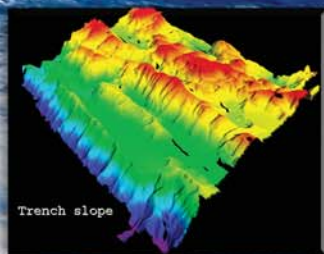


JAMSTEC

2004 Annual Report



Japan Agency for Marine-Earth Science and Technology

JAMSTEC 2004 Annual Report

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FY2004 Steps of Japan Agency for Marine-Earth Science and Technology with Photos

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FY2004 Steps of Japan Agency for Marine-Earth Science and Technology with Photos



April

Ceremony of Establishment of Independent Administrative Institution, Japan Agency for Marine-Earth Science and Technology



April

Arrival Ceremony of "TANSEI MARU"



April

The facilities of the Yokohama Institute for Earth Sciences opened to the public.



May

The facilities of the Yokosuka Headquarters opened to the public.



May

Mr. Mouri, Director of the National Museum of Emerging Science and Innovation visited "CHIKYU".



June

"SHINKAI 6500" and "YOKOSUKA" started on a voyage across the South Pacific (NIRAI KANAI)



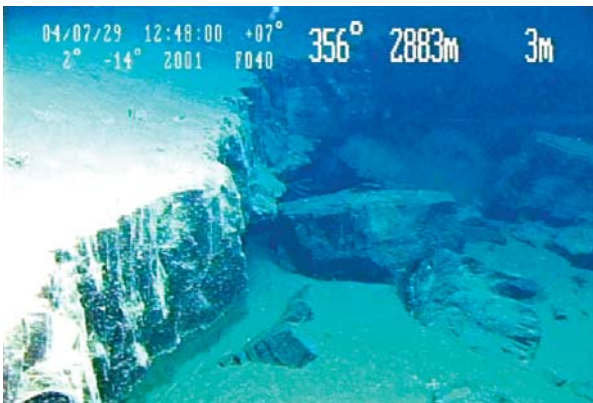
June

The Earth Simulator made five consecutive records of the world's highest performance in 2 years.



July

Arrival Ceremony of "HAKUHO MARU"



August

On the NIRAI KANAI voyage, the world's largest undersea lava flow discovered.



October

The Third Symposium of the Earth Simulator Center held.



October

The Fourth Deep-Sea Bio-Forum held.



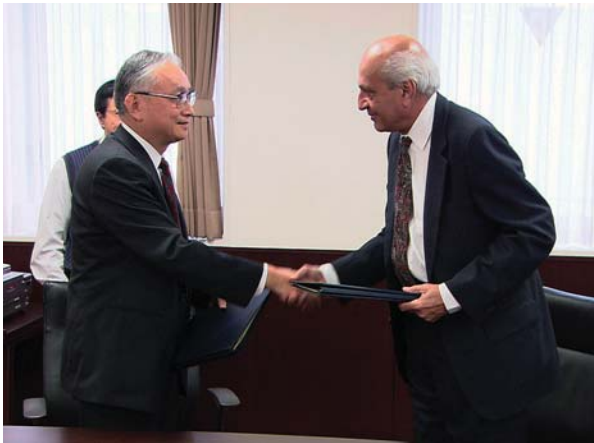
October

Mr. Hodgson, Research, Science and Technology Minister of New Zealand, visited "YOKOSUKA" and "SHINKAI 6500" at Auckland port



November

Participated in the exhibition "OCEANS' 04 MTS/IEEE/TECHNO-OCEAN' 04 (OTO'04)"



November

Signed the memorandum of understanding on the Integrated Ocean Drilling Program (IODP) with IODP Management International, Inc.



December

Mr. Tanahashi, Minister in charge of science and technology, visited Yokohama Institute for Earth Science.



December

Mr. Nakayama, Minister of Education, Culture, Sports, Science and Technology, visited Yokosuka Headquarters and Yokohama Institute for Earth Science.



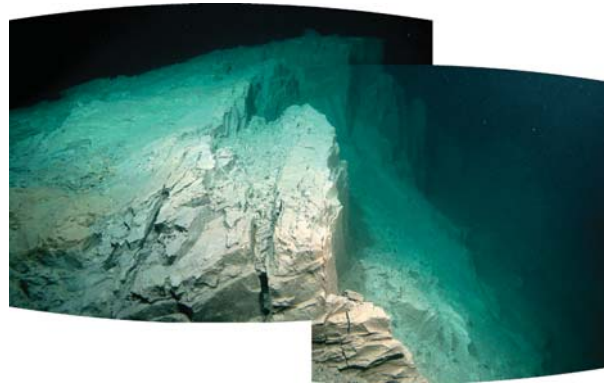
January

Blue Earth '04 was held.



February

"NATSUSHIMA" started an emergency survey around the epicenter of the Sumatra Earthquake.



February

The Deep Sea Cruising AUV "URASHIMA" set a world record for the continuous cruise of 317 km.



March

Awarding ceremony of the 7th National Children's "Contest Ocean Dream Image on Postcard"

Preface

On April 1, 2004, the Japan Marine Science and Technology Center was reorganized as an independent administrative institution, the Japan Agency for Marine-Earth Science and Technology (JAMSTEC).

The prediction and elucidation of global-scale environmental changes such as global warming, as well as global change phenomena such as marine earthquakes and volcanic eruptions that cause large-scale natural disasters and environmental pollution are urgent issues facing mankind in the 21st century.

JAMSTEC was established for the purpose of "contributing to the advancement of marine science technology and the development of academic research by comprehensively conducting activities such as fundamental ocean research and development and cooperation in academic ocean research, based on the philosophy of peace and well-being of mankind." On the basis of the purpose, the government set a target (mid-term target) of operations that should be performed by JAMSTEC, and JAMSTEC made a plan (mid-term plan) to achieve the target.

In order to elucidate the global environmental change through perceiving the Earth as one system centering on the ocean, JAMSTEC carries out various fundamental research and development such as observational researches, prediction research and technological development. Moreover, we are determined to strive to contribute to the sustainable development of mankind, public safety, social and economic development, and advancement of human knowledge through public relations, propagation and educational activities on our R & D results, etc.

At the inauguration of JAMSTEC, we took over the operation of two research vessels, HAKUHO-MARU and TANSEI-MARU, from the Ocean Research Institute of the University of Tokyo. We are committed to implementing the operation control of them safely and effectively and promote cooperation in academic research extensively.

As for the actual activities in FY2004, JAMSTEC was reorganized on a large scale in July, and the new system of JAMSTEC was organized. In December, we prepared the action plan stipulating the specific targets and activities in order to realize the mid-term plan. According to the plan, all the executives and the staff have been carrying out the operations together.

As for the major research results obtained in FY2004, first, in the field of global environmental change study, we completed the predictive calculation on global warming of 100 years from now using the "Earth Simulator," and found that due to global warming, Japan would be hit by hot weather and torrential rain more frequently. We also succeeded in reproduction of the current of deep water in the Antarctic Ocean in simulation, which is expected to contribute to study of the ocean general circulation and elucidation of climate change. In order to diffuse simulation science in industry and put it into practical use, we have actively conducted joint researches with private sectors such as automobile industry.

Also, using the KAIREI and the KAIYO, we made a scientific contribution to the research for the delimitation of boundaries of the continental shelf. In the great voyage in the Pacific Ocean, "NIRAI-KANAI," with the SHINKAI 6500 and the YOKOSUKA, we conducted geophysical research and biological research over 150 days or so in the sea areas such as the East Pacific and discovered the world's largest lava flow at the ocean floor.

In terms of hardware, the deep sea cruising AUV URASHIMA was able to carry out a long-distance cruise with fuel cells successfully for the first time in the world and set a cruising distance record of 317km. We will continue to strive to improve not only the cruising performance but also the function as a "research facility" for researchers by implementing tests on the on-board observational equipment such as underwater vehicles.

Furthermore, to clarify the cause of the giant earthquake and tsunami which occurred off Sumatra Island in Indonesia on December 26, 2004, we conducted the urgent study with the research vessel NATSUSHIMA, mainly in the epicentral sea area of the earthquake during the period from February 18 to March 19, 2005. As the result of the

research using the high-definition camera of the HYPER-DOLPHIN, we found for the first time in the world that collapse of cliffs, landslides, etc. were caused in a wide range of areas, and we could record clear pictures.

On the other hand, regarding the administrative aspect of JAMSTEC, we devoted the first year of the independent administrative institution to establishing a system as so-called "independent administrative institution," that is, we strived to implement operations toward the target efficiently so that the results should be evaluated. From now on, we will direct our attention more to intellectual property, be more cost-conscious, and try to contribute to the society.

JAMSTEC, with your cooperation, will make every effort to open up the future of mankind through exploration of the Earth centering on the ocean. We would appreciate your continued support, understanding and guidance.

March 2006

Yasuhiro Kato

President

Japan Agency for Marine-Earth Science and Technology

Chapter 1.

Outline of Japan Agency for Marine-Earth Science and Technology

1. Activities

1.1 Objective

The objective of the Independent Administrative Institution, Japan Agency for Marine-Earth Science and Technology (hereinafter, referred to as the "Agency") is to contribute to development of the academic ocean researches as well as to elevate the level of ocean science and technology through comprehensive activities such as fundamental ocean research and development and cooperative academic ocean researches according to the philosophy of contribution to peace and welfare. (Article 4, Law concerning the Independent Administrative Institution, Japan Agency for Marine-Earth Science and Technology [hereinafter, referred to as the "Law"])

1.2 Scope of activities (Article 17, Section 1, Nos. 1 to 7 of the Law)

- To conduct a fundamental ocean research and development
- To make the achievements through the above activity widespread and to promote the utilization of the achievements.
- To cooperate with universities and inter-university research institutes in the academic ocean researches through operation of vessels, etc.
- To make the facilities and equipment of the Agency available for use by those who conduct research and development or academic research on science and technology.
- To train researchers and engineers on ocean science and technology and to enhance their qualification.
- To collect, organize, store and provide internal and external information and materials on ocean science and technology.
- To conduct ancillary operations of the above activities.

2. Locations of offices and institutes

Headquarters

2-15, Natsushima-cho, Yokosuka city, Kanagawa, Japan
Tel: 046-866-3811

Yokohama Institute for Earth Science

3173-25, Showa-cho, Kanazawa-ku, Yokohama city, Kanagawa, Japan
Tel: 045-778-3811

Mutsu Institute for Oceanography

690, Kitasekine, Sekine, Mutsu city, Aomori, Japan
Tel: 0175-25-3811

Washington Office

1133 21st Street, NW, Suite-0543, USA

Seattle Office

810 3rd Avenue, Suite 632, Seattle, WA 98104, USA

Tokyo Office

Hibiya Central Bldg. 10F, 2-9 Nishi-Shimbashi 1-chome Minato-ku, Tokyo, Japan
Tel: 03-5157-3900

Global Oceanographic Data Center

224-3, Toyohara, Nago city, Okinawa, Japan
Tel: 0980-50-0111

Kochi Institute for Core Sample Research

Otsu 200, Monobe, Nankoku-shi, Kochi, Japan
Tel: 088-864-6705

3. Status of capital fund

The capital fund at the time of inauguration on April 1, 2004 was 84,217 million yen, and the capital fund as of March 31, 2005 is 84,215 million yen.

(Breakdown of capital fund) (Unit: thousand yen) ※rounded down to the thousands.

	April 1, 2004	March 31, 2005
Government investment	84,210,463	84,210,463
Private investment	6,732	4,712
Total	84,217,195	84,215,176

4. Executive officers (Article 10, Sections 1 and 2 of the Law)

Seats for executive officials: Two shall be assigned as President and Auditor in the Agency.

Three may be assigned as Executive Director in the Agency.

(As of March 31, 2005)

Title	Name	Term of office	Personal history
President (full-time)	Yasuhiro Kato	From April 1, 2004 to March 31, 2009	1967 Graduated from University of Tokyo, Faculty of Engineering 1995 Director-General of the Research and Development Bureau of the Science and Technology Agency 1999 Vice-Minister for Science and Technology
Executive Director (full-time)	Hajimu Kinoshita	From April 1, 2004 to March 31, 2006	1967 Graduated from Doctoral Course, Department of Geophysics, Graduate School of Science, University of Tokyo 1990 Professor, Earthquake Research Institute, University of Tokyo 1999 Japan Marine Science and Technology Center Director of Frontier Research Program for Subduction Dynamics
Executive Director (full-time)	Kiyoshi Suehiro	From April 1, 2004 to March 31, 2006	1980 Graduated from Doctoral Course, Department of Geophysics, Graduate School of Science, University of Tokyo 1996 Professor, Ocean Research Institute, University of Tokyo 1999 Japan Marine Science and Technology Center Director of Deep Sea Research Department
Executive Director (full-time)	Tsutomu Imamura	From July 15, 2004 to March 31, 2006	1971 Graduated from Graduate School of Engineering, Kyoto University 2001 Director General, R&D Bureau, Ministry of Education, Culture, Sports, Science and Technology 2002 Director-General, National Institute of Science and Technology Policy
Auditor (full-time)	Takeaki Miyazaki	From April 1, 2004 to March 31, 2006	1972 Graduated from Graduate School of Science and Engineering, Aoyama Gakuin University 1989 Japan Marine Science and Technology Center Senior Scientist, Marine Development Research Department 2000 Director, Administration Department
Auditor (part-time)	Yukiko Hori	From April 1, 2004 to March 31, 2006	1963 Graduated from College of Social Relations, Rikkyo University 1974 President, Enoshima Aquarium Co., Ltd. 2001 Councilor, Japan Marine Science and Technology Center

5. Staff

The number of full-time staff at the beginning of FY2004 was 331 in total, which consisted of 268 people who were in the employment of the Japan Marine Science and Technology Center as of the end of FY2003 and 63 people transferred from the Ocean Research Institute of the University of Tokyo. The total number of full-time staff as of the end of FY2004 is 331.

6. Law constituting grounds for establishment

Law concerning the Independent Administrative Institution, Japan Agency for Marine-Earth Science and Technology (2003 law No. 95)

7. Competent minister

Minister of Education, Culture, Sports, Science and Technology

8. History

- 1971 October
As requested by Japan Federation of Economic Organizations, the authorized corporation, "Japan Marine Science and Technology Center", was established based on the government and industrial investments and contributions.
- 1990 June
The system of "SHINKAI 6500" completed.
- 1995 March
"KAIKO" succeeded in the world's deepest dive in the Mariana Trench.
- 1995 October
"Mutsu Office" opened.
- 2000 September
"Washington Office" opened.
- 2000 September
"Mutsu Institute for Oceanography" inaugurated.
- 2001 April
"Seattle Office" opened.
- 2001 November
"Global Oceanographic Data Center" (Nago city, Okinawa) opened.
- 2002 April
"Earth Simulator" recorded the world's highest computing performance.
- 2002 August
"Yokohama Institute for Earth Sciences" opened.
- 2004 April
Independent Administrative Institution, Japan Agency for Marine-Earth Science and Technology inaugurated.
- 2004 July
Japan Agency for Marine-Earth Science and Technology reorganized as four research centers and three centers.
- 2005 February
Survey on the Earthquake off the coast of Indonesia's Sumatra Island implemented.

- 2005 February

"URASHIMA" set a new world record for the continuous cruise of 317 km.

9. Introduction of offices and institutes

9.1 Yokosuka Headquarters

9.1.1 Maintenance of facilities and equipment of Yokosuka Headquarters

① Land

In April 1972, JAMSTEC acquired the nationally-owned land of 40,159.57 m² at Yokosuka city, Kanagawa Prefecture as investment in kind. The reclamation work for the land of 18,391.84 m², which started in 1980, was completed in 1982. In 1983, JAMSTEC purchased the land of 855.99 m² from the government. In May 1985, the second-stage reclamation work for 4,518.93 m² was completed. Since the level of the reclaimed land and that of the existing ground was different, the work for raising the level of the existing ground was executed during a period from 1986 to 1987. In a period from 1988 to 2000, the on-the-premises environment maintenance works were conducted. JAMSTEC purchased the land of 1,118.99 m² in 2001 and its adjacent land of 1,030.62 m² in 2002. As a result, the total land area became 66,075.92 m².

② Building

As shown in Table 1, construction and modification of buildings have been conducted sequentially since 1972. In 2000, the number of research buildings reached 34, and the total floor area became 37,232.93 m².

In 2001, JAMSTEC purchased the common use building (old Information and Power Source Building) from Fuyo General Lease Co., Ltd. In 2003, the Maintenance Building and the Gas Bank Building were dismantled, resulting in 32 research buildings with a total floor area of 36,953.63 m².

Table 1 Construction/Modification Status of Research Facilities of Yokohama Headquarters

Building	Total floor area (m ²)	Year of construction/modification
Diving Simulator Building	1,586.64	Constructed in FY1972, Modified in FY1975
Marine Training Building	584.88	Constructed in FY1972, Modified in FY1992
Marine Engineering Experiment Building	3,000.00	Constructed in FY1972-73, Modified in FY1994
Diving Training Building	1,595.85	Constructed in FY1973, Modified in FY1995
Waste Treatment Building	153.90	Constructed in FY1973
Marine Science and Technology Building	2,249.93	Constructed in FY1974, Modified in FY2000 (earthquake-resistant reinforcement)
Hyperbaric Experiment Water Tank Building	622.33	Constructed in FY1975
Common Use Building	796.50	Constructed in FY1976, Modified in FY1995
Ecosystem Experiment Building	202.05	Constructed in FY1977
	749.00	Expanded in FY1979
Maintenance Yard for Research Submersible Vessel	1,220.74	Constructed in FY1983
Warehouse for Marine Experimental Equipment	112.18	Constructed in FY1984
Transformer Building for the Research Submersible Vessels Maintenance Yard	72.00	Constructed in FY1987
Attached Building for the Research Submersible Vessels Maintenance Yard	800.00	Expanded in FY1991
Deep-sea Research Building	5,639.82	Constructed in FY1993
Ocean Research Building	1,981.80	Constructed in FY1994
Maintenance Yard for Remotely Operated Vehicles	493.51	Constructed in FY1995
Marine Ecosystems Research Building	1,124.32	Constructed in FY1995, Purchased in FY2001
Frontier Research Building	1,980.00	Constructed in FY1996
Guard House	25.11	Constructed in FY1996
New Prefabricated Building	99.37	Constructed in FY1996
Chemical Wastewater Temporary Storage Building	19.59	Constructed in FY1997
Special High-Voltage Power Receiving Station	458.54	Constructed in FY1998
Canteen (Shin-kai Tei)	484.70	Constructed in FY1999
Marine Technology Research Building	2,091.23	Constructed in FY1999
Headquarters Building South Wing	3,366.25	Constructed in FY1999
Headquarters International Exchange Facility	344.18	Expanded in FY2000
	19.61	Expanded in FY2003
Headquarters Building North Wing	4,858.25	Expanded in FY2000
Others	221.35	
Total	36,953.63	

9.2 Outline of Activities of Yokohama Institute for Earth Sciences

Yokohama Institute for Earth Sciences is a research center for elucidation and prediction of global environmental change and research on the earth core dynamics, where simulations for the global environmental prediction research and the earth core dynamics research are under development, with the full use of

the world's fastest computer "The Earth Simulator." Yokohama Institute is also used for researches of advanced science and technology.

Furthermore, Yokohama Institute for Earth Sciences plays a role as a data center of global environmental information. It has established a system for providing the latest research results widely to the public, where various data obtained from research and observation

activities in this institute are complied and managed as electronic information.

Number of visitors in FY2004 6,338 people in 302 groups

9.3 Mutsu Institute for Oceanography

9.3.1 Outline of Activities of the Mutsu Institute for Oceanography

① Outline of the Mutsu Institute for Oceanography

In October 1995, Independent Administrative Institution, Japan Agency for Marine-Earth Science and Technology (then-Japan Marine Science and Technology Center) opened the "Mutsu Office" in Sekinehama of Mutsu city, Aomori Prefecture, to use Sekinehama Port as the home port of the oceanographic research vessel "MIRAI". In October 2000, the Mutsu Office was restructured and the "Mutsu Institute for Oceanography" was inaugurated. In April 2004, Japan Marine Science and Technology Center was reorganized as an Independent Administrative Institution, and "Mutsu Institute for Oceanography of Japan Agency for Marine-Earth Science and Technology" was inaugurated.

The Mutsu Institute for Oceanography has the facilities in the vicinity of Sekinehama Port, such as Administration Building, Observation Equipment and Machinery Maintenance Shop, Sample Analysis Facility, and Mutsu Research Exchange Building, and functions as the home port of the "MIRAI" to conduct operation control (See Fig. 1). In 2004, the Mutsu Institute for Oceanography conducted maintenance and tests of observation equipment such as TRITON buoys (oceanographic observation buoys) and ARGO floats (automatic elevating floats), and contributed to clarification and prediction of climate change such as global



Fig. 1 Full View of Mutsu Institute for Oceanography.



Fig. 2 Open Public Day at Mutsu Institute.

warming through the development of chemical analysis of seawater and research activities for clarification of history and mechanism of ocean environmental change as well as ocean material cycle (carbon cycle) mainly in the North Pacific Ocean.

② Major public relations activities

To smoothly operate the oceanographic research vessel "MIRAI", understanding and cooperation from the local people in Mutsu city, which is a home port, are indispensable. The Mutsu Institute for Oceanography is conducting public relations activities for the general public, especially the young people who will lead the next generation.

On August 7, 2004, as in the previous year, the oceanographic research vessel "MIRAI" and the facilities of the Mutsu Institute for Oceanography were opened to public in Sekinehama, and 607 visitors had a tour around the facilities (See Fig. 2). From August 17 to 30 and September 7 to 9, as part of an internship project (working experience), the Institute invited technical junior college and industrial high school students to provide positive educational activities through analysis of ocean samples, data analysis, and practical maintenance training of TRITON buoys.

9.3.2 Maintenance of Facilities and Equipment of the Mutsu Institute for Oceanography

① Land

The Mutsu Institute for Oceanography has occupied part of the Sekine premises of Mutsu Establishment of Japan Atomic Energy Research Institute. Since 1995, the Mutsu Institute has obtained additional lease at the minimum as needed.

As of the end of 2004, the total area of leased land is 13,110.25 m². The breakdown is as shown in Table 1.

② Building

As shown in Table 2, the buildings have been constructed sequentially since 1996. At present, the number of buildings is 5 and the total floor area is 7,079.17 m².

③ Facilities

As shown in Table 3, facilities have been maintained and operated.

Table 1 Status of Use of Leased Land in Mutsu Institute for Oceanography.

Site	Major buildings	Area of the site (m ²)
Material Building Site	Administration Office building, parking lot, etc.	3,335.33
Port Guard House and Sample Analysis Facility Site	Sample Analysis Facility, Mutsu Guest House, site for piping, etc.	5,096.21
Observation Equipment and Machinery Maintenance Shop Site	Observation Equipment and Machinery Maintenance Shop, Dangerous Object Warehouse, site for piping, etc.	3,103.71
Container yard site	Ship container depot	1,575.00
Total		13,110.25

Table 2 Status of Maintenance of the Research Facilities in Mutsu Institute for Oceanography.

Building	Specification	Total area of the site (m ²)	Maintenance year	Remark
Observation Equipment and Machinery Maintenance Shop	Steel structure Three story with a partial well	3,046.26	FY1995-1996	See Fig. 3
Administration Office Building	Steel reinforced concrete structure Two story	521.90	FY1996	The building of Japan Atomic Energy Research Institute was occupied and remodeled.
Sample Analysis Facility Building	Steel reinforced concrete structure Two story	1,942.59	FY1996-FY1997	See Fig. 4.
Mutsu Guest House Building	Steel structure Three story, 1-story penthouse	1,547.42	FY1998	
Dangerous Object Warehouse	Concrete block structure One-story structure	21.00	FY2000	



Fig. 3 Observation Equipment and Machinery Maintenance Shop and "MIRAI" in Sekinehama Port.



Fig. 4 Sample Analysis Facility.

Table 3 Status of Maintenance of the Facilities in Mutsu Institute for Oceanography.

Facility	Major specification	Structure	Maintenance year	Remark
Hyperbaric experiment water tank	Effective internal diameter: 1000 mm, Effective height: 3000 mm, Working pressure: 25MPa	Pressure-tight steel	FY2001	
Research facilities for strong acid use	Strong acid-proof draft chamber, scrubber, pure water processing equipment, air-conditioning equipment	Container for 20ft vessel	FY2003	
Iso-barn (Isotope barn)	Handling and storage of unsealed radioactive source, storage of RI waste	Container for 20ft vessel	FY2002	RI facility
Waste barn	Storage of RI waste	Container for 20ft vessel	FY2002	RI facility
Equipment analysis room	Use and storage of sealed radioactive source	Second floor of Sample Analysis Facility Building	FY2002	RI facility

9.4 Global Oceanographic Data Center

9.4.1 Outline of Activities of the Global Oceanographic Data Center

JAMSTEC was commissioned to manage the "Nago City Global Oceanographic Data Center" which had been maintained by Nago City, and has operated the Global Oceanographic Data Center (GODAC) since 2001. Since its opening, the GODAC, in collaboration with the Yokohama Institute for Earth Science, has been conducting the operations such as conversion to electronic formats of the images obtained through deep-sea surveys and research result data that are held by JAMSTEC and collection/processing/provision of data on ocean and global environments, etc.

In addition, to contribute to extracurricular lessons such as "Comprehensive Learning Class" and "On-the-Job Work-Study Program" at elementary and junior high schools mainly in the northern regions of Okinawa Prefecture, training for people who make researches about the Asia-Western Pacific Region, promotion of the

local tourist industry and others, the GODAC opens its facilities and equipment such as a lecture room and an educational video system to public, and actively accepts tours requested by not only organizations but also general visitors. Educational contents were developed and organized, too. In this way, the GODAC has been managed and operated as a base for the transmission of ocean and global environmental information useful for better understanding of marine science and technology.

10. International collaboration

To deal with the issues of global-scale environmental variations including climate change, ocean observation and research on a global scale is required.

To elucidate those issues and promote ocean observation and research more effectively and efficiently, JAMSTEC is making efforts to establish cooperative relationship with international organizations and overseas research institutions and promote international joint projects.

10.1 International organizations

JAMSTEC sends experts to various task forces in the IOC (Intergovernmental Oceanographic Commission) of UNESCO (United Nations Educational, Scientific and Cultural Organization) to support their activities, and studies the international movements required for a smooth implementation of ocean observations and researches under the enforcement of the Law of the Sea.

JAMSTEC is a member of SOPAC (South Pacific



Fig. 1 General view of Global Oceanographic Data Center.

Applied Geoscience Commission), which is an influential commission in the South Pacific region that is one of its major observation and research areas, and also a member of POGO (Partnership for Observation of the Global Oceans), which is a forum of major oceanographic research institutions around the world. According to need, JAMSTEC sends researchers to other oceanographic international organizations to contribute to their research activities.

10.2 International joint projects

JAMSTEC participates in the following international joint projects and activities.

- The Array for Real Time Geostrophic Oceanography (ARGO)
- The Climate Variability and Predictability Programme (CLIVAR)
- Global Ocean Observing System (GOOS)
- International Continental Scientific Drilling Program (ICDP)
- The International Margins Program (InterMARGINS)
- An initiative for international cooperation in ridge-crest studies (InterRIDGE)

- Integrated Ocean Drilling Program (IODP)
- North Pacific Marine Science Organization (PICES)

10.3 Cooperation under the Intergovernmental Cooperative Agreement

JAMSTEC conducts cooperative researches based on the Intergovernmental Cooperative Agreement concluded among the United States, the United Kingdom, Australia, Canada, Korea, China, Germany, France, Russia, EU and Japan.

The intergovernmental cooperative task force held in FY2004 is as follows:

- December of 2004

Japan-Canada Joint Panel on Earth Science and the Environment under the Canada-Japan Agreement on Cooperation in Science and Technology

10.4 Cooperation with foreign institutions

Under the memorandums and agreements signed with the institutions concerned in the United States, the United Kingdom, India, Indonesia, Australia, Canada, Korea, Germany and France, JAMSTEC provides inter-organizational research cooperation.

Country	Research Institution	Conclusion status	Joint research subjects
US	Woods Hole Oceanographic Institution (WHOI)	June 4, 2002 to June 3, 2007	1) Marine geology and geophysics 2) Research on polar regions 3) Biogeochemistry and carbon cycle 4) Marine physics and WOCE line re-observation 5) Geochemical evolution of Solid Earth 6) Submersible engineering and safety 7) Deep-sea floor observation station 8) Operating information
	Scripps Institution of Oceanography (SIO)	From December 19, 1996 (Automatically renewed by 5 years)	1) Research on the ocean general circulation and climate 2) Research and study on distortion of the sea-floor plate of the Pacific Ocean 3) Research on adaptation mechanism of micro-organisms to deep-sea environment 4) Research on thermal and material flux on ocean-floor

Country	Research Institution	Conclusion status	Joint research subjects
	Lamont-Doherty Earth Observatory (LDEO)	From December 7, 1997	1) General information exchange 2) Scientific information exchange and personnel exchanges • Marine physics and thalassiochemistry • Marine Solid Earth Science (oceanic earthquake and ocean drilling program)
	Pacific Marine Environmental Laboratory of the National Oceanic and Atmospheric Administration (PMEL/NOAA)	From December 15, 2002 to December 14, 2007	1) Cooperation on maintenance of TRITON buoy/TAO array 2) Ocean and climate research 3) Ocean and atmospheric monitoring 4) Data management 5) General information exchange
	Monterey Bay Aquarium Research Institute (MBARI)	From June 5, 2001 to June 4, 2006	1) Comparative study of the colonies of chemotroph distributed on the periphery of the North Pacific Ocean 2) Genetic study of biocoenoses at hydrothermal vents 3) Comparative study of the structure and ecology of biocoenoses in the middle and deep undersea layer of the eastern and western North Pacific Ocean 4) Control and operation method of remotely operated vehicle 5) Long-term breeding of benthic organisms 6) Development of database of moving-image information 7) Development of deep-sea observation station
	Texas A & M University (TAMU)	From August 23, 2002 (Automatically renewed by 5 years)	1) Plate tectonics/geophysics 2) Global ocean circulation/climate change 3) Drilling and sampling technology
	University of Hawaii (UH)	From April 1, 2004 (April 28) to March 31, 2009	Contract research on the International Pacific Research Center (IPRC)
	University of Alaska (UA)	From April 1, 2004 (May 4) to March 31, 2009	Contract research on the International Arctic Research Center (IARC)
	IODP Management International, Inc. (IODP-MI)	From October 1, 2004 to March 31, 2009	Planning of activities for Integrated Ocean Drilling Program (IODP) with the IODP Management International, Inc. (IODP-MI) and establishment of a formal framework on implementation of the activities
UK	Southampton Oceanography Centre (SOC)	From March 25, 2002 to March 24, 2007	1) Geology and geophysics 2) Marine physics 3) Thalassiochemistry 4) Underwater technology 5) Atmospheric and ocean simulation 6) Information exchange

Country	Research Institution	Conclusion status	Joint research subjects
India	National Institute of Oceanography (NIO)	From May 31, 2000 to May 30, 2005 (Renewal for another 5 years unless otherwise required)	1) Ocean observation associated with climate research 2) General information exchange
Indonesia	Indonesia Agency for the Assessment and Application of Technology (BPPT)	From November 20, 2000 to November 19, 2005	1) Research on ocean climate change 2) Deep-sea research
Australia	Commonwealth Scientific and Industrial Research Organization (CSIRO)	From August 6, 2003 to August 5, 2008 (5 years)	1) Research on thermal and material flux related to the ocean circulation and its variation 2) Research on carbon dioxide balance on the Indian Ocean 3) Distribution of chlorofluorocarbons on the South Pacific Ocean 4) General information exchange
Canada	Department of Fisheries and Oceans (DFO)	From March 20, 2000 (Automatically renewed)	1) Observation and model research on ocean climate change in the upper undersea layer of 200 to 300m of the Arctic Ocean 2) Physical, scientific and biological observation of interaction of the continental shelf and the sea basin and its model research 3) Observational research on balance of freshwater and chemical components on the Bering Sea, the Chukchi Sea, and the Beaufort Sea 4) Observation and model research on variation of ice thickness distribution on the continental shelf and the sea basin
Korea	Korea Ocean Research & Development Institute (KORDI)	From September 18, 2002 (Automatically renewed by 5 years)	1) Geological and geophysical research of the peripheral sea of oceanic trenches 2) Technical development of remotely operated undersea vehicle 3) Deep-sea biocenoses 4) Use of deep-sea water 5) Diversification of deep-sea micro organisms and separation method of individual species 6) General information exchange
Germany	Earth Science Center in Potsdam (GFZ)	From October 31, 2000 to October 30, 2005 (Currently, under adjustment for continuation)	Implementation, management and operation of ICDP (International Continental Scientific Drilling Program)

Country	Research Institution	Conclusion status	Joint research subjects
Germany	Alfred Wegener Institute for polar and marine research (AWI)	From July 5, 1995 (Automatically renewed by 5 years)	1) Deep-sea research and technology (a) Research on deep-ocean floor environment and development of its methodology (b) Development of deep-sea technology 2) Polar-region science and technology (a) Marine physical instruments and observation (b) Polar-region oceanography and related mooring technology
France	French Institute of Research and Exploitation of the Sea (IFREMER)	From July 17, 1998 (Automatically renewed by 5 years)	1) General information exchange 2) Scientific information exchange and personal exchanges (a) Underwater technology (b) Micro organisms

10.5 Others

In April of 2004, JAMSTEC celebrated the 30-year anniversary of its foundation at the Tokyo Chamber of Commerce and Industry, invited foreign embassy officials in Tokyo and introduced the objective and activities of the Agency to them.

From October 19 to 25, 2004, the support vessel "YOKOSUKA" and the manned research submersible "SHINKAI 6500" called at Auckland port in New Zealand for preparation of implementation of the "Ocean Scientific Research Program in the Kermadec Arc off-shore New Zealand." During the call at Auckland port, Mr. Hodgson, Research, Science and Technology Minister of New Zealand, was invited to visit "YOKOSUKA" and "SHINKAI 6500", and "YOKOSUKA" and "SHINKAI 6500" were opened to public. Through these activities, we introduced our activities and tried to win the better understanding of people about the importance of ocean scientific research.

In January of 2005, a lecture meeting in commemoration of the launch the UK-Japan Collaboration Project on Climate Change Modeling was held at the British Embassy. At this meeting, President Mr. Kato and Executive Directors Dr. Kinoshita and Mr. Imamura had a confabulation with Mr. Straw, British Foreign Secretary.

10.6 Overseas business trip, dispatch of research groups and research workers to foreign countries and invitation of foreign researchers

The details are described in the separate-volume material 10 "Overseas business trip, etc." (only in Japanese).

10.7 Acceptance of foreign researchers through the programs of Fellowships for Foreign Researchers of the Japan Society for the Promotion of Science

The details are described in the separate-volume material 10 "Overseas business trip, etc." (only in Japanese).

Chapter 2.

FY2004 Activities Results

I. Measures to be taken to achieve the objectives for improving the quality of services and other operations provided to the public.

1. Fundamental research and development concerning ocean science and technology

1.1 Promotion of key research activities

1.1.1 Global environmental observation research

① Institute of Observational Research for Global Change (IORGC)

(1) Climate Variations Observational Research Program

1) Tropical Ocean Climate Group

a. Intraseasonal variations observed by a subsurface ADCP mooring at the equator in the eastern Indian Ocean

We have obtained for 4-year long data (November 2000 - July 2004) of the upper ocean current profile from a subsurface ADCP mooring deployed at the equator, 90E. Fig.1 obtained from wavelet analysis applied to the zonal and meridional current of first 3-year data indicated that the intraseasonal fluctuations at a few 10 days periods are dominated (Fig. 1). In the previous studies, it is believed that the surface current fluctuation of annual signal is related to annual signal of monsoon, and semiannual signal related to the Wyrtki jets. However, this result demonstrates that the intraseasonal variation is a significantly important physical process, at least, in the eastern Indian Ocean. We note that the semiannual Wyrtki jets have never appeared without any time averaging procedure as monthly mean. It is also interesting that the dominated periods in the

intraseasonal time scale are changed seasonally and interannually. We emphasize that such long term continual ADCP mooring observation enabled us to reveal those oceanographic processes.

2) Argo Group

a. Deployment of Argo floats

We deployed 118 Argo floats in the North and South Pacific, the Indian, and the Southern Oceans in cooperation with associated organizations. Above all, deployment by students of Misaki Fishery High School was a great step in the Argo activity. Argo floats operating in the world amount to 1,808 in April 2005, among which 288 floats are Japanese making the second largest contribution next to the United States.

A special apparatus has been improved to launch floats from cruising vessels. Seventy among 118 floats were launched using this apparatus with a 100% success.



Fig. 2 Misaki Fishery High School students are ready to deploy Argo floats.

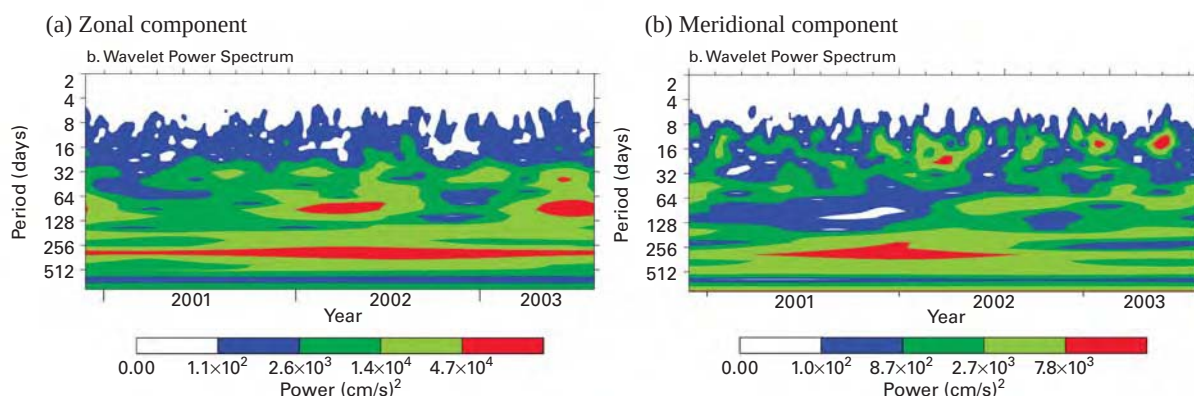


Fig. 1 Wavelet power spectrum of current at 40 m depth. (a) Zonal and (b) meridional component.



Fig. 3 Launching apparatus to deploy Argo floats from a cruising vessel.

The long-term reliability of salinity sensor of float was examined by recalibrating the sensors of 4 recovered floats with -0.004 psu/year.

b. Quality control of Argo data and Pacific Regional Center

We have just initiated the Pacific Regional Center monitoring the quality control level of all Argo floats deployed in the North Pacific and the South Pacific north of 30°S . We filed and released a high quality temperature and salinity dataset of the Indian Ocean to CSIRO (Australia) and INCOIS (India) which monitor the quality control level of floats deployed in the Indian ocean.

c. An analysis of Argo data

We have been analyzing Argo data in the sub-arctic area of the North Pacific focusing the temperature inversion in the subsurface layers. The sub-arctic Pacific is one of the least observed area especially in winter, and Argo floats have been rapidly filling the gap. We revealed that the extent of temperature inversion in the eastern sub-arctic varies year after year and has a relation with the surface temperature in winter.

(2) Hydrological Cycle Observational Research Program

This research program focuses on the hydrological cycle and processes of East Eurasia and western Pacific Ocean. These processes directly affect the climate in Japan, Asian monsoon region which has an adverse effect of global warming like abnormal precipitation,

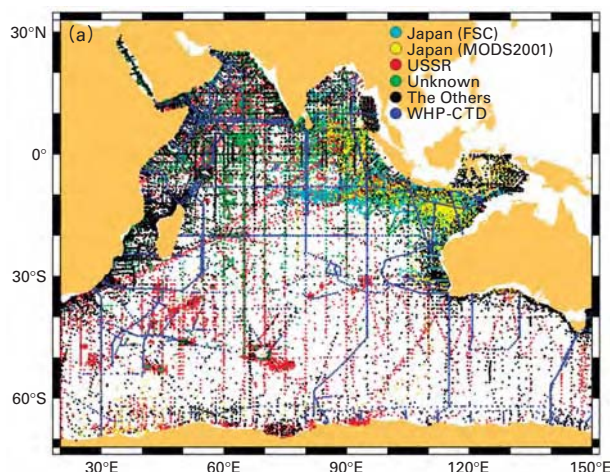


Fig. 4 Raw data distribution used the high quality temperature and salinity dataset in the Indian Ocean.

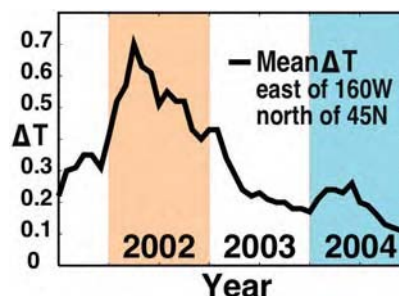


Fig. 5 Annual variation of temperature inversion in the eastern sub-arctic area of the North Pacific.

and Arctic regions through the changes of snow and ice, and vegetation. Objectives of our program are to clarify the phenomena of specific hydrological cycle affecting at global and continent levels and to understand the role of the climate formation and changes. Research on the hydrological cycle and processes are made through modeling, simulation and sensitivity experiments, in addition to the main observational network.

Our program consists of three groups, including Cold Region Hydrological Cycle, Cloud and Precipitation Processes, and Large-scale Hydrological Cycle. Places of in-situ measurements and major equipments are shown in Fig. 6.

Our program obtained data continuously and successfully in northern Eurasia, China, Tibet, and Asian monsoon region in FY 2004. These data include data from land surface meteorological and hydrological observation, radar and wind profilers. Our program newly established water sampling sites for isotope analysis from central to east Siberia this year, and initiated preliminary investigation of precipitation processes



Fig. 6 Places of in-situ measurements and major equipments.

in Philippines, and GPS observation points in Asian monsoon region including Myanmar. Additionally, we collaboratively held an international workshop, named "3rd International Workshop on Terrestrial Change in Mongolia", with other research programs and institutions in November 2004 and published the Proceedings.

Our research outcomes in FY 2004 are as follows.

1) Large-Scale Hydrological Cycle Group

a. Research on hydrological cycle in Indonesia region:

We clarified diurnal variations of convection and their intra-seasonal changes, the distribution of precipitation and the characteristics of the changes, and the relationship between seasonal and intra-seasonal changes of the low-level wind through the intensive observations of GPS rawinsonde for one month at an observational station in Jambi, Eastern Sumatra. This research also clarified the characteristics of the vertical wind of the precipitating clouds, important for the estimation of profiles of non-adiabatic heating (latent heat) (Fig. 7). Additionally, continuous data of precipitating



Fig. 8 Observational system in Kototabang, west Sumatra, Indonesia. Automatic climate observational equipment (back left), GPS antenna (front), rawinsonde receiver (back right).

clouds were obtained by rawinsonde and Doppler radar observation during the R/V Mirai Indian Ocean cruise.

b. GPS observation in the area of Sumatra and Kalimantan Islands:

We deepened our knowledge of the diurnal change and vapor transport relating to the increases in the amount of precipitable water vapor in clear day evening. We also made a progress in understanding the diurnal change over the Tibetan Plateau through the analysis of observational data in Naqu of the eastern plateau and precipitation processes through the re-analysis data (NCEP), which are related to the vapor transport during the summer monsoon season.

c. Research on large-scale hydrological cycle by using stable water isotopes:

The mass spectrometer was introduced in 2003 to

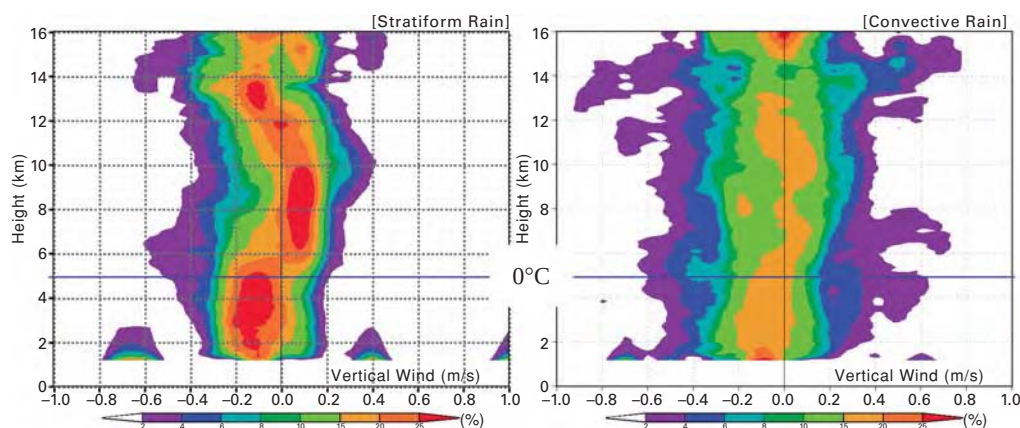


Fig. 7 Average profile of vertical wind of precipitating clouds (CFAD: Contoured Frequency by Altitude Display). left: distribution of stratiform precipitation, right: convective precipitation.

measure the ^2H and ^{18}O of water. Water sampling points were developed in Siberia and the samples were collected from summer 2004. The isotopic analysis in Tibetan Plateau suggests that the precipitation by a cyclonic disturbance is formed by the water vapor coming outside the Plateau. On the other hand, water vapor evaporated from land surface contributes to the precipitation by an anti-cyclonic disturbance.

The temporal and spatial distributions of water origins showed a clear transition from the Indian Ocean to the Pacific Ocean, occurred in early May and late September, as the Asian monsoon retreated from Indochina. This indicated that qualitative information of stable isotopes of water is important for a prospective research to understand the Asian monsoon.

2) Cold Region Hydrological Cycle Group

a. Research on the hydrological cycle in tundra:

We have analyzed interannual changes of evaporation through the long-term data in tundra region (Tiksi, Russia) since 1998. The analysis shows that evaporation is low when the precipitation is high at summer time. On the other hand, evaporation is high when the precipitation is low at summer time (Fig. 9). The relationship shows the feature of the interannual changes of the hydrological cycle in tundra and indicates an opposite trend from regions of lower latitude such as Yakutsk and northern Mongolia.

b. Research on water and heat change processes in taiga, Siberia:

We started series observation of sap flow (red pine) to assess the effect of vegetation in taiga (Yakutsk, Russia).

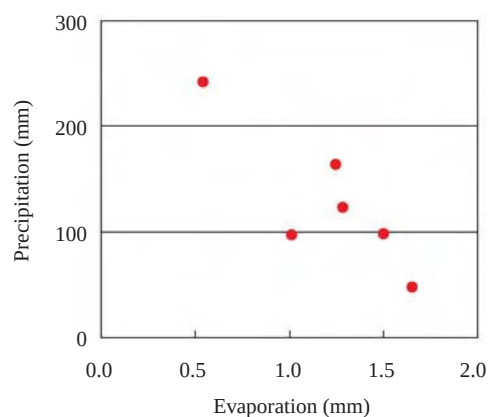


Fig. 9 Relationship between precipitation and evaporation in snow-free period from 1998 to 2003.

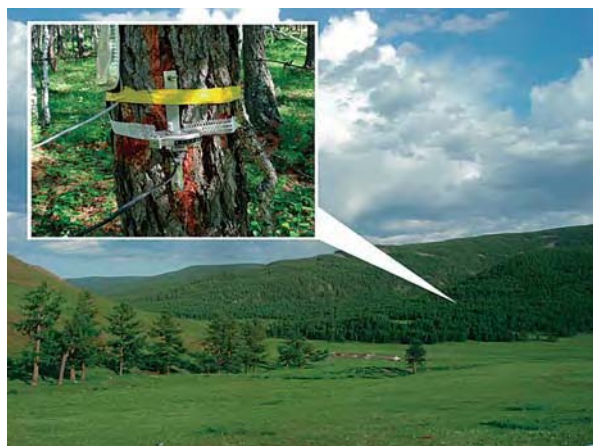


Fig.10 Forest in Mongolia and observation of sap flow by the Garnier Method.

The sap flow rate decreases clearly in relation to the degree of dryness compared to the previously known changes. According to the model calculation of land-surface processes, the change of evapotranspiration is smaller compared to the interannual change of precipitation in Yakutsk. When leaf blooming is early, total evapotranspiration during the warm period tends to increase.

In addition, seasonal changes of water and heat fluxes at sites in different climate were roughly reconstructed by modeling. The sensitivity study of the modeling parameters suggests that it is important to know the maximum conductance of each leaf and the parameter indicating the decrease in the conductance in relation to the dryness.

c. Research on the hydrological cycle in northern Mongolia:

This research indicates that melting of snow has a greater role in increasing the temperature of inner layer than the direct influence of the snow cover to the temperature of active layer for the processes of land surface in high-dryness region (Fig.11). There is no large difference in the amount of transpiration between low precipitation years and high precipitation because transpiration of vegetation is less likely to depend on soil moisture of land-surface. Therefore, the research shows that the percentage of transpiration in evapotranspiration is higher in low precipitation year.

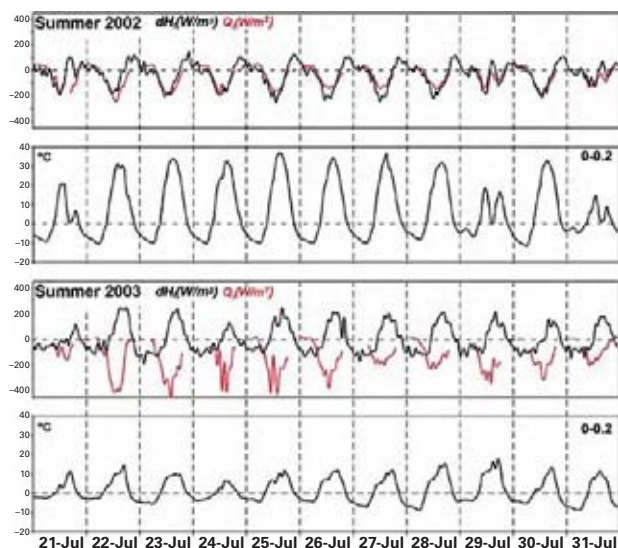


Fig.11 Comparison of heat flux (Q) and latent heat (dH) in deep layer (0-20 cm) in 2003 and 2004 with humid and dry summer, respectively. The figure shows that dH s are in opposite phases in these two years.

3) Cloud and Precipitation Processes Group

a. Observational research in the downstream region of the Yangtze River, China:

During the Meiyu/Baiu season of FY 2004, four major precipitation events have been observed. The events occurred on June 14-15, 18-19, 23-25, and July 5-7, respectively. Combined with the observations in previous years, observational data from this year would be useful to research the structures of precipitation systems and their annual variations.

b. Observational research in the Philippines:

In FY 2004, an Implementation Arrangement between our institute and the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) for a collaborative field experiment in the Philippines was achieved. According to the Arrangement, observations on



Fig.12 Automatic Weather Station installed in Daet, the Philippines.

monsoon precipitation systems in the Philippines began from this year.

c. Analyses of cloud and precipitation systems:

The development of cloud clusters during the Meiyu/Baiu seasons has been classified according to their relative positions to the Meiyu/Baiu front, using data from satellite and upper-air observations (Fig.13). Meanwhile, the research on the structure and evolution of a mesoscale convective system around a Meiyu/Baiu front was made, and it was found that the lifting of the conditionally unstable air by an intensified low-middle level northeasterly flow would have aided the rapid development of the convective system instead of the downdraft.

(3) Global Warming Observational Research Program

1) Arctic Ocean Climate System Group

a. Arctic Climate Oceanography Sub-Group

The variation of the sea ice extend has been explained by the well known atmospheric variation mode represented by Arctic oscillation (AO). During the positive

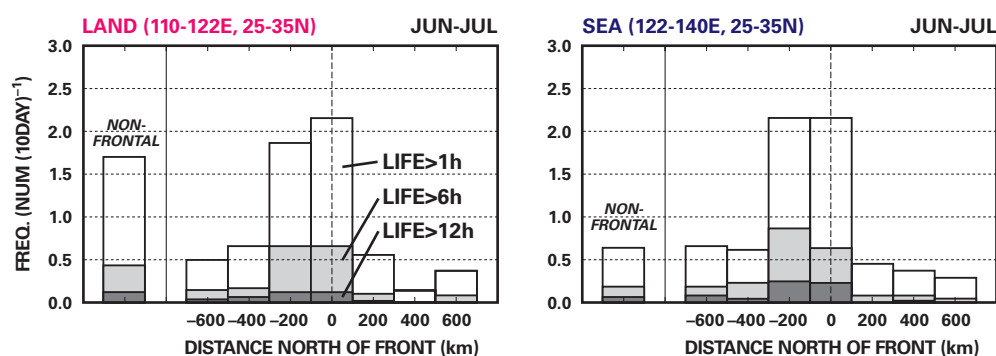


Fig.13 Histogram of occurring frequency of cloud clusters classified according to their relative positions to the Meiyu/Baiu front. The left is for continent clusters and right for oceanic clusters.

phase of AO, the sea ice extent should decrease. However, in late 1990s the index was in a phase of negative or neutral.

This discrepancy suggests that another mechanism acts the recent reduction of sea ice. Recent large reduction of the sea ice cover in the Arctic Ocean is not spatially uniform, but is outstanding in the Canada Basin. This regionality implies that the Pacific inflow is a key player acting the anomalous Arctic climate change. The spatial pattern of the recent sea ice reduction shows a quite similar pattern to the distribution of warm Pacific Summer Water (PSW). Not only the spatial distribution, but also was the time series of sea ice concentration well correlated with that of PSW temperature in the western Canada Basin.

However, the temperature of PSW in the Canada Basin was not always correlated with the upstream temperature in the northeastern Bering Sea. This suggests that temperature of Pacific Summer Water at the Bering Strait is not a primary significant parameter. The coherent changes in both the sea ice reduction and the warming of PSW could be caused by a strengthening of upper ocean circulation, which carries the oceanic heat transport within PSW layer into the basin.

Simultaneously with the warming of PSW, Pacific Winter Water (PWW) just beneath the PSW in the basin was getting cold after 1998. After 1998, winter-time easterly wind was strong associated with the negative or neutral phase of Arctic oscillation. The strong easterly enhanced the formation of coastal polynya along the Alaskan coast in the eastern Chukchi Sea. Substantial negative heat flux in the localized polynya

caused an effective formation of cold and saline water. Thus the warming of PSW and cooling of PWW are not an independent variation but a coherent variation.

b. Studies on Coupling system of Ocean-Sea ice-Atmosphere

To understand ongoing changes in the Arctic Ocean, we have been conducting automated ice-drifting buoy observation as part of US-Japan joint project NPEO (North Pole Environmental Observatory) every year since 2000. In 2004, we deployed J-CAD No.8 at 86.4 N 165.5 E on April 25. J-CAD 8 drifted 1100 km from the Makarov Basin across the Lomonosov Ridge to the Amundsen Basin and collected unique oceanographic and meteorological data in the Arctic multiyear ice area (Fig.15).

Fig.16 shows potential temperature and potential density sections observed by J-CAD 8 through its drift. The temperature at 200 m, above the core depth of the Atlantic water, is greater in the Makarov Basin than in the Amundsen Basin. This is surprising; all else being constant we would expect the temperature to be cooler in the Makarov Basin than in the Amundsen Basin because the path of the Atlantic Water to the Makarov Basin is longer than that to the Amundsen Basin. From the analysis of recent historical data including NPEO data indicates that the arrival of high temperature anomaly in the Makarov Basin is delayed about seven years after arrival on the Amundsen Basin side. Our analytical results support the idea that the Atlantic water circulates cyclonically around the periphery of the Makarov Basin at an average speed of 1-2 cm s⁻¹.

