Report from the Decadal Climate Prediction Panel (DCPP)

- evolution
- activities
  - volcanoes
  - survey
  - Aspen workshop
  - bias correction
  - recommendations for CMIP5 decadal predictions and data
- analysis
- members
- future
Decadal prediction is an agenda item
  • WGSIP interest
International scientific interest

WORLD CLIMATE RESEARCH PROGRAMME

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JOINT SCIENTIFIC COMMITTEE

TWENTY-EIGHTH SESSION

ZANZIBAR, TANZANIA, 26-30 MARCH 2007

Cross-Cutting Topic: Decadal Prediction
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
What are the Prospects for Decadal Prediction?

G.J. Boer
Canadian Centre for Climate Modelling and Analysis (CCCma)

(in future CCCmap...?)
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
Prospects are good for decadal prediction

- Existence of “long timescale” processes - ✔
- Results of predictability studies - ✔
- Scientific interest - ✔
- Demonstrations of forecast skill - ✔
- Societal importance of modestly skillful decadal prediction – ✔
The Decadal Historical Forecasting Project
Based on the Aspen Protocol
Evolution

WGCM Paris

- meeting focused on CMIP5 design and participation
- featured core and tier 1 and 2 simulation experiments
- additionally included decadal prediction experiments
WGCM Paris (September 22-24, 2008):
- Featured core and tier 1 and 2 *simulation* experiments (including early version of bulls eye diagram)
Evolution

- WGCM Paris (2008):
  - WGSIP’s interest in *decadal prediction* as natural extension of seasonal-interannual prediction
  - Attempted decadal prediction diagram to match simulation diagram
CMIP 5 near term climate

- 20th C + RCP4.5 to 2035 ensembles (1.4)
- Decadal forecasts (1.1)
- 30 year forecasts (1.2)
- "Control" 1% per year (1.5)
- Hi res time slice
- Volcano hindcast designer Pinatubo forecast
- Initialization methods
- Air quality
- Aerosols
- Ozone chemistry

Artistic attempt
The timeslice problem
Evolution

- **WGCM Paris (2008):**
  - WGSIP’s interest in *decadal prediction* as natural extension of seasonal-interannual prediction
  - decadal prediction “target” parallels \ simulation “target”
  - formation of a “Joint WGCM-WGSIP Contact Group on Decadal Predictability/Prediction” consisting of Tim Stockdale and/or GJB (WGSIP), M. Latif, R. Stouffer (CMIP), G. Meehl (WGCM)
  - initial question concerning volcanoes
WGSIP Miami (2009):

- action items included
  - *confirmation* T. Stockdale and G. Boer as WGSIP members of the CMIP-WGCM-WGSIP group coordinating the CMIP5 near term experiments.
  - *determination* the interest within the WGSIP community in participating in the CMIP5 near term experiments and diagnostics analysis
    - resulting survey
  - *interfacing* between US CLIVAR WG on decadal prediction and the CMIP-WGCM-WGSIP group (A. Kumar, T. Stockdale, G. Boer).
Organizational aspects of decadal prediction: Survey

- SIP community natural participants
- Experience/ability in most needed aspects
  - IPCC-class models
  - initialization, ensemble generation
  - retrospective forecast methodology
  - forecast combination, calibration, skill measures ...
  - (external forcing)
- Survey of intended participation in CHFP and CMIP5 decadal prediction
Survey

Subject: Survey of Current and Planned Participation in:
- Climate-system Historical Forecasting Project (CHFP)
- CMIP5 Decadal Climate Prediction component

From: G.J. Boer, B. Kirtman, A. Scaife (WGSP)
G. Meeth, S. Bony (WGCM)

The Working Group on Seasonal to Interannual Prediction (WGSP) has interests in prediction on timescales from seasons to decades. As such it is sponsoring the Climate-system Historical Forecasting Project (CHFP)

Details at: http://www.clivar.org/organizations/wgsp/chfp/chfp.php

and supporting, together with the Working Group on Coupled Modelling (WGCM), the Decadal Climate Prediction component of CMIP5


These are multi-model and multi-institutional experiments aimed at improving our understanding of the physical climate system and our ability to predict its evolution on timescales from seasons to decades.

Many groups have, are, or soon will be undertaking the experiments involved. This Survey of Current and Planned Participation will aid the coordination between WGSP, WGCM and PCMDI in support of WCRP and IPCC in furthering Studies and Workshops in these areas.

We would appreciate your completing the survey below in as brief or extensive a manner as you would care to.

THANK YOU in anticipation of your returning the survey by 24 September to Anna Pirani at anna.pirani@noc.soton.ac.uk

Survey of Current and Planned Participation

Please return to Anna Pirani at anna.pirani@noc.soton.ac.uk by 24 September, 2010.

