What are the Prospects for Decadal Prediction?

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(in future CCCmap…?)

Prospects for decadal prediction?

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

Decadal prediction motivations

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

Decadal predictability and prediction

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

What's special about decadal timescales?

- Not much according to spectra

(e.g. Pelletier,1997)

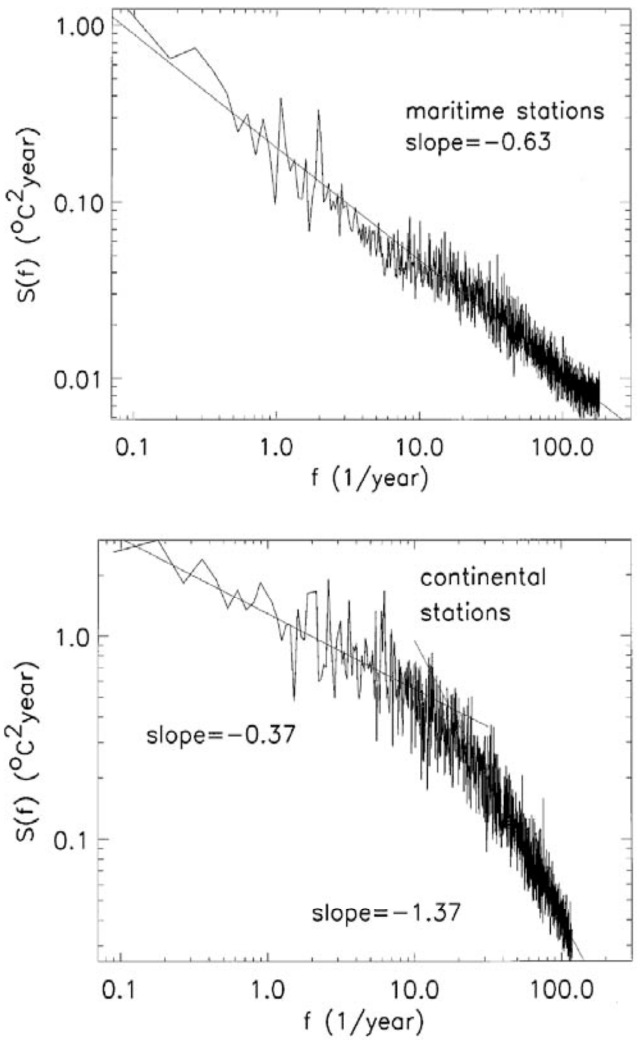

FIG. 4. Averaged power spectrum of (a) 90 maritime daily temperature and (b) 1000 continental daily temperature time series with the annual variability removed as a function of frequency in yr^{-1}. The crossover frequency for the continental spectra is $f_2 = 1$ (1 month)$^{-1}$.

Modes of climate variability according to the AR4

Box TS.2: Patterns (Modes) of Climate Variability

Analysis of atmospheric and climatic variability has shown that a significant component of it can be described in terms of fluctuations in the amplitude and sign of indices of a relatively small number of preferred patterns of variability. Some of the best known of these are:

- El Niño-Southern Oscillation (ENSO), a coupled fluctuation in the atmosphere and the equatorial Pacific Ocean, with preferred time scales of two to about seven years. ENSO is often measured by the difference in surface pressure anomalies between Tahiti and Darwin and the SSTs in the central and eastern equatorial Pacific. ENSO has global teleconnections.
- North Atlantic Oscillation (NAO), a measure of the strength of the Icelandic Low and the Azores High, and of the westerly winds between them, mainly in winter. The NAO has associated fluctuations in the storm track, temperature and precipitation from the North Atlantic into Eurasia (see Box TS.2, Figure 1).
- Northern Annular Mode (NAM), a winter fluctuation in the amplitude of a pattern characterised by low surface pressure in the Arctic and strong mid-latitude westerlies. The NAM has links with the northern polar vortex and hence the stratosphere.
- Southern Annular Mode (SAM), the fluctuation of a pattern with low antarctic surface pressure and strong mid-latitude westerlies, analogous to the NAM, but present year round.
- Pacific-North American (PNA) pattern, an atmospheric large-scale wave pattern featuring a sequence of tropospheric high- and low-pressure anomalies stretching from the subtropical west Pacific to the east coast of North America.
- Pacific Decadal Oscillation (PDO), a measure of the SSTs in the North Pacific that has a very strong correlation with the North Pacific Index (NPI) measure of the depth of the Aleutian Low. However, it has a signature throughout much of the Pacific.

