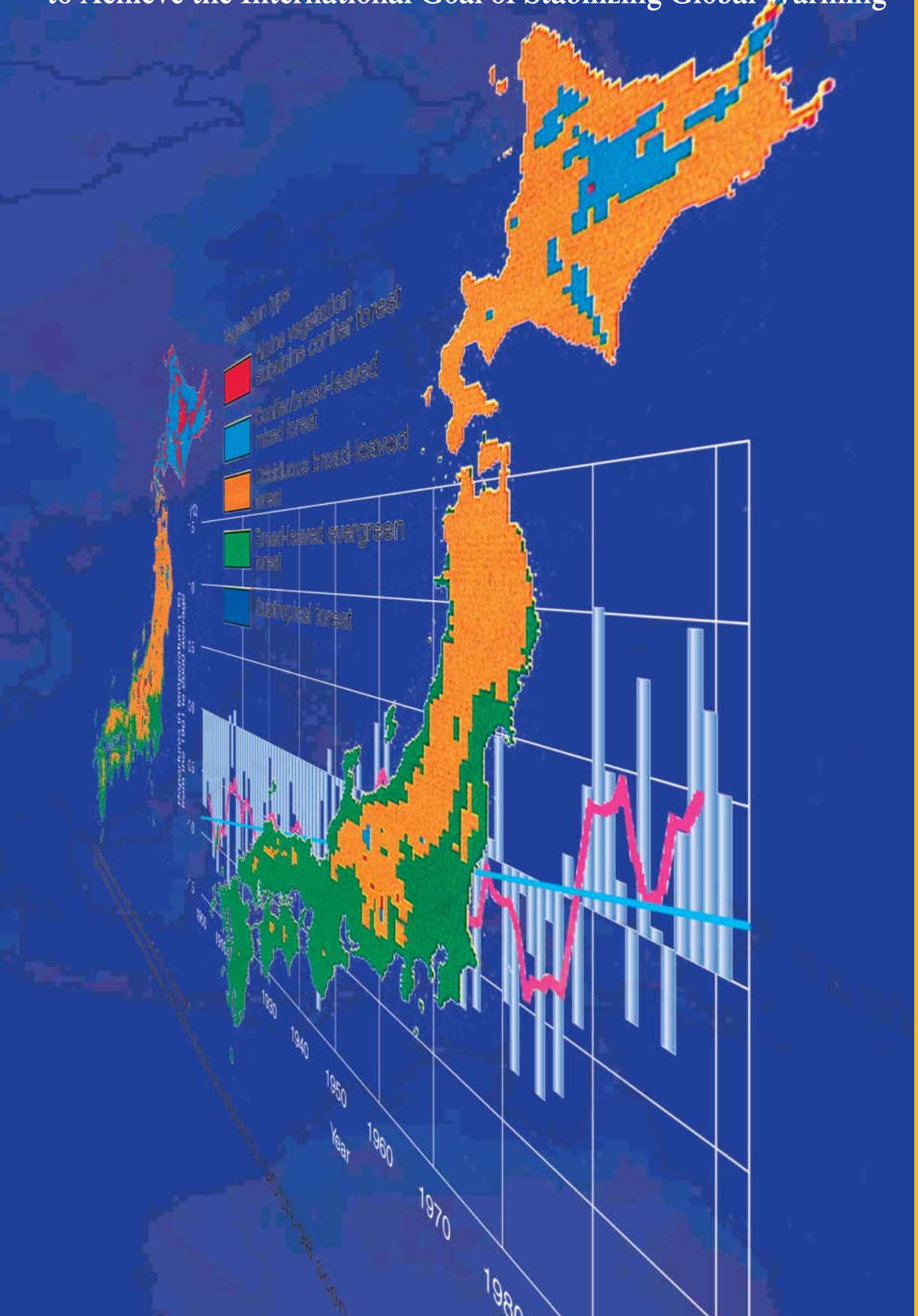
JAPAN'S GLOBAL WARMING RESEARCH INITIATIVE

New Research Challenges toward Discovering Pathways to Achieve the International Goal of Stabilizing Global Warming



CCRA

Climate Change Research Area

Japan's Global Warming Research Initiative

Council for Science and Technology Policy Launched Environmental Research Initiatives

Council for Science and Technology Policy (CSTP) was established within the Cabinet Office through the reform of Japan's governmental administrative system in 2001. CSTP is expected to act as a leader with strong vision and responsibility to promote broad strategic scientific and technological policies. The year 2002 held special significance as an epoch-making year in the environmental research in Japan. CSTP initiated the "Environmental Initiative," a Japanese research framework, to promote inter-disciplinary research among governmental ministries and agencies in the environmental field. This is a new national program to pursue environmental research in a more comprehensive manner.

