



PCMDI Report No. 24

**DOCUMENTATION OF THE AMIP MODELS ON THE
WORLDWIDE WEB**

by

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**DOCUMENTATION OF THE AMIP MODELS
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ABSTRACT

Summary documentation of the numerics, dynamics, and physics of models participating in the Atmospheric Model Intercomparison Project (AMIP) is now available on the Internet's World Wide Web. This paper describes the principal attributes of the electronic model documentation and provides instructions on how to access it.

1. Introduction

The intercomparison of atmospheric general circulation model (AGCM) experiments of a similar type has become an increasingly popular methodology for assessing the strengths and weaknesses of climate simulations (e.g., Cess et al. 1990, Randall et al. 1992). In such endeavors, attempts to attribute differences among the simulations to specific model properties require, as a minimum prerequisite, the accurate and comprehensive documentation of these features.

Regrettably however, atmospheric model documentation typically is fragmentary and scattered across numerous publications. It is also often inaccurate, in the sense that the pace of model development and the proliferation of new model versions usually outstrip their recorded descriptions. More often than not, the detailed configuration of a model for a particular experiment also is undocumented. In addition, there may be much unevenness in the descriptions of different facets of models (e.g., the description of atmospheric dynamics often eclipses that of surface processes). This incompleteness usually is replicated in published results of an intercomparison experiment, in that participating models' features often are summarized only perfunctorily.

By the early 1990's, developments within the World Climate Research Programme (WCRP) set the stage for redressing this state of affairs. A notable example was the 1991 launching of the Atmospheric Model Intercomparison Project (AMIP), an ambitious effort to evaluate the performance of current AGCMs in simulating the climate of the decade 1979-1988 under common specification of ocean temperatures and radiative forcings (Gates 1992). The widespread participation of international modeling groups (Table 1a) and the unprecedented scope of model diagnosis within the AMIP (Table 1b) made it imperative to set new standards in model documentation, as well as in a host of other arenas relevant for model intercomparison. Crucial support by the U.S. Department of Energy (DOE) also made it possible for the Program for Climate Model Diagnosis and Intercomparison (PCMDI) to meaningfully address these tasks in the course of its coordination of the AMIP on behalf of the WCRP.

Initially, documentation of the AMIP models crystallized in the form of PCMDI Report No. 18 (Phillips 1994), an extensive summary of the numerics, dynamics, and physics of 30 participating models. The report's chief strength was that it centralized information on these models according to a common, and reasonably comprehensive

Table 1a: A list of the AMIP modeling groups and their locations.

Acronym	AMIP Group	Location
BMRC	Bureau of Meteorology Research Centre	Melbourne, Australia
CCC	Canadian Centre for Climate Research	Victoria, Canada
CCSR	Center for Climate System Research	Tokyo, Japan
CNRM	Centre National de Recherches Météorologiques	Toulouse, France
COLA	Center for Ocean-Land-Atmosphere Studies	Calverton, Maryland (USA)
CSIRO	Commonwealth Scientific & Industrial Research Organization	Mordialloc, Australia
CSU	Colorado State University	Fort Collins, Colorado (USA)
DERF	Dynamical Extended Range Forecasting (at GFDL)	Princeton, New Jersey (USA)
DNM	Department of Numerical Mathematics (of the Russian Academy of Sciences)	Moscow, Russia
ECMWF	European Centre for Medium-Range Weather Forecasts	Reading, England
GFDL	Geophysical Fluid Dynamics Laboratory	Princeton, New Jersey (USA)
GISS	Goddard Institute for Space Studies	New York, New York (USA)
GLA	Goddard Laboratory for Atmospheres	Greenbelt, Maryland (USA)
GSFC	Goddard Space Flight Center	Greenbelt, Maryland (USA)
IAP	Institute of Atmospheric Physics (of the Chinese Academy of Sciences)	Beijing, China
JMA	Japan Meteorological Agency	Tokyo, Japan
LMD	Laboratoire de Météorologie Dynamique	Paris, France
MGO	Main Geophysical Observatory	St. Petersburg, Russia
MPI	Max Planck Institut fuer Meteorologie	Hamburg, Germany
MRI	Meteorological Research Institute	Ibaraki-ken, Japan
NCAR	National Center for Atmospheric Research	Boulder, Colorado (USA)
NMC	National Meteorological Center	Suitland, Maryland (USA)
NRL	Naval Research Laboratory	Monterey, California (USA)
RPN	Recherche en Prévision Numérique	Dorval, Canada
SUNYA	State University of New York at Albany	Albany, New York (USA)
SUNYA/NCAR	State University of New York at Albany/ National Center for Atmospheric Research	Albany, New York/ Boulder, Colorado (USA)
UCLA	University of California at Los Angeles	Los Angeles, California (USA)
UGAMP	The UK Universities' Global Atmospheric Modelling Programme	Reading, England
UIUC	University of Illinois at Urbana-Champaign	Urbana, Illinois (USA)
UKMO	United Kingdom Meteorological Office	Bracknell, United Kingdom
YONU	Yonsei University	Seoul, Korea

