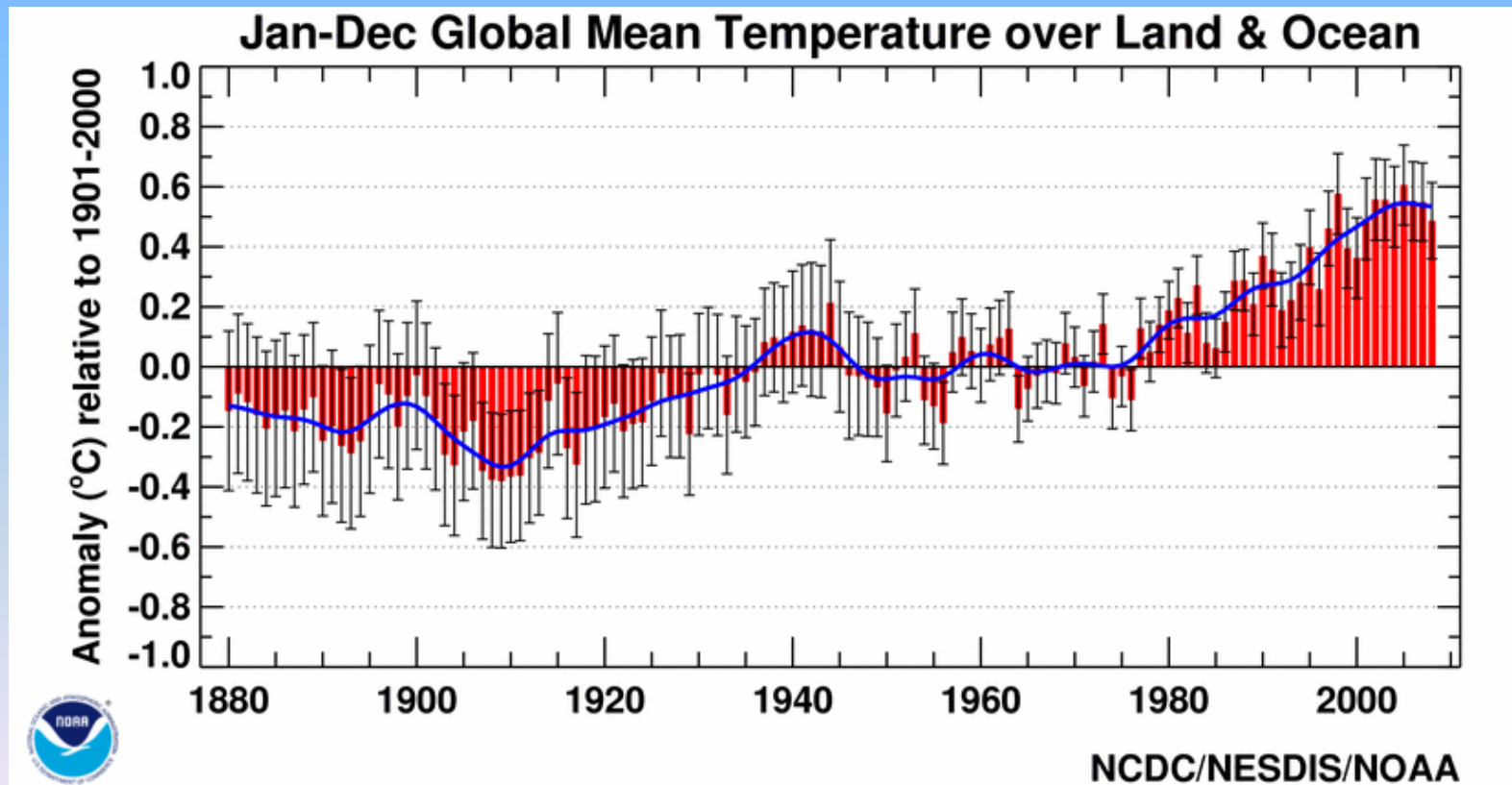# Advancing Climate Prediction Science – Decadal Prediction

Mojib Latif
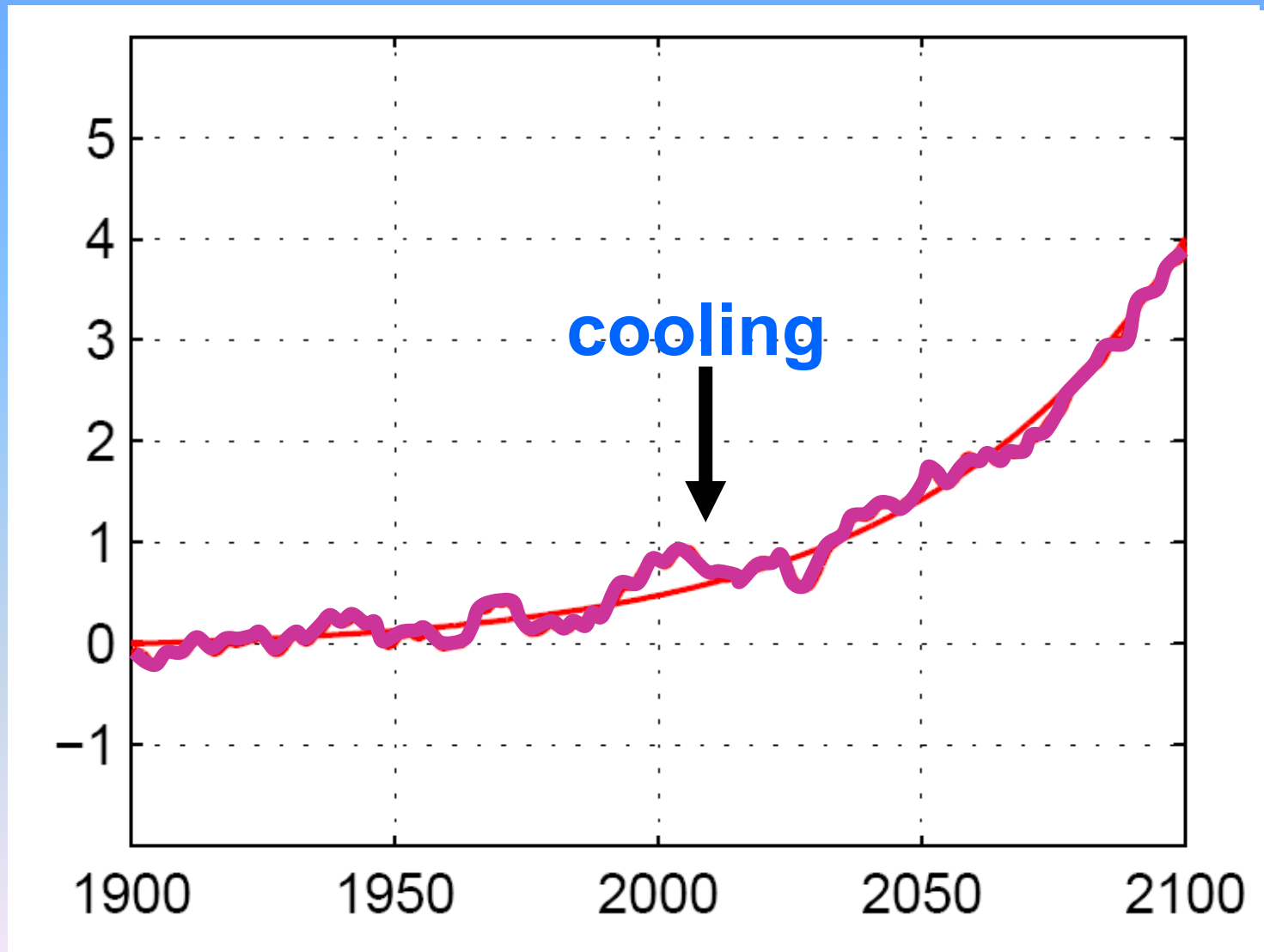### Leibniz Institute of Marine Sciences, Kiel University, Germany