Positive Phase of NAO and NAM

Box TS.2, Figure 1. *A schematic of the changes associated with the positive phase of the NAO and NAM. The changes in pressure and winds are shown, along with precipitation changes. Warm colours indicate areas that are warmer than normal and blue indicates areas that are cooler than normal.*

The extent to which all these preferred patterns of variability can be considered to be true modes of the climate system is a topic of active research. However, there is evidence that their existence can lead to larger-amplitude regional responses to forcing than would otherwise be expected. In particular, a number of the observed 20th-century climate changes can be viewed in terms of changes in these patterns. It is therefore important to test the ability of climate models to simulate them (see Section TS.4, Box TS.7) and to consider the extent to which observed changes related to these patterns are linked to internal variability or to anthropogenic climate change. {3.6, 8.4}

Modes of Variability

- Modes of climate variability cover a range of timescales
  - can have decadal variation in strength/envelope
- For Modes:
  - how do we properly characterize a mode
  - how do we determine its predictability
  - how do we assess its *importance*
  - is there mode interaction
- Area of active research but we really don't understand the physics behind most "modes"
- No governing equations for modes

Long timescales

- clearly exist in the system
- forced component becoming more important
- internally generated component may have "modal" aspects which require much research to understand
- long timescale modes generally live in the ocean but we need to investigate also their impact over land

Decadal prediction motivation

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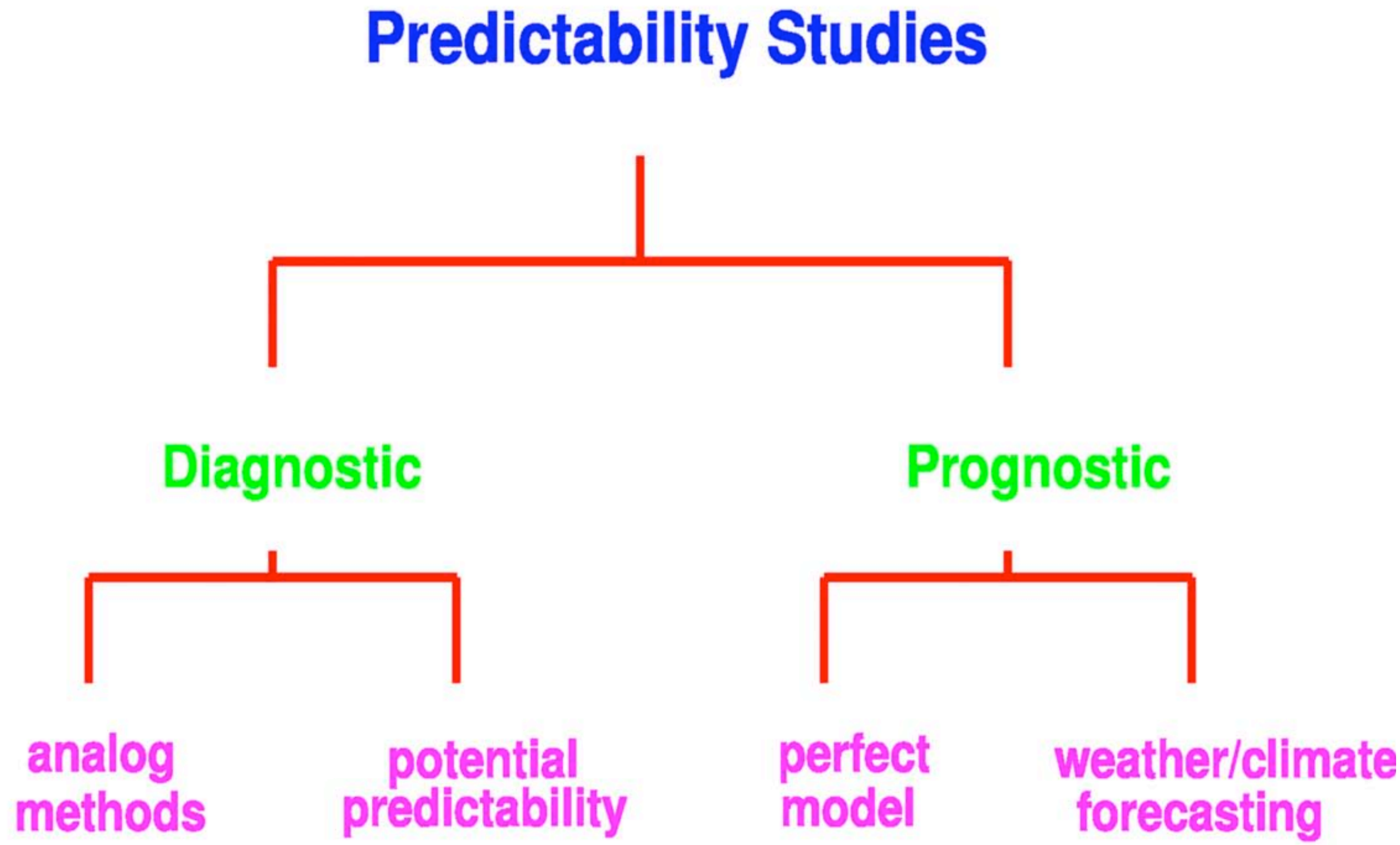
Predictability Studies
Diagnostic
Prognostic
analog methods
potential predictability
perfect model
weather/climate forecasting

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

- Perfect model predictability studies
  - Griffies and Bryan (1997)
  - Boer (2000)
  - Collins (2002)
  - Collins et al. (2006)
  - Latif et al., (2006)
  - and others
- Potential predictability studies
  - Boer (2004, 2006)
  - Pohlmann et al. (2004)
  - Predicate (2000-2003)
  - and others
- We also begin to investigate forecast skill
  - Smith et al. (2007)
  - Keenlyside et al. (2008)
  - Pohlmann et al. (2008)