Table 1b: A list of the AMIP diagnostic subprojects and their scientific foci. (Coordination with other World Climate Research Programme initiatives is noted as appropriate.)

Subproject	Scientific Focus
1	Variability of the tropics: synoptic to intraseasonal time scales
2	Intercomparison of low frequency variability
3	Cyclone frequencies and extratropical intraseasonal variability
4	Clear-sky greenhouse sensitivity, water vapor distribution, and cloud radiative forcing
5	Surface boundary fluxes over the oceans
6	Monsoons (coordinated with MONEG/TOGA, WGNE)
7	Intercomparison of hydrologic processes in general circulation models
8	Polar phenomena and sea ice (coordinated with SIOMP/ACSYS)
9	Validation of high latitude tropospheric circulation in the Southern Hemisphere
10	Diagnostics of atmospheric blocking in general circulation models
11	Validation of humidity, moisture fluxes, and soil moisture in general circulation models
12	Land surface processes & parameterizations (coordinated with PILPS/GCIP/GEWEX, WGNE)
13	Diagnoses of global cloudiness variations in model results and observational data
14	Cloud radiative forcing: intercomparison and validation
15	Atmospheric angular momentum fluctuations in global numerical models
16	Simulations of the stratospheric circulation
17	Multi-scale water and energy balance processes (coordinated with GCIP/GEWEX)
18	Capability of current models to simulate extreme events and associated circulation patterns
19	Model validation by microwave sounding unit (MSU) data
20	Intercomparison of model simulated circulation features related to Southern Africa
21	Surface monthly and daily time-scale climatologies and regional climate anomalies
22	Comparative energetics analysis of climate models in the wavenumber domain
23	Variations of the centers of action
24	Analysis of Caspian Sea regional climate data as compared to AMIP model outputs
25	General circulation model simulation of the East Asian climate
26	Monsoon simulation in the AMIP models

ACSYS: Arctic Climate System Study

GCIP: GEWEX Continental-Scale International Project

GEWEX: Global Energy and Water Cycle Experiment

MONEG: Monsoon Numerical Experimentation Group

PILPS: Project for Intercomparison of Land-Surface Parameterization Schemes

SIOMP: Sea Ice and Ocean Modelling Panel

TOGA: Tropical Ocean-Global Atmosphere

WGNE: Working Group on Numerical Experimentation

framework (Table 2a). The bulk of the report qualitatively summarized the representation of these features in each AMIP model; tables also elucidated the ways in which selected properties played out across the models (Table 2b).

Despite the impressive scope of PCMDI Report No. 18, it suffered from an inherent limitation, in that the printed page is not well suited for the frequent updating of information that is endemic to the AMIP models. For example, since the 1994 publication of the report, the Center for Climate Systems Research has entered its model in the AMIP (Table 1a), and 8 groups have repeated the intercomparison experiment with new model versions.

Such frequent changes make it impractical to repeatedly issue printed revisions. The obvious need for a "living document" therefore demands the use of an electronic medium for rapid amendment and widespread dissemination of model documentation. While, in principle, this could be effected by physical transfer of archival media to AMIP participants (e.g., magnetic diskette or optical compact disk), the Internet's World Wide Web offers a much less costly means for transferring information, and in "real time" as well.

