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# NIES Annual Report

# 2008

AE - 14 - 2008

National Institute for Environmental Studies
http://www.nies.go.jp/

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# Foreword

This annual report is an official record of research activities at the National Institute for Environmental Studies (NIES) for fiscal year 2007 (April 2007 to March 2008), the second year of our second 5-year research plan as an incorporated administrative agency.

This year, all research units, most of which were founded or reorganized in April 2006, concentrated on their research plans. About half of NIES researchers have been involved in four priority programs: climate change, sustainable material cycles, environmental risk, and the Asian environment. The other half have performed fundamental and pioneering studies in the six research divisions – Social and Environmental Systems, Environmental Chemistry, Environmental Health Sciences, Atmospheric Environment, Water and Soil Environment, and Environmental Biology – as well as in the Laboratory of Intellectual Fundamentals for Environmental Studies.

Through collaboration with researchers both nationally and internationally, we have produced a number of outcomes for a wide range of environmental issues at the local, national, regional, and global levels. In particular, our long-term contribution to the work of the Intergovernmental Panel on Climate Change was rewarded with its winning of the Nobel Peace Prize for 2007. Our research activities and our outreach activities, such as the dissemination of research findings and other environmental information through press releases, our homepage, public symposia, and open campus days, received an A grade rating from the Examination Committee of the Ministry of the Environment.

In a new approach for fiscal year 2007, each research unit has issued a policy statement outlining its own mission and yearly plan. These statements have been formulated through extensive talks among all unit members and between the unit director, executive directors, and the president of NIES, and they have been disclosed on our homepage to contribute to mutual understanding among NIES researchers and the development of communication with the public.

It is my sincere hope that the readers of this report will maintain an interest in NIES and will offer comments and suggestions on our activities; such input is invaluable for the continuous improvement of our work.

Ryutaro Ohtsuka, D.Sc.
President

# Contents

During the 1950s and 1960s, Japan experienced serious environmental pollution problems that accompanied rapid economic growth. In 1971, the Environment Agency was established within the Japanese government to develop measures to counteract serious environmental pollution problems such as Minamata disease, caused by poisoning from organic mercury in factory wastewater, and chronic bronchitis and asthma, caused by sulfur oxides emitted from factories in large industrial complexes. In 1974, on the recognition that research on environmental sciences was necessary and could address public needs, the Environment Agency established the National Institute for Environmental Studies (NIES) in Tsukuba Science City, about 50 km north of Tokyo. NIES is now Japan's primary institute for comprehensive research in environmental science.

During the two decades following the establishment of NIES, rapid technological progress, structural changes in industry, and lifestyle changes created additional issues for environmental science to confront. Moreover, concern about global environmental problems such as climate change, depletion of the stratospheric ozone layer, acid deposition, destruction of tropical rain forests, and desertification became more prominent worldwide.

NIES underwent a major reorganization in 1990 to enable it to conduct more intensive research on conservation of the natural environment and on global environmental changes and their effects. The new structure included two research project divisions, six fundamental research divisions, and the Center for Global Environmental Research. In addition, the Environmental Information Center was given the task of providing access to research publications and environment-related databases.

In January 2001, the Environment Agency became the Ministry of the Environment as a part of structural changes within the Japanese government. At the same time, NIES established a Waste Management Research Division.

In April 2001, NIES became an incorporated administrative agency, giving it a degree of independence from the national government. The change from government institute to non-government status allowed more flexibility in operations, thus enabling the institute to respond with more agility to the demands of society. At the same time, NIES prepared a 5-year (2001–2005) plan that corresponded to the objectives of the Ministry of the Environment.

In 2006, NIES embarked on its second 5-year (2006–2010) plan and reorganized its research system to focus its resources on four priority research areas: climate change, sustainable material cycles, environmental risk, and the Asian environment. At the same, NIES renewed its resolve to engage in fundamental research in order to respond to emerging and potential environmental issues. In collaboration with many institutions in Japan and abroad, it continues to engage in scientific research on environmental issues.

Researchers at NIES are skilled in various fields, such as physics, chemistry, biology, health sciences, engineering, agricultural and fisheries sciences, law, and economics. Interdisciplinary studies are also carried out, particularly in the context of our priority research projects. NIES has various types of experimental facilities and remote research stations, such as the Lake Kasumigaura Water Re-

search Laboratory, Fuji Hokuroku Flux Observation Site, and the Global Environmental Monitoring Stations in Hateruma and Cape Ochi-ishi.

As of 1 April 2008, the total number of NIES regular permanent staff was 254 (including five foreign researchers). There were also 603 non-permanent researchers, including 75 foreign researchers, as of 31 March 2008. The total budget for FY 2007 was 14860 million yen.

**Table 1** Number of Permanent Staff (as of April 1, 2008)

| | | |
|---|---|---|
| Research | 192 | 75.6% |
| Administration | 53 | 20.9% |
| Environmental Information Center | 9 | 3.5% |
| Total | 254 | 100% |

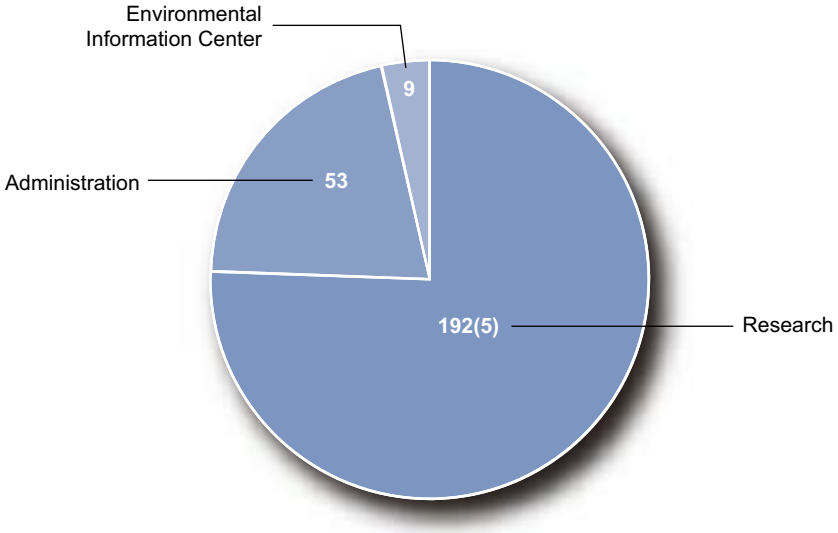
**Table 2** Budget for the Second 5-Year Plan of NIES

(Unit: million yen)

| | Category | 2006-2010 Budget (5 years) | Fiscal 2007 Budget |
|---|---|---|---|
| Revenues | Grant for Operating Costs | 48 196 | 9 680 |
| | Subsidies for Facilities | 2 420 | 1 111 |
| | Commissioned Work | 20 275 | 4 055 |
| | Others | 70 | 14 |
| | Total | 70 961 | 14 860 |
| Expenditures | Project Costs | 30 898 | 6 215 |
| | Facility Improvements | 2 420 | 1 111 |
| | Expenses for Commissioned Work | 20 275 | 4 055 |
| | Personnel Expenses | 14 795 | 2 951 |
| | General Administrative Expenses | 2 573 | 528 |
| | Total | 70 961 | 14 860 |

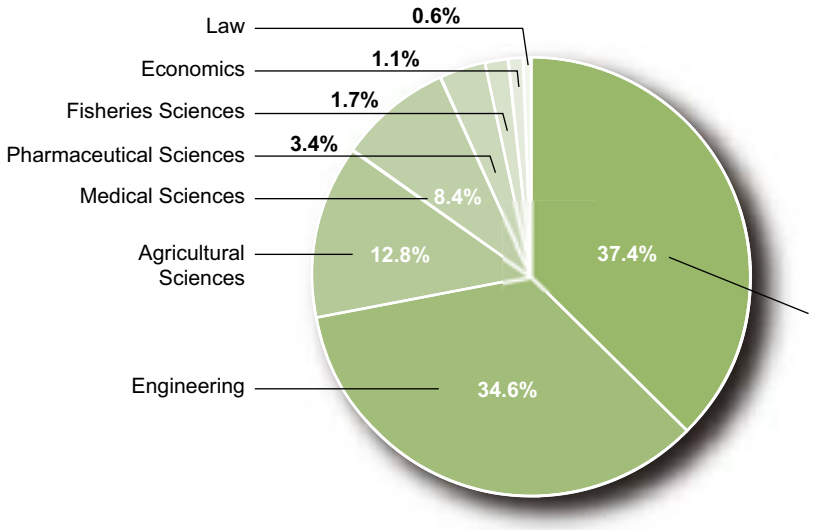
Note: The budget for each annual work plan will be requested and decided each fiscal year, based on the second five-year plan.

## Human Resources



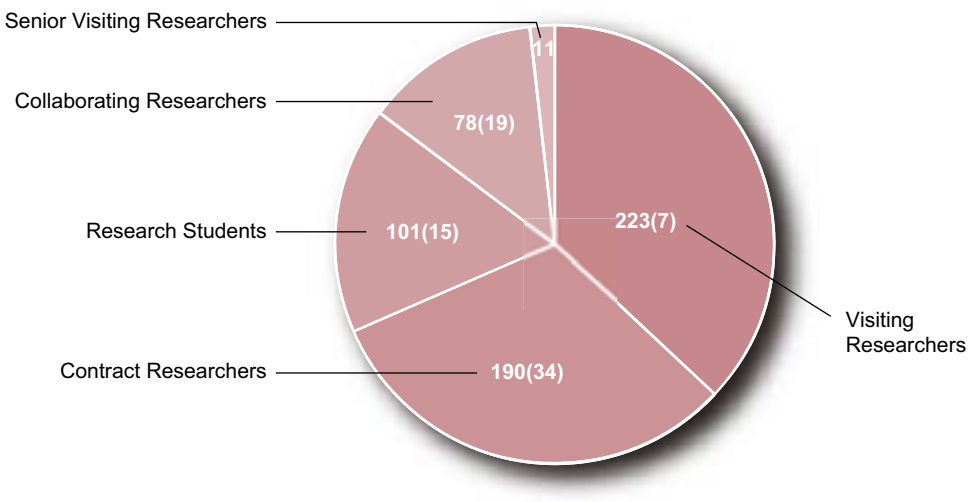

Number of Permanent Staff
254 (5)

Notes: 1. Data is as of April 1, 2008.
2. Figures in parentheses indicate number of foreign researchers.




Fields of Expertise
Researchers holding doctorates
93.2%

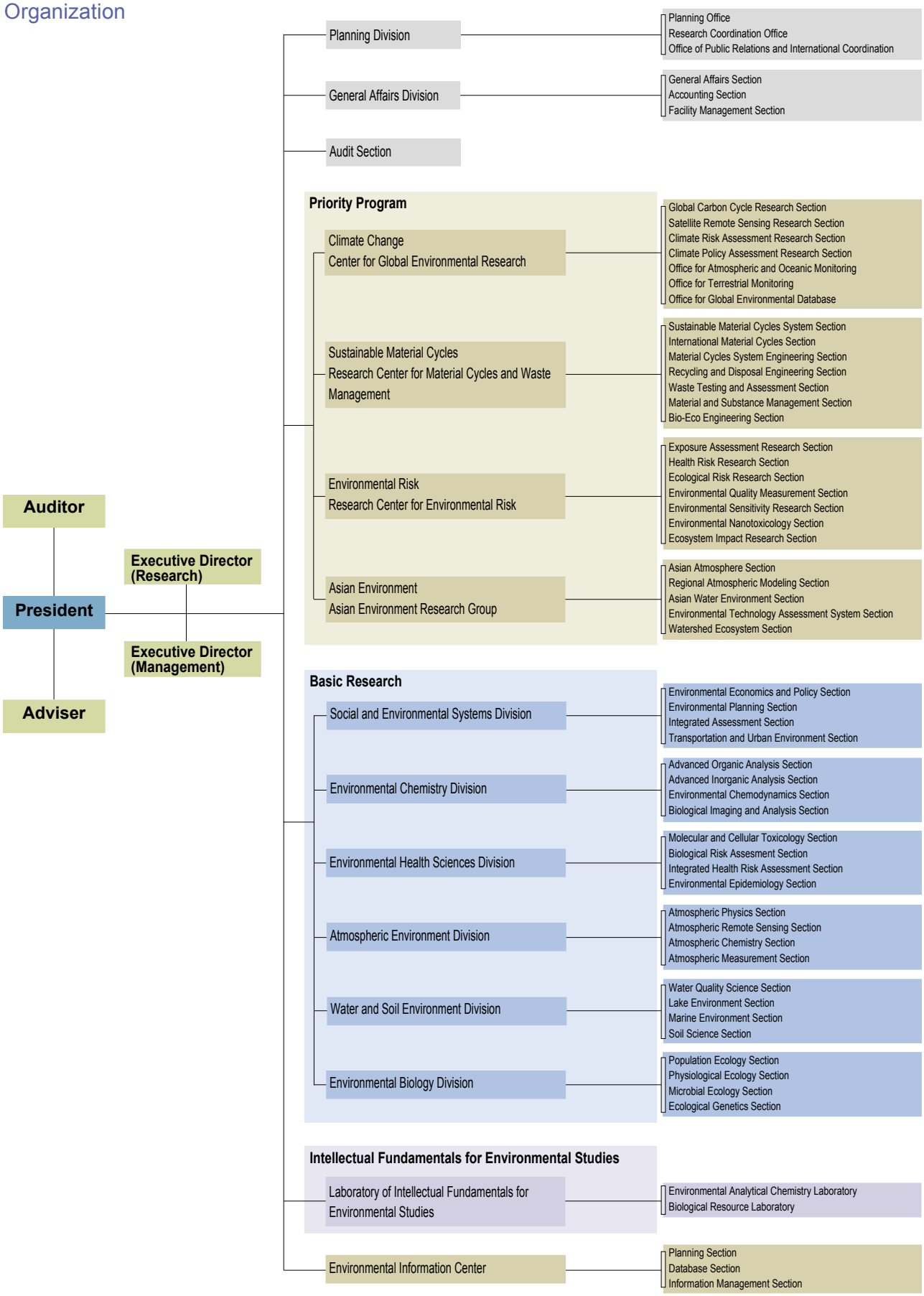
Note: Data is as of April 1, 2008




Number of Visiting Researchers
603 (75)

Notes: 1. Data for Contract Researchers is as of April 1, 2008.
2. Data for Visiting Researchers, Research Students, Collaborating Researchers, and Senior Visiting Researchers reflect the total number accepted in 2007
3. Figures in parentheses indicate number of foreign researchers.

## Organization



# Center for Global Environmental Research

Fieldwork on Lake Kasumigaura

The Center for Global Environmental Research (CGER) was established in 1990 as a focal point for Japan's contribution to global environmental research. To create a foundation for measures targeted at environmental preservation, it has been working to clarify, from a scientific perspective, the effects that humanity has on the environment. As the core organization for research on climate change at NIES, CGER performs research ranging from greenhouse gas (GHG) observations to climate change predictions, risk assessments, and future scenarios involving a low-carbon society. This research, "Climate Change" as one of the four Priority Programs, is performed through the following four core research projects:

Project 1 Long-term variation mechanisms of greenhouse gas concentrations and their regional characteristics
Project 2 Greenhouse gas observations from space and use of the observations to estimate global carbon flux distribution
Project 3 Assessment of climate risk based on integrated climate, impact, and land-use models
Project 4 Developing visions of a low carbon society and integrated analysis of climate policies

In addition to the climate change research, CGER contributes to the effective implementation of research at the national and international levels and the creation of a network of researchers through strategic monitoring, the creation of a global environmental database, and integration and support of global environmental research. The results of these activities are made available not only to other researchers and related organizations, but also to the general public. Some of the main topics covered by CGER activities are introduced below.

**Observational studies of GHGs (Core research project 1)**

This project consists of a large variety of atmospheric, oceanic, and terrestrial observations of GHG concentrations and their fluxes in the Asia-Pacific–Russian region. Oxygen and isotopic observations over the Pacific and two monitoring sites (Hateruma and Ochi-ishi) supported global $CO_2$ budget calculations for over 8 years from 1999 to 2007. About 30% of anthropogenic emissions of $CO_2$ was estimated to be taken up by the ocean and 10% by terrestrial plants. The observations also revealed that the $CO_2$-absorbing potential of these media is being maintained despite the recent trend toward increased temperatures. $CO_2$ observations from commercial passenger airplanes were continued, recording the vertical distribution of $CO_2$ over many international airports in Asia, Europe, Australia, and the USA. We found that there was a characteristic vertical distribution of $CO_2$ in each region, and that large Asian cities had relatively increased concentrations below 4 km altitude, compared with the concentrations in other regions such as the Pacific and Europe.

In the near future the terrestrial $CO_2$ sink flux may decrease because of temperature rises. As part of this project we studied the response of soil respiration to higher temperatures at three forestry field sites by using a heater attached to an instrument for measuring soil respiration. To evaluate oceanic sinks, observations

in the North Pacific continued, and the trends of the sinks in this area were evaluated.

**GHG observations from space (Core research project 2)**

The Greenhouse Gases Observing Satellite (GOSAT) is planned to be launched in early 2009. We are currently conducting research to derive precise column abundances of $CO_2$ and $CH_4$ from the GOSAT observations. We have found that *kosa* ("yellow sand") aerosols, which are present at high altitudes, and large dust particles are two major sources of error, although our algorithms can retrieve the column abundances of gaseous species precisely in most cases despite the presence of these aerosols. We have prepared *in situ* instruments and a high-resolution ground-based Fourier Transform Infrared Spectrometer for the upcoming validation of the GOSAT data products.

By using computer simulations we have completed our analysis of the impact of the inclusion of GOSAT observations on uncertainties of inverse-model estimated $CO_2$ flux. We confirmed that the mean regional flux uncertainty can be reduced by about 50% by the addition of satellite observations (Fig.1) to the monitoring data from currently operational ground stations.

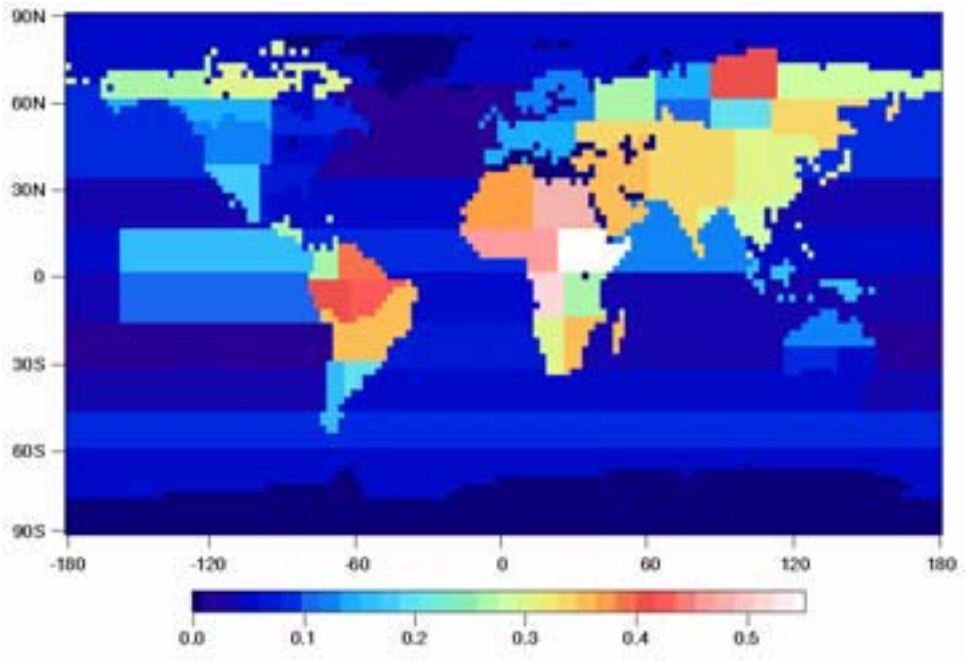



**Fig. 1** Relative uncertainty reductions of estimated annual $CO_2$ fluxes for 66 regions (unitless). Relative uncertainty reductions are defined as {1 − (Uncertainty with GOSAT and ground-based observations)/ (uncertainty with ground-observation only)}.

**Terrestrial ecosystem and land-use modeling (Core research project 3)**

Atmosphere–ecosystem exchange of trace gases, especially GHGs, is one of the key processes modulating atmospheric composition and climate change. It is therefore an essential component of the climate risk assessment project. We developed a process-based model of the terrestrial carbon–nitrogen cycle and trace gas exchange (VISIT), which simulates plant and microbial exchange of $CO_2$, $CH_4$, $N_2O$, as well as sporadic emissions from land-use conversion and biomass

burning. This model is being used to evaluate the impacts of global warming on terrestrial biogeochemical cycles, the potential feedback of warming to the climate system, and an earlier assessment of ecosystem management for adaptation against climate change.

In addition to the terrestrial ecosystem model, we developed a land use change projection model. We have developed a model to project conversions between cropland and forestland over the next 30 years. The model uses prices, costs, and environmental constraints to judge the suitability of land use on the basis of the benefits of forestry and agriculture. The results showed that much of the rain forests in developing countries could disappear over the next 30 years, and that the patterns of change in Africa and Brazil could be very different depending on scenarios.

**Climate policy assessment (Core research project 4)**

Achieving a low-carbon society requires significant changes in lifestyles and practices in both developed and developing countries. To encourage these changes it is vital to raise the awareness of individuals and organizations about the impacts of our actions on all aspects of the global environment. We have been conducting a Japan–UK Joint Research Project, and this FY we held its third workshop on a sustainable low-carbon society. A set of key areas has been identified as critical to putting us on global low-carbon pathways that are consistent with achieving goals for climate stabilization and economic development.

We have also been conducting a study on projected international climate regimes after 2012. In FY 2007 the study focused on Japanese stakeholders' perceptions of this topic, and in August 2007 we held a group seminar to discuss this theme. In parallel, we have also conducted a questionnaire survey based on the "Delphi Method" to forecast the direction of international negotiations over the next five years in regard to post-2012 climate regimes .

To gather useful information for the negotiations on the post-2012 scenario, we have been estimating GHG reduction potentials (Fig. 2). China, the USA, India,

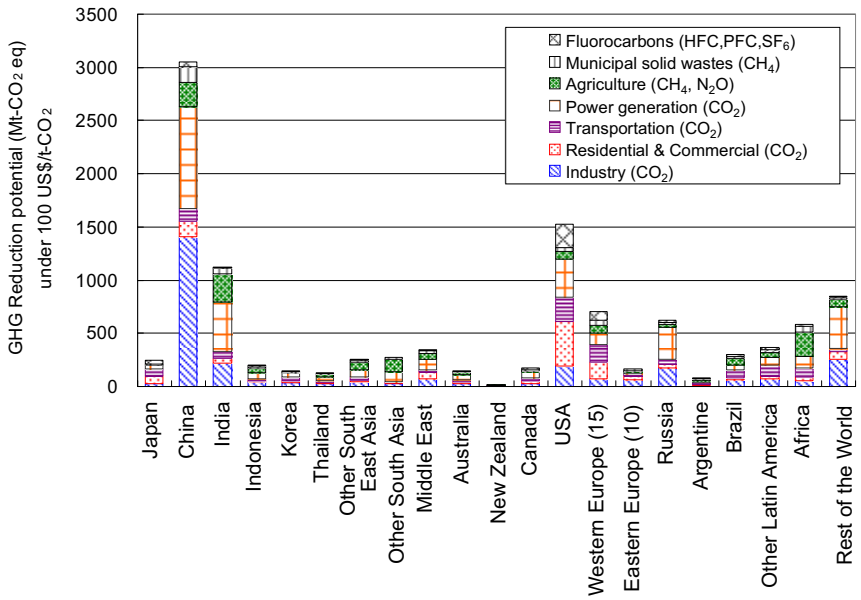



**Fig. 2** Greenhouse gas reduction potentials under $US 100/t $CO_2$ at a 5%/year discount rate. Reduction potentials in 21 regions and seven sectors are illustrated. Reduction potentials in China and the USA are relatively large, and those in the industry and power sectors are significant.

Western Europe, and Russia are five major regions that account for around 60% of the world's total GHG emission reduction potential. The major sectors with large reduction potentials vary depending on the socioeconomic characteristics of each region. However, large reduction potentials in the power generation and industry sectors are attributed to the use of low energy-efficient technologies, particularly in Non-Annex I countries. These sectors combined account for around 50% to 60% of the world's total reduction potential. The residential/commercial sector and the transportation sector account for about 10% of the total potential, respectively, and other sectors that release non-$CO_2$ emissions, such as the agriculture sector, the municipal solid waste sector, and the fluorocarbon emission sector, account for around 20% of the total potential.

**Long-term monitoring of GHGs and other trace gases**

We monitor GHGs (e.g., $CO_2$, $CH_4$, and $N_2O$) and other chemical species (CO, $NO_x$, and $SO_x$) from various platforms. We have two ground-based stations, at Hateruma Island, over 1000km southwest of the Japanese mainland, and Cape Ochi-ishi, in northeastern Hokkaido. We also use airplanes that fly over three sites in Siberia and commercial ships that traverse the Pacific to measure atmospheric GHGs and partial pressure of $CO_2$ ($pCO_2$) in surface seawater. In addition, continuous observations of vertical ozone profiles in the stratosphere have been performed by the millimeter-wave radiometers here at Tsukuba and at Rikubetsu, Hokkaido. UV-A and UV-B on the ground are monitored, and real-time UV indexes obtained at 15 sites in Japan are available to the public via our Web page.

$CO_2$ mixing ratios observed over Surgut, West Siberia (61°N, 73°E), have increased by about 30 ppm over the last 14 years (Fig. 3). The increase rate of $CO_2$ was more than 3ppm/year in 2005, but it declined to 2 ppm/year in 2007. The vertical difference in the annual mean $CO_2$ mixing ratio over Surgut is only 0.3 ppm between 7 and 2 km.

$CH_4$ mixing ratios have been almost stable since 1998 at all altitudes over Surgut, although a slight increase was found in about 2005. Annual mean $CH_4$ mixing ratios at lower altitudes over Surgut are apparently higher than those farther aloft. This is because huge amounts of $CH_4$ are released from the wetlands around Surgut.

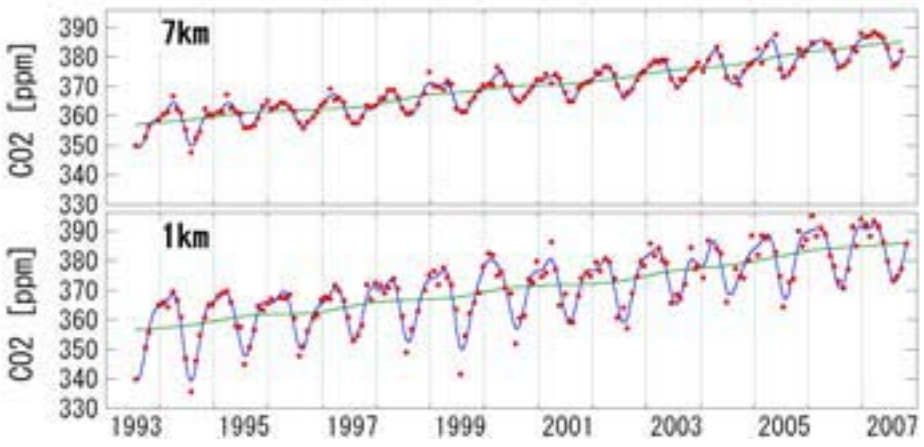



**Fig. 3** Time series of $CO_2$ mixing ratio at 1 and 7 km over Surgut, Siberia. Red circles, observation data; blue solid line, best fit curve; green solid line, secular trend.

**Carbon dioxide flux monitoring of terrestrial ecosystems**

As one of the AsiaFlux network activities we conducted a synthesis analysis involving 10 East Asian universities and institutes. Net ecosystem production over forest stands (net C uptake by forests) was observed from 13 long-term flux measurement towers in the sub-arctic, temperate, and tropical regions of East Asia between 2000 and 2005. The sites extend over a wide latitude, ranging from 3ºN to 64ºN, and they include sub-arctic and temperate needle-leaf deciduous forests (larch) (central Siberia, Mongolia, China, and northern Japan); temperate mixed, broadleaf deciduous – needle-leaf evergreen forests (northern and central Japan); and seasonal and tropical rain forests (Thailand and Malaysia).

Annual values of gross primary production (total amount of photosynthetic uptake) are simply regulated by annual mean air temperature across East Asia (Fig. 4). This clear relationship is caused by the fact that the air temperature influences both growing period length and seasonal variation in maximum photosynthetic capacity. On the other hand, there is a strong exponential relationship between annual ecosystem respiration (total amount of respiratory C released) and annual mean air temperature, similar to that obtained on an individual-site scale.

The dataset, which was obtained from a wide variety of forest ecosystems in East Asia over several years, is essential for validating ecosystem models. It is also essential for generating, from satellite remote sensing, technological developments in our understanding of the distribution of the terrestrial carbon budget in Asia.

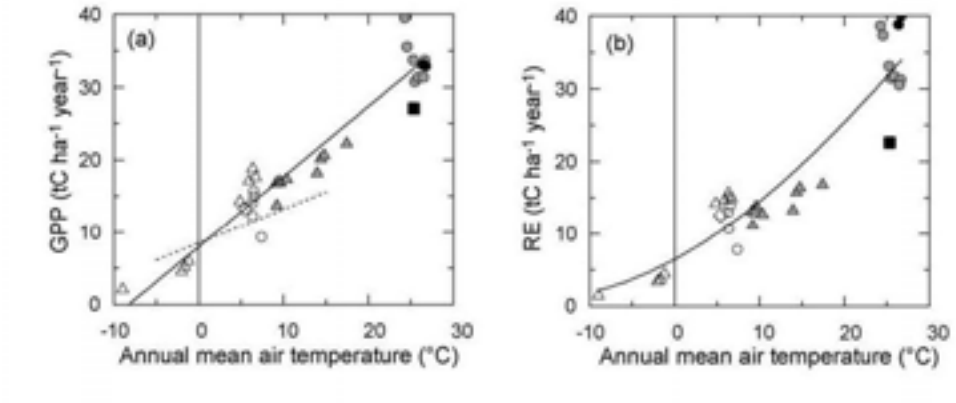



**Fig. 4** Relation between annual mean air temperature and (a) gross primary production (GPP) and (b) ecosystem respiration (RE). Data is categorized by forest type (△ deciduous coniferous forest; ○ deciduous broadleaf forest; ◇ mixed forest; ▲ evergreen coniferous forest; ● tropical forest; ● tropical peat swamp forest; ■ tropical forest disturbed by forest fire).

**Global environmental database**

We are developing and managing various databases, Web sites, and data analysis tools for global environmental research and making them available to the public.

A fully redundant backup server system for the CGER database, designed and partly procured in FY2006, was completed and became operational in FY2007. Now http accesses to db.cger.nies.go.jp are automatically transferred or allocated to one of two identical http servers, depending on the server's access loads.

The following five database projects were conducted in FY2007:

1. Development of a global environmental monitoring database and related tools
2. Development of a terrestrial carbon sink model database and related tools

3. Development of a GHG emission scenario database and related tools
4. Development of a GHG emission database and related tools
5. Development of a carbon flow database and related tools.

Two new Web-based databases for NIES and the staff of related research organizations were developed and released as components of the global environmental monitoring database. The first one is the Contrail DB, which is used for searching and obtaining atmospheric $CO_2$ data from five commercial airliners. The second is the JaLTER (Japan Long-Term Ecological Research Networks) database for registering, searching, and obtaining data from ecological monitoring sites within Japan. This database itself was originally developed at the University of Tokyo with funding from the Ministry of the Environment. It was then moved and now operates within CGER's database system.

In the project on "Development of a terrestrial carbon sink model database and related tools", we continued to develop a new database of *in situ* land-cover data for the validation of global land-cover maps derived mainly from satellite data. The part of the database covering the Asian region is almost complete. We used the database to investigate the accuracy of previous land-cover maps. The database is contributing to the new global land-cover map being developed by CGER (Fig. 5).

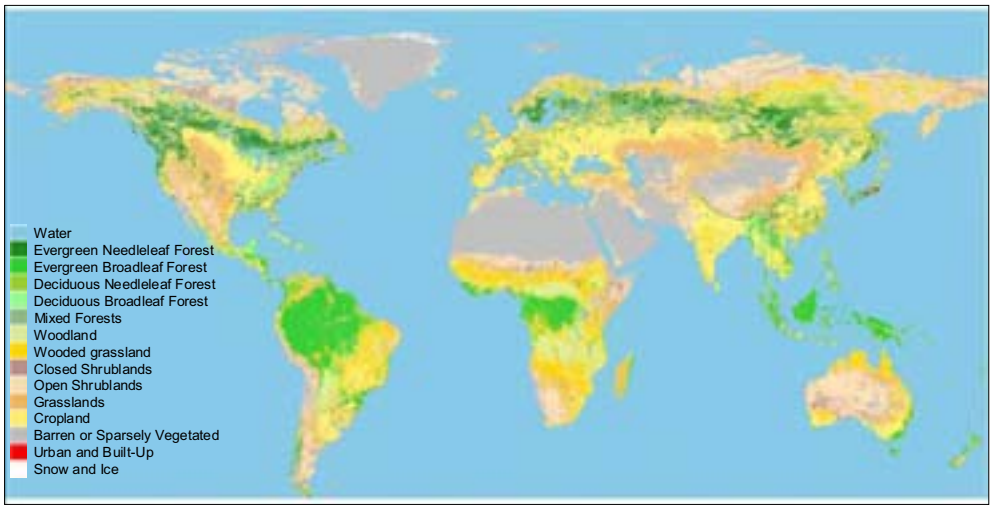



**Fig. 5** NIES landcover map in 2000 with simplified IGBP clasification, resolution is half degree (Iwao et al. )

**NIES GOSAT Project Office**

GOSAT is scheduled for launch in early 2009. To prepare the routine data handling system before the launch, the NIES GOSAT Project Office completed a critical design review in July 2007. It started developing software for the GOSAT Data Handling Facility and procured the hardware needed for the software development. The office also generated the basic plan for GOSAT data validation, prepared the first research announcement, and conducted other outreach activities.

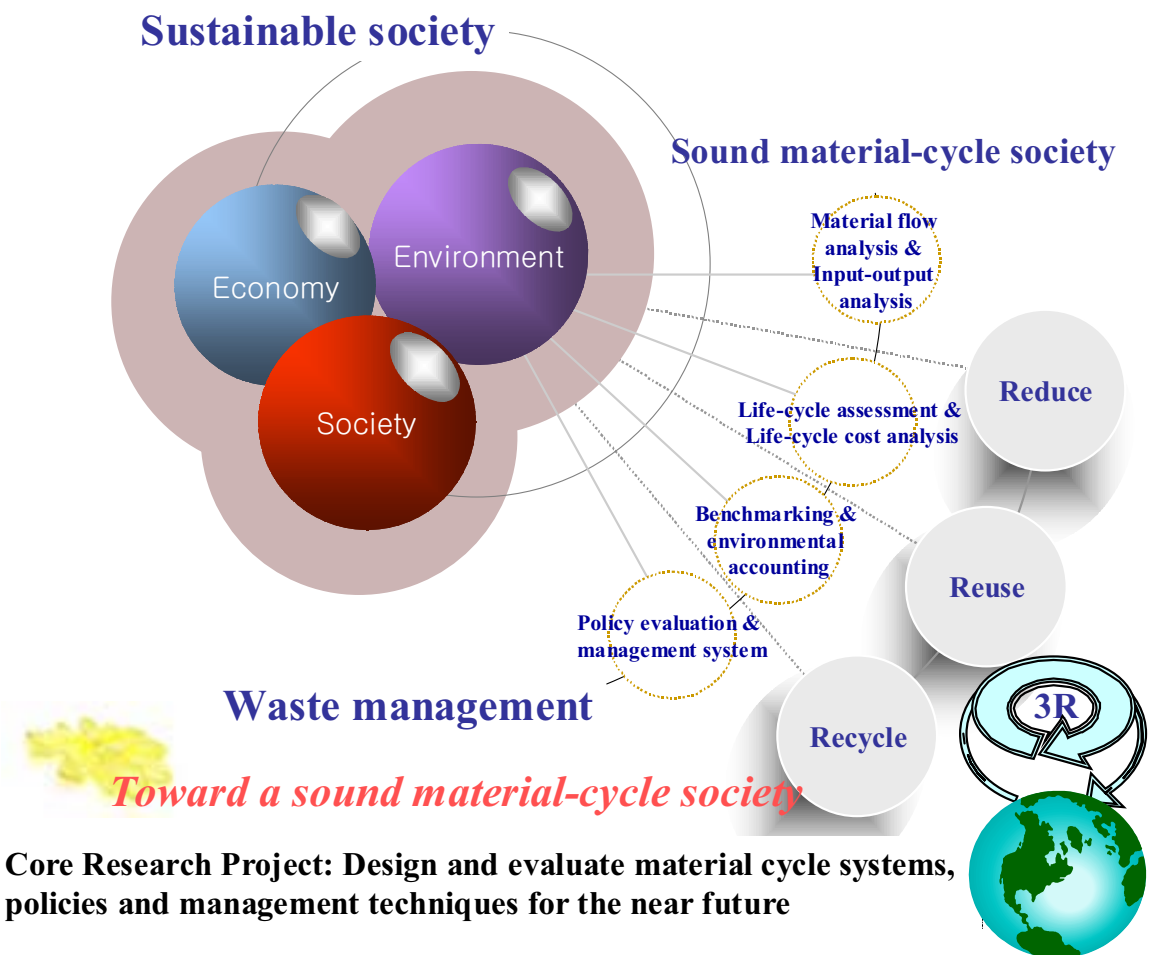
**Office for Coordination of Climate Change Observation**

The Office for Coordination of Climate Change Observation (OCCCO) is acting

as secretariat for the Japanese Alliance for Climate Change Observation (JACCO). OCCCO's activities include investigating the need for climate change observations; enhancing the accessibility of observation data and coordinating the use of observation platforms; convening meetings; and managing public relations activities.