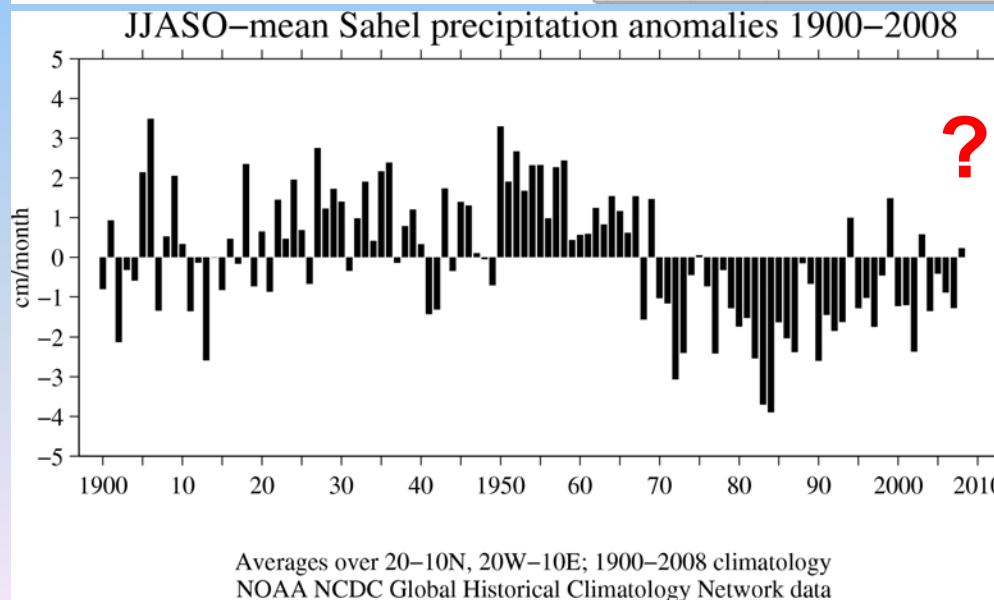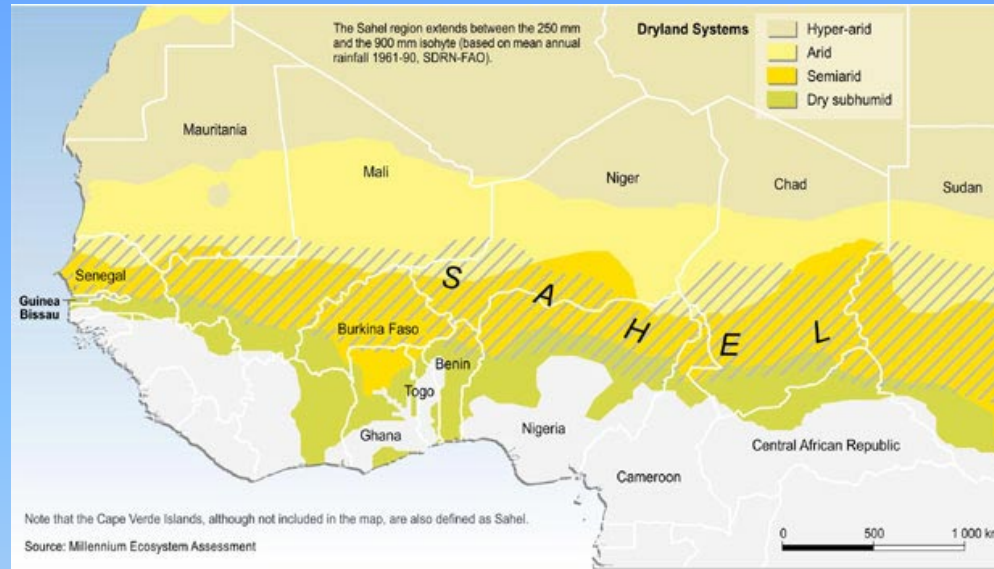Jan-Dec Global Mean Temperature over Land & Ocean

NCDC/NESDIS/NOAA

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Outline

- **Why decadal prediction**
- **Mechanisms of decadal variability**
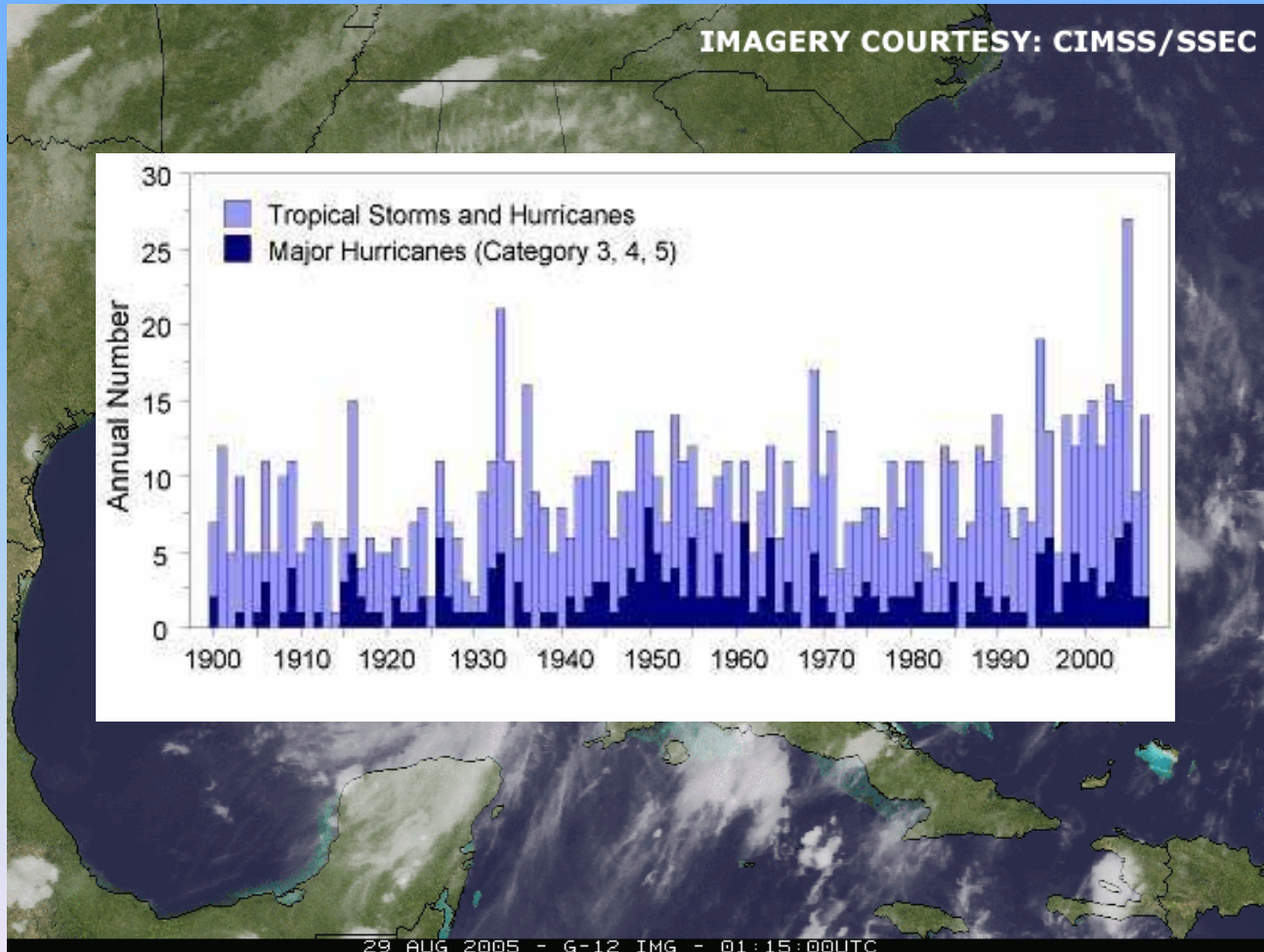- **What is the decadal predictability potential**
- **Challenges**

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"Climate surprises"

cooling

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Decadal variations in Sahel rainfall

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Decadal variations in Atlantic hurricane activity

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Decadal variability in sea level

Linear trend 1993-2003

Kwajalein (8°44'N, 167°44'E)

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Global change prediction is a joint initial/boundary value problem

IPCC 2007
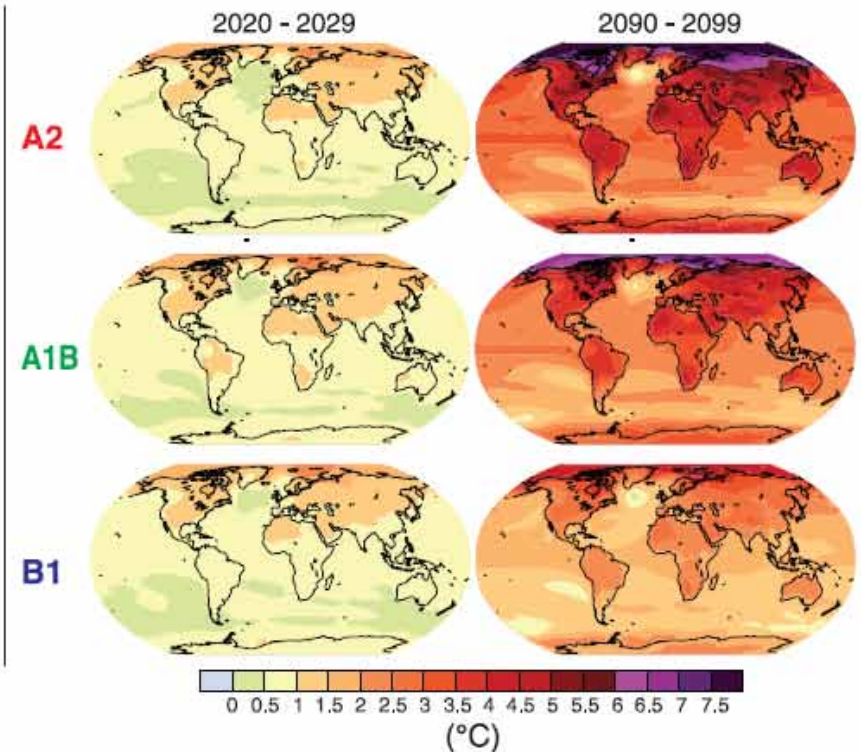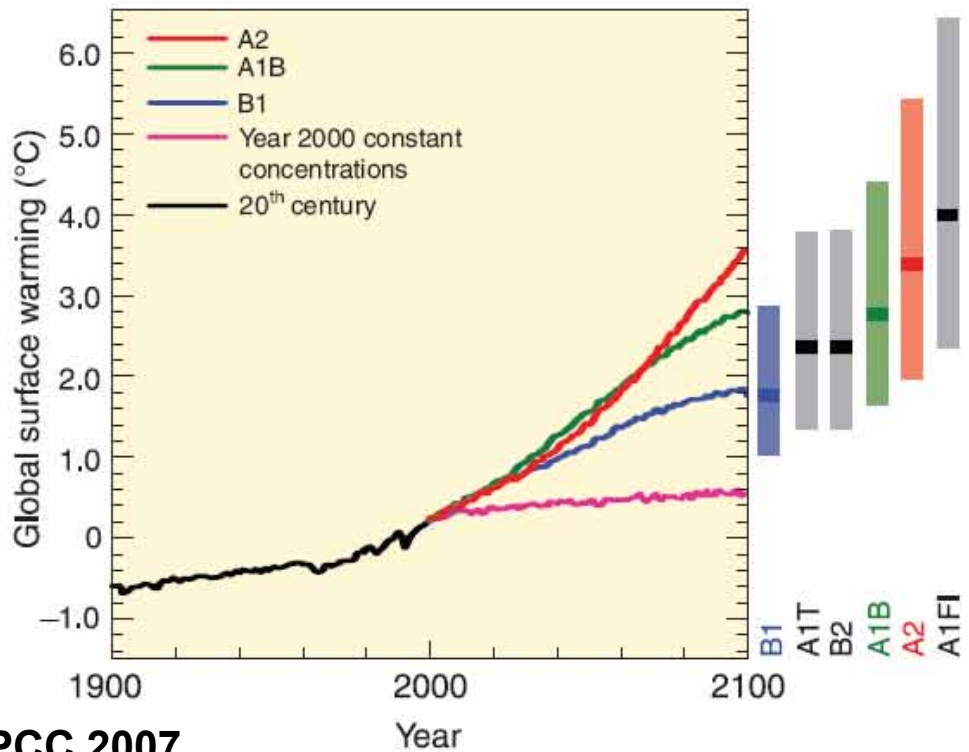
Projections were not initialized in IPCC-AR4

