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NIES Annual Report 2010

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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) in fiscal year 2009 (April 2009 to March 2010), the fourth year of our second five-year research plan as an incorporated administrative agency.

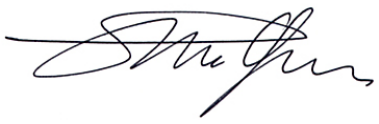
This year, all research units have pursued research in various fields based on the five-year plan formulated in 2006. About half of NIES's researchers have been involved in four priority programs: Climate Change, Sustainable Material Cycles, Environmental Risk, and the Asian Environment. The other half 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. 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, have given us a high reputation as a government-funded institute.

Our NIES Charter says:

> The National Institute for Environmental Studies (NIES) strives to contribute to society through research that fosters and protects a healthy environment for present and future generations. Proud to work at NIES and keenly aware of our individual responsibilities, we will pursue high-level research based on a firm understanding of the interaction between nature, society, and life on our planet.

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.



OHGAKI, Shinichiro.
President
October, 2010

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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, understanding 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, global environmental problems such as climate change, depletion of the stratospheric ozone layer, acid deposition, destruction of tropical rain forests, and desertification attracted greater concern 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 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-governmental 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 five-year (2001–2005) plan that corresponded to the objectives of the Ministry of the Environment.

In 2006, NIES embarked on its second five-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. NIES also 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 performed, 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 Research

Laboratory, the Fuji Hokuroku Flux Observation Site, and the Global Environmental Monitoring Stations in Hateruma and Cape Ochi-ishi.
As of April 1, 2010, the total number of NIES regular permanent staff was 247 (including 5 foreign researchers). There were also 662 non-permanent researchers, including 67 foreign researchers. The total budget for FY 2009 was 13,961 million yen.

Table 1 Number of Permanent Staff

Research	188	76.1%
Administration	44	17.8%
Environmental Information Center	10	4.0%
Executive	5	2.0%
Total	247	100%

(As of April 1, 2010)

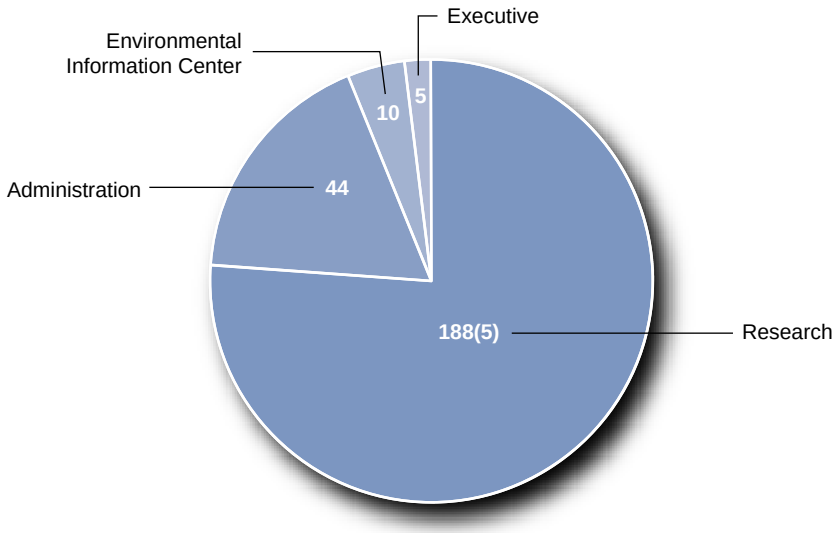
Table 2 Budget for the Second Medium-Term Plan

(Unit: million yen)

	Category	2006-2010 Budget (5 years)	Fiscal 2009 Budget
Revenues	Grant for Operating Costs	48,196	9,292
	Subsidies for Facilities	2,420	534
	Commissioned Work	20,275	4,055
	Others	70	80
	Total	70,961	13,961
Expenditures	Project Costs	30,898	6,052
	Facility Improvements	2,420	534
	Expenses for Commissioned Work	20,275	4,055
	Personnel Expenses	14,795	2,818
	General Administrative Expenses	2,573	502
	Total	70,961	13,961

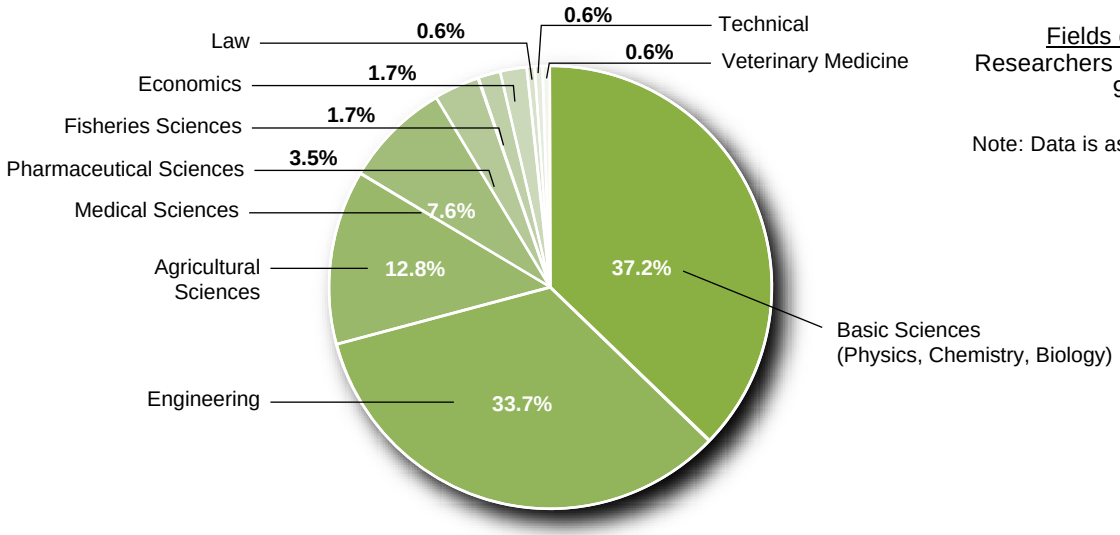
Note: The budget for each annual work plan will be requested and decided each fiscal year, based on the second medium-term (five-year) plan.

Human Resources



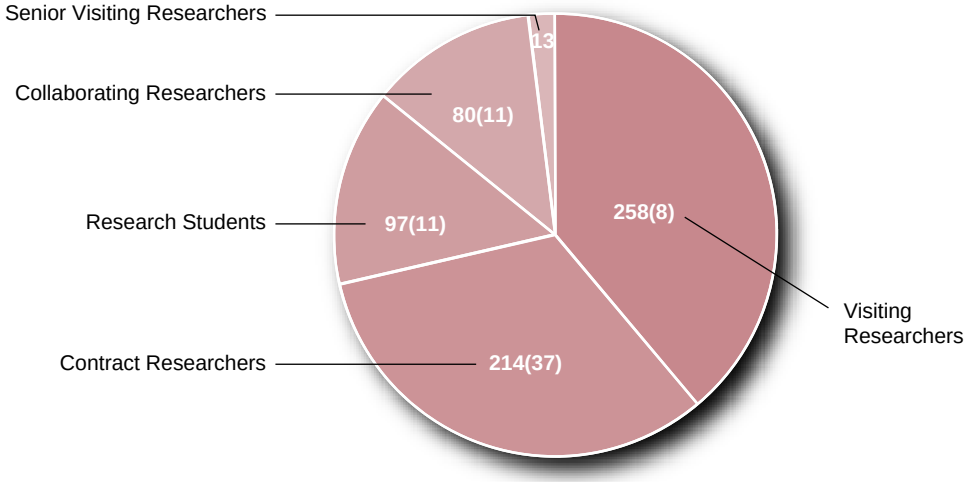
Number of Permanent Staff
247 (5)

Notes: 1. Data is as of April 1, 2010.
2. Figures in parentheses indicate number of foreign researchers.



Fields of Expertise
Researchers holding doctorates
94.5%

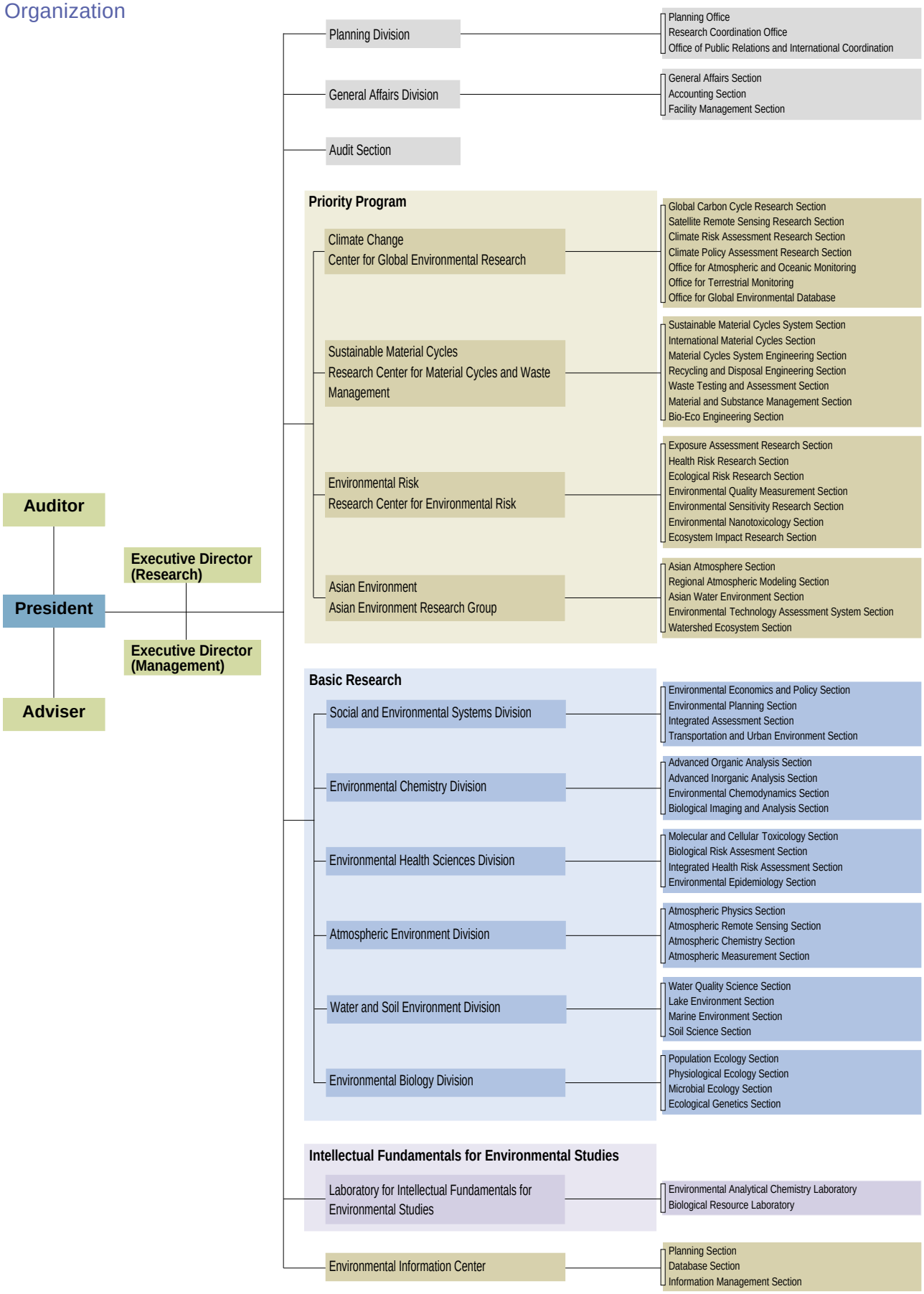
Note: Data is as of April 1, 2010



Number of Visiting Researchers, etc
662 (67)

Notes: 1. Data for "Contract Researchers" is as of April 1, 2010.
(Data for Limited-Term Researchers, NIES Fellows, NIES Post Doctoral Fellows, NIES Assistant Fellows, NIES Research Assistants reflects the total number accepted in FY2009).
2. Figures in parentheses indicate number of foreign researchers.

Organization



Center for Global Environmental Research

Lake Mashu in Hokkaido, a fieldwork site in FY 2009.’

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–Russia region. To investigate GHG source regions in SE Asian, new observations by Asian cruise ships have begun, in addition to the observations taken by the network of JAL (Japan Airlines) passenger aircraft (CONTRAIL: Comprehensive Observation Network for Trace gases by AIrLiner).

We have used these data to clarify the patterns of inter-hemispheric mixing of CO_2 through high altitudes. From winter to spring in the Northern Hemisphere, a barrier to inter-hemispheric mixing exists around the equator, and large amounts of CO_2 are accumulated in the mid-latitudes of this hemisphere. However, in the Northern Hemisphere summer, CO_2 at high concentrations is transferred from the Northern to the Southern Hemisphere at high altitudes (above 4 km).

Although anthropogenic CO_2 emissions recently increased beyond 8 Pg-C/year, the atmospheric CO_2 growth rate is still about 2 ppm/year. Atmospheric oxygen and CO_2 isotope observations have revealed that the apparent terrestrial uptake in the past 3 years was higher than that in 2001–2005. It therefore seems that the higher atmospheric CO_2 level may give good effect for terrestrial photosynthesis

in addition to the lack of large-scale forest fires. The oceanic CO_2 sink was maintained for a long time and seemed to slightly increase according to growing CO_2 level in the atmosphere.

In the face of future rapid climate change it may become difficult to estimate the future status of sink–source relationships. For this reason, at five forestry field sites from Kyusyu to Hokkaido in Japan, we are trying to study how soil respiration responds to temperature increase. So far, all of the sites except the northern one have shown lower responses than expected from laboratory experiments. To clarify the mechanisms involved, further research is planned.

GHG observations from space (Core research project 2)

Nearly a year and a half has passed since the Greenhouse Gases Observing Satellite (GOSAT) was placed in orbit in early 2009. GOSAT Level 2 data products, which store the column-averaged volume mixing ratios of CO_2 and CH_4 (XCO_2 and XCH_4) derived from GOSAT observational data, are now available to both registered researchers and general users (see Figure 1 for samples of the data products that have been released). We are conducting research to improve the accuracy of the Level 2 XCO_2 and XCH_4 data. The research effort includes improving the current Level 2 data processing algorithms. Also ongoing are our data product validation activities, in which we compare the Level 2 column concentrations with reference values obtained from *in-situ* instruments onboard NOAA (National Oceanic and Atmospheric Administration) and JAL aircraft and from ground-based high-resolution Fourier transform spectrometers (FTSs) participating in the TCCON (Total Carbon Column Observing Network). We found that the Level 2 XCO_2 values (ver. 00.50) were negatively biased by 2% to 3% when compared with the ground-based FTS and aircraft data. Moreover, some of the Level 2 column concentrations retrieved over major desert areas (e.g., the Sahara Desert and Arabian Peninsula) and their surroundings were found to be positively biased, possibly because of the influence of dust particles. The outcomes of the retrieval algorithm research and the data product validation activities will be reflected in the next version of the Level 2 data processing algorithm. We are also preparing higher-level (Level 3 and 4) data products. Data that will cover the strengths of CO_2 sources and sinks in 64 global regions and will be stored in the Level 4 data product are being inversely inferred from the space-based Level 2 column concentration data and ground-based concentration data obtained over the network of flask sampling stations. The GOSAT Level 4 operational data processing system has been developed and is currently being tested.

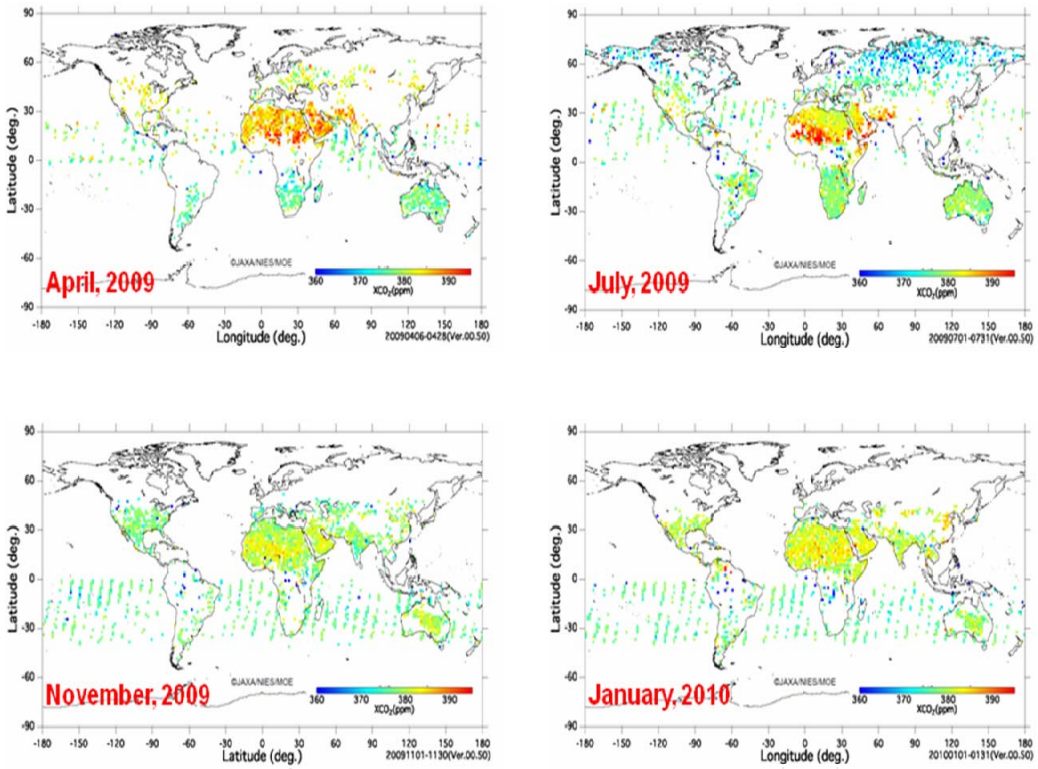


Fig. 1 Monthly global maps of CO_2 column-averaged volume mixing ratios (GOSAT Level 2, ver. 00.50) in a 1.5° × 1.5° mesh. Elevated concentrations were found over the deserts and surrounding areas on the Arabian Peninsula and in northern Africa. The high concentrations in these areas appeared to be seasonal and were probably largely influenced by aerosols of dust blown up from the deserts.

Assessment of climate risks (Core research project 3)

Quantification of uncertainties in the projections of climate change impacts is an urgent research problem with policy relevance. In FY2009, we conducted a risk assessment of the global warming impact on human health in terms of the number of excess mortalities due to heat stress, with explicit consideration of the uncertainties in future climate projections and in other factors.

The risk was evaluated for three different GHG emission scenarios (IPCC SRES B1, A1B, and A2) and for four different time periods (1971–2000, 2011–2040, 2041–2070, and 2071–2100). To consider the uncertainty ranges of climate projection estimates, we utilized climate projections according to 14 GCMs (General Circulation Models) evaluated in IPCC AR4 (the fourth assessment report) and estimated heat stress mortality on the basis of each projection. In addition to the uncertainty in climate projections, we estimated mortality rates with different assumptions of acclimatization rate in order to investigate the effect of uncertainty in expected adaptation levels.

Assuming that there was no acclimatization in future, excess mortality due to heat stress was projected to increase significantly for all three scenarios by 2071–2100. For the A2 scenario, which had the highest GHG emissions, excess mortality was estimated to increase globally by 328% (mean of 14 estimations), with an uncertainty range of 207% to 412% (5th to 95th percentile range). For the A1B and B1 scenarios, excess mortality was estimated to increase by 257% (160% to

353%) and 150% (86% to 206%), respectively. These results indicated that the ranges of uncertainty due to choice of climate projection were comparable with the difference in estimates among different emission scenarios.

Climate policy assessment (Core research project 4)

Pathways toward achieving a low-carbon society (LCS) in Japan have been developed, and it has been shown that early action can lead to the development of such a society. Our calculation showed that early investment could reduce the total cost of achieving a LCS, because introduction of energy efficient technologies saves not only energy consumption but also energy costs and the learning effect reduces the future fixed costs of technologies (Figure 2). These models have been extended and applied to other Asian regions. Several LCS scenarios in Asia have been developed by proposing policy options. An econometrics-type energy demand and supply model has also been developed. To meet the target halving of emissions by 2050, we are attempting to evaluate further possibilities for CO_2 emission reduction through the use of additional technological options and scenario assumptions. Asia LCS scenarios have been introduced at COP15 (the 2009 United Nations Climate Change Conference, i.e., the Copenhagen Summit) and CMP5 (the 5th meeting of the Parties to the Kyoto Protocol) side events and at other opportunities.

We have been studying the positions of major countries such as the United States, European Union, China, India, and Russia in international negotiations and policy-making processes. We have found that domestic factors such as political and economic situations have a great influence on these countries' positions at international climate change negotiations. We have also looked at actions beyond the national, including those that are taken by various institutions and organizations at regional levels in the Asia and the Pacific. We have discussed the implication of a range of the Japan's midterm target in light of several indexes from the standpoints of, for example, equity, responsibility for emissions, and reduction capability.

The simulation results from the AIM activities (Asia-Pacific Integrated Model) were provided to a meeting of the Taskforce convened by the ministerial committee on global warming. The main purpose of this meeting was to discuss the 25% reduction target in GHG emissions in the period 1990 to 2020. To assess the longer-term perspective, the revised AIM model was applied to give the emission pathways required to stabilize radiative forcing at 6 W/m^2 through to 2100. We have also studied an extension through to 2300 in accordance with new IPCC scenarios.

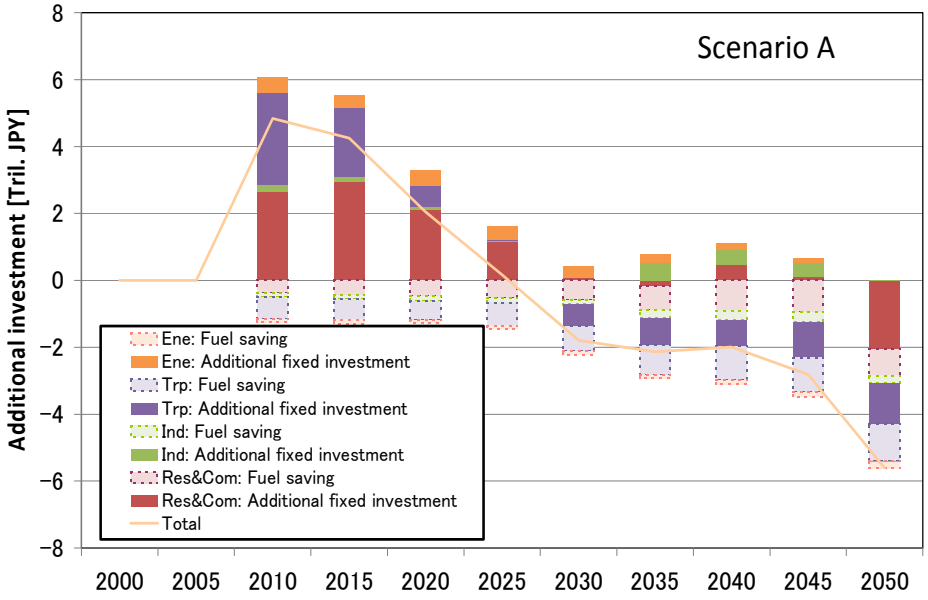


Fig. 2 Additional investment required to achieve optimum low-carbon pathways in Japan by 2050

Long-term monitoring of GHGs and other trace gases

Atmospheric GHGs (e.g., CO_2, CH_4, and N_2O) and other chemical species (CO, NO_x, and SO_x) are monitored by various platforms to determine the long-term variations in their concentrations and spatial distributions. We have two ground-based stations, at Hateruma Island (over 1000 km southwest of the Japanese mainland) and at Cape Ochi-ishi in northeastern Hokkaido. Commercial ships operating between Japan and Australia, New Zealand, and North America are used to observe the latitudinal or longitudinal distributions of GHGs and the partial pressure of CO_2 (pCO_2) in the surface waters of the Pacific. Routine samplings are conducted by aircraft over three sites in Siberia to measure the vertical distributions of GHGs. 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 in Hokkaido. UV-A and UV-B on the ground are monitored, and real-time UV indexes obtained at 17 sites in Japan are available to the public via our web page.

We revealed the long-term trends of net CO_2 flux in the North Pacific by analyzing pCO_2 data recorded by commercial ships (Figure 3). The oceanic CO_2 fluxes in 40°N and 45°N of the western North Pacific in 2008 were enhanced by about 70% compared with that in 1995. In contrast, the CO_2 flux around 35°N in the eastern North Pacific was reduced by about 20% over the same period.

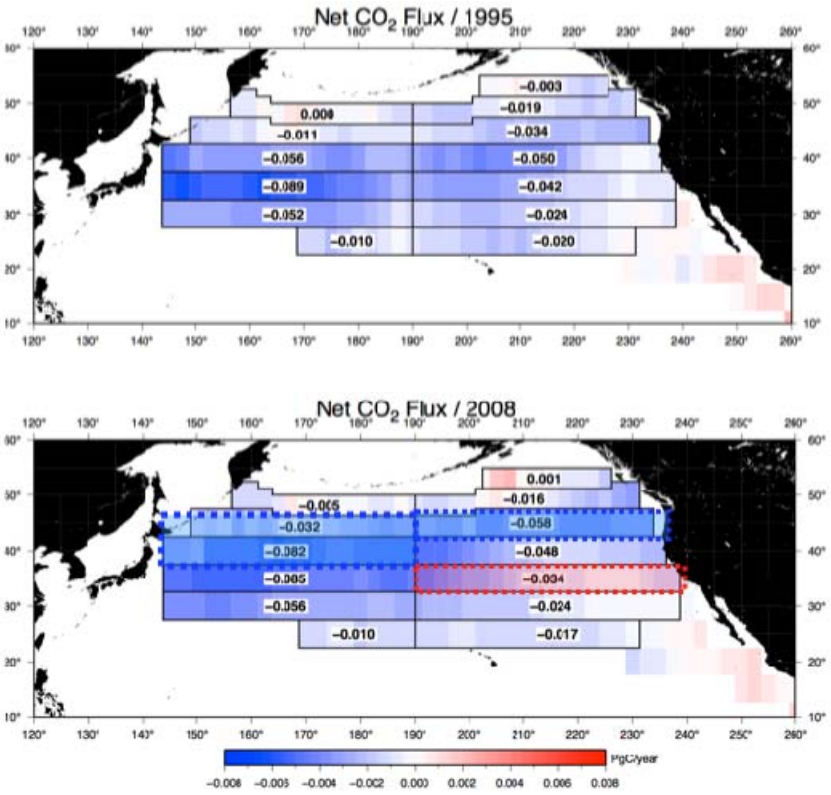


Fig. 3 Net CO_2 flux in the North Pacific in 1995 (upper panel) and 2008 (lower panel).

Carbon dioxide flux monitoring of terrestrial ecosystems

We have conducted long-term monitoring of carbon, water, and energy exchange between larch forests and the atmosphere, as well as of biological processes, in three larch forests in Japan to determine how the forests respond to climatic changes and how the responses depend on tree age and the process of recovery from natural and artificial disturbances.

The Teshio Carbon Cycle and Larch Growth (CC-LaG) Experiment Site is located in northern Hokkaido; 14 ha of the forest was clear-cut and saplings of larch were planted in 2003. The clear-cutting resulted in decreased photosynthesis and increased decomposition of dead roots and soil organic carbon. The carbon efflux decreased over the following 4 years because of the rapid growth of young trees. It took 5 years for the annual carbon balance to stabilize (Figure 4a). The Tomakomai Flux Research Site was established in 2000 in a mature larch forest. Here, clear seasonal changes were observed in the carbon uptake, depending on the phenology of the larch trees (Figure 4b). The Fuji-Hokuroku Flux Observation Site is located in a mature larch forest at the foot of Mt. Fuji. Measurements started in 2006, and a clear seasonal pattern in carbon uptake, similar to that at the Tomakomai site, has been observed for the past 4 years (Figure 4c).

These three larch forest sites provide useful information to help us understand and predict functional changes in carbon and water cycles associated with disturbance.

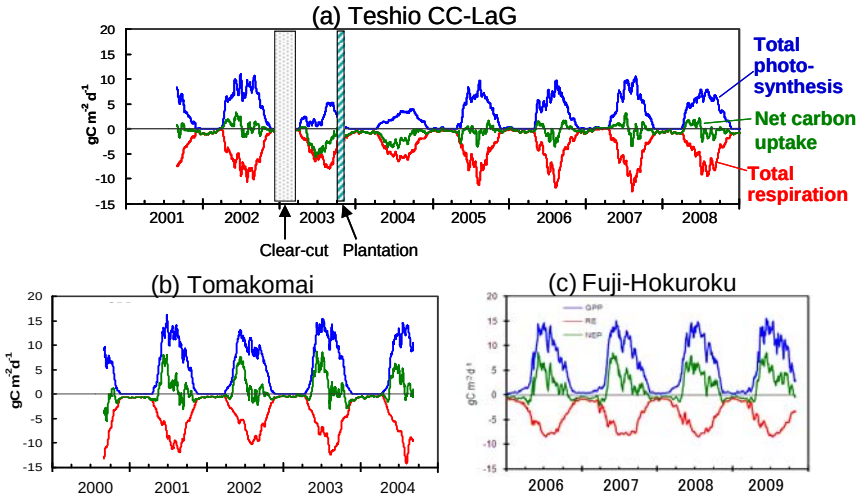


Fig. 4 Seasonal and year-to-year changes in the total photosynthesis (blue lines), total ecosystem respiration (red lines), and net carbon uptake (green lines) observed in the three forest sites at (a) Teshio CC-LaG, (b) Tomakomai, and (c) Fuji-Hokuroku.

Global environmental database

We are developing and managing various databases, websites, and data analysis tools for global environmental research and making them available to the public. The following five database projects were conducted in FY 2009:

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.

Data obtained by ILAS (Improved Limb Atmospheric Spectrometer) and ILAS-II spectrometers observing the polar stratospheric ozone layer onboard Japanese ADEOS (ADvanced Earth Observing Satellite) and ADEOS-II Earth observation satellites were transferred from the Atmospheric Environment Division of NIES to CGER. Since FY 2009, these data have been archived and distributed to users as a part of CGER's Global Environmental Database.

Development of a web GIS system for visualization of data in the CGER Global Environmental Database was started in FY 2009. This system utilizes various types of open-source GIS-related software and currently contains more than 40 datasets, including data on UNEP GRID (United Nations Environment Programme Global Resource Information Database) Tsukuba. It will become publicly available in FY 2010.

Updates to the database of large point sources in China and India were made for such factors as electricity generation and steel and cement production (Figure 5). A new version of the gridded emission database and maps for Asian countries as of 2005 were also developed from various energy statistics and large-point-source data.

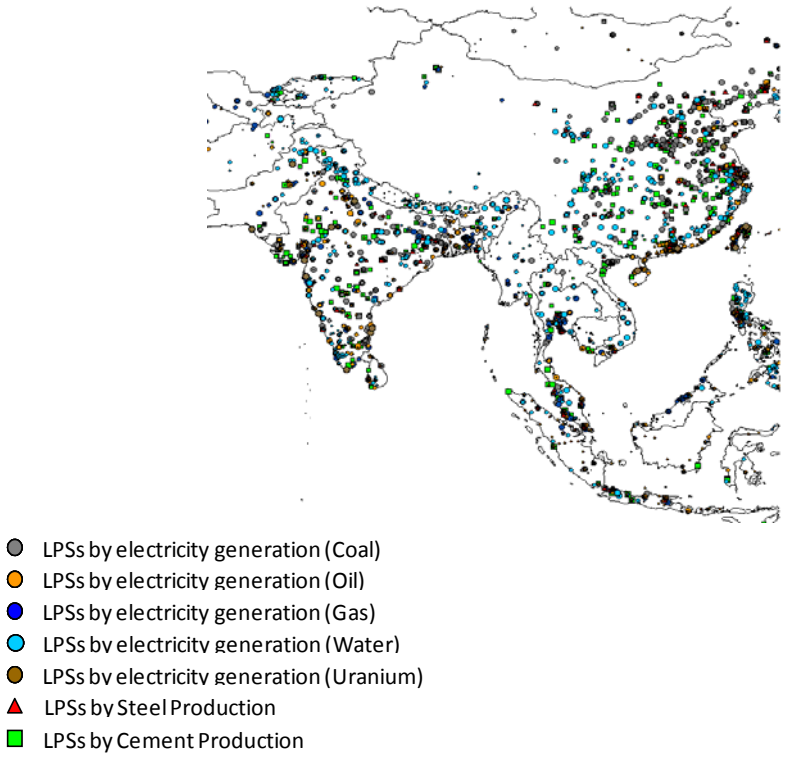


Fig. 5 Map of large point sources (LPSs) in Asia.