On 4 October 2007, OCCCO held a JACCO domestic workshop in Tokyo. Entitled "Toward the integration of climate change observation", it reflected the need for long-term continuation of observations and for inter-organizational and inter-disciplinary collaboration. As one of the early achievements of the Global Earth Observation System of Systems (GEOSS), OCCCO and the GOSAT Project Office presented "Global Monitoring of Greenhouse Gases" at an exhibition at the Fourth Earth Observation Summit and GEO IV, held in Cape Town, South Africa, from 28 to 30 November 2007. OCCCO and CGER co-hosted the "Asia-Pacific Workshop on Carbon Cycle Observations" at NIES at Tsukuba from 17 to 19 March 2008. The first report of the Scientific Working Group of JACCO, edited by OCCCO, was published in March with the aim of contributing to future planning for climate change observation by Japanese ministries and organizations.

# Research Center for Material Cycles and Waste Management




**Core Research Project: Design and evaluate material cycle systems, policies and management techniques for the near future**

Since its foundation in 2001, the Research Center for Material Cycles and Waste Management has aimed to realize a society with desirable material cycles, i.e., reduced usage of natural resources, reduced generation of waste, increased recycling of materials, and appropriate waste management. In accordance with the second 5-year plan of NIES (covering 2006–2010), the center is playing a main role in promoting a research program on "Sustainable Material Cycles" as one of the four Priority Programs. The program comprises four core research projects and other research activities that aim to ensure appropriate waste management.

**1. Designing and evaluating material cycle systems, policies, and management techniques for the near future (Core research project 1)**

A future vision for achieving an effective material-cycling society is needed at a variety of levels ranging from local to national government, as well as in the public, administrative, and industrial sectors. In envisaging technologies and socio-economic systems that would create a sound material-cycle society (SMS) in 10 to 20 years, we developed social transition scenarios and specific plans to reach the strategic target in terms of technological and political improvement. We used forecasting and back-casting approaches. The following results were obtained in the second year of the project.

First, as a result of discussions with experts from related fields at a workshop on "Scenario Planning", we produced a descriptive model that shows cause-and-effect relationships between changes in social factors and material flows. Having identified several social factors that have impacts on, and produce uncertainties in the state of material flow, we then described several social change scenarios for the near future (Fig. 1).

We created a quantitative model of the material flows, predicting the effects of various pathways of realizing an SMS under constraints on natural resource consumption and GHG emissions. The model consists of three functions: those related to material demand, material discharge, and processing, with material inputs and outputs (Fig. 2).

We also performed a life-cycle inventory analysis for material cycle technology

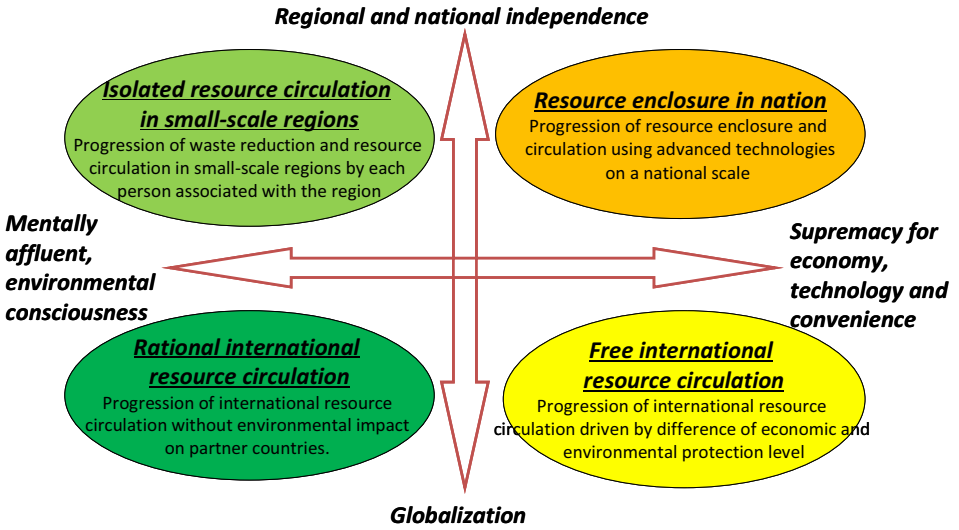



**Fig. 1** Social change scenarios for the near future associated with material flow.

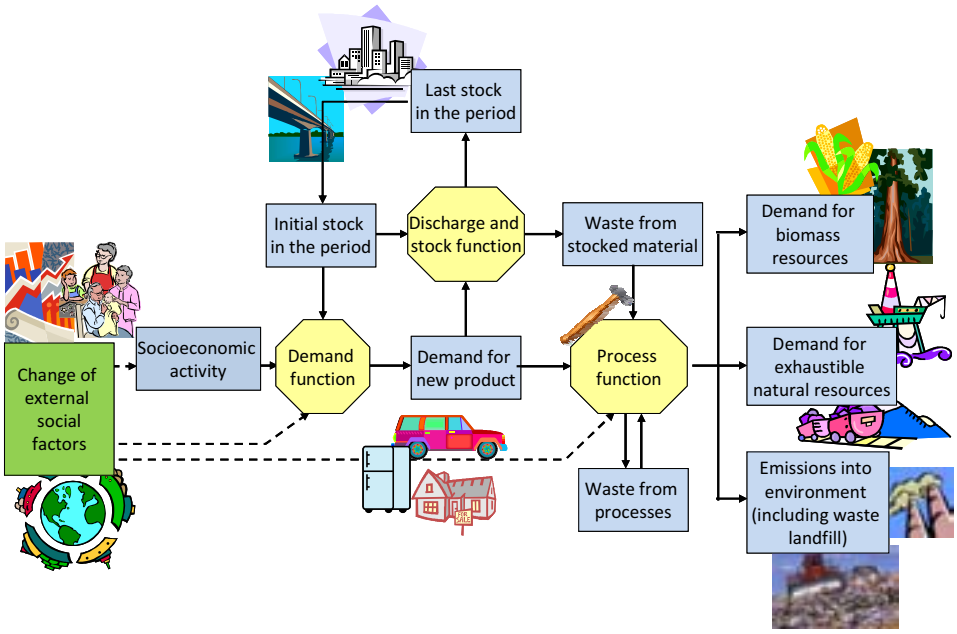



**Fig. 2** Quantitative modeling to predict material flows in the near future.

systems, focusing on several principal types of resources that would play important roles in the future scenario, along with the pathways. A benchmarking approach was proposed as a technique for improving the municipal solid waste (MSW) management system of each local government and comparing the MSW management performances of different governments. We measured the degrees of recycling and waste management that would be needed to comply with the Container and Packaging Recycling Law, and we collected data on the "invisible" flows of electronics wastes to help us empirically evaluate the consequences of various recycling laws. We also investigated real-life applications of extended producer responsibility in the EU and deposit–refund systems abroad.

**2. Management of hazardous and valuable substances in the life cycles of materials and products (Core research project 2)**

*Determination of levels of emission of brominated flame retardants (BFRs) as plastic additives in products*

Attention is being given to indoor air and dust in homes as important media of human exposure to BFRs as plastic additives. However, product users or residents do not know what kinds and quantities of BFRs are being used in products and emitted indoors. When flame-retardant-treated home electrical appliances and textiles with known concentrations of BFRs were placed in a model room under controlled ventilation conditions, they were experimentally confirmed to be sources of BFRs in indoor air. Polybrominated diphenylether (PBDE) levels in the indoor air increased significantly when electrical appliances such as television sets and computers were placed in the room, and the hexabromocyclododecane (HBCD) concentration increased when curtains were fitted (Fig. 3). Emissions of PBDEs from a television set used in this study to the indoor air were estimated at 7.0 μg $year^{-1}$; emissions of HBCDs from a pair of curtains used were estimated at 22 μg $year^{-1}$.

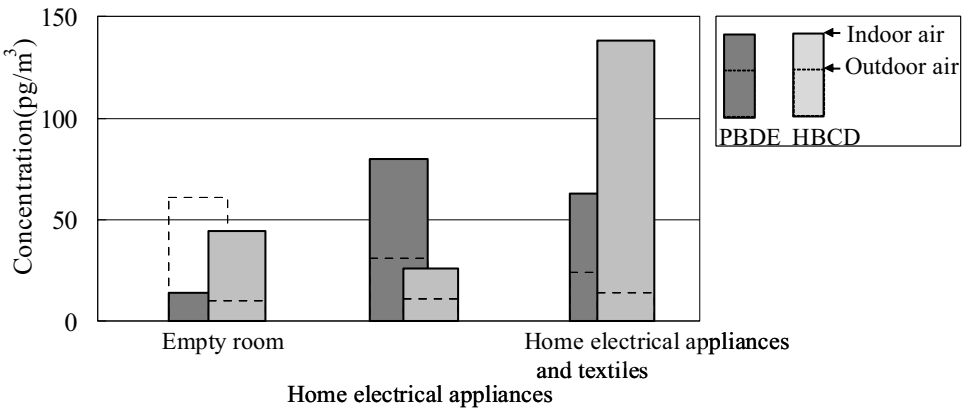



**Fig. 3** Concentrations of BFRs in a model room.

*Measures for managing the recycling and disposal of valuable but hazardous metals*

We obtained the content of 40 metals in a waste personal computer (PC) by disassembling and precise chemical analysis and then evaluated the potential recovery of each metal at each disassembly phase. Domestic and international flows of Au, Ag, Pd, Cu, and Pb associated with waste PCs were also estimated by using material flow data on waste PCs. We proposed an "inherent resource potential" index and applied them to metals in the printed circuit boards of waste PCs. The data on emissions of the hazardous metal mercury to the air in Japan were refined, and the annual release was estimated as 24 to 28 t $year^{-1}$. This result was presented to United Nations Environment Programme through the Ministry of the Environment, Japan. Emission inventories of mercury species ($Hg^0$ and $Hg^{2+}$) were also estimated from experimental data and field surveys.

*Evaluation of environmental impact of recycled construction products*

As a way of evaluation of environmental impact by leaching of toxic metals from recycled construction products, we developed a draft standard for environmental availability testing and made a cross-validation. A cyclic immersion-drying test was designed to elucidate the factors that affect the release of toxic metals from recycled products in construction sites. By incorporating these test data into a numerical model that we developed, we estimated the long-term environmental impact of copper slag on the basis of a reuse scenario.

**3. Developing a win-win resource recycling technology for waste biomass (Core research project 3)**

Project 3 aims to develop recycling technologies that recover energy and materials from biomass and organize applications for them. Using laboratory-scale catalytic reformers and gasifiers, we evaluate the usefulness of catalytic reforming in terms of durability and regeneration properties of the catalyst under low temperatures (1023− 1123 K). Commercial Ni-based catalyst and calcined limestone (CaO) were applied to the reforming reaction. The experiment achieved more than 90% carbon gasification efficiency and a high calorific value (around 8 MJ $m^{-3}N$). We also conducted a long-term hydrogen-methane fermentation ex-

periment with kitchen garbage discharged from a cafeteria. Acetic acid and butyric acid were the main intermediates, and hydrogen gas production was achieved in a lab-scale fermenter. Ammonia, which inhibits fermentation, could be oxidized by using immobilized nitrifying bacteria in the advanced treatment of effluent from methane fermentation. Another ammonia-reduction technology—the MAX (MAP-ANAMMOX Hybrid) denitrification system—was developed and the design parameters of its unit processes were determined. We then constructed a bench-scale MAX plant, and started the operation in the yard of Tarumizu Biogas Plant in Kagoshima Prefecture.

In an investigation of wet biomass, we showed that the use of a zero-emission-type process of lactate fermentation of food wastes brought the development of a key recycling technology appropriate to an SMS a step closer.

We investigated the effects of fermentation residue on chicken health and meat quality. We also determined the optimum operational conditions for a pilot-scale phosphorus adsorption–desorption processes for centralized wastewater treatment. We also examined phosphorus recovery from sludge produced in a wastewater treatment tank, known as “Johkasou”, equipped with an iron electrolysis process; around 70% of the influent phosphorus was satisfactorily recovered from domestic wastewater.

Finally, to develop and evaluate material cycle systems that integrate raw materials and waste processing, we designed, developed, and evaluated energy recovery systems using waste biomass as an energy resource. We emphasized not only the development of a highly efficient process for producing biodiesel fuel (BDF), but also the design and evaluation of technological systems for recovering energy from sewage sludge. For BDF production, to convert low-quality waste greases such as grease-trap waste and waste cooking oil gels to BDF, we developed new pretreatment and production technologies that use liquefied dimethyl ether. Use of our BDF production technology (Fig. 4) resulted in a super-fast reaction—it was faster than the conventional production method such as homogeneous alkali catalyst method by two orders of magnitude. In an investigation of energy recov-

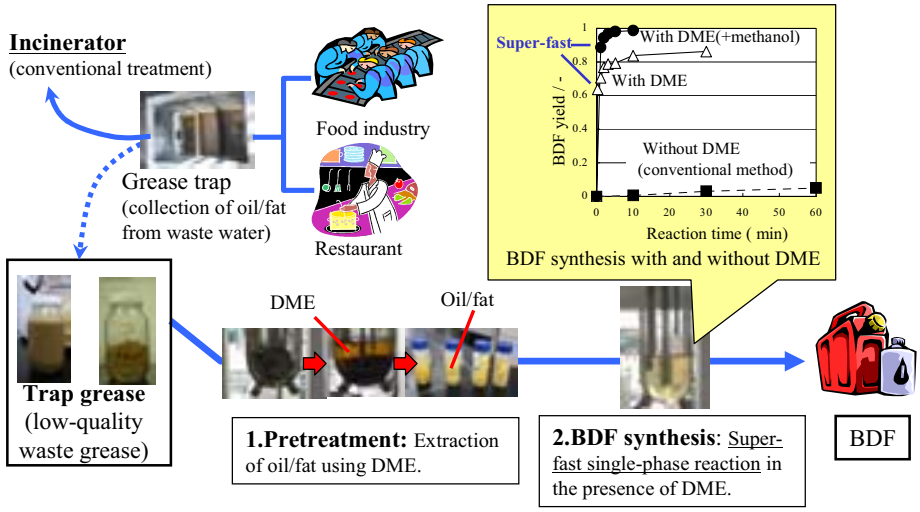



**Fig. 4** Development of new BDF production technology from low-quality waste grease.

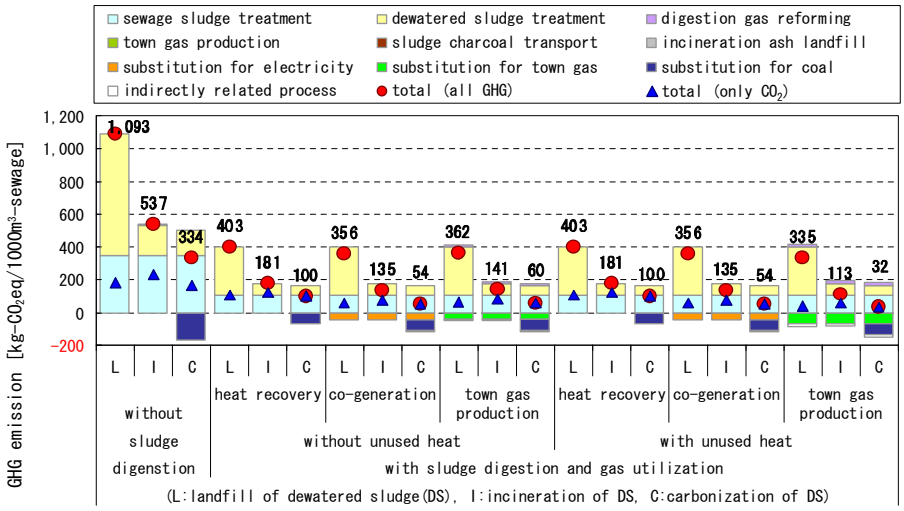



**Fig. 5** GHG reduction by linkages of sewage sludge treatment with energy utilization.

ery from sewage sludge, we found that linkages of sewage sludge treatment with energy utilization reduced GHG emissions (Fig. 5).

**4. Establishing appropriate management networks and technology systems to support sound international material cycles (Core research project 4)**

To promote appropriate material cycles in developing Asian countries, we examined the current transboundary movement of recyclable resources and related recycling in each country. In addition, we designed, applied, and evaluated waste management technologies and systems that mitigate disposal and global warming. We analyzed the material flows of internationally traded recyclable resources such as e-wastes and plastics (Fig. 6). Increasing trends in domestic e-waste generation in Asia and the volume of secondhand electronic equipment exported

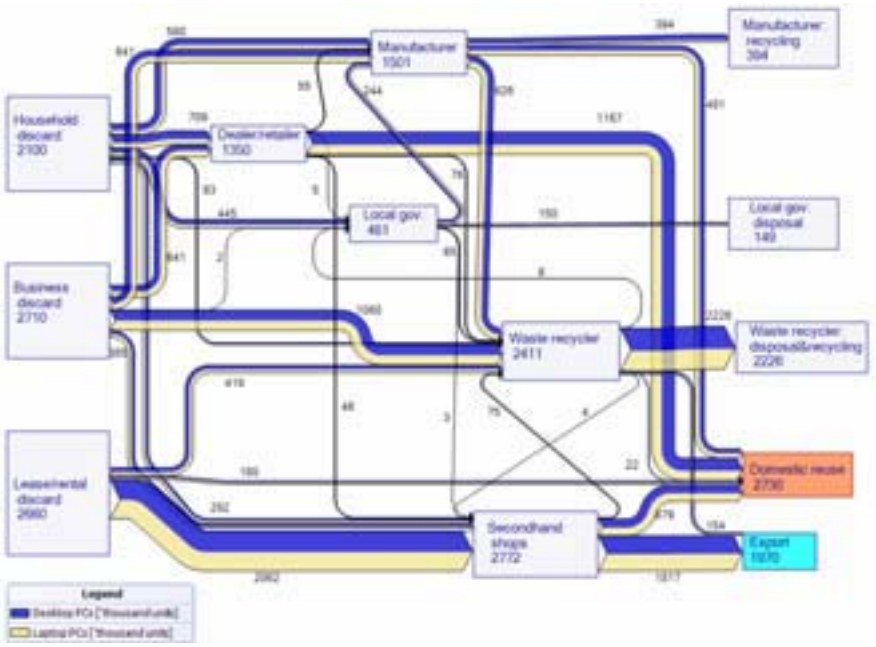



**Fig. 6** Estimated material flows of used personal computers in Japan (FY 2004).

from Japan were clarified. As examples of international flows, an actual repair, resell case of secondhand TVs imported from Japan to the Philippines was surveyed, and flows of dismantled printed circuit boards from Vietnam into China were confirmed. We also organized the fourth NIES Workshop on E-waste and exchanged advanced information with Asian researchers.

The occurrence of persistent organic pollutants and heavy metals was reviewed in relation to material recycling and waste disposal in Asia. Sediment samples were bioassayed, and experiments were performed to simulate the incomplete combustion of printed circuit boards. We dismantled personal computers and estimated the precious metal content of the printed circuit boards for the evaluation of future e-waste resource potential.

Solid waste streams in Asia were broken down into four patterns. A life cycle assessment model was developed to estimate changes in environmental loads with the introduction of waste management technologies such as separation at source, resource recovery facilities, and semi-aerobic landfills. We also started to identify potential parameters for evaluating the effects of landfill technologies on reducing GHG emissions and pollutant levels in leachate.

An investigation of the regional characteristics of domestic wastewater in Beijing showed that pollutant concentrations and volumes were quite different as compared with the data from Japan. Simulated domestic wastewater was used as influent to a wetland constructed with eco-engineering wastewater treatment technology, and operational inflow was optimized for pollutant removal and GHG emission control.

**5. Research to ensure appropriate waste management practices**

By tracing industrial waste streams, including the separation of items during intermediate treatment, we estimated the material flows of plastics, wood, metals, and residues. The substantive flow of construction and demolition waste was also estimated. We concluded that crushing and separation are important for quality control of recyclable and disposable materials. An existing model that illustrated the reactions occurring within landfills was improved. The time required for stabilization of waste was estimated from initial organic content and permeability of the soil covering the wastes. The analytical simulation showed that the time required was reduced to less than one-tenth with 1000-fold enlargement of the diffusion coefficient of the covering soil, or to one-fifth with a one-fourth reduction in initial organic content. We used a semi-continuous measurement apparatus to collect monitoring data on organic halogens as surrogates for dioxins, and we used the measurement device to reduce dioxin emissions from the thermal treatment of wastes. The amounts of dioxins emitted with both flue gas and dust could be estimated from the surrogate monitoring.

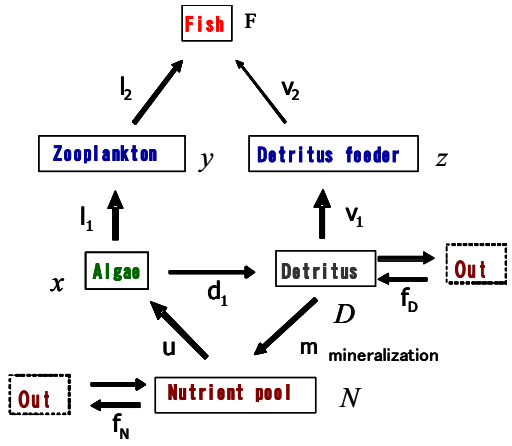
We also investigated a liquid-waste treatment system. The characteristics of simultaneous treatment of domestic wastewater and kitchen garbage in a Johkasou were investigated, and some operational parameters that could increase treatment efficiency were found. Life-cycle $CO_2$ analysis suggested the possibility of $CO_2$ emission reduction in a simultaneous treatment.

**6. Promotion of fundamental research**

We proposed a method of using transmission electron microscopy (TEM) for the precise testing of samples to assess waste asbestos treatment. The method has a low detection limit (1 million fibers [Mf] $g^{-1}$) for the verification of "no detection of asbestos fibers" in solid samples. We developed an effective sample pretreatment procedure to compare asbestos fiber examination by other methods (phase contrast microscopy, polarized light microscopy, and scanning electron microscopy) with the results of TEM. We evaluated the asbestos fibers of thermally treated amosite, tremolite, crysotile, and crocidolite by TEM. The concentrations of crysotile and crocidolite fibers decreased to 100 Mf/g above 1000°C, whereas the other two types of asbestos required a temperature of more than 1400°C to achieve the same level of reduction.

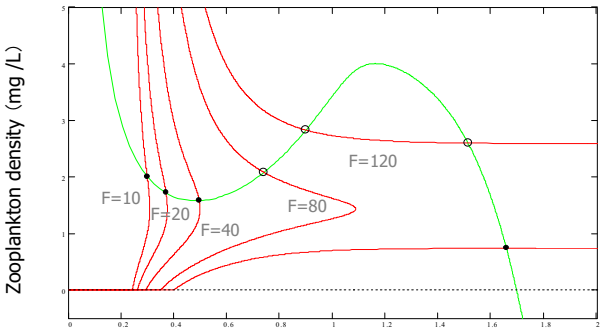
In addition, the categorization of "material cycling and waste disposal process data", "material flow data", and "chemical characteristic data on recyclable resources and wastes" contributed to the establishment of several databases. These databases will help us not only to design and evaluate material cycle systems, but also to promote appropriate waste management.

# Research Center for Environmental Risk




Japanese irrigation ponds

Isocline at a eutrophic state




$$dN/dt = (Q - N) f_N - U_{max}\, u(N)\, x + m\iota D$$
$$dx/dt = c_1 U_{max}\, u(N)\, x - \eta_1 x^2 - G_{max}\, g(x)\, y - d_1 x - f_1 x$$
$$dy/dt = c_2 G_{max}\, g(x)\, y - P_{max1}\, p_1(y)\, F - d_2 y - f_2 y$$
$$dz/dt = c_3 V_{max} v(D)\, z - \{1 - P_{max1}\, p_1(y)\}\, P_{max2}\, p_2(z)\, F - \eta_2 z^2$$
$$dD/dt = (L - D) f_D + d_1 x + d_2 y - V_{max}\, v(D)\, z - \iota D$$

Tri-trophic ecosystem model for ecological risk assessment

Schematic diagram of nutrient flows in a model freshwater ecosystem (top left). The model is based on the minimum pelagic model for shallow lake ecosystems and incorporates a detritus pool and detritus feeders. Isocline analysis has revealed the basic properties of the model: at higher fish densities and intense nutrient loadings the plankton community exhibits an ecosystem regime shift to the steady-state turbid condition with inflated phytoplankton density (bottom left; closed circles represent stable points, and open circles represent unstable points). Photos at right: Japanese irrigation ponds. Such ponds exhibit apparent regime shift and are typical of freshwater ecosystems under study.

The Research Center for Environmental Risk (RCER) is conducting an Environmental Risk Priority Program based on the second 5-year plan of NIES (covering 2006–2010) . In this program, we perform comprehensive research on how to assess environmental risks, such as the effects of chemical substances, invasive species, and nanoparticles on human health and the ecosystem.

The Environmental Risk Priority Program incorporates the following four Core Research Projects:

1. Integrated exposure assessment analysis of the complex factors involved in chemical exposure
2. Methods for the health risk assessment of environmental chemicals that cause sensitivity reactions
3. Assessment of the health risks associated with environmental nanoparticles
4. Development of environmental risk assessment methods that take into account biodiversity and ecosystem functioning.

We are also conducting the following research on issues that may have future applications in environmental decision-making:

- Fundamental research to improve environmental risk assessment methodologies
- Collection and dissemination of information on environmental risks
- Environmental risk assessment practices for regulatory objectives.

**1. Integrated exposure assessment analysis of the complex factors involved in chemical exposure (Core research project 1)**

We aim to establish an exposure assessment process that effectively and comprehensively considers the complex nature of exposure to chemicals. The project will integrate a number of exposure variables, including chemical composition and spatial and temporal scales, to provide a more comprehensive view of the status of exposure to multiple chemicals for future risk assessment. The project consists of three main topics: (1) development of methods of hierarchical exposure analysis based on GIS from the regional to the global scale; (2) exposure measurement based on *in vitro* and *in vivo* bioassays; and (3) exhaustive development of integrated exposure analysis, as described below (Fig. 1).

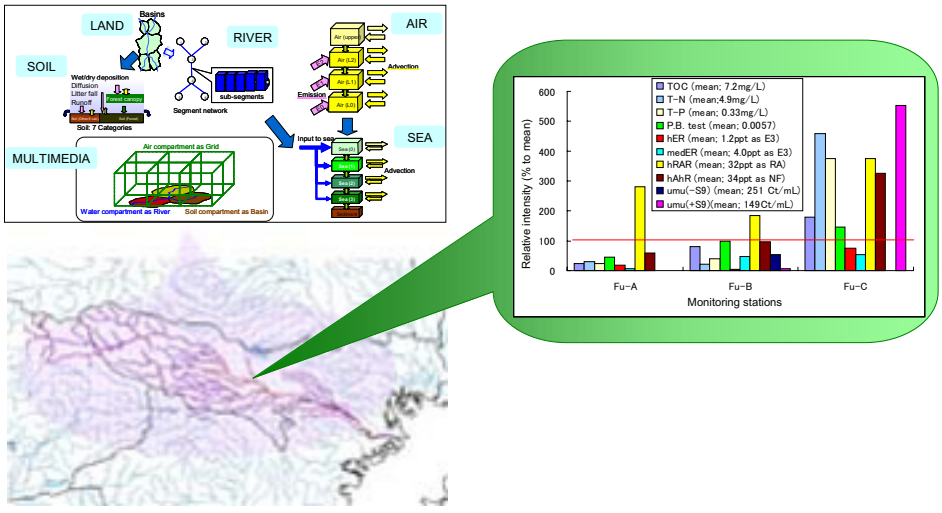



**Fig. 1** General concept of the integration of hierarchical modeling outputs and exposure monitoring by bioassays.

Through the use of fate-modeling methodologies to model the natural and environmental dynamics of chemicals, the development of hierarchical exposure analyses as part of topic 1 will help us to understand exposure to multiple chemicals. This year we validated a regional-scale GIS fate model, expanded it to a global fate model, and performed a case study of the global fate of polychlorinated biphenyls to estimate the regional contribution to global levels. We also studied the sediment–water dynamics of selected hydrophobic chemicals on the basis of field surveys and laboratory experiments, and we performed a survey to assess the exposure of children to chemicals by inhalation.

To analyze the complex causes of exposure we are applying bioassays and exhaustive chemical analyses to environmental samples. We have used various bioassays and analyses to perform a preliminary field survey of selected river waters; developed new methods for analyzing and testing airborne mutagenic compounds and *in vivo* methods for testing aquatic organisms; and performed related basic studies with both *in vitro* and *in vivo* bioassays.

We aim to present the methods and results of our integration of multiple exposures and to be able to analyze various types of data (e.g. socioeconomic) in order to develop effective measures for exposure reduction and control. This year, we have explored methods of integrating various exposure data and have begun the collection, compilation, and conversion of socioeconomic and other data for their incorporation into the GIS database.

**2. Methods for assessing the health risk of environmental chemicals that cause sensitivity reactions(Core research project 2)**

Our aim is to establish experimental models for assessing the health risks posed by environmental chemicals at low doses in susceptible individuals.

We developed a system for evaluating the threshold for the olfactory detection of volatile organic compounds, and we found that the threshold for toluene in mice is under 5 ppb—at least two orders of magnitude lower than that reported in humans. Low-level exposure to toluene resulted in increased proliferation of thymocytes without influencing the expression of cell-surface molecules on lymphocytes, and in the activation of the transcription factors NF-ρB, STAT5, and NFAT in thymocytes. Among four strains of mice, ovalbumin-immunized C3H/HeN mice seemed to be most susceptible to toluene exposure at low levels. Low-level toluene exposure modulates the expression of neurotrophin and memory-related genes in the hippocampus of the mice dependent on strain (Fig. 2).

Perinatal exposure to toluene significantly increased the number of apoptotic cells in the sexually dimorphic nucleus of the preoptic area (SDN-POA) of both sexes, suggesting that the formation of the SDN-POA is affected by the developmental exposure to toluene. Only low-level toluene exposure from the fetal stage to the neonatal stage may enhance systemic Th2 function in infant mice. However, exposure to low-level toluene combined with peptidoglycan stimulation suppressed Th1 and Th2 immunity. Impaired mineralization resulting from a reduction in osteoblastic activity via TCDD-mediated upregulation of vitamin D may

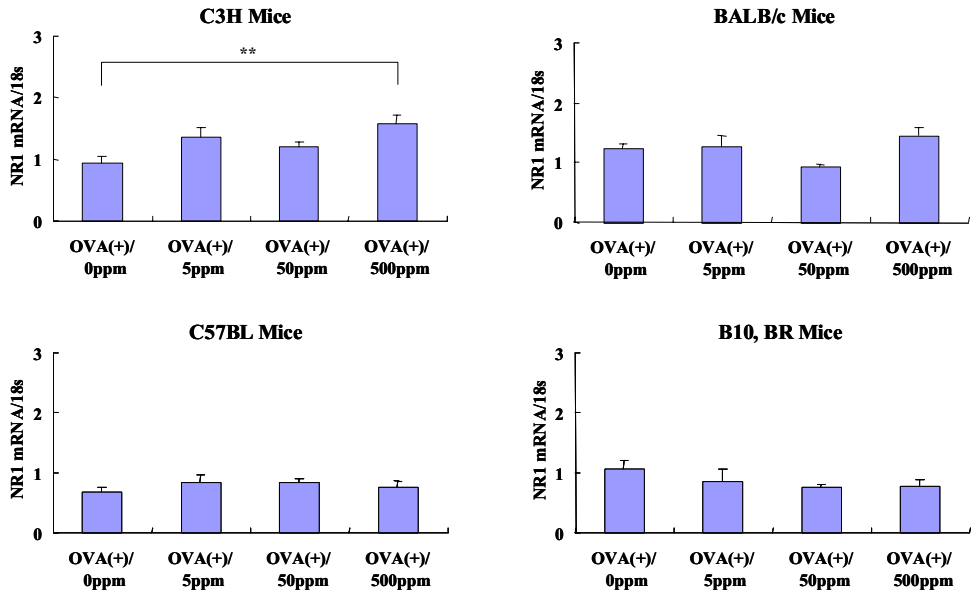



**Fig. 2** Expression of *NR1* mRNA in the hippocampus of toluene-exposed mice Exposure of 5-day-old rats to bisphenol A caused hyperactivity in juveniles, but not in adults, although the pathological features of neurodegeneration were still observable in the adults.

be responsible for the bone developmental toxicity. Repeated exposure of neonatal rats to rotenone facilitated spontaneous motor activity in juveniles, whereas exposure of adult rats caused akinesia, bradykinesia, and rigidity, as seen in patients with Parkinson's disease. The brains of permethrin-treated fetal mice became smaller than those of controls and showed disrupted vascular formation involving shortened vessels, more small branches and, in some cases, insufficient fusion of the anterior communicating arteries.

Exposure to environmental chemicals accelerated atopic-dermatitis–like skin lesions related to mite allergen exposure in NC/Nga mice, an *in vivo* screening model. In an *in vitro* screening system, exposure to di-ethylhexyl phthalate, di-isononyl phthalate, or bisphenol A, all of which can also aggravate atopic-dermatitis–like skin lesions, increased T cell receptor expression, interleukin-4 production, and proliferation of splenocytes.

### 3. Assessment of health risks associated with environmental nanoparticles (Core research project 3)

We have been investigating the biological impacts of ultrafine particulate matter and environmental nanoparticles and determining how these materials behave in the body. Our final goal is to establish health-risk assessment methods that are geared to these kinds of particles rather than to regular chemicals.

Nanoparticle-rich diesel exhaust was generated by an idling diesel engine (Fig. 3). We then analyzed the size and chemical composition of the nanoparticles. We found that the main components generated under these conditions originated from unburned diesel fuel or lubricants. We have been exposing rats and mice to nanoparticle-rich diesel exhaust or filtered diesel exhaust to see whether it is the nanoparticles or the gases in the exhaust that are primarily responsible for the effects of the diesel exhaust. Interestingly, the effects of the nanoparticles in the exhaust were not as great as we had expected from the effects of the whole exhaust. However, cardiac function was still significantly affected by the nanoparti-

**Fig. 3** Engine used to generate nanoparticle-rich diesel exhaust (left), and inhalation chambers for accommodating small rodents (right).

cles, suggesting that inhaled nanoparticles have extrapulmonary effects. The results of particle-dynamic studies using scanning transmission electron microscopy suggested that the nanoparticles can migrate through lung epithelial cells.
We investigated the interaction of multi-walled carbon nanotubes (MWCNTs) with macrophages and found that dispersed MWCNTs were highly reactive with macrophage receptors with collagenous structure on the plasma membrane. At the nanoparticle health effects building we have installed a facility for inhalation of MWCNTs to investigate the *in vivo* effects of nanofibers.

The toxicity of heat-treated chrysotile and crocidolite asbestos was determined in an animal model. Intratracheal and intraperitoneal injection of these forms of asbestos induced acute inflammation in the lung and peritoneal cavity, respectively. However, injection of heat-treated asbestos caused only marginal inflammation. The toxicity of amosite, another amphibole asbestos mineral, was evaluated *in vitro* by using macrophages and mesothelial cells.

**4. Development of environmental risk assessment methods that take into account biodiversity and ecosystem functioning (Core research project 4)**

The stock of the megabenthic assemblage in Tokyo Bay has been decreasing since the late 1980s. To elucidate the factors depressing stock-size recovery, we examined the spatiotemporal pattern of the megabenthic assemblage in relation to environmental variables. Megabenthos occurred throughout the bay, except in August, during which defaunation and severe hypoxia were observed in the northern part of the bay. Non-parametric multivariate analyses showed significant spatiotemporal differences in the community structure, and hypoxia was suggested as an important cause of defaunation in the northern area. Classification and regression tree analysis showed that the threshold bottom dissolved oxygen concentration for the presence of megabenthos was between 1 and 2 mL $L^{-1}$.