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The uncertainty in climate projections for the 21st century
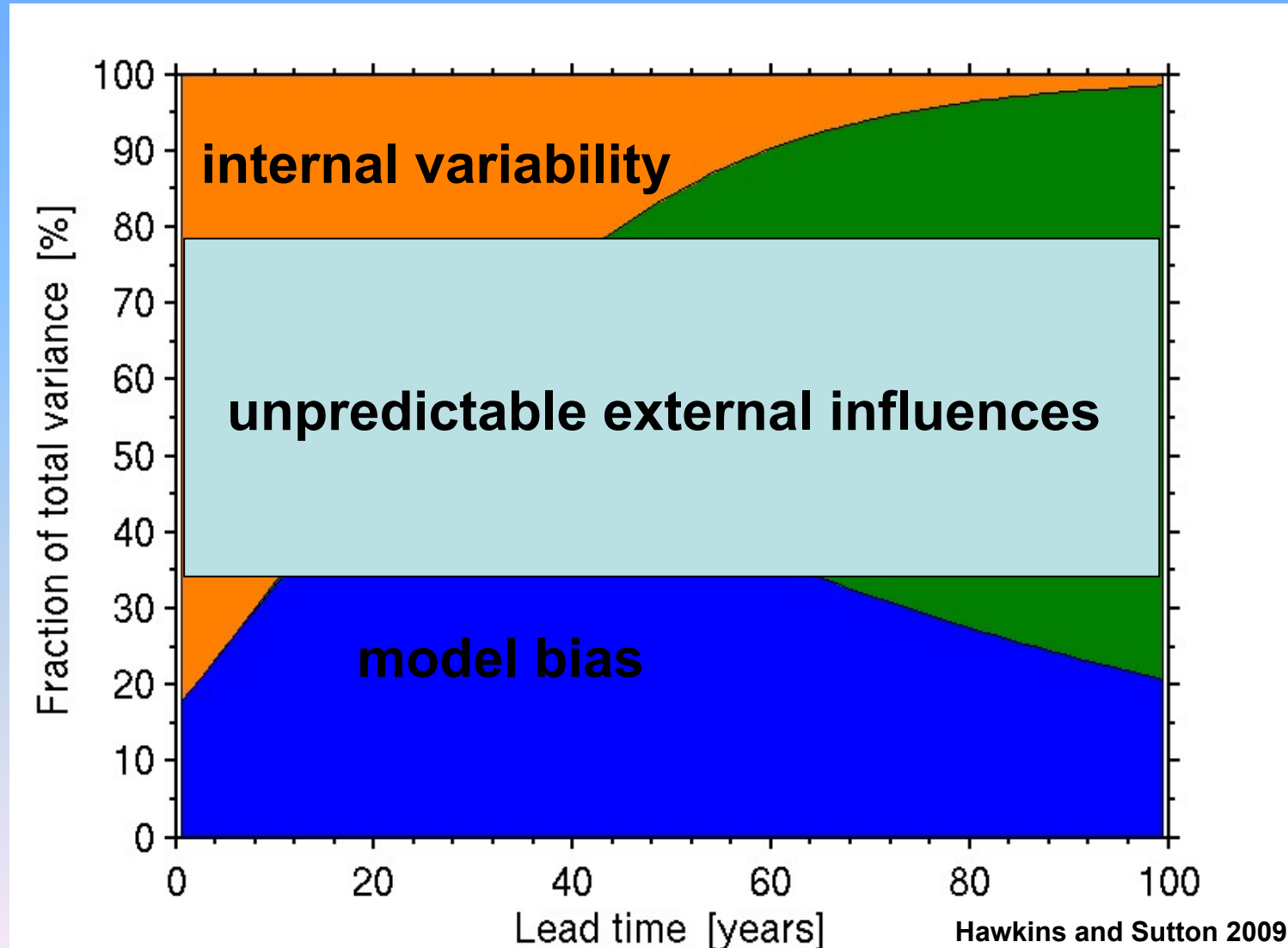
internal variability

unpredictable external influences

model bias

Fraction of total variance [%]

Lead time [years]

Hawkins and Sutton 2009

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Outline

- **Why decadal prediction**

- **Mechanisms of decadal variability**

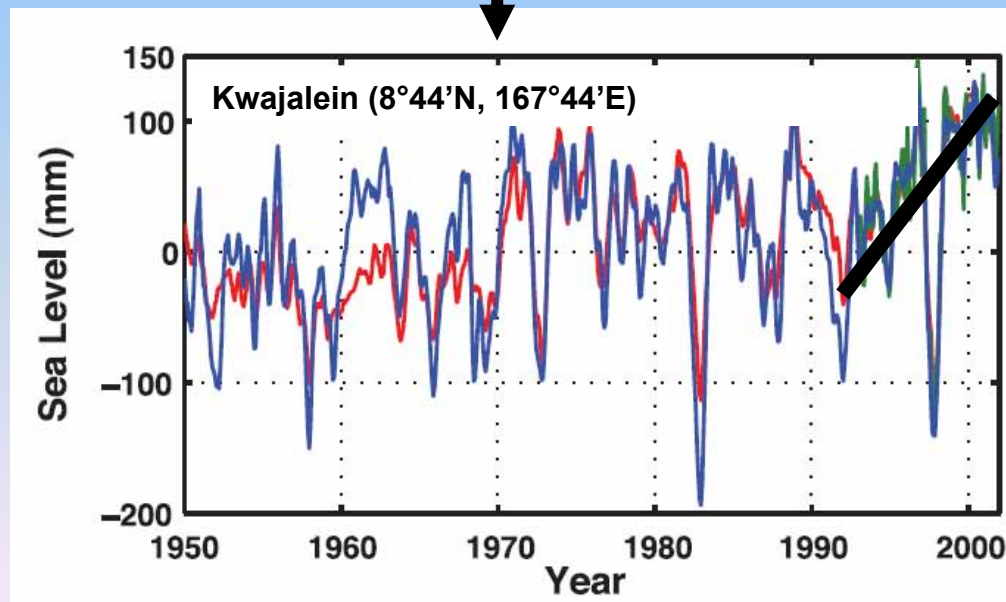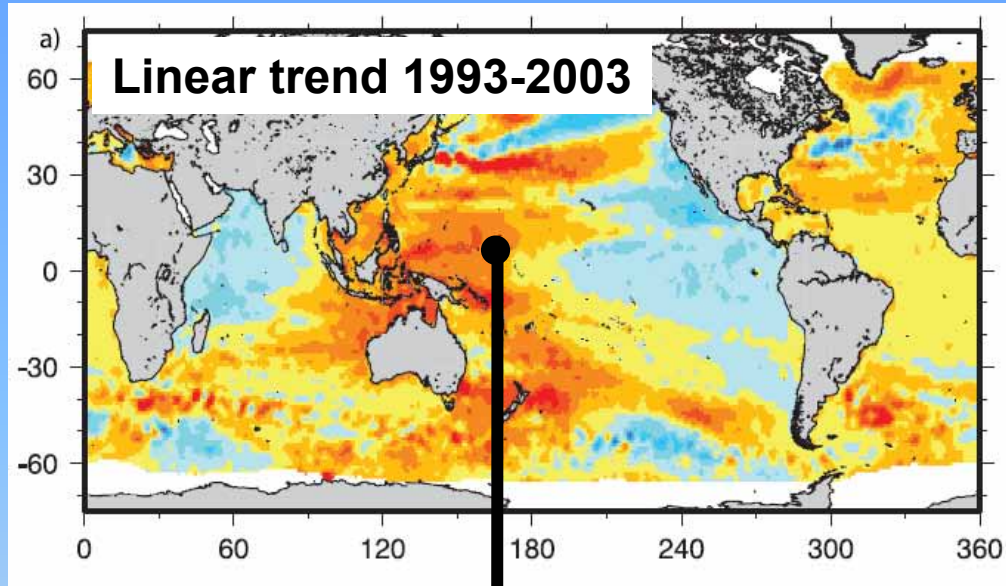- **What is the decadal predictability potential**

- **Challenges**

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Internal vs. external influences

Northern Hemisphere SAT anomaly rel. to 1951-1980

How much did internal decadal variability contribute to the warming during the recent decades?