2. The World Wide Web

For some years, scientists have exchanged information on the Internet, e.g., via electronic mail and newsgroups, the File Transfer Protocol (FTP), and the Gopher and Wide Area Interactive System (WAIS) Protocols. However, the recent emergence of the World Wide Web, based on the Hypertext Transfer Protocol (HTTP), has qualitatively transformed the relationship of scientists to the Internet (Berners-Lee et al. 1994).

Since the inception of the World Wide Web (WWW, or W3) only a few years ago, the application of this technology has grown exponentially (from less than 100 Web sites in 1993 to about 35, 000 by mid-1995). In part, this growth is due to a server-client protocol that reprises the interaction exemplified originally by anonymous FTP: information is served automatically "on demand" to each client. However, the phenomenal popularity of the Web is due mostly to its support of multimedia applications (text, images, sound) which can be accessed "seamlessly" across different computing platforms. The scientific utility of these capabilities is apparent. (Indeed, the World Wide Web was created at CERN, the European Laboratory for Particle Physics, in order to foster collaborative exchange of scientific information in a variety of forms--see Segal 1995.)

Table 2a: A list of feature categories considered in the AMIP model summary documentation. The representation of these features is summarized for each AMIP model.

- AMIP representative(s)
- Model designation (following the WGNE-recommended form: institution, model and version, horizontal/vertical resolution)
- Model lineage (predecessor and related models)
- Model documentation (key references)
- Horizontal representation (spectral or finite differences)
- Horizontal resolution
- Vertical domain (lowest/highest atmospheric levels)
- Vertical representation (coordinates and differencing schemes)
- Vertical resolution
- Computer/operating system (for the AMIP simulation)
- Computational performance (minutes per simulated day)
- Initialization (of atmospheric state, snow cover/depth, and soil moisture)
- Time integration scheme(s)
- Smoothing/filling (types of algorithms used)
- Sampling frequency (AMIP history storage interval)
- Atmospheric dynamics (state variables)
- Diffusion (horizontal and vertical)
- Gravity-wave drag
- Solar constant/cycles (AMIP solar constant, inclusion of diurnal cycle)
- Chemistry (radiatively active gases and aerosols)
- Radiation (shortwave/longwave schemes, cloud-radiative interactions)
- Convection (deep and shallow)
- Cloud formation (prognostic or diagnostic schemes)
- Precipitation (formation and subsequent evaporation)
- Planetary boundary layer (representation and depth)
- Orography (datasets, smoothing procedures)
- Ocean (treatment for AMIP simulation)
- Sea ice (treatment for AMIP simulation)
- Snow cover (formation/melting, effects on surface characteristics)
- Surface characteristics (surface types, roughness, albedo, emissivity)
- Surface fluxes (momentum, heat, and moisture)
- Land surface processes (vegetation and soil thermodynamics/hydrology)

Table 2b: List of 15 feature tables included in the AMIP model summary documentation. The table entries consist of concise descriptors of the expression of the feature across all the AMIP models.

1. Model representation/resolution
2. Computational information
3. Initialization
4. Time integration
5. Filtering, smoothing, and filling
6. Diffusion and gravity-wave drag
7. Atmospheric chemistry
8. Atmospheric radiation
9. Cloud-radiative interactions
10. Convection
11. Cloud formation and precipitation
12. Planetary boundary layer
13. Snow cover and sea ice
14. Surface characteristics
15. Land surface processes

Exchange of multimedia is made possible by the Web's *lingua franca*, the Hypertext Markup Language (HTML). "Hypertext" is a means of conveying electronic information by first fragmenting it, and then spanning the fragments by "hyperlinks" that are activated by "point-and-click" operations. A body of information therefore can be explored "nonlinearly", according to the user's whims (Nelson 1981, Schneiderman and Kearsley 1989). In HTML, the hyperlinks may span different media (e.g., text and images) as well as different servers (hence the term "World Wide Web"). For HTML multimedia to be rendered intelligible, however, one needs to use a W3 navigation tool (see Appendix).