Climate prediction of long timescale internally generated variability

- "early days" coupled climate change simulations
- forcing is weak early in the simulation
- gives information on "predictability" of internally generated variability
- "long" timescales

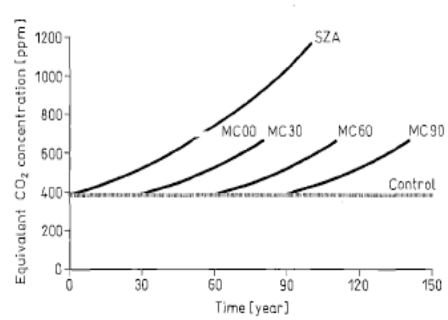

Fig. 1. Schematic diagram of the "Monte Carlo" climate forecasts

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]

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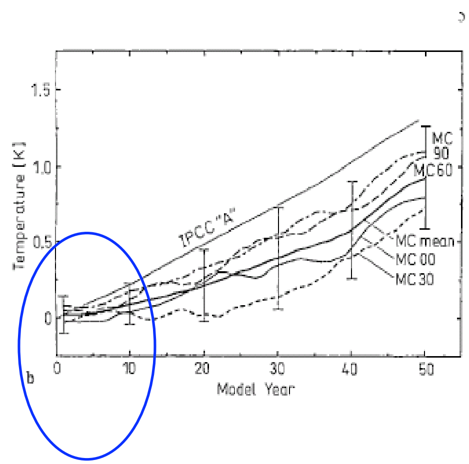
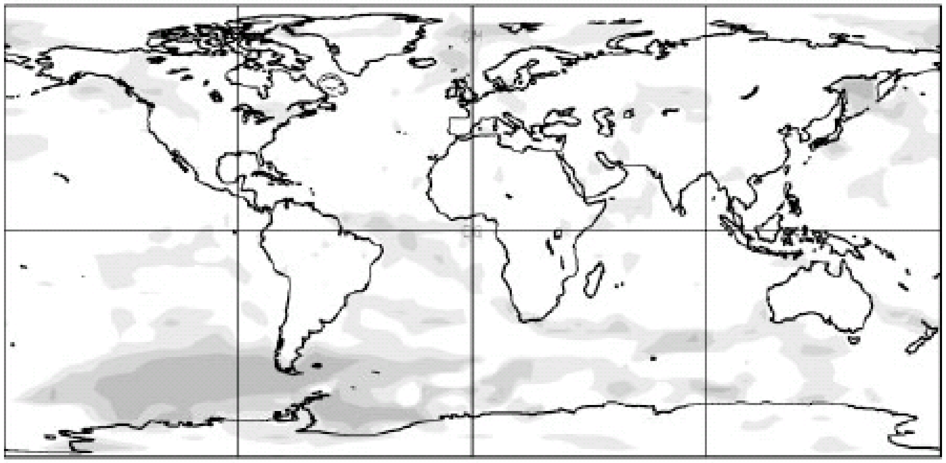


Long-timescale predictability study

- Not able to overcome culture shock at MPI to use their utilities etc.
- Later, CCC managed to produce several runs
- Initial "perfect model" predictability estimates from CCCma model

