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MEAN STATISTICS OF THE TROPOSPHERIC MRI·GCM–I BASED ON 12–YEAR INTEGRATION

BY

FORECAST RESEARCH DIVISION, MRI

気象研究所技術報告

第20号

気象研究所対流圏大気大循環モデル(MRI·GCM-I)による12年間の積分

予 報 研 究 部

気象研究所

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序

本報告は，気象研究所予報研究部の大気大循環研究にたずさわる諸氏による大気大循環モデル（MRI・GCM-I）による12年間に及ぶ長期積分の結果から，各種気象要素の気候値，偏差について水平分布，南北断面，時間変動などを図示したものである。

大気の大規模な循環の実態を把握し，その維持や変動の機構を解明することは，気象学の中心課題の一つである。大循環に関する解析的研究はこれまでも進められてきたが，FGGE以後，特に全球的資料の蓄積とそれらの解析を通して実態把握は，より定量的かつ詳細になってきた。

一方，大気大循環に関する数値シミュレーションによる研究は，それぞれに特徴を備えたモデルを用いて世界の主要な気象センターにおいて行なわれてきており，その成果はめざましいものがある。気象研究所においても筑波移転に伴って電子計算機が設置され，気象研究所で開発された大循環モデルによる数値実験が本格的に始められた。このモデルの内容の詳細については，既に，気象研究所技術報告 No.13（1984）に示されている。

現在，世界気候研究計画（WCRP）の実施が WMO, ICSU を中心に企画されており，大気大循環の季節変動，年々変動の解明は重要な課題の一つとなっている。数値シミュレーションはこのための一つの有力な手段であり，現実大気の長期変動の特徴がどの程度再現されるかを調べておくことは，特に必要である。

本報告は，この点についての MRI・GCM-I の特性を示すものであり，更に今後の改良，発展と共に，気候研究分野における主要な道具として成果を挙げることが期待される。

昭和 61 年 6 月

気象研究所　予報研究部長
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Foreword

This report summarizes the results of the preliminary analyses of a 12-year integration of the atmospheric general circulations (AGC) based upon the MRI·GCM-I. This work has been done by the collaboration of staff members who participated in the study of the AGC, one of the principal research subjects of the Forecast Research Division.

It is widely recognized that one of the central problems in meteorology is to understand the causes and physical mechanisms which control the characteristics of the AGC. The amount of knowledge on the behaviors of the atmospheric circulation system has been much increased due to the elaborate analyses on the basis of meteorological data obtained from the global observation network, notably after the FGGE. On the other hand, another approach based upon numerical experimentation has seen considerable progress at several meteorological research centers and universities in various countries, and many remarkable results have been published in the journals every year.

A high-speed electronic computer was installed in the Meteorological Research Institute (MRI) at the time of its removal from Tokyo to Tsukuba Science City. Since then, research activities on the general circulation at the MRI have been greatly expanded. Details of the numerical model (the MRI·GCM-I) used in this study have already been described in the Technical Report No.13 (1984) of this series.

Implementation plans of the World Climate Research Program (WCRP) are now going on under the joint cooperation of the WMO and ICSU. The purpose of this research program is to understand the climate variability and its causes, so that the understanding of the long-term fluctuations of the global atmosphere, for example, variations over the time scale from one season to several years, are one of the important subjects.

Numerical experimentation seems to be the most appropriate for achieving this end. However, it is desirable to estimate to what extent the numerical model simulates the characteristic features of the large-scale circulations in the real atmosphere. In this report, the performances of the MRI·GCM-I in the evaluations of the climatological averages and fluctuations around them under the annual cycle of

climatological boundary forcings are shown. Through the continual efforts to improve the quality of the present MRI·GCM, we are sure that the MRI·GCM will eventually make it possible to predict climatic variability in a fairly satisfactory manner.

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Hovmöller diagram

概　　要*

気象研究所技術報告第13号で述べた気象研究所大気大循環モデルーⅠ（MRⅠ・GCMーⅠ）を用いて12年間の数値積分を行った。モデルは100 mbにトップを持ち，上下5層，経度方向に5度，緯度方向に4度の解像度を持つ。外部データとして必要な海面水温と海氷分布に関しては気候値を用いた。従ってモデル実験では両者は毎年同じ季節変化を繰り返す。

大気大循環は年々気候値のまわりを変動しているが，モデル大気の長期間積分の平均として得られる気候値とその気候値のまわりの変動がどのように再現されるかを検討することが今回の実験の主要目的である。