Promotional Strategies in Prioritized Fields

The Second Basic Plan for Science and Technology (2001-2005) enacted in 2001 defines a prioritization policy for research and development (R&D). Based on this plan, CSTP focuses on four fields: life science, information technologies, environment, and nanotechnology. Also prioritized were the four fields of energy, manufacturing technology, social infrastructure, and space science and marine frontiers, necessary for building a strong foundation for a viable society. Objectives were clarified, and five-year R&D plans were set for these fields.

Today's environmental problems are extremely complex and diverse. Therefore, a comprehensive framework is essential for promoting research across existing academic boundaries. Environmental R&D policies foster coordination and cooperation among ministries and between industry and academia, both domestically and internationally. To fulfill these objectives, five research initiatives have been established. (1) Global Warming, (2) Waste-Free and Resource Recycling Technologies, (3) Eco-Harmonious River Basin and Urban Area Regeneration, (4) Chemical Substance Risk Management, and (5) Global Water Cycle.

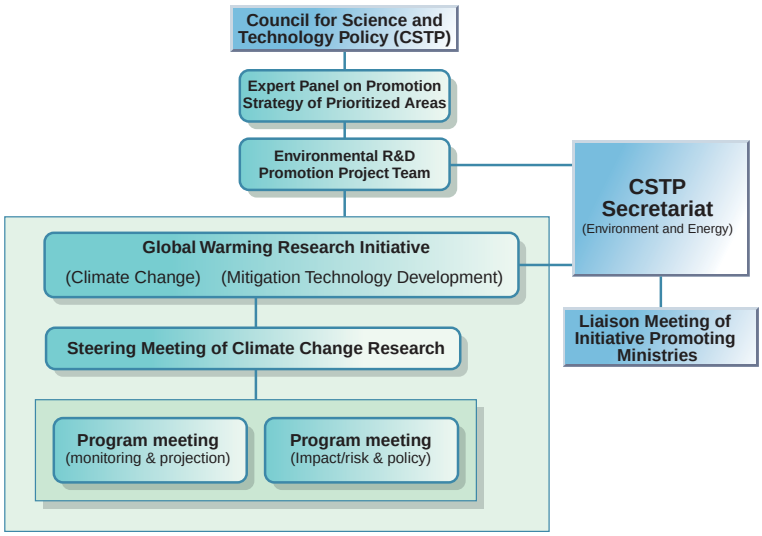


Fig. 1. Initiative Promotion System.

Changing Climate, Changing Earth, and Changing Society

Climate is a fundamental component of the Earth's natural system. Under a relatively stable climate, civilizations have developed and mankind has enjoyed prosperity for several millenaries. In response to global warming caused by anthropogenic emission of CO_2 and other greenhouse gases, the climate system is now changing.

Effects of global warming are already visible. The global mean temperature has increased by 0.6 degrees Celsius over the last century, and many organisms and ecosystems have experienced changes. There is a perception that extreme natural disasters, such as floods, droughts, and heat waves, have become more frequent. This change in climate plays an important role in the Earth's sustainability.

How will climate change proceed in the future? How significant will the effects be to humanity? If humanity changes, what will be the relationship between human activities and climate? Do we have effective measures to prevent or to adapt to climate change?

To answer these questions, we need a comprehensive set of scientific knowledge collected through the collaborative research pursued in an inter-disciplinary manner. Japan's Global Warming Research Initiative is one answer to this challenging task.

Photo: *Year 2002 Flood Disaster Investigation in Europe Summary Report*, Japan Society of Civil Engineers, March 2003.

Global Warming Research Initiative

Global warming is one of the most serious global environmental issues facing humankind. There are still many questions for science and technology to respond to.

Is the Earth really warming?
How CO_2 emissions and carbon cycle control global warming?
Will global warming worsen and cause irrecoverable damage?
If so, how can such problems be avoided?
What preventive measures can be taken?

The Global Warming Research Initiative was set up to answer such questions as shown in the right box. The Initiative's primary objective is to determine what scenarios of greenhouse gas emissions should be set to minimize increases in the concentration of greenhouse gases in the atmosphere that harm both humans and the global ecosystem, with a hierarchical structure of a series of questions. Refinement of the hierarchy of key questions resulted in establishing programs for Monitoring and Process Study; Projection Modeling and Climate Change Study; Impact and Risk Assessment; Response Policy; Greenhouse Gas Fixation and Sequestration; and Anthropogenic Greenhouse Gas Emissions Reduction.

Climate Change Research Area and Its Four Programs

The research fields were integrated into two categories to efficiently promote the initiative. The first category, Climate Change Research Area (CCRA), consists of four programs: the Monitoring and Process Study; Projection Modeling and Climate Change Study; Impact and Risk Assessment; and Response Policy. The second category, the Mitigation Technology Development Area, consists of two programs. Hereafter, we introduce only the Climate Change Research Area as the two areas are independent, but with close collaboration between them.

