INTERNATIONAL COUNCIL FOR SCIENCE

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

WORLD METEOROLOGICAL ORGANIZATION

WORLD CLIMATE RESEARCH PROGRAMME

Report of the 12th Session of the JSC/CLIVAR Working Group on Seasonal to Interannual Prediction (WGSIP)

12 - 14 January 2009
Miami, USA

March

ICPO Publication Series No. 138

WCRP Informal Report No 4/2009

CLIVAR is a component of the World Climate Research Programme (WCRP). WCRP is sponsored by the World Meteorological Organisation, the International Council for Science and the Intergovernmental Oceanographic Commission of UNESCO. The scientific planning and development of CLIVAR is under the guidance of the JSC Scientific Steering Group for CLIVAR assisted by the CLIVAR International Project Office. The Joint Scientific Committee (JSC) is the main body of WMO-ICSU-IOC formulating overall WCRP scientific concepts.

Bibliographic Citation

INTERNATIONAL CLIVAR PROJECT OFFICE, 2009: Report of the 12th Session of the JSC/CLIVAR Working Group on Seasonal to Interannual Prediction (WGSIP). March. International CLIVAR Project Office, CLIVAR Publication Series No. 138. (not peer reviewed).

CONTENTS

Action Items and Recommendations

Reports from CLIVAR and WCRP

1. WGSIP to review the imperatives for seasonal prediction for the WCRP implementation plan and contribute to the discussion of the long-term vision of WCRP science and infrastructure requirements.

2. WGSIP to contribute to the WCC3 agenda.

CHFP

3. Issue recommendations for CHFP participants on how to upload new versions of data or replace/disable old versions.

4. Each CHFP contributing group should provide a contact person to the data servers for technical issues.

5. Determine whether there will be a common registration approach for accessing CHFP data to acquire information on the use and dissemination of the CHFP data. Need to give guidelines on the CHFP website on how to acknowledge the data origin. Circulate a draft data policy to WGSIP for endorsement.

6. Circulate proposal for course on the CHFP, seasonal prediction and applications that is being organized by CIMA in Buenos Aires in March 2010 for endorsement by WGSIP (C. Vera).

7. Confirm whether groups contributing CHFP data to the APCC server can send a wider list of variables including metadata than those outlined in the APCC proposal (W.-J. Lee).

8. Develop interactions with CLIVAR regional panels to develop CHFP diagnostic sub projects.

9. Develop a clearing-house of applications-relevant tools, scripts, etc. for evaluating CHFP datasets (A. Pirani, A. Morse).

GEWEX interactions with WGSIP

10. Report to the CLIVAR and GEWEX SSGs our views on how to build and maintain appropriate links between WGSIP and GEWEX. Discuss with CLIVAR SSG the general issue of links with projects outside CLIVAR.

SPARC interactions with WGSIP

11. Endorse a joint WGSIP-SPARC subproject of the CHFP using high-top, stratosphere resolving models (Scaife, Stockdale, Kirtman).

12. SPARC to make recommendations on what diagnostics are needed to analyse downward propagating signals from the stratosphere in low-top models participating in the CHFP (Scaife).

CliC interactions with WGSIP

13. Develop a proposal on how to move forward in a CHFP/CliC/GEWEX study of snow cover and soil moisture (J. Christensen, R. Koster).

Applications

14. Develop a list of diagnostics that production centres could run which would be useful for the impacts and applications community (A. Morse).

15. Develop stronger links between WGSIP and WCP, including making WCP aware of the availability of CHFP data (B. Kirtman, T. Stockdale).

16. Lobby the WCC-3 on rendering long-term observational datasets available.

Decadal Prediction

17. Confirm T. Stockdale and G. Boer as WGSIP members of the CMIP-WGCM-WGSIP group coordinating the CMIP5 near term experiments.

18. Circulate to WGSIP the list of data, in particular variables that will be useful for impacts studies, that will be stored from the near term experiments. (T. Stockdale, G. Boer).

19. Determine the interest within the WGSIP community in participating in the CMIP5 near term experiments and diagnostics analysis.

20. Interface between US CLIVAR WG on decadal prediction and the CMIP-WGCM-WGSIP group (A. Kumar, T. Stockdale, G. Boer).

C20C Project

21. Link to C20C dataset from the CHFP website.

22. Continue conference calls with C20C to see what the possibilities are for collaboration with CHFP (A. Scaife and B. Kirtman).

The Ocean Observing System

23. Initiate an email discussion between WGSIP, IOP and AAMP on how to best demonstrate the benefit of the Indian Ocean Array, RAMA, on forecast skill (B. Kirtman, T. Stockdale, H. Hendon).

Standard hindcast verification

24. Recommend that the CAWCR multi-model evaluation be updated to include newly contributed models and then distribute the result to WGSIP (O. Alves).

Linkages to other CLIVAR panels

25. Circulate the US CLIVAR MJO WG and AAMP-led proposal for a WCRP-WWRP WG on the MJO, as an extension of the US CLIVAR WG activities, for endorsement by WGSIP (H. Hendon).

26. Endorse the SAWS multi-model product and its application in the SACD region by the SARCOF process.

27. WGSIP to foster PPAI interest with regards to the CHFP data set (B. Kirtman, A. Kumar).

1. Introduction

The 12th Session of WGSIP was held on 12-14 January 2009, hosted by B. Kirtman at the University of Miami Rosenstiel School of Marine and Atmospheric Science (RSMAS), Miami, USA. The meeting agenda is in Appendix A and the list of participants is in Appendix B. The presentations given by the meeting participants, together with some reports, are available on the meeting webpage (http://www.clivar.org/organization/wgsip/wgsip12/wgsip12.php).

The meeting focused on the major projects that are underway for which the panel is responsible, namely the Climate-system Historical Forecast Project (CHFP) and the decadal prediction component of CMIP5. We heard about activities in all the WCRP activities: J. Christensen - CliC, R. Koster - GEWEX, A. Scaife - SPARC and this provided a fertile discussion on how to integrate the full climate system to seek improved skill at seasonal and longer timescales. C. Vera, representating the WCRP JSC was also in attendance. There was discussion on the impact and requirements of the ocean observing system for seasonal prediction and on standard hindcast verification. Linkages with other projects and components of CLIVAR and WCRP were also explored.

WGSIP welcomed A. Scaife as a new member representing the seasonal to decadal prediction activities of the UK Met Office Hadley Centre, as well as the SPARC and C20C projects. C. Saulo was also welcomed to WGSIP, though she was unable to attend the meeting. C. Saulo represents the seasonal prediction activities of CIMA, Argentina, as well as the VAMOS community.

M. Visbeck, co-chair of CLIVAR was able to attend part of the meeting and discussed the third World Climate Conference (WCC-3), organizational issues within CLIVAR and collaborations with GEWEX. D. Leger from US CLIVAR attended the meeting and reported on the US CLIVAR organizational structure and development of working groups, drought and decadal prediction in particular. A. Kumar represented the US CLIVAR Predictions, Predictability and Applications panel. C. Vera and W.-J. Lee reported on the status of the CHFP distributed servers hosted by CIMA and APCC, respectively. H. Hendon represented the Centre for Australian Weather and Climate Research (CAWCR) group, in O. Alves' absence, and CLIVAR AAMP.

2. Reports from CLIVAR and WCRP

The organization of CLIVAR has been under discussion since the last Scientific Steering Group (SSG) meeting in 2008 and will be revisited at the next meeting in May 2009. There is also an on-going debate on whether the WCRP is best organized by means of its current Projects (CLIVAR, SPARC, GEWEX and CliC). CLIVAR is no longer facing a clear sunset in 2013 so that its future is now being viewed in terms of an evolution or transition of its activities to a new structure for WCRP. The discussion includes the question of reducing the number of panels, integrating activities that are common between different panels and Projects, and coping with a shrinking budget.

The WCRP is developing two documents over the course of this year that will be published in time to contribute to the Third World Climate Conference in August 2009. The first is the implementation plan for the WCRP strategic framework as defined by the Coordinated Observation and Prediction of the Earth System (COPES). The Projects have been charged with identifying the imperatives for the next five years or so of WCRP research, as well as a vision of the frontiers of science that WCRP should address in the long term. The second is a document on the accomplishments of the WCRP and its Projects, focusing on the activities since the launch of the COPES strategic framework in 2005.

This is an important opportunity that WGSIP should take advantage of for a bottom-up discussion on the future evolution of WCRP.

ACTION 1: WGSIP to review the imperatives for seasonal prediction for the WCRP implementation plan and contribute to the discussion of the long-term vision of WCRP science and infrastructure requirements.

The Third World Climate Conference (WCC3) is being organised under the theme ‘Climate prediction and information for decision-making’ in Geneva, Switzerland. It will take place on the 31 August - 4 September 2009. CLIVAR (and WCRP more widely) will have a presence, with M. Visbeck being a member of the organising committee and being Chair of the program committee. Past WCCs have had a major impact on the climate research landscape, with WCRP and the IPCC launched after WCC1, and the UNFCC and JCOSS launched after WCC2. The next conference will address the need for an international framework to provide the interface between research and users, particularly for the seasonal to decadal timescale.

ACTION 2: WGSIP to contribute to the WCC3 agenda.

3. The Climate-system Historical Forecast Project

3.1 Current status

The following is the list of current confirmed participants of the CHFP and their status in terms of running the experiments. The project is designed to be long term with no hard deadlines, particularly as making data available at the distribution centers is still a learning experience. This also means that groups can join the experiment when ready and data from new model versions can be included. There is the option for groups to disable access to data from old model versions or to provide multiple sets of data from different model versions. Groups can also participate if not all the data recommended in the experiment protocol are saved. The protocol is meant to provide guidelines and the project aims to be all-inclusive.

Participating Groups:

- EU ENSEMBLES Project - data will be publicly available in March 2009.
- APCC, CliPas
- NOAA-NCEP - done and transferring data to CIMA server.
- NOAA-GFDL
- NASA-GMAO - waiting for model version to be frozen.
- COLA-NCAR - done and transferring data to CIMA server.
- BMRC CAWCR - done and data is available on their local server and APCC.
- MRI-JMA - done and data to be made available.
- CCCma - experiments to be re-run with new model version and will be ready in 2-3 months’ time.
- CPTEC
- IRI

The following associated numerical experiments are in progress, planned or under consideration:

- GEWEX: GLACE-2
- SPARC: Seasonal Prediction Skill Assessment: Troposphere-Stratosphere Interactions
- CliC: Sea-ice predictability experiments, and/or impact of snow cover
-

ACTION 3: Issue recommendations for CHFP participants on how to upload new versions of data or replace/disable old versions.

3.2 Data servers

There are three distributed data centres that are participating in the CHFP: CIMA, APCC and ENSEMBLES. They will not be mirror sites, though some data will be available on multiple servers. Data will be linked from the central CHFP website and data can be downloaded in a common format and grid. The data needs to be in netCDF, CF compliant, with common metadata. CIMA are in the early stages of conforming to the metadata requirements. The hope is to have data from two US models hosted at CIMA by March 2009. It may be useful to mirror some APCC CHFP data at the CIMA server while the APCC server is being developed.

ACTION 4: Each CHFP contributing group should provide a contact person to the data servers for technical issues.

In addition to the distributed data centres, some groups will support their own local servers, such as the Centre for Australian Weather and Climate Research (CAWCR).

