Newsletter of the Climate Variability and Predictability Programme (CLIVAR)

Exchanges

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December 2003

Special issue on: Coupled Modelling

Latest CLIVAR News

- CLIVAR Conference Registration Deadline for a discounted fee is March 15th 2004
- Indian Ocean Panel formed. Visit http://www.clivar.org/organization/indian/
- Visit the calendar for details of meetings and conferences: http://www.clivar.org./calendar/index.htm

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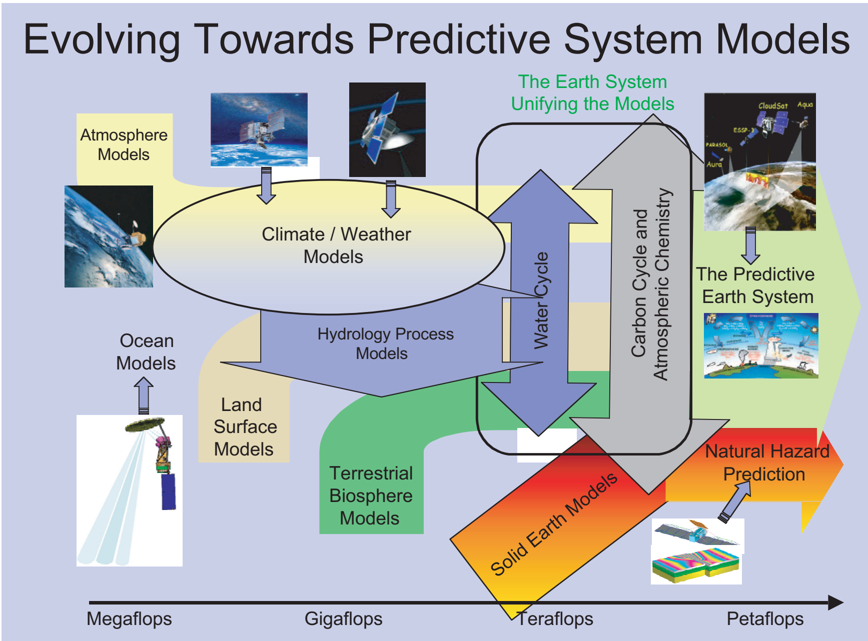
The European Network for Earth System Modelling (ENES)



Coupled Climate Modelling evolves towards comprehensive Earth system modelling encompassing more and more components, such as biosphere, land surface, atmospheric chemistry and carbon cycle.

The PRISM approach described on page 18 will facilitate the exchange of different model components by building up an infrastructure of Earth System Models.

The figure illustrates the complex interactions of the different model components and their increasing demand in computational resources.

Call for Contributions

We would like to invite the CLIVAR community to submit papers to CLIVAR Exchanges for the next and subsequent issues. The overarching topic of the next issue will be on **'science related to the South American Low Level Jet Experiment'**. The deadline for this issue is **January 31, 2004.** The topic for the subsequent issue is **'Applications to CLIVAR Science'** and the deadline is **March 31st, 2004.**

Guidelines for the submission of papers for CLIVAR Exchanges can be found under: http://www.clivar.org/publications/exchanges/guidel.htm

CLIVAR is an international research programme dealing with climate variability and predictability on time-scales from months to decades.

CLIVAR is a component of the World Climate Research Programme (WCRP).

Editorial

Dear CLIVAR community,

CLIVAR in 2004

5 years after the 'official' start of CLIVAR, at the CLIVAR Conference in Paris, the impact of CLIVAR as a major driving force for international coordinated climate research is getting more and more visible. A number of countries already have specific CLIVAR funding lines, others have devoted funding for CLIVAR research under various programmes (e.g. Rapid (UK), DEKLIM (Germany) and others). Even for regions where we expected that the implementation of internationally coordinated research will be difficult, such as Africa or the Southern Ocean, our panels have made considerable progress to develop activities in order to facilitate CLIVAR research.

During the next year our main emphasis will be to assess what we already have accomplished during this first phase of the programme and even more important we will set the course for the future of CLIVAR. The CLIVAR Conference in Baltimore (http://www.clivar2004.org/) will be the milestone for the assessment, supported by a more objective review of the entire programme which will be done during the next months. These two pieces together will document where we stand now, identify gaps, and provide a vision for the future.

New CLIVAR groups developing

In order to address the specific needs for international coordinated projects within the Indian Ocean, CLIVAR has formed an Indian Ocean Panel in collaboration with IOC. The panel will be chaired by Dr. Gary Meyers (CSIRO, Australia) and meets for the first time jointly with the Asian-Australian Monsoon Panel in Pune, India, February 2004. Preliminary information about this group can be accessed through the CLIVAR web site under http://www.clivar.org/organization/indian/. Another group which is currently under development is the CLIVAR Global Synthesis and Observations Panel. This group will address issues related to global observations, data assimilation and synthesis as well as data management.

This issue of Exchanges

Over the years, Exchanges has documented the development and progress of the programme. We started almost 8 years ago reporting mainly from CLIVAR meetings but as more and more science was done under the CLIVAR umbrella, we shifted the scope in that direction. This issue, focusing on coupled modelling, has for the first time a topic that we already had before, 4 years ago. Since a number of meetings related to climate modelling have taken place during this fall, e.g. the International Conference on Earth System Modelling in Hamburg, followed by the second CMIP workshop and the JSC/CLIVAR Working Group on Coupled Modelling, we thought that it would be very appropriate to focus again on this topic to document the progress made over the past years. Again, as for the previous issues, we have received an overwhelming response. Due to the gracious support of our new sponsors, the Chinese Academy of Sciences, which is now providing funding for the printing of Exchanges, we are able to highlight the wide range of CLIVAR science in the area of coupled modelling. The full suite of contributions, including those of this printed issue, is available in reprint-style pdf-format under: http://www.clivar.org/publications/exchanges/ex28_cont.html.

Staff news

As some of you might have already heard, my official CLIVAR involvement will end by end of this year. We are very grateful to the German funding agency BMBF who has supported the office and part of my position for more then 8 years. Unfortunately, it was not possible for BMBF to continue their commitment for the ICPO. My new affiliation will be with Peter Lemke, the chairman of the Joint Scientific Committee for WCRP. Although my responsibilities will have a more general WCRP-wide focus, I hope to be able to spend part of my time to support the ICPO and CLIVAR. Nevertheless, I will resign from my function as an editor of Exchanges. Howard Cattle will continue as the lead editor, assisted from staff members, depending on the overarching theme. I would like to thank you all for your contributions and efforts over the past years. It has been a pleasure to work with all of you in the CLIVAR community. I wish you a Happy New Year and all the best for the future.

Andreas Villwock

As you will have read above, Andreas is moving on from his work for CLIVAR to play a wider WCRP role. During his years with the ICPO, Andreas has been a tower of strength in his provision of support for CLIVAR. Not only has he been the lead editor of Exchanges but he has acted as manager of the CLIVAR web site overall and provided key support, in particular, to CLIVAR's modelling groups and the CLIVAR/PAGES Intersection. Andreas's enthusiasm for CLIVAR and his guardianship of it have been boundless and we in the CLIVAR community owe him a debt of gratitude for all of his efforts over the years. We are working out the division of Andreas's tasks within the ICPO but are indeed grateful to Peter Lemke, Chairman of the JSC, for agreeing that Andreas can spend some of his time on CLIVAR activities. Many thanks, Andreas, and very best wishes in your new job, which is of course still much in the interests of CLIVAR in the wider WCRP context.

Howard Cattle

A Study of the Antarctic Circumpolar Wave in the NCAR Coupled Model

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Abstract

The simulation results obtained with a version of the National Center for Atmospheric Research/ Community System Model – CSM, run for 150 years, are used to identify the Antarctic Circumpolar Wave. Hovmoeller diagrams show eastward propagating patterns of sea surface temperature and of subsurface ocean temperature anomalies (at 250m depth). In this coupled model ocean dynamics play a predominant role in explaining the Antarctic Circumpolar Wave. Preliminary results from Empirical Orthogonal Function analysis reveal, for example, that the first spatial mode for subsurface temperature exhibits a combination of both zonal wave numbers two and three which is in agreement with other numerical studies that show a predominance of the same wave numbers.

1. Introduction

The Antarctic Circumpolar Wave (ACW) was first discussed by White and Peterson (1996). They used four types of data to characterize it: i) anomalies in sea ice edge (SIE), sea level pressure (SLP), sea surface temperature (SST) and wind stress. The ACW as revealed by their analysis exhibits a wavenumber two structure and takes 8-10 years to travel around the globe. This is also consistent with the ACW observed by Jacobs and Mitchell (1996) using sea level height data.

Analytical ocean-atmosphere coupled models of the ACW were constructed by Qiu and Jin (1997), White et al. (1998) and Haarsma et al. (2000). Qiu and Jin (1997) proposed a mechanism for the ACW based on local ocean-atmosphere interaction. Following this idea, White et al. (1998) using a simplified model, found that in the absence of ocean-atmosphere coupling, the SST anomalies are advected slowly and soon dissipate, whereas with active coupling advection occurs at the observed speed. Haarsma et al. (2000) using the ECBilt model investigated the physical processes and feedback mechanisms of the ACW. In their model, the ACW-like mode is generated by the advective resonance mechanism of Saravanan and McWilliams (1998), which assumes that the ocean passively advects SST anomalies that are generated by the atmospheric circulation anomalies. On the same note, White et al. (2002) found the ACW in the eastern Pacific and western Atlantic sectors to be a result of damped resonance remotely forced by the slow eastward phase propagation of covarying SST and SLP anomalies associated to what they called Global ENSO Wave (GEW).

In this paper, we investigate the existence of an ACW-like signal in the CSM 1.4 coupled model using 150 years of simulation data. The model description is summarized in section 2. Section 3 contains the preliminary results and discussion. Finally, in section 4 the conclusions are drawn.

2. Model Description

The coupled climate system model contains four components: atmosphere, ocean, land surface processes and sea-ice, as discussed in Bonville and Gent (1998). The atmospheric component, the CCM3, which is described in Kiehl et al. (1998), Hack et al. (1998) and Briegleb and Bromwich (1998), is a spectral model. The standard configuration employs T31 truncation (3,75º) with 18 levels in the vertical. The land surface biophysics model is the LSM 1, described in Bonan (1996), and runs on the same grid as CCM3. The ocean model (NCOM) described in Otto-Bliesner and Brady (2001) has a configuration of 3.6º resolution in longitude and variable resolution in latitude. In the vertical, 25 levels are used, with 3 equal depth levels in the upper 50m and 12 levels in the upper kilometer of the ocean. The sea-ice model is described in Weatherly et al. (1998). The control run used here is also described in Otto-Bliesner and Brady (2001).

3. Results and Discussion

Hovmoeller diagrams of SST anomalies (with the mean seasonal cycle removed) are examined in order to bring out propagation characteristics that could be associated with the ACW mechanism proposed by White and Peterson (1996). The pattern of dominating eastward propagation from the simulation results from year 69 until 77; from year 73 until 81 and from year 76 until 84 is shown in Figure 1 for the latitudinal average between 50ºS – 60ºS. This pattern progresses taking 8 years to circle 360º around the globe. The magnitude of the SST anomalies are as large 0,9ºC in the Pacific sector. Comparison with White and Peterson (1996) shows consistency in magnitude and location with their SST anomalies, obtained from observed data. It is clear that the model is able to capture an ACW-like pattern similar to that observed by White and Peterson (1996).

In Figure 2, the Hovmoeller diagrams, averaged between 50ºS - 60ºS, for the simulated subsurface temperature anomaly at a depth of 250m (T250) are shown. T250 is investigated to look for ACW-like eastward propagation without surface contamination. The Hovmoeller diagrams clearly show eastward propagation for the same intervals as for SST (e.g. Figure 1). Maximum amplitudes of up to 0,35ºC are found between 130ºW – 100ºW. Marsland et al. (2003) have observed salinity and

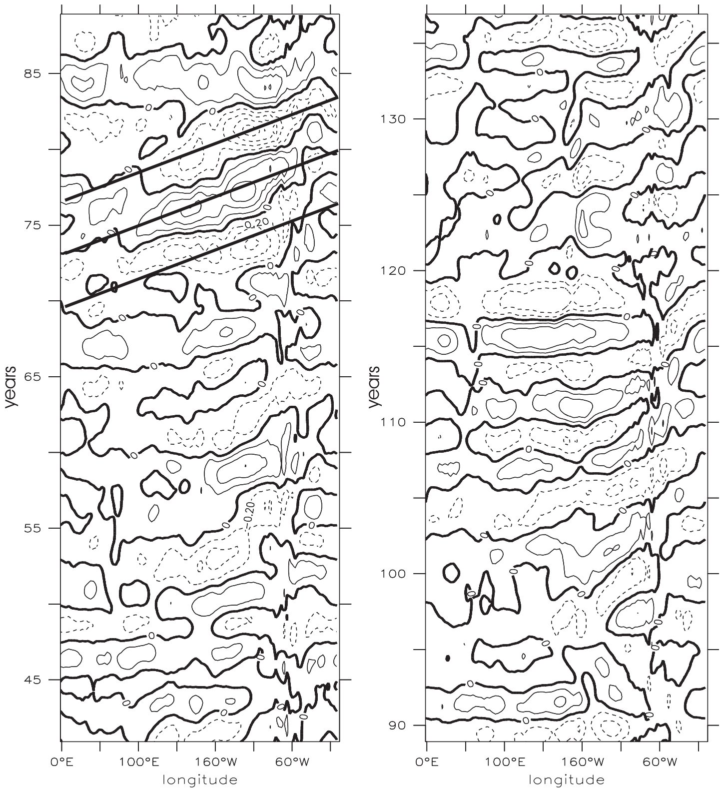

Fig. 1: Hovmoeller diagrams of SST anomalies (latitudinal average 50ºS – 60ºS). Unit of temperature in ºC and contour line intervals in 0,2ºC.

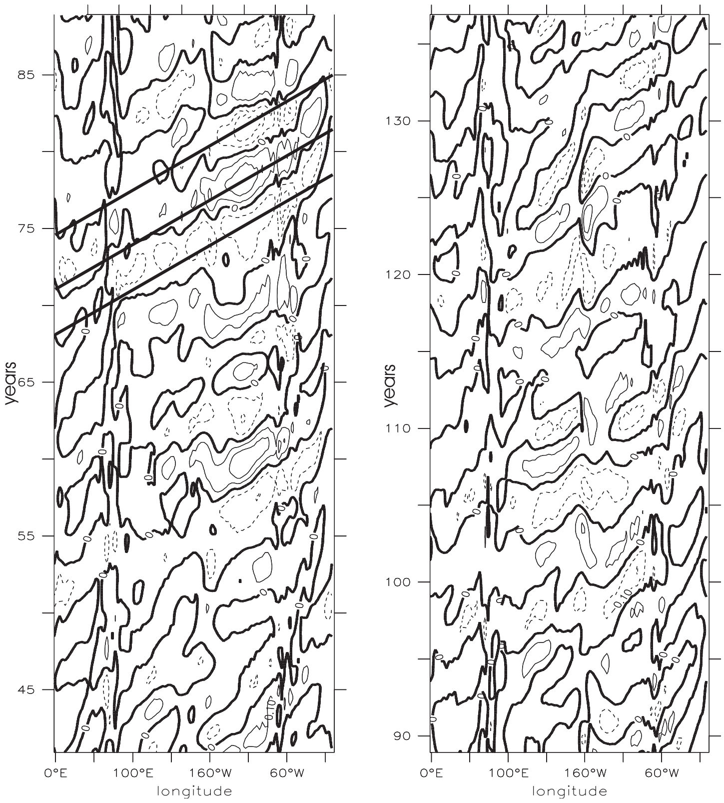

Fig. 2: Hovmoeller diagrams of T250 anomalies (latitudinal average 50ºS – 60ºS). Unit of temperature in ºC and contour line intervals in 0,1ºC.

subsurface temperature anomalies between 225 – 275m in the ECHO-G model, described in Legutke and Voss (1999). They have shown that both salinity and subsurface temperature display eastward propagation characteristics similar to Figure 2. They also discuss two important discernable features; firstly that the magnitude of the anomalies attains a maximum in two regions: the SE Indian Ocean near 90ºE and in the SE Pacific Ocean near 270ºE; and secondly that the propagation rate of the patterns is reduced with depth which does not occur in the CCM-simulated T250 field with respect to the surface.

