Aspects of decadal polar prediction

G.J.Boer

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What are the prospects for decadal prediction in polar regions?

- *Excellent* prospects that decadal predictions will be made for polar regions
- *Modest* prospects that *skillful* decadal predictions will be made for polar regions
- *Improving* prospects for suitable use of decadal prediction for polar regions

Motivations for decadal polar prediction

- ***Scientific interest***
- *Existence of "long timescale" processes*
- *Results of predictability studies*
- *Demonstrations of forecast skill*
- *Societal importance of modestly skillful decadal prediction*

Early days of climate modeling

- initial climate models had reasonably complete atmospheres but “mixed layer” oceans
  - thermodynamics of climate change
  - used to simulate a new climate equilibrium for 2xCO2 for example
  - could not simulate *time evolution* of climate or climate change without full ocean
- a model with a 3D ocean was necessary for simulating the temporal evolution of climate variability and change
  - MPI first study with simplified 3D ocean with both dynamics and thermodynamics of ocean
  - ensemble simulation of climate change and variability

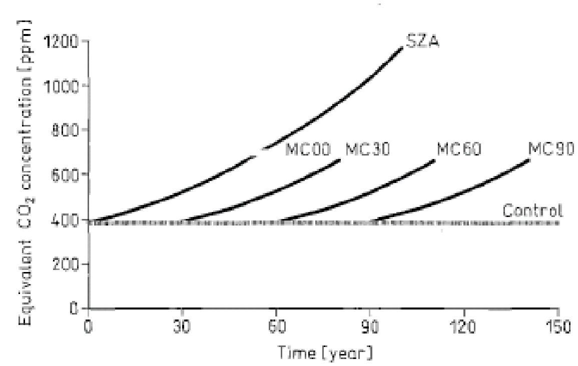
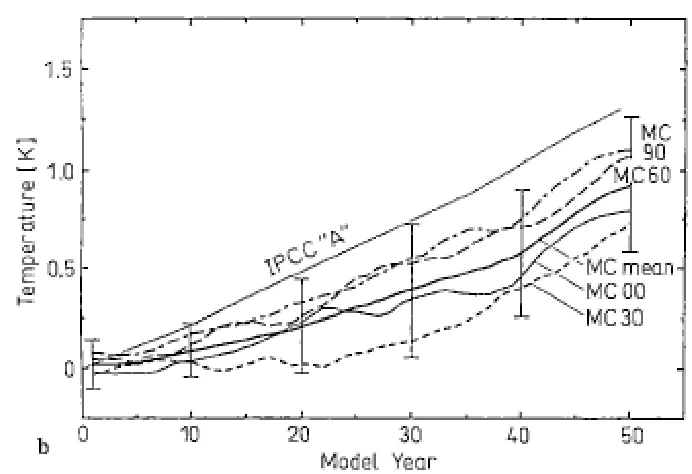


Fig. 1. Schematic diagram of the “Monte Carlo” climate forecasts

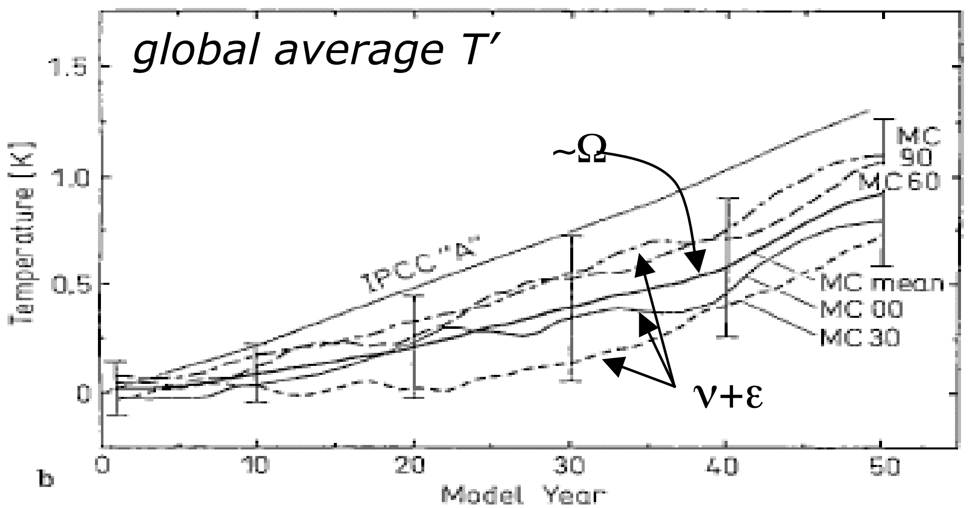


b

Monte Carlo climate change forecasts with a global coupled ocean-atmosphere model

U. Cubasch[1], B. D. Santer[2], A. Hellbach[1], G. Hegerl[3], H. Höck[3], E. Maier-Reimer[3], U. Mikolajewicz[3], A. Stössel[3], R. Voss[4]

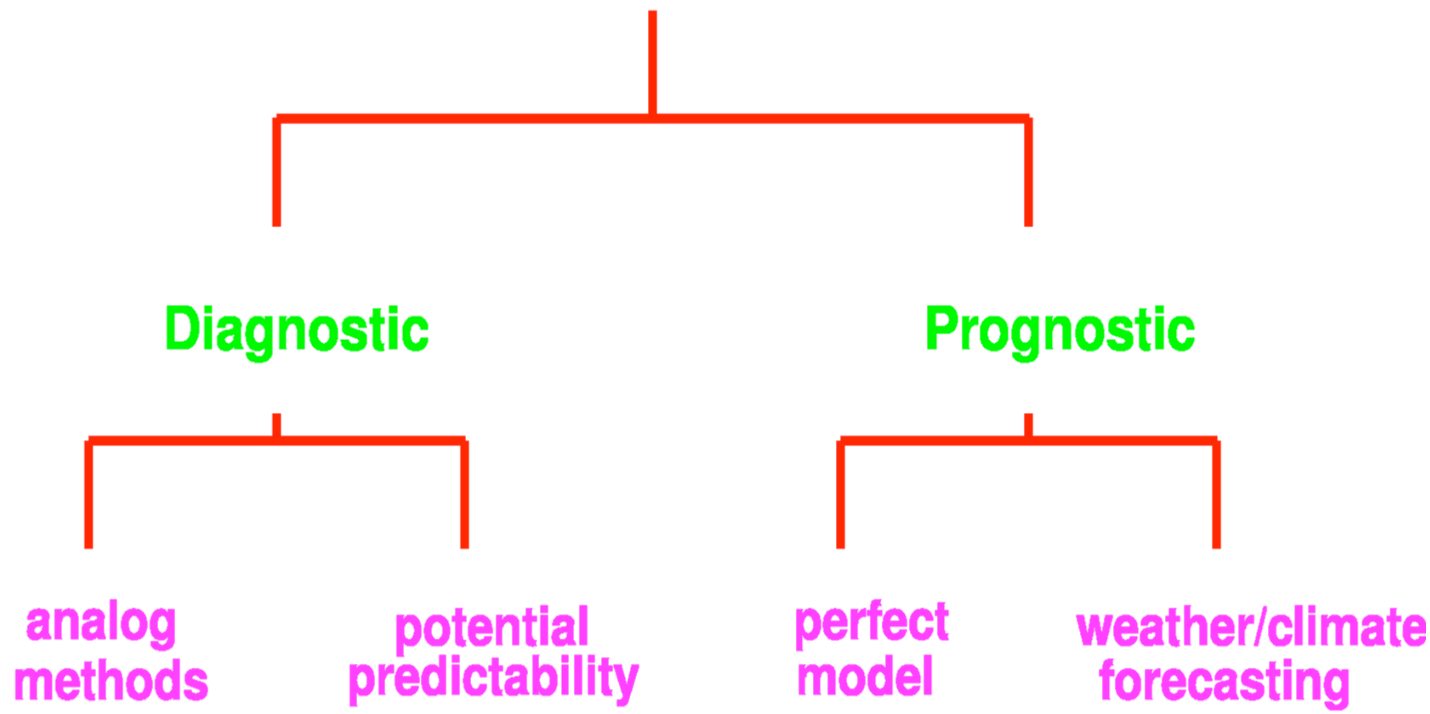
Forced and internally generated climate variability



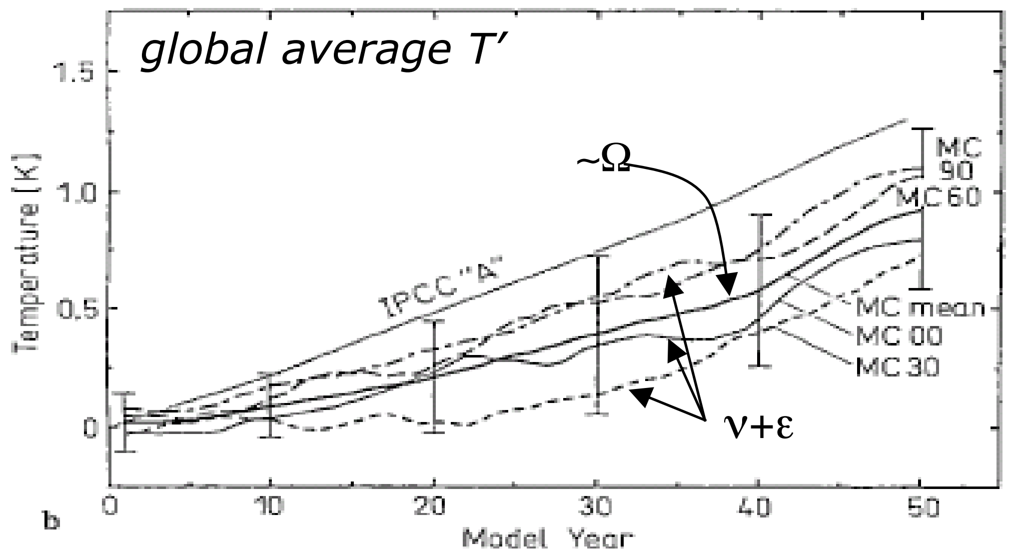
Example is for global average *T* but applies generally

- *Anomaly from the mean represented as* $X' = \Omega + \nu + \varepsilon$
  - Ω is the *deterministic externally forced* component
  - ν is long timescale *internally generated variability*
  - ε is short timescale *unpredictable "noise"*
- "early days" of coupled climate change simulations sought the forced *climate change* component Ω
  - perform several experiments (if you can afford the computer time)
  - average out the internal component and the noise to approximate Ω
  - retain a statistical measure of the "natural variability" $\sigma_\nu^2 + \sigma_\varepsilon^2$ for detection and other purposes
- I realized when visiting MPI that results could be the basis of a *perfect model* predictability study of the *internally generated* component at early times before the forcing was important

Predictability Studies



Climate prediction vs climate simulation



- almost all the components were there in MPI study
  - forced component + internally generated component
  - ensemble of solutions representing probability distribution of natural variability
- aspects of climate prediction
  - forced component + internally generated component
  - *initialization* of the system
  - attempt to predict *actual evolution* of both components on *scales of interest* (not all scales)
  - ensemble of solutions intended to represent *uncertainties* and provide probability distribution for forecast

WGCM/WGSIP and Decadal Predictability

INTERNATIONAL COUNCIL FOR SCIENCE

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

WORLD METEOROLOGICAL ORGANIZATION

WORLD CLIMATE RESEARCH PROGRAMME

Climate Variability & Predictability
CLIVAR
World Climate Research Programme

JSC/CLIVAR Workshop on Decadal Predictability

Scripps Institution of Oceanography
La Jolla, CA, USA
October 4-6, 2000

Workshop on Decadal Climate Predictability

Executive Summary

Scripps Institution of Oceanography, La Jolla, CA, USA, 4-6 October 2000

George Boer
Canadian Centre f. Climate Modelling & Analysis, University of Victoria
Victoria, Canada
George.Boer@ec.gc.ca

Mojib Latif, Max-Planck-Institute for Meteorology, Hamburg, Germany

Roger Newson, Joint Planning Staff for WCRP, WMO, Geneva, Switzerland

The joint WGCM/WGSIP Workshop on Decadal Climate Predictability took place at the Scripps Institution of Oceanography, La Jolla, CA, USA, from 4-6 October 2000. There were over 30 participants from 18 different scientific institutions, groups and organizations. The objective of the workshop was to form an overall sense of the "state of the art" in decadal predictability. Since this area of study is in its infancy, the intent was a true "workshop" which would explore observed and simulated decadal variability, decadal predictability, and such practical attempts to produce decadal forecasts as were available. The Workshop was organized into a series of presentations in these broad areas followed, on the final morning, by three break-out working groups. The groups summarised the status of observations and observed variability, simulations and simulated variability, and prediction/predictability and made recommendations and suggestions.