JWACS 2002 - 2004 stations in the Western Arctic

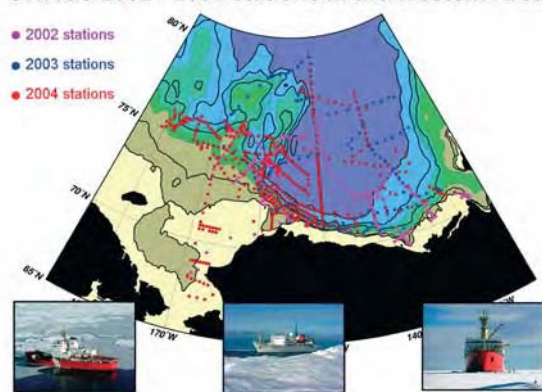


Fig.14 Observation points during Arctic Ocean observation (Pacific side), 2002-2004.



Fig.15 Map of J-CAD 8 trajectory.

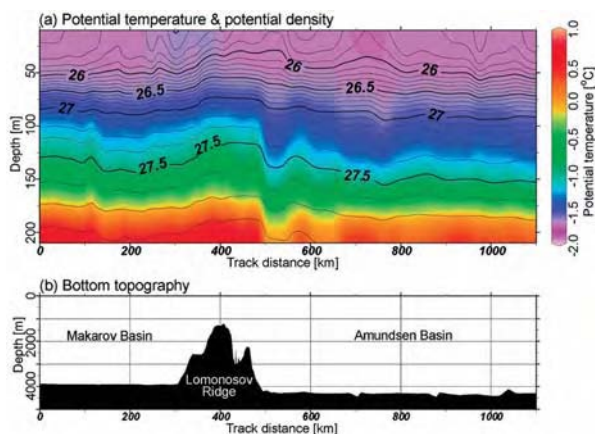


Fig.16 (a) Potential temperature and density sections observed by J-CAD 8, (b) Bottom topography under J-CAD 8 trajectory.

2) Paleoclimatology and Paleoceanography Group

Environmental variations of Okhotsk sea plays the dual role of being affected by the global climate variation and a driving force of climate changes of East Asia, including Japan. In this study, we aim to reconstruct the variations of surface temperature (SST) and salinity (SSS) in the southwestern Okhotsk sea of the past 120 thousand years in order to understand the roles of the Okhotsk sea on the climate change of the northern hemisphere.

A marine sediment core was collected at the southwestern Okhotsk sea during the international research program IMAGES, which is part of Scientific Committee on Ocean Research (SCOR). (Fig.17 MD 01-2412, 44°32'N, 145°E; at 1,225m depth). Alkenone, which is a biomarker, was used as a proxy for SST and SSS.

Fig.18 represents the alkenone-derived temperature and salinity variations, precipitation variations at 10-20m water depth. The air temperature variation recorded in the Greenland ice core and the precipitation variation recorded in the stalactites in China were also referred. The graph suggests that alkenone-derived temperature increased with the warm periods that are evident in the GISP 2 (marked with numbers), and this variation repeated in approximately a decadal cycle. This is to be remarked as the first finding of studying in the SST in high time resolution of 20-40 year-scale at the high latitude areas of the Northern Pacific Ocean. The alkenone-derived temperature suggests that glacial period, particularly 18-55kyrBP, was not entirely cold, but some warm periods had existed. On the other hand, the alkenone-derived salinity was low during the warm

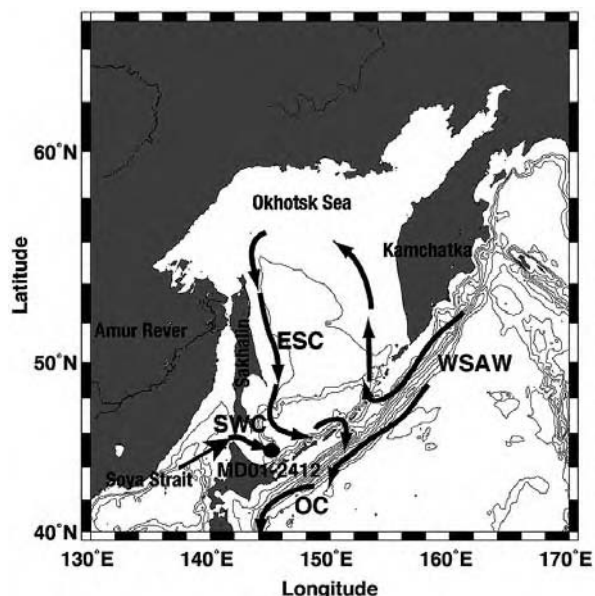


Fig.17 Location map of marine sediment core in southwestern Okhotsk sea (marked with dark dot) Arrows represent the direction of currents: WSAW (Western Subarctic Water), ESC (East Sakhalin Current), SWC (Soya Warm Current), OC (Oyashio Current)

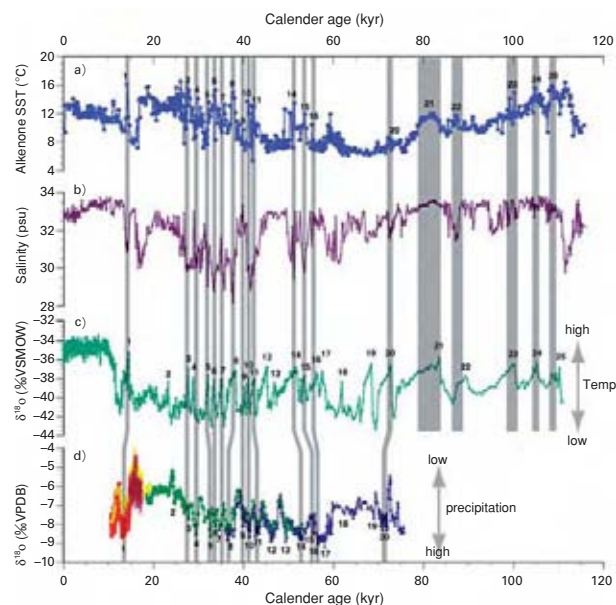


Fig.18 a) Alkenone-derived temperature of Southwestern Okhotsk sea of 120K years. b) Variation of alkenone-derived salinity estimated from C37:4. c) Variation of oxygen isotope ratio of Greenland ice core GISP2. d) Variation of oxygen isotope ratio of stalactites in Hulu Cave, China.

periods of 18-55kyrBP. The reasons for this low salinity event might be explained by the small or less contribution of salty Soya Warm Current (SWC), increased precipitation due to active summer Asian Monsoon, and melting of sea ice. Moreover, extremely low salinity (lower than 30 psu), which can never be seen today, took place during the study period. Since the only difference in the condition between the study period and

modern condition is the existence of SWC, SWC is believed to have caused the low salinity of the surface layer of the southwestern Okhotsk Sea.

(4) Ocean General Circulation Observational Research Program

1) General Circulation Dynamics Group

a. Trans-ocean Hydrography

We published a data book "WHP P6, A10, I3/I4 Revisit Data Book" as a product of quality controls on the data that were obtained during a revisit of WHP Line P6, A10 and I3/I4, namely "Blue Earth Global Expedition (BEAGLE) 2003", implemented during the period from August 2003 to January 2004. The followings are results of our comparative analyses on water temperature, salinity and dissolved oxygen with those obtained during WOCE in the 1990s. On the whole, water temperatures (θ) rose by $+0.017^{\circ}\text{C}$ on average in the layer below 1000 m depth, where long-term variability is dominant (Fig.19). Bottom and/or deep temperatures also became higher by 0.01°C or more in the basins through which the major part of the Antarctic Bottom Water (AABW) or Circumpolar Deep Water (CDW) flows to each ocean. A modification of CDW, namely, a shift in its $\theta - S$ relationship, was detected in the

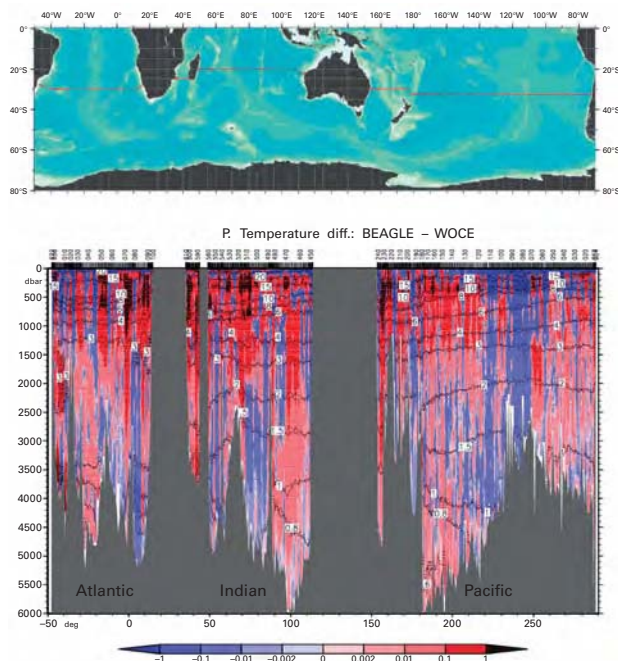


Fig.19 Observation line for BEAGLE2003 (top) and difference in water temperature between BEAGLE 2003 and WOCE (bottom). Warm color blocks show the areas where water temperature observed during BEAGLE2003 was higher than that during WOCE.

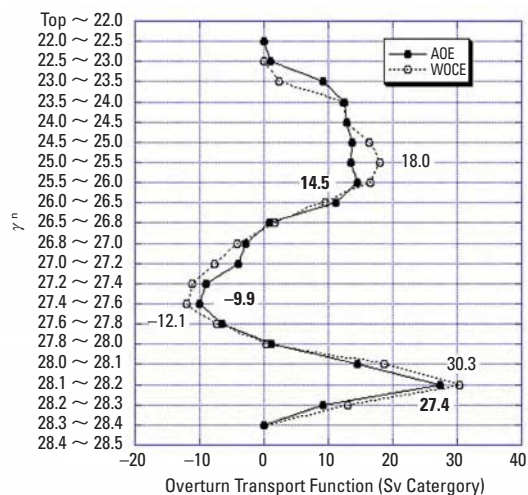


Fig.20 Transport function for the global overturn during BEAGLE2003 (solid line) and WOCE (dotted line). The vertical axis indicates neutral density, and the horizontal axis indicates mass transport. Figures attached to the lines show overturn transports for deep, intermediate and shallow layers from the bottom.

Southwest Pacific Basin. Mass and heat transports across the circum southern hemispheric section were estimated by an inverse model with constraints of mass and salt conservations, bottom topographies and so on. As the result, 10 percent decrease in large-scale meridional overturn and 20 percent decrease in intermediate layer overturn were evaluated for the whole section (Fig.20).

b. Observation in the Wake Deep Channel

The Wake Deep Channel (15°N , 170°E) is located in the main path of CDW entering the North Pacific. We have deployed a mooring array across this channel since May 2003 and replaced it in October 2004 to

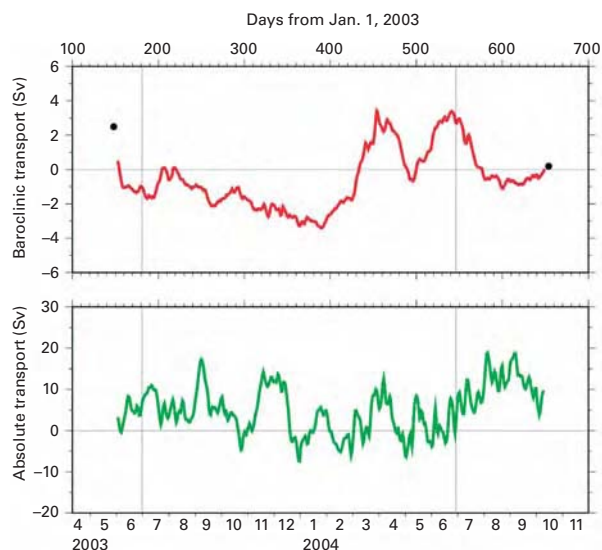


Fig.21 Time series of baroclinic (top) and absolute (bottom) transports of CDW passing through the Wake Deep Channel

obtain the data of current velocity, temperature and salinity for one and a half years. With these data, we calculated geostrophic transports of CDW passing through the channel (Fig.21). The mean value of absolute transports (baroclinic transports) for a year from July 2003 to June 2004 was 3.6Sv (−0.7Sv), and its standard variation was 5.2Sv (1.9Sv).

2) Chemical Tracers Study Group

a. Compilation of dissolved chemicals data with high accuracy

We conducted quality-control of data obtained during "BEAGLE2003" and compiled a data book "WHP P6, A10, I3/I4 Revisit Data Book".

b. Temporal variation of CFCs concentrations in the South Atlantic and the Indian Oceans

High concentration of CFC-11 was detected in the deep water flowing below the slope of the Kerguelen Plateau. It implies that the bottom water sinking from the surface of the Southern Ocean gives significant impact on the CFC-11 concentration. The CFC-11 concentration in the bottom water has nearly doubled, compared to the value obtained on neighboring WOCE-I8 line nine years ago. We invented a new calculation method for evaluating age of water mass by comparing the increase of CFC-11 concentration in the ocean for nine years with increasing rate of CFC-11 in the atmosphere. The age of the bottom water was evaluated as 10 to 20 years old by this new method.

Significant increases in CFCs concentrations were observed in the bottom water at several basins where Antarctic Bottom Water (AABW) formed in the Weddell Sea presumably flows (Fig.22b). On the isopycnal surface of $\sigma_4 = 45.87$, a characteristic of AABW, the increase is consistent with the distribution of CFC-11. The fact means that CFCs detected at the bottom layer are transported to the basins by the bottom water formed in the Southern Ocean. In the Cape Basin, CFCs were not detected by WOCE a decade ago (Fig.22a), therefore, it is presumed that bottom water formed after the 1950s when CFCs began to be detected in the atmosphere, has reached the basin. In the Indian Ocean, CFC-11 was detected in bottom layer between Central Indian Ridge and Madagascar. The

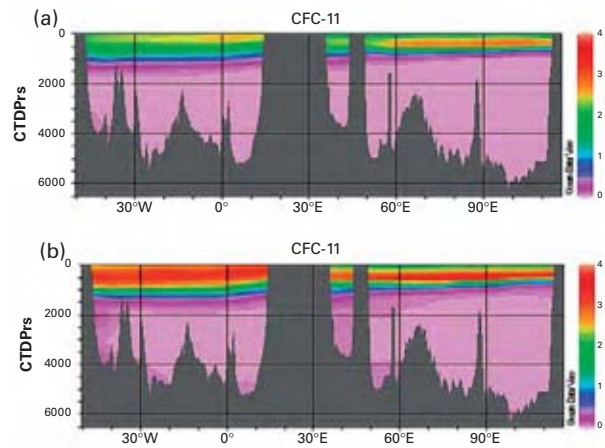


Fig.22 Distribution profiles of dissolved CFCs-11 in the Atlantic (around 30°S) and the Indian Ocean (around 30°S) during (a) WOCE and (b) BEAGLE periods.

fact implies that AABW is transported from the west to the north in the Indian Ocean.

c. Detection of decadal-scale increase of anthropogenic CO_2

To evaluate increase of anthropogenic CO_2 in the ocean, we revised data on total carbonates (C_T) obtained during BEAGLE2003 using apparent oxygen utilization (AOU); we subtracted increases of C_T by remineralization from original values, and standardized the data by a salinity of 35 ($nC_T^{\text{CAL}}(\text{B})$). The data for WOCE in the 1990s were also calculated by the same measure ($nC_T^{\text{CAL}}(\text{W})$). Most of the differences between the two data ($=nC_T^{\text{CAL}}(\text{B}) - nC_T^{\text{CAL}}(\text{W})$) is presumed to be a result of increase of CO_2 in the atmosphere.

The nC_T^{CAL} for Sub-Antarctic Mode Water (SAMW; $26.6 - 26.9\sigma_\theta$; 350 – 700 dbar) that originates in high latitude regions of the South Pacific Ocean increased to $10.3 \pm 3.1 \mu\text{mol kg}^{-1}$ in the Pacific Ocean. Moreover, the nC_T^{CAL} showed further increase in the eastern Pacific Ocean (over $10 \mu\text{mol kg}^{-1}$). The increase in the eastern Pacific Ocean far exceeds the value based on the assumption of CO_2 equilibrium between the atmosphere and the ocean, and it could be presumed to reflect possible oceanic change in the formation area of SAMW.

There was increase of CO_2 up to $4.1 \pm 2.0 \mu\text{mol kg}^{-1}$ in Antarctic Intermediate Water (AAIW; $27.0 - 27.5\sigma_\theta$; 700 – 1450 dbar) that originates in the regions with higher latitude than the origin of SAMW. Averaged increase was approximately $10 \mu\text{mol kg}^{-1}$, although increasing trend of CO_2 in SAMW varied in ocean and

longitude. On the other hand, increasing trend of CO_2 in AAIW showed few differences in each ocean or among the oceans. These facts imply that anthropogenic CO_2 absorbed around the Southern Ocean is transported to the global oceans by SAMW and AAIW.

d. Temporal Variation in Carbon Isotope

As a result of data analyses using the data for WOCE obtained in the 1990s and BEAGLE2003, it was verified that temporal variation of the concentration of ^{13}C in the mid latitude regions of the South Pacific Ocean (approx. lat 30°S) was remarkably smaller than that in the mid-high latitude regions of the North Pacific Ocean. The fact implies that there are more effects of natural causes on the variation in concentration of ^{13}C in the North Pacific Ocean than in the South Pacific Ocean. Likewise, the existence of a two-decade variation in properties such as oxygen, nutrients, carbon and ^{13}C dissolved in intermediate layer of the mid-high latitude regions of the North Pacific Ocean was presumed.

3) Kuroshio Transport and Surface Flux group

The Kuroshio Extension region is one of the major areas where heat flux from the ocean to the atmosphere is very large. As the western boundary current of the North Pacific Subtropical Gyre, the Kuroshio has been thought to affect largely the global climate change through its large heat transport to the Kuroshio Extension region. However, the close relation between

the interannual variations of net heat transport of the Kuroshio in the Shikoku Basin and the surface heat flux in the Kuroshio Extension region has not been confirmed yet. Therefore, in July - October 2004, we have began the mooring observations of net heat transport of the Kuroshio in the Shikoku Basin using 11 PIESs (Pressure gauge equipped Inverted Echo Sounder) and 9 current meters in the ASUKA-line (ASUKA: Affiliated Survey of the Kuroshio off Cape Ashizuri) north of 30°N and the S-line along 30°N between 134.6°E on the ASUKA-line and 143.0°E east of Izu-Ogasawara Ridge. In order to correct, validate, and interpolate the data obtained by these mooring observations, we have conducted also the hydrographic observations and current measurements along the ASUKA-line north of 30°N , S-line, and E-line between the Cape Nojima and the easternmost edge of S-line. The E-line is coincident with the ground track of altimeter-mounted satellite.

From the hydrographic data obtained on Oct. 11 - 29 along the ASUKA-, S-, and E-lines, we estimated vertical sections of geostrophic current referred to current velocity at 700 m layer observed by ship-mounted ADCP. Total volume transport across the top 1000 m layer of the three observational lines was calculated to be excess inflow of 7.9 Sv ($1 \text{ Sv} = 10^6 \text{ m}^3 \text{ s}^{-1}$). After eliminating this excess inflow by adding the uniform out flowing current velocity of 0.007 m s^{-1} to pre-corrected geostrophic current velocity, we calculated the volume, salinity, and temperature transports at each line. The cal-

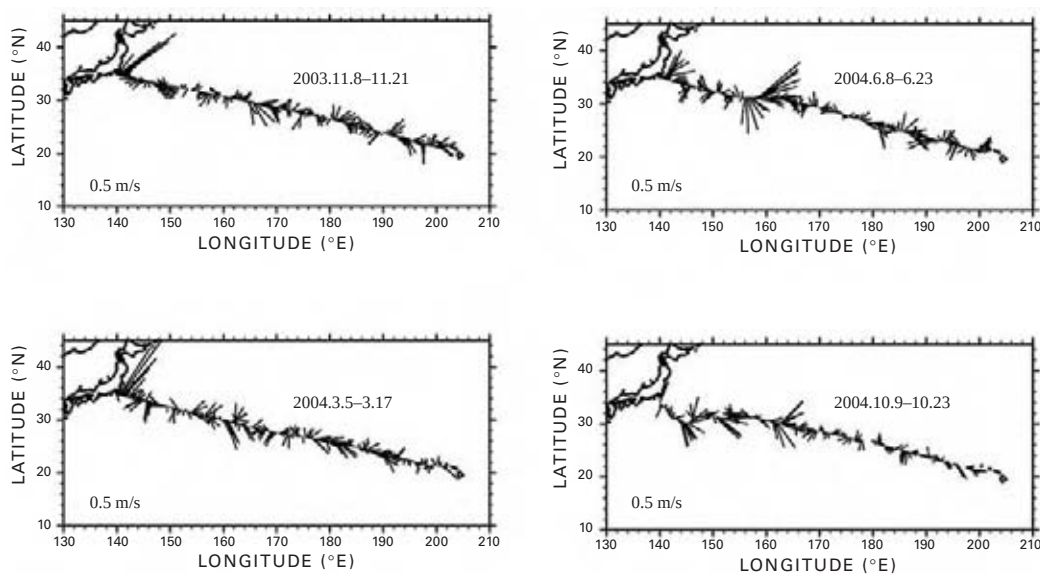


Fig.23 Current vectors vertically averaged in the top 200 m layer along the ship's return trip from Honolulu to Misaki.

culated volume and temperature transports at ASUKA-line north of 30°N were confirmed to be in the same order of magnitude as reported in the previous observations. The net volume transport and net temperature transport of the Kuroshio south of Japan were calculated respectively by summing the transports across the ASUKA and S-lines to be 40.9 Sv and 2.34 pW, and net-volume-transport-averaged mean temperature to be 14.33°C. Using the data obtained by mooring observation which will be retrieved in September 2005, these values will be estimated more precisely with taking into account the temporal variations during Oct. 11 - 29 caused by typhoons.

By VOS observations between Japan and Hawaii started in JFY 2003, we have examined the surface current structure in the Kuroshio and the Kuroshio Extension regions and oceanic eddies in the Subtropical Gyre region. Fig.23 shows the distributions of current vectors vertically averaged in the top 200 m layer along the ship's return trip from Honolulu to Misaki derived from ship-mounted ADCP data. The dominant eddies in the Subtropical Gyre region shown in this figure were confirmed to be correlated well with the temperature sections derived from XBT data obtained during the same cruise.

(5) Ocean, Land and Atmosphere Interactions Integrated Research Project

1) Tropical Ocean Convective Activities Group

Around the western tropical Pacific region, we have been continuously operating a surface weather observation site at Peleliu, a small island in Palau, since November 2000. We are also carrying out Wind profiler, ceilometer, microwave radiometer, and AWS observations at Aimeliik, on the mainland of Palau from March 2004. In the fiscal year 2004, we developed rain gauge network around South-West Islands of Palau, and installed new disdro-meter to obtain rain-drop size distribution continuously. These instruments will provide us valuable data to analyze precipitation generation mechanism coupling with monsoon activity in detail.

In November 2004, we installed a Doppler radar system of JAMSTEC at the Aimeliik station (Fig.24). Also, in cooperation with Nagoya University, the Doppler radar of Nagoya University was deployed in



Fig.24 The Doppler radar system of JAMSTEC at Aimeliik site, the Republic of Palau.

Peleliu Island. The JAMSTEC Doppler radar system covers 300km range, and the Nagoya radar covers 64 km in radius. In addition, C-band Doppler radar on R/V Mirai was also utilized to conduct dual-Doppler analysis during Intensive Observation Period (IOP).

The IOP was set during easterly monsoon season from December 2004 to January 2005, corresponding to the cruise of R/V Mirai "MR04-08". During the IOP, we obtained three dimensional datasets of several radar parameters. The time interval is 7.5 minutes, and the space resolution is 1 km in horizontal and 0.5 km in vertical. Fig.25 is an example of the calculated results from the datasets. The wide range observation using the radar on R/V Mirai frequently shows that cloud clusters passing over Palau affected by terrain of the Palau islands.

From our long-term observation around Palau region, we found the seasonal change of Z-R relation corresponding to the monsoon wind direction. We can also identify the seasonal change of DSD (rain drop size distribution), and the result means precipitation processed around Palau region affected not only MJO (intra-sea-

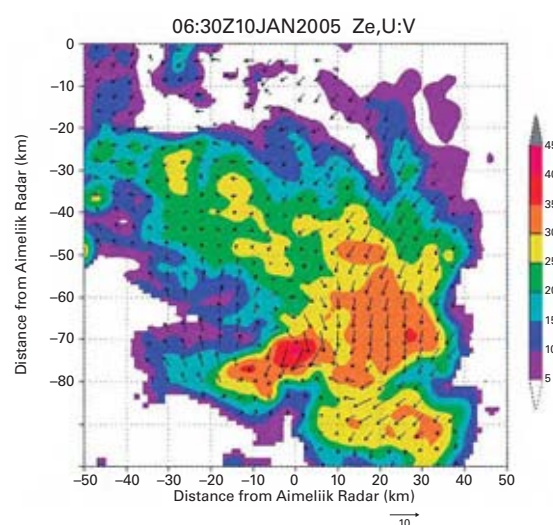


Fig.25 Horizontal distribution of radar reflectivity and wind field calculated from dual-Doppler analysis using two radars on R/V Mirai and Aimeliik.

sonal oscillation) but also monsoon (seasonal) variations.

Diurnal variation of convection originated over New Guinea Island in maritime continent was propagated northward further up to 6°N where Palau Islands were located, when southerly wind was intensified due to the passage of equatorial wave. This result was found from the stationary observation by R/V Mirai.

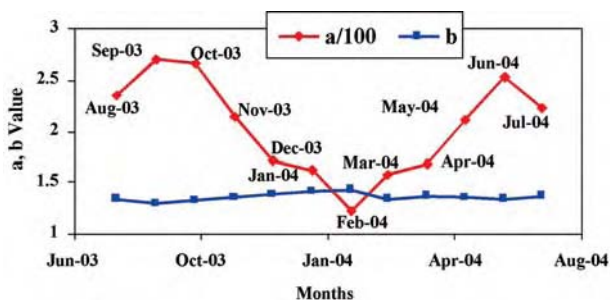


Fig.26 Seasonal change of two parameters (a and b) derived from Z-R relation ($Z = a \times R^b$), where Z is radar reflectivity and R is rainfall intensity, using disdrometer data at Aimeliik.

② JAMSTEC Mutsu Institute for Oceanography

(1) Time series observation research of biogeochemical cycles

The climate change, notably the global warming, is a critical issue for all human beings. It is necessary to study the biogeochemical cycles in the ocean and atmosphere for understanding climate change. Especially it is important to study the exchange of carbon dioxide through air-sea interface, the biological activity and those variations in the northwestern North Pacific.

In this study, we have been conducting observations in the Western Subarctic Gyre, which shows particular characteristics of northwestern region of Northern Pacific as known High Nutrient Low Chlorophyll Ocean. Through these observations, we aim to quantify the seasonal variation of dissolved chemical matters and these

trends, and to estimate the particulate flux in this area. In the FY 2004, three research cruises were conducted in order to obtain the variations of carbon species and other chemicals. In addition, a biogeochemical mooring, which was built up with the sediment traps, automatic water sampler, plankton collector and other instruments, were deployed at the JAMSTEC time-series station, K2 (47°N, 160°E). Following are the summary of results obtained.

Improvement of time series observation mooring

A few improvements were made on the time series observation mooring in order to avoid the loss of data including; change of mooring chains, addition of swivels, prevention of tangle-resistance, and installation of a long life Argos position transmission. A device to measure the in-situ cable tension was also added in the mooring system. This tension was measured during R/V Mirai cruise in 2004 (MR05-01 cruise) for short-term moorings with this device, and no excessive tension giving damage to mooring system was measured.

Observation near Kuril Islands, Kamchatka Strait, and western Bering Sea

During Mirai's cruise, MR04-04, we have conducted observations in the northern North Pacific and its marginal sea including the Russian Exclusive Economic Zone

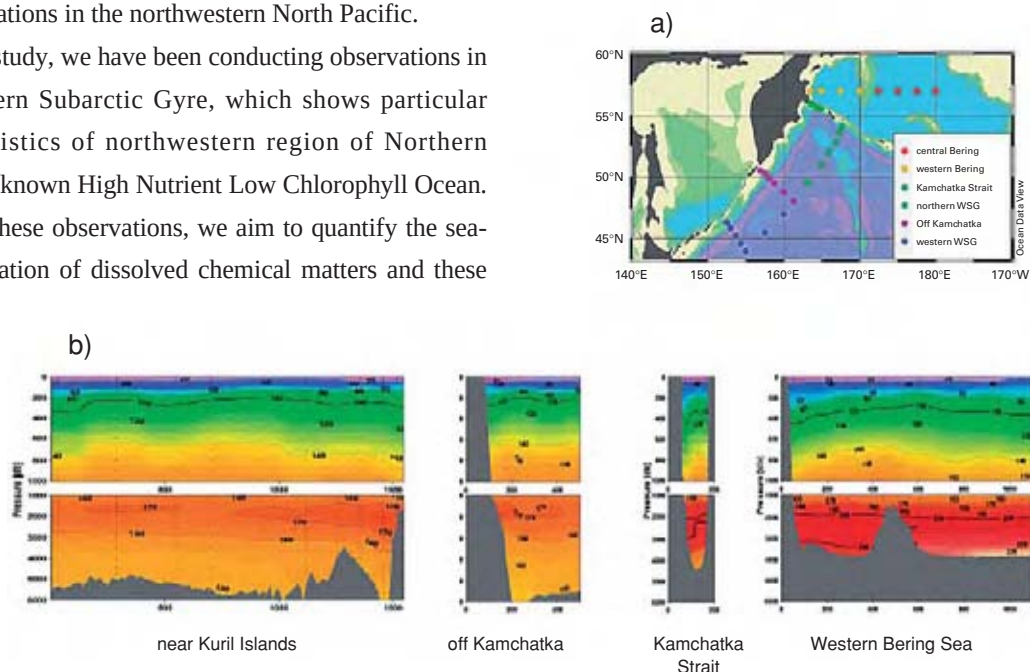


Fig. 1 Distribution of silicate concentration near Kuril Islands, Kamchatka Strait, and the western Bering Sea during MR04-04 cruise.
a) CTD-RMS stations, b) silicate distribution at each section.

(EEZ), in cooperation with V.I. Il'ichev Pacific Oceanological Institute. We were able to obtain distributions of chemical properties which are important to understand the chemical cycle on northwestern region of Northern Pacific and yet have not fully been investigated.

Fig. 1 shows the dissolved silicate distribution of observed areas. Silicate concentration is increasing from Northern Pacific towards Bering basin through Kamchatka Strait. This indicates that the bottom water in Bering Sea inflow from northern North Pacific. On the other hand, the surface water off Kuril Islands flew out toward south by Kamchatka peninsula.

Observation along 155°E

During the MR04-04 and MR04-07 cruises, we have conducted the investigation along 155°E from 44°N to

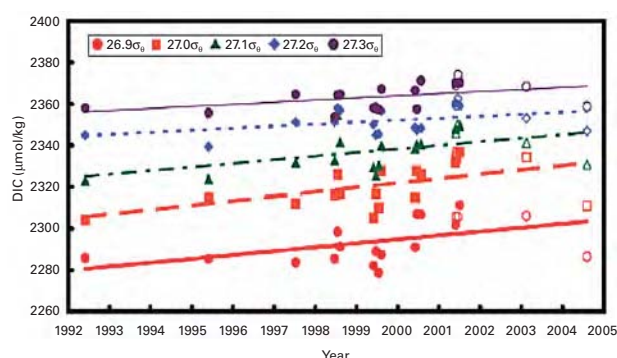


Fig. 2 Change of dissolved inorganic carbon concentration at the isopycnal surfaces of 26.9, 27.0, 27.1, 27.2, and 27.3 of Station KNOT (44°N, 155°E).

Red, orange, green, blue, purple closed circles are the concentrations at the isopycnal surfaces of $\sigma_\theta = 6.9, 27.0, 27.1, 27.2, 27.3$, respectively, which were referred to Wakita et al. (2005). These open circles represent data obtained by R/V Mirai cruise.

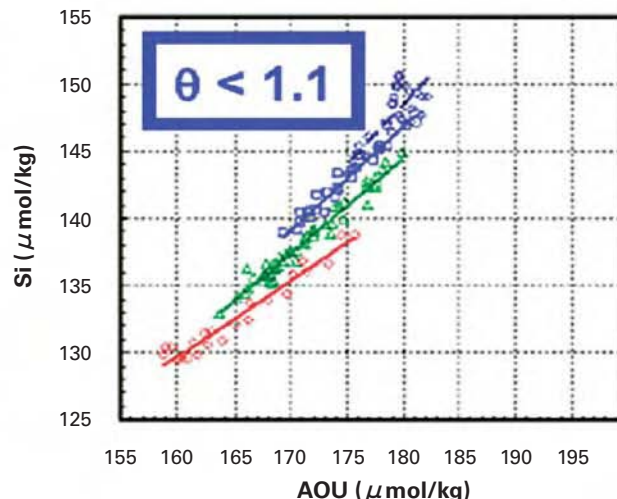
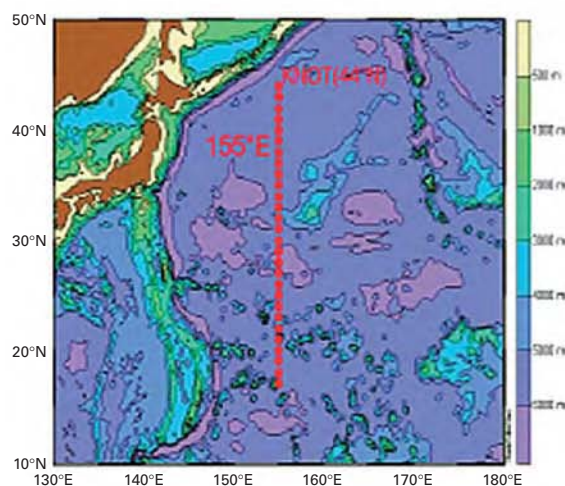


Fig. 3 The relation between silicate concentration and AOU in the bottom water below 1.1 degrees during R/V Mirai MR04-04 cruise.

the equatorial area. The obtained data are compiled for understanding the year-by-year variations of chemical with properties. The recently observed data were combined the published data at Japanese time-series station KNOT (44°N, 155°E). It is suggested that the trend of dissolved inorganic carbon includes possibility of decadal change, which was reported to increase lineally (Fig. 2).

The inflow direction of bottom water in the western North Pacific was estimated using the precise concentrations of dissolved oxygen and silicate between 44°N to 17°N, which was obtained during the MR03-K01 cruise. The relation between silicate and AOU (apparent oxygen utility, difference in saturated and measured oxygen concentrations) differed among the each basin (Fig. 3). Both concentrations are affected by the amount of organic matters and silicate transported from the surface layer to the bottom layer. Diatoms, which make silicate shell, are not the dominant alga species in southern areas from 35°N. The observed difference in the ratio between 17-21°N and 22-31°N indicates that the bottom water at 22-31°N is affected by the water of northern areas of 35°N.

Organic carbon flux and primary productivity

Primary productivity and organic carbons flux estimated from the trap moored in the station K-3 (39°N, 160°E) was compared. This observation was conducted from November 2002 to October 2003. Primary productivity was estimated by the combining of the observed optical data and the past observation data. Fig. 4 shows

the seasonal variation of measured organic carbon flux (left axis) and estimated primary productivity (right axis). The seasonal variation of organic carbon flux in the bottom layer suggests the possible relation with biological productivity in the surface layer.

Evaluation of Particle Organic Carbon by ^{234}Th

In estimating the amount of Particle Organic Carbon (POC) that falls from the euphotic layer, ^{234}Th deficiency in the surface ocean was measured at the

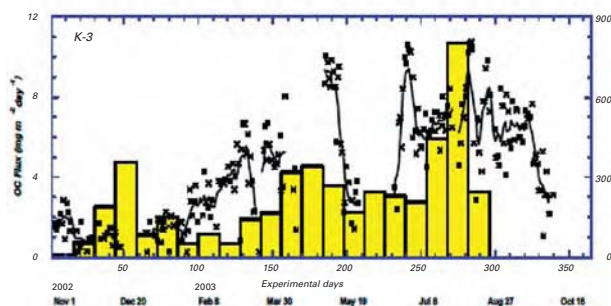


Fig. 4 Organic carbon flux at 5,000 m depth and seasonal variation of primary productivity.

Bars: organic carbon flux, X: primary production estimated by under water optical measurement.

stations, K1 (51°N, 165°E), K2 (47°N, 160°E), K3 (39°N, 160°E), and KNOT (44°N, 155°E). The ratio between ^{243}Th activity and organic carbon content in the particle, which was collected by a large amount filtering system, was also measured. The seasonal variation of organic carbon flux estimated from the deficiency of ^{234}Th is shown in Fig. 5. This variation is similar to that of carbon fixation, which is estimated from the change of carbon dioxide.

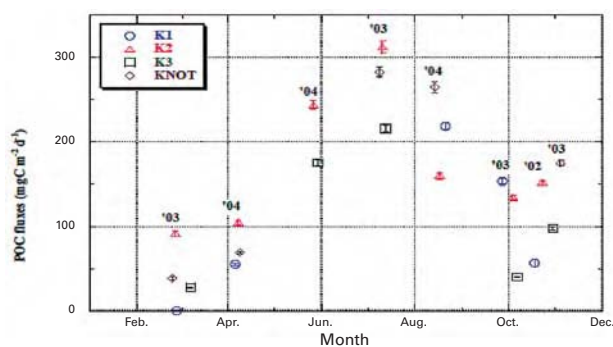


Fig. 5 Seasonal variation of particulate organic carbon export flux estimated from ^{234}Th deficiency.

1.1.2 Global environmental prediction research

① Overall Events and Activities (Frontier Research Center for Global Change)

It had been seven years since our organization, Frontier Research System for Global Change (FRSGC), started its research activities on elucidation and prediction of various global change mechanisms since October 1997. This FY2004, the eighth year from the establishment, with the transformation of the former Japan Marine Science and Technology Center (JAMSTEC) into an independent administrative institution, the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), and FRSGC made a new start as the Frontier Research Center for Global Change (FRCGC). At the same time, research activities based on a new five-year mid-term research plan began in this year.

The small organizational changes have also been made at the level of research groups in FRCGC. Kyousei Theme 1 group in the Integrated Modeling Research Program moved into the Global Warming Research Program to strengthen the Global warming research group. The Coupled model development group was established newly in the Global Warming Research Program as the core group of FRCGC's coupled model development. The Carbon cycle research group in the same program moved into the Ecosystem Change Research Program to enable carbon cycle modeling for both oceanic and terrestrial domains within one program. The Integrated Modeling Research Program was renamed as the Global Environment Modeling Research Program to better characterize the program.

In this way, FY2004 was an epoch of great change for our organizations. However, we could obtain as many research accomplishments from various areas as that of usual years. Followings are the summary of our activities and accomplishments in FY2004.

(1) The appointment of Dr. Eitaro Wada as Director of the Ecosystem Change Research Program

Dr. Eitaro Wada was appointed as Director of the Ecosystem Change Research Program in August 2004, as a full-time Program Director after Dr. Yoshifumi Yasuoka who had served the same position from October 1999 until the end of FY2003. Dr. Wada had served various posts in different sectors including as a

visiting researcher at Ocean Research Institute, University of Texas, Department Director of Mitsubishi Kagaku Institute of Life Science, and Director-General of Center for Ecological Research, Kyoto University. His latest position before joining FRCGC was a professor of Research Institute for Humanity and Nature, part of National Institute for Humanities (Inter-University Research Institute Corporation). Dr. Wada is expert in biogeochemistry and isotope ecology. Keeping his expertise, by utilizing his broad experiences and knowledge, he has conducted his research on various ecological fields in both marine and terrestrial environments.

(2) Global Warming Scenario Experiments contributed to the IPCC AR4

FRCGC performed global warming scenario experiments for the 4th assessment report of the Intergovernmental Panel on Climate Change (IPCC AR4) in time for the deadline of submitting scenario projection data, the end of August 2004, with the use of a coupled model of the existing highest spatial resolution in the world. The press release of the quick analyses of this experiment, showing that the number of hot summer days after 70 years might double the current number in Japan, was very timely after the experience of very hot summer 2004 in Japan. This news was ranked as the 5th most impressive news of 2004 after the Nikkei BP survey.

(3) Events

- 2004.7.17: "Geo-Cosmos", National Museum of Emerging Science and Innovation, Tokyo
"Global Chemical Weather Forecast System has become one of the Geo-Cosmos Exhibitions at National Museum of Emerging Science and Innovation"
- 2004.7.20-23 : Miyoshi Memorial Auditorium, Yokohama Institute for Earth Sciences
"The 2004 International Workshop on the Solution of Partial Differential Equations"
- 2004.8.4 : United Nations University, Tokyo
"FRCGC/IORGC Symposium 2004, Changing Atmosphere and Global Warming –Our Environment after Kyoto Protocol"

- 2004.10.28-29 : Miyoshi Memorial Auditorium,
Yokohama Institute for Earth Sciences
"Workshop on Climate Change Research"
- 2004.11.29-12.3 : Honolulu, Hawaii, USA
"Indian Ocean Modeling Workshop"
- 2004.12.6-8 : Buenos Aires, the capital of Argentina
"The 10th Session of the Conference of the Parties
(COP10)"
- 2005.1.17-18 : Miyoshi Memorial Auditorium,
Yokohama Institute for Earth Sciences
Joint Workshop on Coupled Model Simulation and
Assimilation
- 2005.1.20-21 : Miyoshi Memorial Auditorium,
Yokohama Institute for Earth Sciences
"The Third Japan-EU Workshop on Climate Change
Research"
- H17.3.17-18 : Miyoshi Memorial Auditorium,
Yokohama Institute for Earth Sciences
IORGC/FRCGC Annual Symposium FY2004

② Research Program

(1) Climate Variations Research Program

The Climate Variations Research Program (CVRP) studies climate variations from seasons to decades and related oceanic phenomena in the Asia-Pacific sector including the Indian Ocean, polar and sub-polar oceans. To understand fundamental processes of those climate variations, our research is conducted using ocean and atmosphere models of various degrees of freedom as well as various analysis methods. We also conduct predictability and application studies on the influence of the global climate variability upon regional atmospheric and oceanic phenomena. The year 2004 was an epoch-making one for IOD study, since the newly discovered phenomenon was finally authorized at the first international CLIVAR conference after years of debate. In addition to this memorial event, we have done a lot of excellent research efforts such as successful prediction on the onset of Kuroshio meandering and the initiation of short-term climate prediction experiment using SINTEX-F1 model. Due to the space limitation, in what follows, we only give itemized lists of research done in this fiscal year with short descriptive statements on the major outcome. More information on our research activities is given in FRCGC annual report.

1) Model Group

a. Climate variability in the tropical and mid-latitude regions

a-1. Study on IOD influence on East African long- and short-rains using SINTEX-F1.

- The observed double peaks in the annual rainfall of the Eastern Africa (East African long and short rains) were successfully reproduced by the model.
- An important link between the short rain index and the large-scale rainfall anomalies related to the IOD over the Indian Ocean was found.

a-2. Study on the formation mechanism of the spring mini-warm-pool in the southeastern Arabian Sea using SINTEX-F1 CGCM.

- It was found that the presence of the barrier layer is a key factor for the SST warming in the region of interest.
- The atmospheric response to this positive SST anomaly demonstrates higher precipitation of 3 mm/day in the southeastern Arabian Sea in May, due to additional moisture transport into this region. The onset of the Indian summer monsoon is delayed by 10 to 15 days in the case without the barrier layer.

a-3. Predictability study on ENSO using SINTEX-F1CGCM.

- All the past El Niño and La Niña events were predicted successfully at 12-month lead time, with the model ACC skill scores of above 0.7 and the RMSEs much smaller than one standard deviation for the Nino3.4 SST index.
- As to the effort on the reduction of model biases, significant improvement in the reproduction of the Pacific cold tongue was attained.

a-4. IOD related studies (data analyses and model studies other than SINTEX-F1)

- Termination mechanism of IOD was studied: it was found that the intra-seasonal disturbances and the warming by incoming solar radiation coinciding with seasonal thermocline deepening are key factors for pure and El Niño co-occurred IODs respectively.
- Decadal IOD was investigated by looking into the one thousand year simulation data of GFDL CGCM.

b. Japan Coastal Ocean Predictability Experiment (JCOPE)

b-1. Further development of JCOPE system

- Successful prediction of the Kuroshio Large Meander in summer 2004 (Fig. 1) was accomplished and we studied its onset mechanism.
- Extensive output data validation by a cooperative study with Fishery Research Agency is now being done.
- Development of a higher resolution coastal ocean model with a two-way nesting scheme is going on.

c. Collaboration with the Earth Simulator Center

c-1. OFES data analyses

- Formation mechanism of a zonal jet in the Kuroshio extension region was studied.
- Study on potential vorticity distribution in the Atlantic and Pacific Oceans to identify PV source and sink regions is done together with the transport and mixing characteristics of mesoscale eddies. In some key areas, eddies are found to be anti-diffusive in an organized manner casting doubt on the widespread use of diffusive eddy parameterization. We also investigate transient wave activities to suggest the presence of baroclinic edge wave interactions.
- OFES data validation by TRITON buoys and an ADCP mooring in the Indian Ocean under the col-

laboration with the Institute of Observational Research for Global Change was done to evaluate the quality of OFES data in that region.

2) Climate Diagnostics Group

a. Variability in the Extra-tropical Atmosphere

a-1. Inter-annual surface pressure "seesaw" between the Aleutian (AL) and Icelandic (IL) lows.

Since the late 1960s, their seesaw tends to form in late winter through eastward propagation of Rossby wave trains from the North Pacific, accompanying significant anomalies in surface air temperature over many regions over the extra-tropical Northern Hemisphere.

- We have identified anomalous circulation over the North Pacific in January as a good precursor for February surface air temperatures in the Euro-Atlantic sector.
- We have also found that the AL-IL seesaw underwent multi-decadal modulations during the 20th century. While diminished around 1960, the seesaw was pronounced in the 1920s through the 1940s with its impact on surface temperatures as extensive as in the recent period. Although its maturity was in January, the precursory signal of the seesaw in that early period was also found in the North Pacific one month earlier.

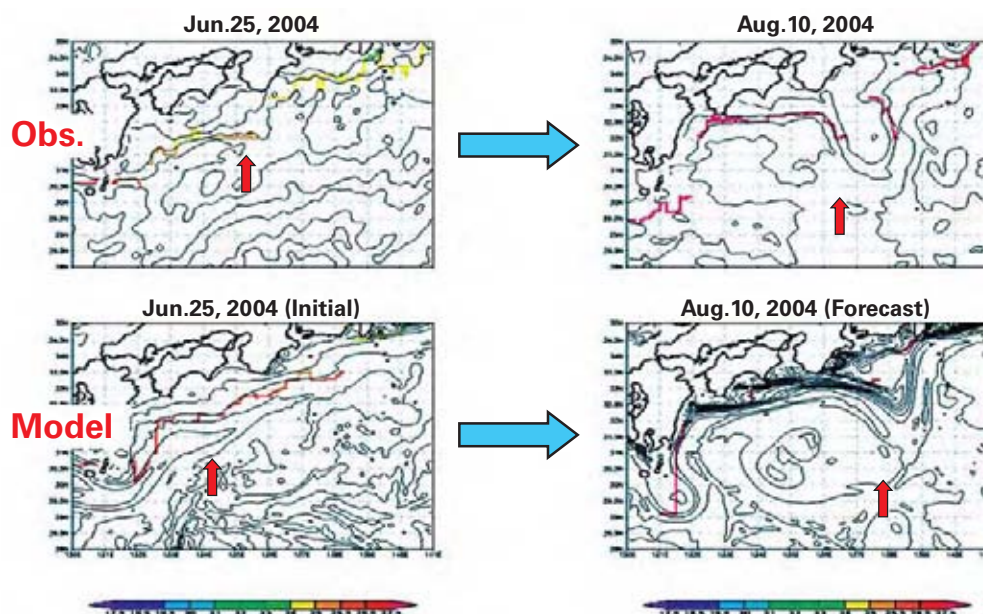


Fig. 1 Validation of the formation of the Kuroshio Large Meander in summer of 2004. Upper panels: snapshots of daily sea surface temperature provided from the New Generation Sea Surface Temperature project. Lower panels: initial state of the JCOPE system (lower left panel) and predicted stated (lower right panel). Colored contour and arrow indicate northern edge of the Kuroshio axis and meander position, respectively

b. Variability in the Extra-tropical Coupled Atmosphere-Ocean System

b-1. Decadal scale variability manifested in the North Pacific oceanic fronts.

As our continuous collaboration with our modeling group and ESC, the output from the 54-year hindcast integration of OFES driven by the daily-mean NCEP/NCAR reanalysis data from 1950 to 2003 has been analyzed. Owing to its super-high resolution (10 km), the OFES can realistically reproduce the extensions of the Kuroshio and Oyashio currents (KE and OE, respectively) and the associated fronts with their distinct vertical structures.

- Our analysis strongly suggests that prominent decadal-scale variability observed in the North Pacific sub-arctic frontal zone was a manifestation of the decadal migration of the two frontal axes and that the variability in SSH and SST was concentrated into a deep KE and a shallow OE fronts, respectively (Fig. 2).
- The frontal migration along the KE arises from the arrival of Rossby waves forced in the central portion of the basin by anomalous wind stress, while those waves cannot fully explain the migration of the OE front.

c. Collaboration with ESC

c-1. High resolution AMIP-type simulations and others.

Our continuous collaboration with ESC includes the use of high-performance AGCM(AFES), where we have started an AMIP-like ensemble hindcast experiment of the global atmosphere for 25 recent years with 50-km horizontal resolution (T239) and 48 vertical levels. Furthermore, we have been contributing to the development of a high-performance coupled model (CFES) in ESC. The atmospheric and oceanic fields simulated by CFES look fairly realistic during the first few years of time integration.

3) Predictability and basic process studies

a. Predictability of the atmospheric motions.

a-1. Ensemble-run experiments using AFES

Closely collaborating with ESC, we have done ensemble-run experiments for the short-term predictability of the atmosphere, in which ESC's high resolution atmospheric model AFES was employed. In constructing the model ensemble, we change not only the initial conditions but boundary conditions and model parameters as well. Now our experiments are still in a preliminary stage, but we plan to execute a

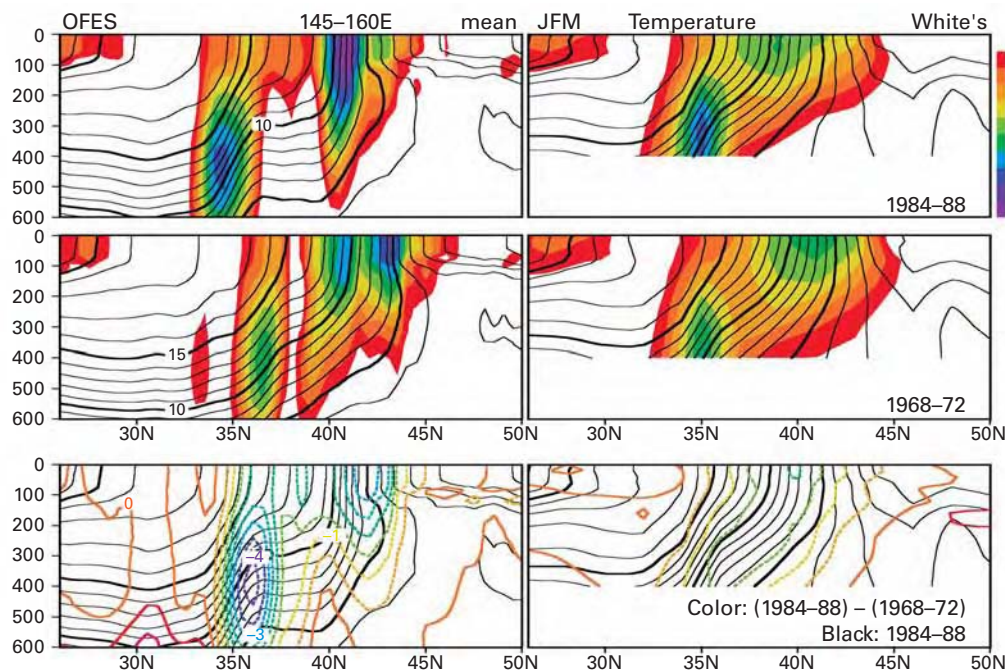


Fig. 2 Meridional sections of 5-winter (Jan.-Mar.) mean fields of temperature (black contours for every 1°C) and its meridional gradient (°C/100km; color shading as indicated to the right of the upper-right panel) for (top) 1984-88 and (middle) 1968-72. Based on (left) the OFES simulation and (right) White's (1995) observational data. Color contours in the bottom panels indicate the changes in the 5-winter mean temperature from 1968-72 to 1984-88 (every 0.5°C).

1000 ensemble members run to study the characteristics of the predictability limit of the atmosphere.

b. Selected topics on process studies

b-1. New forms of mesoscale eddy parameterization studies.

- We proposed new parameterization schemes for the extra transport velocity with particular emphasis on baroclinic instability. These come in the form of elliptic equations, previously unmentioned, which we derive for the eddy-induced overturning stream function. The parameterized velocity is nonsingular at the bottom and the sea surface, contrasting with previous constant-coefficient theories based on depth diffusion (Gent and McWilliams, 1990).
- We investigated an alternative approach of using the thickness-weighted mean momentum equations with the modified hydrostatic pressure gradient (de Szoeke and Bennett 1993; Greatbatch, 1998; Aiki et al., 2004) in parameterizing mesoscale eddies, which none of the climate centers have introduced yet. In an attempt to describe the role of the layer thickness form drag, we study the energy cycle of the adiabatic Boussinesq equation of ocean circulation. It is shown that the eddy form drag allows transfer between the mean kinetic and eddy potential energies (Iwasaki, 2001), which replaces the route through the eddy kinetic energy (Plumb, 1983). This may help to introduce the momentum approach in future OGCMs.

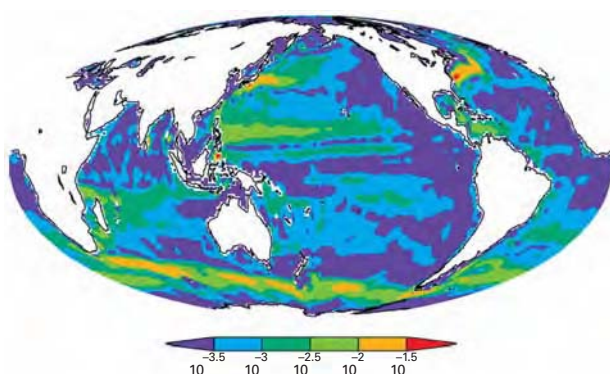


Fig. 3 Work of parameterized eddy stress [W/m^2] for Aiki et al. (2004) with $C' = 0.03$. The global energy conversion rate amounts to 0.412 TW.

(2) Hydrological Cycle Research Program

Very essential and urgent issues for us living in monsoonal Asia may be how the hydrological cycle change and vary due to anthropogenic and other large-scale forcings. How regional and river basin scale hydro-climate and water resources vary associated with these large-scale forcings is also an important issue.