Greenhouse Gas Inventory Office of Japan

The Greenhouse Gas Inventory Office (GIO) of Japan develops and prepares annual GHG inventories and a national inventory report in accordance with the United Nations Framework Convention on Climate Change (UNFCCC). Since 2003, in cooperation with the Ministry of the Environment of Japan, GIO has been annually organizing a Workshop on GHG Inventories in Asia (WGIA) to support Asian countries in developing and improving their GHG inventories through the promotion of regional information exchange.

NIES GOSAT Project Office

Since GOSAT was launched in early 2009, the GOSAT Data Handling Facility (GOSAT DHF) has continued its routine data processing, including data reception from JAXA, higher-level data processing (see above under “Core research project 2”), data archiving, and data product distribution to users. The office’s activities include GOSAT data product validation, making research announcements (RA) from the GOSAT RA office, revising and publishing GOSAT Project pamphlets in Japanese and in English, maintaining the GOSAT Project website, and other outreach activities.

Research Center for Material Cycles and Waste Management

Abandoned cathode ray tube (CRT) TVs in Vietnam

CRT TV recycling plant in Japan

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 and policies and management techniques for the near future (Core research project 1)

To create a sound material-cycle society (SMS) for the near future (i.e. 10 to 20 years from now), this research project aims to develop transition scenarios and specific plans for technological and socioeconomic systems. For this purpose, we have developed several social change scenarios, focusing on material flows and waste management systems in particular and based on scenario planning methodology. We have also been creating a model for quantitative assessment of these scenarios and of the effects of various political interventions, and we have evaluated existing and potential schemes for waste management and recycling. The following results were obtained in the fourth year of the project.

We estimated material flows in the near future on the basis of two typical social scenarios that we developed: (A) a technology-oriented, globalized, rapidly changing society and (B) a nature-oriented, regionalized, slowly changing society. For example, increases in the production of animal waste and in the production of food waste by the restaurant industry were estimated for scenario A because of the assumed Westernization of dietary habits (increased consumption of meat) and increased rates of eating out. In contrast, decreases in the production of animal waste and increases in rice straw waste production were estimated for scenario B in response to the assumed Japanization of dietary habits (decreased consumption of meat and increased consumption of rice).

Then we assessed the effects of changes in technological systems and lifestyles on material flows (Figure. 1). For example, we evaluated the environmental performances of food-system waste recycling from a life-cycle perspective (e.g., the use of wastes as animal feeds and in composting, methane fermentation, and bio-plastics and bio-diesel fuel production). We estimated that prevention and recycling of food wastes could decrease the amount of waste landfilled from food systems by more than 50%, although at the same time it would increase CO_2 emissions because of increased energy consumption in recycling systems.

On the basis of these analyses, we developed two preliminary visions for creating an SMS. These visions were comparable with two the typical social scenarios. For example, rapid introduction of new recycling technologies is expected in SMS vision A. On the other hand, the emphasis is on lifestyle changes in SMS vision B. These visions are still preliminary, but in developing them we are taking into consideration their compatibility with visions for a Low Carbon Society

developed under the NIES climate change program, so that by integrating our activities we can tackle waste and climate issues.

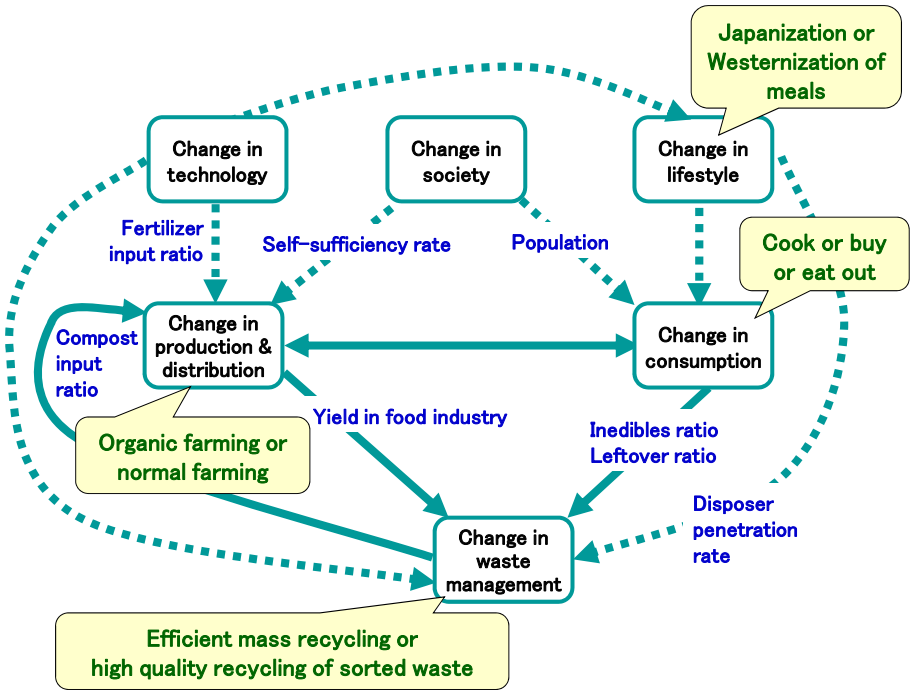


Fig. 1 Points of analysis in food systems.

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

Project 2 evaluates the behavior of hazardous and valuable substances during various recycling processes. Here, we present two detailed case studies in which we (1) illustrate the behavior of hazardous substances in the material recycling phases of plastic wastes and (2) use thermodynamic analysis to estimate the distributions of valuable and hazardous elements among gas, slag, and metal phases during metal recovery.

Behavior of organic compounds during recycling of waste plastics

Because of recent volume increases, appropriate management of plastic recycling such as shredding, compressing and molding, which generates various volatile and semi-volatile organic compounds, is required to ensure the chemical safety of the processes. To gain an understanding of the emission behaviors of various chemicals during the recycling of waste plastics, we examined air and emission gas samples taken from working environments. Chemicals detected very frequently were toluene and low-molecular-weight aldehydes, followed by chemicals originating from resins. Offensive odor substances were not detected frequently but were detected at relatively high concentrations. The levels of all of these chemicals were lower than those dictated by the standards. Most chemicals were present in concentrations comparable to those in air in the general environment, although levels of some of the offensive odor substances and chemicals originating from resins were higher. Chemical emissions during the

compression process for waste plastic volume reduction were low, and seem to influence less on working environment levels compared to other heated recycling processes. Emission levels of some substances were related to the types of resins treated.

Thermodynamic analysis of metal resources recoverability during conventional metallurgical processes

We have developed a chemical thermodynamics approach to evaluate the recyclability of steel, Cu, Pb, Zn, and Al products from secondary resources and the limitations on impurity removal in pyrometallurgical processes. In particular, we thermodynamically evaluated the refining capabilities of oxidization and volatilization, which are suitable for removing impurities from the main metal product during remelting. On the basis of our results, we proposed an “element radar chart” that explicitly shows the connection of minor elements to commodity metals and the extent to which certain metals can economically be recovered by using existing processes (Figure. 2). In the element radar chart, the radian direction indicates the trend in element distribution by oxidation, and the circular arc direction indicates that by volatilization. The chart demonstrates the difficulties in removing impurities in steelmaking and aluminum remelting and shows that removing impurities from Al is far more difficult than from Fe. In contrast, the smelting of Cu and Pb includes an effective impurity removal post-process (electrolytic smelting), which acts as an excellent refiner for a number of impurities. Therefore, the control of impurities in the disassembly process and the quality of scrap play important roles in suppressing contamination in steel and aluminum recycling.

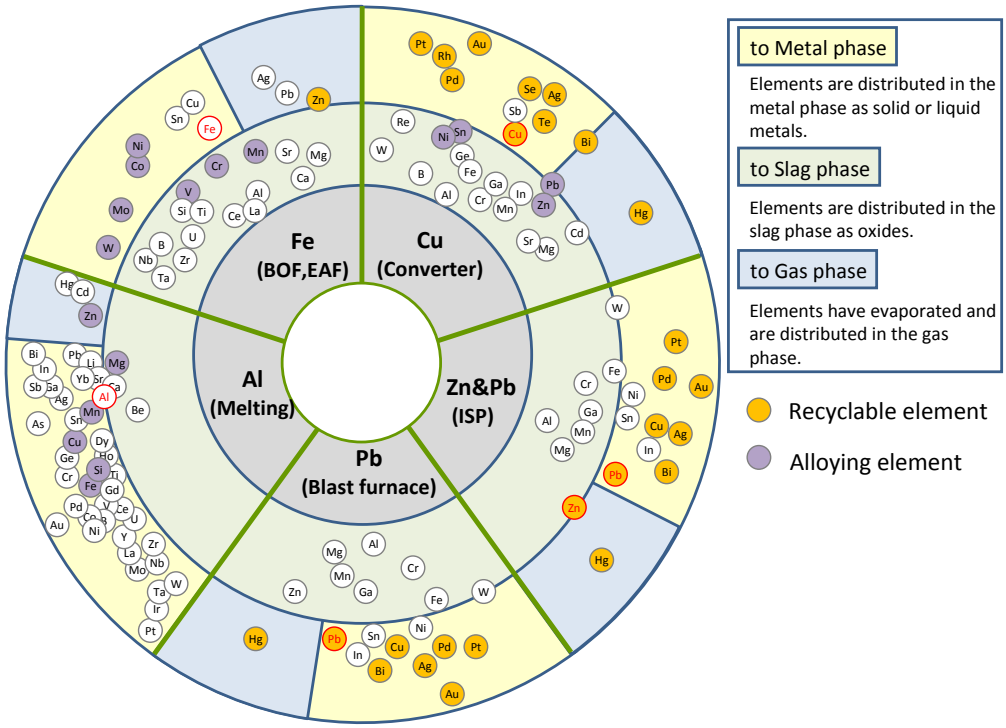


Fig. 2 Element radar chart of pyrometallurgical processes used to remove impurities from base metals. In the figure, BOF, EAF and ISP represent blast oxygen furnace, electric arc furnace, and imperial smelting process, respectively.

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

Project 3 aims to develop and systematize recycling technologies that recover energy and materials from biomass. Using laboratory-scale catalytic reformers and fluidized-bed gasifiers, we evaluated the usefulness of both a steam-reforming Ni catalyst and supplementary materials at reducing tar concentrations under low temperature (1023 K) during the gasification of both woody biomass fuel and waste paper and plastic fuel. When porous silica was located upstream of a Ni-based catalyst bed, the concentrations of polycyclic aromatic hydrocarbons and other by-products in the gases decreased. Furthermore, process simulation with experimental data is enabling us to perform technical and cost assessments of the gasification and reforming processes and of other processes that are under development.

To increase the efficiency of H_2 and CH_4 production by the fermentation of food waste, we investigated the effect of alkalinity in recirculated digestion sludge on continuous two-stage fermentation. In a two-stage process of H_2 and CH_4 production with the recirculation of digestion sludge, the alkalinity of the recirculated sludge was adjusted by altering the mixing ratios of food waste to digestion sludge between 0.5 and 1.0 ($Q_{recycle}/Q_{influent}$). Hydraulic retention times, based on recycle, were 2.2 days (H_2 fermenter) and 14.3 days (CH_4 fermenter), respectively. Higher H_2 production rate of 2.9 L-H_2/L/day was achieved at the recycle ratio of 1.0 in an alkalinity range of $9,000$ to $10,000$ mg-$CaCO_3$/L. The maximum CH_4 production rate was stably maintained at the range of 1.85 to 1.88 L-CH_4/L/day without alkalinity change. The average volatile solids degradation rate in the overall process increased from 94% to 96% as the digestion sludge recycle was increased from 0.5 to 1.0. These results show that the recycle of the digestion sludge is crucial factor in determining biogas (H_2 and CH_4) productions and a reduction in the organic solids content; carbonate alkalinity in digestion sludge could control the H_2 partial pressure in the headspace of the fermentation reactor and biogas production capacity in the two-stage fermentation process.

In another study, we conducted advanced phosphorus removal and recovery from domestic wastewater (Figure. 3). A mass balance of total P was analyzed in a *johkasou* system, which is a type of domestic wastewater treatment device. This *johkasou* equipment uses an iron electrode for P removal. The result of a 1-year experiment in a full-scale *johkasou* showed that about 90% of the P in domestic wastewater was removed and precipitated in an anaerobic tank as ferric phosphate. All of the retained P could be collected with excess sludge. We achieved conditions that were effective for the elution and recovery of P from the collected excess sludge. There were no impurity problems, so the product was potentially suitable for use as fertilizer. This effective way of recovering P for agricultural and other uses needs to be assessed further.

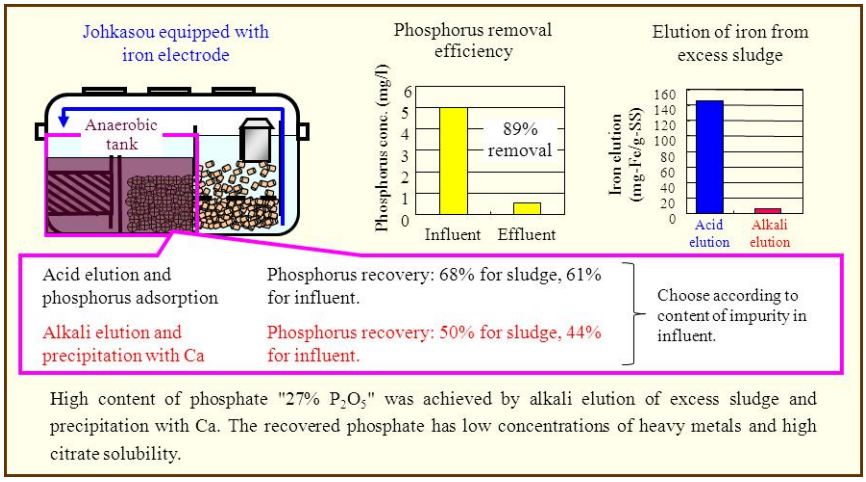


Fig. 3 Efficiency of phosphorus recovery from liquid waste, and quality of the recovered phosphorus.

We investigated effect of some cosolvents on biodiesel fuel (BDF) production with an immobilized enzyme resin. The cosolvents inhibited aggregation of the enzyme resin, resulting in high BDF yield. To upgrade low-quality waste oils and greases to raw materials for second-generation BDF production, we characterized thefuel components and impurities in these wastes. From this characterization and information on thermodynamic properties, a new upgrading technology was proposed. Finally, we showed that the upgraded greases were completely converted into second-generation BDFs.

As another sub-theme of this project, we established a framework for building regional material cycle systems for waste biomass. Case studies were conducted on wet and dry biomasses. In the former case, by analyzing the balance between food waste generation and feed acceptance potential in Ibaraki Prefecture, we determined which technology was suited to each municipality. In the latter case, we analyzed the balance between wood waste generation and the treatment potential of existing facilities in the Kanto region to determine the feasibility of material cycling in each prefecture. In addition, we designed an efficient system by introducing developing technologies into our project, and we collected background data on inputs and outputs of energy and materials.

4. Establishing appropriate management networks and technological 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 movements of recyclable resources and the 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 secondhand cathode ray tube (CRT) TVs and other electrical appliances exported from Japan. We gained an understanding of the change in destination to countries with less strict import controls, the recent (since 2009) increase in export potential from Japan, and the

effect of the export control enforcement introduced by Japan in September 2009. For China, the Philippines, and Vietnam, we characterized techniques of e-waste recycling by informal sectors and discussed the need to formalize this recycling to achieve environmentally sound management in developing countries.
In a field survey, we investigated items such as e-waste and hazardous substances contained in scrap mixed metal exported from Japan. In addition, we analyzed the emission of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/PCDFs) from scrap with fired case. To prevent the export and fired release of hazardous substances, we proposed export control measures.

In developing countries, garbage is usually not separated, and everything is dumped en masse into solid waste landfill sites, which mostly practice open dumping without the use of adequate technology. To understand the leaching behavior of brominated flame retardants (BFRs) in waste consumer products, we prepared landfill lysimeters in three different conditions—aerobic, semi-aerobic, and anaerobic—simulating those in waste dumping sites in developing countries. Leachate from each lysimeter was collected periodically for 3.5 years and analyzed for BFRs, including polybrominated diphenyl ethers (PBDEs), tetrabromobisphenol A (TBBPA), tribromophenols (TBPhs), and hexabromocyclododecanes (HBCDs). Elution of BFRs was demonstrated under all three conditions from the beginning of the experiment. The amount of BFRs leached under aerobic conditions tended to be lower than that under anaerobic conditions (Figure. 4), suggesting that the supply of air to the inside of the landfill reduces the elution of BFRs to the surrounding environment.

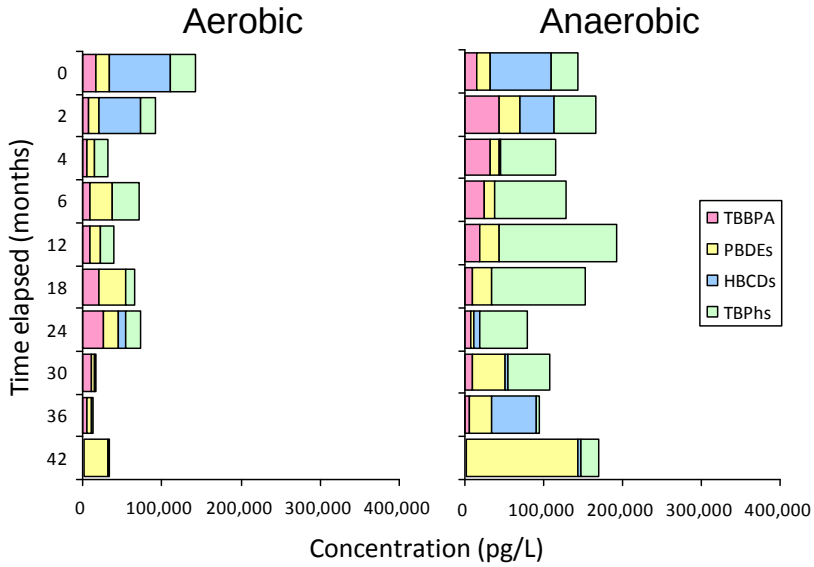


Fig. 4 Temporal changes in BFR concentrations detected in leachates collected by landfill lysimeters under controlled aerobic and anaerobic conditions. See text for explanations of the abbreviations in the key.

We applied the small borehole and closed chamber method to gas emission monitoring at several landfills in Southeast Asia and Japan. Low methane correction factors reflected the semi-aerobic conditions in some landfills. The oxidation factor varied according to the age of the landfill and the degree of landfill gas flux. Analysis of test cells for validation of the performance of

semi-aerobic landfills in tropical countries was completed in December 2009 in a Thai landfill, and we then began to monitor emissions. We have now collected data on municipal solid waste management in Southeast Asia, and in Vietnam we have obtained results on the physical composition of municipal solid waste and on waste flows, including flows of municipal solid waste, recyclable waste, sludge, and food from businesses.

We investigated the functions of small-scale decentralized wastewater treatment systems—including wetlands, *johkasou*, and soil treatment systems—in rural areas. We found that differences in the regional characteristics, weather conditions, and economic development levels were likely to influence the technical adaptability of these systems.

5. Research to ensure appropriate waste management practices

To obtain parameters that would help us predict the stabilization of wastes in final disposal site, we developed column test equipment that can follow the same thermal environment as in the field. As part of a numerical landfill process model, a module for simulating gas movement in the covering soil layer was developed and used to estimate the measuring errors in the closed chamber method. Validation of our logistics model for simulating regional flows of industrial waste and recyclables was carried forward. We field-tested a leachate treatment plant that uses a reverse osmosis process and found that it could remove about 80% of boron in raw leachate. Numerical analysis of the movement of internal leachate in offshore landfills revealed that the change in inner leachate quality was lower when density-dependent flow and leaching phenomena were taken into account than when leaching was not considered in the simulation result.

To establish general assessment indexes for incineration plants, we collected operational data from various kinds of real plants. The results showed that the ratio of power and heat recovery compared to residue emissions could be a good index for incineration plants. The concentrations of dioxins and surrogate organic halogens were measured and analyzed. The applicability of the index to monitoring of flue gas was evaluated in light of accumulated data.

Long-term experiments on the simultaneous treatment of kitchen garbage and domestic wastewater revealed no obvious differences in the concentrations of organic components and suspended solids in excess sludge between a typical process used to treat domestic wastewater and a process for simultaneous treatment of garbage and domestic wastewater. Greenhouse gases (GHGs) emission from *johkasou* were examined on site. We have now begun a full-scale experiment aimed at elucidating the mechanisms of GHG emission from *johkasou* and establishing optimum conditions for operating these systems to reduce GHG emissions.

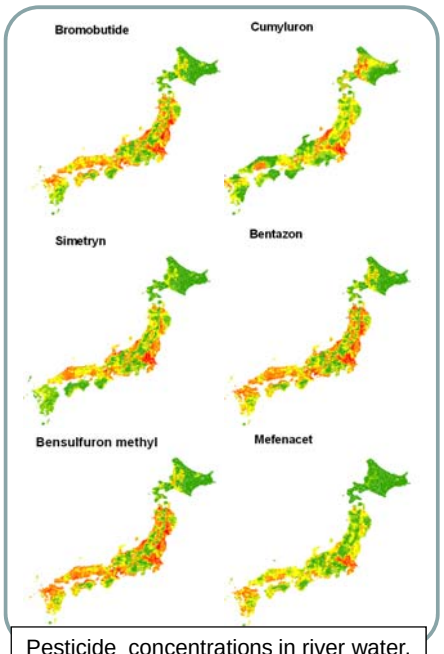
6. Promotion of fundamental research

In a study of the proper management of risks from waste asbestos, we developed analytical methods by scanning electron microscopy that would be suitable for use with all media and for all processes in the treatment of waste asbestos. We

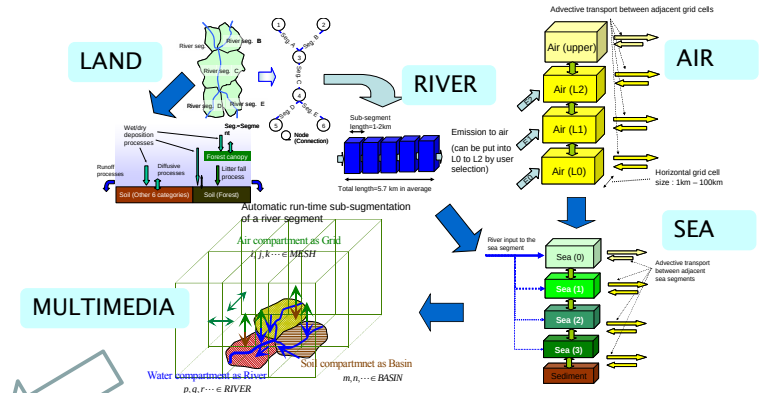
also investigated techniques for measuring low-level asbestos in bulk materials such as construction materials and solid wastes by polarized light microscopy (PLM). We conducted a quality control (QC) program for asbestos analysis by Phase contrast microscopy (PCM) and found that misjudgment of fiber length was one of the factors involved in analytical error. We also conducted an interlaboratory test of asbestos analysis by electron microscopy. We investigated the emission behavior of asbestos in a waste treatment facility; although we found asbestos fibers in flue gas samples collected before passage through a bag filter, the filter efficiently removed such fibers.

In addition, we have been creating several databases on material cycling and waste disposal processes, material flows, and the chemical characteristics of recyclable resources and wastes. In FY 2009 a lifespan database for vehicles, equipment, and structures (LiVES) was published on our web site (http://www.nies.go.jp/lifespan). It includes more than 1300 records, along with explanations of related terminologies and methodologies.

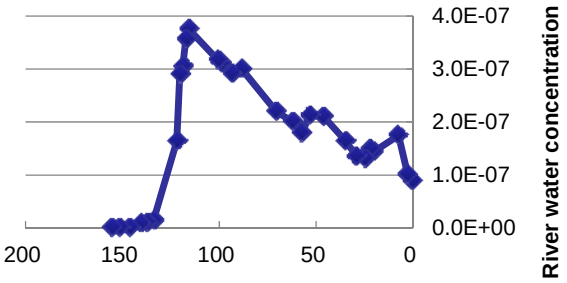
Research Center for Environmental Risk



Pesticide concentrations in river water, as simulated by emission estimation and the use of a G-CIEMS model with resolution at individual catchment and daily concentration fluctuation



G-CIEMS (Grid-Catchment Integrated Environmental Modeling System) multimedia fate model



Simulated river water concentration along river from upstream to river mouth

The Research Center for Environmental Risk (RCER) is conducting an Environmental Risk Priority Program based on the second 5-year plan of NIES, covering the period 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 assessing the health risks posed by environmental chemicals that cause sensitivity reactions.
3. Assessment of 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 research activities 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.

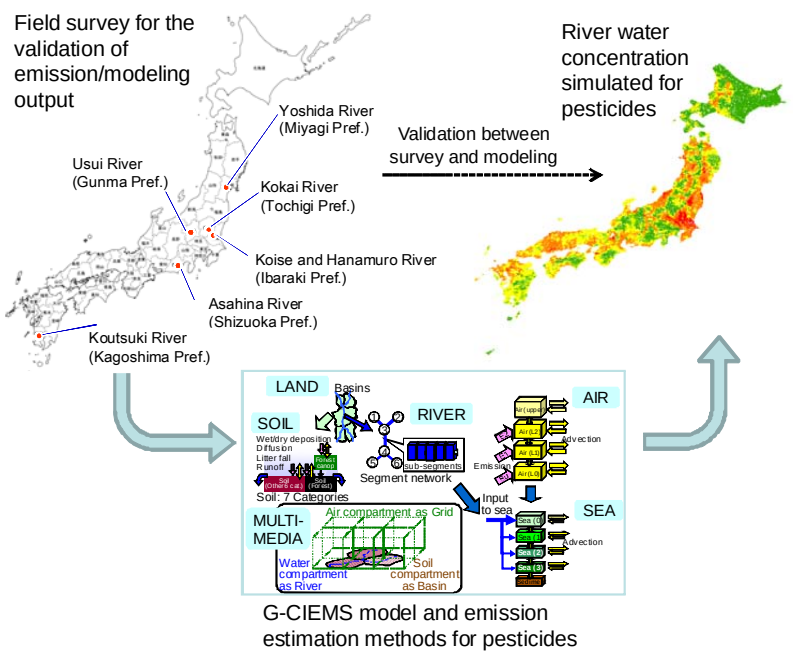
Among these activities, annual progress of two subjects about (5) prediction of carcinogenic potency and (6) chemical database is reported.

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. This year the project puts more focus on two main topics relating to fate modeling that are based on the revised research plan applying after 2009: (1) development of methods of hierarchical exposure analysis based on a geographic information system (GIS), from the regional to the global scale; and (2) development of emission estimation methods for pesticides that vary over time, and expansion of the application of these estimates to general chemicals.

Through the use of fate-modeling methods to model the natural and environmental dynamics of chemicals, the development of hierarchical exposure analyses will help us to understand exposure to multiple chemicals. This year we explored the integration of an air quality model and a multimedia fate model. We have integrated the CMAQ (Community Multiscale Air Quality) model and the G-CIEMS (Grid-Catchment Integrated Environmental Modeling System)

multimedia GIS model to develop a fundamental structure for an integrated model. We have also developed a model dataset for a G-CIEMS model for sewage collection and treatment systems and for water intake in drinking water systems. We used laboratory experiments to study the sediment–water dynamics of selected hydrophobic chemicals, and we studied methods of estimating emissions of pesticides and their temporal variability, with a case study for paddy field application. The method we developed for estimating emissions of pesticides at the country (Japan) scale has resolved at individual catchment and contained information on daily fluctuation. Pesticide concentrations and their variability in river water are simulated by combining the emission estimates and the G-CIEMS model to produce a detailed distribution of pesticide concentrations in river water with geographical variability at the resolution at individual catchment and temporal fluctuation at the days to week scale. The simulation result was validated by a new, extensive field survey performed in seven regions of Japan over 3 months (Figure 1). There was generally good agreement between the modeling and survey results. We also extended the existing MuSEM model to enable expansion of the emission estimation method to more general chemicals.



G-CIEMS model and emission estimation methods for pesticides

Fig. 1 Development of an emission estimation method: simulation by G-CIEMS model, and field survey for validation of pesticides.

2. Methods for assessing the health risks posed by environmental chemicals that cause sensitivity reactions (Core research project 2)

We aim to establish experimental models and biomarkers for assessing the health risks posed by environmental chemicals at low doses in susceptible individuals. Individuals with different immunogenetic backgrounds have different sensitivities to toxic chemical exposure. Currently, our laboratory has been using real-time RT-PCR in three mice strains (C3H/HeN, BALB/c, and C57BL/10) with or

without allergic stimulation to investigate the role of strain differences in sensitivity to low-level toluene exposure on neurotrophins and their receptor levels in the mouse hippocampus. We found that low-level toluene exposure may upregulate neurotrophin-related gene expression, depending on the mouse strain, and allergic stimulation in sensitive strains may decrease the exposure threshold for sensitivity. Using the same experimental schedule, we also investigated the influence of strain differences on NMDA (*N*-methyl-D-aspartic acid) receptor expression in the olfactory bulb after low-level toluene exposure. We observed that strain C3H/HeN seems to be more sensitive to toluene exposure through modulation of NMDA receptor subunit expression in the olfactory bulb than BALB/c or C57BL/10, and that allergic conditions in this sensitive strain may decrease the threshold for sensitivity (Table 1). Our findings clearly demonstrated that not only genetic factors, but also allergic conditions influence the susceptibility of individuals to the effects of volatile organic compounds.

There is increasing evidence that environmental chemicals exert a toxic effect on dopaminergic neurons, and that the resulting behavioral abnormalities depend on the exposure period. The pesticide rotenone causes hyperkinesia and Parkinson's disease in rats, both of which might be accompanied by inflammation, as deduced by gene set enrichment analyses. Behavioral analysis indicated that the exposure window for eliciting rat hyperactivity might occur up to age 5 days; this effect is not elicited at age 14 or 21 days. We examined the immune effect of combined exposure to low-level toluene by inhalation (50 ppm for 6 h/day, 5 days) and peptidoglycan (PGN). Exposure of mice to toluene alone resulted in increases in total-IgG1 and -IgG2a antibody levels in the plasma at age 3 weeks. Exposure of mice to toluene together with PGN resulted in lower total-IgG2a levels than with toluene exposure alone. Cytokine (Th1 and Th2 type) production at age 3 or 6 weeks in the lung and spleen in response to toluene or toluene + PGN remained low. We also examined the effects of maternal exposure to permethrin on vascular formation in the fetal brain and motor behavior in the adult, and we determined the critical exposure window. Pregnant mice were orally exposed to thalidomide, fumagillin, and permethrin on gestation days (GDs) 5, 10, and 15. Anatomical analysis on GD 17.5 revealed that fetal exposure to chemicals induced alterations in arterial formation in the circle of Willis. A motor behavior test at 8 weeks of age showed a decrease in locomotor activity in chemical-exposed mice. Mice were most susceptible to the test chemicals at GD 5. The results suggest that alteration of fetal vasculogenesis influenced brain development.

Table 1. Summary of the expression of NMDA receptor subunits in the olfactory bulb of three strains of mice after 6 weeks toluene exposure.

