Blue Planet Prize 1992

Commemorative Lectures and Symposium Report

September 25, 1992 New Pier Hall, Tokyo

THE ASAHI GLASS FOUNDATION

Preface

This report reviews the first Blue Planet Prize commemorative lectures and symposium, held at the New Pier Hall in Tokyo on September 25, 1992.

More than a simple awards ceremony, the event provided a forum for debate on environmental problems. The success of the occasion owes much to the enthusiastic help of many people.

A plethora of ideas emerged during the course of the prizewinners' lectures, panelist presentations and ensuing question-and-answer session. This report aims to share those ideas with a wider audience.

The theme of the inaugural Blue Planet Prize commemorative lectures and symposium was "Our Future Inheritance—Toward the Creation of a New Civilization Which Harmonizes with the Environment." Japan has hitherto given the impression of being a country whose only contributions to the solution of environmental problems are financial or technological. The symposium aimed to contribute ideas from the viewpoints of the arts and social sciences. The questionnaire on environmental problems and the survival of humankind was conducted in the same spirit. The results of the questionnaire were released on the day of the symposium, and a brief synopsis is provided herein. For fuller details, please refer to the separate questionnaire report.

We sincerely hope that you find this publication of interest. Thank you.

March 1993
The Asahi Glass Foundation

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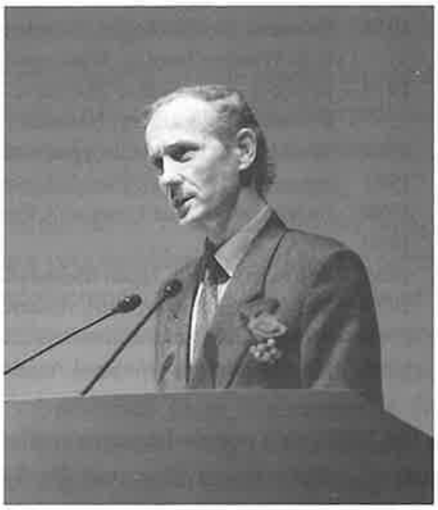

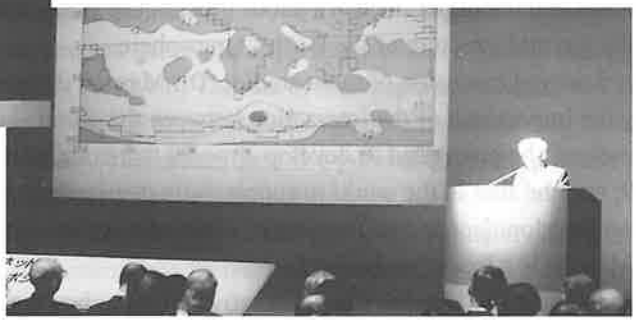

Dr. Syukuro Manabe (U.S.A.)

Blue Planet Prize Academic Award Winner

Member of the Senior Executive Service, U.S.A., Geophysical Fluid Dynamics Laboratory, National Oceanic and Atmospheric Administration, Princeton, New Jersey
Born on September 21, 1931
Selection Rationale: Pioneering research for predicting climatic change by numerical models

• Education and Professional Activities	1953	Bachelor of Science, University of Tokyo
	1958	Research Meteorologist, Geophysical Fluid Dynamics Laboratory, U.S. Weather Bureau, Washington, D.C.
	1979 ~	Member of the Senior Executive Service, U.S.A., Geophysical Fluid Dynamics Laboratory, National Oceanic and Atmospheric Administration, Princeton, New Jersey
	1981 - 1987	World Meteorological Organization / International Council of Scientific Union / United Nations Environmental Program, Joint Scientific Committee
	1989 - 1990	Intergovernmental Panel on Climate Change, Lead Author for Group I Report (Scientific Assessment)
• Awards (excerpt)	1966	Fujiwara Award, Japan Meteorological Society
	1977	2nd Half Century Award, American Meteorological Society
	1989	Presidential Rank Meritorious Executive Award
	1990	Elected Member, National Academy of Sciences

It was as recent as the 1980s that people began to realize that the problems of the Earth's environment, such as global warming, were issues of global concern. However, Dr. Syukuro Manabe foresaw very early the possibility of significant climatic changes resulting from expanding human activities. Since the early 1960s, he has done pioneering studies of the mechanisms that are responsible for maintaining climate and causing it to change.

For example, Dr. Manabe studied the effect of greenhouse gases on the radiation balance of the atmosphere. He constructed the Radiative Convection Equilibrium Model of the atmosphere on the farsighted hypothesis that the vertical structure of the Earth's atmosphere was essentially determined by radiation and convection. He successfully simulated the observed vertical structure of the atmosphere by this model. For the first time ever, Dr. Manabe quantitatively demonstrated the importance of various greenhouse gases, such as water vapor, ozone and carbon dioxide, in determining the thermal structure of the Earth's atmosphere.

