Day 2 (February 19, Thu.)

Session 3: CMIP3 model intercomparison (Chair: Y. Takayabu)

Peter Gleckler (PCMDI)
Performance Metrics for Climate Models in AR5

Climate model performance metrics concisely quantify how well model simulations agree with available observations and can be distinguished from many diagnostic approaches because as scalar measures metrics are usually not expected to identify causes of model error. They have been used for, among other things, quantifying the relative strengths and weakness of different models, evaluating performance changes during the model development process, or, more broadly, for tracking the collective fidelity of state-of-the-art models as they evolve over the longer term. Recently, metrics have received considerable attention with expectations that they may help move beyond a "one model, one vote" use of multi-model ensembles of future climate projections. If proven suitable for this purpose, metrics will play a crucial role in how scientists relay information to policy makers. To date, however, the relationship between a model's ability to simulate the present day climate and its reliability for future projections remains largely unknown. This talk will highlight progress in metrics research, and suggest how metrics might influence future reports prepared by the Intergovernmental Panel on Climate Change.

Chidong Zhang (Univ. of Miami)
Simulations of the Madden-Julian Oscillation by Global Climate Models

The role of the Madden-Julian Oscillation (MJO) in cross-scale interactions ranging from the diurnal cycle to ENSO has been increasingly recognized. Mounting evidence has shown that improvement in MJO simulations in coupled global climate models (GCMs) leads to improvement of their ENSO. Meanwhile, the ability of simulating realistic MJOs is an undeniable manifestation of model fidelity. The ability of reproducing realistic MJO statistics is therefore not an option for GCMs; it is demanded for their credibility.

While GCMs have been improved in many ways during the past decade, in terms of their abilities of reproducing the MJO, some models remain as impotent as in the past and others have advanced substantially. A more severe problem is the lack of thorough understanding of why the MJO can be reproduced by some models but not by others. This leads to the need of systematic and standardized diagnostics that would make it more consistent to compare simulations by different models and by the same model at its different development stages. Such diagnostics have recently been designed, recommended, and used by the US CLIVAR MJO Working Group.

To aid our understanding of the MJO dynamics and factors key to MJO simulations, future diagnostics of GCM simulations must stride out of conventional boxes. Quantities uncommon to traditional diagnostics of GCMs, such as water vapor sources, diabatic heating profiles, cloud structures, and high-frequency surface wind forcing to the ocean, will have to be scrutinized. This requires coordination and collaboration between climate modelers who need to start archiving unconventional fields and diagnosticians who help analyze these fields.

Finally, as innovative parameterization methods (e.g.,"super-parameterization") emerge and GCM resolutions increase to cloud-resolving scales, we are facing new challenges of validating not only the large-scale patterns of the simulated MJO but also its small-scale details. To meet such challenges, we

have to continue the effort of collecting in situ observations, especially from remote regions where input to data assimilation is sparse.

Yukari N. Takayabu (CCSR, Univ. Tokyo)

Evaluations of CMIP3 Model Performances for Various Phenomena in the Atmosphere and Oceans, in the Present-Day Climate and in Future Projections in the MOE S-5 project

As one of key components in the S-5 Project entitled "Integrated Research on Climate Change Scenarios to Increase Public Awareness and Contribute to the Policy Process" supported by the Global Environment Reserch Fund of the Ministry of the Environment (MOE), Japan, we started a subproject to evaluate CMIP3 model performances in terms of reproducibilities of various atmospheric and oceanic phenomena which largely affect our society. This subproject consists of members from eight institutions, who take charge of individual phenomena, and calculate metrics for reproducibility of each phenomenon. We first aim to translate the implications of model performances represented by metrics by understanding the physics in reproducing the phenomena. Furthermore, we aim to integrate our studies to understand the relationships between reproducibilities of Asian climate and various weather and oceanic phenomena. In this talk, I will briefly introduce the purpose and the strategy of our project and will hand it over to the following presetations for outcomes from individual groups.

