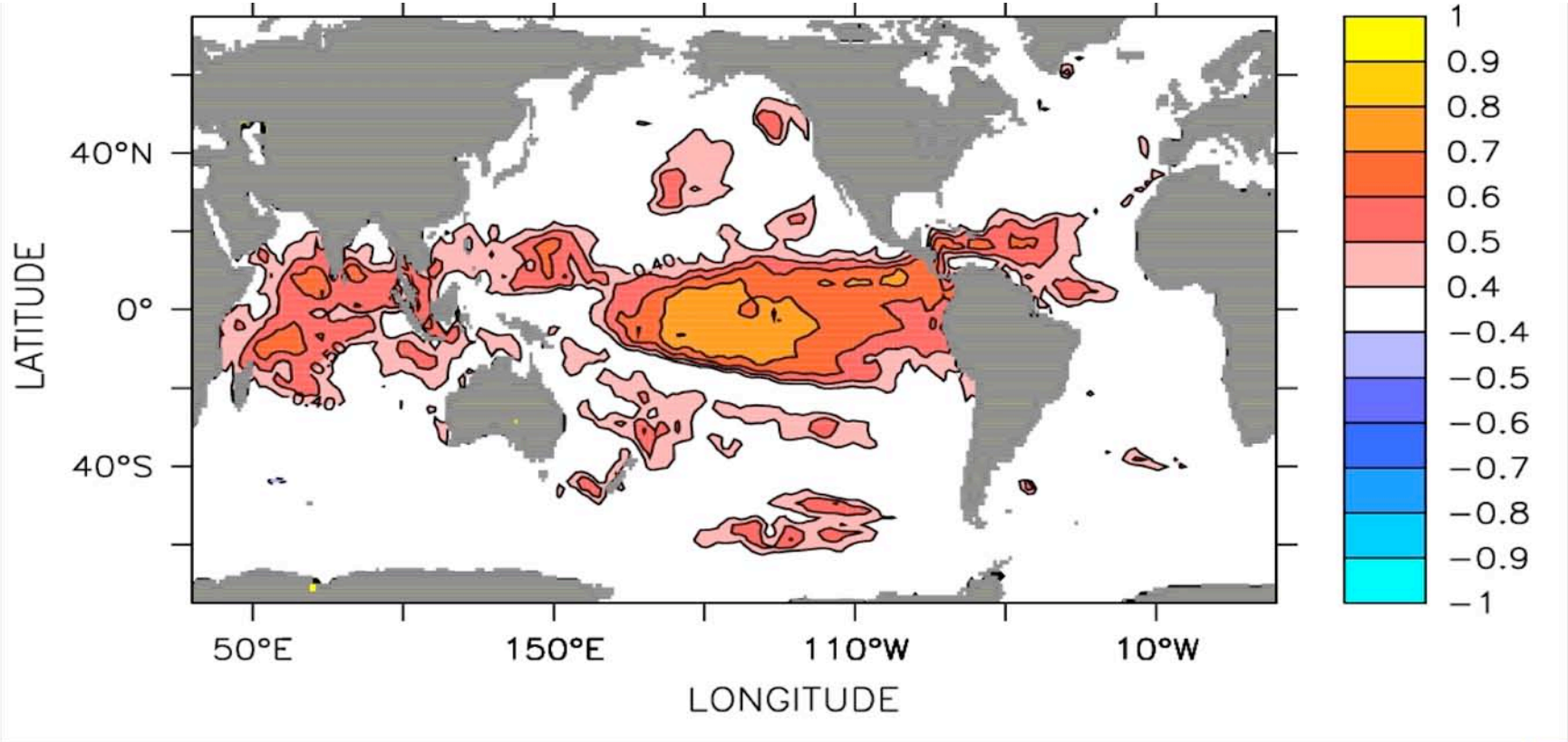
IFM-GEOMAR

Seasonal prediction skill - 6-month lead

Correlation with observed sea surface temperature anomalies

1960-2005; 9-ensemble members; 4 per year

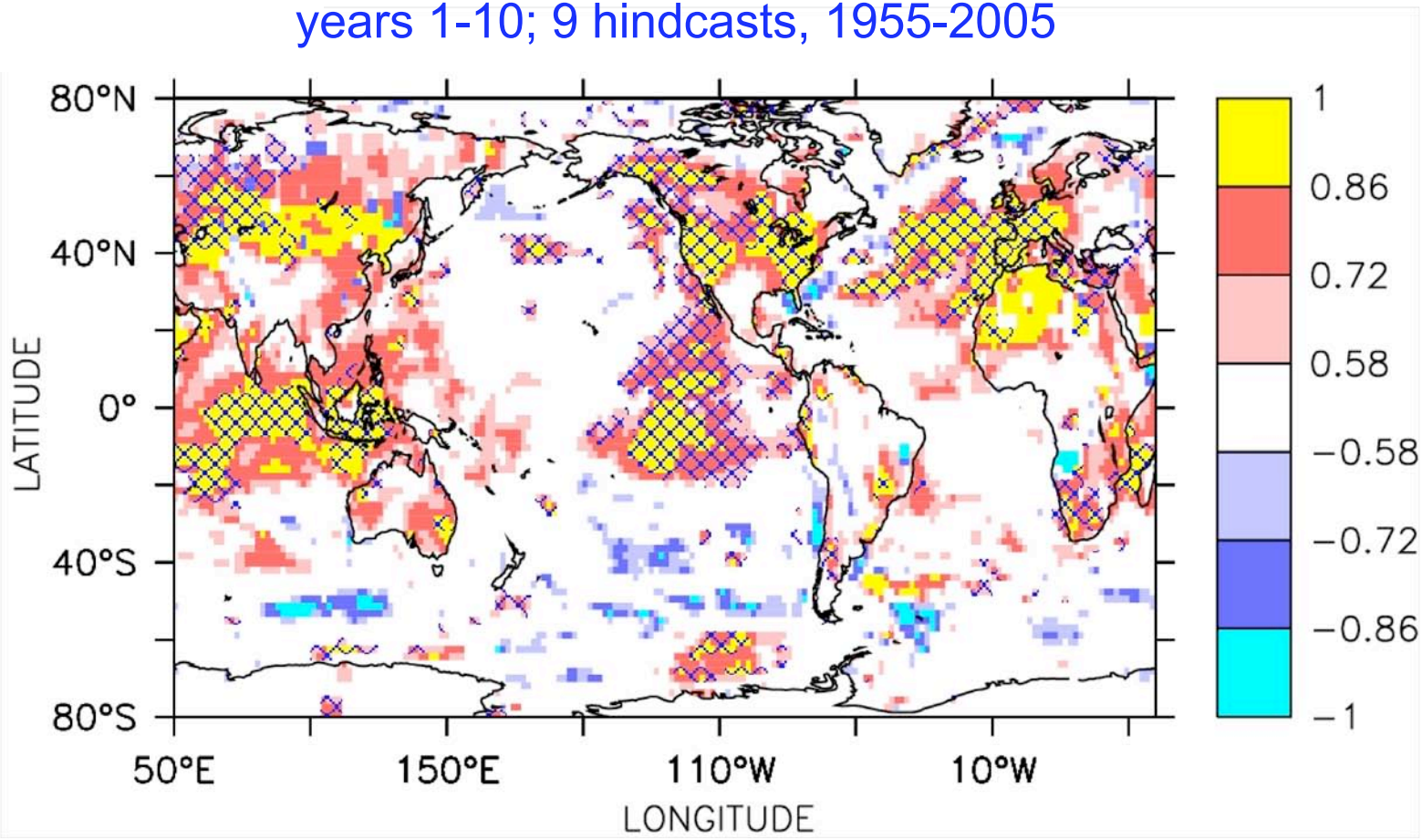
Initialised by restoring to full SST



IFM-GEOMAR

Decadal prediction skill - Initialised hindcasts

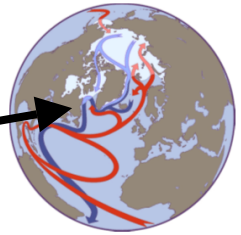
Correlation with observed surface temperature anomalies
years 1-10; 9 hindcasts, 1955-2005