International scientific interest

WORLD CLIMATE RESEARCH PROGRAMME

JSC-XXVIII/Doc. 2.4
(13.II.2007)

JOINT SCIENTIFIC COMMITTEE

Item 2

TWENTY-EIGHTH SESSION

ZANZIBAR, TANZANIA, 26-30 MARCH 2007

Cross-Cutting Topic: Decadal Prediction

PREDICATE

Mechanisms and Predictability
of Decadal Fluctuations in
Atlantic-European Climate

An R&D project funded by the
European Union under Framework 5

ENSEMBLES

CLIMATE PREDICTION TO 2030:

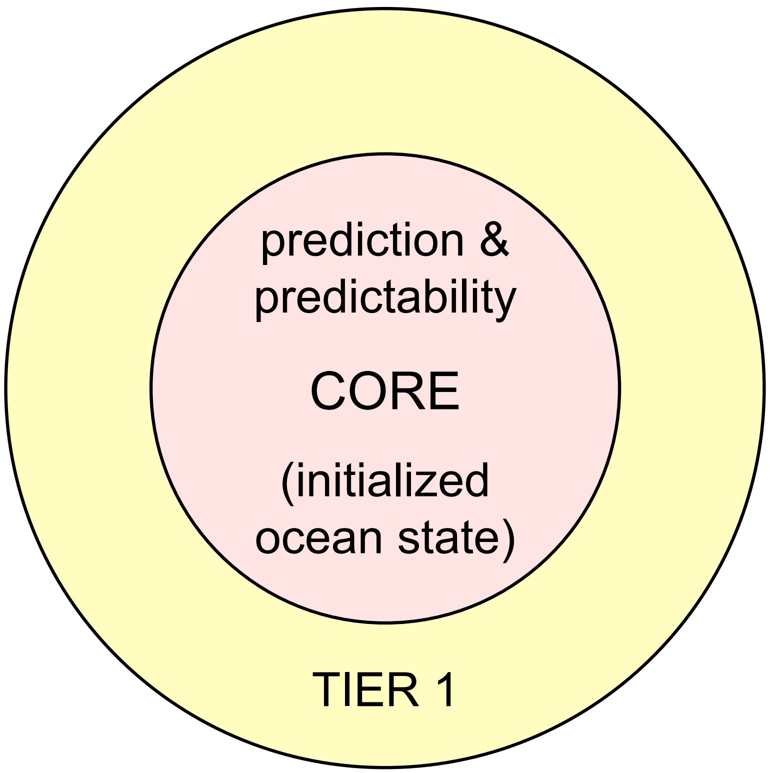
Is it possible, what are the scientific issues, and how would those predictions be used?

22-28 June 2008 in Aspen, Colorado

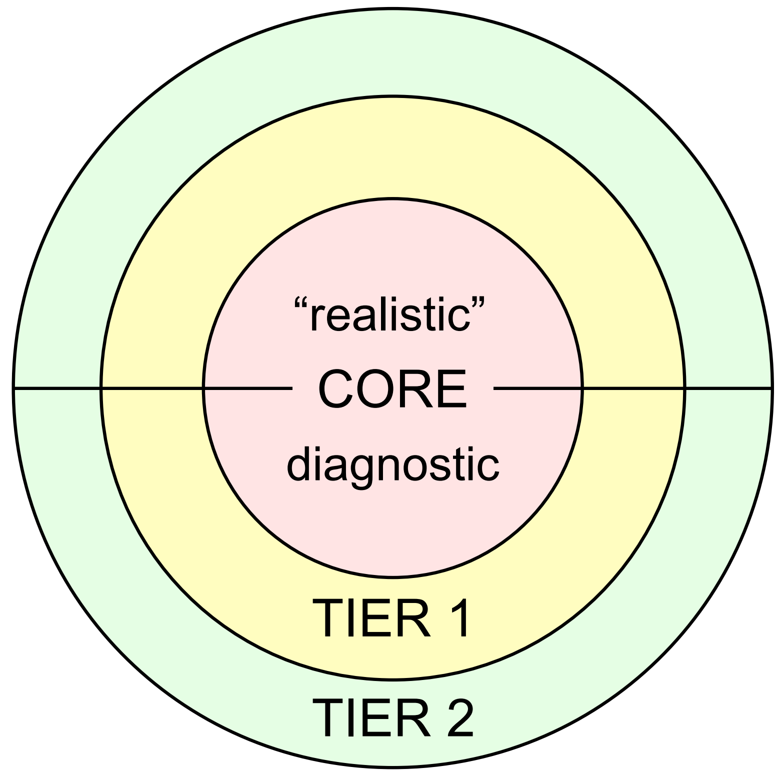
ASPEN GLOBAL CHANGE INSTITUTE

CMIP5 Experiment Design

"Near-Term"
(decadal)



"Long-Term"
(century & longer)

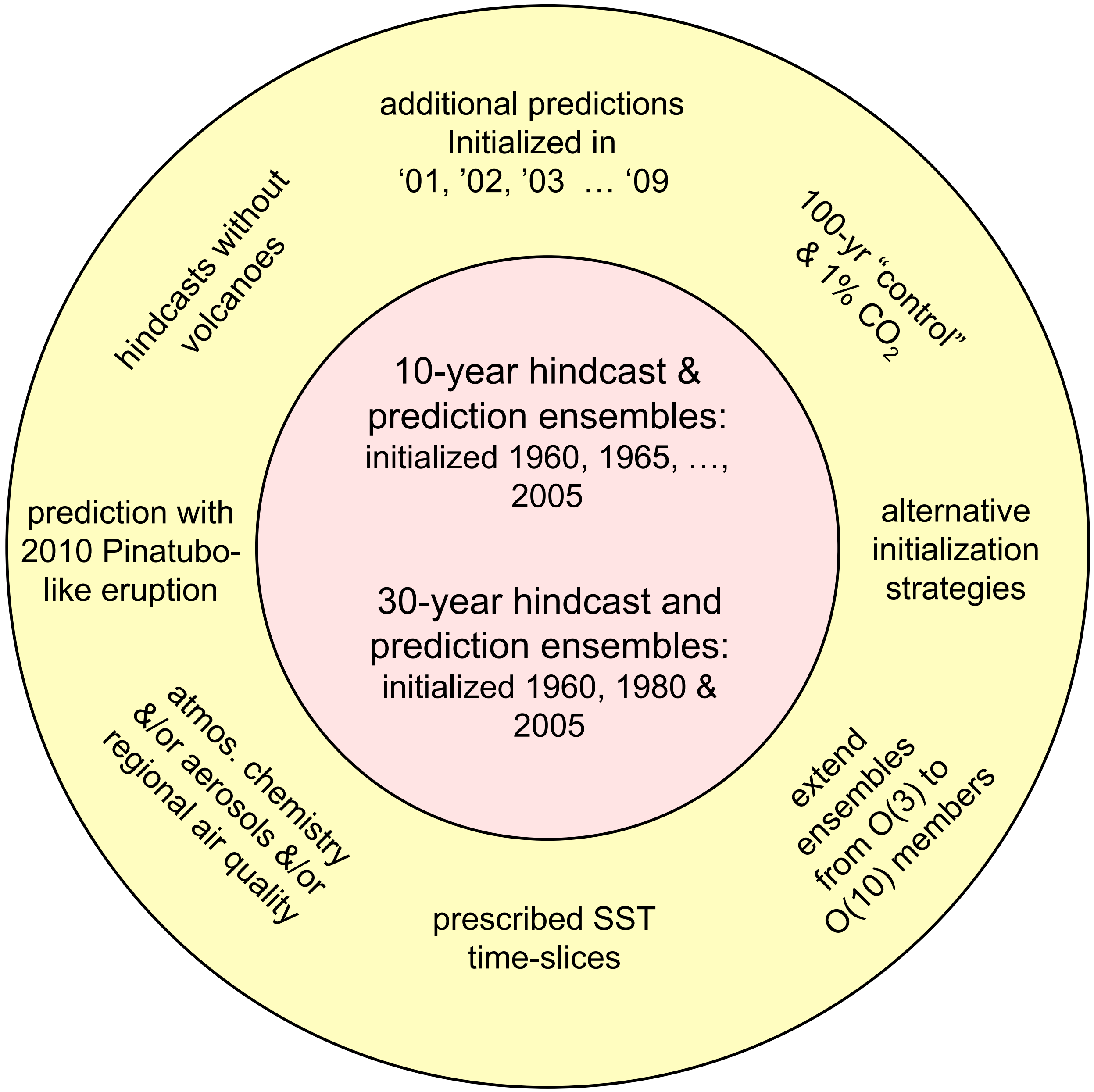


- initialized and forced *predictions*
- seek to predict evolution of forced plus internally generated variability $\Omega + \nu$
- measures of *forecast skill*

- uninitialized forced *"simulations"*
- forced component Ω
- *statistics* of natural variability

CMIP5 Decadal Predictability/Prediction Experiments

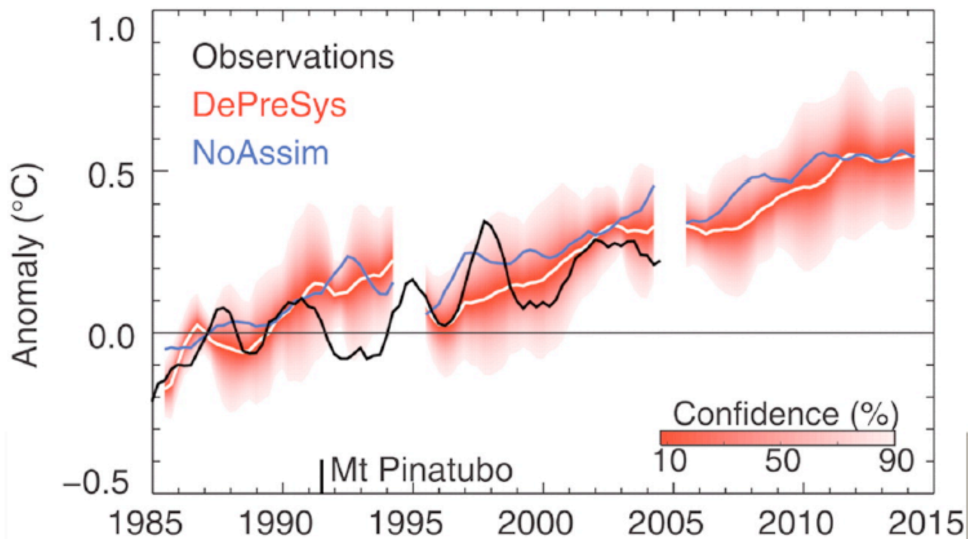
Adopted at the WGCM meeting, September, 2008



What do we need to do?

WCRP Priority Tasks (7)

- Develop and test next generation climate models: First decadal climate prediction



Fundamentals: coupled climate model run including the oceans.

Smith et al., Science 10.08.2007

Active meeting and workshop schedule

- OceanObs09 (Venice, Sept 09)
- 8th Workshop on Decadal Climate Variability (Maryland, Oct 09)
- Earth-System Initialization for Decadal Prediction (deBilt, Nov 09)
- Predicting Climate of the Coming Decades (Miami, Jan 10)
- WGSIP-13 (Buenos Aires, July 10)
- Conference on Decadal Predictability (Triest, Aug, 10)
- Workshop on Decadal Variability, Predictability and Predictions: understanding the role of the oceans (NCAR, Sept 10)
- WGCM-14 (Exeter, Oct 10)
- Seasonal to Multi-decadal Predictability of the Polar Climate (Bergen, Oct 10)
- IPCC 1st LA Meeting (Kunming, Nov 10)

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Press corner
Questions?
Links

Final Draft Conference Statement

The **Final Draft Conference Statement** is **open for comment** on the web through 4 October 2009.

Conference Proceedings

The **Conference Proceedings** will consist of:

- The community-negotiated and adopted **Conference Statement**
- The **Conference Summary**, which will be published in draft form for open comment on the web in early October. Comments will close 31 October 2009.
- The peer-reviewed **Plenary Papers** led by the plenary speakers
- The peer-reviewed **Community White Papers**
- The **Additional Contributions**

The **Conference Proceedings** will be issued as ESA Special Publication, printed as a bound volume by BSH.

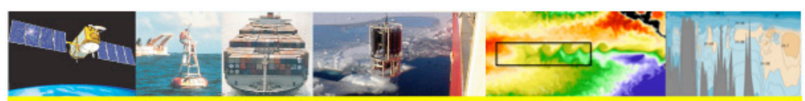
All three types of contributions are due 31 October: in review draft form for the Plenary Papers, and in final camera-ready form for the Community White Papers and Additional Contributions. **Submit your contribution »**

Venice logistics

Download **instructions for finding the conference venue,** Palazzo del Casinò, on the island of Lido »
Due to construction, the **main entrance is on the canal (western) side**, facing away from the Adriatic Sea.

A conference bus service will link Lido hotels with the Palazzo del Casinò in the morning and evening, **download schedule »**

21-25 September 2009, Venice Convention Centre, Venice-Lido, Italy



Klimaat

Clivar Workshop, KNMI, November 4-6 2009

EARTH-SYSTEM INITIALIZATION for DECADAL PREDICTIONS
Workshop 4-6 November, Utrecht, the Netherlands

The main goal:
The workshop aims to Exchange best practices and provide future directions for earth-system initialization for decadal predictions

Specific goals:
- To make an inventory of initialization and perturbation techniques in earth system models; compare and contrast, where possible, forecast made with these different initializaiton strategies.
- To discuss the effectiveness of initialization and perturbation techniques
- To review the observing system and available data for initialization: ocean, soil moisture, ice, snow, atmospheric composition (including aerosols).

The outcome will be a report and/or a series of papers that contains an inventory of best practices of earth system initializations and advice on future directions.

Predicting The Climate Of The Coming Decades

Rosenstiel School of Marine and Atmospheric Science,
University of Miami, Miami, FL, USA
January 11-14, 2010

The goal of this workshop is to bring together people from different communities who have shared interests in predicting the climate of the coming decades. This will include researchers involved in developing prediction systems, understanding mechanisms of decadal and forced climate variability, and assessing the needs of potential users. Discussions will focus on bridging the gap between what is feasible from a technical and scientific perspective and the realities of what kind of information users need.