Mouse strain	NMDA receptor subunit expression					
	NR1		NR2A		NR2B	
	OVA (-)	OVA (+)	OVA (-)	OVA (+)	OVA (-)	OVA (+)
C3H/HeN ($H\text{-}2^k$)	→	↓	↑↓	→	↓	↓
BALB/c ($H\text{-}2^d$)	→	↓	→	↓	→	↓
C57BL/10 ($H\text{-}2^b$)	→	→	→	↓	→	→

→ Not significant; ↓ Significantly decreased at 500 ppm; ↑ Significantly increased at 50 ppm

OVA (-) = without ovalbumin immunization OVA (+) = with ovalbumin immunization

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 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. Nanoparticles are defined as small particulate substances that have one or more dimensions of the order of 100 nm or less. In this project asbestos is included, because the width of a single fiber of asbestos is within this limit.

On the basis of an acute study we performed from FY 2005 to 2007, using several strains of mice (including A/J, BALB/C, and CB6F1-Tg rasH2) we started a long-term exposure study in 2008 to determine the chronic effects of nanoparticle-rich diesel exhaust. Exposure continued for 18 months and has just ended. The animals are to be examined for histopathological and biochemical changes in the lung, heart, and other tissues. We have also analyzed the size, concentrations, and chemical composition of nanoparticles in the exhaust, as well as the fluctuations in their concentrations. We have found that the main components of nanoparticles generated from the diesel engine were similar to those found in busy intersections in urban areas.

We investigated the interaction of multi-walled carbon nanotubes (MWCNTs) with several cell lines and found that dispersed MWCNTs interacted with a membrane molecule called a macrophage receptor with collagenous structure (MARCO). We engineered the murine MARCO gene into a vector containing the gene for green fluorescent protein (GFP) and transfected it into mammalian cells. Confocal microscopic analyses indicated that MARCO was localized in the plasma membrane, intracellular vesicles, and extracellular matrix. MWCNTs were associated with MARCO molecules and were taken up by the cells. We

exposed mice to aerosolized MWCNTs with an average width of 80 nm and length of 3.7 μm. MWCNTs were found in alveolar macrophages, indicating that the aerosolized MWCNTs had reached the alveolar region. We found lung tumors and thickening of mesothelial cells in mice that had received intra-thoracic injection of MWCNTs 18 months before examination, suggesting that MWCNTs cause asbestos-like diseases if the MWCNT fibers are able to migrate from the alveolar space into the thoracic cavity (Figure 2).

We investigated the toxicity of heat-treated asbestos in both an *in vivo* animal model and an *in vitro* cell culture system. We have been comparing the effect of asbestos with that of MWCNTs to determine whether biopersistent nanofibers have the same effects as asbestos in the lung tissue and mesothelial cells. So far we have found that heat treatment of asbestos at 800 °C or more render the asbestos less harmful.

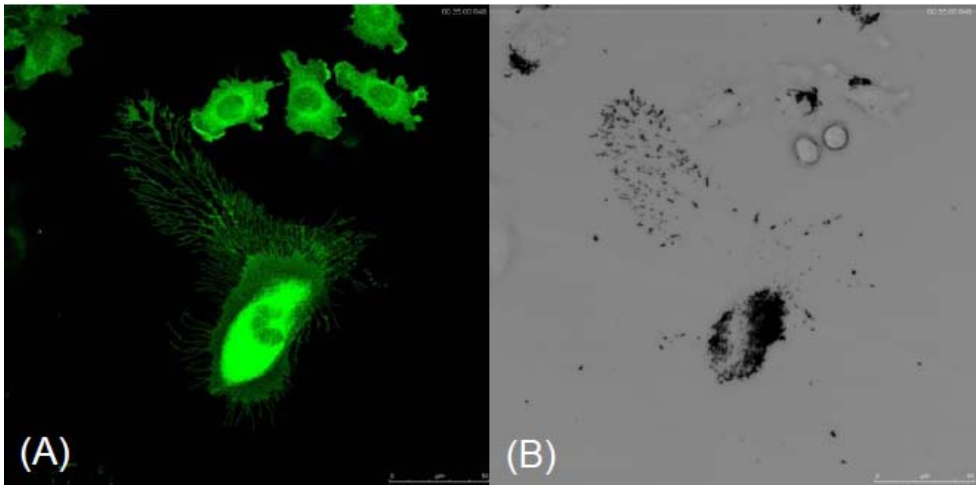


Fig. 2 Uptake of multi-walled carbon nanotubes by Chinese hamster ovary (CHO)-KI cells transfected with GFP-MARCO (green fluorescent protein – macrophage receptor with collagenous structure). (A) GFP fluorescence; (B) phase contrast).

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

This project aims to assess ecological risks and to develop effective risk management methods that take into account biodiversity and ecosystem functioning, with field surveys, laboratory and field experiments, and theoretical approaches.

The results of our analysis of the life-history traits of mantis shrimp (*Oratosquilla oratoria*) and the possible impacts of environmental stressors on the shrimp population in Tokyo Bay strongly suggest that hypoxia in summer caused the marked decline in recruitment of larvae and juveniles into the population. On the basis of data observed in field studies of the fecundity of this shrimp and the densities of larvae and settled juveniles, as well as the residual current and the distribution of the hypoxic water mass in the bay in summer, we performed a computer simulation to estimate how often newly hatched larvae were likely to encounter a hypoxic water mass before they settled. For larvae that hatched from late July to early September, the number of days when they would encounter a

hypoxic water mass with dissolved oxygen (DO) < 1.1 ml/L was estimated to be 5 to 11; the number on which they would encounter a water mass with DO < 1.7 ml/L was 10 to 19. Comparison of values in the literature for 72-h LC_{50} (50% lethal concentration) in hypoxic water for larvae and juveniles of the swimming crab (*Portunus trituberculatus*) suggested that larvae of the mantis shrimp could be severely affected after they encountered hypoxia in the bay, and that mass mortalities could follow.

One of the promising approaches to monitoring the status of biodiversity is to assess the status of the pressures driving biodiversity. To achieve this, we need to identify the principal pressures causing simultaneous biodiversity loss across taxonomic groups, and then clarify how the multiple pressures act together synergistically, or at least simultaneously, to decrease biodiversity in a focal ecosystem. Using an agricultural pond ecosystem as a case study, we constructed a framework to develop an integrated biodiversity indicator (Figure 3-1). Using the framework, we found that eutrophication had much larger effects on the state of biodiversity than did habitat destruction or invasive alien species. We also demonstrated that the integrated indicator that considered the estimated relative importance of multiple pressures explained well the behaviors of several individual biodiversity indicators, including total richness, endangered species richness, and functional diversity of focal taxa (Figure 3-2).

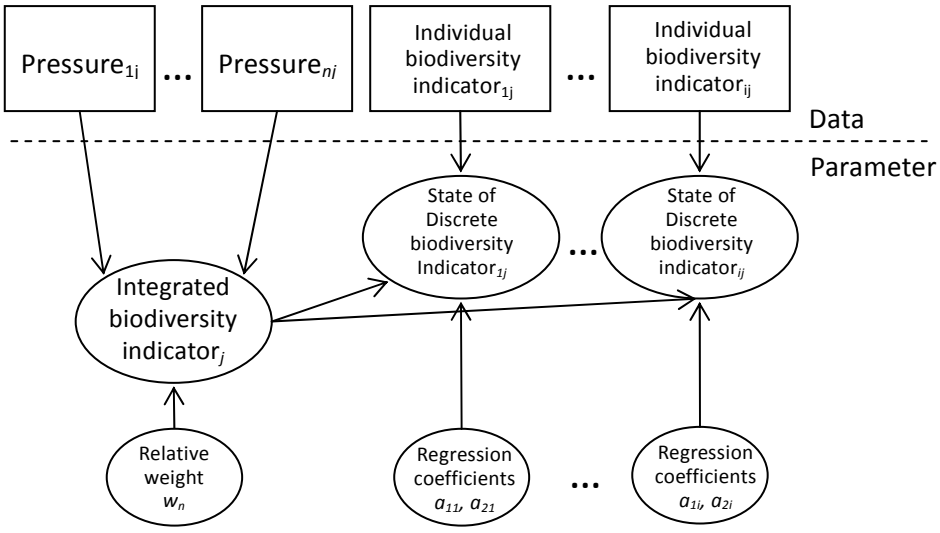


Fig. 3-1 Flow diagram of the model for estimating integrated biodiversity indicators. Using a Bayesian framework, the relative weights of pressures to that of an integrated biodiversity indicator, together with the regression coefficients determining the dependency of individual biodiversity indicators on the integrated indicator, were estimated from observed data.

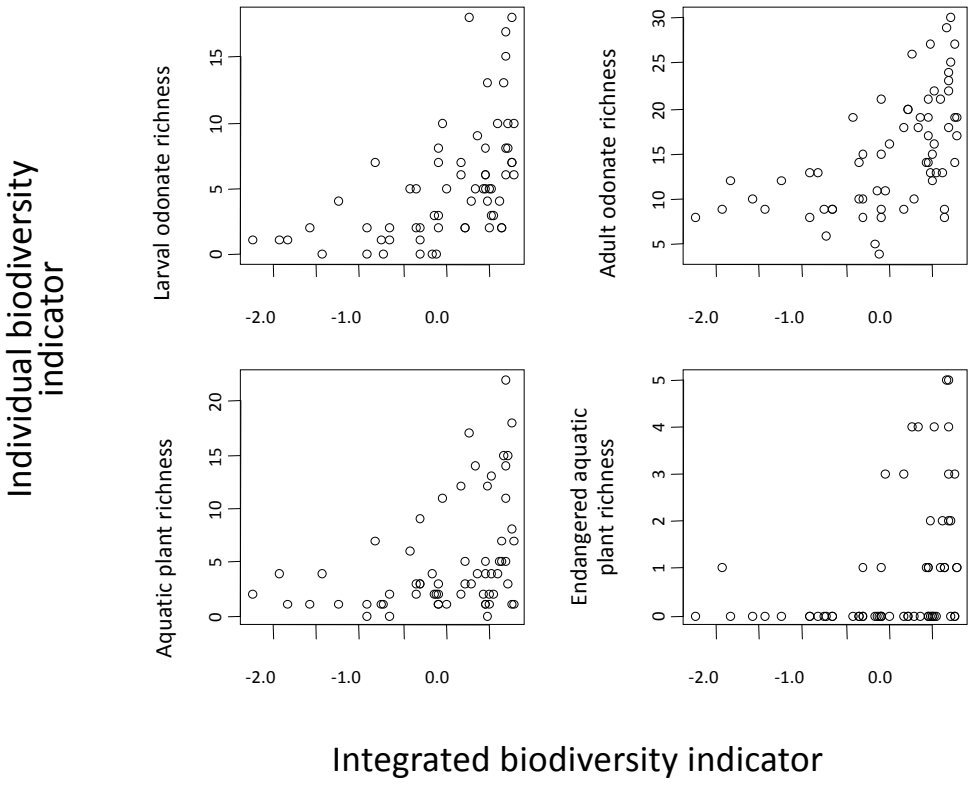


Fig. 3-2
Relationships between estimated integrated biodiversity indicator and observed individual biodiversity indicators.

We inspected the mechanism of supercolony formation by the Argentine ant *Linepithema humile* in the Kobe area, where four supercolonies are distributed. Behavioral and genetic analyses suggested that gene flow via males can occur between adjacent supercolonies, and colony fusion can occur during winter, when intercolony aggression levels between workers are low. We also used laboratory toxicity tests and field tests to assess the ecological risks of the insecticide fipronil, which is used for control of the species.

We sampled golden mussel *Limnoperna fortunei* populations from various points in Japan and several foreign countries and analyzed their DNA variation. We revealed that several haplotypes are shared by Japanese eastern populations and those of Eastern China and South Korea; these latter countries are therefore the expected origin of the invasive populations of golden mussel. We also clarified the process of expansion of this species along irrigation channels in the Kanto area.

We analyzed the DNA variation of chytrid fungus *Batrachochytrium dendrobatidis* extracted from swab samples of amphibians' skin and revealed that the genetic diversity of the internal transcribed spacer (ITS) DNA of this fungus in Japan was much higher than in other countries; we were able to detect a fungal strain that has been isolated as specific to the Japanese giant salamander *Andrius japonicus*. Laboratory infection tests showed that the Japanese strains were harmful to exotic amphibian species but not to Japanese native species,

suggesting that Japanese amphibians are resistant to the fungus. From these results, we suggest that the chytrid fungus originated in Japan or elsewhere in Asia.

To examine the relative importance of environmental factors (temperature and water quality) to ecosystem function, we have analyzed the community-level dynamics of functional traits in lake zooplankton communities. A previous study in this project indicated that the ecosystem function of the grazer zooplankton community is represented by a functional trait (the ecological efficiency) averaged over all composite species. Other functional traits, including optimum temperature, body size, and tolerance to pollution , which are responsible for species responses to environmental drivers, were also analyzed as covariates. A time-series data analysis (wavelet analysis) coupled with a multiple regression analysis (the covariance structure analysis) of the mean functional trait and environmental factors on the basis of long-term monitoring of Lake Kasumigaura, revealed that the mean ecological efficiency of zooplankton had periodic fluctuations that were synchronized with temperature fluctuations in lake water. Water quality contributed less to trait dynamics than did temperature dynamics. These results imply that the ecosystem function of Lake Kasumigaura may be associated with long-term water temperature changes.

5. Prediction of carcinogenic potency from *in vivo* mutagenicity of tested chemicals

Prediction of carcinogenic potency is an important issue for the health risk assessment of environmental chemicals. We investigated whether the carcinogenic potency of a chemical could be assessed from *in vivo* mutagenicity data obtained in transgenic rodents (Muta Mouse, BigBlue mouse, and gpt delta mouse) in which a target gene for detecting mutation was integrated into the genomic DNA. We compared the carcinogenic potencies (TD_{50}; tumorigenic dose rate 50, i.e. the daily dose for two years causing a 50% increase in cancer incidence) cited in the Carcinogenicity Potency Data Base (University of California, Berkeley) and the *in vivo* mutagenicity data cited by Lambert et al. (Mutat. Res. 590(1), 2005) to determine their relationship. Our comparison for chemicals whose potencies had been determined in both types of test in each species with the same dosage routes and target organs revealed that the correlation (r^2) between log(TD_{50}) and log[*in vivo* mutagenicity (total dose of chemical / increment in mutant frequency)] in mouse liver was good. Comparison of mouse lung data with other, reliable data showed the same correlation. The carcinogenic potency and *in vivo* mutagenicity of diesel exhaust was lined on this correlation. These results suggest that the carcinogenic potency of a single chemical, as well as a mixture, can be evaluated from the *in vivo* mutagenicity of the chemical.

6. Chemical database

To promote chemical management based on risk communication, we are trying to provide the public with adequate risk-related information via a web-based database on the Internet. So far, we have developed the Webkis-Plus chemical database and the EnvMethod environmental analytical methods database. This financial year, we have updated the following data in the Webkis-plus chemical database:

1) Exposure-related information, environmental monitoring data from Ministry of the Environment (MOE) reports published between 1991 and 2007, and data derived from pollutant release and transfer registers showing the amounts of pollutants discharged from 2001 to 2007.

2) Chemical regulation lists (especially environmental regulations up to 2009), including data on toxic air pollutants under the Clean Air Act.

3) Risk assessment lists, including information on environmental risk assessment in the seventh volume of the MOE Initial Environmental Risk Assessment.

We have also updated the EnvMethod environmental analytical methods database and have added a new function that displays analytical methods from the environmental monitoring data in Webkis-Plus. We have improved our web page design to make the page more accessible and efficient by adding a new page which gathers all the information selected by users. We have also added a printout function that allows users to gather all the information they need on a target chemical at the same time.

Asian Environment Research Group

The middle route of the South-to-North Water Diversion (SNWD) Project in China (center); a meteorological monitoring system in Nalaikh grassland, Mongolia (left); and a water quality monitoring system in the Hanjiang (Han River), China (right).

Japan is closely connected to Asia both geographically and economically, and rapid future development is expected in Asia. Therefore, 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 trans-boundary air pollution; sustainable management of water environments in terrestrial, coastal, and oceanic areas; and ecosystem management and conservation in catchments of large rivers. In the second 5-year plan at 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. The core research projects promote Asian environmental management and will help to establish the scientific knowledge and the foundations of policy recommendations necessary to creating 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 dusts) of East Asia is being investigated through comprehensive field monitoring, development of an emissions inventory, and chemical 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. Under this project, two sections and collaborative sections are working on the following sub-projects: (1) the study of regional-scale air quality in East Asia; (2) the evaluation and future projection of the atmospheric environment in East Asia; and (3) the application of dust and sandstorm data measured by the lidar (light detection and ranging) observation network in East Asia.

Study of regional-scale air quality in East Asia

The **Asian Atmosphere Section** has continued 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. At the Fukue station in Nagasaki Prefecture, ozone, NO_x, volatile organic compounds, and total reactive nitrogen are continuously measured. In October 2009, ground-based observations, including filter sampling for organics and metal species, were performed at both places simultaneously with aircraft observations over the East China Sea as part of a project on “Impact of Aerosols in East Asia on Plants and Human Health (ASEPH),” funded by research funds from Shin-Gakujutsu. In spring 2010, an intensive research campaign was carried out in the cities of Fukue and Fukuoka on Kyushu: two aerosol mass spectrometers (AMSs) were used to study the impact of transboundary air pollution on these

cities. In the same period, lidar measurements and filter sampling for inorganic species, heavy metal species and organic species (including elemental carbon and polycyclic aromatic hydrocarbons: PAHs) were carried out at CHAAMS and Fukue.

At CHAAMS, the chemical compositions and mass concentrations of fine particles have been measured for several years by AMS and by tapered element oscillating microbalance (TEOM) technology. Sulfate is a major component of these particles, and its average mass concentration in spring (March to May) from 2004 to 2008 was about 5 to 6 μg m^{-3}. This was about double that in previous measurements taken in the early 1990s, indicating that sulfate levels in Okinawa have increased in recent years. A preliminary analysis showed that there was a marked contribution of SO_2 emissions from China. The annual mean mass concentration of fine particles ($PM_{2.5}$) measured by TEOM was about 14 μg m^{-3}, which is close to the Japanese Environmental Quality Standard for $PM_{2.5}$ (15 μg m^{-3}). The reason for this is under investigation. At Fukue, a detailed analysis of results for 8 April and 9 May 2009 showed that the variations in ozone levels were not correlated with those of fine particles (sulfate, nitrate, organics, and black carbon). One of the reasons was that the origin of ozone differed from that of fine particles.

Particle-associated PAHs and *n*-alkenes were measured at Cape Hedo, Fukue, and Fukuoka. As the samples from spring 2010 have not yet been analyzed, only the results from spring 2009 and autumn 2009 are reported here. The average concentrations of total PAHs were 0.49 ± 0.46 ng m^{-3} (Hedo, spring), 0.73 ± 0.61 ng m^{-3} (Hedo, autumn), 1.7 ± 1.1 ng m^{-3} (Fukue, spring), 2.2 ± 0.6 ng m^{-3} (Fukue, autumn), and 5.3 ± 3.1 ng m^{-3} (Fukuoka, spring); the average at Fukuoka was the highest, followed by those at Fukue and then Hedo. Fukuoka is an urban site and the other two are remote sites. Only long-range transport from East Asia would be likely to affect the observed PAH levels at Fukue and Hedo, whereas both long-range transport and local emissions would affect the levels in Fukuoka.

Information on CHAAMS, including an outline of research and a list of instruments, is made available via the CHAAMS home page (http://www.nies.go.jp/asia/hedomisaki/home-e.html). Currently, some preliminary results are provided as graphs.

Evaluation and future projection of the atmospheric environment in East Asia

The **Regional Atmospheric Modeling Section** is carrying out integrated research for chemical transport modeling and emission inventory development using ground and satellite observation data. This research system was used to analyze the current status, historical trends, and future outlook of urban, regional, and trans-boundary air pollution in East Asia.

We conducted long-term simulations of air quality in the East Asian region during 1980–2008 by using a regional-scale chemical transport model (Community Multi-scale Air Quality Modeling System, CMAQ) and the year-by-year Regional Emission Inventory in Asia (REAS). By using simulated tropospheric ozone,

anthropogenic aerosols, and acid depositions, we analyzed historical and interannual variations and spatial variations in regional-scale air pollution and the impacts of transboundary pollution on air quality in Japan.

We examined springtime ozone trends at nine remote locations in Japan during the last decade. The observed decadal ozone trends were relatively small at surface sites but substantially larger at a mountainous site. We are using the CMAQ/REAS system to explore the observed changes and how changes in Asian anthropogenic emissions have contributed to the observed increasing trends. An numerical experiment with year-dependent regional emissions successfully reproduced the levels, variability, and interannual variations of ozone at all surface sites. It predicted increasing trends at the mountainous site, suggesting that increasing Asian anthropogenic emissions accounted for about half the observed increase.

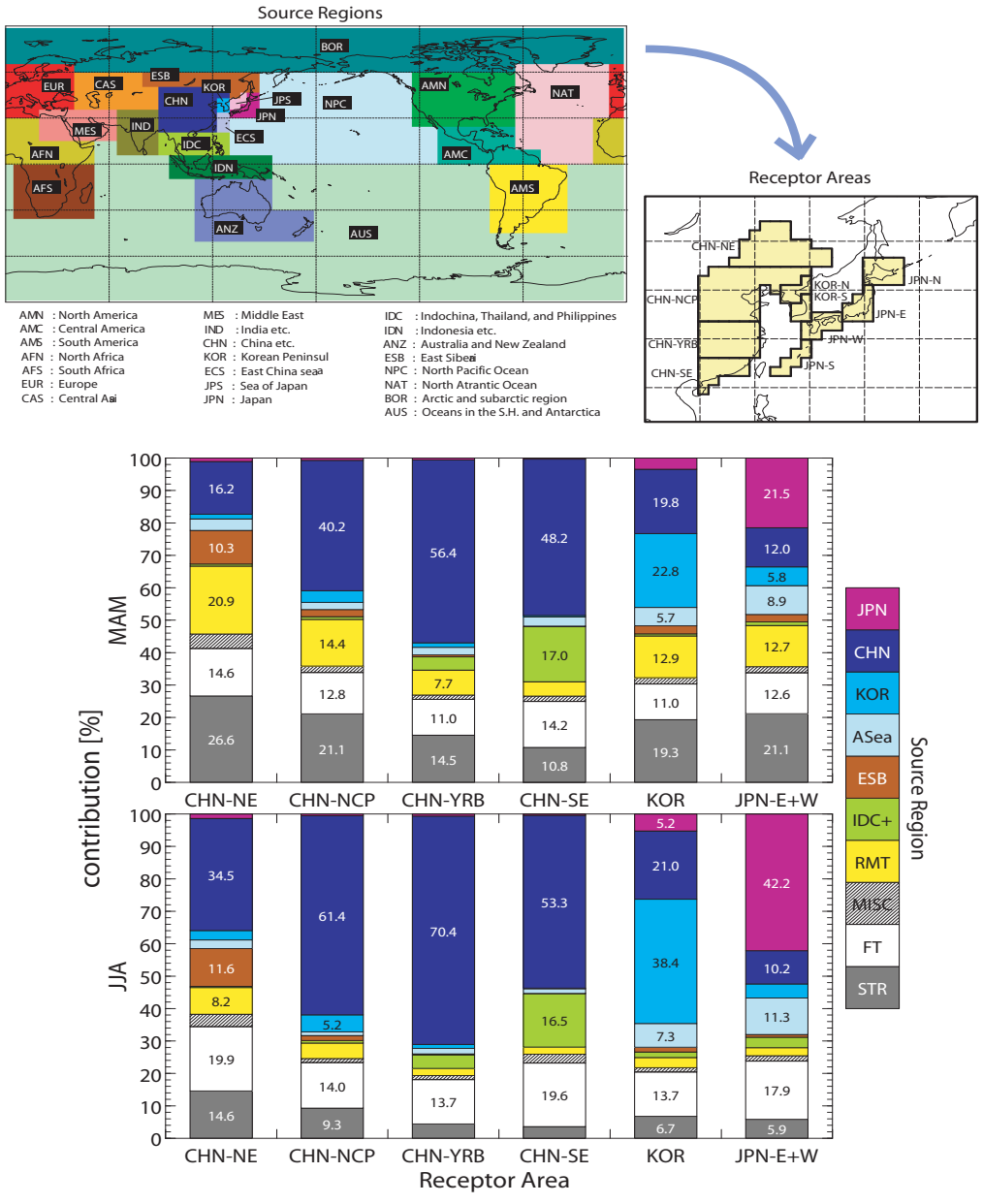


Fig. 1 Seasonal mean relative contributions (%) of surface ozone from source regions to receptor areas in East Asia in spring (months abbreviated as MAM) and summer (JJA). Source regions and receptor areas are shown in the top two figures. For the source regions: ASea (Adjacent Sea) is the sum of NPC, JPS, and ECS; IDC+ is the sum of IDC and IND; and RMT is the sum of AMN, EUR, CAS, MES, and NAT. For the receptor area: JPN-E+W is the sum of JPN-E and JPN-W; and KOR is the sum of KOR-N and KOR-S.

The source–receptor relationship for surface ozone in East Asia was estimated for recent years in this study by utilizing the tagged tracer method with a global chemical transport model (CHASER) (Figure. 1). The estimation shows the importance of intra-continental transport of ozone within East Asia as well as the transport of ozone from distant source regions. More than half of the surface ozone is attributable to ozone transported from distant sources outside East Asia in the cold season. In the warm season, most of the surface ozone in most areas of East Asia is created within East Asia. In spring, domestically created ozone accounts for 20% of surface ozone in Japan and the Korean Peninsula, 40% on the North China Plain, and about 50% in the southern part of China; these proportions increase greatly in summer. The contributions of ozone from China and the Korean Peninsula to ozone in Japan are estimated at about 10% and 5%, respectively. The contribution of intercontinental transport increases with latitude: in spring it is 21% in Northeast China but only 13% in Japan and on the Korean Peninsula.

Other research activities were (1) estimation of NO_x emissions in China by using inversion modeling systems and the tropospheric NO_2 column density obtained by satellite observation; (2) collaboration with Chinese researchers to improve Asian emission inventories; and (3) dispatch of a short-range forecast of regional air quality in six regions in Japan via the NIES environmental GIS (geographic information system) site (http://www-gis.nies.go.jp/) (in Japanese).

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

The collaborative research sections continued its observations of Asian dust using the lidar dust-monitoring network, including a lidar in Beijing and three in Mongolia. Data from the network were processed in real time to derive the vertical profiles of the extinction coefficient estimates for Asian dust and air pollution aerosols. The results were used for analysis of dust events and real-time validation of dust transport models. Real-time dust extinction coefficient data were also provided for the *kosa* web information service (http://soramame.taiki.go.jp/dss/kosa/) of the Ministry of the Environment.

A significant dust event was observed from 18 to 21 March 2010. An analysis with the CFORS (Chemical weather FORecasting System) model showed that the event originated near Ejinaqi, in Inner Mongolia, China. The main body of dust was transported southeast, passing west of Beijing, and spread to the northeast near the east coast of China. The CFORS results reproduced the lidar observations and surface PM_{10}, suspended particulate matter, and $PM_{2.5}$ data reasonably well. The total amount of dust transported to Japan, as estimated by CFORS, was approximately 3.4 Tg; about 1.36 Tg of this (40% of the total) was deposited on the surface.

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 (Figure. 2).

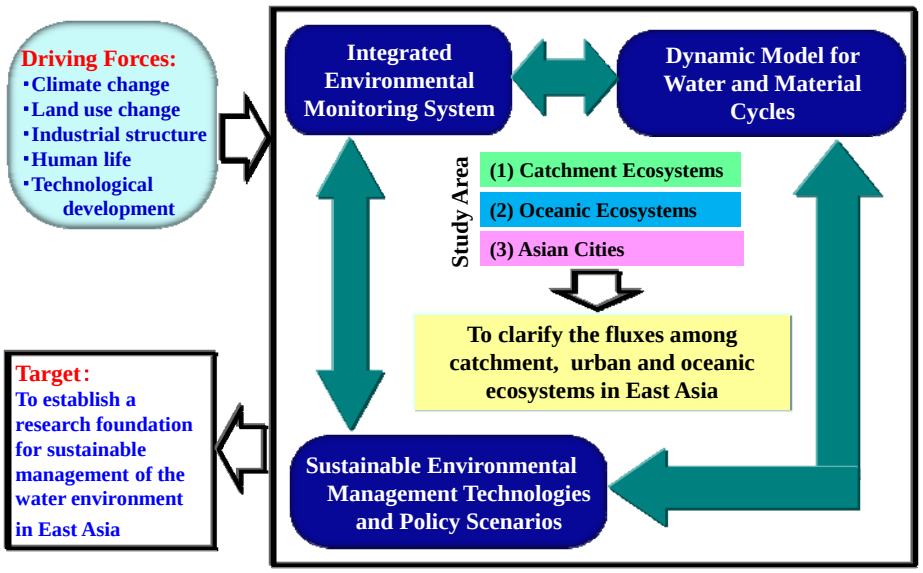


Fig. 2 Research objectives, main contents and framework of Core research project 2.

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

The **Asian Water Environment Section** has been conducting research (1) to develop an information database covering water, thermal, and material cycles based on satellite, GIS, and observation data in large catchments in East Asia; and (2) to develop a regional biogeochemistry model to assess how human-induced changes in climate, land use, and management affect water cycles (e.g., water shortages) and material cycles (e.g., carbon and nitrogen cycles) in a large catchment in East Asia. The model was improved through the use of the Soil and Water Assessment Tool (SWAT), and it has successfully integrated the effects of dams and land use and cover types, as well as management factors.

The improved model has been successfully applied to the catchment of the Hanjiang (Han River), one of the largest tributaries of the Changjiang (Yangtze River) and the source river for the middle route of the South-to-North Water Diversion (SNWD) Project in China (see cover photo for this section). To gather both input data and validation data for the model, an advanced automatic water quality monitoring system was established in December 2007 on the Hanjiang in

cooperation with the Changjiang Water Resources Commission (CWRC) of China. The automatic system is simultaneously measuring pH, temperature, dissolved oxygen, conductivity, suspended solids (SS; in formazin turbidity units: FTU), chemical oxygen demand (COD), total nitrogen (TN), total phosphorus (TP), and chlorophyll-*a* (Chl.) (Figure. 3).

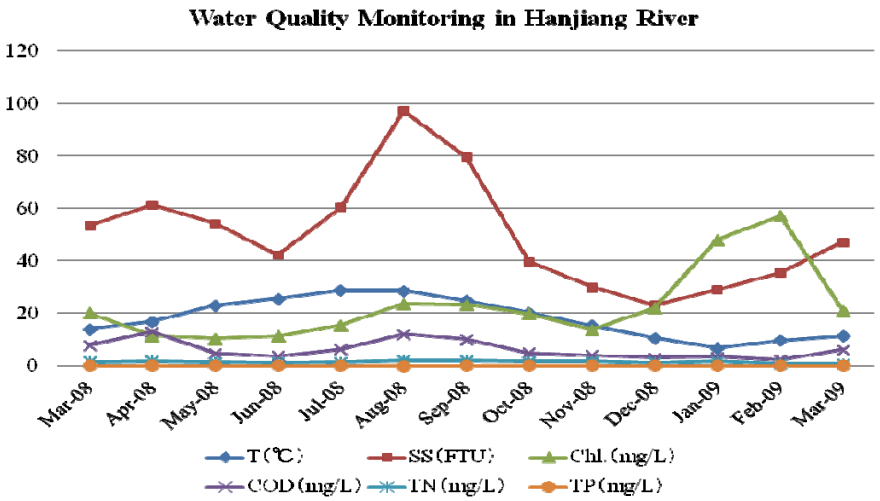


Fig. 3 Water quality monitoring data collected by the automatic monitoring system at Xiantao Station, on the Hanjiang River. See text for abbreviations.