The spatial pattern for the first EOF of T250 anomalies is plotted in Figure 3. It accounts for only 13% of the total variance. This mode shows a combination of both wavenumbers two and three in its spatial pattern that is in part consistent with the ACW in White and Peterson (1996). Other model studies such as that of Christoph et al. (1998), are able to capture an ACW-like oscillation with the same spatial structure. They found propagation characteristics in SST similar to the ACW in the Max Planck Institute coupled general circulation model, though they noted that in this model the ACW-like oscillation had the predominance of both wavenumbers two and three rather than the observed wavenumber two of White and Peterson (1996).

In the CSM 1.4, the subsurface temperature signal that is in phase with the surface hints that it's ACW-like wave is a result of predominant ocean dynamics rather than air-sea interactions like most other modelling studies: Bonekamp et al. (1999) studied the ACW using experiments with a geostrophic ocean model forced by ECMWF reanalyses. They found that oceanic anomalies with an ACW-like signature could be generated by a one-way atmosphere to ocean forcing. Weisse et al. (1999) forced the same ocean model with spatially realistic and temporally random atmospheric forcing, and generated a variety of ACW-like oceanic anomalies, depending upon the pattern of forcing imposed.

4. Conclusions

Variability associated with the ACW-like pattern simulated by the CSM 1.4 bears similarities to the ACW described by White and Peterson (1996). The temporal evolution of the simulated sea-surface temperature anomalies seen in the Hovmoeller diagrams, indicate intermittent eastward propagation with consistent periods of 8 -10 years circling the globe. Considering that the subsurface signal is stronger than the surface, as shown in the EOF analysis, it is thought that air-sea coupling is not essential for generating the structure and the time scale of the ACW-like mode in the CSM. The

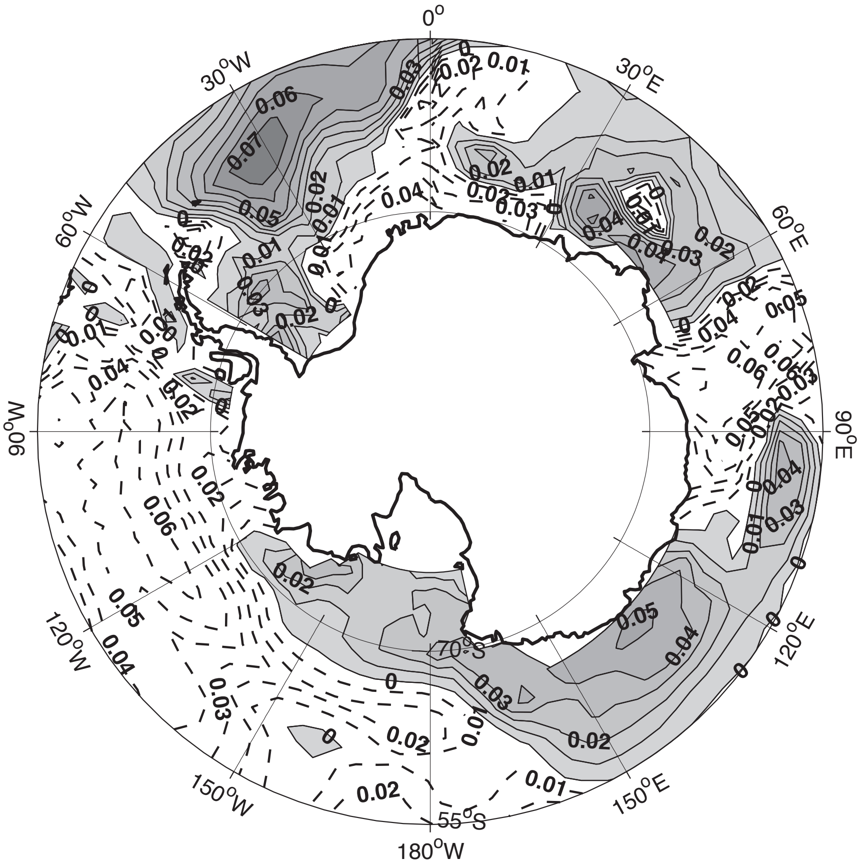

Fig. 3: First EOF spacial mode for T250. Contour line intervals in 0,01ºC.

ACW-like mode shown here could be thought of an oscillation in the interior of the ocean with surface manifestations. Currently more work is being done to understand its genesis in the model and the physical processes associated along with its links to other global scale phenomena, such as ENSO.

Acknowledgements

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North Atlantic Decadal Predictability

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Introduction

There is increasing evidence (from both observations (e.g. Koltermann et al., 1999) and models (e.g. Dong and Sutton, 2001)) of decadal time-scale fluctuations in the circulation of the Atlantic Ocean. Variations in the meridional overturning circulation (MOC) may impact on the surface climate of both the ocean and the atmosphere through changes in the northward transport of heat by the ocean. Predictions of such decadal variations could bring considerable benefit to society, yet these remain unrealised partly because previous studies of predictability have revealed low levels of potential skill (Griffies and Bryan, 1997; Grötzner et al., 1999). This study represents an assessment of the potential predictability of variations in MOC and associated Sea Surface Temperature (SST) anomalies in a range of recent coupled atmosphere-ocean-sea ice models. It is found that, while different models do produce different estimates of predictability, some models show high levels of potential skill on time-scales of decades and longer that may, one day, be exploited by forecasters.

Experimental Design

The coupled model experiments are of the form of "perfect ensemble" experiments, in which ocean initial conditions are fixed and the ensemble is generated by taking different atmospheric initial states. Thus the ensemble spread represents that which would be obtained in a hypothetical operational forecast system in which the ocean state is exactly known and the model is perfect (Collins, 2002). Thus it provides an upper limit on the estimate of predictability. Five models were used to perform experiments (HadCM3 (Gordon et al., 2000), ECHAM5/MPI-OM1 (Latif et al., 2003), ARPEGE3 (Jouzeau et al., 2003), BCM (Furevik et al., 2003) and INGV (Frankignoul et al., 2003)) initiated from unforced control integrations, with ensemble sizes varying from 3 to 9 and the length of the experiments varying from 20-30 years. An attempt was made to initiate experiments from high, low and (in the case of 2 models) intermediate values of the strength of the MOC. The experiments were performed as part of the European Union Framework 5 project PREDICATE (Sutton et al., 2003) and represent 1340 coupled model years of ensemble experiments, together with 3100 years of control experiments used to assess levels of natural variability. None of the models used employ flux corrections.

Results

The coupled models all have very different magnitudes of natural internal decadal variability in their respective control integrations (Figure 1, page 16). The ECHAM5/MPI-OM1 model shows the largest variability, with peak-to-peak variations of up to 6 Sverdrups in the MOC and 2K for SSTs averaged in a region of the North Atlantic. The HadCM3 model shows slightly weaker variability than does ECHAM5/MPI-OM1 and the ARPEGE3 and BCM models (which share a common atmosphere) show the weakest. Output from the INGV model is also shown, although it is difficult to assess levels of variability as in this model the ocean component is not in equilibrium resulting in a drift in MOC strength and SST.

We identify potential predictability in the ensemble experiments when either the ensemble spread is small with respect to the background levels of natural variability, or when the ensemble mean is shifted with respect to the climatological average value indicating a bias in the probability of greater or less than average conditions. Without resorting to quantitative measures of ensemble "skill" or predictability (there is no universal measure) it can be clearly seen that there is some potential skill in the ensemble experiments on decadal time scales (Figure 1). The ECHAM5/MPI-OM1 model shows the highest level of decadal predictability: for each ensemble member the spread in both MOC and SST is significantly smaller than the background level of variability and the ensemble mean is displaced with respect to the long term climatological mean (Pohlmann et al., 2003). The HadCM3 model also has some decadal predictability (Collins and Sinha, 2003, give quantitative measures) but less than that seen in ECHAM5/MPI-OM1. For both these models there is also some indication of weak but significant potential predictability of surface temperatures over land areas in Europe (Collins and Sinha, 2003). The ARPEGE3 and BCM models perhaps show the lowest levels of predictability with the ensemble spread saturating after only a few years. While the INGV model appears to show significant levels of decadal predictability, this may be related to the model drift. Care should be taken in assessing levels of predictability in models that are not in equilibrium.

Summary

These new model experiments indicate that there may be some potential for initial-value decadal predictions of climate. In general, models that show the highest levels of decadal variability also show the highest levels of decadal predictability: so which model is right? Quantitative validation of the levels of decadal variability in the models is hampered by the short observational record and sparse palaeo-proxy record, and by the fact that these are records of not only the natural internal variability but also forced natural and anthropogenic variations (Collins et al., 2002). Hence it is not possible, at present, to say which model has the more realistic decadal variability and hence more realistic decadal predictability.

Studies of this type, which identify predictable signals, are the first step towards any future operational forecasting system. In any such system the most pressing problem would be in producing an adequate ocean analysis from which to initiate the forecast from sparse subsurface ocean observations. However ocean-only model experiments carried out during the PREDICATE project (Sutton et al., 2003), forced with the same time-history of surface fluxes of heat, moisture and momentum show that this alone may be adequate to constrain the trajectory of the ocean model, at least in terms of the decadal component of the variability of the MOC. Hence a *balanced* set of fluxes from, e.g., a re-analysis product would be a high priority. Further work should also concentrate on why the models shown here produce such a wide range of decadal variability and predictability.

Acknowledgements

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The Response of Climate Variability and Mean State to Climate Change: preliminary results from the CSIRO Mark 3 coupled model

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1. Introduction

The response of the mean state and modes of climate variability to climate change forcings is one of the most important issues in climate research. This issue is particularly relevant for Australia, where a highly variable climate, often characterised by severe floods and drought, is strongly influenced by the El Niño-Southern Oscillation (ENSO), north-south variations in the mid-latitude high-pressure belt position (Pittock, 1973), and, possibly, Indian Ocean sea surface temperature (SST) variations (e.g., Nicholls, 1989). A change in the properties of such modes may result in significant changes to Australian rainfall variability. Further, global warming signals may project onto these modes, contributing to secular trends in rainfall climatology. Trends towards lower rainfall in some regions suggested by global climate models would compound with rising temperatures and potential evaporation to exacerbate the strain on future water resources.

Several of the above aspects have been examined using the CSIRO Mark 2 model, including whether the Pacific warming pattern is El Niño-like or La Niña-like (Cai and Whetton, 2000; 2001) and whether an observed rising trend in mean sea level pressure (MSLP) at southern mid-latitudes (Cai et al., 2003a) can be at least partially attributed to global warming. The Mark 2 model studies are, however, limited by low resolution of the model and the fact that the model ENSO is too weak, with an amplitude of about one third of the observed. Thus the issue of ENSO response to climate change could not be addressed.

A greatly improved, non-flux adjusted, higher-resolution model, referred to as the CSIRO Mark 3 model, has since been established. This model has resolution of 1.85^{o} longitude, and 1.85^{o} or 0.93^{o} latitude for the atmospheric and oceanic components, respectively. More details can be found in Gordon et al. (2002). One control and two climate change experiments with the Mark 3 model have been carried out, providing an opportunity to revisit some of the issues discussed above. Here we present some preliminary results. In particular, we focus on processes that potentially control changes in Australian climate variability and rainfall patterns.

2. Model simulations

The two climate change simulations begin in calendar years 1961 and 1871, respectively, and follow the IPCC A2 emissions scenario for greenhouse gases, sulfate aerosols and ozone concentrations through to 2100. The results from the two climate change simulations are consistent within bounds of natural variability over the 21st century, and the simulations will be referred to as the "1961 transient" and "1871 transient", respectively. The 1871 transient simulation has been continued beyond 2100, using perpetual atmospheric concentrations as in 2100. Both experiments include the observed time-varying ozone concentrations (including stratospheric ozone depletion) up to year 2000 and a projection thereafter.

3. Model ENSO Response

A description of ENSO behaviour in the Mark 3 control simulation can be found in Cai et al. (2003b). The SST and wind anomalies associated with ENSO extend somewhat too far into the western Pacific warm pool, in common with many other models. The spectrum of central equatorial SST displays strong power at periods of 3-5 year as observed but also excessive biennial variability (another common model problem). Nevertheless, the otherwise broadly realistic amplitude and pattern of the model ENSO allows us to address how ENSO may respond to climate change.

Spectral analysis of time series of Niño3.4 SST anomalies for the Mark 3 climate change experiment reveals there is little change in the distribution of ENSO frequency during global warming. The anomalies are calculated with reference to a climatology of the control experiment. The model ENSO under a warming climate still has 3-5 year period and biennial components that are as prominent as in the control run (in terms of percentage of the total ENSO variance).

To address the question of change in ENSO amplitude, time series of standard deviation of Niño3.4 SST anomalies (calculated using a 31-year sliding window) for the three Mark 3 experiments and also two experiments using the Mark 2 model, one control and one forced with the IS92A emissions scenario, are plotted in Fig. 1 (page 16). There is little evidence from Fig. 1 of any substantial change in amplitude of ENSO in the climate change simulation. These results suggest that ENSO will continue to be a robust feature of the future climate.

4. Mean State Response

Cai and Whetton (2000, 2001) found that in the Mark 2 warming run, the change in SST since the 1970s shows an El Niño-like pattern. Such an El Niño-like warming pattern is also obtained in the warming run of the Mark 3 coupled model. Figure 2 (page 17) expresses this pattern, which is derived via the following procedures.

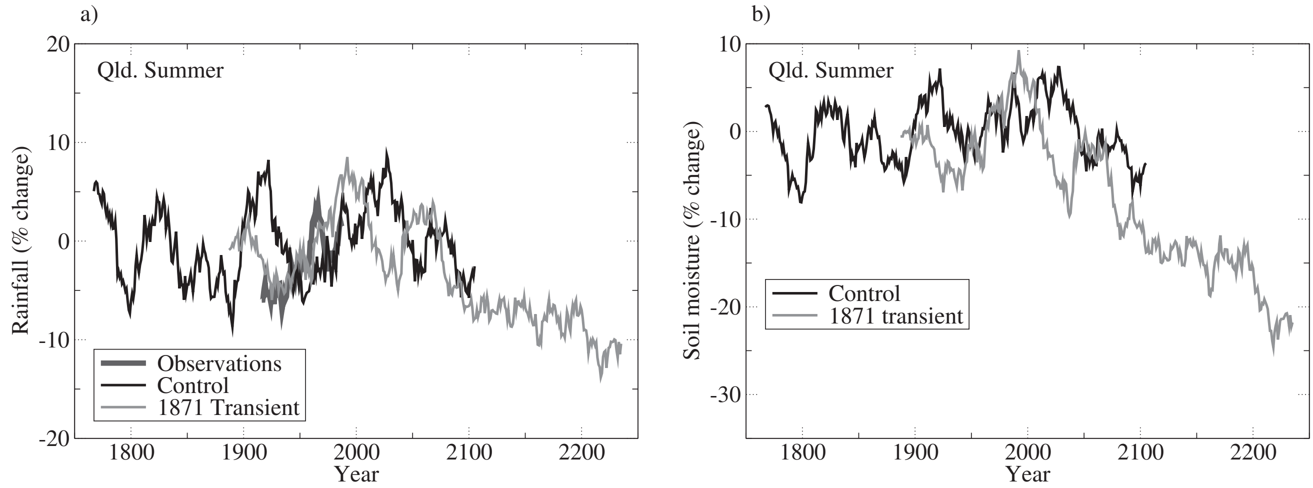

Fig. 3: a) Time series of summer rainfall (11-year running mean) over northeastern Australia (20°S northward and 145°E eastward) in Mark 3 control experiment (dark grey curve), and climate change experiment (light grey curve). b) the same as a) but for soil moisture 10 m below surface.