CIMA, Argentina

The Centro de Investigaciones del Mar y la Atmósfera (CIMA) has 10 terabytes of storage available, which is extendable. The server has its own website: http://chfp.cima.fcen.uba.ar/index.html and by the second half of 2009, it is hoped that the server will have some tools available so that some analyses can be performed without having to download the data. The server currently has Ftp access, and will have Thredds and OPenDAP access in a few months' time.

CIMA will request registration details to acquire information on the use and dissemination of the CHFP data.

ACTION 5: Determine whether there will be a common registration approach for accessing CHFP data to acquire information on the use and dissemination of the CHFP data. Need to give guidelines on the CHFP website on how to acknowledge the data origin. Circulate a draft data policy to WGSIP for endorsement.

In order to increase the visibility of this dataset to the rest of Latin America, CIMA is organizing a two-week course on the CHFP, seasonal prediction and its applications that will be held in Buenos Aires in March 2010.

ACTION 6: Circulate proposal for course on the CHFP, seasonal prediction and applications that is being organized by CIMA in Buenos Aires in March 2010 for endorsement by WGSIP (C. Vera).

APCC, Republic of Korea

The Asia Pacific Economic Cooperation (APEC) Climate Centre (APCC), Republic o Korea, has started work on the development of the Asia Pacific Data Exchange Portal (ADEPT) to be one of the distributed data centres for the CHFP data. Currently, APCC provides its hindcast data from its multi-model ensemble (MME) based operations through an OPeNDAP server (http://cis.apcc21.net). There are six coupled models participating in the MME. The Climate Information Tool Kit (CLIK) enables users to do web-based online climate predictability experiments and downscaling (prototype at http://clik.apcc21.net).

The addition of external CFHP data is expected for July-Sept. 2009. Data will be served as netCDF and on the common CHFP grid.

ACTION 7: Confirm whether groups contributing CHFP data to the APCC server can send a wider list of variables including metadata than those outlined in the APCC proposal (W.-J. Lee).

ENSEMBLES, ECMWF

The ENSEMBLES Stream 2 matches the CHFP protocol (Stream 1 grid not exactly as specified by CHFP protocol) and will be available on OPeNDAP server in March 2009. ENSEMBLES has order 10 terabytes of data with monthly mean ocean and atmospheric fields, as well as daily atmospheric fields.

3.3 Diagnostic sub-projects

- Asian Monsoon (H. Hendon): As there is no skill in predicting rainfall over land once the monsoon has begun, a project is proposed that assesses hydrologically relevant variables, such as soil moisture, that are needed to drive crop models.

- Intraseasonal variability (B. Wang).
- Predictability of the South Atlantic Convergence Zone (P. Nobre).
- Predictability issues in the La Plata Basin (C. Vera).

ACTION 8: Develop interactions with CLIVAR regional panels to develop CHFP diagnostic sub projects.

- Applications (A. Morse): Some simple algorithms can be applied to the CHFP datasets to render available some diagnostics that are relevant to applications. It would be useful if WGSIP could provide a clearing-house for tools, scripts, etc. that are available, particularly for applications.

ACTION 9: Develop a clearing-house of applications-relevant tools, scripts, etc. for evaluating CHFP datasets (A. Pirani, A. Morse).

4. GEWEX interactions with WGSIP

The seasonal prediction problem extends further than the ocean-atmosphere, as primarily addressed by CLIVAR, with potential predictability sources from other components of the physical system. The Global Land/Atmosphere System Study (GLASS) panel within GEWEX looks at modelling the interactions between the land and atmosphere on a global scale, though without focusing specifically on seasonal prediction. GLACE-2 is the main activity on seasonal prediction within GEWEX.

The significant role played by land-atmosphere coupling in seasonal predictability suggests that closer ties should exist between WGSIP and the GEWEX community, particularly as regards the CHFP. It may be that we need more than a single GEWEX person as WGSIP panel member to adequately engage with the GEWEX community, and the principle of "joint sponsorship", in the sense of WGSIP enjoying the support of GEWEX and providing them feedback, had been put forward as a possibility. When discussed by WGSIP, there was some concern over the practicalities of "joint sponsorship", which would need to be addressed if it were to go ahead:

- GEWEX-related issues are an important but relatively small part of WGSIP activities.
- Having a GEWEX nominated co-chair would probably not be appropriate, given the balance of WGSIP activities.
- Reporting to/from GEWEX should be done efficiently. This might happen most naturally by a WGSIP panel member being "from" an appropriate part of GEWEX, and communications being primarily handled via this person. The written summary reports that are prepared for the CLIVAR SSG can also be sent to the GEWEX SSG, but requiring attendance of WGSIP co-chairs as a matter of course might be too much.
- Any revision to WGSIP terms of reference would need to be looked at carefully, to ensure that a reasonable focus and workload is retained.

WGSIP is also in the process of building links with the stratospheric and perhaps the cryospheric community. WGSIP would like to put into place arrangements with GEWEX that can in future be duplicated with other WCRP "projects" (to the extent that such projects continue to exist). This again argues for a GEWEX person being on the panel, rather than a GEWEX co-chair.

ACTION 10: Report to the CLIVAR and GEWEX SSGs our views on how to build and maintain appropriate links between WGSIP and GEWEX. Discuss with CLIVAR SSG the general issue of links with projects outside CLIVAR.

4.1 GLACE-2 report

The Global Land-Atmosphere Coupling Experiment (GLACE-1) was a successful international modelling project that looked at soil moisture impacts on precipitation. GLACE-2 extends this work to consider the full initialisation forecast problem. The two goals of the project are to calculate “potential predictability”, determining where atmospheric noise overwhelms any potential signals, and to calculate skill in precipitation and surface temperature prediction associated with the accurate initialization of land surface states.

Twelve models are participating in a set of coordinated experiments. The atmosphere is initialized from reanalyses and the soil moisture is initialized either with the associated observed land states or with ‘randomized’ land states that do not correspond to the observed atmospheric conditions. The difference in forecast skill between experiments using realistic and unrealistic land initialization will be the skill due to land initialization. The potential predictability is the *maximum* predictability possible in the forecasting system. For a given ensemble forecast, assuming that the first ensemble member represents “nature” and that the remaining ensemble members represent the “forecast”, and potential predictability is determined by the degree to which the “forecast” agrees with the assumed “nature”.

The greatest predictability is found in regions where soil moisture influences evaporation the most, such as over the Amazon, Equatorial West Africa and in the US Mid West, with predictability reduced if soil moisture is not initialized.

GLACE-2 has been endorsed by WGSIP in the WCRP Position Paper on Seasonal Prediction and the project complements the CHFP experimental protocol in that no additional future information is included in the runs. The data are available on request from the NASA GSFC and a final report should be available by the next WGSIP meeting.

5. SPARC interactions with WGSIP

SPARC has three areas of focus:

- Climate-Chemistry Interactions
  - How will stratospheric ozone and other constituents evolve?
  - How will changes in stratospheric composition affect climate?
  - What are the links between changes in stratospheric ozone, UV radiation and tropospheric chemistry?

- Detection, Attribution, and Prediction of Stratospheric Change
  - What are the past changes and variations in the stratosphere?
  - How well can we explain past changes in terms of natural and anthropogenic effects?
  - How do we expect the stratosphere to evolve in the future, and what confidence do we have in those predictions?

- Stratosphere-Troposphere Dynamical Coupling
  - What is the role of dynamical and radiative coupling with the stratosphere in extended-range tropospheric weather forecasting and determining long-term trends in tropospheric climate?
  - By what mechanisms do the stratosphere and troposphere act as a coupled system?

The area most relevant for WGSIP is stratospheric-tropospheric coupling. The SPARC Dynamical Variability activity (DynVar) is a subproject that will be of primary interest for WGSIP. It has the following components:

- DynVar Top
- DynVar intraseasonal
- DynVar climate change
- DynVar ideal

SPARC could interact with WGSIP in experiments looking at improved seasonal prediction skill resulting from a resolved stratosphere. Some groups within SPARC are able to run coupled ocean-atmposphere models for a sub-set of CHFP experiments, and some groups within WGSIP are able to extend their atmospheric model to resolve the stratosphere. A joint WGSIP-SPARC CHFP-related activity is proposed in Appendix C; the Stratosphere-resolving Historical Forecast Project.

There is also scope for diagnosing downward propagating signals in low-top models participating in the CHFP.

ACTION 11: Endorse a joint WGSIP-SPARC subproject of the CHFP using high-top, stratosphere resolving models (Scaife, Stockdale, Kirtman).

ACTION 12: SPARC to make recommendations on what diagnostics are needed to analyse downward propagating signals from the stratosphere in low-top models participating in the CHFP (Scaife).

5.1 Overview of stratospheric processes and their impact on predictability

Stratospheric dynamics are important for surface variability at timescales ranging from intraseasonal and seasonal to annual and decadal scales. There are several sources of predictability/variability:

- Sudden stratospheric warmings -> persistent anomalies 30-60 days
- ENSO -> extratropics -> stratosphere -> NAO
- Volcanoes -> stratosphere -> extratropics -> NAO
- QBO -> extratropics -> NAO

Low top models do not correctly represent stratospheric dynamics and there is a measurable effect of extending the model top to resolve the stratosphere. Raising the lid also improves blocking frequency statistics in both the Pacific and Atlantic sectors.

At intraseasonal to seasonal timescales, early studies suggest an NAO/AO response to imposed stratospheric changes in GCMs (Boville 1984). Observations show downward propagation of wind anomalies from the upper stratosphere after sudden stratospheric warming events (Kodera 1995, Baldwin and Dunkerton 1999). These are followed by surface cooling over Europe. Some studies show additional predictability from the stratosphere on monthly to seasonal timescales. Simulations of the 2005-06 cold winter anomalies over Europe show increased skill when including a stratospheric perturbation, compared to the skill obtained from just prescribing observed SSTs (Scaife and Knight, QJRMS, 2008).

Key elements of interannual to decadal variability are strongly influenced by stratospheric processes that have a long memory, for example the QBO, which has a period of 2-3 yrs and is predictable for 1-2 cycles. There is a potential impact on seasonal to longer predictability. ENSO teleconnections that can influence the stratospheric high over the Arctic are poorly resolved in low-top models. These teleconnections can lead to easterly wind anomalies in the stratosphere (Hamilton 1993, Manzini *et al*. 2006) and negative NAO/AO conditions and cooling over Europe (Brönnimann *et al.*, 2004, Ineson and Scaife, 2009). Wind anomalies, as well as temperature anomalies, propagate downward and so may impact the surface, as in the case of seasonal downward propagating anomalies.

The stratospheric effects of the Quasi-biennial Oscillation (QBO) are similar to the ENSO teleconnections, reducing the Arctic vortex and generating easterly wind anomalies, with surface cooling over Europe (Boer and Hamilton 2008, Marshall and Scaife, 2009). The AO response is captured in the early stages of winter seasonal hindcasts and the QBO is predictable on interannual timescales, implying that a better representation of the QBO could lead to improved winter forecasts at seasonal-to-multiannual timescales.