この技術報告では，12年間の積分で得られたモデルの気候値，標準偏差，季節変化等を主要な変数について図示する。結果についての詳細な解析は現在進行しており，ここでは結果の解釈・議論はほとんど行なわない。まず結果を図の形で公表するのが本報告の目的である。第1章では，月平均の気候値の水平分布図を示す。第2章では海面気圧等の5つの量について月平均値の標準偏差の水平分布図を示す。あわせて各年の月平均値の気候値からの偏差の分布図も示す。第3章は月平均の気候値の緯度・高度断面図及び月平均値の標準偏差の東西平均図，東西平均量の月平均値の標準偏差を示す。第4章では，東西平均量の緯度・時間断面図を示す。第5章では，経度・時間断面図を示す。対応する観測量が得られるものについては，あわせて図示してあるので，観測値のデータ・ブックとしても利用されたい。

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Introduction*

The climate system is composed of the atmosphere, the ocean, the cryosphere, the lithosphere and the biomass. It has various time-scales of variation. The shortest one is the upper limit of the predictable period in the sense of short-range weather forecasting. The largest one is the span of the earth's age itself. Even if we limit ourselves to the shortest time-scale, our present knowledge and understanding of their characteristics are still very fragmentary. As is repeatedly stated in the documents of the World Climate Research Program, model research is one of the promising approaches for the improvement of our present knowledge and understanding of them. Atmospheric general circulation models have succeeded in reproducing the basic characteristics of the global circulations of the atmosphere. Of course, the models are still far from complete. Model atmospheres show systematic biases from the real atmosphere. For example, see Tokioka *et al.* (1985) for the Meteorological Research Institute model (the MRI·GCM-I).

Although the model is not identical to the real atmosphere yet, we can still consider the former as a good analogue of the latter. Study of long-term variations of a model atmosphere is therefore useful for the understanding of the variations of the real atmosphere as well as for the understanding of the model climate itself and thus for the improvement of the model. Manabe and Hahn (1981) first conducted such a study. They integrated a spectral general circulation model with rhomboidal truncation at wavenumber 15 for 18 model years, and analyzed the 15-year data. Their results show that most variability in the extratropics is reproduced without year-to-year changes in the prescribed sea surface temperature (SST). Lau (1981) has further surveyed the characteristics of long-term variations of the model atmosphere. Recently Lau (1985) has run two 15-year integrations including observed year-to-year changes of the SST over the tropical Pacific basin. He showed that the temporal variance of the 200 mb height in the perturbed SST run is larger than the corresponding quantity in the climatological SST run by a factor of 2–6 over the tropics; whereas the same SST fluctuations are much less effective in enhancing the variability in middle and higher latitudes. At Oregon State University (OSU) a 10-year integration has been performed with the OSU two-layer GCM. Kushnir and Esbensen (1985) have studied a subseasonal variability

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for northern hemisphere winter with the use of simulated data.

Recently, a 12-year integration has been performed at the Meteorological Research Institute (MRI) with the 5-layer MRI·GCM-I without prescribing year-to-year changes in the SST. This technical report is presented for the purpose of showing the mean statistical maps of the MRI·GCM-I based on the 12-year run. Therefore detailed descriptions, interpretations and discussions of the results are not included. They will be published in separate papers in near future.

Model

The model (the MRI·GCM-I) used for the present study is a tropospheric five-layer grid model with its top at 100 mb. The horizontal resolution is 4° in latitude and 5° in longitude. Physical processes included are the parameterizations of the penetrative cumulus convection by Arakawa and Schubert (1974) and of the planetary boundary layer based on Randall (1976), radiation (Katayama, 1972), ground thermodynamics and hydrology (Katayama, 1978). The diurnal variation as well as the seasonal variation of solar insolation is included in the model. There are no interannual variations in prescribed boundary conditions, *i.e.*, the sea surface temperature and the sea ice coverages. The prescribed sea surface temperature and the sea ice distributions together with the model topography used are shown in Fig. 0. See Tokioka *et al.* (1984) for further details of the model. January and July performances of the model are presented in Tokioka *et al.* (1986) and Kitoh and Tokioka (1986).

Experiment

The run was started at January 1 00Z of year 1 and was continued until March 1 00Z of year 13. The initial condition of the run was taken from the atmospheric condition on January 1 produced by another simulation with a different version of the model. Excluding the first two months of the simulation, the 12-year simulated data are analyzed in this report. Data were originally sampled for every 6 hours. In this report, maps are based not on the original but on the 10-day mean and the monthly mean data.

Chapter 1 describes the horizontal distributions of the 12-year average of the monthly mean quantities. Chapter 2 shows the horizontal distributions of the year-to-year variation of the monthly mean quantities. Chapter 3 shows the latitude-height cross sections of the monthly mean quantities. Chapter 4 describes the mean annual variation in the latitude-time

cross sections. Finally, Chapter 5 shows the longitude-time cross sections at selected latitudes. Both the mean annual variation and year-to-year variations are included.