Based upon the comprehensive data and modeling, we will target these issues and to provide physical basis for the prediction of hydrological cycle on a seasonal to interannual time-scale.

1) Group for Large-scale Hydrological Processes

This group focuses on the impact of climate change and variability on continental and regional scale hydrological cycle and their feedbacks to climate variability, based on global scale reanalysis data, and various observational data. Validation of hydrological processes obtained from simulations by General Circulation Models (GCMs) and regional climate models (RCMs) is also being carried out by using the observational data. Some major results found are shown as follows;

Long-term trends in summer precipitation totals, the number of rainy days, and precipitation intensity were investigated with daily rainfall datasets for China from 1961 to 2000 (Endo et al., 2005). Total precipitation significantly increased in summer in the Yangtze River basin and northwestern China, but decreased in other regions as shown in Fig. 4. The number of rainy days also increased in the Yangtze River basin and over northwestern China, but decreased over Tibet and over North China.

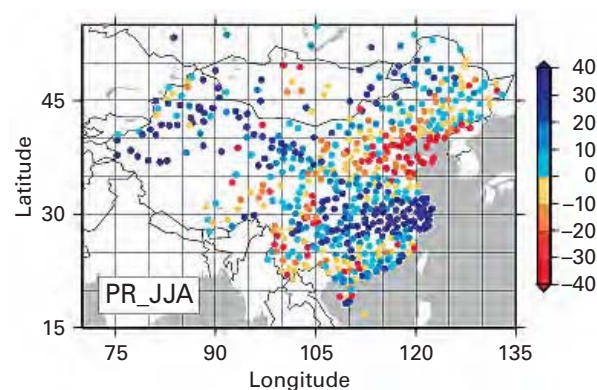


Fig. 4 Trends of summer (JJA) precipitation in China for the period from 1961 to 2000. Trends are expressed as percent of climatological summer precipitation. (Endo et al., 2005).

Tomita et al. (2004) examined the interannual meridional fluctuations of the Baiu front by the EOF analysis. The first EOF mode of precipitation indicates a 5-6 yr low-frequency fluctuation (LF mode) appearing south of 35°N. The development is concurrent with horseshoe sea surface temperature anomalies (SSTAs) in the entire tropical Pacific that are associated with the ENSO, and is negatively correlated with the south-southeast Asian summer monsoon. The second EOF mode is characterized by a meridional seesaw-like fluctuation with a node at around 28°N with a time scale of biennial oscillation (BO mode). The horseshoe SSTA pattern again control the anomalous meridional circulations, but with a different spatial phase through a convection off the Philippines.

The southerly surge on sub-monthly (6-25 days) timescales has proved to be an important bridge linking the tropics and the southern mid-latitudes over the Indian Ocean. Fukutomi and Yasunari (2005) examined southern winter circulations for 23 years (1979-2001) and confirmed that extratropical forcing manifested as a meridional surge does modulate the tropical atmosphere over the eastern Indian Ocean, and the distinct tropical-extratropical connection in the region. It is found that strengthened low-level wind surges cause cross-equatorial flow stretching from the subtropical eastern Indian Ocean to the southern Bay of Bengal,

with the advection of cold, dry air from mid-latitudes into the tropics.

The interseasonal propagation of the dominant circulation called the northern hemisphere annular mode (NAM) from winter to summer was found by Ogi et al. (2004). They applied the EOF analysis of the zonally averaged geopotential field for each calendar month for the period from 1958 to 2002, and noticed that the summer NAM has a smaller meridional scale and is displaced poleward as compared to the winter NAM, and is more strongly related to surface air temperatures over Eurasia than the original Arctic Oscillation.

2) Land-surface Hydrological Cycle Process Group

A hydrological model was developed, which can be applied to various land uses type, with a 0.1° -grid resolution. The results applied to the Yellow River basin, China are as follows: 1) the runoff processes at two main river sections, Tangnaihai and Lanzhou, located at sources region of the Yellow River, were simulated well through 22 years from 1980 to 2001 (Fig. 5); 2) the annual water use in the two large irrigation districts, located midstream region of the basin, was estimated to be about 11.3 km³, which agrees well to the value reported by Yellow River Conservancy Commission.

A vegetation model was developed as part of the hydrological cycle model, which can estimate heat and

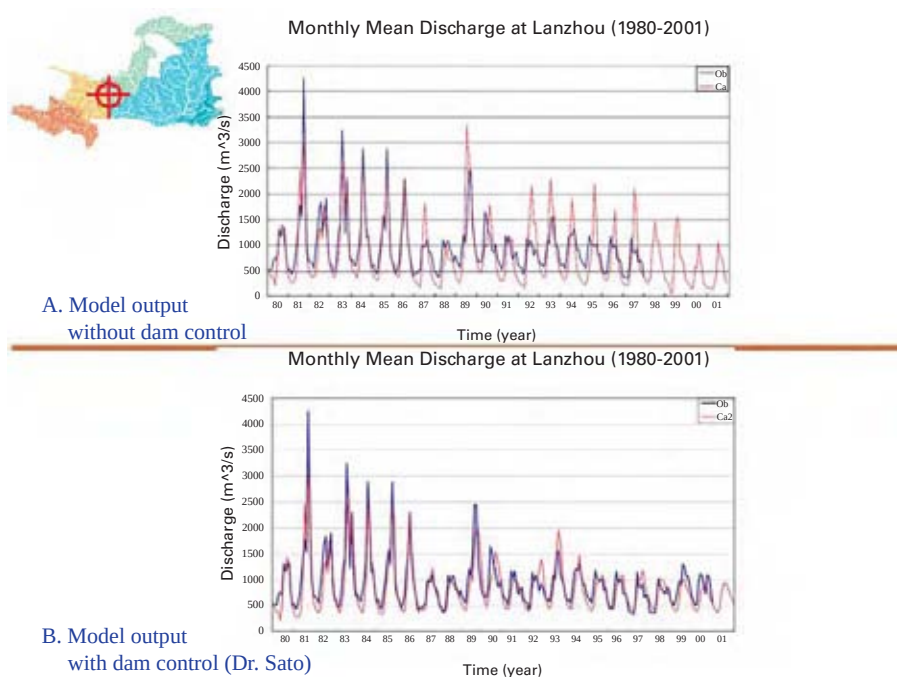


Fig. 5 Comparison of model result at Lanzhou station from 1980 to 2001.

water exchange among vegetation, soil and the atmosphere. The model was applied to the observation data in an evergreen forest in northern Thailand (Tanaka et al., 2004), and showed that a rooting depth must be 4-5 m in order to effectively simulate the characteristic of the late-dry-season transpiration and the annual discharge. This result suggests that the rooting depth should be set deeper than that are often used in GCMs (e.g., 1-2 m) for simulating transpiration from tropical forests.

3) Clouds and Precipitation Process Group

The cloud microphysical model and the simple parameterizations to give the cloud droplet number from the number of CCN and the updraft velocity in the cloud were developed to precisely estimate the effect of aerosol particles on the cloud microstructure of clouds. These models were installed in the AGCM (CCSR/NIES/FRCGC) equipped with aerosol transportation model SPRINTARS. The global distribution of the annual mean effective radius of cloud droplets at the top of clouds were computed, which clearly demonstrates the land-ocean contrast of the effective radius, as is often shown in observational satellite data from AVHRR. The computation without organic carbon particles are also made, and these two results are compared. The results shows that the effect of organic carbon particles on the cloud microstructure is not negligible small at South Africa, Australia and South America continents (Fig. 6).

A new 3D-radiative transfer model (both visible and infrared wavelengths) was developed so as to take into 3D structure of clouds. Preliminary results indicate that the 3D effect of radiation enhances the radiative cooling of the atmosphere.

Our mesoscale-convection-resolving model (MCRM) to simulate rainfall distributions and other important features of typhoons and cloud clusters has nearly attained a reasonable level with respect to parameterization of the effects of cumulus convection.

To understand and model the mesoscale organization processes, a cloud resolving model (CRM) named "CReSS" was developed and optimized for Earth Simulator, which has successfully simulated the various types of mesoscale convective systems. Several CRMs could well simulate the disturbances in the

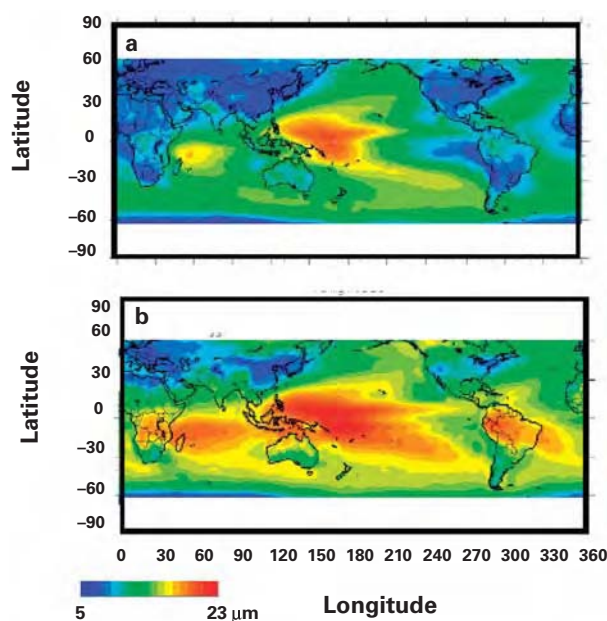


Fig. 6 Calculated annual mean value of the effective radius of cloud droplets at the top of clouds where the temperature is higher than 273 K in 2000. a) Organic carbon aerosol particles are taken into the account. b) Organic carbon aerosol particles are not taken into the account.

Meiyu front observed on July 1st 1998, and indicated the importance of moisture distribution for the continual development of the precipitating system.

(3) Atmospheric Composition Research Program

Increase of emissions of greenhouse gases and air pollutants accompanying with the economic and population growth is exerting heavy burden to global and regional environment in various part of the world. The atmospheric composition change caused particularly by Asian emissions is a serious problem from the point of sustainable development of this region as well as from the point of global environmental change. The mission of Atmospheric Composition Research Program is to elucidate the mechanism of regional and global scale air pollution in Asia Pacific Region, and to study the influence of atmospheric composition change on climate and vice versa by developing advanced chemical transport model and chemistry-climate model.

To clarify the relationship between regional and global atmospheric composition change, physical and chemical processes of emission, transport, transformation and deposition of atmospheric trace constituents are studied focusing on Asian Pacific Region and Eurasian Continent, and global/regional/ urban chemical weather forecast will be made. Three categories of

atmospheric species studied in this program are long-lived greenhouse gasses (CO_2 , CH_4 , N_2O , etc.), short-lived reactive gaseous species (O_3 , CO , NO_x , VOC , SO_2 , OH , HO_2 , etc.) and aerosols.

Important processes such as inter-continental long-range transport of air pollutants, tropospheric photochemistry, and aerosol composition change are modeled. Source and sinks of greenhouse gases are discussed with a forward and inverse modeling technique. Temporal and spatial variability of concentrations and carbon/oxygen isotope ratios of greenhouse gases are analyzed by using a global transport model coupled with an ecosystem model for clarifying source and sink processes including the biosphere. Further, prediction of air quality change by ozone and aerosols in Asian Pacific Region, and elucidation of relationship of regional air quality and climate including chemistry-climate feedbacks are targeted in this program.

Contribution to international programs will be made through ABC (Atmospheric Brown Cloud-Asia) under UNEP, GEIA (Global Emission Inventory Activity) under IGBP, ITCT (Intercontinental Transport and Chemical Transformation)/IGAC/IGBP, TransCom, an international program of Intercomparison of inverse modeling for evaluating source and sink of CO_2 , and international intercomparison program of chemical transport/climate models organized by ACCENT in Europe.

1) Global Chemical Transport Modeling Group

The FRCGC/UCI global CTM has been adapted to run at T106 resolution (1.1×1.1 degrees) with a full simulation of tropospheric chemical processes. The model has been used to study the impacts of resolution on tropospheric ozone production, an inherently non-linear process that is dependent on the timing, location and magnitude of precursor sources. Simulations at four different resolutions demonstrate differences in regional ozone production of as much as 20%. Comparisons with detailed measurement data allow a robust test of these simulations, and demonstrate that the higher resolution model runs bring improvements in performance over a wide range of trace gas species. This is the first time that a global chemical model has been run at such high resolution, and the study demonstrates and quantifies the improvements to be gained.

Both the FRCGC/UCI and CHASER models of JAMSTEC/FRCGC were involved in recent international model intercomparison organized by the European ACCENT project with the aim of contributing to the upcoming IPCC Fourth Assessment Report. These were the only Asian contributions to the intercomparison studies. One intercomparison focused on the changes in ozone between pre-industrial, present and future (2100) times and their impacts on climate, including both stratospheric and tropospheric changes, and the impacts of changing climate for GCMs such as CHASER. The second intercomparison involved studying the impacts on air quality and climate changes in ozone and other gases between the present day and the medium-term future (2030) using a variety of different assumptions about emissions. Twelve and twenty-four models participated in the first and second intercomparison experiments, respectively, including ULAQ (Italy), UIO (Oslo Univ., Norway), LMDzINCA (CNRS/CEA, France), DLR (Germany), TM4/5(KNMI, the Netherlands), STOCHEM/ UM_CAM/STOCED/SLIMCAT/TOMCAT (UK_Met, Cambridge Univ., Edinburgh Univ.), etc., from Europe, NCAR-WACM (NCAR), MOZART (Illinois Univ.), GISS, GEOS-CHEM (Harvard Univ.) from USA. Both FRCGC/UCI and CHASER models performed well in these studies and made a significant contribution to the success of the projects.

As an example, Figure 7 shows the change of ozone field between preindustrial era to present, and contributions by different factors calculated by CHASER. Net ozone change is the increase of more than 10 ppbv in the troposphere (particularly more than 20 ppbv in the upper troposphere in the northern hemisphere). On the contrary, large ozone decrease is observed in the stratosphere centering at Antarctic ozone hole. The cause of the tropospheric ozone increase is mostly due to the increase of emissions of precursors but the impact by stratospheric ozone decrease and redistribution of ozone by climate change are also not negligible.

2) Greenhouse Gases Modeling Group

We have developed a high-resolution (64 regions) time-dependent inverse model (TDIM), which uses forward chemistry-transport model simulations with inter-annually varying (IAV) meteorology from NCEP/NCAR

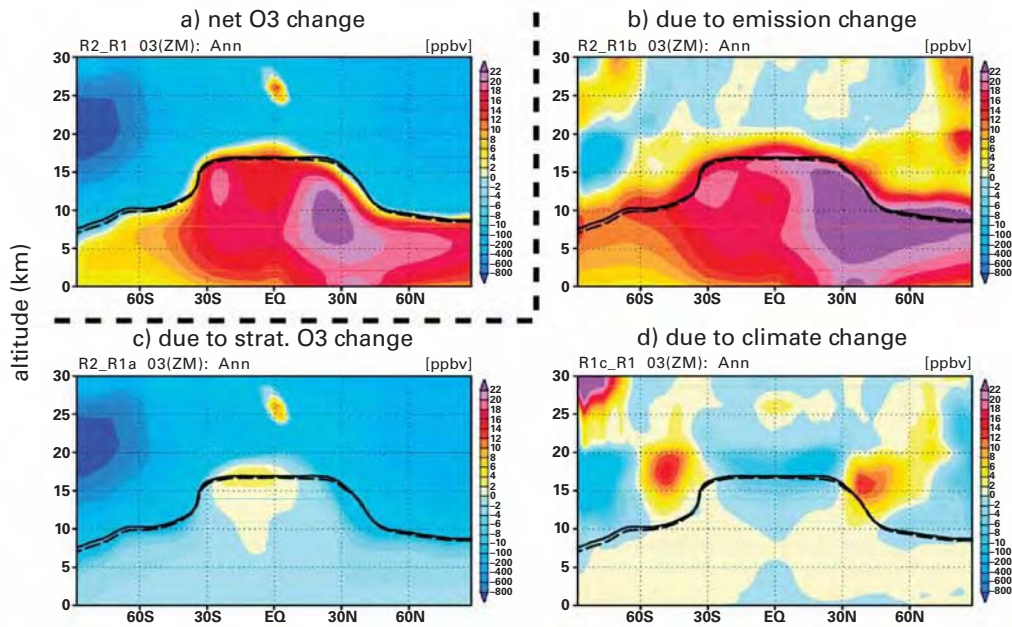


Fig. 7 a) Net zonal ozone change between preindustrial era and present calculated by CHASER, due to b) emission change, c) stratospheric ozone change, and d) climate change

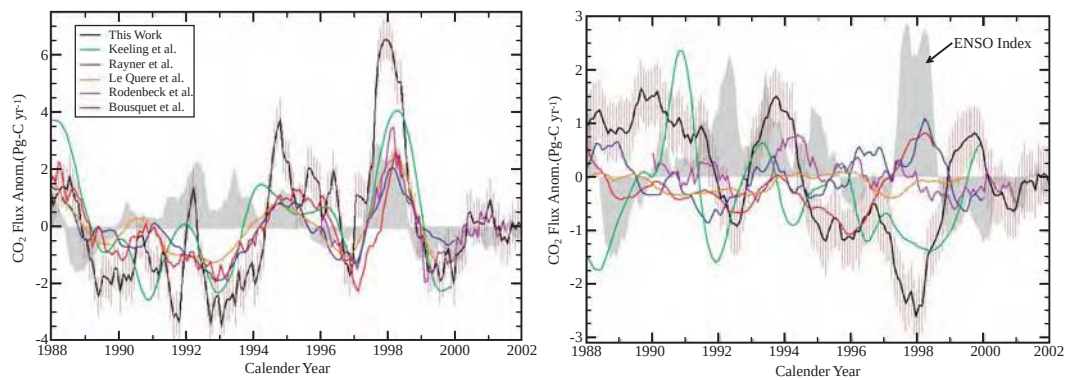


Fig. 8 Comparison of our TDIM derived CO₂ fluxes with several other results for global land (left panel) and ocean (right panel).

reanalysis and atmospheric CO₂ observations from up to 100 stations. Use of the IAV meteorology helps for better simulations of inter-annual variations of CO₂ concentration due to changes in transport caused by climate oscillations such as El Niño-Southern Oscillation (ENSO) and North Atlantic Oscillation (NAO). To understand causes of interannual and decadal changes in the observed CO₂ growth rate, we examined the TDIM CO₂ flux variability on regional scale. The results indicated that ENSO is the single largest controlling factor for inter-annual and decadal variability in land and oceanic CO₂ fluxes, and that the effect of Mt. Pinatubo eruption in June 1991 on the terrestrial ecosystem is detectable (Fig. 8). During the ENSO period, tropical ocean (mainly east equatorial Pacific) upwelling is suppressed because of enhanced thermal stratification in the upper ocean, and such a situation leads to negative

oceanic flux anomalies in 1992 and 1997 (Fig. 8 right). At the same time, drier and warmer surface conditions are formed over the tropical land, under which biospheric CO₂ emission is enhanced (positive flux anomaly) due to lesser photosynthetic uptake and increased heterotrophic respiratory release, as well as to biomass burning (Fig. 8 left), as seen in 1992, 1994 and 1997. After the Mt. Pinatubo eruption, the terrestrial CO₂ uptake is increased during the period 1991-1993, due to deactivated respiration and activated photosynthesis, which was caused by lower ground temperatures, and enhancement of diffused radiation at tree levels by the sunlight scattering by aerosols, respectively.

3) Atmospheric Composition Observation and Data Analysis Group

The seasonal variations of ozone from the observation

at three "regionally polluted" mountain sites of China at Taishan (Shandong Province), Huashan (Shaanxi Province) and Huangshan (Anhui Province) have been obtained. Simultaneously, the seasonal cycles of "background" ozone and carbon monoxide in Eastern Eurasia have also been obtained at the remote mountain site, Mondy in Russia (Southwest of Lake Baikal). The obtained data are shown in Fig. 9. As seen in the figure, high levels of ozone have been found in China, especially in springtime when the 24-hr averages often exceed 80 ppb. Good correlation of ozone among sites is found and this indicates the very large ozone pollution prob-

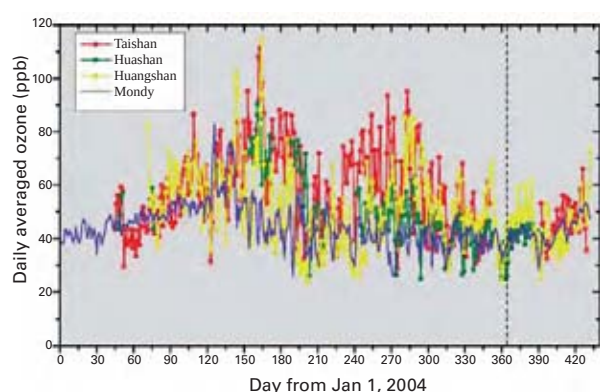


Fig. 9 Seasonal and daily variations of ozone concentration observed at Mondy, Taishan, Huashan and Huangshan in 2004 (daily averaged values).

lem over the eastern mid-latitude region of China. While preliminary trajectory analysis confirms that the seasonal variation of ozone in China are primarily due to East Asian monsoon regime, many pollution episodes found at the three observatories indicate the enhanced effect of regional anthropogenic sources, mega-cities, and regional transport within China. These high ozone episodes would potentially have a serious impact on air quality in China and East Asia.

We have shown by using the ozone sonde data that tropospheric ozone over Sapporo, Tsukuba, and Kagoshima, the observational site of Japan Meteorological Agency (JMA), has increased remarkably over a wide area from 1970 to 2002 (Fig.10). The increase is the largest in Tsukuba and Kagoshima, where effect of regionally polluted air masses passing through the busy area of human activities, such as China and Korea, is notable. It was also found that the increase of ozone is larger near the surface than in the upper troposphere. Moreover, according to the result of trajectories analysis, ozone in air masses originating from East Asian Continent were the highest in springtime in the first half of these 33 years, but highest ozone shifted to the summer in the latter half. From this result, it is suggested that due to the economic

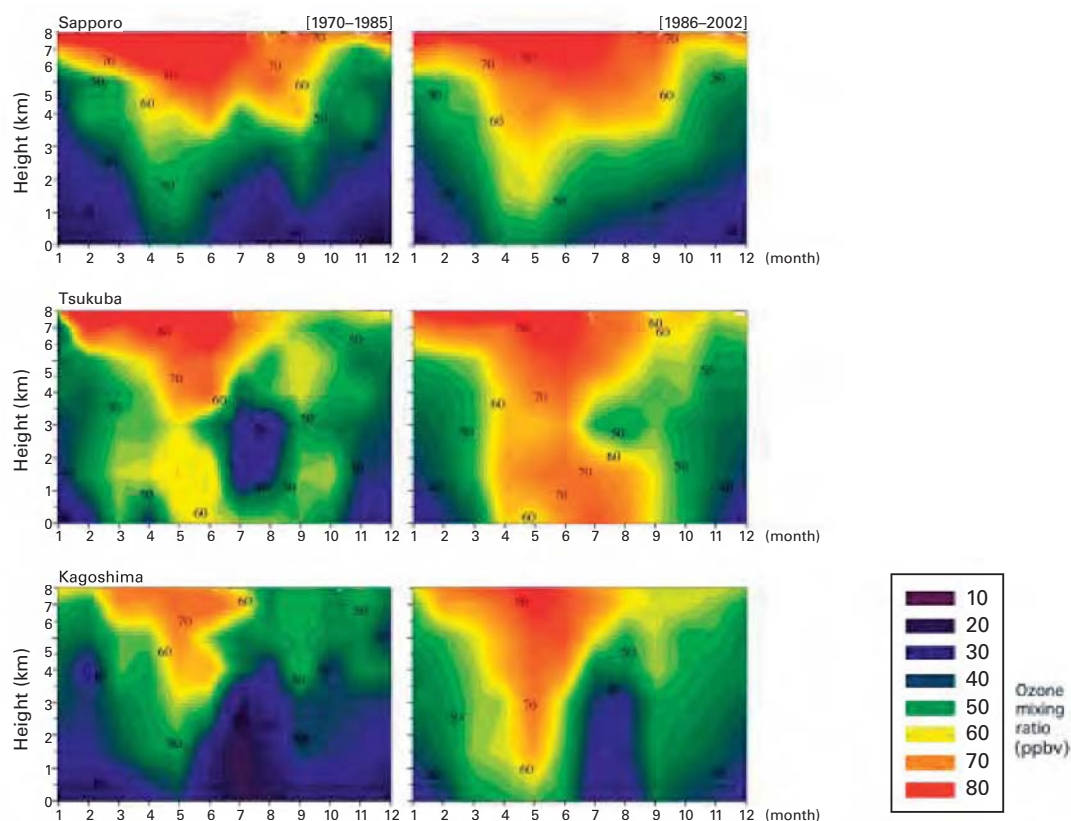


Fig.10 Comparison of the average ozone mixing ratio (ppbv) over Japan for the period of 1970-1985 (left) and 1986-2002 (right).

development in the East Asia, the emission of ozone precursors is accelerating and leading to the active production of ozone in summer. During this period, nitrogen oxide emissions were basically stable or decreased in Japan, compared to its increase in China. It is presumed that the increase of nitrogen oxide emissions originating from East Asian Continent, caused an increase of ozone over Japan, lying their leeward, in summer when photochemical reaction is active.

<Emission Inventory Sub-group>

The emission inventories of SO₂, NO_x, CO, BC, OC, and VOC from fuel combustion activities and CH₄, NO, N₂O and NH₃ from agricultural sources in South, Southeast and East Asia have been completed for the base year of 2000, and named as REAS (Regional Emission Inventories in ASia). The results have been publicized on the web page (<http://www.jamstec.go.jp/frsgc/research/d4/emission.htm>). Particular concern has been focused on the decreased coal consumption in China in late 1990s reported in the official statistics. Considering the above-mentioned increasing trend of NO₂ column in Eastern part of China deduced from GOME satellite data, revised estimate of coal consumption in this period was adopted in REAS. Based on the 1995 and 2000 inventories, we are working in the prediction of the historical emission between 1980 and 2000 and the future emission for 2020.

(4) Ecosystem Change Research Program

Numerical modeling of ecosystems and their responses to such changes is extremely challenging because of the inherent complexity of ecosystems, and often of the insufficient availability of observation data. However, several years efforts of our research members make it possible to develop original ecosystem models to elucidate ecosystem mechanisms as well as to predict ecosystem changes in future. Such efforts have been focused to develop and refine our ecosystem sub-models in both terrestrial and marine environments.

These are Sim-CYCLE, DGVM, NEMURO and NEMURO. FISH models, together with the high resolution marine ecosystem model and forest disturbance model. The long-term decadal survey on marine lower trophic levels have been successfully connected to the

ecosystem model. Significant progresses have been made Remote Sensing group with Emphasis on NDVI, PAR and Aerosols.

In Fiscal Year 2004, our program was reorganized under a new system of operation. At present, ECRP is consist of three research groups: (a) Terrestrial Ecosystem Model Group, (b) Ecosystem Spatial Observation and Modeling Group, and (c) Marine Ecosystem Model Group. Progress and achievements of each group during FY 2004 are summarized below.

1) Terrestrial Ecosystem Model Group

The research is categorized into two sub-themes: (1) local-scale studies, and (2) global-scale studies.

a. Local model studies at field sites

- Takayama site (cool-temperate deciduous broad-leaved forest, Japan)

Through modifications in canopy radiation and photosynthetic scheme and soil carbon dynamics, the model captured appropriately the seasonal change and interannual variability in NEE, which is sensitive to spring temperature and light conditions.

- Yakutsk site (boreal deciduous conifer forest, Russia)

A coupled carbon cycle and fire regime model was developed and applied to a larch forest in East Siberia, near Yakutsk. The model allows us to analyze the effect of wildfire on carbon cycle and landscape-scale heterogeneity.

- Qinghai-Tibetan site (alpine meadow, China).

We found that diurnal CO₂ emission rate was almost independent of light condition but increased exponentially with surface temperature, with a step-wise phase shift at around 0°C. The critical effect of soil freezing on ecosystem respiration in frigid regions should be considered in carbon cycle models.

b. Global model as a component of earth-system model

This group has developed global-scale terrestrial carbon cycle models (termed Sim-CYCLE) and performed several simulation analyses.

- The potential response of the present terrestrial ecosystems to prescribed global warming was investigated with the model (i.e., off-line experiment). The simulations using different scenarios showed a wide variability of terrestrial response to global

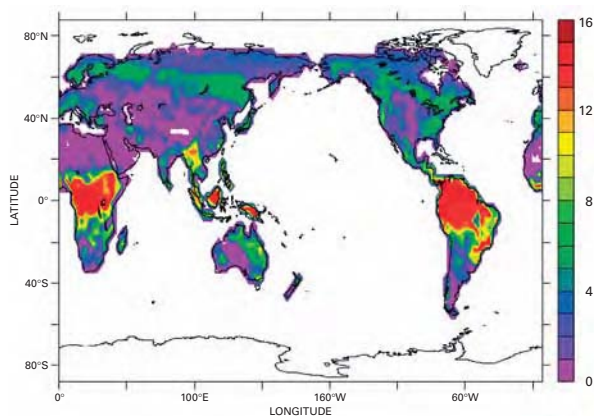


Fig.11 Global distribution of Net Primary Production (NPP) derived by the Sim-CYCLE+MATSIRO+AGCM coupled run (1990-1999 average: Mg/ha/yr)

warming, especially for the net carbon budget of soil organic matter.

- The terrestrial carbon cycle model was interactively coupled with an AOGCM developed by CCSR, NIES, and FRCGC, which incorporates a land-surface parameterization scheme MATSIRO. After spinning-up for 1000 years, the coupled model satisfactorily retrieved global distributions of photosynthetic productivity, carbon storage, and leaf area index (Fig.11).

The purpose of this group is to predict long-term changes in structure and function of forest ecosystems, in response to climatic changes.

b-1. Stand-level models under conditions of frequent loading

Increasing leaf water stress due to gravity and path length resistance may ultimately limit leaf expansion and photosynthesis for further height growth. Despite abundant water resources, trees taller than 40 m are rarely found in Japanese forests.

To examine how diameter growth and crown expansion of two conifer species (*Picea glehnii* and *Abies sachalinensis*) influenced patterns of stem breakage in a crowded *Picea*-*Abies* mixed forest in northern Japan, the relationships between mode of tree death (standing, uprooting, and stem breakage) and crown size were analyzed along the growth trajectory.

b-2. Global model of vegetation dynamics

For providing reliable predictions for the changes of global climate, integrated terrestrial ecosystem models

that include biogeochemical processes and vegetation dynamics would be required. To overcome this situation, we have been developing the SEIB-DGVM. This is one of Dynamic Global Vegetation Models (DGVMs) that can simulate changes in ecosystem functions (ex: carbon and water flux) and ecosystem structures (ex: distribution and composition).

2) Marine Ecosystem Group

a. Study on long-term changes in marine ecosystems

Better understanding of processes linking climate - hydrographic environments - marine ecosystem is indispensable to improve capability of conventional ecosystem models to predict marine ecosystem responses toward global scale environmental changes including future global warming. We have been conducting retrospective study based on the historically collected observational data sets of physical/chemical/biological parameters.

We have been conducting long-term ecosystem change study based on the historical zooplankton collection taken since 1950s. In FY2004, we targeted the Oyashio region, which is known for extensive spring bloom and high productivity. Zooplankton biomass varied in a multi-decadal scale with a significant correlation ($R = -0.843$) to the Pacific Decadal Oscillation index (PDO, <http://tao.atmos.washington.edu/pdo/>), suggesting biomass declined during the cold-phase (Fig.12).

Phenological changes were also detected in the zooplankton community structure. After the mid 1970s, the peak abundance timing delayed one month from April to May in the Spring Community, while it became earlier from July to May in the Spring-Summer Community, resulting in overlap of the high productivity periods of the two communities. After

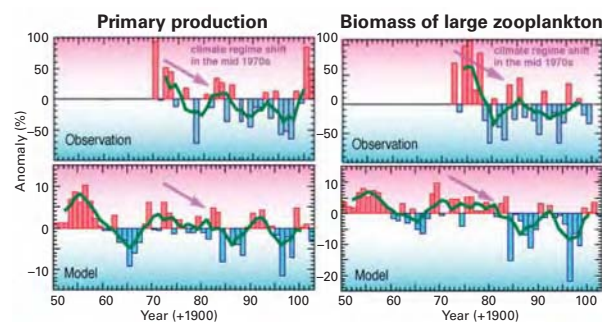


Fig.12

1976/77 climate regime shift, wintertime cooling coupled with rapid summertime warming was likely to be responsible for delayed initiation and early termination of productive season. On the contrary, warm winter and cool summer elongated the productive season in the 1990s. Our study suggested that climatic forcing with a different decadal scale cycle worked in winter and summer to present seasonal and interannual variation of hydrographic conditions.

b. Historical simulation from 1948 to 2002 using a global marine biogeochemical cycle-ecosystem model

Using a three-dimensional NEMURO (North Pacific Ecosystem Model Used for Regional Oceanography) developed in FY2003, which has two phytoplankton, three zooplankton, three nutrients, two particles and dissolved organic matter including carbon cycles with horizontal resolution of 1×1 degrees, we conducted the historical run from 1948 to 2002, to study interannual / decadal variabilities of biological production and oceanic CO₂ uptake according to guidelines in phase 3 of the Ocean Carbon Modeling Intercomparison Project (OCMIP3). Comparing before and after the late 1970s regime shift, primary production and biomass of phytoplankton increased in the North Central Pacific but decreased in the sub-tropical Western and Eastern Northern Pacific. These are consistent with observed primary productions and biomasses (Fig.12). Global CO₂ uptakes by the ocean are 2.1 Pg/yr in 1980s and 2.3 Pg/yr in 1990s, which are consistent with these in the previous studies.

b-3. Development of an eddy-resolving biogeochemical ecosystem model

We continue to analyze the results of chlorofluorocarbons (CFCs) experiments using super-high resolution model with $1/10 \times 1/10$, OFES, on Earth Simulator. Our preliminary results shows chlorophyll-a distribution regulated by meso-scale eddies that are major features observed by satellite images. Especially, realistic physical conditions such as Kuroshio Extension current around Japan obtained by OFES brings spring bloom to realistic distributions.

3) Ecosystem Spatial Observation and Modeling Group

In FY 2004, the ESOM Group research focused on three major themes: 1) spatiotemporal dynamics of vegetation-climate relations, 2) integration of satellite data with ecosystem process modeling, 3) photosynthetically active radiation (PAR) and the terrestrial carbon cycle.

a. Spatiotemporal dynamics of vegetation and vegetation-climate relations

Vegetation-climate relations were investigated through a global scale analysis of satellite measurements of the normalized difference vegetation index (NDVI) and climatic indices of wetness and warmth. Global vegetation regions dominated by either wetness or warmth were identified. The research helps to identify the climatic factors that underlie interannual and long-term variation in vegetation patterns.

A strong correlation between the two NDVI data sets and evapotranspiration reinforced the conclusion that interannual variation in vegetation activity in north Asian land areas influences the climate system through variation in transpiration.

Atmospheric effects on the satellite-derived NDVI were investigated for the Amazon region. The results indicate that NDVI seasonality in the central Amazon region is largely determined by seasonality of cloud cover. In the southern and eastern Amazon, biomass-burning aerosols during the late dry season limits reliable NDVI data primarily to months from April to July.

b. Integration of satellite data with ecosystem process modeling

This research is aimed at improving the accuracy of ECRP's terrestrial carbon cycle model, Sim-CYCLE, by incorporating satellite observations. Achievements in FY 2004 include the initial system design for satellite data transfer and processing for vegetation and radiation variables, and assimilation of the satellite data into Sim-CYCLE.

c. Photosynthetically active radiation and the terrestrial carbon cycle

Our network of ground-based PAR sensors was expanded to include a site at Sapporo, Japan through collaboration with researchers at University of Tokyo's

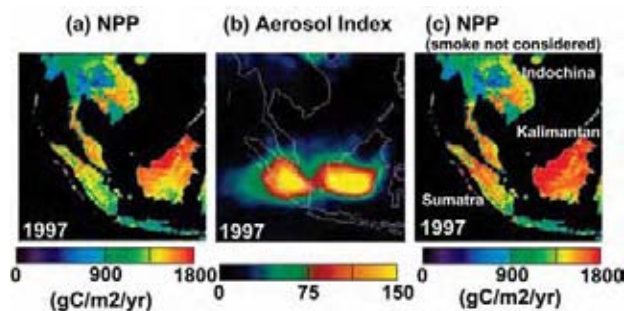


Fig.13 (left) net primary production in Southeast Asia for a smoke-dominated year (1997), (middle) smoke distribution shown by the satellite-derived aerosol index, (right) net primary production under smoke-free conditions.

Institute of Industrial Science. An intercomparison of PAR sensors provided new information about the accuracy of different sensor types. This information is incorporated into our PAR data analysis and supports our research on satellite-based PAR monitoring.

We combined satellite-based estimates of PAR with an ecosystem process model to evaluate the effects of smoke-induced reductions in PAR on terrestrial net primary production in Southeast Asia. The results (Fig.13) show a reduction in NPP during El Niño years that is associated with high temperature and drought and a further reduction in NPP caused by the smoke-related reduction in PAR.

(5) Global Warming Research Program

The principal goal of the Global Warming Research Program is the projection and understanding of global warming. Working towards this goal, the program groups are involved in climate model development and conduct numerical experiments for paleoclimate, present day and future global warming, using the Earth Simulator. The coupled model development project is one of FRCGC "cross-cutting" projects which aims to foster collaboration between different programs in FRCGC. FRCGC, CCSR and NIES have mutually agreed to collaborate on developing climate models. The research goal of Kyousei Project 1 (Representative: Prof. Sumi of CCSR) is incorporated into that of the Global Warming Research Group. Therefore FRCGC's contribution to the K1 project forms part of the research result from the Global Warming Research Group. Selected research accomplishments during the FY 2004 are briefly described below.

1) Global Warming Research Group

a. Global warming Experiment using high resolution coupled model

Since the submission of the global warming prediction experiment result for the 4th IPCC evaluation report (AR4) was set at the end of August, 2004, this fiscal year was a special year for this group. With the support of other group members in the program, CCSR/NIES/FRCGC high resolution atmosphere-ocean-land model (atmosphere~1 degree and ocean~1/4 degree x 1/6 degree) was used to conduct several kinds of experiments for total of 491 years including control experiment (1900 to 2000), 1% CO₂ increase experiment (year 1990), 20th century experiment (1900 to 2000), 21st century scenario experiment A1B and B1 (2001 to 2100 each)

The atmosphere and ocean components of this model have the highest resolutions among the models for AR4. This model shows the top level performance in the world at the IPCC Workshop in Honolulu, March 2005. The experiment results, which have been submitted to the PCMDI data center, are available to the world wide researchers for analysis.

• Summer in Japan in a Global Warming Climate

Based on the above-mentioned global warming experiments, the characteristic changes of summer in Japan were analyzed. The prediction results of the end of 21st Century indicate that the number of the very hot summer days increases in several dozens and that the frequency of heavy precipitation increases if the global warming continues.

• Sea level change under the global warming

The globally averaged sea level rise projected in the model is similar to the sea level rise observed by the satellite during the last decade. The averaged sea level rise due to the thermal expansion is expected to be about 32 cm by the end of the 21st century under the global warming. On the other hand, sea level rise due to the water mass contribution (ex. river-runoff, precipitation minus evaporation) except for the land-ice melt is relatively small.

• Extreme daily precipitation

It is important to study the change of the extreme daily precipitation from the viewpoint of prediction of the influence of the climate events such as flood.

Global distributions of extreme daily precipitation (99 percentile) were compared between the estimation of the satellite observations and the result of the present study. The comparison of the present climates between the model and observation indicates that the reproducibility of precipitation intensity does not necessarily become reliable, even though the model resolution became higher. However, the model can reproduce the precipitation intensity of 1-degree grid interval consistent with the observation, if an appropriate cumulus convection scheme is used. The results of the global warming experiment show that the rate of extreme daily precipitation change is close to the rate of the annual averaged precipitation change in many regions.

- Others

Daily precipitation of the circumference area of tropical cyclones in the western North Pacific is evaluated along their positions. Daily precipitation due to tropical cyclones is intensified under global warming, and there is a tendency that the area where daily precipitation is intensified is extended. Classifying daily precipitation according to the central pressure of a tropical cyclone, it is shown that there is a tendency for precipitation by a tropical cyclone of every strength to increase under global warming. Also, it is shown that the frequency of extremely strong precipitation increases, although the numbers of the tropical cyclones decrease under global warming in the model. The Kuroshio and the Kuroshio Extension, which are not realistically reproduced by a coarse resolution climate model, are reproduced well by a high resolution atmosphere-ocean coupled model, and their responses to global warming were investigated. The result shows that a significant change of the position of the Kuroshio and the Kuroshio Extension at the east coast of Honshu, implicated in the previous researches, do not exist, and the current velocity of the Kuroshio and the Kuroshio Extension increase by 20 to 30%. This acceleration of the current velocity is due to the change of the wind stress over the North Pacific.

2) Coupled model development group

a. Model performance experiment

The Coupled model development group was

launched in the program from FY 2004 in order for FRCGC to contribute its sufficient result to the 5th IPCC assessment report. Based on the model used in the Kyousei project, the group aims to develop a coupled model that has the world highest accuracy in collaboration with CCSR and NIES.

The radiation code of the model used in the experiment for the AR4 in Kyousei Project 1 was replaced with a code of higher precision (Sekiguchi 2004). The integration of the atmospheric model was conducted for 25 years (1978-2002) prescribing the observed sea surface temperatures. The following issues became evident by comparing model-produced and observed climatology.

- a-1. Dry biases in the eastern part of the subtropical highs in the lower troposphere.
- a-2. Considerably low monsoon precipitation in the tropical oceans and excess precipitation over the area elongated zonally to the winter hemisphere.
- a-3. Almost barotropic high pressure errors seen over the area from Greenland to the north-eastern part of Canada in boreal winter.
- a-4. Excessive water vapor and significantly low temperature around the tropopause in high latitudes.
- a-5. At all layers in the troposphere, cloud amount is too much for the cloud of large optical thickness.

Excluding a-3., these issues are considered to have relation with cumulus convection parameterization, diagnosis of the cloud in the model and cloud microphysics. In order to clarify the causes, the group will improve the model. Since insufficient treatment of topography and sea surface temperature anomalies in a distant place may cause anomalies like a-3., both will be examined.

b. Model performance evaluation

–Characteristic phenomena in a high resolution ocean GCM–

Using high-resolution atmosphere-ocean coupled general circulation model, we reproduced seasonal cycle of the Mindanao Dome (MD). The attenuation of MD is due to the negative wind stress curl and westerly wind. By the favor of high resolution, seasonal cycle of the wind stress curl is realistically reproduced.

3) Paleoclimate Research Group

a. Paleoclimate reproduction experiment using mid-resolution coupled model

a-1. Overview of the Last Glacial Maximum (LGM, 21,000 year before present) and analysis of the role of external forcing: orbital parameters, CO₂ and the ice-sheets.

The results of an LGM experiment using mid-resolution coupled model MIROC 3.2 (developed in collaboration by CCSR/NIES/FRCGC) was compared with the paleo-data to evaluate its reproducibility, and furthermore we identified the role of various forcings in the climate changes through additional sensitivity experiments.

The agreement between the data and the model results is very well in terms of the climate sensitivity and the air temperature distribution over the tropical regions where abundant datasets are available. We found it is useful to employ the LGM period in order to determine the sensitivity for the global warming, at least for the low latitudes where the lower concentration of the atmospheric carbon dioxide mostly determine the temperature reduction at LGM. The continental ice sheets significantly affect the atmospheric temperature distribution over the Pacific near Japan, besides the carbon dioxide change, and some prominent features such as the southward relocation of Westerly, intensification of the Aleutian low, reduction of the subtropical high over the Pacific, suppression of Northeastern Pacific cooling, intensification of the Oyashio current, and the southward relocation of the Kuroshio current are observed in the LGM experiment. Regarding the thermohaline circulation in the North Atlantic, the intensity is held above the standard experiment even after 1,000 year integration. The intense circulation is kept by numerous factors: the ice sheets in the northern hemisphere, the stronger ocean currents in the Labrador and near the south of the Denmark Strait, suppression of northern currents which exist near the sea ice margin (which relocate southwards in the LGM experiment) in the standard experiment. The amplitude of ENSO with the coupled model increased in the full LGM experiment as well as in the additional experiment in which only the atmospheric carbon dioxide is set as low as LGM, whereas that in an experi-

ment with increased carbon dioxide is significantly reduced.

a-2. LGM simulation from the viewpoint of climate sensitivity and global warming experiments

It is important to investigate what causes dispersion of climate sensitivity between models in order to discuss uncertainty in global warming projection. This kind of dispersion is closely related with processes and parameters that cannot be determined by the present-day climate observation. We analyzed observational data, control experiments, and global warming simulations in collaboration with the Global Warming Research Group until last year. This fiscal year we examined how exactly we can specify the range of uncertainty in the model climate sensitivity through analysis of LGM and related climate simulations. Firstly we performed (1) comparison between different models (IPCC/PMIP2) and then made (2) comparison of the same model with different parameters. Since the climate sensitivity has been analyzed mainly using an atmospheric model coupled to a slab-ocean component, we first compared the results of an atmospheric general circulation model (GCM) coupled to a slab-ocean, and fully coupled GCMs before that between fully coupled GCMs, in order to systematically identify the influence of the ocean GCM on climate sensitivity. We found that an ocean GCM enhances local variability (e.g La Niña type tropical sea surface temperature changes, and meandering of the prevailing westerlies) but affects little on globally averaged quantities; global climate sensitivity differences come mostly from an atmospheric component of each coupled model. The other analysis employs two versions of MIROC (one with 4°C climate sensitivity of the standard global warming experiment, the other with 6°C by tuning cloud parameters) applied to both the global warming and LGM experiments. The difference of the climate sensitivity of the two versions shown in the LGM experiments is not as large as that in the global warming experiments, and both versions reproduces the LGM climatology well. The reason for this is that the influence of cloud feedback especially in mid- and high-latitudes differs between the global warming and LGM experiments; the globally averaged cloud feed-

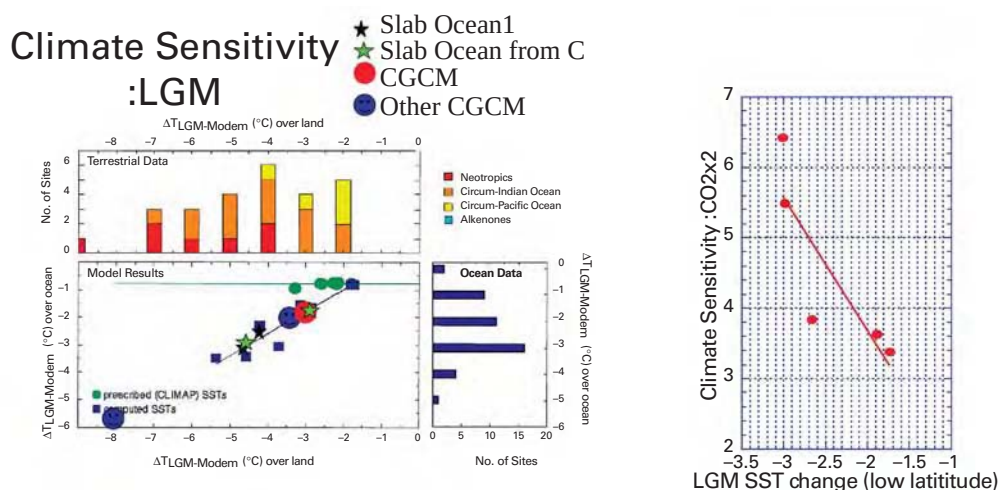


Fig.14 (Left plate): Comparison between the LGM model simulations (including MIROC 3.2 mid-resolution and atmosphere-slab-ocean coupled GCMs) and the PMIP LGM dataset. Our results fit the data relatively well.

(Right plate): Climate sensitivity of the global warming ($CO_2 \times 2$) experiments against that of the LGM simulations (from tropical SST) both using MIROC 3.2

back in the global warming experiment is positive, whereas that in the LGM experiment is negative. These different and nonlinear responses in the LGM and global warming experiments show how complex the cloud and other processes are.

b. The glacial cycle simulation using a high resolution ice sheet model and its underlying mechanism

An ice-sheet model was developed and its uncertainties were examined through the numerical simulations of the model to the Antarctic and Greenland ice-sheets under the modern climate conditions. In this fiscal year, we have made a future projection and analysis of the model ice-sheet response obtained via applications of the polar climate changes from the (IPCC) global warming experiments, in addition to further model refinement. Furthermore, we have successfully reproduced the ice-age glacial history; 100,000 year cycle with realistic 150 meter sea-level amplitude at maximum, and the geographic distribution of ice-sheets. We examined contributing factors in the ice-age climate oscillation, and found that the 100,000 year cycle is mainly driven by the changes of the Earth's orbital factors, and that changes of the atmospheric concentration of carbon dioxide and relating feedbacks enhance the amplitude to a great extent. We also found that geographic distribution of ice-sheets is more strongly influenced by summer temperature than a usually hypothesized precipitation (snow) factor. We consider

these investigation and simulations very important for the projection of the future climate and sea-level changes.

(6) Global Environment Modeling Research Program

The mission of the program is to develop new climate models, global environmental models, and ocean data assimilation systems to be run on the Earth Simulator and study climate phenomena by using these models. There are three major activities in the program as follows.

- The development phase of the "next generation" atmosphere and ocean models have been completed. The atmosphere model using an icosahedral (quasi-uniform) grid system with horizontal mesh size of 5 km or less can simulate tropical cloud clusters and other mesoscale atmospheric systems explicitly without parameterizations. The ocean model using a cubic grid system with horizontal mesh size of 10 km or less can simulate the mesoscale eddies explicitly without parameterizations. Currently, climate phenomena are analyzed by using these models and improvement of the models are also carrying out.
- Development of "integrated" models to include new elements such as atmospheric composition, global carbon cycle, ecosystem dynamics on the basis of currently existing climate models cooperating with other research programs. Development toward this "Integrated Earth System Model" starts from

FY2002 as a part of the MEXT new project.

- In addition to the above described model development, ocean data assimilation systems are also developed in this program. Four-dimensional variational data assimilation systems, which incorporate satellite and in-situ observational data into numerical models, are the target of development. These can provide realistic initial conditions for adequate prediction and also useful re-analysis datasets for accurate estimation of ocean circulation processes.

1) Next-generation model development group

a. Next generation atmospheric modeling group

In order to avoid the ambiguity of cumulus parameterization that is one of the most uncertain factors in the climate modeling, we have been developing a super-high resolution global atmosphere model, which is based on the nonhydrostatic system and the icosahedral grid since the year 2000. This model is called NICAM (Nonhydrostatic Icosahedral Atmospheric Model). By the end of fiscal year 2004, we installed all the physical processes into the dynamical core and completed the development of the first version of NICAM successfully.

In this fiscal year, as the first attempt of global cloud resolving simulation by NICAM, we have conducted an aqua planet experiment, which is proposed as an international model inter-comparison project. Although this experiment is idealized so as that the bottom boundary is assumed to be the ocean, it is useful for basic understanding of organization of cloud cluster in the tropics and global water circulation. To obtain an appropriate initial condition for experiments by use of NICAM, we conducted 3.5-year integration using a conventional AGCM, i.e., CCSR/NIES/FRCGC AGCM version 5.7 with resolution of T42L59. The zonal climatology of the last 3 years in this run is used as the initial condition of NICAM with horizontal resolution of 14km. Then, we conducted 90-day integration by the 14km model. The first 60 days are regarded as a spin-up time and the last 30 days are the analyzed term. Interpolating the result of 14km-run at day 60 into 7km grid points, we conducted 30-day integration by the 7km model. In the similar way, the result of 7km-run at day 80 is used as the initial condition for the 3.5km

model experiment and 10-day integration was conducted for this highest resolution run.

Figure 15 shows the global distribution of precipitation rate at day 85 obtained by the 3.5km-run. The hierarchical cloud structure such as ITCZ, super cloud cluster, cloud cluster, and meso-scale cloud system are well captured. Figure 16 shows the Hovmoller diagram of outgoing longwave radiation (OLR) at the equator for the three runs. These figures well capture that a few of low-value OLR regions are located with several 1000km interval and move eastward. These correspond to super cloud clusters and have structures of the convectively-coupled Kelvin wave. Figure 17 is zoomed-up picture of a typical super cloud cluster. The eastward phase speeds of super cloud clusters are not different

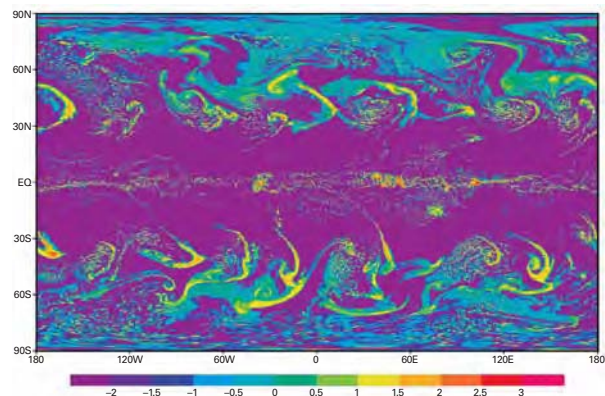


Fig.15 Global distribution of precipitation at day 85 of 3.5km-run. The color scale is log (precipitation/(mm day⁻¹)).

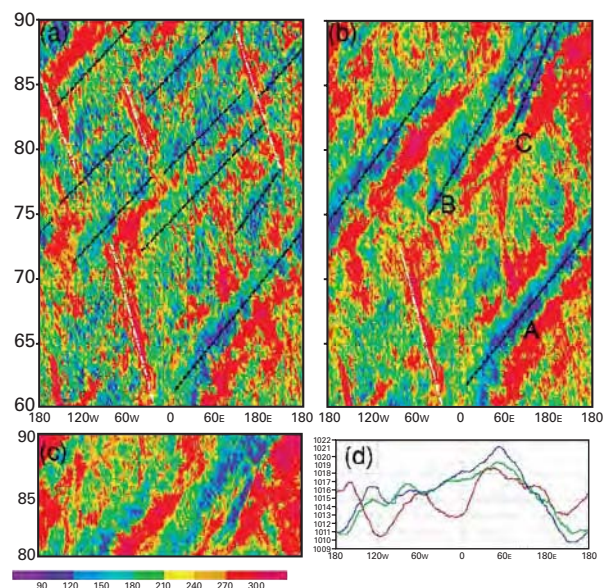


Fig.16 Hovmoller diagrams of OLR averaged in 2S-2N for (a) 14km-run, (b) 7km-run, and (c) 3.5km run. (d) The zonal distributions of surface pressure averaged in the last 1 day and 5S-5N for 14km-run (red), 7km-run (green), and 3.5km run (blue).