On longer decadal timescales, observations show an increase in the NAO index over the second half of the 20th Century that is not reproduced in simulations that include GHG, aerosols, observed SST etc (Kuzmina et al 2005). However, the NAO trend is reproduced if an increase in stratospheric wind from the 1960s to 1990s is imposed (Scaife et al 2005). This suggests that interdecadal stratospheric changes played a key role in decadal variability of northern hemisphere climate. Antarctic climate at decadal timescales is influenced by ozone chemistry. Ozone depletion has led to a deepening of the Antarctic low, with a strengthening of the Antarctic westerlies from the stratosphere to the surface, with observations and models agreeing on the impact: cooling over pole surrounded by warming of the Antarctic peninsula. Ozone recovery is expected by 2060 so there is potentially further decadal predictability from including ozone recovery in decadal forecasts.

6. CliC interactions with WGSIP

The CliC principal goal is to assess and quantify the impacts of climatic variability and change on components of the cryosphere and their consequences for the climate system, and determine the stability of the global cryosphere. Its supporting objectives are to:

- Enhance the observation & monitoring of the cryosphere in support of process studies, model evaluation and change detection.
- Improve understanding of the physical processes and feedbacks through which the cryosphere interacts within the climate system.
- Improve the representation of cryospheric processes in models to reduce uncertainties in simulation of climate and predictions of climate change.

6.1 Cryospheric issues for seasonal prediction

Given the different time scales and geographical distribution of cryospheric components in the climate system, perhaps only the accurate knowledge of varying sea-ice and snow properties can provide predictive skill at seasonal time scales; at these scales, other components of the cryosphere can generally be considered invariant or slowly varying with climatology in time. In particular, the average position of the Polar front is largely determined by the geographical extent of sea ice and snow. We note, however, that frozen ground dynamics have a well-known and important influence on local to regional climate and thus may also play a role.

Sea-ice

Assistance with methods and provision of quality controlled data for the initialization of sea-ice conditions can be provided by members of the CliC community, since sea-ice monitoring, modelling and analysis are core activities in CliC. Products available:

i) fraction
ii) age
iii) movement
iv) surface temperature[1]

Some datasets with ice thickness information are also available. Their quality is assessed to be of limited accuracy. All such data are available on a routine basis either for operational use or for research purposes.

To assist WGSIP, sea-ice related diagnostics can be assessed by climate researchers in the CliC community. The interpretation of predicted near-surface variables such as pressure, winds, temperature and humidity as well as interactive sea-ice information (if available) can be used to assess the quality of prediction systems in polar regions.

Snow

Assistance with methods and provision of quality controlled data for the initialization of snow conditions can be provided by members of the CliC community, since the monitoring, modelling and analysis of snow distribution and properties are core activities in CliC. Products available:

i) areal coverage
ii) albedo

These data are available on a routine basis either for operational use or for research purposes. Some datasets with snow water equivalent information are also under development. Their quality is as yet unknown.

[1] Varying degree of accuracy and availability

The role of snow cover as a controlling mechanism for seasonal developments is not well established apart from a few known teleconnections, such as the influence of Tibetan snow cover on the Asian monsoon and a possible influence of late winter East Asian snow cover conditions on North American spring conditions. But even these relations could be reassessed using the planned CHFP experiments. CliC involvement in such analyses could be of relevance to WGSIP.

One snow-related mechanism that can be examined very efficiently through WGSIP (in conjunction with CliC and GEWEX) involves the effect of winter snow cover and soil moisture on springtime water resources (in particular, streamflow). We can perform a suite of offline experiments, and if the results are promising, we can follow them up with on-line (coupled to an AGCM) experiments:

i) Offline experiments. By driving a continental-scale array of land surface models with observed meteorological forcing (e.g., covering North America at 1 degree resolution for 50 years – such datasets exist), we can establish realistic snow cover, snow water equivalent, and soil moisture states for any number of winter forecast start dates. CliC can help ensure that the snow amounts produced are reasonable. We can then perform a series of offline forecasts with correctly initialized snow and soil moisture but with an assumed lack of skill in predicting meteorological forcing: we can drive the land surface model array with climatological meteorological forcing instead of the observed forcing. Any skill in the forecasted streamflows several months out will thus be derived solely from the information in the imposed initial soil moisture and snow conditions. Supplemental forecasts in which only the snow variables are initialized will allow the isolation of the soil moisture impacts on streamflow prediction skill.

ii) If the offline analyses show that a knowledge of snow in winter leads to improved streamflow prediction skill in spring, we can extend the GLACE-2 approach to the boreal winter season. The proper initialization of snow and soil moisture in the winter, when combined with any additional skill we obtain in predicting spring temperatures and precipitation, could lead to even greater skill in predicting streamflow.

Frozen ground

This is possibly better handled from a GEWEX perspective. But the permafrost community within CliC certainly have analyses and data to provide as well.

CHFP

The CHFP recommendations encourage an interactive ice model, while leaving the nature of the model, whether dynamic or thermodynamic, open. There is an opportunity for running additional CHFP coordinated experiments and diagnostics relevant for the cryosphere. Not only is the cryosphere community very diverse, but there is a wide range of users of cryosphere information that could be targeted to become involved in analysing CHFP diagnostics.

An area of potential collaboration between WGSIP and CliC would be in sea ice prediction and intialization, where various approaches are currently in use, with no knowledge of how this influences predictability.

Another area is spring snow melt into soil moisture and how this influences spring temperature anomalies. This would be relevant to WGSIP, CliC, as well as GEWEX. This has essentially already been done for the warm season in GLACE and similar experiments could be run for the cold season.

ACTION 13: Develop a proposal on how to move forward in a CHFP/CliC/GEWEX study of snow cover and soil moisture (J. Christensen, R. Koster).

7. Applications

The gap between weather and climate is starting to be bridged by the seamless approach. There is also a need to work across this continuum when considering impacts and applications. It is important for users, for example from agronomy and health applications, to use multi-model data, not just a single model or selected models to avoid sub sampling. Applications models should be routinely and consistently applied to multi-model ensemble datasets, though this generally not the case as such an approach is difficult to sustain outside of a research project.

A wide range of users has been involved with the ENSEMBLES project, including sophisticated users originating from the weather community. ARPA (Regional Agency for Environmental Protection in Emilia-Romagna) results indicate the possibility of setting up an operational wheat yield forecasting chain for northern Italy. MeteoSwiss has developed improved estimates of the European winter windstorm climate and the risk of reinsurance loss using climate model data. The Swedish Meteorological and Hydrological Institute has evaluated the likelihood of low water levels in Lake Mälaren, Sweden, constructing an impact response from the change in temperature and precipitation.

Different modelling streams, including RCM and seasonal to decadal systems, are being compared to assess changes in Blue Tongue disease climates over the next decades. The Liverpool Malaria Model (LMM) is a dynamic, process-based model that has been driven by daily temperature and rainfall in seasonal to interannual timescales (Hoshen and Morse, 2004, Jones and Morse, 2007), as well as with climate change scenario datasets. Different techniques can be applied to interpret the skill of LLM incidence ensemble forecasts, including weighting the malaria model output to different models of the multi-model ensemble, and kernel dressing (Broeker and Smith, 2008).

Despite growing experience in using integrated ensemble prediction systems, with initial promising results from the DEMETER and ENSEMBLES projects, better use needs to be made of current products and data and to understand the associated limitations. Impacts should be considered an integral part of the development of ensemble prediction systems as they define forecast skill and potential user/societal value, and make the link to decision makers/stakeholders. A seamless approach needs to be developed with and for impacts especially since impacts allow for linkage across different modelling streams. Despite these opportunities, there continues to be a major problem in terms of a lack of feedback between the impacts and climate science communities, both in terms of impact needs and in the development of ensemble prediction systems.

WGSIP links to the impacts and applications community by making state-of-the-art data available, now through the CHFP, and by working with the CLIVAR regional panels with the premise that they will lead at a regional level the use of data in impacts and applications projects.

The uptake of ensemble prediction system output is not trivial for users with different regions having different support needs. CIMA hosting and organizing a school for users across South America is a successful example of reaching out and working directly with users. Users would benefit from producing centres tailoring output to their needs but these in turn cannot be expected to directly link to all users. There needs to be a connection through regional scientific capabilities that then interface with user needs. Progress is slow in regions that are less well organised and where there is low skill, such as in West Africa.

A way forward, that could be supported by WGSIP, to overcome the difficulty in getting users to use probabilistic skill scores analyses and access datasets, would be to encourage producing centres to run diagnostics useful for users offline or on archived data and then served in a visual format on their websites, providing, for example, information on how the current season compares to previous seasons. Modelling centres may be interested in running diagnostics that will give additional information on model performance, though they will need guidance from the impacts and applications community on what diagnostics would be useful. This list of diagnostics could also be designed in such a way that they could be also orientated as input for Regional Climate Outlook Fora (RCOFs).

While WGSIP cannot be charged with developing user products, it could develop better links with the WMO World Climate Programme (WCP). The World Climate Applications and Services Programme (WCASP) is a WCP project that aims to foster the effective application of climate knowledge and information for the benefit of society and the provision of climate services, including the prediction of significant climate variations both natural and as a result of human activity. The Climate Information and Prediction Services (CLIPS) project is an implementation arm of WCASP. It operates around the globe by taking advantage of current data bases, increasing climate knowledge and improving prediction capabilities to limit the negative impacts of climate variability and to enhance planning activities based on the developing capacity of climate science.

The availability of long-term observational records is another area of importance for users. This year's Third World Climate Conference will be addressing this issue, an area where WGSIP support could be useful.

ACTION 14: Develop a list of diagnostics that production centres could run which would be useful for the impacts and applications community (A. Morse)

ACTION 15: Develop stronger links between WGSIP and WCP, including making WCP aware of the availability of CHFP data (B. Kirtman, T. Stockdale)

ACTION 16: Lobby WCC-3 on rendering long-term observational datasets available.

8. Decadal Prediction

8.1 Prospects for decadal prediction

There are reasonable prospects for producing decadal forecasts, and these are of great interest to planners and decision makers as well as being of considerable scientific interest. The level of skill that might be obtained, especially at the present stage of development of forecasting systems, is not yet clear. The CMIP5 experimental design provides an opportunity for international coordinated research and experimentation in this area. There are two aspects to the decadal problem; the externally forced signal (GHG + aerosols, volcanoes, solar, etc.) and the predictable part of the internally generated variability associated with oceanic mechanisms (e.g. MOC, ACC), coupled processes (e.g. PDO, AMO, ENSO), modulation of climate modes (e.g. PNA, NAO, NAM, SAM) and potentially land, cryospheric and even atmospheric (QBO) processes. To date climate projections have generally treated internal variability as a statistical component of uncertainty. Though there is no marked decadal peak in the spectrum of the climate system, long timescales exist and are potentially predictable. The challenge of prediction/predictability studies is to identify the mechanisms associated with regions/modes of predictability, to better understand the connection between oceanic modes and terrestrial climate variability, and to investigate predictive skill by means of prognostic (including multi-model) decadal predictions.

The results of predictability studies and demonstrations of forecast skill provide the foundations for initiating a coordinated WCRP study of decadal prediction/predictability. There are abundant scientific opportunities to improve and extend models and for the analysis of variability and of modes of variability. There are challenges to develop improved analysis methods, especially in the ocean, and for model initialization, verification and model development, as well as in ensemble generation and the use of multi-model ensembles for prediction on decadal timescales.

8.2 CMIP5 near term experiment design

In addition to the centennial climate change simulations, the CMIP5 experiment design has a near term component. Figure 1 shows the near term and long term experiment summary and Figure 2 show the near term experiments in greater detail, both taken from Taylor *et al.* (2008).