decadal perfect model predictability



Boer,2000: Clim Dyn

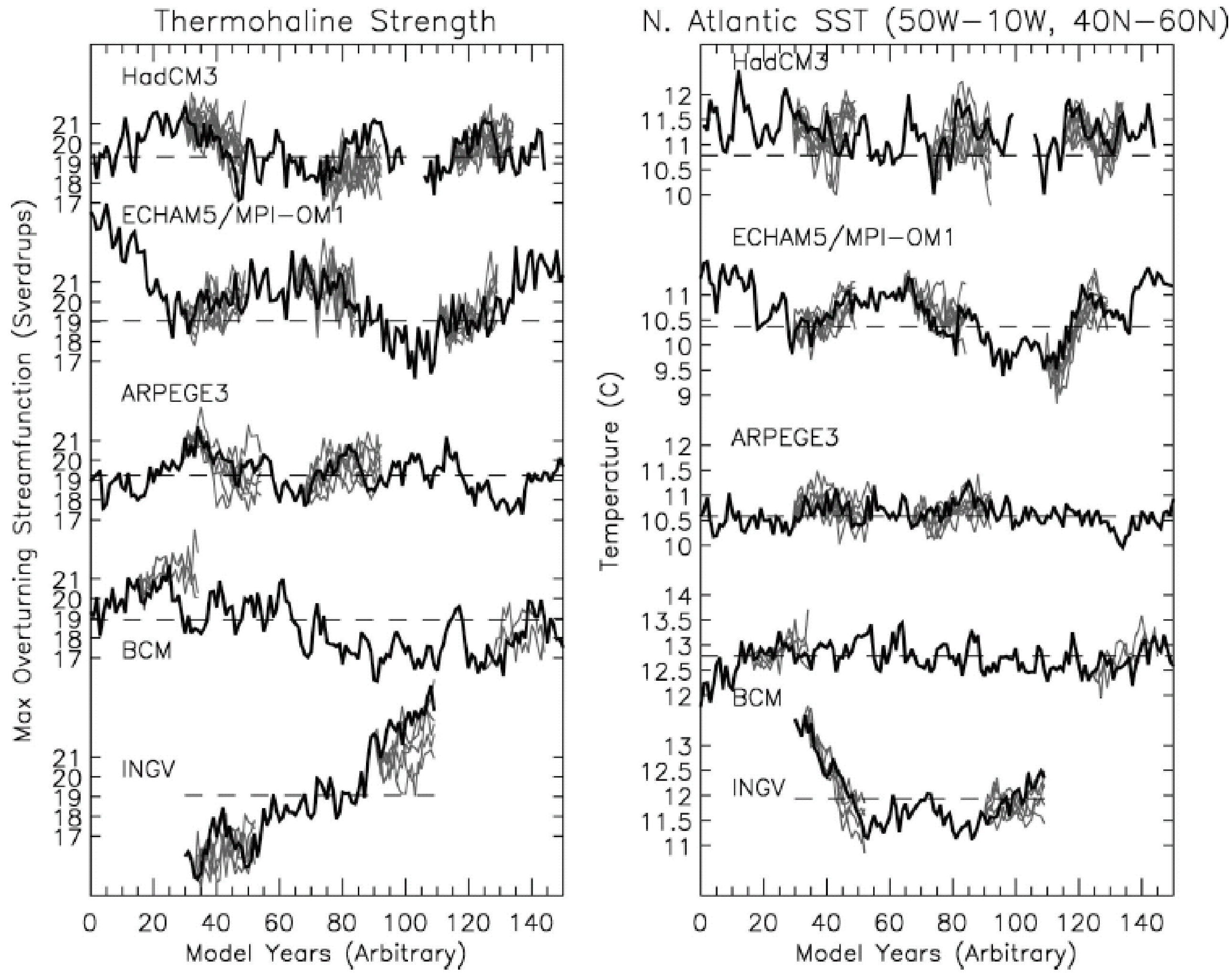
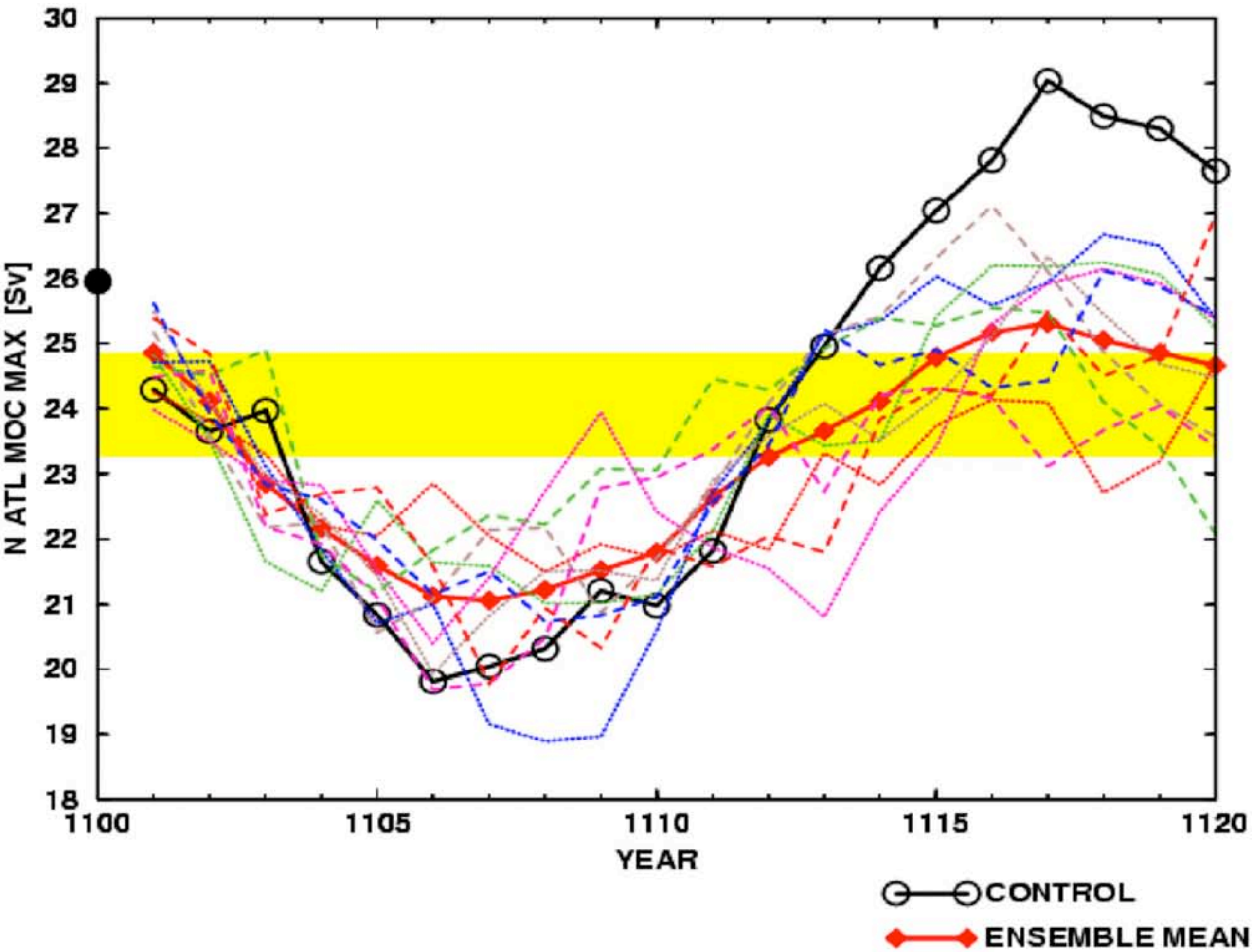