Both invasive carp (*Cyprinus carpio*) and crayfish (*Procambarus clarkii*) may drive catastrophic regime shifts in fresh water. We used an enclosure experiment to elucidate the ecological impact of increasing carp or crayfish abundance on littoral ecosystems. Even at low abundance, carp had strong positive impacts on suspended solids phytoplankton, and nutrients, and negative impacts on benthic macroinvertebrates. In contrast, crayfish had a strong negative impact on submerged macrophytes. Both carp and crayfish have profound effects on community composition and ecosystem processes through the combined consequences of

bioturbation, excretion, consumption, and non-consumptive destruction. However, key variables (e.g., macrophytes) relating to stable state changes showed different responses to increasing carp or crayfish abundances, probably reflecting their differential modes of ecosystem engineering.

We investigated the distribution in Japan of an invasive alien fungus, *Batrachochytrium dendrobatidis*, which is specific to amphibians. To detect even slight infestations of this fungus in the field, we developed a new polymerase chain reaction (PCR) assay system. We found infected individuals not only in exotic amphibian species bred in house, but also in native species in the field. Furthermore, we discovered genetic variation in the DNA sequences of the fungus in the field (Fig. 4). Some individuals of the Japanese native giant salamander, *Andrias japonicus*, were infected by a fungus with unique DNA haplotypes. These results suggest that East Asia may be the origin of the fungal disease.

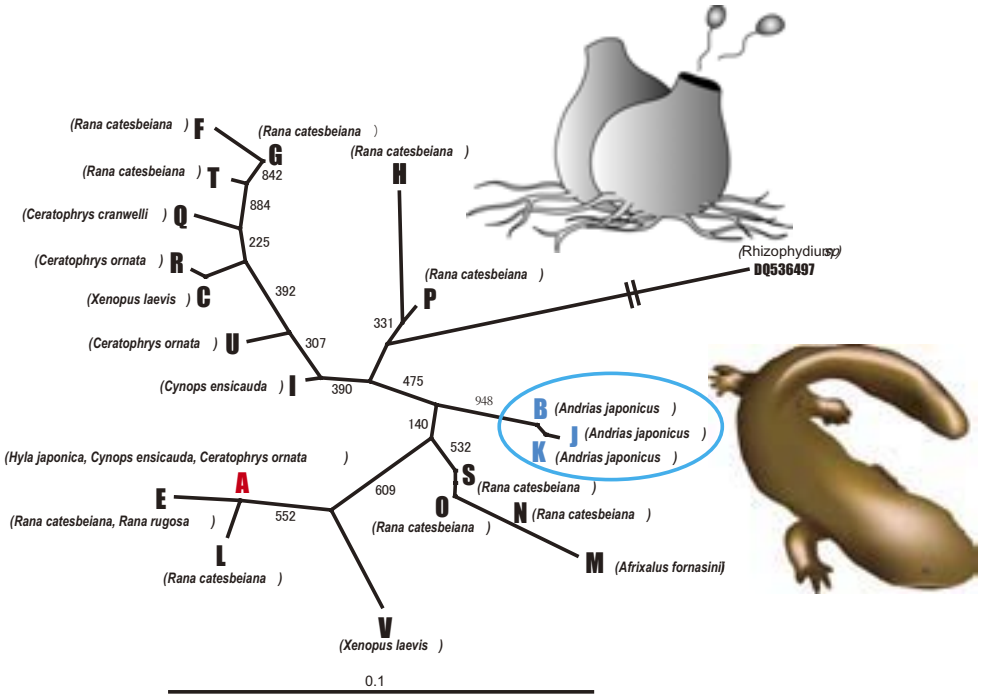



**Fig. 4** Phylogenic tree of ITS haplotypes of the chytrid fungus *Batrachochytrium dendrobatidis*. The tree was constructed by the maximum parsimony method.

Each haplotype was transcribed as an letter code. Numbers at the sides of branches are bootstrap values obtained from 1000 pseudoreplicates. All haplotypes of the fungus were detected from amphibians in Japan, but only haplotype A had been reported in other countries. Notably, peculiar haplotypes B, J, and K (blue ellipse) were detected in the giant salamander, *Andrias japonicus*, which is a rare endemic Japanese species.

For the purpose of ecosystem impact assessment, we have developed a simplified tri-trophic ecosystem model, in which the nutrient density and the densities of the primary producer (algae) and the consumer (zooplankter) are treated as interacting variables, with the predator (fish) density as a constant. Analysis of the model revealed that the most important parameter was the consumer, and the most important corresponding functional trait that optimized nutrient transfer efficiency in the model ecosystem was the consumer's assimilation efficiency. Within a functional group, e.g., a grazer guild, the mean functional trait (e.g., the assimilation efficiency) changes with changing species composition in response to environmental perturbation by chemical pollution. This process was mathematically analyzed and was proved to be highly dependent on functional or trait diversity within a community but fairly independent of species richness and competition

strength. This theoretical finding was checked by numerical simulations and applied to published data on plankton community responses in a whole-lake biomanipulation experiment.

**5. Examination of ecotoxicity test procedures and ecological risk assessment methods for the management of chemical substances**

The aim of this project is to develop ecotoxicity testing procedures and analytical methods that are relevant to estimations of the impact of pollutants on ecosystems. Three specific issues are being investigated: ecological risk assessment based on an ecosystem model; development of a population genetic monitoring method based on resistance genes; and utilization of benthic invertebrate species for ecotoxicity testing.

We have developed a simple mathematical model ecosystem that has three trophic levels: primary producers (algae), primary consumers (zooplankton), and secondary consumers (fish). This type of model is known to describe well the basic dynamic properties of pelagic aquatic ecosystems such as those in lakes and ponds (Fig. 5). By incorporating the dose–response functions of chemical substances on the population growth of the species representing each trophic level, we can estimate the indirect ecological effects of pollutants through the food chain in terms of the population dynamics and risk of extinction of the top predatory species (Fig. 6). By using the trophic transfer efficiency—the amount of biomass taken by fish as a ratio of the total biomass produced by algae—as a criterion of ecosystem functioning, we determined the most sensitive model parameters for ecosystem function as the assimilation efficiency and maximum grazing rate of zooplankton, and the tolerance of algae to grazing.

Genetic or evolutionary acquisition of tolerance to chemical pollutants provides strong evidence for long-term chronic exposure at particular sites. The collection of detailed genetic or biological information that goes beyond geographic variations in tolerance (e.g., acute $LC_{50}$), including the within-population genetic variability of resistance and the gene flow (genetic mixing rate) between local populations, is expected to yield an elaborate ecological risk-estimation method. We selected the water flea *Daphnia galeata* as a model organism. In this crustacean we have detected significant between-population differences in tolerance to

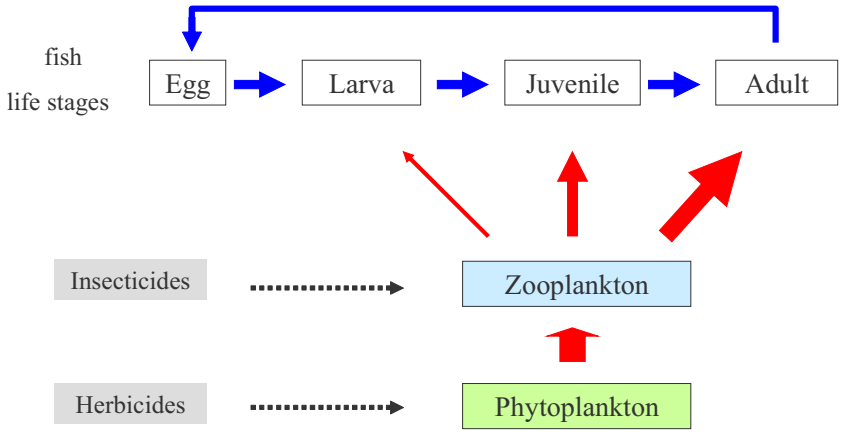



**Fig. 5** Schema of the three-trophic-level community model.

The top predator (medaka) population is further divided into four life stages. Pollutant chemicals have differential adverse effects at different trophic levels and life stages.

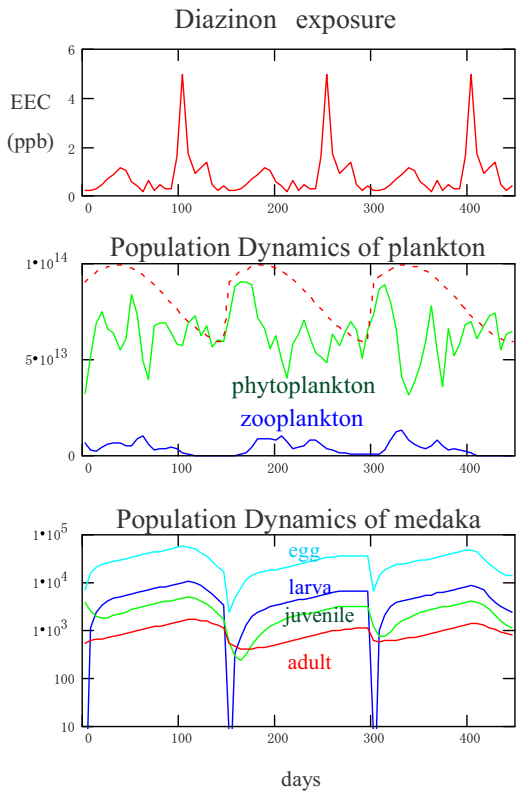



**Fig. 6** Simulated population dynamics of algae, zooplankton, and medaka under diazinon exposure. EEC denotes measured environmental exposure concentration of the chemical. The lower two figures represent simulated numerical abundances. The dashed red curve represents the carrying capacity for the phytoplankton.

fenvalerate, as well as genetic variability at the level of microsatellite DNA, even in a moderately narrow egion of Lake Kasumigaura. These results indicate that local populations of *D. galeata* are genetically isolated enough to become locally adapted to site-specific levels of pollution; this information is therefore relevant to population genetic monitoring.

Benthic macroinvertebrates are important decomposers in river and lake ecosystems. The OECD Test Guideline specifies a guideline for bioassays that use benthic invertebrates as test species. In response to this international agreement in this project we have investigated environmental conditions for rearing and basic life-cycle data in order to establish a standard protocol for bioassays using two oligochaetous species and a midge.

**6. Database for comprehensive chemical risk assessment**

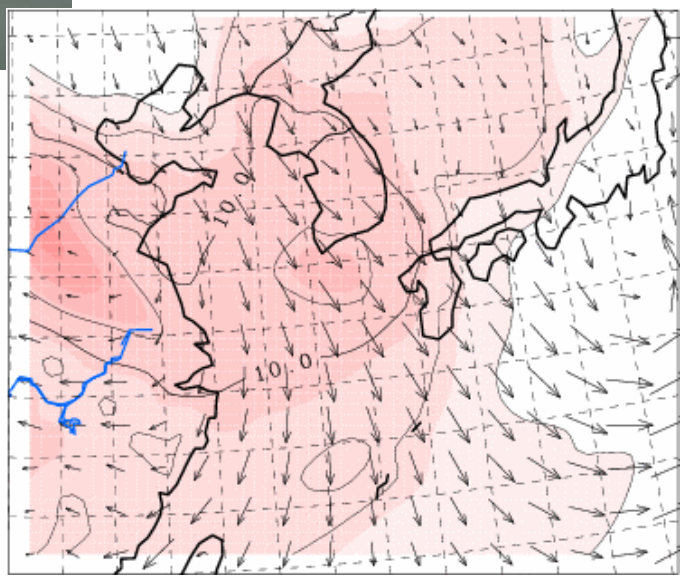
The methods used in, and the results of, chemical risk assessments are linked to the chemical, social, economic, ecological, and geographical data that are required to make effective assessments. Such data are especially needed when more in-depth assessments are required, such as those that have spatially resolved or specific outputs related to GIS. To achieve such in-depth assessments with spatially resolved specificity and distribution we need a well-designed database and data management system.

We designed a database structure suitable for use with various types of temporo-spatial data, such as data from both monitoring and model-predicted sources, meteorological data, and social and economic data. Compilation of data on observed and predicted environmental concentrations of chemicals is under way in this database. Examples are chemical monitoring by the Ministry of Environment, predicted concentration calculated by geo-spatial multimedia fate model G-CIEMS (Grid-Catchment Integrated Modeling System). Social fundamental grid data were also accumulated such as population, land use category, and industrial statistics.

We are developing a system for the analysis and management of the compiled data. The system is ready for use in GIS presentations through organized spatial coding systems.

# Asian Environment Research Group

Observation by aircraft over the East China Sea (courtesy by the Yomiuri Shimbun)



Space distribution of sulfate, as simulated by the Chemical Weather Forecasting System (CFORS)

Cape Hedo Aerosol and Atmosphere Monitoring Station (CHAAMS) in Okinawa, Japan

Japan is closely connected to Asia both geographically and economically, and rapid future development is expected in the region. Therefore, the preservation of the environment and the creation of a society in harmony with nature are crucial to environmental security and a sustainable society throughout Asia. Against this background, the Asian Environment Research Group conducts research on air quality, long-range transboundary air pollution, sustainable management of water environments in terrestrial, coastal, and oceanic areas, and ecosystem management and conservation in catchments such as those of large rivers. In the second 5-year plan of NIES (covering 2006–2010), we have been carrying out three core research projects and other research activities as part of our Asian Environment Priority Program. The Asian Environment Research Group has five research sections, an independent senior research scientist, and two collaborative research sections. These core research projects promote Asian environmental management and will help to establish scientific knowledge and the foundations of policy recommendations to create a society in harmony with nature through international cooperation.

**1. Developing methods for evaluating the atmospheric environment of East Asia (Core research project 1)**

The regional air quality (e.g. ozone, anthropogenic aerosols, mineral dust) of East Asia is being investigated through comprehensive field monitoring, the development of an emissions inventory, and transport modeling. The final goal of this project is to develop an integrated method based on observation and modeling that will give us an understanding of the current status of the air quality of East Asia and allow us to predict future changes in the atmospheric environment.

***Study of regional-scale air quality in East Asia***

**The Asian Atmosphere Section** has made continuous and comprehensive observations of the chemical, physical, and radiative properties of aerosols and gases at Cape Hedo Aerosol and Atmosphere Monitoring Station (CHAAMS) in Okinawa, Japan. In addition, ground-based observations for gas and aerosol at Changdao in China and at Fukue in Nagasaki Prefecture were carried out in spring 2007. In spring 2008, observations were made from aircraft over the East China Sea to investigate the vertical distribution and transformation of chemical species in air masses. In the same period, ground-based observations as part of the Western Pacific Air–Sea Interaction Study (W-Pass) and for an aerosol–cloud interaction study were conducted at CHAAMS in collaboration with several Japanese institutions. Measurements of total reactive nitrogen ($NO_y$), $NO_{y(g)}$ (gas-phase $NO_x$ + $HNO_3$), and particulate nitrate at CHAAMS showed that concentrations of $NO_y$, $NO_{y(g)}$, and particulate nitrate were high in spring, but low in summer. This difference was related mainly to the air mass history. We analyzed the chemical transformation of particulate nitrate during transport. As the transport time of air masses increased, particulate nitrate shifted from fine to coarse particles. As a result, nitrate was mainly found in coarse particles at CHAAMS. In contrast, sulfate stayed in fine particles during transport and was found in fine particles at

CHAAMS. Since the lifetime of $NO_y$ and $SO_y$ ($SO_2$ + sulfate) partly depends on particle size, differences in the chemical transformation process during transport influence the abundance of transported $NO_y$ and $SO_y$. Chemical transformation was also investigated by Lagrangian methods. In the air mass traveling to CHAAMS via Fukue, an increase in sulfate and a decrease in $SO_2$ were quantitatively shown by the ratios of $SO_2$ to CO and of sulfate to CO. Measurement of PAHs (polycyclic aromatic hydrocarbons) revealed that the average benzo[a]pyrene to benzo[e]pyrene ratio was 0.48 during winter and spring, lower than those measured in Chinese cities (~0.85). This indicates that the PAHs observed at CHAAMS have been aged by the photochemical reactions that occur during long-range transport. These results suggest that pollutants transported by the monsoons from the continent contribute to the PAH load observed at CHAAMS.

***Evaluation and future projection of atmospheric environment in East Asia***

**The Regional Atmospheric Modeling Section** conducted long-term simulations of surface ozone over East Asia during 1980–2003 by using a regional-scale chemical transport model (Community Multi-scale Air Quality modeling system, CMAQ) and the newly developed year-by-year Regional Emission Inventory in Asia (REAS). CMAQ with REAS reproduced the spatial and seasonal variations in the observed surface $O_3$ concentrations in 2000 and 2001. A historical simulation for the period 1980–2003 demonstrated that the annually averaged concentration of surface $O_3$ over Central East China has increased by about 12 ppbv (1% $year^{-1}$) over the quarter century; the value for Japan was 5 ppbv (0.4% $year^{-1}$). This simulated trend in Japan generally agrees with the observed trend measured at monitoring stations and is correlated with the trends in Chinese $NO_x$ and NMVOC emissions. Future emissions up to 2020 were projected on the basis of three emission scenarios (PSC, policy succeed case; REF, reference; and PFC, policy failure case). In 2020, the Chinese $NO_x$ emissions under each scenario are expected to change by –3% (PSC), +40% (REF), and +131% (PFC) over 2000 values. Under the worst scenario (PFC), East Asian $NO_x$ emissions would almost double between 2000 and 2020. We found that surface $O_3$ concentrations in East Asia will increase markedly in the near future because of these projected increases in $NO_x$ emissions.

Other research activities were: (1) estimation of the contribution of emission areas on a global scale to the tropospheric ozone over Japan by using a global chemical climate model (CHASER); (2) development of an inversion model for estimating $NO_x$ emissions in China by using the RAMS/CMAQ/4DVAR system; (3) development of a chemical forecast system for the prediction of multi-scale air quality in East Asia, Japan, and the Kanto region; and (4) a model analysis of an episode of photochemical ozone pollution in May 2007 over Japan.

***Application of dust and sandstorm data measured by the LIDAR observation network in East Asia***

**The Collaborative Research Section** investigated atmospheric mineral dust,

which has huge effects on the global environment. The mineral dust generated from arid areas in the interior of China and Mongolia is known as *kosa* aerosol. Our research objectives were: (1) to develop quality assurance and quality control methods and a real-time data-processing system for the LIDAR (light detection and ranging) dust-monitoring network; (2) to establish a useful forecasting system through a feasibility study of the development of a four-dimensional variational assimilation system for regional dust modeling based on the LIDAR network monitoring data; and (3) to study the three-dimensional movement of *kosa* by using the quality-assured network data. A network dataset from the LIDAR system was provided for the data assimilation experiment. The data were processed in real time in 2007. The results of LIDAR network monitoring were also provided as part of the *kosa* information in a trial Web service (http://soramame.taiki.go.jp/dss/kosa/) offered by the Ministry of the Environment.

**2. Development of systems for evaluating regional water and material cycles in East Asia (Core research project 2)**

The comprehensive tools needed for sustainable management of the water environment and water resources of East Asia are developed by gathering scientific knowledge and information through strategic international collaborative research. This core research project has been developing a system for the observation and evaluation of water and material cycles in catchment ecosystems by coupling satellite monitoring with an integrated catchment model. The aim is to investigate the health status of catchment ecosystems, oceanic ecosystems, and Asian cities.

***Development of a system for the observation and evaluation of water and material cycles in a catchment ecosystem***

**The Asian Water Environment Section** has developed a system for the observation and evaluation of water and material cycles in a catchment ecosystem of East Asia. Field surveys have been conducted since 2006 along the Hanjiang (Han River), one of the largest tributaries of the Changjiang (Yangtze River) and the source river for the middle route of South-to-North Water Diversion Project in China. An autonomous water quality monitoring system was established in December 2007 at Xiantao Hydrological Station in cooperation with the Changjiang Water Resources Commission (CWRC). To assess the sustainability of rural management in the Hanjiang basin, the impact of human behaviors (in terms of food consumption, lifestyle patterns, and human waste disposal) on nitrogen flow has been investigated since 2007. At the same time, the structure, content, format, and framework of a database were developed from satellite, GIS, and observation data taken from the basins of East Asian rivers. Some of the data, such as those on climatic factors, geographic features, land-cover maps, and soil properties, as well as part of the socioeconomic inventory and the hydrological data have been input into the database. An integrated assessment model for the evaluation of water and material cycles has been improved on the basis of the Soil and Water Assessment Tool (SWAT) and the biogeochemical cycles (Biome-BGC) model. The

model has been running experimentally for the target river basins in China. We will try to validate the model by using observation data through cooperation with our counterparts. To make further progress in research with CWRC, the Second Sino–Japan River Basin Water Environment Workshop was held in Tsukuba, Japan, in June 2007.
Also, to investigate the influence of the Changjiang water on the oceanic environment and ecosystem, an investigative cruise was held in the East China Sea in June 2007. Of the 5 such cruises held so far, this cruise found the largest blooms yet recorded of the dinoflagellate *Prorocentrum dentatum*, which occurs as a red tide along the coast of China.

***Development of a comprehensive Circular Economy Urban Simulator to design and evaluate alternative environmental technology and policy scenarios***

**The Environmental Technology Assessment System Section** developed a comprehensive system called the "Circular Economy Urban Simulator" to simulate the circular policies of Asian cities. The simulator provides practical scientific platforms covering water resources management, urban energy management, and solid waste management for industrial Asian cities. It consists of an urban environmental GIS database; a technology and policy inventory for circular economies; and integrative analytical models for water and energy migration, socioeconomic transportation, evaluation indicators, and decision-support process design. The GIS database compiles environmental monitoring information from municipal governments, including water resources and solid waste data, and statistical socioeconomic information such as demographic data and industrial and sales information, all of which is supplemented by satellite photo data. The technology inventory covers end-of-pipe–type environmental treatment technologies, cleaner technologies, and industrial symbiotic technologies, which are applied to the city of interest along with coordinated social technologies such as regulation and subsidization. The integrative analytical model was developed for quantitative analysis of the spatial distribution and migration properties of different flows and stocks of environmental resources, including water, atmosphere, heat, energy, and material recycling, in urban areas. A three-dimensional physically based process model (NICE-URBAN) was developed to estimate the quantities of water and heat recycling in the study area, including in the atmosphere, soil, and underground water systems. It can evaluate the impacts of human activities on the natural ecosystem. The accuracy of the simulator was verified in the domestic industrial city of Kawasaki. Applications of the model for use in Chinese cities and regions are being developed in cooperation with the Liaoning Provincial Government and the cities of Shenyang and Wuhan, and with our counterparts at Dalian University of Technology and Wuhan University.

**3. Developing methods for environmental impact assessment of catchment ecosystems in Southeast Asia and Japan (Core research project 3)**

**The Watershed Ecosystem Section** is developing methods for the environmental impact assessment of Asian catchment ecosystems in Southeast Asia and Japan.

We are building an international network in the Mekong River catchment. We provide the scientific knowledge to support the sustainable development of catchments through international joint research. We are clarifying the current state of wetland vegetation and freshwater fish species in the Mekong River. By understanding the dynamics of catchments, we can assess the ecological impact of dams and other facilities.

***Satellite monitoring of the spatiotemporal changes in surface-water regimes and riparian environments in the entire Mekong Basin***

The vast mangrove ecosystem connecting the upper inland ecosystem and the ocean should have an important role in preserving the environment of the Mekong River basin. Several remote sensing studies of mangrove forests have been conducted for the purposes of inventory mapping, change detection, and management planning. We aim to quantify the effect of tidal water on the remotely sensed data by using a radiative transfer modeling approach. The outcome will help to establish a more robust method for remote sensing of vast mangrove forests (Fig. 1). To clarify the function of the mangrove ecosystem in the estuary basin, we focused on the plants that form the basis of the ecosystem. We examined the effects of oxygen-releasing mangrove plant roots on microbial activity in the sediments. Three representative mangrove plants, *Avicennia marina*, *Rhizophora stylosa*, and *Bruguiera gymnorrhiza*, were used. Our measurements revealed that ferric oxide plaques accumulate on the root surfaces of these plants, thus providing evidence that the three species release oxygen from their roots to the surrounding sediments (Fig. 2). These results indicate that mangrove roots clearly affect microbial activity and function in the sediments.

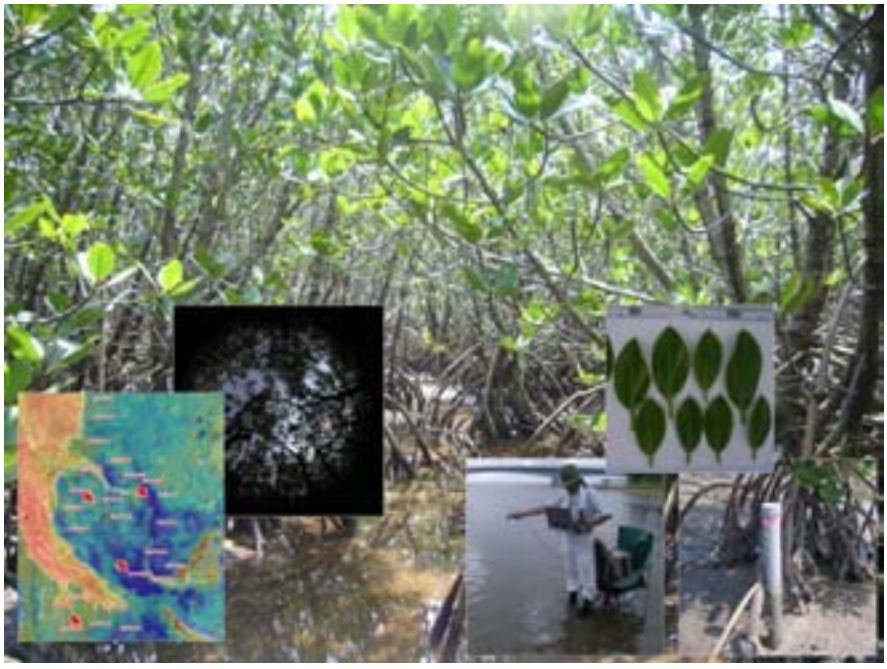


**Fig. 1** Remote sensing of a vast mangrove forest

**Fig. 2** Ferric oxide plaques on mangrove root surface.

***Predicting fish distributions in the Mekong River***

The Mekong River supports one of the largest (2.6 million t year$^{-1}$) and most diverse inland fisheries in the world. Dams pose a serious threat to Mekong fishes and fisheries, because the majority of the fish species migrate over long distances (often across national boundaries) during their life histories—for instance, between feeding and spawning habitats. As of April 2008, we have collected otoliths from nearly 400 individuals of 71 species in 17 families from the Mun River (a Mekong tributary) and the Mekong mainstream in Thailand. Chemical analyses of these otoliths will reveal spatial and temporal patterns of migration by various fish species and will allow us to assess the potential impacts of proposed dams on a scientific basis.

***Developing methods to assess environmental impacts on Mekong River catchment environments***

Development in the catchment has modified the natural seasonal river-flow dynamics, gradually degrading those ecological interactions in the catchment that are sustained by the natural hydrological regime. We simulated annual river runoff dynamics in 1945 and in 2002 (before and after construction of the Ubonrat Dam) along the middle Mun River and the Chi River in the middle Mekong catchment. We compared our calculated results (e.g., temporal changes in the inundated area over the course of 1 year) with actual hydrological measurement data for verification. We then validated the shape of the simulated flooded area by comparing it with Landsat ETM image data recorded synchronously. In the target catchment, the whole flooded area was classified into five zones on the basis of the cumulative annual number of flooded days before Ubonrat Dam construction (Fig. 3a, b). We then compared the results with the cumulative number of flooded

days in the zones after dam construction and found shrinkage of the flooded area in each zone. This trend was most pronounced immediately downstream of the dam site (Fig. 3c).

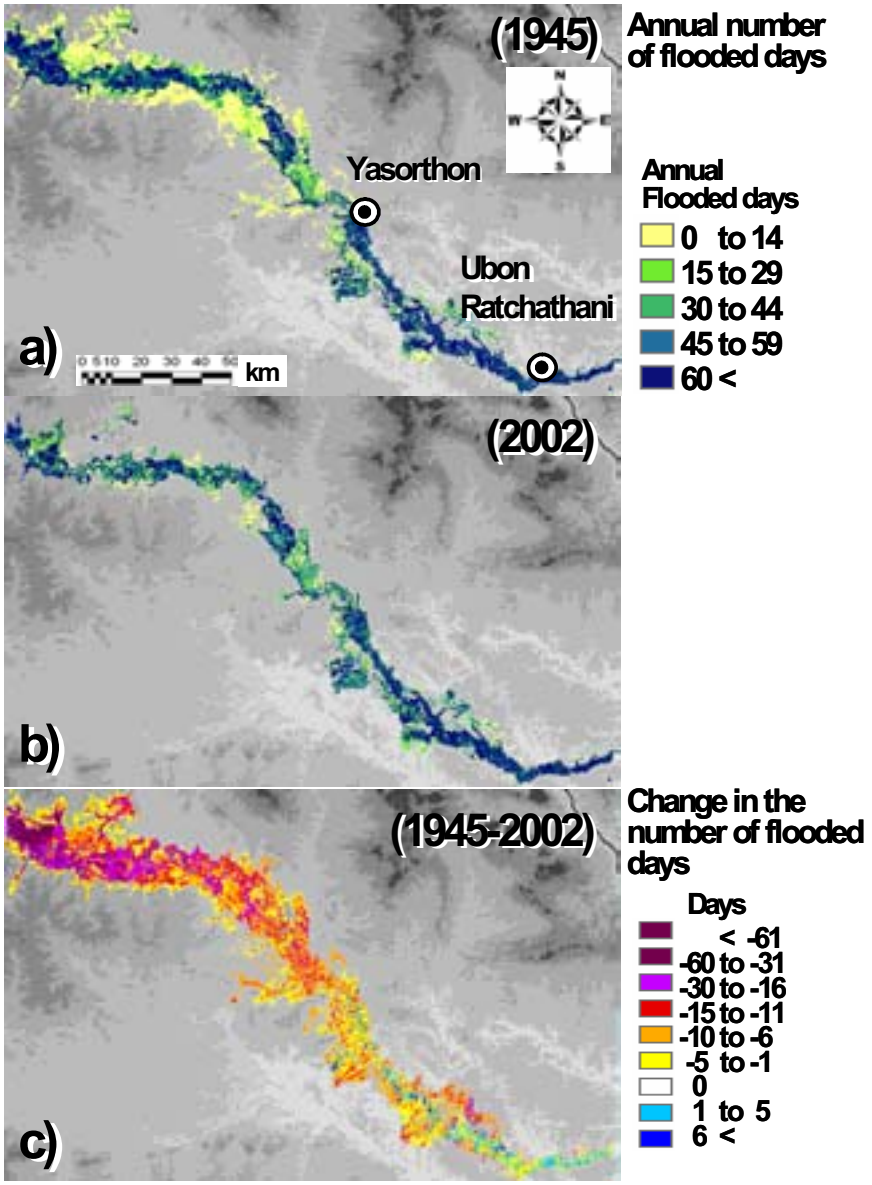



**Fig. 3** (a) Area flooded in 1945, classified according to the cumulative number of flooded days. Darker colors indicate longer-term flooding. (b) Area flooded in 2002, as simulated by the same procedure used for 1945. (c) Change in the cumulative annual number of days flooded over the whole flooded area between 1945 and 2002 (from Kameyama et al. 2008).

# Social and Environmental Systems Division

<Kanazawa "Eight Views">
Kanagawa Prefecture

The Eight Views of Kanazawa, in Kanagawa Prefecture

A type of landscape appreciation, called Hakkei was established in ancient China of Sung Dynasty of 10th century and was popularized in the Ming and Qing dynasties. It spread to surrounding areas and subsequently affected landscape appreciation in those regions. Thus, it contained the past appreciation of landscape in East Asia. The Shosho Hakkei concept was introduced to Japan in the 14th century during the Kamakura era, and was popularized in the 18th and 19th centuries. It influenced landscape appreciation in Japan for more than five centuries.

This Division targets the linkages between human activities and the natural environment in order to clarify the relationships between socioeconomic systems and environmental issues. The work of the Division results in proposals for environmental policies. It covers a broad area, from global environmental issues such as global warming to local issues like recycling and lifestyle. There are four research sections:

**The Environmental Economics and Policy Section** conducts studies relating to the economic and policy aspects of environmental conservation. It analyses the economic and political effectiveness of environmental policies.

**The Environmental Planning Section** works on planning and evaluation techniques and applications relating to environmental conservation, including local goal-setting of environmental policies, and on the prediction and assessment of global warming impacts.

**The Integrated Assessment Section** develops a set of environment–economy Integrated models to assess environmental policies, such as those on global warming mitigation and adaptation, and sustainable development policies.

**The Transportation and Urban Environment Section** analyzes urban environmental issues such as air pollution caused by automobiles and the urban heat-island effects caused by mass consumption of fossil fuels in urban areas.

Our main research outcome is as follows.

**Environmental Economics and Policy Section**

To investigate a wide range of environmental issues we are studying the interaction between current social and environmental systems by using approaches from social science, natural science, and systems analysis. In addition, we are analyzing the economic impact of environmental policies such as carbon taxes and emissions trading. We are also analyzing the environmental policy decision-making processes in use by various countries and investigating the possibility of international cooperation on global environmental conservation.

***Effects of trade openness on the environment***

We explore how trade openness affects the pollution ($SO_2$, $CO_2$, and BOD(biochemical oxygen demand)) in each country by using country level panel data. Overall effect of trade openness on the pollution is decomposed into three effects: trade induced scale effect, technique effect and composition effect. The scale effect refers to an increase in emissions due to an increase in production (e.g., GDP). The technique effect refers to a decline in pollution levels with increasing income. This occurs because as income increases, more stringent environmental regulations are implemented, and thus more environmentally friendly production methods are employed, resulting in increased demand for a better

environment. The composition effect explains how the composition of the production output and the structure of the industry are affected. Since trade openness affects the composition of the production and GDP, it changes the country level emissions. In this study we estimated the scale and technique effects as an integrated effects and the composition effect and then obtained overall effect. We found that that a 1% increase in trade openness causes a mean decrease of 0.344% in $SO_2$ emissions, 0.754% in $CO_2$ emissions, and 1.909% in BOD in the long term. The country-specific impact of trade openness on $CO_2$ emissions is shown in Fig. 1.

**Fig. 1** Country-specific impacts of trade openness on $CO_2$ emissions.

| Elasticity | Country |
|---|---|
| 0.5 to 1.0 | Bangladesh |
| 0 to 0.5 | Pakistan, Congo, Zambia, Nepal, Burundi, Togo, Sierra Leone, Ghana, Malawi, India, Mali, Kenya, Central Africa, Benin, Senegal, Mauritania, Ethiopia, Barbados, Cameroon, Mozambique, Bolivia |
| –0.5 to 0 | Niger, Haiti, Zimbabwe, Rwanda, Uganda, Honduras, Peru, China, Guatemala, Nicaragua, Egypt, Sri Lanka, Indonesia, El Salvador, Ecuador, Syria, Paraguay, Philippines, Colombia, Romania, Brazil, Jamaica, Fiji, Dominica, Guiana, South Africa, Venezuela, Trinidad and Tobago |
| –1.0 to –0.5 | Iran, Costa Rica, Jordan, Tunisia, Mauritius, Panama, Uruguay, Argentine, Mexico, Chile, Thailand |
| –1.5 to –1.0 | Hungary, Cyprus, Greece, Portugal, New Zealand, Britain, Sweden, Ireland, Malaysia, Spain |
| –2.0 to –1.5 | Iceland, Finland, Korea, Israel, Japan, Italy, France, Denmark, Netherlands, Australia, Canada, Austria, Switzerland, Hong Kong, Belgium, USA, Singapore |

***Application of risk assessment and management to climate change issues***

This study focused on how we could apply risk assessment and risk management frameworks to climate change issues. In the existing literature, we looked at what benefits could be expected from such an application. The benefits were as follows: (i) we could address uncertain phenomena in the quantitative manner and demonstrate the explicit depiction of the size of the uncertainty; (ii) we could compare the results of climate change risk assessments with those of assessments of other risks, and devise an adaptation policy in the perspective of mainstreaming of adaptation to sustainable development ; (iii) we could consider mitigation and adaptation strategies comprehensively; and (iv) we could examine differences in response characteristics, including individual and regional differences, differences among the recipients of impacts, and occasions to actively understand them. Our investigation of adaptations aimed at reducing climate change risk indicated that this adaptation is an urgent task in terms of responding to impacts within Japan, supporting developing countries, and formulating its position for international negotiation. Research needs to be expanded urgently, both to investigate climate change policy in Japan and to take the initiative in discussions within an international framework.

**Environmental Planning Section**

We are conducting research into the development and assessment of regional plans and basic environmental plans for environmental conservation. In this research, we are investigating environmental indicators that can be used as regional environmental targets and against which we can monitor the progress of environmental policies. We are also developing new methods of understanding and assessing regional environments by using geographical information systems (GIS).