Figure 1: Summary CMIP5 Experiment Design (Taylor et al., 2008)

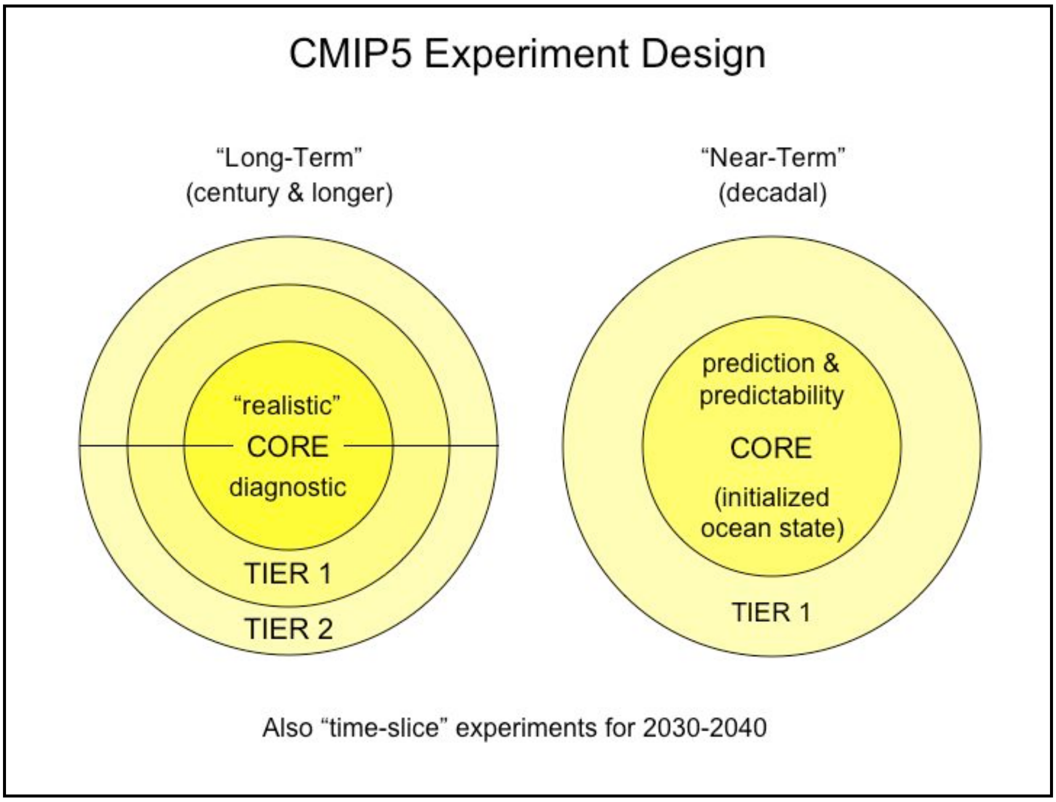
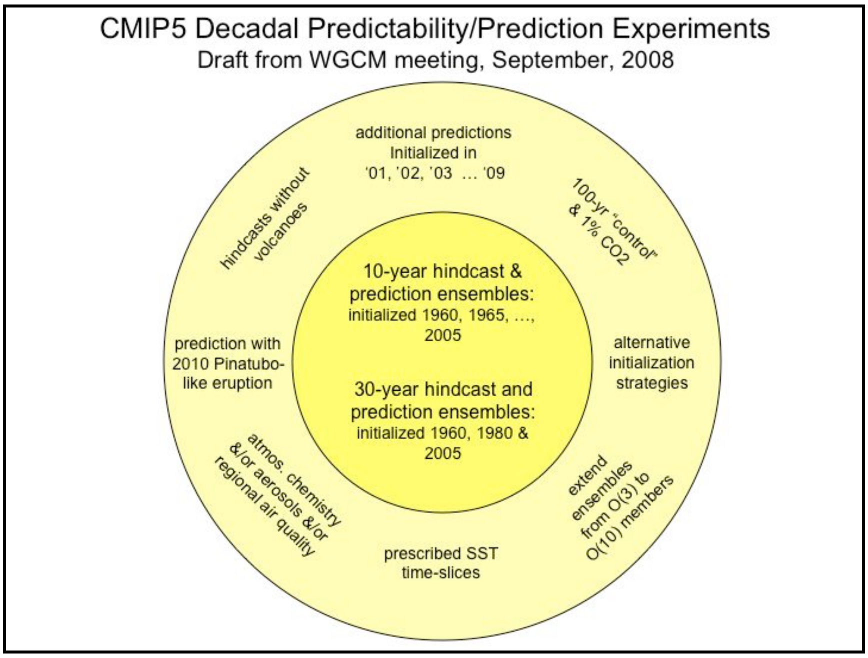


Figure 2: Near-term CMIP5 Experimental Design Summary (Taylor et al., 2008)



There are two core experiments, one a set of 10 year hindcasts or predictions initialized from climate states in the years 1960, 1965, 1970, and every five years to 2005, with this last simulation representing the sole actual prediction beyond the present (i.e., beyond 2009). In these 10-year simulations, it will be possible to assess model skill in forecasting climate on time-scales when the initial climate state, particularly the ocean initial conditions, may exert some influence. The other core experiment extends the 10-year simulations initialized in 1960, 1980, and 2005 by an additional 20 years. Groups can participate in the near term experiments without running the climate simulations, provided they generate the short 20th century runs as controls. The complete list of near term experiments is provided in Appendix D, which is Table A from Taylor *et al.* (2008).

The external forcing prescribed for the experiments is based on the observational record for the past and adopts the mid-range RCP4.5 scenario for the future. The choice of future scenario is not critical since forcing differences are small on these relatively short timescales, although the treatment of tropospheric aerosols is a potential source of uncertainty as these may change rapidly. Since volcanic eruptions cannot be predicted their occurrence is also a source of uncertainty for decadal forecasts although once they have occurred their effects become part of the forcing. Past volcanic eruptions are to be included in the hindcast simulations that may partially over-estimate skill because of this. The error associated with future eruptions can in any case only be partially quantified from the impact of past eruptions in the hindcasts, since the error depends on the characteristics of each eruption. The experiment protocol includes a tier-1 suite of sensitivity experiments on the effect of including or not a Pinatubo-like eruption.

WGSIP is a co-sponsor of the CMIP5 near term experimental protocol and a CMIP-WGCM-WGSIP subgroup has been formed to oversee this framework. WGSIP will be active in addressing the science questions that present themselves. The protocol has been designed to extend beyond the requirements for AR5 and to serve the future science development needs in the area. It has also been designed to mesh with decadal predictability studies already underway in Europe.

Initialization is a central theme of decadal prediction and WGSIP will participate actively in the workshop on ocean initialization for decadal experiments that is being led by the Atlantic Implementation Panel. CLIVAR and WCRP as a whole must redouble efforts to identify and include all sources of potential decadal forecast skill, such as the cryosphere, soil moisture, etc. Connections should be maintained between the CMIP-WGCM-WGSIP group and the emerging US CLIVAR Working Group on decadal variability and prediction, led by A. Kumar.

ACTION 17: Confirm T. Stockdale and G. Boer as WGSIP members of the CMIP-WGCM-WGSIP group coordinating the CMIP5 near term experiments.

ACTION 18: Circulate to WGSIP the list of data, in particular variables that will be useful for impacts studies, that will be stored from the near term experiments. (T. Stockdale, G. Boer).

ACTION 19: Determine the interest within the WGSIP community in participating in the CMIP5 near term experiments and diagnostics analysis.

ACTION 20: Interface between US CLIVAR WG on decadal prediction and the CMIP-WGCM-WGSIP group (A. Kumar, T. Stockdale, G. Boer)

9. C20C Project

The C20C Project is a CLIVAR-endorsed project for very long AMIP-style experiments using ensemble simulations to characterize and understand variability and predictability of the climate over the past ~130 years associated with slowly varying forcing functions that include SST.

The experimental design initially focused on ensembles of AGCM simulations of at least 4 members, all forced with the same HadISST sea surface temperature and sea ice analysis. This differs from AMIP as it deals with longer timescales and the focus is on climate variability and predictability rather than model evaluation. The protocol has been expanded to include other forcing data sets, including greenhouse gases, ozone, volcanic aerosols and solar variability Recent extensions include "Pacemaker" experiments where SST is specified in regions where the ocean is expected to force the atmosphere, and coupled elsewhere, in order to more accurately simulate variability that is inherently coupled. Land surface forcing has been addressed by interacting with LUCID (Land Use and Climate – IDentification of robust impacts), and HadISST2, a more highly resolved SST product will be available later this year.

In terms of reproducing climate variability, the results give an evaluation of how well the multi-model ensemble resolves climate processes. If a 20th Century climate event, such as a surface temperature trend, is consistent with the ensemble mean then it is potentially predictable, "forced" and well modelled. If it is not consistent with the ensemble mean but with some ensemble members, then there is unpredictable internal variability that is well modelled. If neither of these two apply, then there are some missing processes or forcing that are poorly modelled by this experiment. Various examples have been examined in a multimodel context (Scaife et al. 2008, Kucharski et al. 2008, Zhou et al. 2008)

The data and diagnostics are available from the links found at: http://www.iges.org/c20c/sharing_data.html

Experience from this coordinated experiment favours collaborative data analysis rather than developing a large on-line database. It has proved more useful to agree on a concise set of diagnostics from the start that everyone participating generates, with benefits for joint publications. Caution is also advised with the use of normalised indices as normalised, ensemble mean anomalies can give the impression of reproducible and potentially predictable anomalies, when members do not even span the observations.

The C20C project can attribute certain phenomena to certain SST patterns where these are directly forced phenomena. There is a potential for comparison with CHFP data if the same model is used, as in the case of the Met Office, instead of using a comparison to data to determine the limit of predictability. If phenomena or an event can be attributed as a forced response to SST, then one can see whether this SST forcing can be predicted by a coupled model forecast. Using the C20C dataset for identifying events/case studies where there is or is not predictability can be useful for explaining failed forecasts.

ACTION 21: Link to C20C dataset from the CHFP website.

ACTION 22: Continue conference calls with C20C to see what the possibilities are for collaboration with CHFP (A. Sacife and B. Kirtman).

10. The Ocean Observing System

One of the WGSIP terms of reference specifies its role to advise on the adequacy of the CLIVAR ocean observing system in terms of what are the requirements and impacts of the observing system for seasonal prediction. It is difficult to demonstrate improvements in ENSO prediction that are the direct result of improvements in the observing system because, in general, model error still dominates the absolute error. Although studies of observing system impact are very much encouraged by WGSIP, it was felt that it was not appropriate at this time to organize any coordinated experimentation on this topic - there is little ongoing work to coordinate, and model error is still a real problem. WGSIP itself does not command the resources to ensure that work like this is done.

While there is skill in forecasting ENSO in the Pacific Ocean, there is little skill in the Indian Ocean. This could be due to model error, a lack of observations compared with the Pacific, a smaller climate signal, or maybe because there is less predictability in this region. The Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA) activity is underway to enhance the observing system in the Indian Ocean (McPhaden *et al.*, 2009), the implementation of which is being coordinated by the CLIVAR Indian Ocean

Panel. How to demonstrate the benefit of the array for forecasts remains an open question that could be addressed by WGSIP, IOP and AAMP.

ACTION 23: Initiate an email discussion between WGSIP, IOP and AAMP on how to best demonstrate the benefit of the Indian Ocean Array, RAMA, on forecast skill (B. Kirtman, T. Stockdale, H. Hendon).