As a natural extension of these studies, Dr. Manabe developed a general circulation model of the atmosphere. Realizing the importance of the interaction between the atmosphere and oceans in determining the structure of the Earth's atmosphere, he proceeded to develop a model that coupled the oceans with the atmosphere. This model, completed in 1969, was the first in the world to successfully demonstrate the effects of ocean currents on the global climate. Today, further development and refinement of ocean-atmosphere models is a major challenge in the field of climatology, and Dr. Manabe is a leader in this area.

Meanwhile, Dr. Manabe has quantitatively researched the link between climatic change and increases in greenhouse gases, including carbon dioxide. Recently, he coauthored a chapter of the 1990 report released by the Intergovernmental Panel on Climate Change, *Equilibrium Climate Change--Its Implications for the Future*, that predicted climatic change. The publications of Dr. Manabe and his coworkers are extensively cited throughout the entire report.

In Dr. Manabe's field of study, most numerical experiments compute the response of climate in thermal equilibrium to the doubling of atmospheric carbon dioxide. However, Dr. Manabe has successfully estimated the change of climate in response to gradually increasing atmospheric carbon dioxide. Dr. Manabe's experiments showed that there was a significant difference between the results of the two approaches, thereby demonstrating that equilibrium response experiments would not be sufficient for predicting future climatic change. This is the first time that the effect of oceanic general circulation was explicitly taken into consideration for solving this problem.

Dr. Manabe continues to play a leading role in developing computer models for the study of climate. He played a leading role in the emergence of the modeling approach as one of the most promising avenues for the study of climate, and he has received worldwide acclaim for his outstanding achievements in the modeling study of climate. Dr. Manabe truly deserves the Blue Planet Prize, especially now that climatic problems such as global warming threaten our lives and future.

"Prediction of Greenhouse Warming by Climate Models"

Summary of Lecture

Dr. Syukuro Manabe
Geophysical Fluid Dynamics Laboratory / NOAA
Princeton University
Princeton, New Jersey U.S.A.

This presentation describes briefly my involvement in the development of climate models during the last 35 years and the application of these models to the study of the global warming. The main emphasis of the presentation is placed upon the recent modeling study of the transient response of climate to a gradual increase of atmospheric carbon dioxide. It concludes with a dicussion of the strategy for the reliable prediction of the global warming.

My involvement in the modeling study of climate began in the fall of 1958 when Joseph Smagorinsky of the U.S. Weather Bureau invited me to join his group and participate in a very ambitious project for the development of comprehensive models of climate. The initial assignment was the incorporation of the radiative effect of various greenhouse gases (e.g., water vapor, carbon dioxide, and ozone) into a climate model. By use of a one-dimensional model of the atmosphere in which both radiative transfer and vertical convective mixing of heat are incorporated, it was possible to quantitatively evaluate, for the first time, the role of various greenhouse gases in maintaining the observed thermal structure of the atmosphere (1,3). This study was one of the important stepping stones towards the development of comprehensive, general circulation models of the atmosphere. The success in simulating many of the basic features of atmospheric circulation and climate in the 1960s and early 1970s (2,5,7,9) encouraged us to use such a model for evaluating the global warming (6,8,10).

One of the important factors which control the transient response of climate to a greenhouse forcing is the oceans. If the heat trapped by increased greenhouse gases is sequestered into deep layers of the ocean through vertical mixing, it is possible that the global warming could be delayed substantially. Thus, the oceans can exert a profound impact upon the rate and the distribution of global warming. This is one of the important reasons why Kirk Bryan and I started the construction of a coupled ocean-atmosphere model in the middle 1960s.

In this presentation, I would like to describe results from a recent numerical experiment which explored the response of climate to a gradual increase of atmospheric carbon dioxide (11,12,13). The rate of increase was chosen to be 1%/year (compounded), which is approximately equal to the rate at which the total CO2-equivalent radiative forcing of various greenhouse gases other than water vapor is increasing currently. The model used is a general circulation model of the coupled ocean-atmosphere system with global geography and seasonal variation of insolation.