***Theory and effects of voluntary environmental actions by citizens and enterprises***

Since the establishment of the ISO 14001 environmental management system in 1996, Japanese facilities have led the world in numbers of certifications. This research utilizes survey data from more than 1700 Japanese facilities, as well as follow-up interviews, to identify the determinants of ISO certification; to examine differences between early and recent certificate holders and in-process applicants; and to investigate how ISO 14001 certification affects various environmental and managerial outcomes in Japan. Our findings show that ISO-certified facilities are larger and report greater environmental management capacity. In addition, early qualifiers are more likely to have established voluntary environmental agreements and are more active in international trade and business. Our findings also provide evidence that although many facilities believe that ISO 14001 certification is excessively costly, they also report that certification has resulted in the establishment of new energy efficiency and waste reduction targets and higher target levels. Nevertheless, evidence indicates that certification does not generally result in longer-term outcomes such as post-certification adjustment of non-regulated targets.

***Effect of urban thermal mitigation by heat circulation through Tokyo Bay***

To mitigate urban thermal conditions, we have formulated a new strategy that effectively uses the sea breezes flowing into the Tokyo Metropolitan Area from Tokyo Bay with efficiency, when the temperature goes above 30 °C on a typical summer's day. Tokyo Bay can develop high surface water temperatures in response to high daily levels of anthropogenic heat discharge. If cool breezes were to flow into the Tokyo Metropolitan Area from Tokyo Bay on a typical summer's day, when the temperature goes above 30 ºC, then it might be possible to mitigate urban heat make more smoothly. To decrease the bay surface temperatures and thus enhance the cooling effect of the sea breezes, we therefore need to introduce deep-ocean water (from 300 m below the surface) to the surface waters of Tokyo Bay when they are affected by these warm discharges. In numerical studies, we found that a 2-°C decrease in bay surface temperature would lead to a 1-°C cooling of central Tokyo and a 1 m/s enhancement of the bay breeze. We also demonstrated (1) a mechanism of heat exchange between the bay surface and the atmosphere; (2) a mechanism for keeping the bay surface cool after introduction of the deep-ocean water; (3) the advantage over with already well known counterac-

tions like rooftop vegetation and water retentive pavement, etc of the described strategy as determined by a cost analysis; and (4) strategies for minimizing the negative ecological impacts of this plan (Fig. 2).

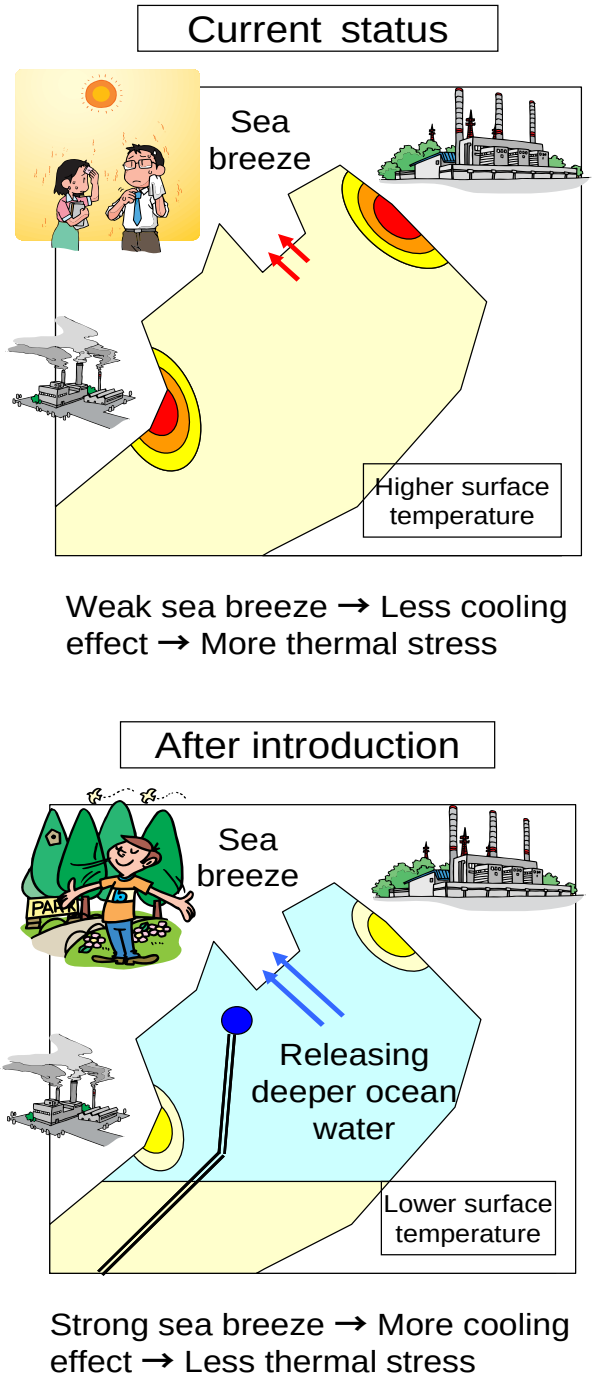



**Fig. 2** Introduction of deep-ocean water to Tokyo Bay from the Pacific Ocean: how to enhance the cooling effects of sea breezes.

***Study of Asian lifestyles and their relationship with environmental issues***

To promote environmentally conscious behavior, we investigated the factors promoting people's behavioral change in the Asian region. We evaluated an "en-

vironmental housekeeping book" and movies that dealt with environmental issues, and we examined the effectiveness of these items in changing people's actions.

**Integrated Assessment Section**

Integrated assessment" is a framework for linking the policymaking process with scientific knowledge from a wide range of disciplines. The core tool in integrated assessment is the integrated assessment model, which evaluates policy options for solving various environmental problems. We developed and modified the Asia–Pacific Integrated Model (AIM) to assess climate policy. The model takes into account the fact that in developing Asian countries, local environmental problems are more severe than global environmental issues such as climate change. We are expanding the AIM to include not only climate problems, but also other environmental issues related to sustainable development. The following four topics were our main activities in 2007:

(1) We have been developing the AIM/Impact [Policy] model to assess long-term climate policies, taking into account climate change impacts. Analysis of stabilization scenarios with the AIM/Impact [Policy] model revealed that when a low greenhouse gas (GHG) stabilization level is set, the GHG emission peak needs to be reached as soon as possible, and efforts should be made to reduce GHG emissions drastically by 2050.

(2) To develop long-term scenarios for climate change, we modified the multi-regional global computable general equilibrium model. In the modified model, to reflect perspectives in developing countries, we introduced sectors promoting human development, such as education. Moreover, not only $CO_2$ but also other gases related to global warming, such as $CH_4$, $N_2O$, CO, non-methane volatile organic compounds, and $SO_2$ are calculated by the modified model. This model is linked with the AIM/Impact [Policy] to reproduce global GHG emissions.

(3) We developed a computer program to estimate the changes in national water resources under climate change. Using a distributed global hydrological model, we ran 252 sets of simulations, with shifts in temperature from –5 to +15 °C and in precipitation from –75% to +200% compared with the current values, and developed a database of national water resources under climate change. The output of this scheme agrees well with that of the original detailed model, with an uncertainty of ± 20%.

(4) We developed an economic model for use in discussing the long-term environmental vision of Japan. This model covers GHG and air pollutant emissions and their reduction, material cycles, water demand, water pollution, and land-use change. We used the model to demonstrate the socioeconomic activity and environment in 2050 that would be realized if a sustainable society were to be achieved in Japan.

**Transportation and Urban Environment Section**

This section pursues studies related to transportation and urban environmental problems. We use our vehicle emission test facility and on-board emission meas-

urement devices to evaluate the environmental impacts of motor vehicles. We also formulate and evaluate environmental improvement scenarios in transportation and urban systems.

In FY 2007, we examined the environmental suitability of electric-powered city commuting vehicles and the latest diesel vehicles equipped with diesel particulate filters.

A GIS-based tool combined with our on-board measurement devices was developed to track the paths of emissions from vehicles and to precisely estimate the emission intensities on each section of a road through data aggregation.

As part of our analysis of eco-driving, we examined the factors contributing to improved fuel economy and their applicability within automotive engineering (Fig. 2). Eco-driving was effective for not only gasoline-fuelled passenger cars, but also a hybrid electric vehicles (HEVs) and battery– electric vehicles.

On the basis of real-world driving patterns—especially everyday ones—we quantitatively evaluated vehicular emissions and the effects of technologies aimed at improving fuel economy, and we proposed ways of using less energy for daily transportation.

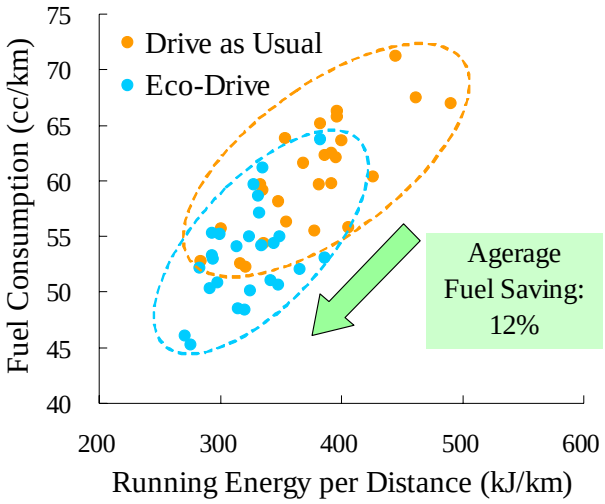



**Fig. 3** Running energy – fuel consumption relationship in an eco-drive trial run. The reduction in energy use resulted mainly from constant running below legal and advisory speed limits and explained the fuel saving.

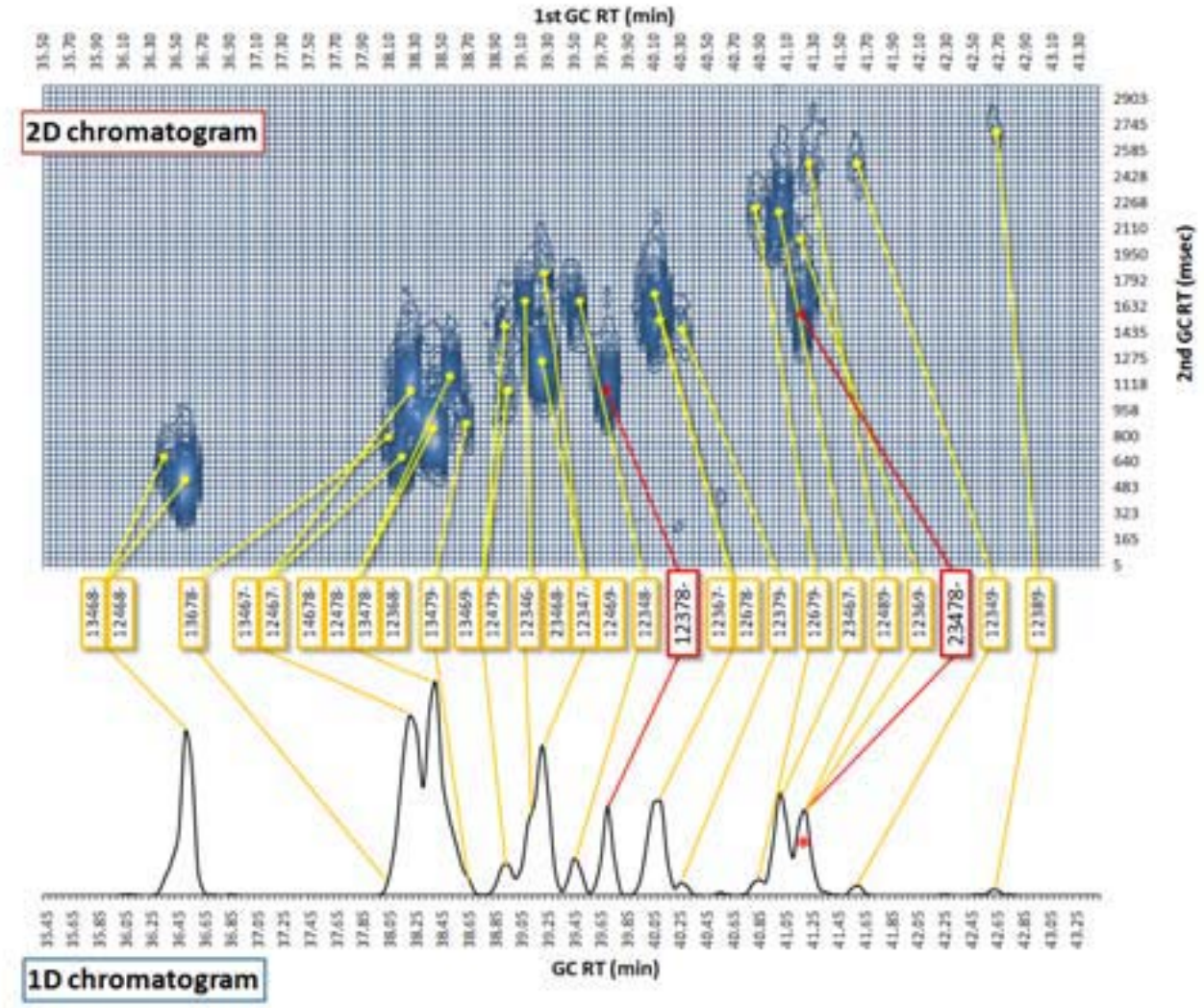
As part of the transport section scenarios of the Japan Low Carbon Society 2050 Project, we revised our environmentally sustainable transport (EST) scenarios for 2020, which are focused on the market penetration of HEVs. Outlines of EST 2050 scenarios and policy implications were addressed as part of a combination of countermeasures fitted to suit regional characteristics.

***Research on the "Eight Views"***

A type of landscape appreciation called the "Eight Views" was established in China in the 10th century during the Sung Dynasty. It spread to surrounding areas and subsequently affected landscape appreciation in East Asia. We published a report on the distribution of the Eight Views in Japan and summarized recent research in this area in China, Korea, and Japan. For the publication, we chose 91

good examples of the Eight Views by taking votes from volunteers at our institutes and at Chiba University. We are delivering the report to local government, specialists in landscape appreciation, universities, and researchers abroad in order to gather more information about the Eight Views. Investigation of the Eight Views in the countries neighboring China, including Vietnam, Thailand, Myanmar, Nepal, India, Russia, Kazakhstan, Kyrgyzstan, Tajikistan and South East Asia, will provide valuable information on the effective sphere of Chinese culture.

# Environmental Chemistry Division




Pentachlorodibenzofuran (PeCDF) isomers on 2D and 1D chromatograms at *m/z* 339.8597, as measured by multidimensional gas chromatography – high-resolution time-of-flight mass spectrometry (GC×GC/HR-TOFMS).

A toxic dioxin isomer, 2,3,4,7,8-PeCDF, was isolated from 1,2,4,8,9- 1,2,3,6,9-PeCDFs on the 2D chromatogram but not on the 1D chromatogram, which is usually result of conventional GC; the peak of interest is marked by an asterisk. See text for more details.

The Environmental Chemistry Division has been working on the development of various methods for the analysis of organic chemicals and elements or isotopes; the monitoring of their environmental and biological fates and behaviors; and the analysis of biological responses to pollutant exposure. Various kinds of topics have been studied: global environmental change; the presence and transport of elements or chemicals on global, regional, and local scales; long-term environmental monitoring and specimen banking; the identification and apportionment of major sources of pollutants; the development of new analytical methods such as nanoparticle analyses and magnetic resonance imaging (MRI) of the central nervous system; behavioral and biochemical responses to chemicals; and scientific and technical support against various environmental issues (e.g., implementation of the Stockholm Convention; groundwater pollution by organoarsenic compounds).

The **Advanced Organic Analysis Section** has developed methods for analyzing organic pollutants such as persistent organic pollutants (POPs) in the environment, and is investigating their application to environmental monitoring. Special research, entitled "Development of analytical methods using multi-dimensional separation for POPs", has been performed. Its aim is to develop revolutionary new methods for analyzing POPs in environmental samples by using comprehensive multidimensional gas chromatography (GC×GC) – high-resolution time-of-flight mass spectrometry (HR-TOFMS) as a key technology. Polychlorinated dibenzo-*p*-dioxins (PCDDs) and -dibenzofurans (PCDFs) in crude extracts of fly ash and flue gas from municipal waste incinerators were quantified by direct injection into the GC×GC/HR-TOFMS system; this effectively reduced interference from concomitants and enabled us to isolate all congeners with tetrachlorodibenzo-*p*-dioxin (TCDD) toxic equivalency factors from the other isomers with only one injection (see Figure on the Division's cover page). The instrumental limit of detection of TCDD by GC×GC/HR-TOFMS was 0.9 pg. The analytical results agreed well with the values obtained by using a generic high-resolution gas chromatography / high-resolution mass spectrometry (HR-GC/HR-MS) system. We have used the new method to analyze thousands of polychlorinated biphenyl (PCB) metabolites. We are also attempting the rapid analysis of POPs such as hexachlorobenzene, hexachlorocyclohexane, chlordane, and PCBs in the air by using a thermal desorption (TD) unit combined with the GC×GC/HR-TOFMS system. Moreover, we used TD-GC×GC/HR-TOFMS in the quantitative analysis of polycyclic aromatic hydrocarbons (PAHs) in atmospheric particles. The PAH values determined by TD-GC×GC/HR-TOFMS agreed reasonably well with the values determined by the conventional method.
The introduction of a TD unit, a GC inlet, a small double-focusing MS unit, and a selected ion monitoring method greatly improved the sensitivity of the analysis of atmospheric particulate matter, especially in the nanometer range. The quantification limits were 4–17 pg for 12 PAHs, 13 pg for 17α(H),21β(H)-hopane, and 13–39 pg for $C_{18}$–$C_{36}$ n-alkanes. TD-GC/MS was applied to size-resolved particles in diesel exhaust, at the roadside, and in background air to determine the ori-

gin and environmental behavior of nanoparticles and to assess the performance of a newly developed laser ionization TOFMS system. This was part of a study entitled "Development of simultaneous detection methods of chemical compounds and compositions in nanoparticles". We also searched for sources of perfluorooctane sulfonate (PFOS) emissions in the upper basin of the Tama River, and we identified a factory releasing wastewater containing PFOS at 50 000 ng/L. Several investigations were performed as part of the "Study on environmental monitoring methods and quality control in environmental monitoring. 2: Quality control in measurement of PCDDs/PCDFs and related compounds". Samples of water, algae, aquatic insects, and fish were collected from several rivers, and their PCDD/PCDF contents were determined by HR-GC/HR-MS. The origins of the PCDDs/PCDFs were estimated from the concentrations of these compounds and from the congener profiles in each sample.

The **Advanced Inorganic Analysis Section** has been measuring precisely the stable-isotopic abundance of elements by multi-collector inductively coupled plasma mass spectrometry (MC-ICPMS). Twelve environmental certified reference materials (CRMs) issued by NIES were analyzed for precise determination of their Pb isotope ratios (Fig. 1). After separation of the lead from acid digests by chelate or anion exchange resins, four stable lead isotopes were measured by MC-ICPMS. A typical concentration of lead in the final test solution was 20 ng/g. The precision (2 SD) of the isotope analysis was 0.09% for $^{206}Pb/^{204}Pb$ and 0.02% for $^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$.

Elemental concentrations in house dust samples collected from 10 households were measured by ICP atomic emission spectrometry and ICPMS to obtain general information on the elemental composition of house dust in Japan and to gain an insight into the source of Pb in this dust. Ca, Al, and Fe were the major elements in the dust, followed by alkali and alkaline-earth elements. The enrichment of Cd, Cu, Pb, S, and Zn relative to their crustal abundance indicated anthropogenic pollution of house dust with these metals. Factor analysis revealed a large loading of Pb, together with Ba, Cr, S, and Ti, indicating that the Pb in the house dust came from paint.

The accelerator mass spectrometry (AMS) facility, NIES-TERRA, conducted about 1400 radiocarbon measurements this fiscal year, including analyses of fossil carbonate and organic carbon in marine sediments, airborne particles, ancient tree rings, atmospheric carbon dioxide, marine dissolved inorganic carbon, and lake water dissolved organic carbon. Radiocarbon of acetaldehyde and formaldehyde in indoor air was also measured for the source apportionment of "sick-house" pollutants. The AMS facility has been updated to generate more stable and higher acceleration voltages for more sensitive analysis. Microscale radiocarbon measurement has made it possible to investigate the carbon cycle in past environments by using compounds of marine and terrestrial origin.

We have started a new project aimed at developing a super-high-density capacitor based on high-energy-density interfaces. We have investigated new solid-state electrolyte materials with high voltage tolerance with the aim of increasing

charging voltage, which will increase stored energy density. Our approach is to develop electrolyte materials superior to the present organic-liquid ones through the advanced processing of nano-hybrid solid-state ionics materials. We prepared nanocrystalline yttrium-stabilized $ZrO_2$, which has a large surface area and increased defect densities, and studied its structure and conducting properties.

We have also been investigating the application of surface analytical and elemental mapping methods (e.g. X-ray fluorescence analysis [XRF], secondary ion mass spectrometry [SIMS], X-ray photoelectron spectroscopy [XPS]) to environmental and geological samples.

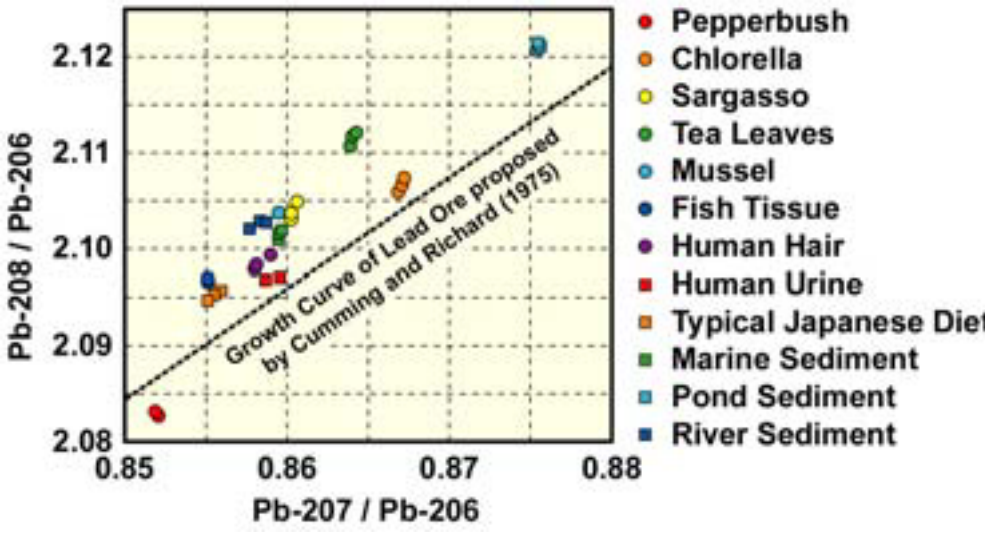



**Fig. 1** $^{207}Pb/^{206}Pb$, and $^{208}Pb/^{206}Pb$ isotope ratios of environmental certified reference materials. (Growth curve of lead ore: G. L. Cumming and J. R. Richards, *Earth Planet Sci. Lett.*, **28**, 155 [1975])

The **Environmental Chemodynamics Section** has been investigating the chemodynamics of natural and anthropogenic volatile organic compounds (VOCs), as well as carbon cycles in the ocean.

(1) *In situ* high-frequency monitoring of halocarbons at Hateruma Island and Cape Ochi-ishi has been done as a part of "An observational study for the halogenated greenhouse gas inventory of East Asia". The baseline concentrations of some hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs) showed a continuous rapid annual increase with significant seasonal variations and occasional short-term enhancements. Concentrations of HFC-134a and HFC-152a at Hateruma Island in the period 2004–2008 are shown in Figure 2. (2) A new system for the quantification of VOCs in seawater has been developed as a part of the SOLAS (Surface Ocean – Lower Atmosphere Study) project. The system is based on a silicone membrane tube equilibrator combined with an *in situ* preconcentration GC-MS system. It successfully measured hourly halocarbon fluxes from the subarctic region of the northwest Pacific Ocean. (3) We have also been studying the terrestrial emission of halocarbons. We measured stable carbon isotope ratios of methyl chloride ($CH_3Cl$) in foliar emissions from 14 species of tropical plants growing in a glasshouse. From the measured isotope signature of $CH_3Cl$ (–83.2‰ ± 15.2‰) emitted from tropical plants and from previously reported isotopic data on other $CH_3Cl$ sources, we estimated global $CH_3Cl$ emis-

sions by tropical plants to total approximately 1500–3000 Gg year$^{-1}$, which could account for 30% to 50% of global emissions. Measurements of $CH_3Cl$ above a tropical rain forest in Peninsular Malaysia suggested an upward flux of $CH_3Cl$ of ~20 σg m$^{-2}$ h$^{-1}$ from the forest. (4) A study of the dynamics of organic carbon transported to the ocean through rivers was continued by taking carbon isotope measurements of riverine particulate and dissolved matter. The results suggested that carbon isotopes of particulate organic carbon are useful tools for tracing sources and behavior. (5) A joint study with the Japan Atomic Energy Agency, entitled "Measurement of radiocarbon and its application to study on carbon cycle in the ocean", was continued. Spatial variations in radiocarbon and particulate matter in the Japan Sea were investigated to study changes in deep-sea circulation in response to global warming.

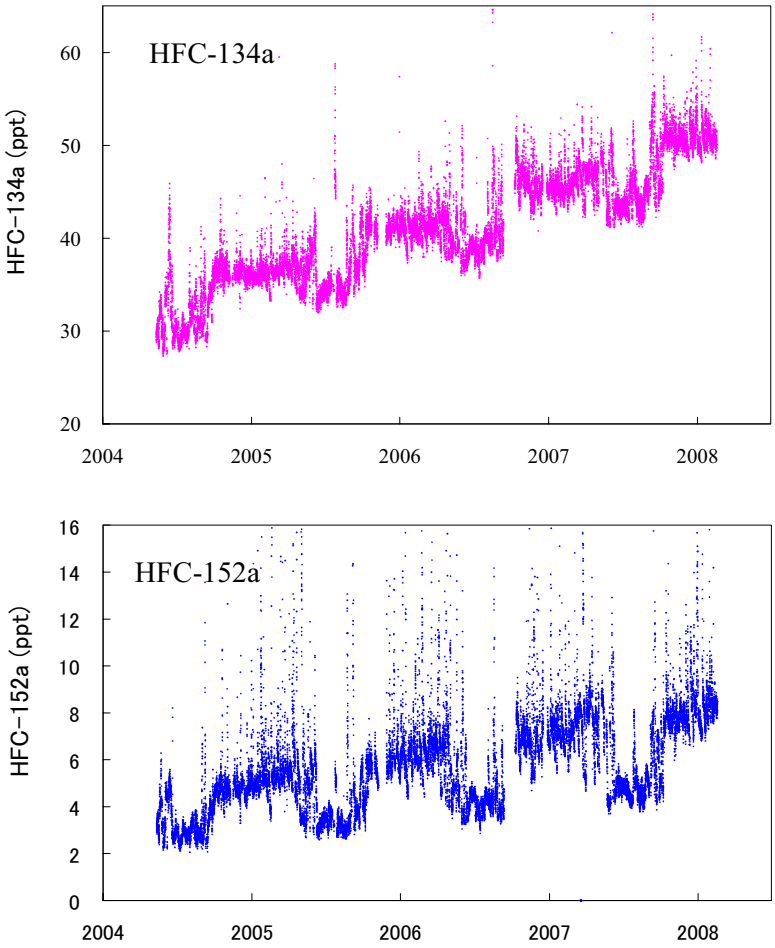



**Fig. 2** HFC-134a and HFC-152a measured at Hateruma Island (May 2004 – February 2008)

The **Biological Imaging and Analysis Section** has been developing methods and instruments for detecting and analyzing the *in vivo* responses of biological systems to various environmental factors. The long-term objective of this section is to establish methods for monitoring human health and ecosystem soundness in noninvasive and nondestructive ways.

We focused our efforts on quantitative analyses of the human brain *in vivo* by us-

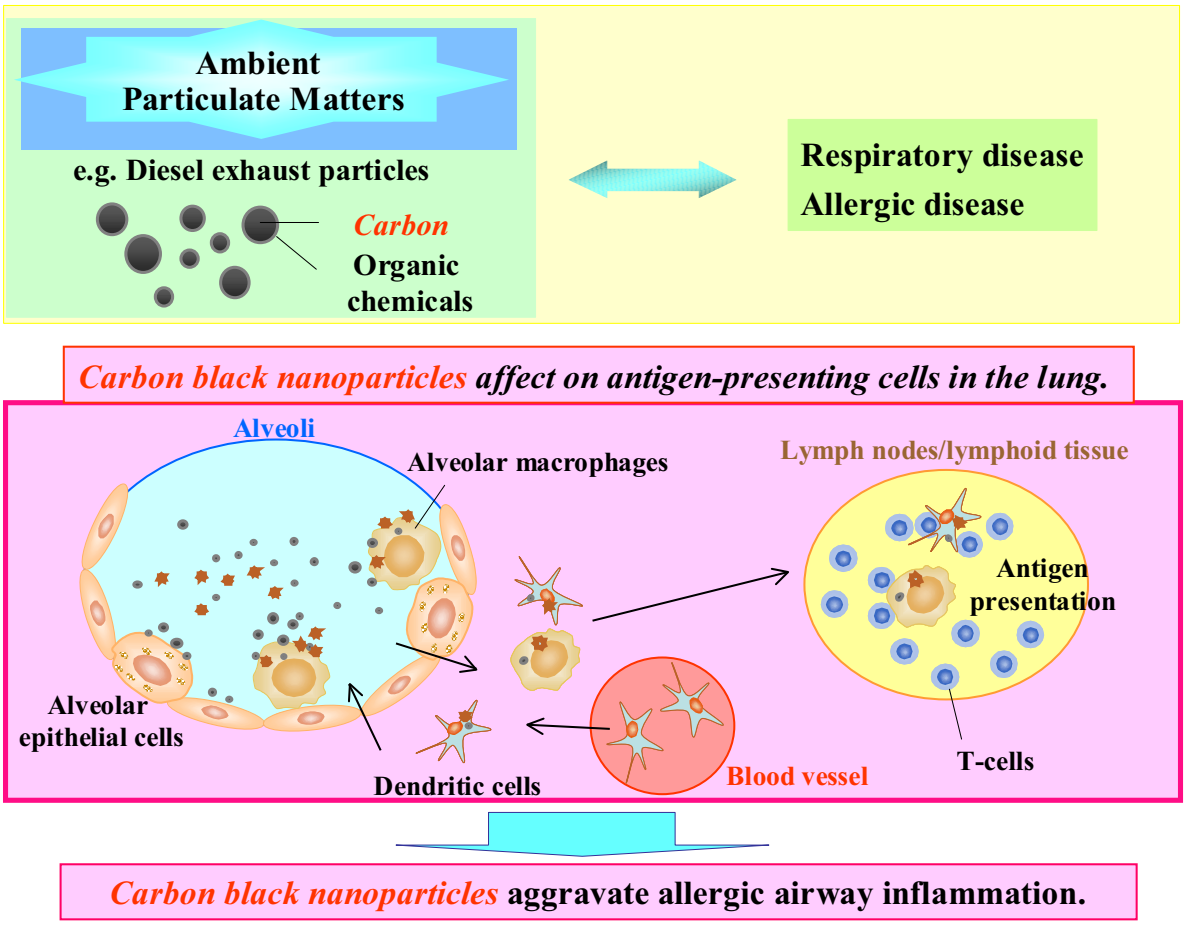
ing a 4.7-T high-field magnetic resonance imaging (MRI) spectrometer. We developed a method to accurately obtain the $T_2$ relaxation time of tissue water in the human brain. We found that the transverse relaxation rate ($1/T_2$) varied linearly with the tissue iron concentration ([Fe]), with a linear regression coefficient of 0.97. The linear coefficient relating $1/T_2$ and the regional [Fe] was 0.551 (s·mg Fe/100 g fresh wt.)$^{-1}$ at 4.7 T. These findings are consistent with the superparamagnetism shown by ferritin, an iron storage molecule in biological systems. Iron is an element essential to mammalian cells, but excess causes various kinds of diseases through the production of reactive oxygen species (ROS). Our findings could open a door to the evaluation of brain regional [Fe] and thus the risks posed by ROS *in vivo*.

We also developed a two-dimensional constant-time PRESS method with good spectral resolution for the observation of $\gamma$-aminobutyric acid, an inhibitory neurotransmitter with higher sensitivity than in the constant-time COSY spectra.

For our study of the health effects of diphenylarsenic acid (DPAA), we established a technique of liquid chromatography–tandem MS (LC/MS/MS) with nano-flow LC to analyze DPAA in microsamples. We then coupled this technique with a microdialysis method for examining the toxicokinetics of DPAA in the brains of living animals. Use of this method revealed that the DPAA level in the living mouse brain increased immediately after oral administration, peaking 2 h after administration and then rapidly decreasing. We also examined the effects of perinatal exposure to DPAA on brain function in mice. DPAA did not affect recognition ability, as evaluated by a novel-object recognition test, or short-term memory, as evaluated by spontaneous path alterations in a Y maze. DPAA exposure affected the emotional state, as measured by a marble-burying test, and caused hyperactivity in the Y maze test. The effects of prenatal DPAA exposure were observed for up to 13 months after birth, but DPAA did not affect brain size in mice.

For the maintenance of ecosystems we need to isolate microorganisms that effectively degrade various kinds of chemical pollutants in water and soil environments. We have been developing a microdevice for rapid isolation and evaluation of those microbial cells. An electrochemical microsensor made from a patterned Pt electrode was fabricated in a microchamber in the microdevice to measure the respiration and enzymatic activity of various microbial cells. We succeeded in measuring the activity of a single yeast cell. Moreover, we fabricated a microscale lid above the opening of the microchamber to improve the device's sensitivity in measuring the oxygen and metabolic product contents of microbial cells. The lid, made of PDMS polymer, is closed by applying gas or water pressure after a microbial cell is loaded into the microchamber by electrophoresis. The lid is coated with Parylene to inhibit the diffusion of oxygen into the PDMS. To optimize the design, we performed numerical simulations of diffusion and electrochemical reactions in the microdevice.

# Environmental Health Sciences Division




Ambient particulate matter derived from combustion products, which is associated experimentally and epidemiologically with aggravation of allergic and respiratory diseases, usually consists of a carbon core and organic chemicals. The diameter of the carbon core in the environment is becoming smaller and smaller possibly due to developled technology for mobile engenes. Carbon nanoparticles can increase/augment infiltrated number/activation of antigen-presenting cells in the lung, implicating these effects in the aggravation of allergic airway diseases.

The mission of the Environmental Health Sciences Division is to study the possible effects of environmental chemicals (e.g., dioxins, arsenite, phthalate plasticizers, metals, air pollutants) and physical agents (e.g., heat stress, UV radiation) on human health. We aim to use the information as a scientific basis for the risk assessment of these agents, alone or in combination. We perform both epidemiological and experimental studies. In the latter, we use laboratory animals as experimental models, and we use organs and cells to elucidate the mechanisms underlying toxicity. In particular, we are interested in hypersensitive populations that are susceptible to the harmful effects of environmental stress—especially subjects with allergic or immunological disorders. Below, we highlight our progress in several study areas.

The **Director** researched the effects of environmental chemicals on several cardinal features of allergic diseases and clarified the mechanisms of action of these chemicals *in vivo* and *in vitro*. He has demonstrated that systemic exposure to some kinds of environmental chemicals can enhance atopic-dermatitis–like skin lesions, possibly via the activation of immune cells such as antigen-presenting cells and lymphocytes. Furthermore, he examined the effects of nanosized particles and materials on health—especially of the respiratory, cardiovascular, and immunological systems—and on the skin.

In the **Molecular and Cellular Toxicology Section** we have been studying how a variety of environmental pollutants affect biological and physiological functions. We have been focusing on transcriptional changes and epigenetic effects, such as DNA methylation and modification of histones.

Recent studies reported that exposure of pregnant mice to inorganic arsenic from gestational day (GD) 10 through GD18 increased the incidence of liver tumors in the male pups when the pups reached age 18 months, and that DNA methylation modification at the estrogen receptor (ER) α promoter is involved in the development of these tumors. We started breeding and exposure experiments to double check these results and to further extend observations on the epigenetic effects of inorganic arsenic. We established optimum conditions for bisulfate sequencing to measure DNA methylation of specific genes and for HPLC analyses of 5-methylcytosine to measure global DNA methylation. Our investigations showed that the DNA methylation status of ERα did not differ between the control and exposed groups in GD18 fetuses and 4-month-old pups. We will continue our examination of the pups until they reach age 18 months.

In contrast, our studies of male mice given water containing 50 ppm arsenic for 6 months showed, in the liver, a change in the expression of a tumor suppressor gene that is reported to be regulated by DNA methylation in many cell types. Further studies of the mechanism of this expression change are under way.