Meeting website and registration:
www.clivar.org/rsmas_decadal.php
Deadline for travel support applications - 01 October 2009

Confirmed speakers:

Kenny Broad (UM/RSMAS)
Tom Delworth (NOAA-GFDL)
Lisa Goddard (IRI)
Ed Schneider (COLA/George Mason)
Leigh Welling (National Park Service)
Jayantha Obeysekera (South Florida Water Management District)
Howard Kunreuther (Univ. of Penn.)
Scott Power (Australian Bureau of Met)
Ben Kirtman (UM/RSMAS)
Doug Smith (UK MetOffice/Hadley Centre)

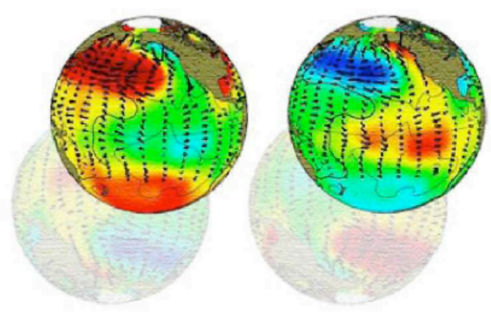
Organizing Committee

Amy Clement, co-Chair (RSMAS)
Peter Swart (RSMAS)
Ad Reniers (RSMAS)
Rana Fine (RSMAS)
Chunzai Wang (NOAA-AOML)
Jim Todd (NOAA)
Ben Kirtman , co-Chair (RSMAS)
Claire Paris (RSMAS)
Andrew Baker (RSMAS)
Bob Meyer (Univ. of Miami)
David Enfield (NOAA-AOML)
Carol Daniels (South Florida and Carribean CESU)

The Abdus Salam
International Centre for Theoretical Physics

Conference on Decadal Predictability

August 16 - 20, 2010
ICTP, Trieste, Italy



The Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy, is organizing a **Conference on Decadal Predictability**, to be held from August 16 - 20, 2010 in Trieste, Italy.

Plenary Speakers

Magdalena Balmaseda (ECMWF)
Claus Boening (IFM-GEOMAR)
Grant Branstator (NCAR)
Stuart Cunningham (NOC)
Gokhan Danabasoglu (NCAR)
Tom Delworth (NOAA/GFDL)
Clara Deser (NCAR)
Helge Drange (University Bergen)
Lisa Goddard (IRI)
Stephen Griffies (NOAA/GFDL)
Ed Harrison (PMEL)
Wilco Hazeleger (KNMI)
Patrick Heimbach (MIT)
Marika Holland (NCAR)
Jim Hurrell (NCAR)
Armin Koehl (University Hamburg)
Joanie Kleypas (NCAR)
Mojib Latif (IFM-GEOMAR)
Eric Lindstrom (NASA)
Jochem Marotzke (MPI-M)
Rui Ponte (AER Inc.)
Tony Rosati (NOAA/GFDL)
Bernadette Sloyan (CSIRO)
Doug Smith (UK MetOffice)
Detlef Stammer (University Hamburg)
Rowan Sutton (University Reading)
Laurent Terray (CERFACS)
Anne-Marie Treguier (IFREMER)
Gabriel Vecchi (NOAA/GFDL)
Carl Wunsch (MIT)

WGOMD-GSOP Workshop on Decadal Variability, Predictability and Predictions: Understanding the Role of the Ocean

September 20-23, 2010
National Center for Atmospheric Research
Boulder, Colorado, USA

This workshop has the following main goals:

- Assess how well the ocean models and ocean syntheses reproduce observed decadal variability;
- Understand and evaluate the robustness of simulated oceanic internal and forced variability;
- Identify the underlying physical mechanisms in the ocean in decadal climate variability;
- Identify shortcomings of ocean models, syntheses, and observations for decadal variability studies;
- Evaluate the outcomes of the CMIP5 decadal prediction experiments.

Sessions will cover i) Observed and simulated oceanic decadal variability, ii) Decadal Climate Variability and the Role of the Ocean, iii) Initialization, Predictability, and Predictions: The Role of Ocean Synthesis and Hindcasts, iv) Ocean and coupled syntheses, and v) Climate Observations Required for Understanding Predictions.

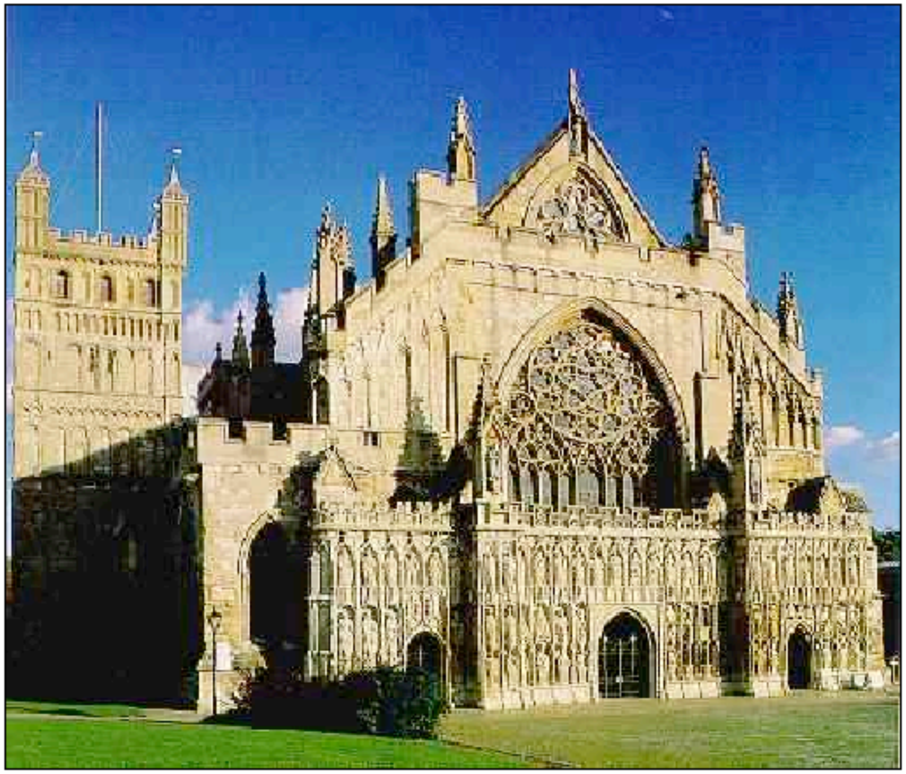
The workshop will consist of invited plenary speakers and contributed talks and posters. The plenary talks will review and encourage the discussion of the current state of research related to a particular topic with candid and critical comments. Session discussions will assess community consensus and future coordinated directions and the workshop will culminate in a final summary discussion session on what could be achieved by a joint effort, looking at whether the community could develop a common framework.

For more information, to register, submit abstracts and apply for travel support see:

www.clivar.org/decadal.php

14th Session of the Working Group on Coupled Modelling

4-6 October 2010, UK Met Office, Exeter, UK



Draft Agenda
Logistical Information

WCRP
World Climate Research Programme

Seasonal to Multi-decadal Predictability of Polar Climate

A pan-WCRP workshop initiated by SPARC and CliC

October 25-29, 2010

Bjerknes Centre, Bergen, Norway

WCRP Homepage

INTERGOVERNMENTAL PANEL ON climate change

Working Group I (WG I) – The Physical Science Basis

IPCC Working Group I Fifth Assessment Report
First Lead Author Meeting
Kunming, China, 8 – 11 November 2010

Chapter 11: Near-term Climate Change: Projections and Predictability

Executive Summary

- Predictability of interannual to decadal climate variations and change
- Projections for the next few decades
- Regional climate change, variability and extremes
- Atmospheric composition and air quality
- Possible effects of geoengineering
- Quantification of the range of climate change projections

Frequently Asked Questions

Motivations for decadal prediction

- *Scientific interest*
- ***Existence of "long timescale" processes***
- *Results of predictability studies*
- *Demonstrations of forecast skill*
- *Societal importance of modestly skillful decadal prediction*

What's special about decadal timescales?

- Not much according to spectra
  (e.g. Pelletier,1997)
- a human rather than physical timescale

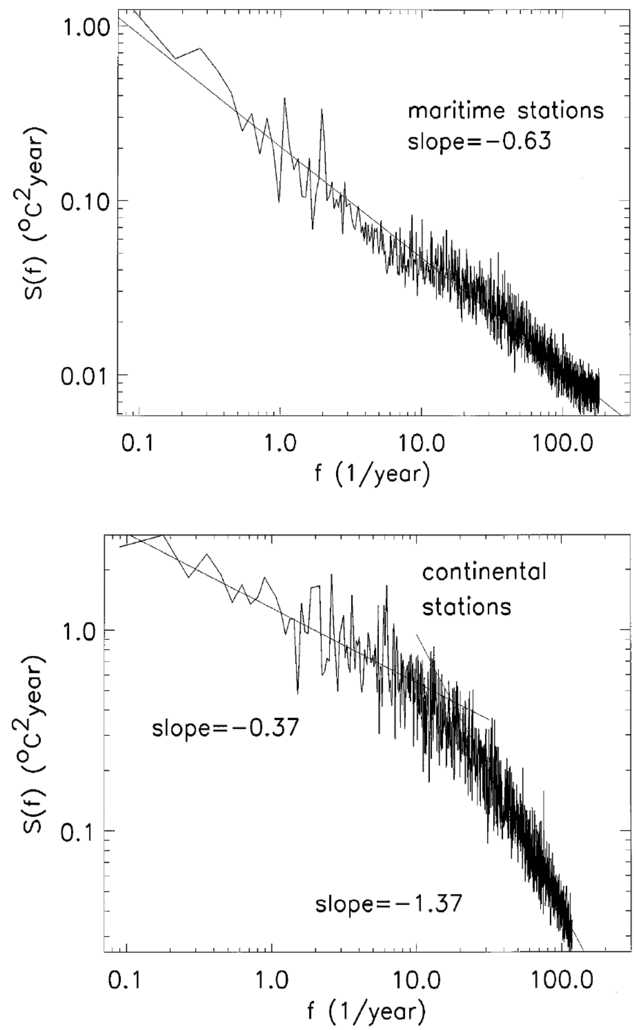
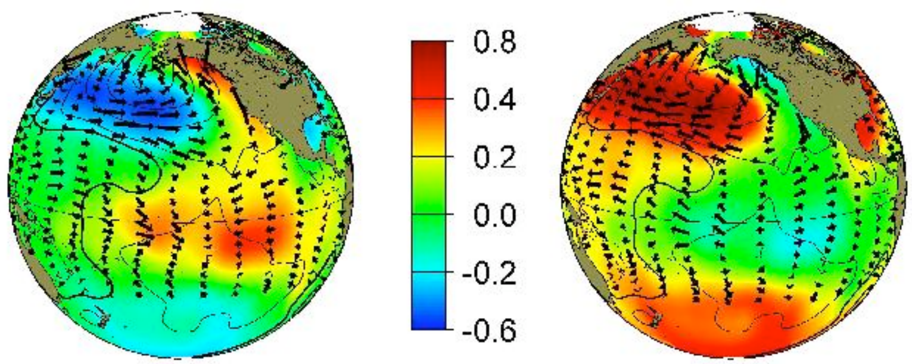


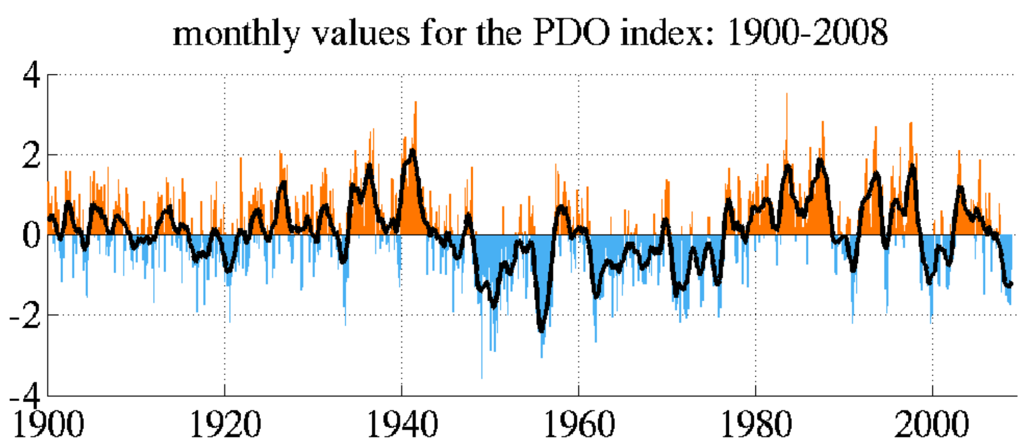
FIG. 4. Averaged power spectrum of (a) 90 maritime daily temperature and (b) 1000 continental daily temperature time series with the annual variability removed as a function of frequency in yr^{-1}. The crossover frequency for the continental spectra is $f_2 = 1$ (1 month)$^{-1}$.

Decadal predictability and prediction

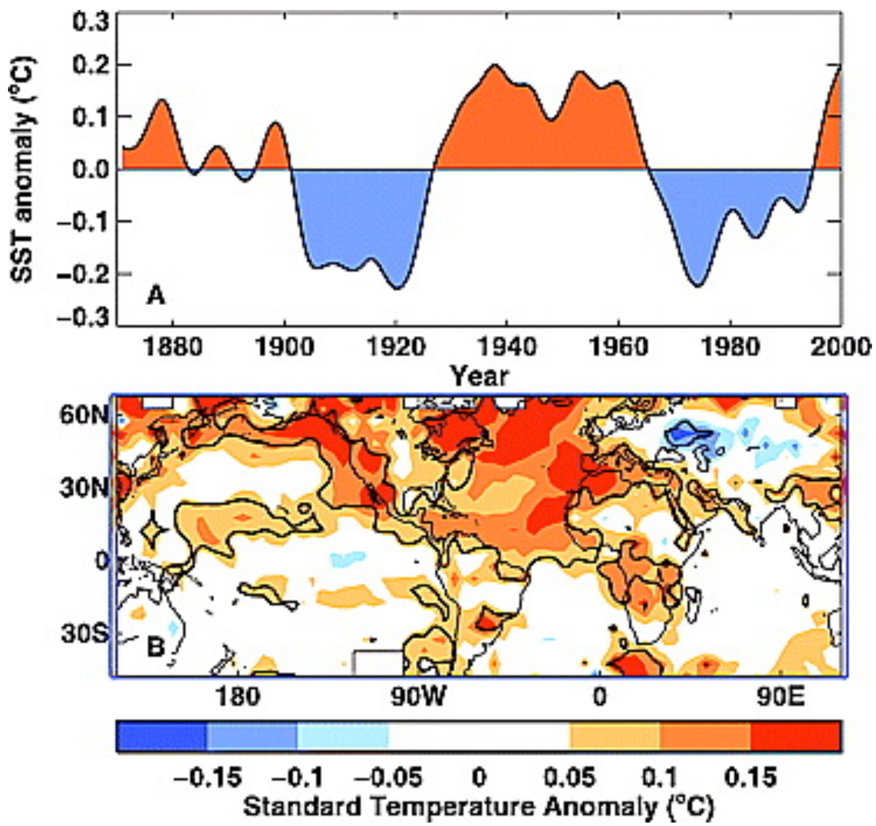
- Appeals to "long timescale" processes
  - *externally forced* (GHG+A, volcanoes, solar, ….)
  - *internally generated*
    - oceanic mechanisms (AMO=>AMV, SO, …)
    - coupled processes
      - PDO, AMO, NPMO, PGO, ENSO…
      - modulation of "atmospheric" modes (PNA, NAO, NAM, SAM, ….)
    - atmospheric processes (QBO, ...)

