Preprint
UCRL-JC-136057

The Program for Climate Model Diagnosis and Intercomparison Diagnostic System: Implementing a New Strategy Beyond the Atmospheric Model Intercomparison Project (AMIP)

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This article was submitted to
Annual Bureau of Meteorology Research Centre's Workshop on
Parallel Computing in Meteorology and Oceanography
Melbourne, Australia
November 9-16, 1999

October 18, 1999

The Program for Climate Model Diagnosis and Intercomparison diagnostic system: implementing a new strategy beyond the Atmospheric Model Intercomparison Project (AMIP)

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AMIP Background

The Program for Climate Model Diagnosis and Intercomparison (PCMDI) was established in 1989 at the Lawrence Livermore National Laboratory (LLNL) with the principal mission to develop improved methods and tools for the diagnosis, validation and intercomparison of global climate models. The goal of the process is to eventually improve simulation of the regional climate effects of increasing greenhouse gases. In addition to comparing models, PCMDI continues to develop a modeling infrastructure by creating diagnostics that will be shared throughout the research community.

PCMDI's early model intercomparison strategy was to solicit a few models that could be run for a specified period with prescribed sea-surface temperatures after being imported and adapted to the LLNL unclassified computer systems. Because of the enormous time required to prepare each model, the experiment was reversed and the modeling groups were asked to perform the controlled simulations themselves. In order to reach out to the entire atmospheric modeling community, the Working Group for Numerical Experimentation (WGNE) became the parent organization and the project was named the Atmospheric Model Intercomparison Project (AMIP). Eventually, more than thirty atmospheric modeling groups joined the effort to compare their model output (Gates et al. 1999). The general results showed that the models vary widely for some variables and are tightly clustered for other variables. Fig. 1 characterizes the wide array of results obtained in AMIP and underscores the need to better understand differences among models and between models and observations.

As a result of AMIP, model development and improvement strategy has incurred a permanent change. Modeling groups routinely perform AMIP-like simulations as they improve their models and create new versions containing substantial modifications to parameterizations. Other "MIPs" – model intercomparison projects have since sprung up, most notably, the Coupled Model Intercomparison Project (CMIP) and the Paleoclimate Model Intercomparison project (PMIP).

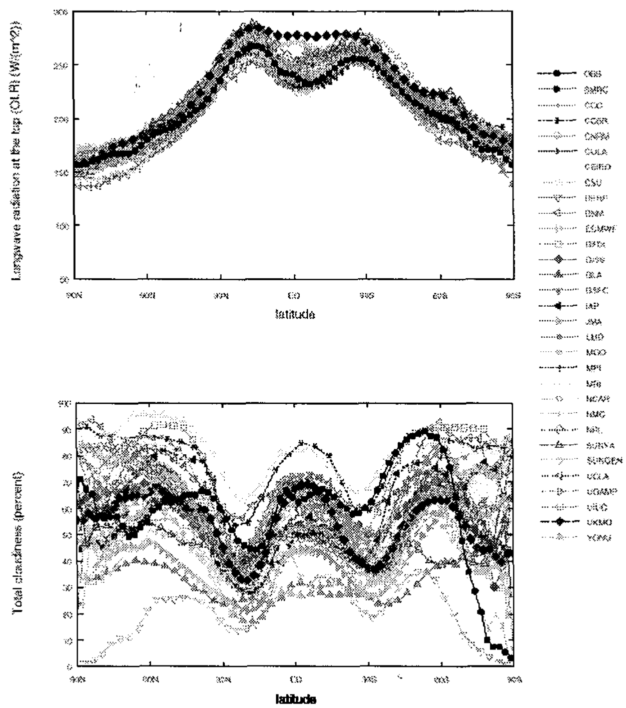

Fig. 1 Zonal plot showing the AMIP models' remarkable agreement for long-wave radiation and huge disagreement for total cloud cover. One of the goals of AMIP is to understand the reasons for the differences.

AMIP itself has undergone substantial changes as we realized that the type and amount of data saved was inadequate. AMIP II was initiated to provide the community with a more comprehensive data set, a longer simulation period, and most important, a chance to evaluate more current models. For the most part the AMIP II simulation have been completed and the data are in the process of being prepared for distribution to research subprojects.

Diagnostic needs and solutions:

For anyone involved in working with model data, particularly data from a variety of sources, one issues becomes painfully apparent – every model output will be different in some way. Because of the model output differences, the routines for input to diagnostics and intercomparison routines the data must be customized to accommodate the differences. One of PCMDI's goals is to develop the diagnostic infrastructure sufficiently sophisticated that the concerns about data format and structure will be minimal.

The first step to satisfy the need for more in-depth analysis of climate simulations and observations is to insure clear description of climate related data. This processing includes rearranging and restructuring data in a model invariant form with checks for consistency of many details including boundary conditions, latitude and longitude limits, and units.

The next step beyond data processing is the development of a hierarchy of model statistical descriptors. These preliminary diagnostics consists of a series of tests involving calculated global-time-mean values. Some obvious errors in the data can be corrected by modifying a meta-file descriptor created for each set of model output data. Once the general quality of data is determined, performance plots are generated and distributed to the AMIP community via PCMDI's WWW page. These plots characterize the basic behavior of the models, variable by variable. Fig. 2 shows a typical performance plot that gives a brief yet comprehensive view of comparative model output for evaporation suggesting that more complex treatments of surface processes actually produce results closer to those from reanalysis (Phillips, 1999).