FIG. 9. Classical predictability experiments with five different European coupled ocean–atmosphere GCMs: (left) prediction of thermohaline strength and (right) prediction of North Atlantic SST. The ensemble experiments (thin gray) were initialized from control experiments (thick black) by only perturbing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

Collins, 2006



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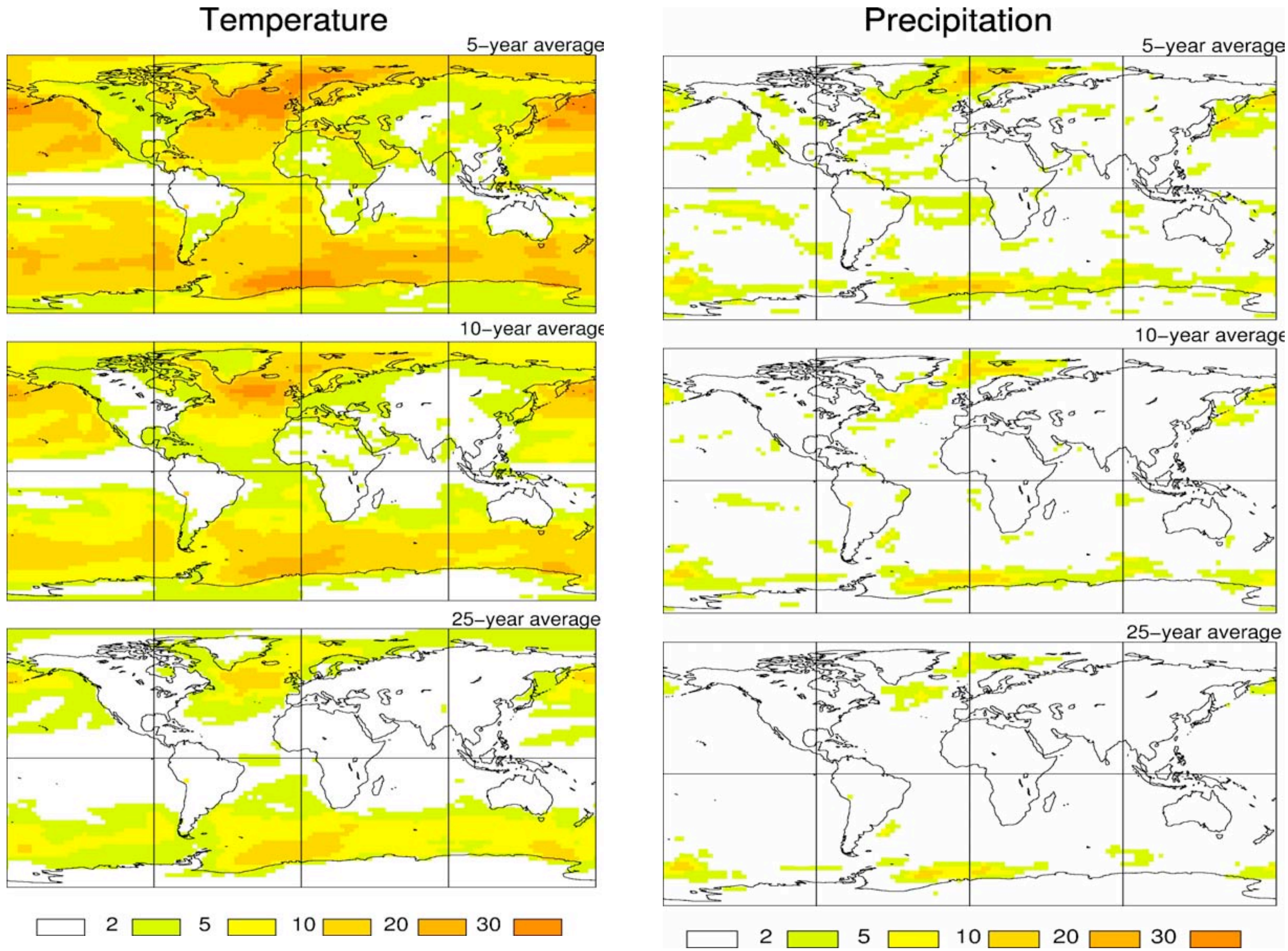

Temperature
5–year average
10–year average
25–year average
2
5
10
20
30
Precipitation
5–year average
10–year average
25–year average
2
5
10
20
30

The challenges of predictability

- to identify the mechanisms associated with regions/modes of predictability
- to better understand the connection between oceanic modes and terrestrial climate variability
- to investigate predictive skill by means of (multi-model) prognostic decadal predictions

Decadal prediction motivation

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

Improved Surface Temperature Prediction for the Coming Decade from a Global Climate Model

Doug M. Smith,* Stephen Cusack, Andrew W. Colman, Chris K. Folland, Glen R. Harris, James M. Murphy