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Decadal variations in the North Atlantic Oscillation

How much of the decadal NAO variability is forced by changes in the boundary conditions?

Decadal North Atlantic sea surface temperature variations

North Atlantic SST
(70°W - 0, 0 - 60°N)
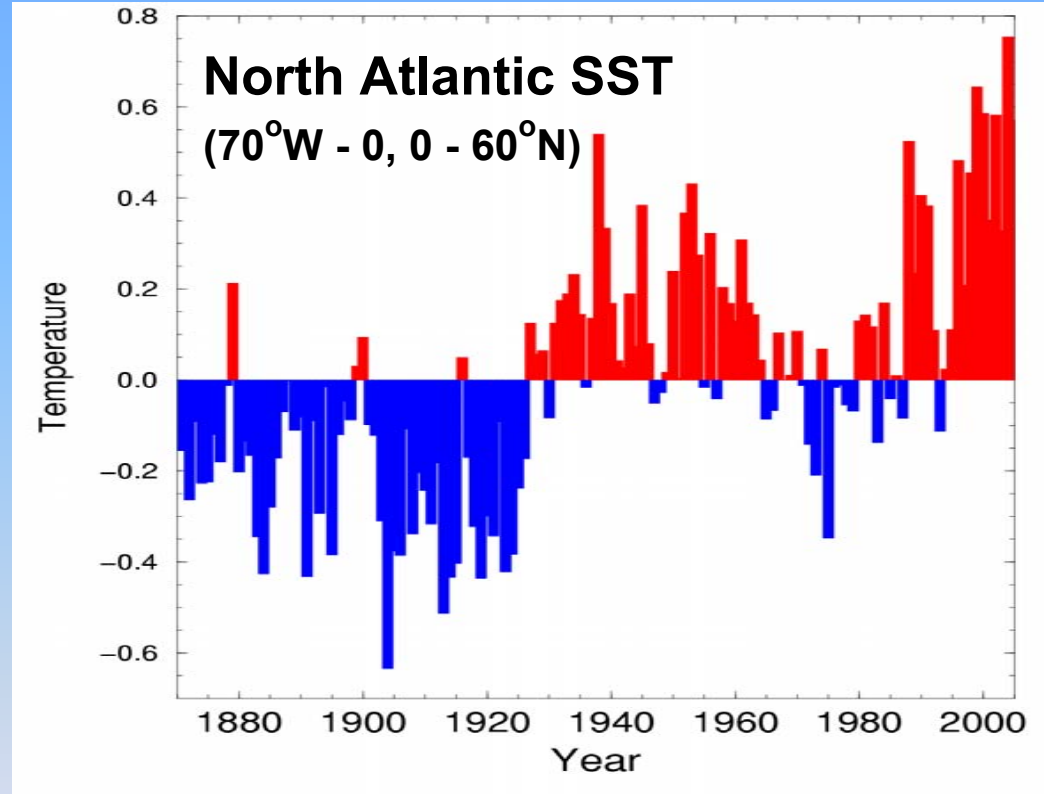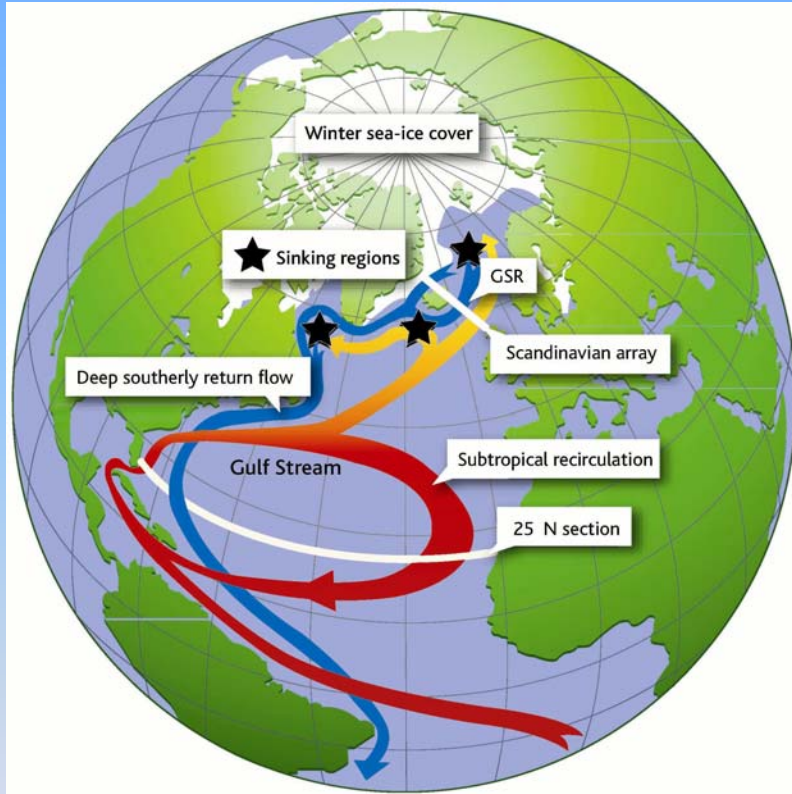
Changes in hurricane activity and Sahel rain, for instance, can be traced back to variations in Atlantic sea surface temperature (SST)
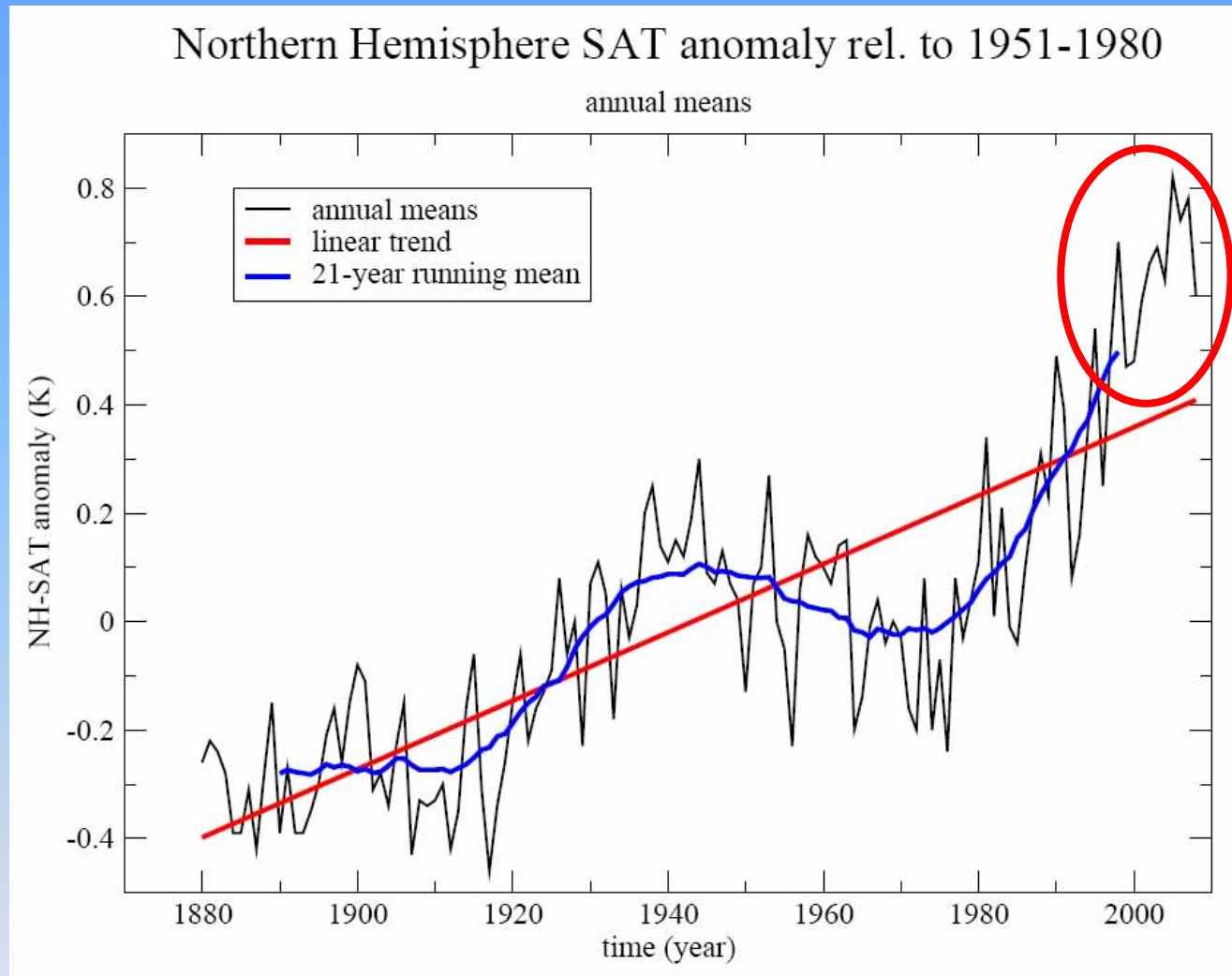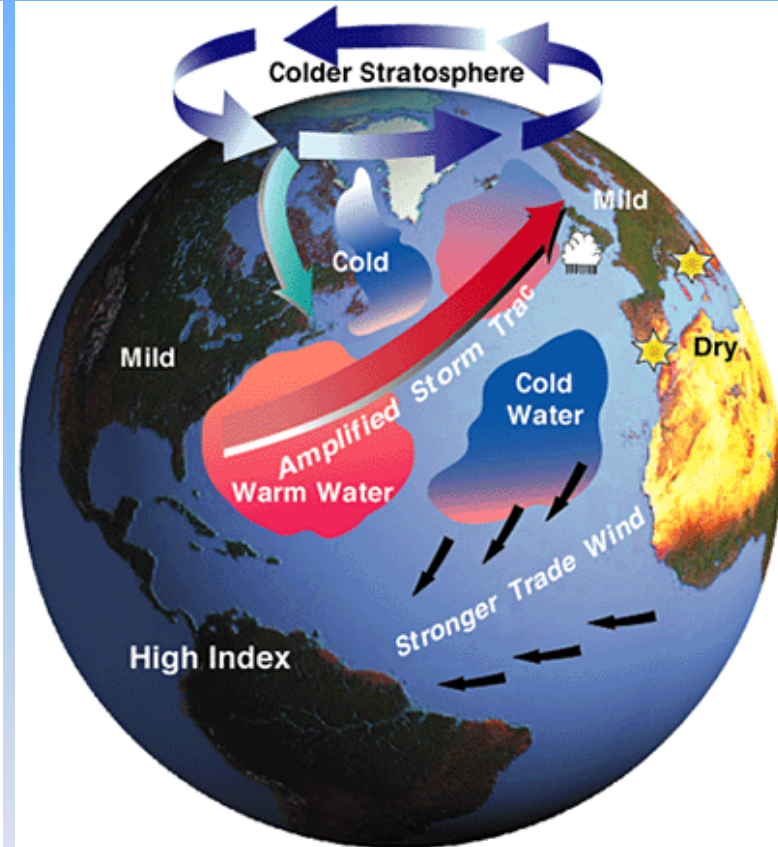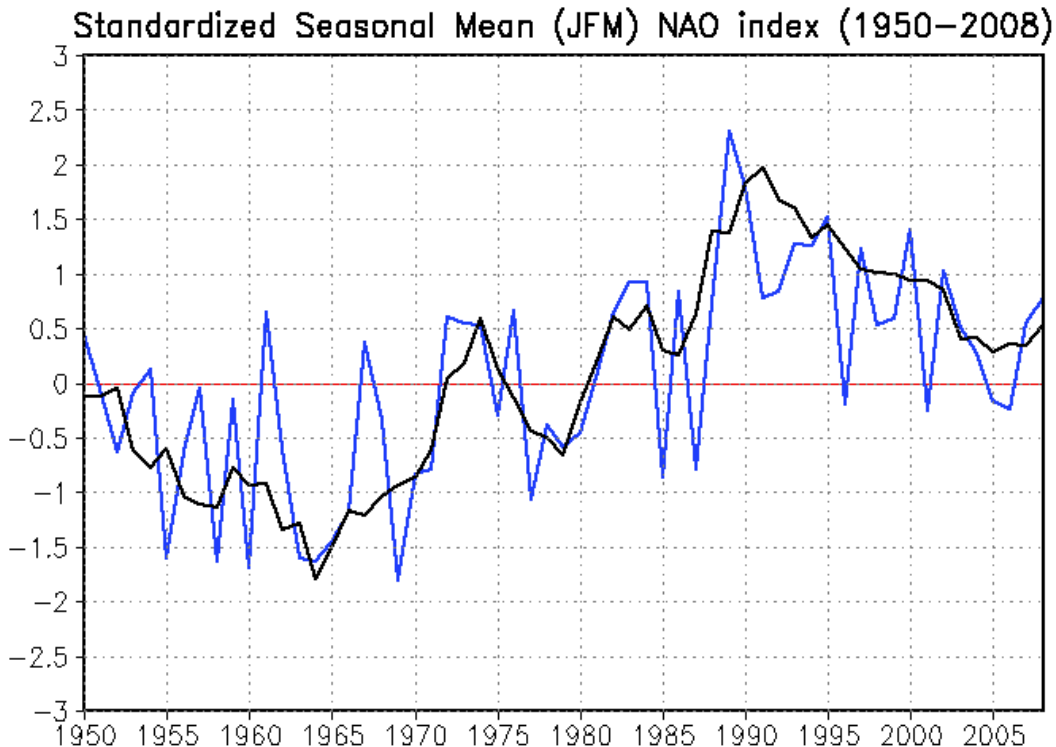
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Potential predictability of surface air temperature (SAT)