11. Standard hindcast verification

11.1 Dependence of model comparisons on skill score

It is confirmed that better anomaly correlation does not necessarily indicate better mean square skill score (MSSS) in model comparisons. This is because MSSS is dependent on model standard deviation (and/or bias) in addition to the anomaly correlation. The root mean square error (RMSE) is comparable to MSSS. Regions of low RMSE do not necessarily correspond to the regions of good seasonal forecasts.

Temporal anomaly correlation is the most fundamental skill measure for SI forecast predictability. The square of the anomaly correlation is the ratio of forecast signal variance to the total variance. Bias, standard deviation, MSSS and RMSE can be corrected by linear transform using observations, while the anomaly correlation is invariant. The anomaly correlation is widely used and most users are familiar with it and it is easy to understand.

11.2 CAWCR Multi model skill evaluation

The Centre for Australian Weather and Climate Research (CAWCR) is conducting a multi-model evaluation of coupled forecast systems skill for the Indian and Pacific Oceans. The POAMA, ECMWF and Sintex models anomaly correlation, standard deviation and bias have been compared for the Nino-3, Nino-4 and for the Indian Ocean dipole. COLA, NASA and two versions of the GFDL model have also been contributed and IRI may also contribute its model. This analysis gives insight into how well the models are simulating interannual variability and its amplitude, as well as drift.

ACTION 24: Recommend that the CAWCR multi-model evaluation be updated to include newly contributed models and then distribute the result to WGSIP (O. Alves).

12. Linkages to other CLIVAR panels

12.1 CLIVAR-wide activities related to the MJO

US CLIVAR Working Group on the MJO

U.S. CLIVAR MJO Working Group was formed in June 2006. MJO Simulation Diagnostics (developed by the working group) are available at http://climate.snu.ac.kr/mjo_diagnostics/index.htm and hold promise in guiding future model testing and improvement as well as increased sub-seasonal forecast skill.

The two-year term of the working group has now expired. A proposal to extend this activity for the continued development of MJO diagnostics and metrics for improved simulation and prediction of the MJO is being led by the US CLIVAR WG, in conjunction with the CLIVAR Asian-Australian Monsoon Panel (AAMP). The AAMP would like to see a new MJO WG formed that has a similar 2 year term with a tight focus and international participation that might possibly sit across WWRP (THORPEX) and WCRP (CLIVAR). The MJO WG has already had success in getting WGNE to support their activity of forecast verification of the MJO at operational centres worldwide. This sort of activity needs to be further developed and coordinated to ensure uptake of the products developed by the WG. Moreover, the activities of the MJO WG are closely aligned with objectives of the CLIVAR Pacific Panel and WGSIP. From this perspective, the proposed foci of the new group includes the following:

- Further development of process-oriented diagnostics/metrics that improve our insight into the physical mechanisms for robust simulation of the MJO and that facilitate improvements in convective and other physical parameterizations relevant to the MJO.
- Analysis of the multi-scale interactions within the context of convectively-coupled equatorial waves, both in observations and by exploiting recent advances in high-resolution modeling frameworks, with particular emphasis on vertical structure and diabatic processes. (synergies with YOTC, CMMAP, CASCADE, AMY, etc).
- Expand efforts to develop and implement MJO forecast metrics under operational conditions, including boreal summer focus and multi-model ensemble development.
- Develop an experimental modeling framework (e.g., hindcast experiment/dataset) to assess MJO predictability as well as forecast skill of the MJO and closely related phenomena from contemporary/operational models.

ACTION 25: Circulate the US CLIVAR MJO WG and AAMP-led proposal for a WCRP-WWRP WG on the MJO, as an extension of the US CLIVAR WG activities, for endorsement by WGSIP (H. Hendon).

Hindcast Experiment for Intraseasonal Prediction

The proposed intraseasonal variability (ISV) prediction experiment (with a monsoon focus), which is complementary to the CHFP, is presented in Appendix E. The proposal aims to gain the involvement of a broad community of modelling and prediction centres in an activity to compare numerical model retrospective forecasts of the Intraseasonal Oscillation (ISO), which includes both the MJO and Monsoon Intraseasonal Oscillation (MISO).

Pan-WCRP Monsoon intraseasonal variability simulation and prediction

Following on from the First 1st Pan-WCRP Workshop on Monsoon Climate Systems: Toward Better Prediction of the Monsoons, held Irvine, USA on 15-17 June 2005, a proposal has been made to establish a Pan-WCRP monsoon panel/working group within the COPES initiative. It would hold targeted workshops to foster interaction for sustaining CLIVAR and GEWEX interactions and develop a joint CLIVAR-GEWEX approach to the Asian-Australian monsoon, building on the current CLIVAR-GEWEX collaboration on the American and African monsoon systems.

12.2 VAMOS Modeling Plan

The VAMOS Modeling Plan is available online at http://www.clivar.org/organization/vamos/Publications/Vamos_Modeling_Plan_Jun08.pdf and a summary has being published in the VAMOS newsletter (Kirtman and Saulo, 2009).

12.3 Activities related to VACS: The SAWS multi-model forecasts for the Southern African region

The SAWS (South African Weather Service) started issuing operational multi-model forecasts for the Southern Aftican Development Community (SADC) from July 2008. Currently, four models contribute to the multi-model ensemble. Five ensemble members of the Conformal-Cubic Atmospheric Model (CCAM) are run at the University of Pretoria, 12 of ECHAM4.5 at the SAWS, 24 of CCM3.6 at the IRI and 40 of CFS at the CPC. The ensemble members are combined averaging with linear weights and the IRI Climate Predictability Tool (CPT) is used for downscaling. In the future the multi-model ensemble is planned to be extended with other models (GloSea4 at UKMO and CPTEC/COLA at INPE, ECMWF(?)).

Figure 3(a) shows a typical example of the forecast format for rainfall in January-March 2009, issued in December 2008. This is in stark contrast to the subjective consensus forecast for the same period issued by the Southern African Climate Outlook Forum (SARCOF), shown in Figure 3(b), that always gives the highest weighting to normal conditions.

Figure 3(a) – Muti-model rainfall forecast issued for January – March 2009, issued in December 2008

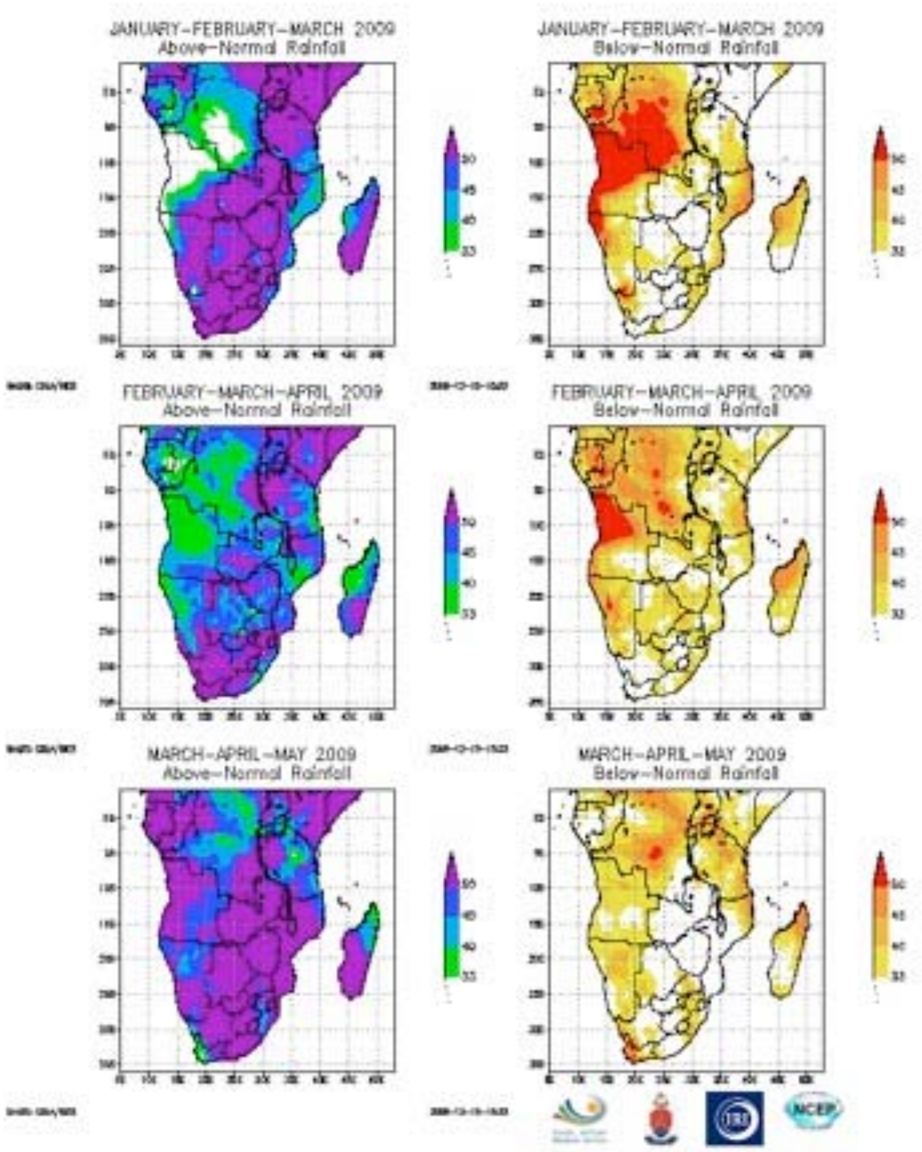
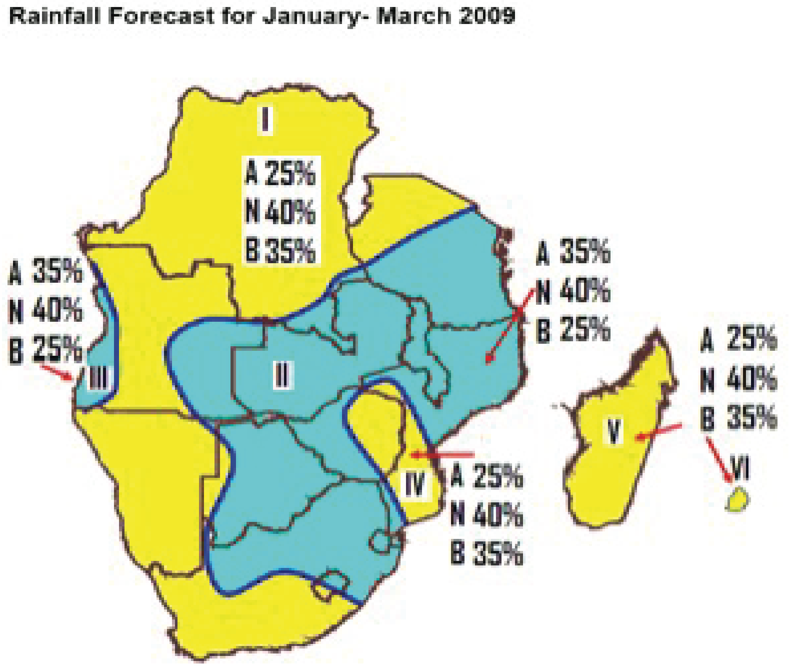


Figure 3(b) – SARCOF consensus rainfall forecast for January-March 2009, issued in December 2008.