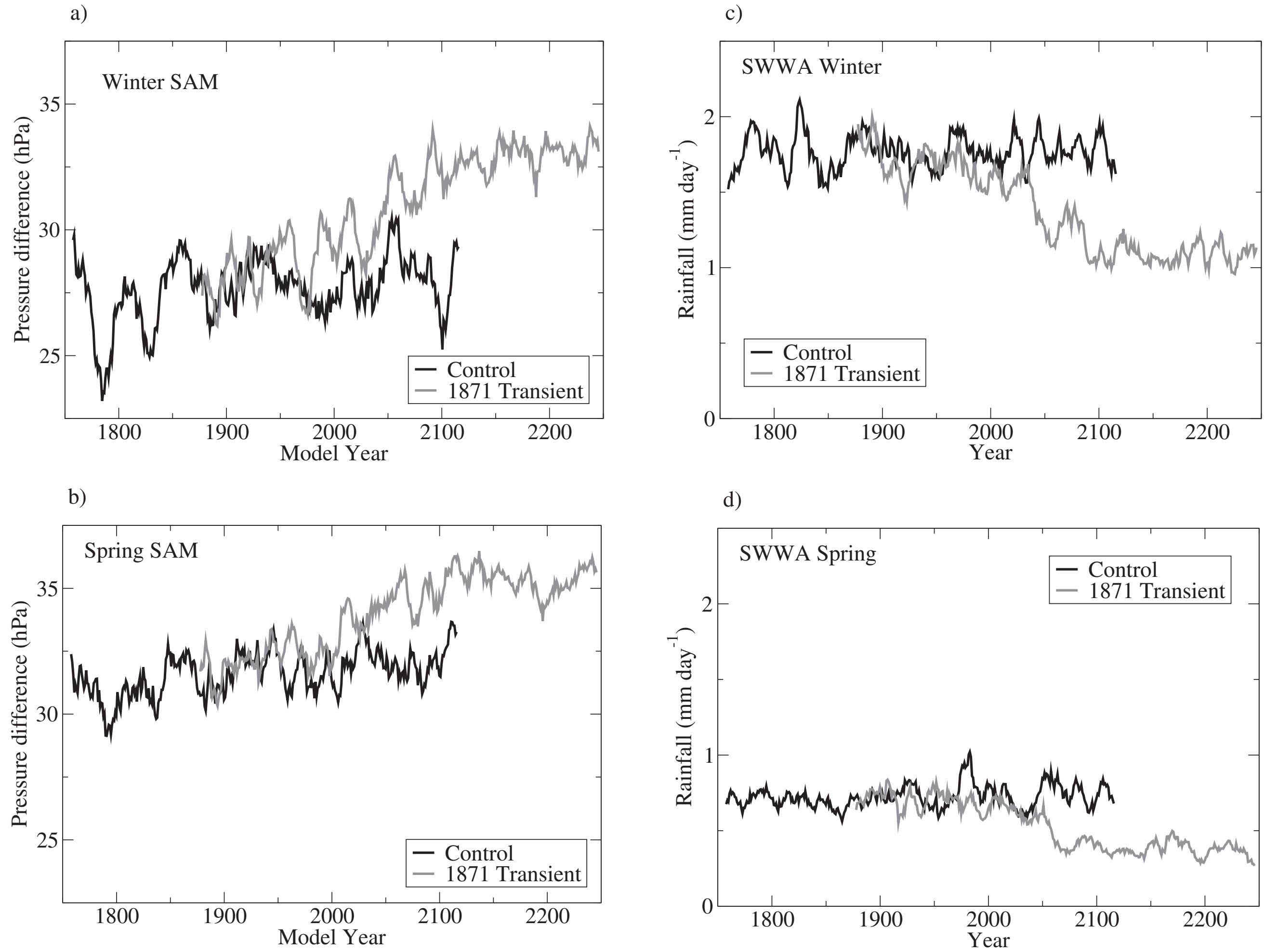

Fig. 4: Time series of an index (11-point running mean) of the SAM for a) winter season and b) spring season for the control (dark grey curve) and climate change (light grey curve) experiments. The index is defined as the difference between MSLP averaged over the latitude band 35°S-45°S and that averaged over 55°S-65°S. Also shown are time series of rainfall (mm per day) over SWWA in c) winter and d) spring season.

First, a time series of the annual mean global surface temperature is constructed. Second, a linear regression is carried out by regressing annual mean SST at each grid point onto the annual mean global surface temperature. Plotted in Fig. 2 are the regression coefficients. Fig. 2 then indicates the warming rate at each grid point per unit increase in global mean temperature. The model El Niño-like pattern is clearly shown with the tongue feature that extends too far into the western Pacific.

Other interesting features include a dipole-like response in the northwest North Atlantic region, strong warming in the Greenland, Iceland and Norwegian Seas, and strong warming in the Tasman Sea region. The warming rate expressed in the western Tasman Sea region is the largest in the Southern Hemisphere, at almost twice the rate of the global mean warming. This prominent feature did not appear as noticeably in the Mark 2 warming experiment, presumably due to the lower resolution (when compared to Mark 3) not resolving the region adequately. The processes controlling this feature are under investigation. The dipole response pattern in the northwest North Atlantic is due to a weakening in North Atlantic Deep Water Formation.

5. Rainfall and Soil Moisture Response in Northeastern Australia

As in Mark 2, a consequence of the model El Niño-like warming pattern is that rainfall over the northeastern Australian region decreases, as shown in Fig. 3a, which shows 11-year running mean rainfall in terms of percentage of the control climatology for the summer season. As warming proceeds, the decreasing trend eventually exceeds the range (-10% to 10%) of decadal and interdecadal variations. The maximum reduction in rainfall reaches 14%. A similar time series of summer soil moisture change for the same region (Fig. 3b) demonstrates a rather more substantial decline in soil moisture, with a maximum reduction reaching 24%. This much larger decrease in the soil moisture is due to increased potential evaporation in a warming climate and illustrates the compounding effect of warming upon a decreasing rainfall trend.

6. Response of the Southern Annular Mode (SAM)

Early studies (e.g., Pittock, 1973) showed that the position of the mid-latitude high-pressure belt fluctuates, so when the high pressure belt moves southwards, MSLP at mid-latitudes increases and rainfall over southwest Western Australia (SWWA) decreases. This is part of the southern annular mode (SAM) (Thompson and Wallace, 2000), the predominant mode of the Southern Hemispheric circulation. Superimposed on these variations is a trend associated with an increasing MSLP in mid-latitudes, and a declining MSLP in high latitudes. This “upward” trend in the SAM indices appeared to form in the late 1960s and early 1970s. In association, since this time, there has been a rainfall decreasing trend in SWWA, with winter rainfall decreasing, in some parts by as much as 20% (Smith et al., 2000; IOCI, 2002). As in Mark 2 warming experiments (Cai et al., 2003a), the Mark 3 climate change experiments produce an upward trend of the SAM (Fig. 4a and 4b) and a decreasing trend of rainfall over SWWA (Fig. 4c and 4d), in both winter and spring. The rate of the SAM upward trend is slightly greater in the winter season.

In contrast to the observed decrease in winter rainfall, a decrease in the spring season rainfall has yet to be observed in SWWA.

7. Conclusions

Preliminary results from climate change experiments using the CSIRO Mark 3 model, show that ENSO continues to be a robust predominant mode of variability in a warming climate. In each of the two-members of the ensemble forced by the IPCC A2 scenario, there is little change in the ENSO frequency and amplitude. Both ensemble members show an El Nino-like pattern of mean-state change for the tropical Pacific, with a decreasing rainfall trend apparent over northeastern Australia. The impacts of this decreasing rainfall trend are exacerbated by the higher temperature and potential evaporation over the land. Both climate change experiments produce a warming rate in the Tasman Sea region twice as large as that of the global mean surface temperature. As in the CSIRO Mark 2, the southern annual mode index shows an upward trend with increasing MSLP in midlatitudes and a decreasing rainfall trend over SWWA in both the winter and the spring seasons. The relative importance of ozone and greenhouse forcing in generating these changes in each season needs further investigation.

Acknowledgement

We are grateful for the efforts of other members of the Earth System Modelling Programme who are responsible for the development of CSIRO climate models.

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Transient coupled ensemble climate simulations to study changes in the probability of extreme events

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Introduction

Over the last decade, climate models have grown in complexity at a fast pace. One reason is the inclusion of an increasing number of physical processes that are thought to be relevant. Another reason is the extended range of spatial scales that is captured due to an increased numerical resolution. Both factors increase the computational load of climate model simulations and limit the amount of sensitivity studies that can be performed.

It is an empirical fact that climate models need to be tuned; when components are coupled from realistic initial states, the coupled system drifts toward its own statistical equilibrium. Additional integrations allow researchers to pinpoint possible causes of the drift and adjust specific model parameters to improve the match with the observed behaviour of the climate system. Although improved physical parameterizations and increased resolution should in principle lead to more realistic simulations, it is often only after the 'tuning' process that the latest model version generally outperforms the previous.

To assess changes in the climate due to presumed increasing levels of greenhouse gases (GHG) in the near future, often just one or a few transient coupled climate simulations are performed for a given scenario of the future emissions due to the high computational demand of a single simulation. This allows an assessment of the mean climate change. But if one wants to investigate possible changes in the probability and character of extreme events, a large ensemble of such simulations is necessary.

The ensemble experiment

In order to study the probability of extreme events in a changing climate, the Netherlands Centre for Climate Research (CKO) decided to produce a large ensemble of transient climate simulations. This summer the NCAR Community Climate System Model, version 1.4, was ported to the SGI 3800 machine of the Academic Computing Centre at Amsterdam (SARA). During three months, 256 of its processors were dedicated to this project. The choice for CCSM1.4 was motivated by computational constraints, the fact that this version was carefully tuned to simulate the ENSO phenomenon rather well (Otto-Bliesner and Brady, 2002) and the relative little effort involved in preparing the system to suit our purpose.

The system was integrated 62 times for the period 1940-2080. During the historical part of the simulation, GHG concentrations, sulphate aerosols, solar radiation and vulcanic aerosols were prescribed according to observational estimates, kindly provided by C. Ammann (Ammann et al, 2003). From 2000 onwards, the solar constant was held constant and sulphate aerosols were kept fixed. Only the GHG concentrations varied according to a Business-as-Usual scenario. This scenario is similar to the SRES A1 scenario (Dai et al, 2000). The ensemble members differ only in a small random perturbation in the initial temperature field of the atmosphere, enough to lead to entirely different atmospheric evolutions within the first couple of weeks of the integrations. The initial state was obtained from the simulations of Ammann (personal communication).

Some preliminary results

Figure 1 shows the global mean surface air temperature as simulated by all 62 members, the ensemble mean and an observational estimate obtained from the Climatic Research Unit (CRU). The simulated temperatures cover the observations very well. The effect of the volcanos, Agung (1963), El Chichon (1982) en Pinatubo (1991) is clearly visible as a temporary cooling on the order of several tenths of a degree. The temperature decrease between 1940-1970 is related to the decreased solar radiation in this period. The temperature rise after 2000 is solely due to the increased concentrations of GHGs. Extrapolating the rise to 2100 leads to a global warming of about 1.5 degrees in this century. This is on the low

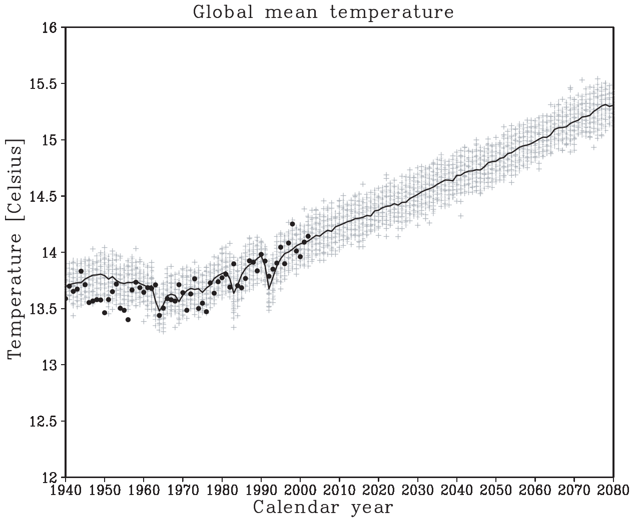

Fig. 1: Global mean temperatures of all 62 simulations (light crosses), the ensemble mean (solid line) and observed temperatures from the Climate Research Unit (dark dots). The CRU timeseries obtained were anomalies wrt the 1960-1990 period. We added the ensemble mean simulated temperature over this period.

side of the range (1.4 to 5.8 degrees) established in the IPCC Third Assessment Report (2001). This range is based on results from different model simulations and emission scenarios.

For a grid box, partially overlapping the Netherlands, we calculated the mean winter and summer temperatures in all simulations (Fig. 2, grey crosses) and compared these with temperatures from weather station De Bilt in the Netherlands (black dots). Apart from a summer bias of -1.7 degrees Celcius and winter bias of +2.6 degrees Celsius, the range of simulated temperatures covers the observations very well. The hottest summer on record (1947) is also a rare event in the simulations, as is the coldest winter (1963). The probability of extreme hot summers increases faster as might be expected on the basis of the mean warming. In contrast, probabilities of extreme cold winters decrease faster. Extreme cold winters, although more rare, still occur.

These results suggest that the probability density function (PDF) of temperature not simply shifts with the mean, but changes its shape in the warming climate. Figure 3 shows the PDF for January daily mean temperatures for the same grid point.

Clearly the cold tail depopulates. The one in 10 year cold event warms 4.2 degree Celsius, more than twice as much as the mean warming. Physical causes for the PDF shape changes are currently under study.

We have also looked at the simulation of the North-Atlantic Oscillation based on the simulated mean sea level pressure fields. The simulated NAO pattern compares well with the observed (not shown). Simulation #13 tracks the observed trend towards positive NAO index in the past 30 years remarkably well (Fig. 4). However, other members simulate opposite trends; the ensemble mean shows no trend (black line), also not in this century. These preliminary results suggest that the observed trend can be explained by natural, unpredictable, climate fluctuations. Although the ensemble mean NAO index does not change, the ensemble mean global temperature rises. This suggests that the global warming of the past 30 years is not due solely to the trend in the NAO, as suggested in the literature (Hurrell, 1996).

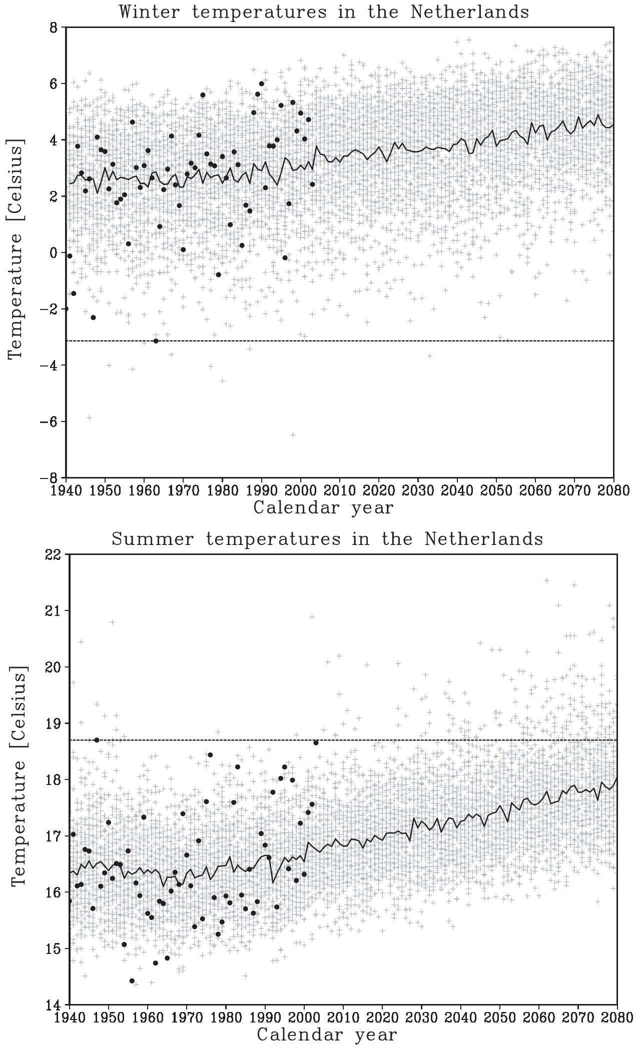

Fig. 2: Mean winter and summer temperatures in a grid box partially overlapping the Netherlands of all 62 simulations (light crosses), the ensemble mean (solid line) and observed temperatures at weather station De Bilt in the Netherlands (dark dots). A summer bias of –1.7 degrees Celsius and winter bias of 2.6 degrees Celsius has been removed from the simulated temperatures. The horizontal line marks the coldest winter and warmest summer on record.