We also investigated how short-term exposure to inorganic arsenic suppresses lymphoid cells. The results suggested the involvement of pocket proteins. We developed prototype microarrays to detect the toxic effects of environmental chemicals on the immune and respiratory systems. Further studies to accumulate

data on changes in gene expression with these arrays and continuous efforts to improve the arrays will be pivotal to the establishment of methods to assess the toxic effects of environmental chemicals.

We investigated the role of the transcription factor arylhydrocarbon receptor (AhR) in the T cells of transgenic (Tg) mice in mediating the immunotoxicity of dioxin. Tg mice express a constitutively active mutant of AhR (CA-AhR) specifically in T-lineage cells. Exposure of the mice to dioxin, which activates AhR in a number of types of cells, suppresses Th2 cytokine and antibody production and increases interferon (IFN)-γ production. The results of our studies in the Tg mice indicated that AhR activation in the T cells alone increased IFN-γ production. However, suppression of Th2-cytokine and antibody production were not efficiently induced by AhR activation in the T cells alone, suggesting that AhR activation in other cell types was also needed.

In the **Biological Risk Assessment Section**, we investigate how environmental pollutants facilitate immune responses. *In vivo*, we are examining the effects of environmental chemicals, nanoparticles and nanomaterials on pathological conditions such as allergic disorders and inflammatory lung damage in view of hypersensitivity to these materials. *In vitro*, we are elucidating the impacts of these materials on the maturation, activation, proliferation, and survival of immune cells, including antigen-presenting cells, lymphocytes, mast cells, and polymorphonuclear cells. In 2007, we obtained some interesting data and partly reported them in English, as follows:

1) Maternal exposure to di-(2-ethylhexyl)phthalate (DEHP) during neonatal periods in mice can accelerate atopic dermatitis–like skin lesions related to mite allergens in male offspring, possibly via a Th2-dominant response (Figs. 1, 2).

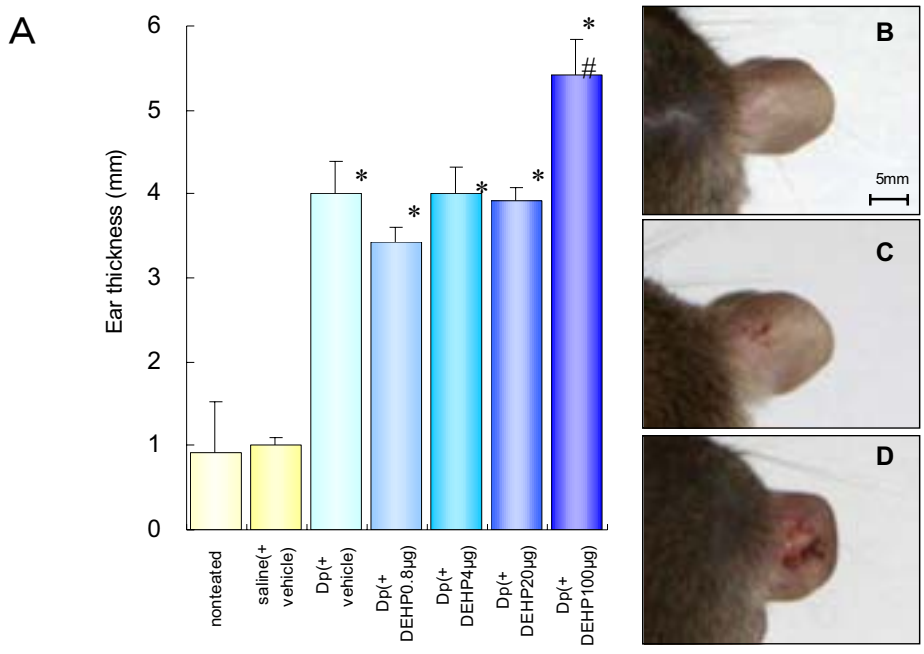



**Fig. 1** Maternal exposure to di-(2-ethylhexyl) phthalate (DEHP) during neonatal periods enhanced the severity of atopic dermatitis–like skin lesions in offspring. We measured ear thickness (A) and show the macroscopic features (B–D): (B) Saline (+ vehicle) group; (C): *Dermatophagoides pteronyssinus* (Dp) (+ vehicle) group; (D): Dp (+ DEHP 100 μg / week per mouse) group. * $P < 0.01$, Dp treated groups vs. untreated group and saline (+ vehicle) group; # $P < 0.01$, Dp (+ DEHP 100 μg / week per mouse) group vs. Dp (+ vehicle) group.

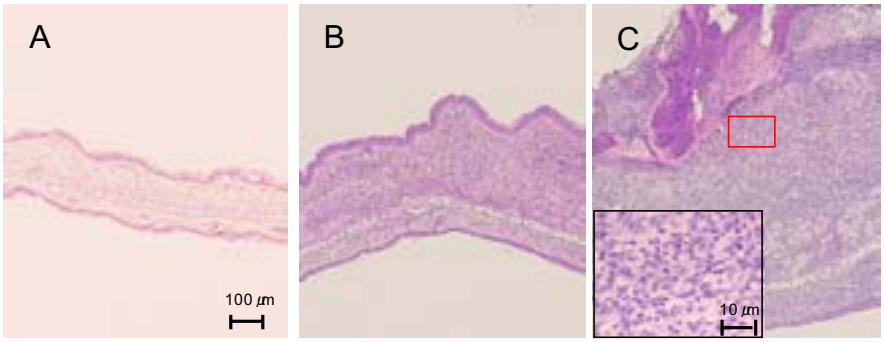



**Fig. 2** Histological changes in the ear. Infiltration of eosinophils was morphometrically evaluated using hematoxylin–eosin staining. Maternal exposure to DEHP during neonatal periods enhanced inflammation in Dp-related atopic dermatitis–like skin lesions in offspring. (A) Saline (+ vehicle) group; (B) Dp (+ vehicle group); (C) Dp (+ DEHP 100 μg / week per mouse) group.

2) Naphthoquinone, a chemical compound present in diesel exhaust particles, can aggravate allergic airway responsiveness *in vivo*.
3) Pulmonary exposure to several nanomaterials (including latex and $TiO_2$) exacerbates septic acute lung injury and subsequent systemic inflammation with coagulatory disturbance in mice.
4) Pulmonary exposure to carbon black nanoparticles can increase the number of antigen-presenting cells in the mouse lung, especially in the presence of antigen (Fig. 3).

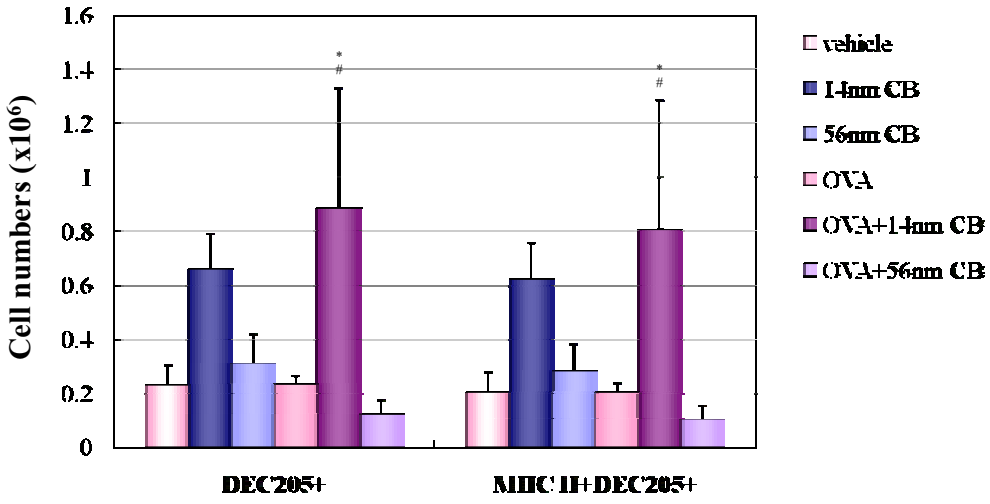



**Fig. 3** Pulmonary exposure to carbon black (CB) nanoparticles increased the number of dendritic cells in the lung, especially in the presence of antigen (ovalbumin: OVA). Six groups of mice were intratracheally given vehicle, OVA, CB nanoparticles, or OVA + CB nanoparticles for 6 weeks. Lung cells were prepared 4 h after the last intratracheal instillation. Expression of major histocompatibility complex (MHC) class II and dendritic and epithelial cells, 205 kDa (DEC205) as a marker of dendritic cells was analyzed by flow cytometry. Values are presented as means ± SEM of four animals.
*$P < 0.05$ vs. vehicle group; # $P < 0.05$ vs. OVA group.

5) Inhalation exposure to diesel engine–derived nanoparticles enhances acute lung injury related to bacterial endotoxin through the amplified production or release of chemotactic factors for inflammatory leukocytes in the lung.
6) A cell culture system for dendritic cell maturation, differentiation, and activation, derived from mouse peripheral blood mononuclear cells, has been established.
7) Carbon nanoparticles can promote the maturation and function of bone-marrow–derived dendritic cells *in vitro*.
8) Phthalate esters can promote functional maturation of bone marrow–derived dendritic cells, the proliferation of splenocytes, and IL-4 production/release *in vitro*.

The **Integrated Health Risk Assessment Section** conducted epidemiological and experimental research with the financial support of the Ministry of the Environment (MOE), the Global Environmental Research Foundation (GERF), and the New Energy and Industrial Technology Development Organization (NEDO). One study assessed the future health impacts related to heat and air pollution under global warming. We projected risk maps of air-pollution–related mortality in the Kanto, Chubu, Kansai, and Kyushu districts. Another assessed the development of novel culture substrata for tissue and embryonic stem cells that grow and differentiate on basement membrane (BM) *in vivo*. We focused on BM formation by several kinds of animal and human epithelial cells *in vitro*, and on processing the BM extracellular matrices to culture substrata by removing only the covering epithelial cells without impairing the newly formed lamina densa *de novo* underneath. On the novel substrata, airway epithelial basal cells could be induced to terminally differentiate into ciliated cells as *in vivo*.

We also conducted field research with personal particulate matter (PM) monitors, personal $PM_{2.5}$ samplers, and handheld condensation particle counters to assess roadside exposure to fine and ultrafine PM near congested trunk roads in Tokyo. We confirmed brief but high-concentration exposure of pedestrians walking by the roadside. We also continued an assessment of exposure to air pollutants, in particular $PM_{2.5}$ and polycyclic aromatic hydrocarbons, in the cities of Shenyang and Shanghai, China.

We established a monitoring system by which patients with heat-related disorders were monitored by an emergency transportation network covering 18 major cities in Japan. Using the data obtained, we created a system to provide the newest information regarding the heat-disorder patients occurred from the home page. We also engaged in research conducted by MOE on short-term morbidity and mortality and an epidemiological study of traffic-related air pollution exposure and respiratory health; the latter study was launched by MOE with the cooperation of the Environmental Epidemiology Section.

The **Environmental Epidemiology Section** has been engaged in research on the health effects of environmental exposure. Our current focus is the development of epidemiological methods and their application to studies that assess the health impacts of air pollutants. As members of a working group established by MOE, we contributed to the design of a set of epidemiological studies and to detailed investigations of the health effects of both short-term and long-term exposure to fine particulate matter ($PM_{2.5}$). Among our findings were the following:

1) In analyses of vital statistics from 20 Japanese areas (both urban and non-urban), we found a positive association between concentration of $PM_{2.5}$ and mortality, especially mortality due to respiratory disease; and variability among areas (Fig. 4).
2) A study investigating acute effects on lung function in children with asthma revealed that an increase in the concentration of $PM_{2.5}$ in the evening was associated with a decrease in peak expiratory flow at night on the same day and

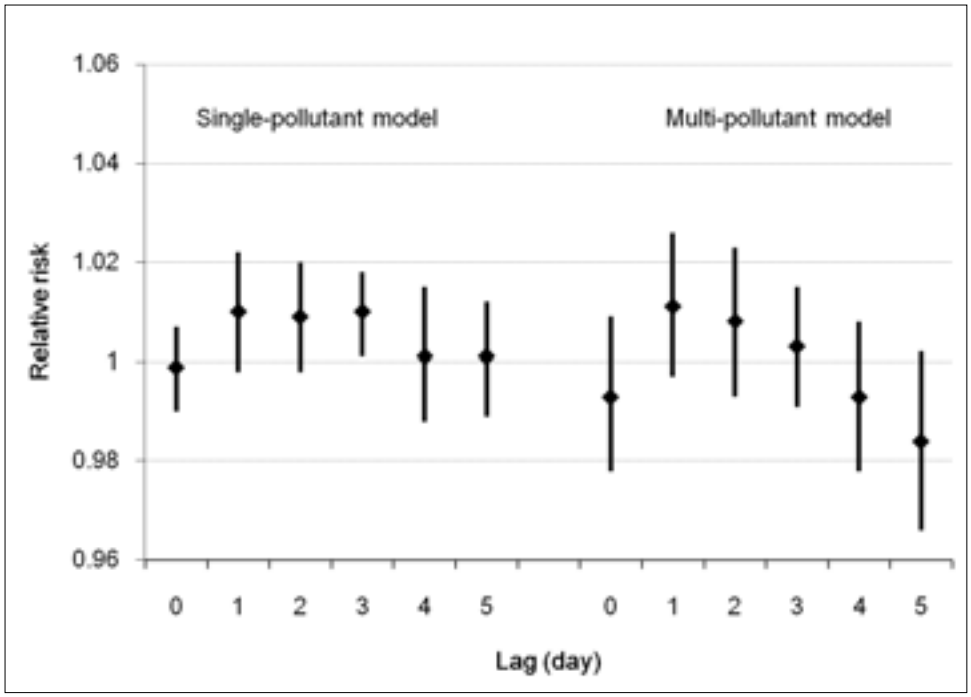



**Fig. 4** Meta-analysis summary estimates of relative risk of respiratory mortality per 10 $\mu g/m^3$ increase in $PM_{2.5}$ on each lag day in 20 Japanese areas. The single-pollutant model was adjusted for ambient temperature and relative humidity. The multi-pollutant model was additionally adjusted for nitrogen dioxide and ozone.

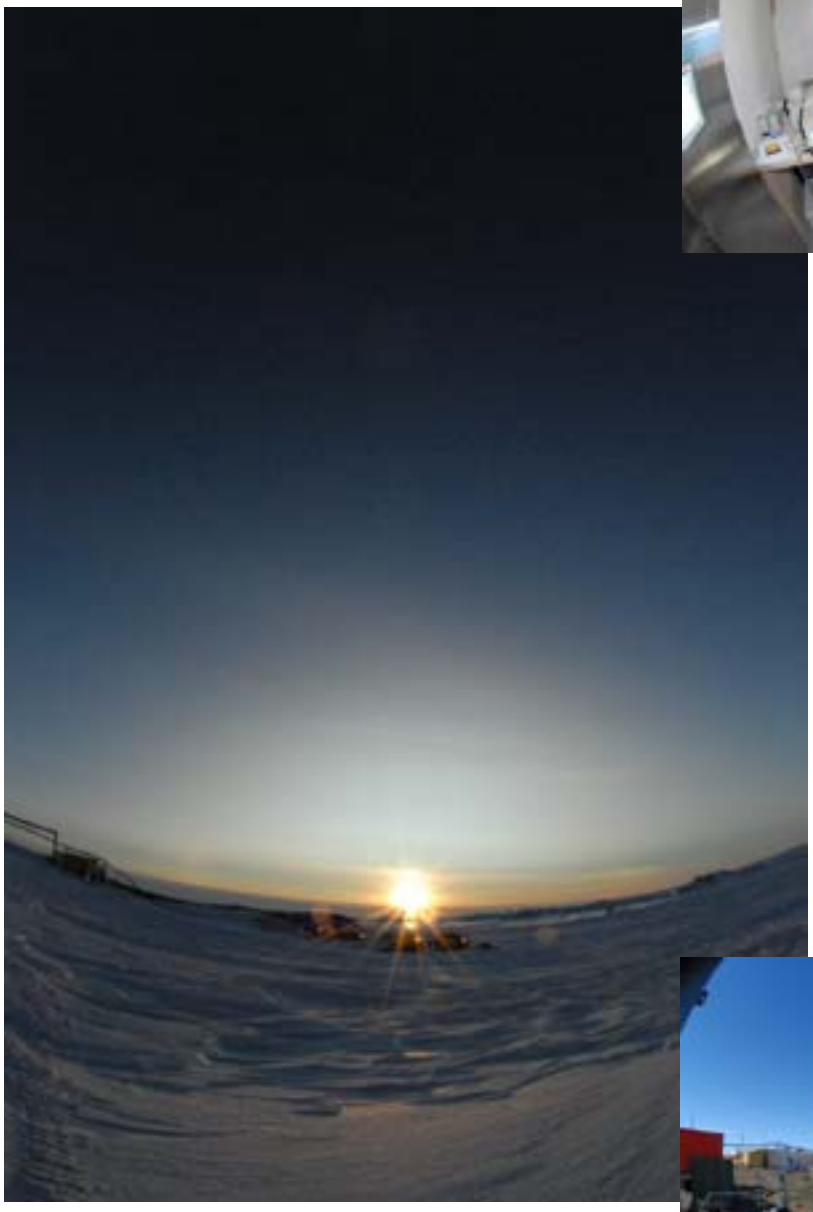
in the morning of the next day.

3) A cohort study following children and their parents for 5 years suggested that air pollutants increase the risk of persistent cough and sputum production in the parents but not in the children.
4) We found no significant associations between $PM_{2.5}$ concentrations and the incidence of emergency visits due to asthma attack.
5) In a preliminary study we found no significant association between $PM_{2.5}$ exposure and the occurrence of ventricular arrhythmias in patients with implantable cardioverter-defibrillators.

We have been engaged in another epidemiological study since 2005. The "Study on respiratory disease and automobile exhaust" (the SORA project), was organized by MOE in 2005 to study the adverse effects of traffic-related air pollution on respiratory health. The project consists of three studies: (1) a cohort study of 16 000 schoolchildren, with a questionnaire for each year and blood sampling (for measurements of serum total IgE, mite-specific IgE, and Japanese cedar pollen–specific IgE) at baseline; (2) a questionnaire about infant health in nine metropolitan areas; and (3) a study of adults that involves a questionnaire, blood sampling, and lung function test. By using information on traffic volumes, vehicle emission rates, meteorological conditions, types of road construction, and distance to roadways, we developed a model to estimate each participant's level of exposure to traffic air pollutants (elemental carbon and nitrogen oxides). We will perform further analyses by using the data obtained these studies.

# Atmospheric Environment Division

Taking Fourier-transform infrared measurements of the Antarctic stratosphere



Antarctic spring.
An ozone hole is developing in the stratosphere

Taking ozone sonde measurments

The aim of the Division's research is to understand and solve atmospheric environmental problems ranging from urban air pollution to global and trans-boundary issues. The Division consists of four sections: the Atmospheric Physics Section, which conducts research on numerical modeling and data analysis of atmospheric dynamics and climate systems; the Atmospheric Chemistry Section, which conducts research on trans-boundary air pollutants and chemical processes taking place in the atmosphere; the Atmospheric Remote Sensing Section, which studies the atmospheric environment by using remote sensing techniques such as LIDAR (laser radar); and the Atmospheric Measurement Section, which conducts field research on natural and anthropogenic trace species. Observation of ozone-depleting species and the polar stratospheric cloud over Antarctica is being tackled independently as an activity of the current Antarctic expedition team. Many of the members of this Division also work for Priority Research Programs such as the Climate Change and Asian Environment programs.
Following are brief accounts of some of the important results of our research in FY 2007.

**Impact of carbonaceous aerosols on observationally constrained warming attributable to anthropogenic greenhouse gases**

It is well known that carbonaceous aerosols affect the Earth's climate, and some climate modeling centers have started to include their climatic impacts in transient climate change experiments simulated by atmosphere–ocean general circulation models (AOGCMs). In this study, we performed a series of transient climate change experiments with and without the effects of carbonaceous aerosols by an AOGCM called the Model for Interdisciplinary Research on Climate (MIROC), and we investigated the impacts of historical changes in carbonaceous aerosol levels on past warming attributable to increases in atmospheric concentrations of greenhouse gases. Observationally constrained warming in the 20th century as determined by MIROC is similar to that estimated by using the other AOGCMs if, as in these models, historical changes in carbonaceous aerosol concentrations are not considered. However, when we do consider these historical changes, observationally constrained warming increases, and the uncertainty ranges in anthropogenic signals become larger. This finding implies that other processes (e.g., the carbon cycle, atmospheric chemistry, dynamic vegetation changes) that have not been introduced in the AOGCMs might also have significant impacts on past attributable warming.

**Temporary denitrification in the Antarctic stratosphere, as observed by ILAS-II in June 2003**

Polar stratospheric clouds (PSCs) are formed in winter polar vortices and play a crucial role in determining rates of heterogeneous chemical reactions. To examine the time scale of temporary denitrification due to the PSC particles and the characteristics of PSCs in the Antarctic, we analyzed short-time (≤5 days) changes in gaseous nitric acid ($HNO_3$) concentration and the aerosol extinction coefficient (AEC) at a wavelength of 780 nm, focusing on the near-20 km altitude, as ob-

served by the Improved Limb Atmospheric Spectrometer (ILAS)-II in June 2003. The so-called Match technique, which is based on the air parcel trajectory, was applied to the ILAS-II data. Several Match pairs revealed decreased $HNO_3$ values with increased AEC values within short times, indicating "temporary" denitrification (Fig. 1). The observed PSCs could be nitric acid trihydrate (NAT) particles, as the temperatures were above those necessary for the existence of supercooled ternary solutions but below those for NAT. Given the appropriate size distributions of NAT particles, the median radius of the particles was less than 3 μm.

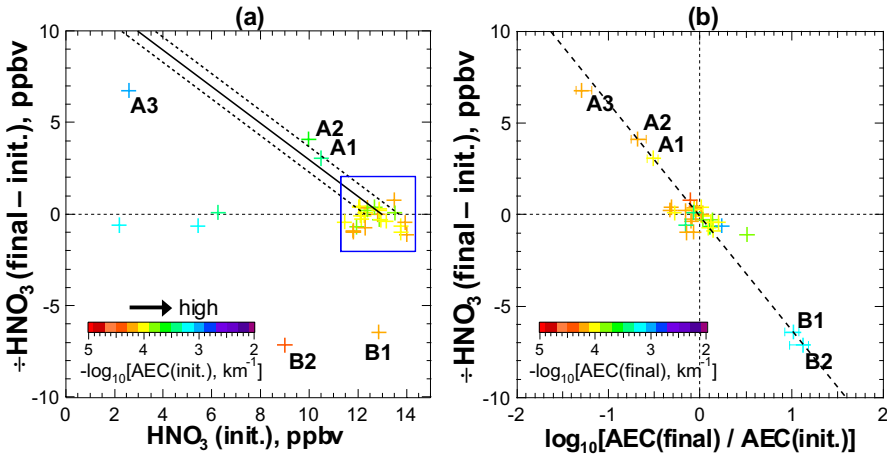



**Fig. 1** Difference in $HNO_3$ values at the initial and final times as a function of $HNO_3$ values at the initial time, (a), and as a function of a ratio of aerosol extinction coefficient (AEC) values at the final and initial times, (b). Data points are color coded by $-\log_{10}$[AEC] value (e.g., $10^{-4}$ $km^{-1}$ = 4) at the initial time, (a), and at the final time, (b). Results for June 2003 at 20 km are shown.

**An algorithm that retrieves aerosol properties from dual-wavelength polarization LIDAR measurements**

A LIDAR network used to trace the movement of Asian dust is operated in collaboration with research institutes and universities in China, Korea, Mongolia, and Japan. Asian dust and anthropogenic aerosols were differentiated by a data analysis method based on differences in the polarization properties of non-spherical (mineral dust) and spherical aerosols (mostly air-pollution aerosols).

To expand aerosol LIDAR measurements into maritime environments, we developed a new data analysis method from three-channel LIDAR measurements. The new method uses the spectral properties of aerosols and makes it possible to retrieve the vertical profiles of the extinction coefficient of each aerosol type, i.e., water-soluble, sea salt, or dust. The method consists of two types of algorithm, backward and forward. These two algorithms are designed to improve the accuracy of the retrievals and to extend the areas where the aerosol properties can be retrieved: the backward algorithm is applied to data under a clear sky and determines the calibration constant of the LIDAR; the forward one derives the aerosol properties below the clouds.

We applied the new data analysis method to ship-borne LIDAR data measured over the western Pacific Ocean near Japan in May 2001. Figures 2a, 2b, and 2c show the temporal and vertical distributions of the extinction coefficient at a

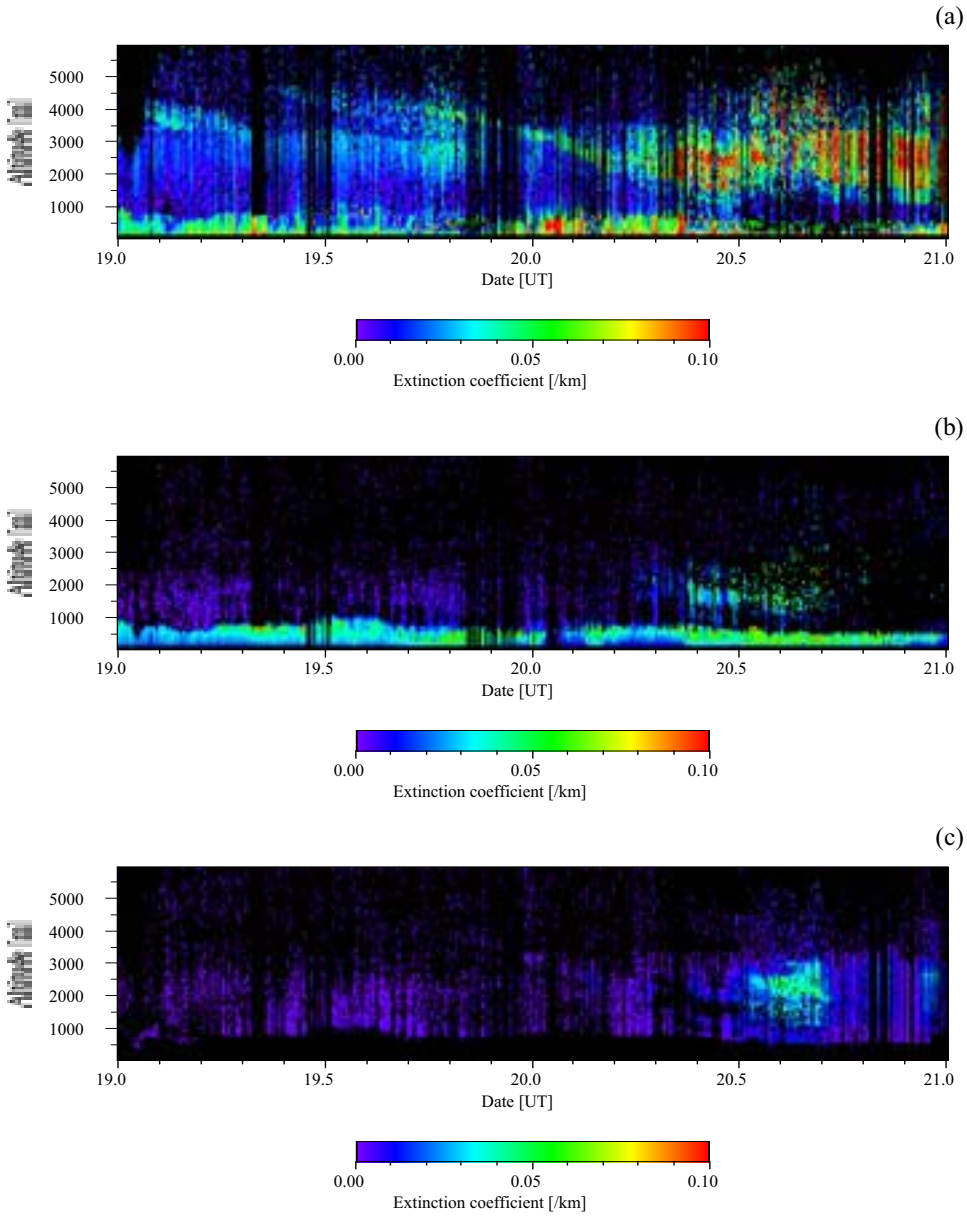



**Fig. 2** Time–height cross-sections of the extinction coefficient at a wavelength of 532 nm for (a) water-soluble, (b) sea-salt, and (c) dust particles retrieved by forward-type algorithm from LIDAR data measured on 19 and 20 May 2001 during the MR01-K02 cruise.

wavelength of 532 nm for water-soluble, sea-salt, and dust particles, respectively, as retrieved by the new algorithm. It can be seen that most of the water-soluble and sea-salt aerosols were concentrated in the planetary boundary layer. Plumes of water-soluble and dust particles were found at about 2.5 km on 20 May.

**Proton transfer reaction time-of-flight mass spectrometry at low drift-tube field strengths using an $H_2O$ – rare gas discharge–based ion source**

A discharge-based proton transfer reaction (PTR) ion source was operated using a mixture of $H_2O$ and rare gases such as He, Ne, Ar, and Kr in combination with a custom-built time-of-flight (TOF) mass spectrometer. In contrast to an "$H_2O$-only" discharge, which usually functions above a field strength ($E/N$) of 100 Td for a drift tube, an "$H_2O$ – rare gas"–based discharge was operated suc-

cessfully at $E/N$ values between 30 and 50 Td. ($E$ is the electric field strength [V $cm^{-1}$], $N$ is the buffer gas density [molecules $cm^{-3}$], and 1 Td [Townsend] = $10^{-17}$ $cm^2$ V $molecule^{-1}$.) The intensity of the primary ions ($H_3O^+•(H_2O)_n$) generated in the "$H_2O$ – rare gas" discharge was comparable to that in the "$H_2O$-only" discharge. Although the sensitivities of detection of nonpolar molecules such as isoprene, benzene, toluene, and *p*-xylene decreased, those of polar molecules such as acetone and acetaldehyde increased. This suggests that operation of the PTR-TOF mass spectrometer at low drift-tube field strengths improves both the sensitivity of detection of polar molecules and the selectivity. In addition, in the low $E/N$ operation the fragmentation of fragile species such as methyl nitrate in the drift tube was suppressed significantly.

**Use of *in situ* measurements of atmospheric oxygen-to-nitrogen ratio to detect regional-scale sea-to-air oxygen emissions related to spring bloom of marine phytoplankton near Japan**

Air–sea exchange of oxygen is much faster than that of $CO_2$. It takes only 3 weeks for dissolved oxygen to equilibrate with the atmosphere, whereas it takes about a year for $CO_2$. The apparent independence of the air–sea exchange of $CO_2$ and $O_2$, as exemplified by the fast response of $O_2$ relative to that of $CO_2$, means that short-term variation in atmospheric oxygen concentration can be a useful tool for estimating marine productivity. We have been monitoring the atmospheric $O_2/N_2$ ratio at the Cape Ochi-ishi (lat 43°10N, long 145°30E) station of CGER since March 2005 by using a modified gas chromatography – thermal conductivity detector (GC-TCD). The standard deviation of the $O_2/N_2$ ratio was estimated to be about ±14 per meg (≈ 3 ppm) from measurements taken at 10-min intervals. Thus, the *in situ* measurement system has a 1-σ precision of ±6 per meg (≈ 1.2 ppm) for the 1-h mean $O_2/N_2$ ratio. Atmospheric potential oxygen (APO ≈ $O_2$ + 1.1 $CO_2$) is a unique parameter, which is conserved with respect to terrestrial photosynthesis and respiration but reflects changes in the air–sea $O_2$ and $CO_2$ fluxes. The value of APO was calculated by using *in situ* $CO_2$ data obtained from the monitoring station. APO during 1 April to 12 May 2005 is plotted in Figure 3. APO varied markedly during this period. To examine the reasons for this wide variability we performed back-trajectory analyses. The distribution of satellite-derived marine primary production indicated the occurrence of a strong

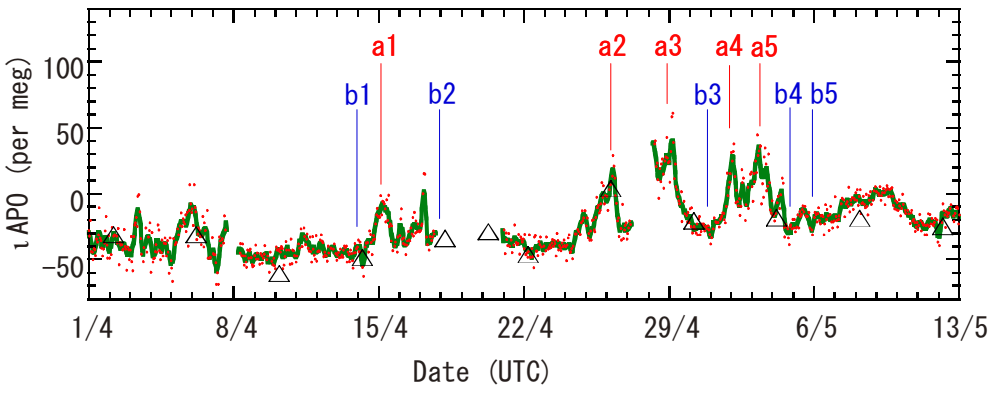



**Fig. 3** One-hour mean change in atmospheric potential oxygen (δAPO) at Cape Ochi-ishi for the period 1 April − 12 May 2005. Times indicated by a1 to b5 represent the starting times of the back trajectory calculations shown in Figs. 4a and 4b. Date is expressed in Coordinated Universal Time (UTC).

bloom of marine phytoplankton in the Sea of Japan and in a latitudinal band of 30°N to 40°N in the western Pacific in April (Fig. 4). Back-trajectory analysis of air masses (Figs. 4a, b) indicated that high APO values lasting for several hours or days were attributable to the oxygen emissions associated with the spring bloom of active primary production.

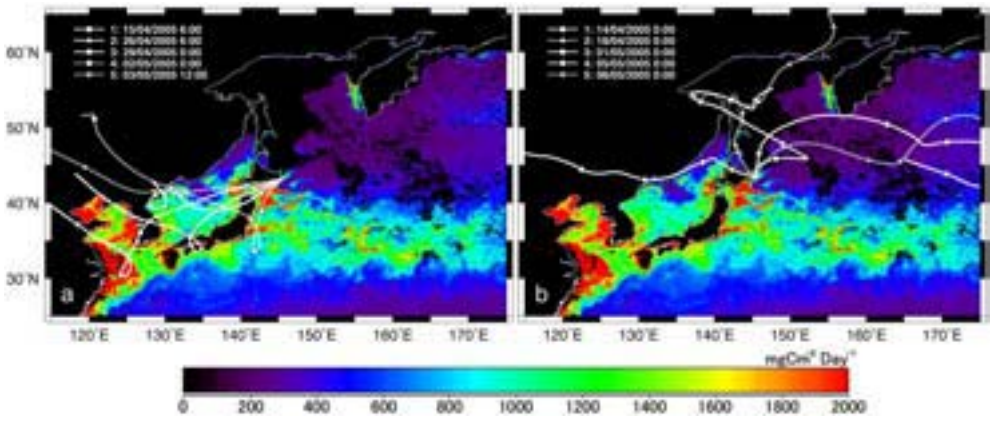
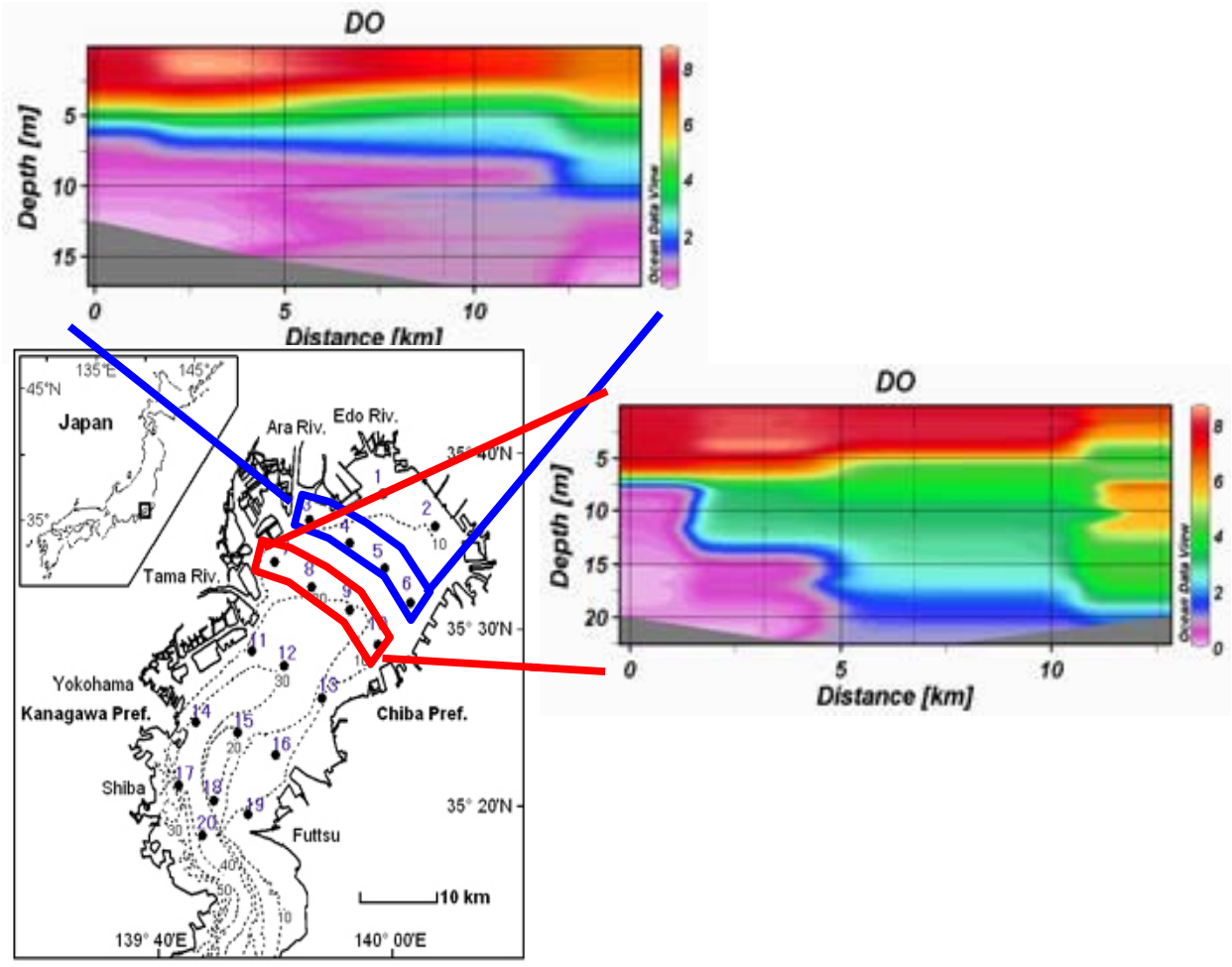



**Fig. 4** Monthly average distribution of net primary production in April 2005, as estimated from the Vertically Generalized Production Model [Behrenfeld and Falkowski (1997), *Limnol. Oceanogr.*, **42**(1), 1-20] along with 5-day air-mass back-trajectories.