Program for Monitoring and Process Study

The goal is to establish an integrated monitoring system of global warming focused primarily on the Asia-Pacific region and data archives and delivery networks. Several ministries have promoted various land, ocean and atmospheric monitoring projects, including AsiaFlux, by using satellite, aircraft, ground stations, and ocean platforms. Further efforts are necessary to establish a structure responsible for archiving data from more expanded and improved monitoring, and to enhance the system for managing quality assurance and accuracy of the observation data.

Program for Projection Modeling and Climate Change Study

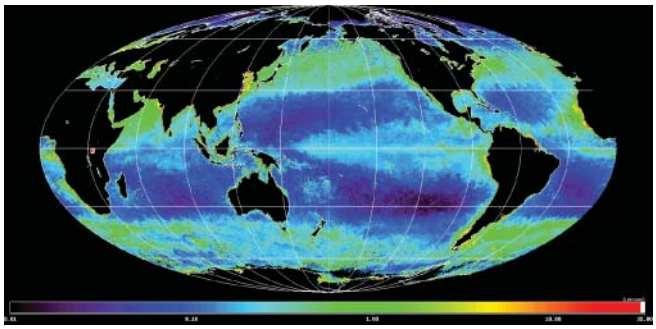
The goal is to project climate changes due to global warming with higher precision by clarifying the mechanism of the global environment change and elaborating projection models for future greenhouse gas concentration and for climate changes. The ministries relevant to the Program are then required to promote the development of their original climate models with their own specialized bases and/or in coordination with each other, and implement their projections.

Program for Impact and Risk Assessment

The goal is to assess the overall influence of global warming and to propose appropriate measures to avoid risks. The program promotes and implements joint research to assess the impacts of climate change on the ecosystem, disaster prevention/land conservation, water resources, food, forests, industry/energy, and health/civil life, based on the knowledge obtained from the two programs listed above. These efforts will clarify vulnerable sectors and regions with greater risks of global warming. The final goal of this program is to explore the optimal comprehensive strategy for adaptation and mitigation of global warming.

Program for Response Policy

The goal is to propose a counter scenario to prevent global warming. The program also includes the development of a standard methods for evaluating the effectiveness of global warming mitigation technologies, estimation of future socioeconomic tendencies and the effects of relevant measures to be taken, clarification of the adaptation and mitigation strategies, depending on the climate scenario, and establishment of international consensus-building techniques.



January, 1999

Fig. 2. Variation of surface chlorophyll concentration in the global ocean (Japan Aerospace Exploration Agency (JAXA) and National Aeronautics and Space Administration (NASA)).

Fig. 3. Earth Simulator, a supercomputer system developed by JAXA, Japan Atomic Energy Research Institute, and Japan Marine Science and Technology Center, provides the highest performance in the world for climate modeling.

Program for Monitoring and Process Study

Major Research Results

The Japan Meteorological Agency (JMA) monitored the annual average surface temperature in the 20th century at 17 observation sites where human impact on temperature changes resulting from urbanization is minimal (Fig. 4). The temperature changed within the lower levels in Japan until 1940; it turned sharply upward in the 1960s and 1990s, which is much higher than the global average rate of about 0.6°C. Mid-latitude countries like Japan are thought to be vulnerable to warming due to a decrease in the Sun's reflection caused by reduced snowfall in high-latitude continents.

The atmospheric concentration of greenhouse gases, such as carbon dioxide, methane, and aerosols, which impacts global warming, is steadily increasing as a result of human activities. Presently, Japan operates 15 regular monitoring stations among some 30 sites worldwide, including Minamitorishima (JMA), Hateruma Island (National Institute for Environmental Studies (NIES)), and Syowa Station (Institute of Polar Research and Tohoku University) (Fig. 5). All data show steady increases toward present, while monitoring data, except for Syowa Station which exhibits very small seasonal variations, reveal repeating similar seasonal changes.

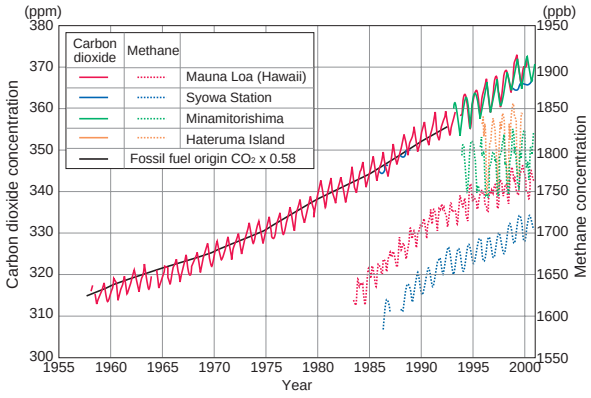


Fig. 5. Long-term carbon dioxide and methane monitoring data at Mauna Loa (National Oceanic and Atmospheric Administration (NOAA)), Syowa Station (National Institute of Polar Research and Tohoku University), Minamitorishima (JMA), and Hateruma Island (NIES) (from World Meteorological Organization (WMO) World Data Centre for Greenhouse Gases (WDCGG) database). Black line indicates the 58% value of accumulated carbon dioxide from fossil fuel combustion.