Acknowledgements

We wish to thank Bette Otto-Bliesner, Caspar Ammann and Grant Branstator of NCAR for their input to the project. Use of the computing facilities was sponsored

by the National Computing Facilities Foundation (NCF) with financial support from NWO.
Challenge website: http://www.knmi.nl/onderzk/CKO/Challenge_live

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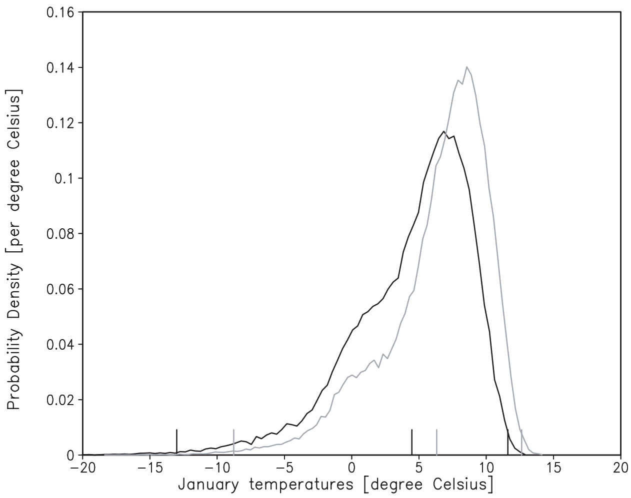

Fig. 3: Probability density function of daily mean temperatures in the same grid box as Fig. 2, for January for the period 1951-1980 (black solid) and 2051-2080 (grey solid). Short vertical lines indicate the temperatures of the one in 10 year cold extremes (left ones), the mean temperatures (middle ones) and the one in 10 year warm extremes (right ones).

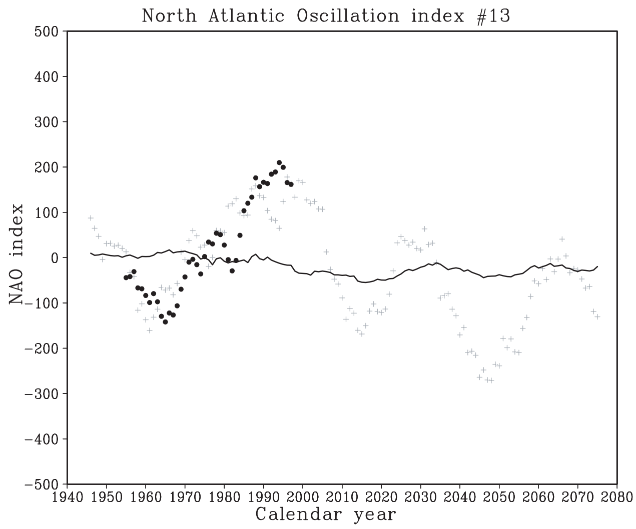

Fig. 4: The NAO index based on NCEP-NCAR reanalysis of mean sea-level pressure (dark dots), the NAO index of simulation #13 (light crosses) and the ensemble mean NAO (solid line). Timeseries are low-pass filtered with an 11 year running mean.

Announcement:

CLIVAR Workshop on North Atlantic Thermohaline Circulation Variability
Kiel, Germany, 13-16 September 2004

This Workshop is organized under the auspices of the International CLIVAR Project by the Atlantic Implementation Panel, the Working Group on Ocean Model Development, and the Special Research Programme on the "Dynamics of Thermohaline Circulation Variability" (SFB 460) at Kiel University.

The Workshop intends to bring together expertise from physical oceanographers, geochemists, and ocean and climate modelers, to discuss recent advances and outstanding problems in our understanding of the mechanisms of deep water formation in the subpolar North Atlantic, their relation to large-scale thermohaline circulation (THC) variability and impact on the uptake anthropogenic trace gases, and the future of the THC under changing climate conditions.

Main Goals:

1) To take stock of our understanding and best estimates of the present and future state of the Atlantic Thermohaline Circulation.

2) To guide implementation plans by assessing the capabilities and future needs of THC observing and synthesis systems to detect low-frequency changes or trends.

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For general information:
http://www.ifm.uni-kiel.de/allgemein/naw2004.htm

GLACE: Quantifying Land-Atmosphere Coupling Strength Across a Broad Range of Climate Models

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In analogy to ocean heat content, land surface soil moisture and snow cover have a longer memory than atmospheric quantities and can potentially contribute to atmospheric variability and seasonal predictability. The degree, however, to which the atmosphere responds to land surface anomalies (i.e., the land-atmosphere coupling strength) is still largely unknown. Modeling studies do abound; many AGCMs have quantified, for example, the impact of soil moisture variations on model precipitation. Nevertheless, all such results are keyed to the model's intrinsic land-atmosphere coupling strength, a model-dependent quantity that is not well determined, validated, or even understood. This coupling strength is not specified explicitly by the modeler but is rather a complex function of the numerous interacting model parameterizations controlling the land surface energy balance, the development of the boundary layer, precipitation generation (particularly convection), and other AGCM features. Most modelers appear to accept their own model's coupling strength completely on faith, not addressing either its realism or how it compares with that in other models.

The quantification and documentation of coupling strength across a broad range of models would be valuable, if only to serve as a frame of reference when interpreting the experimental results of any particular model. This quantification and documentation is the goal of GLACE (Global Land Atmosphere Coupling Experiment), an experiment jointly sponsored by the CLIVAR Working Group on Seasonal-to-Interannual Prediction (WGSIP) and the GEWEX Global Land Atmosphere System Study (GLASS) panel. In essence, GLACE is a highly controlled AGCM experiment that allows the computation of objective indices of coupling strength – indices that can be directly compared between models. At present, ten AGCM groups have completed the GLACE experiments. Output from a few additional groups is expected soon.

The design of the GLACE experiment follows closely that used by four participants in a recent pilot study (Koster et al., 2002), a study hinting at a wide range of coupling strengths among today's models. In GLACE, each participating AGCM group generates the following three ensembles of simulations:

- *Ensemble W:* Sixteen 92-day simulations spanning June 1 – August 31, using prescribed SSTs from a particular year of interest.
- *Ensemble R:* Sixteen simulations spanning the same time period and using the same SSTs, but with the following twist: all simulations are forced to maintain the same geographically-varying time series of land surface prognostic variables (soil moistures, surface and subsurface temperatures, etc.). This is achieved by replacing, at every time step, the prognostic variables' values with those produced at that time step by a particular member of Ensemble W.
- *Ensemble S:* The same as Ensemble R, except only the subsurface soil moisture prognostic variables are forced to be identical amongst the member simulations.

In Ensemble R, the atmospheres in all member simulations see the same time-varying, spatially varying anomalies of temperature and moisture at the land surface. In Ensemble S, they see the same time-varying, spatially varying anomalies of subsurface moisture. In either ensemble, we can quantify coupling strength by examining the agreement in the weather generated amongst the ensemble members (see below). Note that Ensemble S is probably the most relevant to CLIVAR. Subsurface soil moisture is the land state that, during summer, has the greatest memory and thus the greatest potential for contributing to seasonal forecasts. Ensemble S is designed to quantify the responsiveness of the atmosphere to this potentially predictable land variable.

Land-atmosphere coupling strength can be calculated in a number of ways. Here, we examine the "variance ratio": the variance of total (92-day) precipitation across the 16 members of ensemble S divided by the corresponding variance for ensemble W. The idea, illustrated in Figure 1, is that if precipitation is strongly controlled by subsurface soil moisture state, then the precipitation variance for ensemble S, which utilizes the same soil moisture time series in each member simulation, should be smaller than that for ensemble W, which allows soil moisture to vary across the simulations. In other words,

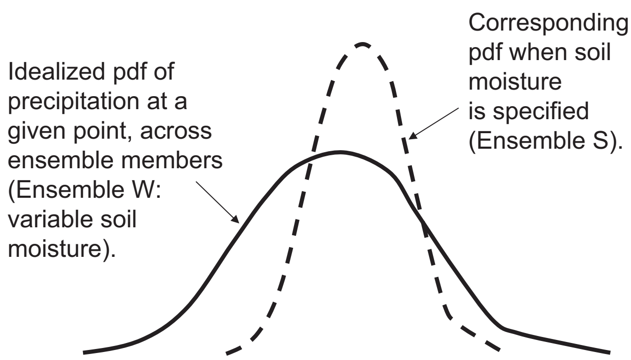

Fig. 1: Illustration of variance reduction associated with the fixing of subsurface soil moisture.

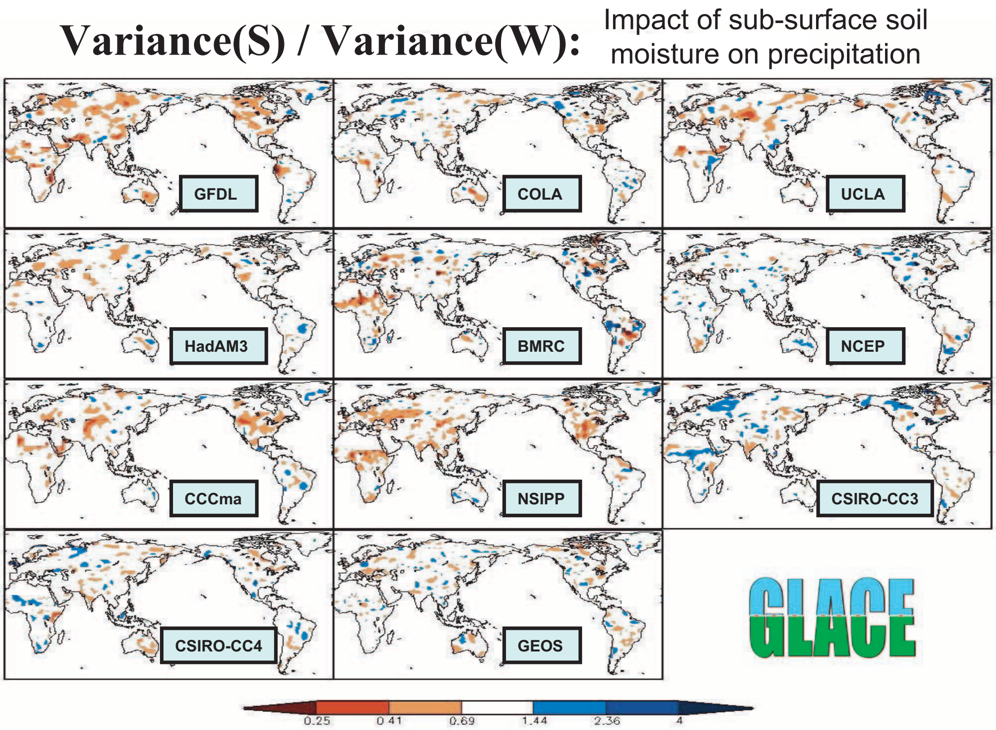

Fig. 2: Degree to which subsurface soil moisture variations influence precipitation in ten different AGCMs, as measured by the variance ratio described in the text. Eleven panels are shown because one model performed the experiment twice, with two different land surface schemes. The blue and orange values are statistically significant at the 75% level, assuming a normal distribution for the seasonal totals; the dark orange and dark blue are statistically significant at the 95% level. Based on the apparent field significance, these significance levels are, if anything, conservatively low.

the variance ratio should be less than 1. Indeed, if soil moisture *completely* controls precipitation, the variance ratio should be zero.

Figure 2 shows the variance ratio across the globe for ten of the participating GLACE models. Land-atmosphere coupling strength, as measured by the variance ratio, clearly varies amongst the models – some show a relatively high strength (GFDL, UCLA, CCCma, NSIPP), and in others (NCEP, CSIRO, GEOS), the coupling strength is weak, apparently overwhelmed by atmospheric chaos. This is the first order result. Ongoing additional analysis aims to identify the reasons for the intermodel differences and for the geographical variations in the ratio and other relevant indices. The plan is to relate the patterns, for example, to spatial variations in energy-limited versus water-limited regimes and to intermodel differences in precipitation mechanisms, e.g., the use by some models of convection triggers.

The GLACE experiment is not able to identify the "best" model, that is, the one that most closely reproduces observed land-atmosphere coupling strength. This is because direct measurements of land-atmosphere interaction at large scales simply do not exist. The point of GLACE is rather to document the coupling strength across a broad range of models, to allow individual models to be characterized as having a relatively strong, intermediate, or weak coupling. Only when this fundamental characteristic of an AGCM is quantified can a "land impacts on climate variability" study be properly interpreted and understood in the context of parallel studies. Note that as models change and evolve, the GLACE experiments can be re-run easily, and the inherent coupling strength of the newer model version can be put immediately into context.

GLACE results (which, by the way, will also focus on the land's connection to air temperature) highlight a very uncertain aspect of AGCM modeling, an aspect of direct relevance to CLIVAR studies involving land processes. By improving the realism of the physical mechanisms controlling land-atmosphere coupling strength (e.g., moist convection, boundary layer structure, and evaporation), modelers can hope to be more confident in the coupling strength they simulate, even if this coupling strength cannot be measured in nature. Hopefully, the broad disparity shown in Figure 2 will diminish as models improve.

Further details regarding GLACE may be found at http://glace.gsfc.nasa.gov/. For the generation of Figure 2, we acknowledge invaluable contributions from the following participants: Tony Gordon and Sergey Malyshev (GFDL); Yongkang Xue and Ratko Vasic (UCLA); David Lawrence, Peter Cox, and Chris Taylor (HadAM3): Bryant McAvaney (BMRC); Sarah Lu and Ken Mitchell (NCEP/GFS); Diana Verseghy and Edmond Chan (CCCma); Ping Liu (NSIPP); and Eva Kowalczyk and Harvey Davies (CSIRO).