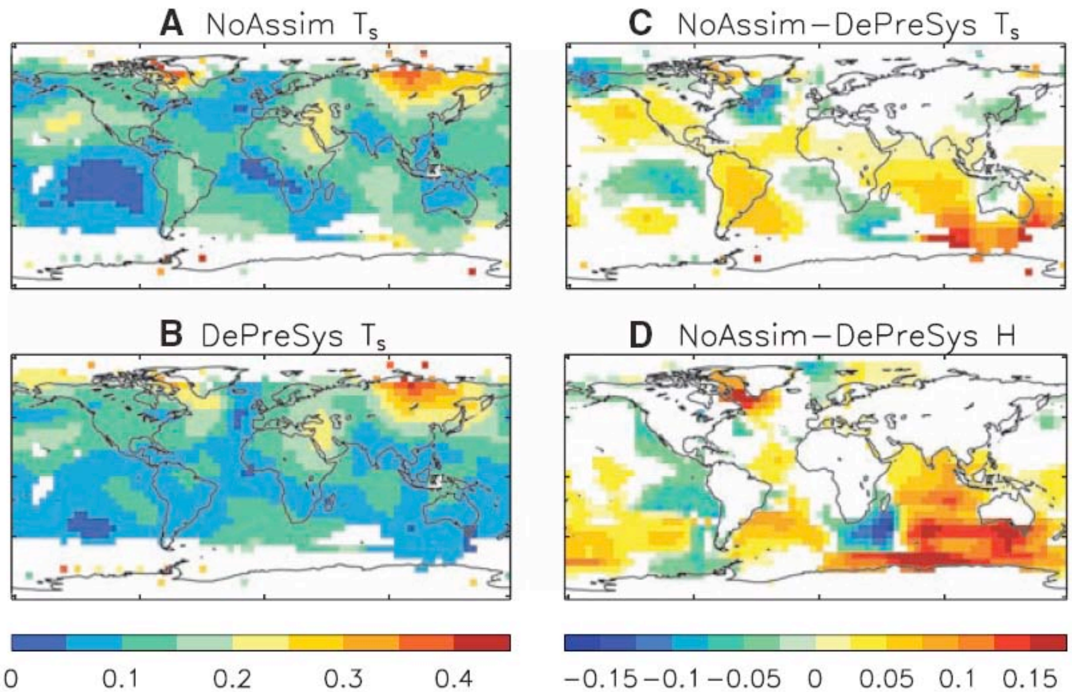
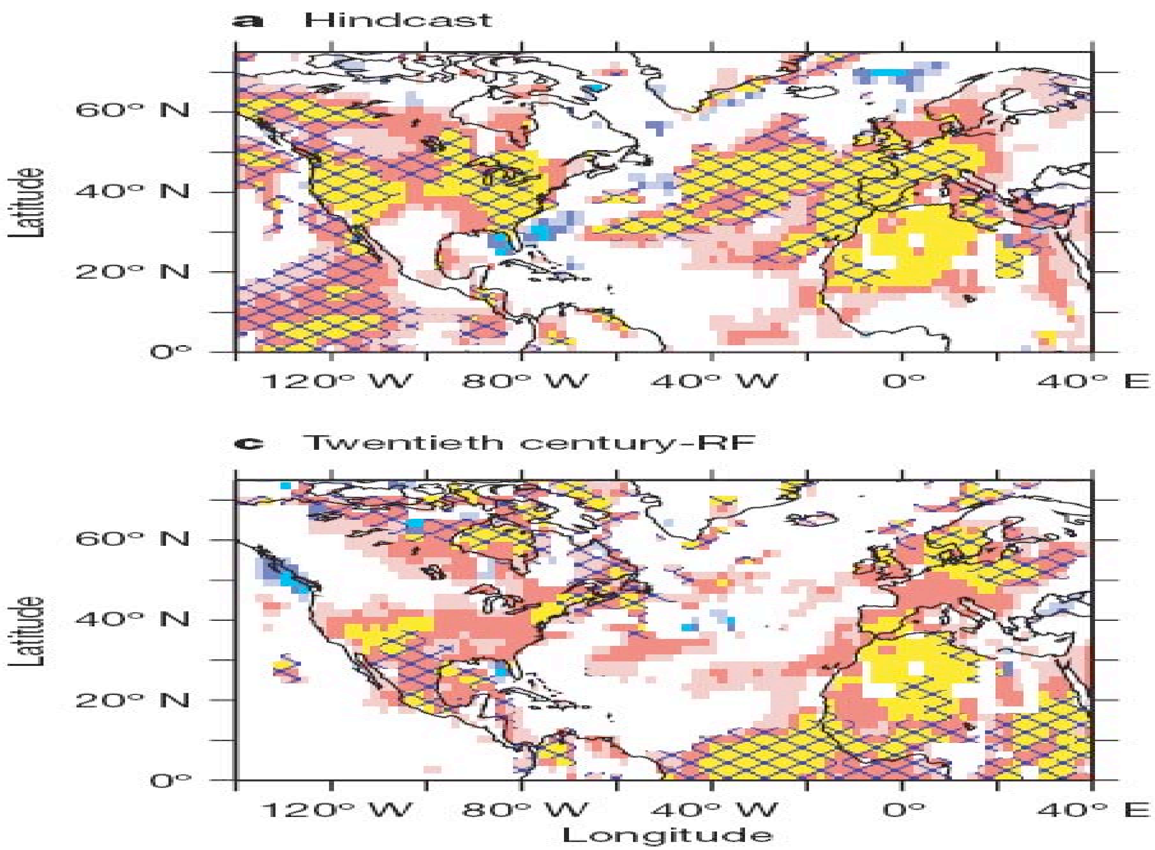


