I-3. Global Warming Research Program

Program Director : Syukuro Manabe

The staff members of this division are engaged in three research topics: they are global warming, carbon cycle and Paleoclimate. During this fiscal year, the Global Warming Research Group has continued to investigate how the behavior of daily whether disturbances is affected by global warming. The Carbon Cycle Research has begun to construct an improved version of the parameterization of so-called “biospheric pump” to be incorporated into a general circulation model of ocean. The Paleoclimate Group has continued to investigate the mass budget of past and present continental ice- sheets using CCSR/NIES atmospheric GCM with high computation resolution. Staff members of Paleoclimate Research Group have also made important contribution to the study of cloud feedback process and cumulus convection that could play very important role in shaping global warming.

In addition to the research activities mentioned above, the staff members of the Paleoclimate Research Group also participate in the evaluation and improvement of the CCSR/NIES atmospheric GCM with high computational resolution. Adjusting the parameterization of vertical momentum transport in the troposphere, Nishimura achieved markedly improved simulation of general circulation of the atmosphere.

In close collaboration with the staff members of Integrated Modeling Division, Motoi and his subgroup has started the testing of an oceanic GCM (MOM) to be coupled with CCSR/NIES atmospheric GCM.

These projects for model development are essential for the successful usage of the Earth Simulator to be completed in a few years.

a. Global Warming Research Group

(Group Leader: M. Sugi, Group Members: J. Yoshimura, R. Krishnan, Z. Geng)

This group has continued to investigate how the behavior of tropical cyclones and extratropical cyclones is going to change associated with global warming. The basic strategy for modeling research employed by this group is illustrated in Fig.1. Using sea surface temperature obtained from global warming experiment as a lower boundary condition, they conduct a short-term integration of an atmospheric GCM with high computational resolution, thereby performing the geographically detailed projection of future climate change. Employing this strategy, Sugi, the group leader, attempted to predict the future change of tropical cyclone in collaboration with Yoshimura. To their surprise, they found that, in general, the frequency of tropical cyclones is going to decrease associated with global warming. Based upon well-designed set of numerical experiments, they have begun to identify some of important factors which are responsible for the general reduction of the frequency of tropical cyclones.

Krishnan found negative correlation in precipitation rate between Baiu and Indian Summer Monsoon. He noted that the quasi-stationary pattern of wave train over Eurasian Continent in middle latitudes is responsible for the negative correlation. He is currently exploring the simulated intensification of this wave train associated with global warming.

Using the results from the reanalysis of weather data which have been obtained during the last 45 years, Geng is investigating how the frequency of extratropical cyclones has changed associated with global warming. He has found intriguing regional trends in cyclone frequency. He has begun to explore whether such trends exist in the results from a global warming experiments which he conducted using a high resolution JMA/MRI atmospheric GCM.

In collaboration with Wetherald of GFDL/NOAA, Manabe analyzed a global warming experiment which incorporates not only the warming effect of greenhouse gases but also the cooling effect of sulfate aerosols. They noted the change of soil moisture associated with global warming and found substantial percentage reduction of soil moisture in semi-arid regions of the world such as Central Asia, regions that surrounds Mediterranean Sea, and southern California(Fig.3-a-1). Abe, the group leader of Paleoclimate Research Group, obtained similar results using a high-resolution version of CCSR/NIES atmospheric GCM.

One of the most difficult issues of global warming research is the cloud feedback process. Based upon the analysis of data obtained from the Earth Radiation Budget experiment, Tsushima investigated the contribution of the cloud feedback process upon the annual variation of global mean surface temperature. She found that the cloud feedback process neither amplify nor damp the annual variation of global mean surface temperature. This is a very interesting finding which may be useful for the study of global warming.

Using a simple two-dimensional model of cumulus convection, Iwasa demonstrated that desiccation of the tropical atmosphere, such as Lindzen suggested, will not occur associated with the general warming of the atmosphere, supportting the positive water vapor feedback theory of global warming.