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From Collins et al.: North Atlantic Decadal Predictability (page 6)

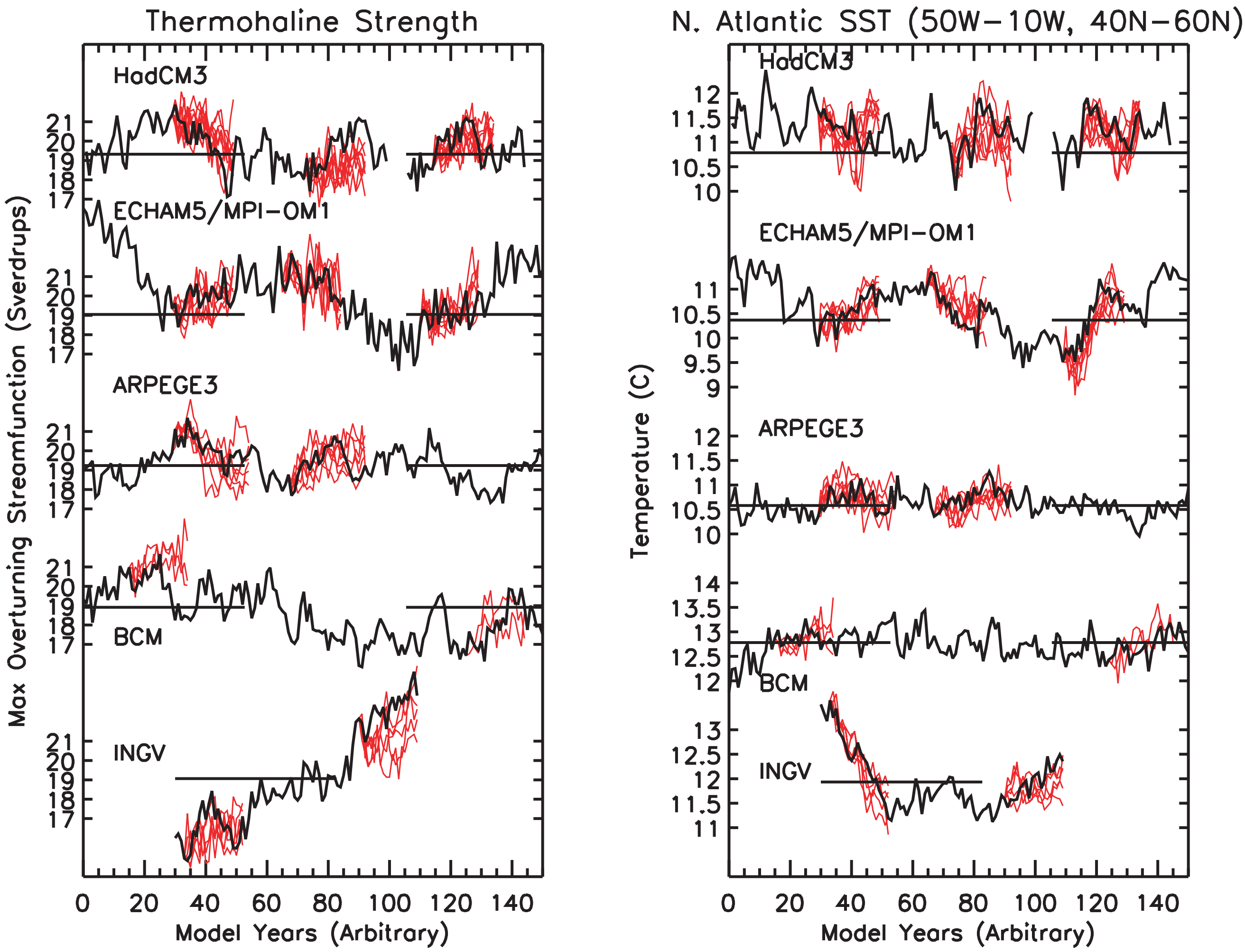

Fig. 1: The strength of the ocean Meridional Overturning Circulation (MOC – left panel) and Sea Surface Temperatures averaged in the region 50°W-10°W, 40°N-60°N (right panel) from control experiments (black lines) and perfect ensemble experiments (red/grey lines) from 5 different coupled atmosphere-ocean models. The perfect ensemble experiments allow the assessment of the potential predictability of N. Atlantic climate on decadal time scales. The experiments were performed as part of the EU PREDICATE project.

From Cai et al.: The Response of Climate Variability and Mean State to Climate Change: preliminary results from the CSIRO Mark 3 coupled model (page 8)

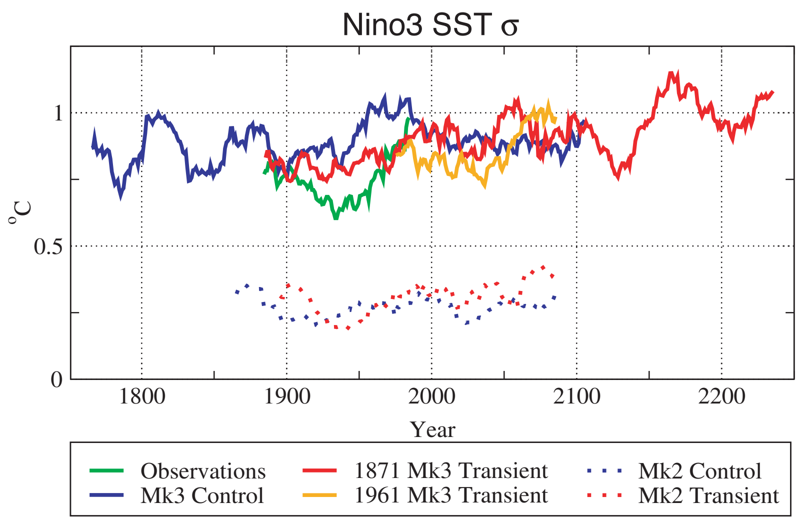

Fig. 1: Time series of the amplitude of ENSO cycles in the CSIRO Mark 2 and Mark 3 experiments. Shown are the standard deviations calculated using a 31-year sliding window. The observed (green curve) is also shown for comparison. Time series for the control experiments are in blue and those for the climate change experiments are in red and orange.

From Cai et al.: The Response of Climate Variability and Mean State to Climate Change: preliminary results from the CSIRO Mark 3 coupled model (page 8)

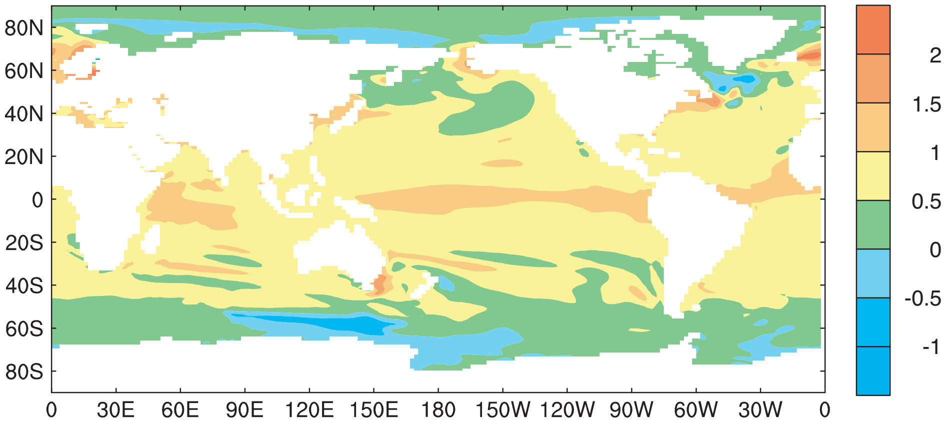

Fig. 2: Pattern of warming rate expressed as change per degree global warming (PDGW). The warming rate is calculated by regressing the time series of annual mean SST at each grid point onto the time series of annual mean global surface temperature.

From Zhao et al.: Impacts of the human emissions on climate change in China as simulated by the multi-model ensembles (page 21)

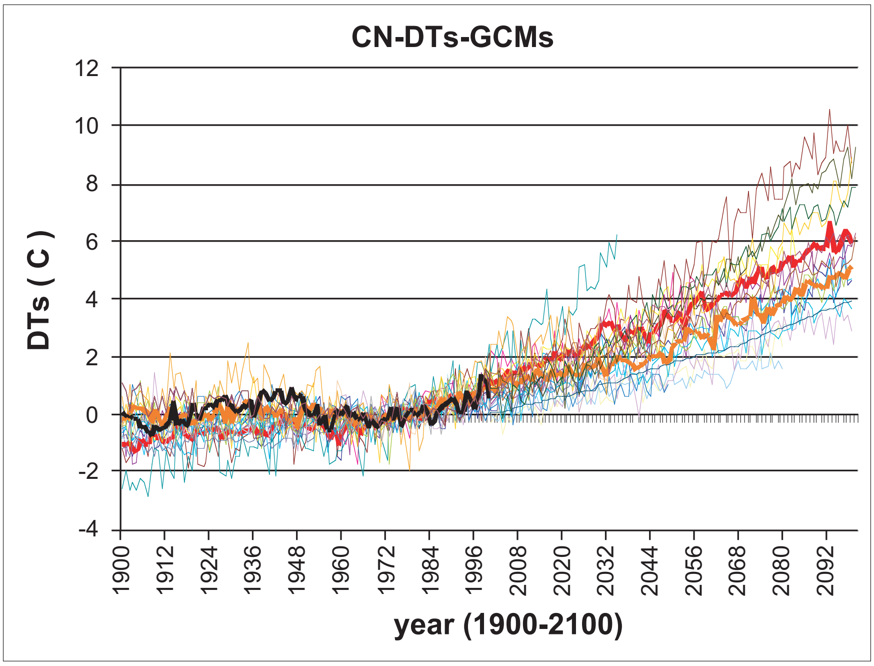

Fig. 1: Evolutions of annual surface air temperature in China for the 20th and 21st centuries (to compare with the 30 years mean of 1961~1990) as simulated by the climate models with the different scenarios (thick and black curve is the observation, Jones, Gong and Wang, personal communication) (ensemble GCM7-GG are red and thick curve, ensemble GCM7-GS are apricot color and thick curve) (updated from Zhao and Xu, 2002; Zhao et al., 2003).

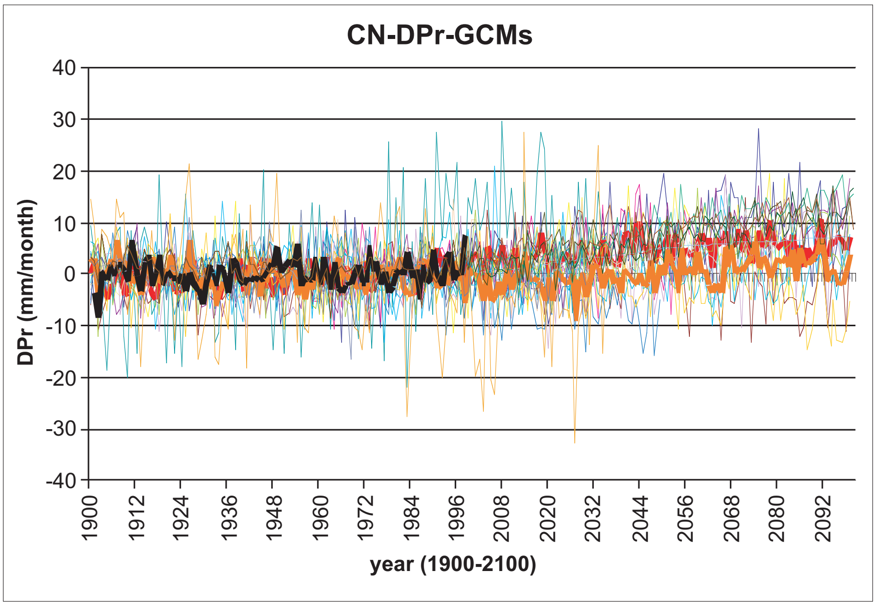

Fig. 2: Annual precipitation change in the 20th and 21st centuries (to compare with the 30 years mean of 1961~1990) in China as simulated by the GCMs and scenarios (ensemble GCM7-GG is a red and thick curve, ensemble GCM7-GS is a apricot color and thick curve) and the observations (black and thick curve, Hulme, Gong and Wang, personal communication) (updated from Zhao and Xu, 2002; Zhao et al., 2003).

The Program for Integrated Earth System Modelling (PRISM) and the European Network for Earth System Modelling (ENES)

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The development of climate models has been an important milestone towards the quantitative assessment of human-driven perturbations in the Earth system. Complex models have been developed in several research centres in Europe, North America and Japan. These models have been evaluated, inter-compared, and used for various assessments including those performed by the Intergovernmental Panel for Climate Change (IPCC). In spite of the large efforts conducted by the scientific community during the last decades, many processes are still poorly represented in climate models, so that large uncertainties still exist in current models. These are often related to the way sub - grid processes (i.e., cloud and convective processes, precipitation, ocean eddies, etc.) are parameterized. Ensembles of multi-model integrations should help quantify these uncertainties and should provide a sense of the probability that a specific climate prediction may occur. Several groups are already developing the statistical methodologies needed to conduct and interpret such ensemble integrations.

Running codes by combining different model components developed in different institutions is an important aspect of the strategy developed in Europe. To achieve such a goal, model components need to be interchangeable without major efforts. This is being achieved by developing common physical interfaces that follow certain pre-established specifications. The PRISM Project (Program for Integrated Earth System Modelling[1]), an infrastructure project supported by the European Commission, is precisely designed to facilitate the exchanges of component models, and to integrate complex Earth System models under chosen configurations on different supercomputing platforms. The "science of model coupling" remains a challenging problem, as illustrated for example by Figure 1. Coupling different state-of-the-art atmospheric general circulation models with different ocean models leads, for example, to very different representations of the El Niño events. Issues related to the coupling of model components will become even more crucial as nonlinear biological and chemical processes are fully implemented in complex Earth system models (Figure 2).

[1] Funded by the European Commission under contract No.: EVR1-CT-2001-40012; http://prism.enes.org

PRISM was established following recommendations made in a Euroclivar report published in November 1998. This report called for increased cooperation between the different climate modelling centres in Europe, and suggested that model development consortia be established to perform model inter-comparisons and improve parameterizations. The exchange of software and model results was encouraged, and the need for a large European climate computing facility to perform long high-resolution multi-model ensemble integrations was identified. The objective of PRISM is therefore to develop a flexible model structure with interchangeable model components that can exchange information through standard interfaces and through a universal coupler. As a result, the European scientific community will adopt a common software framework for model development, model diagnostics and visualization. When completed, this infrastructure will become available to the scientific community. PRISM is coordinated by the Max-Planck-Institute for Meteorology in Germany, jointly with the Royal Netherlands Meteorological Institute.

What has soon become clear is that, beside the development of common software infrastructures, the various European centres must increase their scientific cooperation, and share a common vision for future research. The purpose of the European Network for Earth System Modelling (ENES - http://www/enes.org) is to facilitate exchanges of ideas and to develop new scientific and support initiatives. ENES includes more than 50 partners representing the academic world, national research centres, meteorological services, computing centres, and industry. The ultimate objective of ENES is to accelerate progress towards a better understanding of the processes governing the Earth system and towards the development of improved predictive capability. The ENSEMBLES project, recently approved by the European

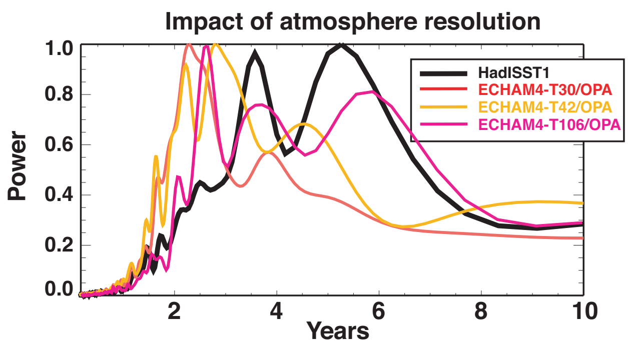

Figure. 1: Different Spectra of the El-Niño phenomenon for different representations of the atmosphere in coupled Atmosphere-Ocean Global Circulation Model runs. From Guilyardi, 2003.

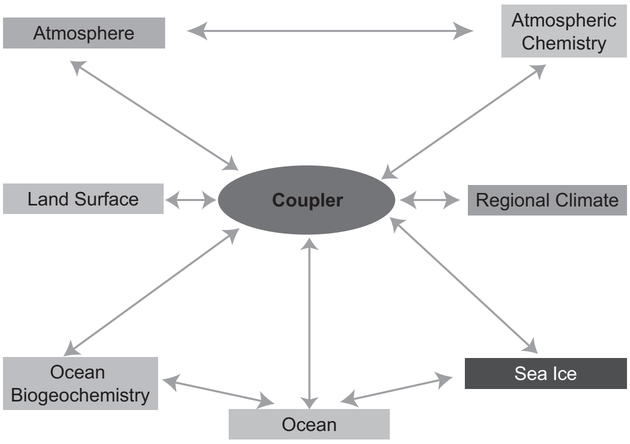

Figure. 2: The PRISM configuration

Commission, will address important scientific issues in support of the ENES objectives. ENSEMBLES, which includes 72 partners, is co-ordinated by the Hadley Centre in the UK.