3. Hypertext Model Documentation

Hypertext formatting greatly enhances the utility of lengthy treatises such as PCMDI Report No. 18, and atmospheric model documentation lends itself readily to this representation (Phillips and Meyer 1990). That is, because the individual scientist often has a particular interest only in a subset of models and properties, it is natural to break the hypertext documentation according to model (Table 1a), with provision for rapid access of all feature descriptions (Table 2a).

For the AMIP models, this schema is implemented by lists of hyperlinks that map the features of Table 2a to each model in Table 1a (Phillips et al. 1995a). In addition, hyperlinks provide convenient cross referencing of related features within each model summary (see Display below). Moreover, each citation of a reference from the model documentation literature is connected to the associated bibliographic information by means of a hyperlink. The latter feature is essential for those scientists requiring quantitative details on model algorithms and parameterizations--information that is beyond the intended scope of the hypertext documentation. (A bibliography of references specific to each AMIP model is provided in addition to a comprehensive listing of more than 500 references.)

As in PCMDI Report No. 18, tables provide an overview of selected properties expressed across the AMIP models. A "History of Changes" page lists each update of the AMIP model documentation and a "What's New?" page advertises the most recent changes. In addition, a glossary explicates the many acronyms of the AGCM world, while hyperlinks connect to the Internet servers of these institutions.

Aside from the enhancements afforded by hypertext formatting, there are other

significant advantages to accessing AMIP model documentation on the World Wide Web. For example, W3 browsers allow one to search on key words, and to save, annotate, and print HTML documents at the home site.

Display: Excerpted summary documentation of the representations of precipitation and planetary boundary layer in the AMIP version of the NCAR CCM2 model. Note usage of hyperlinks to cross reference related summaries of convection, diffusion, and surface fluxes in the model (indicated by underlined text) as well as bibliographic information on cited references (indicated by bracketed numerical footnotes).

Precipitation

Subgrid-scale precipitation is generated in unstable conditions by the moist convective scheme (see Convection). Grid-scale precipitation forms as a result of supersaturation under stable conditions. In this case, the moisture is adjusted so that the layer is just saturated, with the excess condensing as precipitation; the layer temperature is adjusted according to the associated latent heat release. (Moisture and temperature are mutually adjusted in two iterations.) Subsequent evaporation of falling precipitation is not simulated. Cf. Hack et al. (1993) [3] for details.

Planetary Boundary Layer

The PBL height is determined by iteration at each 20-minute time step following the formulation of Troen and Mahrt (1986) [26]; the height is a function of the critical bulk Richardson number for the PBL, u-v winds and virtual temperature at the PBL top, and the 10-meter virtual temperature, which is calculated from the temperature and moisture of the surface and of the lowest atmospheric level (at $\sigma = 0.992$) following Geleyn (1988) [27]. Within the PBL, there is nonlocal diffusion of heat and moisture after Holtslag and Boville (1993) [9]; otherwise (and under all conditions for momentum), properties are mixed by the stability-dependent local diffusion that applies in the model's free atmosphere. See also Diffusion and Surface Fluxes.

4. Future Plans

In only a few years, the advent of the World Wide Web has revolutionized the manner in which much scientific information is exchanged. In the future therefore, PCMDI plans to vigorously apply this new technology in order to further the validation, intercomparison, and improvement of global climate models.

Having pioneered in developing hypertext AGCM documentation, PCMDI will maintain its currency for the AMIP. Feature descriptions of each new model version will be made available on the Web, as the requisite output data (Gates 1992) are quality assured and archived. Moreover, each model version will be identified unambiguously, as recommended by the WCRP's Working Group on Numerical Experimentation (see "Model Designation" in Table 2a), and will be situated historically in relation to other models (see "Model Lineage" in Table 2a). This documentation therefore will serve as an ongoing record of international AGCM development in coming years.

In the longer term, PCMDI plans to document the properties of coupled ocean-atmosphere models that will increasingly become the focus of future intercomparison experiments. This will require development of new features categories (analogous to Table 2a) that are relevant for coupled models. The resulting summary descriptions of model properties also will be made available on the Web.