The SAWS has been providing the Drought Monitoring Centre (DMC) in Gaborone, Botswana with the multi-model forecast since August 2008. The SAWS and the DMC are developing a document that discusses how the SARCOF process could be modernized to make more use of this objective forecast product. The SAWS multi-model product will also be linked to the CLIVAR Variability of the African Climate System panel (VACS) activities and will be introduced at a workshop that VACS in planning on rainfall onset.

The SAWS multi-model effort is seeking WGSIP endorsement to continue to improve on their multi-model forecasting system. The main objective of the multi-model effort is to provide objective seasonal probabilistic forecasts for the SADC in order to modernize the SARCOF process and at the same time provide the DMC, with a monthly-issued forecast guidance product that they can pass on to their members.

The following is requested of WGSIP:

- Support the SAWS endeavor of producing objective seasonal probabilistic forecasts of rainfall and surface temperature for SADC;
- Encourage international centres that run global models to make their operational forecast output available for inclusion in the SAWS multi-model forecasting system;
- Encourage the SAWS to produce forecasts for extreme conditions;
- Encourage the SAWS to produce verification statistics of the multi-model system; and,
- Encourage VACS (Variability of the African Climate System) to endorse the above items.

ACTION 26: Endorse the SAWS multi-model product and its application in the SADC region by the SARCOF process.

12.4 Links to US CLIVAR

The following are the main US activities of relevance to WGSIP:

- Drought Working Group (see below)
- Decadal Predictability Working Group – Its first goal is to define a framework to distinguish natural variability from anthropogenically forced variability on decadal time scales for the purpose of assessing predictability of decadal-scale climate variations. Its second is to develop a framework for understanding decadal variability through metrics that can be used as a strategy to assess and validate decadal climate predictions/simulations. This group has a two-year lifespan, beginning in January 2009, aiming to make its recommendations on diagnostics to coincide with the availability of the AR5 dataset.
- Climate Process and modelling Teams (CPTs) – The initial CPTs, addressing how to improve parameterizations in IPCC class models, have now finished and the US funding agencies are being approached to support new CPTs in 2010 and beyond.
- Atlantic Meridional Overturning Circulation (AMOC) – a five year program, part of the US Ocean Research Priorities Plan (ORPP). The anticipated outcomes are:
  - Enhanced understanding of the AMOC system
  - Design of a comprehensive MOC observation and monitoring program.
  - New forecasting capabilities
  - Improved ocean models, coupled models, and ocean analyses for their initialization.
  - Characterization of the impacts and feedbacks of changes in the MOC on ecosystems, carbon budgets, and regional climate.
- PPAI Panel – The Predictability, Predictions and Applications Interface Panel's (PPAI) mission is to foster improved practices in the provision, validation and uses of climate information and forecasts through coordinated participation within the U.S. and international climate science and applications communities. PPAI’s interest in the seasonal prediction problem may be occluded by its growing interest in the decadal problem. It is hoped that the imminent availability of CHFP data will renew PPAI’s interest.

ACTION 27: WGSIP to foster PPAI interest with regards to the CHFP data set (B. Kirtman, A. Kumar).

12.4.1 US CLIVAR Drought Working Group

The USCLIVAR Working Group on Drought has coordinated a multi-model assessment of the impact of SST anomalies on regional drought (http://www.usclivar.org/Organization/drought-wg.html). Its terms of reference have been to propose a working definition of drought and related model predictands of drought, coordinate evaluations of existing relevant model simulations, suggest new model experiments designed to address some of the outstanding uncertainties concerning the roles of the ocean and land in long term drought, coordinate and encourage the analysis of observational data sets to reveal antecedent linkages of multi-year drought and organize a community workshop in 2008 to present and discuss results.

Different combinations of idealized Pacific and Atlantic SST patterns of annual variability have been used to force global models. Monthly data are available here:
ftp://gmaoftp.gsfc.nasa.gov/pub/data/clivar_drought_wg/README/www/index.html

Models tend to agree over the USA to indicate:

- Cold Pacific+Warm Atlantic => drought/warm
- Warm Pacific+Cold Atlantic => pluvial conditions/cold

There are substantial differences in the details of the anomaly patterns and there is a large seasonality in the responses. The potential predictability from the Pacific signal to noise ratio is largest in spring and model results agree more on the precipitation response compared to surface temperature response. A special issue highlighting the results is now being put together for J. Climate.

13 WGSIP Business

13.1 Overall work plan and priorities

The major priorities of WGSIP in the coming year are:

(i) Ensure that the CHFP experiments are completed and that the data is made available to the research community
   a. Continue GLACE collaboration
   b. Develop SPARC and CliC seasonal prediction experimental protocols

(ii) Continue to promote the Decadal Prediction experimental protocol and encourage wide participation
   a. Coordinate with emerging US Clivar Working Group for Decadal Prediction and Predictability

(iii) Participate of the organization of WCC-3 and the development of the white papers on seasonal prediction

13.2 Membership

Memberships that are up for renewal since the end of 2008 are:

T. Stockdale
A. Morse
P. Nobre

13.3 Next meeting

The 13th WGSIP Session is proposed for Buenos Aires in July 2010, during the week preceding the two-week course on the CHFP, seasonal prediction and its applications that is being organised by CIMA. C. Saulo and C. Ereno would be the local points of contact.

References

Baldwin M. P., and T. J. Dunkerton, 1999: Propagation of the Arctic Oscillation from the stratosphere to the troposphere. *J. Geophys. Res*., **104**, 30937–30946.

Boer, G. J., and K. Hamilton, 2008: QBO influence on extratropical predictive skill. *Clim. Dyn*., **31**, 987–1000.

Boville, B. A., 1984: The influence of the polar night jet on the tropospheric circulation in a GCM. *J. Atmos. Sci*., **41**, 1132-1142.

Broeker, J. and L. A. Smith, 2008: From ensemble forecasts to predictive distribution functions, *Tellus A*, **60**, 663-678.

Brönnimann, S., J. Luterbacher, J. Staehelin, T. Svendby, G. Hansen, and T. Svenøe, 2004: Extreme climate of the global troposphere and stratosphere 1940-1942 related to El Niño. *Nature*, **431**, 971–974.

Hamilton, K., 1993: A general circulation model simulation of El Niño effects in the extratropical northern hemisphere stratosphere. *Geophys. Res. Lett.*, **20**(17), 1803-1806.

Hoshen, M.B., Morse, A.P., 2004: A weather-driven model of malaria transmission,. *Malaria* Journal, **3**(32), pp14.

Inneson and Scaife, Nature Geosciences, 2009 The role of the stratosphere in the European climate response to El Nino. *Nature Geoscience*, **2**, 32-36.

Jones, A. and A. Morse, 2007: DEMETER-driven prediction of epidemic malaria in Africa: initial results from a continental-scale study, *CLIVAR Exchanges*, **43**, 34-35.

Kirtman B., and C.Saulo, 2009: Modelling issues: an update after the 11th (VAMOS) panel meeting. *CLIVAR Exchanges/VAMOS Newsletter*, **14/No. 5**, 19-23.

Kodera K., 1995: On the origin and nature of the interannual variability of the winter stratospheric circulation in the Northern Hemisphere. *J. Geophys. Res*., **100**, 14077–14087.

Kucharski, F., A. A. Scaife, J. H. Yoo1, C. K. Folland, J. Kinter, J. Knight, D. Fereday, A. M. Fischer, E. K. Jin, J. Kröger, N.-C. Lau, T. Nakaegawa, M. J. Nath, P. Pegion, E. Rozanov, S. Schubert, P. V. Sporyshev, J. Syktus, A. Voldoire, J. H. Yoon, N. Zeng and T. Zhou, 2008: The CLIVAR C20C project: skill of simulating Indian monsoon rainfall on interannual to decadal timescales. Does GHG forcing play a role? *Climate Dynamics*, 10.1007/s00382-008-0462-y.

Kuzmina, S. I., and L. Bengtsson, O. M. Johannessen, H. Drange, L. P. Bobylev, and M. W. Miles, 2005: The North Atlantic Oscillation and greenhouse-gas forcing. *Geophys. Res. Lett*, **32**, L04703, doi:10.1029/2004GL021064.

Manzini, E., M.A. Giorgetta, M. Esch, L. Kornblueh, and E. Roeckner, 2006: The influence of sea surface temperatures on the northern winter stratosphere: ensemble simulations with the MAECHAM5 model. *J. Climate*, **19**, 3863-3881.

Marshall A. and A. A. Scaife, 2009: Impact of the Quasi-Biennial Oscillation on Seasonal Forecasts. *J. Geophys. Res*., submitted.

McPaden MJ, Meyers G, Ando K, Masumoto Y, Murty VSN, Ravichandran. M., Syamsudin, F., Vialard, Yu, J.-L., and W. Yu. 2008: RAMA: The Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction. *Bulletin of the American Meteorological Society*: In Press

Meehl, G.A. and coauthors, 2008: Decadal prediction: Can it be skillful? *Bull. Amer. Meteorol. Soc.*, submitted

Scaife, A. A., J. R. Knight, G. K. Vallis, and C. K. Folland, 2005: A stratospheric influence on the winter NAO and North Atlantic surface climate, *Geophys. Res. Lett*., **32**, L18715, doi:10.1029/2005GL023226.

Scaife A. A. and J. R. Knight, 2008: Ensemble simulations of the cold European winter of 2005-2006, *Quarterly Journal of the Royal Meteorological Society*, **134**, 1647-1659.

Scaife A. A., F., Kucharski, C. K., Folland, J., Kinter, D., Fereday, A., Fischer, S., Grainger, K., Jin, J. R., Knight, S., Kusunoki, M. J., Nath, T., Nakaegawa, P., Pegion, S., Schubert, P., Sporyshev, J., Syktus, A., Voldoire, J. H., Yoon, and T. Zhou, 2008: The CLIVAR C20C project: selected 20th century climate events. *Climate Dynamics*, submitted.

Taylor, K.E., R.J. Stouffer, and G.A. Meehl, 2008: A summary of the CMIP5 Experimental Design (http://www-pcmdi.llnl.gov/).

Zhou T, B.,Wu, A. A., Scaife, L., Li , A., Fischer, A., Voldoire, B., Wang, C. K. Folland, D., Fereday, F., Kucharski, J., Kinter, K. E., Jin, M. J., Nath, N.-C., Lau, P., Pegion, S., Kusunoki, T., Nakaegawa, and J., Syktus, 2008: The CLIVAR C20C Project: Which components of the Asian-Australian Monsoon variability are forced and reproducible? *Climate Dynamics*, submitted.

Appendix A - 12th WGSIP Session Agenda

Monday 12th January 9.00 - 5.30 pm

1. **Welcome and review of Agenda** (B. Kirtman and T. Stockdale (co-chairs, WGSIP))
   - 1.1. Opening remaks by M. Visbeck
   - 1.2. Structure and main aims of meeting
   - 1.3. Review of action items from last meeting

2. **Reports on CLIVAR and WCRP activities**
   - 2.1. Summary report on overall CLIVAR / WCRP issues (A. Pirani and B. Kirtman)

3. **Climate-system Historical Forecast Project (CHFP)** (B. Kirtman and T. Stockdale)
   - 3.1. List of models and status of data (all)
   - 3.2. Data servers at ECMWF, CIMA, APCC
   - 3.3. Datasets to be served locally
   - 3.4. Diagnostic sub-projects
     - led by WGSIP
     - proposed by others
   - 3.5. Future developments
     - Use of the data
     - Evolution of the data system
     - Additional experimentation

4. **GEWEX and land surface issues** (R. Koster)
   - 4.1. GLACE-II reports
   - 4.2. Possible focus on land surface for a future meeting: analysis of CHFP, GLACE-II, operational systems and any other work.
   - 4.3. Any other comments on GEWEX links regarding CHFP?