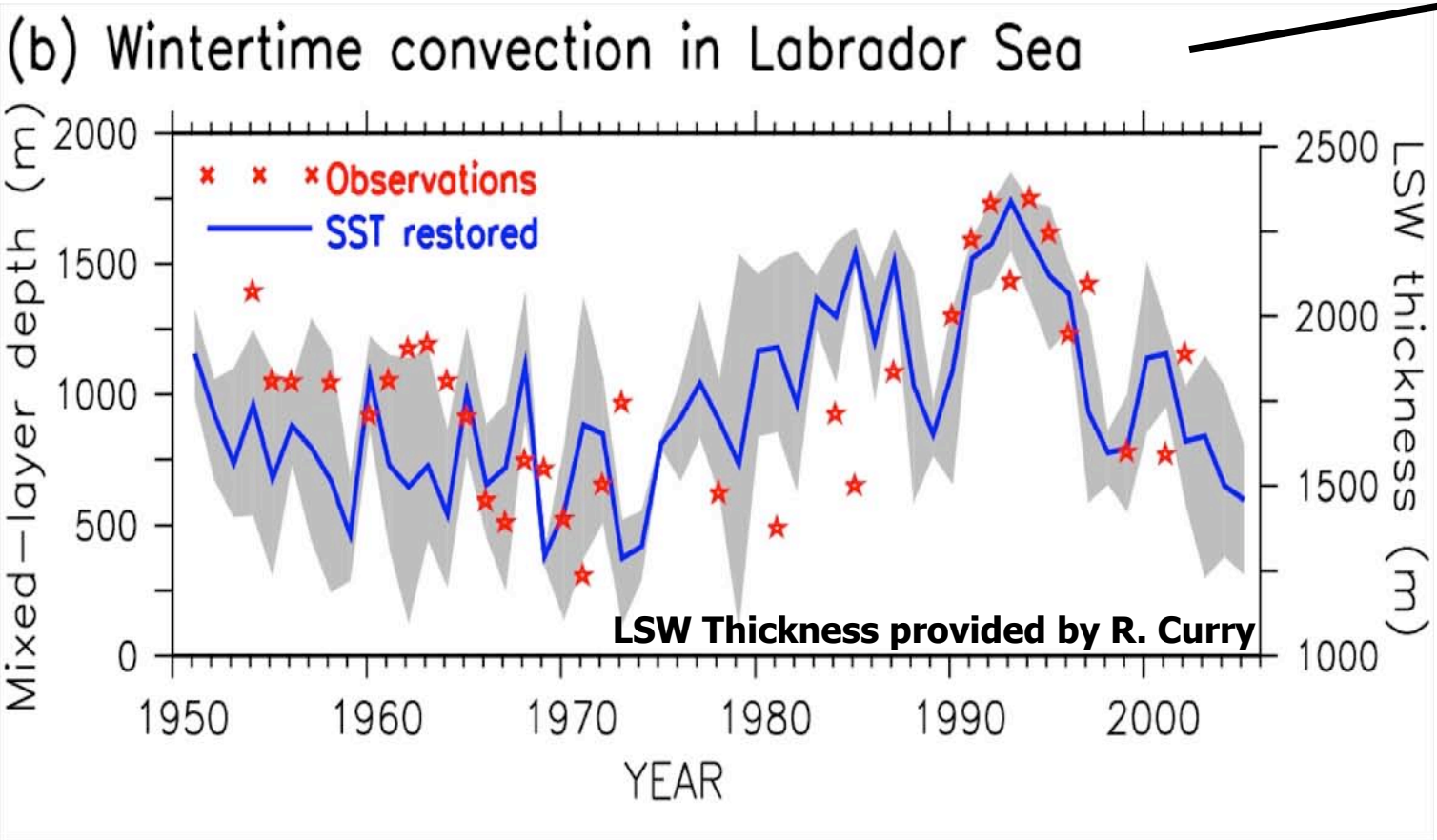


IFM-GEOMAR

Initialisation of low-frequency variability in Atlantic ocean circulation

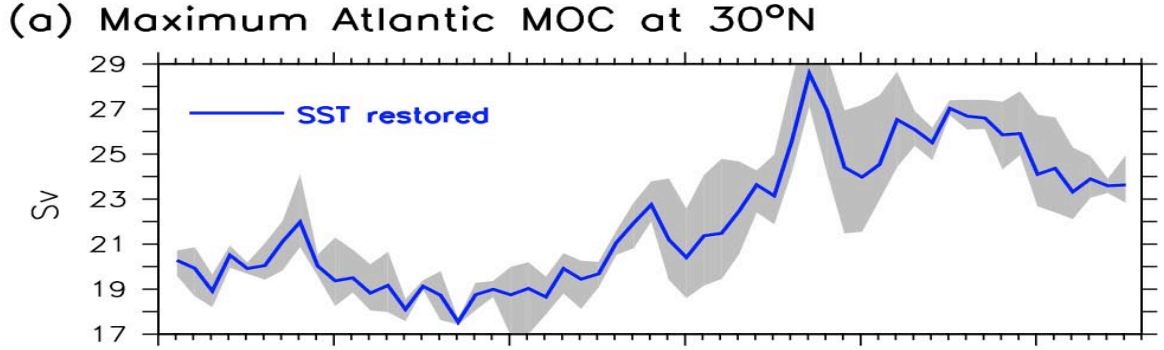
MOC

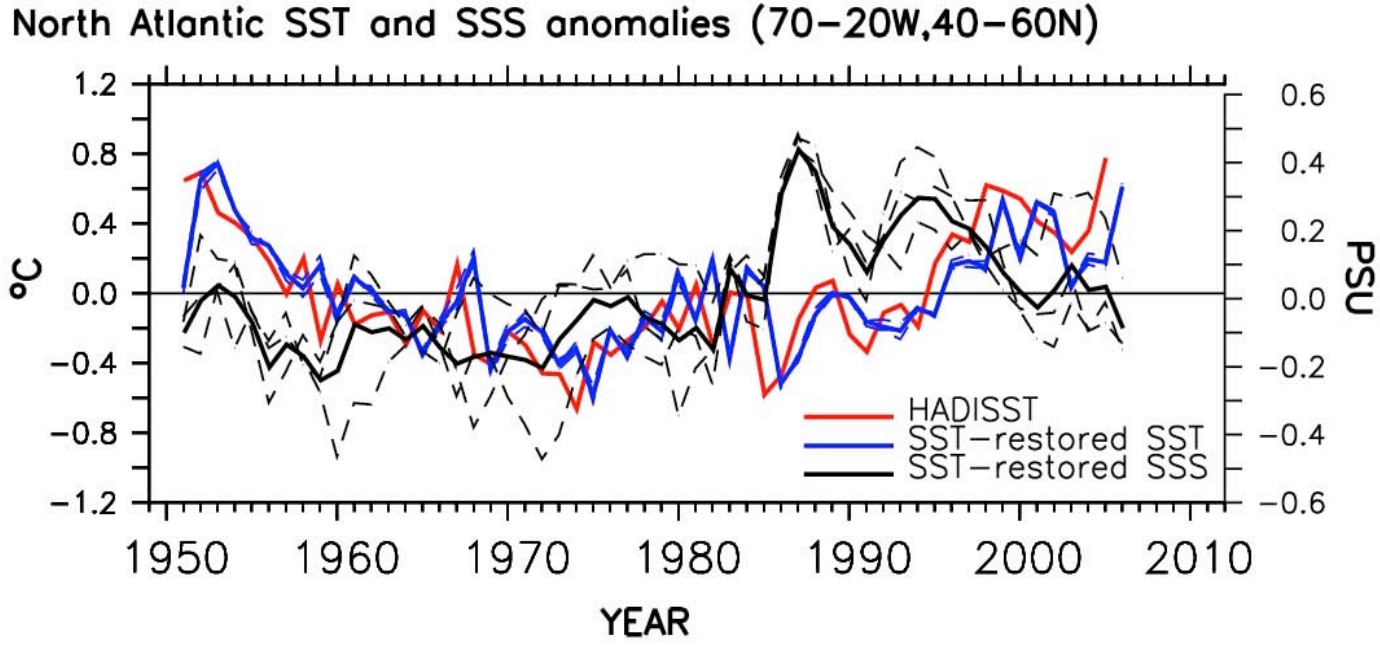




IFM-GEOMAR

Simulated Atlantic MOC changes: SST restoring amplified by salinity changes