Finally, PCMDI intends to expand its other W3 applications that presently exist in embryonic form (Phillips 1995, Phillips et al. 1995b). These include W3 dissemination of PCMDI software, observational data products for model validation, and publications describing the activities of the PCMDI staff. In addition, information on AMIP participants, datasets, and publications will be appropriately updated with the further progress of this intercomparison project.

Questions or comments on PCMDI's World Wide Web pages are welcome, and may be directed to the author at phillips@tworks.llnl.gov.

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Appendix: Accessing AMIP Information on the World-Wide Web

a. Internet Addressing Conventions

To access information on the World Wide Web (W3), the essential first step is to obtain a connection to the Internet, either directly or through an Internet host computer, online service provider, etc.).

Each W3 server on the Internet has an associated address known as a Uniform Resource Locator (URL), which takes the form

http://server_name/

Here the string 'http' denotes the Hypertext Transfer Protocol. Every file on a W3 server is accessed according to a URL that is relative to that of the server's, e.g.

http://server_name/file_name.html

where the extension 'html' identifies the file as one containing information expressed in the Hypertext Markup Language (HTML), the medium of exchange on the Web. The "home page" of a W3 server is a file that functions as a directory to other server files. (Access of the home page sometimes requires specification of a URL that includes its file name, but often the system is configured so that access of the W3 server alone is sufficient to bring up the home page.)

b. Navigation Tools

To operate on the Web, it is necessary to acquire a navigation tool, or "browser", that interprets documents written in HTML. A multitude of such browsers are presently available. Among these are the the Mosaic browser, whose development by the National Center for Supercomputing Applications (NCSA) sparked much of the early interest in the Web. Because it offers some additional enhancements, the Netscape Navigator (developed by the Netscape Communications Corporation) is now also very popular. Both Mosaic and Netscape browsers are available for use on X Window (Unix), Apple Macintosh, and Microsoft Windows computing platforms. These browsers also come with "viewers" and "players" for rendering images and audio applications. Users of computers that do not support multimedia may acquire a text-only browser such as Lynx, which currently runs in Unix, VMS, or DOS operating systems. A catalogue of other possible choices of navigation tools can be accessed from the home page of the World Wide Web (see Section *d*).

Mosaic and Lynx browsers are freely available for nonprofit applications, and an unsupported (beta) version of Netscape Navigator also can be acquired for free (the supported version being available at nominal cost). All these browsers may be downloaded via anonymous FTP, and Mosaic and Netscape browsers can be obtained on diskette as well.

Most browsers come with "help" documentation to orient the new user to basic procedures (e.g., how to "open" a URL, navigate the Web, save and print W3 files, etc.). The W3 home pages for NCSA and Netscape also provide general information on the World Wide Web and the Hypertext Markup Language, as well as directories and "search engines" that can be used to identify URLs of interest. Much useful information of a similar type may also be obtained from the home page of the World Wide Web (see Section *d*).

c. Accessing PCMDI's W3 Pages

Once in possession of a W3 browser, a user can access the PCMDI home page at URL

<http://www-pcmdi.llnl.gov/>

The home page contains a directory of hyperlinks (indicated by highlighted entries); clicking on these will pull up other PCMDI Web pages containing information, software, or data pertinent to climate modeling. For example, clicking on entries labeled "Model Features Documentation" will bring up the hypertext documentation of AMIP model features. This also can be accessed directly by opening URL

<http://www-pcmdi.llnl.gov/phillips/modldoc/amip.html>

Entries to other information on the AMIP (Phillips 1995) are provided on the PCMDI home page, or these can be accessed at URL

<http://www-pcmdi.llnl.gov/phillips/AMIP.html>

d. Address Information

Addresses and FTP/W3 servers where the Mosaic, Netscape, and Lynx W3 browsers may be obtained are listed below. The URLs of relevant pages on the World Wide Web's home server are included as well.