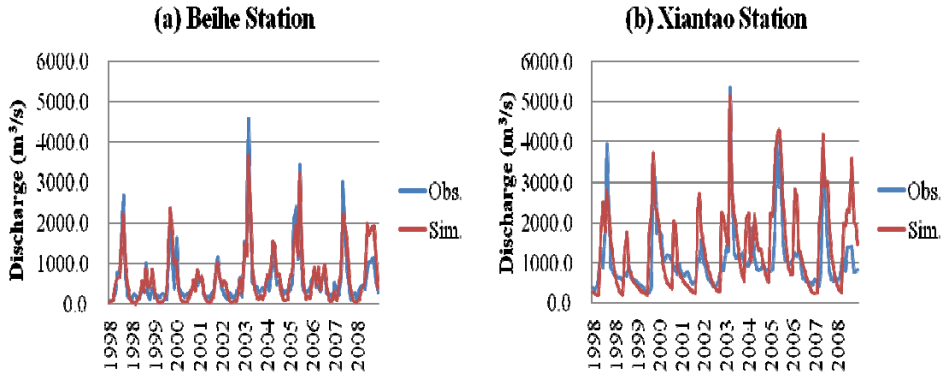


Fig. 4 Comparison of simulated values and observation data at (a) Baihe station, in the main stream of the upper reaches of the Hanjiang, and (b) Xiantao station, in the lower reaches.

The improved model generates data on items associated with water cycles (e.g., evapotranspiration, runoff, and river discharge) and with material cycles (e.g., sediment loads, COD, dissolved oxygen, TN, and TP) in each tributary and main river. The model has been validated against observation data from several tributaries in the upper, middle, and lower reaches of the Hanjiang River. The results show that the improved model behaves very well in the upper reaches, where the influence of human activity is smaller than in the lower reaches. Figure. 4 compares the simulated values and observation data at (a) Baihe station, in the main stream of the upper reaches of the Hanjiang, and (b) Xiantao station, in the lower reaches of the river. This comparison shows that the actual river discharge values agree with the simulated values very well, with a high regression coefficient ($r^2 = 0.8237$) in the upper reaches. Although agricultural water use and dam water allocation have been coupled to the improved model, the variance

between observed data and simulated values in the lower reaches remains large, with a low regression coefficient (r^2 = 0.5856). To solve the problem, we need to collect correct data on the water allocation by large dams, such as Dan Jiang Kou dam in the middle reaches of Hanjiang.

The validated model has been used to evaluate the impacts of human activities such as construction of the SNWD, as well as the Chinese policy on Reforestation of Cultivated Land (RFCL), on ecosystem services such as water resources (evapotranspiration, runoff, and river discharge), water qualities (sediments, biochemical oxygen demand, ammonium nitrogen, nitrate nitrogen, and dissolved oxygen), and on vegetation production in the catchment ecosystem. The numerical simulation shows that the SNWD might have a large effect on not only the discharge but also the water quality of the lower reaches of Hanjiang, especially in dry seasons. In contrast, RFCL might have a relatively small effect on river discharge but have an obvious effect on the water quality of Hanjiang.

Investigation of the influence of water from the Changjiang on the marine ecosystem of the continental shelf of the East China Sea

The **Asian Water Environment Section** is also investigating the influence of dilution of seawater by the Changjiang on the oceanic environment and ecosystem of the East China Sea. To meet this objective, we focused mainly on the adverse effects of large terrestrial N and P loadings entering the sea via the Changjiang. To understand the environmental changes occurring in Chinese coastal areas, we have been promoting a collaborative program with Zhejiang Oceanic University, China (a joint research program: “Development of an Adaptive Management System for the Marine Ecosystem and Fishery Resource in the East China Sea”, beginning in 2007). In addition, with the Seikai National Fisheries Research Institute, Japan, we have continued periodic investigative cruises in the East China Sea (Figure. 5a). We performed an onboard tracer experiment using a stable isotope to quantify nutrient uptake and recycling in plankton ecosystems, and we measured micro-turbulent shear stress to determine the correlation between the vertical mixing rate and the vertical distribution of phytoplankton.

Using our cruise data gathered over the past 4 years, we found that the dominant algal class on the continental shelf of the East China Sea in early summer was not diatoms but dinoflagellates. To reveal the influence of freshwater from the Changjiang on the oceanic ecosystem, we developed a numerical simulation model coupled with hydrodynamic and biogeochemical cycle models. In addition, we quantified phytoplankton class abundances within the euphotic zone in order to estimate the potential contribution of dinoflagellates to primary production. To do this, we used algal pigment analysis and a matrix factorization program to derive the taxonomic structures of phytoplankton from photosynthetic pigments (CHEMTAX computation) by using historical cruise data (Figure. 5b). We have been analyzing the impacts of water from the Changjiang on the oceanic environment and ecosystem in the East China Sea on the basis of both the simulated and observed results (Figure. 5c).

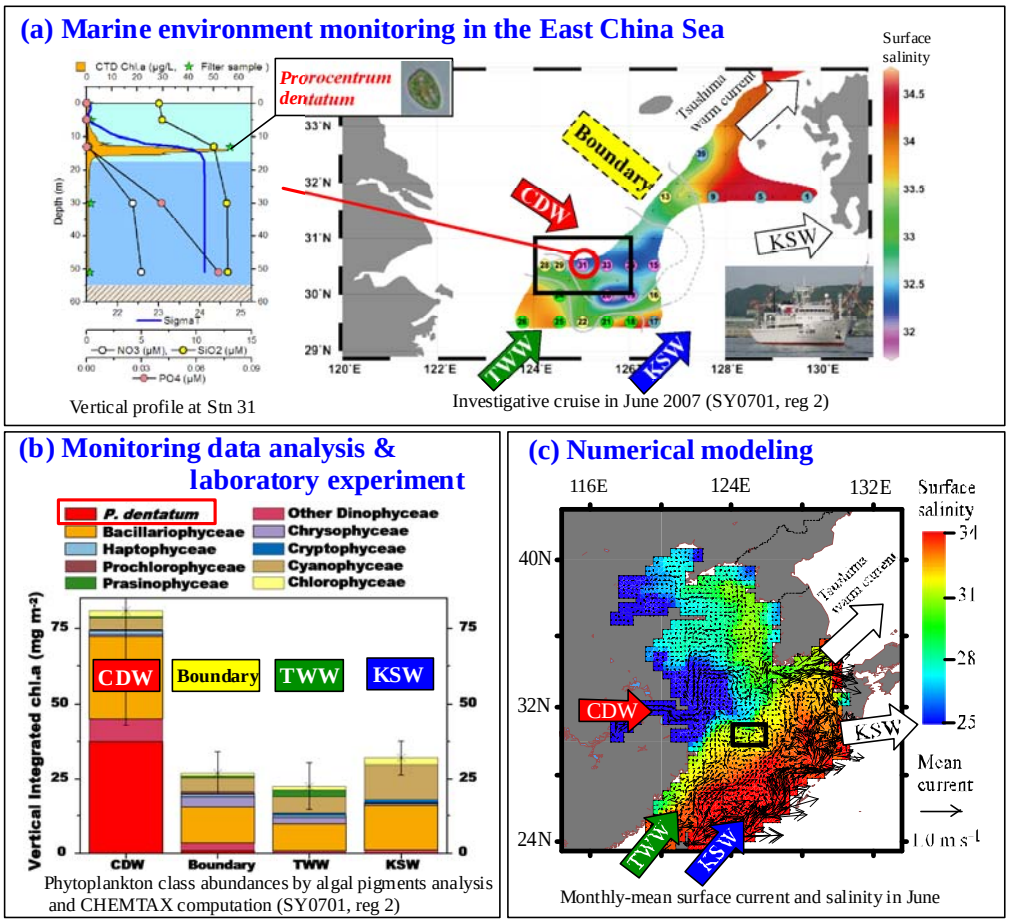


Fig. 5 Schematic of the research project on the marine environment and ecosystem in the East China Sea (CDW, TWW and KSW are sea currents of "Changjiang Diluted Water", "Taiwan Warm Water" and "Kuroshio Surface Water", respectively).

Development of a comprehensive circular economy urban simulator to design and evaluate alternative environmental technology and policy scenarios

The **Environmental Technology Assessment System Section** aims to develop a comprehensive circular economy urban simulator to quantitatively assess environmental flux, taking into account the spatiotemporal distributions of water, resources, heat, and GHG emissions from urban and industrial activities. The simulation system can be used to evaluate the current status and potential of ecosystem services under the constraints and interactions of urban and industrial activities. The main focus of this research is to develop an urban- and regional-scale environmental GIS database that can be used to quantitatively evaluate the environmental impacts of urban and industrial activity, and to develop an integrative, urban, environmental, spatial analytical model for quantitative analysis of the spatial distribution and migration of resource flows and stocks. By combining the database and the model, it will be possible to establish an integrated system for the evaluation of environmental flux by decision-makers (Figure. 6). The system will be important in helping to provide a research collaboration platform for the Japan–China collaborative project in the environmental-friendly cities of Kawasaki and Shenyang. This project is being developed in response to an agreement made by the two national environmental ministries in June 2009.

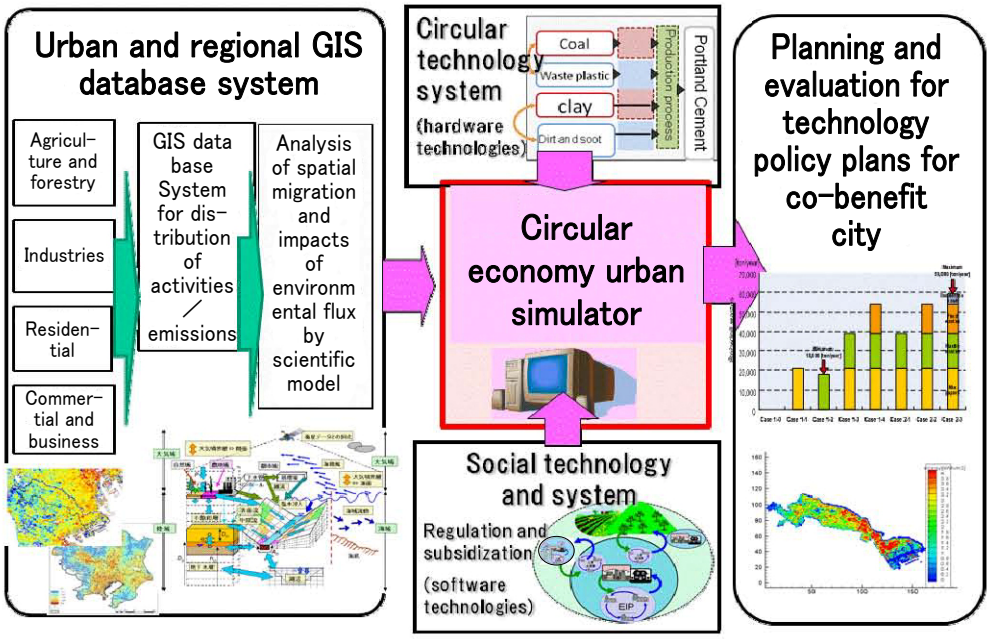


Fig. 6 Framework of the urban environmental technology and policy assessment system.

To promote optimum urban and industrial system design, we need to design different urban scenarios and develop a system for assessing low-carbon potential of the society by using technology and policy inventories and an environmental impact assessment method. This system makes it possible to evaluate the allowable environmental impacts for each urban stakeholder and to propose the final goals and action plans under different technological and policy scenarios, thus maximizing the urban contribution to global environmental conservation. This kind of decision-support system is also needed to optimize the technological and policy scenarios and thus enable information sharing among different stakeholders, as it builds up a scientific foundation and helps to identify the most appropriate technologies and policies.

Based on the governmental agreement between two ministries, the international research collaborations of NIES have been extended to those with the governments of Liaoning Province and Shenyang City. Sustainable water resource management is planned for both the Dalian and the Shenyang regions, each of which has approximate population of 5 million. Sustainable solid waste management from the perspective of the circular urban economy is also being investigated for each city.

The urban simulator has been used to evaluate heat-island reduction and low-carbon measures in the city of Kawasaki. The use of greening, water-holding pavements, underground heat pumps, energy-efficient buildings, and other measures was considered. A simulation study covering the period from 1 to 10 August 2006 showed that if a collection of low-carbon measures (a combination of the use of energy-efficient buildings, ground greening, underground heat pumps, and ground spraying) were administered to the physically achievable maximum, summer energy consumption for air conditioning could be reduced by

61%. Urban canopy temperatures calculated by using a canopymodel effectively represented the values measured at 12 points in the test area by the Metropolitan Environmental Temperature and Rainfall Observation System (METROS). Moreover, the calculation results for August 2009 corresponded with the measurement values at eight points in central Tokyo. However, on the pseudo-color images made by subtraction of the simulation result and satellite data, temperature anomalies were found in the areas surrounding large-scale facilities.

Using a material flow and environmental effect analysis model, we also evaluated the environmental effect potential of various scenarios for an industrial symbiosis-type system for the city of Kawasaki and the surrounding area. The three scenarios were closed recycling in Kawasaki (the baseline scenario); receipt of waste from Kawasaki by the surrounding area (scenario 1), and waste transfer into Kawasaki from the surrounding area (scenario 2). The evaluation results indicated that regional circulation provided lower life-cycle CO_2 emissions, particularly in scenario 2 with a wide-area recycling system (Figure. 7).

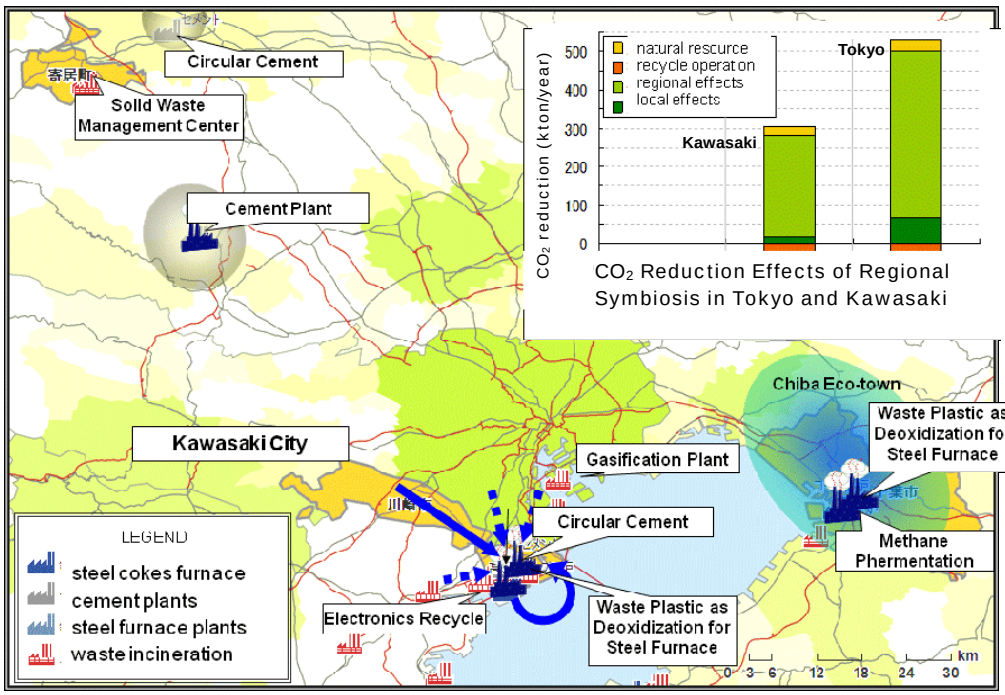


Fig. 7 Evaluation of industrial symbiosis technologies and circular regional policy scenarios.

Among the research findings in Shenyang and in Liaoning Province, the simulation results showed that more benefits could be realized by introducing multiple technologies with appropriate policies. The potential environmental gains of a given set of technologies depend not only on the technologies themselves but also on local conditions such as the energy structure and the carbon intensity of electricity generation. The development of clean energy and the promotion of recycling programs would contribute to additional GHG emission reductions. Our technology simulation demonstrated the maximum

potentials of different management options and should be useful as a scientific reference for planning and policy-making.

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

Hydropower development in the riparian countries of the Mekong River has dramatically accelerated in response to rising demand for electricity. Currently, there are only about 35 hydroelectric dams in the river basin, but according to the Mekong River Commission there will be construction proposals for more than 100 additional dams, including 11 mainstream dams, within the next decade. Although it is relatively easy to accurately estimate the amounts of electricity and income that will be generated by dams, it is extremely difficult to estimate the impact that the dams will have on fisheries resources, aquatic biodiversity, and the livelihoods and food security of the people who depend on these resources.

One of the goals of the **Watershed Ecosystem Section** is to establish a method of forecasting the losses of fisheries resources and biodiversity caused by the proposed dams (especially by migration barriers created by the dams), to apply the method to the Mekong region, and to give stakeholders the information they need in order to prevent or mitigate such impacts. The specific research objective is to identify as many important corridors of migratory freshwater fish species in the Mekong River as possible. We have relied on otolith microchemistry to accomplish this objective. Otoliths (ear bones) are paired calcified structures used for balance and hearing in all teleost fishes. Crystalline and protein materials accrete on the exterior surfaces of otoliths daily, incorporating various minor and trace elements from the ambient water. Chemicals are continually accumulated and permanently retained within the otoliths because of the acellular and metabolically inert properties of these structures. An accurate chronology of exposure to environmental conditions is therefore recorded, from the core toward the outer and surface layers.

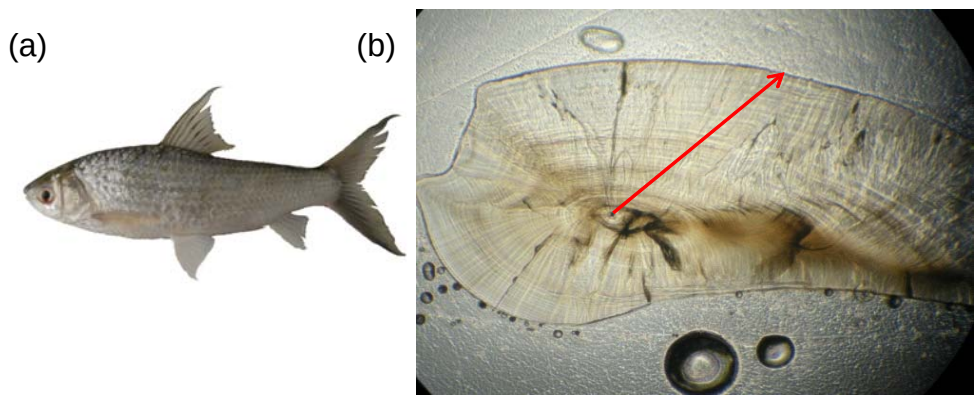


Fig. 8 Siamese mud carp (*Henicorhynchus siamensis*) (a) and its otolith section (b), showing core, daily rings, and a possible transect (red arrow) for the measurement of trace element profiles.

We applied otolith microchemistry using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) to otoliths of Siamese mud carp (*Henicorhynchus siamensis*), a small, migratory cyprinid that is one of the most abundant and commercially important fish species in the Mekong River (Figure. 8a). Siamese mud carp were sampled in villages in Thailand, Laos, and Cambodia between 2007 and 2009, and river water was sampled in nearby tributaries or in the main stream of the Mekong River. We found that the concentrations of sodium, zinc, strontium, and barium, measured by directly applying a laser beam to the surface of the otoliths, were positively correlated with the concentrations of these same elements expressed as ratios of calcium concentrations in the river water where the fish were captured (Zn and Sr, $P < 0.001$; Na and Ba, $P > 0.05$; Figure. 9).

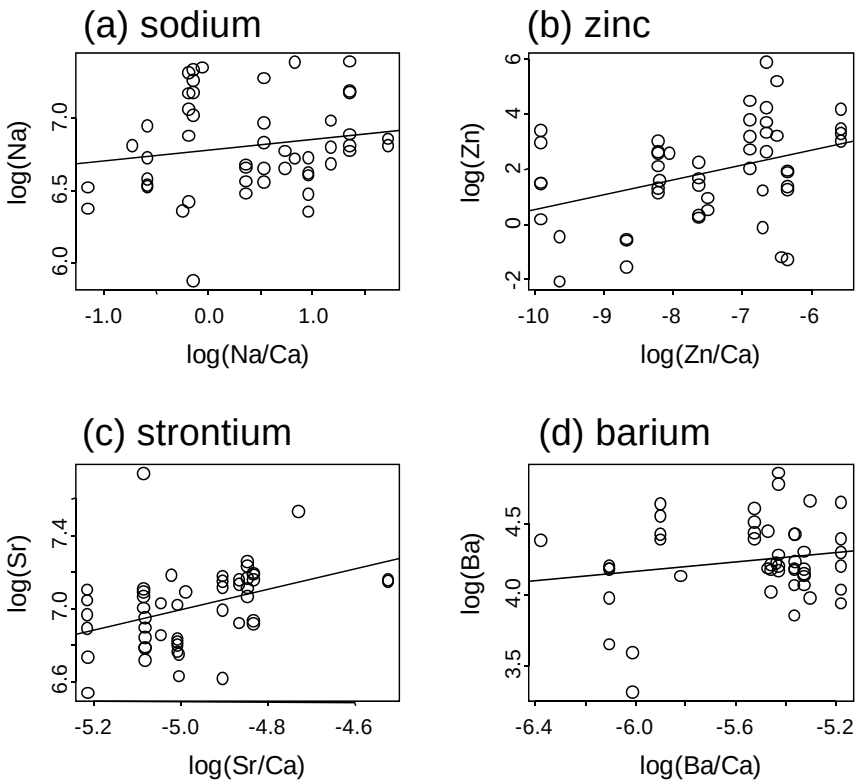


Fig. 9 Relationships between element concentrations in otolith surface and element-to-Ca ratios in river waters. A total of 49 otolith samples of Siamese mud carp were analyzed by LA-ICP-MS.

In addition to the positive correlations between otolith surface and river water concentrations of elements, there is another premise that is important for this methodology to be successful in reconstructing fish migration patterns. The element concentrations in river waters need to differ sufficiently from tributary to tributary of the Mekong River. The profiles of trace elements measured along a transect from otolith core to edge (Figure. 8b) become interpretable only if this premise is accepted. Analysis of water samples (including those used in Figure. 9) collected from about 200 locations in six major tributaries and the main stream of the Mekong River (Figure. 10) revealed significant differences among rivers in the concentrations of many of the elements. These rivers were distinct from each other in the plot of first and second linear discriminant functions, suggesting that the analysis of otolith elemental profiles will enable us to reconstruct the

exposure histories of individual fishes to specific river waters (Figure. 11).

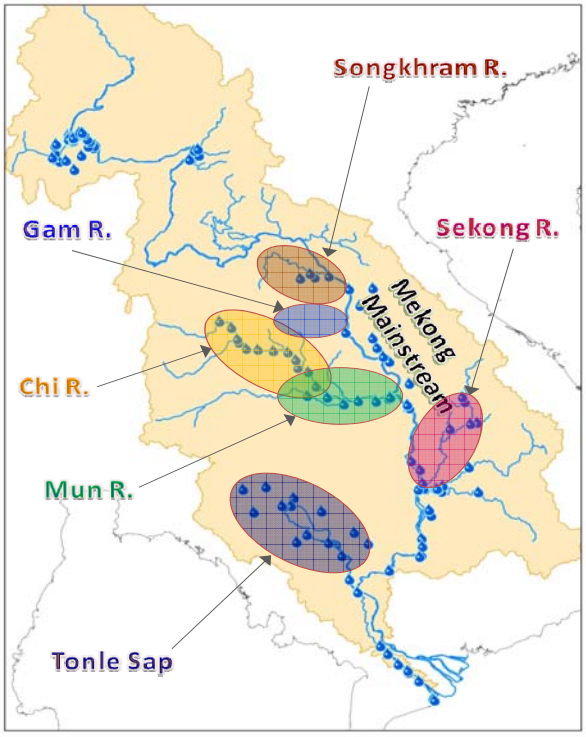


Fig. 10 Map of the Mekong River, showing the six tributaries and the main stream where water samples were collected.

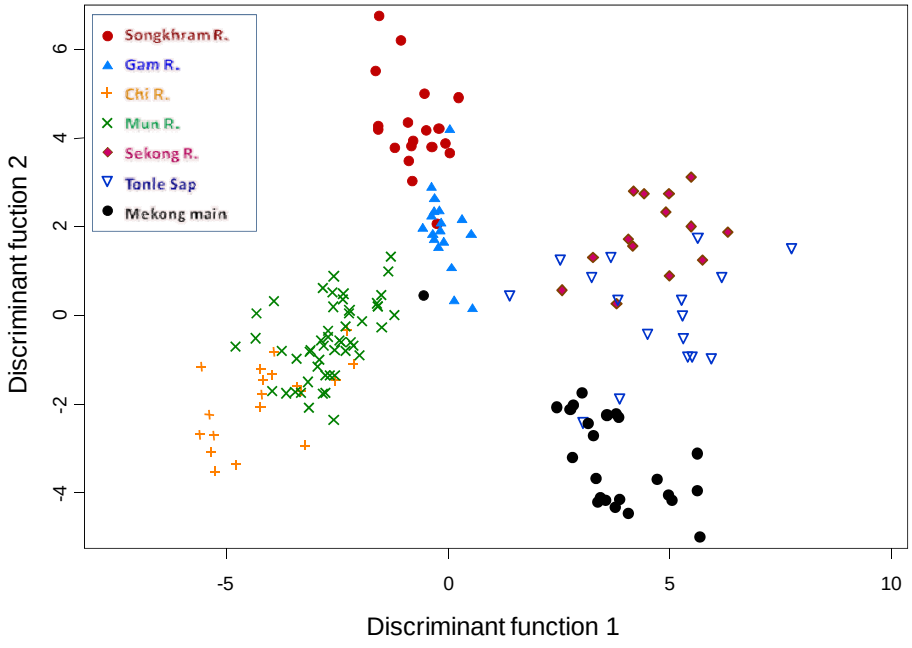
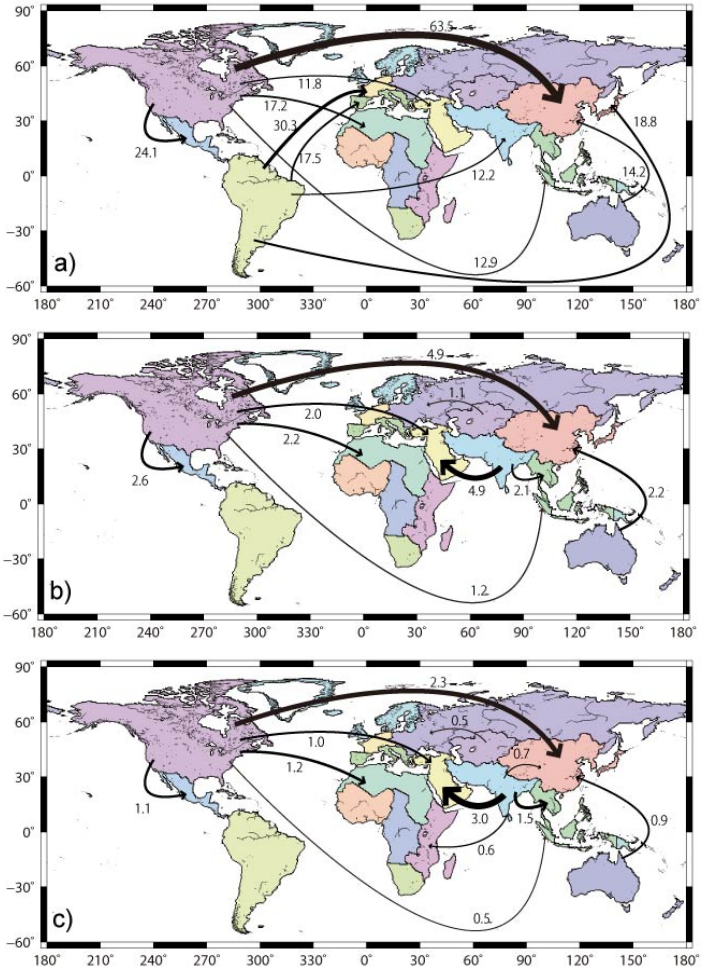


Fig. 11 Linear discriminant function analysis of river waters from the Mekong tributaries and main stream, based on the concentrations of various elements.

It is crucial that we fully appreciate the value of the fisheries and biodiversity resources that are being threatened by fast-moving dam development in the Mekong River. Although the river is located far from Japan, as people who have built many dams and have devastated inland fisheries at least partly because of these dams, we are responsible for sharing our experience with other Asian countries.

Social and Environmental Systems Division



World maps of virtual water exports (i.e., the volume of water that an exporting nation consumes to produce the commodities that it trades abroad).

- ***a) Total virtual water exports for five crops and three livestock products (flows exceeding 10 km^3/year are shown); total 545 km^3/year***
- ***b) Flows of virtual water exports originating from blue (irrigation) water (flows exceeding 1.0 km^3 /year are shown); total 61 km^3/year***
- ***c) Virtual water exports originating from non-renewable and non-local blue water (flows exceeding 0.5 km^3/year are shown); total 26 km^3/year***

Source: Hanasaki, N., Inuzuka, T., Kanae, S. and Oki, T. (2010). An estimation of global virtual water flow and sources of water withdrawal for major crops and livestock products using a global hydrological model. J. Hydrol., 384(3–4): 232–244.

This Division targets 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:

1. The Environmental Economics and Policy Section studies the economic and policy aspects of environmental conservation and analyzes the economic and political effectiveness of environmental policies.

2. 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 climate change impacts.

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

4. The Transportation and Urban Environment Section analyzes urban environmental issues such as air pollution and global environmental issues such as climate change caused mainly by automobiles.

Our main research outcomes in FY 2009 were as follows.

1. Environmental Economics and Policy Section

To investigate a wide range of environmental issues we are studying the interactions between current social and environmental systems by using approaches from social science, natural science, and systems analysis. In addition, we are analyzing the economic impacts 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.

(1) Econometric study of the effect of trade openness on a country's energy use

Trade openness, an important international policy issue, affects the energy use of each country through trade. This is because, for example, trade openness is likely to encourage some countries to import energy-intensive products instead of producing them, and encourages others to increase their exports of these products. Energy use is an important topic for analysis, because it is related to issues such as global warming and global energy security. Hence, in this study, we developed an econometric model of a country's energy use and are explored how trade openness affects a country's energy use.

Our main findings were as follows (See also Table 1):

(a) Trade openness increases energy use by developing countries in both the short and long term. On the other hand, it decreases energy use by developed countries in the short-term but increases it in the long term.

(b) The short-term effect of trade openness on energy use is limited, but the long-term effect is highly significant.

Table 1 Trade elasticity (percentage increase in energy use due to increase in trade openness)

	Short-term effect	Long-term effect
Developed countries	–0.003	2.221
Developing countries	0.031	1.334

(2) Study of WTO rules and their potential impact on the climate regime after 2012

International activities to combat climate change do not always remain within the scope of the UNFCCC (United Nations Framework Convention on Climate Change). There are various policy options to enhance cross-institutional coordination on climate change. Of specific importance is the overlap between the climate regime and the rules of the World Trade Organization (WTO). This overlap affects several core elements of the climate regime.

The objective of this study was to explore the role of trade in motivating action on climate change, using the specific example of developments within the WTO, with primary attention on border carbon adjustment. We undertook the following tasks: (a) analysis of the treatment of competitiveness issues under the UNFCCC process; (b) assessment of key trade rulings with environmental implications; and (c) analysis of the potential effects of border carbon adjustment. Our main findings were that the design of border carbon adjustment measures is likely to influence the compatibility of these measures with the WTO rules and therefore the effectiveness of the measures.

(3) Quantitative analysis of promotion of energy substitution in China

Emission reduction in developing countries such as China, India, and Brazil is a major concern in the prevention of global warming. China has become the biggest CO_2 emitter, and its economic growth will continue for decades. Energy substitution from coal to natural gas in China will help emission reduction through the improvement of CO_2 intensity (CO_2 emissions per gross domestic product). However, coal is the cheapest fuel in China, and it is difficult to increase the consumption of gas in preference to coal without changing the relative costs of these commodities. We developed a multi-regional dynamic CGE (computer general equilibrium) model for the Chinese economy and quantitatively evaluated energy policies to promote energy substitution with a focus on the relative prices of energy, capital, and other goods. Our main finding was that capitalization aimed at the development of gas fields in western China would enhance natural gas supply from west to east and would reduce the economic gap between regions.