Derived from control integrations with climate models

10-year means

Boer 2004
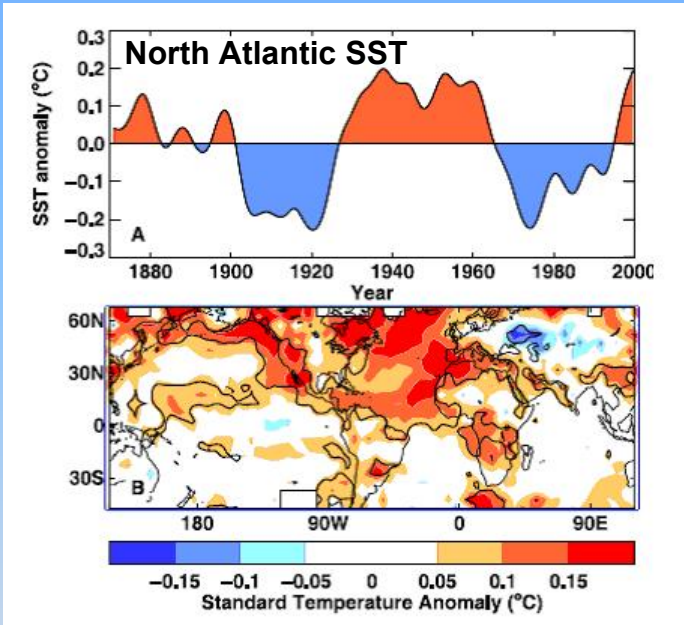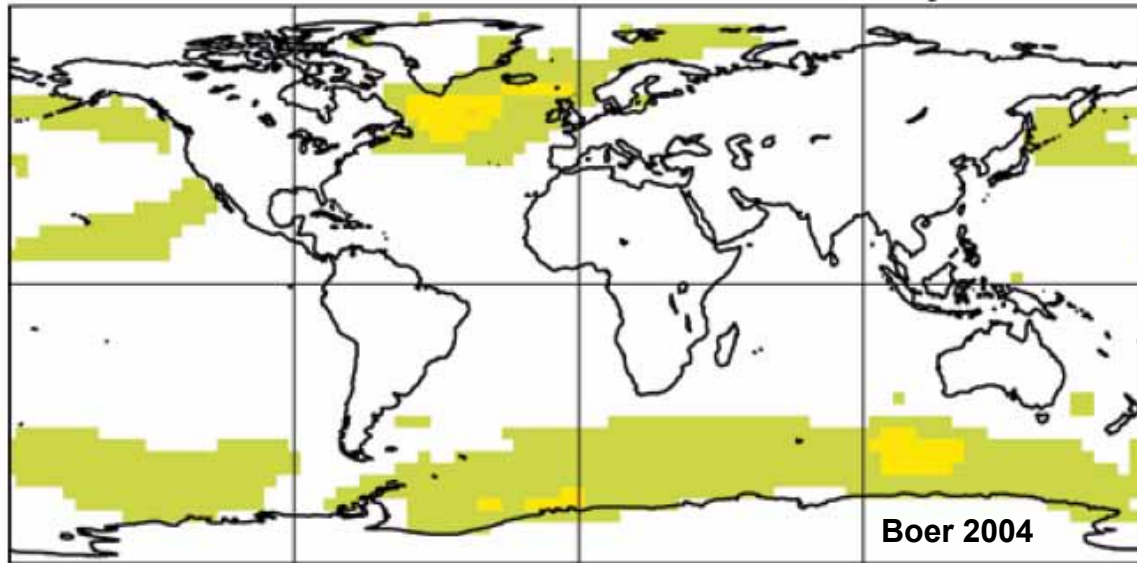
North Atlantic SST

Knight et al. 2005

The North Atlantic Sector appears to be one of the promising regions

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Predictability of the Meridional Overturning Circulation (MOC)