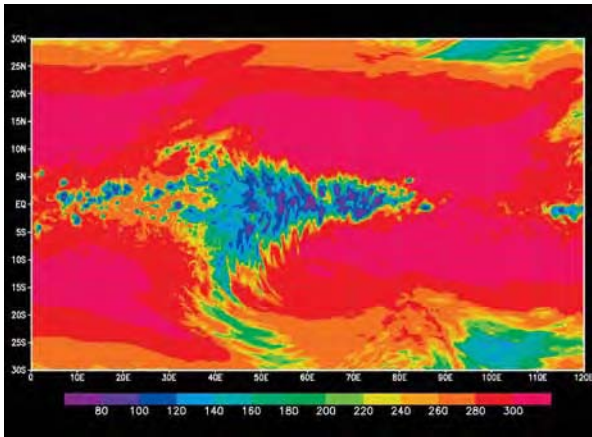


Fig.17 OLR in a typical cloud cluster (7km-run).

between 7km-run and 3.5km run; it takes about 25-40 days to move around the globe. On the other hand, the phase speed for 14km-run is faster than those of the higher resolution runs. The high resolution results may be relatively realistic in terms of intra-seasonal oscillation such as MJO. We also analyzed the diurnal cycle of precipitation rate. As a result, the conventional GCM (T42) that employs the cumulus parameterization has a peak of precipitation rate at the midnight, while the NICAM has its peak at the early morning. Furthermore, we found that NICAM can also capture the weak maximum in the afternoon. These features are consistent with observation on the open ocean.

b. Next Generation Ocean Modeling Group

In order to study mesoscale eddy activities in the world ocean, an ocean general circulation model which has high computational performance has been developed. The model employs a cubic-grid system to increase the time-step-width. A long time-integration is carried out to evaluate the physical performance. Fig.18 shows the calculated meridional stream function after 1000 year integration. For comparison, that of a lon-lat model is also shown. The result of the cubic model agrees very well with that of the lon-lat model. Fig.19 shows the relation between the maximum grid size and the time-step-width. The time-step-width of the cubic model is at least 5 times longer than that of a rotated lon-lat one and the high computational performance of the new model is clearly shown.

Before studying the mesoscale eddy activities in the world ocean, the activities in the Southern Ocean is investigated. Figure 20 shows the eddy buoyancy flux

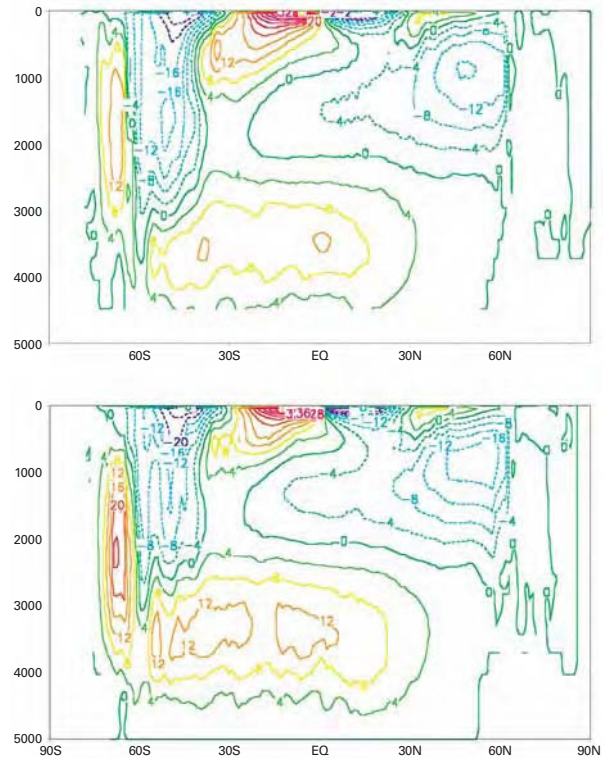


Fig.18 Meridional stream function [Sv] of cubic (top) and longitude-latitude (bottom) grid systems after 1000 yr integration.

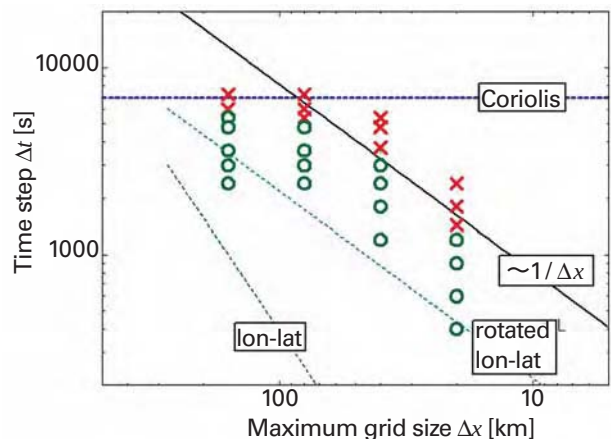


Fig.19 Relation between maximum grid size Δx and time-step-width Δt . The circles denote the time-step-width of successful integration, while crosses denote that of failed integration.

convergence (EBFC) in the Southern Ocean obtained by using the COCO model. The distribution contains rich information regarding the role of eddies to large scale ocean current. It shows that the intensity is strong in the ACC and Agulhas Retroflection region. In the ACC, the EBFC is positive on the poleward flank and negative on the equatorward flank of it. In Drake Passage and Argentine Basin, the negative EBFC regions are located north of Subantarctic Front and the positive regions are located south of Polar Front. In the east of the Kerguelen Plateau, the strong negative (positive) region exists

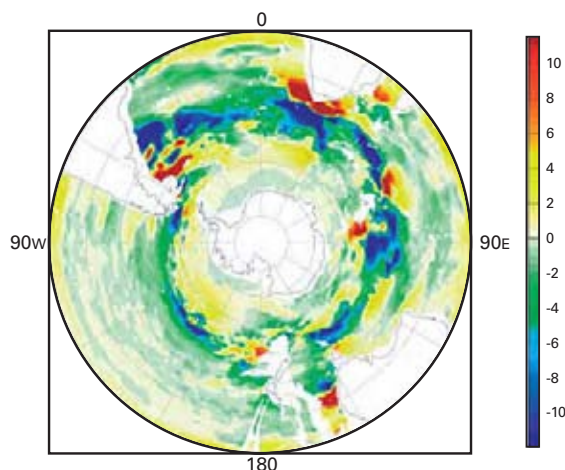


Fig.20 The eddy buoyancy flux convergence at 2000 m depth (unit: $4 \times 10^{-13} \text{ ms}^{-3}$).

north (south) of Polar Front. In Agulhas Retroflection region, the EBFC is positive on the north side of the Agulhas Current and negative on the south side of it. The EBFC distribution contributes to flatten the tilting of isopycnal surfaces in these regions.

2) Development of an integrated earth system model for global warming prediction

The objective of the Subject 2 of the Project for Sustainable Coexistence of Human, Nature and the Earth (hereinafter Kyousei-2 after its Japanese name) is to develop an integrated Earth system model which enable us to understand the way how various components consisting the Earth's environment interact each other and evolve as a system under the global warming and cause consequent changes in climate and vegetation. Kyousei-2 is a cross-cutting project involving members from multiple programs of FRCGC and other institutes, because development and application of such a model requires expertise from various fields. It is this aspect that makes Kyousei-2 unique among activities of FRCGC.

Figure 21 shows the structure of the integrated earth system model that is being developed. As of March, 2005, all the components except the vegetation dynamics model have been introduced to our coupled atmosphere-ocean model (MIROC) and interactions among components are built in. Further, the effort is directed to extending the top of the atmosphere model from the current 20 Km to 80 Km to better reproduce the stratospheric processes. Kyousei-2 has 4 sub-themes, namely, "development of a coupled carbon cycle - climate

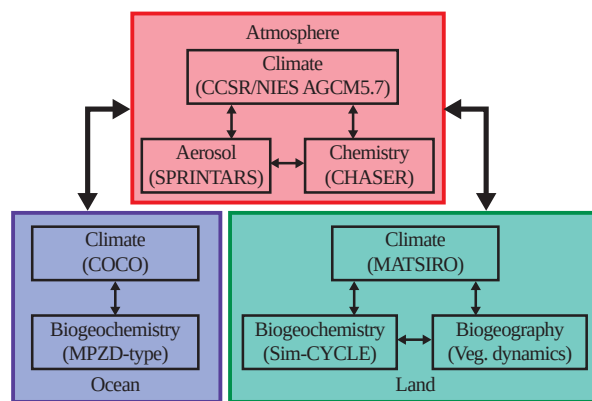


Fig.21 Structure of the integrated earth system model of FRCGC. Note that the vegetation dynamics model is now separately developed and yet to be incorporated in the integrated model.

change model", "development of a coupled atmospheric composition - climate change model", "development of a cryospheric climate system model" and "improvement of the physical climate system model". Each sub-theme constitutes a group, which contributes to the model development while conducting studies in its own right.

a. development of a coupled carbon cycle - climate change model

We performed a preliminary experiment to investigate the feedback between climate and carbon cycle using our coupled carbon cycle - climate model. The results show that the feedback is weaker than is obtained by the two precedent models of the Hadley Centre and IPSL (Fig.22). Analysis also reveals that the model yields a good agreement on the oceanic storage of anthropogenic CO_2 on a larger-than-basin spatial scale. In particular, it is encouraging that there is a good match for both concentrations and distribution in the Southern Ocean. It has been suggested that there exists

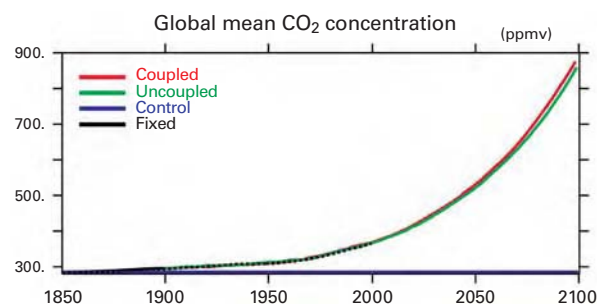


Fig.22 Development of atmospheric CO_2 concentration obtained by the FRCGC integrated earth system model providing CO_2 emission data as input after 1900. The red line shows the case where interactions between climate and carbon cycle are considered, and the green line not. Units are ppmv.

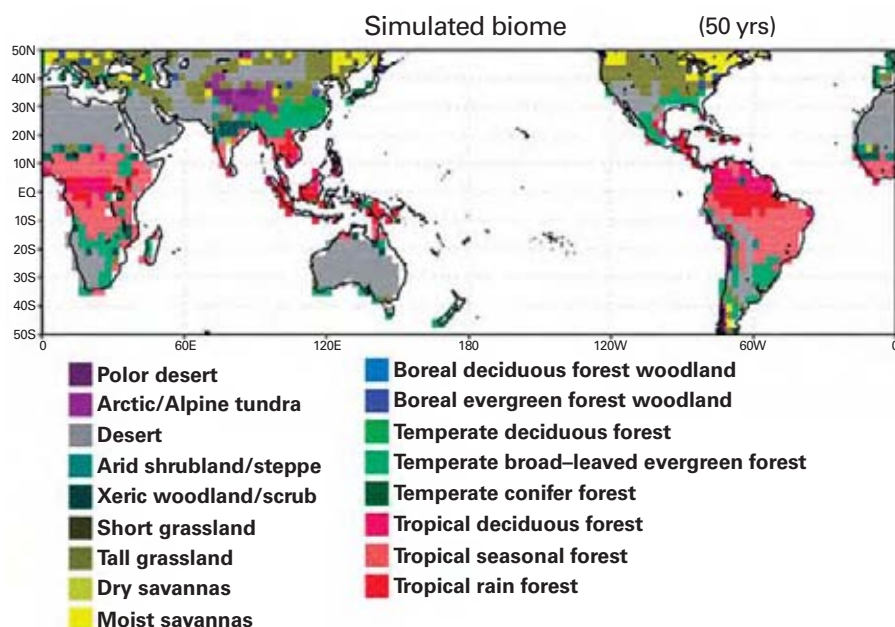


Fig.23 Vegetation distribution on global scale obtained by a preliminary experiment using SEIB-DGVM. The map shows the result of 50-year integration starting from bare land. Different colors correspond to different vegetation types.

largest uncertainty for estimating the oceanic uptake of anthropogenic CO_2 (Orr et al., 2001; Friedlingstein et al. 2003). In parallel with the preliminary experiment, parameter tuning has been performed to improve the model results by comparison with observations.

Furthermore, we are developing a dynamic global vegetation model (DGVM) called Spatially-Explicit, Individual-Based DGVM (SEIB-DGVM). As of March, 2005, fundamental coding is completed and preliminary results show that the model can reproduce basic distribution of vegetation on global scale (Fig.23) and some phenomena typically observed during succession of vegetation types.

b. development of a coupled atmospheric composition-climate change model

Under this subject there are two activities. One is for developing a model that explicitly treats interactions between atmospheric composition changes and global warming, and the other is for developing global models that treat cloud-microphysical processes in a more realistic or rigorous way.

For the former, processes from our aerosol model SPRINTARS have been introduced into our atmospheric chemistry model CHASER. So we can perform an experiment for simultaneous estimate of the effects of changes in ozone, methane, and aerosol on radiation

budget under the global warming incorporating chemical and physical interactions among these constituents. After introducing the aerosol processes, CHASER has been implanted into the integrated earth system model. Also, experiments have been performed on the influence of climate change on atmospheric composition, the results of which were submitted to a group which is preparing materials for IPCC 4th Assessment Report (AR4). For example, projected global mean methane concentration at 2100 is estimated to be 20% lower when one takes into account influences of the global warming than it is in the case where this feedback is ignored (Fig.24).

For the latter, an attempt has been made to improve parameterization of CCN number density by development of a new scheme for CCN number density based on a detailed cloud microphysics model and also by comparison with satellite data. Results obtained through this effort indicate that organic aerosol is more important as CCN than has been previously thought. Especially in the tropics, organic aerosols emitted from vegetation on land are crucial to determine cloud droplet size in the region. Also, a framework has been established for collaboration between the development team for the global cloud-resolving model NICAM (Nonhydrostatic ICosahedral Atmospheric Model) and Kyousei-2. We plan and partly started to incorporate

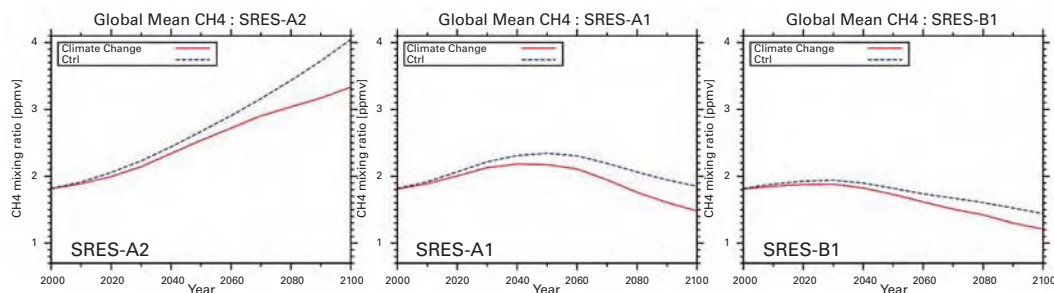


Fig.24 Temporal evolution of global mean methane concentrations projected from 2000 to 2100 for SRES A2 emission scenario (left) which is a high case, A2 which is an intermediate case (middle), B1 which is a low case (right) from 2000 to 2100. Solid lines show results from the simulations which include climate change as well as emission changes, with dashed lines for the control simulations with emission changes only (using present climate).

SPRINTARS and a cloud microphysics model with the base function method into NICAM.

c. development of a cryospheric climate system model

Efforts have been directed so far to elaborate the ice sheet model developed at the Center for Climate System Research, Univ. of Tokyo and the sea ice model embedded in our coupled atmosphere-ocean general circulation model MIROC. This year (FY 2004), computer programs have been developed so that one can perform numerical experiments combining MIROC and the ice sheet model. Furthermore, we have started examination on the influence of the global warming on the cryosphere including the ice sheets and sea ice in Antarctica and Greenland. Specifically, we have started experiments where CO_2 concentration is increased by factors of 2, 4, and 8 with integration periods of 1200, 800, and 300 years, respectively, in order to see how climate and ice sheets respond on such long time scales.

d. improvement of the physical climate system model

This year (FY 2004), we improved Hines (1997)'s gravity wave drag parameterization (HGWDP), which was introduced into our atmospheric general circulation model (AGCM) in the previous FY, by utilizing data of gravity wave intensity spectra generated by high resolution versions of our AGCM. The purpose is to relieve the cold bias at high latitudes of the winter hemisphere and reproduce stratospheric Quasi-Biennial Oscillation in the equatorial region with the standard resolution (T42) of physical climate system model which is to be adopted as the base model of the integrated earth system model. While efforts have been

made since the last year (FY 2003) to extract information on sources of non-orographic waves from results of a high-resolution AGCM, that is to be provided to HGWDP, the results from a T106 model, however, do not exhibit enough upward transport of momentum. In FY 2004, therefore, the horizontal resolution was increased to T213. Global distributions and properties of gravity waves that emerged in the T213 model were examined to devise more elaborated way to estimate gravity wave sources and to provide information to HGWDP.

3) Data Assimilation Group

The progress of the group is described in the report of the Research Project for Sustainable Coexistence of Human, Nature, and the Earth, "Development of 4-D Data Assimilation of System and Construction of Data Base for Climate Research".

(7) High-Resolution Ocean Data Assimilation and Subject 7 of RR2002 "Research Development of Advanced Four-Dimensional Data Assimilation System Using a Coupled Atmosphere-Ocean-Land Surface Model Toward the Construction of High-Quality Reanalysis Datasets for Climate Prediction"

A data assimilation approach has increasingly gathered attention from both scientific and social viewpoints (e.g., CLIVAR Report in 2004), since it enables us to obtain an optimum synthesis of observational data and model results for a better description of global environmental processes.

Data Assimilation experiments so far show that among a variety of assimilation methods, the 4-dimensional variational (4D-VAR) adjoint approach is one of

the most attractive methods, as it has the ability to provide the best time-trajectory fit to observational data and thereby produces a dynamically self-consistent space-time dataset. Such datasets are urgently required for more accurate seasonal to interannual (S-I) prediction and are essential to our understanding of the nature of climate variability and global warming processes. In fact, previous studies using the variational adjoint method in meteorology and oceanography have significantly contributed to the identification and characterization of realistic features of the climate state.

However, all of the previous data assimilation systems lack some important aspect of the climate system, particularly in both resolutions required for the reproduction of realistic meso-scale features and descriptions of multi-sphere interaction processes that play crucial roles in important climate events such as the monsoon, El Niño and Southern Oscillation (ENSO) phenomena. This is due to the primary difficulty arising from two major problems; [1] the huge computational resources required for the use of a coupled model as a base state of the assimilation system and hence [2] the existence of large differences in the statistical characteristics of tempo-spatial variabilities inherent among atmospheric, oceanic, and land-surface processes. In fact, no truly coupled data assimilation system has yet been realized.

In our research project, we take up the challenge of developing both a high-resolution 4D-VAR ocean data assimilation system and a leading-edge 4D-VAR coupled data assimilation system, with the aim to better represent the dynamical state of climate variability and thereby construct a comprehensive reanalysis dataset offering greater information content and forecast potential than existing approaches. We use the Earth Simulator as it offers the highest computational performance in practical use and hence enables us to avoid problem [1] above. To cope with problem [2], our assimilation strategy is directed to the direct correction of the monthly-mean state (here described as the "slow-mode") by data assimilation. Note that the monthly mean state is regarded as a background state from which many of meso-scale events characterizing "fast-mode" fluctuations emerge. Such a comprehensive correction can improve both fast- and slow-mode

features through enhanced performance of the forward model calculation.

1) Dynamical ocean state estimation and water mass analysis using a 1990's ocean data assimilation experiment

We have developed a 4D-VAR ocean data assimilation system and have applied it to a reanalysis experiment during 1990-2002. This experiment assimilated all the observational data available (e.g., Reynolds SST, World Ocean Database1998, FNMOC, TOPEX/POSEIDON sea surface height anomaly data, and recent ARGO float data) into an ocean general circulation model.

The obtained reanalysis dataset shows good consistency with previous knowledge of important climate events. For example, the evolution of Nino3 SST is well reproduced (its error value reduces to about 1/2 of that from the earlier simulations of Fig.25), which supports the notion that our dataset accurately represents the climate variability in this region. Further, our reanalysis dataset exhibits realistic subsurface water mass distribution and enables us to clarify the water mass formation and movement processes (Fig.26). An application of a sensitivity experiment to the dichothermal and mesothermal water pathways that characterize the northwest North Pacific circulation is performed in which we investigate the sensitivity to an artificial cost given in the subarctic Pacific region. The distribution of adjoint variables shows good consistency with previous studies of the subtropical Kuroshio Extension

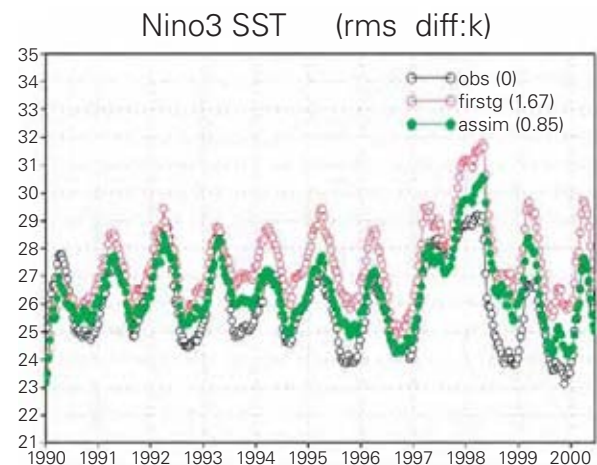


Fig.25 Time change of NINO3 SST. Black line for observation, red line for simulation, and green line for assimilation, respectively.

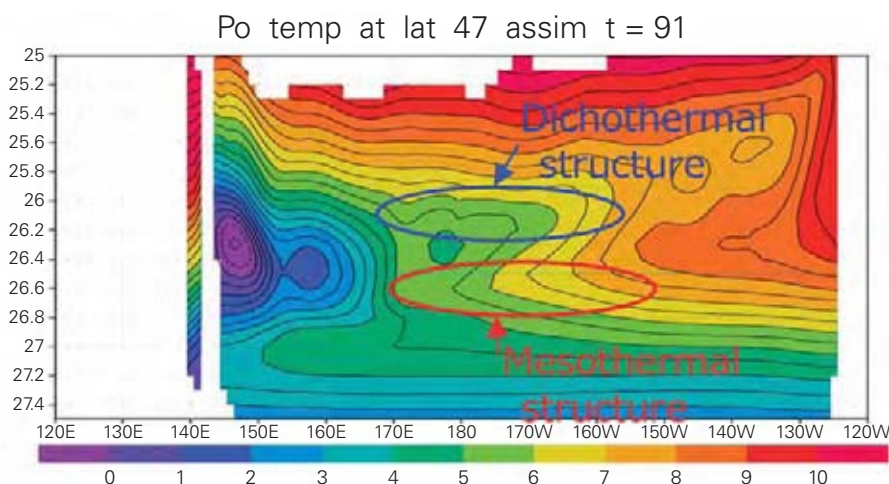


Fig.26 Dichothermal and mesothermal water structure reproduced by our assimilation experiment.

region and western subarctic region. This result clearly represents the source region of this water.

2) A 4D-VAR coupled data assimilation system study

a. Improvement of the climate model

In general, models used in any 4D-VAR approach inevitably require levels of performance sufficient to provide full descriptions of the essential physical processes as describe above. Hence, we have improved the coupled atmosphere-ocean-sea ice-land surface model for the Earth Simulator (CFES). For this reason, by collaborating with staff of the Earth Simulator Center, we have made many modifications and have generally fixed the system by improving key aspects of the physics, thereby enhancing the physical and computational performance of the CFES to levels suitable for a 4D-VAR system. For example, we have incorporated three important new schemes into the CFES: [1] A diagnostic calculation scheme for lower stratocumulus based on Slingo (1987), [2] a land parameterization scheme MATSIRO (Minimal Advanced Treatments of Surface Interaction and Runoff; Takata et al.,2003) instead of the so-called bucket model, and [3] a new version of radiative process scheme (MstrnX; Nakajima et al. 2000).

Fig.27 demonstrates the effect of the new stratocumulus scheme on the representation of the global climate. The left panel of Fig.27 was derived from the old model and lacks a stratocumulus component on the west of continents. The scarcity of stratocumulus works to generate a sea surface temperature (SST) bias, which is also found in many other climate models. On the other hand, the new scheme (right panel) works to increase an amount of stratocumulus so that the warm SST bias along the coasts significantly weakens.

The effect of including the MATSIRO scheme on the hydrological cycle over land is illustrated in Fig.28, in which the difference in precipitation between the bucket model and the MATSIRO case is apparent. Precipitation with the bucket model (the middle panel) is too high over the continents as compared with observations (left panel), whereas that in the MATSIRO case becomes more realistic in both spatial distribution and intensity (the right). This is because the MATSIRO scheme has the ability to treat the evapo-transpiration process by vegetation adequately.

The new scheme for radiative processes also reduces the model biases. Fig.29 shows the climatological annual mean of the zonal averaged air temperature.

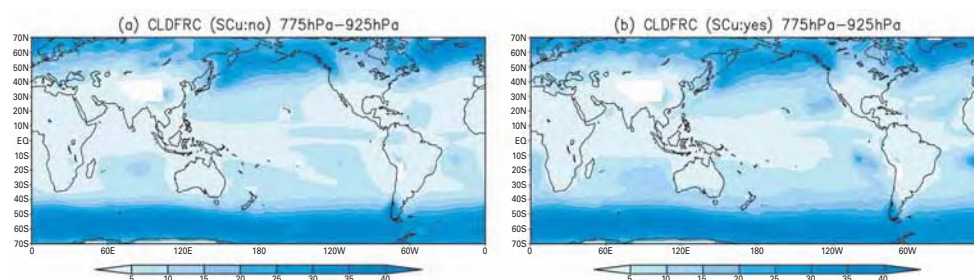


Fig.27 Annual averaged cloud amount (925-775hPa). Left: Old scheme. Right: New scheme.

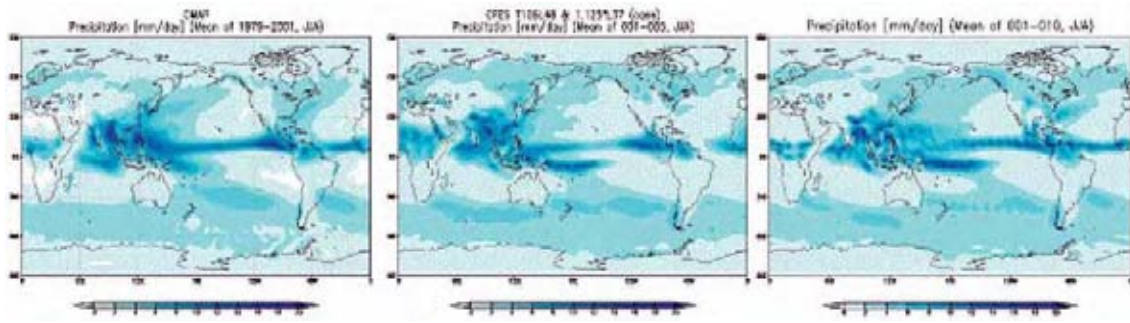


Fig.28 Climatological mean precipitation from June to August. Left: Observation (CMAP). Middle: Calculation with the bucket model. Right: Calculation with the MATSIRO.

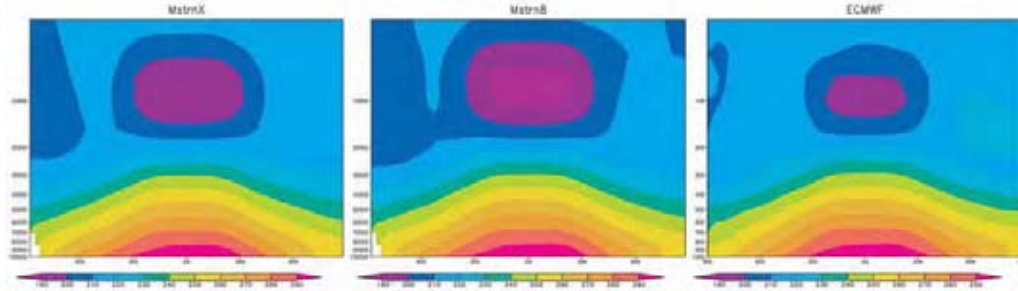


Fig.29 Climatological annual mean of zonal averaged temperature. Left: the ECMWF. Middle: Calculation with the old scheme. Right: Calculation with the new scheme.

The temperature within the stratosphere with the old scheme is too cool relative to the ECMWF. The new scheme largely removes this deficiency. This radiation scheme also refines the mid-latitude wind jets.

b. Coupled data assimilation experiment.

In line with our assimilation strategy, we have successfully constructed a 4D-VAR coupled data assimilation system on the Earth Simulator. To reproduce realistic seasonally-varying states of the global environment in a climatological sense, optimum values of the bulk parameters for air-sea fluxes (chosen as the control variables together with the initial condition) are sought by performing a 4-ensemble experiment that treats the climatological mean of the multi-year model state. In this experiment we assimilated all the observational data available (e.g., PREPBUFFER for the atmosphere, in addition to data observed in ocean described earlier). Based on Sasaki's (1970) "strong constraint formalism", we have obtained an optimized 4-dimensional dataset by minimizing a cost function (e.g., Awaji et al., 2003).

Our output exhibits significant improvements in the quantitative representation of annual mean states and seasonal change. For example, the map of global precipitation (Fig.30) reflects most of the familiar features of past studies. The sea-surface temperature obtained

by our experiment (Fig.31) is in quantitatively good agreement with observational results, and the onset sequence of Indian monsoon rainfall is well reproduced (not shown). Furthermore, our sensitivity experiment using the adjoint model clarified the probability density distribution of moisture sources of rainfall in several key regions (for Russia in Fig.32), thereby enabling us to identify the major source regions. These results confirm that our 4D-VAR coupled data assimilation system is better able to represent the dynamical state of the global environment than earlier models and, further, create new information for better understanding of climate change mechanisms.

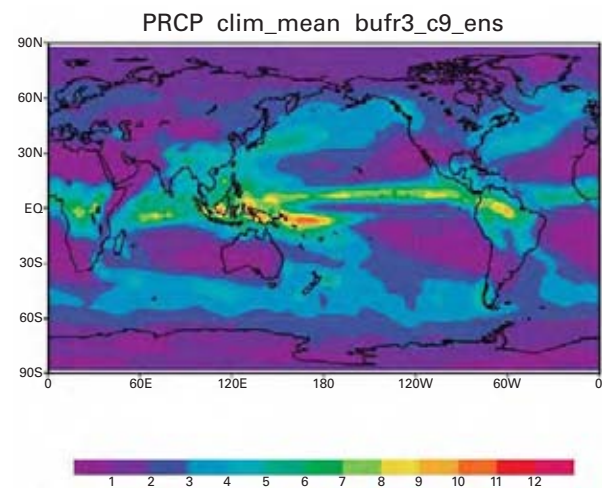


Fig.30 Climatological global precipitation map

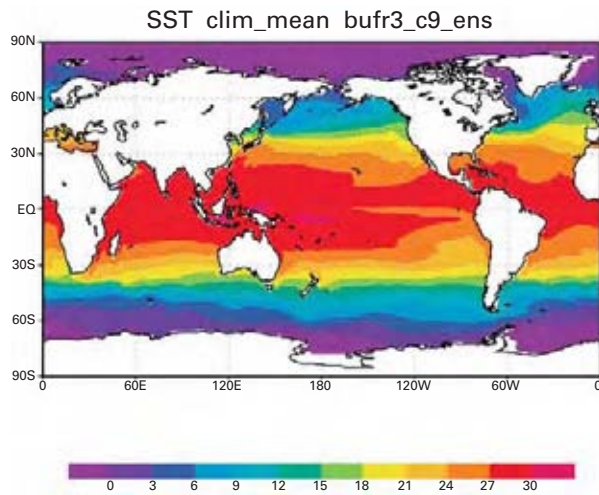


Fig.31 Climatological global SST map

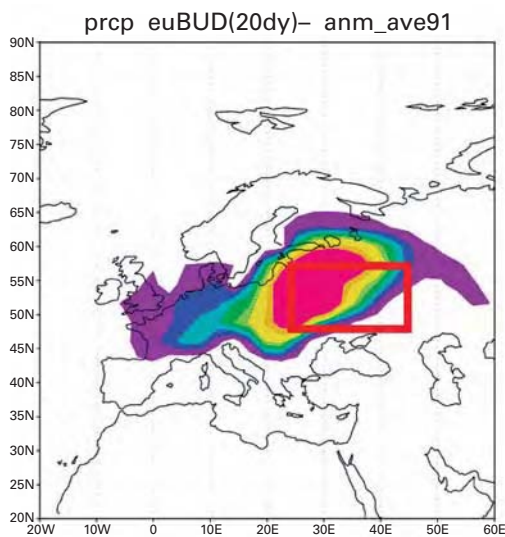


Fig.32 Evaporative source distribution for precipitation around Russia.

The red square is a target region for rainfall events.

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1.1.3 Research on dynamics of the inside of the earth

① Institute For Research on Earth Evolution

(1) Mantle-Core Dynamics Research Program

1) Multi-scale mantle tomography

a. S-wave speed structure beneath the Philippine Sea

We have obtained an S-wave speed model of the upper mantle (shallower than 200 km) beneath the Philippine Sea and its vicinity using data from broadband ocean bottom seismographs (called BBOBS hereafter) and land-based stations. The shallower part of the model has a good correlation with surface tectonics and the deeper part has anomalies associated with the subducted Pacific slab and the spreading Mariana trough (Fig. 1; submitted to Geophys. J. Int.). This work was performed by cooperation with Earthquake Research Institute of the University of Tokyo and partially supported by Grants-in-Aid for Scientific Research.

b. Very slow localized anomaly above the core-mantle boundary beneath western Pacific

Anomalous slow ScS arrivals, delayed by 5-10 s with respect to a reference Earth model, were found on the Hi-net records from Tonga-Kermadec deep earthquakes (Fig. 2). In contrast, S and SKS waves, having similar ray paths near the earthquakes and stations, do not show such anomalies. The slow ScS arrivals are attributed to a very slow localized thin layer above the core-mantle boundary beneath western Pacific.

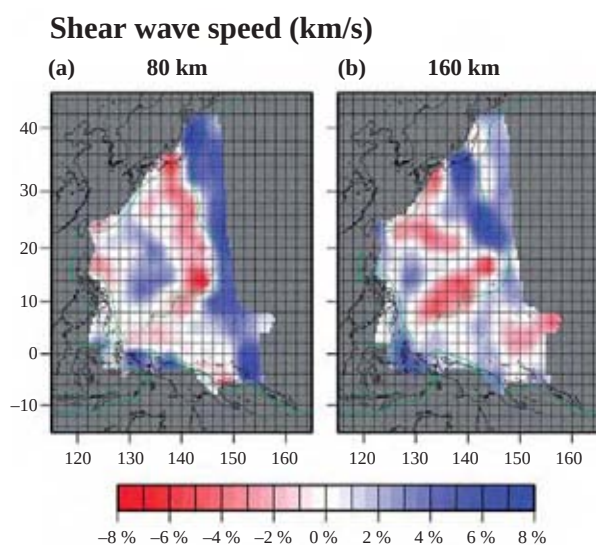


Fig. 1 S-wave speed model beneath the Philippine Sea. (a)80km; (b)160km.

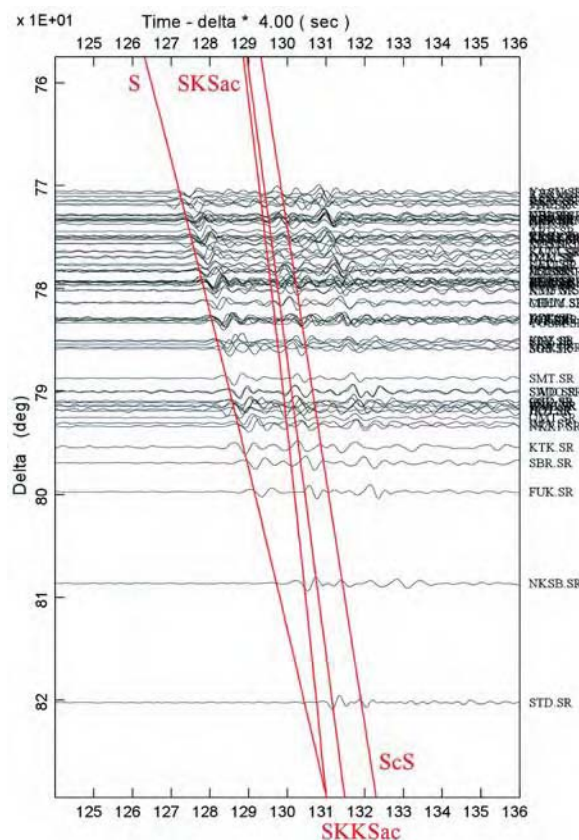


Fig. 2 Record section of Hi-net records for a Tonga-Kermadec deep earthquake. Red curves are theoretical arrival times of S, ScS, SKS, and SKKS waves.

c. Topography on the mantle discontinuities beneath the Japanese Islands

Detailed topography on the 410-km and 660-km discontinuities was determined by ScS reverberations observed on the Hi-net to study thermal anomalies in the mantle transition zone beneath the Japanese Islands. Depression of the 660-km discontinuity associated with the stagnant Pacific slab is found beneath the western Japan (published on J. Geophys. Res.). This work was partially supported by Grants-in-Aid for Scientific Research.

d. A region of High Poisson's ratio is imaged near the slow-slip area detected by GPS observations beneath the Hyuga-nada region in Japan.

e. Arrival time measurements for various body and surface waves have been continued for constructing the arrival time database for high-resolution seismic tomography.

2) Ocean bottom observation for mantle upwelling and down welling

a. Polynesia BBOBS array

We have performed the Polynesia BBOBS array observation successfully, in which ten broadband ocean bottom seismographs (BBOBS) were deployed from 2003 to 2005 in the French Polynesian region by cooperation with Earthquake Research Institute of the University of Tokyo and related French institutions. Noise spectra computed using one-year long data are shown in Fig. 3. The noise level in the frequency range of the micro tremor is lower than that previously observed in other oceanic area as the Philippine Sea and the northwestern Pacific. The work is partially supported by Grants-in-Aid for Scientific Research.

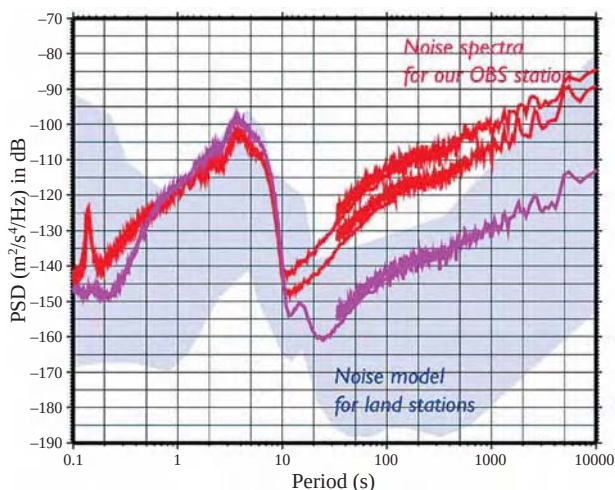


Fig. 3 Noise spectra computed from one-year long data of the Polynesia BBOBS array. Red curves denote spectra from two horizontal components and pink denote those from vertical component. The shaded zone indicates a range of noise spectra computed from land-based broadband stations over the world (Peterson, 1993).

b. The mantle transition zone structure beneath the Philippine Sea from OBS and deep-sea borehole broadband data

The mantle discontinuity depths beneath the Philippine Sea were determined from BBOBS and deep-sea borehole broadband data to estimate temperature anomalies and water contents in the mantle transition zone (published on Bull Seism. Soc. Am.). The work was performed by cooperation with Ehime University and partially supported by Grants-in-Aid for Scientific Research.

c. High temperature anomaly of the mantle transition zone beneath northwestern Pacific

We found a high temperature anomaly in the mantle transition zone beneath northwestern Pacific from seismic waveform and tomographic analyses (published on Earth Planet. Sci. Lett.). We have conducted ocean bottom electromagnetic observation to further confirm its presence and study a nature of the temperature anomaly. We investigate a relationship with "petit spot", which was recently found on the sea floor above the temperature anomaly from geological and petrologic studies.

d. OBEM observation in the Mariana trough

We determined lateral temperature variation and dehydration associated with the seafloor spreading in the Mariana trough by electromagnetic tomography using data from ocean bottom electro-magnetometers.

3) Modeling convection in the mantle and core

a. Computer simulation of the mantle convection

We have succeeded in a computer modeling of mantle convection with Earth Simulator in a realistic regime of Rayleigh number. The post-spinel phase change makes spatial and temporal scales of the simulated convection similar to those estimated by geophysical studies (Figs. 4 and 5). The work is partially supported by Grants-in-Aid for Scientific Research.

b. Analog experiment of the outer core convection

In order to study the outer core convection, we have developed an analog experiment device using liquid metal (Gallium) which enables flow velocity measurement of the liquid by cooperation with Hokkaido University. The measured velocity distribution shows convection cells generated by thermal convection of Gallium.

(2) Research Program for Geochemical Evolution

In order to comprehensively understand the evolution of the solid Earth, the Research Program for Geochemical Evolution is decoding characteristics of volcanic rocks from subduction zones and hotspots, and conducting ultra-high-pressure experiments on Earth-forming materials, in collaboration with satellite

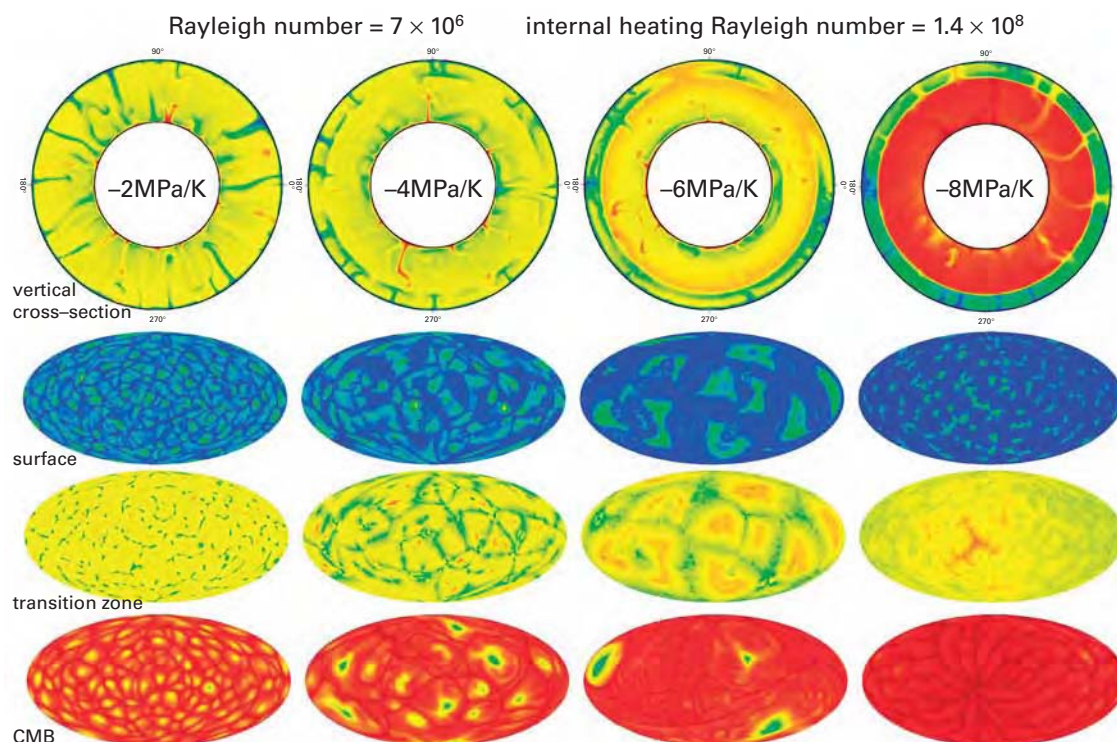


Fig. 4 Temperature distribution by simulation of the mantle convection. The post-spinel phase change is introduced at a depth of 660 km. From top to bottom, a vertical cross-section of temperature distribution, temperatures at surface, 660 km depth, and the core mantle boundary are shown. The Clapeyron slopes are $\gamma = -2, -4, -6, -8$ Mpa/K from left to right.

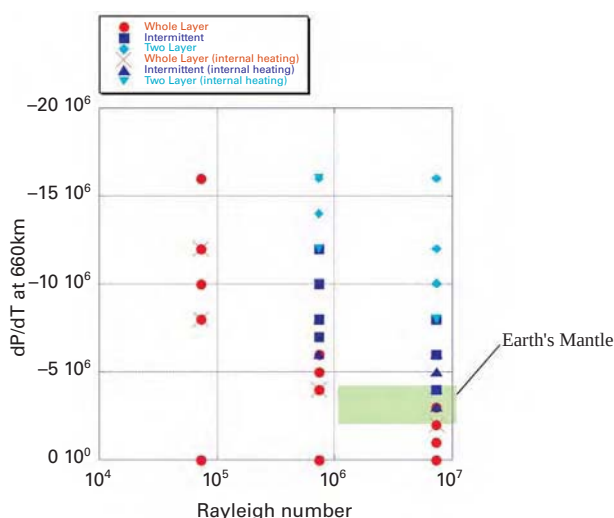


Fig. 5 The mantle convection pattern obtained by various values of the Rayleigh number and the Clapeyron slope of the post-spinel phase change.

laboratories at BGRL of Kyoto Univ., EAR of Univ. Tokyo, Tokyo Inst. Tech., Okayama Inst. Sci., JASRI/SPRing-8. and LIPPI Indonesia.

1) Subduction Zone Magmatism

In order to understand the process of continental crust formation in subduction zones, volcanic rock samples have been systematically collected from arcs with

different maturity, i.e., juvenile Sangihe arc, immature Izu-Bonin-Mariana arc, and mature NE Japan arc. Samples both from on-land and ocean floor have been examined petrographically and geochemically.

One remarkable finding among results of the subduction zone research in this fiscal year would be an innovative view of andesite genesis. Precise Sr-isotope micro-analyses (Fig. 6) were conducted on plagioclase phenocrysts from calc-alkalic (CA) and tholeiitic (TH) andesites from the Quaternary Zao Volcano in the NE Japan arc. $^{87}\text{Sr}/^{86}\text{Sr}$ of plagioclase occurring in TH rocks is constant at 0.70428 ± 0.00005 , whereas that for CA rocks varies from 0.70337 to 0.70418 with decreasing the anorthite component. These results may not be consistent with a general consensus that the major mechanisms of TH and CA andesite production are fractional crystallization of a mantle-derived TH basaltic magma and mixing between TH basaltic and crust-derived felsic magmas, respectively. Instead, two isotopically distinct basaltic magmas could form beneath the volcano, one for the TH series produced by anatexis of the preexisting, hence more radiogenic mafic lower crust, and other for the CA series by par-

tial melting of less radiogenic mantle wedge peridotites (Fig. 7). A mantle-derived CA basaltic magma will mix with crustal TH melts to form CA andesites.

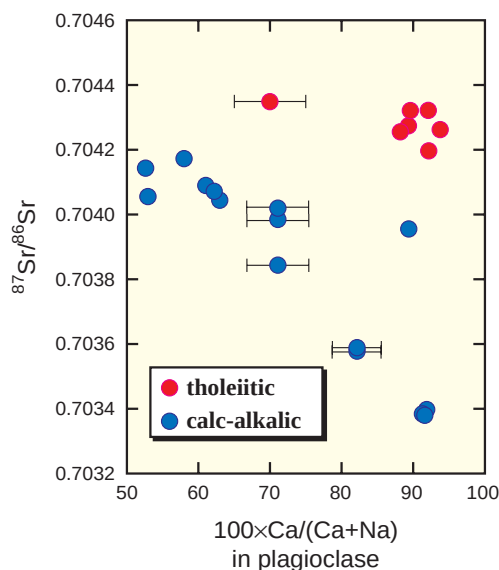


Fig. 6 An example of Sr-isotopic micro-analyses for a plagioclase in a calc-alkalic andesite from Zao Volcano. The $^{87}\text{Sr}/^{86}\text{Sr}$ results are shown relative to the anorthite contents ($=100 \times \text{Ca}/(\text{Ca}+\text{Na})$). The presence of a zoned plagioclase in terms both of $^{87}\text{Sr}/^{86}\text{Sr}$ and $\text{Ca}/(\text{Ca}+\text{Na})$ may be explained by crystallization of high- $\text{Ca}/(\text{Ca}+\text{Na})$ plagioclase from a low $^{87}\text{Sr}/^{86}\text{Sr}$, less-differentiated, possibly basaltic magma, followed by its mixing with high $^{87}\text{Sr}/^{86}\text{Sr}$, differentiated felsic magma and overgrowth of plagioclase within the mixed magma.

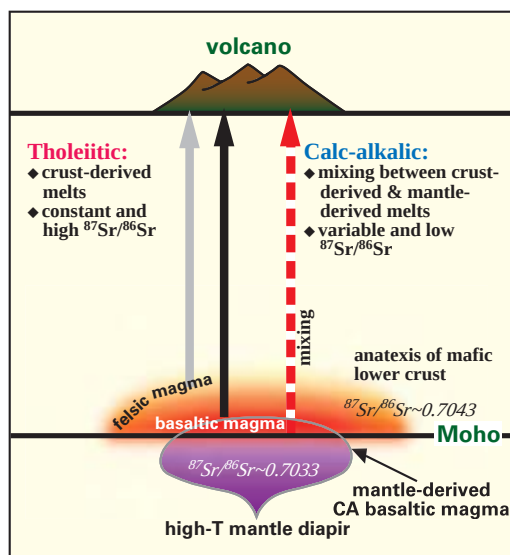


Fig. 7 A new model for generation of two types of magmas beneath arc volcanoes. Tholeiitic magmas are produced by anatexis of mafic lower crust, which can be triggered by heat from a mantle diapir rising to the crust-mantle boundary. Differences in temperature during melting causes variable degrees of melting, ultimately resulting in compositional variations in tholeiitic magmas. A mantle diapir-derived, calc-alkalic basalt magma will entrain intra-crustal tholeiitic melts to form mixed calc-alkalic andesite magmas.

2) Plume Magmatism

In order to define the geochemical characteristics of the Earth's mantle, especially those of the deep mantle down to 2900 km depth, petrological and geochemical analyses have been conducted for basaltic rocks from hotspots in the Asian continental margin, S Pacific and S. Atlantic. One major target of sampling this year was W. Samoa where a geochemical end-member mantle component, EMI, has been proposed.

One major results from this research topic would be on the Jeju plume located immediately behind the SW Japan arc. The upper mantle beneath Jeju Island is characterised by an increased degree of metasomatism and a change in major metasomatic hydrous minerals from amphibole to phlogopite with decreasing depths (Fig. 8). The original plume material, having rather depleted geochemical characteristics, entrained shallower metasomatised uppermost mantle material, and segregated least-enriched low-alumina alkalic, moderately enriched high-alumina alkalic, and highly enriched sub-alkalic magmas, with decreasing depth (Fig. 8).

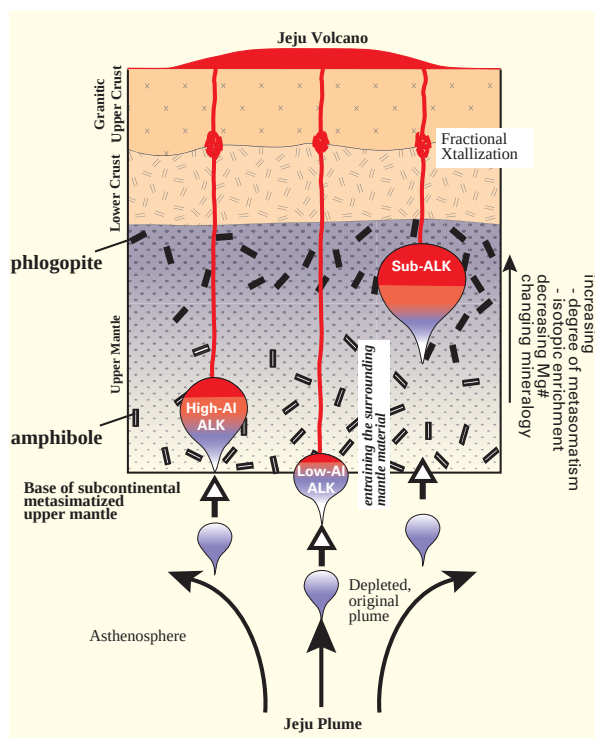


Fig. 8 A schematic diagram illustrating the mineralogical and geochemical characteristics of the upper mantle and the melting regime beneath Jeju Island.

3) High-Pressure Experiments

In order to understand physical properties of deep-earth-forming materials that are critical for decoding the dynamics of the Earth's interior, ultra-high-pressure experiments, combining laser-heating diamond-anvil cells with analyses by ultra-brilliant synchrotron radiation at SPring-8, have been conducted. One important result in this year is the density relationship between materials of the subducting crust and the mantle at whole mantle pressures (Fig. 9), confirming that the oceanic crust is sinking to the base of the Earth's mantle, i.e. to the mantle-core boundary.

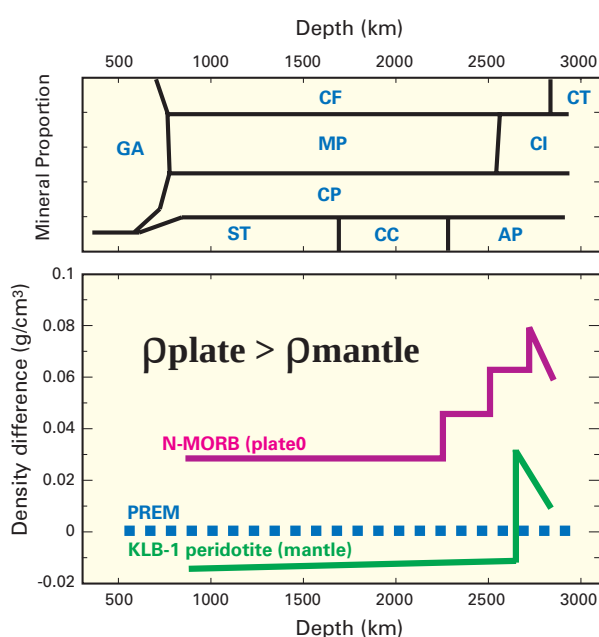


Fig. 9 The change in mineral assemblages in subducting oceanic crust in the deep mantle (upper) and the density relationship between the slab and mantle materials (lower).

(3) Research Program for Plate Dynamics

1) We carried out seismic refraction/wide-angle reflection surveys promoted by "A research project for subduction earthquakes in Nankai and Tonankai". This was also a cooperative research with "A special project for earthquake disaster mitigation in urban area". A result of the surveys shows structural discontinuities at the rupture segmentation boundary between the Nankai and Tonankai earthquakes off the Kii peninsula. (Fig.10, 11)

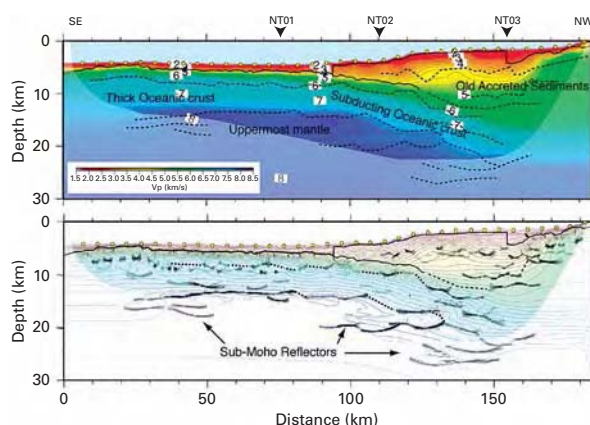


Fig.11 • Thickness variation of the incoming/subducting oceanic crust

- Basically thicker than normal oceanic crust extends to the east of the segmentation boundary.
- Still thicker beneath the topographic high seaward of the trough axis.
- Intracrustal & sub-Moho reflectors beneath the incoming/subducting oceanic crust
 - These reflectors are considered to be originally formed before subduction.
 - Sub-Moho reflectors may play a role as seismic faults of intraplate earthquakes like the 2004 off the Kii Peninsula earthquake.