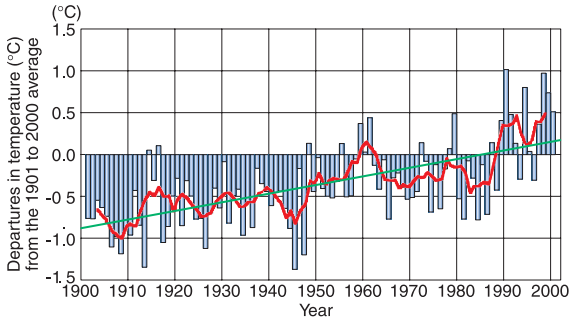


Fig. 4. Surface temperature variations in Japan from 1901 to 2000. Bar graph indicates departures of annual average temperature from the 1901 to 2000 average, and the red curve indicates 5-year running mean. Green curve indicates long-term trend.

Since the ocean absorbs about half of the total amount of carbon dioxide of anthropogenic origin after subtracting the amount accumulated in the atmosphere (3.3PgC), monitoring of spatial and seasonal variations of CO_2 flux in the ocean is quite important. To cover basin-scale monitoring of ΔPco_2 (difference of Pco_2 between atmosphere and surface of the ocean) with seasonal variations, ΔPco_2 in the sub-arctic Pacific waters was monitored from 1995 to 2001 by NIES using commercial vessels cruising a regular route and equipped with CO_2 measuring instruments (Fig. 6). The sub-arctic Pacific undergoes substantial seasonal variations, acting as a CO_2 sink for spring and summer but becoming a CO_2 source in winter.

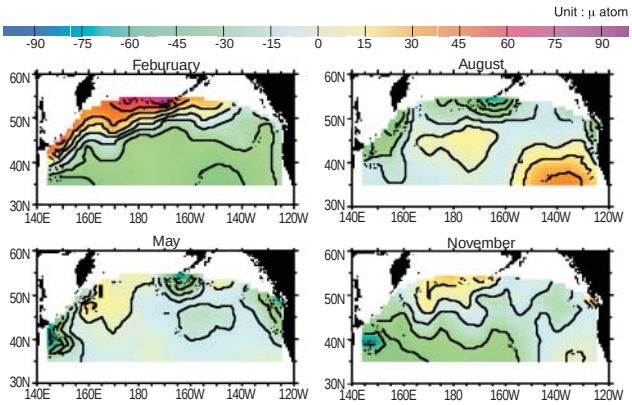


Fig. 6. Seasonal variation in air-sea ΔPco_2 distribution in the sub-arctic Pacific. It is obtained by a joint project of the National Institute for Environmental Studies and the Institute of Ocean Sciences, Canada, using a cargo ship "Skaugran" from 1995 to 1999.

Future Research Directions

To advance monitoring and research of global warming, collaborative observations and studies with several on-going international projects, including Global Climate Observing System (GCOS), Integrated Global Observation Strategy Partnership (IGOS-P) and Global Carbon Project (GCP), are required. In addition, Japan's geographical setting in the eastern end of the Eurasian Continent and facing the Pacific Ocean, provides a unique opportunity to contribute observation of global warming, through collaboration with Asian countries, including a huge area of Siberia, to expand land based observation sites, and with Pan-Pacific countries to expand ocean observation tracks and sites in the North and South Pacific Ocean, Southern Ocean, the Bering Sea, and the Polar Sea.

The following are highly recommended targets of global warming monitoring and required development of technologies for the next 10 years.

- ✔ Establishment of regionally distributed land-based monitoring stations in Siberia, China, and Southeast Asia to monitor integrated global-warming components such as greenhouse gases and aerosols, CO_2 flux, vegetation, and soil moisture.
- ✔ Intensive seasonal monitoring of surface ΔPco_2, chlorophyll a, and nutrients of the Pacific Ocean using research vessels and ships of opportunity, and the establishment of fixed time-series stations in the sub-arctic Pacific region for intensive monitoring of the carbon cycle and CO_2 flux in the upper ocean.
- ✔ Development of satellite sensors and other technology to monitor atmospheric CO_2 concentrations with an accuracy of 1ppm from the space.
- ✔ Aircraft and satellite observations of the interaction between physico-chemical characteristics of aerosols and cloud conditions in the atmosphere.

Program for Projection Modeling and Climate Change Study

Major Research Results

Since its relocation to Tsukuba in 1980, the Meteorological Research Institute (MRI) of JMA has promoted climate modeling, contributing to the past Intergovernmental Panel on Climate Change (IPCC) assessments. Since its establishment in 1991, the Center for Climate System Research (CCSR) at the University of Tokyo has also pursued climate modeling jointly with NIES, reflecting their outcomes in the Third Assessment Report (TAR) of IPCC (2001). Results from MRI and CCSR/NIES global climate models are shown in Fig. 7. The models have different climate sensitivities but similar spatial response patterns.