2. Environmental Planning Section

We are studying the development and assessment of regional plans and basic environmental plans for environmental conservation. In this research, we are investigating new methods of understanding and assessing regional environments by using geographic information systems (GIS) and numerical simulations. We are also investigating the current status of public environmental awareness and promoting voluntary action by individuals.

(1) Theory and effects of voluntary environmental actions taken by individuals and enterprises

Volunteers are becoming increasingly important to the effectiveness of environmental projects and activities. Although, in many cases, the motives for participation in volunteer activities can be explained in cost–benefit terms, including mental utility, past theoretical predictions on the motives have not concurred with empirical outcomes. To assess the effects of costs and benefits on volunteers' participation, we asked questions about items such as transportation expenses that could prevent volunteer participation, and we tested the relationship between these items and rates of volunteer participation. The results indicated that the costs and benefits of volunteer participation were important at the beginning of participation and the costs were quite low, but they were not important for retention and continuance of volunteer activities. For recruitment of volunteers, strategies such as increasing opportunities for participation were thought to be more effective than emphasizing the benefits.

(2) Study of national trends in public interest in environmental issues

We are conducting monthly public opinion surveys to evaluate the levels of public support for environmental policies. Our questionnaires cover "The most important issues in the world" and "The most important issues in Japan." Our sample populations consist of 4000 men and women aged at least 20 years and drawn from across the nation. These respondents are randomly selected every month. The response rate for "environmental/pollution" issues (Figure 1) was about 20% until December 2006; it then rose sharply from January 2007 and remained high until summer 2008. Then, because of the global financial crisis, the "environment" response rate dropped sharply, and the "economy" response rate rose. Since January 2009, the response rate for "environment" has risen again because of the discussion about the mid-term target for reduction of greenhouse gas (GHG) emissions. Those changes were closely associated with mass media (both television news and newspaper) coverage of environmental issues.

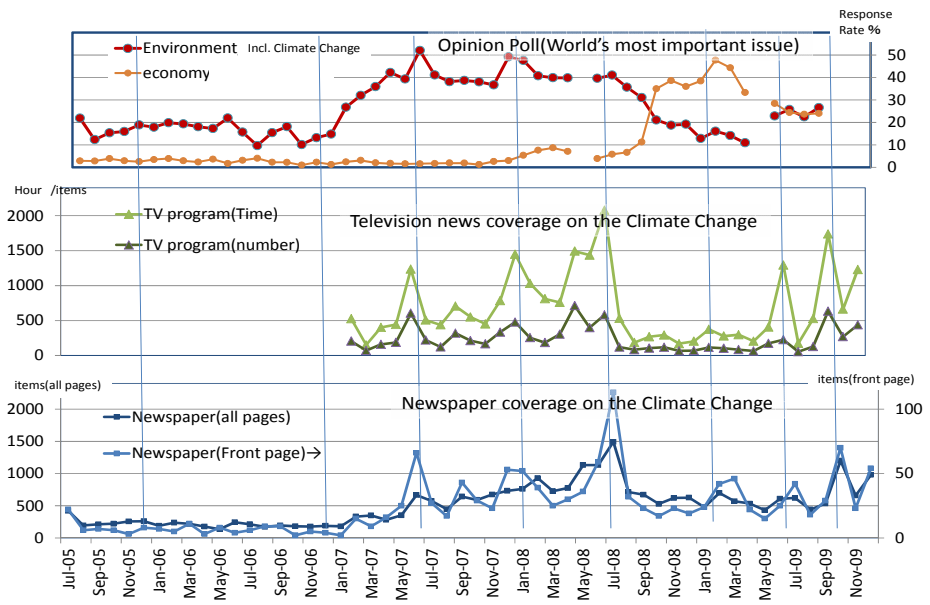


Fig. 1 Changes of Public perception, mass media coverage from May 2005, to November 2009.

(3) Study of strategic urban planning and assessment of low-carbon cities

In the planning and building of low-carbon cities, the use of architectural methods that take into account global environmental conservation generally involves a reduction in the heat load of buildings. Shade from nearby structures alters building cooling, heating, and lighting loads by reducing incident solar radiation. We used the energy simulation tool eQUEST to simulate the energy demands of mid-rise multi-family residences in the hot summer and cold winter climate zone of China. Shanghai was used for the case study. Cooling, heating, and lighting energy demands due to shading from nearby buildings in the same building cluster were analyzed for different W/H (street width / building height) values. (An optimum W/H minimizes the energy use of a typical residential building.) Eight identical buildings in eight orientations were modeled. The different values of W/H were used to represent different energy demands (Figure 2; Table 2). The results showed that increasing W/H increased cooling energy demand and reduced heating and lighting energy demand. The minimum total energy demand was reached when W/H was 1.5 (Figure 3). A line of mature deciduous shade trees was modeled in eQUEST, with seasonal transmittance. Energy demand was simulated with different distances from the tree to the south wall of the building. Decreasing the distance reduced the building's total energy demand. Adjusting the site layout of the building cluster and planting trees are therefore likely to be useful future energy conservation strategies for buildings.

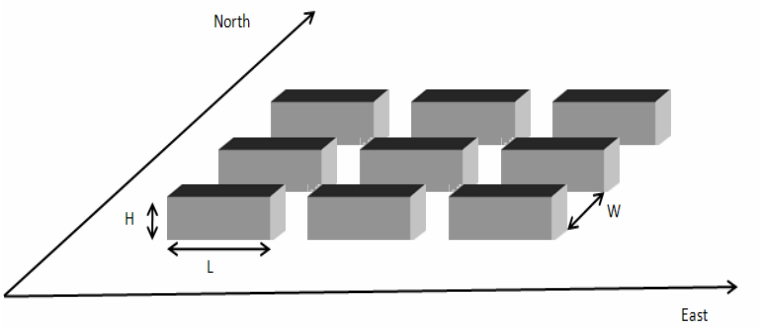


Fig. 2 Site layout of a hypothetical residential building cluster.

Table 2 Details of the generic building used in the modeling.

building type	Multifamily, Mid-Rise, Strip, 6 floors
floor geometry	Length 54m, Depth 12m, Height 3m
envelop structure	National Standard JGJ 134-2001
set point of air conditioner and light	Space Heating: 18° C, Space Cooling: 26° C, Lighting: 500 lux
local weather	TMY of Shanghai
analysis period	from 1st, Jan. to 31th, Dec.

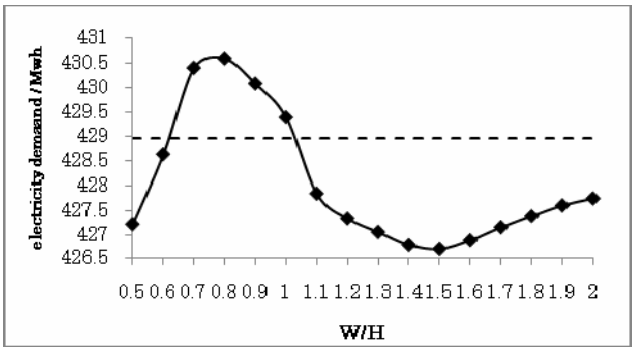


Fig. 3 The street width (W) to building height (H) ratio influences a building's total electricity demand.

3. 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 a model that evaluates policy options for solving various environmental problems. We developed and modified the Asia–Pacific Integrated Model (AIM) to assess climate policy. The model results are provided to environmental policymakers in Japan. 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 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 2009:

(1) We have developed an integrated assessment model to comprehensively analyze and assess the emission reductions needed to achieve climate stabilization targets, as well as the impacts and risks occurring under such stabilization targets. By integrating the findings (impact functions) obtained from sectoral impact assessment results, we have been able to comprehensively assess the impacts in multiple fields. The results should be of unprecedented value globally. They include the finding that Japan will also experience severe climate change impacts even with a relatively low temperature increase. If a significant reduction in global GHG emissions is achieved, the damage to Japan is expected to be reduced to a considerable extent. However, even if the GHG concentration is stabilized at 450 ppm CO_2 equivalent, a certain amount of damage is unavoidable (Figure 4).

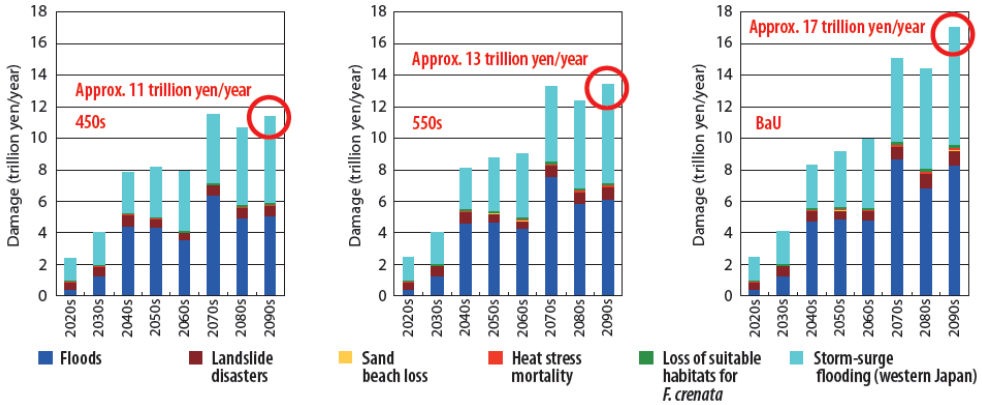


Fig. 4 Costs of damage caused by climate change in Japan, by scenario and by index

(2) The concept of virtual water, which is the volume of water consumption required to produce commodities traded to an importing or exporting nation (or any region, company, or individual), is a useful complement to analyses of water availability and use by region. Identifying the source of virtual water, such as precipitation (green water) and irrigation water (blue water), further enhances this concept, because each source differs in its level of sustainability and opportunity cost. We conducted a global hydrological simulation for 15 years from 1985 to 1999 at a spatial resolution of 0.5° × 0.5° (longitude and latitude). Using global trade data for 2000 and the simulated virtual water content of major crops, the virtual water flow was estimated globally. Our results indicated that the global virtual water export (i.e., the volume of water that an exporting nation consumes to produce the commodities that it trades abroad) of five crops (barley, maize, rice, soybean, and wheat) and three livestock products (beef, pork, and chicken) was 545 km^3/year. Of the total virtual water exports, 61 km^3/year (11%) was blue water (i.e., irrigation water) and 26 km^3/year (5%) was non-renewable and non-local blue water.

(3) We have started to build a new module for estimating energy service demand in the residential sector in AIM/Enduse[Global] model. As a first step, we have developed a reconciliation method to estimate energy consumption and energy service demand in the residential sector. The method estimates the most valid data on the basis of the relationships among energy consumption, service demand, and energy device share and efficiency. The reconciled data is input into AIM/Enduse[Global] model as a benchmark year dataset. The results reveal that about 60% of energy consumption in developing countries is used for cooking.

(4) The results of an AIM/CGE[Japan] simulation used to estimate the economic impact of the introduction of GHG reduction countermeasures were provided to a Taskforce meeting under the ministerial committee on global warming, which was formed in October 2009. The main purpose of this meeting was to discuss the targeted 25% reduction in GHG emissions between 1990 and 2020. The features of future macro-economic frameworks (e.g., gross domestic product [GDP] and steel production) were not discussed. The practical countermeasures proposed by the ministerial committee were limited to selected options, such as enhancement of renewable energy supplies. Consequently, the quantitative results were not dramatically different from the results calculated in April 2009. As a policy option to mitigate economic damage, we proposed a low-carbon tax and recycling of carbon tax revenue to support the countermeasures contributing GHG emission reductions. By introducing this policy mix, the GDP loss in 2020 can be mitigated from 3.2% to 2.7%.

4. Transportation and Urban Environment Section

This section pursues studies related to transportation and urban environmental problems. We use our vehicle test facility and onboard measurement devices to evaluate the environmental impacts of motor vehicles. We also formulate and evaluate environmental improvement scenarios in transportation and urban systems.

(1) Evaluation of electrically powered transport for personal use

The use of electrically powered vehicles (EPVs) may be one way to reduce CO_2 emissions in the transportation sector. We evaluated the performance of four electric bicycles (EBCs) with three kinds of supplementary motor use, viz., a motor assisting the front wheel, the rear wheel, or the pedals. An electric vehicle (EV) and an electric motorcycle (EMC) made by small companies were also examined. The EBC with front-wheel motor assist consumed more energy than the ones with real wheel or pedal assist under similar conditions. The EV examined had the same energy consumption per 1 km of travel as the EVs manufactured by well-known auto makers, but it was about half the weight of these well-known EVs. The performance of the EMC was extremely low; it had slow acceleration and a low maximum speed. The chargers of most of the EPVs examined had low performance. Chargers with high efficiency and reduced standby energy are needed.

(2) Study of long-term CO_2 reduction strategies by the transport sector towards a low-carbon society

As part of the transport section studies of the Japan Low Carbon Society 2050 Project, we used origin–destination data from the national road census to estimate CO_2 emissions from automobiles by municipality (Figure 5). This estimation enabled us to analyze the regional characteristics of automobile CO_2 emissions, trip frequencies, and average trip lengths. A decrease in CO_2 emissions per capita from 1999 to 2005 was observed, especially in metropolitan regions. This study will help to establish national and local action plans for global warming countermeasures.

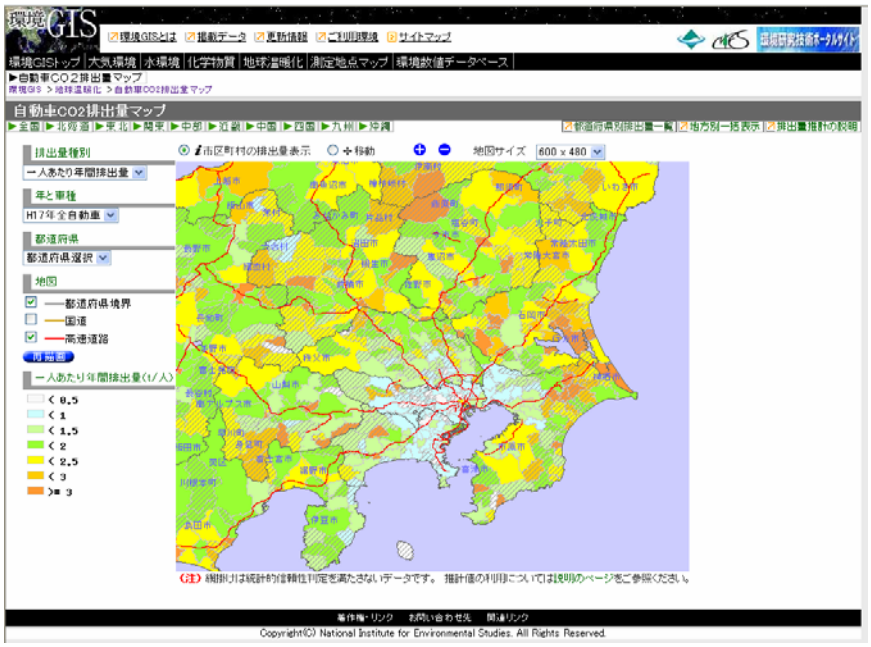
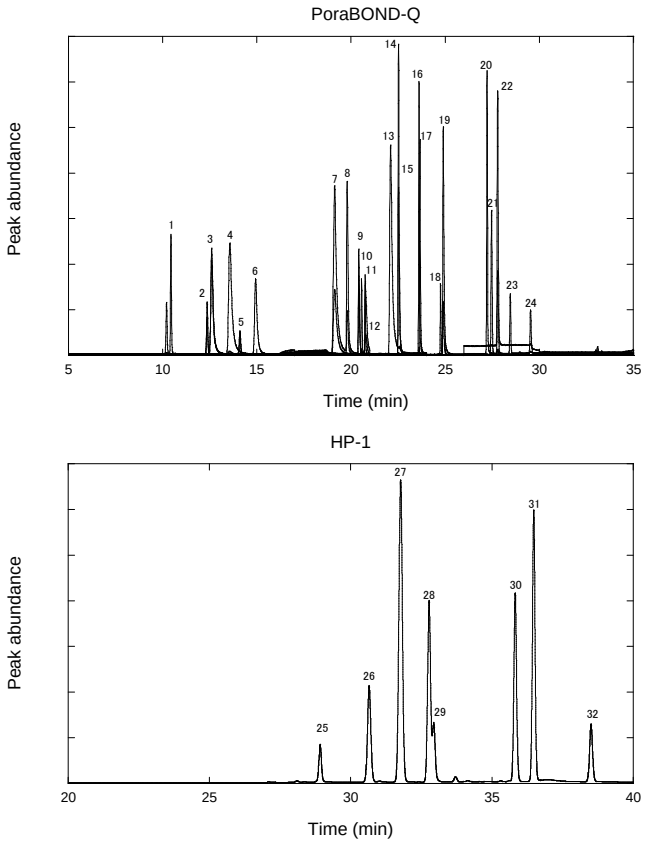


Fig. 5 This motor vehicle CO_2 emissions map is available via the Environmental GIS Website of NIES (http://www-gis5.nies.go.jp/carco2/co2_main.php) (in Japanese). This system provides information on CO_2 emissions from passenger cars and freight vehicles.

Environmental Chemistry Division



High-resolution analysis of halocarbons by multidimensional gas chromatography. Top: PoraBOND-Q column; bottom: thick-film HP-1 column.
1: PFC-14 (m/z = 69); 2: HFC-23 (*m/z* = 51); 3: PFC-116 (*m/z* = 119); 4: SF6 (*m/z* = 127); 5: HFC-32 (*m/z* = 33); 6: CFC-13 (*m/z* = 69); 7: PFC-218 (*m/z* = 169); 8: Halon-1301 (*m/z* = 129); 9: HFC-134a (*m/z* = 83); 10: HFC-152a (*m/z* = 65); 11: HCFC-22 (*m/z* = 67); 12: CFC-115 (*m/z* = 85); 13: PFC-318 (*m/z* = 100); 14: CFC-12 (*m/z* = 85); 15: HFC-227 (*m/z* = 69); 16: HCFC-124 (*m/z* = 67); 17: HCFC-142b (*m/z* = 65); 18: Halon-1211 (*m/z* = 85); 19: CFC-114 (*m/z* = 85); 20: CFC-11 (*m/z* = 101); 21: HCFC-141b (*m/z* = 81); 22: HCFC-123 (*m/z* = 85); 23: 24: CFC-113 (*m/z* = 101); 25: $CHCl_3$; 26: CH_3Cl_3; 27: CCl_4; 28: CH_2Br_2; 29: C_2HCl_3; 30: $CHBr_2Cl$; 31: C_2Cl_4; 32: $CHBr_3$

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 methods of analysis of the central nervous system, such as nanoparticle analyses and magnetic resonance imaging (MRI); behavioral and biochemical responses to chemicals; and scientific and technical support in various environmental issues (e.g., implementation of the Stockholm Convention; evaluation and treatment of 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 applying these analyses to environmental monitoring. We have started special research on "Comprehensive analysis of trace environmental organic pollutants such as organohalogen compounds by using multidimensional separation" to develop next-generation analytical methods for organic pollutants in the environment on the basis of comprehensive multidimensional gas chromatography (GC×GC), high-resolution time-of-flight mass spectrometry (HR-TOF-MS), and quadrapole-type tandem mass spectrometry (MS/MS). We have developed a GC×GC-MS/MS analytical system that is the first of its kind in the world. The system has wider dynamic range and higher sensitivity than the GC×GC-HR-TOF-MS developed in our previous research. The new system is suitable for global detection and quantification of trace organics without tedious pretreatment in cases where GC×GC-HR-TOF-MS is good in identification of compounds.

We applied thermal desorption (TD)-GC×GC-MS/MS to direct analysis of polycyclic aromatic hydrocarbons (PAHs) and PAH derivatives (oxy-, methyl-, and nitro-) in airborne particles. The instrumental detection limits were 0.01 to 0.35 pg, showing the extremely high sensitivity of this method. The results of analyses of trace amounts (ca. 20 μg) of Standard Reference Material 1649a agreed with the certified or reference values within a factor of about 2. We also investigated TD-GC with high-resolution mass spectrometry (HR-MS) of PAH derivatives. The quantification limits for oxy- and methyl-PAHs were equivalent to those for PAHs (2 to 40 pg), but those for nitro-PAHs were relatively poor (60 to 90 pg). The TD-GC/HR-MS measurements revealed that the concentrations of oxy- and nitro-PAHs were equivalent to, or larger than, those of the corresponding PAHs in diesel exhaust particles under some conditions.

We investigated the highly sensitive monitoring of ambient POPs by using a laboratory-designed automatic multiple TD-tube sampler and TD-GC×GC-MS/MS. Five POPs (hexachlorobenzene *trans*-/*cis*-chlordanes, and alpha-/gamma- hexachlorocyclohexanes) in only 0.18 m^3 of air were quantified

by TD-GC×GC-MS/MS. The results agreed with those obtained by low-volume sampling (14.4 m^3 of air) followed by a conventional cleanup procedure and GC/HR-MS analysis. The automatic sampler works well, but it needs some improvements to reduce measurement blank and increase recovery rates.
We also tried global detection of organohalogens in fly ash extract by neutral-loss scan of GC×GC-MS/MS. Many peaks attributable to chlorine, bromine and fluorine compounds were found on 2D chromatograms. Similar results were successfully extracted from GC×GC-HR-TOF-MS data by using laboratory-made software.

The Advanced Inorganic Analysis Section has been investigating the precise measurement of stable-isotopic abundance of heavy metals (lead and mercury) in biological, geological, and environmental samples by multi-collector inductively coupled plasma mass spectrometry (MC-ICP-MS). Radiocarbon (^{14}C) has being measured by accelerator mass spectrometry (AMS). The AMS facility, NIES-TERRA, conducted more than 1000 radiocarbon measurements this financial year, including analyses of airborne particles, atmospheric carbon dioxide, and carbonate and organic matter in soil and marine sediment. We have also been investigating the application of surface analytical and elemental mapping methods such as XRF (X-ray fluorescence analysis) and SIMS (secondary ion mass spectrometry) for the characterization of environmental and geological samples.
We have started new research on the mechanisms of soil organic carbon accumulation and their effects on global climate change. Japanese volcanic ash soil samples were taken at several sampling sites (including the Teshio experimental forest of Hokkaido University and the Fuji-Hokuroku flux observation site in the foothills of Mt. Fuji) and fractionated by density. Dynamics of soil organic carbon were examined by using excess radiocarbon emitted by nuclear-bomb tests in the mid 20th century as a tracer to assess the turnover and storage of organic matter in the soils.
Biomonitoring of trace elements can provide valuable information to evaluate the contamination status of environments and to warn of possible adverse effects of these elements on health. Trace element concentrations (i.e., V, Cr, Cu, Zn, As, Se, Cd, Hg, and Pb) in the livers of red stingray (*Dasyatis akajei*) collected from Tokyo Bay between 2007 and 2008 were analyzed. The results showed no significant enrichment, except in the case of As (12.81 ± 5.08 μg/g, dry wt.), and they should help to establish environmental baseline levels of hepatic concentrations of these elements in stingray for future monitoring.
We have been monitoring the water quality (chlorophyll, turbidity, temperature, and photon flux) in Lake Mashu, Hokkaido (a baseline monitoring station of the UNEP GEMS/Water program) by using data loggers moored in the lake to find the cause of a decline in transparency. Seasonal changes in chlorophyll (Figure 1) and the downward beam attenuation coefficient (Kd) calculated from the photon flux densities showed that the transparency was high (i.e., low Kd values) in winter.

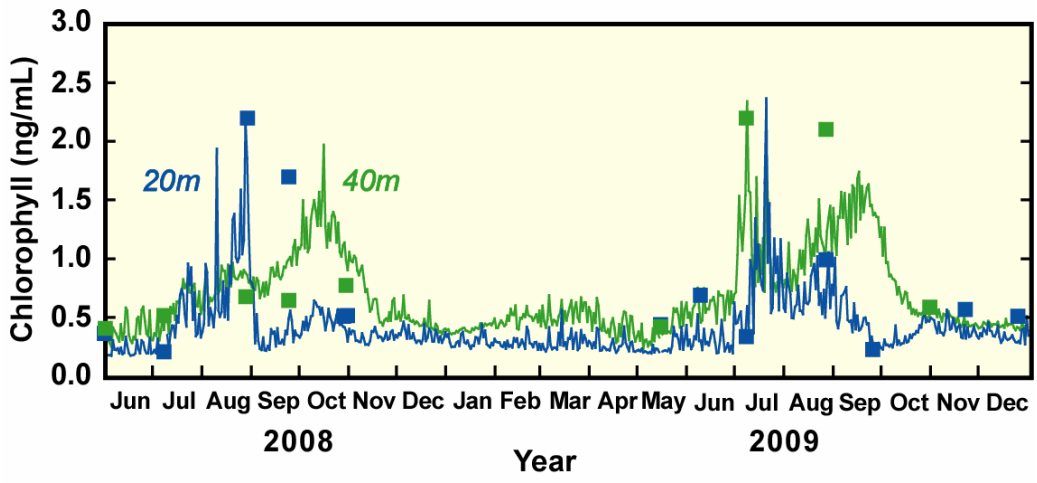


Fig. 1 Seasonal changes in chlorophyll concentration in Lake Mashu from June 2008 to December 2009, observed by data loggers moored at water depths of 20 and 40 m, indicate the growth of plankton during summer and autumn; these plankton reduce water transparency. Chlorophyll concentrations of discrete samples measured by conventional fluorometry are also plotted (filled squares).

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

(1) *In situ* high-frequency monitoring of halocarbons at Hateruma Island in Okinawa and Cape Ochi-ishi in Hokkaido has been done as a part of a "High-frequency and advanced monitoring study of the halogenated greenhouse gas inventory in East Asia." The following mean baseline concentrations in 2009 and rates of increase from last year were recorded: HCFC-22, 211.7 ppt (+5.5%) at Hateruma and 213.6 ppt (+4.9%) at Ochi-ishi; HCFC-141b, 21.8 ppt (+3.1%) and 21.2 ppt (+2.4%); HCFC-142b, 21.4 ppt (+5.5%) and 21.4 ppt (+2.9%); HFC-23, 23.6 ppt (+3.3%) and 23.2 ppt (4.2%); HFC-134a, 56.7 ppt (+9.4%) and 57.9 ppt (+8.2 ppt); HFC-152a, 7.7 ppt (+8.6%) and 8.9 ppt (+2.0%); HFC-32, 4.2 ppt (+29.7%) and 3.9 ppt (+21.3%); and SF6, 7.1 ppt (+6.0%) and 6.9 ppt (+4.5%).

(2) To improve the method used to analyze a wide variety of atmospheric halocarbons, a multidimensional GC system based on a Deans switch was developed and evaluated for the separation of halocarbons. The GC system showed improved performance for some halocarbon measurements due to the improved resolution and the high sensitivity of the newly installed micro-Electron Capture Detector (ECD) (see Figure on the front page of this section).

(3) Partial pressures of volatile halocarbons in surface seawater and the marine boundary layer were measured over the Northwest Pacific in May and over the Indian Ocean in November–January. We found that pCH_2Cl_2 (partial pressure of CH_2Cl_2) water values were higher than pCH_2Cl_2 air values between 10°S and 65°S, thus providing evidence for the *in situ* production of CH_2Cl_2. In the South Indian Ocean (20°S), both the CH_2Cl_2 and the chlorophyll-*a* concentrations were highest in the subsurface layer, suggesting phytoplankton production of CH_2Cl_2.

(4) Transport behavior of particulate organic carbon during rainfall events in the Teshio River, a small river in Hokkaido passing though an alluvial plain and forest, was investigated. The $\Delta^{14}C$ values were positively correlated with C/N molar ratios and negatively correlated with $\delta^{13}C$ values, with the exception of the data obtained when both the turbidity and the water level peaked because of rainfall. These results indicate that the source of organic matter entering the river changed to the surface layer of soil from lower layer as the water level rose with rainfall.

The **Biological Imaging and Analysis Section** has been developing methods and instruments for detecting and analyzing *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 in non-invasive and non-destructive ways.

We have collected brain images from over 200 healthy human subjects aged from 19 to 75 years. Whole-brain images have been segmented into typical tissue types of gray and white matter and cerebrospinal fluid, and quantification of the volume of each type of tissue is under way. Quantification of regional ferritin iron ([Fe]) in the brain is another subject of our observations of the human brain by MRI. Although iron is essential to life, excessive amounts of iron in our body become harmful because of the production of reactive oxygen species (ROS). Iron toxicity is known to be involved in various life events such as aging, cancer development, and neurodegenerative conditions such as Alzheimer's and Parkinson's diseases. We found that the iron concentration is linearly correlated with the apparent transverse relaxation rate ($R_2^\dagger = 1/T_2^\dagger$) of tissue water in the brain, which is observable by MRI (Figure 2). We have found that the $R_2^\dagger$ obtained in the live human brain using our 4.7 T high-field MRI can be described by a linear combination of brain regional [Fe] and macromolecular mass fraction (f_M), defined as 1 – water fraction (f_w); thus $R_2^\dagger = \alpha\,[Fe] + \beta\, f_M + \gamma$, where α , β , and γ are coefficients. This year we confirmed that the relationship between $R_2^\dagger$, [Fe], and f_M was also valid in a low magnetic field of 1.9 T, and that the multiple regression coefficient of the correlation at 1.9 T was as high (0.99) as that obtained at 4.7 T. This finding may lead to accurate iron quantification *in vivo* through the use of ordinary clinical MRI systems.

We also developed an imaging method for accurate quantification of the water content of the human brain using MRI. This is required for non-invasive mapping of ferritin iron and metabolites in the brain. The signal intensity in the images obtained by MRI is originally proportional to the water content. However, radio frequency (RF) interference effects derived from transmission and reception RF fields cause non-uniformity of these images at high magnetic fields. This non-uniformity is one of the major obstacles to the accurate imaging of water content. Although maps of both transmission and reception fields are required to achieve uniform imaging, methods of reception field mapping have not been strongly investigated, and water content imaging had therefore not been achieved. We found experimentally that the relationships between transmission and recep-

tion fields have the same pattern from one person to another. Thus, the reception field can be calculated from the measurable transmission field by a simple formula. We developed a non-uniformity correction method using the measured and calculated fields. Human brain images obtained at high fields of 4.7 T were successfully corrected by our method. Regional water fractions (f_w) obtained from the corrected images were in good agreement with previously reported values based on dissection.

In a study of the health effects of organic arsenic in experimental animals, we examined the toxicity of diphenylarsenic acid (DPAA) administered daily to mice by examining the mice's behavior and the amount of glutaminase in the cerebellum. DPAA at 5 mg/kg was perorally administered to ICR male mice once a day for 36 days; miliQ water was administered to the control animals at the same dosage schedule. Rota-rod, bridge, and traction tests were conducted repeatedly during the administration period, and passive avoidance and spontaneous alteration tests were done on the last day of administration. DPAA affected the performances of the mice in rota-rod and bridge tests but not in the traction, passive avoidance, or spontaneous alteration tests, indicating that DPAA selectively inhibited coordinated motor abilities. These effects were not products of a change in cerebellar glutaminase levels, because the enzymatic activities and amounts of the protein in the cerebella of DPAA-treated animals were not affected.