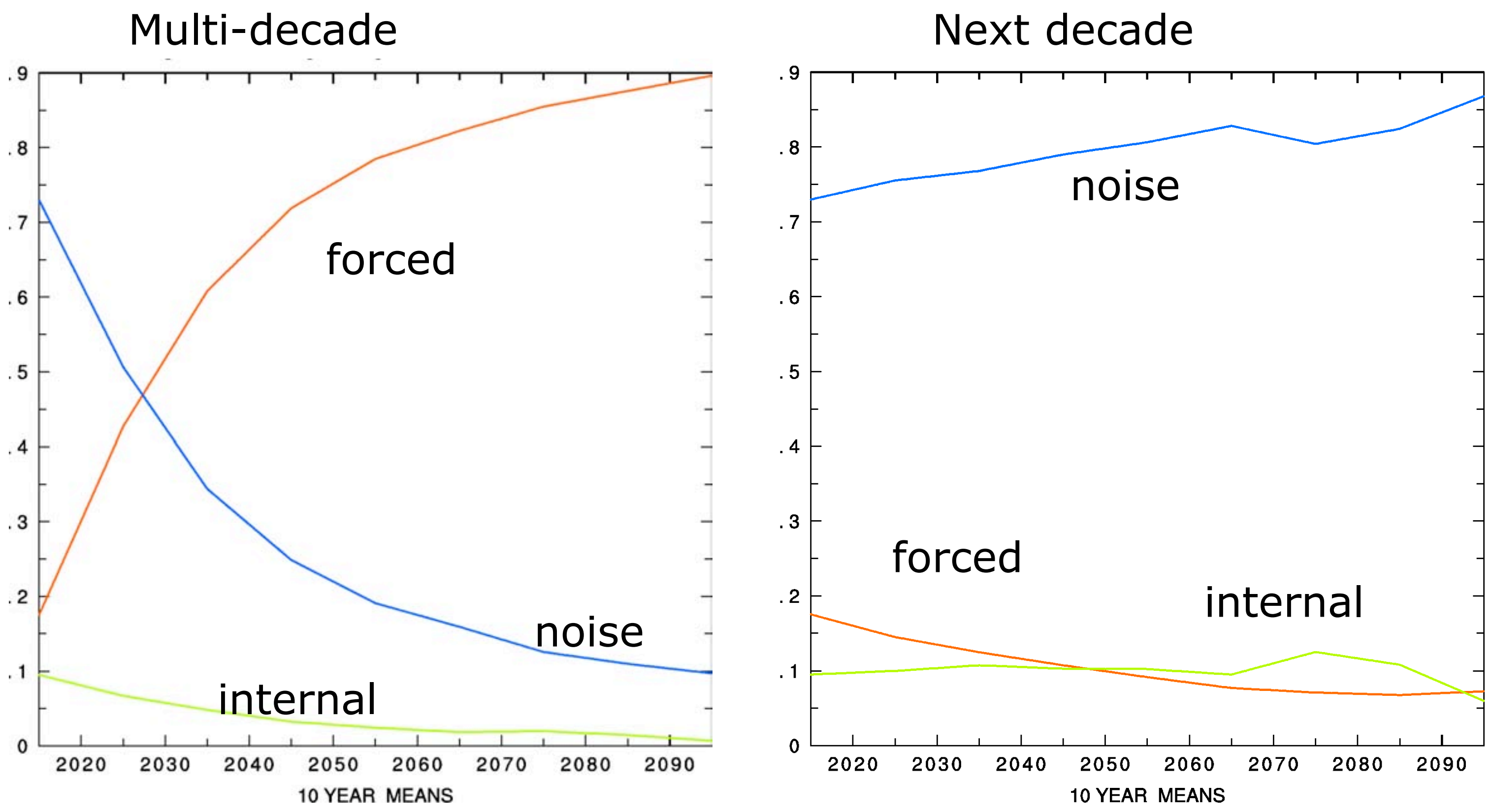
Fig. 3. Impact of initial conditions on regional hindcast skill. (**A**) RMSE of 9-year mean T_s anomalies (relative to 1979–2001) for the ensemble mean NoAssim hindcasts, verified against observations from HadCRUT2v (*36–38*). (**B**) As (A), but for DePreSys. (**C**) NoAssim minus DePreSys RMSE of 9-year mean T_s. Differences are shown only where they are significant at the 5% level (*18*). (**D**) As (C), but for 9-year mean H anomalies (relative to 1941–1996). In all panels, each 5° latitude by 5° longitude pixel represents the RMSE for predictions of T_s spatially averaged over the 35° latitude by 35° longitude box centered on that pixel.