To obtain regional-scale information (i.e., downscaling), regional climate models have been developed at MRI, NIES and the Central Research Institute of Electric Power Industry (CRIEPI). Figure 8 displays winter precipitation over and around Japan calculated by three models. Despite differences among the models, regional characteristics, e.g. heavy precipitation in the Japan Sea side, are reproduced better by all regional models than by global models.

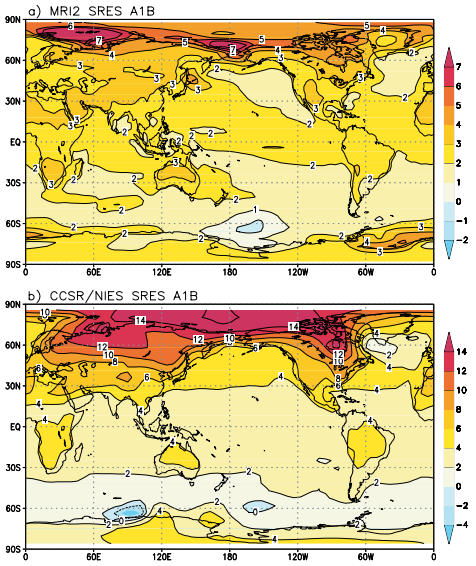


Fig. 7. Change in annual mean surface air temperature for the SRES (the IPCC Special Report on Emission Scenario) scenario A1B for the period 2071 to 2100, relative to the period 1961 to 1990 as simulated by the MRI model (top) and the CCSR/NIES model (bottom). The colors differ between them.

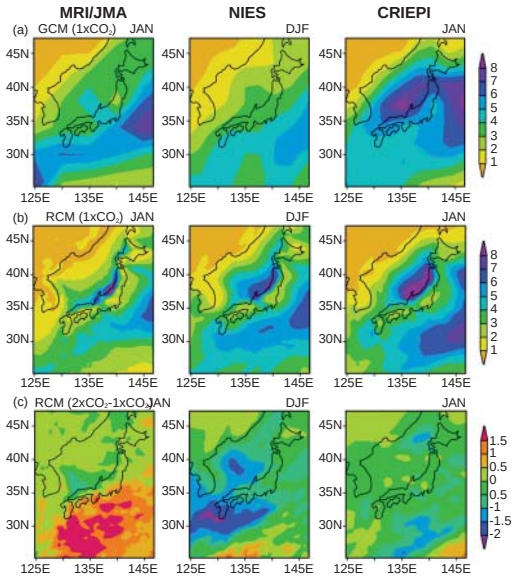


Fig. 8. Daily mean precipitation (mm/day) in winter simulated by global climate models (top) and regional climate models (middle), and the change due to CO_2 doubling simulated by the regional models (bottom). The results differ by research center (left, MRI/JMA; middle, NIES; right, CRIEPI).

Future Research Directions

The following are possible future modeling directions under the new situation with rapid progress in advanced computational ability.

- ✔ Increase horizontal and vertical resolutions within the framework of existing models.
- ✔ Develop new models by resolving the current parameterized small-scale phenomena or structure with much higher resolutions beyond the limits of existing models.
- ✔ Deal with model parameterization of physical processes in greater detail or more precisely.
- ✔ Other challenges, such as developing a new integrated model for the Earth environment for simulating the carbon cycle.

Along these directions, making use of the most advanced super-computer, the Earth Simulator made available in 2002, an ambitious “Project on Sustainable Co-existence of Human, Nature and the Earth” was launched in the same year by the Ministry of Education, Culture, Sports, Science and Technology (MEXT). The five-year Project includes global projection studies expected to contribute to the Fourth Assessment Report of IPCC (AR4) as follows:

- ✔ High-resolution climate modeling and climate-change projection under the IPCC scenarios being conducted jointly by CCSR, NIES and the Frontier Research System for Global Change (FRSGC).
- ✔ Climate-change projection for long-term stabilization scenarios using the National Center for Atmospheric Research (NCAR) model by CRIEPI.
- ✔ Super-high resolution global climate change projection focusing on tropical cyclone, Baiu front, and also cloud resolvable regional modeling focusing on extreme events, e.g. severe rain storms by MRI and JMA (Fig. 9).
- ✔ Integrated Earth system modeling for projecting Earth environment change, introducing carbon cycle, atmospheric chemistry, and an ecosystem change into climate models by FRSGC.