Hurrell et al. 2009
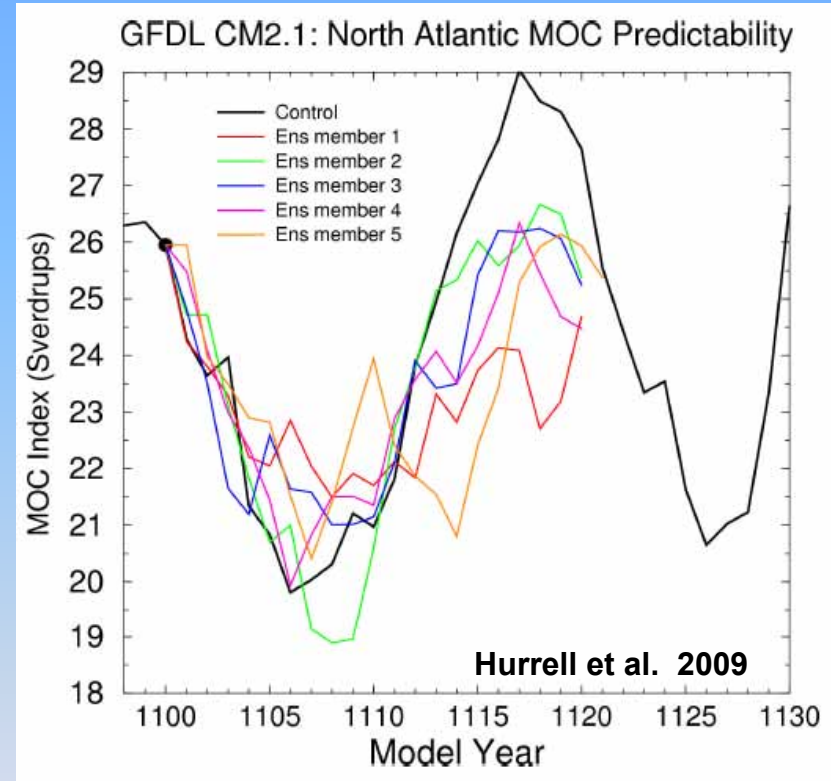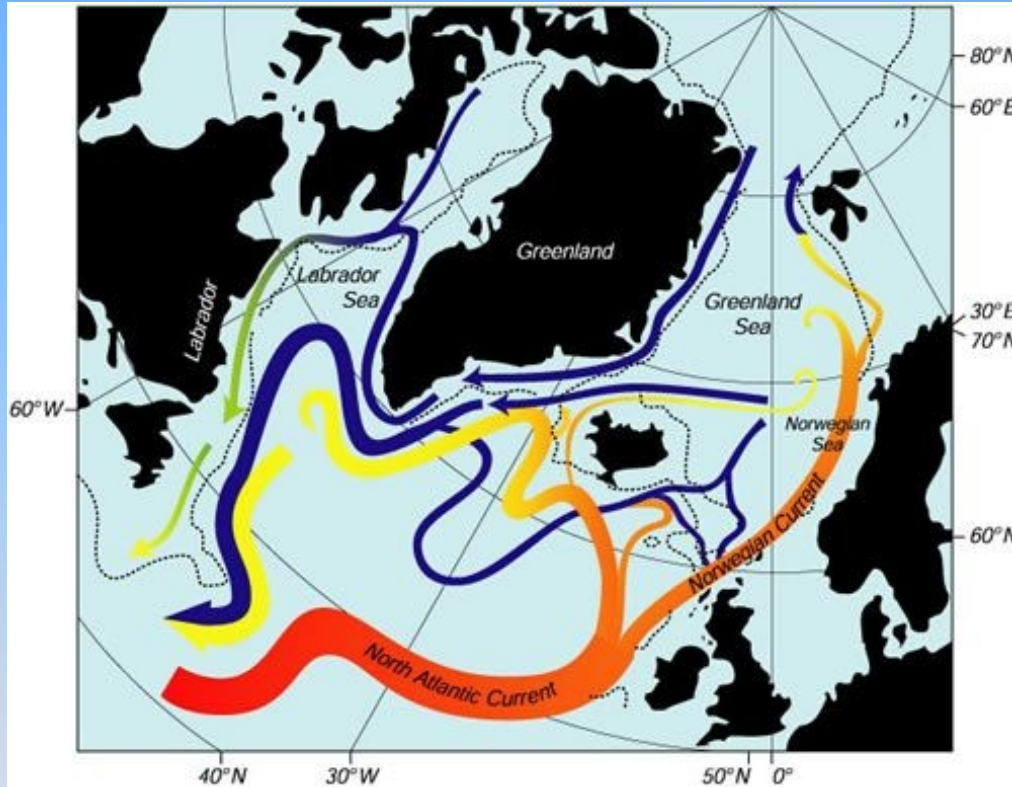
The MOC is predicable at a lead of one to two decades in perfect model studies

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Unpredictable external influences

Composite Total Solar Irradiance (Frohlich and Lean)

Solar constant 1976-2008
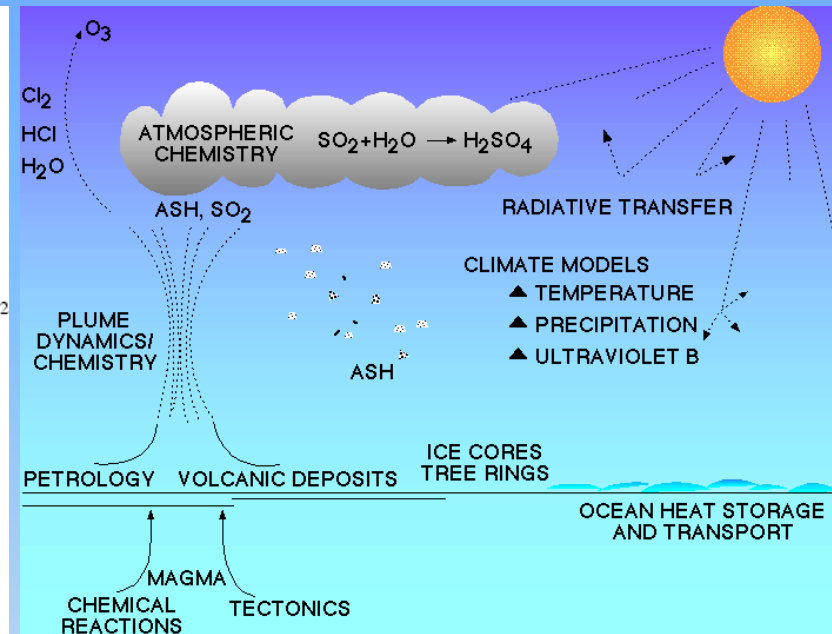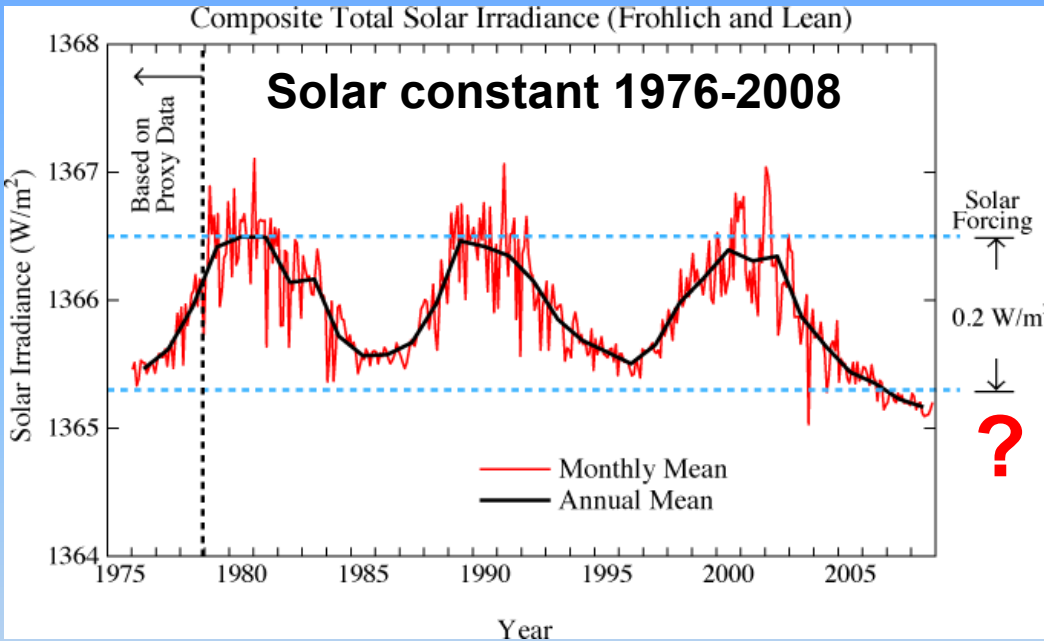
Strong volcanic eruptions, for instance, can cause global cooling of about 0,2°C for a few years and persist even longer in the ocean heat content. If they happen, we can exploit their long-lasting climatic effects.