Wide-angle OBS survey

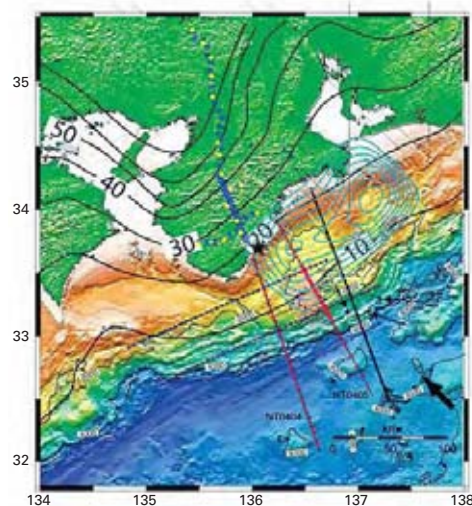


Fig.10

- 2004/ 11
- R/V Kaiyo
- 200L Airgun Array
- 110 OBSs (Red circles)
 - NT0404 (180km)
 - 36 OBSs (5km int.)
 - 100m int. shot
- 12ch MCS
- Land Explosives (Yellow circles)
 - Collaborated with Kyoto Univ.

- 2) We conducted a multi-channel seismic reflection survey to figure out crustal structure of 2004 coseismic rupture area in the Nankai trough off east Kii Peninsula. We have imaged significant seismic reflectors of intraslab thrust faults cutting through the subducting oceanic crust, which are interpreted to be closely related to the 2004 events.
- 3) We conducted a refraction and reflection experiment in the area off Miyagi in the Japan Trench region. This experiment was a part of the pilot research of Miyagi-prefecture offshore earthquake. We are analyzing these data with integrating other data sets in this region. (Fig.12, Fig.13)

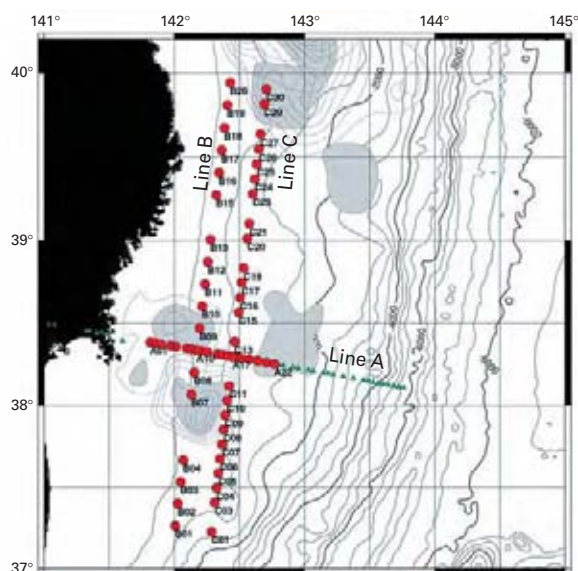


Fig.12 Location map of the experiment off Miyagi. Red filled circles represent Ocean Bottom Seismometers (OBSs). Gray contour lines show the slip distribution for M>7 earthquakes occurred after 1930 (Yamanaka and Kikuchi, 2004).

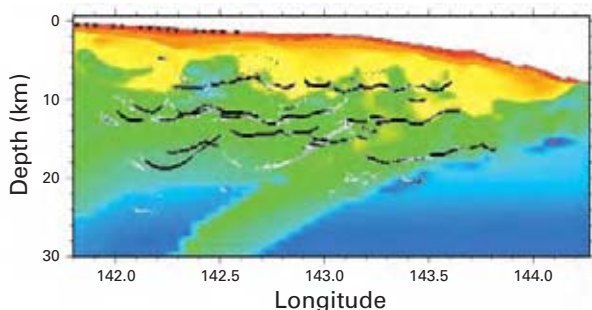


Fig.13 Result of reflection traveltime mapping on the P-wave velocity structure model obtained by the first arrival tomography.

- 4) We are keeping on researching the lithospheric structure and investigating the process of continental growth in the Izu-Ogasawara-Mariana region. We have been conducting the seismic reflection and refraction surveys for the boundary demarcation of the extent of the extended continental shelf in cooperation with Hydrographic and Oceanographic Department, Japan Coast Guard.
 - 5) Material analysis of exhumed seismogenic fault rock progressed to understand micro faulting mechanism in the Shimanto ancient subduction zone.
 - 6) We simulated the rupture process during the 1999 Chi-Chi earthquake, Taiwan, based on high-velocity friction experiments.
 - 7) Plate dynamics modeling group has promoted some simulation and modeling studies on plate dynamics around subduction zone. Especially, it has demonstrated earthquake generation cycle simulation using the Earth Simulator, and developed a new simulation method based on discrete element method. In the earthquake cycle simulation along the Nankai trough, a fluctuation pattern in recurrence interval and earthquake size is qualitatively reproduced (Fig.14).
- (4) Deep Sea Research Program
- One of our Program's objectives is to perform a basic study on seafloor geo-hazard mapping related to earthquakes/landslides. In 2004, we conducted surveys on the seafloor, including in-situ and/or long-term measurements:
- 1) Urgent survey in the 2004 Great Sumatran Earthquake focal area was carried out. We successfully located the ocean floor 'shattered' by earthquake movement, and obtained detailed bathymetry around the focal area, aftershock distribution, etc (Fig.15).
 - 2) Electro-magnetic structure was mapped in the Nankai Trough forearc off Kii Peninsula, revealing a transition from conductive to resistive region along the subducting slab.

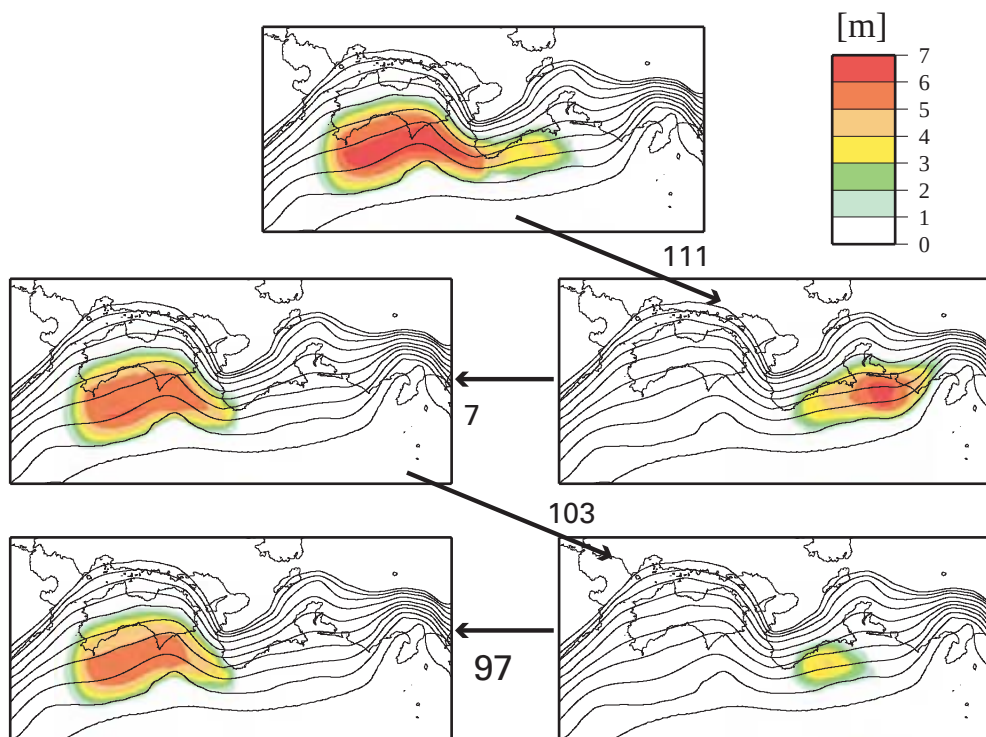


Fig.14 Numerical simulation of earthquake generation cycle in the Nankai subduction zone using the Earth Simulator. The left figure shows the coseismic slip distribution calculated from the simulation results. In the simulation, heterogeneous frictional property is assumed based on the results of seismic imaging that reveals the distribution of subducting seamount, ridge, and so on. Rupture area, slip amount and recurrence intervals are different for each earthquake cycle. This pattern is similar to that of the historical great earthquakes along the Nankai trough estimated from observed data and historical documents.

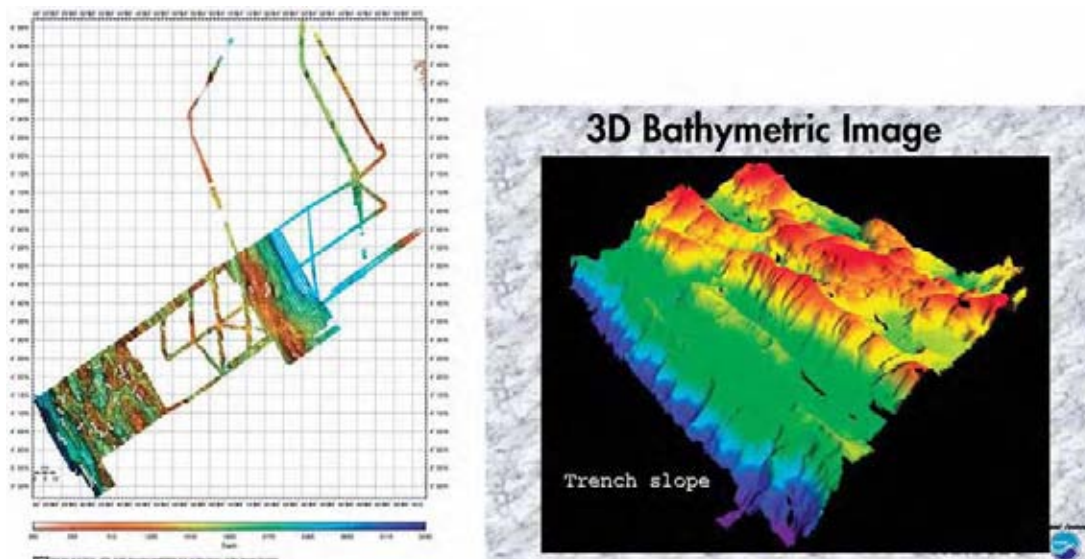


Fig.15 (Left) Bathymetry Map obtained during Natsushima cruise in the Sumatran area.
(Right) Whale's eye view of the trench slope bathymetry.

3) Analysis of core samples taken from Enshu Fault off Tokai area shows that the fault was activated at least 1ky B. P. with a vertical offset of 30 cm.

Activity of Taiwan Chelungpu Fault during the Chi-chi earthquake in 1999 has been investigated through scientific drilling (TCDP):

4) A 2-km scientific drilling was successfully completed. A fresh fracture zone, a possible candidate for the fault at 1999 event, was clearly detected at 1111 m. In-situ stress was measured from core samples.

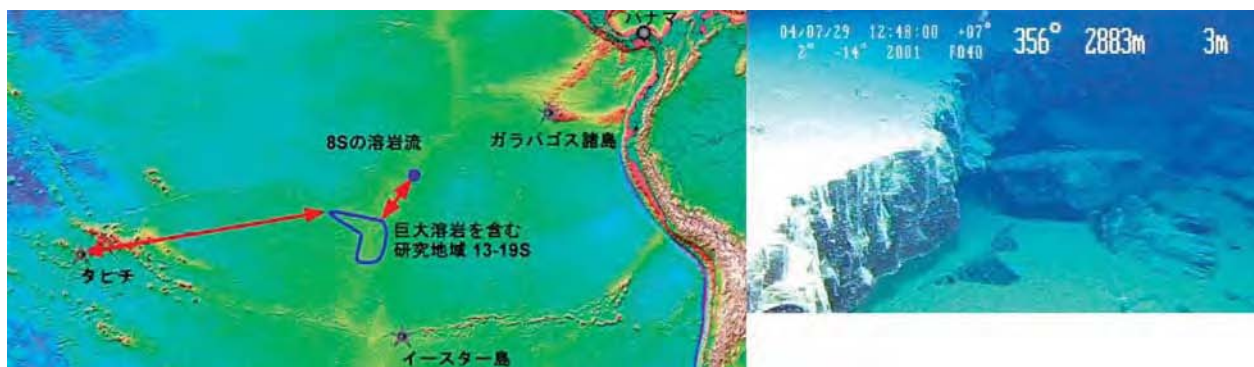


Fig.16 (left) Index map showing the location of gigantic lava flow area.
(right) Edge of lava flow observed by Shinkai6500.

5) The second hole (Hole B) was drilled at 40 m apart from Hole A. Clear fractures were also identified. We started non-destructive measurements of physical properties, etc. for the half-round core samples.

Series of proposals for drilling and monitoring at the Nankai Trough seismogenic fault zone was submitted to Integrated Ocean Drilling Program (IODP) and approved by its Science Program Committee.

Other activities at sea include the following:

- 6) Intra-plate volcanic activity called the 'Petit-Spot' was investigated in the NW Pacific.
- 7) The world-largest lava flow was discovered near (but off) the axis of the East Pacific Rise off southern America (Fig.16). Comparison with axial magma will reveal the origin of this mega-scale lava flow.

International collaboration was essential for the success of our research. For Sumatran earthquake, we also paid attention on as quick reporting as possible through media, aiming at removing unnecessary panic or fear to the earthquakes or tsunamis. We made some preliminary contribution to the construction of Indonesian Tsunami disaster prevention system.

Other activities related to Sumatran earthquake:

- Disclosure of information via website was made possible 3 days after the earthquake (<http://www.jamstec.go.jp/jamstec-j/sumatra/index.html>).
- Organizing the urgent fund from Japanese Government
- Urgent survey using R/V 'Natsushima' of JAMSTEC was successfully carried out two month after the event. No safety issues occurred. This cruise, directed

by Wonn Soh of IFREE, JAMSTEC, was made as an international collaboration, with onboard researchers from Indonesia, Germany and United States. We also received a letter of interest from China and India.

(5) Program for Paleoenvironment

We have worked sediments deposited on continental margins and collected from on-land outcrops to characterize paleoenvironmental variations in the geological past. We determined many chemical compositions of these samples including biomarkers and lead isotopic compositions of aluminosilicate fraction. They suggested that the Cretaceous Oceanic Anoxic Events were ultimately triggered by eruption of large igneous provinces. In the same time, several techniques for analyzing sedimentary samples have been developed. We succeeded to substantially (1/50) reduce the amount of sediments required for the precise determination of carbon and nitrogen isotopic compositions of sedimentary organic matter. Furthermore, we developed a sampling technique in a small area, which is currently proposed to take out a patent for this technique.

We observed sediment/water interface in the modern continental margin which is potentially an analogue for anoxic events in the geological past to discuss dynamic material cycles related to the biological activity in such environment. This observation was achieved by in situ measurements using ROV. To this end, we developed a high-sensitivity optode film which is able to measure dissolved oxygen concentration in interstitial water of the sediments. We are currently studying dynamic relationship between chemical properties of pore water and activity of benthic organisms (Fig.17).

Our group has collaborated with Hokkaido University,

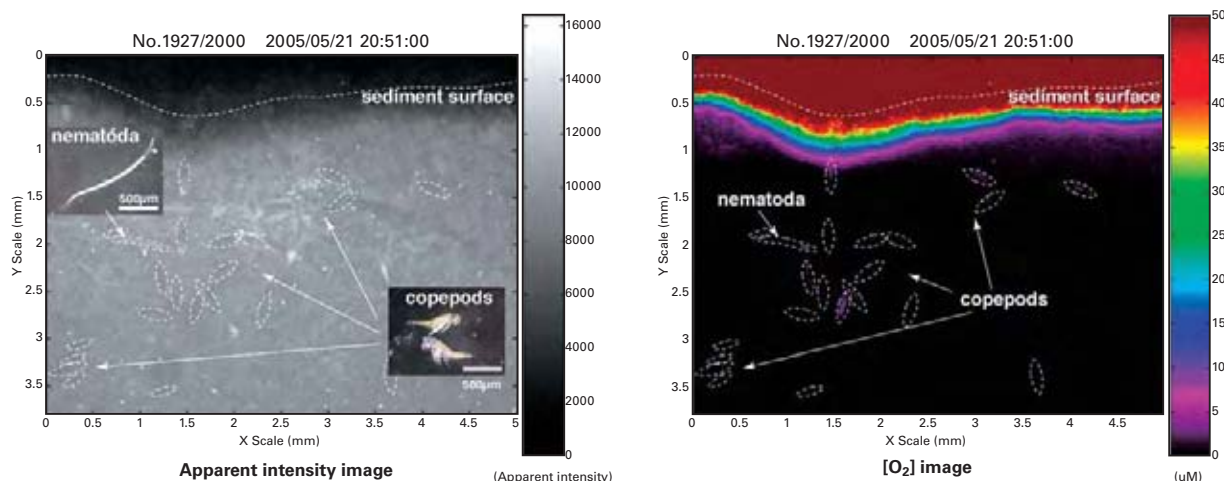


Fig.17 Images of sediment/water interface (on the left) dissolved oxygen content in the interstitial water (on the right).

University of Tokyo, Shimane University, National Oceanography Centre Southampton, Copenhagen University. A part of the results of collaboration with National Oceanography Centre, Southampton was published in Science that attracted several mass media (Fig.18). Many papers were published in international journals including textbook and review papers and presented in both domestic and international conferences. Furthermore, we educated many graduate students working topics related with our scientific goals.

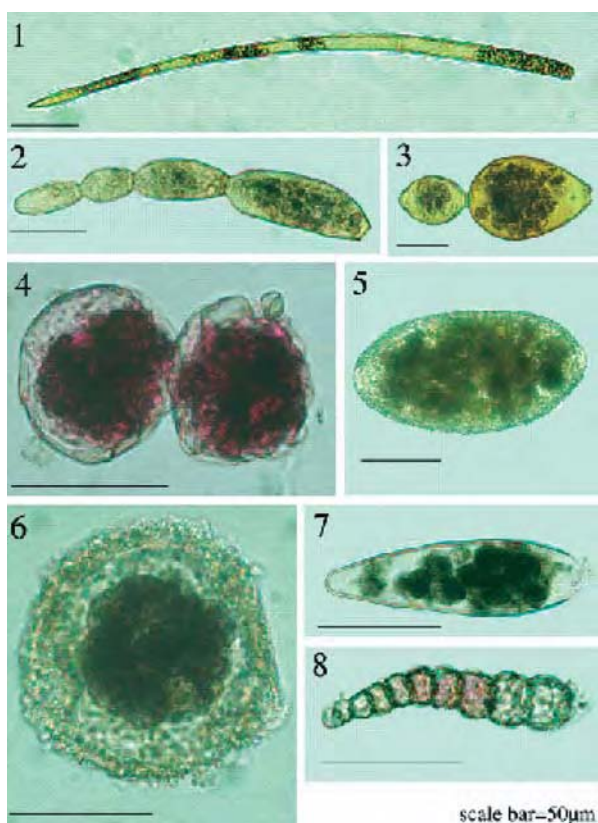


Fig.18 Photos of benthic foraminifera collected from Challenger Deep, the deepest point on Earth (Todo et al., 2005).



Fig.19 A photo of IODP cruise in Arctic Ocean (ACEX: Arctic Core Expedition).

<http://www.ecord.org/exp/acex-gallery/302gallery.html>

In IODP scientific plans, some of our members participated and played important roles in cruises of North Atlantic I and ACEX in Arctic Ocean (Fig.19). In the former scientific plan, we conducted measurements of trace elemental compositions of foraminiferal shell in the sediments and in the latter, we determined physical properties in the sediments.

(6) Program for Data and Sample Analysis

Program for Data and Sample Analysis has three research groups, which are Pacific Data Network group, Seismic Data Processing group and Sample Analysis group. Each group provides basic data for IFREE research programs through geophysical observation and chemical analysis. Pacific Data Network group has performed large scale seismic wave propagation simulation using the Earth Simulator. Figure 20 shows that the scattering of surface waves, which pass through mountain

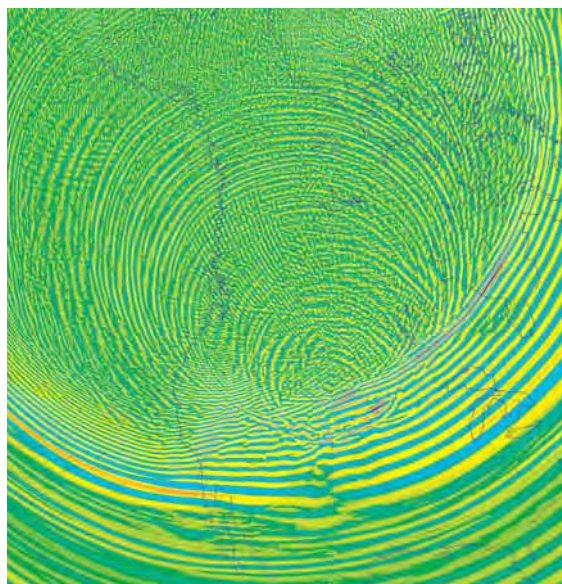


Fig.20 Snapshot of a numerical simulation of ground motion for the November 3, 2002, Denali fault earthquake 20 minutes after the origin time. The North American coastline is delineated in blue. The colors show normalized vertical displacement and red is up and blue is down. The largest amplitudes are direct long-period Rayleigh wave and continental Airy phase.

regions in North American Continent, can be modeled precisely. Pacific Data Network group has maintained broadband seismographic stations in western Pacific region. Figure 21 shows the seismograms recorded at station in Sumatra Island for December 26, 2004 large Sumatra earthquake. Seismic Data Processing group has constructed a database of seismic survey for crustal structure performed under IFREE projects and opened this database through web site (Fig.22). Sample Analysis group has developed an analytical technique for samples with extremely low concentration of plat-

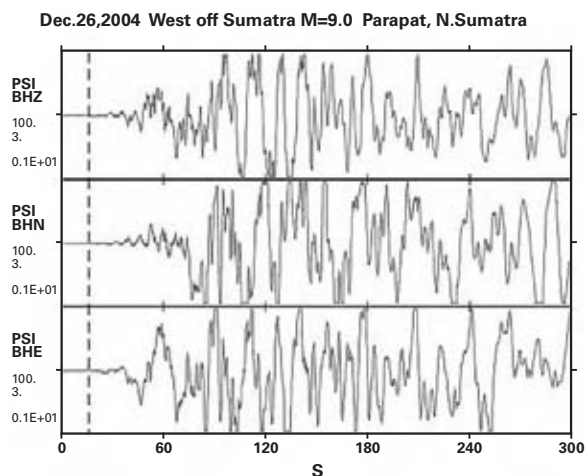


Fig.21 Broadband seismograms recorded at PSI, Parapat Indonesia, for December 26, 2004 Sumatra earthquake. 5 minutes velocity seismograms of vertical (top), horizontal north-west (middle) and east-west components are shown.

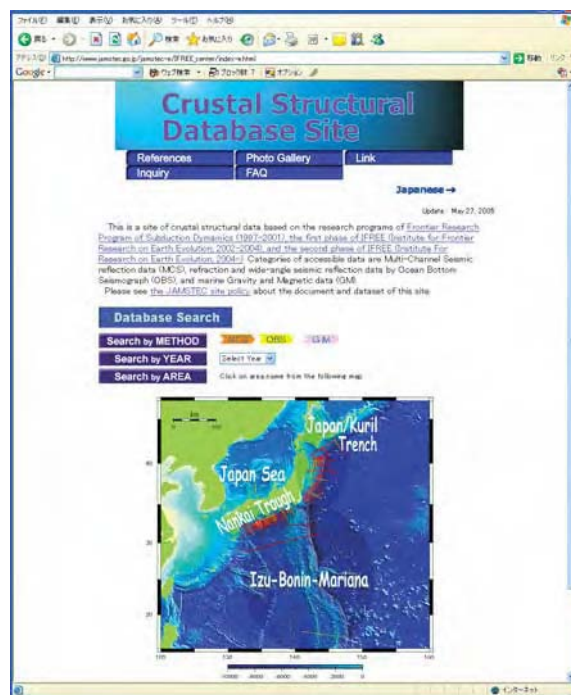


Fig.22 Top page image of crustal structure data site.

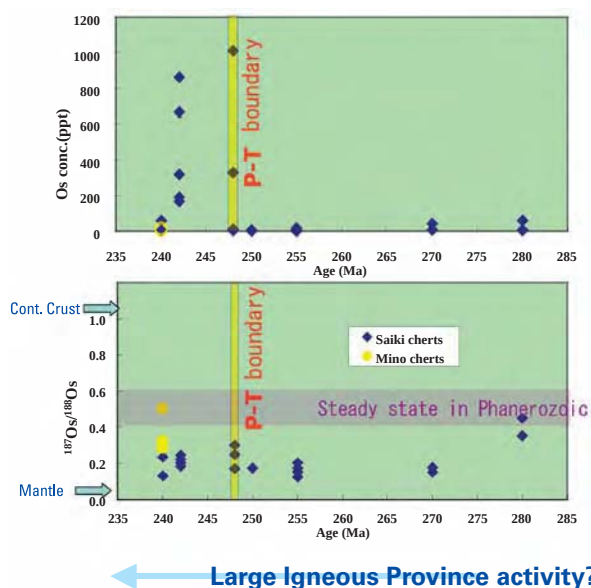


Fig.23 Secular change in the Os isotopic composition and Os concentration of marine sediments across Permian - Triassic boundary.

inum group element and achieved reproducibility of less than 10% using standard basalt rock sample with low concentration of platinum group element (Table 1&2). Sample Analysis group has also analyzed low concentration Os in sedimentary rocks which have an age of around Permian-Triassic (P-T) boundary. We found that the ocean floor became reduced environment at P-T boundary and material export from mantle increased dramatically before P-T boundary, which may closely relate to the largest mass extinction.

Table 1 Analytical results for TDB-1 (Diabase, CCRMP)

Elem.	This study								Ref.1 ^{*1}	
	Run 1 (ppb)	Run 2 (ppb)	Run 3 (ppb)	Run 4 (ppb)	Run 5 (ppb)	Mean (ppb)	RSD (%)	Yield ^{*2} (%)	Mean (ppb)	RSD (%)
Ru	0.205	0.190	0.244	0.200	0.201	0.208	10	82~91	0.179	2.9
Pd	24.5	22.8	22.1	22.4	22.4	22.8	4.3	71~85	24.3	7.8
Re	0.825	0.767	0.798	0.809	0.830	0.806	3.1	84~85	0.794	3
Ir	0.0713	0.0717	0.0654	0.0751	0.156	0.0709	5.1	86~89	0.075	13
Pt	5.13	4.69	4.65	4.78	4.87	4.82	3.9	68~86	5.01	3.6
Os ^{*3}	0.105	0.103	0.111	0.104	0.119	0.108	6.1	73~101	0.117	10

^{*1} Ref.1, Meisel and Moser (2004); n=7

^{*2} Chemical yields are calculated from the amounts of PGEs in the samples and spike solutions, and the sensitivities of ICP-MS.

^{*3} Individual run for the determination of the other PGEs .

Table 2 Analytical results for JP-1 (Peridotite, GSJ, sp.7&9)

Elem	This study								Ref.1 ^{*1}		Ref.2 ^{*2}
	Run 1 (ppb)	Run 2 (ppb)	Run 3 (ppb)	Run 4 (ppb)	Run 5 (ppb)	Mean (ppb)	RSD (%)	Yield (%)	Mean (ppb)	RSD (%)	Mean (ppb)
Ru	6.27	6.28	5.52	5.83	6.12	6.01	5.4	84	5.29	12	-
Pd	1.39	1.27	1.57	1.40	1.53	1.43	8.3	74	1.63	25	-
Re	0.0230	0.0250	0.0237	0.0244	0.0244	0.0241	3.2	95	0.29	125	0.0299
Ir	3.04	2.65	2.52	2.72	3.01	2.79	8.2	94	2.47	8	-
Pt	4.16	4.50	4.07	3.79	5.18	4.34	12	90	5.09	61	-
Os ^{*3}	2.72	4.06	3.36	3.85	4.41	3.68	18	79~106	3.78	19	2.58

^{*1} Ref.1, Meisel and Moser (2004); n=7

^{*2} Ref.2, Suzuki and Tatsumi (2001); n=2, N-TIMS was used for the measurements.

^{*3} Individual run for the determination of the other PGEs.

1.1.4 Research on ocean and extreme environmental organisms

① Extremobiosphere Research Center

(1) Marine Biology and Ecology Research

- The method for isolating genomes from chemosynthetic symbionts of a deep-sea clam, *Calyptogena ocutanii*, was developed, and a genomic library was successfully constructed. Unique symbiotic mussels were found in the whale bone animal community and bred successfully in the laboratory. The mussels have the possibility of becoming a model organism for studying the mechanism of symbiosis between deep-sea bivalves and symbiotic bacteria.
- The multi-net system, IONESS, has been using for seasonal survey of plankton community in the Sagami Bay. In the four cruises, the cooperative operation of ROV and IONESS has been performed to take a complementary data for analysis of community structure in deep-sea layers.
- In all research cruise including the cruise of JAMSTEC deep-sea research program, the sample collection has performed and physicochemical factors surrounding the habitats has been determined to analysis the interlinkage with environmental constraints.

(2) Extremophiles Research

- By comparison of the genomes of thermophilic *Bacillus* and ordinary-temperature one, genes associated with the thermophilic property were estimated. One of gene products (flotillin) highly expressed under alkaline pH conditions was purified, and the relation with alkaliphily was under study. Through the statistical procedure based on the amino-acid

composition of protein, the prediction method and program of thermostable protein were developed. The method is useful in the search of thermostable useful enzyme.

- Among 17 ubiquitin-specific proteases coded by yeast genome, 3 enzymes of Doa4, Ubp6 and Ubp14 were found to be involved in high-pressure growth.
- Theoretical support about the colloid aggregation mechanism in high-temperature and high-pressure water was obtained. The role of cell surface protein in the thermal resistance of super-thermophile was clarified. With the use of highly porous cellulose plate developed for search for useful enzymes, a screening of new useful microorganisms and useful enzymes was started.
- The capturing method of deep-sea organism with pres-

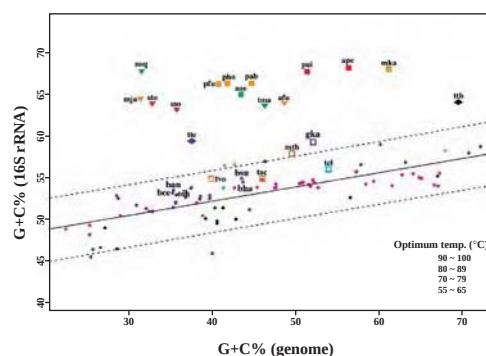


Fig. 2 Relationship between G+C content in the total genomes and G+C content in 16 S rRNA.

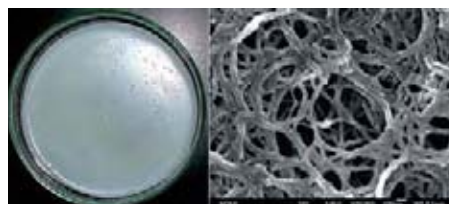


Photo 3 Porous cellulose plate.



Photo 1 The multi-net system, IONESS.



Photo 4 "Enoshima Aquarium" and tanks for stockyard and exhibition.

sure maintenance was developed and implemented.

- Cultivation of fibroblast (1 strain) of deep-sea conger eels became possible.
- The long-term breeding project of deep-sea multicellular organisms under atmospheric pressure was started in collaboration with Enoshima Aquarium.

(3) Deep Subsurface Extremophiles Research

- The search and survey of active subsurface microbial habitat and community were carried out as planned. Elucidation of the diversity and distribution of microorganisms in the deep subsurface biosphere was furthered, and a number of new microorganisms were isolated successfully.
- As for the snail that was discovered in a deep-sea hydrothermal field, at Indian Ocean, the magnetic property, physical strength and origin of iron atom of iron sulfide scale were clarified, which are expected to lead to better understanding of symbiotic system and coevolution and new biotechnology.
- Energy and carbon metabolism of deep-sea-floor hydrothermal ϵ - and γ -proteobacteria were analyzed, and the carbon assimilation pathway of ϵ - and γ -proteobacteria was characterized enzymologically. As for energy metabolism, new knowledge was obtained through elucidation of sulfur and hydrogen oxidation pathway.
- Metagenomic analysis of microbial communities at the Hishikari gold mine was conducted, and the pos-

sibility of application of the method to exploration of useful genetic resources and analysis of environmental genome in the deep subsurface and deep sea was suggested.

(4) Cooperative Research Project for Extremophiles

- To present research results by the Extremobiosphere Research Center to related companies and explore the possibilities for cooperative research with them, the 4th Deep-Sea Bio Forum was held at the Sasakawa Hall on October 22 (Fri), 2004.
- Under the Cooperative Research Project for Extremophiles, cooperative researches with over 10 companies have already been started. The research fields cover a wide range including search for physiologically active substances, search for useful enzymes, environmental purification, and structural analysis and improvement of useful protein. Through the researches, many useful enzymes were found from the microorganisms in deep sea and deep subsurface environments. Concerning part of the enzymes, patent applications were filed and the papers were submitted.

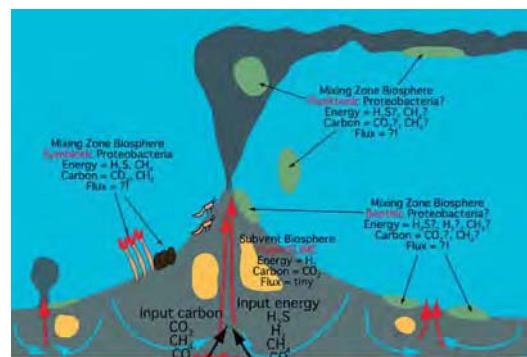


Photo 6 Geobiological energy and carbon flux with microbial ecosystem in the deep-sea hydrothermal field.

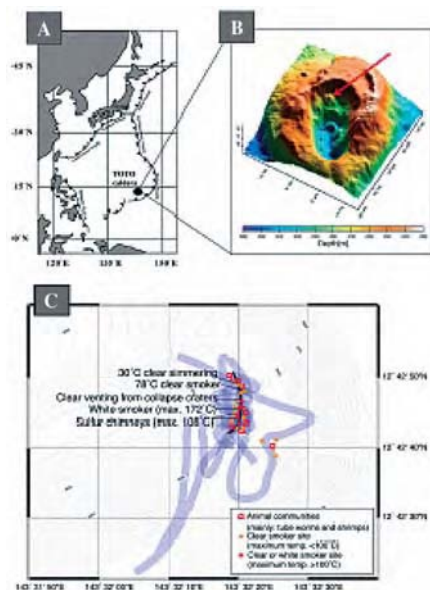


Photo 5 Bathymetry of TOTO caldera and submersible tracks of Shinkai6500.



Photo 7 The 4th Deep-Sea Bio Forum.

1.2 Promotion of priority developments

1.2.1 Research and Development of fundamental technology in ocean research field

To promote various ocean research activities, we have been developing the technologies for a high-functionality underwater research vehicle, an autonomous underwater vehicle, an underwater observation system, etc. In addition, we have been conducting research and development of advanced fundamental technologies with an eye to their applications not only in the marine science technology field but also in other research and development fields.

① Research and development of technologies on high-performance underwater research vehicle

In this research and development project, we will conduct R & D of a high-functionality underwater vehicle with the latest in research and observation technology introduced that can go underwater to a depth of 11,000 m. No deep-sea survey equipment that is capable of going underwater to a depth of 11,000 m exists in the world. To respond to the needs for observation survey in the deep-sea research, it is necessary to develop a research vehicle that can go underwater to the deepest part and conduct research and observation work. The "Kaiko" vehicle which was lost adrift in 2003 could go underwater to a depth of 11,000 m for survey. Since the construction of the "Kaiko", its peripheral technologies have been remarkably developed. Therefore, in addition to the reconstruction of the "Kaiko" vehicle, we will conduct research and development of a high-functionality underwater vehicle with the latest in research and observation technology introduced. The technical factors to be newly developed include a buoyant material for a great depth, a neutral buoyant cable for a great depth, a high-speed fiber-optic communications system for a great depth, and optical equipment for a great depth. Furthermore, the performance of acoustic equipment should be enhanced, and observation and operating equipment should be improved. For development of the buoyant material for a great depth, we will study various types of combinations of hollow beads and resin to be used as its materials and develop a buoyant material having such an overall property of composite material that can

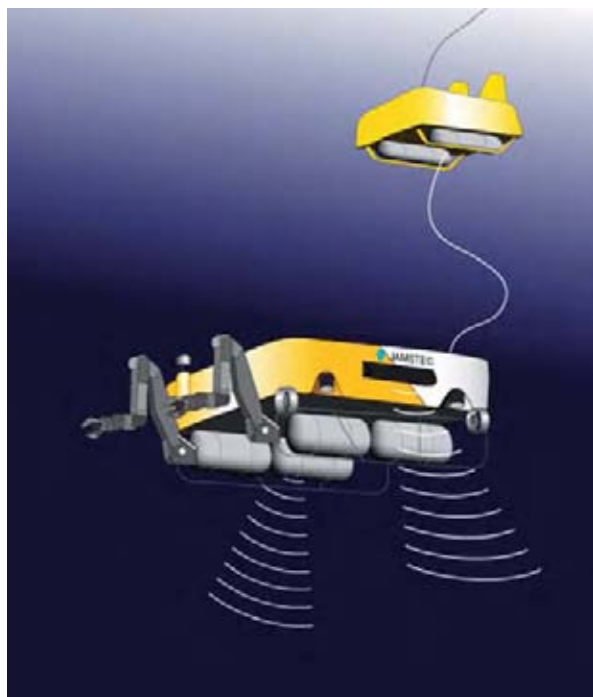


Fig. 1 Image of high-performance underwater research vehicle.

endure in underwater use at a depth of 11,000 m. As for cables, the structure of them will be reviewed to enhance the reliability, and a cable system that is equipped with high-speed optical transmission communications for transmitting large-capacity data such as images obtained at the ocean floor will be developed. For promotion of functionality, the activities such as development of optical equipment for a great depth and enhancement of the performance of acoustic equipment will be conducted. This year, among those technologies to be developed, we have been conducting a prototype manufacturing of a buoyant material for a great depth and a performance test for it, a prototype manufacturing of a neutral buoyant cable for a great depth and a performance test for it, and a study of a high-speed fiber-optic communications system for a great depth. The development of a high-functionality underwater vehicle will make it possible to respond to the needs in the deep-sea research, and contribute to the study of the biosphere at the world's deepest points and the study of ocean bottom crustal movement.

② Research and development of technologies on Autonomous Underwater Vehicle

Autonomous Underwater Vehicle is an unmanned research vehicle that can cruise underwater autonomously according to the predetermined schedule program. In

this research, an autonomous underwater vehicle test machine (hereinafter referred to as a "test machine"), for which major particulars are shown in Table 1, will be developed. It is designed to be capable of going underwater to a depth of 3,500 m and have a cruising speed of 3 kn and a range of 300 km. The vehicle body has a tubular shape to decrease the resistance to it. A high-performance power source and a high-performance navigation system are indispensable to cruise a long distance. For the former, a proton-exchange membrane fuel cell and a lithium-ion secondary battery are used. For the latter, instruments such as an optical ring laser gyro and a Doppler speedometer are used in combination to minimize errors caused by the inertial navigation. Devices such as a sensor and a side scan sonar for data collection

Table 1

Dimensions	Length	10 m
	Width	1.3 m
	Height	1.5 m
	Weight	10 tons
Maximum Range	300 km (Fuel Cell)	
Maximum Depth	3,500 m	
Cruising Speed	3 kn. (Maximum 4 kn.)	
Positioning	Inertial Navigation System Doppler Sonar Homing Sonar	
Operation Mode	Autonomous Remote (Acoustic, Optical)	
Sensors	Side Scan Sonar Snap Shot Digital Camera Forward Looking Sonar CTDO	

and observation work under the sea are equipped with the vehicle body, and ocean data can be obtained and undersea survey can be conducted. Fig. 2 shows the external appearance of the test machine.

The test machine was named Autonomous Underwater Vehicle "URASHIMA", and the first underwater test cruise was carried out in 2000. In 2003, a fuel cell system using hydrogen stored in hydrogen absorption alloy and oxygen gas stored in a high-pressure vessel was equipped. Fig. 3 shows the general arrangement view of the vehicle with a fuel cell on board. Hydrogen absorption alloy uses the exhaust heat of fuel cell to release hydrogen. In FY2004, a total of five underwater cruising tests were carried out in the actual sea areas. As a result, URASHIMA achieved a cruise of 317 km for 56 hours with the consumption of all of the fuel on board. Fig. 4 shows the cruise track. Starting in FY2005, we will conduct test cruises in the actual sea areas toward the practical use.



Fig. 2 External appearance of the test machine "URASHIMA".

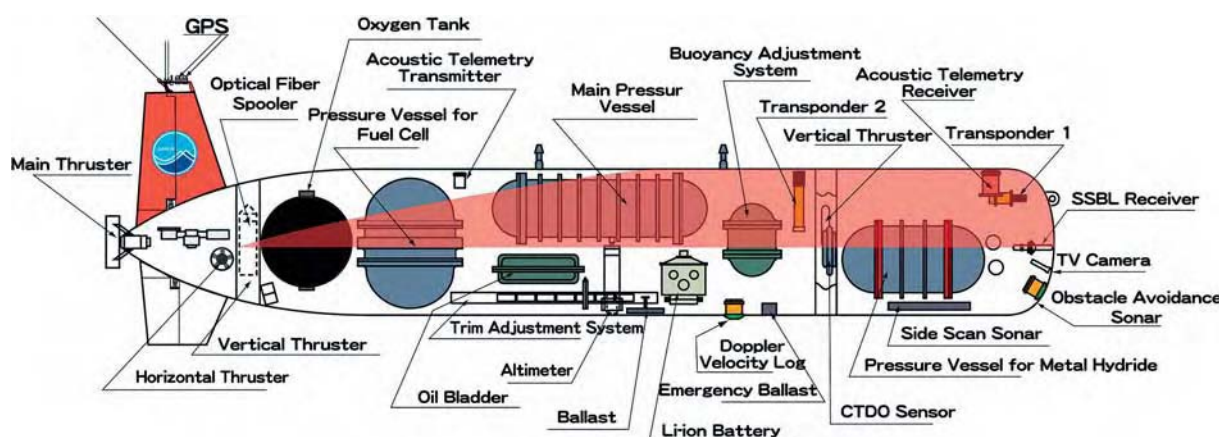


Fig. 3 General arrangement view of the vehicle with fuel cell on board.

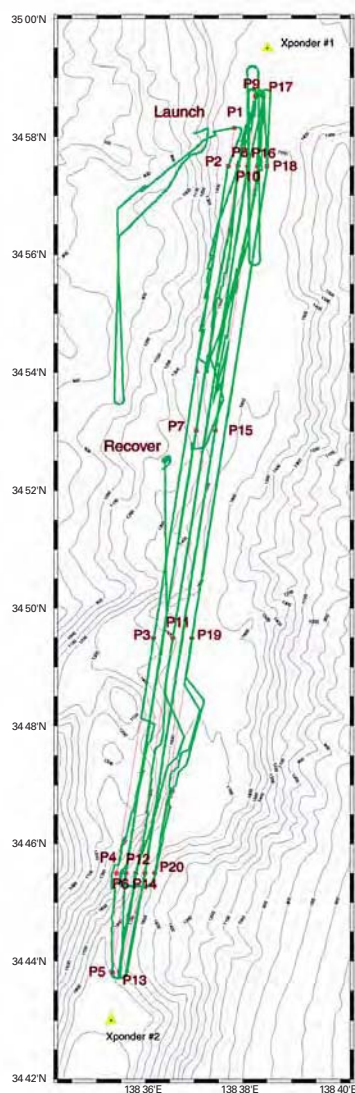


Fig. 4 Cruise track of the test cruise (for 317 km).

③ Research and development of technologies on comprehensive undersea observation network system

It has been pointed out that it is important to conduct a long-time continuous observation in the researches of earthquakes occurring at the seafloor plate boundaries, environmental changes under the sea, and the ecological system. As a means of realizing such an observation, we propose the undersea cable network for scientific observation using undersea cables, and we are conducting fundamental research and development toward its realization. Fig. 5 shows the concept of the proposed undersea cable network ARENA. Observation nodes are installed at every 50km or so to the undersea cables connected like a mesh. Various sensors for a seismometer, a tsunami meter, a TV camera and a current direction and speedometer are connected to the respective observation nodes via detach-

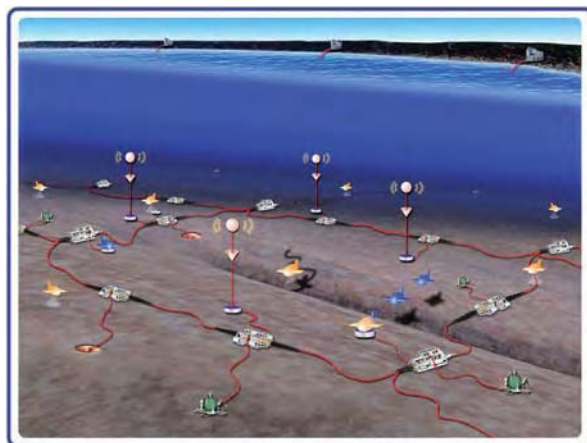


Fig. 5 Image of the undersea cable network ARENA for scientific observation.

able submersible connectors, and they can be used in various research fields. By linking the network with observation buoys and autonomous underwater robots, the observation areas can be expanded, realizing three-dimensional continuous observation.

This year, we proceeded with the fundamental research on optical transmission system and power supply system. Unlike an optical underwater system for communications, a scientific observation system needs to use a broadband optical transmitting and receiving device which can be installed in the underwater equipment. Fig. 6 shows the configuration of the proposed optical signal transmission system of a light wavelength multiplex mode which uses the modulation of carrier light by the Raman amplifier. With this mode of system, wavelength doesn't need to be stabilized precisely through temperature control in the underwater observation equipment. As a result, the reliability of the transmission system is enhanced, the problem of temperature rise due to power consumption and heat generation can be eliminated, and a practical optical signal transmission system can be realized. As the result of prototyping, we found that the system is capable of 310 Mbits/s transmission. On the other hand, in the power supply system of long lengths of undersea cable network, various phenomena associated with resistance of transmission line and propagation delay occur. It is necessary to understand those properties and to observe the stability of the power supply system and the transient phenomena caused by power ON and OFF. Also, the optical undersea cable uses only one electric supply line, and seawater is used for the current return line.

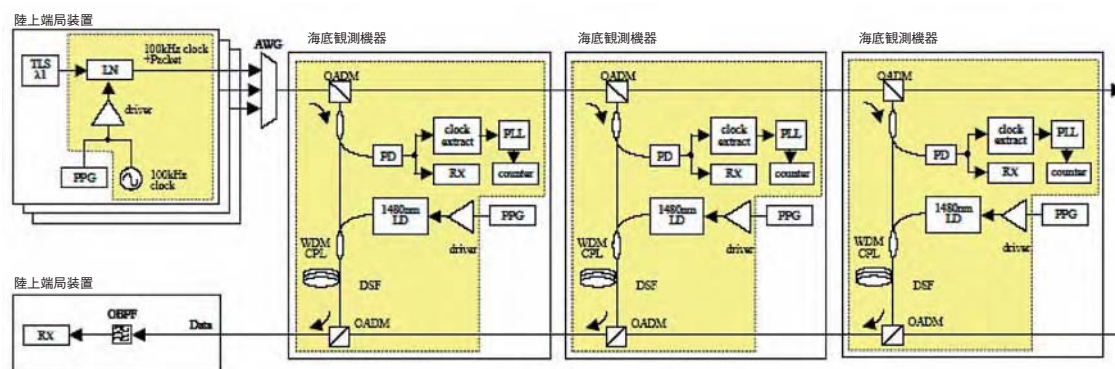


Fig. 6 Optical signal transmission system using the modulation of carrier light by the Raman amplifier.

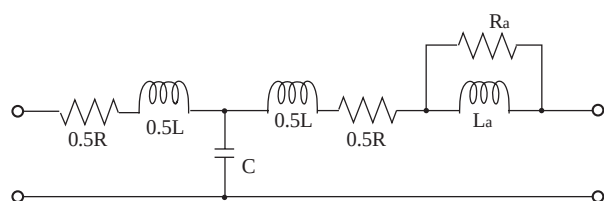


Fig. 7 Electric equivalent circuit of the electric supply line of optical undersea cable.

Therefore, its electrical propagation properties are complicated. It's difficult, however, to observe the phenomena by experiments using long-distance undersea cables, and it's important to establish an evaluation method in a computer simulation. In this research, the propagation property of the assumed equivalent distribution constant circuit shown in Fig. 7 was examined with an electronic circuit simulator, and the theoretical analysis results were compared. As the result, we confirmed that with the circuit shown in Fig. 7, the electrical propagation property of the optical undersea cable could be represented well. Through this research project, the foundation for analyzing the power supply system of the undersea cable network by the electronic circuit simulator was established.

④ Research and development of advanced ocean technologies

We are conducting research and development of various fundamental technologies with an eye to their applications not only in the ocean researches field but also in the other fields in the future.

(1) Research on structural components for ocean equipment

To reduce the weight of a water resistant container for protecting electronic equipment from seawater and water pressure is a matter of high priority in develop-



Fig. 8 Pressure-tight container made of magnesium alloy.

ment of submersibles. In this project, research and development of materials having a higher specific tensile strength than the current pressure-tight container made of titanium alloy has been conducted. This year, a small test pressure-tight container was prototyped using magnesium alloy which was newly developed, and with the evaluation test piece cut from the prototype, the material property evaluation test was conducted (Fig. 8). The result showed that the magnesium alloy had almost the same specific tensile strength as the comparative reference material (Ti-6V-4Al alloy).

(2) Research and development of sensors

Among chemical measurement methods, a basic study of electrochemical measurement methods was made. Among the electrochemical measurement methods, the electrode using ion-sensitive field-effect transistor was tested, and basic data about the property at temperature change was obtained. To examine the property of chemical sensors in high-pressure water, land test devices were designed and manufactured.

(3) Research on power source

To realize a long-distance cruise of the Autonomous Underwater Vehicle (AUV), we have been making a study for improvement of efficiency of power source. This year, the method of gold plating to a titanium separator which was developed last year was optimized, and the increase in its efficiency was confirmed. Furthermore, we started development of electrode using nano-material, studied the kind of nano-material and the method of coating to ion exchange membrane, and prototyped it (Fig. 9). We have continued to make an evaluation bench since last year.

(4) Research and development of underwater acoustic technologies

We are conducting the study of using acoustic signals for communications with manned submersibles, untethered unmanned vehicles, observation equipment set up on the sea bottom and other equipment. In 2003, we started a second-stage research for realization of a higher-speed communications. The purpose of the research is to apply such technologies to image transmission for controlling untethered unmanned vehicles and to a data transfer of a sea-floor setting type of seismometer, etc. The target transmission speed is 64 kbps for a transmission distance of several hundred meters.

To provide a wide band transmission, we studied about communications using a frequency of 80 kHz. At this frequency, absorption loss through seawater is very large. Therefore, communication distance becomes short, but propagation delay is reduced. Also as a result, a better response for control of unmanned

vehicles is obtained. It is also expected that a good operability of the vehicle can be secured because of being untethered. This year, a test device was made in the same way as last year, and using the test device, the experiment was conducted in the actual sea area. In the experiment, communications over distances of about 100 meters at a speed of 50 kbps was achieved under the relatively steady condition (Fig.10).

Furthermore, the basic study of a long-distance horizontal underwater acoustic communication using phase conjugate wave in connection with underwater acoustic technologies was conducted. Generally, in a long-distance horizontal acoustic communication, a number of multipaths such as reflection wave and refraction wave get mixed and interfere with the securement of communication path (inter-symbol interference). On the other hand, by using the convergence by phase conjugate wave (time-reversal wave), reflection wave and refraction wave are converged, and the original waveform is almost completely restored. As a result, signals including few multipath waves can be received, and high-level signals without inter-symbol interference can be received. In this research project, the method of using the convergence by phase conjugate wave and the treatment with an adaptive filter in combination was tested, too. Verification was conducted in simulations in the shallow and deep sea areas. The result showed that by using the effect of phase conjugate wave and the adaptive filter in combination, communications could be carried out even in such an environment that couldn't secure the communication path according to the conventional method. We also manufactured a low-frequency sound source, a wave receiver, a

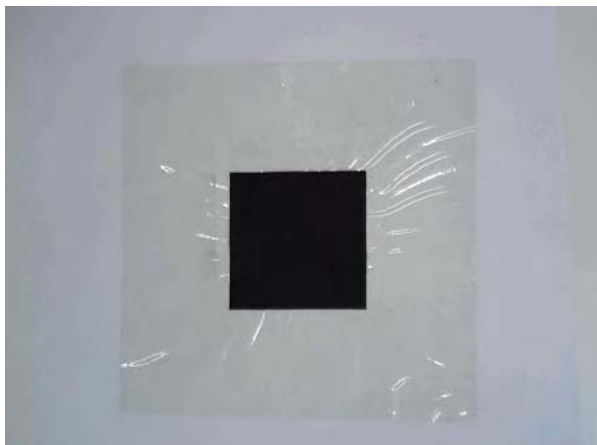


Fig.9 MEA made of nano-materials (electrode-coated ion-exchange membrane).



Fig.10 Example of demodulated picture (320 × 225 pixels)(transmission time 1.2 seconds) No error.

transmitter-receiver, etc. to be used in the tests in the actual sea area in FY2005.

(5) Research on measurement and sensor technologies

To predict a global-scale change, survey and observation are being conducted in the Arctic area. The method of using the Autonomous Underwater Vehicle (AUV) as an effective means of observing underneath the ice field in the Arctic area is proposed. In this method, the AUV needs to autonomously navigate several thousand kilometers. To implement the method in the sea where GPS cannot be used, a sensor for determining the location of the AUV itself is needed.

The purpose of this research is to improve the performance of the Optical Ring Laser Gyro (RLG) serving as a sensor for determining the location of the AUV and the Inertial Navigation System (INS) that is composed of an accelerometer as a main component. From FY1998 to FY2002, the RLG with an improved mirror and a larger optical path diameter was made to raise the accuracy of the INS. In FY2003, the test of canceling Long Term Drift by rotating the INS which was mounted on the turntable rotating at a certain rate, was conducted. The test result showed that the performance of the INS could be improved by reducing the Bias Drift errors and that the turntable method had an effect on the reduction of errors. Based on the result, in FY2004, the change of reduction of errors depending on the rotation speed and timing of the turntable was verified. Accordingly, we confirmed that by giving a rotational movement to the INS with a turntable during alignment, errors could be reduced more effectively.

(6) A satellite communications system on the ocean

This project is for development of a test model device with which researchers on land can collect data on the ocean in real time by monitoring and remote control operation of the observation equipment on the ocean of ships, research vessels, buoys, etc. In the first year, a satellite communication line was designed, and the specification of a necessary radio communication system was designed. Furthermore, an image compression device was developed so that high-quality pictures could be sent even if a degradation of radio lines causes the reduction of communication speed.