CHFP: Climate-system Historical Forecast Project

Name of Group:
Contact/email:
Will you participate in CHFP:
Model designator and resolution:
Status of integrations:
Where data is/will be available:

Comments or other information:

Please note that if you intend to store your data (as is highly desirable) at CIMA (http://chfp.cima.fsem.nba.ac/index.html):
- the target date for CHFP data to be received at CIMA is 31 January 2011
- it is important that you send a test file to CIMA as soon as possible, that is by 17 September 2010, to enable technical aspects to be addressed. See the website for details (to appear shortly).

CMIP5 near-term decadal climate prediction

Groups planning to participate in the near-term decadal climate prediction component of CMIP5 are asked to consult the web page (http://pcmdi3.llnl.gov/cmip5/index.html) under the Modeling Info/Getting Started links and to follow the “Guide for Modeling Groups Participating in CMIP5: Stage 1”. If they have not already done so, groups are asked to provide information on their planned participation.

An email updating this information request will be forthcoming in the next week from PCMDI/CMIP5.
CMIP5 website – decadal prediction data

- decadal prediction data becoming available
- multi-model analyses for Chapter 11 AR5 active
- **WGCM Exeter (2009):** action items include
  - WGCM-WGSIP Decadal Climate Prediction Panel (DCPP)
  - encourage panel support the organization of the 2011 *Aspen Global Change Institute Workshop* on decadal prediction
  - WGSIP and the Decadal Climate Prediction Panel should consider providing recommendations/guidance on
    - *bias correction* (common in SIP but not for climate)
    - if *bias corrected* decadal prediction *data* should be submitted to the CMIP5 archive
  - with recommendations circulated to WGCM so that they can be passed on to modeling groups as soon as possible (G. Boer, D. Smith)
Bias correction/adjustment report

Data and bias correction for decadal climate predictions

January 2011

Secret authors: GJB and Doug Smith
Initialization

There are two main approaches to forecast initialization referred to as “full field” and “anomaly” initialization. Bias correction and verification can depend on which initialization method is used.

*Full field initialization* constrains the model initial conditions to be close to the observed values with

\[ Y_{j\tau=0} \approx X_{j\tau=0} \]

while *anomaly initialization* adds the observed anomaly to the model climatology of the variable in question as

\[ Y_{j\tau=0} \approx <Y> + (X_{j\tau=0} - <X>) \]

In the case of an ensemble of forecasts the initial conditions are not all the same although “close” to one another. The nature of the perturbations around the value at \( \tau = 0 \) will depend on the approach taken by a particular modelling group.
Basic bias correction/adjustment

a. For full field initialization

The bias correction is calculated from the collection of hindcasts and the corresponding observations. The model drift is estimated as the difference between ensemble mean forecasts and the observations averaged over all cases as

\[ d_\tau = \overline{Y}_\tau - \overline{X}_\tau \]

and the bias corrected forecast \( \hat{Y}_j^\tau \) is obtained by subtracting this drift from each ensemble member as

\[ \hat{Y}_j^\tau = Y_j^\tau - d_\tau = \overline{X}_\tau + (Y_j^\tau - \overline{Y}_\tau) = \overline{X}_\tau + Y_j'^\tau \]

Here \( Y_j'^\tau = Y_j^\tau - \overline{Y}_\tau \) is the anomaly of the raw forecast with respect to the forecast average. It is generally considered to be best practice to calculate the bias correction in a “cross-validated” manner where the particular forecast to be corrected does not contribute to the forecast average.

b. For anomaly initialization

In this case the bias has been at least partially removed by the initialization method. The drift is characterized as the difference between the modelled and observed climates as

\[ D = \langle Y \rangle - \langle X \rangle \]

and the bias corrected forecast is

\[ \hat{Y}_j^\tau = Y_j^\tau - D = \langle X \rangle + (Y_j^\tau - \langle Y \rangle) = \langle X \rangle + Y_j'^\tau \]

Note: that the “full field” version of bias correction can also be applied to anomaly initialized forecasts but may not be optimum.
Data aspects

5. CMIP5 decadal climate prediction data submission and data use

a. Raw data

Raw decadal prediction data sets as specified in documentation available from the CMIP5 website (http://cmip-pcmdi.llnl.gov/index.html) should be submitted in all cases. Users should regard these data as the basis for analysis.

b. Bias correction

Bias correction can be undertaken in order to use the decadal prediction results. The methods outlined in Sections 4a or 4b are recommended. In every case it is important to specify clearly what has been done when reporting results.

c. Bias corrected data

Data providers may also contribute a set of bias corrected CMIP5 data but this is limited by practicalities to basic climatological parameters. These comprise monthly means of bias corrected

- near-surface air temperature (tas)
- surface temperature (ts)
- precipitation rate (pr)
- sea level pressure (psl)

on the atmospheric grid.