# Water and Soil Environment Division




Tokyo Bay, a representative enclosed coastal sea surrounded by heavily urbanized areas, has been suffering from severe hypoxia such as the one observed in August 2006 (above figures). Water and Soil Environment Division is performing a research project on this matter composed of in situ experiments and numerical modeling.

**Water and Soil Division**

Water—in precipitation, rivers, lakes, seas, and soil—is vital for our lives. Once the environment has been polluted, the time and cost needed for its restoration are enormous. Our Division undertakes research from a variety of approaches on the environmental pollution and ecological changes that occur via the media of water and soil.

**Quantification of *Microcystis* in a eutrophicated lake by real-time PCR**

The genus *Microcystis* is a major cause of the cyanobacterial blooms observed in many eutrophic lakes. Many attempts have been made to determine the factors influencing the appearance and disappearance of these blooms. The results of these studies suggest that various factors are involved, including the nitrogen-to-phosphorus ratio, nutrient levels, predation by zooplankton, temperature, light levels, and the amount of dissolved organic matter. However, the effects of these factors on the occurrence of blooms have not been persuasively verified in Lake Kasumigaura, a typical eutrophic lake in central Japan. Algal blooms caused by *Microcystis* occurred almost every summer until 1986, when the highest microcystin concentration in the lake water was recorded; since then, blooms have not been recorded, and the microcystin concentration has correspondingly decreased. In light of the fact that Lake Kasumigaura has remained eutrophic, the mechanism behind this rise and fall in *Microcystis* levels remains unclear. One of the reasons why it is difficult to determine the cause of the blooms is that their appearance and disappearance have been sudden, unpredictable events. Even in past years when *Microcystis* blooms were still occurring, the cells of *Microcystis* were not detected in winter and spring, yet the blooms appeared suddenly in summer. This trend has been recognized in other lakes. However, it may be that the apparent absence of *Microcystis* cells is simply the result of an inability of the test method to accurately detect *Microcystis* cells present in very low numbers.

We therefore attempted to develop a method for the accurate wide-range, long-term monitoring of *Microcystis* cells in natural environments. Microscopic analysis, which is the most popular method of observing the abundance of *Microcystis* spp., is unsuitable for accurate wide-range monitoring. The samples from eutrophic lakes generally contain other fluorescent materials such as soil particles, cells of cyanobacteria other than *Microcystis*, green algae, and diatoms. Molecular biological techniques have recently been applied to quantification of the specific microorganisms. We developed the forward primer Micro229f, which has high specificity for *Microcystis*. Micro229f supported amplification of the rDNA of almost all *Microcystis* species that have been recorded in the International Nucleotide Sequence Database Collaboration. We also tested several commercial DNA extraction kits for efficiency and reproducibility. By using the FastDNA SPIN Kit for DNA extraction and Micro229f as the *Microcystis*-specific primer for real-time PCR, we were able to detect *Microcystis* down to a cell count as low as 3 cells $mL^{-1}$. We quantitatively detected *Microcystis* rDNA in water samples from Lake Kasumigaura in which no *Microcystis* cells had been observed by microscopy. Consequently (Fig. 1), our new methods can be used to quantita-

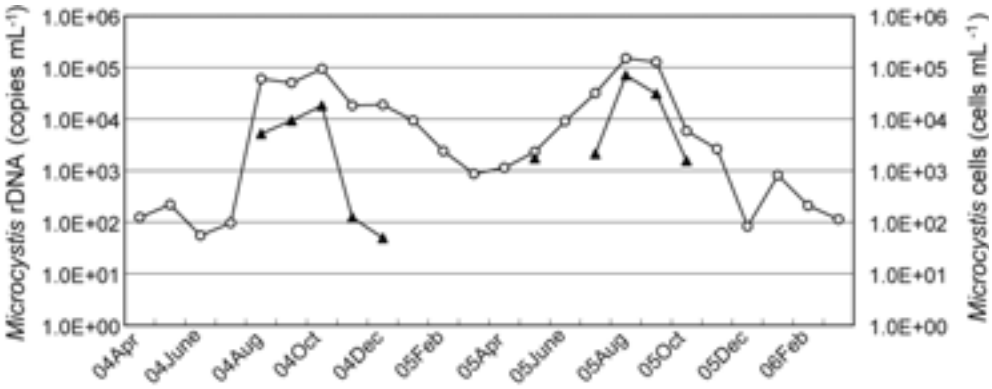



**Fig. 1** Seasonal variations in rDNA concentration of *Microcystis* by RT-PCR (○) and in *Microcystis* cell count by microscopy (from the Lake Kasumigaura database) (▲); samples were taken at St. 3 in Lake Kasumigaura. Twenty milliliters of each water sample was filtered through a membrane filter, and DNA was extracted from the filters.

tively monitor a wide range of fluctuation in *Microcystis* cells in lake water throughout the year.

**Speciation of aluminum in circumneutral Japanese stream waters**

Speciation of aluminum (Al) is important, because inorganic monomeric Al ($Al_i$, the sum of aquo, hydroxy, and inorganically complexed forms) is more toxic than organically complexed Al. Speciation of Al has been intensively studied in eastern North America and northern Europe, where serious acidification enhances the mobilization of Al. In Japan, the waters of peri-urban streams have not yet become acidified and retain a pH ranging from about 6 to 8, and thus speciation of Al in stream waters has received little attention. To investigate the events that occur in systems under latent acidification and to set baselines for the long-term study of inorganic monomeric Al in Japanese stream waters, we investigated the speciation of Al, including $Al_i$, organic monomeric Al ($Al_o$, the organically complexed form), and colloidal mineral Al ($Al_c$, the fine particulate form that passes through a 0.4-μm-pore-size membrane filter), in the stream waters (pH 6–8) of four watersheds in Japan (Fig. 2).Total dissolved Al ($Al_t$, the sum of $Al_c$, $Al_i$, and $Al_o$) ranged from 0.03 to 3.31 μM; $Al_c$ was a minor component (<22% of $Al_t$) in

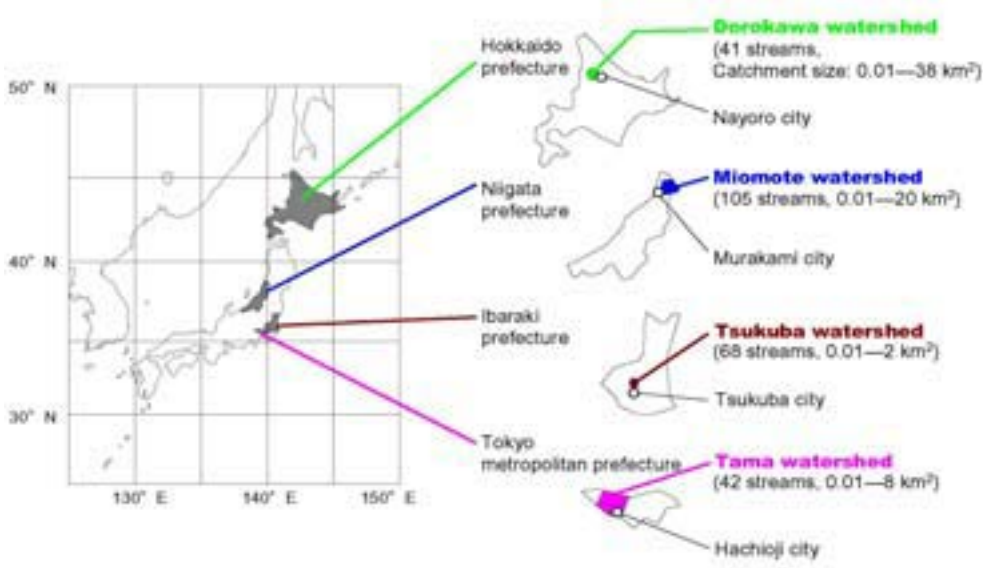



**Fig. 2** Locations of the four catchments studied. Streams selected have small forested catchments that receive no inflows from human-related activities.

most of the streams. $Al_i$ was dominant (71% of $Al_t$) in stream waters with low concentrations of $Al_t$ (<0.25 μM), whereas the $Al_o$ fraction (37%) was almost as large as the $Al_i$ fraction (39%) in streams with the highest $Al_t$ levels ($Al_t$ > 1 μM). Despite the variation in the range of reactive Al ($Al_r$, the sum of $Al_i$ and $Al_o$) in the four watersheds (Miomote, 0.03–3.27 μM; Tsukuba, 0.06–0.71 μM; Dorokawa, 0.05–0.71 μM; Tama, 0.03–0.38 μM), the entire dataset for $Al_r$ could be expressed as a function of the ratio of dissolved organic carbon (DOC) and calcium (Ca): [$Al_r$ (μM)] = 0.13 [DOC/Ca (mol/mol)] + 0.11 ($r$ = 0.86, $P$ < 0.001). $Al_r$ increased with increasing DOC-to-Ca ratio in the waters of the stream in all four areas tested. Although acidic deposition in Japan has already resulted in elevated concentrations of $NO_3^-$ + $SO_4^{2-}$ in stream waters, Ca (instead of Al) present at high levels is serving as a major counter-ion for $NO_3^-$ + $SO_4^{2-}$. However, additional acidic deposition loading may result in a shortage of Ca and mobilization of Al as a counter-ion for $NO_3^-$ + $SO_4^{2-}$. Continued observation of the speciation of Al in Japanese stream waters may reveal future changes in conditions—from the current "high Ca and high DOC" situation to a "low Ca and high $NO_3^-$ + $SO_4^{2-}$" situation— that will increase the mobilization of Al

**Analysis of dissolved organic matter in Japanese lakes**

A steady increase in the concentrations of recalcitrant dissolved organic matter (DOM) has been observed in several lakes in Japan. This recalcitrant DOM may represent a new type of lake water pollution that has never been considered. The accumulation of recalcitrant DOM in lake water will clearly influence the way in which lakes must be managed for environmental protection. It also presents a serious challenge for drinking water management, because recalcitrant DOM could be a major precursor of the trihalomethane produced during chlorination in water treatment. Therefore, detailed evaluation of the characteristics of DOM in lake water is urgently needed.

To examine the bioavailability and characteristics of lake-water DOM, we investigated the neutral sugar composition and concentration in polysaccharides, because neutral sugar typically constitutes a major fraction of the microbial cellular materials in aquatic systems. We used high-performance liquid chromatography with pulsed amperometric detection (HPLC-PAD) to analyze neutral sugar in algal-derived DOM, which is representative of autochthonous DOM in lake water. We also investigated changes in the composition of neutral sugar during bacterial degradation of the DOM by comparing the results from before and after degradation.

The total concentration of dissolved neutral sugar (TDNS) in algal (*Microcystis aeruginosa*)-derived DOM increased sharply from the latter part of the exponential growth phase to the stationary phase, when the TDNS yield (% of dissolved organic carbon: TDNS/DOC) was 23% (Fig. 3). This yield did not change dramatically after the biodegradation test (23%→19%), indicating that the bacteria used the neutral sugar carbon non-preferentially relative to the bulk DOM. The same tendency was also observed with algal DOM derived from *Anabaena flos-aquae* (*A.f.*) and *Planktothrix agardhii* (*P.a.*).

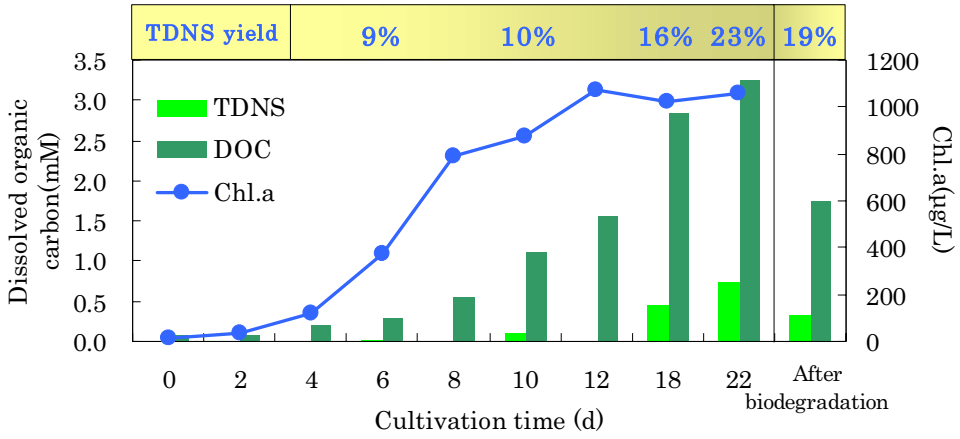



**Fig. 3** Total concentrations of dissolved neutral sugar (TDNS) and of dissolved organic carbon (DOC) and TDNS yields of algal DOM released from *Microcystis aeruginosa* before/after degradation.

The compositions of neutral sugar in algal-derived DOM differed among *M. aeruginosa* (*M.a.*), *A.f.*, and *P.a.* (Fig. 4). The neutral sugar derived from *M.a.* DOM before biodegradation was largely arabinose, deoxysugars such as rhamnose and fucose, and glucose. In contrast, in the neutral sugar derived from *P.a.*, glucose was overwhelmingly dominant (84%). The most distinct change in neutral sugar composition before and after biodegradation was a considerable decrease in the percentage glucose, resulting in a more uniform composition of neutral sugars after the degradation»>.

The order of molar percentage fractions (mol %) of glucose in neutral sugar before the biodegradation test (*P.a.* 84% > *M.a.* 66% >> *A.f.* 35%) corresponded well with one of the percentage degradations of algal-derived DOM (*P.a.* 79% > *M.a.* 46% >> *A.f.* 16%). This suggests that DOM including glucose-abundant polysaccharides is easily utilized and consumed by bacteria. Therefore, the composition of neutral sugar in polysaccharides should be a useful index of the bioavailability of DOM.

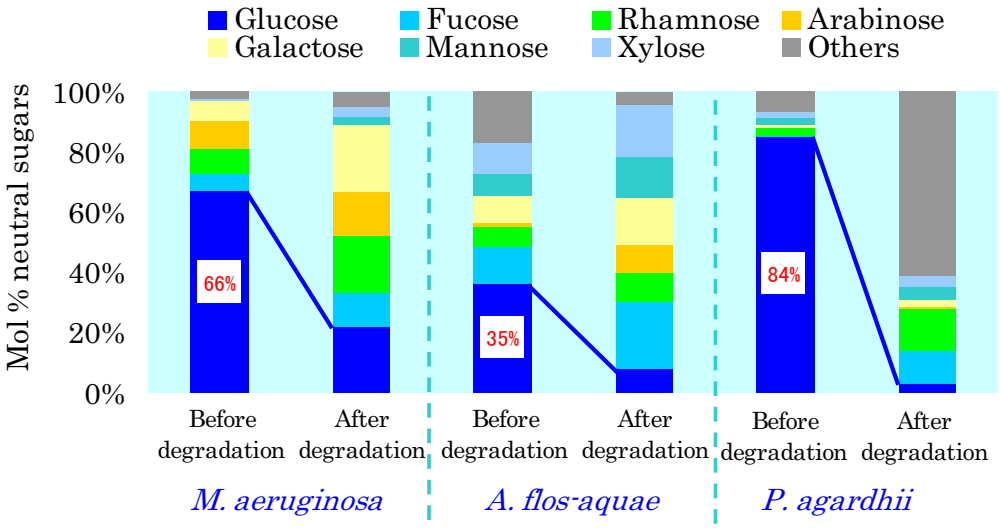



**Fig. 4** Profiles of neutral sugar composition in algal-derived DOM during biodegradation (M. aeruginosa, Microcystis aeruginosa; A. flos-aquae, Anabaena flos-aquae; P. agardhii, Planktothrix agardhii).

**Hypoxia generation and evaluation of its impact on benthic biota**

Intensive hypoxia is occurring in some coastal and enclosed seas in Japan, as well as in certain areas of the Baltic Sea, the Gulf of Mexico and Chesapeake Bay. Tokyo Bay, a representative enclosed coastal sea that has been suffering from severe hypoxia, is surrounded by heavily urbanized areas. The catchment has a population of approximately 2.8 million and receives vast amounts of fresh water, containing enormous amounts of nitrogen and phosphorus, via wastewater treatment plants and rivers. Consequently, the aquatic ecosystem of Tokyo Bay is extremely eutrophicated, and the chlorophyll *a* concentration of the algal blooms (mainly diatoms) found there sometimes exceeds 100 µg/L. Moreover, approximately 90% of the coastline of Tokyo Bay has been reclaimed, resulting in great losses of tidal flats as habitat for benthic fauna such as bivalves, which assimilate enormous amounts of phytoplankton biomass. We are now focusing on the following points in order to gain insight into the quantitative analysis of the causes of hypoxia and the influences on the benthic biota of Tokyo Bay (Cover Figure).

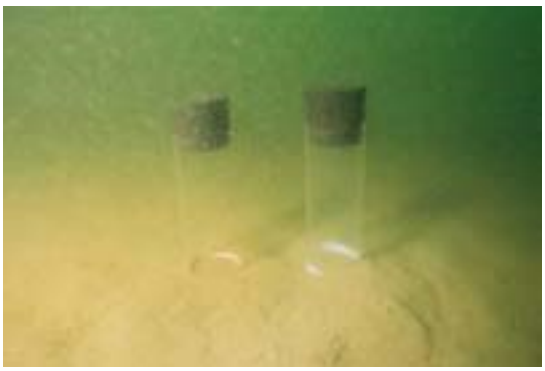


**Fig. 5** Core sampling to evaluate oxygen consumption (top) and experiment to evaluate survivals of each bivalve by using cages buried in an artificial tidal flat in a channel receiving treated and/or treated sewages (middle and bottom).

Pelagic organic matter in Tokyo Bay can be classified according to its origin into categories such as phytoplankton biomass and raw and treated sewage. Preliminary experimental work shows that both dissolved and particulate organic matter originating from phytoplankton is much more labile than that originating from sewage and runoff.

Sediments play a role in the consumption of dissolved oxygen in the water column in coastal seas. The redox potential, sulfur and organic matter contents, and particle size distribution of sediments in Tokyo Bay vary. Our measurement of sediment oxygen consumption (SOC) rates (Figure 5, top) in core samples with different characteristics showed that silty sediments with higher contents of sulfur and organic matter consume dissolved oxygen 2.5 to 10 times faster than sandy ones with lower contents of sulfur and organic matter. However, the highest content of sulfur, organic matter, or silt in sediments was not necessarily correlated with the highest SOC rate (Fig. 6).

Bivalves are susceptible to hypoxia, because unlike fishes and crustaceans, they cannot actively migrate. We conducted field experiments in Tokyo Bay to evaluate the survival and growth of some bivalve species. Four clam species were introduced into cages buried on the Oi tidal flat in the Keihin Canal, where hypoxic waters invade annually during the warm season (Figure 5, midle and bottom). We monitored the survival and growth of the clams and environmental variables. No individuals of *Ruditapes philippinarum* or *Mactra veneriformis*, which are abundant on some tidal flats in Tokyo Bay but rarely present on the Oi flat, survived in summer, when hypoxic waters intruded onto the flat. In contrast, the exotic hard

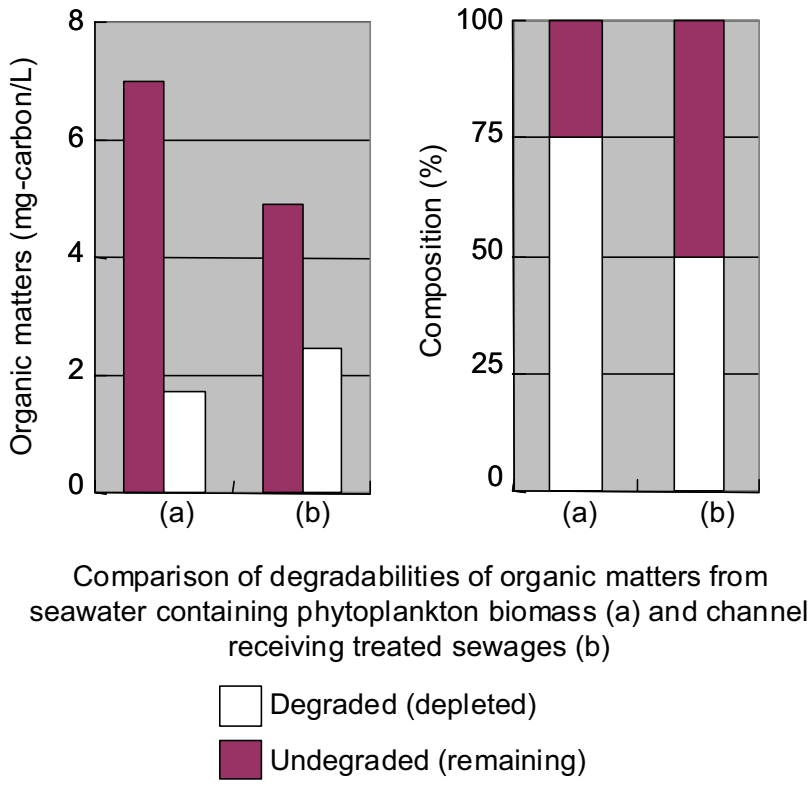



**Fig. 6** Comparison of degradabilities of organic matter from seawater containing phytoplankton biomass (a) and channel receiving treated sewage (b). White: degraded (depleted); red: undegraded (remaining).

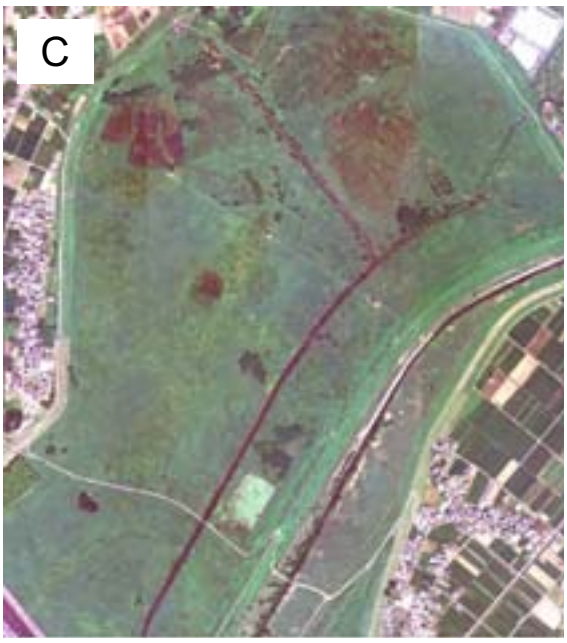
clam *Mercenaria mercenaria*, which is dominant on the Oi flat, survived well, suggesting that the resilience of this species in hypoxic waters is the cause of its dominance. Contrary to our expectation, *Meretrix lusoria*, which has almost disappeared from Tokyo Bay, survived very well, with high growth rates comparable to those of *M. mercenaria*. Therefore, vulnerability to hypoxic conditions is probably not responsible for the decline of this species.

We developed a numerical quasi-3D hydrodynamic model to evaluate enclosed coastal environments. The model was applied to Tokyo Bay to investigate its performance and usefulness. The calculated profiles of salinity and water temperature agreed well with the observed ones. The results confirmed the validity of the model, and improvements made to the method of solving the advection terms means that we are increasing the accuracy of vertical profiling in the surface layer.

# Environmental Biology Division

The plant cover of the Watarase wetland looks like turf (A) but is in fact dense grasses 4 m high that are hard to walk through (B). Analysis of images taken with an airborne camera (C) facilitates the analysis of the distribution of rare plants in the wetland.





The mission of the Environmental Biology Division is to help conservation of biodiversity and ecosystem functions. In the pursuit of this mission, our activities include ecological, physiological, and molecular genetic studies. The Division consists of four sections: Population Ecology, Physiological Ecology, Microbial Ecology, and Ecological Genetics. The staff of the four sections are collaborating to tackle the following four tasks.

**Studies of the conservation of threatened species**

We developed statistical models to predict the distribution of endangered plants from information obtained from aerial photographs of the Watarase Wetland. We compared models with and without consideration of the aggregated distribution of plant species. The wetland plant species that we examined tends to be distributed in aggregation, possibly because of limited dispersal ability or unknown environmental factors. We used a conditional autoregression (CAR) model to account for this aggregated distribution. The prediction performance was greatly improved by the use of this CAR model (Fig. 1).

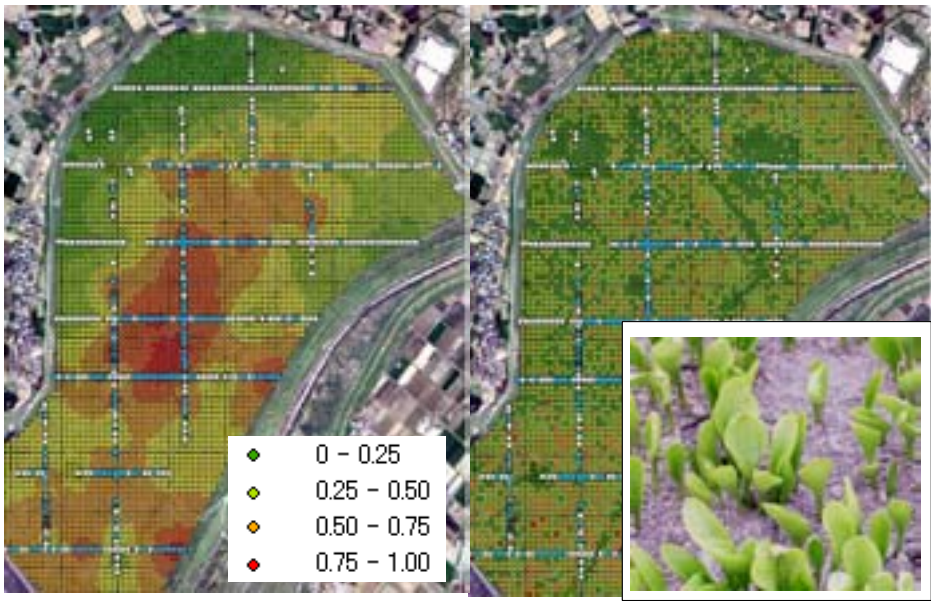



**Fig. 1** Maps of the probability of existence and observed presence/absence of a fern species, *Ophioglossum namegatae* (inset), by modeling with (left) and without (right) consideration of the aggregated distribution of the fern. Predicted probability is high at red points and low at green points. Blue and white points arranged in a lattice show sites where the fern was observed (blue) or not observed (white). Taking the aggregated distribution into account greatly improved the accuracy of the prediction.

On Sado Island in the Sea of Japan, the last wild population of the crested ibis in Japan become extinct in 1981. Recently, a program for the reintroduction of the bird was developed. The release of 10 captive-bred ibis to the wild is planned for autumn 2008. We examined the environmental conditions of the types of landscapes in which the ibis have ever observed, and from this examination we made a map of habitat suitable for the ibis. The map showed that the suitable habitat has been fragmented by logging and pine die-off, even though the total area has not changed during last 30 years.

Marimo (literally “spherical alga”) is a green alga living in fresh water lakes. Its spherical shape is well known, but it is also found in a fibrou shape. It is assumed that the spherical marimo develops from the fibrous shape, but this has not yet

been proved. Marimo propagating in Lake Akan, Hokkaido, is designated as a Special Natural Monument. In years gone by there were four sites along the coast of Lake Akan that were habitats for spherical marimo. However, two of these sites have been destroyed. We have established a molecular genetic marker (SSR, simple sequence repeat) to classify the *marimo* populations of Lake Akan. The genetic maker will be used as a tool to analyze the life cycle of *marimo. F*urthermore, use of the marker will help us to choose a suitable local marimo population for reintroduction to the former habitats.

**Studies of invasive alien species and genetically modified organisms**

Millions of tonnes of agricultural products are now imported by Japan, and about one-tenth is oilseed rape (*Brassica napus* L.) seeds. It has been estimated that about half of the imported rapeseed has been genetically modified for resistance to herbicides. Some of these imported seeds are likely to be dispersed unintentionally during their transport within Japan. In 2005, we started a census of oilseed rapes growing along a 20-km stretch of a major route (Fig. 2). Herbicide-resistant plants were found every year from 2005 to 2007: 35 plants in 2005, eight in 2006, and five in 2007.

By using a molecular genetic technique (real-time PCR), we succeeded in detecting three harmful phytoplankton species in sediment samples from the ballast tanks of a bulk carrier plying between Japan and Australia (Fig. 3). The highest cyst concentrations were 8050/kg of sediment in the case of *Heterosigma aka-*

**Fig. 2** Oilseed rape growing on the roadside. The genetic nature of such rape plants was determined by using molecular genetic techniques. Some of them had genes artificially incorporated for herbicide resistance; we suspect that these plants had grown from seeds dropped by vehicles carrying imported genetically modified seeds.

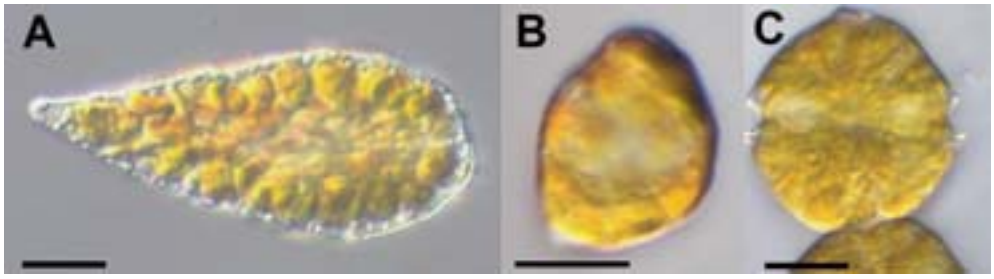



**Fig. 3** Three harmful species of phyoto-plankton: (A) *Chattonella marina*; (B) *Heterosigma akashiwo*; and (C) *Alexandrium catenella*. The black bar in each photo represents 10 μm. Use of the genetic markers that we found enabled the detection of these plankton when only a few cells were present in the sample water.

*shiwo*, 1230 for *Alexandrium* spp., and 142 for *Chattonella* spp. *Alexandrium* spp. is known for its worldwide spread via ballast tanks. We confirmed the presence of *Heterosigma* and *Chattonella* in ballast tanks for the first time; this suggests that they are likely to spread.

**Studies of the effects of environmental stress and climate change**

To understand better the responses of plants to environmental stressors such as air pollutants, we characterized an ozone-sensitive (*ozs1*) mutant strain of the model plant species *Arabidopsis thaliana*. The mutant plants showed enhanced sensitivity to ozone, desiccation and sulfur dioxide, but they have normal sensitivity to hydrogen peroxide, low temperature, and high light levels. Transpiration levels, stomatal conductance levels, and stomatal aperture size were greater in mutant plants than in the wild type (Fig. 4). The stomatal apertures of the mutant plants responded to light fluctuations but were always larger than those of the wild-type plants under the same conditions. We suspect that the different stomatal response of the mutant plant is responsible for its high ozone sensitivity.

Selenium (Se) is an essential element for many organisms, but excess Se is toxic.

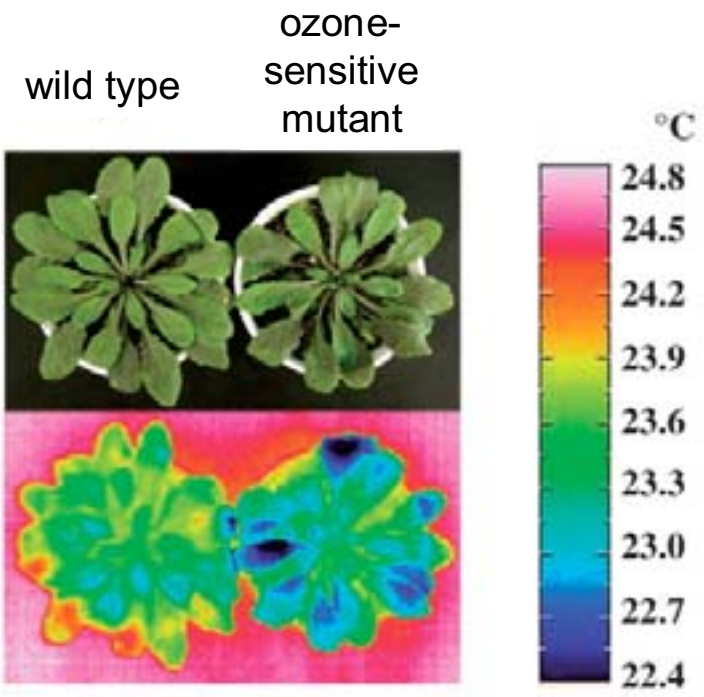



**Fig. 4** Photograph (top) and thermal image (bottom) of an ozone-sensitive mutant (right) and a wild-type (left) *Arabidopsis thaliana* grown on soil in a greenhouse for 2 months. The thermal image of the mutant plant shows the plant's lower leaf temperature (blue): the presence of more widely open stomata (small openings on the surface of leaves) in the mutants increased their transpiration rate. This high stomatal conductance is responsible for the high ozone sensitivity of the mutant plants.

To better understand plant Se resistance mechanisms, we studied the physiological and molecular responses to Se in two *Arabidopsis* accessions, Col-0 (Se resistance) and Ws-2 (Se sensitive). The results showed that two plant hormones, ethylene and jasmonic acid, play important roles in Se resistance. From an applied perspective, enhanced Se resistance in plants may be developed by artificially by increasing the levels of these plant hormones. The use of these plants for cleaning up excess Se in polluted soils and water is well worth considering.

We are continuing long-term meteorological and ecological monitoring at two sites on the northeastern and central Qinghai–Tibetan plateau. We found that flower coverage could be estimated well from surface hyperspectral reflectance in alpine meadows. Ten years' experimental warming treatment of plants *in situ* in an open-top chamber resulted in significant temperature acclimatization of photosynthesis in *Gentiana straminea*.

We explored the past history of the distribution of the alpine shrub *Potentilla fruticosa* on the Qinghai–Tibetan plateau by analyzing genetic markers on chloroplast DNA. In high altitude areas, genetic diversity was high and there were ancestral variations. In contrast, the populations at low altitude had relatively low genetic diversity and recently derived variations (Fig. 5). These data suggest that *P. fruticosa* survived in the high altitude and then expanded into low altitude areas.