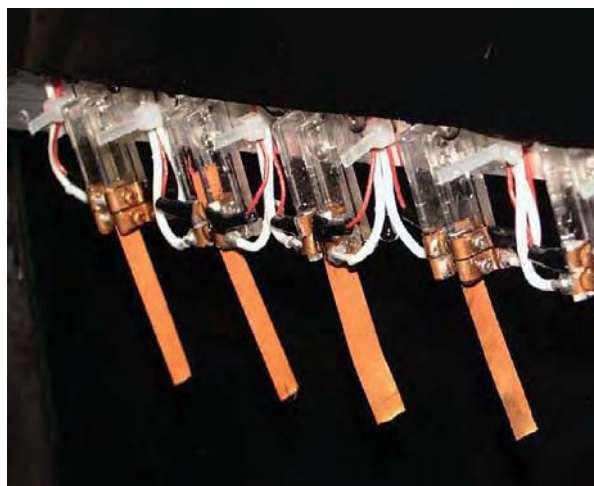


Fig.11 Artificial muscle under operation in the water tank for pressure test at a depth of 11,000 m.

By using the Engineering Test Satellite VIII which is planned to be launched in the near future, a high-speed communication for the transmission of compressed image between an underwater vehicle on the surface and land equipment or between a mother ship and land equipment can be realized. However, such a small and pressure-tight antenna of a satellite tracking type that can be mounted on an underwater vehicle does not exist. The autonomous underwater vehicle, URASHIMA has been utilized as a test bed in this research. This research is for development of an antenna and a tracking device that is most suitable for the "URASHIMA", and the antenna and tracking device actually mounted on the "URASHIMA" will be tested. This year, to downsize the antenna tracking device, we started the development of a tracking device using artificial muscle and conducted a property test of the artificial muscle underwater (Fig.11). To operate the tracking device by artificial muscle, a smaller antenna compared to that of last year was prototyped, and its property test was carried out in a propagation dark room.

(7) Other researches and developments

1) A working-type AUV for the survey in ice-covered sea and deep ocean floor

This research project is for the detailed research of deep ocean floor and for the study of the technologies for unmanned vehicles needed in collection of CTD data and carbon dioxide in the Arctic area. This year, using the control platform most suitable for autonomous operation which was developed last year, we made improve-

ments of basic hardware and software so that the onboard equipment could operate stably. Furthermore, the basic autonomous control software that could operate on the platform was developed. Borrowing the water tank from the Tokyo University of Marine Science and Technology, we conducted an operation performance test and obtained the data (Fig.12).

2) A hybrid unmanned submersible for shallow sea

The ocean data such as water temperature, dissolved

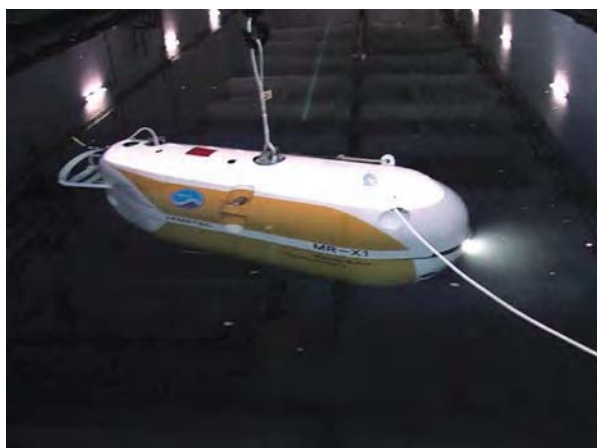


Fig.12 Scene of the water tank test.

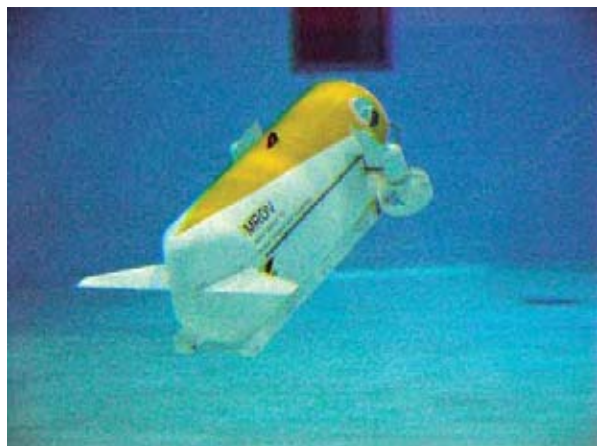


Fig.13 Scene of the test in the pool.



Fig.14 Scene of the test in the sea area and the underwater picture.

gas and microorganism vary greatly in shallow sea with depths of 500 m or less, and a submersible that can collect data efficiently in a wide area in shallow sea is required. For this purpose, we have been developing a simple and convenient submersible that can move to a horizontal direction over a wide area and can be used as either of AUV or ROV. This year, the development of the system was completed. At the academic, business, and governmental exchange fair, the announcement of its completion was made, and the sales of the system started at the joint research companies. Also, to improve the performance, an operation test was conducted in the pool (Fig.13, Fig.14).

3) Research of sub-bottom exploration system by electromagnetic pulse

By sending high power electromagnetic pulse into the ground such as the bottom of the sea and measuring the reflection echo, the subduction of plate and the structure of fault, etc. can be checked, and water holes, buried objects, etc. may be found. By using electromagnetic pulse for survey, more data can be collected, compared to the use of the conventional methods of using acoustic wave and surveying the sea floor using magnetic fields. This year, we built up the electromagnetic pulse generator, and conducted the system test (Fig.15). On the other hand, the underwater propagation simulation was performed (Fig.16).

4) Research of power supply equipment using thermoelectric conversion technology around the hydrothermal vents

Thermoelectric conversion technology using a thermoelectric conversion element that can convert heat



Fig.15 Electromagnetic pulse generator and receiving antenna.

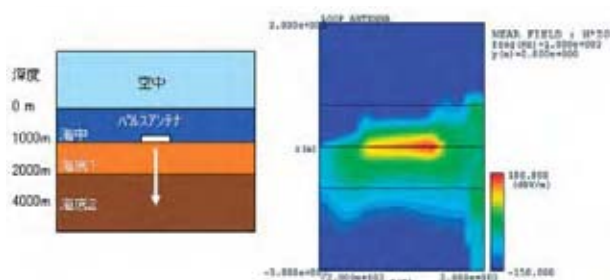


Fig.16 Underwater electromagnetic field simulation result.

energy directly to electric energy is expected to be useful as a means of supplying power to observation equipment in the deep sea. This research project is intended to study the present thermoelectric conversion technology in consideration of application of the thermoelectric conversion technology in the deep sea, especially, areas with hydrothermal vents, and then to develop application technologies in such an extreme deep-sea environment as under water and under high pressure. This year, we conducted survey and research about the past thermoelectric conversion technologies, and studied the basic efficiency of thermoelectric conversion.

5) Empirical research by prototype synthetic aperture sonar

Survey and observation of the sea bottom topography and its surface states correspond to the land survey and geological survey, and they are regarded as important



Fig.17 Oscillating device for water tank test.

surveys to be conducted before other underwater works. Sonars are used for such survey and observation, and among them, a high-resolution and synthetic aperture sonar that can survey the structure of the bottom of the sea, too, is now gaining the spotlight. This research is intended to establish a technology for motion compensation which plays an important role to get a good performance of the synthetic aperture sonar. So far, we developed a new motion compensation method and confirmed its effect in simulation. Based on the result, we conducted a water tank test this year, and confirmed the effect of the developed motion compensation method (Fig.17). In addition the prototype specification was determined and the detailed design was completed.

6) Research of gas storage using nano-materials

Hydrogen and oxygen are used for fuel cell. How those gases should be stored not only in the AUV but also in other systems using fuel cell has been an issue. This research is intended to establish a technology of gas occlusion and exhaust using nano-carbon material, etc. as a storage method for fuel cell used as the underwater power source of AUV, etc. This year, we prototyped the oxygen gas storage test container based on the test results of the past years, and conducted a gas adsorption property test (Fig.18). The result showed that the test container had a storage capacity 3.5 times larger than storage in gas.



Fig.18 Oxygen gas storage test container.

7) Research of restoration of the environment in the bay

In this clean-up method, air is fed from the sea floor (aeration) to secure and promote survival and growth of oyster, which is a local special product of Omura Bay. It's impossible to recycle entrophicated materials only by aeration, and it's difficult to clean up only by farming of oysters. This research is intended to prove that sustainable use is compatible with recovery only by the combined use of non-feeding farming and aeration. While contributing to the promotion of the fishing industry and local industries, it cleans the sea and prevents a deficiency of oxygen and a red tide. The test result showed that oysters grew to such an extent that



Fig.19 Oysters raised in the test farm (right) and oysters cultured in the ordinary farm (left).

(The sizes of the meats are obviously different. In addition, oysters raised in the test farm (right) have a larger white portion (glycogen), which enhances a good taste.)

the rafts in the test farm sank (Fig.19). The concentration of dissolved oxygen in the sea was maintained in good condition at an average of 6.4mg/ℓ (the target value is 4.3mg/ℓ or more) from July to October. On the other hand, most of the oysters that were raised in the other ordinary farms in the same bay died, and there was no harvest. We will plan to conduct three experiments repeatedly by FY2005, and work toward practical use as well as profitability study.

1.2.2 Simulation research and development

① The Earth Simulator Center

(1) Computational Earth Science Research

- Case studies are conducted to investigate interactions between meso-scale phenomena and planetary-scale flows by conducting high-resolution global simulations using atmospheric general circulation model AFES. For example, key structures leading to typhoon genesis are identified and the heat wave occurred on 20 July 2004 is found to be caused by the teleconnection along the subtropical jet, called "Silkroad pattern."
- A global high-resolution hindcast simulation using ocean general circulation model OFES is conducted to investigate interannual variation. The amplitude and phase of the simulated El Niño events coincide with those in the observation. For example, the 1997/98 El Niño event is simulated realistically.

- We applied our original spherical grid, "Yin-Yang grid" (Fig. 3) to the core convection (or geodynamo) and spherical mantle convection simulations. The Yin-Yang core code achieved 15.2 TFlops calculation on the 4096 processors of the Earth Simulator by which we were awarded Gordon Bell Prize at SC2004 conference. With this Yin-Yang core code, we could simulate finer structures of the core convection and geodynamo. We also performed computer simulations of the spherical mantle convection using the Yin-Yang grid. Special focus in FY2004 was on effects of internal heating on the spherical mantle convection. We also developed a new basic algorithm for the mantle convection simulation. This algorithm, ACuTE method (Fig. 4) enables us to investigate influence of temperature-dependent viscosity on the convective platforms in the mantle. We found that under certain conditions the variation of

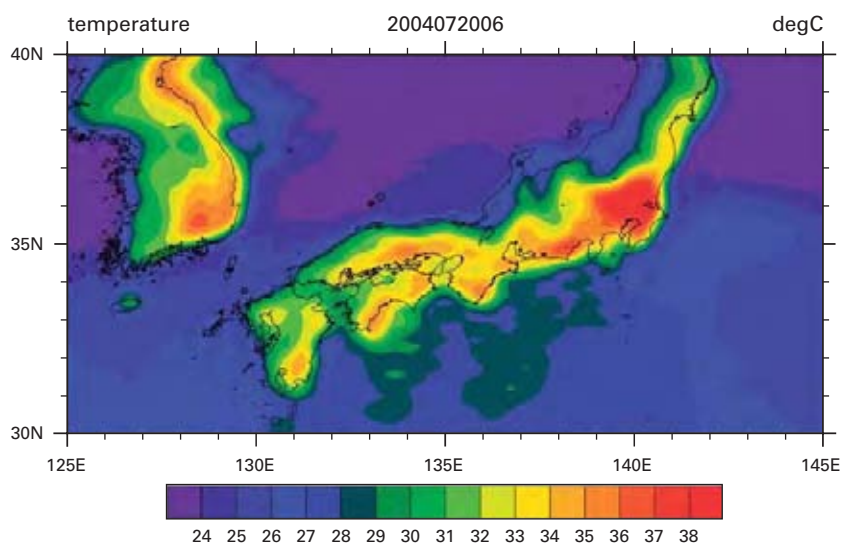


Fig. 1 Near-surface temperature simulated using AFES from 5 days before. Anomalous high temperature, especially in the Tokyo area, is realistically reproduced.

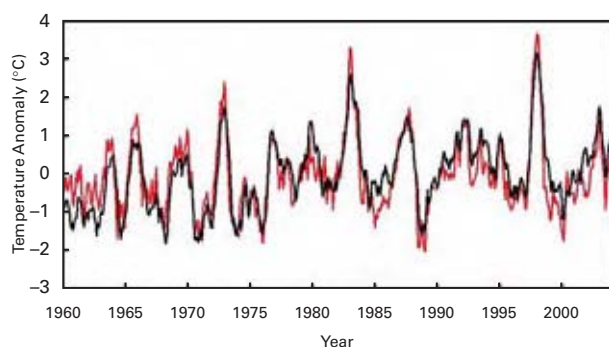


Fig. 2 Sea surface temperature anomaly in the eastern tropical Pacific (Niño3 region) based on observation (red curve) and the simulation (black curve).

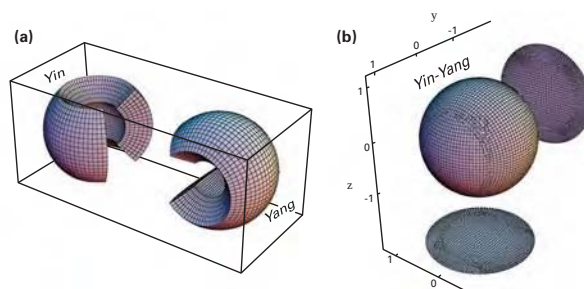


Fig. 3 A spherical overset grid named Yin-Yang grid. Two identical component grids shown in (a) are combined to cover a spherical surface with partial overlap (b). The component grid is a low latitude part of the usual latitude-longitude grid.

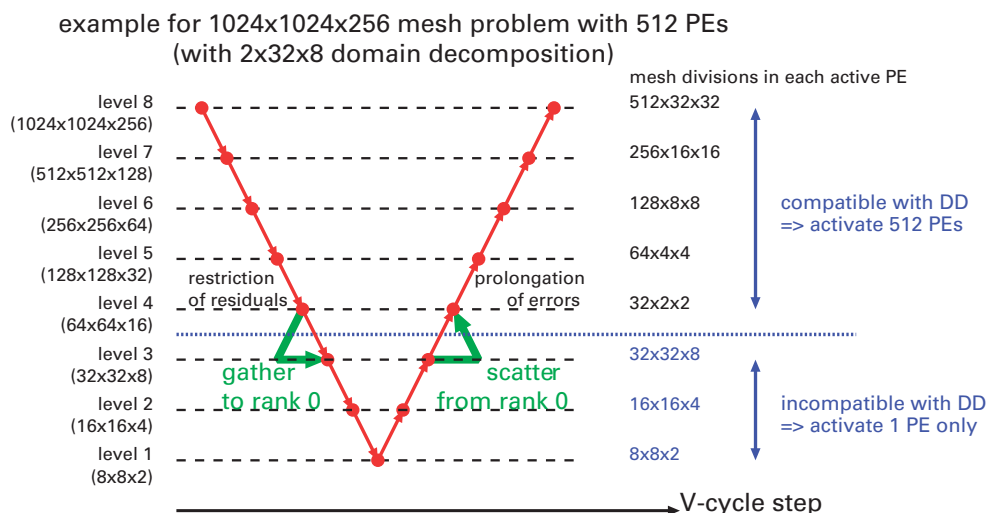


Fig. 4 A schematic diagram of the course of multigrid iterations optimized for highly parallel computations. The dotted blue line indicates a threshold grid level which divides the entire grid levels into two groups. The grid levels finer than the threshold contain a sufficient number of meshes compared to that of available processor elements (PEs) for parallel computations, while the coarser levels do not. The calculations on the finer grid levels are performed in parallel using all available PEs, while the calculations on the coarser levels are done using only one PE with rank 0.

the thermal conductivity can exert significant impact on convective flow patterns, by stabilizing the boundary-layer instability at the bottom surface and by enlarging horizontal spacings of upwelling plumes. These results may imply the potential importance of the radiative heat transfer on the occurrence of "superplumes" observed in the Earth's mantle (Fig. 5, 6).

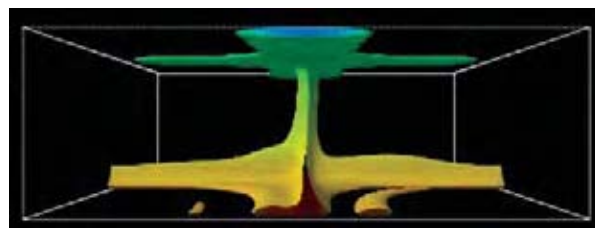


Fig. 5 Zoom-up view of hot upwelling plumes of mantle convection obtained for the case with temperature-dependent (radiative) thermal conductivity. The upwelling plumes become thick in the presence of radiative thermal conductivity.

(2) Advanced Simulation and Technology Development

- We have been developing two different software packages for scientific visualization of large scale simulation data; YYView (Fig. 7) and VFIVE (Fig. 8). YYView is an interactive visualization software for large scale geoscientific simulations, used on PC's or graphic workstations. VFIVE is a virtual reality visualization software used in a room-sized, CAVE-type virtual reality system. In FY2004, we developed a basic version of YYView by which spherical simulation data are visualized based on the Yin-Yang grid system. We also developed VFIVE with a special focus on the volume rendering and VTK integration to the software. We also helped simulation researchers of the Earth Simulator Center and other research groups of JAMSTEC to visualize their large scale data from the Earth Simulator.

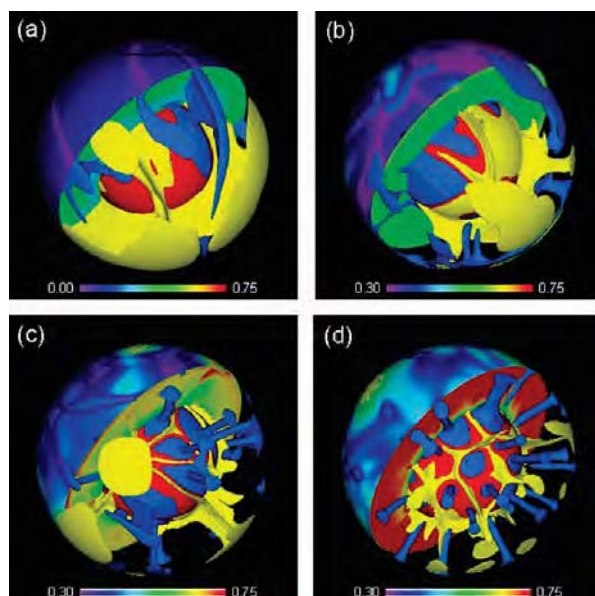


Fig. 6 High Rayleigh number mantle convection with internal heating

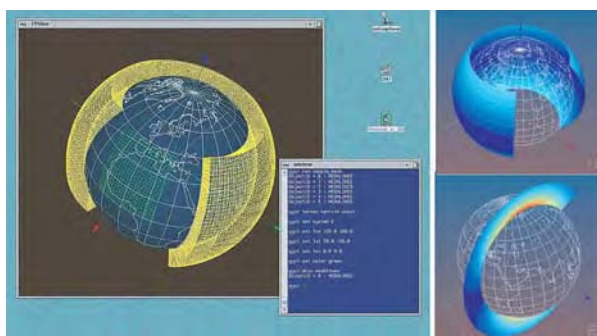


Fig. 7 Left: Two kinds of windows of YYView, the graphic viewer and the command shell. Right: Examples of visualization by YYView.

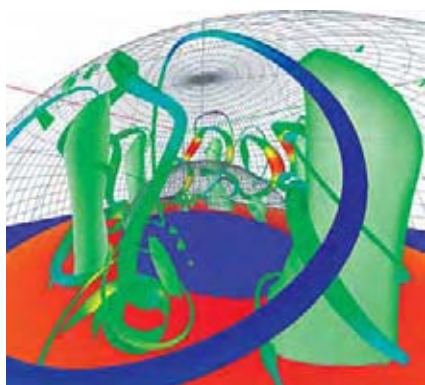


Fig. 8 Flow velocity of an Earth's dynamo simulation visualized by a visualization method "Tube", which has been newly incorporated into VFIVE.

- 72 hours prediction experiments have been performed with the non-hydrostatic global/regional atmosphere simulation code. These 72 hours forecast experiments of ETAU initialized at 0000UTC 8 August 2003 have been performed with 11km or 5.5km horizontal resolution with 64 or 32 vertical layers. In Fig. 9, tracking forecast of ETAU and the official 'best track' (presented in a black line) which is reported by Japan Meteorological Agency. Simulated tracking in all cases are comparable to the best track. After 72 hours prediction had been carried out with 5.5km resolved global atmosphere component, one way nested experiment to Japanese region with 1.15 km horizontal was performed. Fig.10 (b) shows precipitation distribution simulated by nesting scheme with 1.15 km horizontal resolution in Japanese region. The fine distribution is showed and is comparable to observational data presented from Tokyo Meteorological Observatory. Not only events in summer, but also the cold wind occurred in winter season can be presented with the non-hydrostatic global atmospheric simulation code.

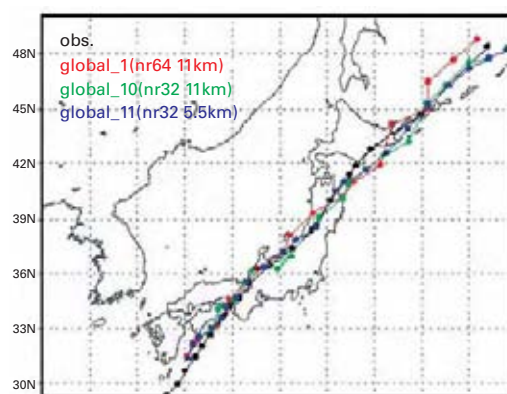
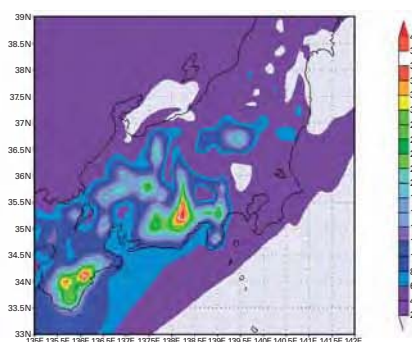
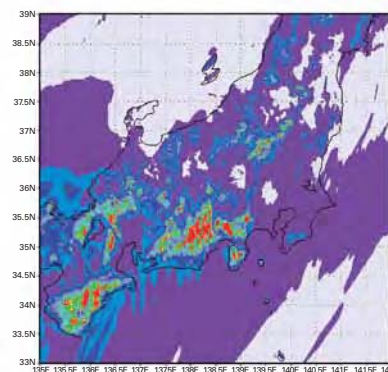


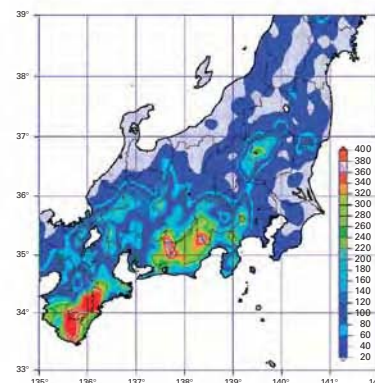
Fig. 9 72hours tracking forecasting of Typhoon ETAU in 2003.



(a) Simulated result of precipitation with 5.5 km horizontal resolution.



(b) Precipitation results in nested Japanese region with 1.15 km horizontal resolution.



(c) Observation data delivered from Tokyo Meteorological observatory.

Fig.10 Precipitation distribution summed up during the term from 18:00 on 7th to 24:00 on 9th August in 2003 when ETAU attacked Japanese region.

- We started the collaboration research project with Japan Automobile Manufacturers Association, Inc. for studying all-inclusive, accurate and real-time simulation. We succeeded in the simulation of the automobile deformation during collisions using the resolution of 10 million elements for the first time in the world, and could reproduce the deformation of body parts seen in real experiments (Fig. 11).
- Started was the collaboration research project with Institute of Economic Research of Hitotsubashi University for executing economic simulations of the whole world.
- We also started the collaboration research project with Tohoku University and Mitsubishi Heavy Industries, LTD. for developing the design technology by the simulations of the whole aircraft.

(3) Holistic Simulation Research

- a. New research groups have been established to develop the algorithm and the architecture for the interlocking multi-scale simulations.
- b. A prototype of the multi-scale plasma simulation has been developed by interlocking the magnetohydrodynamic model and the particle model, which can handle the macroscopic and microscopic instabilities of 10^5 km and 10 cm scales, respectively. The auro-

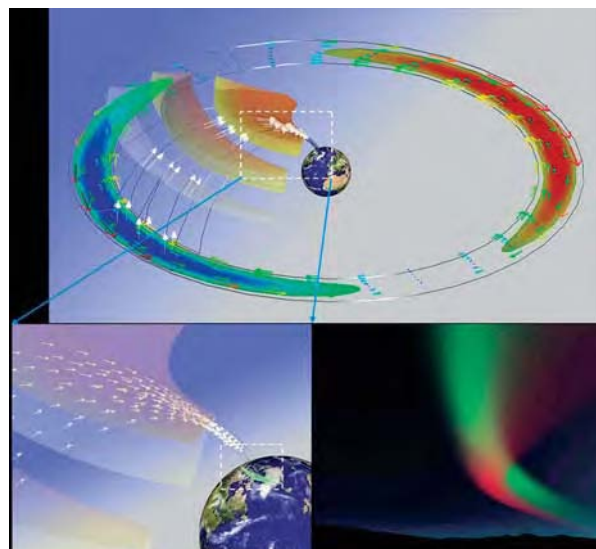


Fig.12 The interlocking simulation result of the auroral arc formation process. The auroral arc luminescence is successfully reproduced (bottom-right), by calculating the interaction between the concentration of electric current channel due to the macroscopic instability (top and bottom-left) and the microscopic instability in the current channel.

ral arc formation is successfully simulated first ever using the new interlocking model (see Fig.12).

- We made the basic design, specifications, and roadmap of the innovative simulator, "Holistic Simulator", which aims to conduct holistic simulations with high efficiency. We applied for a patent for the basic design (Patent # 2005-15868).

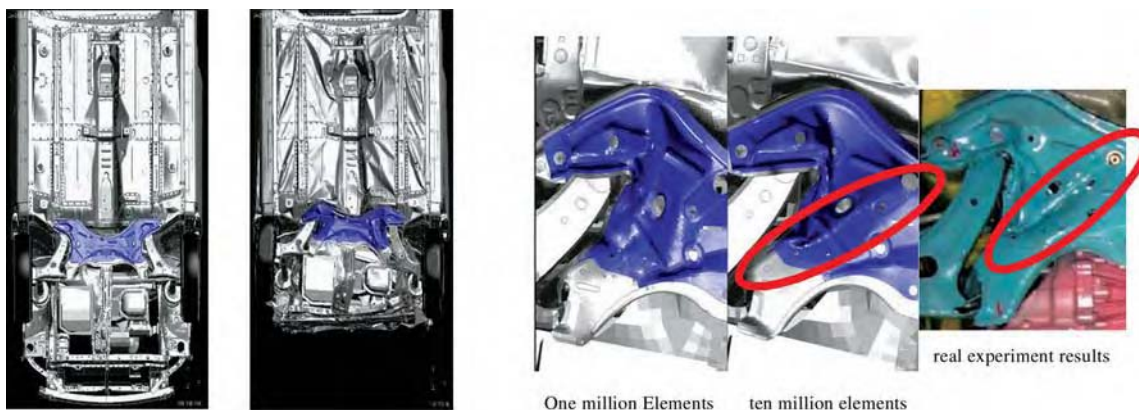


Fig.11 Simulation results of the automobile body deformation. The left panel of the left figures and the most left panel of the right figures are the results using one million elements, and the right panel of the left figures and the central panel of the right figures are those using ten million elements. The most right panel of the right figures is the real experiment result. The simulation using 10 million elements shows a good agreement with the deformation in the real automobile experiment.

1.3 Various activities on research and development

1.3.1 Promotion of ingenious and rudimentary research and development

To promote inter-sectional (inter-center) research projects in the Agency and technical development projects based on cooperative coordination with external

institutions such as industry circles, the "Inter-sectional Research and Development Promotion Award (Incentive system)" was established. Research and development projects were solicited, and three projects were selected. Research resources were allocated to the adopted projects

Name of Theme	Centers/institutions that jointly conduct the research	Research outline
Hierarchical structure science	Institute for Research on Earth Evolution Earth Simulator Center Extremobiosphere Research Center	Finding of common principles in the complex phenomena having a very wide range of hierarchy through study on five sub-themes of "Relationship between micro-particle movement and flare phenomena of space plasma", "Relationship between coagulation of fine particles and occurrence of typhoon or torrential rainfall", "Relationship between movement of intracellular molecules and production of life function", "Relationship between mineral movement and fault movement", and "Relationship between existence of water and formation of continent", and description of the findings in a common language for understanding.
Interaction of mantle plume with life in the Earth history: Verification of [Ultramafics-Hydrothermalism-Hydrogen-HyperSLiME] linkage (UltraH3 linkage)	Extremobiosphere Research Center Institute for Research on Earth Evolution	Verification of the hypothesis that the [Ultramafics-Hydrothermalism-Hydrogen-HyperSLiME] linkage (UltraH3 linkage) prepared the place for the origin of life in the early stage of the Earth, brought the subsequent birth of the primary ecosystem, and has supported the ecosystem up to now
Research and development of next-generation remotely operated vehicle	Marine Technology Center Extremobiosphere Research Center Institute of Observational Research for Global Change Kyushu University	Development of the next critical technology with an eye to the development of small probe vehicles used for virtual mooring and remotely operated vehicles for long-distance observation that are used in survey of the Arctic Circle and observation of undersea volcanoes. - Establishment of the optimal design method for a propeller having a structural shape of remotely-operated submersible with a reduced fluid resistance during sailing. - Study on the configuration of actuators where in the event of failure in one actuator, a stable operation can be maintained with other actuators and development of an intelligent control algorithm to secure a fail-safe.

1.3.2 Promotion of collaborative research and research partnership

① Collaborative researches, etc.

- A total of 62 collaborative research projects were conducted: 22 with private companies, 22 with universities, etc., 8 with governmental organizations, 8 with independent administrative institutions, and 8 with charitable organizations. 5 projects among them generated revenue.

(The sum of the above numbers with the respective partners is different from the total number of projects because some projects were conducted with multiple partners.)

- The simulation research using the Earth Simulator was conducted in collaboration with the Hadley Center for Climate Prediction and Research in UK and the Centre for Global Atmospheric Modeling.
- The joint research with the Japan Automobile Manufacturers Association, Inc., "Real-Time High-Precision Simulation Studies of Whole Vehicles" using the Earth Simulator, was conducted.

(Only major projects were listed above.)

② International Arctic Research Center (IARC)

Research programs for FORSGC and FRSGC at IARC have been resolved in March 2004. From April in 2004, IARC/UAF should perform IORGC research based on the new contract between UAF and JAMSTEC. Interim research plan has been submitted in March 2004 and then the plan has been executed with considerable modifications for comprehensiveness to the existing IARC/NSF research program in FY2004. Five projects were carried out in 2004 and major achievement from each project in FY2004 is presented in the following sections.

(1) Ocean Ecosystem Modeling

Under this project, comprehensive 1-dimensional-ecosystem model applicable in Bering Sea and Arctic Ocean is developed and tested its validity through comparison with field observations. The model developed will be incorporated into a 3-dimensional model, which is under development in other project at IARC. Understanding of sudden start of coccolithophore bloom in Bering Sea is one of the prime targets of this project.

The NPZD model is a lower level N-based biological model with phytoplankton and zooplankton with different sizes. The model has been modified and tuned for Bering ecosystem with sea ice environment. Seasonal pattern for primary production was demonstrated to be realistic only with both wind-driven surface and tidal bottom mixing. The sensitivity study unambiguously showed surface mixed layer depth (MLD) is a key to switch major primary producer. If $MLD > 15$ m, diatom becomes dominate and flagellate (including coccolithophores) dominates, if $MLD < 15$ m.

Simulation of sea ice algae production showed reasonable onset and peaking of primary productivity but overestimate the productivity after the peak, indicating suppression of the production after maturing bloom need to be improved. 3D physical model in Bering Sea is under development for this biological model to expand the simulation capability to entire Bering Sea.

(2) Arctic Ocean Models and Observations

This project mainly focused on freshwater and Atlantic water behavior in Arctic Ocean through historical data analysis, 4-D data assimilations, field observations and modeling. Understanding mechanisms for Arctic long-term climate variability is a special focus of this project in terms of air-sea (land) interaction in and surrounding Arctic Ocean, and fresh water circulation.

NABOS is officially recognized as apart of SEARCH (Studies of Environmental Arctic CHange) Program of the United States. NABOS cruise by Russian Ice Breaker was carried out from 5th Sept. to 27th Sept., 2004. It occupied 26 hydrographic stations and 2 mooring stations. Although one shallower mooring could not retrieved, two moorings are deployed as planned. Preliminary data from deeper mooring stations showed clear warming of AIW. CTD hydrographic observation also confirmed AIW warming by 0.3 to 0.7°C since the 2003 observations.

One mooring was retrieved from Beaufort Sea by using a Canadian Ice Breaker on 7th Aug. 2004 and redeployed on 30th Aug. 2004. The data recovered from the mooring revealed capturing multiple subsurface cyclonic and anti-cyclonic eddies and low frequency wave propagations in deep sea. By using Norwegian Ice Breaker, one mooring at Franz-Victoria Channel in

Barents Sea was first deployed in order to capture the upstream AIW, which could flow into NABOS observation sites.

Model study revealed that AO shifts from the negative to positive phase promote more fresh water exports from Arctic Ocean. The increases of exports through Fram Strait and the Canadian Archipelagos are estimated 12 and 6%, respectively. It implicates freshening of GIN (Greenland, Iceland, Norwegian) Seas.

Oxygen isotope and Alkalinity data from recent research cruises and historical data compiled as Hydrochemical atlas by AARI/IARC collaboration are analyzed for spatiotemporal variations of freshwater and brine content in Arctic Ocean from 1929 to 2002. The study revealed deeper penetration of freshwater and brine in Arctic Ocean than previously thought. It also showed that less contribution of fresh water from Mackenzie River in Canada Basin than previously suggested by Ba contents and other evidences. 4-dimensional (4D-var) data assimilation system is now under development for Arctic Oceanographic data. Preliminary application for velocity field in Bering Sea and Tsushima Strait is promising and expecting to provide synthetic atlas of realistic Arctic Ocean circulation based on current limited observation data.

(3) Terrestrial Ecosystem Models and Observations

Carbon exchange between atmosphere and permafrost vegetation is expected to change drastically due to near future climate change in the Arctic. Especially hydrological alternation and morphological change are believed to be major factors to affect it indefinitely. This project aims to establish a novel technique to determine NEP and CH₄ flux by combining satellite observation and process-based biogeochemical model tuned by field observation. This technique allows us to examine climatic response of Arctic permafrost region in terms of water and carbon cycle.

Annual NEP mapping technique has been established and applied for taiga forest region in central Alaska. The more sophisticated technique for daily to monthly NEP estimation, surface soil temperature retrieval from MODIS products and tuning BIOME-BGC model were carried out. Comparison with in situ temperature data at East Kuparuk permafrost observa-

tion site, North Slope, Alaska revealed a promise but needs for further calibration due to soil moisture and land cover variations. CH₄ flux observation at Pt. Barrow since 1999 showed large inter-annual variability. This is likely caused by air temperature and radiation in early growing season at the site. At UAF tower observation site revealed very small CH₄ exchange due to severe early summer drought in 2004.

(4) Arctic Atmosphere: Weather and Climate Variability, Models & Observations

In this project, the interaction between atmosphere and iced ocean surface is closely examined and the implications for the change in arctic and global climate are fully evaluated. Mechanism for major climate regime shift such as AO and arctic storm activities are major topics in this activity.

Counts for coastal storm events in Arctic Ocean revealed no significant temporal trend despite the common claim for recent frequent storm hits and severe damage to coastal communities in the Arctic. However, CAI (new index for the activities of storm considering frequency, intensity and duration of storms) revealed clear more active storms in recent years. Low frequency oscillation (7-8 year period) is revealed in the trends, indicating significant association to major regime shifts such as NAO (AO).

(5) Coupled Atmosphere-Ocean-Ice-Ecosystem Models

JAMSTEC is developing comprehensive global climate model, which can fully utilize a super computer called Earth Simulator. This group will devote fully to improve arctic climate model module for Earth Simulator through analysis of the model output and validation, although the group is developing independent Regional Coupled Ice-Ocean Model (CIOM) to run at Arctic Regional Supercomputer Center, UAF for scientific climate research.

The CCSR/NIES/FRCGC coupled atmosphere-ice-ocean model on Earth Simulator is at first evaluated for its performance in Arctic region. The model was parameterized so that an equilibrium could be achieved without any T/S restoring and any flux adjustment. The model output is compared with the available observations, such as sea ice extent, T and S. The model simu-

lation demonstrated that it could maintain Atlantic water layer. The absolute values somehow deviate from the observations. However, the anomaly trends from the model are clearly captured major key features observed in the Arctic Ocean. The trend sea ice area anomaly (Fig. 1) estimated from model output clearly matches at a glance. The temporal trend of normalized Atlantic water core temperature reveals a remarkable

agreement to the observation (Fig. 2). There is still a lot of detailed to be worked out for better performance. The first analysis for ES simulation output provides us a great promise.

Lastly, IARC research staff presented 42 oral presentations in international meetings and published 49 papers in peer-reviewed international professional journals in last 2 years including FY2004.

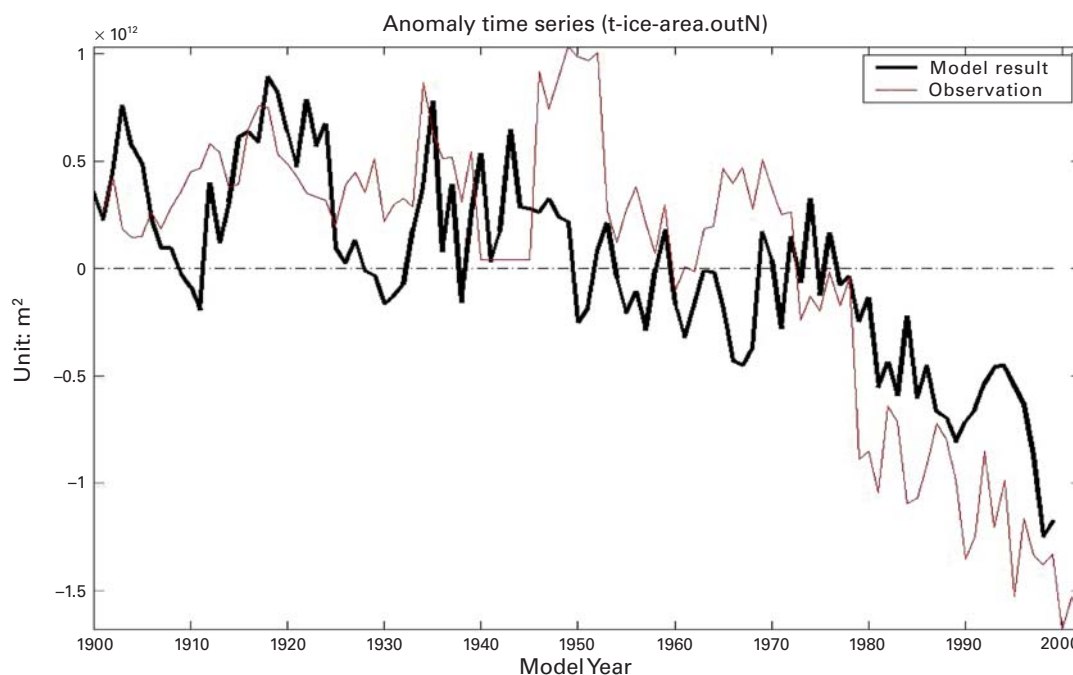


Fig. 1 Temporal change of sea ice covered area anomaly in Arctic Ocean obtained by CCSR/NIES/FRCGC model together with observation result.

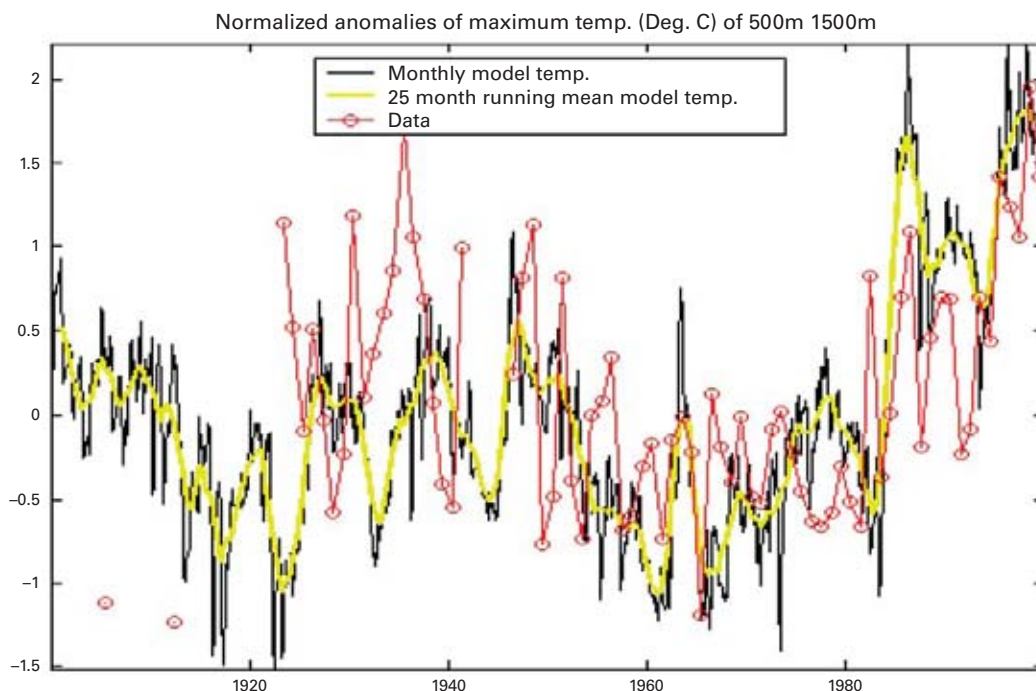


Fig. 2 Temporal variation of normalized water temperature at 500 m water depth obtained by CCSR/NIES/FRCGC model and the observation result.

③ International Pacific Research Center (IPRC)

The International Pacific Research Center (IPRC) conducts research on Asia-Pacific climate. The center was conceived under the "U.S.-Japan Common Agenda for Cooperation in Global Perspective," and was founded in October 1997 as part of the School of Ocean and Earth Science and Technology at the University of Hawaii (UH) Manoa Campus. Its mission is "to provide an international, state-of-the art research environment to improve understanding of the nature and predictability of climate variability in the Asia-Pacific sector, including regional aspects of global environmental change." Financial support for the IPRC comes from Japan through the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), from the United States primarily through the National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), and the National Science Foundation (NSF), and from the State of Hawai'i through UH. Support is now divided roughly equally between Japan and U.S. agencies, so that today the IPRC truly represents a Japan - U.S. collaboration for the advancement of climate research.

IPRC research is being conducted under five themes:

- 1) Indo-Pacific Ocean Climate, 2) Regional Ocean Influences, 3) the Asian-Australian Monsoon System; 4) Impacts of Global Environmental Change, 5) The

Asia-Pacific Data-Research Center (APDRC). This report highlights some (but by no means all) IPRC accomplishments in those themes for the period April 04-March 05.

(1) Indo-Pacific Ocean Climate (Theme 1)

Theme-1 research aims to uncover the ocean's role in the climate system by conducting studies on air-sea interaction, climate variability, and ocean processes. The studies in 2004-05 cover a broad range of topics in these areas, including research on the climatically important Kuroshio system, conducted in collaboration with colleagues at FRCGC.

Air-Sea Interaction:

Air-sea interactions were studied both regionally and globally. In the region of the Kuroshio Extension, ocean-atmosphere soundings were conducted in collaboration with Japanese scientists. They show that surface winds are strong (weak) in regions where the near-surface layer is unstable (stable). Moreover, the atmospheric response to heat-flux anomalies is located downstream of the anomalies, and depends on nonlinear processes and the Pacific storm track. A global survey of air-sea interactions at ocean fronts shows that sea surface temperature (SST) varies mostly in response to advection of mean gradients by eddies; SST and wind-speed anomalies at mesoscales are in phase, with higher (lower) speeds on the warmer (cold-

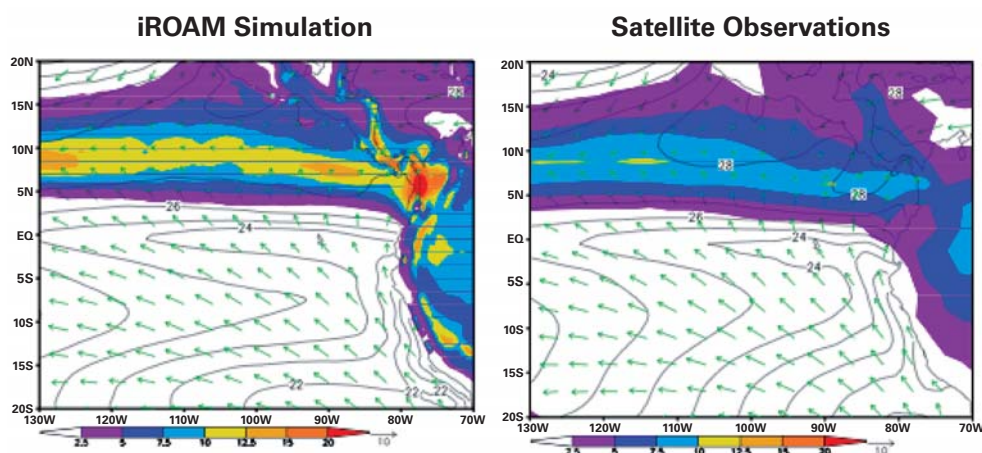


Fig. 1 Sea surface temperature, precipitation, and surface wind velocity averaged over 1999-2003, as simulated by the IPRC regional ocean-atmosphere model (iROAM; left) and observed by TRMM and QuikSCAT satellites (right). The model successfully maintains the ITCZ north of the equator and simulates a pronounced annual cycle in the eastern equatorial Pacific, two key features of Pacific climate that global models have difficulty simulating. This multiyear iROAM simulation was carried out on the Earth Simulator in collaboration with FRCGC and the Kyosei-7 Project.

er) flanks of the fronts. A simulation with the IPRC regional atmospheric model (IPRC-RegCM) shows that thermal advection across the front is important for the surface-wind adjustment, a mechanism confirmed by aircraft observations.

Stratus clouds and their interaction with the ocean are important for eastern Pacific climate. The IPRC-regional ocean atmosphere model (iROAM) maintains a stratus cloud deck south of the equator, maintains the intertropical convergence zone (ITCZ) north of the equator most of the year, and has a pronounced annual SST cycle on the equator (Fig. 1)-features that global coupled models simulate poorly. iROAM has been implemented on the Earth Simulator, enabling long integrations and additional experimentation.

Climate Variability:

In collaboration with JAMSTEC scientists, the role of air-sea interaction in Indian Ocean intraseasonal variability was explored. Analyses of satellite and in situ observations reveal unusually large intraseasonal variations in SST, wind, and rainfall over the tropical South Indian Ocean, a variability that differs in structure from the Madden-Julian Oscillation. Observational analyses showed that the IOD is related to regional rainfall around the Indian Ocean rim as well as to remote subtropical land-surface temperatures; simulations support the hypothesis that convection in the eastern Indian Ocean during positive IOD events affects the Southern Hemisphere subtropics through Rossby-wave propagation.

The mechanisms that drive the PDO were investigated statistically both in observations and model output. Observations show that a realistic PDO can be obtained from SST generated by an autoregressive model forced by El Niño, the Aleutian Low, and wind-driven ocean adjustments in the Kuroshio-Oyashio Extension.

Analyses of SST observations in the Atlantic reveal a new mode of variability, phase-locked to November-December when the thermocline shoals in the eastern equatorial Atlantic. Though sustained by Bjerknes feedback, the mode is temporally unrelated to the Atlantic Niño, which peaks in June-August when the thermocline depth in the Gulf of Guinea reaches its seasonal minimum.

Ocean processes:

The major ocean currents and equatorial thermocline are key to the oceanic heat-budget and to climate. Research this year has focused on several important ocean features and their climatic impact. (i) The equatorial subsurface countercurrents (e.g., Tsuchiya Jets) associated with arrested fronts were realistically reproduced for the first time in an ocean general circulation model (GCM) and their dynamics investigated, yielding valuable information about the importance of the diffusion parameterization for realistic simulations of this circulation. (ii) A study of the Kuroshio Extension shows that narrow jets form between Japan's coast and the dateline in response to incoming broad Rossby waves, a consequence of the nonlinear interaction between the waves and potential vorticity advected from the western boundary region. This squeezing of the jet's meridional scale in the Kuroshio Extension has implications for ocean observing systems, fisheries, and air-sea interaction. (iii) In our ocean GCM experiments, a reduction of the midlatitude westerlies in the North Pacific produces a thinner and shallower equatorial thermocline as a consequence of less water upwelling there by Ekman suction in the subpolar gyre.

(2) Regional Ocean Influences (Theme 2)

Aimed at understanding oceanic phenomena and their impact on climate and climate variability in the western Pacific Ocean, the marginal seas, and the connection with the Indian Ocean, Theme-2 research has focused on climate-related aspects of currents and transports in these regions, analyzed zonal jets noted in high-resolution ocean models and satellite altimetry measurements, generated enhanced ocean datasets, and developed and applied data assimilation techniques.

In hindcast numerical experiments, the interannual variation in the bifurcation of the North Equatorial Current (NEC) and its associated transport were found to be due mainly to variation in wind-stress curl integrated from the American coast to the Philippines, with some influence from wind-stress anomalies along the equatorial Pacific.

The low-latitude western-boundary currents (LLWBCs) on the western flank of the Pacific are narrow and intense. Two such currents, the Mindanao

Current and the lower-latitude portion of the Kuroshio, result from the bifurcation of the westward-flowing NEC. A combination of observations, model output, including the Ocean Model For the Earth Simulator (OFES), and 4dVar data-assimilation techniques suggest that LLWBC water transported through the Luzon Strait affects the heat content of the South China Sea (SCS). The transport has a strong ENSO signature, with its maximum strength during El Niño and minimum during La Niña. Water entering the SCS through the Luzon Strait tends to surface 5-7 months later in the cyclonic gyre east of Vietnam, possibly affecting local climate and the Asian monsoon.

Understanding what factors control SST in the

Indonesian sea is important because it affects not only local climate, but may also influence the Asia-Australian monsoon. Advection from the Pacific LLWBCs, local wind-driven upwelling, and tidal mixing all affect SST in this region. To understand their relative contributions and how they vary on different time scales, outputs of various GCMs, including OFES, were analyzed. Results show that inflow through Lombok Strait and local winds destabilize the surface currents and the stratification, causing intraseasonal sea-level variability (Fig. 2).

Evidence of alternating zonal jets in the world ocean has been found in geostrophic velocity and vorticity altimetry measurements and in simulations with OFES

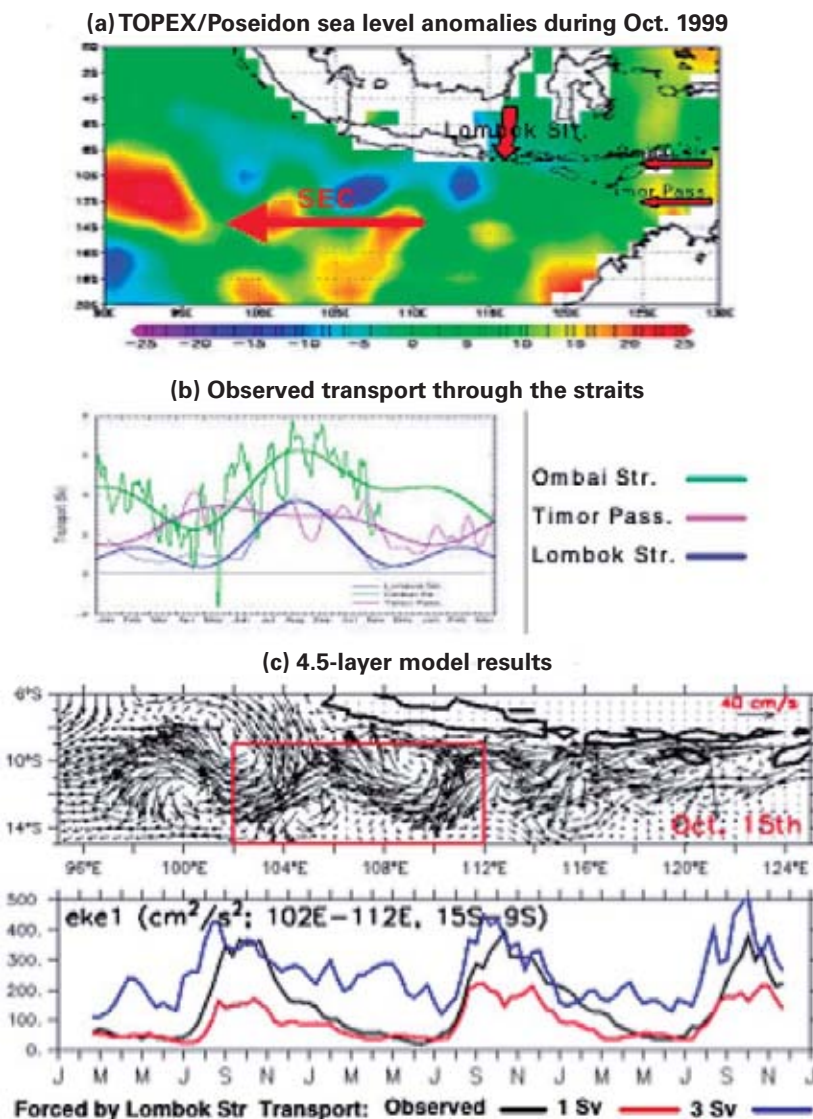


Fig. 2 (a) TOPEX/Poseidon measurement, which indicates strong eddy activity near the outflow of the Indonesian Throughflow during October; (b) a collection of transport observations through the 3 major straits, showing their seasonal changes; (c) a snapshot of the surface currents from a 4.5-layer model, and model sensitivity to transport values through Lombok in terms of the area-averaged eddy kinetic energy, which increases substantially with the transport.

and other high-resolution ocean models run on the Earth Simulator. The characteristics of the jet-like structure are independent of sub-grid scale parameterization, and their spatial meridional variation agrees reasonably well with geostrophic turbulence theory. Estimates of the effective diffusion caused by the coherent structure of the jets suggest that the jets may significantly increase the zonal dispersion of tracers.

Producing enhanced datasets of oceanographic variables for use in climate studies is an important activity at the IPRC. One such example is the production of a decadal-mean sea-surface height field with a resolution high enough to capture the fine-scale structure of the flow field. Generated by combining the best available sea-surface dynamic topography with a dataset composed of drifter velocities, satellite sea-level anomalies, and atmospheric winds, the set was improved by using a better parameterization of Ekman velocities in the ocean mixed layer. This new set shows a strong seasonal cycle and significant spatial variation in the parameterization coefficients. The improved Ekman currents allow an accurate description of the horizontal convergences and divergences at the sea surface, processes important for biological studies.

(3) Asian-Australian Monsoon system (Theme 3)

Theme-3 research aims to understand the processes related to the climate variability and predictability of the Asian-Australian monsoon, the ultimate goal being to improve monsoon prediction, particularly rainfall prediction.

