Development of a Coupled Atmosphere-Ocean-Land General Circulation Model (GCM) at the Frontier Research Center for Global Change

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The radiation code of the atmospheric model developed in Kyosei project 1 (CCSR/NIES/FRCGC AGCM) has been replaced with a newly developed code (Sekiguchi 2004) and the performance of the model was evaluated in terms of the reproducibility of seasonal mean fields. The temperature error in the model has been reduced in the stratosphere and around the tropopause. The following points require improvements in the future:

a) Dry biases in the eastern part of the subtropical highs in the lower atmosphere.
b) Considerably low monsoon precipitation in the tropical oceans
c) High amount of water vapor and significantly low temperature around the tropopause in the mid to high latitudes.
d) High pressure errors barotrpically seen in the Greenland to north-eastern part of Canada in boreal winter.
e) Over all layers in the troposphere, optical thickness of cloud is large. In the middle layer, cloud amount is too small.

The reproduction of baiu by AGCM was examined. The model realistically reproduces the characteristics of baiu in a 15-daily mean field of precipitation However in the atmospheric model, the intense rainfalls during the baiu season, which develop along the baiu front actually shift significantly northward and arise with the passage of low pressure. Such inconsistency can be attributed to the cumulus convection scheme and it requires to be improved.

Keywords: global warming, coupled model, atmospheric model, radiation scheme, Baiu

1. Model performance experiment

The radiation code of the model applied for the experiment for the 4th IPCC report in Kousei project 1 was replaced with the code (Sekiguchi 2004) of higher precision. The integration of the atmospheric model was conducted for 25 years prescribing the sea surface temperature based on the observed data from 1978 to 2002. The following points became evident by comparing seasonal mean fields in the present model with those of the previous model and observations.

1.1. Temperature and zonal wind

The zonal mean temperature error is 2°C or less in the troposphere excluding some areas (Fig. 1) and the model is one of the atmospheric models with the highest accuracy at the present. The low temperature error around the tropopause has significantly reduced except in the polar regions. In the stratosphere over 20 hPa, high-temperature biases are seen, though the biases were confirmed to dissolve when the oxidation process of methane was taken into consideration. Aside from these biases, the temperature errors appear to be within 6°C in the middle and high latitudes of boreal winter. In response to these errors, other errors are seen in the zonal wind and it is found that the errors are associated with the high pressure anomalies, which approximately has a barotropic structure from the troposphere to the stratosphere centered in the northeast part of Canada to Greenland. The identification and removal of these errors are an issue. As for zonal wind, the subtropical westerly jet tends to be slightly too strong.

1.2. The amount of the water vapor and precipitation

The model has errors which express inadequate amount of water vapor centered in the subtropical region (Fig. 2) and they remain unsolved so far. The errors are significant especially in the eastern regions of subtropical highs. They are related to the poor reproducibility of the stratocumulus there. The excess of humidity is seen around the tropopause in high latitudes. This corresponds with the excessive amount of clouds there. The cause of the excessive amount of the clouds may be related to a slow falling rate of cloud water. The model shows insufficient amount of monsoon precipitation over the tropical and subtropical oceans, and the belt of

excessive amount of precipitation is formed on the Northern Hemispheric side to compensate the precipitation gaps (Fig. 3). The error of extremely strong and weak upward flow of 500hPa was also confirmed over the areas respectively for the former and latter precipitation errors.

1.3. Cloud amount

In this model, clouds with large optical thickness are excessive at all layers in comparison with ISSCP data. On the other hand, the cloud amount is small in the middle layer. Cloud is an element having a great degree of influence on climate sensitivity, and a future improvement is required so that the three-dimensional distribution of cloud can be reproduced well by the model.

Bibliographies

Sekiguchi, M., A study on evaluation of the radiative flux and its computational optimization in the gaseous absorbing atmosphere. Thesis Dr. Sci., University of Tokyo, 121pp, 2004.