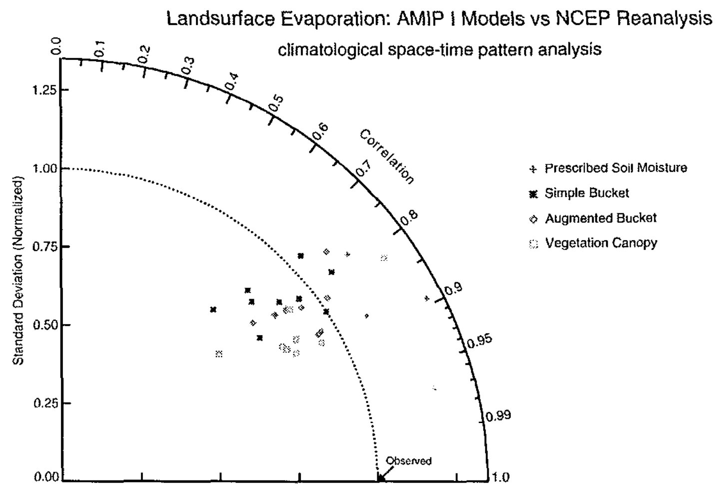

Fig. 2 shows several measures that characterize models' variability and spatial correlation with reanalysis.

Advanced Diagnostics

Another, more ambitious goal, is to collect and enhance more complex diagnostic techniques and incorporate them into a package that can be readily accessed by any user and exported to collaborating groups and to the general scientific community. The methods for assimilating these packages into the PCMDI Software Library will be discussed in another presentation given at this conference.

At present, we are preparing new diagnostics that will be incorporated into the Climate Data Analysis Tool (CDAT). These tools will be made available through a common interface using software freely available to the user community. Modules of diagnostics can be made up of FORTRAN, C, C++, or Python. One of the first modules to be imported into CDAT is SPHEREPACK, which is a package of Fortran 77 routines for computing spherical harmonic analyses and syntheses useful in problem solving in spherical coordinates. Examples of applications include: interpolating (regridding) and smoothing on the sphere, computing differential expressions such as laplacians and gradients, computing vorticity, divergence, streamfunctions and velocity potential from the winds.

Another module planned for inclusion into the PCMDI Software System is based on the recent work of Hodges (1994) and is a technique for identifying, tracking and generating statistical diagnostics, cyclones and anticyclones, which contribute a significant proportion of the synoptic scale variability in the storm tracks. This approach has been applied to MSLP systems as well as vorticity and geopotential at multiple tropospheric levels. Studies using these techniques examine the characteristics of synoptic systems in the different phases of the NAO, PNA and arctic oscillation. Fig. 3 is an example of the storm track analysis produced for the reanalysis.

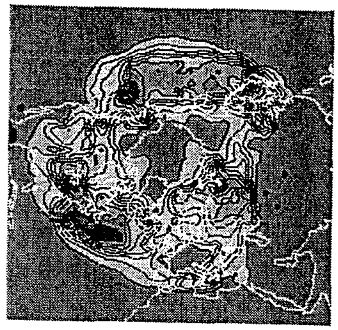

Fig. 3. Track density of the North Atlantic Oscillation (NAO) for the cyclonic part of the mean sea level pressure field.

PCMDI's role in coupled model diagnosis

PCMDI has joined an NCAR-University partnership for diagnosis of the Climate System model (CSM) and the Parallel Climate Model (PCM) (Washington et al., 1999). The objectives are to make the CSM and PCM history tapes available to the community in a format consistent with the standards set by international programs such as AMIP and CMIP. We also expect to implement an expanded list of diagnostic quantities and conduct interannual variability analysis of extended CSM and PCM runs. With the increased attention to the CSM and PCM models we will increase focus on the thermodynamic and dynamical budgets, and simulation error attribution from modeling analysis.

One major challenge is the amount of data generated by the coupled atmosphere/ocean models that are being run on modern large-scale parallel computers. When PCMDI was first started, a 10-year AMIP simulation would take several months to complete, and once the output was prepared, several months more went by before the data would be shipped to PCMDI. Months more would be required to process the data in a consistent form for distribution to the research community. Modern computers now can perform the simulations in a few days, the output is sent to PCMDI quickly and the processing can be completed in a few days. Present simulations of centuries takes about a week and the output data files are enormous. We estimate that the PCM alone will produce about 5 Terabytes of data for a few key runs. Modeling groups are presently overwhelmed by the volume of data and in response, PCMDI plans to expand its climate model data holdings to include many of the large coupled atmosphere/ocean model simulations being produced today. Discussions are in progress with NCAR, the Max Planck Institute für Meteorologie, and GFDL to archive many of their coupled simulations.

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Acknowledgements

I would like to thank the PCMDI staff in particular, Dean Williams, Peter Gleckler, Jim Boyle, Karl Taylor, Charles O'Connor, Tom Phillips, Jay Hnilo, Curt Covey for input to this report. I would also like to thank Sumant Nigam and Kevin Hodges for their input.