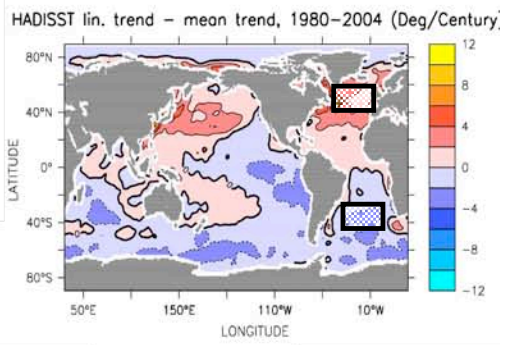




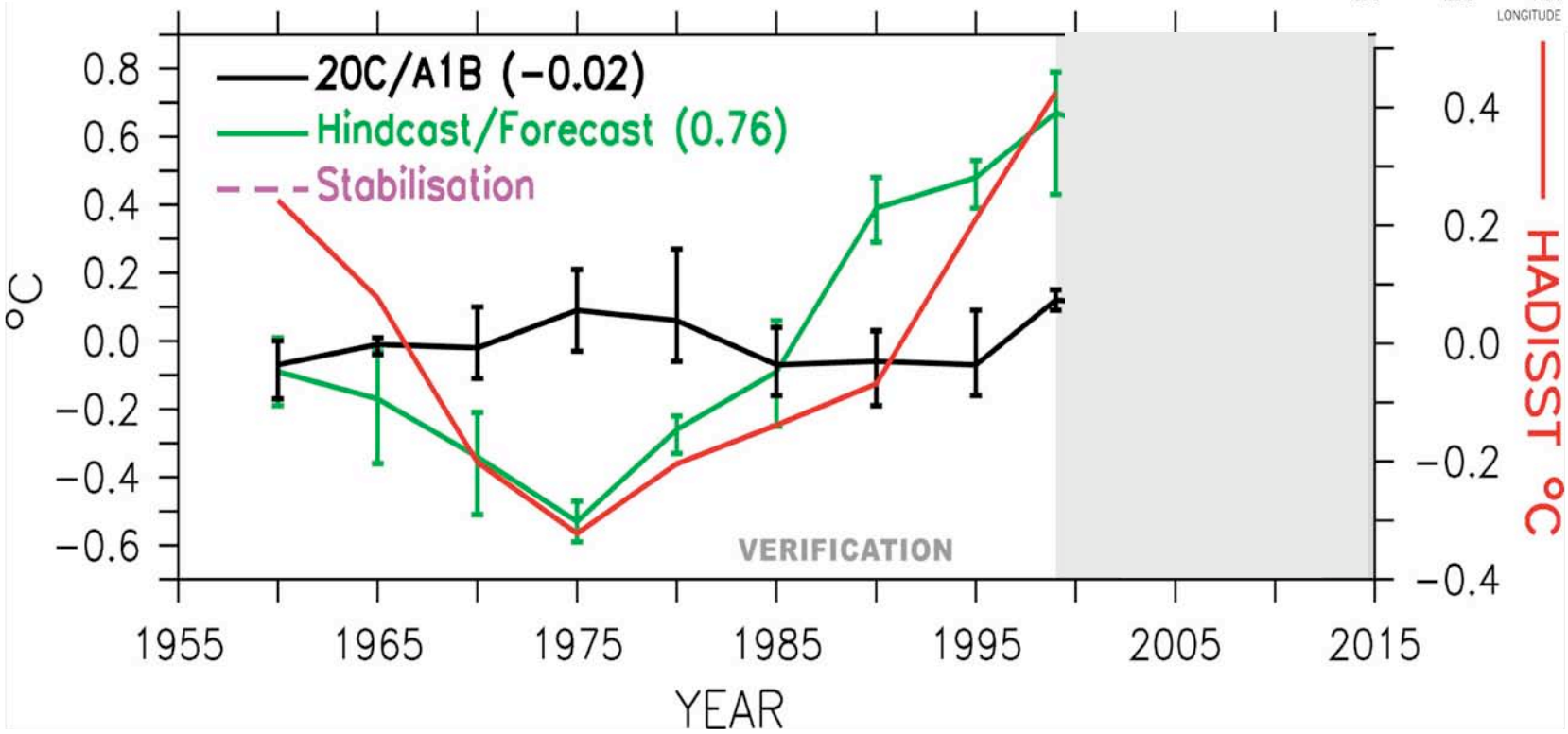
IFM-GEOMAR

Hindcast/Prediction: Atlantic sea surface temperature dipole index

(60-10W,40-60N minus 50-0W,40-60S)



(Centred decadal means, vertical bars show ensemble spread)