Satoru Yokoi and Yukari N. Takayabu (CCSR, Univ. Tokyo)

Multi-model Projection of Tropical Cyclogenesis over the Western North Pacific using CMIP3 Archive

This study examines global warming impacts on tropical cyclogenesis frequency (TCGF) over the western North Pacific (100E-180, 0-40N) predicted by climate models that participated in the third phase of Climate Model Intercomparison Project (CMIP3), by detection of cyclone-like disturbances from daily-mean outputs. Among eight CMIP3 models that have atmospheric horizontal resolution of T63 or T106, five models reproduce realistic horizontal distribution and gross summer-to-winter contrast of TCGF. Examination of the global warming impacts reveals that all of the five "high-performance" models project increasing trends of TCGF in the central North Pacific and decreasing trends over the South China Sea and westernmost part of the North Pacific. The former increasing trends are primarily attributable to projected intensification and eastward elongation of monsoon trough, while the latter decreasing trends may be associated with projected weakening in activity of tropical depression-type disturbances that can later be developed into tropical cyclone. In contrast, all five models project increase trends of environmental potential indices of TCGF proposed by previous studies all over the western North Pacific basin. Therefore, we should design a potential index with consideration of these results in order to utilize it for assessment of global warming impacts over this basin.

Yu Kosaka and Hisashi Nakamura (Univ. of Tokyo)

Atmospheric Circulation and Its Variability over the Summertime Northwestern Pacific Simulated in the CMIP3 Climate Models

Large-scale climate variability is sensitive to a configuration of the climatological-mean state. One of the dominant low-frequency atmospheric variation patterns over the summertime Northwestern Pacific, extracted through an EOF analysis applied to a reanalysis dataset, is the Pacific-Japan (PJ) teleconnection pattern characterized by meridional anomaly dipoles of lower-tropospheric vorticity and precipitation over the Northwestern Pacific. The same EOF analysis is applied to the 20th century climate integrations by

each of the CMIP3 climate models, to construct a metric to the measure the model's reproducibility of the dominant variation pattern in this region. Meanwhile, skill for those models in reproducing the climatological-mean field in boreal summer is examined through "inter-model EOF analysis" based on an ensemble of climatological-mean fields simulated by the individual models. Structure of the leading "inter-model EOF" resembles the PJ pattern, consistent with our recent hypothesis that the PJ pattern is a dynamical mode that may be excited sensitively to model configuration to yield bias to model climate. It is also confirmed that the ensemble-mean climatological-mean field is close to the real atmospheric one. Using the conventional and inter-model EOFs for the CMIP3 models, we have verified that those models that can realistically reproduce climatological-mean field can also realistically reproduce structure of the PJ pattern extracted as the dominant mode of variability. While this result is consistent with our hypothesis on the dynamics of the PJ pattern, it also proves the adequacy of the metric we have constructed.

Tomoshige Inoue and Hiroaki Ueda (Univ. Tsukuba)

Comparison of the Seasonal Evolution of the Summer Monsoon over the Asian and Western North Pacific Sector in the WCRP CMIP3 Multi-model Experiments

Based on the WCRP CMIP3 multi-model datasets, summer monsoon over the Asian and western North Pacific (WNP) sector is compared in terms of reproducibility of the seasonal mean structure. Also investigated is a stepwise eastward progress of convection center from the Indian Ocean toward the WNP occurring at one month interval that is involved in the summertime maturing process of the continent-ocean monsoons.

Most models roughly reproduce seasonal mean broad-scale features on the Asian summer monsoon (ASM), but lower-tropospheric circulation over the East Asia through the WNP, and the location and intensity of the North Pacific subtropical high exhibit large inter-model variability. Some models fail to reproduce a reversal of the upper-tropospheric meridional temperature gradient over the South Asia and the North Indian Ocean sector.

The large inter-model variability over WNP and East Asia could be attributed to insufficient reproducibility associated with the oceanic monsoon. We compare the stepwise seasonal evolution over the South China Sea and WNP. The seasonal march commences in May almost concurrently with large-scale circulation of the ASM in quite a number of the models, whereas most models tend to reproduce accelerated seasonal transitions over the WNP. Metrics on the stepwise seasonal evolution of precipitation fields over the WNP and its vicinity suggest that these models still have more or less difficulty to reproduce the stepwise seasonal evolution accurately.