Fig. 1 illustrates the geographical distribution of the increase in annual mean surface air temperature when the atmospheric concentration of carbon dioxide is doubled. Such a warming may be realized between the present and sometime towards the end of the next century. It indicates that the simulated response of surface air temperature is slow over the northern North Atlantic and the Circumpolar Ocean of the Southern Hemisphere, where the vertical mixing of the heat trapped by the increased greenhouse gas penetrates very deeply. However, in most of the Northern Hemisphere and low latitudes of the Southern Hemisphere, the distribution of the change in surface air temperature is very similar to the results obtained earlier without the delaying effect of the oceans. For example, surface air temperature increases with increasing latitudes in the Northern Hemisphere and is larger over continents than oceans. The increase is at a maximum over the Arctic Ocean and its surroundings in the early winter and is minimum in summer. The enhanced heat conduction through thinner sea ice is responsible for the early winter maximum, whereas sea ice prevents the temperature of the oceanic mixed layer and the overlying air to rise substantially above the freezing point, and is responsible for the summer minimum in warming. Although the Arctic sea ice loses its thickness in winter as mentioned above, it becomes much narrower as well as thinner in summer.

The increase of a greenhouse gas affects not only the thermal structure of the coupled system but also the hydrologic cycle. For example, the global mean rates of both precipitation and evaporation increase. In high latitudes of the Northern Hemisphere, the increase in the rate of precipitation far exceeds that of evaporation, markedly increasing the rate of runoff and reducing the surface salinity in the Arctic and surrounding oceans. This capping of the oceanic surface by relatively fresh water weakens the thermohaline circulation, further reducing the surface warming in the northern North Atlantic. It has also been noted that the soil moisture is reduced in summer over extensive mid-continental regions of both the Eurasian and North American continents of the model. Thus, it is likely that summer drought may become more frequent as the greenhouse warming intensifies.

One should note here that the prediction of future climate changes is subject to large uncertainty because of our inability to model realistically various processes that control future climate change. It is therefore necessary to improve various components of the climate model, such as the cloud feedback and land surface processes. In addition, it is essential to carefully assess the simulated climate change by comparing it with the actual climate change. The agreement between the two changes should enhance our confidence in model prediction.

A comprehensive strategy for predicting future climate changes is illustrated by the box diagram shown in Fig. 2. It involves the monitoring of the factors that force climate, the prediction of climate change by state-of-the-art models, the monitoring of the actual climate change by in-situ and remote sensing, and the comparative assessment of the predicted and observed climate changes. The insight gained from this comprehensive effort is indispensable not only for enhancing our confidence in model prediction of future climate, but also by adapting and mitigating the natural and man-induced climate change.