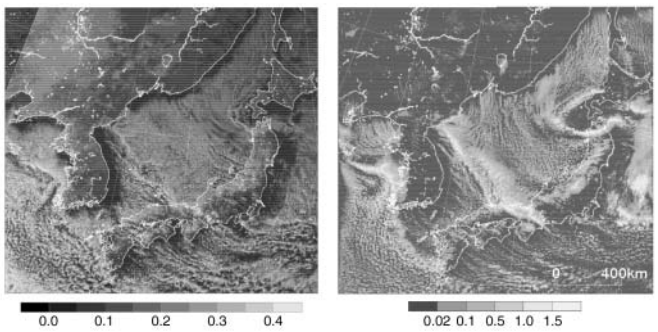


Fig. 9. The cold outbreak over the Japan Sea observed by Geostationary Meteorological Satellite - 5 (GMS-5) (visible image; left) and simulated by an MRI 1km-mesh non-hydrostatic model (total water path; right).

Program for Impact and Risk Assessment

Major Research Results

Impacts on Forests and Vegetation

Among the changes in potential vegetation in Japan, it is predicted that a decline in the distribution of alpine vegetation and sub-alpine coniferous forests will occur by 2050. There is also a risk that northern coniferous forests will be replaced by broad-leaved deciduous forests, and that southern broad-leaved deciduous forests will be replaced by broad-leaved evergreen forests, as depicted in Fig. 10. This figure also shows a marked reduction in mountain ecosystems with a northward shift in the vegetation zone for the main islands of Japan.

Impact on Agriculture and Food Security

In Japan, approximately 1.7 million ha of paddies provide about 9 million tons of rice in recent years, but a change in temperature would affect this productivity. Roughly, rice production will increase in high latitudes and decrease in low latitudes due to differences in growth and development efficiency. If the same cultivars are introduced in the future, it will be necessary to grow rice earlier in the Tohoku and Hokkaido regions, the northern parts of Japan, and later in the other regions to maintain current yield levels.

As the Japanese diet has been westernized since the high economic growth period of the 1960s, the yield from domestic agricultural production continues to decrease with a rapid increase of food imports. As a result, the food self sufficiency in calories has dropped to about 40%. Japan depends on imports from abroad for feed crops such as wheat and soybeans, which makes the country extremely vulnerable to impacts of climate change on the producing country.

Heightened Health Risks

Rising temperatures will directly impact human health, with an increased overall death rate from heat stroke and other disorders. Elderly and people with underlying medical conditions will be at greatest risk. Worsening atmospheric pollution and epidemics of vector-borne infectious diseases, such as malaria and dengue, are also possibilities. There have been recent reports of mosquitoes that transmit communicable diseases moving northward to the Tohoku region, and the risk of infectious disease may become a reality as the mosquito habitat expands. However, social aspects play a greater role in the stress that healthy people feel in daily life and work, as well as in the chronic diseases.

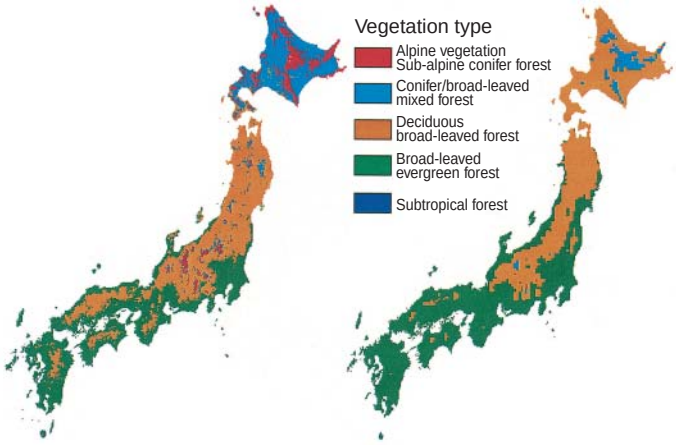


Fig. 10. Predicted changes in natural vegetation in 2050. The Left figure shows the distribution of potential natural vegetation at present, and the right one shows that for 2050 climate predicted for CCSR-98 scenario.

Future Research Directions

Research continues to clarify the impacts of global warming in an extremely broad range of areas. Table 1 lists the distribution of research activities to date. Numerous results have been obtained for terrestrial ecosystems; the agriculture, forestry, and fisheries industries; and coastal zones compared with other fields.

In impact and risk studies, a wide range of research is needed, including detection of emerging impacts, impacts on individual sectors, nationwide assessments, identification of thresholds of impacts and vulnerable areas, and adaptation strategies and measures. Many of the studies to date focused on fundamental aspects, such as methods of predicting the impact. However, to tie these with countermeasures against global warming, we need clear answers to the following questions.

- ✔ What extent (e.g., number of people at risk and monetary amount to be lost) will these impacts reach on a national scale?
- ✔ Which sectors in which regions will sustain the severest impacts?
- ✔ Threshold of impacts - How many degrees can the surface temperature rise, and how many centimeters can sea levels rise, before the world will have intolerable impacts?
- ✔ When will these occur?