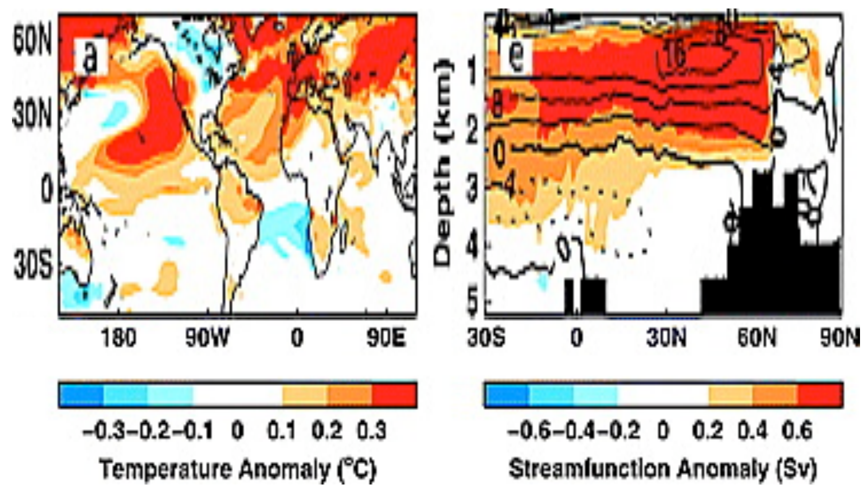
Pacific Decadal Oscillation





Atlantic Multidecadal Oscillation

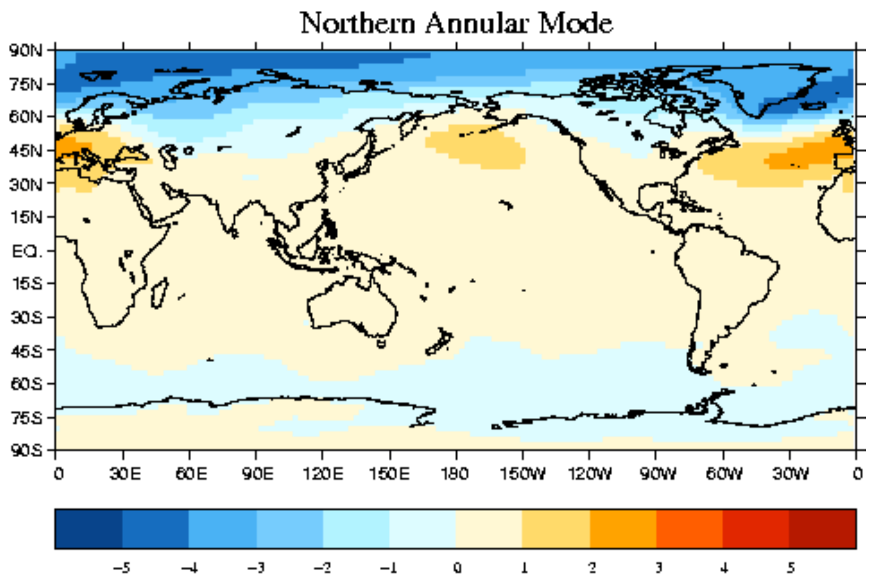




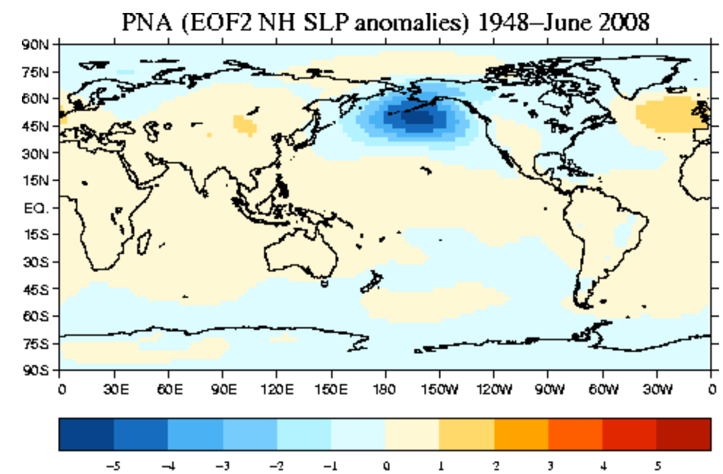
(in model)

Knight et al. 2005

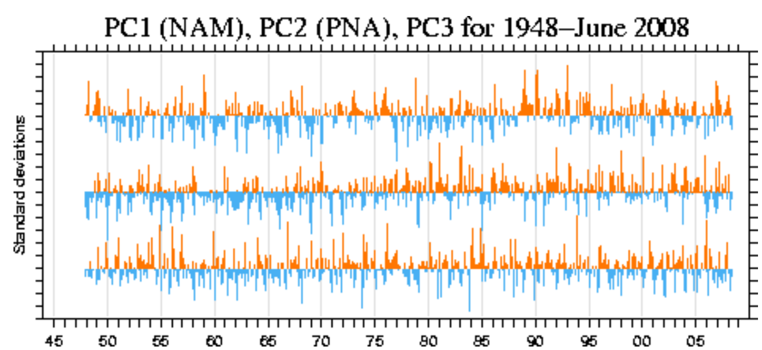
NAM and PNA



EOF one of NH SLP anomalies for 1948–June 2008.
All calendar months. 18% of the variance.
Plotted as regression coefficients, with units of mb.

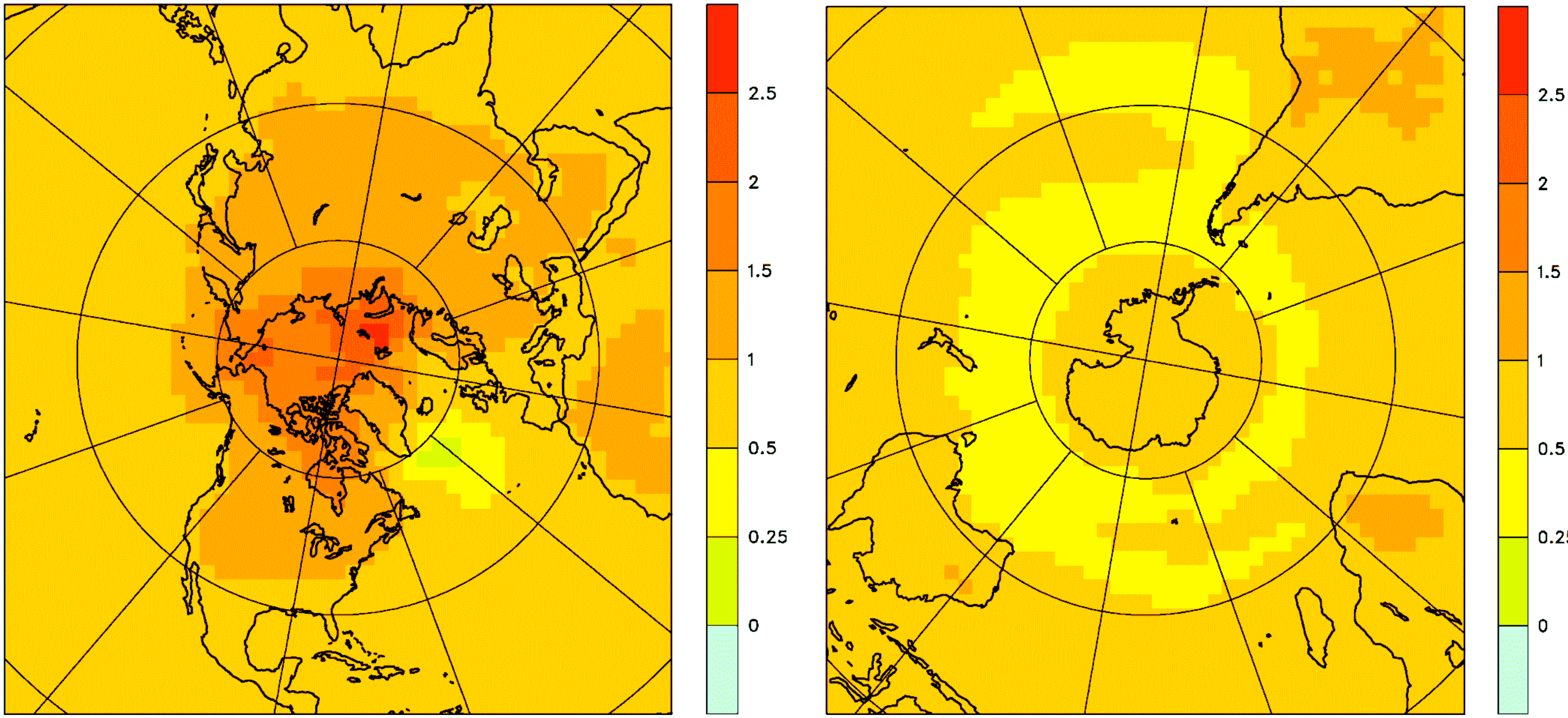


10.3% of the variance.
Plotted as regression coefficients, with units of mb.



JISAO website

Multi-model decadal mean *forced* temperature change: *from decade 2000-10 to 2040-50*



rate of change is roughly linear

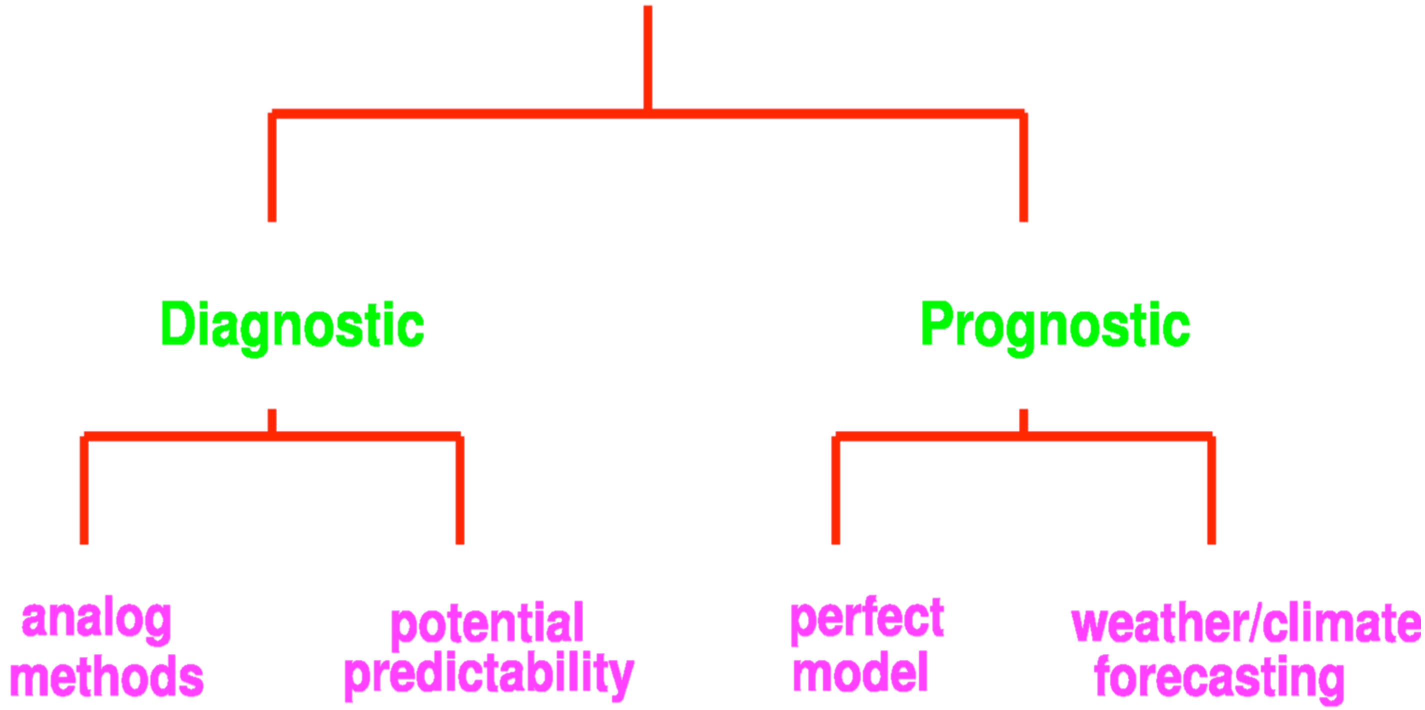
Polar aspects of long timescales

- *forced component* becoming more important
- *internally generated component*
  - generally live in the ocean/coupled system
  - some indication of polar concentration of patterns

Motivations for decadal prediction

- Scientific interest
- Existence of “long timescale” processes
- ***Results of predictability studies***
- Demonstrations of forecast skill
- Societal importance of modestly skillful decadal prediction

Predictability Studies



How do we determine the *predictability* of the system on decadal timescales?