Monsoon variability and predictability:

Significant progress was made in understanding the internal atmospheric dynamics and ocean-atmosphere coupling involved in the intraseasonal oscillations (ISOs)--of the summer monsoon. A mixture of observational, numerical and theoretical modeling studies revealed that northward propagation of the summertime ISOs is due to: (i) interaction between convection and the vertical shear of the mean-monsoon flow, and (ii) moisture-convection feedback. A comparison of solutions in a hybrid coupled general circulation model conducted under coupled and uncoupled conditions showed that the coupled solution matches observations

well. It may be possible to modify this analysis procedure to be useful in forecasting the dry and rainy periods associated with these ISOs.

Efforts to understand the interannual variability of the Asian-Australian monsoon, particularly that of the tropospheric biennial oscillation, have shown that monsoon anomalies are not driven solely by SST anomalies in the warm pool. Rather, they result from air-sea interaction involving positive feedback between an anomalous atmospheric anticyclone and the Indian Ocean SST dipole.

Our observational and multiple model analyses indicate that anomalous SST in the monsoon region is largely a response to local atmospheric forcing. We demonstrated that only a coupled model produces a realistic rainfall-SST phase relationship and that the traditional two-tier system for predicting monsoon rainfall from specified local SST is inappropriate.

Anthropogenic impacts:

Theme-3 scientists carried out several studies investigating human impacts on climate. Results from a modeling study of replanting desert areas in northwest China suggest that replanting may weaken the East Asian summer monsoon, decreasing rainfall in northern China and increasing rainfall in the Yangtze River region. A modeling study of the paths of tropical cyclones in the western North Pacific demonstrated that the model reproduced recent historical tracks well, and it is useful in projecting changes in the landfall of tropical cyclones over East Asia in response to increasing CO₂ concentrations. Finally, a 40-year trend analysis of precipitation and atmospheric circulation showed that changes in rainfall are related to changes in the summer circulation over China, particularly the Maiyu front, which now remains in the Yangtze River basin for a longer period. The summertime increase in extreme rainfall events in this region is associated with this circulation change.

Satellite data application:

QuikSCAT and TRMM products were used to study (i) the evolution and final structure of the Rossby wave-train resulting from the energy dispersion of a tropical cyclone and the subsequent development of another

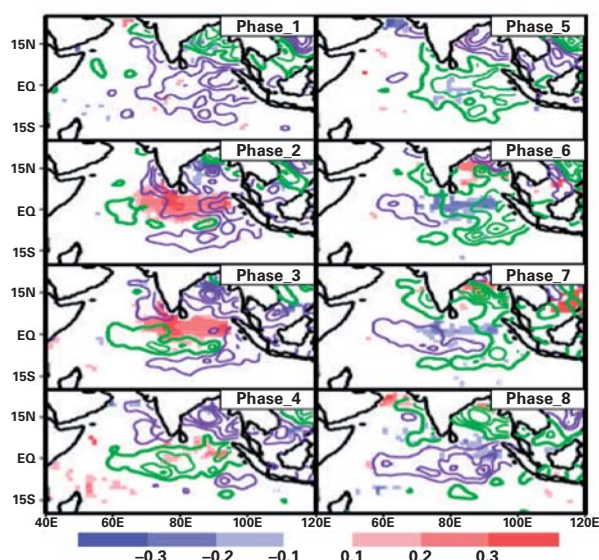


Fig. 3 The life cycle of rainfall and SST anomalies of the Indian monsoon intraseasonal oscillation. The analysis is based on a composite of TRMM satellite measurements of 24 events during the summers of 1998-2003. The mean oscillation period is 32 days; the interval between adjacent phases is about 4 days. The green contours (lavender) are positive (negative) precipitation anomalies starting from 2 mm/day (-2 mm/day) with a contour interval of 3 mm/day. The thick green contour outlines the major positive precipitation anomalies; the color shading represents SST anomalies in °C.

cyclone; (ii) the ISO life cycle of rainfall and SST anomalies on a composite of 24 events and (iii) the generation of Rossby waves by ISO convection over the west coast of Sumatra (Fig. 3).

(4) Impacts of global environmental change (Theme 4)

Theme-4 researchers continued work on understanding the climate sensitivity to radiative and land-surface perturbations, global controls over regional climate, and paleoclimate and high-resolution atmospheric modeling.

Climate sensitivity to radiative and land-surface perturbations:

Climate sensitivity work has progressed in several areas. (i) Our modeling work has shown that at some threshold of radiative forcing, the model climate becomes unstable. This "runaway" climate response seems to be mainly due to a reduction in shortwave albedo associated with low clouds. (ii) To understand why global climate models differ in their climate sensitivity to increasing greenhouse gas concentrations, the local feedback parameter fields in NCAR CCSM2 and Canada's CGCM3 were diagnosed and decomposed

into shortwave and longwave radiative components and into feedback from clouds and from the surface in a cloud-free atmosphere (Fig. 4). Though the shortwave cloud-component behaved differently in the two models, the global mean being negative in CCSM2 and positive in CGCM3, both models have a region of positive feedback in the tropical Pacific, whose geographical structure depends on the longwave cloud-feedback (iii). Finally, in order to assess the effects of a warmer climate on the occurrence of tropical cyclones in the western North Pacific, the IPRC-RegCM was adapted successfully to simulate tropical cyclones in this region.

Global controls over regional climate variability:

Work continues on the effects of radiative perturbation due to stratospheric aerosol loading following large explosive volcanic eruptions. Experiments with the GFDL "SKYHI" troposphere-stratosphere model show that a realistic representation of the quasi-biennial oscillation in the tropical stratosphere modulated the strength of the tropospheric response to the volcanic aerosols following the 1991-eruption of Mt. Pinatubo. Simulations are now underway to study how the stratosphere under unforced, natural conditions affects intraseasonal and interannual variability of tropospheric circulation.

Paleoclimate modeling:

Comparisons of model simulations with reconstructions of past climates are an important test for climate models used in increased-greenhouse-gas prediction experiments. Several such projects, mostly with the ECBilt-CLIO, have been conducted in collaboration with researchers elsewhere.

Results of simulations under forcings thought to have occurred during the last millennium were compared to available climate reconstructions. The impact of hemispheric forcing is evident in all the simulations, whereas the impact of local forcing is negligible. This result suggests that temperature changes during the "Medieval Warm Period" and "Little Ice Age" did not occur at the same time over the whole Northern Hemisphere.

Simulations in which ice-sheet topography reconstructions, the Vostok greenhouse concentrations, and orbital forcing were used to drive the coupled model fit paleoclimate reconstructions well. Effects of glacial

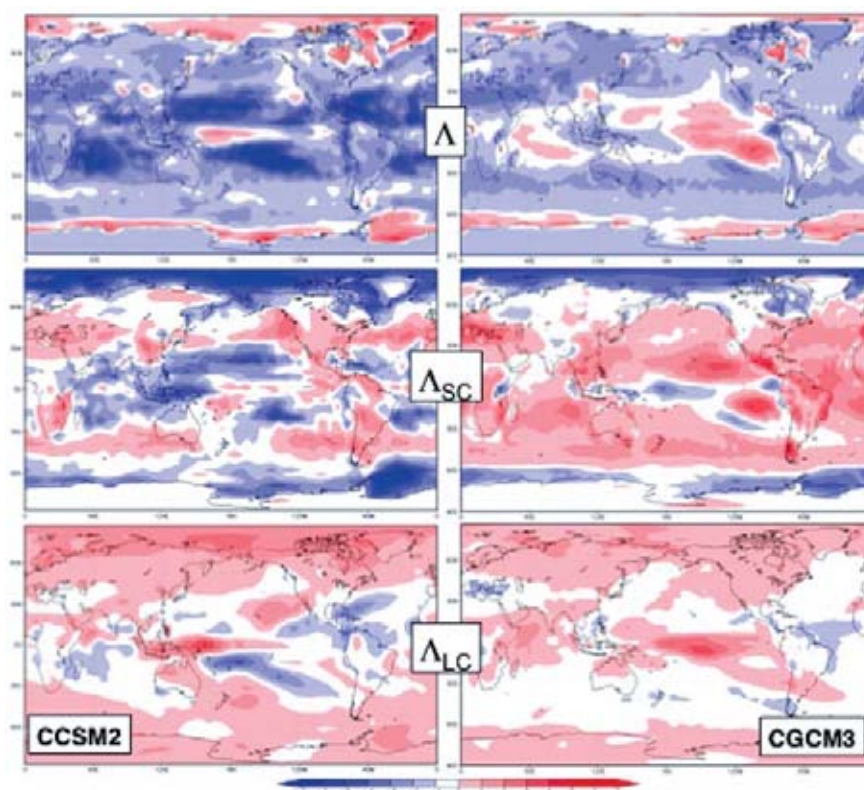


Fig. 4 The figure shows the local shortwave cloud component, Λ_{sc} , the longwave cloud component, Λ_{LC} , and the total feedback parameter field diagnosed in the NCAR CCSM2 and CCCma CGCM3. The most striking difference between the models arises from the different behaviors of the shortwave cloud (SC) component, the global mean being negative in the CCSM2, but positive in the CGCM3. Despite these differences, both models show a region of positive feedback in the tropical Pacific. In the Canadian model, the tropical Pacific Λ maximum is associated with an El Niño-like SST warming-pattern in the eastern Pacific; in the NCAR CCSM2, the strongest warming occurs in the western Pacific. The structure of the geographical pattern in each case is mainly attributable to the longwave cloud (LC) feedback.

meltwater pulses (occurring during Heinrich events) are now being studied on global climate, and on the Atlantic and the North Pacific-North Atlantic SST seesaws.

Simulations representing orbital changes from 142,000 year before present to 22,000 years after present were conducted to assess effects of insolation variations. The amplitude of ENSO was found to be large (small) when insolation differences during the annual cycle are small (large). A further simulation with a simple coupled atmosphere-ocean model for the tropical Pacific showed the ocean stratification appears to be important in this interplay between the annual cycle and ENSO.

In another modeling study, the North Atlantic thermohaline circulation (THC) was shut down in response to a freshwater pulse in the North Atlantic. This resulted in a deeper Pacific thermocline and a temporary shutdown of the Southern Oscillation. These results are now being followed up with the CSM1.4 CGCM, to determine their relevance for ENSO variability in ancient and future climates.

High-resolution atmospheric modeling:

Our analyses of integrations with the Atmospheric Model for the Earth Simulator (AFES) conducted by colleagues at the Earth Simulator Center show that AFES can simulate a realistic horizontal-scale spectrum over three decades, including the shallow mesoscale regime observed in the real atmosphere at horizontal wavelengths less than 500 km. The small-scale variations in high-resolution (T1279) control runs are now being analyzed to identify implications for subgrid-scale parameterization in lower resolution models.

(5) Asia-Pacific Data-Research Center (Theme 5)

Data holdings at the APDRC have increased in three broad areas: (i) extremely large ocean model datasets, (ii) *in situ* oceanographic observations, and (iii) remote/*in situ* atmospheric measurements. Regarding (i), OFES products are now served (only to IPRC and ESC-affiliated scientists) and include monthly mean climatologies, 3-day snapshots from a specific model

year, long-term hindcast surface fields (sea level and SST), and a ten-year climatology. In addition, output from the $1/16^\circ$ "nowcast" and "forecast" runs of the U.S. Navy Layered Ocean Model (accessible to the general public) are archived daily. With regard to (ii), the APDRC holdings now include JAMSTEC Argo data, WOCE in situ data, and FNMOC/GODAE profile data. Concerning (iii), the atmospheric data archive has increased considerably this year with a comprehensive assembly of satellite data. The ECMWF 40-year reanalysis surface- and pressure-level data have been added, as well as a 16-year, 6-hourly, ECMWF operational analysis of surface fields. Also added have been the following: four TRMM datasets, which include the microwave imager and precipitation radar measurements together with other satellite data; the satellite lightning data from the lightning imaging sensor and the optical transient detector; monthly International Satellite Cloud Climatology Project data containing cloud and radiation parameters; four datasets of the gridded precipitation and air temperature from DAAC/NASA, the University of East Anglia, and the University of Delaware. Historical records now include precipitation datasets from more than 6 Asia-Pacific countries.

With regard to its servers, the APDRC has installed DAPPER, a DODS-type server for in situ data and has upgraded the LAS, CAS and GDS. Progress has also

been made in establishing the APDRC as a "sister server" to the US GODAE program. Building upon these experiences, APDRC staff visited Yokohama to upgrade and install Tomcat, LAS and GDS servers on the Frontier machines. The Frontier machines were also set-up as "sister servers" with the APDRC and the US GODAE program.

Other accomplishments include a major upgrade of the APDRC home page (Fig. 5); the development and implementation of a data-search tool on the home page; the introduction of tutorials; completion of work under the WHOI subcontract on HydroBase2 data-quality control for the historical $T(z)$ and $S(z)$ database for the world ocean excepting the Southern Ocean; and near completion of work under the CSIRO subcontract for quality control of the historic Indian Ocean upper-ocean thermal $T(z)$ database.

1.3.3 Promotion of Integrated Ocean Drilling Program ("IODP")

On November 2004, JAMSTEC and IODP-MI signed on the Memorandum of Understanding ("MOU") to establish the formal framework of the Integrated Ocean Drilling Program ("IODP"). Based on this MOU, JAMSTEC is recognized as the Japanese implementing organization ("IO") and operator of D/V *CHIKYU* of IODP.

To promote IODP smoothly, CDEX supported the

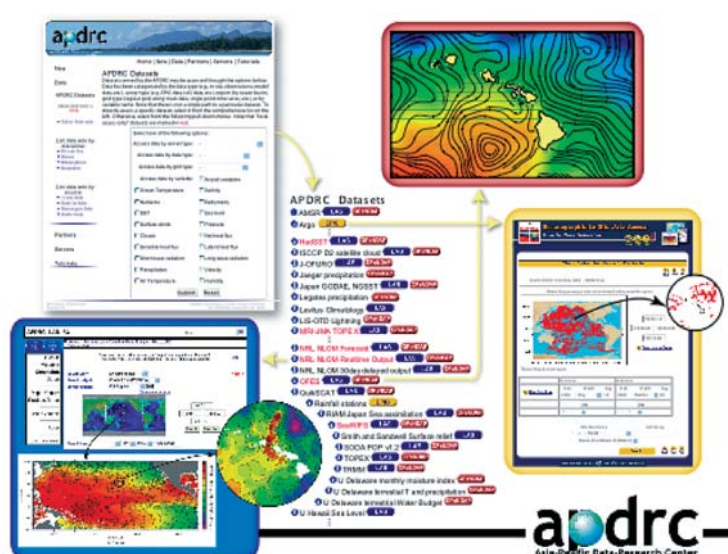


Fig. 5 The enhanced APDRC web page (top left) now includes a search utility and direct links to the data archive. A sample listing of data sets (center), gives the data set name followed by an icon indicating the server type (OpenDAP, LAS or EPIC). Sample output from each of the servers is shown by yellow arrows linking the output and a certain data set.

management of IODP-MI and the IODP Science Advisory Structure ("SAS") in cooperation with other member countries. CDEX representative and liaison participated actively in SAS and IODP-MI task forces activities.

CDEX supported 32 Japanese researchers for the IODP onboard research programs.

CDEX made promotion materials, such as pamphlets, posters, exhibition materials as a part of the Education and Outreach activities. CDEX promotion movie, "To identify changes in a new global system ~IODP's message to researchers~", won the encouragement prize of the 42th industrial movie and the video contest. CDEX published Newsletter "CHIKYU HAKKEN ~Earth Discovery~" Volume 1.

CDEX held the promotion events, "Science Square" for the public at the National Science Museum, "IODP university & museum campaign" with J-DESC for university students and educators, and "IODP Booth" for scientists and educators at the Asia Oceania Geosciences Society(AOGS) 2nd Annual Meeting.

CDEX released the latest information from CDEX

Web, CHIKYU HAKKEN Web, and CHIKYU HAKKEN mailnews.

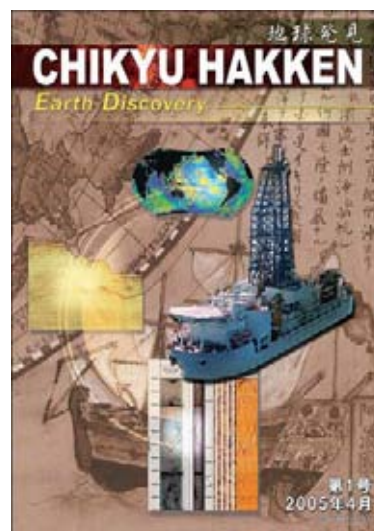


Fig. 3 CHIKYU HAKKEN Newsletter vol. 1.



Fig. 1 the MOU signing ceremony at JAMSTEC Yokosuka Hqs.
Yasuhiro Kato, President of JAMSTEC (Left)
Manik Talwani, President of IODP-MI (Right)



Fig. 2 Awarding ceremony of the encouragement prize of the 42th industrial movie and the video contest.



Fig. 4 Exhibition Booth of IODP at the AOGS 2nd Annual Meeting.

1.3.4 Promotion of research activities by external funds

- Grant-in-Aid for Scientific Research, 67 projects (including continuing projects) were implemented in FY2004.
- The following funded research projects (including continuing projects) were conducted.
 - Coordination of Science and Technology Promotion4 projects
 - Project for Sustainable Coexistence of Human, Nature, and the Earth.....5 projects
 - Disaster prevention field of RR2002.....1 project
 - Comprehensive promotion of the global environmental research4 projects
 - Others (funded by private companies, etc.)6 projects

2. Promotion of research and development achievements

2.1 Main achievements of research and development

- As the results of research and development, 838 reports were presented (including the reports at the submitting stage.) There were 697 peer-reviewed reports, which constituted 83% of all the reports presented. 486 reports of the 697 peer-reviewed reports were presented overseas.
- About 20 international symposiums and meetings for presenting research results were held.
- The following awards were received in Japan and overseas.

Aoki Program Director et al.:

The special prize from the examiner's committee of the Japan Industrial Technology Award organized by the Nikkan Kogyo Shinbun, Ltd. (April of 2005)
"URASHIMA"

Kageyama Group Leader et al.:

2004 Gordon Bell Award (November of 2004)

Yamagata Program Director:

Thomson Scientific Research Front Award 2004 (November of 2004)

Yamagata Program Director:

Sverdrup Gold Medal of American Meteorological Society (January of 2004)

Tsuboi Program Director et al.:

2003 Gordon Bell Award (November of 2003)

- The observation using the Long-term deep sea floor observatory No.1 (off Muroto Cape) and No.2 (off Kushiro-Tokachi) was continuously carried out, and the data from seismographs and tsunami meters were delivered to the Japan Meteorological Agency, etc.

2.2 Public relations activities

For public relations, the corporate information of JAMSTEC and the brochures of research vessels and equipment owned by JAMSTEC were prepared and distributed. The information was also provided through the Internet website. For opening the facilities of the Yokosuka Headquarters to public, applications of 150 tours with 4,488 visitors were accepted by telephone and Internet during the year.

As related projects for the Week of the Science and Technology Campaign, the facilities were open to pub-

lic at Yokosuka Headquarters (May 15, 2004: 3,047 visitors), Yokohama Institute for Earth Sciences (April 17, 2004: 647 visitors), and Mutsu Institute for Oceanography (August 7, 2004: 607 visitors). Hatsushima Ocean Reference Library was opened throughout the year for the first time after relocation (FY2004: 13,501 visitors). Global Oceanographic Data Center in Nago city was open all the time. The total number of visitors to all the facilities of the Agency in FY2004 was 25,982.

66 press announcements about research results and activities were made, and 224 interviews mainly for newspapers and programs were accepted.

The publication "NATSUSHIMA" that provides information requiring the immediacy was issued 12 times a year. The publication "Blue Earth" that provides detailed information about research results was issued 6 times a year. The website was updated once or more a week, and the number of accesses to the website in FY2004 was 6.18 million.

For coordination with science museums, exhibitions (special exhibitions, etc.) were given at Aomori Prefectural Asamushi Aquarium (Period: August 23, 2004, Monday to November 4, 2004, Thursday), Nagasaki Science Museum (Period: December 11, 2004, Saturday to February 2, 2005, Friday), Tokorozawa Aviation Museum (Period: January 2, 2005, Sunday to February 20, 2005, Sunday). At Tokorozawa Aviation Museum, extension lecturers by the staff members of the Agency were given. Furthermore, as one of the operations taken over from the Japan Marine Science and Technology Center, JAMSTEC gives exhibits collaboratively at OSTEC Exhibition Hall (Osaka Science & Technology Center), Tsukuba Expo Center (Tsukuba Science Expo Memorial Foundation) and Marine Science Museum (Kotohira Marine Hall).

2.3 Intellectual property activities

- Along with the reorganization as the Independent Administrative Institution, the name of the owner of the rights was changed.
- In FY2004, 30 patent applications were filed and 4 patents were obtained.
- Among the 30 patent applications were 24 joint applications with private companies and 12 foreign

applications.

- Whether holding patents should be maintained or not was deliberated at the Employee Confirmation Invention Committee, and 20 patents were abandoned. (Number of holding patents at the end of FY2004: 51)

- For bioresources, 490 newly isolated strains and 10 kinds of deep-sea bottom mud were obtained. At the end of FY2004, 4,700 strains of deep-sea microorganism and 370 kinds of bottom mud and organisms as sources of deep-sea microorganisms have been preserved with liquid nitrogen. Those strains are provided to private companies under joint research contracts.

3. Cooperation in operation of vessels for academic researches

On the occasion of the inauguration of the Independent Administrative Institution, Japan Agency for Marine-Earth Science and Technology (hereinafter referred to as "JAMSTEC") in April 2004, the research vessels, "Hakuho-maru" and "Tansei-maru", were transferred from the Ocean Research Institute of the University of Tokyo to JAMSTEC, and the Research Vessel Operation Department was newly organised for operation and management of the two vessels in JAMSTEC.

In cooperation with the Ocean Research Institute of the University of Tokyo, the Research Vessel Operation Department conducted the operation and management of the research vessels for their safe and efficient use.

The "Use of Marine Investigative Vessels and Organization of ShiptimE Committee"(UMIVOSE Committee), "Science Evaluation and Planning Subcommittee", "Installed Equipment Subcommittee" and "Remoral Equipment Subcommittee", were newly established in the Ocean Research Institute of the University of Tokyo. The researchers from JAMSTEC joined them as committee members, and the members of the Research Vessel Operation Department also joined as an observer to provide necessary suggestions.

(1) Actual operation of the research vessels

To prepare the operation schedules of the research vessels, the Cooperative Research Vessel Steering Committee of the Ocean Research Institute of the University of Tokyo, which serves as a cooperative research organization for researchers across the nation, solicits proposed research projects and draws up research project plans. Then, the schedules are determined upon approval of the board of directors of JAMSTEC. According to the operation schedules, the Research Vessel Operation Division operates the research vessels as JAMSTEC's independent operating vessels in close cooperation with the Ocean Research Institute of the University of Tokyo.

For operation, the Research Vessel Operation Department made arrangements for voyage several months before the respective research voyages to work in concert with the Office for Cruise Coordination of the Ocean Research Institute of the University of Tokyo, researchers on board, crew, and the divisions on land of JAMSTEC.

1) "Hakuho-maru"

In FY2002, the Research Vessel Operation Committee (renamed "Use of Marine Investigative Vessel and Organization of ShiptimE Committee"(UMIVOSE Committee) in FY2004) of the Ocean Research Institute of the University of Tokyo solicited long-term voyage projects for the period from FY2004 to FY2006, and major three-year research projects were determined. Based on those major research projects and the small research projects solicited by the Committee in FY2003, the cruise schedule for FY2004 was planned.

According to the cruise schedule, "Hakuho-maru" implemented four actual voyages in 291 actual operating days in total during FY2004. The total number of operating days includes 5 days for navigation to the dockyard and 5 days for training, etc.

Actual voyages by major research field (main theme) are as follows:

- a) Operation for research in the fields of biology, geo-science and technology in Mariana and Midwestern Pacific Ocean, 57 days
- b) Operation for research in the biological field in the Northwest Pacific Ocean, 65 days
- c) Operations for research in the fields of physics and geo-science in the Western North Pacific Ocean, 65 days
- d) Operation for research in the chemical and biological fields in the South Pacific Ocean and the Antarctic Ocean, 111 days (Fig. 1, Fig. 2)

In FY2003, the number of actual operating days was 180. (Table 1 Number of operating days, Table 2 Actual voyages of "Hakuho-maru" in FY2004, Fig. 5 Navigation chart of "Hakuho-maru" in FY2004)



Fig. 1 Drift ice on the Antarctic Ocean (KH-04-5)



Fig. 2 "Hakuho-maru" in Auckland Port, New Zealand after voyage in the Antarctic Ocean (KH-04-5).



Fig. 3 Tansei-maru at the quay of Kaio-maru in Toyama Bay (KT-04-21 to 22).

Table 1 Number of operating days.

Name of vessel	Hakuho-maru		Tansei-maru	
	2003	2004	2003	2004
Number of voyages (actual operation)	4	4	20	31
Number of operating days (actual operation)	180	291	177	270

Preparation works for maintenance and operation of vessels and observation facilities/equipment, which had been conducted by the Ocean Research Institute of the University of Tokyo before transfer of the vessels, were taken over, and annual inspection works were implemented at the Shimonoseki Shipyard & Machinery Works of Mitsubishi Heavy Industries, Inc. during the period from April 5, 2004 to May 6, 2004

2) "Tansei-maru"

The operation schedule for FY2004 was planned so that the research projects in the fields of biology, physics, chemistry, geo-science and fisheries which were adopted in FY2003 by the Research Vessel Operation Committee of the Ocean Research Institute of the University of Tokyo could be implemented efficiently.

According to the operation schedule, "Tansei-maru" implemented 31 actual voyages in 270 actual operating days in total in the surrounding ocean area of Japan (Fig. 3, Fig. 4). The total number of operating days includes 51 days for berthing at ports outside the home port (Daiba, Tokyo) and 3 days for navigation to the dockyard. The number of actual operating days in FY2003 was 177. (Table 1 Number of operating days, Table 3 Actual voyages of "Tansei-maru" in FY2004,



Fig. 4 CTD observation and sampling of water (KT-05-1).

Fig. 6 Navigation chart of "Tansei-maru" in FY2004)

The annual inspection work, with outsourcing of supervisory work, was carried out at the Osaka Factory of Sanoyas Hishino Meisho Corporation during the period of January 13, 2005 to February 21, 2005. The vessel body was partly remodeled to add on a cabin where one marine technician could stay on a full-time basis, and the number of researchers on board was increased from 11 to 12.

(2) Implementation of observation support activities

As for "Hakuho-maru," in response to requests from the Office for Cruise Coordination of the Ocean Research Institute of the University of Tokyo and the researchers on board, JAMSTEC dispatched marine technician having skills in nutritive salt analysis, CTD operating management, air gun/OBS operating management, etc. that were required for the respective operations to provide research support (in 5 operations in a total of 124 people/days).

As for "Tansei-maru", specialized observation sup-

port was requested, including coordination between the crew and the researchers having little field experience, because the number of such researchers was increasing along with the increase of the operating days. In response to the request, JAMSTEC established a system in which one marine technician could be dispatched and stay all through year. In various fields such as biology, physics, chemistry, geo-science and fishery, research support on board (in 19 operations in a total of 186 people/days) was provided.

(3) Appropriate operation system (crew management)

To establish an appropriate operation system matching the increase of operating days, the annual manning schedule was planned, taking work environment and other conditions into consideration, and a good labor-management relationship was newly established.

To correspond to the increase of operating days of both vessels, it's necessary to increase the number of seafarers. Therefore, reserved seafarers were recruited. In addition, coordination between labor and management and adjustment of work environment and other conditions were conducted.

(4) Safety and security of vessels

The International Ship and Port Facility Security (ISPS) Code and its related domestic laws took effect on July 1, 2004. Accordingly, for Hakuho-maru, necessary qualified persons were procured, regulations were prepared, certificates were acquired, and necessary security measures were implemented. The "Safety Management Manual" in conformity with the International Safety Management (ISM) Code (which is not applied to academic research vessels) was also prepared.

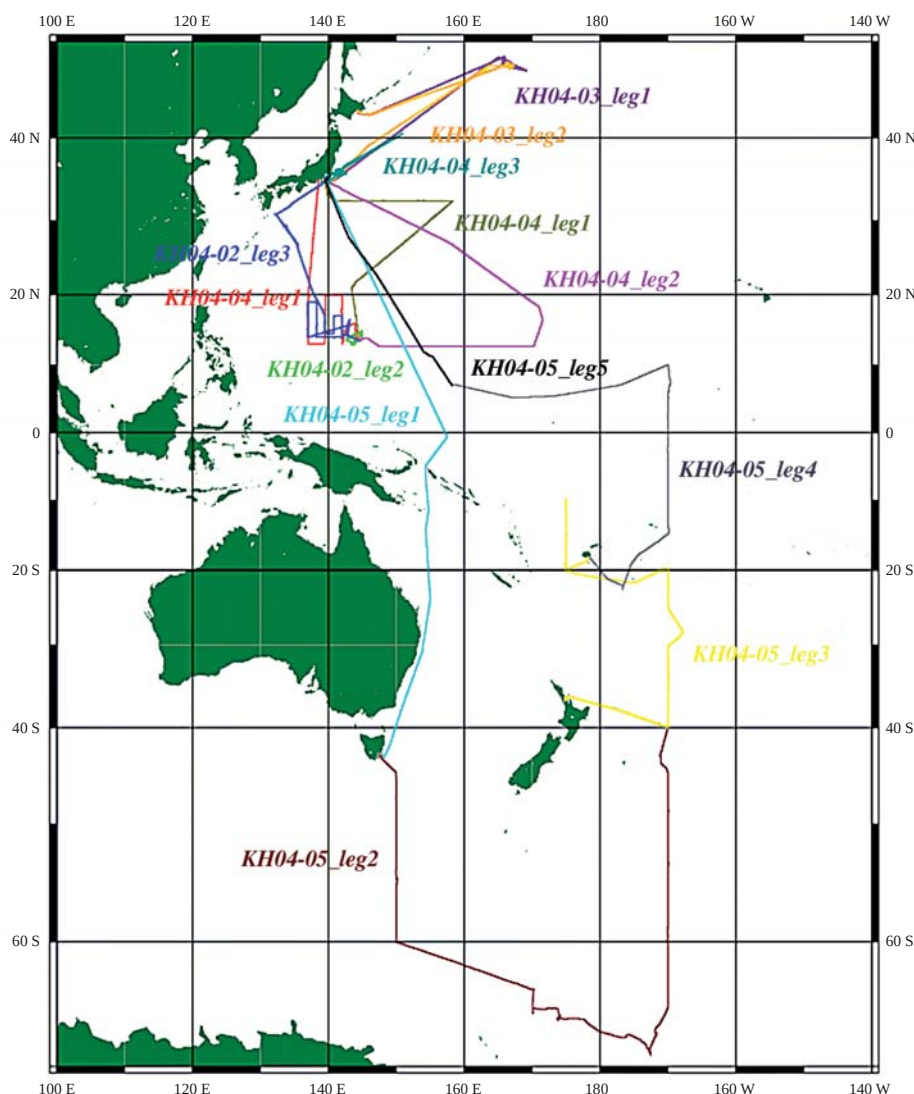


Fig. 5 Navigation chart of "Hakuho-maru" in FY2004.

Table 2 Actual voyages of "Hakuho-maru" in FY2004.

4 Apr.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sun
			Harumi - Shimonoseki Cruising																	Annual Inspection											
5 May	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon
																				Mariana - Midwestern Pacific Ocean KH-04-2 (55days)											
6 Jun.	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu
7 Jul.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat
8 Aug.	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue
9 Sep.	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Thu
10 Oct.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
11 Nov.	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Thu
12 Dec.	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri
1 Jan.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon
2 Feb.	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon			
3 Mar.	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu

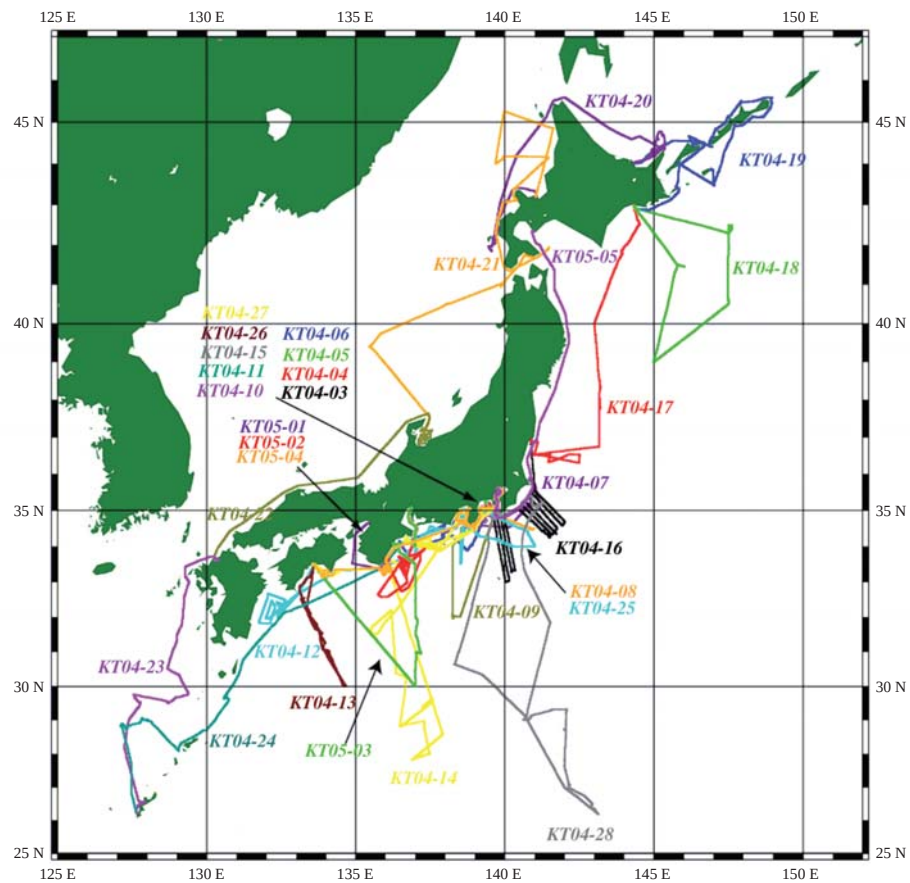


Fig. 6 Navigation chart of "Tansei-maru" in FY2004.

Table 3 Actual voyages of "Tansei-maru" in FY2004.

4 Apr.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
								Daiba						Sagami Bay KT-04-3 (3days)		Daiba			Sagami Bay KT-04-4 (5days)			JAMSTEC			Sagami Bay KT-04-5 (5days)			Daiba			Kumano Nada · Enshu Nada	
5 May	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	
		Suruga Bay																		Sagami Bay · Tokyo Bay												Sagami Bay · Tokyo Bay · Izu Area
	KT-04-6 (7days)																			KT-04-8 (7days)				JAMSTEC							KT-04-9 (7days)	
6 Jun.	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	
		Daiba																		Sagami Bay KT-04-11 (4days)											Kumano Nada · Hyuga Nada KT-04-12 (10days)	

7 Jul.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
8 Aug.	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	
9 Sep.	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	
10 Oct.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	
11 Nov.	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu
12 Dec.	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	

1 Jan.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	
2 Feb.	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	
3 Mar.	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	

4. Provision of use of facilities and equipment to those who conduct research and development or academic research on science and technology

4.1 Provision of use of test research facilities and equipment such as research vessels and deep sea research systems

4.1.1 Research Support Department

Along with the inauguration of the Marine Technology Center in July 2004, the Research Operation Department was renamed the Research Support Department. The conventional four divisions were also reorganized into Research Support Group, Ship Operations Group, Marine Engineering Group and Research Facilities Group. The operations of the new Groups include research support/coordination, operation management of ships, manned research submersibles, unmanned research vehicles, etc., maintenance and management of equipment, etc. and maintenance and management of facilities at the JAMSTEC, which are basically the same as before. The topic on the FY2004 research cruise was that in the "NIRAI KANAI", S/V YOKOSUKA & SHINKAI 6500 Great Voyage in the Pacific Ocean for deep-sea research, the world's largest-class lava flow was discovered in the southern East Pacific Rise. In January 2005, the "Blue Earth '04" was held to report the achievements of the deep-sea survey researches and the R/V MIRAI research projects selected from public proposals, and had a total of 1214 participants in 2 days. Furthermore, the Machine Shop was newly established in the Research Facilities Group to collectively manage and operate the working machines and tools which had been located at dispersed places within the JAMSTEC.

① Public Invitation System for Deep Sea Research Projects

For deep sea research, the "Deep Sea Research Promotion Committee (hereinafter referred to as the "Promotion Committee"), the "Deep Sea Research Planning Committee" (hereinafter referred to as the "Planning Committee") and the "Deep Sea Research Implementation Plan Coordination Working Group" (hereinafter referred to as the "Coordination Working Group") peer reviews publicly invited projects and lay out research implementation plans.

We have proposed that deep sea research projects should be selected in an open public invitation system in accordance with the "Mid-Term Plan for Deep Sea Research". In order to avoid confusion with the mid-term plan prepared along with the establishment of the JAMSTEC and to keep pace with changes in the research environment including the progress of earthquake research and observational studies and the Integrated Ocean Drilling Program (IODP), the "Mid-Term Plan for Deep Sea Research" was reviewed by the Planning Committee and revised as the "5-Year Research Guideline for Deep Sea Research".

The public invitation for the FY2005 Deep Sea Research Projects was implemented on the Internet from July 20 to August 19, 2004. The vessels, etc. to be used for the publicly invited research projects were the Manned Research Submersible SHINKAI 6500 (87 dives in 173 days), R/V KAIREI, and R/V NATSUSHIMA (with the systems such as HYPER-DOLPHIN and Deep Tow, and the newly added vehicle, Deep Sea ROV KAIKO 7000, which is a provisional alternate vessel to KAIKO). The number of project applications was 73, which were made by 69 proponents with 687 joint researchers. The Planning Committee peer reviewed and rated the applications, and 55 projects were adopted. Based on the selected projects, the Coordination Working Group laid out the next-year annual research implementation plan (draft). In October 2004, the annual research implementation plan (proposal) was deliberated at the Promotion Committee and approved at the board of directors' meeting in March 2005.

② Public Invitation System for R/V MIRAI Cooperative Use Projects

For research cruises by R/V MIRAI, major subjects are determined according to the R/V MIRAI Long-Term Observational Study Plan (five-year plan for the period of 2004 to 2008). Projects related to the subjects are publicly invited, and which projects should be adopted is determined at the R/V MIRAI Operation Study Committee.

The FY2004 public invitation of projects for the R/V MIRAI was implemented on the Internet from July 1 to July 31, 2004. The total number of project applications was 61, and the number of applicants for boarding the ves-

sel was 46. In August 2004, 60 projects and 44 applicants for boarding were selected at the R/V *MIRAI* Operation Study Committee. Among them, 22 projects were adopted by the JAMSTEC, 26 projects by the national, public and private universities, and 12 projects by the national research institutions, etc. They were approved at the board of directors' meeting in March 2005.

③ Blue Earth '04

In January 13 and 14, 2005, the Blue Earth '04 (the 21st "SHINKAI Symposium" and the 8th "MIRAI Symposium") was held at the Pacifico Yokohama over a two-day period. During the two days, it had 1214 participants in total, that is, the number of participants slightly increased compared to the Blue Earth '03 (1100 participants). In the Blue Earth '04, the achievements of the BEAGLE2003 (cruise by the R/V *MIRAI* around the Southern Hemisphere) were reported, and especially, the "MIRAI Symposium" attracted a lot of attention. The "SHINKAI Symposium" included 30 oral presentations and 78 poster presentations, while the "MIRAI Symposium" included 23 oral presentations and 45 poster presentations.



Fig. 1 Scene of the oral presentation venue at the Blue Earth '04.



Fig. 2 Scene of the poster presentation venue at the Blue Earth '04.

④ MIND

MIND is an abbreviation for "Marine INformation and Discussion", and it was inaugurated in FY2000 as a place for exchanging opinions about ideas, problems, etc. arising at the actual research and observation sites. The MIND is intended to improve skills and safety by sharing information of different sites and giving feedback of them. In FY2004, a total of 11 programs from the 37th to the 47th MIND, were held, including the external lecture by Ms. Kazumi Shibata, shipboard technician of the Woods Hole Oceanographic Institution, US.

⑤ EEZ application

To conduct surveys within the Exclusive Economic Zone (EEZ) of the coastal countries in the research sea areas based on Article 13 of the UN Convention on the Law of the Sea, we went through the procedure for the "Request of Extension of Convenience on Research Cruise to the Ministry of Foreign Affairs" for the FY2004 research cruises of 10 operations in 22 countries, and all the cruises were conducted smoothly. We proceeded with the same request for FY2005 cruises, too.

⑥ Research support

The JAMSTEC has an established research support system by observation engineers having specialized skills. To smoothly and efficiently implement the publicly invited cruise projects in which Japanese and foreign researchers including the JAMSTEC's researchers participate and research cruises conducted by the JAMSTEC's researchers, we provide support such as preparations for cruise in advance, support of survey and observation during cruise, operation of observation equipment, preparation of cruise reports, and management jobs of data and samples. In addition, at the research facilities on land, maintenance and storage of oceanographic observation buoys including TRITON Buoy and the ocean-bottom seismometer (OBS) and storage, quality management and provision of various collected data including image data were conducted. With the aim of upskilling of observation engineers, the "Observation Skill Improvement Program" was implemented to promote the improvement of performance of various kinds of observation equipment and data quality.

Major research support activities are as follows:

(1) Research support on deep sea research projects, etc.

In the research cruises of R/V *NATSUSHIMA*, S/V *YOKOSUKA*, R/V *KAIREI* and R/V *KAIYO*, we provided research support to the deep sea researches such as ocean-bottom geological study and marine organism study and the JAMSTEC's research projects. We also conducted operation and maintenance of the multi-channel reflection method/refraction method survey system (MCS) and the ocean-bottom seismometer (OBS) for suboceanic structure survey using R/V *KAIREI*, R/V *KAIYO*, etc. Especially, in the survey of the Special Coordination Fund for Promoting Science and Technology, "Tonankai-Nankai", using the ocean-bottom seismometer, 170 OBSs, which was the largest in number, were operated concurrently. The total amount of support operations was 4,729 people · days.

(2) Research support on cruises of R/V *MIRAI*

In the research cruises of the R/V *MIRAI*, we provided mainly marine physical and chemical oceanographic research support for the adopted projects by external



Fig. 3 OBS maintenance work on R/V *KAIYO*.



Fig. 4 Streamer cable installation work on R/V *KAIREI*.

researchers, etc. in 6 major research projects. The number of days for observation cruises by the R/V *MIRAI* was 311 in FY2002, 328 in FY2003, and 307 in FY2004. Using the large research space and the boarding capacity of 43 science members of the R/V *MIRAI*, a comprehensive oceanographic observation covering the fields of physics, chemistry, biology, geology, and atmospheric oceanography has been conducted. Consequently, the total number of observation engineers supporting the observation cruises reached 6,509 people · days.

(3) Research support on cruises of R/V *Hakuho-maru* and R/V *Tansei-maru*

Since April 1, 2004, R/V *Hakuho-maru* and R/V *Tansei-maru* have been operated by the JAMSTEC Research Vessel Operation Department. The number of annual operation days increased from 180 to 280. For the cruises of the R/V *Hakuho-maru*, observation engineers were assigned to CTD survey, nutrient salt analysis, ocean-floor structure surveys, etc. to provide research support. For the cruises of the R/V *Tansei-maru*, one or two observation engineers depending on the purpose of cruise were assigned to provide research support. The total amount of support operations for both vessels reached 518 people · days.

(4) Research support on urgent research cruises

In December 26, 2004, the great earthquake of M9.3 and tsunami occurred off the Indonesian Sumatra Island. As part of the urgent research project of "Clarification of the source rupture process of the earthquake that caused the great tsunami" by the Ministry of Education, Culture, Sports, Science and



Fig. 5 Observation work by CTD on R/V *MIRAI*.



Fig. 6 Observation work by sonde on R/V *MIRAI*.

Technology, the R/V *NATSUSHIMA* and the *HYPER-DORPHIN* were dispatched to conduct the funded research project of "Survey of the ocean bottom around the earthquake epicenter". For the research project over a 41-day period from February to March 2005, 4 observation engineers specializing in seismic survey were dispatched on board, and research support of a total operation amount of 164 people · days was provided.

(5) Research support at Mutsu Institute for Oceanography, Yokohama Institute for Earth Sciences, and Global Oceanographic Data Center in Nago

At the Mutsu Institute for Oceanography, we provided support such as maintenance and storage of collected TRITON Buoys, buoyant force adjustment and sensor calibration works for ARGO FLOAT, and chemical analysis of samples collected through ocean observation, and those support activities were conducted by 15 observation engineers, resulting in a total operation amount of 3,600 people · days. At the Yokohama Institute for Earth Sciences and the Global Oceanographic Data Center in Nago, quality management and archiving of data obtained through observation surveys were conducted by 40 observation engineers and observation sub-engineers, resulting in a total operation amount of 9,600 people · days.

⑦ Operation of vessels

The Research Support Department provides support for research projects such as deep sea surveys and oceanographic observations using the five research vessels of R/V *NATSUSHIMA*, R/V *KAIYO*, S/V *YOKOSUKA*, R/V *KAIREI* and R/V *MIRAI*, and the deep sea



Fig. 7 Survey work on R/V *NATSUSHIMA* and *HYPER-DOLPHIN*.



Fig. 8 Participants in the survey of the Off Sumatra Island by R/V *NATSUSHIMA*.



Fig. 9 Loading work of TRITON Buoy after maintenance to R/V *MIRAI* at Mutsu Institute for Oceanography.



Fig.10 Checking work of ARGO FLOAT sensor at Mutsu Institute for Oceanography.

research systems of *SHINKAI 6500*, *HYPER-DOLPHIN*, *KAIKO 7000* and *Deep Tow*, and also cooperates in public relations activities such as public opening of vessels at ports of call.

The operation and maintenance of research vessels and deep sea research systems have been outsourced.

(1) Research Vessel *NATSUSHIMA*

R/V *NATSUSHIMA* conducted 12 operations in 286 operating days in total for the publicly invited deep sea research projects and the JAMSTEC's research projects. (See Table 1 Actual operations of the respective vessels in the past three years, Table 2 Diagram indicating actual operations, and Fig.11 Cruise tracks)

The breakdown of the operations is as follows: research dives by the *HYPER-DOLPHIN* - 9 operations, 209 days (off the coast of Kushiro, off the coast of Sanriku, Sagami Bay, Izu-Ogasawara, Nankai Trough, the sea area to the west of Kagoshima, Kagoshima Bay, Southwest Islands, Off Sumatra Island), deep sea towing researches by the *Deep Tow* - 1 operation, 12 days (the sea area to the east of the Minami Daito Island), independent cruise - "Time-series observation" - 1 operation, 18 days (the northwestern North Atlantic Ocean), "Prediction experiment at the coastal area of Japan" - 1 operation, 18 days (Southwest Islands), etc. Furthermore, the urgent study project of the "Funded Research of the Earthquake Off Sumatra and Tsunami" was implemented. The operations which the R/V *NATSUSHIMA* was supposed to conduct but couldn't because of this urgent study were conducted by other vessels. On August 15, 2004, the R/V *NATSUSHIMA* was open to public at Nago Fishing Harbor in Nago City, Okinawa Prefecture.

Overview of the cruise for "Funded Research of the Earthquake Off Sumatra and Tsunami"

On December 26, 2004, the Earthquake of magnitude 9.0 having a hypocenter located off the coast of Sumatra occurred, and then the giant Tsunami hit the surrounding countries in the Indian Ocean. In the international framework for calling for the clarification of the causes of the Earthquake and Tsunami and the reconstruction from the disaster, we conducted the ocean-floor survey around the hypocenter to examine changes of the ocean floor immediately after the occur-

rence of the earthquake in cooperation with the Indonesian Agency for the Assessment and Application of Technology (Badan Pengkajian dan Penerapan Teknologi: BPPT).

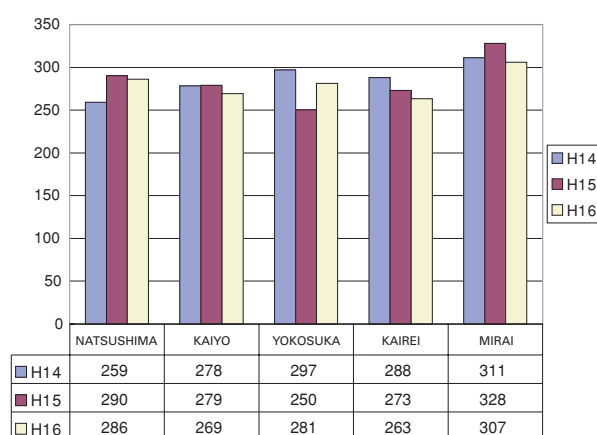
The cruise was conducted off the coast of the Ache province of Indonesia over a 26-day period in total under two stages: the first stage (Feb. 18 to March 5; Singapore to Penang) and the second stage (March 10 to 19; Penang to Bali). This survey cruise turned out to be an international survey cruise in which researchers mainly from Japan and Indonesia and researches from Germany and the US, too, participated aboard.

Topographic surveys of the sea bottom by the multi-beam sonic depth finder equipped with the *NATSUSHIMA*, surveys of minute topographic changes of the sea bottom through direct observation by the *HYPER-DOLPHIN*, and the aftershock distribution observation using the ocean-bottom seismometer were conducted.

These surveys were conducted in the FY2004 Urgent Study Program of the Special Coordination Fund for Promoting Science and Technology (Project name: Urgent Survey Study about the Disaster of the Great Earthquake off Sumatra Island and the Tsunami in the Indian Ocean) by the Ministry of Education, Culture, Sports, Science and Technology.

As for the annual maintenance, the intermediate inspection and repair works were conducted at the Keihin Shipyard of Universal Shipbuilding Corporation from October 13, 2004 to November 17, 2004. The works for assuring continued performance of special devices as well as continued fundamental vessel performances of the structure of the body, the propulsion

Table 1 Actual operations of the respective vessels in the past three years.



R/V NATSUSHIMA Cruise Tracks, FY2004

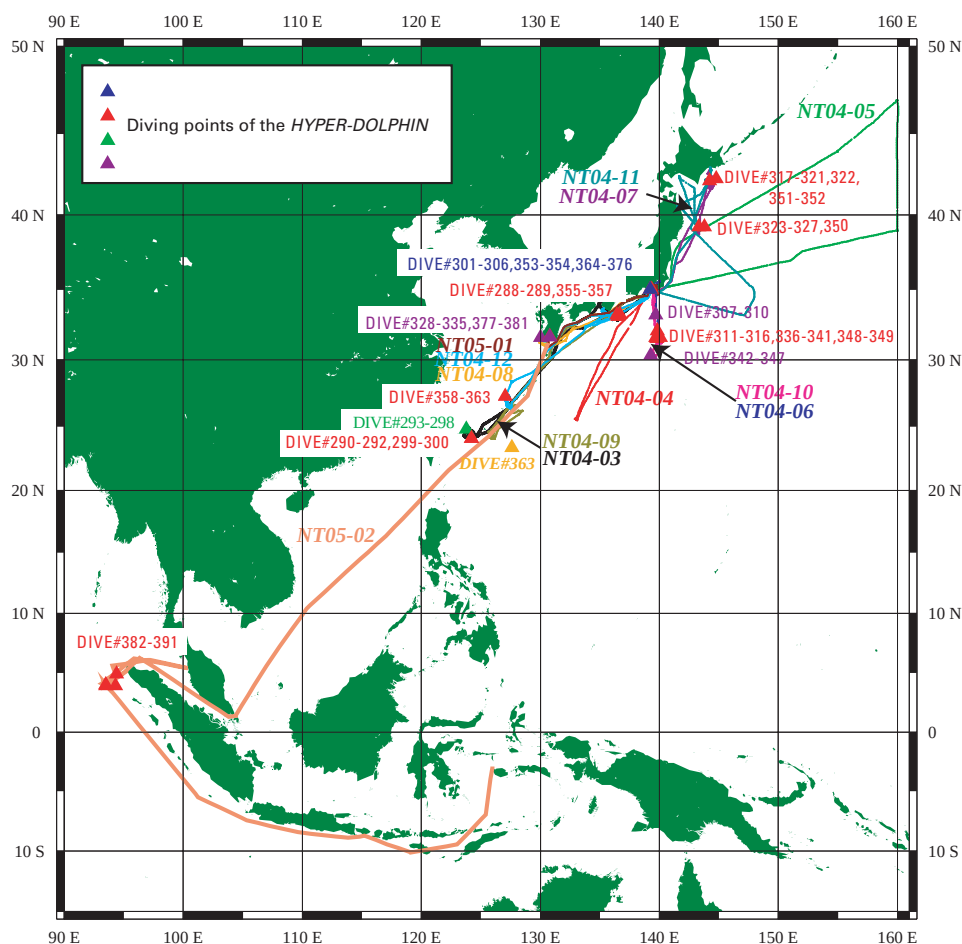


Fig.11 R/V NATSUSHIMA Cruise Tracks, FY 2004.

unit, etc. were carried out, and the following works for improvement of functions were conducted.

- [1] Additional installation of XBT/XCTD devices
- [2] Conversion of the diver preparation room into the bath room for women and the laundry room
- [3] The maintenance supply equipment and the external rescue equipment for the *SHINKAI 2000* were removed to have work space, etc.
- [4] Upsizing of the diameter of the seawater piping for research in the container lab
- [5] Improvement of the work environment of the researcher's equipment and materials preparation room
- [6] Ensuring of work space on the carriage on which the container lab is mounted

After completion of the works, the following tests and operation checks were conducted during the test

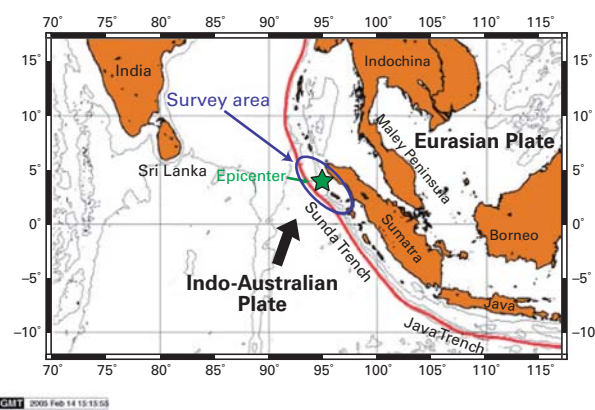


Fig.12 Sea area off the Indonesian Sumatra Island for the urgent survey.

cruise (November 17 to 26). From November 19 to 22 (for four days), one JAMSTEC's staff member got on board as a trial.