Table 1. Map of impact/risk studies

	Water resources Water environment	Terrestrial ecosystem	Agriculture, forestry and fishery	Ocean environment	Coastal zones	Land preservation, disaster prevention, and human settlement	Industry Energy	Human health
Impact detection		●●●		●●	●			●
Element studies on assessment methodology	●●	●●●	●●●	●	●●●	●●	●	●●●
National assessment Impact map	●	●●●	●●●		●●●	●		●
Threshold of impacts Vulnerable sectors and areas Economic assessment	●	●●	●●	●●	●●		●	●●
Adaptation	●		●●	●	●	●	●	●
Impacts on the Asia and Pacific region	●	●●	●●		●●			●

●●● : Studies with results in most areas ●● : Studies with results in some areas ● : Studies in limited areas None : No studies or unknown situations

Program for Response Policy

Major Research Results

Formulating 100-year scenarios

The extent of global warming will be greatly affected by the directions taken in the development of human society. Estimating emission scenarios based on all available scientific data is, therefore, a fundamental element of global warming response policies. Japan is one of the world's leaders in research on emission scenarios. In the process of developing SRES scenarios, two teams from Japan, out of six in the world, prepared 100-year emission scenarios in IPCC. More than 400 non-IPCC emission scenarios have been entered into a database by a Japanese research team. Figure 11 shows the remarkably large range of these scenarios. Following this, Working Group III of IPCC worked on "post-SRES scenarios." Nine research teams throughout the world participated in their development, three of which were from Japan. The Japanese teams also coordinated the study program on projected concentration-stabilization scenarios.

Estimated Costs of the Kyoto Protocol

The IPCC TAR published in 2001 mentions cost study assessments to achieve the numerical target of the Kyoto protocol, including the Japanese studies. The costs of mitigation measures have conventionally been estimated by rough calculations using highly abstract economic models.

There is a need for more accurate cost estimations that consider the reductions in costs resulting from the progress of mitigation technologies. For this purpose, a "bottom-up" model that describes the processes and technologies of individual energy use in detail becomes necessary. The development of such detailed models is progressing, such as a model named AIM (Asia-Pacific Integrated Model) by a Japanese team, which was applied not only in developed countries but in developing countries in Asia as well. This model estimates, without dependence on the Kyoto Mechanisms, that the marginal cost ranged from slightly more than 10,000 to about 35,000 yen/tC to achieve Japanese targets of the Kyoto Protocol. GDP loss estimates ranged from 0.1% to 0.8%, which was reported to the Global Environment Subcommittee, Central Environment Council, Japan, in 2001.

Technological Innovation Making Greater Progress Than Expected

Table 2 provides an overview of the technological potential for reducing greenhouse gas emissions in 2010 and 2020. The model introduced above, developed by Japanese research teams, is used exclusively to estimate the effects of the development and diffusion of such technologies. Investigations into the overall potential for emission reductions and the possibility of absorption by forests have also recently begun in Japan. Cost reductions have been estimated by detailing the processes and technologies of individual energy use and assuming relations between technological innovation and diffusion on one hand, and reduction in technology cost on the other. Various studies concerning individual technologies support these model studies. Japan is leading the world in research on energy-related technologies and carbon fixation technologies.

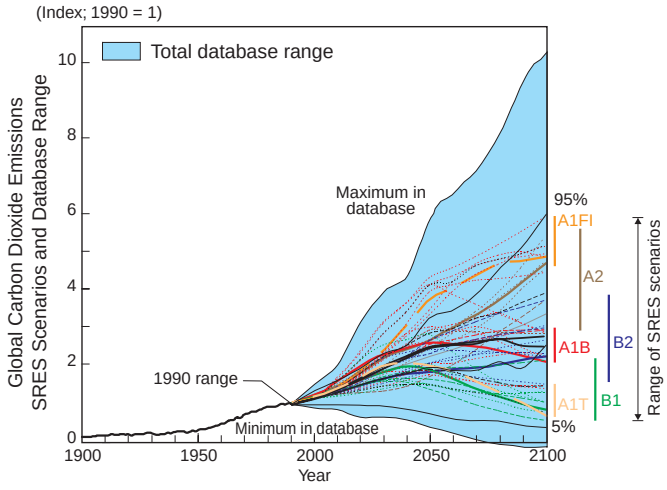


Fig. 11. Global CO_2 emissions from energy and industry, historical development from 1900 to 1990 and in 40 SRES scenarios from 1990 to 2100, shown as an index (1990 = 1) (IPCC WGIII, 2001).

Table 2. Potential for emission reduction by 2020.