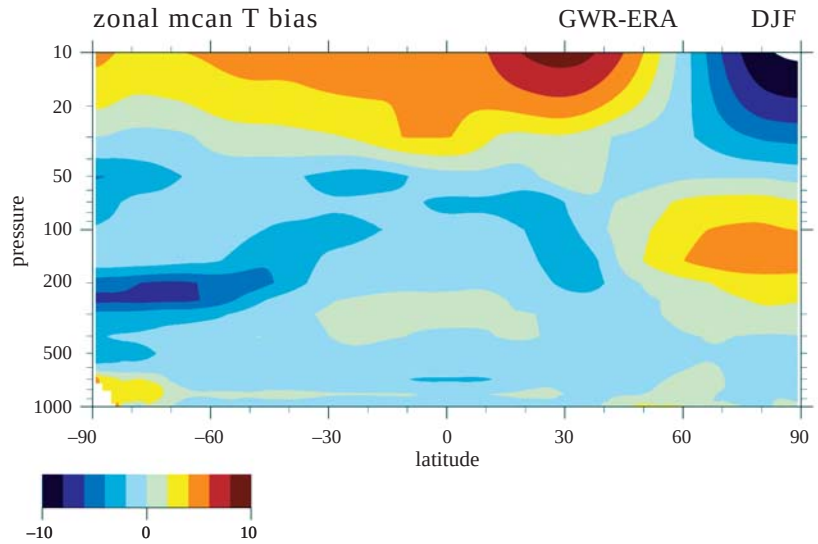

Fig. 1 Errors of zonal mean temperature (degree Kelvin) averaged from December to February.

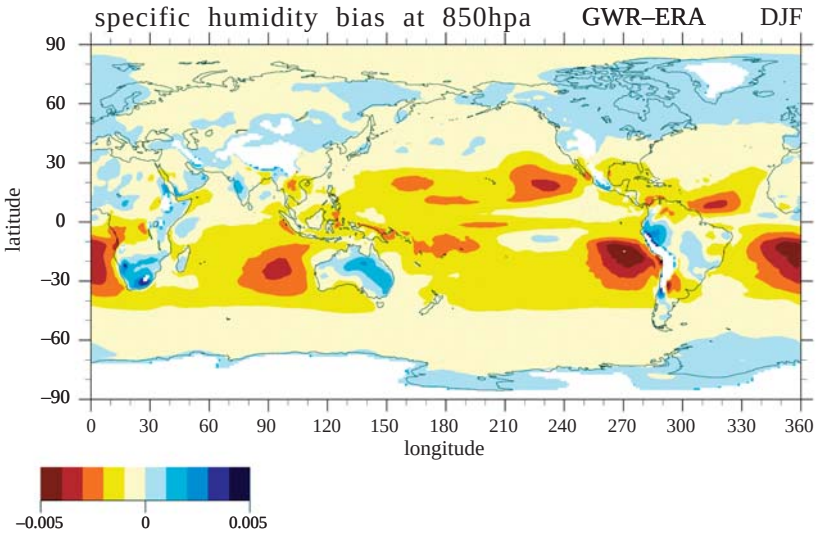

Fig. 2 Errors of specific humidity (Kg/Kg) at 850 hPa averaged from December to February.