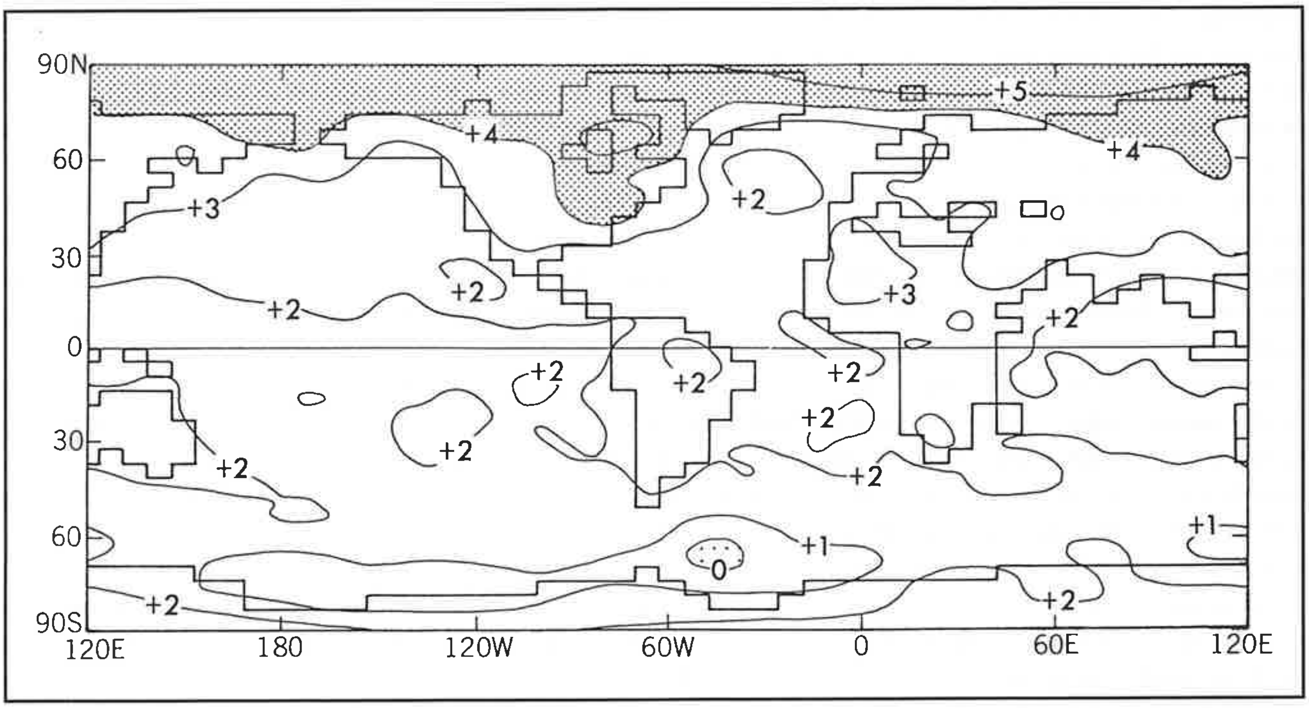

Fig. 1. The transient response of the surface air temperature of the coupled ocean-atmosphere model to the 1%/year increase of atmospheric carbon dioxide. The response represents the warming averaged over the 60th-80th year period when the CO2 concentration is doubled.

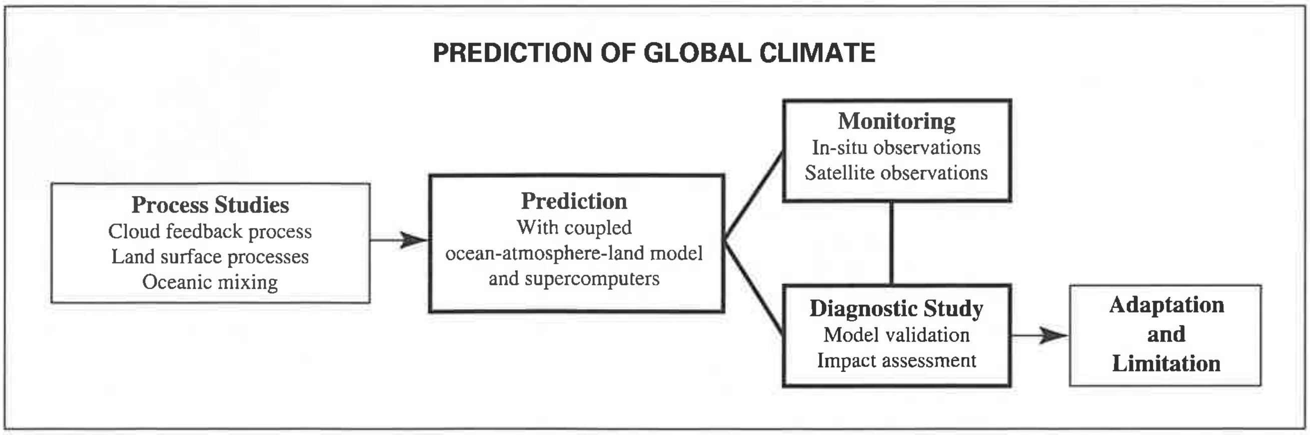

Fig. 2. Diagram illustrating the strategy for the prediction of interdecadal climate change.

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(3) Manabe, S., and R.T. Wetherald, "Thermal Equilibrium of the Atmosphere with a Given Distribution of Relative Humidity," *J. Atmos. Sci.,* 24(3), 241-259, 1967

(4) Manabe, S., and K. Bryan, "Climate Calculations with a Combined Ocean-Atmosphere Model," *J. Atmos. Sci.,* 26(4), 786-789, 1969

(5) Manabe, S., D.G. Hahn and J.L. Holloway Jr., "The Seasonal Variation of the Tropical Circulation as Simulated by a Global Model of the Atmosphere," *J. Atmos. Sci.,* 31, 43-83, 1974

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(8) Manabe, S., and R. Stouffer, "Sensitivity of a Global Climate Model to an Increase of CO2 Concentration in the Atmosphere," *J. Geophys. Res.,* 85(C10), 5529-5554, 1980

(9) Manabe, S., and A.J. Broccoli, "A Comparison of Climate Model Sensitivity with Data from the Last Glacial Maximum," *J. Atmos. Sci.,* 42, 2643-2651, 1985

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(12) Manabe, S., R.J. Stouffer, M.J. Spelman, and K. Bryan, "Transient Responses of a Coupled Ocean-Atmosphere Model to Gradual Changes of Atmospheric CO2, Part I: Annual Mean Response," *J. Climate,* 4(8), 785-818, 1991

(13) Manabe, S., M.J. Spelman, and R.J. Stouffer, "Transient Responses of a Coupled Ocean-Atmosphere Model to Gradual Changes of Atmospheric CO2, Part II: Seasonal Response," *J. Climate, 5,* 105-126, 1992