National Center for Supercomputing Applications (NCSA Mosaic)

The University of Illinois at Urbana-Champaign

605 E. Springfield, Champaign IL 61820

e-mail: mosaic@ncsa.uiuc.edu

Anonymous FTP: <ftp.ncsa.uiuc.edu/Mosaic> (use subdirectories **/Unix**, **/Mac**, or **/Windows** according to computing platform; see 'readme' files for installation directions.)

W3 URL: <http://www.ncsa.uiuc.edu/General/NCSAHome.html>

Netscape Communications Corporation (Netscape Navigator)

501 E. Middlefield Road, Mountain View, CA 94043

e-mail: info@netscape.com

Anonymous FTP: <ftp.netscape.com/pub/netscape> (Use subdirectories **/unix**, **/mac**, or **/windows** according to computing platform; see 'readme' files for installation directions.)

W3 URL: <http://www.netscape.com>

Lynx (text-only W3 browser)

c/o Academic Computing Services

The University of Kansas

Lawrence, KS 66045

e-mail: lynxhelp@stat1.cc.ukans.edu

Anonymous FTP: <ftp2.cc.ukans.edu/pub/lynx> (Use subdirectories **/lynx** for Unix and VMS computing platforms and **/DosLynx** for DOS platforms; see 'readme' files for installation directions.)

W3 URL of Lynx Users Guide:

http://www.cc.ukans.edu/lynx_help/Lynx_users_guide.html#TOC

The World Wide Web Server

W3 URL of home page : <http://www.w3.org/hypertext/WWW/TheProject.html>

W3 URL of catalogue on client (browser) software for Web navigation:

<http://www.w3.org/hypertext/WWW/Clents.html>

PCMDI REPORTS

<u>Number</u>	<u>Title</u>	<u>Author(s)</u>	<u>Date</u>
1	The Validation of Atmospheric Model	W.L. Gates	March 1992
2	Analysis of the Temporal Behavior of Tropical Convection in the ECMWF Model	J.M. Slingo K.R. Sperber J.-J. Morcrette G.L. Potter	April 1992
3	The Effect of Horizontal Resolution of Ocean Surface Heat Fluxes in the ECMWF Model	P.J. Gleckler K.E. Taylor	July 1992
4	Behavior of an Ocean General Circulation Model at Four Different Horizontal Resolutions	C. Covey	August 1992
5	The Effects of Sampling Frequency on the Climate Statistics of the ECMWF General Circulation Model	T.J. Phillips W.L. Gates K. Arpe	September 1992
6	Sensitivity of Dynamical Quantities to Horizontal Resolution in a Climate Simulation with the ECMWF Atmospheric General Circulation Model (Cycle 33)	J.S. Boyle	October 1992
7	AMIP: The Atmospheric Model Intercomparison Project	W.L. Gates	December 1992
8	The Impact of Horizontal Resolution on Moist Processes in the ECMWF Model	T.J. Phillips L.C. Corsetti S.L. Grotch	January 1993

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|----|---|---|---------------|
| 9 | A Modeling Perspective on Cloud Radiative Forcing | G.L. Potter
J.M. Slingo
J.-J. Morcrette
L. Corsetti | February 1993 |
| 10 | The Use of General Circulation Models in Detecting Climate Change Induced by Greenhouse Gases | B.D. Santer
U. Cubasch
U. Mikolajewicz
G. Hegerl | March 1993 |
| 11 | Preliminary Validation of the Low Frequency Variability of Tropospheric Temperature and Circulation Simulated for the AMIP by the ECMWF Model | J.S. Boyle | April 1993 |
| 12 | Simulation of the Indian and East-Asian Summer Monsoon in the ECMWF Model: Sensitivity to Horizontal Resolution | K.R. Sperber
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| 14 | Ocean Variability and its Influence on the Detectability of Greenhouse Warming Signals | B.D. Santer
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| 15 | Cloud-Radiative Effects on Implied Oceanic Energy Transports as Simulated by Atmospheric General Circulation Models | P.J. Gleckler
D.A. Randall
G. Boer
R. Colman
M. Dix
V. Galin
M. Helfand
J. Kiehl
A. Kitoh
W. Lau
X.-Z. Liang
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