- [1] General operation check of engine and its related parts
- [2] Check test of auto pilot tracking function
- [3] Operation check of echo sounder (sonic depth finder)

for cruise)

- [4] Performance check test of sonic navigational device
- [5] Performance check test of XBT/XCTD devices
- [6] Performance check test of Multi Narrow Beam Echo Sounder
- [7] Topographic survey of the sea bottom

(2) Research Vessel *KAIYO*

R/V *KAIYO* conducted 14 operations for 269 days in total for the JAMSTEC's research projects. (Table 2 Diagram indicating actual operations, Fig.13 Cruise Tracks)

The breakdown of the operations is as follows:
 "Survey by the Deep Tow" (off the coast of Kushiro-Tokachi, Sagami Bay, Southwest Islands) - 2 operations, 57days; "Survey by the Deep Tow and the Piston Core"

(Kumanonada) - 1 operation, 20 days; "Survey by MCS/OBS (Ocean-Bottom Seismometer)" (Tonankai/Nankai, Nankai Trough, Izu-Ogasawara) - 5 operations, 92 days; "Survey by SCS (Single Channel Reflection Method Survey System)" (Kumanonada) - 1 operation, 9 days; "Elucidation of the old ocean and the material recycling at the formation of cold sapropel in the Sea of Japan" (Sea of Japan) - 1 operation, 13 days; "Research about hydroacoustic technology" (Suruga Bay) - 2 operations, 16 days, "NSS: Survey by the Navigable Deep Sea Sampling System" (Tokai and Nankai Troughs, Shikoku Basin) - 1 operation, 28 days; "Survey of tidal current in the Kumanonada sea - Preliminary survey for drilling on the IODP" (Shikoku Basin, Izu Ridge) - 1 operation, 25 days, etc. On May 15, 2004, the facilities of the R/V *KAIYO* were opened to the

R/V *KAIYO* Cruise Tracks, FY2004

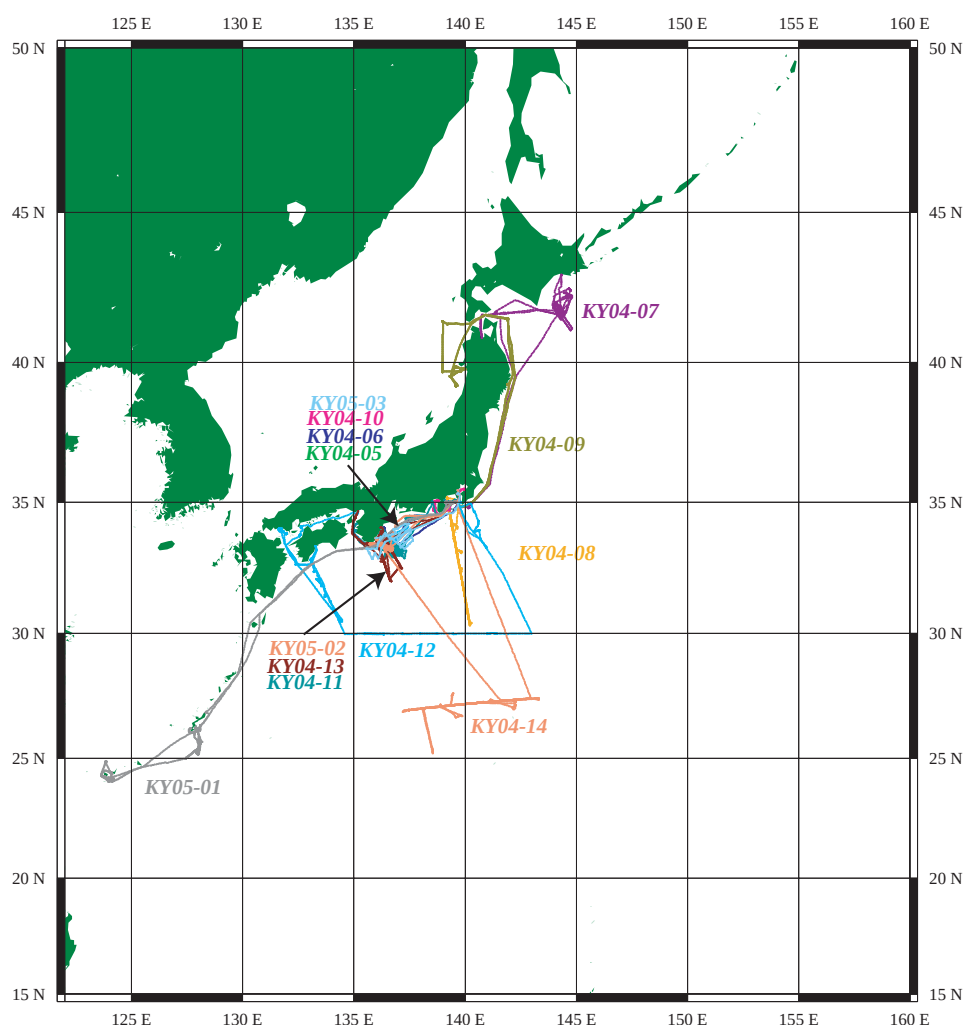


Fig.13 R/V *KAIYO* Cruise Tracks, FY 2004.

public at the JAMSTEC Yokosuka Headquarters, and the orientation cruise for the public was implemented around the Yokosuka Port.

As for the annual maintenance, the annual inspection and repair works were conducted at the Yura Ship Repair Department of Mitsui Engineering & Shipbuilding Co., Ltd. from April 5, 2004 to May 7, 2004. The works for assuring continued performance of special devices as well as continued fundamental vessel performances of the structure of the body, the propulsion unit, etc. were carried out, and the following works for improvement of functions were conducted.

- [1] New installation of the AC100V distribution board for power supply to the research equipment used in the topside stern section
- [2] Additional installation of the emergency stop switch to the No.2 hydraulic source device
- [3] Improvement of the work environment of the Gun Room
- [4] New installation of a tap for research seawater in the fourth laboratory
- [5] Integration of the wave receiver and the motion sensor of the acoustic positioning device for improvement of the acoustic positioning accuracy (Fig.14)
- [6] Replacement of the acoustic positioning device SSBL receiver to the new model

After completion of the works, in the test cruise (May 7 to 12), the below-mentioned tests and operation checks were conducted. 2 observation engineers of Global Ocean Development Inc. (GODI) got on board as a trial (throughout the cruising period) and had technological exchanges and opinion exchanges with the observation engineers of Nippon Marine Enterprises, Ltd. (NME).

- [1] General operation check of engine and its related parts
- [2] Performance check test of the acoustic positioning device
- [3] Performance check test of Multi Narrow Beam Echo Sounder
- [4] Performance check test of Acoustic Doppler Current Profiler (ADCP)
- [5] Performance check test of multi-channel reflection method survey system

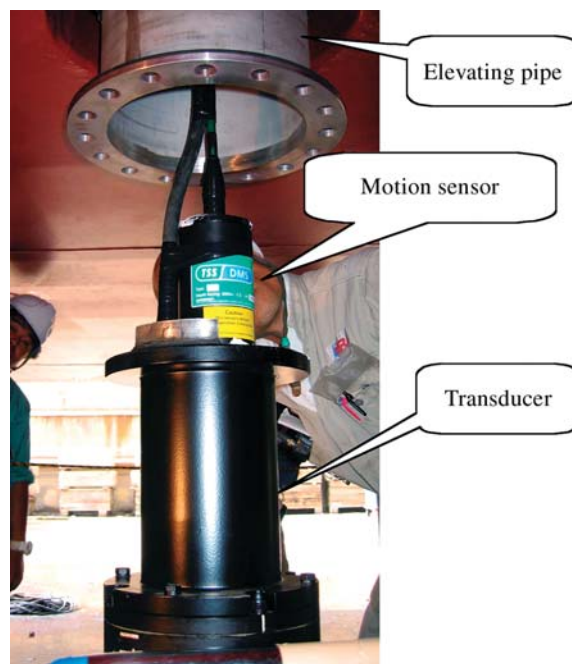


Fig.14 Wave receiver and motion sensor of the acoustic positioning device of the R/V KAIYO.

- [6] Performance check test of the ocean-bottom seismometer

(3) Support Vessel YOKOSUKA

S/V YOKOSUKA conducted 11 operations in 281 days in total for the publicly invited deep sea research projects and the JAMSTEC's research projects, including the Great Voyage in the Pacific Ocean "NIRAI KANAI" (Table 2 Diagram indicating the actual operations, Fig.15 Cruise Tracks)

The breakdown of the operations is as follows: Dives for research by the *SHINKAI 6500* (Sagami Bay, Izu-Ogasawara, Southwest Islands, EPR, Lau Basin, French Polynesia) - 5 operations, 186 days; tests in the actual sea area by the Deep Sea Cruising AUV *URASHIMA* (Suruga Bay) - 4 operations, 22days; independent cruise for "Piston Core and OBS survey" (French Polynesia, South-East Pacific) - 1 operation, 43days; "Deep Tow Training" (Southwest Islands) - 1 operation, 13 days, etc.

Overview of the "NIRAI KANAI"

"NIRAI KANAI" is the abbreviation of Nippon Ridge Arc and Intra-plate Key processes Apprehension NAvigational Initiative, and it means a paradise which they believed in the Amami-Okinawa region was lying over the sea or at the bottom of the sea or under the

S/V YOKOSUKA Cruise Tracks, FY2004

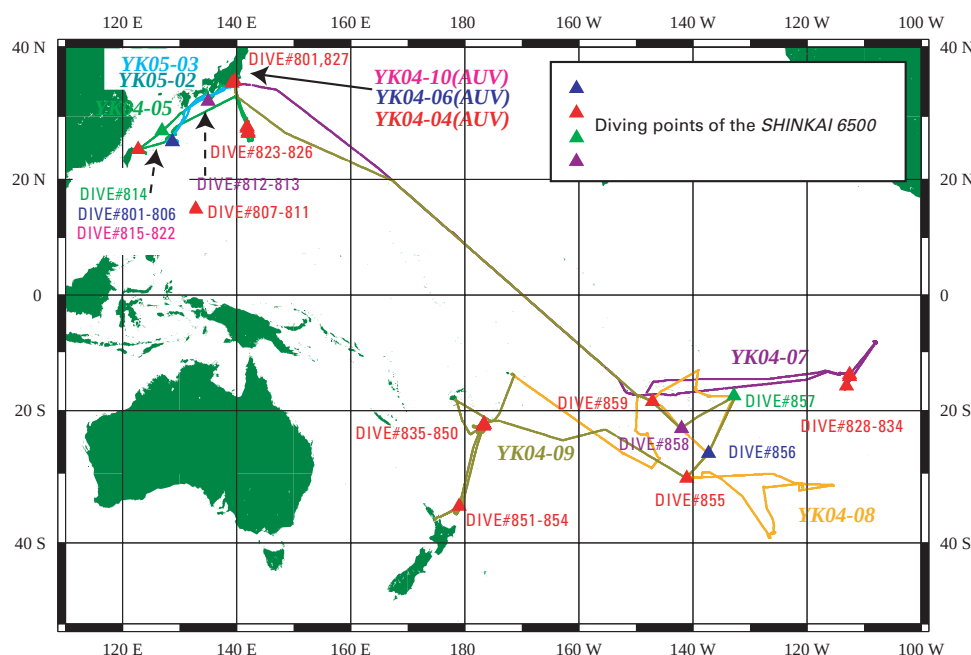


Fig.15 S/V YOKOSUKA Cruise Tracks, FY 2004.

ground. (Excerpt from the Daijirin dictionary)

On June 19, 2004, they left the JAMSTEC's berth of Yokosuka, the home port, and carried out the following geophysical and biological surveys, [1] to [4], with the *SHINKAI 6500* and the S/V *YOKOSUKA*, and returned to the Yokosuka port on December 14, 2004.

- [1] Observational survey of the seafloor and sampling at the place on the East Pacific Rise where new seafloor is being created
- [2] Installation and collection of a seismometer for hot plume survey in French Polynesia
- [3] Basic survey of the topography of the bottom in the unsurveyed region on the southern East Pacific Rise
- [4] Biological deep sea survey toward a detailed clarification of the hydrothermal ecosystem including the chemosynthetic ecosystem of the South Pacific on the Lau Basin and Kermadec Ridge

On the way, the S/V *YOKOSUKA* made port calls at Papete (Tahiti), Apia (Independent State of Samoa), Auckland (New Zealand) and Suva (Fiji) for maintenance and resupply. On October 24, the special opening to the public was performed at Auckland port.

As for the annual maintenance, the main storage battery device of the *SHINKAI 6500* was changed from sil-

ver oxide zinc cell to lithium ion cell, which resulted in the increase of the number of possible annual dives. Then, it was decided that the legal inspection and repair works of the S/V *YOKOSUKA* should be conducted around the same time as those of the *SHINKAI 6500*, and two annual inspection works were carried out for the purpose of increasing the number of annual operation days.

From April 1, 2004 to April 13, 2004, the works such as preparation for mounting of 9,000m-class wire winch (used for piston corer and dredge) necessary for "NIRAI KANAI", installation of towing winch on the S/V *YOKOSUKA* and replacement of the motion sensor built in the wave receiver of the acoustic navigation



Fig.16 Overview of "NIRAI KANAI".

device, as well as minimum works required for receiving the annual inspection, were conducted at the Kobe Shipyard of Kawasaki Shipbuilding Corporation.

After completion of the works, during the shift to Yokosuka, the general operation check of engine and its related parts and the performance check test of the acoustic navigational device were implemented.

As the result of receiving the above annual inspection, the reference date for the next annual inspection was set on May 19, 2005. For the previously mentioned purpose, however, the date was moved forward, and during the period from December 28, 2004 to February 8, 2005 (the schedule was changed because of the collection of BBOBS), the annual inspection and repair works were conducted at the Kobe Shipyard of Kawasaki Shipbuilding Corporation. The works for assuring continued performance of special devices as well as continued fundamental vessel performances of the structure of the body, the propulsion unit, etc. were carried out, and the following works for improvement of functions were conducted.

- [1] Integration of the first laboratory room and the second laboratory room (Fig.17)
- [2] Expansion of the peripheral devices of the multi-beam sonic depth finder
- [3] Renewal of the aging ship gravity meter

After completion of the works, in the test cruise (February 8 to 18), the tests and operation checks listed below were conducted for the devices such as the Deep Tow (Fig.18) which was mounted on the S/V YOKOSUKA this year and the passive sonar system (for search of the Solid Rocket Booster [SRB-A]) owned by the Japan Aerospace Exploration Agency (JAXA) which the JAMSTEC cooperated in manufacturing. Furthermore, from February 15 to 18 (for 4 days), three members of the Crew Management Team of the Research Vessel Operation Department got on board as a trial.

- [1] General operation check of engine and its related parts
- [2] Operation check of the Deep Tow on the S/V YOKOSUKA
- [3] Performance check test of the passive sonar system
- [4] Performance check test of the acoustic navigational



Fig.17 Integration of the first laboratory room and the second laboratory room on the S/V YOKOSUKA.



Fig.18 Deep Tow for the S/V YOKOSUKA.

device

- [5] Performance check test of the multi-beam sonic depth finder
- [6] Operation check of the ship gravity meter and magnetometer
- [7] Topographic survey of the sea bottom

(4) Deep Sea Research Vessel *KAIREI*

R/V *KAIREI* conducted 15 operations in 263 days in total for the publicly invited deep sea research projects and the JAMSTEC's research projects. (Table 2 Diagram indicating actual operations, Fig.19 Cruise Tracks)

The breakdown of the operations is as follows: Test and training of the *KAIKO 7000* (Sagami Bay, Suruga Bay, Izu-Ogasawara, Nankai Trough, Japan Trench, Southeast Islands) - 4 operations, 55 days; "Survey by the Deep Tow" (Sagami Bay) - 2 operations, 14 days; "Survey by MCS/OBS" (Japan Trench, Izu-Ogasawara, Ontong Java) - 4 operations, 103 days; surveys using the devices such as "Piston Corer", "Dredge", "Heat Flow"

R/V KAIREI Cruise Tracks, FY2004

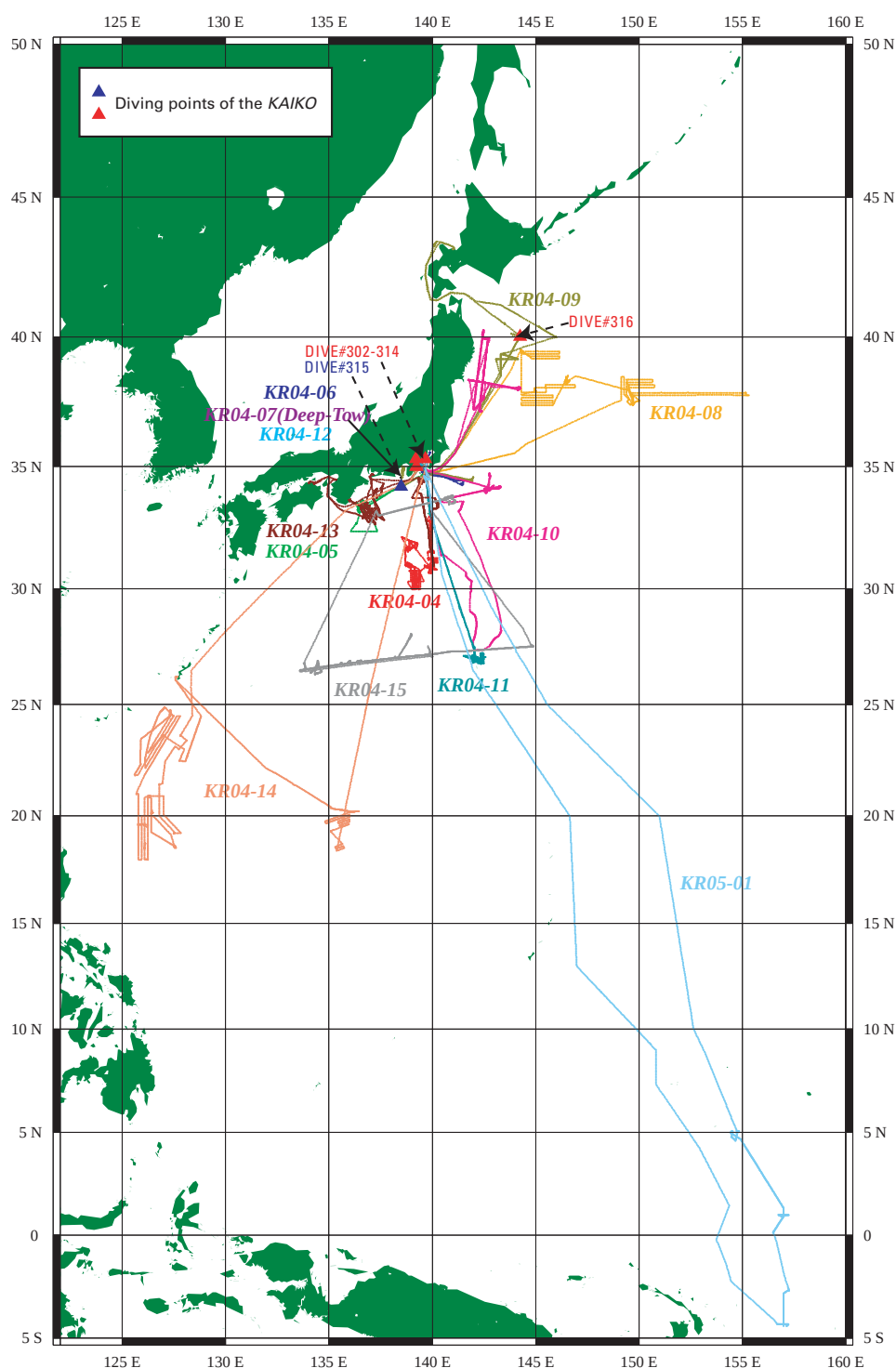


Fig.19 R/V KAIREI Cruise Tracks, FY 2004.

and "AUV (Autonomous Underwater Vehicle)" (Hokkaido Rise, Japan Trench, Izu-Ogasawara, Kumanonada) - 5 operations, 81 days.

As for the annual maintenance, from January 29 to March 5, 2005, the annual inspection and repair works were conducted at the Kobe Shipyard of Kawasaki Shipbuilding Corporation. The works for assuring

continued performance of the devices such as the launch/retrieval system for the KAICO, the diving support device and the primary cable handling device as well as continued fundamental vessel performances of the structure of the body, the propulsion unit, etc. were carried out, and the following works for improvement of functions were conducted.



Fig.20 New Wet Lab on the work deck of the R/V *KAIKEI*.

- [1] Relocation of the Wet Lab (Fig.20)
- [2] Replacement of the motion sensor of the Multi Narrow Beam Echo Sounder
- [3] Alteration of MCS

After completion of the works, the following tests and operation check were conducted during the test cruise (March 5 to 15). Also, seven JAMSTEC's staff members got on board as a trial (for two-to-four days).

- [1] General operation check of engine and its related parts
- [2] Performance check test of the acoustic navigational device
- [3] Performance check test of the Multi Narrow Beam Echo Sounder
- [4] Operation check of the MCS
- [5] Operation check of the launch/retrieval system for the *KAICO 7000* and free fall of the primary cable
- [6] Operation check of the ship gravity meter and the magnetometer
- [7] Topographic survey of the sea bottom

(5) Oceanographic Research Vessel *MIRAI*

R/V *MIRAI* conducted 8 operations in 306 days in total for the cooperative use projects. (Table 2 Diagram indicating actual operations, Fig.21 Cruise tracks)

The breakdown of the operations is as follows: "Time-series observational research on the North Pacific" (Northwestern North Pacific) - 2 operations, 34 days; "Atmospheric and oceanographic observational research in the tropical regions" (Equatorial sea area of the West Pacific, Equatorial sea area of the East Indian Ocean) - 1 operation, 91 days, "Survey of the chemical environmen-

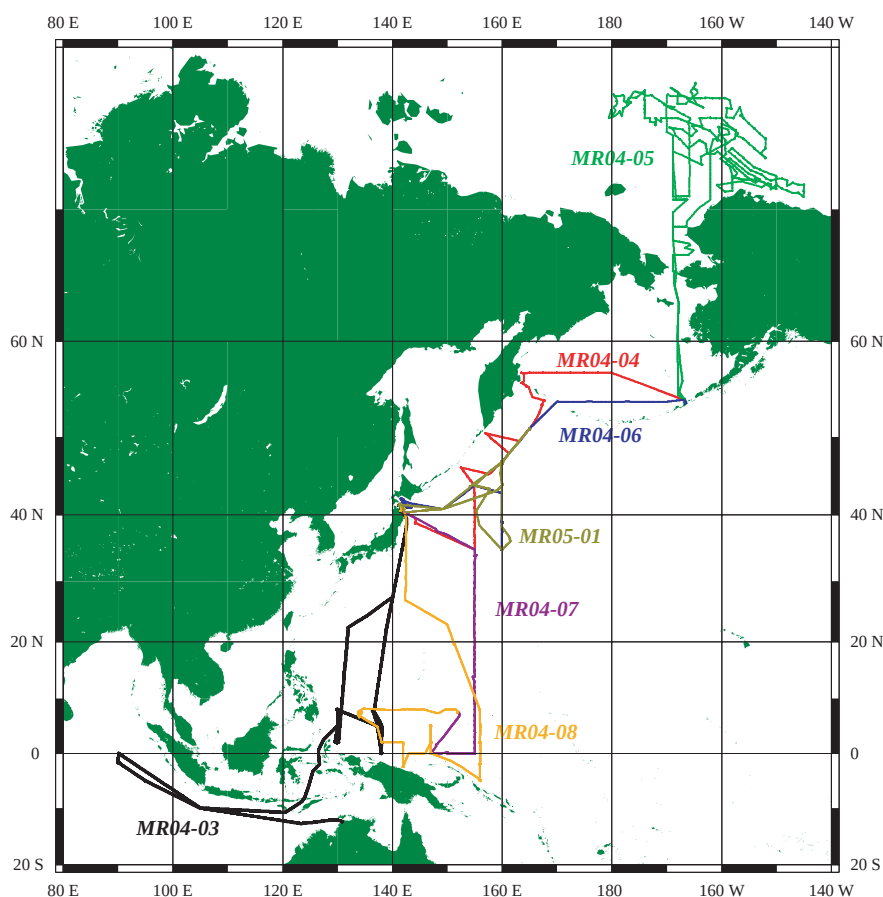
tal change on the western North Pacific and its peripheral sea areas" (Western North Pacific sea area) - 2 operations, 48 days; "Observational research in the Arctic Ocean sea area" (the Arctic Ocean sea area) - 1 operation, 42 days; "Observational research about the atmospheric and oceanographic interaction" (Western Tropical Pacific Ocean sea area) - 1 operation, 32 days; "Time-series observational research on the North Pacific" (Northwestern North Pacific) - 1 operation, 25 days.

As for the annual maintenance, the annual inspection and repair works were conducted at the Shimonoseki Shipyard & Machinery Works of Mitsubishi Heavy Industries, Ltd. from April 17, 2004 to May 21, 2004. The works for assuring continued performance of special devices and observation devices as well as continued fundamental vessel performances of the structure of the body, the propulsion unit, etc. were carried out, and the following works for improvement of functions were conducted.

- [1] Additional installation of an Autosol room, a biochemical treatment room, a surface seawater analysis room, an atmospheric gas observation room, an X-ray room, a CTD room, a photo-developing dark room, power receptacles at necessary points in the rear wheelhouse, lighting fixtures, heating equipment
- [2] Laying of new cables for sending eddy flux data to 12 to 15 rooms for researchers
- [3] Replacement of the Doppler radar control and data processing work station into the personal computer (Linux)
- [4] Replacement of laundry machine, improvement of bathroom drain, CATV noise-control measure in the vessel
- [5] New installation of a water heater in the pantry room
- [6] New installation of a vending machine of soft drink

After completion of the works, the following tests and operation checks were conducted during the test cruise (May 21 to June 2).

- [1] General operation check of engine and its related parts
- [2] Performance check test of the Acoustic Doppler Current Profiler (ADCP)
- [3] Operation check of the Doppler radar
- [4] Performance check test of the acoustic navigational device
- [5] Operation check of the radio sonde

R/V *MIRAI* Cruise Tracks, FY2004Fig.21 R/V *MIRAI* Cruise Tracks, FY 2004.

- [6] Performance check test of the Multi Narrow Beam Echo Sounder
- [7] Operation check of the ship gravity meter and magnetometer
- [8] Operation check of the anti-rolling system
- [9] Operation check of the small CTD winch crane
- [10] Operation check of the observation winch
- [11] Operation check of the large CTD winch and A-frame crane
- [12] Bottom sampling by 20m piston corer
- [13] Bottom sampling by multiple corer
- [14] Measurement and water sampling by a small CTD water sampling system
- [15] Measurement and water sampling by a large CTD water sampling system
- [16] Operation check of winding winch for mooring system
- [17] Operation check of various meteorological sensors
- [18] Operation check of various analyzers
- [19] Operation test of XCTD/XBT

⑧ Operation of deep sea survey system

(1) Manned Research Submersible *SHINKAI 6500*

5 operations and 75 dives (including test and training dives) during the year were planned for *SHINKAI 6500*, and 43 survey dives and 10 test and training dives, that is, 53 dives in total, were conducted in Sagami Bay, Izu-Ogasawara, Trench, Nansei Shoto, EPR, Lau Basin and French Polynesia.

As for the annual maintenance, the intermediate survey and repair works were conducted mainly at the Research Submersible Maintenance Shop in JAMSTEC from December 14, 2004 to March 20, 2005. After that, land operation tests, 1 settling test at Yokosuka harbor and 4 test dives in the Nansei Shoto were carried out, and all the tests and survey completed on March 30.

In the intermediate survey, along with the survey, check and maintenance of various devices and replacement of the parts necessary for assuring continued performance were conducted. In addition, it was made possible to equip the *SHINKAI 6500* with a DO sensor

requested by many researchers, especially those who study microorganism. An underwater still camera was replaced with a digital camera (5 million pixels, possible to take about 380 photos).

(2) 3,000 m-class Remotely Operated Vehicle *HYPER-DOLPHIN*

HYPER-DOLPHIN conducted 9 operations, 85 survey dives and 11 training dives, that is a total of 96 dives, during the year, in the sea areas off the coast of Kushiro, off the coast of Sanriku, Sagami Bay, Izu-Ogasawara, Nankai Trough, the west of Kagoshima, Kagoshima Bay, Southeast Islands and off the coast of Sumatra.

The digital still camera (SEA MAX), which was installed on the vehicle last year, is a high-performance camera with a built-in 10 cm-square long range laser scaler for linear measurements. Last year, the camera was used just on a trial basis, and it was found that a distortion was generated at the central portion of the object on the photo when it was taken in a wide mode because of the dome shape of the pressure-tight lens. This year, a plane glass of the camera was used for the pressure-tight lens to improve the picture quality, then it started for practical operation use.

The buoyancy loss due to aging of the main buoyancy material had affected the vehicle operating performance and the loading of researchers' carry-on equipment (payload). Therefore, the specific gravity, form and maintenance principles of the buoyancy material were reviewed.

Last year, the vehicle diving data of the recording device such as HDTV camera information that had been individually managed into a single file. This year, the device management system was improved in functions such as synchronizing of time of the video deck and the hyper dolphin system, and also the part of recording items was changed.

(3) 7,000 m-class Deep Sea Remotely Operated Vehicle *KAIKO 7000* (Fig.22)

After the accident of the *KAIKO* vehicle on May 29, 2003, *KAIKO 7000* was developed as an alternate vehicle. Assembling had been completed by March 2004, and sea trials started in April.

4-stage tests in Sagami Bay, Japan Trench, Shikoku Basin, etc. were carried out, and the modified devices



Fig.22 *KAIKO 7000* being raised up.



Fig.23 Video image of the sea floor taken by the *KAIKO 7000* at depth of 7,005 m.

such as safety devices, power supply, thrusters manipulator were adjusted and improved.

The thrusters did not work well because of electric noise, and we took measures against it.

In the final performance test from March to April, 2005, 14 dives (5 times to depths of 1,000 m to 2,000 m, 7 times to depths of 4,000 m to 6,500 m, twice to a depth of 7,000 m) were carried out for trainings of bottom sampling, biological observation, recovering of mooring system, etc.

(4) *Deep Tow*

Either of three types of *Deep Tows* of 4,000 m-class deep sea towing camera system (4KC), 6,000 m-class deep sea towing camera system (6KC), and 4,000 m-class deep sea towing sonar system (4KS) was used depending on the purpose of the survey. They were mounted on the R/V *NATSUSHIMA*, R/V *KAIYO* and R/V *KAIREI* and

used for the towing survey in the 7 operations conducted during the year in the sea areas off the coast of Kushiro-Tokachi, of Sagami Bay, Kumanonada, Southeast Islands and the sea area to the east of Minami Daito Island

(5) Deep Sea Cruising Autonomous Underwater Vehicle *URASHIMA*

The *URASHIMA* performed 4 operations for the actual sea trial in Suruga Bay. On February 28, it succeeded in an autonomous cruise of 317 km.

(6) *BENKEI*

At the Remotely Operated Vessel Maintenance Shop, maintenance works and operation checks were conducted appropriately.

⑨ Operation of the ocean observation buoy system "TRITON Buoy"

(1) Preservation of TRITON Buoy Array

For the study of climate change associated with El Niño, the Asian monsoon, etc., the observation buoy network was expanded in the tropical region over the Indian Ocean and the Pacific Ocean to collect marine meteorological and oceanographic data over a long period of time. On the Pacific Ocean, in cooperation with the US NOAA, we have contributed to the monitoring of El Niño through the TAO/TRITON Buoy array starting in 2000. The obtained data is being delivered to the meteorological agencies in the world via the Global Telecommunication System and being used for daily weather information and El Niño prediction models. The quality-managed data is being published on the TRITON web page. (<http://www.jamstec.go.jp/jamstec/TRITON/http://www.pmel.noaa.gov/tao/>). The web page is planned to be totally renewed in FY2005, and its test operation within the JAMSTEC started.

In FY2004, the observation by the buoys has been continued at 15 points on the Pacific Ocean and 2 points on the Indian Ocean, that is, 17 points in total (Fig.24). There have been no end to damages to buoys caused by human. This year, the buoys of site Nos. 9, 16, and 18 (Fig.25) were damaged.

(2) Antitheft measures and improvement of operability

According to the statistical data, total 71 buoys have

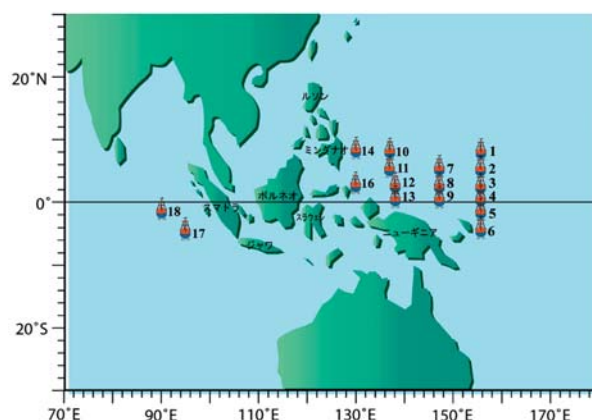


Fig.24 Expansive location plan of TRITON Buoys.



Fig.25 Damage of the Unit No.18 located on the Indian Ocean.

It was found that the meteorological sensor on the surface of the buoy and the electrical equipment box in the buoy had been stolen.

been recovered so far, and some damages were found on 19 units. Among them, 3 units were damaged seriously so that a real-time data transmission was disabled because the electrical equipment containers were stolen. To protect the buoys from being damaged or stolen, in FY2004, we implemented measures such as strengthening of the fixing method of the lid of the storage tube for the electrical equipment container, use of both the conventional type and the new type of antitheft bolts and fitting of a deck cover to the unit of site No.16 for preventing a thief from getting on the buoy (Fig.25 A damage and a loss found in November 2004).

The remaining strength of nylon rope was confirmed, and to reduce operational costs and labor, all the recovered ropes were reused at 4 sites where tidal current is comparatively mild. To improve the operation in the future, we conducted a survey of sessile organisms (review of the equipping procedure of air-



Fig.26 Deck Cover for preventing a theft from getting on the buoy.

foil-shaped fairing), a trial use (performance check) of CT sensors of domestic-make, a trial use (performance check, open of suppliers) of nylon ropes and lithium batteries of other companies, etc.

(3) Development of small TRITON Buoy (m-TRITON Buoy)

The present TRITON Buoy has cost and operational problems. For example, there is a large economic loss caused by damage and theft on some sea areas, and the buoy is large in size and difficult to handle. By realizing a buoy that can overcome those problems, it seems possible to expand the observation sea areas on the Indian Ocean having growing research needs with a limited cost and to use it to replace with the aging TRITON Buoy. Under the above-mentioned circumstances, we started development of a new smaller oceanographic observation buoy (m-TRITON Buoy) based on the operation experiences of TRITON Buoy. In FY2004, we conducted a formation of the whole concept, a trial production of electronic circuit board, a trial production of wire rope and a design of floating body, etc. toward the sea trial of a prototype model in FY2005.

Table 2

Schedule of R/V *NATSUSHIMA* in 2004 Fiscal year

2005 3. 30.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat
4 Apr.	Yokosukashinko				f.f	① #288	② #289	Wakayama																							J
5 May																															
6 Jun.																															
7 Jul.																															
8 Aug.																															
9 Sep.																															
10 Oct.																															
11 Nov.																															
12 Dec.																															
1 Jan.																															
2 Feb.																															
3 Mar.																															

J : JAMSTEC
t : Transit

Table 2

Schedule of R/V KAIYO in 2004 Fiscal year

2005 3. 30.

2005 3. 30.																																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
4 Apr.	J		Yokosuka shinko		Yura																											
5 May	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue
6 Jun.	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Wed
7 Jul.																																
8 Aug.	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed
9 Sep.	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Wed	Thu
10 Oct.	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon
11 Nov.	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu
12 Dec.	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat
1 Jan.	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue
2 Feb.	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Wed
3 Mar.	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Wed

J : JAMSTEC
t : Trasit

Table 2

Schedule of S/V YOKOSUKA in 2004 Fiscal year

2005 3. 30.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	
4 Apr.																																	
	Maintenance (Setting of Winchies)																																

J : JAMSTEC
t : Transit

2005. 3. 30.

J : JAMSTEC
t : Transit

2005. 3. 30.

J : JAMSTEC
t : Transit

4.2 Provision of use of the "Earth Simulator"

To transfer simulation results to the other laboratories faster, Earth Simulator connected to Super SINET, 2.5Gbps Ultra high-speed network, operated by National Institute for Informatics.

The Earth Simulator Center held some classes for the

usage of Earth Simulator, computer language such High Performance Fortran and MPI and technique of programming, and also provided technical support to the users.

We consolidated the accounting system of fare-paying usage of Earth Simulator and would be started to operate this system from FY2006.

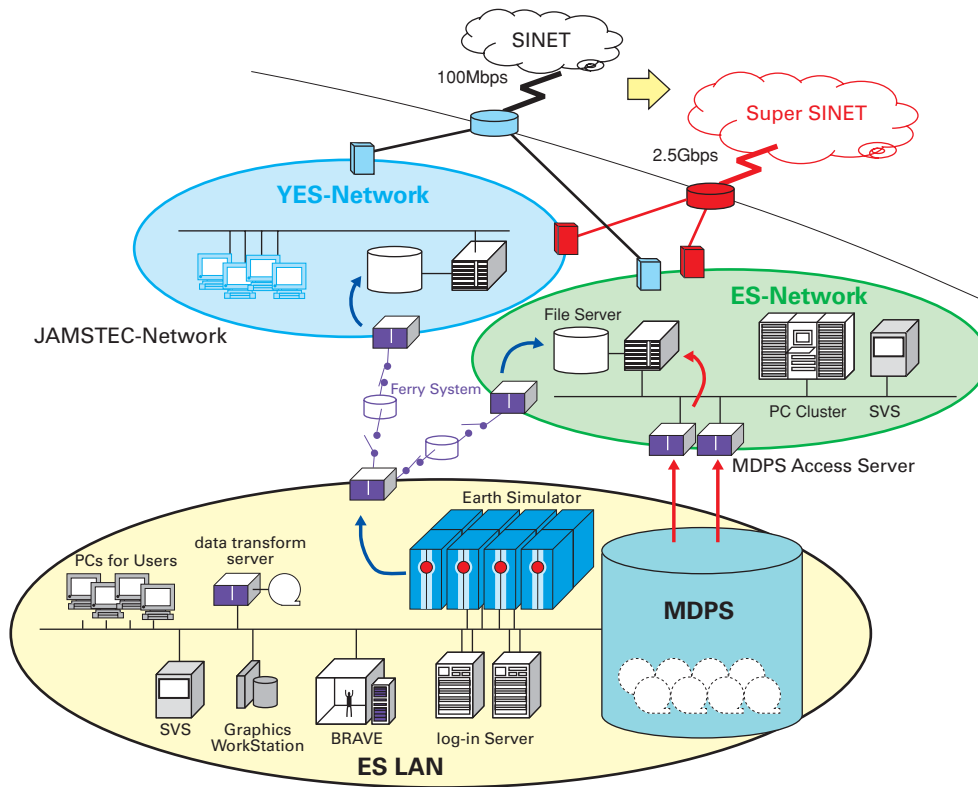


Fig. 1 Connection to Super SINET.

4.3 D/V CHIKYU operation

CDEX sent Supervisor to D/V *CHIKYU* for management of construction, the equipment test, and the installation. December 2004, D/V *CHIKYU* executed the sea trial off Goto, Nagasaki.

CDEX examined, and procured the specification of the onboard laboratory facilities, the onboard equipments, and the drilling tools.

CDEX developed and installed the onboard scientific data base "J-CORES", that is possible to accumulate and to distribute analysis result of shipboard and science data of sample description, and CDEX site survey data base "DEXIS".

The location survey of the Kumano-Nada was executed, and CDEX was analyzed as the basic data to

evaluate the drilling hazard of D/V *CHIKYU*.

CDEX executed the research facilities installation and maintenance of the Kochi core center (present Kochi core laboratory).

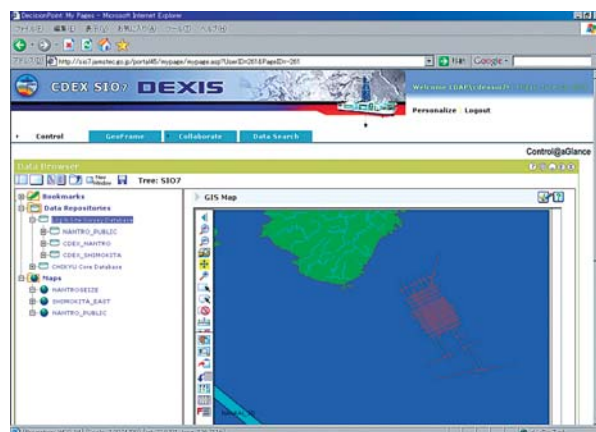


Fig. 3 DEXIS



Fig. 1 D/V *CHIKYU* sea trial off Goto, Nagasaki.

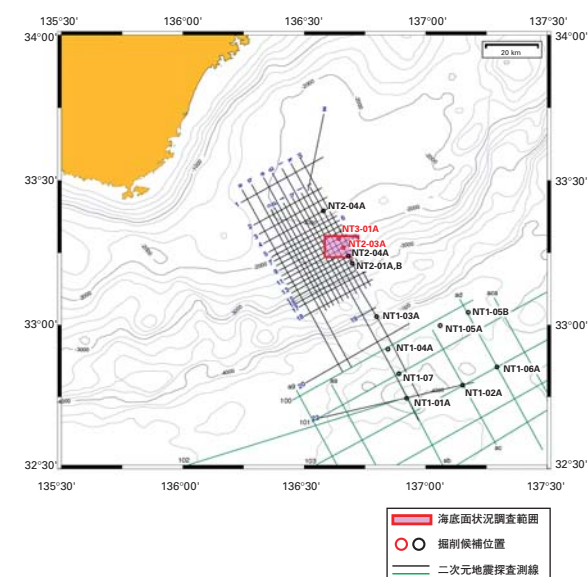


Fig. 4 The location survey area of the Kumano-Nada.



Fig. 2 Installation of Blow-Out Preventer.

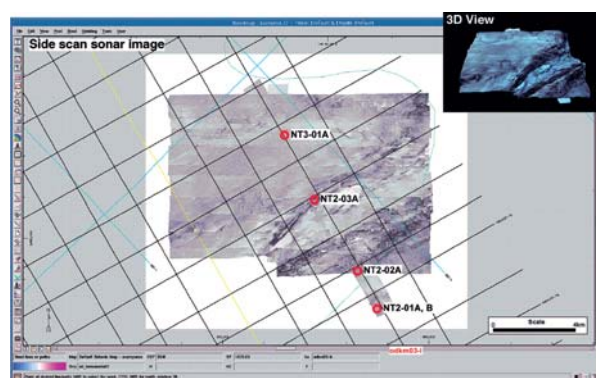


Fig. 5 The image of side scan sonar.

5. Training of researchers and engineers and enhancement of their qualifications

- As for cooperation with graduate schools, JAMSTEC had concluded a joint graduate school agreement with 7 universities in or by FY2003. In FY2004, a joint graduate school agreement with Toyo University was concluded in October, and an adjustment was made toward the conclusion of a joint graduate school agreement with Kyushu University. (The joint agreement with Kyushu University will be concluded in April 2005.)
- 23 researchers of JAMSTEC have engaged in educational research activities as faculty members (17 professors, 6 associate professors) of collaborative graduate schools.
- 4 researchers and 2 staff members were dispatched overseas, and one new researcher was selected as a next-term dispatched candidate.
- Through the fellowship programs for foreign researchers of the Japan Society for the Promotion of Science and other programs, 13 researchers dispatched for a long term or short term were accepted.
- 70 diving trainings were given to 389 people working at police stations and fire departments.
- Marine Science School and Science Camp for high-school and tertiary college students and teachers were held. In addition, Marine Science and Technology School was held for university students and graduate students.
- For staff training, instructors were dispatched four times to the National Police Academy, etc.

6. Collection, organization, storage and provision of information and materials

- At the Yokosuka Headquarters and the Yokohama Institute for Earth Sciences, the books (in a total number of about 29,500), magazines (in a total number of about 3,100) and video materials (in a total number of about 1,950) have been stored, and circulation work of them was conducted. In cooperation with the external research institutions, search service for the location of books, etc. that are not owned and copy service were offered. 180 volumes of electronic journals were subscribed to and offered to the researchers in the Agency.
- Our Internet web site was improved. Along with the inauguration of the Independent Administrative Institution in April of 2004, the web site was renewed. On the web site which was updated once or more times a week, information was provided. Our web site had 6.18 million accesses a year (Fig. 1).
- Annual Report was published both in Japanese and English. In addition, the house magazine, "JAMSTEC Report of Research and Development" was issued, and 10 research papers were included in the magazine.
- With the deep-sea image database which was developed for managing and releasing the freeze-frame pictures taken on research submersibles, etc., over 320 thousand images were registered and released to outside through Internet.



Fig. 1 Top page of JAMSTEC Web Site.

- In FY2004, the ocean bottom topography data obtained in 60 sailings with the research vessels operated by JAMSTEC were received, and the data were managed collectively. Using those data and conventionally managed data, 73 bathymetric charts were provided in response to the requests for making them in FY2004. To effectively use the data and charts, the ocean bottom topography database was developed.
- The observation data obtained in the joint sailings with the Oceanographic Research Vessel "MIRAI" were received, and the system for checking and partially correcting the data was developed. Efforts to improve the "MIRAI" Data Web for the purpose of managing, releasing and providing the data were made, and the data from 37 sailings that had been registered by FY2004 were provided to outside. As for the data published through Internet, the number of downloads from outside computers was 1.18 million in FY2004.
- In FY2004, the quality-controlled data of sounding, magnetic force and radiosonde were newly published and provided.
- The Global Oceanographic Data Center (GODAC) was opened for public use on Saturday and Sunday, too, and had 10,524 visitors in FY2004. As part of promotion activities of opening to public, the GODAC held 4 seminars and participated in the IT EXPO Okinawa and the Nago Cherry Blossom Festival. As for digital archive operations, the following operations were conducted: encode processing of 1,921 digital master images, indexing processing of 20,495 shots of encoded image data, public release processing (scanning, OCR processing, etc.)

of 9,904 pages of the periodicals, preparation of 1,618 video digital masters of deep-sea research records, preparation of 1,937 digital sub-masters (DVCAM) for storage in the GODAC, digital processing of 4,309 photos and negatives stored in the Public Relations Division. The GODAC portal site and the Coral Reef Web Site had 847,767 accesses. In collaboration with researchers, the foraminifer database was constructed (Fig. 3).

- To promote the efficiency of archiving work of deep-sea images, the automatic extraction, identification and indexing methods for the events in images were studied.
- To enhance the usability of the computer network environment in the JAMSTEC, shared computing systems such as the supercomputer SC system and the vector operation server SX-5 were operated and maintained to provide the operation and management of a better research environment.
- At the Earth Science Museum of the Yokohama Institute for Earth Sciences, the visualization system was operated to expand the contents to be displayed. The Earth Science Museum was opened for public use.
- As for the network environment in the Agency, the Internet connection was changed from SINET to Super SINET, and the communication speed was increased (from 100Mbps to 2.4Gbps). Network services (e-mail, Web access) were operated stably. Furthermore, the basic policy of information security was laid down, and stepped-up antivirus measures and monitoring were implemented for operation and management of network security, and the Internet security system was operated stably (Fig. 4).



Fig. 2 Management and provision of various data.



Fig. 3 Top page of GODAC Web Site.



Fig. 4 Network connection map.

7. Evaluation

- For self-evaluation, the institutional evaluation council that consists of external members was established. An evaluation committee was established in each of seven centers of JAMSTEC to conduct a self-evaluation. To implement the self-evaluation, Regulation for Implementation of Research and Development Evaluation (H16 Regulation No.104), Regulation to Authorize the Establishment of Institutional Evaluation Council (H16 Regulation No.131) and Regulation to Authorize the Establishment of Evaluation Committee at Centers (H16 Regulation No.132) were developed.
- As for evaluation of research subjects, the ex-post evaluation of the FY2003 completed subjects and the interim evaluation about the Earth Simulator were conducted. For implementation of the intersectional research and development promotion award, the ex ante evaluation by the commission including external members was conducted.

8. Information disclosure

- In FY2004, we had 3 requests for information disclosure and 2 inquiries, and replied to them.
- Furniture and fixtures for the stack room of documents were organized to strengthen the management of corporate documents, and measures for appropriate safety management were taken by introducing lockable furniture and fixtures to prevent a leakage of confidential documents.
- Provision of information stipulated by Article 12 of the Enforcement Regulations for the Law Concerning the Disclosure of Information Held by Independent Administrative Institution was enhanced.
- In compliance with the Law on Protection of Personal Information Held by Independent Administrative Institutions (2003 Law No.59) which will come into effect in FY2005, the regulations concerning protection of personal information were developed, and information disclosure was enhanced through the opening of the Web page which supports request of personal information disclosure.

II. Promotion of the efficiency of activities

1. Organization and administration

1.1 Organization

- In July 2004, the organization was reformed, and to reflect the leadership of the President, the "Planning Department" for taking charge of planning of corporate management and distribution of research resources was established. In addition, Research Coordinator who takes charge of research planning, etc. for the whole Agency was assigned in the Planning Department. Old research departments and frontier research systems were reorganized based on fields, and 7 centers were newly established.
- The "Research Administration Meeting" where President and Director-Generals of the Centers exchange opinions was established.
- To discuss and obtain advice on important issues about the management of the Agency from a wide-ranging and high point of view, "Management Advisory Council" that consists of external well-informed personalities was established as an advisory committee for President. The first meeting was held in December 2004, and a consultation about public affairs was conducted in February 2005.
- In the Planning Department, the Knowledge Infrastructure Division was established to aggressively promote cooperation with external organizations and to improve and strengthen the evaluation system corresponding to the evaluation of the Independent Administrative Institution.
- To study the efficiency of operations, the "Operational Efficiency Promotion Committee" was established. Improvement measures for efficient operation and personnel affairs and the research environment were studied.
- To generally manage the safety and reliability of the whole Agency, the "Safety Council" was established.

1.2 Administration

- To clarify the authority and responsibility, the specific plans (action plans) for implementing the respective projects in the mid-term plan were prepared at the respective departments, and the authority and responsibility in implementation of the respective projects were

given to each supervisor of the competent department.

- To promote the devolution of authority to the respective departments to implement fast decision making and flexible measures after the reform of the organization, regulations on final decision making were reviewed, and authority was delegated to limited-term officials, too, such as Director-General of each Center and Program Director and Group Leader.
- At the "Operational Efficiency Promotion Committee" established for study of the efficiency of operations, personnel affairs and improvement of research environment for exertion of ability as well as efficiency of operations were deliberated, and feasible projects were implemented in sequence.
- To organize the study and suggestion about personnel evaluation and treatment, the system of personnel department was developed, and personnel regulations were revised.
- Based on the subjects suggested by the Operational Efficiency Promotion Committee, a study for the planning of basic concept toward reform of the personnel system was started.

2. Promotion of the efficiency of operations

To efficiently conduct the operations of the Agency, simplification/speed-up of various paper works such as contracts was accelerated, and WG was formed in the Finance and Contracts Department to study measures for cost reduction and efficiency promotion and streamlining of clerical work.

As for the operation of vessels and facilities, the operation of "SHINKAI 6500" was outsourced, and safe and reliable operation was realized under the supervision of the Research Support Department. Major topics were as follows:

- Lithium battery was adopted for the battery system of the "SHINKAI 6500". 90 dives a year (conventionally, 75 dives) were performed while labor costs as well as expenses were cut down.
- The useful service life of mooring ropes of TRITON buoy was studied, and by providing a technical guarantee, the annual operational cost reduction of about 21 million yen was estimated.

In addition to the above-mentioned outsourcing of

the operation of "SHINKAI 6500", one Deputy Director and one part-time staff were reduced. Under the new system, operations were conducted safely. Along with the change in the internal organization, the constitution

of the survey and observation performance study team members was reviewed and reformed. A new system was made so that requests for improvement of performance from many departments could be handled.

III. Financial statements

• FY2004 Financial Statements

(Millions of yen)

Category	Budget (A)	Closing account (B)	Balance (A-B)
Revenue			
Operation grants	30,714	30,714	0
Subsidies for facility expenses	6,286	5,212	1,074
Income from business, etc.	3,302	2,880	422
Income from contracting businesses	157	599	-442
Total	40,458	39,404	1,054
Expenditure			
General administrative expenses	1,517	1,409	108
(tax and public dues excluded)	1,104	1,109	-5
Personnel costs (for administration)	768	660	108
Non-personnel expenses	336	449	-113
Tax and public dues	413	300	113
Business expenses	32,499	30,649	1,850
Personnel costs (for business)	2,558	2,599	-41
Non-personnel expenses	29,941	28,050	1,891
Facility expenses	6,286	5,198	1,088
Expenses for contracting businesses	157	597	-439
Total	40,458	37,853	2,606

* The integrated Value of the figures in each column may not agree with the total value because of rounding-off in calculation.

IV. Short-term borrowed money

• None

V. Disposal of important properties or planning of mortgage

• None

VI. Disposition of surplus funds

• None

VII. Others

1. Plans concerning personnel affairs

- Along with the large-scale reorganization which was conducted in July 2004 to promote efficient and effective operations, appropriate staffing was implemented. Clerical staff of five people was employed to secure excellent human resources. Four of the five people have completed the master's courses at scientific graduate schools. This agrees with the government policy aiming at the diversification of acceptance of researchers (non-academic career-paths).
- To activate researches and enhance the mobility of researchers, it was decided that younger researchers should be employed as a fixed-term researcher in principle and people who have appropriate researcher's abilities should be selected for staff without a fixed term in office. In 2004, 2 people were employed in the mid-career recruitment.
- With due considerations to appropriate treatments, excellent researchers in Japan and overseas were employed as fixed-term researchers at the respective research centers.

- To improve the personnel system and the personnel management system, such as promotion of greater mobility of research including introduction of an annual salary system, establishment of fair evaluation system and establishment of the way and measure of human resource development, the Personnel Reform Team including external experts was established in the Personnel Division and started its operation.

2. Improvement of working environment

- Research Environmental Improvement Officer was allocated in the Planning Department, and the system for creating a better environment for researchers and engineers was established. Furthermore, the Research Environment Improvement Working Group was set up in the Operational Efficiency Promotion Committee to improve the research environment in the Agency.
- To improve the research environment, a questionnaire survey on the research environment was conducted. The survey result will be studied to be reflected to the future environmental improvement.

Chapter 3.

Supporting Association

With close cooperation with and support from government, industry and academia, Japan Marine Science and Technology Center was established as a center of excellence for research and development on ocean science and technology in Japan in October 1971. The Center was established as an authorized private corporation based on the Law concerning Japan Marine Science and Technology Center.

Since then, we have received enormous support including funding from the industry, which has enabled us to promote the activities such as a comprehensive test research on ocean science and technology, information provision, making our facilities and equipment available to other companies and organizations and improvement of functions and systems.

On April 1, 2004, Japan Marine Science and Technology Center was disincorporated, and Independent Administrative Institution, Japan Agency for Marine-Earth Science and Technology was established. To further the development of the past achievements, the Agency is making efforts to promote comprehensive ocean projects and active participation into international collaboration researches with an aim to solve global environmental problems through combination of science and technology, and to create an open research environment to become a center of excellence for international ocean research and development.

Great assistance has been given to the Agency from various fields. We would like to ask your continued understanding and cooperation about increase of supporting members and addition of the membership fee for the supporting association.

The corporations and organizations that have supported the Agency are given the privileges described below and other favors. In addition, as before, they are

given preferential treatment concerning the membership fee (contributions) according to Article 37 of the Corporation Tax Law.

1. The supporting corporations and organizations are given the following privileges on the activities of the Agency.

- Distribution of publications
- Use of intelligence information such as books
- Invitation to lecture meetings
- Preferential treatment on training cost
- Dispatch of instructors for technical assistance
- Dispatch of instructors for in-house trainings
- Preferential treatment on use of collaborative experiment and research facilities
- Preferential treatment on use of industrial properties
- Preferential treatment on test researches

2. For inquiries about the supporting association, please contact:

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3. Japan Agency for Marine-Earth Science and Technology is supported by the membership fee and contributions from the following corporations and organizations that are members of the supporting association as of March 2005.

JAMSTEC 2004 Annual Report

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