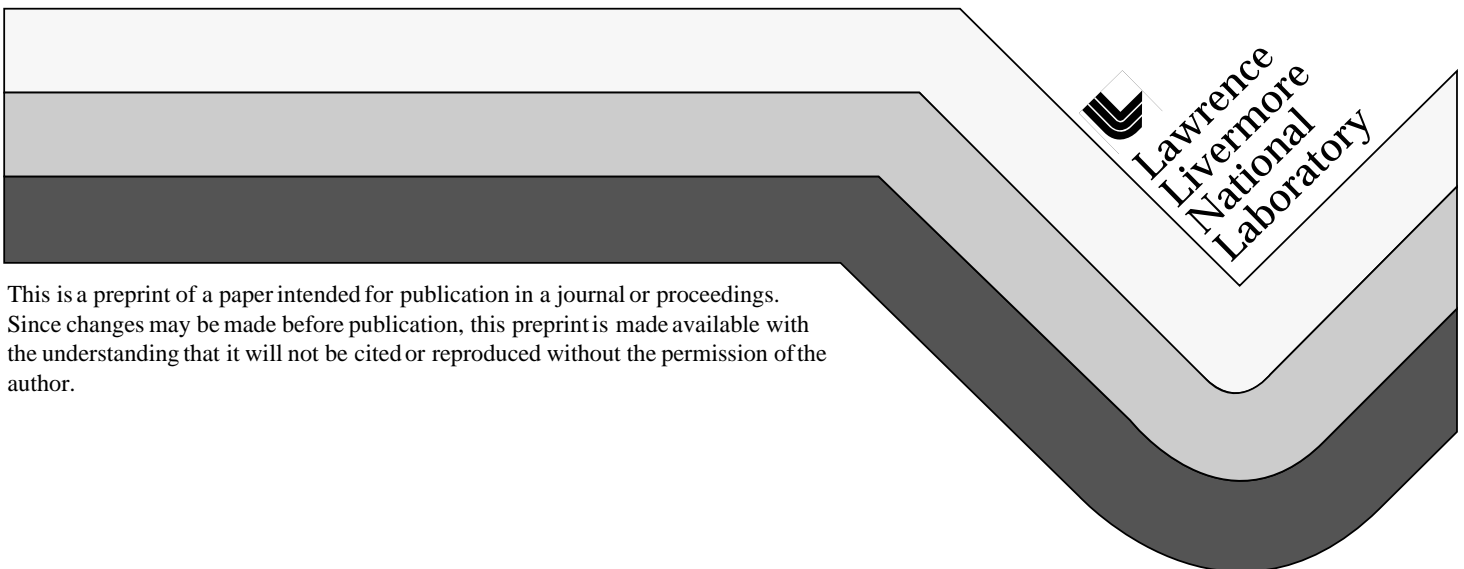


# CMIP: A Study of Climate Variability and Predictability According to General Circulation Models

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## **CMIP: A Study of Climate Variability and Predictability According to General Circulation Models**

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Coupled ocean-atmosphere general circulation models are used to predict future global changes, such as warming due to anthropogenic greenhouse gases (Houghton *et al.*, 1996). In addition, coupled-GCM simulations of the natural climate (without human interference) can be compared with observations over the past century. Recent work along such lines concludes that an anthropogenic signal of global warming is emerging from natural variability “noise” (*ibid.*). More careful and systematic examination of the models seems warranted, however. Toward that end the World Climate Research Program has begun the Coupled ocean-atmosphere Model Intercomparison Project.

Like the Atmospheric Model Intercomparison Project (Gates, 1992, 1995), CMIP aims to comprehensively study model behavior, but there are important differences between AMIP and CMIP. Whereas AMIP examines atmospheric models run with prescribed sea surface temperatures—in essence fixing the climate near observations by imposing a boundary condition—CMIP deals with global coupled models of the atmosphere, ocean and sea ice. CMIP will examine a relatively small subset of model output. The subset includes spatial and temporal averages of some 20 meteorological and oceanographic variables, together with three-dimensional (longitude, latitude, time) fields of just a few variables such as surface air temperature. Finally, CMIP (unlike AMIP) solicits output that for the most part has already been produced by models. This procedure avoids imposing costly new numerical experiments on modelers, but it results in lack of uniformity in model boundary conditions (especially the boundary condition in time: initial conditions and “spin-up” procedures).

In its initial stage, CMIP is examining only so-called control runs, in which external forcing terms—CO<sub>2</sub>, solar luminosity, etc.—are held constant. CMIP has received output from 17 different coupled GCM control runs, including 3 very long (~1000 year) simulations (Table 1). A preliminary look at the model-simulated variability of surface air temperature reveals several noteworthy features. For the shortest time

scale examined, the seasonal cycle, the models agree fairly well with observations. This is a nontrivial result, because about half the models examined refrain from using "flux correction" to move their results closer to observations. Power spectra of the globally and annually averaged surface air temperature (Figure 1) reveal substantial differences in interannual variability among the models. For these time scales, the model-simulated variability is typically less than observed. At the longest (centennial) time scales, observations are scarce, but the models seem to agree well with each other.

More diagnosis of the model simulations is needed. Planned activities include the study of many fields in addition to surface air temperature. For temperature variations, we will examine the geographical pattern and correlation structure of variations, and we will compare the model output with high-resolution paleodata. Consideration of externally forced natural variability (e.g., from solar luminosity changes) is also required in order to assess the realism of the models' long-term variations. CMIP will also invite a limited number of researchers to analyze model output "data." These working arrangements will be similar to the AMIP Diagnostic Subprojects.

