SSEC No.75.11.M1

Permanent File SSEC Publications Office

THE SCHWERDTFEGER LIBRARY
1225 W. Dayton Street
Madison, WI 53706

FINAL REPORT

for

NSF Research Grant GA-31316

on

Numerical Modeling of Atmospheric Circulation Changes Caused by Air Pollution

October 15, 1971 - March 31, 1973

Principal Investigators

Michael McClintock
Space Science and Engineering Center

and

David D. Houghton
Department of Meteorology
University of Wisconsin
Madison, Wisconsin 53706

Submitted November 11, 1975

I. Introduction

This project fell short of its original goals due to extraordinary circumstances involving the principal investigators. Dr. Michael McClintock suffered from considerable personal problems for much of the duration of the grant. He finally left the University of Wisconsin and has been completely out of touch with all involved with this project ever since. As a result, this report is being made by Dr. Houghton alone. Furthermore, Dr. David Houghton was on leave from August 15, 1972 until the expiration of the grant. Although good progress had been made during the first half of the grant period, only one specific study was completed; and that was possible because of the help of Dr. John Kutzbach and Mr. David Suchman who had become involved with the work.

II. Summary of Scientific Findings

Although the research had been intended to address the effects of atmospheric pollutants on the general circulation in the NCAR global numerical model, the accomplished work dealt with only a component of the problem, namely the effect of sea surface temperature (SST) anomalies on the general circulation. The SST anomaly was anticipated to be a concomitant forcing factor that could be treated more directly and had better verification data than the atmospheric pollutants and was therefore more suitable for initial tests. The SST anomaly study was also intended to demonstrate the nature of the model response to general small amplitude forcing anomalies whether internal or at the model boundaries and to provide guidance for experimental design.

The paper by Houghton, Kutzbach, McClintock, and Suchman (1974) summarizes the study. In general, some correspondence to real observations was noted for the warm anomaly experiment although it was very evident that there remained a number of problems with the experimental design and the numerical model itself.

An important conclusion was that there were serious limitations to using current models for this type of experiment. Natural variability within the model needed to be accounted for. Deficiencies in the model control simulation such as poor representation of storm tracks and lack of stationarity made it difficult to determine physically significant results in the solutions. It became clearly evident that much further study with the general circulation model was needed before progressing to meaningful experiments on climatic implications of atmospheric constituent changes. The results of this investigation were considered significant in providing useful diagnostic information about the current state of the art with the NCAR general circulation model.

III. Publications

Houghton, David D., John E. Kutzbach, Michael McClintock, and David Suchman, 1974. Response of a General Circulation Model to a Sea Temperature Perturbation. J. Atmos. Sci. 31: 857-868. (See next page for abstract).

Abstract

Sea temperature anomalies which departed from the December climatic mean by approximately 2C off the coast of Newfoundland were inserted into the NCAR six-layer, 5° mesh, general circulation model of the atmosphere in order to test the model's response to small perturbations in sea surface temperature. The response of the model to the anomalies was analyzed with respect to pressure patterns, heat flux, and cyclone frequency, path and intensity. This response was compared with a statistical analysis of the response of the atmosphere to similar sea temperature anomalies based on approximately 80 years of observations as described by Ratcliffe and Murray.

Analyses of the anomaly experiments are preceded by an analysis of the basic (control) statistics for both model and atmosphere. The most pronounced discrepancies between the two were noted in cyclone statistics. A calculation with double horizontal resolution greatly improved the model features. Detailed comparison was complicated by the fact that the model failed to achieve statistical stationarity.

The extensive verification data of Ratcliffe and Murray proved valuable in distinguishing meaningful anomaly responses from those that could be attributed to the many limitations in the model, including a pronounced natural variability. Both warm and cold anomaly cases were tested. Best agreement with observed data was obtained for the case of the warm anomaly; this agreement was most evident during the middle portions of the integrations and then only in the North Atlantic sector. The response in the case with a cold anomaly was not was satisfactory although there were clear distinctions between the warm and cold anomaly cases.

A reprint of this paper is attached to this report.

IV. Student Support

The grant provided no significant student support and generated no degrees; however, the following students did participate in the research work:

Tom Phillips

Alan Robertson

Steve Sargent

David Suchman

Joe Tikvart

V. Other

This research was present informally on several occasions but not at a regular scientific meeting.