Kazuhiro Oshima, and Yoichi Tanimoto (EES, Hokkaido Univ.)

An Evaluation in Reproducibility of Pacific Decadal Oscillation on the Simulations of CMIP3 Models

We evaluated reproducibility of the Pacific Decadal Oscillation (PDO) in the sea surface temperature (SST) anomaly field in "the 20th century climate in coupled models" (20C3M) simulations of the 24 CMIP3 models. In this evaluation, we examined how well patterns of the PDO match between the observations and simulations by calculating a metric of the patterns that is a function of their spatial correlation and their standard deviation. Among the CMIP3 models, the models with the high PDO metric reproduced the decadal SST variability with opposing polarities between the central North Pacific and the tropical Pacific. Indeed, temporal correlation between the simulated PDO and decadal-ENSO indices in those simulations

are negatively correlated at the statistically-significant level, as observed. The simulated sea level pressure and outgoing longwave radiation anomalies onto the decadal-ENSO index in those simulations are realistic both in the tropical Pacific and North Pacific, indicating that this tropics-extratropics linkage in the SST anomaly field is induced by an atmospheric teleconection pattern over the North Pacific. This notion is consistent with the previous studies for the natural climate variability. By contrast, the models with the low PDO metric failed to reproduce those characteristics.

Masakazu Sueyoshi, Tamaki Yasuda, and Tomoaki Ose (MRI)

First Baroclinic Rossby Radius in CMIP3 models

The first baroclinic Rossby radius of deformation in twenty atmosphere-ocean general circulation models is investigated using the CMIP3 multimodel data set. In order to investigate the agreement between the models and observations, the zonally averaged first baroclinic Rossby radius for the 20th century (20C3M) experiment in the models is compared to that computed from World Ocean Atlas 2005 (WOA05) dataset. The result from some models approximately agrees with that from WOA05, while the result from others does not agree with that from WOA05. In most of the models, the phase speed of the long baroclinic Rossby waves is small compared to that computed from WOA05.

To investigate the response of the first baroclinic Rossby radius to the increase of the atmospheric CO2 in the models, we calculate the difference between the zonally averaged baroclinic Rossby radius for the 20C3M and A1B experiment. In all models, at almost all latitudes, the zonally averaged first baroclinic Rossby radius increases with increasing atmospheric CO2 level. At 35-40 latitude, there is a tendency for the larger increase of the first baroclinic Rossby radius to be associated with the larger increase of the atmospheric temperature near sea surface. At other latitudes, this relationship does not exist. This is related to the meridional difference in the mean structure of oceanic stratification.

Hiroki Ichikawa, Hirohiko Masunaga, and Hiroshi Kanzawa (Nagoya Univ.)

Evaluation of Precipitation and Upper-level Clouds Associated with Large-scale Circulation over the Tropical Pacific Ocean in the Coupled AOGCMs

Simulations of precipitation and upper-level clouds in association with the large-scale circulation over the Pacific Ocean are analyzed for nineteen coupled climate models of Atmosphere-Ocean General Circulation Model (AOGCM) that participate in the Forth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC). To evaluate the spatial linkage of rainfall and upper-level clouds with the large-scale circulation over the ocean, the distribution of rainfall, high level cloud (HLC), and outgoing longwave radiation (OLR) anomalies are composited around the geographical center of tropospheric upper-level (200 hPa) divergence (DIV) along Intertropical Convergence Zone (ITCZ) for the observations and simulations using monthly mean data for 16 years of 1984-1999. The most notable feature is that the spread of enhanced circulation and the related rainfall/convection are all underestimated around the ascent region in the models compared to the observation. Particularly, the underestimation is pronounced in HLC, presumably due to difficulties in simulating horizontal transport of anvil cirrus clouds in the models. In general, a model with a tighter coupling of the large-scale circulation field with the cumulus latent heating tends to have a wider spread of HLC and OLR around the DIV center. A model better reproducing the observed spread tends to have stronger coupling of the large-scale circulation field with the cumulus latent heating than the observation.