5. **SPARC and Stratospheric impacts** (A. Scaife)
   - 5.1. Proposed topic for the future: how will we address this, is CHFP and individual work sufficient, how do we interact with SPARC, sensitivity of results, what datasets etc.

6. **Cryosphere issues** (J. Christensen)
   - 6.1. How will CHFP by analysed regarding the cryosphere
   - 6.2. Modelling and initialising sea-ice
   - 6.3. Linkages with CliC

7. **WCC-3 in Geneva**
   - 7.1. Requirements on WGSIP, and implications for our work plan

8. **Links to and encouragement of Applications**
   - 8.1. Status report on use of and need for research data in seasonal applications (A. Morse)

8.2. Reports on existing readiness of regional panels to make use of CHFP data

8.3. Consideration of further action:

- Will the CHFP data servers, together with real-time distribution systems, be sufficient?
- Do we need any actions to encourage regional panels to work with and or encourage use of the CHFP data?
- Assessment workshop(s)

Tuesday 13th January 9.00 - 5.30pm

9. Decadal prediction (G. Boer and T. Stockdale)

9.1. Review of decadal prediction proposal, as approved by WGCM for use in CMIP5

9.2. Proposed joint subgroup with CMIP/WGCM/WGSIP

9.3. Data handling plans

10. Links to C20C project (A. Scaife)

11. Ocean observing system

11.1. How adequate is the present system for ENSO, and for SIP more generally?

11.2. How adequate for decadal prediction?

11.3. What is the evidence base for our assessment? Should we organize coordinated observing system experiments in the near future, later, or perhaps not at all?

12. Standard hindcast verification (T. Ose, all)

13. Other possible future projects, and linkages with other CLIVAR panels

13.1. ENSO prediction limits: some models now doing well at 12 month range, should we explore these longer ranges (eg up to 2 years??)

13.2. Focus on tropical Atlantic variability, in context of ARGO data

13.3. Focus on Indian Ocean variability and MJO

13.4. VAMOS Modeling Collaboration (P. Nobre and B. Kirtman)

13.5. SAWS multi-model forecasts for DMC and links to VACS (W. Landman)

13.6. AA Monsoon Panel (H. Hendon)

13.7. Assessment of seasonal prediction performance in CHFP for IPCC AR5?

14. Linkages between WGSIP and US CLIVAR (D. Legler, A. Kumar and B. Kirtman)

15. WGSIP priorities for remaining lifetime of CLIVAR

15.1. Input already given to CLIVAR SSG (B. Kirtman)

15.2. Our priorities for the next few years

16. Local presentations

16.1. A chance to enjoy some science presentations from our local hosts

Wednesday 14th January 2009   9.00am - 12 noon

17. Review of activities around the world (all)

17.1. Opportunity for all to present. Request is for 5-10 mins only, highlighting both strategic developments (in terms of science, not organizational issues) and any notable scientific highlights. Can include developments at institutes other than those represented at WGSIP (eg notable national or regional activities). Pre-circulation (or at least, availability at the time of the meeting) of a summary would be helpful.

18. Action items and organization of future activities (T. Stockdale and B. Kirtman).

18.1. Agreement on overall work plan and priorities

18.2. Action items for the coming year

18.3. Membership and distribution of responsibilities

18.4. Timing and possible locations for next WGSIP session.

18.5. Close of WGSIP session.

Appendix B – List of participants

WGSIP Panel members

Tim Stockdale (Co-Chair),
Ben Kirtman (Co-Chair),
Willem Landman,
Pablo Nobre,
Michel Déqué,
George Boer,
Andy Morse,
Dave DeWitt,
Tomoaki Ose,
Hua-Lu Pan,
Randy Koster,
Adam Scaife

CLIVAR ICPO:

Anna Pirani

Invitees

Harry Hendon,
Carolina Vera,
Arun Kumar,
Woo-Jin Lee,
Jens Christensen,
David Legler,
Martin Visbeck

Appendix C

SHFP - Stratosphere resolving Historical Forecast Project

Adam Scaife, Ben Kirtman and Tim Stockdale

<u>Purpose</u>

- To quantify improvements in actual predictability by initialising and resolving the stratosphere in seasonal forecast systems
- To compare with existing seasonal to interannual forecast skill and to provide a hindcast data set that may be used to:
    - demonstrate improvements in currently achievable season forecast skill for a range of variables and lead times
    - understand improvements under particular scenarios such as El Nino and years with an active stratosphere
    - justify changes in operational seasonal forecast approaches and methods

<u>Hindcasts</u>

- A set of parallel hindcasts are requested from stratosphere resolving and stratosphere non-resolving models. A stratosphere resolving model is defined here to have:
    - A domain extending to 1hPa (~50km) or higher
    - At least 15 model levels between the tropopause and 1hPa/50km
- The use of existing HFP data as the non-stratosphere resolving hindcasts is welcomed
- Either coupled ocean-atmosphere model or two-tier forecasts are welcome
- Atmospheric initial conditions are at the choice of the participant but must not include any information from the future
- Land initial conditions are at the choice of the participant but must not include any information from the future.
    - option 1: use "reanalysis" land surface data modified to your model (recommended)
    - option 2: use model climatologies from an AMIP run.
- SST and sea-ice initial conditions
    - SST must not contain information from the future with respect to the forecast
        - option 1: persist the observed SSTA anomaly from the month preceding the forecast period (i.e., this anomaly is added to the climatological seasonal cycle of SST's)
        - option 2: statistical or other objective forecast of SSTA which is not developed with nor makes use of future information (e.g. climatology, relaxation of anomalies toward zero with some time scale, other statistical forecast, anomalies from an ocean model initialized and run separately, etc.)
    - Sea ice: based on the associated sea ice data but containing no future information.

<u>Data</u>

- Basic and optional data are shown in the Table below. The data in any or all entries in the "optional additional" columns is welcomed.
- The NH winter season and SH spring seasons are used: DJF and SON.
- Some data currently available at IRI. New submissions, please contact Ben Kirtman (kirtman@cola.iges.org) for procedures.
- The availability of data at local web sites is encouraged.

	Basic	Optional additional for	
Integrations	4 month lead times (1st November and 1st August start dates) 2 seasons (DJF and SON) Case study years: 1982, 1983, 1987, 1989, 1991, 1992, 1995, 1997, 1998, 2002, 2005 (Total of 11 years) 6 members	12 month lead times 4 seasons 22 years (1979-2000) 10 or more members	
Data	Monthly means of: ts, tas, pr, psl Monthly means of: ta (10, 30, 50, 700, 850hPa) ua, va (10, 30, 50, 200, 850hPa) zg (10, 30, 50, 500, 1000hPa) Daily values (to examine sudden stratospheric warmings) of: ua, ta (10, 30hPa)	Daily values of: pr zg (500hPa)	
Data definitions	ts tas pr psl ta ua va zg snc snw mrso mrsos hfls hfss tauu tauv cl clt rlt hus	ground temperature surface (2m) air temperature total precipitation rate mean sea-level pressure air temperature eastward wind northward wind geopotential height snow cover snow depth (water equivalent) total soil water content surface soil water content (upper 0.1m) surface latent heat flux (+ upward) surface sensible heat flux (+ upward) eastward wind stress (+ eastward) northward wind stress (+ northward) cloud fraction total cloud amount outgoing longwave radiation (+ downward) specific humidity	K K kg/(m**2 s) N/m**2 K m/s m/s m % kg/m**2 kg/m**2 kg/m**2 W/m**2 Wm**2 N/m**2 N/m**2 % % W/m**2 kg/kg

Appendix D

Summary of decadal prediction experiments (Table 1 fromTaylor *et al.*, 2008)

		Experiment	**Notes**	**# of years**
CORE	1.1	Ensembles of 10year hindcasts and predictions	With ocean initial conditions in some way representative of the observed anomalies or full fields for the start date, simulations should be initialized towards the end of 1960, 1965, 1970, 1975, 1980, 1985, 1990, 1995 and 2000 and 2005. A minimum ensemble size of 3 should be produced for each start date. The atmospheric composition (and other conditions) should be prescribed as in the historical run (expt. 3.2) and the RCP4.5 scenario (expt. 4.1) of the long-term suite of experiments.	3x10x10
	1.2	Ensembles of 30year hindcasts and predictions	Extend to 30 years the expt. 1.1 integrations with initial dates near the end of 1960, 1980 and 2005. A minimum ensemble size of 3 should be produced for each start date.	3x3x20
TIER 1	1.1-E, 1.2-E	Increase ensemble size	Additional runs to expand each ensemble to a size of O(10).	~7x10x10, ~7x3x20
	1.1-I	Initialize 10-year simulations from additional start dates	As in 1.1 and 1.1-E, but initialized near the end of 2001, 2002, 2003, 2004, 2006 (2007, and beyond) to take advantage of the better ocean data of the Argo float era	≥3x(≥5)x10
	3.3	AMIP (1979-2008)	This run is described in Table 3 (expt. 3.3).	30
	3.1-S	A shortened preindustrial control	This is a shortened version of the pre-industrial control run described in Table 3 (expt. 3.1).	100
	6.1-S	1%/yr CO2 increase	An- 80 year run with a 1% per year increase in CO2 (a shortened version of expt. 6.1) , initialized at year 20 of the control run (3.1-S)..	80
	1.3	Hindcasts without volcanoes	Additional runs initialized near end of 1960, 1975, 1980, 1985 and 1990 as in expts. 1.1 and 1.2, but without the Agung, El Chichon and Pinatubo eruptions.	≥3x5x(≥10)
	1.4	Predictions with 2010 Pinatubo-like eruption	An additional run initialized near end of 2005 as in expt. 1.1, but with a Pinatubo-like eruption imposed in 2010.	≥3x(≥10)
	1.5	Initialize with alternative strategies	Since there is at present no generally accepted "best" way to initialize models, some groups may choose to try different initialization methods.	≥3x(≥10)
	1.6	Run with more complete atmos. chemistry	The chemistry/aerosol community plans to put together experiments with short-lived species and pollutants (probably two to three years hence).	≥1x(≥10)

Appendix E

Hindcast Experiment for Intraseasonal Prediction

Draft Plan

8 January 2009

1. Introduction

The Madden-Julian Oscillation (MJO, Madden-Julian 1971, 1994) interacts with, and influences, a wide range of weather and climate phenomena (e.g., monsoons, ENSO, tropical storms, mid-latitude weather), and represents an important, and as yet unexploited, source of predictability at the subseasonal time scale (Waliser et al. 2009). The monsoon ISO (MISO), which is more complex in nature due to interaction between monsoon circulations and MJO, is one of the dominant short-term climate variability in global monsoon system (Webster et al. 1998, Lau and Waliser 2005). The wet and dry spells of the MISO strongly influence extreme hydro-meteorological events, which composed of about 80% of natural disaster, thus the socio-economic activities in the World's most populous monsoon region.