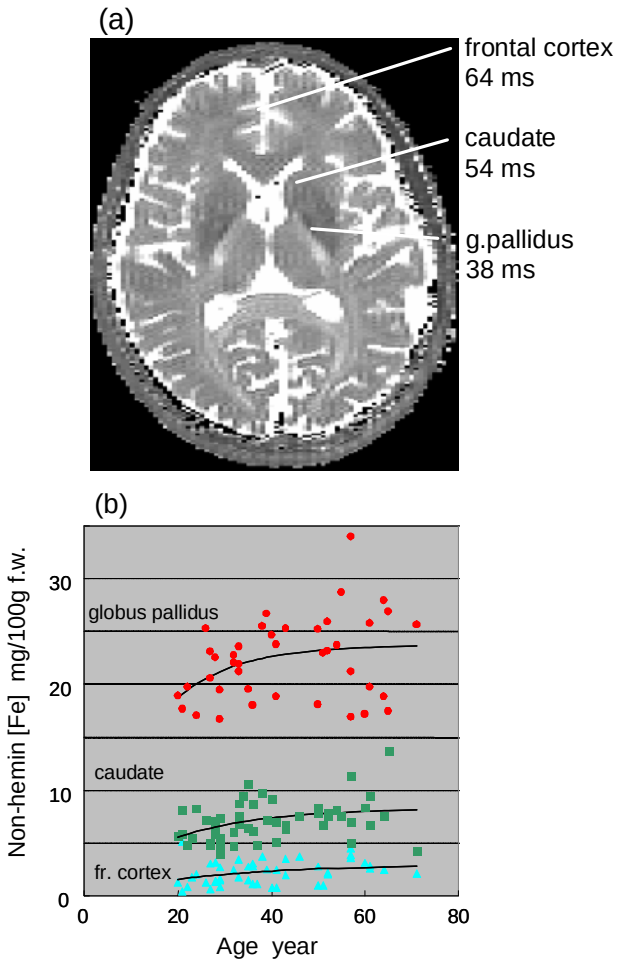
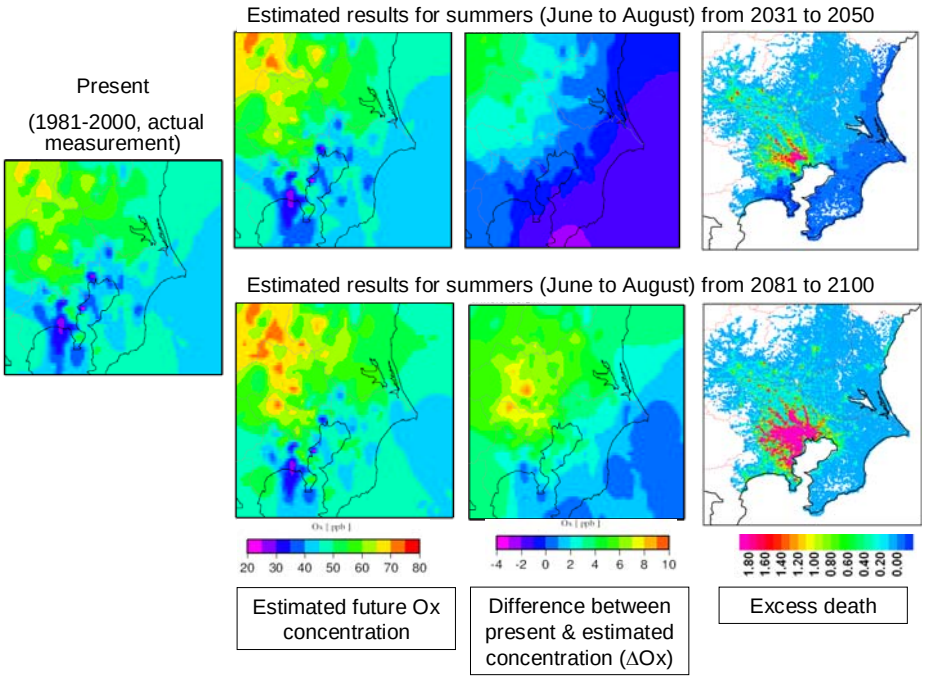


Fig. 2 Brain iron quantification *in vivo* based on imaging of apparent transverse relaxation time ($T_2^{\dagger}$). (a) A $T_2^{\dagger}$ map of the human brain, showing $T_2^{\dagger}$ values in three regions (frontal cortex, caudate nucleus, and globus pallidus). (b) Iron concentrations quantified from the $T_2^{\dagger}$ values in the three brain regions in 54 healthy subjects, plotted as a function of age.

Environmental Health Sciences Division



Future changes in photochemical oxidant (Ox) concentration caused by global warming, and the associated excess death risks

The figures in the middle show the Ox concentration distribution in the Kanto region, estimated from future weather patterns forecast by using the Regional Climate Model 20 (RCM20), and the change from the present (ΔOx).
The figures on the right show the numbers of excess deaths among persons aged 65 and older, obtained by multiplying the death risk associated with the Ox concentration change by the population. Numbers of excess deaths are shown in a 1-km mesh distribution over 20 summers (60 months in total) for future populations estimated on the basis of particular social scenarios.

The mission of the Environmental Health Sciences Division is to study the potential effects of environmental chemicals (e.g., endocrine-disrupting chemicals, dioxins, arsenite, phthalate plasticizers, metals, and air pollutants) and physical agents (e.g., heat stress) on human health. We aim to use the information as a scientific basis for the risk assessment of these agents, alone or in combination with other factors, including allergens. 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 toxicities. In particular, we are interested in hypersensitive populations that are susceptible to the harmful effects of environmental stress. 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. Also, he has evaluated the enhancing effects of a variety of environmental chemicals on allergic diseases *in vivo* and allergic reactions *in vitro*. Furthermore, he examined the effects of environmental chemicals on lifestyle-related diseases, including obesity, diabetes mellitus, and fatty liver.

In the **Molecular and Cellular Toxicology Section,** we have been studying the effects of environmental chemicals on biological and physiological functions and the mechanisms of these effects. Our recent focus has been on epigenetic effects, such as DNA methylation changes and histone modifications, and on alterations in the functions of transcription factors.

In FY 2009, we studied the DNA methylation status in the livers of male and female mice fed a standard diet (methyl-sufficient diet, MSD), a methyl-deficient diet (MDD), or a methyl-deficient diet with water containing inorganic arsenic (MDD + As). Our study showed that the proportion of 5-methylcytosine in the genome, the amount of the methyl-group donor S-adenosylmethionine (SAM), and the expression of DNA methyltransferases in the liver were differently affected in males and females. These findings might provide important clues to the sex-dependent susceptibility of humans to arsenic.

We conducted a genome-wide study of the DNA regions that are affected by arsenic. We obtained highly methylated DNA fragments by a methylated DNA immunoprecipitation (MeDIP) method from the liver genomes of mice fed MSD, MDD, or MDD + As. These samples were subjected to next-generation sequencing. Fifty bases in each of more than 9 million fragments—a total of more than 450 million bases—were sequenced for each genomic sample (Table 1). The images obtained were converted to sequence reads and the reads were mapped onto the UCSC Genome Browser Mouse genome assembly. For each sample, regions where uniquely mapped highly methylated reads accumulated were

defined. From these results, we made files to visualize the reads (Figure 1) and a file that enabled comparison of the results among the groups. We also validated the results of MeDIP-seq by assessing the methylation status by bisulfite sequencing and methylation-sensitive PCR (polymerase chain reaction). The results showed that MeDIP-Seq is a highly sensitive, high-throughput method for detecting DNA methylation changes induced by chemicals.

We also studied the epigenetic effects of dioxin. Toxic effects of dioxin are exerted in a cell-type-specific or tissue-specific manner. Our results suggested that epigenetic alterations, including histone modifications and heterochromatin formation, are involved in the different susceptibilities of the liver and spleen to dioxin.

Table 1 Summary of next-generation sequencing and mapping of DNA regions affected by arsenic in mice. MSD, methyl-sufficient diet; MDD, methyl-deficient diet; MDD + As, methyl-deficient diet with water containing inorganic arsenic

	MSD	MDD	MDD + As
Total number of filter-passed reads	9,412,904	9,658,829	9,070,585
Sequenced read length (bp)	50	50	50
Total number of filter-passed bases (bp)	470,645,200	482,941,450	453,529,250
Mapping results by BOWTIE			
Total number of mapping reads	3,638,345	3,766,084	3,593,512
Sequence error (%)	2.01	1.95	1.87
Number of unique mappings	2,296,947	2,377,170	2,263,846
Number of multiple mappings	1,341,398	1,388,914	1,329,666

Fig. 1 Images from the UCSC Genome Browser display, showing reads from DNA regions affected by arsenic in mice

In the **Biological Risk Assessment Section**, we have been studying how environmental pollutants affect immune systems. In our *in vivo* studies, we have been investigating the effects of environmental pollutants such as chemicals, diesel exhaust particles (DEP), and nanomaterials on preexisting sensitivity disorders such as allergic diseases and inflammatory lung injury. In our *in vitro*

studies, we have been assessing the effects of these materials on immune cells, including antigen-presenting cells and lymphocytes, and on epithelial cells. In 2009, we obtained some interesting and substantial findings:

1) Diisononyl phthalate (DINP) can aggravate atopic dermatitis related to mite antigen (Dp) in atopy-prone NC/Nga mice (Figure 2). The aggravation is consistent with eosinophil-mediated inflammation, mast cell degranulation, and thymic stromal lymphopoietin (TSLP) expression in the ear. DINP can enhance the expression of cell-surface activation markers and the capacity of Dp-specific antigen-presenting activity of bone marrow–derived dendritic cells (BMDCs) *in vitro* (Figure 3). DINP-induced aggravation of atopic dermatitis might be caused by TSLP-related activation of dendritic cells and acceleration of Th2 responses.
2) Intradermal exposure to polystyrene nanoparticles in the presence of skin barrier defect or dysfunction size-dependently exacerbates atopic dermatitis–like skin lesions related to mite antigen. The enhancing effects may be accounted for by Th2-biased immune responses.
3) Multi- and single-walled carbon nanotubes exacerbate murine allergic airway inflammation via the enhancement of Th immunity. The exacerbation may occur partly through the inappropriate activation of antigen-presenting cells.
4) *Candida* soluble cell-wall beta-glucan facilitates murine allergic airway inflammation via the inappropriate activation of antigen-presenting cells, including dendritic cells.
5) Exposure to organic extracts of DEP suppresses the differentiation of induced pluripotent stem cells into cardiomyocytes in mice.
6) Exposure to 1,2-naphthoquinone (1,2-NQ), a chemical component of DEP, downregulates the expression of Toll-like receptors 2 and 4 on BMDCs. In addition, 1,2-NQ suppresses lipopolysaccharide- and peptidoglycan-induced activation of BMDCs.
7) Exposure to organic extracts of DEP and their chemical components, such as benzo[*a*]pyrene, 9,10-phenanthraquinone, and 1,2-NQ, can stimulate the production of inflammatory cytokines and the expression of mucin in human bronchial epithelial cells.
8) Pulmonary exposure to cell-wall beta-glucan induces murine lung inflammation via the local expression of proinflammatory cytokines and enhancement of apoptosis and oxidative stress.
9) Peroxiredoxin I, a ubiquitous antioxidant enzyme, can inhibit allergen-specific T-cell proliferation through regulation of the Th1/Th2 balance, in addition to having antioxidative properties.
10) Elastase-induced pulmonary emphysema model in rats shows that alkaline phosphatase levels in the lung might be a useful biomarker for the disease progression.

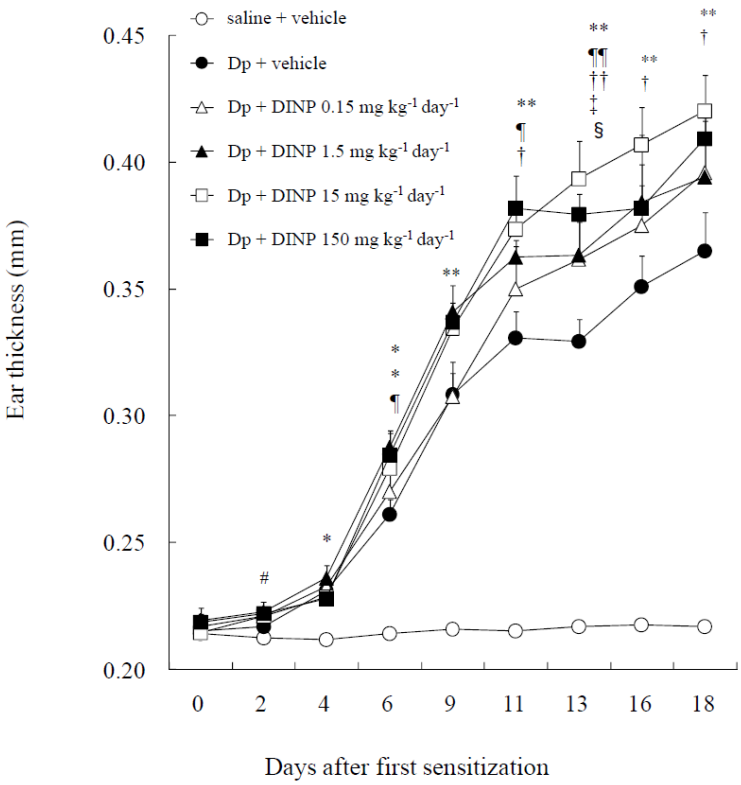


Fig. 2 Effects of DINP (diisononyl phthalate) on atopic dermatitis–like skin lesions induced by mite antigen (Dp) on the ears of mice. Graph shows thickness of the ears 24 h after each intradermal injection of Dp. Data are means ± SEM of 12 animals per group. *P < 0.05, ** P < 0.01, Dp-treated groups vs. saline + vehicle group; # P < 0.05, Dp + DINP groups vs. saline + vehicle group; ¶ P < 0.05, ¶¶ P < 0.01, Dp + DINP 150 mg kg^{-1} day^{-1} group vs. Dp + vehicle group; † P < 0.05, †† P < 0.01, Dp + DINP 15 mg kg^{-1} day^{-1} group vs. Dp + vehicle group; ‡ P < 0.05, Dp + DINP 1.5 mg kg^{-1} day^{-1} group vs. Dp + vehicle group;§ P < 0.05, Dp + DINP 0.15 mg kg^{-1} day^{-1} group vs. Dp + vehicle group.

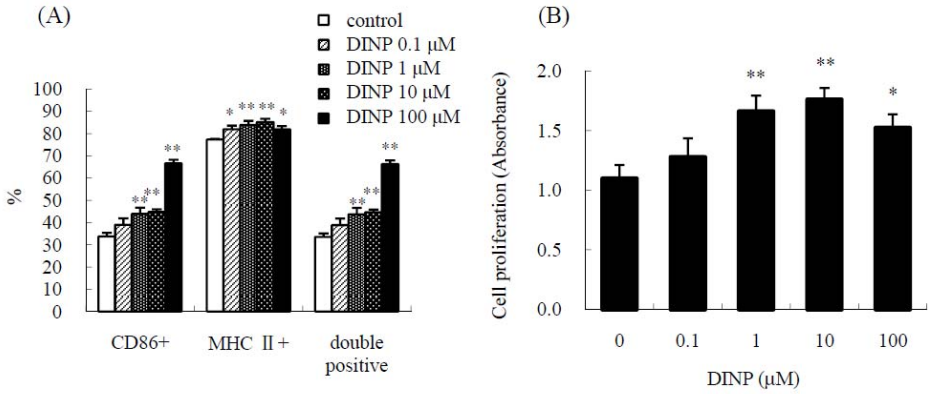


Fig. 3 Effects of DINP (diisononyl phthalate) on expression of activation markers and function of BMDCs. (A) Percentage expression of cell-surface activation markers MHC class II and CD86. (B) Mite antigen (Dp)-specific antigen-presenting activity of BMDCs after DINP exposure for 24 h. Data are means ± SEM of three individual cultures from three animals and are representative of two or three independent experiments. *P < 0.05, ** P < 0.01 vs. control.

The **Integrated Health Risk Assessment Section** conducted epidemiological and experimental research with the financial support of the Ministry of the Environment (MOE) and the Global Environmental Research Foundation. One study assessed the future health impacts of heat and air pollution under global warming. We evaluated future air pollution–related health risks by forecasting

photochemical oxidant (Ox) concentration distributions for 2031–2050 and 2081–2100, and by estimating the excess mortality risks. We then projected risk maps of photochemical oxidant–related mortality in several districts in Japan, namely Kanto, Kansai, the Seto Inland Sea region, and the North Kyushu area.

We continued an epidemiological study among adults in Beijing and Tokyo and began a study in the city of Wuhan, China. The indoor and outdoor PM_{10} concentrations that we measured with personal samplers in Beijing over four seasons closely matched the concentrations calculated from the air pollution index (API) published by the city government (Figure 4). We analyzed the carbon content in PM_{10} samples collected at the same time and found more total carbon (TC) in $PM_{2.5}$ than in $PM_{10–2.5}$ in all seasons, both indoors and outdoors. We also found that the percentage of elemental carbon in the TC in $PM_{2.5}$ was higher outdoors than indoors in all seasons.

We also engaged in research conducted by MOE on short-term morbidity and mortality in relation to air pollution, and an epidemiological study of traffic-related air pollution exposure and respiratory health.

The Japan Environment and Children's Study, which is a birth cohort study of 100 000 people, will be fully under way starting from next fiscal year. NIES will be the core center for the study. As the lead office, we will hold seminars, participate in committees, and perform preliminary work during the current fiscal year.

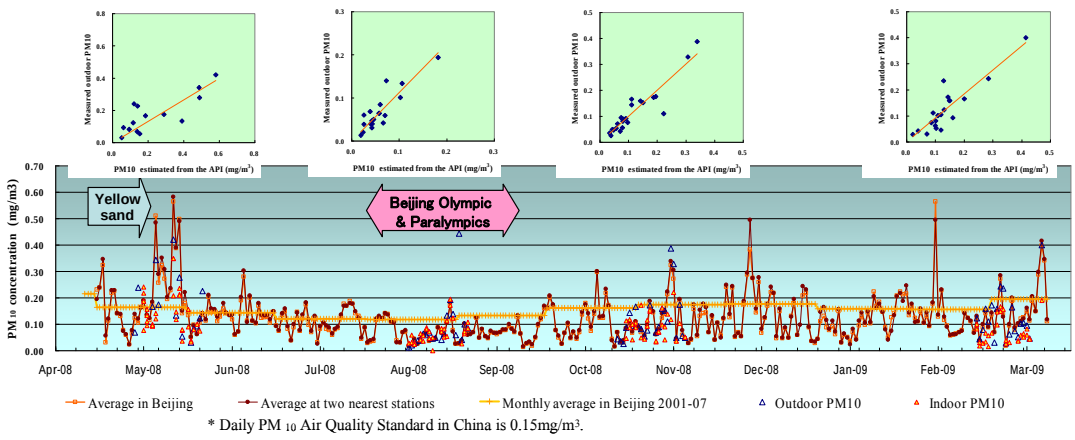


Fig. 4 PM_{10} concentrations in Beijing from April 2008 to March 2009

The **Environmental Epidemiology Section** has been engaged in epidemiological studies of the health effects of environmental exposure. Our current focus is to assess the health impacts of air pollutants. Listed below are the projects with which we have been involved and the findings of the analyses.

We combined the outcome data from previously established cohorts and disease registries with data on air pollution by using a geographic information system (GIS). With these combined datasets, we conducted detailed analyses to investigate the short- and long-term health effects of exposure to air pollutants.

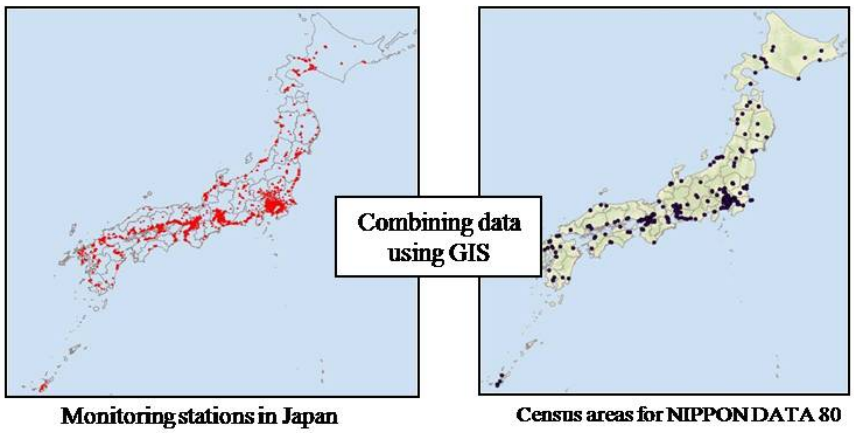


Fig. 5 Location of monitoring stations (left) and census areas for NIPPON DATA 80 (right). To estimate long-term exposure to particulate matter, for each NIPPON DATA80 census area we selected the nearest monitoring station by using a GIS and calculated the annual concentrations of each air pollutant measured at the monitoring station since 1980.

1) The effect of long-term exposure to suspended particulate matter (SPM) on cardiovascular mortality was examined in a NIPPON DATA80 cohort that followed participants recruited from 300 randomly selected districts throughout Japan for 24 years (Figure 5). In general, we did not observe significant effects of long-term exposure to particulate matter on cardiovascular mortality (Figure 6).

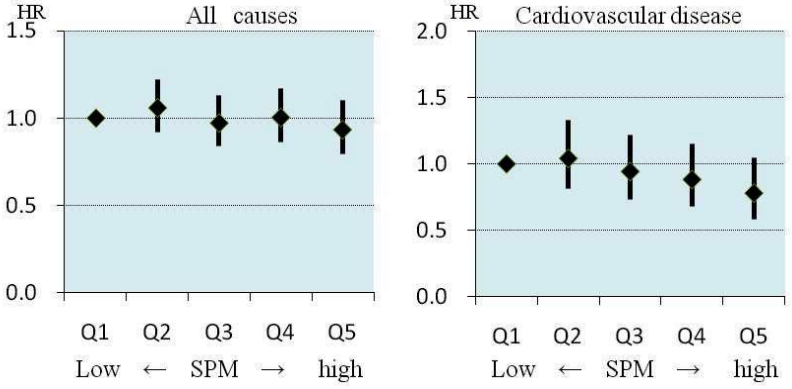


Fig. 6 Multivariate-adjusted hazard ratios (HRs) for mortality from all causes and from cardiovascular disease, according to the quintiles of average suspended particulate matter (SPM) concentrations in NIPPON DATA80. Study participants were allocated to quintiles of average SPM concentration (Q1–Q5). We did not observe any significant association between long-term exposure to SPM and mortality.

2) We explored the short-term effects of chemical components of SPM on mortality in a Japanese urban city. We found that an interquartile range increase in 3-day-averaged concentration of nitrate (1.37 μg/m^3) and sulfate (3.31 μg/m^3) was associated with a 3.0% and 4.4%, respectively, increase in mortality from all causes. Elemental carbon and organic carbon were positively but not significantly associated with mortality from all causes.
3) The "Study On Respiratory disease and Automobile exhaust" (SORA) project was organized by MOE in 2005 to examine the adverse effects of traffic-related air pollution on respiratory health. The SORA project consists of three studies: (1) a cohort study of schoolchildren; (2) a study of infants; and (3) a study of adults. We developed a model to estimate each participant's exposure to traffic air pollutants (elemental carbon and nitrogen oxides) by using information on traffic volumes, vehicle emission rates, meteorological conditions, types of road construction, and distance to roadways.

4) The health effect of Asian dust aerosols is also one of our research interests. We conducted epidemiological studies using data on hospitalization in Fukuoka and emergency room visit data in Nagasaki. We found that the risk in emergency visits increased after Asian dust days in Nagasaki.

The **BM (Basement Membrane) Matrix Laboratory** conducted experimental research with the financial support of the New Energy and Industrial Technology Development Organization (NEDO) and MOE. A typical study examines the *de novo* synthesis of a novel basement membrane substratum (sBM), which has a bare surface of *lamina densa* and co-integration of BM major components such as laminin and type IV collagen, with the aim of differentiating tissue and embryonic stem cells on the substratum *in vitro*. Previously, we synthesized an mLN (mouse laminin)-111-isoformed sBM substratum by culturing immortalized alveolar type-2 epithelial cells (SV40-T2 cells) in the presence of Matrigel as an exogenous mLN-111 source and removing only the covering SV40-T2 cells without impairing the newly formed *lamina densa* underneath. This mLN-111 sBM was effective for the terminal differentiation of airway basal cells to ciliated ones in the same way as *in vivo*. Now we have developed an hLN (human laminin)-511-isoformed sBM substratum with rLN (recombinant laminin)-10 cells, HEK293 recombinant endowed with human laminin-α5, -β1, and -γ1 chains, without the need to supply exogenous BM components. The airway basal cells mentioned above differentiated 1 week faster on hLN-511 sBM than on mLN-111 sBM (Figure 6).

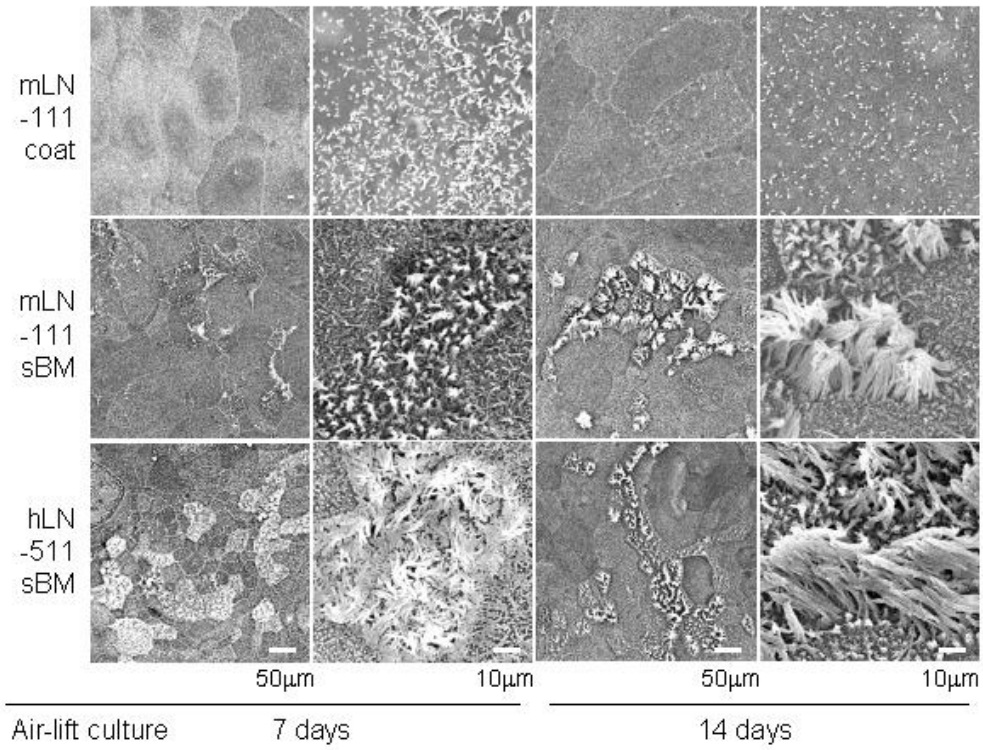


Fig. 6 Terminal differentiation of rat airway basal cells to ciliated cells by air-lift culture on *de novo*-synthesized basement membrane (sBM) substratum. On mouse laminin (mLN)-111 sBM substratum, the basal cells slowly differentiated to ciliated ones, but they failed to differentiate on an mLN-111 coating alone.

Atmospheric Environment Division

From top left, clockwise: Ny-Ålesund scientific station in Svalbard, Norway; polar stratospheric cloud seen on the flight from Oslo to Longyearbyen; lidar observation with aurora lights at Ny-Ålesund; moon's halo seen at Ny-Ålesund.
(Photos: H. Nakajima)

The aim of the Atmospheric Environment Division's research is to understand and solve atmospheric environmental problems ranging from urban air pollution to trans-boundary and global 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 Remote Sensing Section, which studies the atmospheric environment by using remote sensing techniques such as lidar (laser radar); the Atmospheric Chemistry Section, which conducts research on the temporal and spatial distributions and reactions of reactive organic compounds in the atmosphere; 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. 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 2009.

Attribution of a drying trend over the equatorial region of Africa

A drying trend over the equatorial region of Africa ("tropical Africa") has featured among the pronounced climatic changes in precipitation over the low latitudes of the Northern Hemisphere. To clarify the factors affecting the African drying trend and determine their detailed mechanisms, we investigated the impacts of anthropogenic forcing on the long-term drying trend over the northern part of tropical Africa by using 20th century simulations performed with a Coupled General Circulation Model (CGCM) generally known as the medium-resolution version of the Model for Interdisciplinary Research On Climate (MIROC). The atmospheric component of MIROC includes an explicit representation of the first and second kinds of indirect effects induced by soluble aerosols, as well as the direct effects of all aerosols. The baisc experiment (referred to as FULL), in which the simulations were forced with both natural and anthropogenic forcing factors, adequately simulated the distribution of summer precipitation derived from the Climate Research Unit (CRU) observations over tropical North Africa (Figure 1a, 1b). A large amount of precipitation was realistically captured as part of the Intertropical Convergence Zone over the Atlantic Ocean. The drying trend was simulated well over tropical North Africa, as shown by the CRU observations (Figures 1c, 1d). Moreover, the time series of the regional mean summer precipitation showed a similar drying trend to those from the observations (Figures 1e, 1f).
We examined the relative contributions of individual forcing factors, i.e., natural (changes in solar irradiance and stratospheric volcanic aerosols) and anthropogenic (changes in well-mixed greenhouse gases [GHGs], sulfate and carbonaceous aerosols, stratospheric and tropospheric ozone, and land use) forcing factors, by analyzing datasets of several experiments forced with different combinations of external climate forcing factors. We found that increases in the

concentrations of anthropogenic aerosols thermodynamically induce a drying trend because of tropospheric cooling. They also dynamically induce an additional drying trend due to an atmospheric local circulation change stirred up by the strong gradient of a sea surface temperature anomaly over the tropical Atlantic Ocean. Therefore, the drying trend observed over tropical North Africa during the 20th century is strongly affected by the increased concentrations of anthropogenic aerosols through both dynamic and thermodynamic effects. In contrast, increased concentrations of GHGs induce a drying trend through a large-scale dynamic effect, which is canceled out by the thermodynamically induced moistening trend caused by GHGs due to tropospheric warming.

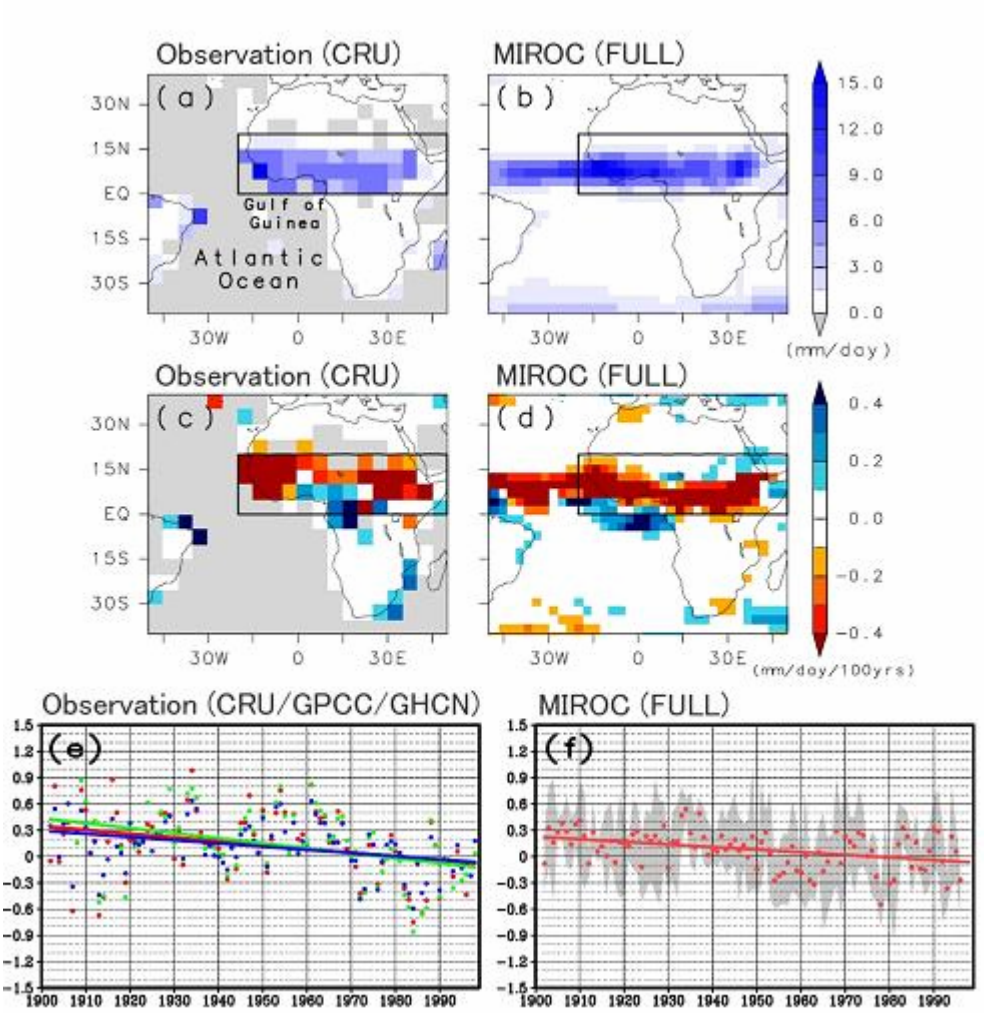


Fig. 1 (a, b) Distributions of climatological summer precipitation averaged from 1961 to 1990. (c, d) Linear trends in precipitation from 1902 to 1998. (e, f) Time series of the summer precipitation anomaly with respect to the climatology from 1961 to 1990, averaged over the land within the rectangular region shown in 1a to 1d. Left, observations (CRU: Climate Research Unit; GPCC: Global Precipitation Climatology Centre; GHCN: Global Historical Climatology Network); right, results of FULL experiments.