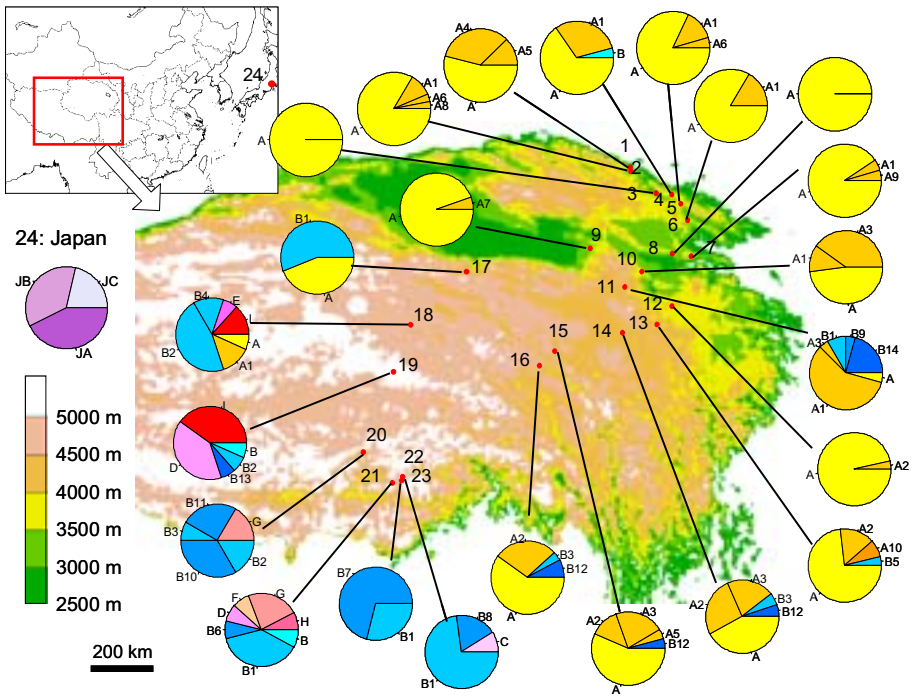



**Fig. 5** Genetic diversity of a shrub species, *Potentilla fruticosa*, on the Qinghai–Tibetan Plateau. Different colors in the pie charts indicate different DNA types. Greater genetic diversity was observed in the western area, which was at high altitude. This indicates that these higher areas acted as a refuge when the climate at lower altitudes was not suitable for this shrub species in the past.

**Studies of the structure and function of ecosystems**

The chironomid midge *Spaniotoma akamusi* is an insect characteristic of lake ecosystems in Japanese eutrophic lakes (Fig. 6). The species was abundant in Lake Kasumigaura in the 1970s and 1980s, but it approached extinction in the 1990s. This decline has been ascribed to bottom oxygen deficiency caused by strong pollution. In recent years, however, the midge has recovered in small numbers, even though the lake is still highly polluted. Monitoring of the midge will be needed to detect any marked changes in the lake's ecosystem.

**Fig. 6** *Spaniotoma akamusi* (left) is an insect characteristic of Japanese eutrophic lake ecosystems. The long-term pattern of the abundance of the species is expected to give us a hint of changes in the ecosystem of Lake Kasumigaura (right).

# Laboratory of Intellectual Fundamentals for Environmental Studies




Examples of Experimental Aquatic Animals for Environmental Risk Evaluation

A: Damsel-fly (*Ischmura senegalensis*)
B: Daphnid (*Daphnia magna*)
C: Zebrafish (*Danio rerio*)

The Laboratory of Intellectual Fundamentals for Environmental Studies (LIFES) incorporates two research laboratories: the Environmental Analytical Chemistry Laboratory (ACLab) and the Biological Resource Laboratory (BRLab). The aim of LIFES is to promote environmental research, not only in NIES but all over the world, through the provision of environmental Certified Reference Materials, cell strains of microbes, and experimental animals for environmental risk evaluation, and through the development of information databases related to environmental biology. In addition to the major topics summarized below, both laboratories conduct research that has both fundamental and frontier themes.

ACLab has been evaluating the quality assurance and quality control (QA/QC) of environmental monitoring; developing new environmental analysis methods; and comparing regulation monitoring methods of atmospheric substances. Recently, methods for monitoring various atmospheric particles have been compared. Some of the results are being applied to the monitoring of Asian dust storms (*kosa*) in the north Asia monitoring network. The molecular extinction coefficient (ε) of cylindrospermopsin, a cyanobacterial toxic alkaloid, was determined to be 9800 (previously reported to be 5800–6250) at a wavelength of 262 nm by purification in an anion-exchange cartridge followed by normal-phase HPLC.

BRLab has been working on several biotechnologies. With the aim of developing new technologies in the field of bioscience, we are studying primordial germ cells (germline stem cells) in the Amniota (mainly in the Aves). We have made germline chimeras by the transplantation of primordial germ cells, and we have obtained offspring originating from the introduced primordial germ cells by backcrossing. We are now trying to put this method to practical use for the proliferation of threatened bird species. Our techniques should be useful in cleaning up infections transmitted via eggs and in the recovery of populations from inbreeding depression by the transplantation of primordial germ cells in the early embryonic stages (Fig. 1). In September and October we conducted a short training course on bird cell culture for eight foreign researchers from Russia, Korea, and

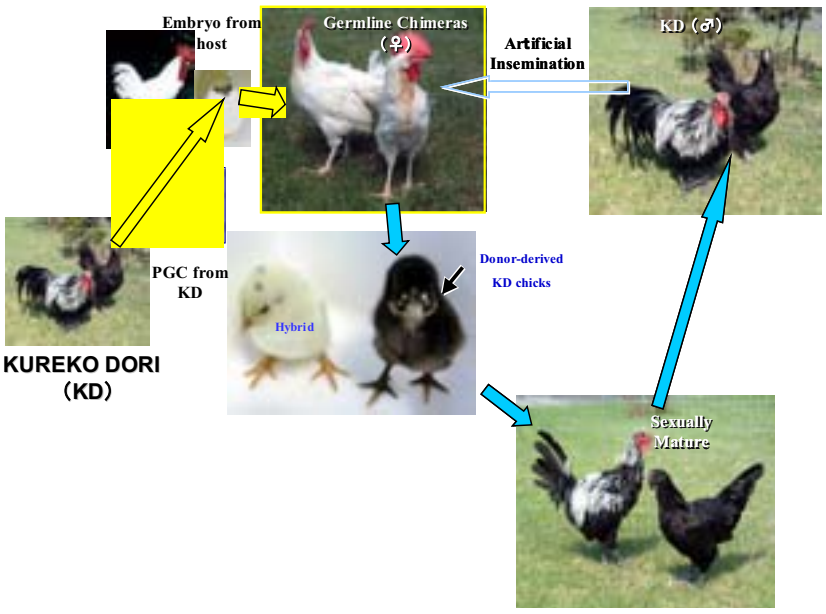



**Fig. 1** The *Kureko Dori*, an endangered domestic fowl breed of the Kureko region of Kumamoto Prefecture in Kyushu, Japan. By strict screening criteria, the *Kureko Dori* was designated a prefectural natural treasure in 1965.
Offspring of the *Kureko Dori* can be obtained from germline chimeras using reproductive stem cells so called primordial germ cells (PGC).

**Fig. 2** Russian participants in a training course on techniques in bird cell culture and cryopreservation of living bird cells.

China (Fig. 2) to disseminate information on techniques for bird cell culture and the cryopreservation of living bird cells.

LIFES functions as a reference laboratory for environmental research in Japan by improving methods for ensuring analytical QC and cross-checking analytical techniques; improving methods for classifying and culturing microalgae and other laboratory organisms; and preserving and supplying these organisms as standards for classification, standard strains for bioassay tests, and strains with special functions.

**Management and operation of key analytical equipment**

ACLab has been working to improve the sensitivity and accuracy of analysis of environmental specimens at NIES through the use of key analytical equipment. An on-demand analysis service has been established and is operated by personnel technically trained in the use of 10 instruments. Over 50 researchers made requests for analyses on about 30 research themes, and we provided them with useful data derived under a high level of QC.

**Preparation of environmental Certified Reference Materials**

Environmental Certified Reference Materials (CRMs) are utilized to evaluate new analytical methods and to control the accuracy of pretreatment and instrumental analyses. We have been preparing and distributing environmental and biological CRMs since 1980. Over 180 CRMs were distributed to researchers worldwide this financial year. We have begun to distribute a new CRM, No. 28, “Urban aerosols”, which will be helpful in determining the presence of multiple elements in the urban aerosols of Asia (Fig. 3).

**Long-term storage of environmental samples (environmental specimen bank)**

We continued to collect and prepare environmental samples for long-term, low-temperature storage as part of our expanded program to make samples available for retrospective analysis of pollutants. Our time-capsule facility accommo-

**Fig. 3** Environmental Certified Reference Materials (CRMs) produced at NIES. Information on NIES-CRMs can be found at {http://www.nies.go.jp/labo/crm-e/index.html}.

dates various items of equipment for low-temperature preparation of environmental specimens for long-term storage. The facility can store such specimens for 50 years under an atmosphere of liquid nitrogen vapor at about –150 ∀C. About 300 samples were added to storage this year; the total number of time-capsule samples registered is now about 1200 (Fig. 4).

**Preservation of cells and gene resources of threatened wildlife species**

(1) Threatened wild animals

In the hope of making future contributions to the conservation of threatened wild animals, we cryopreserve the cells (including germline cells) and tissues of such


**Fig. 4** Environmental Specimen Bank: stingray liver *in situ* after excision; coarse and fine crushing; bottling; and cryopreservation in cold $N_2$ vapor (< –150 °C) over liquid $N_2$.

animals for genetic analysis, with the support of the National Time Capsule Program for the Environment and Threatened Wildlife. As at March 2007, 1076 samples (tissues, cultured cells, and sperm) had been cryopreserved. From April 2007 to March 2008, we accepted another 198 individual threatened wild animals (9 mammals, 189 birds). From these animals we cryopreserved 678 samples (tissues and cultured cells). There were two newly cryopreserved species, the common murre (*Uria aalge*) and the far eastern curlew (*Numenius madagascariensis*). In total, 1754 samples have been cryopreserved since the National Time Capsule Program was started in 2004 (Fig. 5).

**Fig. 5** The Okinawa rail (*Gallirallus okinawae*), a threatened Japanese endemic species.

(2) Threatened algae

We have been surveying the status of threatened algal species in Japan. During FY 2007 we surveyed 48 potential habitats (mostly agricultural reservoirs) of green algae of the order Charales in Kagawa, Saga, and Nagasaki prefectures. Members of the Charales grew at 17 of the sites. We carefully collected several thalli (plant bodies), without disturbing the populations, so that we could establish culture strains.

We now maintain a total of about 300 strains of endangered algae, among which about 100 strains of freshwater red algae are not subcultured but preserved in liquid nitrogen only.

Until early in 2007, we collected information on the presence or absence of Charales from 336 localities, including small ponds, agricultural reservoirs, and paddy fields, in 16 prefectures of Japan. This exercise made an important contribution to the revision of the list of threatened Charales in the Red List for Algae, published by the Ministry of the Environment in August 2007.

Among the endangered Charales, *Nitella mirabilis* var. *inokasiraensis*, which is endemic to Japan, lives in a small pond in Chiba Prefecture, which is now its only

**Fig. 6** Culture strains of *Nitella mirabilis* var. *inokasiraensis*, an endangered Charales alga. These strains originated from oospores taken from the bottom mud of a pond, now the world's only remaining habitat of this alga.

habitat in Japan. We are trying to maintain the genetic diversity of *N. mirabilis* var. *inokasiraensis ex situ* by establishing culture strains from oospores (zygospores) taken from the bottom mud in the pond (Fig. 6).

**Investigation, collection, and storage of microbes useful for environmental conservation and development of laboratory organisms**

At the Microbial Culture Collection (NIES-Collection), we:

- ∉ received 68 strains of microbes from scientists inside and outside NIES
- ∉ distributed 600 algal strains to researchers and technicians
- ∉ continued to renew the Microbial Culture Collection database system.

We now maintain a total of more than 2200 strains, of which more than 1700 are available as NIES strains. To minimize the risk of loss of culture strains in the event of a disaster, the NIES-Collection has started exchanging cryopreserved strains with those of the Kobe University Macroalgal Culture Collection. These activities are being conducted in collaboration with the University of Tsukuba as well as the Kobe University as a part of the National Bio-Resource Project (second phase).

**Provision of Experimental Aquatic Animals for Environmental Risk Evaluation**

In FY2007, we started supplying 12 aquatic animals for evaluation of the environmental risks posed by chemicals (Fig. 7): egg masses of two species of midge (*Chironomus tentans*, *C. yoshimatsui*), larvae of damsel-fly (*Ischnura senegalensis*), scud (*Hyalella azteca*), three species of daphnid (*Daphnia magna*, *Moina macrocopa*, *Ceriodaphnia dubia*), a shrimp (*Paratya compressa improvisa*), medaka (*Oryzias latipes*), zebrafish (*Danio rerio*), guppy (*Poecilia reticulata*), and fathead minnow (*Pimephales promelas*). In FY2007, there were 11 requests for 35 samples of 6 species.

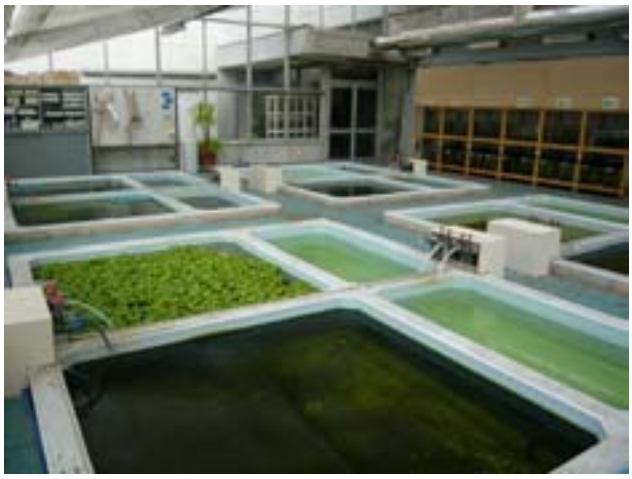


**Fig. 7** Aquaria for culturing experimental animals used to assess the environmental hazards of chemicals.

# Environmental Information Center


The Environmental Information Center provides the public with various kinds of environmental information through websites.

The Environmental Information Center provides information technology (IT) support for research and related activities at NIES; carries out public relations activities for NIES, including the publication of NIES research reports; and performs miscellaneous other activities, including collecting and processing environmental information and disseminating it to the general public, performing tasks commissioned by the Ministry of the Environment, and acting as the national focal point for UNEP-Infoterra. These tasks are described in detail below. To implement the tasks more efficiently, the Center was reorganized in April 2003.

**1. IT support for research and related activities at NIES**

The Center manages and operates the computers and related systems at NIES, uses IT to improve the work efficiency of NIES, and runs a library service.

***a. Management and operation of computers and related systems***

A new computer and network system started operation in March 2007. The UNIX-based computing environment consists of a supercomputer system and various subsystems, including a scalar-computing server, a front-end server, storage devices, and application servers. Our vector supercomputer (NEC SX-8R/128M16), which is equipped with a FORTRAN compiler with high-level debugging capability and high-efficiency optimization, executes the large-scale programs needed to model global environmental problems.

A local-area network called NIESNET was established at NIES in 1992. File transport was upgraded in March 2007. The network configuration was restructured, and the large-scale file transport performance was improved at the same time. Registered users outside NIES can use the supercomputer system through the Tsukuba wide-area network via the Science Information Network (SINET) connection to the Internet.

***b. Use of IT to improve work efficiency***

The Center gives IT support to the management sector of NIES, with the aim of increasing work efficiency. It also provides NIES researchers with processed research data and helps them to disseminate their data through the NIES homepage. In FY 2007, the Center supported the following activities:

- Development of an electronic application and registration system at NIES
- Operation of a thin-client PC management system for the administrative section
- Modification of the NIES research program database
- Modification and operation of a database of basic information on each member of staff at the Institute
- Modification of a registration system for a research information database (e.g., for original papers)
- Support for modifications to a browsing system for budget and settlement of accounts processing system.
- Design and installation of a mass NIES data storage system
- Development, operation, and modification of the NIES eco-management system

***c. Library service***

As of March 2008, the NIES library held 52,174 books, 396 technical and scientific serials, 9,688 maps, 120,229 microfiches, and various other reports and reference materials.

In addition to these materials, researchers at NIES can access documentary information through commercial databases such as Web of Science, Science Direct, JDreamII, STN, G-Search, and the British Library Inside Web.

Library facilities include separate rooms for reading books, journals, indexes and abstracts, reports, maps, and microfiches.

**2. NIES public relations activities**

The Center manages the NIES Worldwide Web (WWW) Internet site. It also edits and publishes NIES reports such as research reports and this *Annual Report.*

***a. Management of NIES WWW***

NIES began to provide public information on its research activities and results via the Internet (http://www.nies.go.jp/) in March 1996. The website was completely renewed and improved in accordance with the restructuring of NIES in April 2001 as an independent administrative institution. Because NIES started the sec-


ond stage of its medium-term plan in April 2006, a newly designed website was prepared in accordance with the new organization and activities. The new site was designed to offer improved usability, including improved accessibility for people with disabilities.

***b. Editing and publication of NIES reports***

Reports of NIES research activities and results, such as the NIES *Annual Report* and research reports, official newsletters (*NIES News*, in Japanese), and NIES research booklets (*Kankyo-gi*, in Japanese) are edited, published and distributed by the Center.

**3. Other activities**

In addition to the activities mentioned above, the Center collects, processes, and disseminates environmental information for the general public; conducts tasks commissioned by the Ministry of the Environment; and acts as the national focal point of UNEP-Infoterra.

***a. Collection, processing, and dissemination of environmental information***

NIES is required to carry out "the collection, processing, and dissemination of environmental information" as one of its major tasks. The Center provides various kinds of environmental information to the public through websites; processes and manages environmental information databases; and provides environmental information via GIS (geographic information systems).

*Environmental Research and Technology Portal Site*

The Center opened the new environmental research and technology site (http://ecotech.nies.go.jp/) in October 2007. The site provides a variety of content, such as news on environmental research and technology from domestic and for-

eign news resources, reports on key topics in environmental technology, and information on seminars and events in environmental research and technology. The site is currently available only in Japanese.

*Processing and management of environmental information databases*

Various environmental data are needed for research, policy decisions, and policy enforcement. The Center compiles and processes air quality and water quality data, as monitored by local governments and reported to the Ministry of the Environment. These processed data can be accessed through the database on the NIES WWW. Duplication and lending services are also available.

*Provision of environmental information via GIS*

The Center, with the cooperation of the Ministry of the Environment, has been using GIS to develop an environmental data provision system. This system helps users to easily understand the status of the environment by showing data on environmental quality and other information on maps. The system has been publicly available through the Internet since September 2002.

***b. Tasks commissioned by the Ministry of the Environment***

In FY 2007 the Center performed the following seven tasks commissioned by the Ministry of the Environment:

- Use of GIS to maintain and manage a system for the exhibition of traffic noise survey data.
- Development of an information system for the total management of aquatic environments.
- Support of work on a comprehensive system for managing information on the living environment. (maintenance of a system for managing information on noise, vibration, and offensive odors.)
- Analysis of the results of a national survey of aquatic animals.
- Development of a database for the investigation of dioxins in all parts of the environment.
- Management of work on the mapping of harmful atmospheric contaminants
- Construction of a pollutant release and transfer register PRTR data map and download site.

***c. National focal point of UNEP-Infoterra***

UNEP-Infoterra is the Global Environmental Information Exchange Network of the United Nations Environment Programme. The network operates through a system of government-designated national focal points. The Center has been the designated Japanese national focal point since 1975. These focal points provide a wide range of environmental information, including directories of information sources.

One of our staff participated in the international meeting held by UNEP from 13 to 16 April 2004 in Geneva and participated in discussions on plans for future activities.

### The 4th Tripartite Presidents Meeting among NIES, NIER and CRAES (TPM) and International Workshop of Air Pollution in Big Cities including Vehicle Exhaust

May 13-17, 2007
Wang Jiang Hotel
Chengdu, China

The TPM worked to expedite joint efforts in environmental research among Japan, Korea and China, while seeking further cooperation on issues of common interest. At the TPM4, three presidents exchanged views and information on the developments made since TPM3 as well as future activities under the framework of TPM. They agreed to establish a working group to develop a joint cooperative project on dust and sand storms. The National Agency for Meteorology, Hydrology and Environment Monitoring (NAMHEM) of Mongolia and the Sino-Japan Friendship Center for Environmental Protection were invited to the TPM4 as observers.

### Japan-UK Joint Low-Carbon Society Research Project, the 2nd Workshop "Achieving a Sustainable Low-Carbon Society"

June 13-15, 2007
The Mermaid Conference and Events Centre
London, United Kingdom

This workshop focused on the implementation of policies and measures to achieve low-carbon societies. Sixty-three experts from 20 countries and 15 international organizations contributed to the workshop and 20 business representatives also attended the symposium. One of the key findings from the workshop was that "a range of country studies has already demonstrated that it is both technically and economically feasible to achieve significant reductions in greenhouse gas emissions by 2050 – as much as 60-80 per cent in developed countries. The costs of a transition to a low-carbon society are far less than the costs associated with inaction." The workshop also identified policy recommendations in six key areas.

### The 27th International Symposium on Halogenated Persistent Organic Pollutants, "Dioxin 2007"

September 2-7, 2007
Hotel Okura Tokyo
Tokyo, Japan

The conference continued the tradition of the symposium series as an interdisciplinary forum for communicating scientific advances and emerging issues on dioxins and other persistent organic pollutants in a friendly atmosphere. More than 1,000 researchers from 43 countries participated in the symposium and discussed various scientific issues, including the status and trends of dioxins/POPs pollution in the environment, their toxicological mechanisms, and emerging POPs, such as brominated fire retardants and fluorinated surfactants. The results of the conference were published in volume 69 of *Organohalogen Compounds.*

### International Expert Workshop for Urban Industrial Symbiosis as a Part of Asia Pacific Eco-business Forum in Kawasaki City

September 7, 2007
Industrial Promotion Kawasaki Center
Kawasaki, Japan

This workshop was held among researchers, business managers and municipal officials from Japan, China and other Asia-Pacific regions, as well as international experts from UNEP and UNESCAP. A focal discussion point among the 50 experts was sharing information and knowledge for sustainable urban development and industrial renovation in an environmentally friendly manner. A discussion and conclusion to the workshop were provided to the public symposium attended by around 200 people. In addition, a detailed presentation of the Urban Circular Economy Simulator, currently being developed by NIES in collaboration with Kawasaki City officials, was held and the knowledge sharing strategies among developing Asian cities were intensively discussed.

### NIES Commemorative Lectures by the Blue Planet Prize Winners

October 19, 2007
National Institute for Environmental Studies
Tsukuba, Japan

Professor Joseph L. Sax and Dr. Amory B. Lovins, winners of the 16th Blue Planet Prize who made outstanding contributions to providing solutions to global environmental problems, gave special lectures to NIES researchers and local residents of Tsukuba.

### Asia Flux Workshop 2007, "International Workshop on Advanced Flux Network and Flux Evaluation"

Oct 19-22, 2007
Aspire Park
Taoyuan, Taiwan

This workshop consisted of reports on various topics such as measurement, remote sensing, modeling, and other methodologies followed by active discussions on mass and energy exchanges and the related hydrometerological and biogeochemical processes taking place in Asian terrestrial ecosystems. In addition to general sessions, a special session on "fluxes and biogeochemical cycles under the humid climate in Asia" was held to discuss the new findings under Asian specific climate influenced by monsoon.

## The 7th Workshop on Fresh Water (Lakes and Marshes) Pollution Project

November 16, 2007
Toyama International Conference Center
Toyama, Japan

This workshop featured three keynote speeches and six oral presentations by experts from China, Japan and Korea. During the workshop participants discussed evaluation techniques of non-point sources and total maximum daily load management system, developments of restoration technology including Bio-Eco systems with submerged/emerged aquatic plants, wetland, water conveyance technology, and greenhouse gas emission control. All agreed on the importance of continuing this workshop, and furthering information exchange among researchers from the three countries. In addition, a copy of "Guideline on the Management for Establishment of Eco-Sound Watershed Environment of Lakes and Marshes" was distributed to the participants.

## The 4th NIES Workshop on E-waste

November 21-22, 2007
Tsukuba International Congress Center
Tsukuba, Japan

Electrical and electronic waste, or E-waste, is a cause of great concern among researchers and policy makers due to its potential for serious environmental pollution in Asia. The conference focused on several important aspects of E-waste such as toxic and resource potentials, inventories, reuse, and extended producer responsibility (EPR). The conference was attended by approximately 90 experts and students, and was successful in understanding the current regional and global issues related to E-waste. The participants confirmed the significance of future cooperation for seeking appropriate 3R policies for E-waste.

## "Carbon Management in Cities: Gaps in Policy Discussions and Scientific Understanding"

**UNFCCC COP13/CMP3 Side Event**

December 6, 2007
Grand Hyatt
Bali, Indonesia

The official side event during UNFCCC COP13/CMP3 "Carbon Management in Cities: Gaps in Policy Discussions and Scientific Understanding" identified and highlighted key gaps in policy discussions and scientific understanding for carbon management in cities of both developed and developing countries. Attended by over 100 people, the event was helpful in contributing to the debate on the importance and role of cities in carbon management for mitigating global climate change. The event highlighted not only the importance of mitigation on a city scale but also the adaptation measures in cities. It concluded that cities should lead the climate change agenda, both in terms of mitigation and adaptation, reinforced by adequate scientific information required for the policy making.

## "Low-Carbon Asia: To be or not to be" - How to Align Climate Change and Sustainable Development

**UNFCCC COP13/ CMP3 Side Event**

December 8, 2007
Grand Hyatt
Bali, Indonesia

The third NIES side event during UNFCCC COP13/CMP3 was held in Bali and attended by around 100 people. Through presentations and the panel discussion, participating researchers discussed four key questions; what are the key dimensions and dilemmas of a transition to LCS in Asia; what could be alternative visions driving LCS development in Asia; what are the challenges and opportunities for developing LCS in Asia; and how should Asia make the transition to LCS a reality.

## International Symposium on Urban Energy and Carbon Management: Challenges for Science and Policy, International Workshop on Urban Energy and Carbon Modeling

February 4-6, 2008
Asian Institute of Technology Conference Center
Pathumthani, Thailand

The symposium and workshop clarified scientific and policy issues surrounding urban energy and carbon management and created the Urban Energy and Climate Modeling Forum. The symposium was attended by 45 researchers and policymakers from 12 countries and the workshop was attended by 35 experts from prominent research and academic institutions working on urban energy and carbon management. Participants in the workshop discussed methodological approaches, data availability issues, energy and carbon modeling techniques, and presented case studies from 14 key cities including 12 leading world mega-cities. The participants also discussed concrete research collaboration opportunities and agreed to publish a special issue in a journal focusing on urban energy and carbon management to enhance knowledge in this important area.

## Japan-UK Joint Low-Carbon Society Research Project, The 3rd Workshop "Roadmap to a Low-Carbon World"

February 13-15, 2008
Hotel Metropolitan Edmont
Tokyo, Japan

The third workshop was attended by 79 experts from 18 countries and international organizations, and the symposium was attended by 279 invited participants. The objectives of this workshop and symposium were to explore feasible roadmaps to a low-carbon society for developed and developing countries. As a result of workshop discussions, including several intensive group discussions around four important topics, a "Call for Action" from the series of three workshops and an "Executive Summary" of the 3rd workshop were summarized and delivered to the 4th Ministrial Meeting of the Gleneagles-Dialogue on Climate Change, Clean Energy and Sustainable Development in Chiba, 2008.

## The13th AIM Workshop

February 16-18, 2008
National Institute for Environmental Studies
Tsukuba, Japan

The 13th AIM international workshop was held and attended by a total of 40 experts, including co-researchers from India, China, Thailand, Korea, Malaysia, Indonesia, and France. The participants discussed the activities of AIM during fiscal year 2006, on both a national scale in Asia and a global scale, including, activities on emission inventory and modeling, environmental modeling, impact modeling, low-carbon society project and roadmap toward low-carbon society. They also discussed and shared ideas for further activities in the new fiscal year and future AIM modeling over the next few years.

COUNTRY
No.Title
Collaborating Institution
NIES Partner (As of Latest Review Meeting)

CANADA
1. Elucidation of the cycling and transformation of chemical substances in the North Pacific Ocean
Dept. Chemistry, University British Columbia
Environmental Chemistry Division
2. Monitoring of the atmosphere-ocean carbon dioxide exchange rate
Center for Ocean Climate Chemistry, Institute of Ocean Sciences
Global Environment Division

CHINA
1. Advanced wastewater treatment processes for China
Research Institute for Environmental Engineering/Dept. Environmental Engineering, Tsinghua Univ.
Research Center for Material Cycles and Waste Management
2. Advanced sewage treatment processes by soil system applicable to China
Institute of Applied Ecology, Chinese Academy of Sciences
Research Center for Material Cycles and Waste Management
3. Development of wastewater and water resources treatment processes applicable to China
Chinese Research Academy of Environmental Sciences
Research Center for Material Cycles and Waste Management
4. Research on the development of water pollution control techniques for the Taihu Lake in China by bio/ecoengineering
Chinese Research Academy of Environmental Sciences
Research Center for Material Cycles and Waste Management
5. Dioxins analysis and survey of dioxins sources in China
Sino-Japan Friendship Center for Environmental Protection
Environmental Chemistry Division
6. Development of eco-engineering technologies for the control of eutrophication in the drainage area Honfeg Lake and Baihua Lake in China Guizhou
Guizhou Provincial Environmental Protection Bureau
Research Center for Material Cycles and Waste Management
7. Study on transport mechanism of *kosa* aerosol to Japan by way of Beijing
Sino-Japan Friendship Center for Environmental Protection
Environmental Chemistry Division
8. Research on development of suitable technologies to control greenhouse gas emissions during the treatment of domestic wastewater using bio-eco engineering system
Shanghai Jiao Tong University
Research Center for Material Cycles and Waste Management
9. Molecular epidemiological studies on the health effects of arsenic
Institution of Environmental Health and Engineering, Chinese Academy of Preventive Medicine
Environmental Health Sciences Division
10. Research on VOCs and ammonia emissions in China
Chinese Research Academy of Environmental Science
Atmospheric Environment Division
11. Studies on Techniques to control emission of Acid-Precursors in East Asia on evaluation of impact of their application on the environment
State Environmental Protection Administration
Atmospheric Environment Division
12. Environmental Impact Assessment of Dams & Floodgates and River Ecosystem Restoration in Huai River, China
Key Lab. of Water Cycle & Related Land Surface Processes
Institute of Geographical Science and Natural Resource Research
Chinese Academy of Sciences （CAS）

CZECH
1. Biogeochemical studies on the acidic deposition and pollutions
Institute of Landscape Ecology, Czech Academy of Sciences
Atmospheric Environment Division
2. Perception of Landscape: From Landscape Appreciation to Landscape Planning
Institute of Landscape Ecology, Czech Academy of Sciences
Social and Environmental Systems Division

FRANCE
1. A molecular biological study for mechanisms of environmental adaptation plants
University of Picardie
Environmental Biology Division
2. Biodiversity of microalgae obtained from the Atlantic and the Pacific Ocean
University of Caen
Environmental Biology Division

KOREA
1. Aircraft and ground-based observations of acidic and/or oxidative pollution in East Asia
Environment Research Center, Korean Institute of Science and Technology
Atmospheric Environment Division
2. Cross-cultural comparison of landscape evaluation between Japanese and Korean People
Kyung Pook University
Social and Environmental Systems Division
3. Study on the monitoring of harmful algal bloom and effects of nitrogen and phosphorus
National Institute of Environmental Research
Research Center for Material Cycles and Waste Management
4. Study on the marine pollution using ship-of-opportunity
Korea Ocean Research and Development Institute
Water and Soil Environment Division
5. Research on the prevention and management of environmental disease
National Institute of Environmental Research (NIER)
Environmental Health Sciences Division

POLAND

1. Molecular mechanisms of plant adaptation to atmospheric stresses
   Plant Breeding and Acclimatization Institute
   Biodiversity Conservation Research Project

RUSSIA

1. Airborne measurement of greenhouse gases over Siberia
   Central Aerological Observatory
   Center for Global Environmental Research
2. Modeling of methane emission rates from natural wetlands
   Institute of Microbiology
   Center for Global Environmental Research
3. Measurement of methane emission rates from permafrost areas
   Permafrost Institute
   Center for Global Environmental Research
4. Greenhouse gases budget of land ecosystems in Siberia
   Institute of Microbiology RAS
   Center for Global Environmental Research
5. Greenhouse gas monitoring to estimate the sink and source distribution in West Siberia
   Institute of Atmospheric Optics
   Center for Global Environmental Research
6. Conservation of genetic resources on wild animals in Khabarovsk region
   Russian Federation Ministry of Natural Resources
   Bolonski State Natural Reserve Laboratory
   Laboratory of Intellectual Fundamentals for Environmental Studies

SWEDEN

1. Underway measurement of $pCO_2$ in the surface water of the Arctic Ocean
   Göteborg University
   Climate Change Research Project
2. Health risk assessment of heavy metal exposure: Effects of increase in human activity
   Karolinska Institute
   Environmental Health Sciences Division

U. K.

1. Cooperation on the development and application of coupled chromatography-accelerator mass spectrometry techniques
   University of Oxford
   Environmental Chemistry Division

U. S. A.

1. Joint implementation of ocean surface $CO_2$ observation in the Pacific Ocean to understand the oceanic sink of $CO_2$
   Pacific Marine Environmental Laboratory, NOAA
   Climate Change Research Project
2. Collaboration on greenhouse gas observation from space
   Jet Propulsion Laboratory
   Center for Global Environmental Research
3. Joint implementation of $CO_2$ flux observations for the identification of carbon fixation ability of forests and the prediction of its fluctuation
   Department of Energy (DOE)
   Center for Global Environmental Research
4. Comparative, standardized and complementary measurement of atmospheric constituents for the evaluation of terrestrial /oceanic sources and sinks of carbon, other non-$CO_2$ greenhouse gases and aerosols
   Climate Monitoring and Diagnostics Laboratory, NOAA
   Center for Global Environmental Research

| | |
|---|---|
| CANADA | Agreement between the National Institute for Environmental Studies, Japan (NIES) and the Institute of Ocean Sciences (1995). |
| CHINA | Memorandum of Understanding (MoU) between NIES and the Sino-Japan Friendship Center for Environmental Protection of the State Environmental Protection Administration of the People's Republic of China on Cooperation in the Field of Environmental Protection (2006)<br>MoU between NIES and Zhejiang Ocean University, China: Cooperative Research on Adaptive Management for the Marine Ecological Environment and Biological Resources of East China Sea (2007) |
| INDIA | MoU between NIES and Anna University, Chennai, India: Collaborative Research on Atmospheric Science (2006). |
| MONGOLIA | MoU between NIES and the National Agency for Meteorology, Hydrology and Environment Monitoring, Mongolia: Joint Research on Quality Assurance/Quality Control (QA/QC) of the Dust and Sandstorm (DDS) Monitoring Network System in Mongolia and the Data Analysis for Early Warning Implemented (2007) |
| RUSSIA | Agreement on Cooperative Research Projects between NIES, Environment Agency of Japan, and Institute of Atmospheric Optics, Russian Academy of Sciences（1997）<br>MoU on Joint Research concerning the Evaluation of Genetic and Cell Preservation of Rare Birds (2007) |
| THAILAND | MoU between NIES and Kasetsart University, Thailand: Joint Research related to the Cryo-Phoenix Project (2007) |
| UN | MoU referring to the Establishment and Operation of a GRID-compatible Center in Japan (1991). |
| UNEP | MoU between NIES and UNEP Risø Centre on Energy, Climate and Sustainable Development, Denmark: Joint Research on Global Energy-Economic Modeling (2007) |

## Host Division

**Researcher**, COUNTRY, Research Period
Research Subject (Host Researcher)

## Center for Global Environmental Research

**Schutgens,** Nicolaas Alexander Johannes, HOLLAND, 2007.5.09～2008.3.31
A study of aerosol and cloud information retrievals from the data of the CAI sensor aboard GOSAT (Yokota, T. / Higurashi, A.)

**Shukla,** Priyadarsh R, INDIA, 2007.6.15～2008.3.31
Development of AIM/India for analyzing the countermeasures of climate change (Kainuma, M.)

**Valsala,** Vinu, INDIA, 2007.10.1～2009.9.30
A robust estimation of the ocean-atmosphere exchanges of Carbon dioxide($CO_2$) (Shamil, M.)

**Wang,** Quan,CHINA, 2007.4.02～2008.3.31
Carbon dioxide flux monitoring in terrestrial ecosystems (Fujinuma, Y. / Liang, N.)

**Zhao,** Yanmin,CHINA, 2007.10.05～2008.3.31
Study on the response of soil microble respiration on global warming of Japanese forest ecosystems (Liang, N.)

## Research Center for Material Cycles and Waste Management

**Fan,** Bin, CHINA, 2007.4.01～2007.11.5
Informal landfill's remediation and groundwater contamination control (Inoue, Y.)

**Kong,** Hai-nan, CHINA, 2007.4.02～2008.3.31
Technological development for liquid wastes using bio-eco engineering system (Xu, K.)