- Prognostic perfect model predictability studies
  - Griffies and Bryan (1997)
  - Boer (2000)
  - Collins (2002)
  - Collins et al. (2006)
  - Latif et al., (2006)
  - Meehl et al., (2010)
  - and others
- Diagnostic potential predictability studies
  - Boer (2000, 2004)
  - Pohlmann et al. (2004)
  - Predicate (2004…)
  - Boer and Lambert (2008)
  - and others
- Investigations of forecast skill
  - Smith et al. (2008)
  - Keenlyside et al. (2008)
  - Pohlmann et al. (2009)
  - *CMIP5 Decadal Climate Prediction (DCP)* (2010 ….)

Perfect model(s) predictability study:

internally generated component only

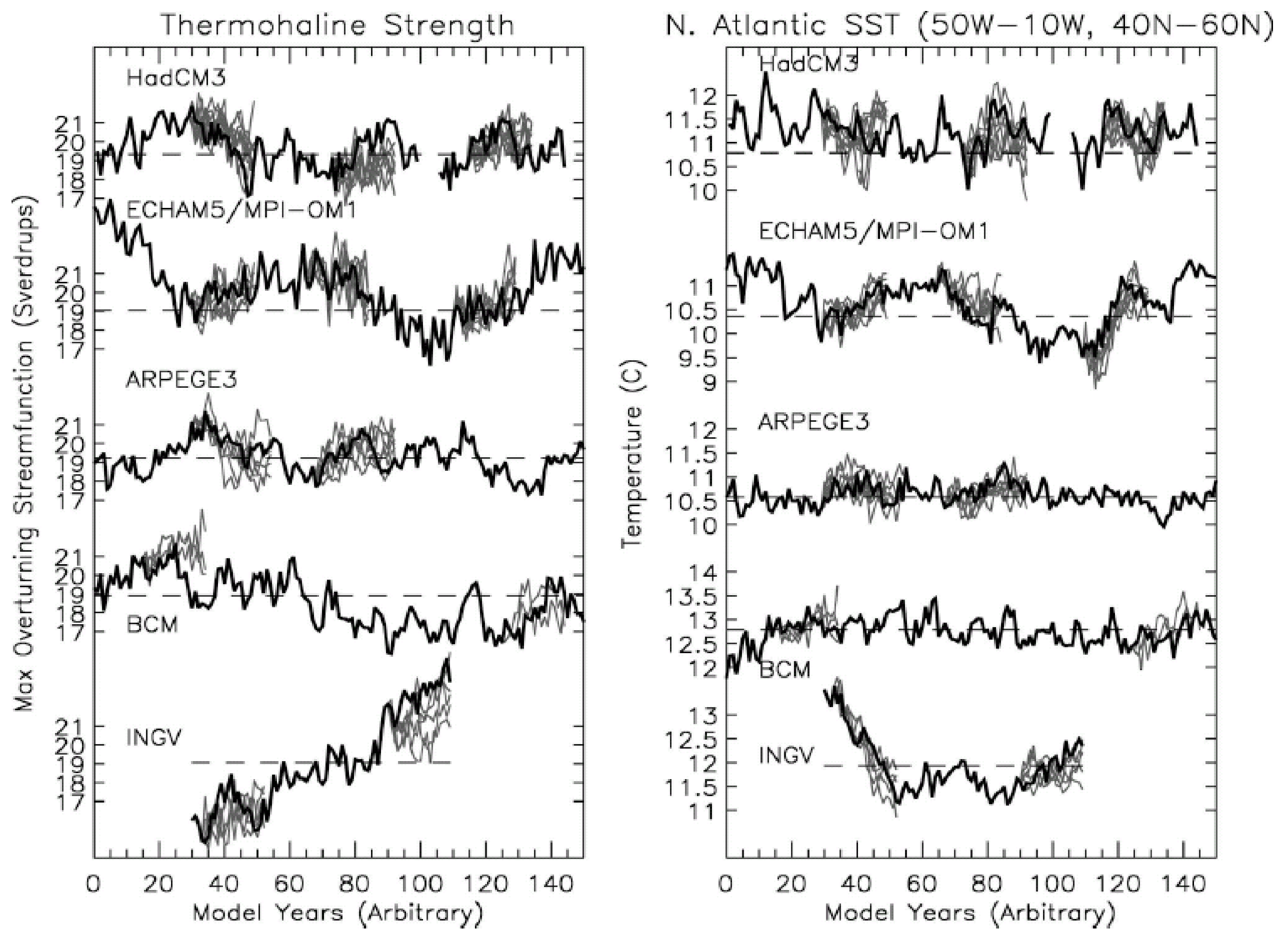
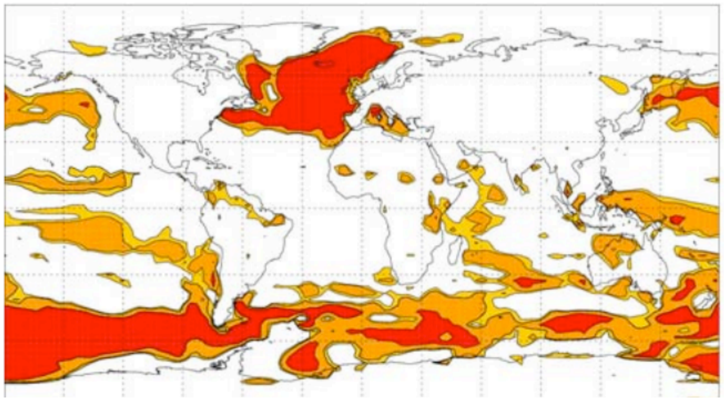


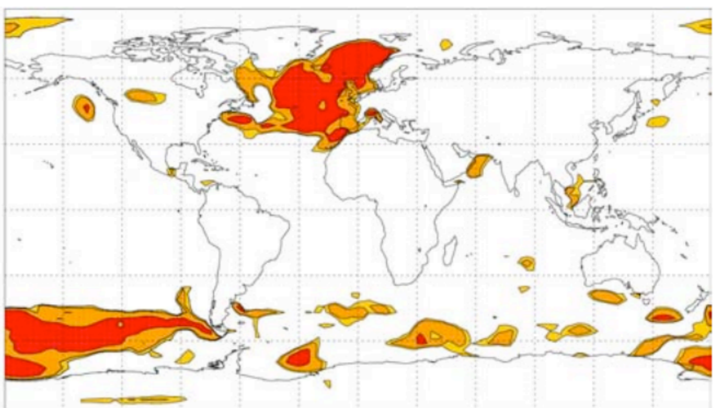
FIG. 9. Classical predictability experiments with five different European coupled ocean–atmosphere GCMs: (left) prediction of thermohaline strength and (right) prediction of North Atlantic SST. The ensemble experiments (thin gray) were initialized from control experiments (thick black) by only perturbing atmospheric initial conditions. The ensemble experiments indicate considerable predictability in the North Atlantic on decadal time scales. From Collins et al. (2006).

Collins et al., 2006

years 1-5

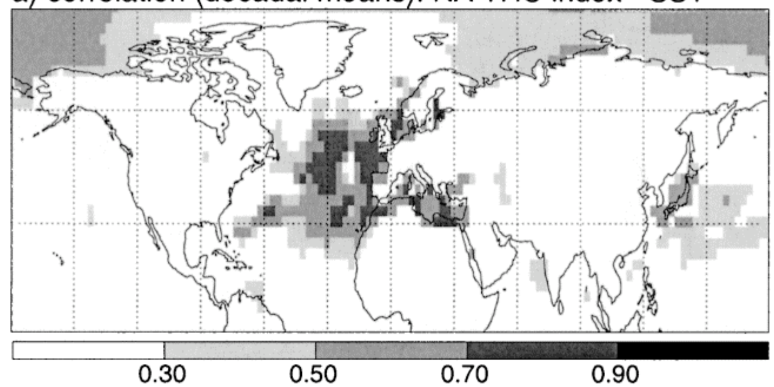


years 6-10

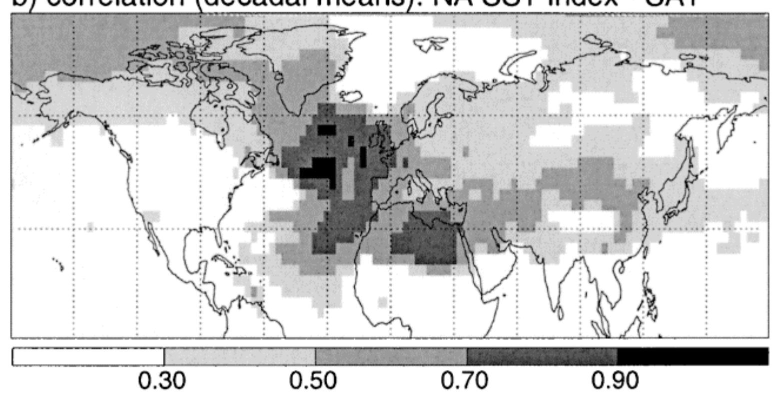


perfect model predictability measure
for the internally generated component

a) correlation (decadal means): NA THC index - SST



b) correlation (decadal means): NA SST index - SAT

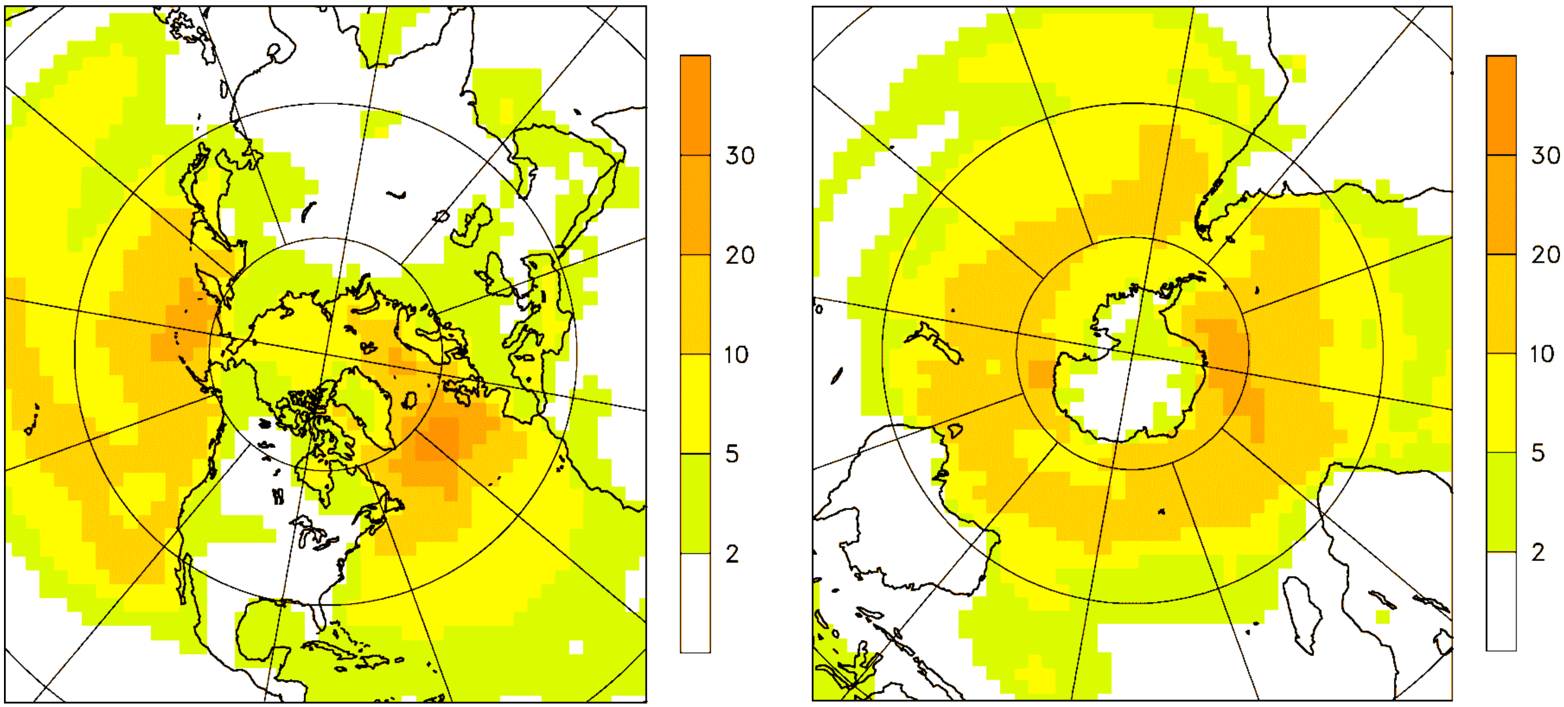


North Atlantic

Pohlmann et al. 2004

Temperature: potential predictability of *internally generated* variability, $p_\nu = \sigma^2_\nu/\sigma^2$ (%), for *decadal means*

control simulations



- long timescales found mainly over extratropical oceans
- near polar latitudes
- only modest incursions over land

  - *ppvf* is max where σ^2 is large over oceans; implies "large" σ^2_ν
  - *ppvf* is small over land where σ^2 is large; implies "large" σ^2_ε

21st Century multi-model decadal potential predictability

- Variable has components

$$X' = \Omega + \nu + \varepsilon$$

with associated variances

$$\sigma^2 = \sigma^2_{\Omega} + \sigma^2_{\nu} + \sigma^2_{\varepsilon}$$

- Ω is long timescale *externally forced* variability
- ν is long timescale *internally generated* variability
- ε is short timescale *unpredictable "noise"* variability

- Potential predictability variance fraction

  $$p = (\sigma^2_\Omega + \sigma^2_\nu)/\sigma^2 = p_\Omega + p_\nu$$

  - the fraction of the total variance accounted for by long timescale components
  - forced p_Ω and internally generated p_ν contributions
  - presumed to be the result of long timescale physical processes that are "potentially" predictable with enough knowledge
  - an estimate of the upper bound of long timescale predictability
- in terms of a signal to noise measure

  $$\gamma = (\sigma^2_\Omega + \sigma^2_\nu)/\sigma_\varepsilon^2$$

  $$p = \gamma/(1+\gamma)$$
- p is small if signal is *small* or if noise is *large*
  - $0 < p < 1$
  - not only existence of signal, however small, but its comparative magnitude
- multi-model approach averages statistics over models