One issue addressed by ENES is the lack of sufficient computing resources available in Europe to maintain a high level of climate modelling activities, and to contribute world-class science. Japan and the US have been developing strategic views on the question of hardware infrastructure. Europe must also establish its strategy, despite the complex institutional situation and the lack of a dedicated project by European industry in this respect. New climate assessments will require more complex and higher resolution models. Model integrations will cover longer time periods, and involve multi-model ensemble runs. Over the last decades, Europe has developed a strong intellectual capability in its research centres and universities, and has provided important scientific information to decision-makers. It will be able to contribute efficiently to future assessments and to decisions related to climate policy only if it maintains a strong research activity with the appropriate supercomputing infrastructure. Figure 3 (page 1) illustrates the processes that lead to more integrative Earth system models, and the associated level of computer resources that will be needed to develop and use these models in the future.

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The second phase of the Paleoclimate Modeling Intercomparison Project (PMIP-II)

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The Paleoclimate Intercomparison Project (PMIP) is a long-standing initiative endorsed by the World Climate Research Programme (WCRP; JSC/CLIVAR Working Group on Coupled Modelling (WGCM)) and the International Geosphere - Biosphere Programme (IGBP; Past Global Changes (PAGES)). The major goals of PMIP are to determine ability of models to reproduce climate states that are different from those of today and to increase our understanding of climate change. The PMIP effort developed out of a NATO Advanced Research Workshop, convened in 1991, which led to a cooperative and coordinated effort to compare model simulations with each other and with paleoclimatic data. The mid-Holocene and the Last Glacial Maximum were the major targets during the first phase of PMIP both for modelling and data synthesis. Simulating the mid-Holocene represents a sensitivity experiment to increased seasonal contrast of incoming solar radiation at the top of the atmosphere in the northern hemisphere, which leads to enhanced summer monsoons in the tropics. On the other hand, simulating the Last Glacial Maximum, allows an assessment of model representation of extreme cold conditions as well as feedbacks arising from a reduced CO_2 concentration and 2 to 3 km ice sheet elevation over North America and northern Europe. Only atmospheric models were considered in the first phase. PMIP results formed a crucial part of the evaluation of climate models in the Third Assessment Report of the Intergovernmental Panel on Climatic Changes (IPCC, 2001)

Complementary experiments, examining the role of the ocean and of the land surface in past climate changes were also carried out by several PMIP participating groups. These experiments demonstrated that the ocean and vegetation feedbacks were both needed to simulate regional patterns and magnitude of past climate changes correctly (Braconnot et al., 2003). The evaluation of fully-coupled ocean-atmosphere and ocean-atmosphere-vegetation models will be the major focus of the second phase of the PMIP project (Harrison et al., 2002). Coupled simulations also allow us to consider new questions such as the role of the thermohaline circulation in climate change, or the changes in interannual to multidecadal variability and the influence of ocean and vegetation feedbacks in modulating these changes. Evaluation of the ability of coupled models to simulate such behaviour is needed to increase our confidence in future climate projections. In addition new periods of interest have emerged. Some of the PMIP participants are interested in the Early Holocene, when the insolation forcing was even larger than during the mid-Holocene, and in glacial inception studies to better constrain the major feedbacks that are needed to amplify the insolation forcing and bring the system from a warm interglacial state to a cold glacial state.

This second phase of PMIPII is just starting. It was initiated at an international PMIP workshop in Cambridge last year (Harrison et al., 2002). In this new phase of the project, we will study the role of climate feedbacks arising in the different climate subsystems (atmosphere, ocean, land surface, sea ice and land ice) and evaluate the capability of state of the art climate models to reproduce climate states that are radically different from those of today. PMIPII is led by Sylvie Joussaume, Laboratoire des Sciences du Climat et de l'Environnement, France, email: sylvie.joussaume@cnrs-dir.fr, and will have five modelling foci:

- the mid-Holocene climate (contact: Pascale Braconnot, Laboratoire des Sciences du Climat et de l'Environnement, France, email: pasb@lsce.saclay.cea.fr)
- the last glacial maximum climate (contact: Chris Hewitt, Met Office Hadley Centre, UK; email: Hewitt@metoffice.com)
- the Early Holocene climate (contact: Paul Valdes, University of Bristol, UK; email: p.j.valdes@bristol.ac.uk)
- the last glacial inception (contact: Gilles Ramstein, Laboratoire des Sciences du Climat et de l'Environnement, France, email: ramstin@lsce.saclay.cea.fr)
- a sensitivity experiment to water hosing in the north Atlantic (contact: Ronald J. Stouffer, NOAA Geophysical Fluid Dynamics Laboratory, USA; email: ronald.Stouffer@noaa.gov). This experiment is a common experiment between PMIP and WGCM's Coupled Model Intercomparison Project (CMIP).

Analyses will be based on model–model and model-data comparisons. Evaluation of model experiments depends on the existence of spatially explicit data sets that can be compared with output from the model simulations. PMIPII will continue to stimulate continuous development and improvement of paleo-environmental data sets (contact: Sandy Harrison, School of Geographical Science, Bristol, UK, email: sandy.harrison@bris.ac.uk).

Results from both coupled ocean-atmosphere models and ocean-atmosphere-vegetation models will be considered in this second phase. The experimental protocols for the first two periods have been widely discussed during the last year and agreed upon during the special evening session on PMIP at the INQUA meeting last July (Reno, 23 – 27 July). For these experiments model outputs will be stored in a common database at LSCE. All the information can be found on the pmip2 web site http://www-lsce.cea.fr/pmip2 (contact: jypeter@lsce.saclay.cea.fr). This site will be updated regularly as new information is available.

The work for the early Holocene and last glacial inception will start in the form of working groups. Several modelling groups will run these experiments and our goal within PMIP is to encourage discussion and comparison of these simulations. The water hosing experiment has already started by a sub group of people involved in the CMIP project.

The PMIPII coordination committee formed with the co-authors of this announcement can be easily reached with the following email address: pmip2-com@lsce.saclay.cea.fr. We invite all the modelling groups interested to know more about the ability of their coupled model to represent a climate different from the present day one to participate to this new phase of PMIP. Let us know if you intent to contribute to this new phase and to which experiments.

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Impacts of the human emisions on climate change in China as simulated by multi-model ensembles

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Abstract

The impacts of the human emissions on climate change in China for the 20th and 21st centuries have been investigated by using multi-model and multi-scenario ensembles. More than 25 CGCMs and scenarios have been employed in this research. To compare with the observations in the 20th century, the multi-model and multi-scenarios ensembles for the surface air temperature and temperature extremes are better than a single model.

1. Introduction

The IPCC WG1 2001 report reported on the global warming in the 20th and 21st centuries as simulated and projected by the many coupled GCMs with human emission scenarios (Houghton et al., 2001). Our research has focused on the impacts of the human emissions on the climate changes in China for the 20th and 21st centuries as simulated and projected by the totality of the available multi-model and scenario ensemble. More than 25 runs from various climate models and scenarios have been employed and summarized in this research. Here CT represents control run; GG runs with increasing greenhouse gases only and GS runs with greenhouse gases plus sulphate aerosols. Note that the SRES scenarios A1, A2, B1 and B2 were used for the model CCSR/NIES. GCM7 represents the ensemble of CCC-GG, CCSR/NIES1-GG, CSIRO-GG, DKRZ-GG, GFDL-GG, HADL-GG, NCAR-GG, GCM7-GG, CCC-GS, CCSR/NIES1-GS, CSIRO-GS, DKRZ-GS, GFDL-GS, HADL-GS, NCAR-GS, GCM7-GS, LASG/IAP1-GG, LASG/IAP2-GG, LASG/IAP2-GS, LASG/IAP2-GS, NCC/IAP T63-GG, NCC/IAP T63-GS, RegCM/CN-GG, RegCM/CN-GS, YONU-GG, CCSR/NIES2 SRES A1, A2, B1, B2. The method of ensembles used takes the simple mathematical mean of all models and scenarios (Luo and Zhao, 1997; Gao et al., 2001; Guo et al., 2001; Zhao and Xu, 2002; Xu et al., 2002; Ma et al., 2002; Zhao et al., 2003).

2. Changes of the annual surface air temperature in China

Fig. 1 (page 17) gives the evolutions of surface air temperature in China for the 20th and 21st centuries as simulated and projected by the climate models with the different scenarios. The anomalous correlation coefficients (ACC) of temperature for all models with GG and GS had much larger positive values than those of CT.

For example, the ACC of GCM7 were 0.37 (GG 1900~1999) and 0.74 (GS 1900~1999), 0.65 (GG 1950~1999) and 0.69 (GS 1950~1999), respectively (Table 1). They reached the 95% significant levels of the confidence. The ranges of ACC of the GCMs with the different emissions are 0.07~0.74 for 1900~1999 and 0.26~0.69 for 1950~1999, respectively. The linear trends of the observed temperature in China were 0.39ºC/100y for 1900~1999 and 0.78ºC/50y for 1950~1999, respectively. The linear trends of the simulated temperature by GCM7 with CT were relatively small. The linear trends of temperature for GCMs with GG overestimated. The linear trends of temperature for GCMs with GS in both 1900~1999 (0.38ºC/100y) and 1950~1999 (0.71ºC/50y) were near the observed values, especially for 1900~1999. The investigations also presented the similar situations for the maximum and minimum temperatures in China (Zhao et al., 2003). It means that the combined effects of both greenhouse effects and sulfate aerosols very likely cause the observed warming of the 20th century in China, especially for the last 50 years. It is also noticed in Fig.1, Tables 1 and 2 that results of the multi-model and scenarios ensembles were better than a single model to compare with the observations.

The linear trends of the annual mean temperature change in China for the 21st century are 4.9 ºC/100y and 2.9 ºC/100y as projected by the GCM7-GG and GS with the range 3.0~9.2 ºC/100y and -0.3~6.9 ºC/100y of all models and scenarios respectively. It is also noticed that the change of temperature in China for the 21st century as simulated by the GCM7-GG and GS is greater than the global and East Asia changes , the linear trends of which were 3.7 ºC/100y and 2.7 ºC/100y with the ranges of 2.9~7.5 ºC/100y and 0.4~5.5 ºC/100y respectively.

3. Changes of the annual precipitation in China

Similar to the study of temperature, Fig. 2 (page 17) shows the evolution of precipitation in China for the 20th and 21st centuries as simulated and projected by the climate models with the human emission scenarios. The anomalous correlation coefficients and linear trends of precipitation changes for the observations and the simulations by the models did not present any significant relationships (Tables are not shown). It means that there was no strong evidence and signal to indicate precipitation change in China for the 20th century caused by the human emissions.

The calculations indicated that the linear trends of the annual precipitation in China for the 21st century are 48~60mm/100y as projected by the multi-model ensembles with a range of -78~185mm/100y by all models.

Table 1: Anomalous correlation coefficients of temperature change between the observation and simulations by the AOGCMs in China for the 20th century (based on Zhao and Xu, 2002; Xu, 2002; Ma, 2002; Zhao et al., 2003).

AOGCMs	**CT**		**GG**		**GS**	
	1900~1999	1950~1999	1900~1999	1950~1999	1900~1999	1950~1999
CCC	0.05	-0.18	0.21	0.49	0.61	0.50
CCSR/NIES	-0.07	-0.04	0.32	0.55	0.51	0.47
CSIRO	-0.09	0.13	0.30	0.51	0.42	0.44
DKRZ	-0.21	-0.02	0.32	0.57	0.27	0.26
GFDL	-0.20	-0.21	0.40	0.40	0.43	0.43
HADL	0.04	-0.26	0.11	0.28	0.31	0.36
NCAR	0.29	0.17	0.36	0.58	0.52	0.43
Mean of above seven GCMs	0.02	-0.06	0.29	0.48	0.44	0.41
GCM7 (above seven GCM ensemble)	0.11	0.02	0.37	0.65	0.74	0.69
NCC/IAP T63	-0.05	-0.13	0.23	0.51	0.18	0.43
LASG/IAP2			0.19	0.47	0.07	0.33
CCSR/NIES2-SRES*			0.20	0.52	0.20	0.52
Mean	0.03	-0.06	0.26	0.53	0.33	0.48

Table 2: Linear trends of temperature change in China for the 20th century (unit: °C/100yrs and °C/50yrs) (based on Zhao and Xu, 2002; Xu, 2002; Ma, 2002; Zhao et al., 2003).

AOGCMs	**CT**		**GG**		**GS**	
	1900~1999	1950~1999	1900~1999	1950~1999	1900~1999	1950~1999
CCC	0.26	-0.04	1.93	1.67	0.61	1.09
CCSR/NIES	-0.16	0.09	0.85	1.51	0.59	1.29
CSIRO	-0.21	0.07	1.33	0.81	0.87	1.08
DKRZ	-0.10	0.03	0.85	1.28	-0.02	0.02
GFDL	-0.14	-0.16	1.71	2.03	0.78	0.93
HADL	0.22	-0.12	1.09	0.69	0.38	0.32
NCAR	0.69	0.23	3.14	2.91	-0.03	0.60
Mean of above seven GCMs	0.08	0.02	1.56	1.56	0.45	0.76
GCM7 (above seven GCMs ensembles)	0.11	0.03	1.53	1.50	0.38	0.71
NCC/IAP T63	0.04	0.07	0.91	0.82	1.73	1.24
LASG/IAP2			1.15	1.24	0.93	0.64
CCSR/NIES-SRES*			-0.49	0.42	-0.49	0.42
Mean	0.08	0.04	0.93	1.11	0.60	0.75
OBS			0.39	0.78	0.39	0.78

* In this line the means of the CCSR/NIES SRES A1, A2, B1 and B2 only are given

4. Conclusions and discussions

As summarized in the above sections, the simulations of the surface air temperature and maximum and minimum temperature in China by the multi-model and multi-scenarios ensembles are better than a single model to compare with the observations in the 20th century. Changes in the precipitation over China show no significant trend either in the observations or the models through the 20th century and are relatively small into the 21st century, implying some value in refining the use of the multi-model approach for prediction of future changes in this parameter.

The further research will concentrate on narrowing the uncertainties.

Acknowledgments

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Climate System Observational and Prediction Experiment (COPE) - Workshop on Seasonal Prediction

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The WCRP Climate System Observational and Prediction Experiment (COPE) Workshop on Seasonal Prediction was held November 3-5, 2003 at the East West Center facilities of the University of Hawaii, Honolulu, USA. The chairman of the COPE Task Force on Seasonal Prediction, Dr. Ben Kirtman (GMU), the local host Dr. Kelvin Richards (IPRC) and Dr. Andreas Villwock (ICPO) welcomed about 30 scientists representing the various WCRP programmes, the main modelling centres involved in seasonal prediction and the CLIVAR Working Group on Seasonal-to-Interannual Prediction (WGSIP). Dr. Kirtman acknowledged in particular the support provided by the World Climate Research Programme, US-CLIVAR, the International Pacific Research Center (IPRC) and the Center for Ocean-Land-Atmosphere Studies (COLA).

Prof. Shukla (GMU), member of the Joint Scientific Committee (JSC) of WCRP and a member of the WCRP Modelling Council, gave an introduction and motivation for COPE. He started with the overall objective of the World Climate Research Programme '*Is climate predictable?*' In order to accomplish this overall goal he stated that there is a need to look into the climate system as a whole. Since nature is continuous, a separation based time-scales is not necessarily helpful. Therefore the COPE initiative aims for seamless climate predictions on all climate timescales ranging from weeks to decades. For this purpose it is required to take the whole climate system into account. Thus an overarching WCRP-wide view is required, since the sub-programmes only focus on certain aspects. CLIVAR's main focus is towards ocean processes, GEWEX's expertise is on land, CliC deals with the cryosphere and SPARC with stratospheric phenomena. Furthermore, such an effort will be directly relevant to society and thus a close interaction with the International Human Dimensions Programme (IHDP) and the International Geosphere-Biosphere Programme (IGBP) will be required.