**Li,** Yu-you, CHINA, 2007.4.02～2008.3.31
Technological development for hydrogen and methane fermentation from biomass (Xu, K.)

**Wang,** Yanhua, CHINA, 2007.5.09～2008.3.31
Characteristics of wastewater treatment and green house gases emission by aquatic-plant and soil purification systems (Xu, K.)

**Zhang,** Jixiang, CHINA, 2007.4.23～2008.3.31
Model analysis of aquatic-plant and soil purification systems as ecological engineering (Xu, K.)

## Research Center for Environmental Risk

**Baek,** Hae jun, KOREA, 2008.2.04～2008.2.17
Study for geographic distribution of Batrachochitrium dendrobatidis over Asian area (Goka, K.)

**Lee,** Jeong Hoon, KOREA, 2007.4.23～2007.11.30
Responses of fishes caused by marine environmental stressors at population/community levels (Horiguchi, T.)

**Li,** Chunmei, CHINA, 2007.4.05～2009.4.4
Effects of diesel exhaust with enrich-nanoparticles on reproductive and endocrine function (Suzuki, A.)

**Puzyn,** Tomasz, POLAND, 2007.9.13～2008.9.12
Development of linked QSPR-MM model for the assessment of Pop-like characteristics of chemicals (Suzuki, N.)

**Sediqyar,** Manila, AFGHANISTAN, 2007.5.09～2008.3.31
Effects of chemical compounds in diesel exhaust on Japanese quails (Suzuki, A.)

**Tin-Tin-Win-Shwe**, MYANMAR, 2007.4.01～2008.3.31
Analysis of the effect of nanoparticles on neuro-immune axis using Push-pull perfusion technique (Fujimaki, H.)

**Tremblay,** Louis, CANADA, 2008.1.14～2008.2.29
Evaluation of the combined effect of hypoxia and harmful chemical substances to marine organisms (Horiguchi, T.)

## Asian Environment Research Group

**Gao,** Ting, CHINA, 2007.10.01～2008.3.31
Study on water environment restoration technology and watershed management (Xu, K.)

**Lun,** Xiaoxiu, CHINA, 2007.4.02～2007.9.30
Studies on organic aerosols transported from East Asia (Takami, A.)

**QI,** Yu, CHINA, 2007.11.1～2008.3.31
Design and evaluation system for industrial symbiosis technologies and policies in Asian metropolises (Fujita, T.)

**Qiu,** Guoyu, CHINA, 2007.4.01～2007.4.11
Response of garden bryophytes and lichens to global warming and its monitoring with thermal image (Shimizu, H.)

**Tang,** Changyuan, CHINA, 2007.4.02～2008.3.31
Degradation of ground water resources in river basin (Murakami, S.)

**Tian,** Hezhong, CHINA, 2007.9.19～2009.9.18
Development and verification of emission inventory for air pollutants in East Asia (Ohara, T.)

**Xu,** Zhenzhu, CHINA, 2007.11.5～2009.11.4
Climate change impacts on dominant species in the severely deteriorated ecosystem of north China grassland (Shimizu, H.)

## Social and Environmental Systems Division

**Geng,** Xin, CHINA, 2007.11.06～2008.3.31
Research on Eight Views (Aoki, Y.)

**Lee,** Lyong-Tae, KOREA, 2007.4.02～2008.3.15
Mitigation of thermal stress by a large restoration of inner-city river (Cheong-Gye Stream in Seoul) (Ichinose, T.)

**Morse,** Zac, Republic of the Fiji Islands, 2007.10.29～2008.3.31
Study on adaptation policy in a Post-2012 framework (Kubota, I.)

**Sha,** Weiming, CHINA, 2007.4.02～2008.3.31
Development and application of a high-resolution urban meteorological LES numerical model in Cartesian Coordinate (Ichinose, T.)

**WU,** En, CHINA, 2007.7.04～2008.3.31
Effects of climatic conditions and cultural backgrounds to environmental perception (Aoki, Y.)

**Yang,** Yufang, CHINA, 2007.4.01～2008.3.31
Research on effect of thermal environmental mitigation by neat circulation through Tokyo Bay (Ichinose, T.)

**Zhang,** Xiaoxi, CHINA, 2007.6.20～2008.3.31
Outlook for household energy demand and its reduction potential in Shenyang City, China (Masui, T.)

## Environmental Health Sciences Division

**Shi,** Jia, CHINA, 2007.9.3～2008.3.31
Effects of environmental chemicals on endometriosis (Takano, H.)

### Atmospheric Environment Division

**Vaidyanathan,** Venkatesan, INDIA, 2007.4.01～2008.3.31
Spectroscopic studies of the formation of secondary organic aerosol compounds (Imamura, T.)

**Zhou,** Libo, CHINA, 2007.4.02～2008.3.31
An analysis study of inter annual variations of the ozone layer (Akiyoshi, H.)

### Water and Soil Environment Division

**Ayoub,** Sameh, Reyad, Egypt, 2007.4.02～2008.3.31
Study on remediation techniques of soil and groundwater pollution with hazardous chemicals (Inaba, K.)

**Guo,** Hong, CHINA, 2007.4.02～2008.3.31
Characterization of dissolved organic matter in lake (Imai, A.)

**Yoochatchaval,** Wilasinee, THAILAND, 2007.4.23～2007.9.30
Study on methane fermentation technology for low strength wastewater treatment (Shutsubo, K.)

### Environmental Biology Division

**Cho,** Kyoungwon, KOREA, 2007.4.01～2008.2.20
Proteomics and genomics of ozone induced changes in the cereal crop genome model rice cultivar Nipponbare (Kubo, A.)

**Kim,** Keumhwa, KOREA, 2007.11.28～2008.2.20
Search by proteomics for proteins showing altered expression levels in transgenic rice plants (Kubo, A.)

**Li,** Cui, CHINA, 2007.4.02～2007.6.30
Genetic diversity of *Potentilla fruticosa* in relation to elevation change on the Qinghai-Tibetan Plateau (Tang, Y.)

**Saghar,** Zarenezhad, IRAN, 2007.9.10～2008.3.31
Phylogenetic and toxicological studies on toxic cyanobacteria (Kasai, F.)

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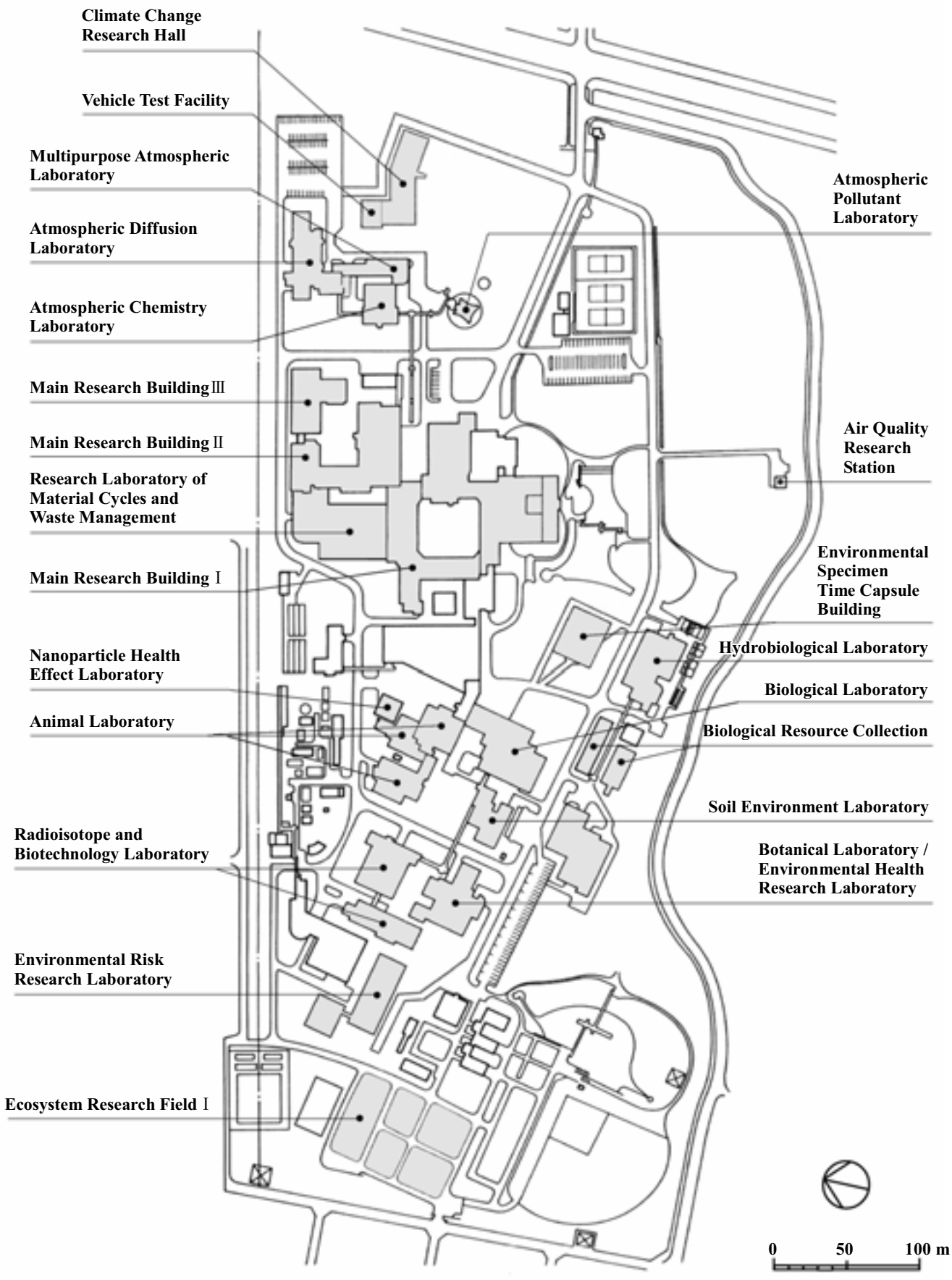
Climate Change Research Hall
Vehicle Test Facility
Multipurpose Atmospheric Laboratory
Atmospheric Diffusion Laboratory
Atmospheric Chemistry Laboratory
Main Research Building Ⅲ
Main Research Building Ⅱ
Research Laboratory of Material Cycles and Waste Management
Main Research Building Ⅰ
Nanoparticle Health Effect Laboratory
Animal Laboratory
Radioisotope and Biotechnology Laboratory
Environmental Risk Research Laboratory
Ecosystem Research Field Ⅰ
Atmospheric Pollutant Laboratory
Air Quality Research Station
Environmental Specimen Time Capsule Building
Hydrobiological Laboratory
Biological Laboratory
Biological Resource Collection
Soil Environment Laboratory
Botanical Laboratory / Environmental Health Research Laboratory
0 50 100 m

**Air Quality Research Station**

Automatic instruments for monitoring the concentrations of seven atmospheric constituents ($NO_x$, $SO_2$, $O_3$, methane and non-methane hydrocarbons, suspended particulate matter, and gaseous Hg) are operated at this station. Wind speed, precipitation, atmospheric pressure, visible and UV radiation, temperature, and other atmospheric characteristics are also measured, and the results are made available to NIES researchers as the fundamental data for various studies. The stability and accuracy of the automated measurements and factors that interfere with them are studied, and new instruments developed for atmospheric monitoring, such as $PM_{2.5}$ monitoring instruments, are evaluated.

**Animal Laboratory**

The animal laboratory has three controlled-environment facilities. Facility I has breeding rooms for specific-pathogen-free laboratory animals, and complex gas or diesel exhaust particle (DEP) exposure chambers for investigating the health effects of $PM_{2.5}$ or DEPs. Facility II has a conventional laboratory animal breeding unit and laboratories for studies on the effects of chemicals, including dioxins and heavy metals. As to Facility III, see Nanoparticle Health Effect Laboratory section.

**Atmospheric Chemistry Laboratory**

This laboratory has a 6-$m^3$ evacuable chamber with an inner surface coated with Teflon. The chamber is used to study atmospheric chemical reactions. This facility is essential to our research on atmospheric pollution, including photochemical ozone formation, degradation of volatile organic compounds, secondary aerosol formation, and other important atmospheric phenomena.

**Atmospheric Diffusion Laboratory**

A wind tunnel is housed in this laboratory. Our wind tunnel is exceptional in that wind velocity (down to 0.2 m $s^{-1}$), air temperature, and floor temperature can be controlled independently to create various atmospheric conditions. Temperature and wind velocity sensors on a computer-controlled gantry can be positioned at arbitrary location to obtain three-dimensional data. These features, together with the use of models of buildings or mountains in the tunnel, allow accurate simulation of air flow and pollutant transport in a variety of real-world situations.

**Biological Laboratory**

This facility consists of controlled greenhouses and growth cabinets used to evaluate the effects of various detailed environmental scenarios on organisms. It includes experimental chambers in which light, temperature, and humidity can be precisely controlled. It facilitates exposure of experimental plants to pollutant gases under these controlled conditions.

**Biological Resource Collection**

The collection is equipped with various standalone incubators (5 to 50 ºC), culture rooms (10 to 22 ºC), a programmable freezer, a liquid nitrogen supply system with sixteen 245-L tanks, a scanning electron microscope, various types of light microscopes, and molecular taxonomy equipment. Two projects are conducted in the collection. One is the Microbial Culture Collection (known as NIES-Collection) and the other is *ex situ* conservation of endangered algae. In these two projects, the collection maintains a total of about 2100 strains of microalgae, protozoa, and endangered macroalgae.

**Climate Change Research Hall**

The Hall was completed in March 2001 and has three floors with a total area of 4900 $m^2$. Three major research programs are conducted in this facility: (1) development and implementation of climate change models based on various socioeconomic and emissions scenarios; (2) monitoring of atmospheric constituents to evaluate ocean and terrestrial carbon sinks; and (3) assessment of forest sinks by remote sensing, forest modeling, and use of statistical data. In addition, it includes equipment to evaluate low-emission vehicles.

**Ecosystem Research Fields**

Main Field I, on the NIES campus, and the Branch Field, 4 km to the west, include experimental fields

for various types of plant-dominated ecosystems, lysimeters, greenhouses observation towers, and laboratories. These fields are used to explore ecosystem processes under regulated outdoor conditions; to develop remote-sensing techniques from small-scale ground truth data; and to supply plants, particularly for bioassays and mitigation studies.

**Environmental Risk Research Laboratory**

This Laboratory is the core research facility of the Research Center for Environmental Risk. Its staff conduct extensive studies of ecological effects, human health effects, and environmental exposure, and collect, analyze, and disseminate related information. The building is equipped with several special facilities, including freshwater and marine exposure systems for ecotoxicological research, a room for breeding laboratory animals, and instruments such as a liquid chromatograph – tandem mass spectrometer for the qualitative and quantitative analysis of environmental chemicals, and a confocal laser scanning microscope for cell biology.

**Environmental Specimen Time Capsule Building**

The strategic and systematic storage of environmental samples and biological specimens provides an important knowledge base and is essential for environmental research. For example, such samples and specimens are needed to study long-term trends in environmental pollutants and to verify past conditions when new types of pollution have been identified. NIES constructed this building to provide central facilities for the long-term storage of environmental specimens such as mussels and air particulates, as well as cells and the genetic material of threatened species.

**Forest ecosystem sites for monitoring carbon sequestration**

These monitoring facilities were established to study the carbon balance of terrestrial ecosystems and to evaluate the methods used to monitor this balance. All three sites are located in planted larch forests: one in Yamanashi Prefecture and two in Hokkaido, Japan's northernmost prefecture.

***1) Fuji Hokuroku Flux Observation Site***

This site was established in January 2006 in a forest composed mainly of planted larches in the foothills of Mt. Fuji in Yamanashi Prefecture. It is used to investigate the magnitude of the carbon sources and sinks in terrestrial ecosystems. It also serves as the principal monitoring site of the AsiaFlux network, an organization that promotes cooperation and the exchange of information on carbon flux observation in Asia.

***2) Teshio Carbon Cycle and Larch Growth Experimental Site***

This site, established in 2001, comprises one catchment in Hokkaido University's Teshio Experimental Forest in Horonobe, Hokkaido. At this site, we are focusing our research on the transition of carbon flow during the tree growing period. After the felling of a natural forest (coniferous and broadleaf trees) in February 2003, we planted larch saplings in October of the same year. We are now using standard forestry practices to manage these saplings and are monitoring the carbon flux.

***3) Tomakomai Flux Research Site***

This site was established in August 2000 in a planted larch forest in the foothills of Mt. Tarumae, Tomakomai, Hokkaido. Unfortunately, it was destroyed by a typhoon in September 2004. Since June 2005, we have been using the restored site to study the transition of the carbon balance in the devastated forest.

**Global Environmental Monitoring Stations (Hateruma and Cape Ochi-ishi)**

These monitoring stations were set up mainly to monitor long-term changes in the baseline levels of greenhouse gases at remote sites in Japan. The island of Hateruma is located in Okinawa Prefecture and is the nation's southernmost inhabited island. The monitoring station was constructed on the eastern edge of the island. Cape Ochi-ishi Station is located in the eastern part of Hokkaido. These stations use automated systems for high-precision monitor-

ing of greenhouse gases (e.g., $CO_2$, $CH_4$, $N_2O$, $O_3$) and other atmospheric species ($NO_x$, $SO_2$, suspended particulate matter). Long-term monitoring data are archived and distributed through the Center for Global Environmental Research homepage and the World Data Center for Greenhouse Gases.

**Hydrobiological Laboratory**

The Hydrobiological Laboratory was established to study organism-related environmental problems in water bodies. The toxicity testing system is suitable for long-term exposure studies. Other associated facilities include temperature- and light-controlled culture rooms, axenic culture rooms, large autoclaves, and an outdoor experimental pond. Some laboratories can be used for chemical and biological experiments on water and soil environment restoration and liquid waste treatment

**Main Research Building Ⅰ**

The building houses analytical instruments and support facilities such as clean rooms. These instruments permit accurate, highly sensitive, and selective detection of harmful substances in environmental samples. Stable isotope analyses facilitate research on global warming and the origins of pollutants. Among the instruments (listed below) are some that are used for research and development of new analytical methods.

**Table of analytical instrumentation in Main Research Building I**

| **Standard instruments (free access to institute researchers)** |
|---|
| Gas chromatograph – mass spectrometer |
| Gas chromatograph with atomic emission detector |
| Scanning electron microscope |
| Transmission electron microscope |
| Ultraviolet/visible microscope spectrophotometer |
| Inductively coupled plasma emission spectrometer |
| Atomic absorption spectrometer |
| X-ray fluorescence spectrometer |
| X-ray photoelectron spectrometer |
| Stable isotope mass spectrometer (for gas samples) |
| Fourier transform infrared spectrometer |
| Nuclear magnetic resonance spectrometer |
| Flow cytometer |
| High-speed amino acid analyzer |
| **Special instruments (restricted access)** |
| Gas chromatograph – mass spectrometer |
| High-performance liquid chromatograph – mass spectrometer |
| Inductively coupled plasma mass spectrometer |
| Secondary ion mass spectrometer |
| High-resolution mass spectrometer |
| High-precision stable isotope mass spectrometer (for gas samples) |
| Thermal (surface) ionization mass spectrometer (for stable isotopes) |
| Atmospheric pressure ionization mass spectrometer |
| Laser Raman spectrometer |
| X-ray diffractometer |

**Main Research Building II**

***Preservation Laboratory***

This facility includes –20 ºC, 5 ºC, and 20 ºC temperature-controlled rooms where various environmental samples collected by field researchers are stored until they are put to practical use. The facility was previously used for environmental specimen banking; samples collected previously for long-term environmental monitoring have now been transferred to the Time Capsule Building.

**Main Research Building III**

***1) Tandem mass spectrometer (MS/MS)***

Two double-focus-type mass spectrometers are connected serially (in tandem). The resolution of the first is $6.5 \times 10^4$ and that of the second is $5 \times 10^3$. Ions selected by the first MS are passed through the collision cell, where the ions yield fragments that are analyzed by the second MS. The chemical structures of complex molecules can be determined with this instrument.

***2) NIES-TERRA: accelerator mass spectrometer (AMS) facility***

An electrostatic tandem accelerator of 5 million V (max.) terminal voltage is interfaced with two ion sources and an analytical mass spectrometer. Isobaric atomic ions can be distinguished by the electrical charges of their nuclei. The AMS is a very sensitive and selective tool for atomic ion detection and is used for measuring long-lived radioisotopes such as $^{14}C$ and $^{10}Be$. These radioisotopes are used as tracers and time-markers (dating agents) in environmental research.

***3) Hazardous Chemicals Area***

Experiments using highly toxic substances such as dioxins (chlorinated dibenzodioxins), polychlorinated biphenyls, and polychlorinated dibenzofurans are conducted in this area. The air pressure inside the area is maintained below atmospheric pressure to prevent leakage of hazardous substances. Exhaust air is treated by high-efficiency particulate air (HEPA) filters and charcoal filters; discharge water is also treated with a charcoal filter system. The Hazardous Chemicals Area contains an analytical lab with a gas chromatograph – mass spectrometer and a microcosm, as well as facilities for microorganism-related research, animal exposure experiments, and measurements of the physical and chemical properties of substances.

***4) GOSAT Data Handling Facility***

The Greenhouse Gases Observing Satellite (GOSAT) Data Handling Facility (DHF) performs stationary processing of GOSAT data. The facility's tasks include data reception from JAXA, processing, reprocessing, and storage; validation of the processed products; and data distribution. The major part of GOSAT DHF is located at NIES, but there are some external facilities to achieve the total function. A critical design review of the development of the DHF system was completed in 2007,and the development is now proceeding to achieve the design. In addition, a second procurement of hardware of the GOSAT DHF was completed.

***5) Millimeter-wave spectrometer for observation of atmospheric ozone***

The millimeter-wave spectrometer measures the emission spectra from rotational transition of ozone molecules in the stratosphere and mesosphere with extremely high resolution. Vertical profiles of ozone from 14 to 76 km are retrieved by using the dependence of the width of the ozone emission spectra on altitude. The spectrometer was installed in 1995. Since then, ozone has been monitored continuously, except on rainy days and heavily humid days.

***6) Facility for receiving and processing NOAA satellite data***

The Advanced Very High Resolution Radiometer (AVHRR) instruments orbit Earth on US National Oceanic and Atmospheric Administration (NOAA) satellites. They monitor five electromagnetic wavelength bands from the visible to the thermal infrared region with high temporal and moderate spatial resolution (about 1 × 1 km). The AVHRR facility of NIES was able to receive the data up to March 2004.

The data received up until that time are being processed and archived by the facility.

***7) Global Resource Information Database (GRID)-Tsukuba information processing center***

GRID-Tsukuba is part of the CGER. The GRID information processing system was introduced at NIES in 1994. This remote-sensing image-processing system and geographic information system processes GRID data and produces original datasets. Several software packages, including ERDAS/IMAGINE, ARC/INFO, IDRISI, and GRASS, are installed on workstations and PCs.

**Nanoparticle Health Effect Laboratory**

This laboratory is equipped with experimental facilities to provide new information on the health effects, chemical and physical properties, behavior, and translocation of nanoparticles. It has four inhalation chambers that were designed for studies of chronic health effects.

**Oku-Nikko Field Research Station**

The field station in Oku-Nikko, Tochigi Prefecture, consists of an observatory and a control and management building. These facilities are used both to confirm the operation of measuring devices developed under field conditions and to monitor dates when Japanese larch put forth leaves in early spring.

**Radioisotope and Biotechnology Laboratory**

This laboratory is used to develop applications of recombinant DNA technology for environmental protection and to study the fate and effects of recombinant organisms in ecosystems. The laboratory's specialized instruments, including peptide and DNA sequencers, are available on the first floor. The second floor is a radioisotope-controlled area used for studies of the transport, accumulation, chemical conversion, and toxicity of environmental pollutants in plants, animals, soil, water, and the atmosphere.

**Research Laboratory of Material Cycles and Waste Management**

In March 2002, NIES established the Research Laboratory of Material Cycles and Waste Management. This laboratory supports research on resource circulation and waste management, including resource recovery and recycling of waste. It also develops technologies for testing, evaluation and monitoring to reduce environmental risk and restore polluted sites.

**Research Station for the Preservation and Enhancement of the Water Environment**

***1) Lake Kasumigaura Water Research Laboratory***

This field station, located on the shore of Lake Kasumigaura, is used as a common research facility by many NIES researchers. The station's location allows *in situ* studies of pollution, water quality recovery, lake ecosystem dynamics, and elemental cycles in this heavily eutrophicated lake.

***2) Bio-Eco Engineering Research Laboratory***

This laboratory studies, develops, and field-tests liquid waste treatment and resource recovery systems such as the *Johkasou* system, hydrogen–methane fermentation systems, phosphorus recovery systems, and aquatic plant–soil purification systems. Domestic wastewater samples are used to develop and evaluate liquid waste treatment technologies. Air and wastewater temperatures are controlled to simulate the four seasons in Japan and the climates of Asian countries. Many people employed in research institutes, universities, government, and private companies visit the laboratory. The laboratory also plays an important role as a core facility for international cooperative research.

**Rikubetsu Stratospheric Monitoring Station**

NIES has been monitoring the stratospheric ozone over Hokkaido in collaboration with the Solar–Terrestrial Environment Laboratory (STEL) at Nagoya University. Monitoring is also performed in a room of Hokkaido's Rikubetsu Astronomical Observatory, which is run by the Rikubetsu town council. The observatory monitors harmful ultraviolet rays (by Brewer spectrometer) and the vertical distribution of stratospheric ozone (by millime-

ter-wave radiometer). The aim is to reveal ozone variations in the stratosphere and the effects of the Arctic ozone depletion. Since parts of the polar vortex sometimes arrive over Hokkaido in winter or spring, Rikubetsu is one of the sites used to study the effects of the ozone depletion in the Arctic.

**Soil Environment Laboratory**

The Soil Environment Laboratory contains unique large and small monolithic lysimeters in which the behavior of pollutants such as heavy metals, nitrates, and sulfates are investigated. The effects of pollutants on soil ecosystems (including the soil–organism–plant system) are also investigated.

**Vehicle Test Facility**

The Vehicle Test Facility is equipped with an environment simulation room, a chassis dynamometer, on-board fuel economy and emission measurement systems, conventional exhaust measurement systems, and devices originally developed by NIES, including an exhaust gas dispersion chamber and a dilution tunnel with high dilution ratio capacity, in order to measure and evaluate real-world vehicle exhaust and performance.

**Number of personnel**

| | |
|---|---|
| President | 1 |
| Executive Director | 2 |
| Auditor | 2 |
| Planning Division | 8 |
| General Affairs Division | 32 |
| Audit Section | 2 |
| Center for Global Environmental Research | 26 |
| Research Center for Material Cycles and Waste Management | 21 |
| Research Center for Environmental Risk | 27 |
| Asian Environment Research Group | 21 |
| Social and Environmental Systems Division | 14 |
| Environmental Chemistry Division | 16 |
| Environmental Health Sciences Division | 13 |
| Atmospheric Environment Division | 12 |
| Water and Soil Environment Division | 15 |
| Environmental Biology Division | 20 |
| Laboratory of Intellectual Fundamentals for Environmental Studies | 9 |
| Environmental Information Center | 9 |
| Total | 250 |

**Fields of expertise**

| | |
|---|---|
| Basic Sciences | 74 |
| Engineering | 64 |
| Agricultural Sciences | 25 |
| Medical Sciences | 16 |
| Pharmaceutical Sciences | 7 |
| Fisheries Sciences | 3 |
| Economics | 2 |
| Law | 1 |
| Total | 192 |

| Division<br>Section/Team | Position | Staff Member |
|---|---|---|
| **Headquarters** | President | OHTSUKA, Ryutaro |
| | Executive Director (Research) | YASUOKA, Yoshifumi |
| | Executive Director (Management) | OHTA, Susumu |
| | Auditor | FUNABASHI, Motohisa |
| | Auditor | KOBAYASHI, Nobuyuki |
| **Planning Division** | Director | MATSUI, Yoshimi |
| | Deputy Director | OTSUBO, Kuninori |
| | Deputy Director | KISHIBE, Kazumi |
| | Principal Research Coordinator (*) | UEHIRO, Takashi |
| | Principal Research Coordinator (*) | TANABE, Kiyoshi |
| Planning Office | Chief (*) | KISHIBE, Kazumi |
| | Research Coordinator | YOKOI, Michitaka |
| Research Coordination Office | Chief (*) | OTSUBO, Kuninori |
| | Research Coordinator (*) | TASAKI, Tomohiro |
| | Research Coordinator (*) | WATANABE, Hidehiro |
| | Research Coordinator (*) | SUGITA, Takafumi |
| Office of Public Relation and International Coordination | Chief | SATO, Kuniko |
| | Research Coordinator | HIROKANE, Katsunori |
| **General Affairs Division** | Director | SHIBAGAKI, Taisuke |
| General Affairs Section | Chief | KUWATA, Nobuo |
| Accounting Section | Chief | SUZUKI, Yoshimitsu |
| Facility Management Section | Chief | KUME, Hideyuki |
| **Audit Section** | Chief | HIRAO, Yoshinori |
| **Center for Global Environmental Research** | Director | SASANO, Yasuhiro |
| | Deputy Director | NOJIRI, Yukihiro |
| | Special Senior Researcher | Shamil Maksyutov |
| | Special Senior Researcher | YAMAGATA, Yoshiki |
| Global Carbon Cycle Research Section | Chief | MUKAI, Hitoshi<br>LIANG, Naishen<br>TAKAHASHI, Yoshiyuki |
| Satellite Remote Sensing Research Section | Chief | YOKOTA, Tatsuya<br>MORINO, Isamu<br>YAMANO, Hiroya |

(*) Multiple roles

| | | |
|---|---|---|
| Climate Risk Assessment Research Section | Chief | EMORI, Seita<br>TAKAHASHI, Kiyoshi<br>OGURA, Tomoo<br>ITO, Akihiko |
| Climate Policy Assessment Research Section | Chief | KAINUMA, Mikiko<br>KAMEYAMA, Yasuko<br>FUJINO, Junichi<br>HANAOKA, Tatsuya |
| Office for Atmospheric and Oceanic Monitoring | Chief | MACHIDA, Toshinobu<br>SHIRAI, Tomoko |
| Office for Terrestrial Monitoring | Chief | SAIGUSA, Nobuko<br>OGUMA, Hiroyuki |
| Office for Global Environmental Database | Chief | MATSUNAGA, Tsuneo |
| | (*) | MORIGUCHI, Yuichi |
| | (*) | NAKANE, Hideaki |
| | (*) | YOKOUCHI, Yoko |
| | (*) | ONO, Masaji |
| | (*) | TOHJIMA, Yasunori |
| | (*) | IMAI, Akio |
| | (*) | TANIMOTO, Hiroshi |
| | (*) | ICHINOSE, Toshiaki |
| | (*) | TANAKA, Atsushi |
| | (*) | ARAMAKI, Takahumi |
| | (*) | MATSUSHIGE, Kazuo |
| **Research Center for Material Cycles and Waste Management** | Director<br>Deputy Director<br>Research Coordinator (*) | MORIGUCHI, Yuichi<br>INOUE, Yuzo<br>YOKOI, Michitaka |
| Sustainable Material Cycles System Section | Chief (*) | MORIGUCHI, Yuichi<br>HASHIMOTO, Seiji<br>NANSAI, Keisuke |
| International Material Cycles Section | Chief | TERAZONO, Atsushi<br>YOSHIDA, Aya |
| Material Cycles System Engineering Section | Chief | OSAKO, Masahiro<br>KURAMOCHI, Hidetoshi<br>TASAKI, Tomohiro<br>FUJII, Minoru |

(*) Multiple roles

| | | |
|---|---|---|
| Recycling and Disposal Engineering Section | Chief | KAWAMOTO, Katsuya<br>YAMADA, Masato<br>ENDO, Kazuto<br>KOBAYASHI, Jun |
| Waste Testing and Assessment Section | Chief | KIDA, Akiko<br>YAMAMOTO, Takashi |
| Material and Substance Management Section | Chief | NOMA, Yukio<br>TAKIGAMI, Hidetaka<br>SAKANAKURA, Hirofumi<br>WATANABE, Mafumi |
| Bio-Eco Engineering Section | Chief (*)<br><br>(*) | MORIGUCHI, Yuichi<br>EBIE, Yoshitaka<br>XU, Kaiqin |
| **Research Center for Environmental Risk** | Director<br>Deputy Director<br>Special Senior Researcher<br>Special Senior Researcher | SHIRAISHI, Hiroaki<br>YONEMOTO, Junzo<br>HORIGUCHI, Toshihiro<br>GOKA, Kouichi |
| Exposure Assessment Research Section | Chief | SUZUKI, Noriyuki<br>SAKURAI, Takeo<br>IMAIZUMI, Yoshitaka |
| Health Risk Research Section | Chief | AOKI, Yasunobu<br>SONE, Hideko<br>NISHIMURA, Noriko<br>MATSUMOTO, Michi |
| Ecological Risk Research Section | Chief | TANAKA, Yoshinari<br>SUGAYA, Yoshio<br>TATSUTA, Haruki |
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| Environmental Sensitivity Research Section | Chief | FUJIMAKI, Hidekazu<br>ISHIDO, Masami<br>YAMAMOTO, Shoji<br>KUROKAWA, Yoshika<br>TSUKAHARA, Shinji |
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(*) Multiple roles

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|---|---|
| 4DVAR | Four-dimensional variational data assimilation |
| AEC | aerosol extinction coefficient |
| AhR | arylhydrocarbon receptor |
| AIM | Asia-Pacific Integrated Model |
| AOGCM | atmosphere-ocean general circulation model |
| APO | atmospheric potential oxygen |
| BDF | biodiesel fuel |
| BFR | brominated flame retardant |
| Biome-BGC | Global Biome Model - Biogeochemical Cycle |
| BM | basement membrane |
| CA | constitutively active |
| CAR | conditional autoregression |
| CB | carbon black |
| CGER | Center for Global Environmental Research |
| CHAAMS | Cape Hedo Aerosol and Atmosphere Monitoring Station |
| CHASER | global chemical climate model |
| CMAQ | Community Multiscale Air Quality Modeling System |
| CRM | certified reference material |
| CWRC | Changjiang Water Resources Commission |
| DEC205 | dendritic and epithelial cells, 205 kDa |
| DEHP | di-(2-ethylhexyl)phthalate |
| DOC | dissolved organic carbon |
| DOM | dissolved organic matter |
| Dp | Dermatophagoides pteronyssinus |
| ER | estrogen receptor |
| EST | Environmentally sustainable transport |
| GC-TCD | gas chromatography-thermal conductivity detector |
| GD | gestational day |
| GEO | Group on Earth Observations |
| GEOSS | Global Earth Observation System of Sytems |
| GERF | Global Environmental Research Foundation |
| GHG | greenhouse gas |
| GIS | Geographical information system |
| GOSAT | Greenhouse Gases Observing Satellite |
| GPP | gross primary production |
| HBCD | hexabromocyclododecane |
| HEV | Hybrid electric vehicle |
| HPLC-PAD | high-performance liquid chromatography with pulsed amperometric detection |
| IFN | interferon |
| Ig | immunoglobulin |
| ILAS-II | Improved Limb Atmospheric Spectrometer -II |
| IT | information technology |
| JACCO | Japanese Alliance for Climate Change Observation |
| LIDAR | light detection and randing |
| MHC | major histocompatibility complex |
| MIROC | Model for Interdisciplinary Research on Climate |
| MOE | Ministry of the Environment |
| MSW | municipal solid waste |
| MWCNT | multi-walled carbon nanotube |
| NAT | nitric acid trihydrate |
| NEDO | New Energy and Industrial Technology Development Organization |
| NICE-URBAN | NIES Integrated Catchment-based Ecohydrology for Urban |
| NMVOC | Non-Methane Volatile Organic Compounds |
| OCCCO | Office for Coordination of Climate Change Observation |
| OVA | ovalbumin |
| PAH | polycyclic aromatic hydrocarbon |
| PBDE | polybrominated diphenylether |
| PCR | polymerase chain reaction |
| PGC | primodial germ cell |
| PM | particulate matter |
| PSC | polar Stratospheric Cloud |
| PTR | proton transfer reaction |
| RAMS | regional atmospheric modeling system |
| rDNA | ribosomal RNA gene |

| | |
|---|---|
| RE | ecosystem respiration |
| REAS | Regional Emission Inventory in Asia |
| RT-PCR | real time PCR |
| SDN-POA | sexually dimorphic nucleus of the preoptic area |
| SMS | sound material-cycle society |
| SOC | sediment oxygen consumption |
| SORA project | Study on respiratory disease and automobile exhaust |
| SWAT | Soil and Water Assessment Tool |
| TDNS | total concentration of dissolved neutral sugar |
| TEM | transmission electron microscopy |
| Tg | transgenic |
| TOF | time-of-flight |
| UNEP | United Nations Environment Programme |
| W-Pass | Western Pacific Air-Sea Interaction Study |
| WWW | Worldwide Web |

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