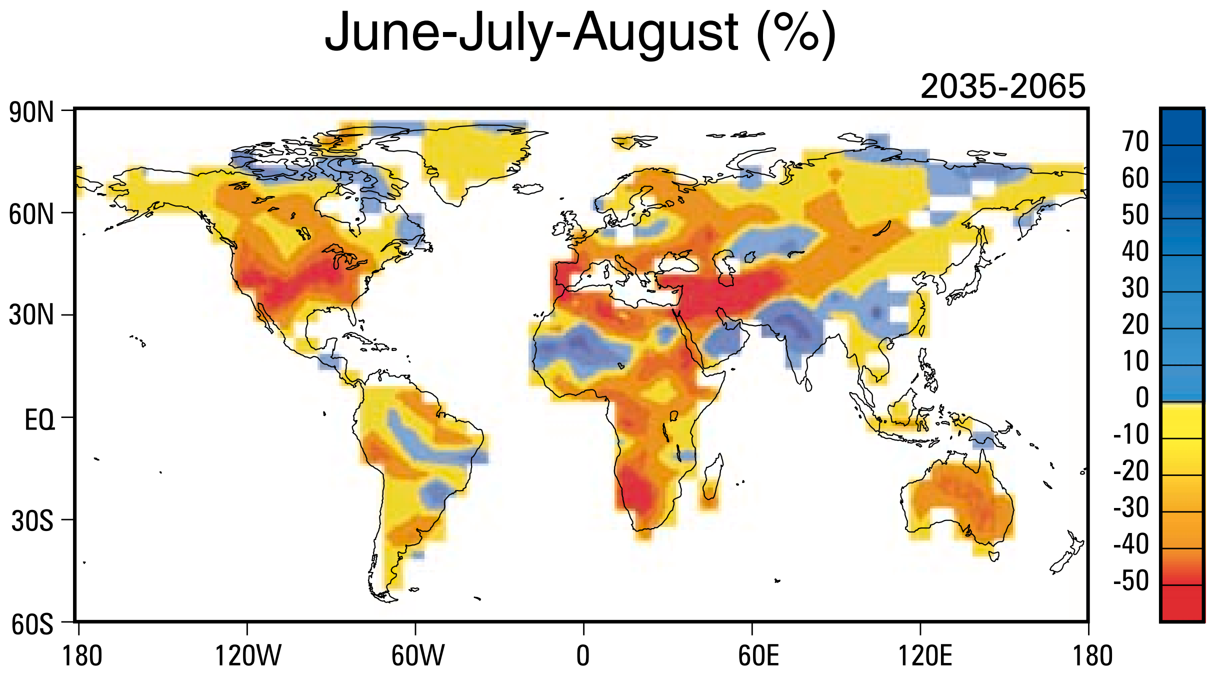

Figure 3-a-1: Geographical distribution of soil moisture change represented as percentage of original soil moisture.

b. Carbon Cycle Research Group

(Group Leader: Y. Yamanaka, Sub-Leader: A. Ishida, Group Members: M. Kishi, S. L. Smith, M. Noguchi)

In order to make the reliable projection of future CO_2 concentration in the atmosphere, it is essential to reliably determine the oceanic uptake of CO_2 which is controlled by not only "Alkalinity Pump" but also "Biospheric Pump". Unfortunately, current parameterization of biospheric pump, which is incorporated in a carbon cycle model of ocean, is primitive and unreliable. During this fiscal year, Kishi (sub-leader), Yamanaka (group leader) and Smith have begun to develop a comprehensive ecosystem model to be incorporated into the carbon cycle model which has been developed by Yamanaka.

Ishida, sub-leader, has participated in the international Carbon Cycle Model Intercomparison Project (OCMIP). As an important component of this project, he has successfully simulated the diffusion of CFC in ocean and noted that his result compare favorably with the results obtained from other oceanic GCM. This type of model intercomparison has become essential for the evaluation and improvement of oceanic GCM.

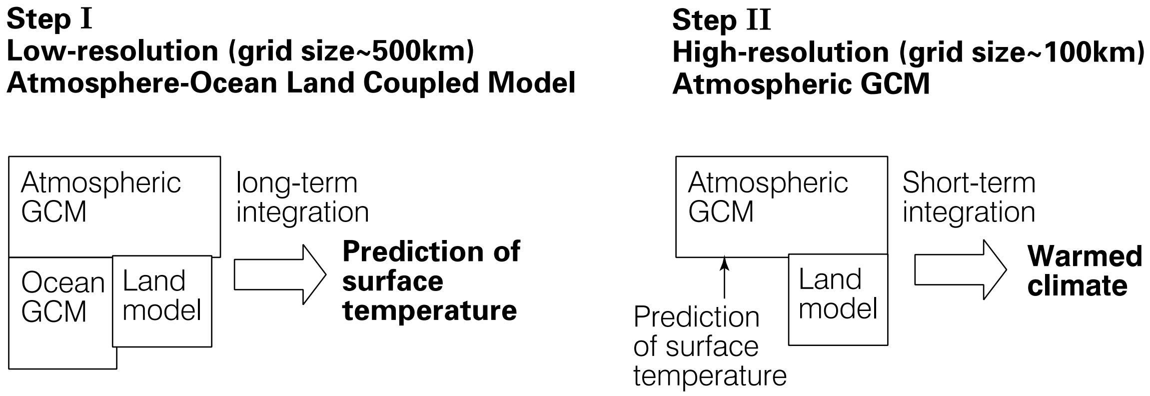

Figure 3-a-2

c. Paleoclimate Research Group

(Group Leader: A. Abe, Sub-Leader: T. Motoi, Group Members: K. Sakai, T. Nishimura, Y. Iwasa, Y. Tsushima, W. Ohfuchi, W. L. Chan, T. Segawa)

In collaboration with Nishimura, Abe has continued to investigate the mass budget of continental ice sheet of the last glacial maximum using the high resolution atmospheric GCM developed at CCSR/NIES. In their numerical experiment, they found that heavy snowfall occurs in winter along the storm track located at the southern periphery of the North American ice sheet. They suggest that this snowfall contributes very much to the growth and maintenance of the massive ice sheet during glacial period.

Using an oceanic GCM (MOM), Sakai has investigated large climate fluctuation of millennium time scale which is associated with the oscillation of thermohaline circulation in the Atlantic Ocean. Varying the parameters of subgrid scale diffusion, he has attempted to determine the necessary condition for the existence of the millennium oscillation.