The second phase of CMIP will begin in 1997. This phase will examine model responses to an idealized scenario of anthropogenic climate forcing: a 1% per year increase in atmospheric carbon dioxide. Diagnosis of the model output will produce the first comprehensive data base on model predictions of future climatic changes.

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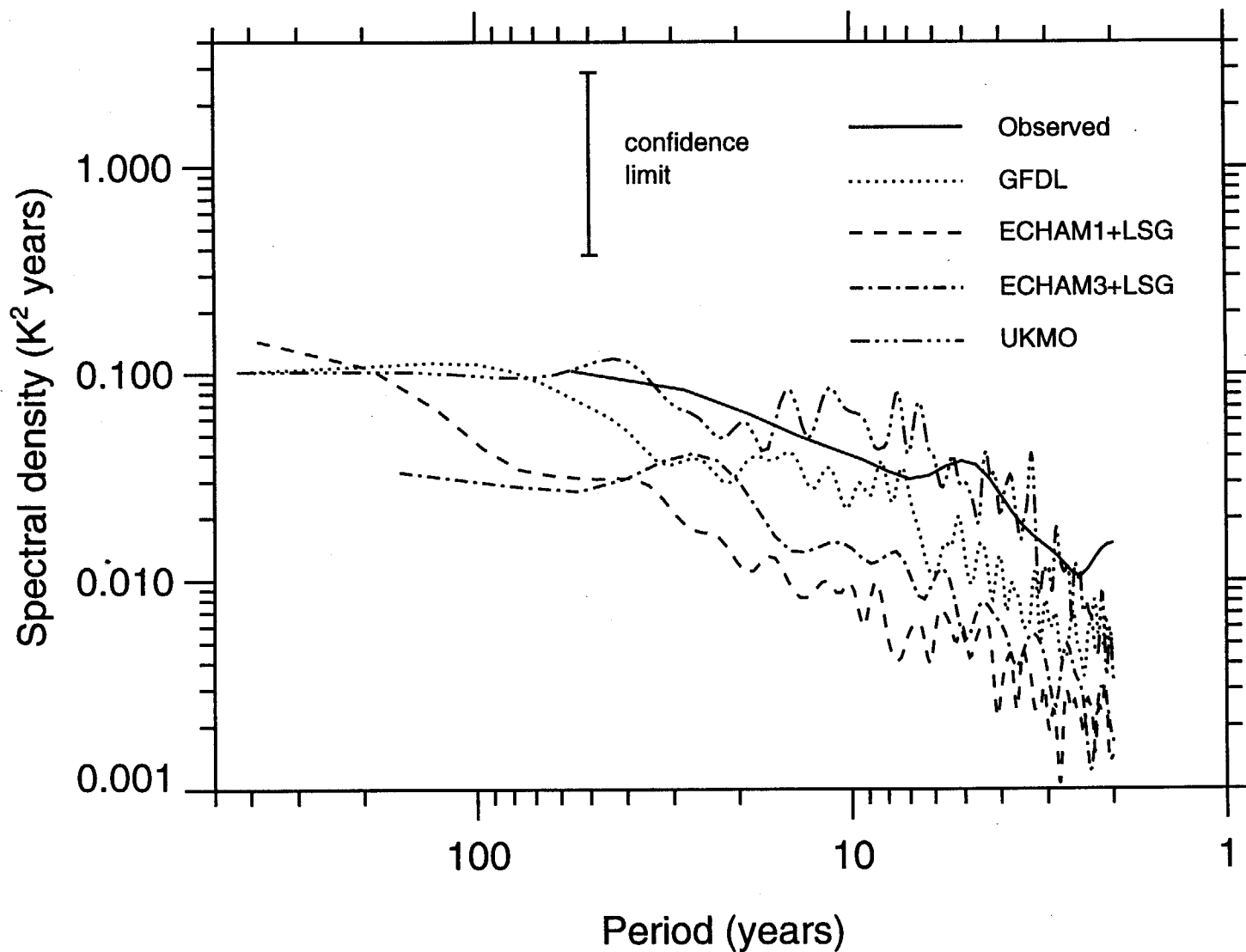
Houghton, J. T., L. G. Meira Filho, B. A. Callander, N. Harris, A. Kattenberg and K. Maskell (eds.), 1996: *Climate Change: The 1995 IPCC Assessment*, Cambridge University Press.

## CGCM Control Run Output Received for CMIP1

Model	Flux Correction	Run Length [yr]	T time-series	Other fields
BMRC	none	105	√QC	√
CCCMA	heat, water	150	√	√
CCSR	heat, water	40	√QC	√
CERFACS	none	40	√QC	√
COLA	none	50	√QC	√
CSIRO	heat, water, momentum	100	√QC	√
GFDL	heat, water	1000	√QC	
GISS (Miller)	none	89	√QC	√
GISS (Russell)	none	98	√QC	√
LMD**	none	24	√QC	
MPI (ECHAM1+LSG)	heat, water, momentum	960	√QC	
MPI (ECHAM3+LSG)	heat, water, momentum	400	√QC	√
MPI (ECHAM4+OPYC)	heat, water (ann. mean)	240	√	√
MRI	heat, water	100	√QC	√
NCAR (CSM)	none	30	√	√
NCAR (Wash. & Meehl)	none	100	√QC	√
UKMO	heat, water	1085	√QC	

QC ==> quality-controlled (E. Cohen-Solal, K. Taylor)

Figure 1: Power spectra of globally averaged surface air temperature as observed (by weather stations over the past century) and as simulated by the four longest-running CMIP models. Spectra are normalized so that the areas under the curves (if plotted linearly) equal the total variances about the means of detrended time series. The 95% confidence interval indicated by the vertical bar is the same for all cases, because the ratio (maximum lag) / (number of time points) is the same for all cases.



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