Influence of lower stratospheric ozone variation on tropospheric temperature and mean meridional circulation in the Northern Hemisphere summer

Ozone heating is a dominant factor in stratospheric adiabatic heating, except in the high latitudes during winter, where strong wave forcing occurs. Unlike in winter, when strong wave forcing occurs in both the troposphere and the stratosphere, in summer the effect of ozone heating is enhanced in the stratosphere, and it is possible that stratospheric ozone variation influences

tropospheric circulation. We performed sensitivity tests by using a numerical model as well as observational data to clarify the influence of stratospheric ozone increases on temperature and circulation in the northern troposphere in summer. Statistical analyses of the observational data showed that an increase in the lower stratospheric ozone concentration strengthens static stability at the tropopause; vertical wave propagation is then trapped there more efficiently. The zonal flow deceleration due to the wave forcing induces an anomalous residual mean circulation, which causes anomalous cooling in the tropospheric temperature. A sensitivity experiment using the CCSR (Center for Climate System Research) /NIES chemistry-climate model showed responses similar to the observations, suggesting that climate change is induced in the troposphere by stratospheric ozone variation.

Raman scattering measurements with the NIES lidar network

Two-wavelength (532 and 1064 nm) polarization (532 nm) lidars are continuously operated at 19 locations in East Asia in the NIES lidar network. The data from the network are used in various studies on Asian dust and regional air pollution. To better characterize light-absorbing aerosols, detection systems for measuring nitrogen Raman scattering at 607 nm were newly added to the lidars at the primary network stations (Tsukuba, Seoul, Fukue, Hedo, and Matsue) (Figure 2). Using Raman scattering signals, the extinction and backscattering coefficients at 532 nm are obtained independently. The same algorithm as that used for high-spectral-resolution lidars can be applied to the measured dataset (i.e., the extinction and backscattering coefficients at 532 nm, the signal intensity at 1064 nm, and the total depolarization ratio at 532 nm) to estimate the vertical profiles of three aerosol types (namely, water-soluble, soot, and dust), although the Raman scattering signals are useful only at night in the low-altitude region because of the small cross-section of Raman scattering. Continuous observations including the Raman measurements have started in a study of the impacts of aerosols on plants and on human health (Figure 3).

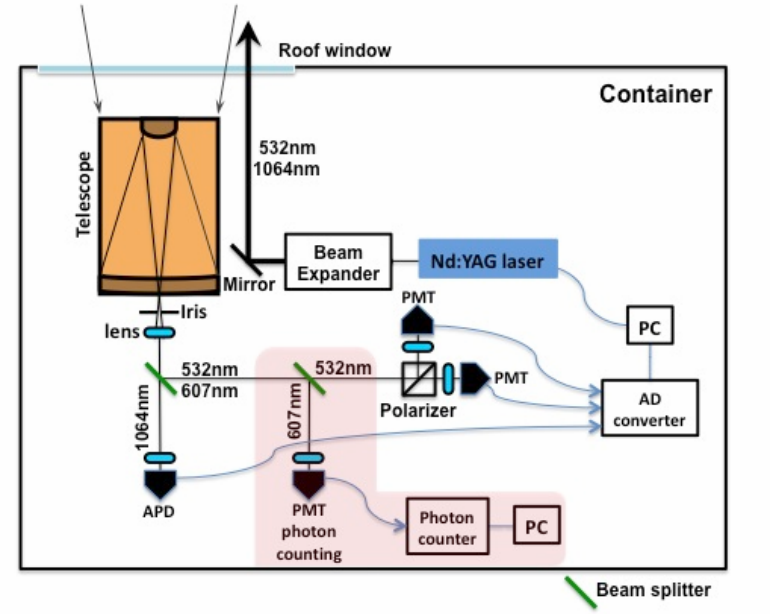


Fig. 2 Block diagram of the network lidar with a Raman receiver. APD: avalanche photodiode, PMT: photomultiplier tube.

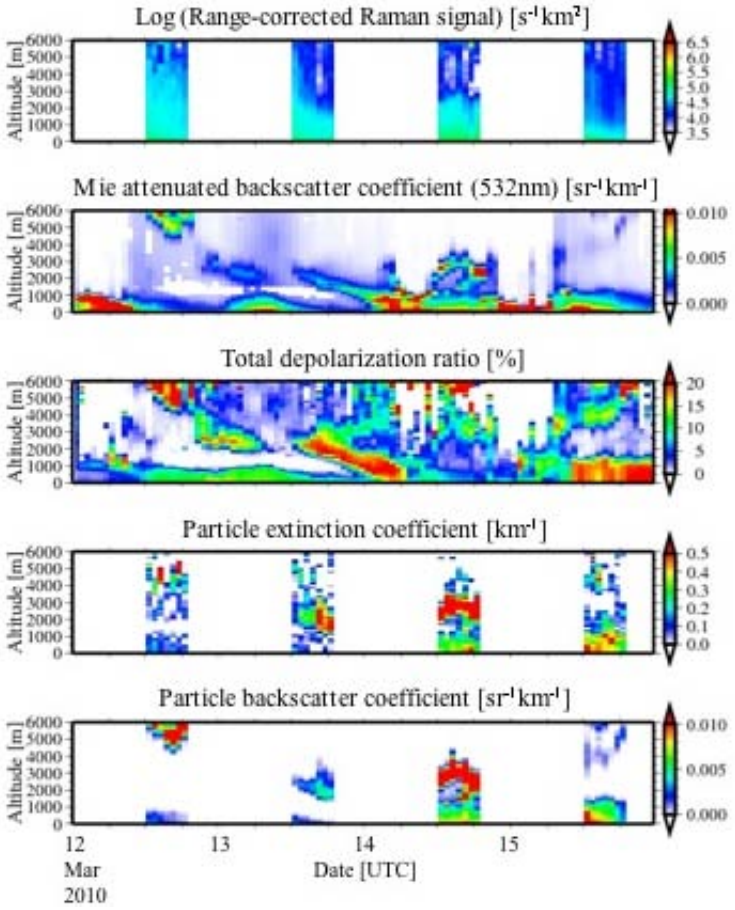


Fig. 3 Examples of the lidar time–height indications in Seoul: Raman scattering signal, attenuated backscatter coefficient (532 nm), tatal depolarizaton ratio, extinction coefficient, and backscatter coefficient.

Kinetic isotope effects in reactions of deuterated CH_3O radicals with O_2

Molecular hydrogen (H_2) is the second most abundant reactive trace gas in the troposphere. H/D (deuterium) isotope measurements are used to constrain the source and sink strengths of H_2. Atmospheric H_2 is known to be enriched in deuterium, whereas both anthropogenic and biological sources of H_2 are strongly depleted in deuterium. Hence, H_2 produced photochemically must acquire enrichment in D relative to the source material (e.g., methane). Reaction of the methoxy radical (CH_3O) with O_2 is thought to be one of the important steps responsible for D-enrichment in the oxidation of CH_4. We used a laser-induced fluorescence technique combined with laser photolysis to measure the rate constants for the reactions of deuterated CH_3O radicals (CH_xD_yO, $x + y = 3$) with O_2. The kinetic isotope effect (KIE) is defined as KIE = k_1/k_i, where k_1 is the rate constant of the $CH_3O + O_2$ reaction and k_i is that of the reactions of isotopic-CH_3O radicals. The KIE values were calculated to be 1.6 ± 0.2 for the CH_2DO (k_1/k_2) reaction, 2.0 ± 0.2 for CHD_2O (k_1/k_3), and 4.4 ± 0.5 for $CD_3O + O_2$ (k_1/k_4). The algebraic average of the rate coefficients k_1 and k_4, depending on the H/D of the CH_2DO and CHD_2O radicals, well reproduced the observed rate coefficients k_2 and k_3. The branching ratio for the CH_2DO and $CHD_2O + O_2$ reactions was estimated from the reaction kinetics. The branching ratio for the $CH_2DO + O_2 \rightarrow HCHO/HCDO + DO_2/HO_2$ reaction was estimated to be 0.90:0.11.

Increasing synoptic-scale variability in atmospheric CO_2 at Hateruma Island associated with increasing East-Asian emissions

Increasing fossil fuel CO_2 emissions in East Asia not only elevate the overall global atmospheric burden, but also enhance the local atmospheric mixing ratios relative to those in the surrounding regions. Thus, a greater emission intensity will produce a larger mixing ratio gradient in the downwind region, resulting in a greater synoptic-scale variation (SSV) in the CO_2 mixing ratios when the synoptic-scale winds change direction. The observations at Hateruma Island (24.05°N, 123.80°E) often show pollution events influenced by continental emissions during the period from late fall to early spring each year. SSVs were extracted from the daily averaged values for the years between 1996 and 2007, along with the annual standard deviations of SSV components (σ_{CO2} for CO_2 and σ_{CH4} for CH_4) for the relevant 6-month periods. Figure 4a shows the temporal changes in σ_{CO2} and σ_{CH4}. There are large interannual variations in both time series—especially the simultaneous abrupt enhancements in 1998 and 2003. However, if we ignore the anomalously high σ_{CO2} values in 1998 and 2003, the data show a gradual increase during 1996–2002 and a sharp rise during 2002–2007. This behavior of σ_{CO2} is clearly observed when the $\sigma_{CO2}/\sigma_{CH4}$ ratio is plotted (Figure 4b). The $\sigma_{CO2}/\sigma_{CH4}$ ratio is correlated closely with the recent rapid increase in fossil carbon emissions from China, as indicated in the Carbon Dioxide Information Analysis Center database.

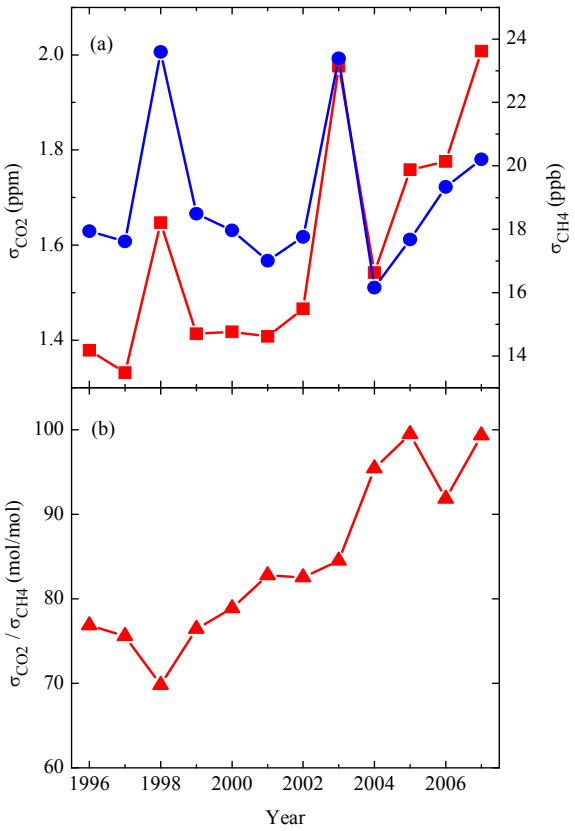
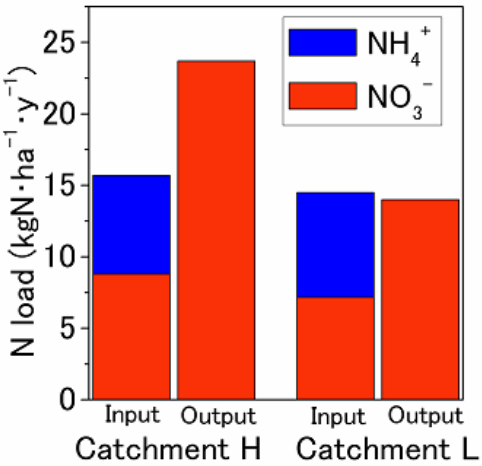


Fig. 4 (a) Temporal changes in the standard deviations of synoptic-scale variation components of CO_2 and CH_4, based on data from the 6-month periods January–April and November–December. Red: σ_{CO2}, Blue: σ_{CH4}. (b) Temporal changes in the $\sigma_{CO2}/\sigma_{CH4}$ ratio.

Water and Soil Environment Division

Monitoring of nitrogen saturation in the forests of Mt. Tsukuba



Clockwise from top left: view of Mt. Tsukuba; rainwater sampler in one of the test catchments at Mt. Tsukuba; comparison of the observed annual inorganic nitrogen budgets in the two test catchments, which have different nitrate-nitrogen concentrations in their baseflows formed by groundwater discharging to streams (annual average concentration of nitrate-nitrogen: 1.3 ppm N in catchment H and 0.50 ppm N in catchment L); and sampling of stream water.

The Water and Soil Environment Division uses a variety of approaches to research the environmental pollution and ecological changes that occur via the media of water and soil. This research includes the long-term monitoring of rivers, lakes, and coastal seas to assess these changes, and the development of technologies to mitigate environmental deterioration.

Decomposition kinetics of chloroethylenes by zero-valent iron powder in the presence of several surfactants

One of the research missions of the **Water Quality Science Section** is to assess new environmentally benign techniques for remediating water and soil pollution. To assess the effectiveness of the injection of washing-reagent at groundwater remediation, we investigated the kinetics of the decomposition of some chroloethylenes (XCEs) such as tetrachloroethylene (PCE), trichloroethylene (TCE), and *cis*-1,2-dichloroethylene (*c*-DCE) by zero-valent iron powder in the absence and presence of sodium linear dodecyl benzene sulfonate, sodium dodecylsulfate, cetyltrimethylammonium bromide, polyoxyethylene(23) laurylether, and polyoxyethylene(20) cetylether.

The decomposition rates were PCE ≥ TCE > *c*-DCE. Decomposition of PCE was faster than that of TCE in pure water and in two anionic surfactant solution systems, whereas the rates were almost similar when the solution contained cationic or nonionic surfactants. Analysis of the reaction products showed that the decomposition reactions were controlled by both β-elimination and hydrogenolysis. The rate constants for the two reaction pathways were simulated by using the concentration profiles of the starting compound and the reaction products (Figure 1).

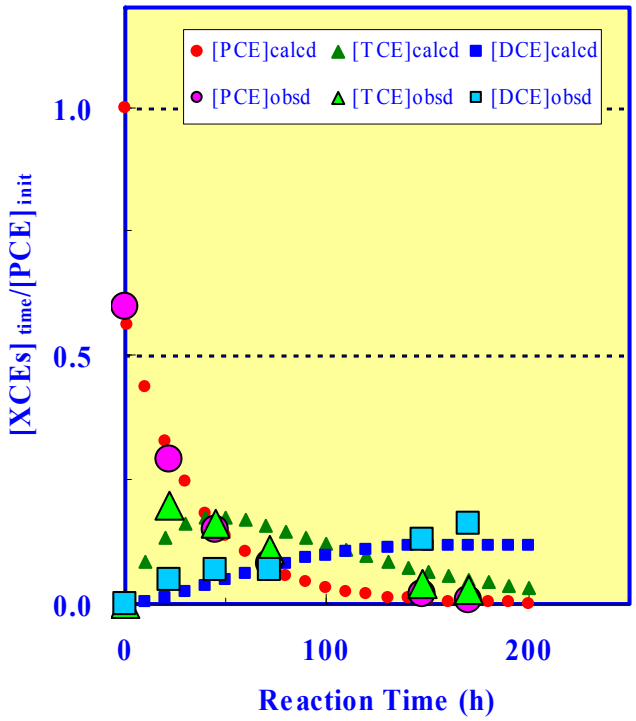


Fig. 1 Typical simulated changes in the concentrations of starting PCE and resulting TCE and DCE. cacld, calculated; obsd, observed; init, initial concentration

The reactions proceeded mainly via β-elimination when the solution contained cationic or nonionic surfactants, whereas a hydrogenolysis reaction occurred additionally when the solution contained no surfactant or anionic surfactants (Figure 2). The hydrogenolysis reaction produces very toxic chloroethylenes, use of anionic surfactants is not recommended for "washing-reagent-injection" remediation.

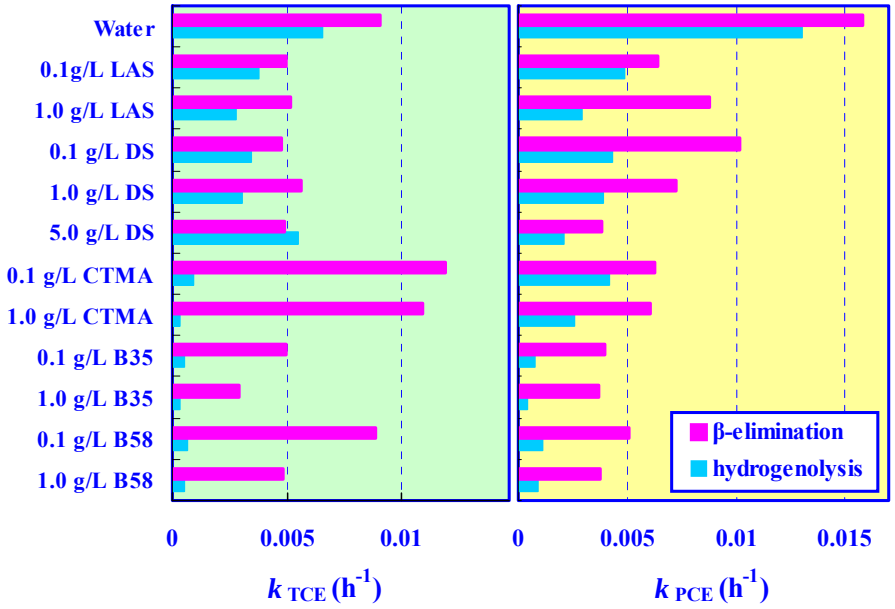


Fig. 2 Variation in the rates of β-elimination and hydrogenolysis reactions of TCE (left) and PCE (right) in the absence and presence of surfactants. LAS: sodium linear dodecyl benzene sulfonate, DS: sodium dodecylsulfate, CTMA: cetyltrimethylammonium bromide, B35: polyoxyethylene(23) laurylether, B58: polyoxyethylene(20) cetylether.

Cumulative inputs of anthropogenic elements in the surface soil layer of montane forests

Transportation emits fine particulate matter from fuel combustion and from the abrasion of brakes and tires. The fine particulate matter, rich in trace elements, is suspended in the air for several weeks, often spreads over large distances, and is then deposited in the soil, even in montane forests far from urban areas. The **Soil Science Section** is studying soil pollution around the Tokyo Metropolitan area, the largest (ca. 31 million) population center in the world, where dense traffic pollutes the air masses. Soil cores and rainwater were sampled under canopies of *Cryptomeria japonica* in four montane areas along an atmospheric depositional gradient.

Soil cores (30 cm deep) were divided into 2- or 4-cm segments for analysis. Elemental enrichment ratios in soils were calculated as $(X/\mathrm{Al})_i/(X/\mathrm{Al})_{\mathrm{BG}}$, where the numerator and denominator are the concentration ratios of element-X and Al in the *i*th and bottom segments of soil cores, respectively. The upper 14 cm of soil showed higher levels of Cu, Zn, As, Sb, and Pb than the lower 14 to 30 cm (Figure 3). In the four areas sampled, the average enrichment ratios in the upper 6 cm of soil were as follows: Pb (4.93) ≥ Sb (4.06) ≥ As (3.04) > Zn (1.71) ≥ Cu (1.56). Exogenous elements accumulated in the upper 14-cm soil layer were as

follows (kg/ha): Zn (26.0) > Pb (12.4) > Cu (4.48) ≥ As (3.43) ≥ Sb (0.49). These rank orders were consistent with those of elements in anthropogenic aerosols and polluted (roadside) air, respectively, indicating that air pollutants probably caused enrichment of these elements in the soil surface. Approximately half of the total concentrations of As, Sb, and Pb in the upper 14 cm were derived from exogenous (anthropogenic) sources.

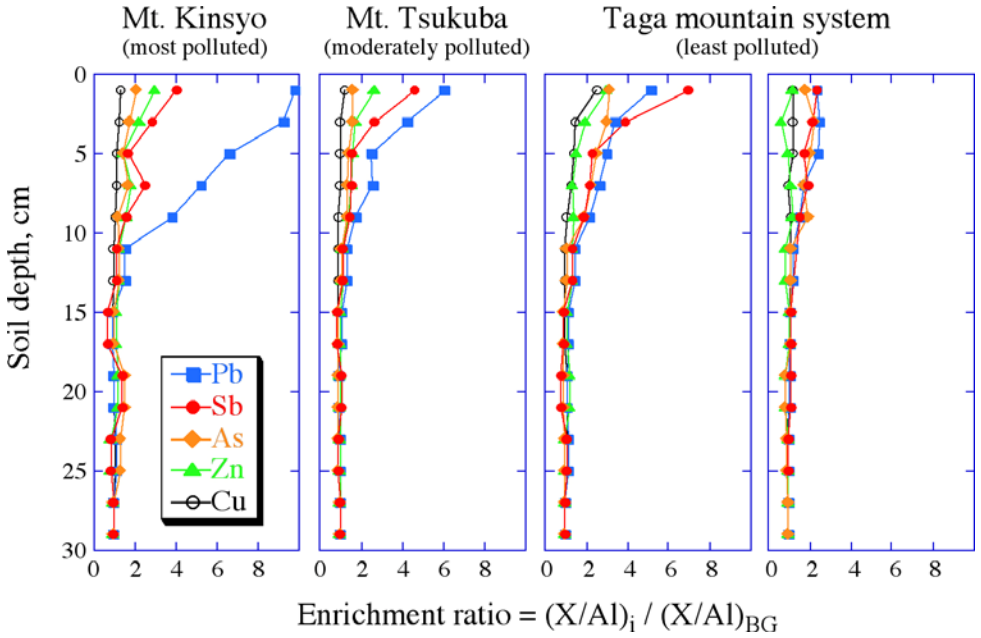


Fig. 3 Vertical distribution profiles of enrichment ratios in selected soil cores from four montane areas.

Rainwater analysis revealed that Sb had a similar deposition behavior to NO_3^-, which is a typical acidic air pollutant. There was a strong correlation between Sb and NO_3^- concentrations in rainwater (Figure 4). Using this correlation, total (cumulative) inputs of NO_3^- were estimated from the accumulated amounts of exogenous Sb in soils, i.e., 16.7 t/ha at Mt. Kinsyo (most polluted), 8.6 t/ha at Mt. Tsukuba (moderately polluted), and 5.8 t/ha in the Taga mountain system (least polluted).

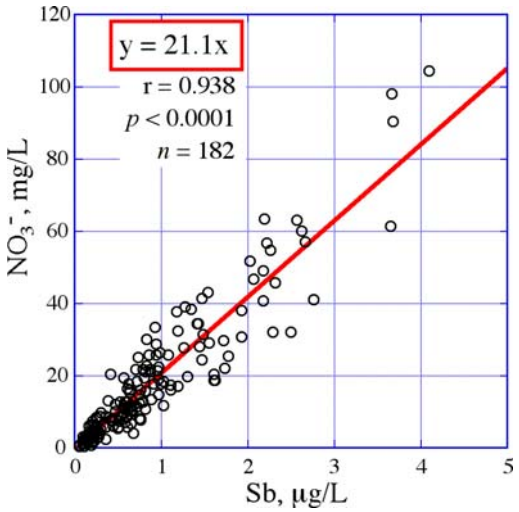


Fig. 4 Relationship between concentrations of dissolved Sb and NO_3^- in throughfall under canopies of *Cryptomeria japonica*. $y = 21.1x$, $r = 0.938$, $P < 0.0001$, $n = 182$.

Although there are currently no visible ecological effects of these accumulated elements in the study region, the concentrations of some elements are within a harmful range according to the Ecological Soil Screening Levels determined by the United States Environmental Protection Agency, and periodic monitoring is required to evaluate pollution in this area.

Catchment monitoring by the analysis of ^{15}N natural abundances of sedimentary organic nitrogen

One of the tasks of the **Lake Environment Research Section** is to develop analytical methods to discriminate nitrogen sources that induce N saturation and eutrophication in ecosystems. Nitrogen pollution has been proceeding globally through excessive supply of N fertilizer to agricultural lands and through the combustion of fossil fuels. This has resulted in a four to five times increase in N supply from atmospheric deposition over the last 100 years. In Japan, most of the forests are saturated with N, and we have observed relatively high N discharges even in mountain streams with little human impact. In lowland areas of Japan, the amount of manure N input into agricultural fields has tripled in the last 40 years and has resulted in large N discharges from agricultural drains. In the Lake Kasumigaura basin, about half of the catchment is agricultural land, and the forest in the basin is recognized as one of the most N-saturated forests in Japan. We therefore need to monitor and evaluate the N budget in the catchment of Lake Kasumigaura, which is at risk of high N inflow.

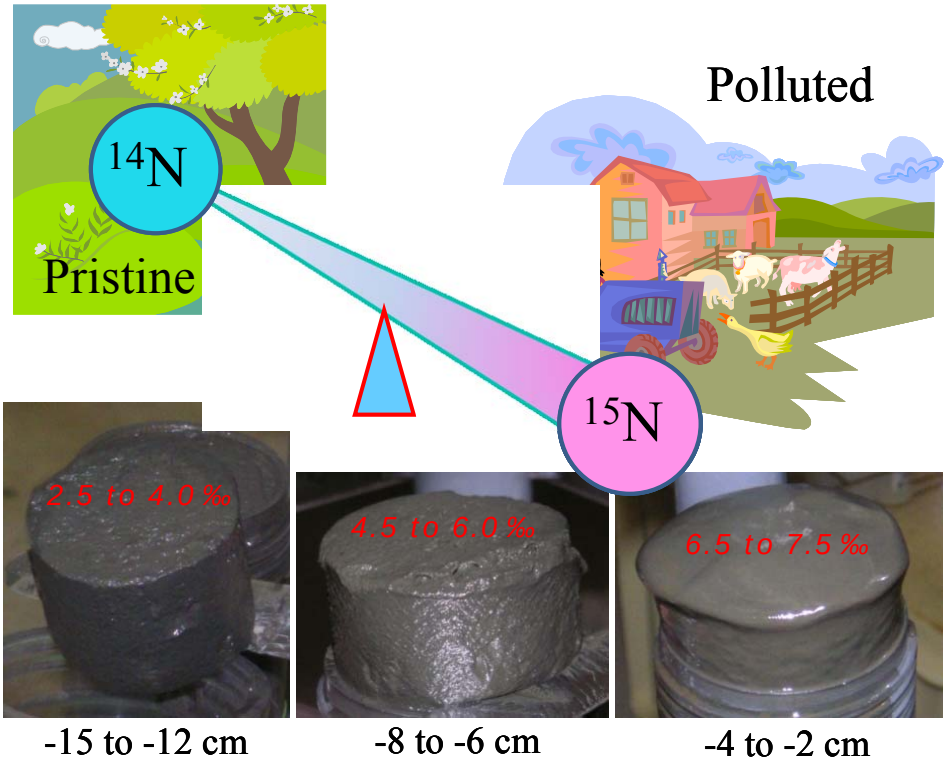


Fig. 5 Schematic diagram of ^{15}N natural abundances in a field under increased N loading from sewage and manure (top). Sediment cores in Lake Kasumigaura show enrichment of ^{15}N in the surface layers (bottom). Red values are mean $\delta^{15}N$ values in the 2000s.

Stable isotope analysis of organic and inorganic N, expressed as $\delta^{15}N$, can evaluate the contribution of N derived from sewage and manure that has been enriched with the heavy ^{15}N isotope (Figure 5). Therefore, on the assumption that the sedimentary organic N in Lake Kasumigaura has preserved the isotopic characteristics of the N originating from the catchment, the sedimentary organic N should be enriched with $\delta^{15}N$ when N loading from sewage or manure increases beyond that due to N saturation of the forests. $\delta^{15}N$ in the surface sediments of Lake Kasumigaura has steadily increased by 1.6‰ in the last 30 years, suggesting a substantial increase in N loading from sewage, manure, or both (Figure 6). However, enhanced denitrification activity within the catchment and lake ecosystems, which modifies the $\delta^{15}N$ content of the original N to more positive values, probably also contributes to this $\delta^{15}N$ increase in the surface sediment.

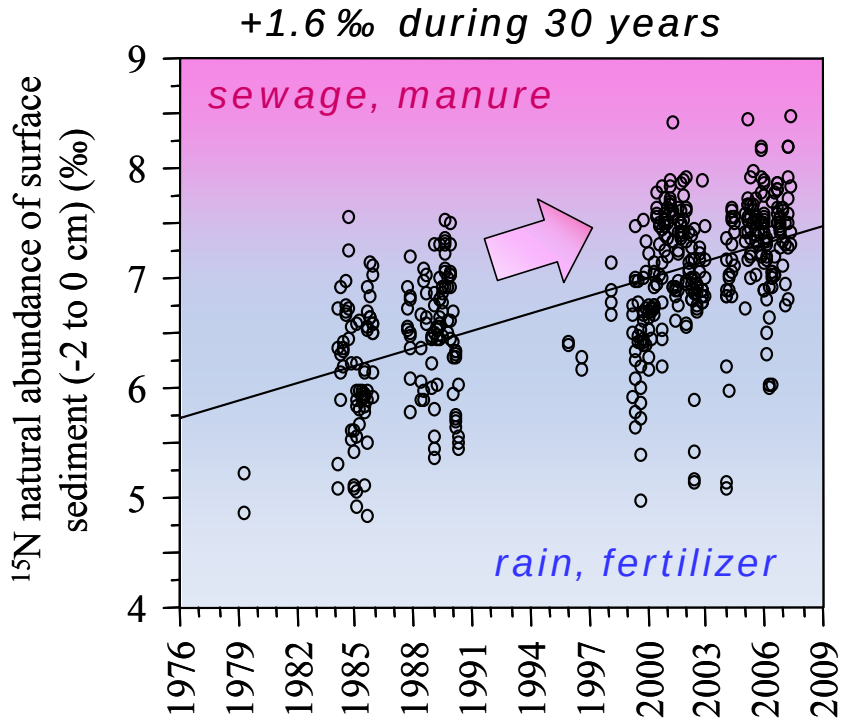


Fig. 6 Historical $\delta^{15}N$ change in the surface 2 cm sediment of Lake Kasumigaura since 1979. On average, the surface sediment ^{15}N content has increased by 1.6‰ over the last 30 years, suggesting either an increase in N loading in sewage or manure or increased activation of denitrification within the Lake Kasumigaura basin.

Ecological function of saltmarsh and tidal flat ecosystems

The **Marine Environment Section** has started a research project on salt-marsh and tidal flat ecosystems in Japan. The aims of this study are: (1) to trace the organic matter flows in the system by using stable carbon and nitrogen stable isotope ratios ($\delta^{13}C$ and $\delta^{15}N$); (2) to reveal the geographical distribution of endangered gastropods (genera *Batillaria* and *Cerithidea*) along the Japanese coast; and (3) to assess the ecological functions of salt-marshes and tidal flats in an estuarine coastal ecosystem. We found significant spatial changes in the trophic bases for macrozoobenthos in the Tanaka River tidal flat in Mie Prefecture (Figure 7). On the bare tidal flats, macrozoobenthos chiefly utilized

autochthonous benthic microalgae as their food source, and utilized little marsh-derived plant litter *(Phragmites australis)* (Figure 8). In contrast, dietary contribution of the marsh plant litter was much higher for invertebrates collected from the adjacent marsh area, suggesting the small-scale heterogeneity of the food source. These studies revealed that macrozoobenthos assimilate various types of organic matters, depending on the habitat type, and may act as a significant sink of organic materials in estuarine coastal areas.