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Large spread for the next decade
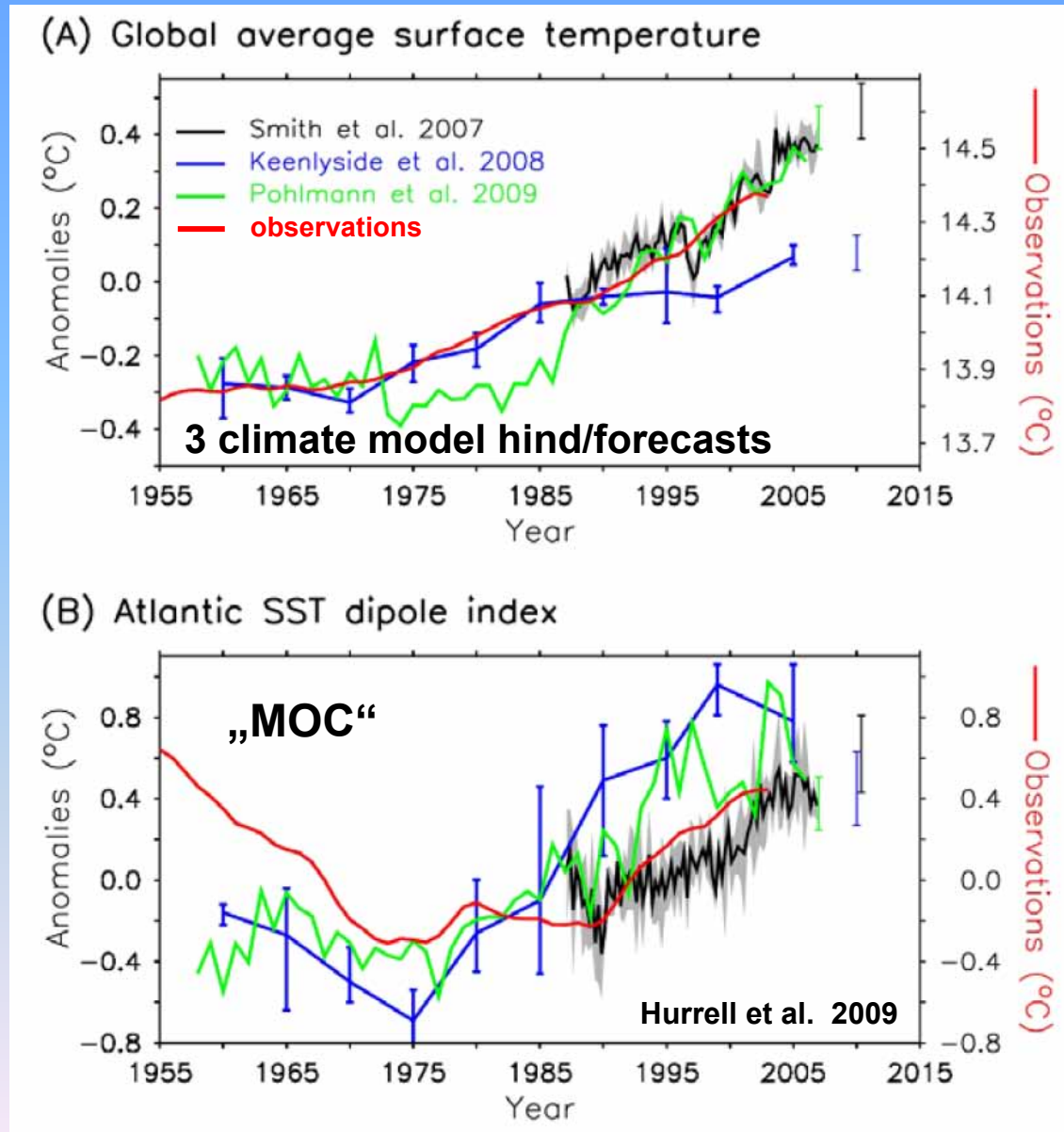
(A) Global average surface temperature

Anomalies (°C) / Observations (°C)

Smith et al. 2007
Keenlyside et al. 2008
Pohlmann et al. 2009
observations

3 climate model hind/forecasts

(B) Atlantic SST dipole index

„MOC"

Hurrell et al. 2009

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- **Why decadal prediction**

- **Mechanisms of decadal variability**

- **What is the decadal predictability potential**

- **Challenges**

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Climate observing system
Example: ocean observing system

Multi-national Argo fleet

3291 Argo Floats   January 2009

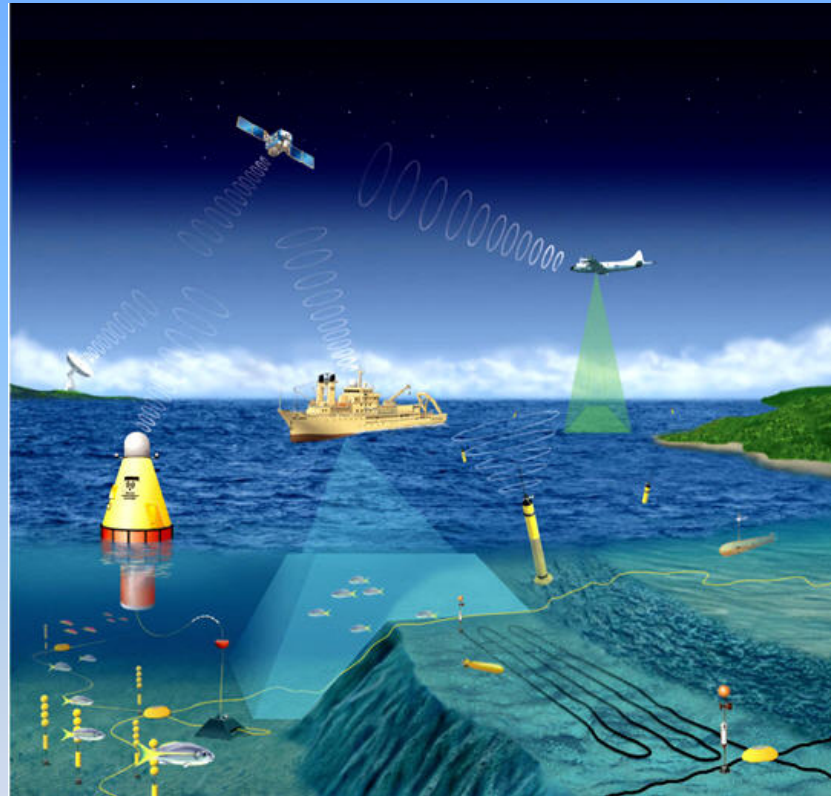|					
ARGENTINA (11)	CHILE (11)	FRANCE (157)	JAPAN (365)	NEW ZEALAND (7)	UNITED KINGDOM (106)
AUSTRALIA (214)	CHINA (22)	GERMANY (184)	SOUTH KOREA (112)	NORWAY (5)	UNITED STATES (1847)
BRAZIL (7)	ECUADOR (3)	INDIA (79)	MAURITIUS (3)	RUSSIAN FEDERATION (1)	
CANADA (108)	EUROPEAN UNION (19)	IRELAND (4)	NETHERLANDS (25)	SPAIN (1)	

jcommops
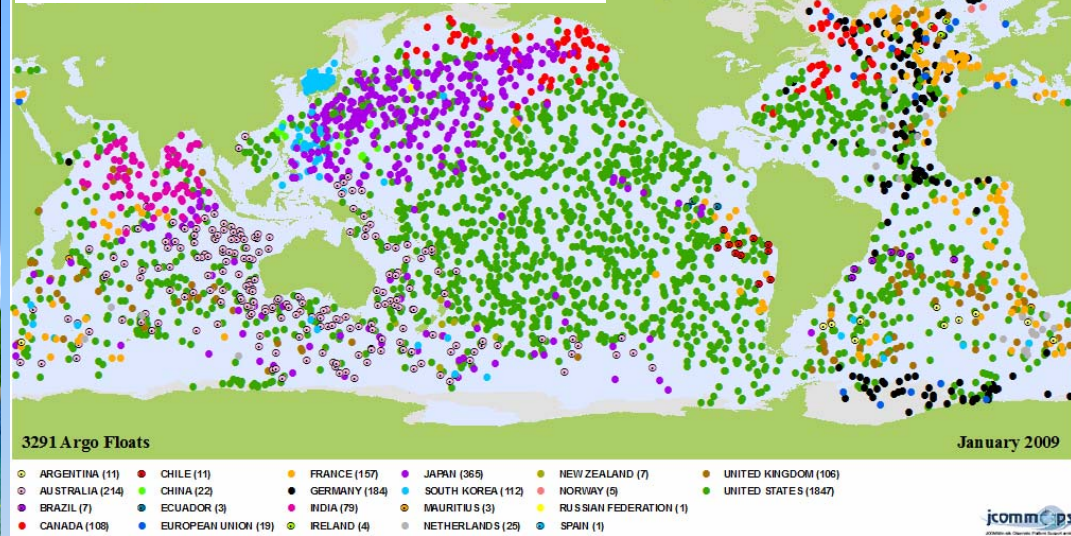
We need climate observations to initialize the models to forecast variations up to decadal time scales