Advancing decadal-scale climate prediction in the North Atlantic sector

N. S. Keenlyside[1], M. Latif[1], J. Jungclaus[2], L. Kornblueh[2] & E. Roeckner[2]



Forced and internally generated variability for predictions of temperature



Decadal prediction motivation

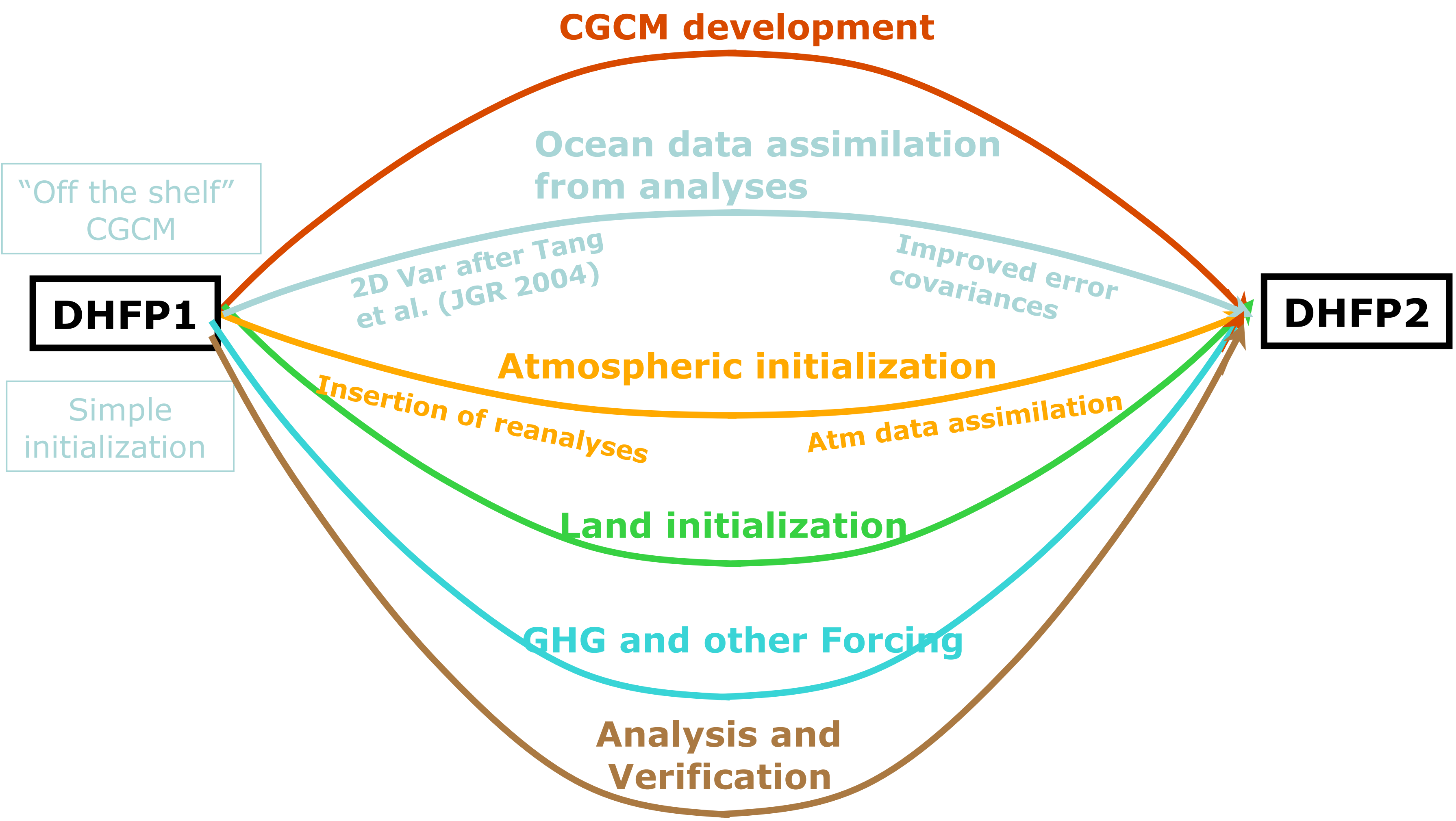
- Existence of to “long timescale” processes
- Results of predictability studies
- Demonstrations of forecast skill
- *Scientific interest and opportunity*
- *Societal importance of modestly* skillful decadal prediction


ASPEN GLOBAL CHANGE INSTITUTE
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

Many scientific “opportunities”

- improved models
- analysis of variability and of modes of variability
- improved analysis methods especially in the ocean
  - for model initialization
  - for verification
  - for model development
- ensembles
  - ensemble generation
  - multi-model ensembles
- prediction studies and the *DHFP*
  - WCRP/WSIP/WGCM coordinated project

Coupled Forecast System Parallel Development Path at CCCma(p)



International scientific interest

PREDICATE

Mechanisms and Predictability of Decadal Fluctuations in Atlantic-European Climate

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

ENSEMBLES

DHFP

The Decadal Historical Forecasting Project

Based on the Aspen Protocol

Decadal predictability motivation

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

skilful

LIST OF POSSIBLE APPLICATIONS OF 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

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

- UKCIP in the UK
- CIC in Germany
- Climate Services in US
- …..

Prospects are good for decadal prediction

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

end of presentation