Boer, 2010

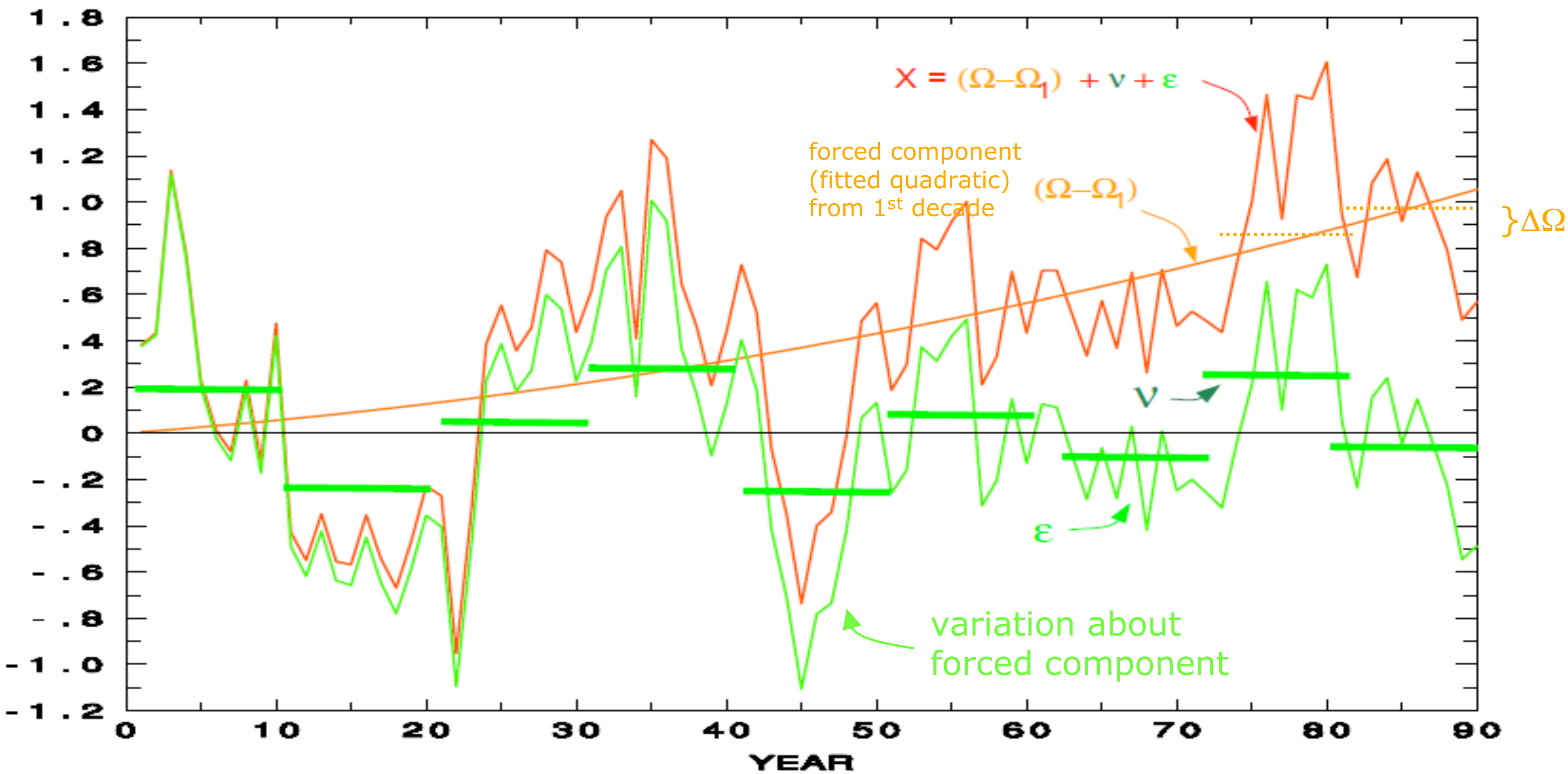
Virtues of multi-model approach

- the multi-model estimates of the variances of annual mean *T* and *P* are in accord with "observation-based" values

- the "multi-model" is generally the "best model"
  - no individual model "best" in all regards
  - the "*n*-best" models differ with criterion used
  - pooled climate statistics (means, variances, covariances) generally closer to observed
  - applied to seasonal forecasting
  - applied to climate change (Chapter 10, AR4)

- increased the amount of data for statistical stability

21st century temperature at a point



$\sigma_1^2 = \sigma^2_{\Omega 1} + \sigma^2_\nu + \sigma^2_\varepsilon$ multi-decade

$\sigma_\Delta^2 = \sigma^2_{\Delta\Omega} + \sigma^2_\nu + \sigma^2_\varepsilon$ *next-decade*

Estimate statistics from sample variances

$$\hat{\sigma}_{\varepsilon}^2 = \frac{m}{m-1} S_{\varepsilon}^2$$

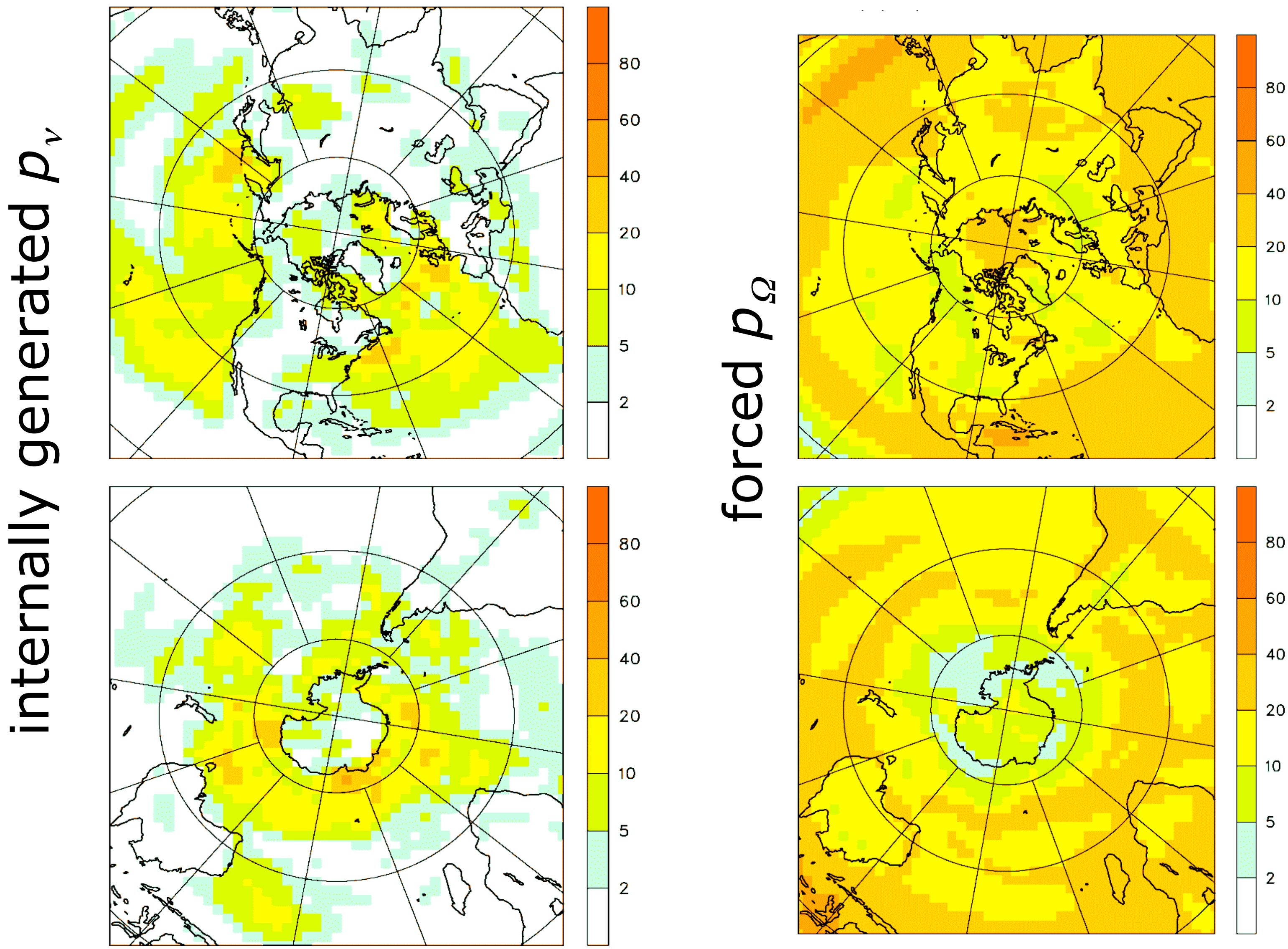
$$\hat{\sigma}_{\nu}^2 = \frac{n}{n-(b+1)} S_{\nu}^2 - \frac{S_{\varepsilon}^2}{m-1}$$

$$\hat{\sigma}_{\Omega 1}^2 = S_{\Omega 1}^2 - \frac{d_1}{n-(b+1)} S_{\nu}^2$$

$$\hat{\sigma}_{\Delta\Omega}^2 = S_{\Delta\Omega}^2 - \frac{d_{\Delta}}{n-(b+1)} S_{\nu}^2$$

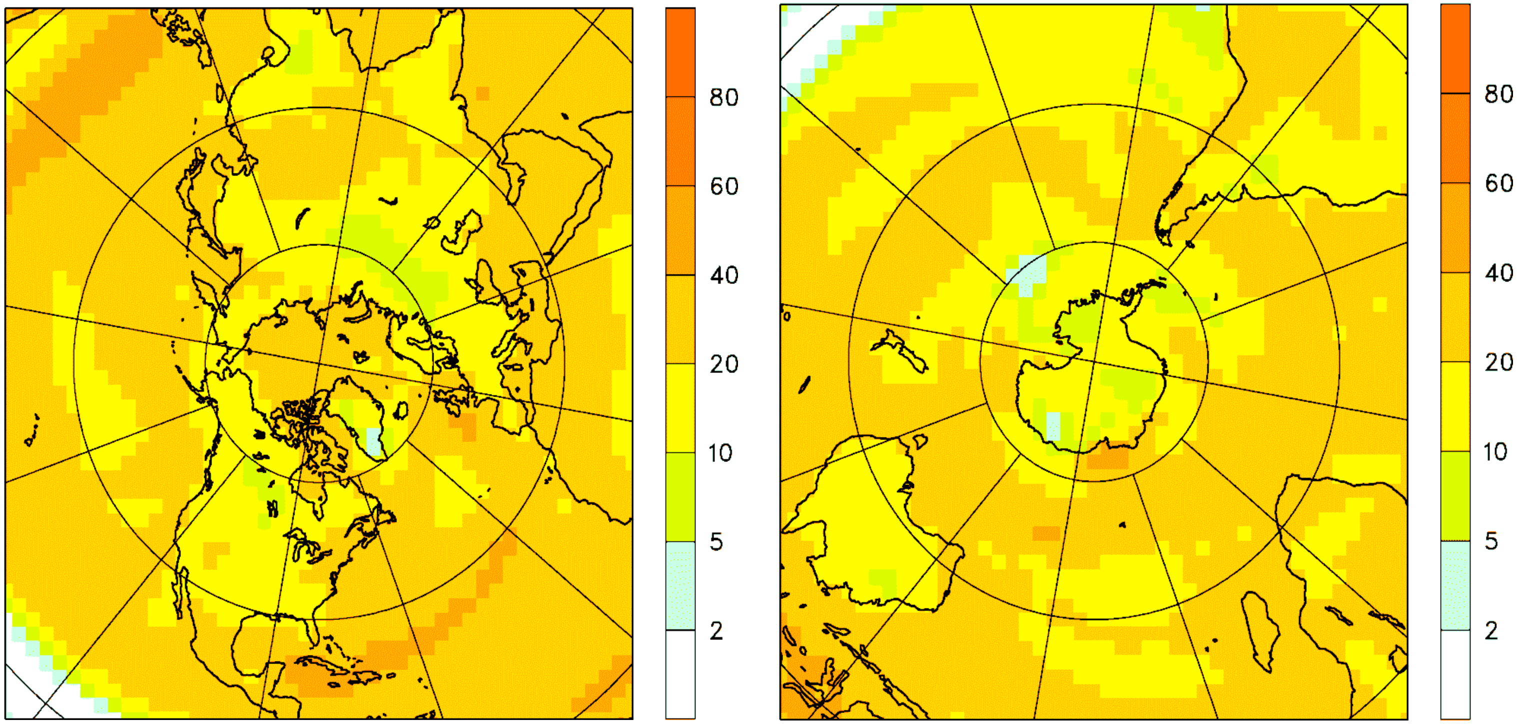
- S^2 are sample variances pooled across models
- m = 10 years in a decade; n = 10 decades in 21st century
- b, d's arise from the fitting polynomial for the forced component
- decadal sample variance is discounted by part of noise variance
- decadal forced variance discounted by part of decadal variance

Potential predictability variance fraction of decadal mean Temperature: for 2010-2020 from 2000-10 and for *“next decade”* generally