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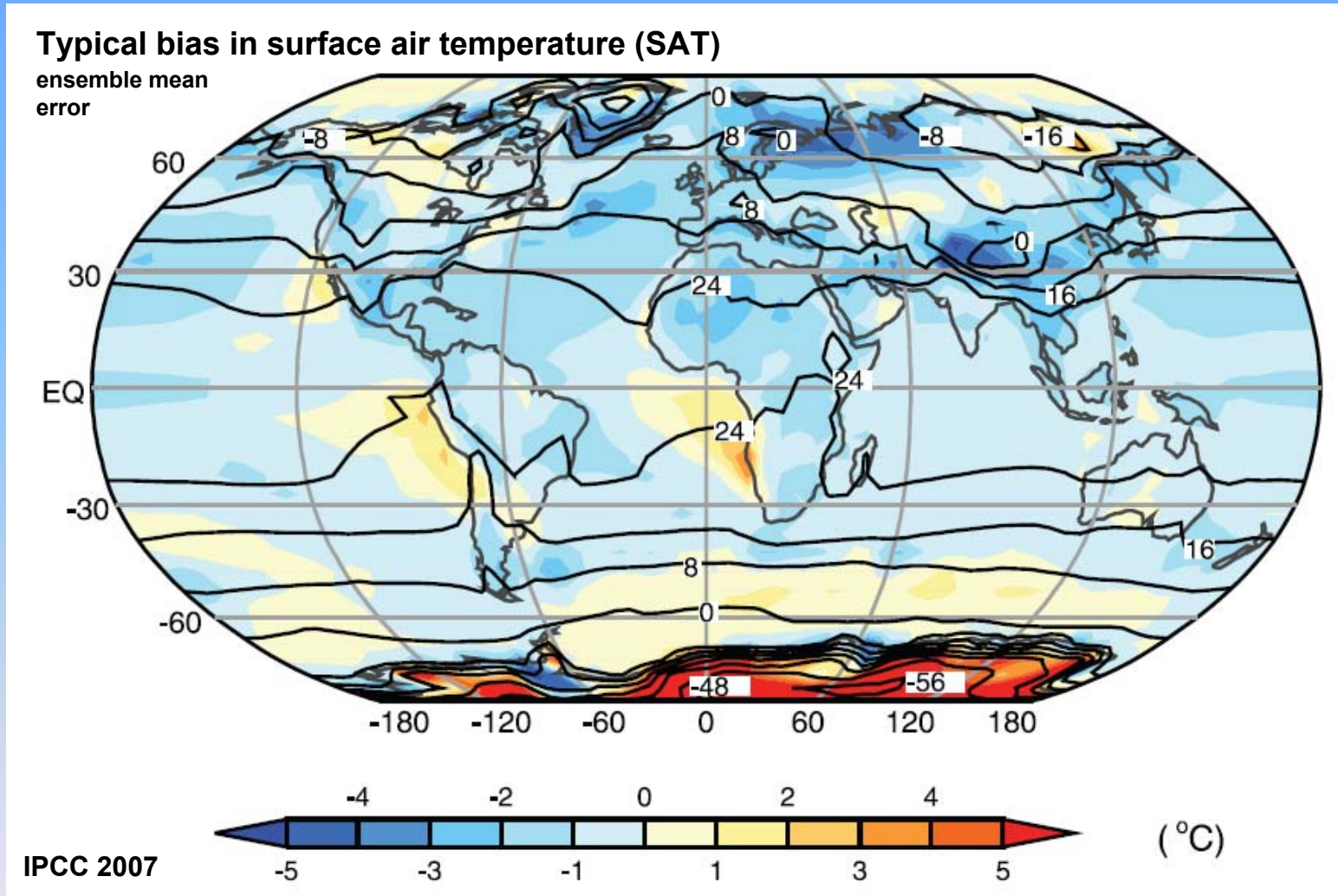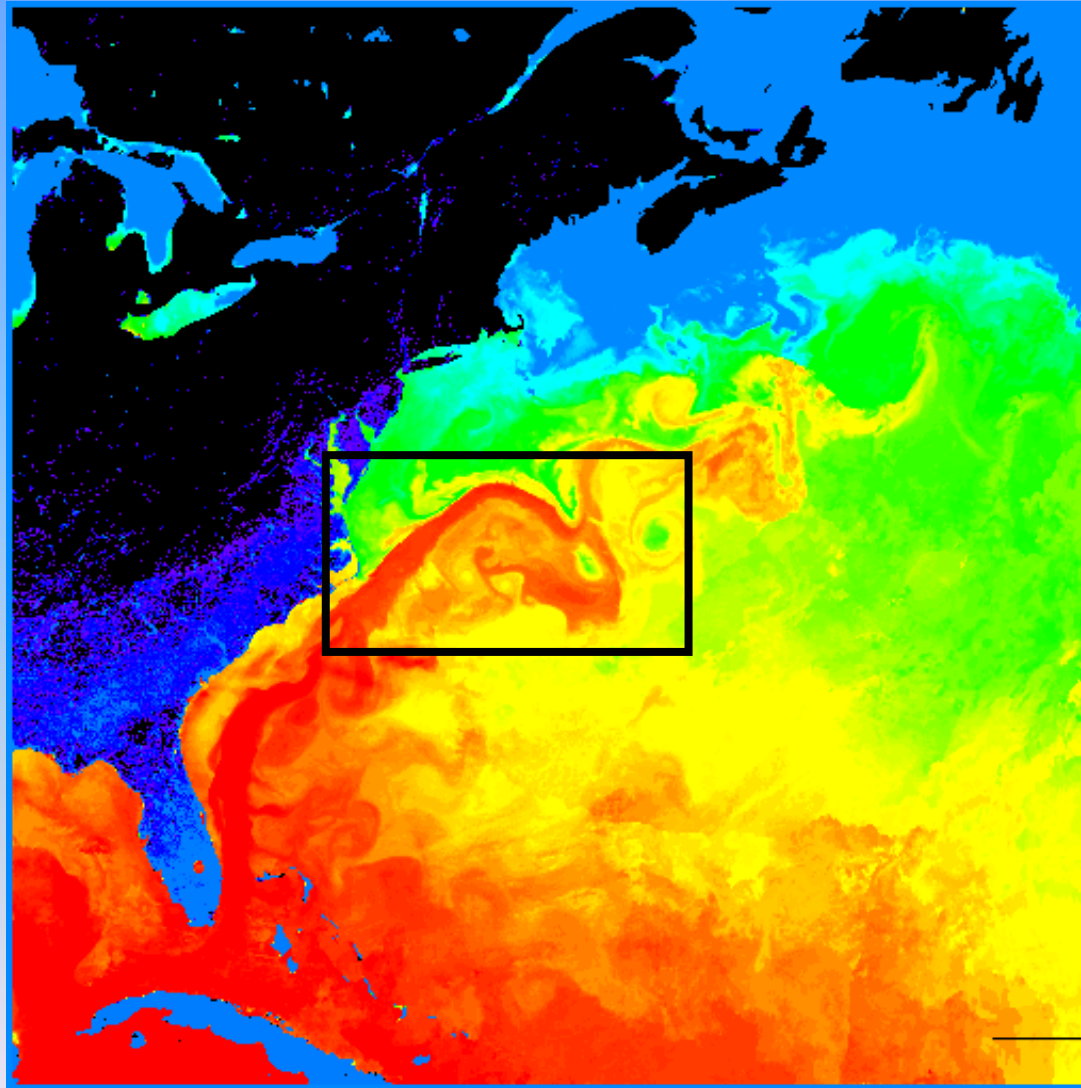# Model biases are large

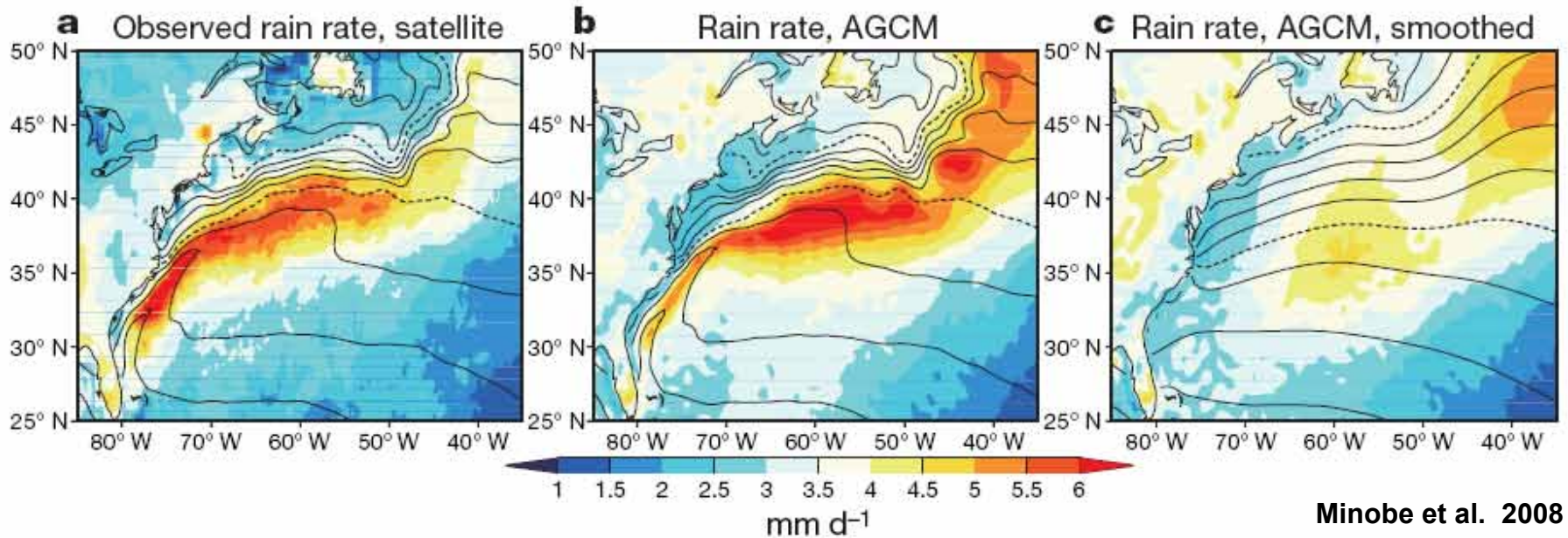

Typical bias in surface air temperature (SAT)
ensemble mean error

IPCC 2007

Errors of several degrees C in some regions

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Gulfstream SST front

Represention of small-scale processes

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Resolution matters

a **Observed rain rate, satellite**   b **Rain rate, AGCM**   c **Rain rate, AGCM, smoothed**

$mm\ d^{-1}$

Minobe et al. 2008

The AGCM has T239 horizontal resolution (~50 km) and 48 levels

Compared to the smoothed SST run, rain-bearing low pressure systems tend to develop along the Gulf Stream front in the control simulation

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Where are we today?

- **A decadal predictability potential for a number of societal relevant quantities is well established.**

- **We need a better understanding of the mechanisms of decadal variability**

- **We need a suitable climate observing system (ocean, land surface, sea ice...)**

- **We need „good" models! We know from NWP that reduction of systematic bias helps. Biases in climate models are still large**

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To realize the full decadal predictability potential we need a coordinated scientific programme under the auspices of the World Climate Research Programme (WCRP)

Thank you for your attention

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Decadal variability in sea level

Topex/Poseidon 1993-2005

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