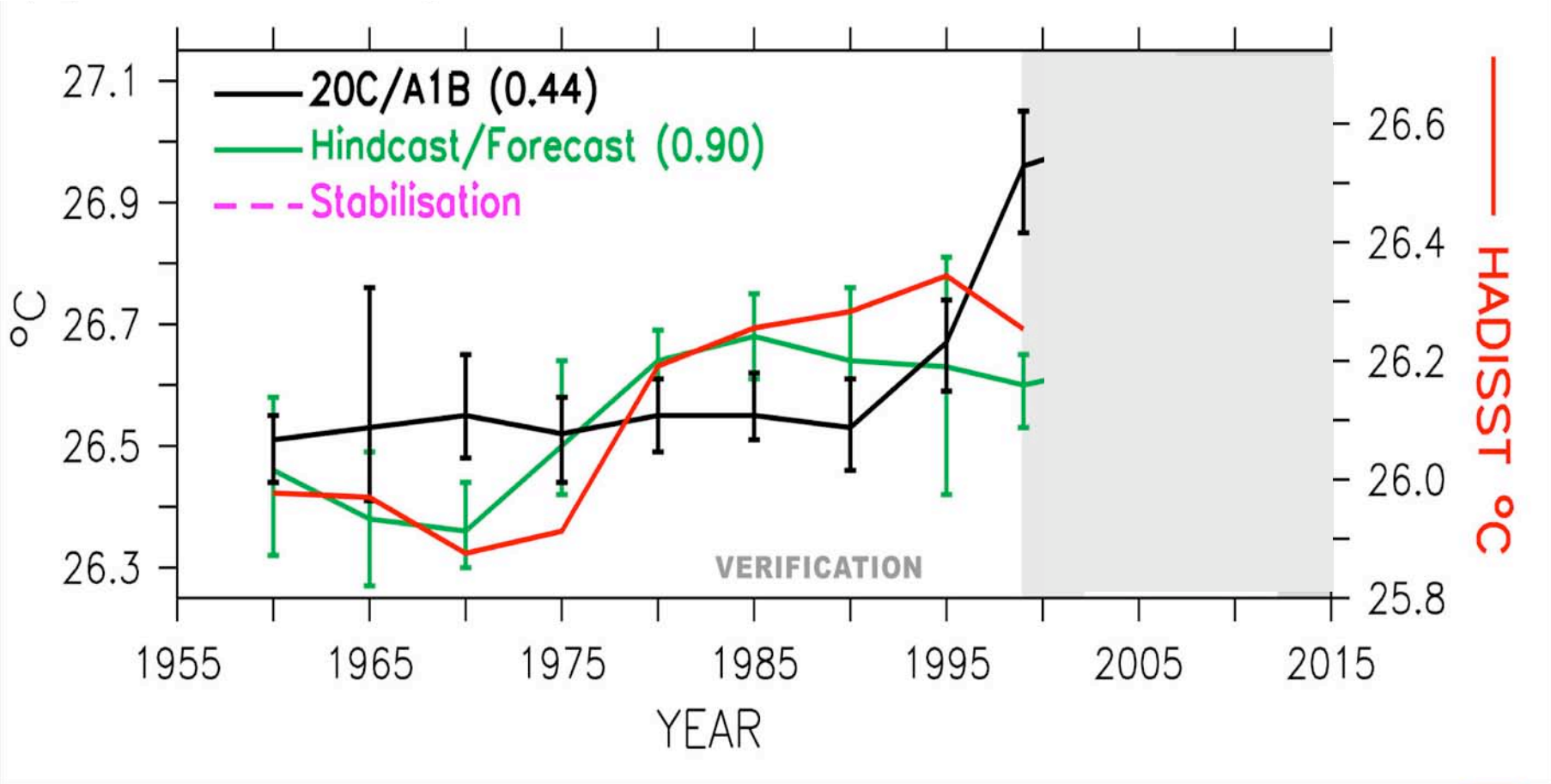


IFM-GEOMAR

Prediction: Eastern Tropical Pacific SST

(150-90W,20S-20N)

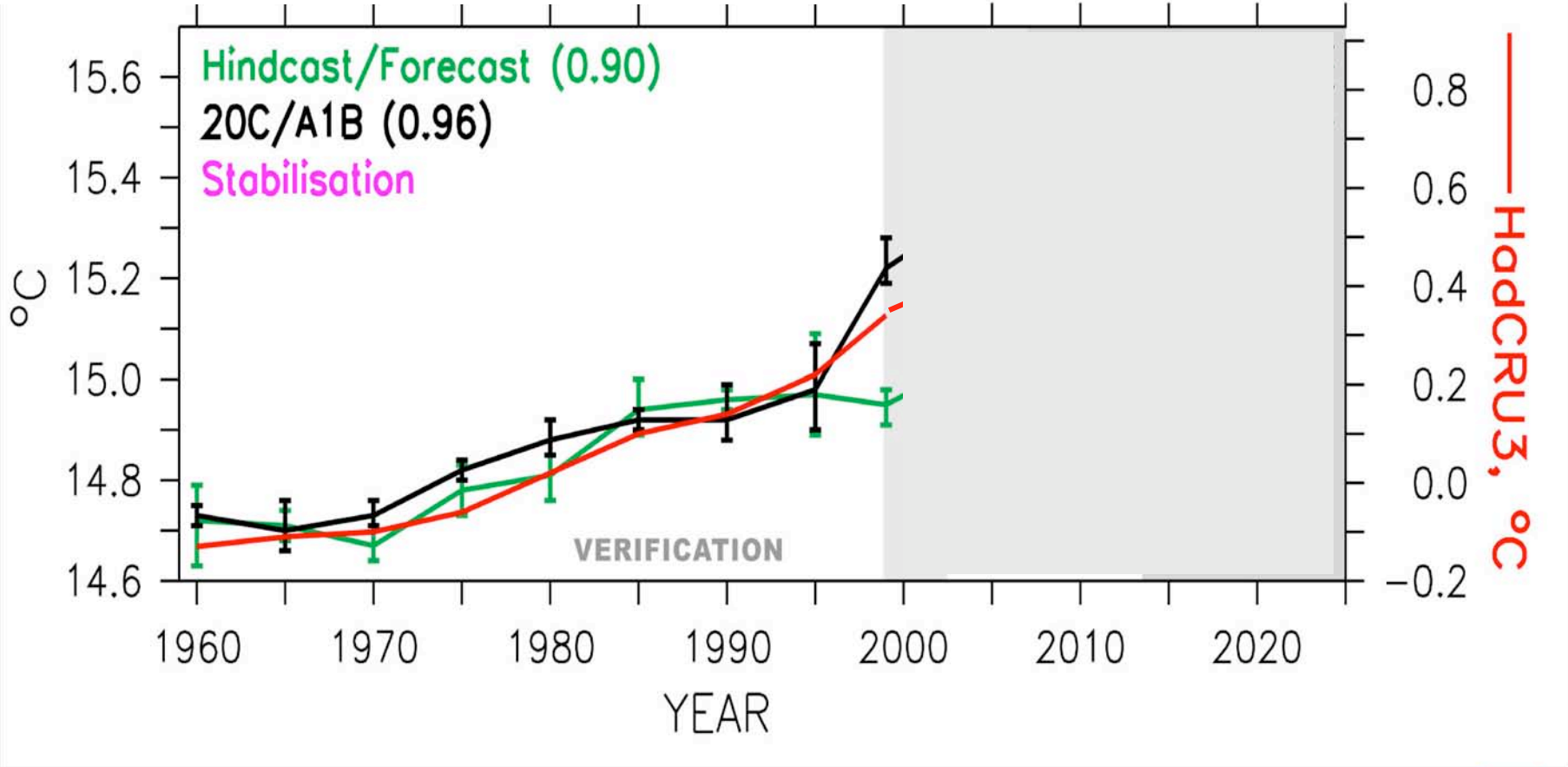
(Centred decadal means, vertical bars show ensemble spread)



IFM-GEOMAR

Hindcast/prediction: Global mean temperature

(Centred decadal means, vertical bars show ensemble spread)



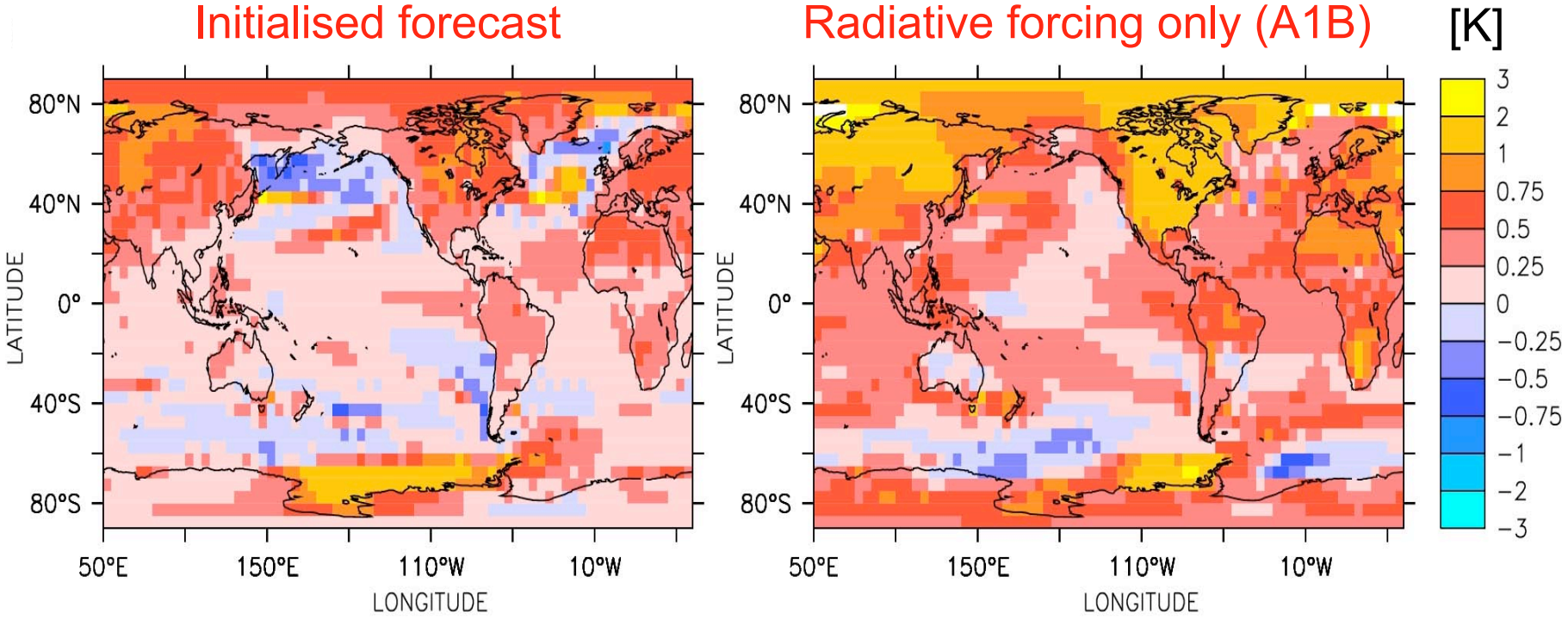
IFM-GEOMAR

Surface temperature anomaly 2005-2015

(Anomaly with respect to the nine decadal means between 1955-2005)