Potential predictability variance fraction of decadal mean Temperature for 2010-2020 from 2000-10 and for *"next decade"* generally

$$\text{net } p = p_{\Omega} + p_{\nu}$$

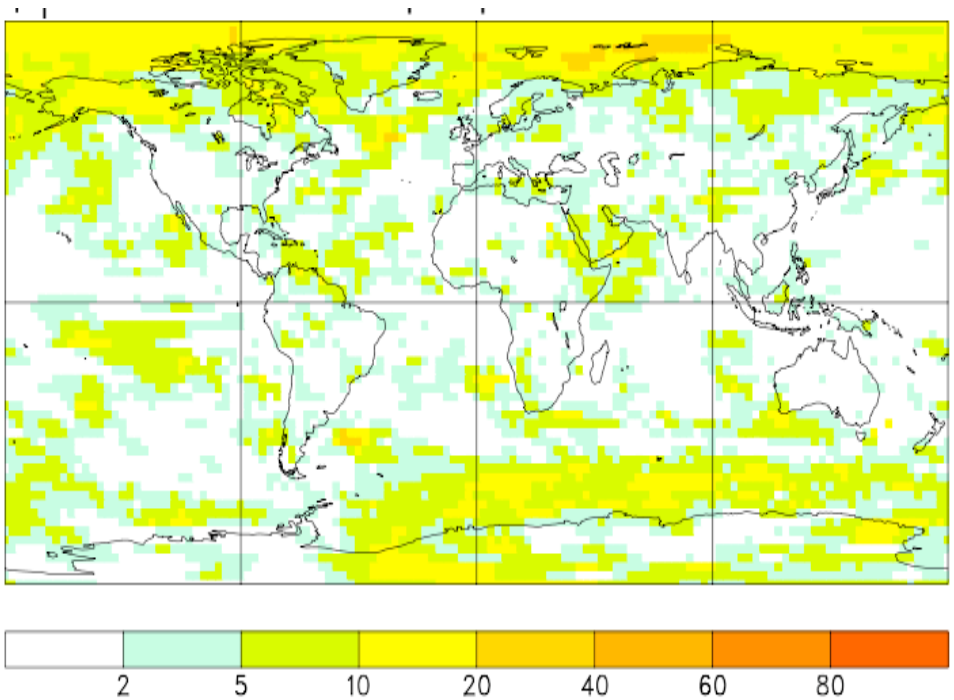


Multi-model next-decade potential predictability of *T* for the 21st century

- generally for potential predictability *p*:
  - forced component p_Ω contributes most to predictability
  - internally generated component p_ν tends to be "complementary"
  - *p* generally weak over mid-latitude land
- polar potential predictability:
  - due to p_Ω over Arctic but weak over surrounding land
  - relatively weak in Antarctic

Potential predictability of precipitation

Potential predictability of precipitation: *2020-30*

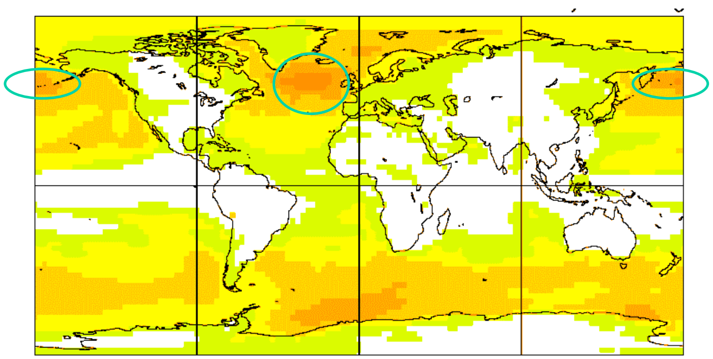


- noise variance for precipitation is large
- internally generated p_{ν} is small as a result
- *next-decade* $p_{\Delta\Omega}$ also small as a result
- only *multi-decade* $p_{\Omega 1}$ contributes and then only modestly
- concentration at polar latitudes

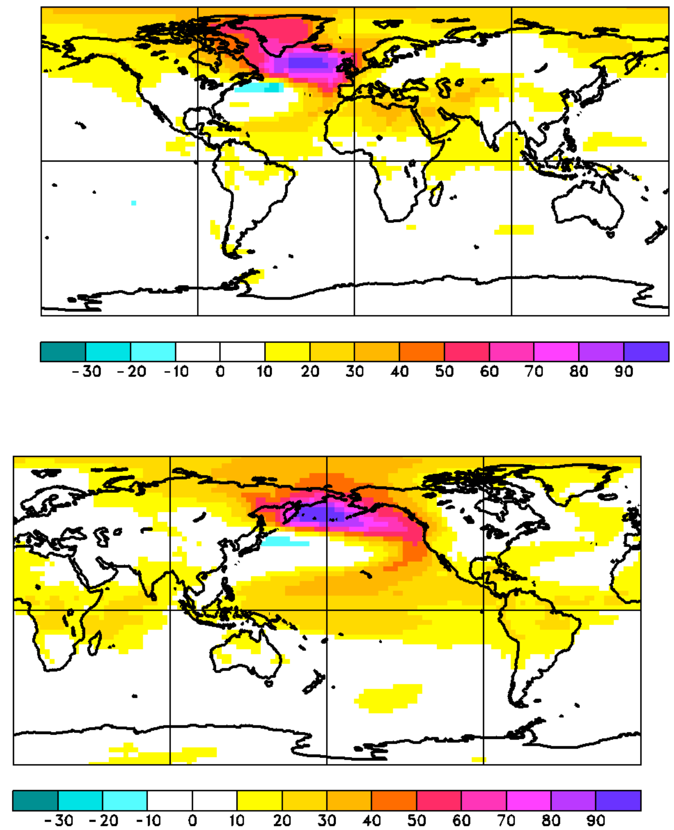
The challenges and caveats of predictability studies

- to identify the mechanisms associated with regions/modes of predictability
- to assess "perfect model" and "potential" vs "actual" predictability
- to investigate predictive *skill* of both forced and internally generated variability

Telleconnections with centres of potential predictability



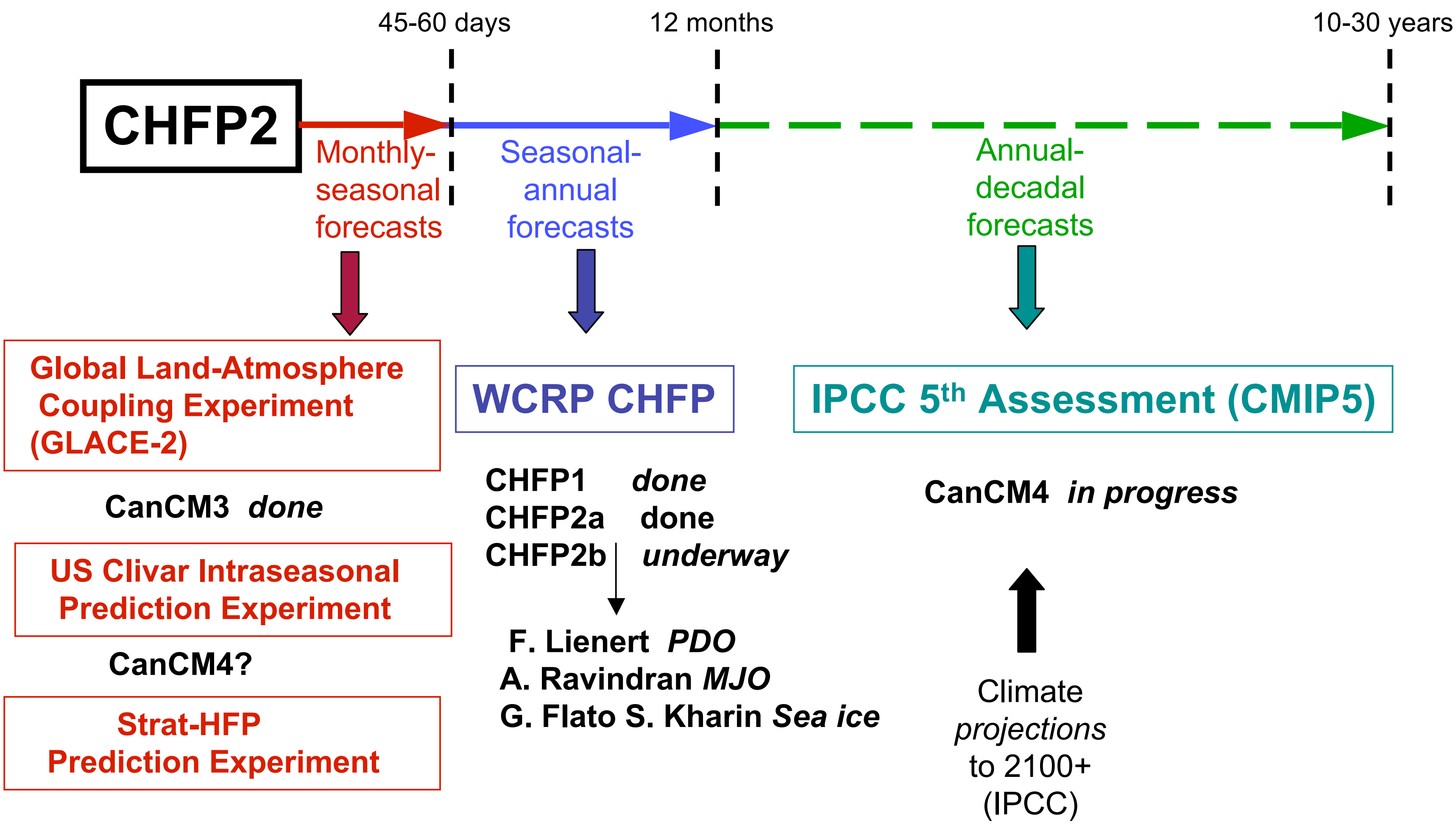
- “centres” are regions where long timescale *internal* variability exists that is not “masked” by noise variability
- suggests that the system should “see” these centres more clearly
- patterns remarkably(?) similar
  - dipole structure
  - connection to eastern sides of basins
  - connections to tropics
  - inter-ocean connections not immediate



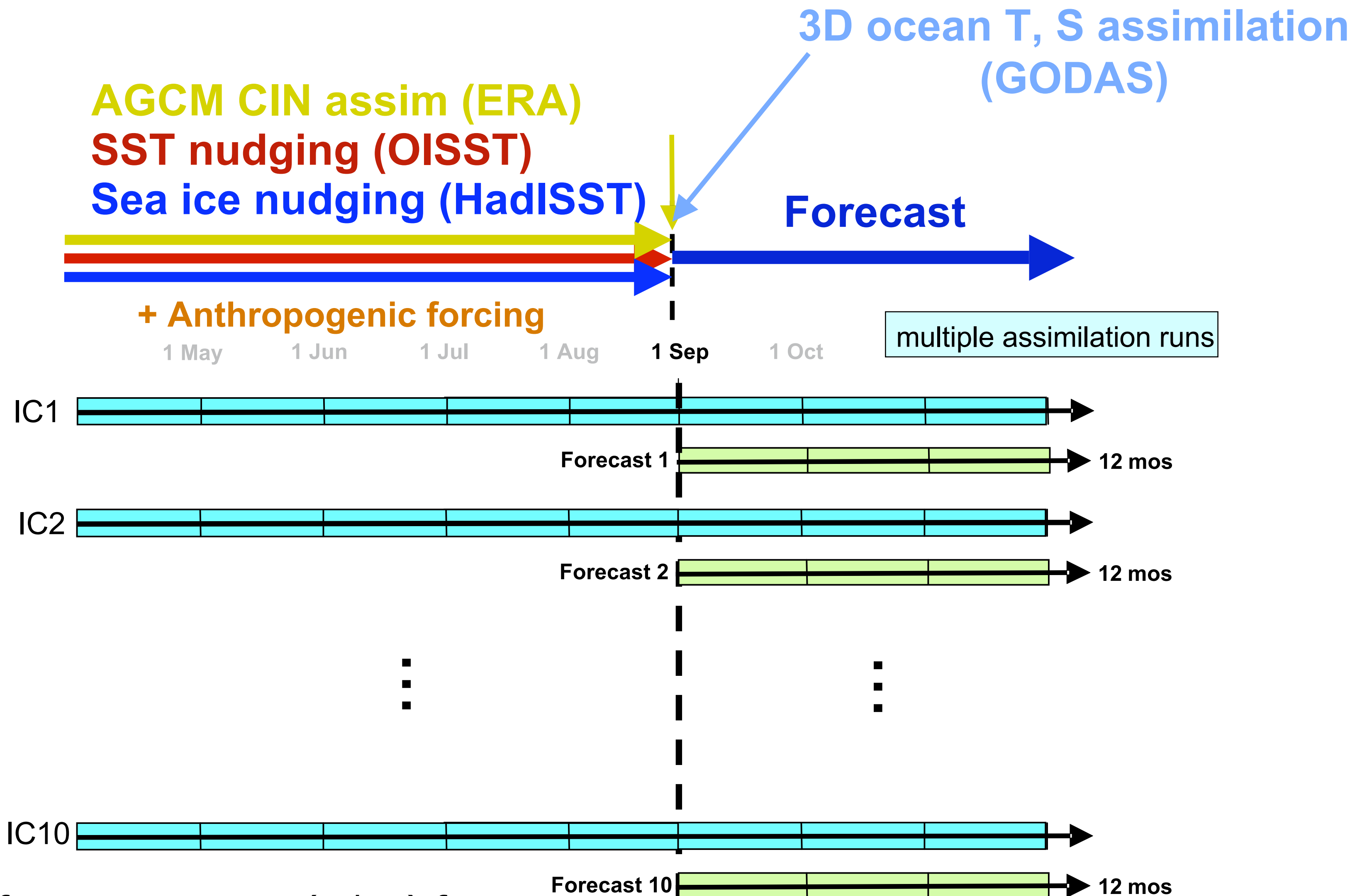
correlation maps of decadal mean temperatures of “centres”

CCCma sub-seasonal to decadal analysis and forecasting

Bill Merryfield, Woo-Sung Lee, Slava Kharin, George Boer, John Scinocca, Greg Flato