Category	Potential emission reduction in 2010 (million tons carbon, equiv./year)	Potential emission reduction in 2020 (million tons carbon, equiv./year)
Buildings	700 ~ 750	1000 ~ 1100
Transportation and Mobility	100 ~ 300	300 ~ 700
Industry		
- Energy efficiency improvement	300 ~ 500	700 ~ 900
- Material efficiency improvement	~ 200	~ 600
- Gases other than CO_2	~ 100	~ 100
Agriculture	150 ~ 300	350 ~ 750
Waste	~ 200	~ 200
Use of alternatives under the Montreal Protocol	~ 100	n.a.
Energy supply and source switchover	50 ~ 150	350 ~ 700
Total	**1900 ~ 2600**	**3600 ~ 5050**

(Note) Reduction potentials calculated based on technologies to be introduced in the market with a direct cost of 100 US dollars or less per ton carbon equivalent. The unit "tons carbon, equiv." means that emissions such as methane and nitrous oxide have been converted into CO_2 emissions based on their degrees of contribution to global warming, and the total amount of greenhouse gas emissions is expressed by the weight of carbon (based on IPCC 2001).

Future Research Directions

Response policy studies are entering into a new phase:

- ✔ An increasing necessity of studies in the social science and humanities.
- ✔ Bridging gaps in studies between developed and developing countries.
- ✔ Ratification of the Kyoto Protocol necessitates various urgent studies, such as the design and calculation of the effects of Emissions Trading, Joint Implementation, and Clean Development Mechanism.
- ✔ Moving rapidly to explore global warming response policies after 2010.
- ✔ Examination of the policy factors for achieving the targets of the Kyoto Protocol has almost been completed in Japan. Domestic policy consistent with an international framework needs to be developed.
- ✔ Verification studies concerning how to strengthen industrial competitiveness under the new world order.
- ✔ Promoting joint studies with the developing countries of Asia and the Pacific, and contributing to international cooperation and understanding.

Contribution to International Activities

Intergovernmental Panel on Climate Change (IPCC)

IPCC has a very important role to bridge between scientific communities and policy-makers in terms of climate change. It was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) to assess scientific, technical and socioeconomic information relevant for the understanding of climate change, and its potential impacts and response strategies and options. IPCC's assessment reports, as well as special reports and technical papers, have been regarded as a basis of authority for policy-makers to implement the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol.

Currently IPCC consists of the three Working Groups with the following target subjects: Physical Science Basis (WG I); Impacts, Adaptation and Vulnerability (WG II); and Mitigation of Climate Change (WG III). IPCC is now preparing the Fourth Assessment Report (AR4) to be published in 2007. We plan to contribute the latest scientific information derived from the Global Warming Research Initiative to the AR4 of IPCC.

Earth Observation Summit and Group on Earth Observations (GEO)

The Earth Observation Summit was initiated to promote the development of a comprehensive, coordinated, and sustained Earth-observation systems among governments and the international community to help understand and address global environmental and economic challenges. The first Summit was held July 31, 2003, in Washington, DC, to begin a process to develop a conceptual framework and implementation plan for building this Earth-observation systems. As a result of the Earth Observation Summit, an ad hoc Group on Earth Observations (GEO) was established to prepare a 10-year implementation plan for a coordinated, comprehensive, and sustained Earth-observation systems.

Earth System Science Partnership (ESSP)

The global research community has a history of enhancing the scientific understanding of global change and the human society through developing international programmes such as World Climate Research Programme (WCRP), International Geosphere-Biosphere Programme (IGBP), and International Human Dimensions Programme on Global Environmental Change (IHDP). Recently, the World Summit of Sustainable Development (WSSD), held in 2002, requested that scientific communities strengthen their activities toward ensuring the full understanding of the nature of global environmental changes and contributing to sustainable development of human society. Based on this request, they have started a new global collaboration program called the Earth System Science Partnership.

The Earth System Science Partnership is a partnership of four global change research programmes (International Programme of Biodiversity Science (DIVERSITAS), IGBP, IHDP and WCRP) for the integrated study of the Earth System, the changes that are occurring to the System and the implications of these changes for global sustainability. The ESSP undertakes joint projects on issues of global sustainability, such as carbon cycle/energy systems, food systems, water resources and human health, and regional studies.

Regional Collaboration through START and APN

The Asia and Pacific region is a focused region from various aspects of global warming and climate change; it has the world's largest population, highest growth rate, and fastest developing economic activities. It has a variety of natural functions, including tropical forests and the Pacific Ocean as sinks of CO_2, and it has been facing severe damage due to cyclones, floods, storm surges, drought, and desertification. Therefore, building scientific and technological capacity is essential for the sustainable development of each country and the region. As an Asian and Pacific country, we try to contribute support the region to achieve these goals in close collaboration with START*, APN** and other relevant programs.

* :Global Change: System for Analysis, Research and Training (START) is cosponsored by IGBP, IHDP, and WCRP, and seeks to establish and foster regional networks of collaborating scientists and institutions in developing countries.

** :Asia-Pacific Network for Global Change Research (APN) is an inter-governmental network for the promotion of global change research and links between science and policy making in the Asia-Pacific Region, which Japan is strongly supporting.

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