- stress that raw data is basic
- reluctantly allow for some bias-adjusted fields
- limit number of fields
Aspen

Making Sense of the multi-model decadal prediction experiments from CMIP5
26 June - 1 July 2011

Workshop Chair(s):
Lisa Goddard
Ben Kirtman
Gerald Meehl

○ successful Workshop and early results
○ further sensitized researchers to questions of:
  ● bias adjustment including trend adjustment
  ● statistical aspects and number of start dates
  ● priority of sub-daily data for CMIP5
Bias correction/adjustment

- model’s which are initialized from observations $X$ subsequently “drift” toward the model climate thereby introducing a “bias” into the forecast $Y$
- the simplest adjustment obtains the drift $D(\tau) = Y(\tau) - X(\tau)$ averaged over all forecasts for each forecast range $\tau$ and subtracts it from the forecast, i.e. $Y'(\tau) = Y(\tau) - D(\tau)$
- presumes drift is the same for all forecasts, more difficult if model’s forced component differs appreciably from observed

(Kharin et al. 2012)
Bias correction/adjustment

- *first order* bias adjustment improves forecast considerably
- if trends differ may be useful to attempt a *second order* adjustment
- question of the stability of the statistics involved
Statistical aspects

- The DCPP also considered the importance of stable estimates of bias adjustment values and of other statistics.
  - CMIP5 protocol calls for forecasts initialized every 5 years from 1960 to 2005 with a minimum of 3 ensemble members.
  - For annual means one needs to estimate 10 values of $D(\tau)$, one for each forecast range $\tau = 1, ..., 10$ years.
    - Result is 30 values with which to estimate the 10 values of $D(\tau)$.
  - Can also be sampling problems with semi-regular and/or large variations in climate (e.g., El Nino, volcanoes).
    - Applies to bias adjustment and other statistics including scores.
Recommendations

- DCPP, in consultation with WGSIP, WGCM, PCMDI recommended
  - *producing* forecasts initialized *every year* over the period to enhance statistical stability
  - *adding* the historical climate simulations made with the model used for decadal predictions as part of CMIP5 (i.e. uninitialized simulations)
    - in order to quantify the utility of the initialization of the forecasts
  - *reducing* the priority of “high frequency” decadal prediction data (3 and 6-hourly) in the archive
CMIP5 website – decadal prediction data

- mainly 5-year start times (~18 models)
- every-year start times (~6 models)
- a number of groups are “filling in” remaining years
Analysis

- active analysis of CMIP5 decadal predictions
- WCRP workshop
- individual model results
- multi-model results (e.g. Paco’s analysis for Chapter 11 of the AR5)
Schematic of forced and internally generated components

- **Linear trend in observation-based T**
  - ~forced

- **Anomaly of T from linear trend**
  - ~internally generated
Potential and actual correlation skill

Globally averaged correlation skill

\( \rho \) is potential skill
\( r \) is actual skill

Forecast range, years

\( \rho_i, \rho_f, r_i, r_f \)
Potential and actual correlation skill

Potential and actual correlation skill Net

potential skill

actual skill

Forced component

Internal component
Potential and actual correlation skill

Potential and actual correlation skill year 1-5 average

Net

Forced component

Internal component
Skill as a function of averaging time

Globally averaged correlation skill

Time averaging

- Initialized
- Initialized
- Actual skill
- Potential skill
Summary

- reasonably early days wrt analysis of decadal predictions although very active
- most analyses are for temperature
- considerable attention to prediction and predictability of AMV and PDV “modes”
- some attention hurricanes, extremes
- less attention paid to precipitation, so far, and less skill
- not yet much attention to other variables
Potential s2d Workshop

- Workshop spanning seasonal to decadal timescale
- Planning underway
- s2d with concentration on
  - CHFP results
  - CMIP5 decadal results
- Target next spring
Decadal Climate Prediction Panel (DCPP) members

- **Current members include**
  - George Boer <george.boer@ec.gc.ca>
  - Karl Taylor <taylor13@llnl.gov>
  - Doug Smith <doug.smith@metoffice.gov.uk>
  - Ben Kirtman <bkirtman@rsmas.miami.edu>,
  - Jerry Meehl <meehl@ucar.edu>
  - Ronald Stouffer <ronald.stouffer@noaa.gov>
  - Mojib Latif <mlatif@ifm-geomar.de>
  - Scott Power <S.Power@bom.gov.au>
Where does the DCPP fit

Connection across Working Groups

Weather
WGNE

initial condition problem

forced boundary value problem

decadal prediction

initial condition + boundary forcing

Climate
WGCM

Seasonal-Interannual
WGSIP
Future DCPP activities(?)

- continue as focus for \textit{practical questions} regarding decadal prediction as appropriate
- \textit{promote common interests} across Working Groups, presumably through membership/attendance at meetings
  - models
  - initialization
  - mechanisms
  - analysis
- \textit{support}
  - continued research into decadal forecasts and applications
  - “operalization” of multi-year forecasting (?)
- \textit{aid in organizing and promoting}
  - proposed s2d Workshop
  - decadal prediction sessions in other scientific meetings
- \textit{contribute} to the decadal prediction aspects of CMIP6 and other intercomparison studies
- .....
end of presentation