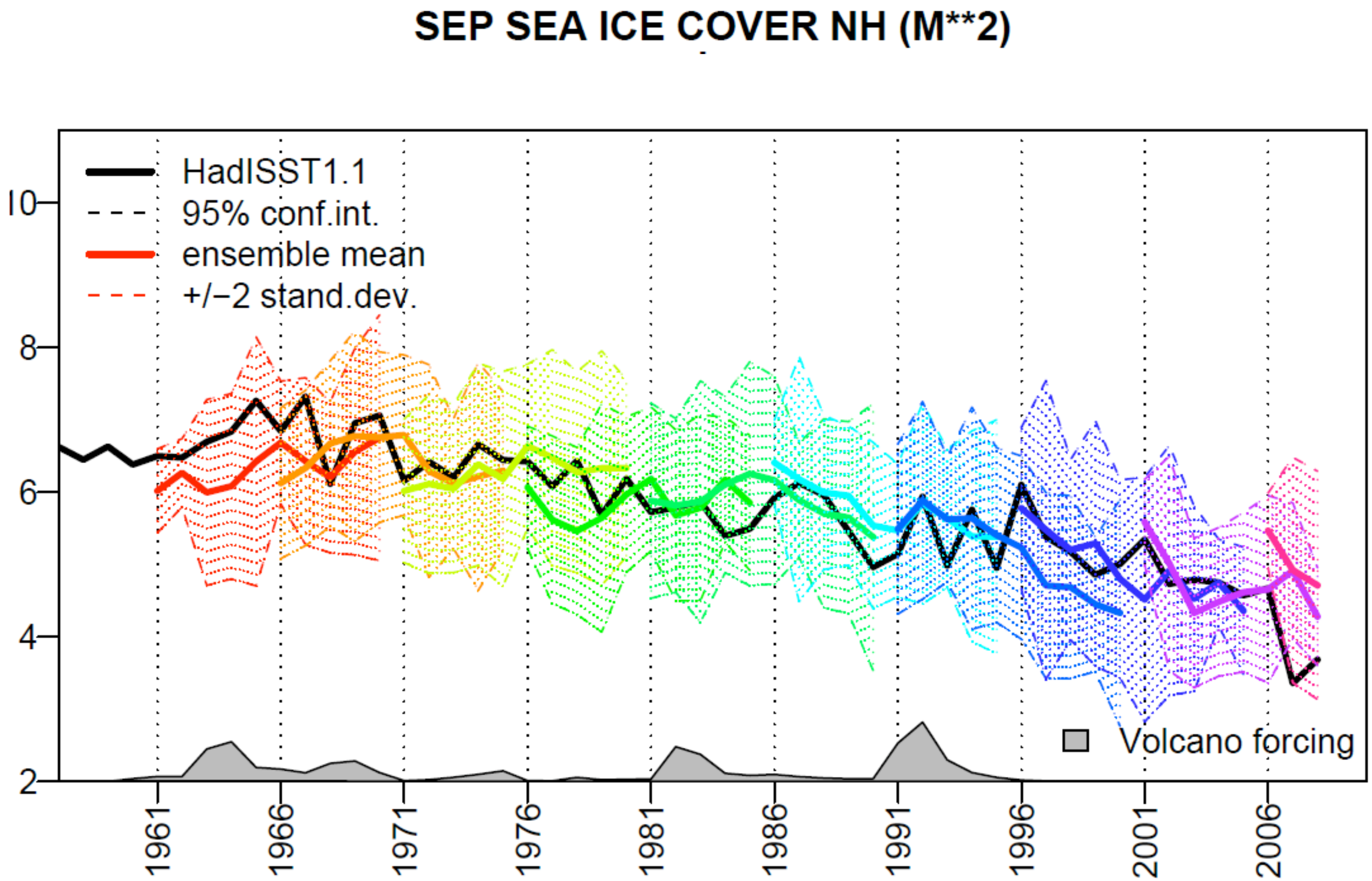


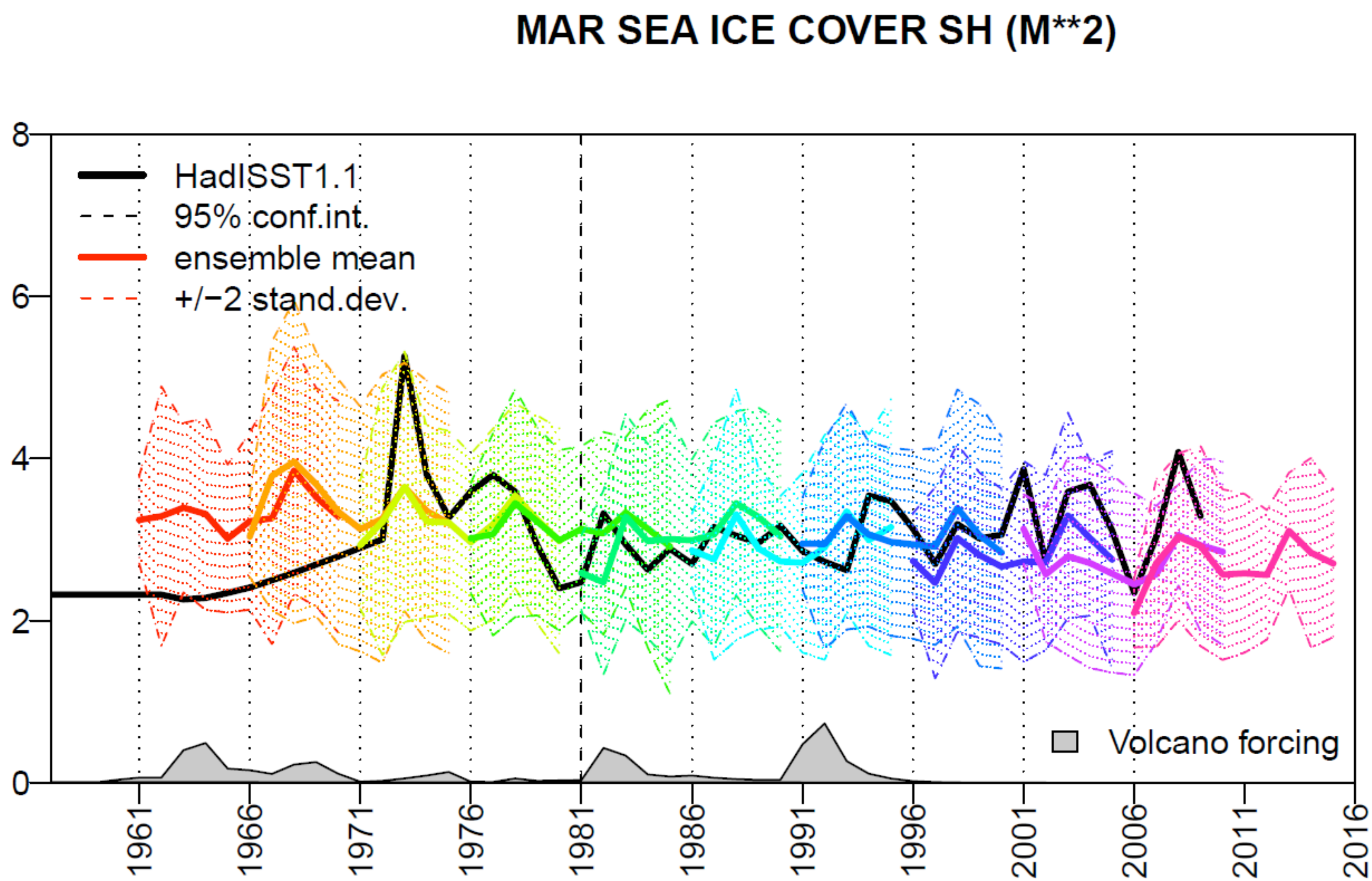
DHFP initialization



3 forecast streams (a,b,c) for
different treatment of ocean data:
a. sfc forcing, b. full assimilation, c. anomaly assimilation)

CanCM4


SEP SEA ICE COVER NH (M**2)
HadISST1.1
95% conf.int.
ensemble mean
+/−2 stand.dev.
Volcano forcing
10
8
6
4
2
1961
1966
1971
1976
1981
1986
1991
1996
2001
2006



MAR SEA ICE COVER SH (M**2)
HadISST1.1
95% conf.int.
ensemble mean
+/−2 stand.dev.
Volcano forcing
8
6
4
2
0
1961
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016

Motivations for decadal prediction

- *Scientific interest*
- *Existence of "long timescale" processes*
- *Results of predictability studies*
- *Demonstrations of forecast skill*
- ***Societal importance of modestly skillful decadal prediction***

LIST OF POSSIBLE APPLICATIONS OF skilful DECADAL PREDICTION

Document prepared for CLIVAR Pacific Panel by:
William Crawford, Rodney Martinez and Toshio Suga.
October 2006

- climate related diseases
- agricultural planning
- drinking water
- sea level rise
- tourism
- forest planning
- fisheries
- arctic navigation
- permafrost and methane gas emissions
- electrical power generation
- shipping and offshore construction

WCC-3

A Global Framework for Climate Services?

WORLD CLIMATE NEWS

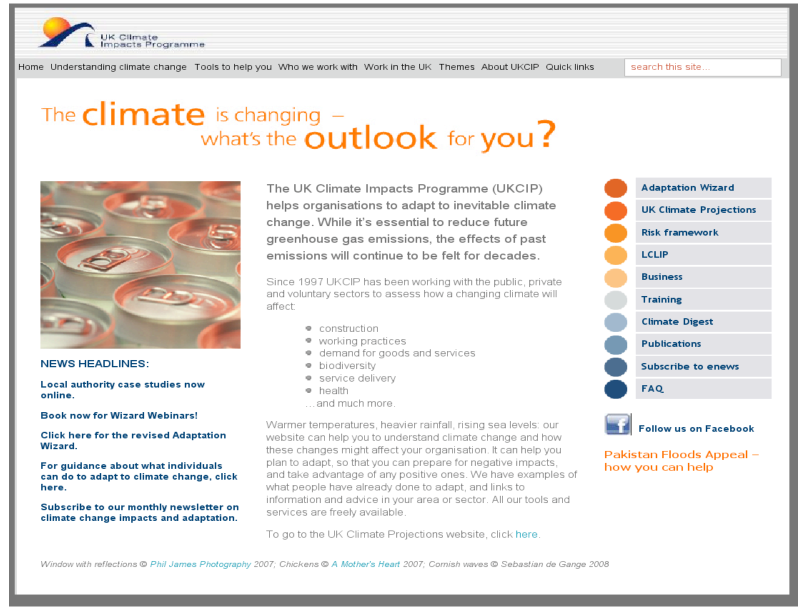
ipcc

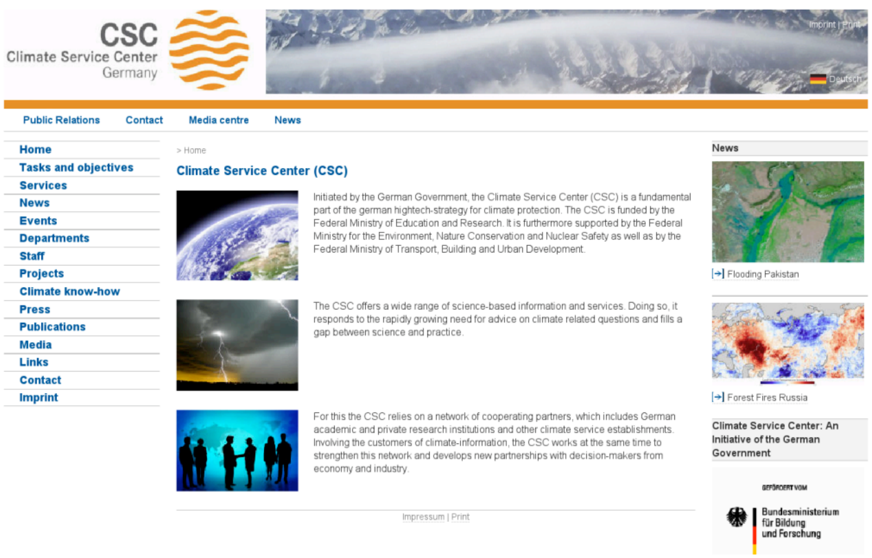
INTERGOVERNMENTAL PANEL ON climate change

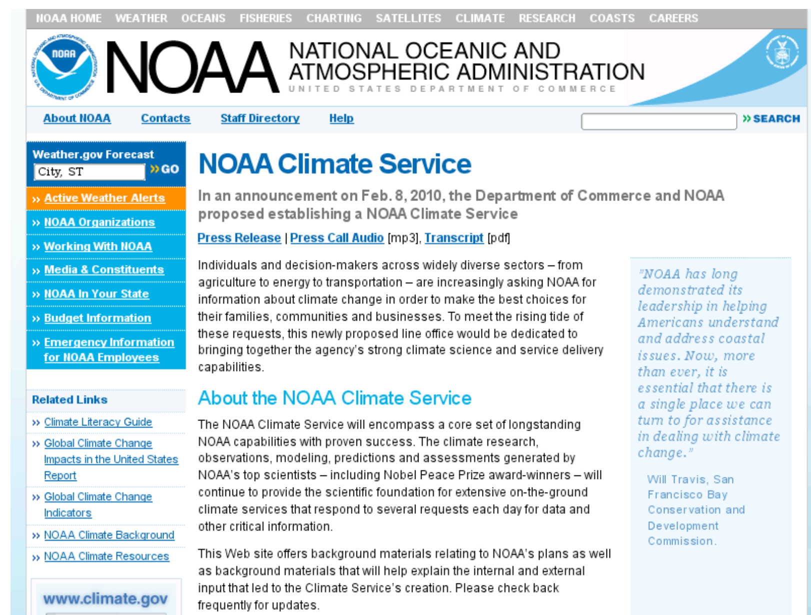
Working Group I (WG I) – The Physical Science Basis

IPCC Working Group I Fifth Assessment Report
First Lead Author Meeting
Kunming, China, 8 – 11 November 2010

Emerging national activities to support (appropriate) use of decadal prediction information







Prospects are good for decadal prediction in polar regions

- Existence of "long timescale" processes - ☑
- Results of predictability studies - ☑
- Scientific interest - ☑
- Demonstrations of forecast skill - ☑
- Societal importance of modestly skillful decadal prediction – ☑