Initialised forecast

Radiative forcing only (A1B)



IFM-GEOMAR

Summary

- Decadal prediction skill achieved for the North Atlantic Sector & Tropical Pacific, above that expected from radiative forcing

- Internal decadal variability may offset expected warming over the next decade, regionally and globally

- Caveat - model suffers from significant biases, but nevertheless results are promising

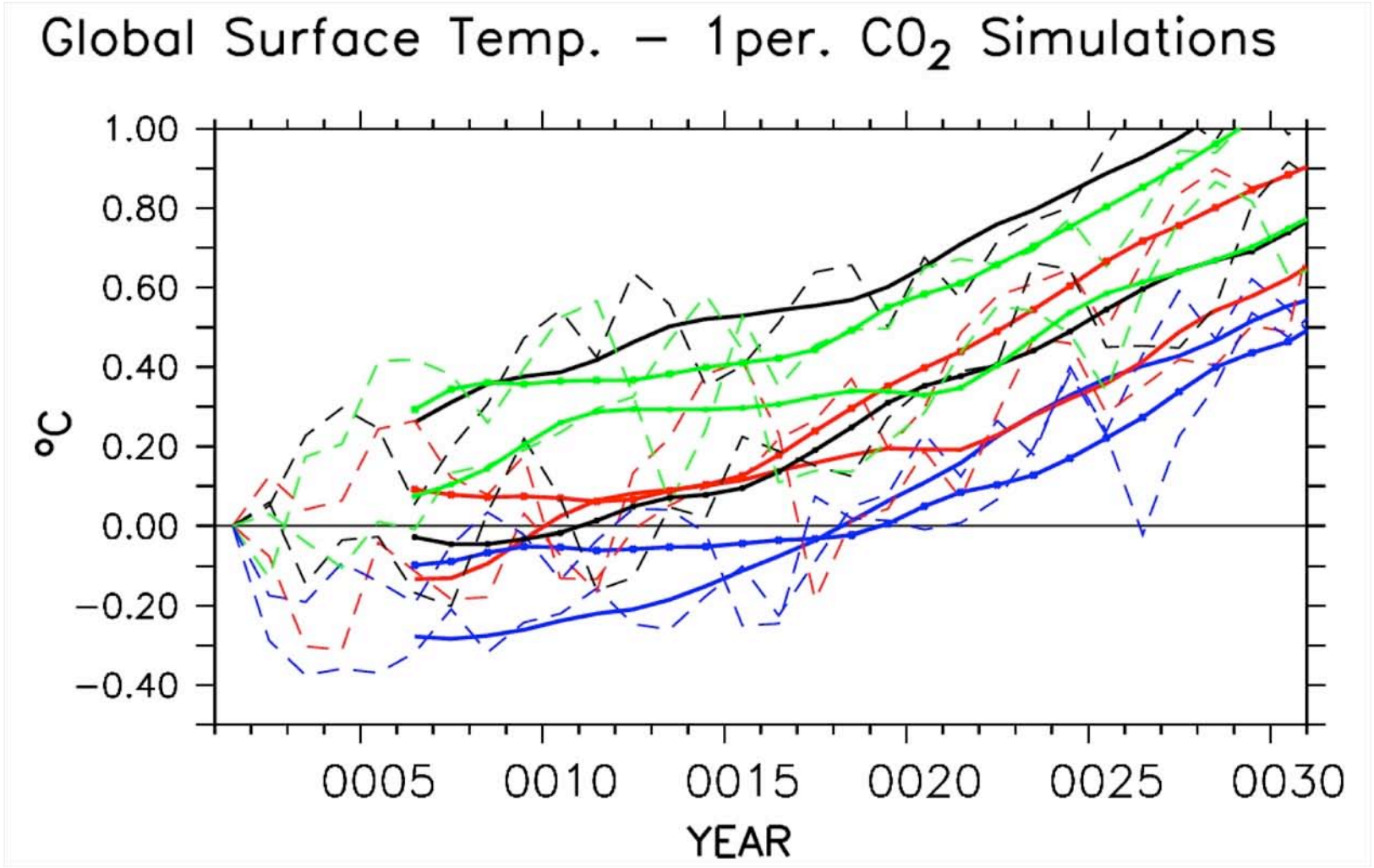
IFM-GEOMAR

Future activities at IFM-GEOMAR

1. Investigate methods to extend simple initialisation schemes:
   - Perfect model experiments to develop better understanding of the utility of SST restoring
   - Investigate methods to account/include salinity variations
   - Investigate statistical methods for using SST data

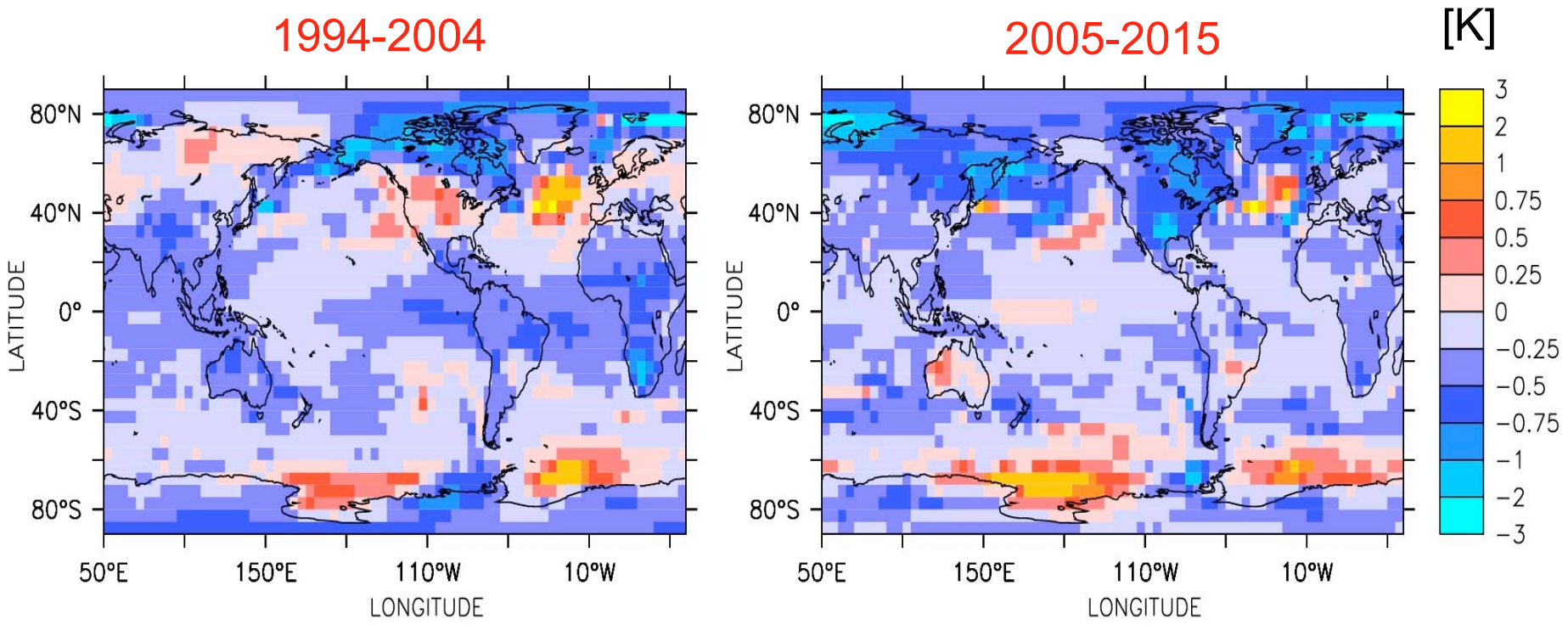
2. Understand the mechanisms for Atlantic multi-decadal variability using model hierarchy