Dr. Kirtman provided more background information about the concept of COPE. It is thought to be an overarching global experiment with modelling and observational components cutting across the existing structure of WCRP. In particular COPE will develop observational and modelling studies in support of:

(i) Description of the structure and variability of the global climate system (atmosphere, ocean, land and cryosphere) for a 40-year period (1979-2020) and to model and understand the mechanisms and coupled processes responsible for observed climate variability and change.

(ii) Determining the extent to which regional climate is predictable by making retrospective forecasts of weekly-seasonal-interannual-decadal variations for a 30-year period (1979-2009), and real time forecasts for a 10-year period (2010-2020).

(iii) Understanding the mechanisms that determine anthropogenic regional climate change and variability and its prediction.

Recognizing the importance of seasonal prediction as a specific objective under COPE, the JSC has recommended establishment of a limited term Task Force on Seasonal Prediction (TFSP). This task force will draw on expertise in all WCRP core projects (i.e. CLIVAR, GEWEX, CliC and SPARC), WGNE, and WGCM, and will report to the JSC in March 2004. The overarching goal of the TFSP is to determine the extent to which seasonal prediction is possible and useful in all regions of the globe with currently available models and data.

The TFSP was charged to organise a seasonal prediction workshop drawing on expertise across all the relevant WCRP activities. The goals and expected outcomes of the workshop include:

(i) Assessing the nature and level of seasonal prediction activities across the whole of WCRP. What is the current state-of-the-art in seasonal predictions? What prediction data sets are currently available?

(ii) Developing a strategy and working plan for determining the extent to which seasonal prediction is possible and useful in all regions of the globe with currently available models and data.

(iii) Identifying the current limitations and prospects for improving seasonal predictions. What are the present data sets that support seasonal prediction? What new/improved data sets are required to advance seasonal prediction skill? What sort of advances might we expect?

(iv) Assessing the current and planned process studies and field experiments that will have a demonstrable impact on WCRP seasonal prediction activities.

(v) Describing the programmatic structures or mechanisms that are needed to facilitate the development and improvement of WCRP seasonal prediction activities.

The overarching objectives of COPE include designing a comprehensive set of WCRP-wide coordinated prediction and predictability experiments with ocean-land-atmosphere models that will ultimately lead to seamless weekly-seasonal-interannual-decadal forecasts. This workshop and the emerging TFSP are the first necessary steps in helping COPE and the WCRP meet these objectives.

A part of the workshop assessed the present status of seasonal predictions and the role of the different subcomponents of the climate system (ocean, land, ice, stratosphere) for seasonal forecasts was highlighted. In addition, a number of participants provided an overview of seasonal prediction activities at various institutions and countries.

The final discussion of the workshop focused on a proposed core seasonal prediction experiment based on the hypothesis that there is currently untapped seasonal predictability due to interactions (and memory) among all the elements of the climate system (Atmosphere-Ocean-Land-Ice). The proposed core experiment is an "Interactive Atmosphere-Ocean-Land-Ice Prediction Experiment." This experiment is to use the best possible observationally-based initialization of all the components of the climate system to make coupled (interactive) atmosphere-ocean-land-ice retrospective predictions. A key element of the experimental design is that *no* "future" information about any of the components of the climate system be used as the retrospective predictions evolve. The component models should be interactive but options are left open to encourage a wider participation, e.g. for groups without sea-ice or vegetation models. Thus, component models are:

- Ocean – open but interactive (e.g., slab mixed layer or GCM)
- Atmosphere – open but interactive, most likely a GCM
- Land – open but interactive, e.g. SSiB, Mosaic, BATS, CLM, Bucket …
- Ice – open but interactive (e.g., thermodynamic or dynamic)

In terms of diagnostic sub-projects a number of potential examples were highlighted. These sub-projects include:

a) Predictability diagnostic
- Limit of predictability when the forecast ensemble distribution is the same as the model climate distribution

b) ENSO mechanism diagnostic
- Recharge oscillator vs. delayed oscillator
- Role of westerly wind bursts/stochastic forcing

c) Impact of the AO on seasonal predictability

d) Regional predictability
- Local land surface predictability
- Extreme events
- Monsoons
- Diurnal cycle

e) Coupled Feedbacks
- Intra-seasonal Variability

Details of the plan for the experiment will be defined within the next months and tabled at the next session of the JSC in March 2004.

Simulation of the El Niño – Southern Oscillation phenomenon with NASA's Seasonal-to-Interannual Prediction Project coupled general circulation model

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Introduction

A comprehensive Coupled General Circulation Model has been developed by NASA's Seasonal-to-Interannual Prediction Project (NSIPP). This CGCM, combined with an ocean data assimilation scheme, is being used for experimental seasonal forecasting. As shown here, the NSIPP CGCMv1 simulates the ENSO phenomenon realistically in long free simulations. Drawbacks of the simulation, possibly interrelated, are a narrow meridional extent of the ENSO pattern and its shorter periodicity. These drawbacks are common in many state of the art CGCMs. Reasons for the bias in the meridional extent include an unrealistic anomalous increase in the intensity of the trades on both sides of the equator during El Niño events. The increased evaporation, oceanic mixing and upwelling due to the stronger trades narrows the meridional extent of the El Niño spatial pattern. This is a bias present in forced experiments with the AGCM component of the coupled model.

The NSIPP CGCMv1

The NSIPP-1 AGCM has a finite-difference, primitive equations dynamical core (Suarez and Takacs, 1995). Its physical parameterizations include: the boundary layer scheme from Louis et al., (1982); solar and infrared radiative heating rates from Chou and Suarez (1996); gravity wave drag from Zhou et al. (1996); penetrative convection originating in the boundary layer is the Relaxed Arakawa-Schubert (RAS) scheme (Moorthi and Suarez, 1992). The AGCM and its behavior are extensively described in Bacmeister and Suarez (2002). The AGCM is coupled to the Mosaic Land Surface Model of Koster and Suarez (1996).

The ocean GCM, Poseidon V4 (Schopf and Loughe, 1995), is designed with generalized horizontal and vertical coordinates including an embedded turbulent surface mixed layer parameterized according to Kraus-Turner. The interior layers are treated in a quasi-isopycnal fashion in which layers do not vanish at outcrops, but retain a thin minimum thickness at all grid points. Vertical mixing and diffusion are parameterized using a Richardson number dependent scheme of Pacanowski and Philander (1981). The model, with prognostic salinity, has been used for equatorial Pacific analyses (e.g. Borovikov et al., 2001) and ocean data assimilation (Keppenne and Rienecker, 2003).

The CGCM runs without any flux correction. Fluxes are exchanged on a daily basis using bilinear interpolation from the atmosphere to ocean grid (e.g., Vintzileos and Sadourny, 1997) and averaging together the underlying ocean grid boxes in the opposite direction.

Simulated ENSO

In the following analysis coupled model data are from the last 130 years of a 150-year simulation. Observations are from the NCEP reanalysis (Kalnay et al., 1996) for the period 1961 – 2001. The forced AGCM data are from an experiment performed with observed SST from 1930 to 2002.

The spectrum of the simulated Niño 3 index (sea surface temperature anomalies averaged over 150°W – 90°W and 5°S – 5°N) is compared to the spectrum of the observed field in Figure 1. The model behavior is more energetic than observed in the range from 0.05 to 0.03 cycles per month (periods from 20 to 33 months). The most noticeable bias is the absence of a quasi-quadrennial oscillation. The smaller than observed total variance, 0.48 instead of 0.82, is mainly due to the fact that the model does not produce events as extreme as those of 1982-83 and 1997-98.

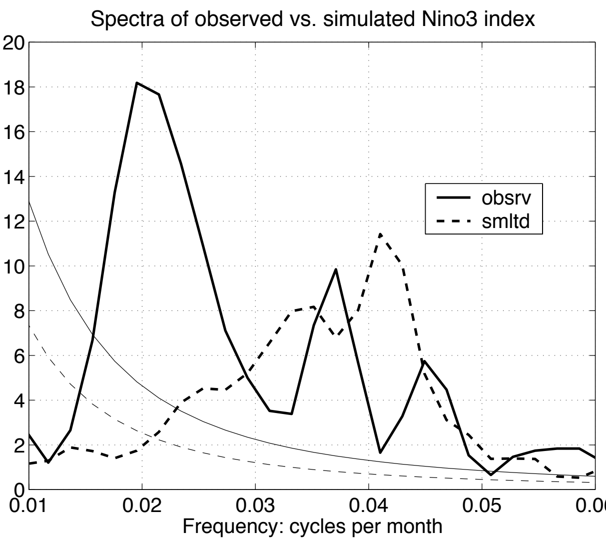

Fig. 1: Spectra of the observed (thick continuous) and simulated (thick dashed) Niño 3 index. Thin lines represent the spectra of ar(1) processes with the variance and autocorrelation of the respective Niño 3 time series.

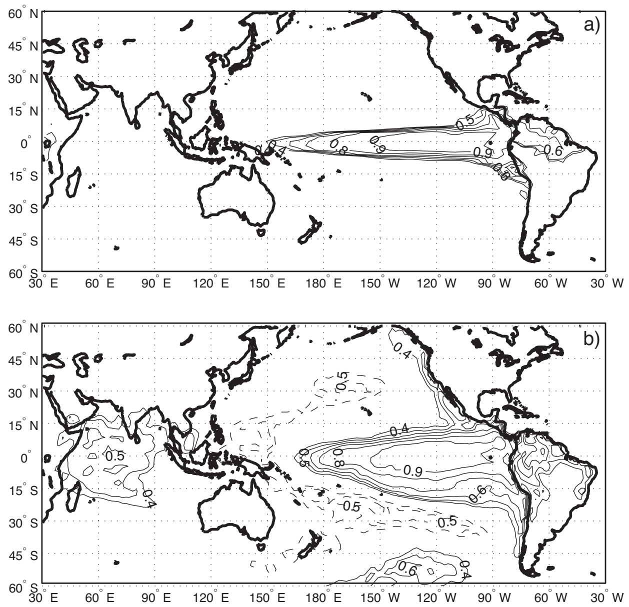

Fig. 2a: Correlation between simulated Niño 3 index and global SST anomalies. A 7-month running meaning has been applied to each field prior to correlation. Only values above an absolute correlation of 0.4 are shown. Contour interval is 0.1. Negative correlation is represented by dashed lines.
Fig. 2b: As in Figure 2a but for the 1961 - 2001 observed Niño 3 index and global SST anomalies.

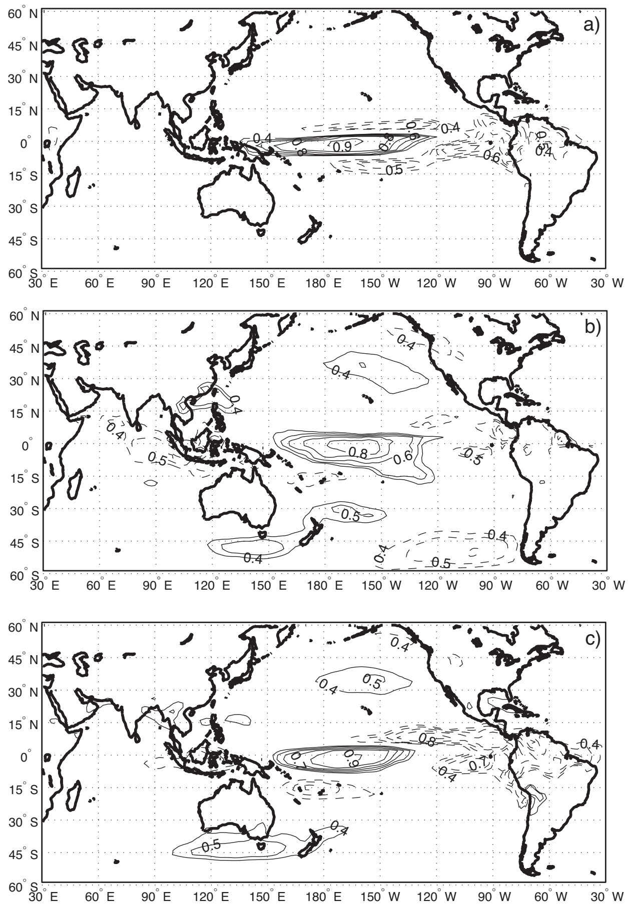

Fig. 3a: Correlation between anomalous zonal wind stress and the Niño 3 index. Only values above an absolute correlation of 0.4 are shown. A 7-month running meaning has been applied to each field prior to correlation. Contour interval is 0.1. Negative correlation is represented by dashed lines.
Fig. 3b: As in Figure 3a for the anomalous wind stress from the NCEP reanalysis from 1961 to 1941.
Fig. 3c: As in Figure 3a for the anomalous wind stress simulated by the forced AGCM.

The correlation between simulated Niño 3 index and global SST anomaly shows the spatial pattern of the simulated ENSO (Fig. 2a) and is compared to the observed pattern from 1961 to 2001 (Fig. 2b). The simulated ENSO presents a zonal large-scale structure similar to observations in the area of the equatorial Pacific. However, the narrowness of the equatorial ENSO tongue and the absence of teleconnection with SST anomalies outside the tropical Pacific are obvious.

The reaction of the atmosphere to the anomalous SST forcing is presented by horizontal correlation maps between Niño 3 index and zonal wind stress in Figure 3. Patterns seen in the forced AGCM response (Fig. 3c) are similar to the ones found in observations (Fig. 3b). Positive zonal wind stress anomalies occur in the western to central Pacific centered on the equator together with warm SST anomalies in the eastern Pacific (correlation exceeds 0.8) in accordance with the standard ENSO theory (e.g., Philander, 1990). However, the meridional extent of these wind stress anomalies is narrow and confined by unrealistic bands of negative correlation to the south and north. Further, negative zonal wind stress anomalies occur in the eastern tropical Pacific during an El Niño in a much larger scale than in observations. A wave-train emanating from the Pacific and extending towards higher latitudes is slightly less clear in the forced experiment than in observations. The strong anticorrelation pattern seen in the eastern tropical Pacific also appears in the correlation map from the coupled model (Fig. 3a). This may help explain the weaker amplitude of simulated ENSO and the lack of extreme events. Bands of negative correlation (increased trades during El Niño) are simulated by the forced AGCM in the central to eastern Pacific at 10°N and in the western to central Pacific at 15°S. This bias means that during El Niño there is increased evaporation, ocean mixing and Ekman pumping straddling the equator. In a coupled model, all of these factors will tend to decrease the meridional extension of the warm SST signal. Indeed, this response is even stronger in the coupled model and may be responsible for the narrowness in the SST pattern (fig. 2a).

Conclusions

Although the NSIPP CGCMv1 simulates many aspects of ENSO realistically it presents a number of shortcomings evident in most CGCMs. This paper has explored the mechanisms responsible for the too narrow meridional SST pattern. The reason is found in the unrealistic response of the forced AGCM which increases the trades to the north and south of the equator during warm ENSO. The resulting narrow ENSO tongue may then explain the lack of extra-tropical response to ENSO that characterizes the CGCM. Work to correct these biases is currently under way. The NSIPP model is used quasi-operationally for seasonal-to-interannual forecasting. Despite the biases presented here the model is skillful on ENSO forecast (Vintzileos et al., 2003). Correction of the AGCM response to ENSO related SST forcing will certainly improve these predictions. For more details on the system and monthly updated forecasts see: http://nsipp.gsfc.nasa.gov.

