DOE/ER/60422--6

DE91 007363

Progress Report
on
Natural and Anthropogenic Climate Change

Grant No. DE-FG02-86ER60422
(March 1, 1990 - October 1, 1990)

Prepared by

W. J. Gutowski, W.-C. Wang*, D. A. Portman and M. J. Iacono

Atmospheric and Environmental Research, Inc.
840 Memorial Drive
Cambridge, MA 02139

Prepared for

Carbon Dioxide Research Division
Physical and Technology Research Division
Office of Health and Environmental Research
Department of Energy
Washington, D.C. 20545

September 30, 1990

*At Atmospheric Sciences Research Center, State University of New York, Albany, N.Y.

This report covers the project progress of grant DE-FG02-86ER60422 for the period March 1, 1990 - October 1, 1990.

The research program includes three tasks: GCM intercomparison and improvement, climate data-model statistics, and China project science coordination. This work has been performed in collaboration with our subcontractor, Dr. Wei-Chyung Wang, SUNY/Albany. Their progress is summarized below.

Task 1: GCM Intercomparison and Improvement

This task includes three subtasks: spectral-to-grid GCM comparison, regional climate study and energy/hydrologic cycle.

Spectral-to-Grid GCM Comparison

Research on this task has been completed and described in a DOE technical report. A manuscript is being prepared for submission to a refereed journal. Significant dynamical differences occurred between the spectral and gridpoint simulations, particularly in simulating the hydrological cycle. Moisture convergence, the frequency of precipitation events and time-average cloudiness were greater in the gridpoint model. These differences produced further differences between the models in their radiation fields. By using different resolutions in the spectral model we could discern which differences varied with model resolution. Varying resolution caused changes no greater than switching numerical schemes.

Reference:

Gutowski, W.J., M.J. Iacono, X.-Z. Liang and W.-C. Wang, 1990: Simulating Climate with Two Different Numerical Schemes. DOE/ER-0459T, 57pp.

Regional Climate Study

We are planning to use output from NCAR CCM1 runs performed under other contracts as input to a set of simulations using the NCAR MM4 model. Drs. Wang and Zhang at SUNY/Albany have performed initial computations running the MM4 for a January test case (see Arid/Semiarid Climate in China, below). We are also developing an approach to make optimum use of the CCM1 output

using techniques of weather typing. We have discussed the approach with T. R. Karl of NCDC/NOAA. Complementary work on the same model output by Karl's group should facilitate our progress.

As an alternative means for evaluating regional climate variability, we have fed tropical, CO_2-doubling changes from GCMs into a hurricane model to determine changes in local, severe-rainfall characteristics. Using these changes in a hydrological basin model, we find that global warming could negate most of the benefits of existing water management practice established for the basin.

Reference:

Gutowski, W.J., G. F. McMahon, P. Kirshen and S. Schluchter, 1990: Projecting climate change to small basins: Potential impact of global warming on flooding in South Florida. Submitted to J. Geophys. Res.

Energy/Hydrologic Cycle

Work on this task was begun during the current year. We have discussed these cycles, particularly the water cycle, with experts in this area, including Jose Piexoto who recently visited AER. We have formulated plans to analyze output from the CCM1 simulations mentioned above to study regional energy and moisture transports, for comparison with available observations and with the planned regional simulations.

Task 2: Climate Model-Data Statistics

The task includes four subtasks: climate statistics, GCM/observations comparisons, the regional climate of China during historical times, and arid/semiarid regions.

Climate Statistics

We examined the temperature and precipitation fluctuations in China using the two DOE datasets of 200 stations and 60 stations prepared under the USA-DOE/Chinese Academy of Sciences joint project on the greenhouse effects. Empirical orthogonal function analysis was used to study the spatial and

temporal patterns during the period 1954-1983. It is found that the 60-station network, for which station histories are available, can provide similar large scale climate characteristics as derived from the more dense 260-station network. A report summarizing the key findings being completed (Wang and Zeng, 1990).