IFM-GEOMAR


Global Surface Temp. – 1per. CO_2 Simulations
1.00
0.80
0.60
0.40
0.20
0.00
−0.20
−0.40
°C
0005
0010
0015
0020
0025
0030
YEAR

IFM-GEOMAR

Surface temperature: Initialised predictions minus radiative forcing only

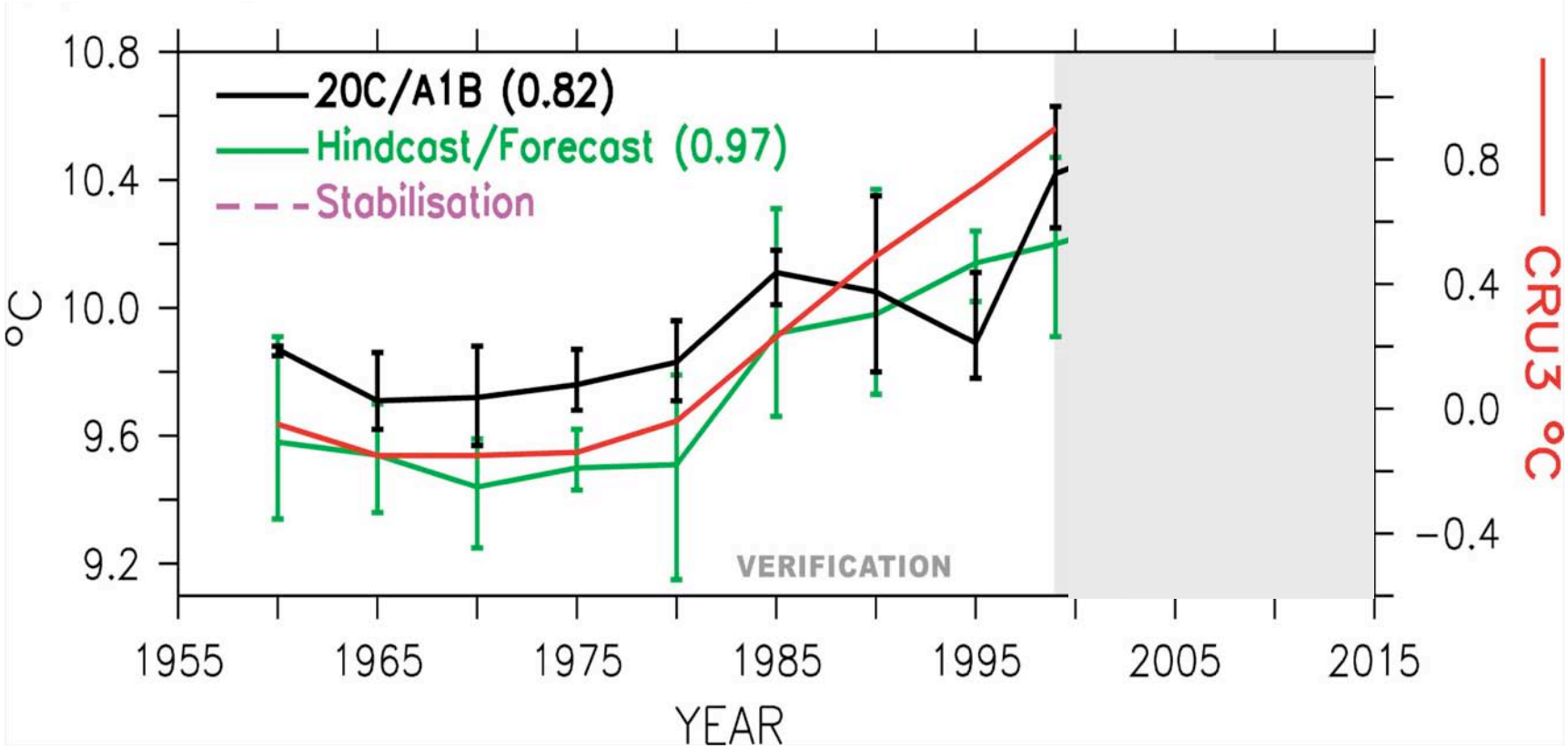


IFM-GEOMAR

Hindcast/Prediction: European surface temperature

(5°W-10ºE, 35-60ºN)

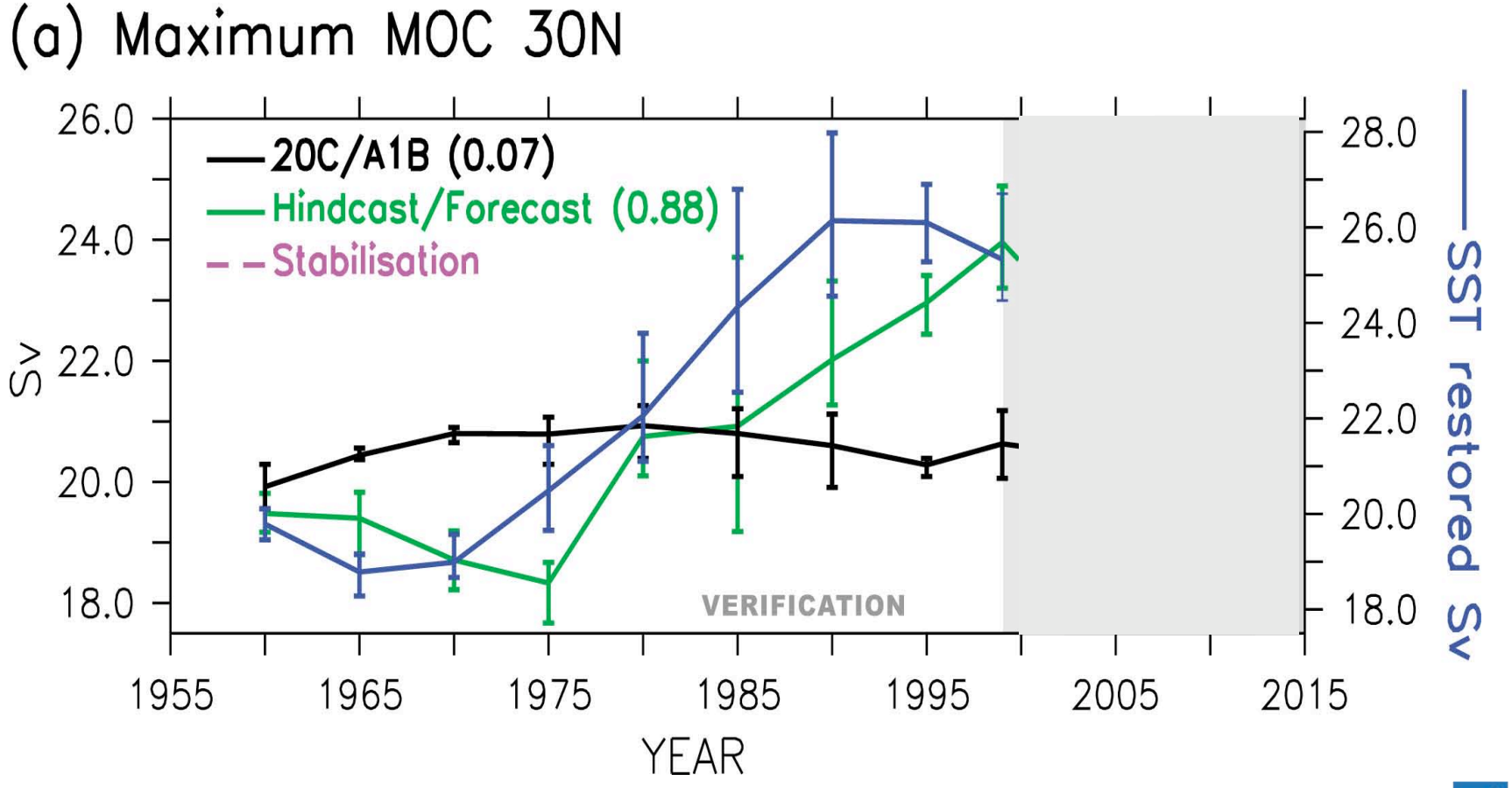
(Centred decadal means, vertical bars show ensemble spread)