Current Status of dynamical MJO Prediction

About a decade ago, dynamical forecasts of MJO made using the atmospheric-only model of the NCEP reanalysis vintage had a useful skill only up to about 7 days for boreal winter season (Hendon et al. 1999). Dynamical models have improved greatly in the past decade (Sperber and Waliser 2008) and a few models have produced rather credible simulations of MJO, with evidence of useful prediction skill of the principal characteristics of MJO out to a lead-time comparable to empirical-statistical schemes (~ 2 weeks) (Kim et al. 2007; Vitart et al. 2008). Air-sea coupling can further extend the MJO predictability by up to a week (Fu et al. 2007; Woolnough et al. 2007).

The multi-model ensemble (MME) approach has proven to be one of the most effective ways to improve seasonal prediction by reducing model errors and better quantifying forecast uncertainties (Krishnamurti et al. 1999; Doblas-Reyes et al. 2000; Shukla et al. 2000; Palmer 2000, Wang et al. 2009). Give the recent growth in interest and expected benefits in MJO prediction; it is of great importance to develop the MME techniques for the ISO prediction. However, it has not been addressed to what extent the MME approach can improve the skill of MJO prediction.

The US CLIVAR MJO Working Group (hereafter MJOWG) has fostered the development of a multi-institution/model operational MJO prediction framework anchored at the National center for Environmental Prediction (NCEP). The MJOWG has also denveloped a set of diagnostics for evaluating model simulations of the MJO (Waliser et al. 2009). Despite the significant societal and environmental demands for accurate prediction of MJO/MISO and notable improvements in our ability to predict the MJO over the past decade, operational prediction of MJO is still in its infancy and its achievement seen as a great challenge faced by operational weather forecast centers.

Need For a coordinated multi-model ISO hindcast experiment

While the establishment of the MJO forecast metric and the coordination of operational forecast activity is a great advance, there is an outstanding challenge and urgent need to exploit these efforts to full potential and produce an MME forecast. However, underlying the development of an MME is the intrinsic need for lead-dependent model climatologies (i.e. multi-decade hindcast data sets) to properly quantify and combine the independent skill of each model as a function of lead-time and season. Thus, there is a great demand for both MME work and the associated hindcast data for its development (e.g., Sperber and Waliser 2008).

<u>Programmatic background</u>

Determination of ISO predictability in the current AOGCMs is a pressing need for WCRP Cross-cutting monsoon research. The MISO forecast is one of the major concerns of APEC Climate Center (APCC) and the

Asian Monsoon Years (2007-2011). Launching a coordinated ISO hindcast experiment has been strongly endorsed and supported by APCC, CLIVAR/AAMP, and the SSC of AMY (2007-2011), and echoed by WCRP/International Monsoon Study (IMS).

This plan is a result of discussions among a group of scientists who have participated in APCC/ Climate Prediction and Application to Society (CliPAS) and MJOWG. The plan seeks to gain the involvement of a broad community of modeling and prediction centers in an activity to compare numerical model retrospective forecasts of the Intraseasonal Oscillation (ISO), which include both MJO and MISO.

Objectives

1) Understanding of the physical basis for intraseasonal prediction. Determine potential and practical predictability of ISO in a multi-model frame work.
2) Developing optimal strategies for multi-model ensemble (MME) ISO prediction system, including effective initialization schemes and quantification of the MME's ISO prediction skills with forecast metrics under operational conditions.
3) Revealing new physical mechanisms associated with intraseasonal variability that cannot be obtained from analyses of a single model.
4) Identifying model deficiencies in predicting ISO and finding ways to improve models' convective and other physical parameterizations relevant to the ISO through development of model process diagnostics.
5) Help to determine ISO's modulation of extreme hydrological events and its interannual variability and contribution to interannual climate variation.

2. Numerical Experiments

Two experiments are designed: Free simulation and hindcast experiment. There is no restriction as to the types of GCM. Although AOGCMs are preferable, AGCM alone is also acceptable. There is no uniform specification regarding model initialization procedures and initial conditions. The state-of-the-art empirical-statistical forecast models will be used for comparison with dynamical models' performance and skills.

Exp 1: Control simulation

The current GCMs exhibit considerable shortcomings in representing MJO, especially MISO due partly to enormous uncertainties inherent in models' physical parameterizations. Conclusions regarding a particular mechanism that is derived based on a single model are often model-dependent and inconclusive. A long simulation allows us to better understand the dependence of the prediction on initial conditions and better define metrics that measure the "drift" of the model toward their intrinsic MJO/MISO modes. For these reasons, a free run (without impacts of initial conditions) will serve as a control experiment. Free coupled runs with AOGCMs or AGCM simulation with specified boundary forcing (e.g., observed SST and Sea ice distribution) are requested for at least 20 years. The period for the forced AGCM run should be consistent with the hindcast period (see below).

Exp 2: ISO hindcast

This experiment requires a set of retrospective ISO forecasts, which covers the last 20 years from 1989 to 2008. The minimum (standard) specifications of the hindcast are: (a) Prediction is initiated every 10 days (before and up to 1st, 11th, and 21st of each calendar month) throughout the entire 20-year period; (b) Integration length for each forecast is 45 days; (c) The ensemble size for each forecast is 5.

3. Requested output data and information

a. Model description and climatology

A concise model description includes model name, characteristics (parameterization scheme etc.), ensemble size, horizontal and vertical resolution, initial conditions and initialization scheme.

Climatological information includes (1) long-term daily mean annual cycle of precipitation, OLR, 850 hPa winds, surface winds and sea-level pressure, and (2) long-term three-hourly mean diurnal cycle of precipitation in global tropics between 30°S and 30°N.

b. Outputs from control simulation and hindcast experiment

The hindcast dataset provides means to determine the predictability and prediction skill of ISO and its seasonal, interannual and MJO life-cycle phase dependencies. To reach this goal, we propose the following output list for further discussion:

Standard atmospheric output variables (daily mean)**:** total precipitation rate (preferably, the convective and stratiform separately), OLR, geopotential, horizontal wind fields (u and v) at 850, 500, and 200 mb, surface (2m) air temperature, SST, mean sea level pressure, surface heat fluxes (latent, sensible, solar and longwave radiation) and surface wind stress, and humidity and temperature at standard levels.

Upper Ocean output variables (daily mean): temperature, salinity, and ocean currents (U and v), and vertical motion from surface to 300m,

c. Recommended data formats

Resolution: 2.5x2.5 degree interval over global domain (144x73 grids)

Writing order: Eastward from 0° to 2.5°W, southward from 90°N to 90°S

Writing format: Any readable format is OK. But, GRIB format (including data control file, such as *.ctl) is highly recommended.

4. Participating modeling Group

The following groups (with contact persons) have expressed interest to participate the coordinated hindcast at this moment and the planned experiments invite any interested modeling group or operation centers to join.

BMRC: Harry Hendon
COLA and UM: J. B. Kirtman, J. Shukla
ECMWF: F. Molteni
GFDL: W. Stern
IAP/LASG: T. Zhou, B. Wang
JAMSTEC/FRCGC: T. Yamagata, J.-J. Luo
NASA/GMAO: S. Schubert
NCEP/CPC: A. Kumar, J. E. Schemm
SNU: I.-S. Kang
UH/IPRC: B. Wang, J.-Y. Lee, X. Fu

References

Doblas-Reyes, F. J., M. Déqué, and J.-P. Piedelievre, 2000: Model and multimodel spread and probabilistic seasonal forecasts in PROVOST. *Quart. J. Roy. Meteor. Soc.*, **126**,2069-2088.

Fu, X., B. Wang, D. E. Waliser, and L. Tao, 2007: Impact of atmosphere-ocean coupling on the predictability of monsoon intraseasonal oscillations. *J. Atmos. Sci*., **64**, 157-174.

Hendon, H.H., B. Liebmann, M. Newman, J.D. Glick, and J. Schemm, 1999: Medium range forecast errors associated with active episodes of the MJO. *Mon. Wea. Rev.*, **128**, 69-86.

Kim, H.-M, I.-S. Kang, B. Wang, and J.-Y. Lee, 2007: Simulation of intraseasonal variability and its predictability in climate prediction models. *Climate Dyn.*, Doi 10. 1007/S00382-007-0292-3.

Krishnamurti, T. N., C. M. Kishtawal, T. E. LaRow, D. R. Bachiochi, Z. Zhang, C. E. Williford, S. Gadgil, S. Surendran, 1999: Improved skills for weather and seasonal climate forecasts from multi-model superensemble. *Science*, **285**, 1548-1550.

Lau, W. K. M., and D. E. Waliser (Eds.), 2005: *Intraseasonal Variability of the Atmosphere-Ocean Climate System*, 474 pp., Springer, Heidelberg, Germany**.**

Madden, R. A. and P. R. Julian, 1971: Detection of a 40-50 day oscillation in the tripics. *J. Atmos. Sci.*, **43**, 3138-3158.

Madden, R. A., and P. R. Julian, 1994: Observations of the 40-50-Day Tropical Oscillation - a Review. *Mon. Wea. Rev.*, **122**, 814-837.

Palmer, T. N., 2000: Predicting uncertainty in forecasts of weather and climate. *Rep. Prog. Phys.*, **63**, 71-116.

Shukla, J., J. Anderson, D. Baumhefner, C. Brankovic, Y. Chang, E. Kalnay, L. Marx, T. Palmer, D. Paolino, J. Ploshay, S. Schubert, D. Straus, M. Suarez, and J. Tribbia, 2000: Dynamical Seasonal Prediction. *Bull. Amer. Meteor. Soc.*, **81**, 2593-2606.

Sperber, K. R. and D. E. Waliser, 2008: New approaches to understanding, simulating, and forecasting the Madden-Julian Oscillation. *Bull. Amer. Meteor. Soc.*, **89**, submitted.

Vitart, F., S. Woolnough, M. A. Balmaseda, and coauthors, 2008: Monthly forecast of the Madden-Julian Oscillation using a coupled GCM. *Mon. Wea. Rev.*, **135**, 2700-2715.

Waliser, D. E., K. R. Sperber, L. Donner, J. Gottschalck, H. Hendon, W. Higgins, I. Kang, D. Kim, D. Legler, E. Maloney, M. Moncrieff, S. Schubert, W. Stern, F. Vitart, B. Wang, W. Wang, K. Weickmann, M. Wheeler, S. Woolnough, and C. Zhang, 2009: MJO Simulation Diagnostics, *J. Climate*, submitted

Wang, B., 2006: The Asian Monsoon. Published by Springer and Praxis Publishing, 787pp.

Webster, P. J., and Coauthors, 1998: Monsoon: Processes, predictability and the prospects for prediction. *J. Geophys. Res.*, **103**, 13341-14510

Woolnough, S. J., F. Vitart, and M. A. Balmaseda, 2007: The role of the ocean in the Madden-Julian Oscillation: Implications for the MJO prediction. *Quart. J. Roy. Meteor. Soc.*, **133**, 117-128.

Yasunari, T., 1979: Cloudiness fluctuations associated with the Northern Hemisphere summer monsoon. *J. Meteor. Soc. Japan*, **57**, 227-242.

National Oceanography Centre, Southampton
University of Southampton Waterfront Campus
European Way, Southampton SO14 3ZH
United Kingdom
Tel: +44 (0) 23 8059 6777
Fax: +44 (0) 23 8059 6204
Email: icpo@noc.soton.ac.uk