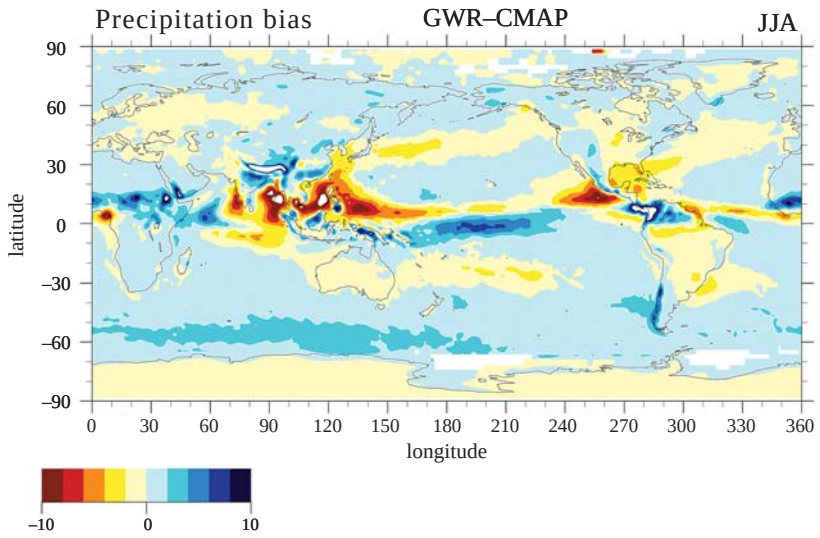

Fig. 3 Errors of precipitation amount (mm/day) averaged from June to August.

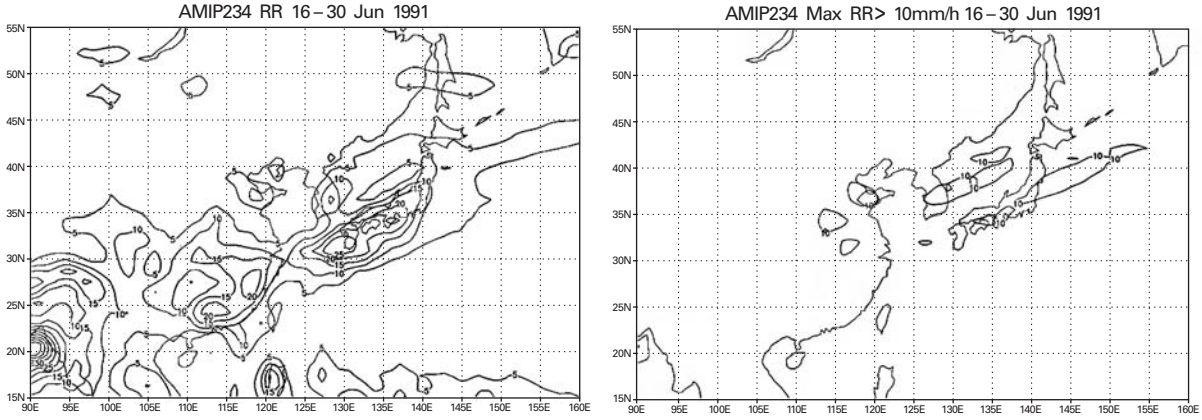

Fig. 4 a) 15-day averaged precipitation for 16-30 Jun 1991 and (b) the areas of the maximum hourly rainfalls in each day exceeding 10mm/h in the same period.

地球環境フロンティア研究センターにおける大気・海洋・陸面結合大循環モデルの開発

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共生課題1で開発したモデル(CCSR/NIES/FRCGCモデル)の放射コードを最近開発されたコード(Sekiguchi 2004)に置き換えて、大気モデルの性能を時間平均場の再現性の点で評価した。モデルは対流圏界面から成層圏にかけて気温誤差が改良されたが、今後改良すべき点として以下の点が挙げられる。

a. 亜熱帯高気圧東部下層大気の水蒸気量が少なすぎる点
b. 熱帯海洋上のモンスーンによる降水が少なすぎる点
c. 中･高緯度対流圏界面で水蒸気量が多く、気温も低い点
d. 北半球冬季のカナダ北東部からグリーンランドにかけて順圧的な高気圧偏差が存在する点
e. 全層にわたり光学的厚さの厚い雲が多い。中層では雲量が過少になっている。

モデルが再現する梅雨について検討した。半月平均場で見れば梅雨の特徴をほぼ再現している。梅雨期の強い降水に関しては、実際には梅雨前線上で生じているが、モデル大気では前線より北にずれた所で低気圧の通過に伴い生じている。このような違いは積雲対流スキームにより生じたと考えられ、その改良が必要である。

キーワード：地球温暖化，結合モデル，大気モデル，放射スキーム，梅雨