IFM-GEOMAR

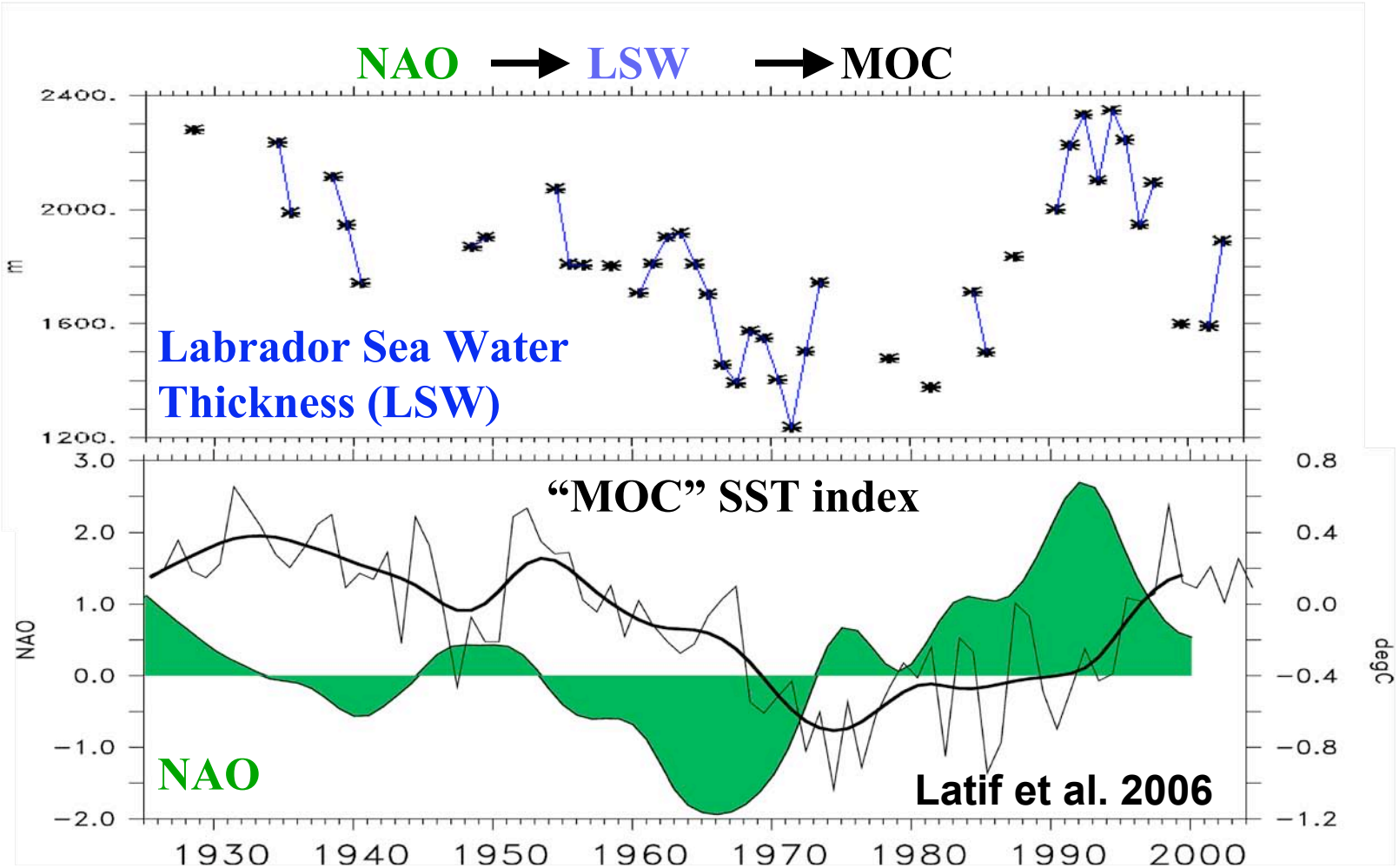
Decadal prediction: Atlantic Meridional overturning circulation

(Centred decadal means, vertical bars show ensemble spread)



IFM-GEOMAR

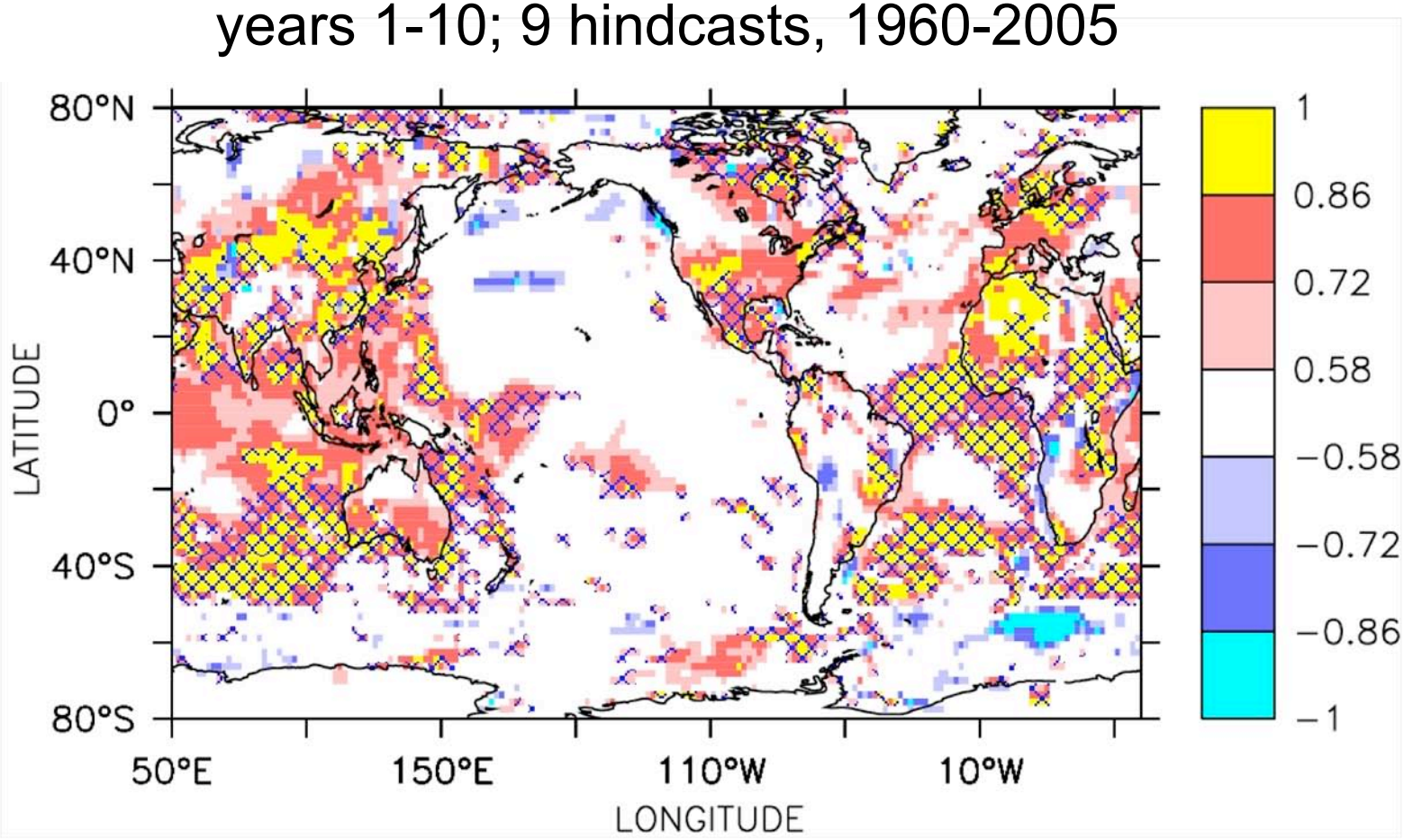
Air-sea interaction and forcing of multi-decadal MOC variations