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SPEEDO: A flexible coupled model for climate studies

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Introduction

In recent years considerable progress in understanding the climate system has been achieved by using models of intermediate complexity. Those models range from idealized one or two-dimensional representations of the ocean and atmosphere dynamics, to more complex 3-dimensional coupled models (see Stocker and Knutti, 2003). The advantage of intermediate complexity models lies in their computational efficiency. Large ensembles, long runs, twin-experiments and parameter sensitivity studies are easier done than with state-of-the-art GCMs. Intermediate complexity models prove to be valuable in detecting mechanisms of climate variability, they can help to interpret results from more complex coupled integrations, and are a precious tool in the assessment of the statistical significance of predictability studies (Molteni et al., 2003). Here, we report on the development of a coupled model of intermediate complexity that is closer to the state-of-the-art GCMs than previously developed simplified models. The atmospheric component is faster than state-of-the-art GCMs by an order of magnitude. A modular setup easily allows configuring integrations with different model components. This makes the model very attractive to study, for instance, the role of oceanic or land processes in climate. In the following, technical aspects of the model are first discussed. The advantage of the modular setup and the hierarchy of ocean models implemented are illustrated with results from a study of South Atlantic coupled variability.

Technical Aspects

The atmospheric module, nicknamed SPEEDY (Simplified Parameterizations primitivE Equation DYnamics, see Molteni, 2003 for a description), uses a set of parameterization schemes based on the same principles adopted in state-of-the-art AGCMs. It is configured with 7 vertical layers and with spectral truncation at wavenumber 30 and is computationally very efficient. Despite its relatively coarse resolution,

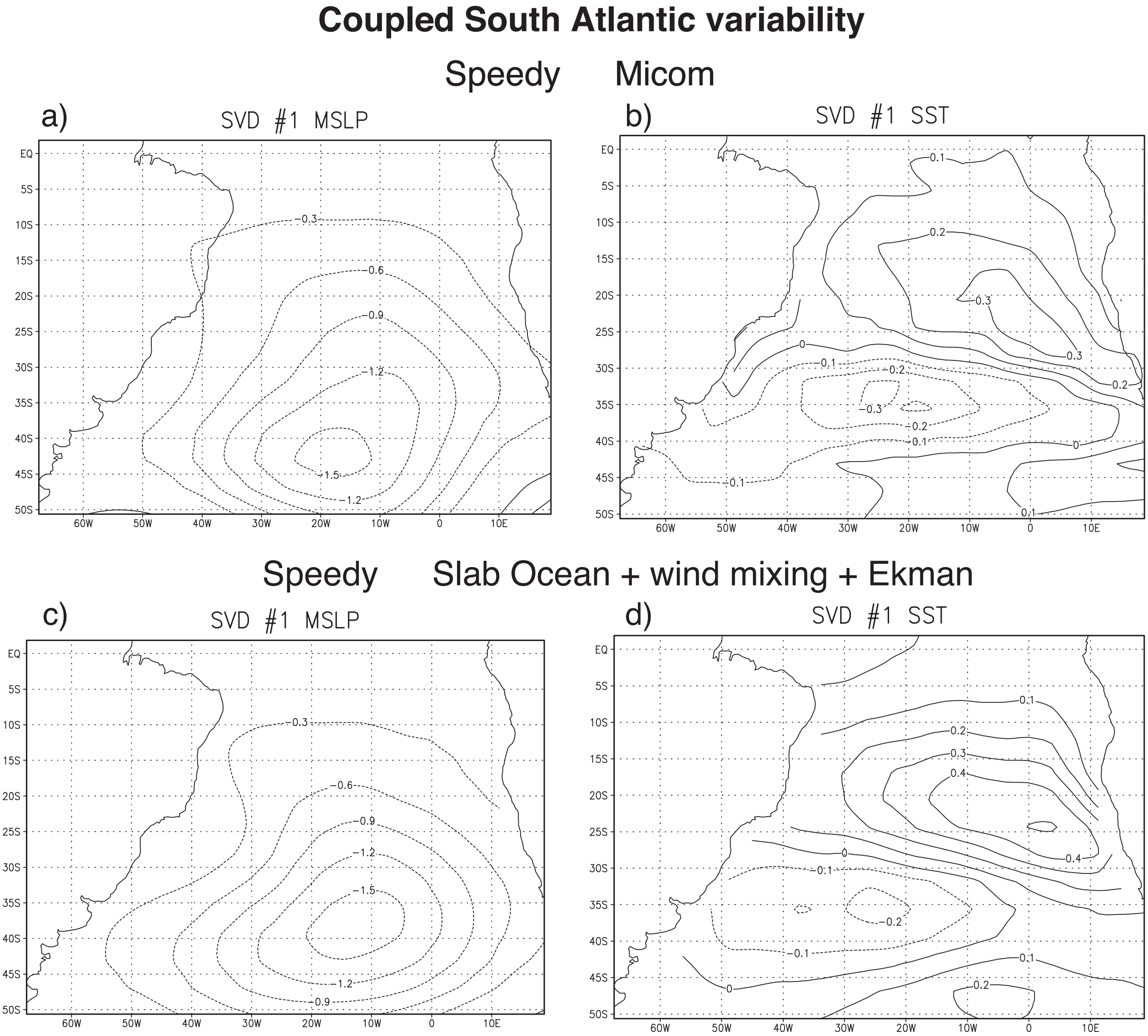

Fig. 1: First SVD pattern of sea surface temperature (right) and sea level pressure (left). Top: the coupled Speedy-Micom model. Bottom: Speedy-Slab Ocean with anomalous wind mixing and anomalous Ekman transport (Haarsma et al., 2003).

SPEEDY has been shown to reproduce reasonably well the observed variability of the atmospheric circulation in the 20th century (Bracco et al., 2003). The land component consists of a land bucket model with interactive temperature, soil moisture, soil ice, snow depth and runoff. The ocean component consists of a hierarchy of models that facilitates studying the mechanisms of climate variability and the role of the oceans therein. Such a hierarchy includes a slab ocean model, a linear ocean model for tropical oceans (Burgers et al., 2002) and a primitive equation isopycnic ocean model (MICOM, Bleck et al., 1992). The slab ocean model can be used in different ways. It can be run in a "qflux" configuration, in which heat fluxes are diagnosed from a run with prescribed SST and then specified, so that only heat transport by the ocean is represented, or including also other processes, such as anomalous Ekman transports, anomalous wind-driven turbulent mixing and anomalous barotropic transport. Regional configurations of these ocean models can be overlayed on the global ocean and land models easily (e.g. it is possible to use MICOM in the Atlantic and a slab ocean in other basins). The coupled model is called SPEEDO (SPEEDy-Ocean).

Except for the atmospheric model, all components have been set up in a Generic Model Framework (GMF). In GMF each module has an initialization phase and a time stepping loop. The latter includes time stepping of the model physics, collection and storing of the output data in a history file, writing of a restart file and preparation for the next time step. Generic functions and subroutines have been developed to implement such a structure in all model components. Each module has a parameter file in which critical parameters such as type of run, calendar, and physical parameters are set. Output and input data are in NetCDF format. SPEEDO uses a distributed coupler implemented as a library that is linked to each component of the coupled system. The modular set up facilitates identifying the role of the different components of the coupled system in determining climate variability and the physical mechanisms involved. More details can be found in a technical report on the model (Hazeleger et al., 2003) together with a validation of the atmospheric component, which is also available in Molteni et al. (2003) and Bracco et al. (2003).

South Atlantic climate variability: use of a hierarchy of ocean models.

Here we present an example of a study in which SPEEDO was used to identify the ocean's role in generating coupled variability in the South Atlantic (Haarsma et al., 2003). Observations show that the dominant mode of coupled variability in the South Atlantic Ocean consists of a dipole in SST and a monopole in SLP variability. The data suggest a dominant role of the atmosphere in generating this mode of variability (Venegas et al., 1997), but the ocean does not seem to be entirely passive. Reanalysis data suggest an important role for wind-driven turbulent mixing (Sterl and Hazeleger, 2003).

The SPEEDO model, with MICOM (1 degree resolution in the horizontal, 16 layers) as ocean model in the South and Tropical Atlantic and slab ocean elsewhere, captures the observed dominant mode of coupled variability (Fig 1a and b). To investigate which oceanic processes are involved in generating this mode of variability we used the hierarchy of ocean models. The hierarchy consists of the following: (I) MICOM, (II) slab ocean model (i.e. interactive surface heat fluxes), (III) slab ocean model including anomalous Ekman currents induced by anomalous wind stress, (IV) slab ocean model including anomalous Ekman currents and anomalous turbulent wind-induced mixing, and (V) slab ocean with anomalous Ekman currents, wind-induced mixing and anomalous barotropic flow. When MICOM is replaced by the slab ocean model with anomalous wind-induced mixing and anomalous Ekman transport, the pattern of coupled variability is similar to the observed one (see Fig. 1c). This confirms the results from Sterl and Hazeleger (2003) who found that surface latent heat fluxes and wind-induced oceanic mixing are the most important mechanisms in generating South Atlantic SST variability. However, the model shows that role of Ekman currents is more important than expected from Reanalysis data. Although their contribution to generating SST variability is relatively small, Ekman currents have a profound impact on the coupled variability. The role of anomalous barotropic flow is relatively small.

This example shows the attractiveness of using SPEEDO for studies after climate variability. By using different ocean model components, mechanisms that are important for generating coupled variability could be identified. As such, the model is very well suited for CLIVAR-related projects. Further work with SPEEDO is under way in the PATCH (Patterns of climate change) project initiated at KNMI. The project focuses on changes in teleconnections from the tropics to the midlatitudes and, especially, over Europe. The effect of CO_2 rise on the changes in teleconnections gets specific attention. Climate variability in the tropical Pacific and Indian Ocean is also under investigation at ICTP.

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JSC/CLIVAR Working Group on Coupled Modelling 7th Session

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The JSC/CLIVAR Working Group on Coupled Modelling met in Hamburg, Germany, Sept. 24-26 following the International Conference on Earth System Modelling and the 2nd CMIP Workshop.

The meeting was kindly hosted by the Max-Planck-Institute for Meteorology and the German Climate Computing Centre (DKRZ). Main foci of the meeting were:

- Restructuring within WCRP – the new COPE initiative
- Intercomparison of cloud feedbacks in models / Idealized Experiments
- Detection and attribution of climate change
- Developments within PMIP
- Review of the CMIP workshop and future plans
- Future perspectives for WGCM

Restructuring within WCRP – the new COPE initiative

Dr. Peter Lemke, Chairman of the Joint Scientific Committee (JSC) of WCRP presented the concept of a long-term Climate system Observational and Prediction Experiment (COPE). COPE should be an overarching WCRP focus to which all the WCRP projects could aim towards and report progress against. The nature of COPE is still under development but it will, in particular look to observational and modelling studies in support of:

(i) Description of the structure and variability of the global climate system (atmosphere, ocean, land and cryosphere) for a 40-year period (1979-2020) and to model and understand the mechanisms and coupled processes responsible for observed climate variability and change.

(ii) Determining the extent to which regional climate is predictable by making retrospective forecasts of weekly-seasonal-interannual-decadal variations for a 30-year period (1979-2009), and real time forecasts for a 10-year period (2010-2020).

(iii) Understanding the mechanisms that determine anthropogenic regional climate change and variability and its prediction.

Recognizing the importance of seasonal prediction as a specific objective under COPE, the JSC has recommended that a limited term Task Force on Seasonal Prediction (TFSP) be established. This task force will draw on expertise in all WCRP core projects (i.e. CLIVAR, GEWEX, CliC and SPARC), WGNE, and WGCM, and will report to the JSC in March 2004. The overarching goal of the TFSP is to determine the extent to which seasonal prediction is possible and useful in all regions of the globe with currently available models and data. A first COPE workshop on Seasonal Prediction was held from November 3-5 in Honolulu, USA (see page 23).

Furthermore, the JSC has set-up a modelling council consisting of the chairs of the WCRP modelling panels to better coordinate the modelling efforts within WCRP. A similar structure is envisaged for observations and data management.

International Cloud Feedback Model Intercomparison Project (CFMIP)

Dr. B. McAvaney reported about the progress of the International Cloud Feedback Model Intercomparison Project which was launched at the last session of WGCM. Currently, 12 groups are participating, two subprojects (experimental protocols): FANGIO and SLOM are defined and first results are becoming available. A website and a newsletter will be available in late autumn. A workshop is planned for April 2004 in Exeter, UK. Furthermore, it is planned to contribute to the Climate Sensitivity Workshop, July 2004 in Paris, France.

Detection

Dr. G. Hegerl reported on progress in regional detection. There is an increasing amount of research on the detection and attribution of extremes and precipitation. Other issues include the uncertainty in past forcing, particularly due to changes in solar output and uncertainties associated with the choice of model parameters (here the new initiative climateprediction.net was highlighted).

Paleoclimate Modelling Intercomparison Project (PMIP)

A new phase of PMIP-2, now also using coupled models has been launched (see http://www-lsce.cea.fr/pmip2/ and Barconnot et al (this issue)) for more information. The main foci are on 6K and 21K BP- the forcing data will become available soon.

Coupled Model Intercomparison Project CMIP

Dr. G. Meehl reported about significant accomplishments of CMIP, during the past year such as:

- 20th Century Climate in Coupled Models (20C3M), has been approved as a CMIP pilot project, the data collection has begun;
- Ocean data from CMIP2+ is now available for analysis of subprojects from PCMDI;

- The catalogue of MIPs completed with cooperation of WGCM and GAIM, is available under http://www.clivar.org/science/mips.htm ;
- CMIP and 20C3M summaries published in CLIVAR Exchanges (end of 2002); a CMIP summary was also published by GAIM (early 2003);
- CMIP subprojects have led to a large number of publications, mostly peer-reviewed and made significant contributions to IPCC TAR; As of September 2003 there are 28 CMIP2+ subprojects currently active, in addition to 10 completed subprojects from CMIP1 and 22 from CMIP2;
- The Second CMIP Workshop, which was held September 2003.

WGCM discussed at length the relationship of CMIP and the IPCC. With respect to the climate change experiment for the 4th Assessment Report of IPCC (AR4), WGCM suggested the addition of an additional scenario experiment (21st century simulation with SRES A2 to 2100) to the experiments proposed by the TGCIA. Furthermore, the group made recommendations on how to ensure an efficient integration of WGCM in the IPCC AR4 process.

The next phase of CMIP (CMIP3) will begin in October 2003. This will include requirements as before for CMIP2, with fields collected as decided for the IPCC and other runs comparable to CMIP2:

1. 1% CO_2 run to year 80 where CO_2 doubles at year 70;
2. 100 year (minimum) control run including same time period as in 1 above;
3. $2XCO_2$ equilibrium with atmosphere-slab ocean;
4. $1XCO_2$ control with atmosphere-slab ocean.

Experiments 3 and 4 will help quantify the net strength of the atmospheric feedbacks.

In addition , the participants are encouraged to run the following idealised stabilization simulations

5. An additional 150 years after CO_2 doubling with CO_2 fixed at $2XCO_2$;
6. 1% CO_2 run to quadrupling with an additional 150 years with CO_2 fixed at $4XCO_2$.

The following experiments were also recommended in order to provide further information on model performance:

7. 20C3M simulation;
8. Participation in AMIP, OMIP, and CFMIP.

Future of WGCM

Finally, WGCM discussed perspectives and priorities for the next 3-5 years. High preference was given to the interaction with IGBP GAIM on the carbon cycle and chemistry through the C4MIP activity, the assessment of systematic errors, issues related to climate sensitivity and climate variability and changes of variability.

Next year's session will be held in Japan from 21 to 25 October, 2004. WGCM is planning to team up with GAIM again for part of the meeting.

Supplementary Papers
Available at http://www.clivar.org/publications/exchanges/ex28/ex28_cont.htm

The CF of Metadata Standard

On inhomogeneities of warming and cooling in the troposphere

Ice shelf regions under climate change: Studies with a coupled ice shelf-coean model approach

Multi-convection as a multi-model proxy for seasonal climate studies

An assessment of the contribution of Ekman Transport to ocean-atmosphere feedback in the mid-latitude North Pacific

Ocean to atmosphere coupling in the North Atlantic

Arctic sea ice sensitivity and variability analysis in global climate model

On the dynamics of the North Atlantic decadal variability

Response of the North Atlantic thermohaline circulation to the atmospheric forcing in a global air-sea coupled model

Contents

Supplementary (electronic) papers (see page 31 for details) are available under:
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