It is known that the urban heat island effect can affect temperature trends. We have investigated urban warming using temperature data from China. Urban-rural station pairs were chosen to study the urban heat island effect, which is found to be quite substantial with large regional and seasonal variations. These results are included in two manuscripts: Jones et al. (1990) and Wang et al. (1990).

References

Jones, P.D., P. Ya. Groisman, M. Coughlan, N. Plummer, W.-C. Wang and T.R. Karl, 1990: Assessment of urbanization effects in time series of surface air temperature over land. Nature, 347, 169-172.

Wang, W.-C., Z.-M. Zeng, 1990: Temperature and precipitation fluctuations in China, in draft.

Wang, W.-C., Z.-M. Zeng and T.R. Karl, 1990: Urban heat islands in China. Submitted to Geophys. Res. Lett.

GCM/Observations Comparisons

We have performed comparisons of climate statistics between an NCAR GCM simulation and observations. Both the mean and variance were compared not only for the surface quantities but also for the upper air. Daily and seasonal gridbox temperatures simulated by the model were compared with observed station temperatures at the surface, 850 mb, 500 mb, and 300 mb levels for three different areas in the United States. Although the GCM's gridbox temperatures are mostly cooler than station temperatures, they are equally variable. For all gridboxes, gridbox-to-station differences decrease with height and vary with time-of-year. Parametric and non-parametric techniques employed provided useful comparisons of GCM regional and local observed temperatures. Results are detailed in Portman et al. (1990).

Dr. Wang and Mr. Portman have collaborated with T. R. Karl and R. Knight of the National Climatic Data Center and M. Schlesinger of the University of

Illinois to adapt techniques used in numerical weather prediction to develop a method of relating GCM simulations of seasonal climate to observations. Generalizing on "model output statistics" and "perfect prog" techniques they find that even an early version of the Oregon State University two-level atmospheric GCM (with prescribed sea-surface temperature) produces free-atmosphere statistics than can, when standardized using the model's internal means and variances, closely approximate the observed local climate. When the model data are standardized by the observed free-atmosphere means and variances, however, the model does not reproduce the observed surface local climate as well. The results indicate that differences between the output of a ten-year GCM control run and the surface-based observations are often smaller than the differences between the observations of two ten-year periods. Such positive results suggest that GCMs may already contain important climatological information that can be used to infer the local climate.

References:

Karl, T.R., W.-C. Wang, M.E. Schlesinger, R.W. Knight, and D. Portman 1990: "A method of relating general circulation model simulated climate to the observed local climate, Part I: Seasonal statistics. J. Climate (in press).

Portman, D.A., W.-C. Wang and T.R. Karl, 1990: Comparison of general circulation model and observed regional climates: daily and seasonal variability. Submitted to J. Climate.

Arid/Semiarid Climate in China

The goals in this task are, first, to gain a better understanding of the climate characteristics in arid/semiarid regions in northern and northwestern China by identifying the geophysical factors that strongly influence the regional climate and, second, to improve and develop regional models for climate impact study of these regions. During the first phase, our effort has concentrated on examining the observational characteristics such as special short term (a few days) events and weather regimes and the simulations of these events and regimes using NCAR MM4 meso-scale model. So far we have picked several cases in January and July. Preliminary results of a test case in January appear to indicate that MM4 is capable of simulating the observed characteristics. However, more simulations and analyses are needed to establish the climate statistics.

Regional Climates in China During Historical Times

A comparison of climate changes in China between 6000 yr. BP and the present with simulated CO_2-doubling changes shows many similar characteristics, lending insight into the possible regional effects of global warming in China.

Reference

Zhang, Y., and W.-C. Wang, 1990: The surface temperature in China during mid-holocene. Acta Geographica Sinica (in press).

Task 3: China Project Coordination

Dr. W.-C. Wang as USA-DOE/PRC-CAS chief scientist, has continued the coordination of the joint project, which included organizing with M. Riches the April 1990 project science meeting in Livermore, CA, and 1990 international climate conference in Beijing. He worked with the Chinese Academy of Sciences to organize the conference and with M. Riches/DOE to present DOE-CAS joint project results and findings.

For the remaining period, we plan to continue the studies still underway. We do not anticipate any technical problems.

END

DATE FILMED

03/05/91