IFM-GEOMAR

Decadal prediction skill - Radiative forcing only projections

Correlation with observed surface temperature anomalies
years 1-10; 9 hindcasts, 1960-2005

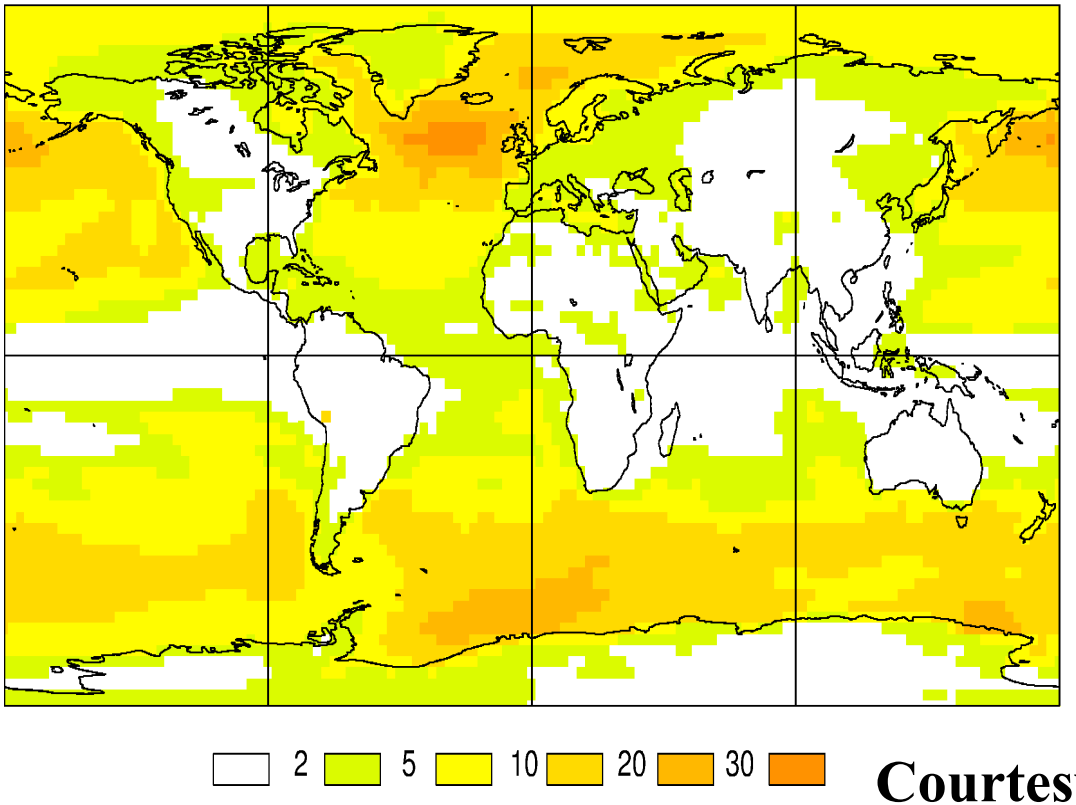


ENSEMBLES

IFM-GEOMAR

Temperature potential predictability: Variance fraction (%) for decadal means

CMIP multi-model ensemble



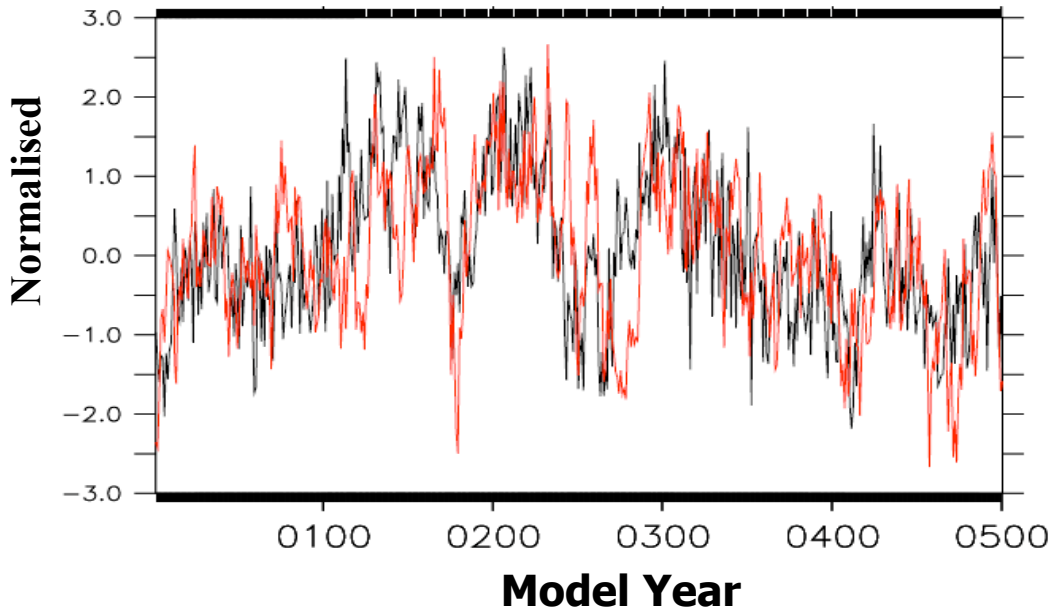
Courtesy George Boer

Decadal prediction is in its infancy: Lack of subsurface ocean data is one limiting factor

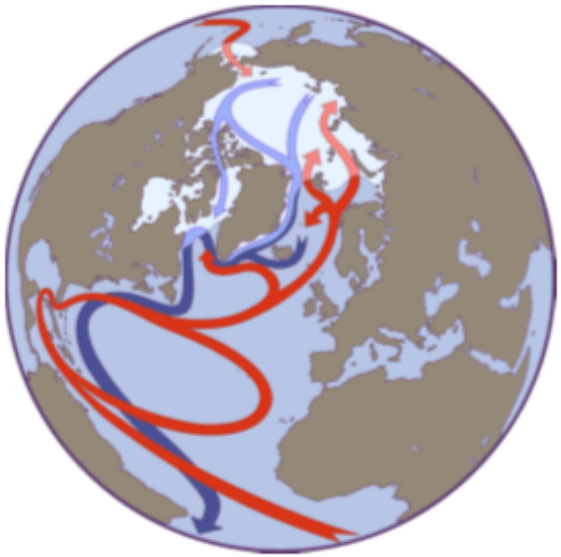
IFM-GEOMAR

Atlantic multi-decadal variability: Role of Meridional Overturning Circulation

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



Meridional overturning circulation (MOC)



[Park et al., in prep.]

Mechanisms for decadal variability -- Atlantic and elsewhere -- are poorly understood

IFM-GEOMAR