Fig. 7 (a) Bare tidal flat and *Phragmites*-dominated marsh in Tanaka River Estuary, Mie Prefecture, Japan. (b, c) Endangered macrozoobenthic species such as (b) crab (*Chasmagnathus convexus*) and (c) gastropods (*Cerithidea* spp.) inhabited the intertidal zone.

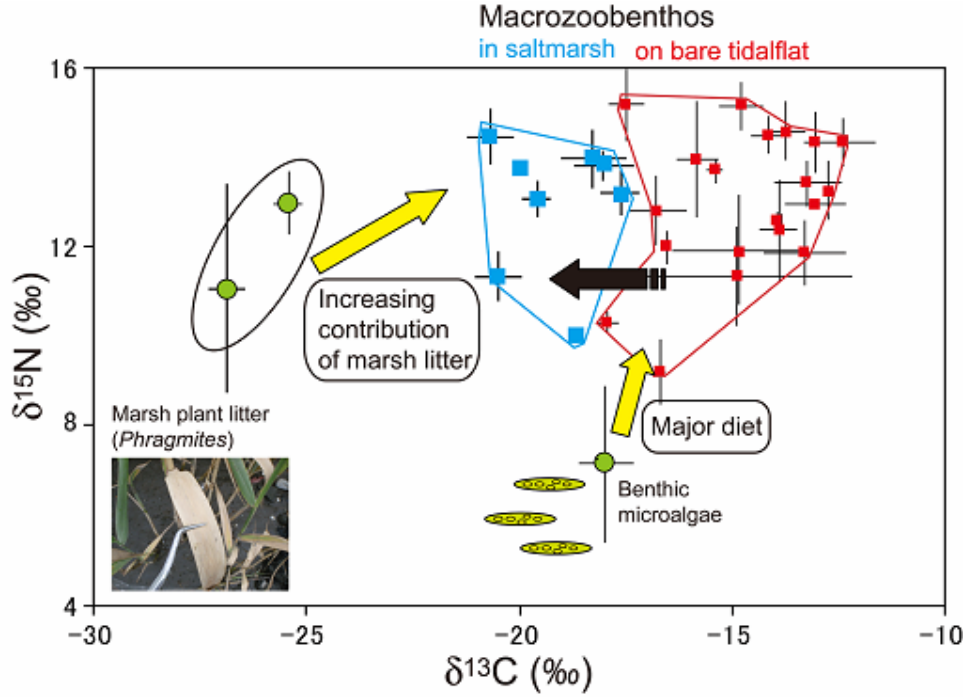


Fig. 8 $\delta^{13}C$ and $\delta^{15}N$ values of two potential food sources, benthic microalgae and marsh plant litter (green circles), and macrozoobenthos on bare tidal flats (red symbols) and in adjacent salt marsh (blue symbols). $\delta^{13}C$ and $\delta^{15}N$ values of an animal are known to increase from 0‰ to 1‰ and from 3‰ to 4‰, respectively, from those of the food source. Black arrow shows the isotopic changes of animals between the habitats.

Environmental Biology Division

The 10th Conference of the Parties to the CBD (Convention on Biological Diversity) is held in Nagoya, Japan, in 2010. More and more efforts from various sectors, including the scientific community, are needed for effective conservation of biodiversity on the global and local scales. Shown here are some of the flora and fauna of Japan.a Japanese trout lilly species (*Erythronium japonicum*, top of left), Japanese tree frog (*Hyla japonica* , top of right), an endangered dragonfly species, (*Ceriagrion nipponicum*, bottom of left) and a Japanese endemic conifer species (*Sciadopitys verticillata*, bottom of right).

The mission of the Environmental Biology Division is to help conserve 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. Staff of the four sections are collaborating in the following tasks.

Studies of conservation of biodiversity

Wetlands are home to many endemic organisms and important habitats for biodiversity conservation. However, they have been under intense human pressures such as development and water degradation, and plant species endemic to the wetlands tend to have a high extinction risk. The Watarase wetland is an extensive lowland wetland of 1500 ha in the Tokyo Metropolitan area. It contains as many as 59 endangered or near-threatened vascular plants. Although mapping of these species is essential for their conservation, it is a difficult task to cover such an extensive wetland by ground survey. We aimed to develop a method to estimate the distributions of rare species from aerial photographs. Consideration of seasonal change is important in aerial surveys of plants. Some endangered plants in the wetland are hidden under dense canopies of tall grasses such as reeds, which grow as tall as 2 to 4 m within 2 months after controlled burns in March. We performed aerial surveys in early April (when the ground was bare, just after the controlled burn), in early May (when the leaves of some of the early-flushing species had opened), and in August (when the reeds had reached their maximum height). By stereoscopic viewing of the aerial images, we also estimated ground and vegetation heights. Vegetation height and surface color in May were found to be good predictors of the presence of some rare species (Figure 1). Color information was a good indicator of coverage by tall grasses.

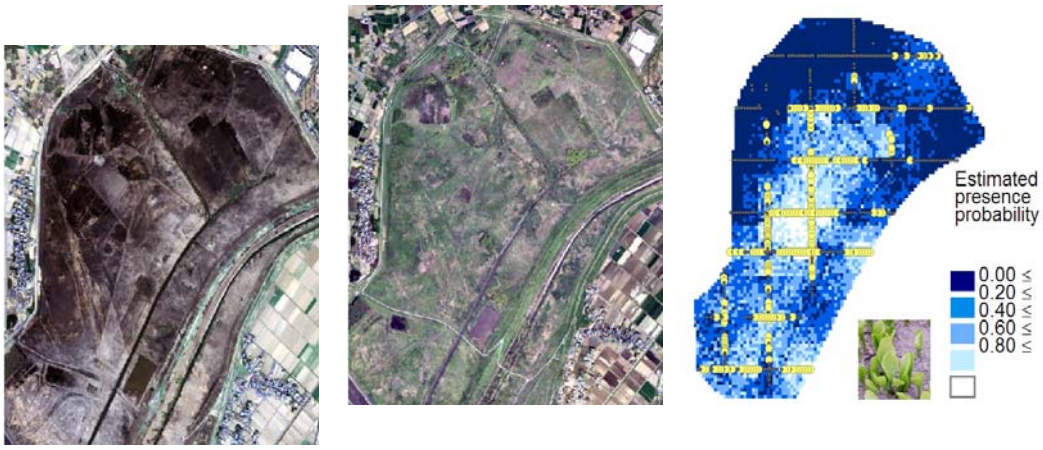


Fig. 1 Aerial images in a part of Watarase wetland in early April (left) and in early May (middle), and distribution of an endangered fern species (*Ophioglossum namegatae*), as estimated by a statistical model based on aerial images. The estimation is good when yellow points (actual observation of *Ophioglossum namegatae* by ground survey) are in good concordance with whitish cells (places where the probability of the fern being present was predicted to be high).

Agricultural landscapes, especially traditional ones, are mixtures of agricultural and non-agricultural land uses and comprise a mosaic of land patches differing in the type and intensity of human intervention. Such mosaic agricultural landscapes have recently come to be appreciated for their contributions to biodiversity, because different types of habitat support different habitat specialists (Figure 2).

Fig. 2 *Satoyama* is a mixture of agricultural and non-agricultural land uses and comprises a mosaic of land patches, including secondary forests and crop fields.

We have developed a biodiversity indicator, the *Satoyama* Index, of agricultural landscape heterogeneity and the land use type of of non-agricultural area. The index varies from 0 (homogeneous monoculture landscape) to 1 (highly heterogeneous landscape with a minimum of agricultural cover). We tested the explanatory power of the *Satoyama* Index at both the local and national scales by analyzing the correlation of the spatial pattern of the index with those of the occurrence (local) and richness (national) of amphibian species. Amphibians are a representative biodiversity group in traditional agricultural landscapes in Japan. Data on their occurrence at the local scale was collected in a local government project, with public participation. There was a significant positive correlation between the index value and both the occurrence of amphibian species at the local scale and the species richness at the national scale. The results indicate that the index is highly promising for assessing and monitoring the status of biodiversity from the local to the national scale.

Studies of the structure and function of ecosystems

In peat mires, the decomposition of plant residues by microbes and the mineralization that follows occur slowly, so peat mires are poorly fertile and are covered by unique types of vegetation. To conserve this vegetation, we need to evaluate the microbial nutrient supply—especially the phosphate supply, which has resulted in changes in vegetation. We revealed the relationship between microbial activity and phosphate supply by determining the soil glucosidase (GLU) and phosphatase (PA) activities in Kushiro Mire, in Hokkaido. These two

enzymes are critical; GLU produces organic compounds and energy for heterotrophic microbes, and PA produces inorganic phosphate usable by plants and microbes. We found that mineralization of organic P to inorganic phosphorus (IP) was more pronounced in a P-limited soil than in IP-rich soil (Figure 3). The negative correlation between the PA:GLU ratio and the IP content in the soil suggests that the activities of these enzymes are indicators of the limitation of P availability for biological processes.

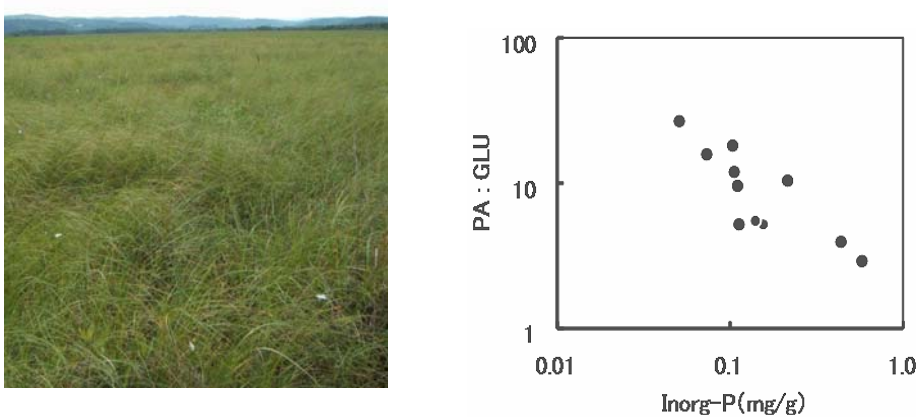


Fig. 3 Left: Kushiro Mire in Hokkaido. Right: Relationship between ratio of phosphatase activity to glucosidase activity (PA:GLU) and soil inorganic phosphorus content. The former increases when soil inorganic P content is low. Heterotrophic microbes produce more PA in P-limited conditions to supplement phosphate.

To understand and predict carbon dynamics under future climate conditions, we are trying to characterize the carbon turnover in terrestrial ecosystems . Using a stable carbon isotope, we tracked photosynthetic carbon fluxes from shoot to roots and to soil in a meadow on the Qinghai-Tibet Plateau. We estimated that a total of 4930 kg C ha^{-1} was allocated belowground during the vegetation growth season; the root pool stocked 2868 kg C ha^{-1} and the soil pool accumulated 613 kg C ha^{-1}. The study suggests that carbon storage in belowground carbon pools plays an important role in carbon cycles in the alpine meadow (Figure 4).

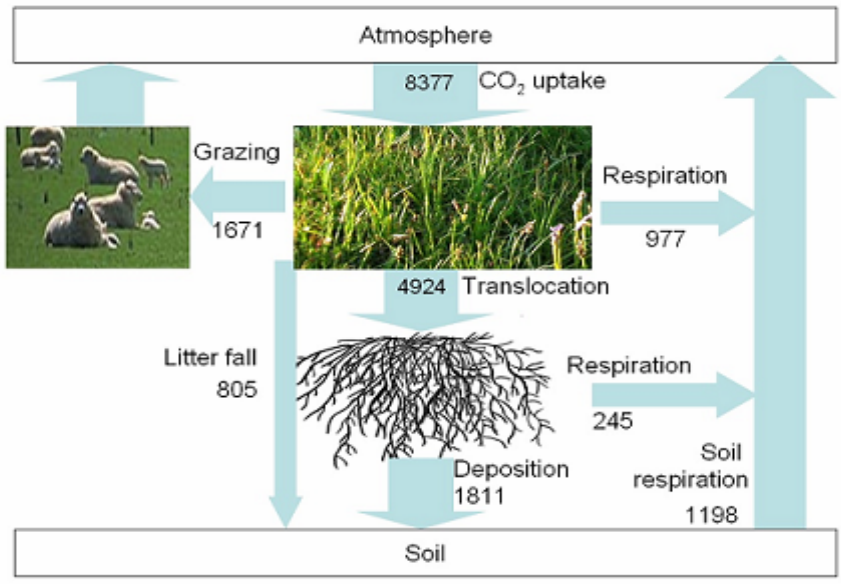


Fig. 4 Schematic diagram of carbon partitioning estimated by ^{13}C labeling and biomass measurements in a meadow plant–soil system (units: kg C ha^{-1}).

Studies of the effects of environmental stress and climate change

We are trying to develop a new method to diagnose plant stress or disease on the basis of gene expression profiles. Rice dieback has been observed in paddy fields in a northern high-altitude area of Nagasaki Prefecture since the 1970s. Although acid fog has been suggested as the cause, the causal factors and mechanisms of the disease have not yet been clarified. We tried to obtain information on the physiological status of acid fog-affected rice leaves through gene expression analyses. We extracted foliar RNA from either field-grown or fog-treated rice plants and measured the expression of almost all rice genes by using a DNA microarray (Figure 5). The expression of photosynthesis genes that are generally inactivated under stress conditions was unexpectedly higher in the leaves from fields suffering rice dieback than in the leaves from rice fields without the syndrome. We found that the physiological status of damaged rice plants in the field was very different from that of fog-treated rice plants in the growth cabinet, and that fog or acid fog was not the sole cause of rice dieback.

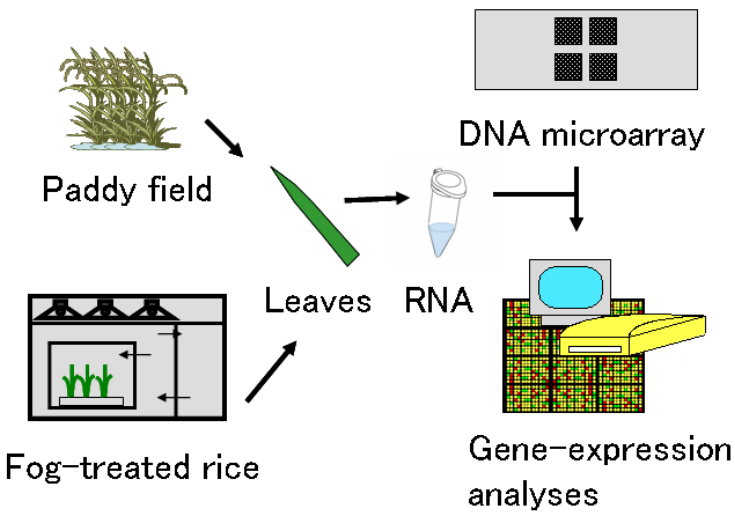


Fig. 5 Diagnosis of stress or damage in rice plants on the basis of gene-expression profiling.

We are trying to use various high-throughput molecular analyses to study the effects of tropospheric ozone (O_3) on plants. Plants exposed to low concentrations of O_3 over long periods suffer early senescence and reduction of photosynthesis, growth rate, and yields. Current results show that O_3 affects various important cellular processes in rice seedlings, including photosynthesis, respiration, amino acid and secondary metabolite biosynthesis, and signal transduction of environmental stimuli. We found that sakuranetin, a major rice secondary metabolite, is accumulated in seedlings exposed to ozone as a result of induction of its biosynthetic pathway. The concentration of sakuranetin was correlated with O_3 tolerance among rice cultivars.

Studies of invasive alien species and genetically modified organisms

Millions of tonnes of agricultural products are now imported into Japan. About one-tenth of the tonnage are oilseed rape (*Brassica napus* L.) seeds. 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 transport within Japan. We censused oilseed rapes growing along Route 51, a major road in the Kanto district. Oilseed rape plants were found each year, but the number of plants varied substantially during the 5 years of the study (Figure 6). These plants are likely to have had their origins in seeds spilled during transportation of cargo from the port, because there are no potential natural *B. napus* seed-source plants along this road.

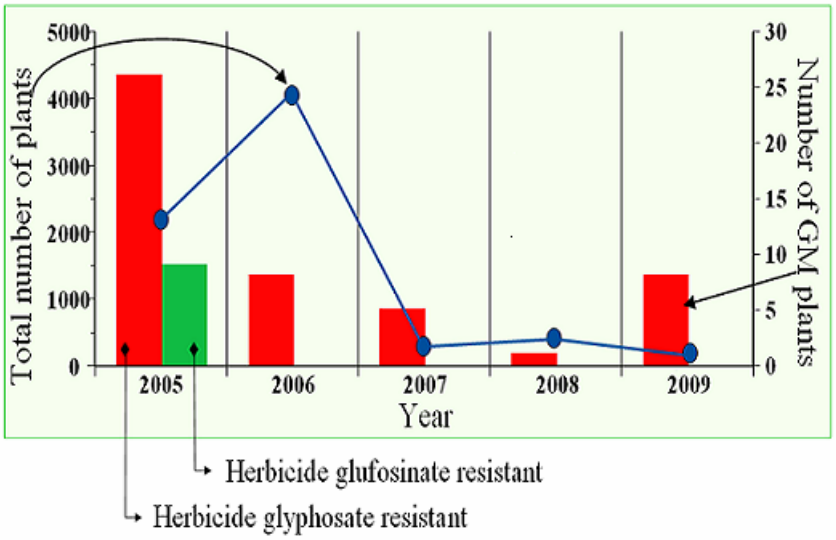


Fig. 6 Numbers of oilseed rape plants found along Route 51. GM, genetically modified.

In 2009, we started a census of oilseed rapes growing along Route 23, a major road in the Tokai area. A preliminary survey indicated that about half the oilseed rapes growing in this area had a protein conferring herbicide resistance.

The seasonal changes in biomass and species composition of *Ulva* spp., which are major seaweeds that form green tides all over the world, were studied on the Yatsu tidal flat in Tokyo Bay. On the tidal flat, a green tide was observed all year round, but the biomass of the seaweed changed seasonally. Large accumulations of *Ulva* spp. were observed from spring to early summer but sharply declined in midsummer. The biomass of *Ulva* spp. recovered in fall and peaked in winter. The dominant species of *Ulva* forming the green tide on the tidal flat was *Ulva ohnoi* all year. It has often been reported that this species is invasive and grows only from autumn to winter in Japan. The seasonal changes in the green tide on the Yatsu tidal flat seem to differ from those on other tidal flats in Japan.

Fig. 7 Green tide of *Ulva* sp. on a tidal flat.

To assess the contributions of large cargo ships to intercontinental introduction of marine organisms, we monitored the biota in the ballast tanks and hulls of bulk carriers. Throughout the study, we determined 77 DNA sequences from ship hull specimens (Figure 8) and registered them in GenBank, an international genetic sequence database.

Fig. 8
Light-microscope images of cyanobacteria from ship hull specimens.

Other studies

Apparent competition is a type of indirect interaction that is defined as a negative effect of one species on the population of another species, mediated through the action of shared natural enemies. In this case, there is no direct interaction between the two prey species, say A and B (Figure 9). When prey species A increases in number, the number of predators simply increases, because they can eat more prey. Then the increased predator eats not only species A, but also species B, whereby the number of prey B decreases. Our study is developing a

method of persistent biological control by combining native predators and the effect of apparent competition between artificially segregated pest populations. To stabilize a local population of native predators, we introduce refuges for the pest to reduce predation and thus avoid its local extinction. To examine the ecological feasibility of our idea, we developed a population dynamics model of an agricultural crop, a pest species of the crop, and a predator species of the pest. We found that the required crop investment can be reasonably small by appropriate adjustment of the refuge effect, as long as the predation efficiency of the predator is sufficiently high. To apply our method to natural organism systems, we are conducting laboratory experiments using model organisms of population ecology, namely beans (crop), bean beetles (pest), and their parasitoid wasps (predator).

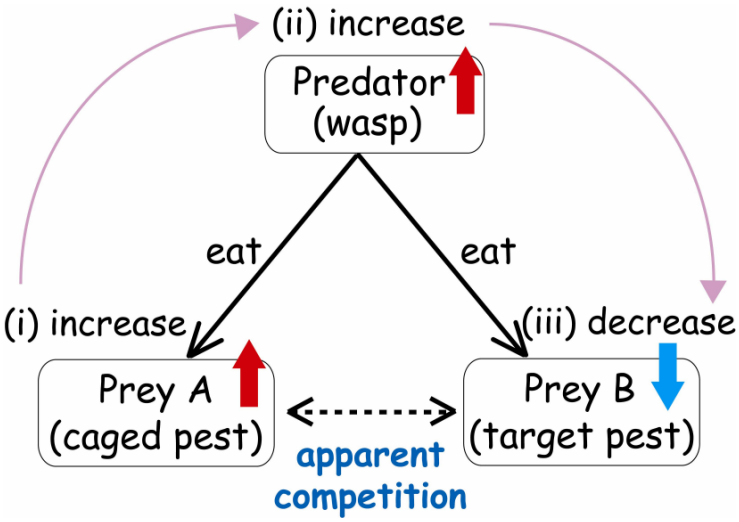


Fig. 9 Schematic diagram of apparent competition. Increased number of prey A indirectly reduces the number of prey B through shared predation pressure.

Laboratory of Intellectual Fundamentals for Environmental Studies

Examples of experimental aquatic animals used in environmental risk evaluation

A: Damselfly (*Ischnura 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, microbial cell strains, and experimental animals for environmental risk evaluation, and through the development of 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 methods for monitoring of atmospheric particles. Some of the results are being applied to monitoring of blue algae in Kyusyu, Okinawa and other south-western area in Japan with the NIES CRM (Certified Reference Material) No. 26 (Blue Algae); this monitoring has been carried out in the joint research project by NIES and several prefectural Institutes. Also, NIES CRM No. 28 (Urban Aerosols) has been used for QA/QC to monitor trace elements in $PM_{2.5}$.

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 transplanting primordial germ cells, and we have obtained offspring originating from these 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 (Figure 1).

In 2009, we organized an international meeting to establish an international network of avian genetic resource banks in the Asian region (Figure 2). Participants were invited from Malaysia, Thailand, Korea, Russia, the Philippines, and Taiwan. We discussed standardization of techniques used in avian cell culture and the cryopreservation of living avian cells.

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

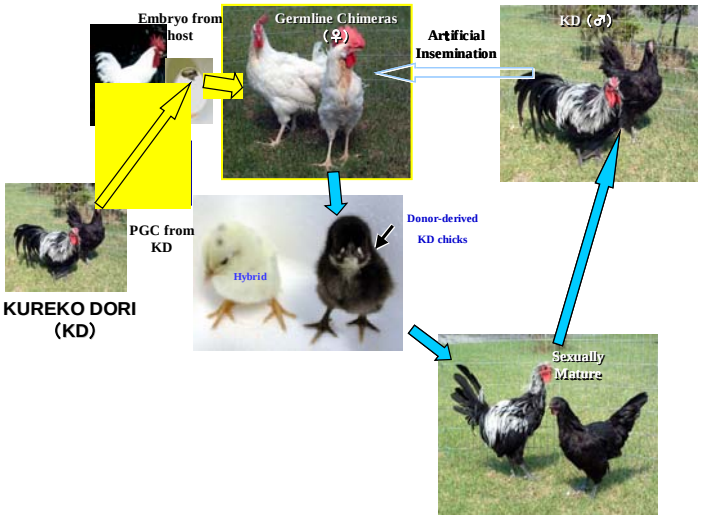


Fig. 1 The *Kureko Dori*, an endangered domestic fowl breed of the Kureko region of Kumamoto Prefecture, in Kyushu. By strict screening criteria, the *Kureko Dori* was designated a prefectural natural treasure in 1965. Offspring of the *Kureko Dori* can be obtained from germline chimeras by using reproductive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

Fig. 2 An international meeting to establish an Asian network of avian genetic resource banks was held at Tsukuba International Congress center on 19 November 2009.

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. In FY 2009 over 50 researchers made requests for analyses on about 30 research themes, and we provided them with useful data derived with a high level of QC.

Preparation of environmental Certified Reference Materials

Environmental Certified Reference Materials (CRMs) are used 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 (Figure 3). A new CRM for organotin compounds in scallop will be completed soon.

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.

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

We have 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 accommodates various items of equipment for low-temperature preparation of environmental specimens for long-term storage. The facility can store specimens for 50 years under an atmosphere of liquid nitrogen vapor at about –150 °C. About 80 samples of bivalves and stingray livers have been added, and the total number of time-capsule samples under liquid nitrogen vapor is now about 1900. In addition to these, several thousand biological specimens and atmospheric samples have been stored in freezers (–80 °C) and freezing rooms (–60 °C) (Figure 4).

Fig. 4 Environmental specimen banking. Clockwise from top left: stingray liver *in situ* after excision; coarse and fine crushing; bottling; and cryopreservation in cold N_2 vapor (colder than –150 °C) over liquid N_2.

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 animals for genetic analysis, with the support of the National Time Capsule Program for the Environment and Threatened Wildlife. As at March 2009, 2578 kinds of samples (tissues, cultured cells, and sperm) had been cryopreserved. From April 2009 to March 2010, we accepted another 166 individual threatened wild animals (7 mammals, 159 birds) from all over Japan. In addition, we cryopreserved threatened Russian wildlife under a joint research project with the Bolonsky Nature Reserve in Russia (Figure 5). We collected samples (skin and blood) from 25 individuals, namely the oriental white stork (*Ciconia boyciana*, 20 individuals) and the red-crowned crane (*Grus japonensis*, 5 individuals).

In total, in 2009 we cryopreserved 787 kinds of samples (tissues, DNA, and cultured cells) from 191 individuals of Japanese and Russian wildlife. Since 2004, 3365 kinds of samples have been cryopreserved by the National Time Capsule Program.

Fig. 5 A joint research project with Bolonsky Nature Reserve was conducted to cryopreserve the genetic resources of Russian endangered bird species.

It is very possible that the Okinawa rail(Gallirallus okinawae) will become extinct. We are therefore focusing on cryopreservation of the cultured cells and genetic resources of this species. As at the end of 2009, cultured cells and genetic resources from 169 individuals had been stocked at –160 °C. Fewer than 800 living Okinawa rails remain (Figure 6).

Fig. 6 This young Okinawa rail on a road in the Yambaru area of Okinawa Island runs a high risk of being killed by a car.

2) Threatened algae

We have been surveying the status of threatened algal species in Japan. During FY 2009 we surveyed 38 potential habitats of Charales algae in Aomori, Okinawa, and Kagawa prefectures. Members of the Charales grew at 27 of the sites. We carefully collected several thalli (plant bodies), without disturbing the populations, so that we could establish culture strains. During FY 2009, we newly established 5 species and 5 strains of the Charales, and 1 species and 2 strains of freshwater red algae. We now maintain a total of 347 strains of endangered algae (25 species and 77 strains of the Charales, and 13 species and 270 strains of freshwater red algae), among which 139 strains of freshwater red algae are preserved in liquid nitrogen only, whereas others are preserved by subculturing.

Recently, Charales algae has been successfully restored from oospores buried in the bottom mud of eutrophic lakes such as Lake Kasumigaura and Lake Teganuma, where several Charales algae were present until the 1960s but are now extinct. In FY 2009, we collected the bottom mud containing the buried oospores from Lake Ashinoko, in central Japan, where the endemic species *Chara globularis* var. *hakonensis* was reported in 1964 but is now extinct. We have tried to restore this extinct species in experimental fields at NIES, but to date only another endangered species, *Chara braunii*, has germinated.

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

In FY 2009 at the Microbial Culture Collection (NIES-Collection), we:

- received 199 strains of microbes from scientists within and outside NIES
- distributed 1114 algal strains for education, research, and development
- renewed the Microbial Culture Collection website by adding image indexes and a "reference search" (Figure 7)
- determined the DNA sequences (mostly 18S and 16S rDNA) of strains for which there were no molecular phylogenetic data, in order to ensure the taxonomic position of these strains.

We now maintain a total of more than 2700 strains, of which 2225 are available as NIES strains. To minimize the risk of loss of culture strains in the event of a disaster, the NIES-Collection has duplicated some of the cryopreserved strains in the Kobe University Macroalgal Culture Collection. These activities are being conducted as part of the National Bio-Resource Project.

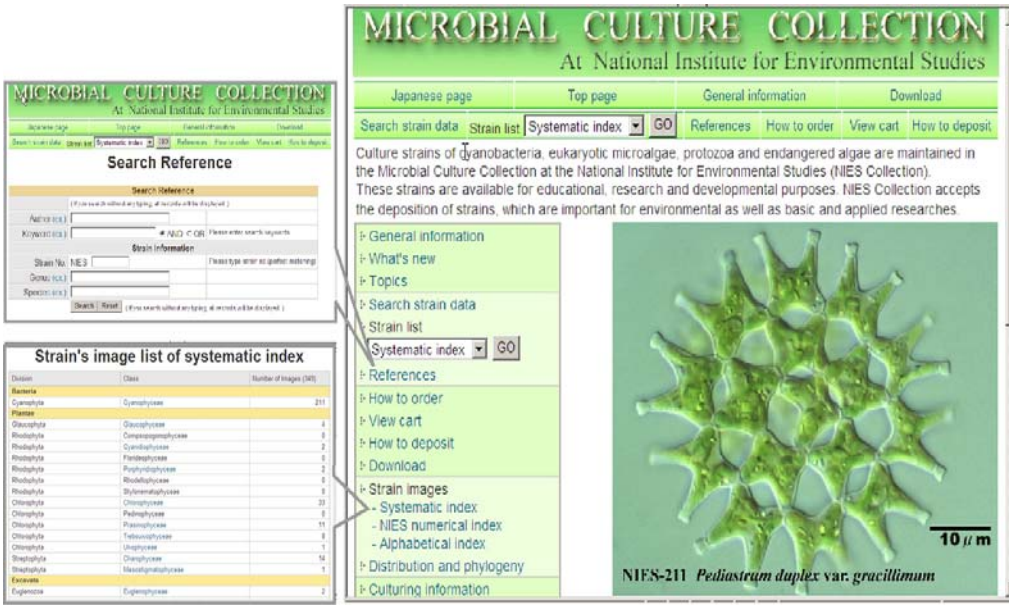


Fig. 7 Home page of the Microbial Culture Collection website, renewed in FY 2009. A reference search and image indexes are now available.

Provision of experimental aquatic animals for environmental risk evaluation

We supply 12 aquatic animals used mainly in eco-toxicity tests (Figure 8): egg masses of two species of midge (*Chironomus tentans*, *C. yoshimatsui*), larvae of damselfly (*Ischnura senegalensis*), scud (*Hyalella azteca*), three species of daphnid (*Daphnia magna*, *Moina macrocopa*, *Ceriodaphnia dubia*), a shrimp (*Paratya improvisa*), medaka (*Oryzias latipes*), zebrafish (*Danio rerio*), guppy (*Poecilia reticulata*), and fathead minnow (*Pimephales promelas*). In FY 2009, there were 51 requests for 123 samples of 9 species.

Fig. 8 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 the 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 (MOE), and acting as the national focal point for UNEP-Infoterra. These tasks are described in detail below.

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 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 home page. In FY 2009, the Center supported:

- the development of an electronic application and registration system at NIES
- the operation of a thin-client PC management system for the administrative section
- the development of the NIES research information database
- the modification and operation of a database of basic information on each member of staff at the Institute
- a basic plan for a processing system to be used for budgeting and settlement of accounts

c. Library service

As of March 2010, the NIES library held 55 857 books, 405 technical and scientific serials, 9688 maps, 122 268 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.

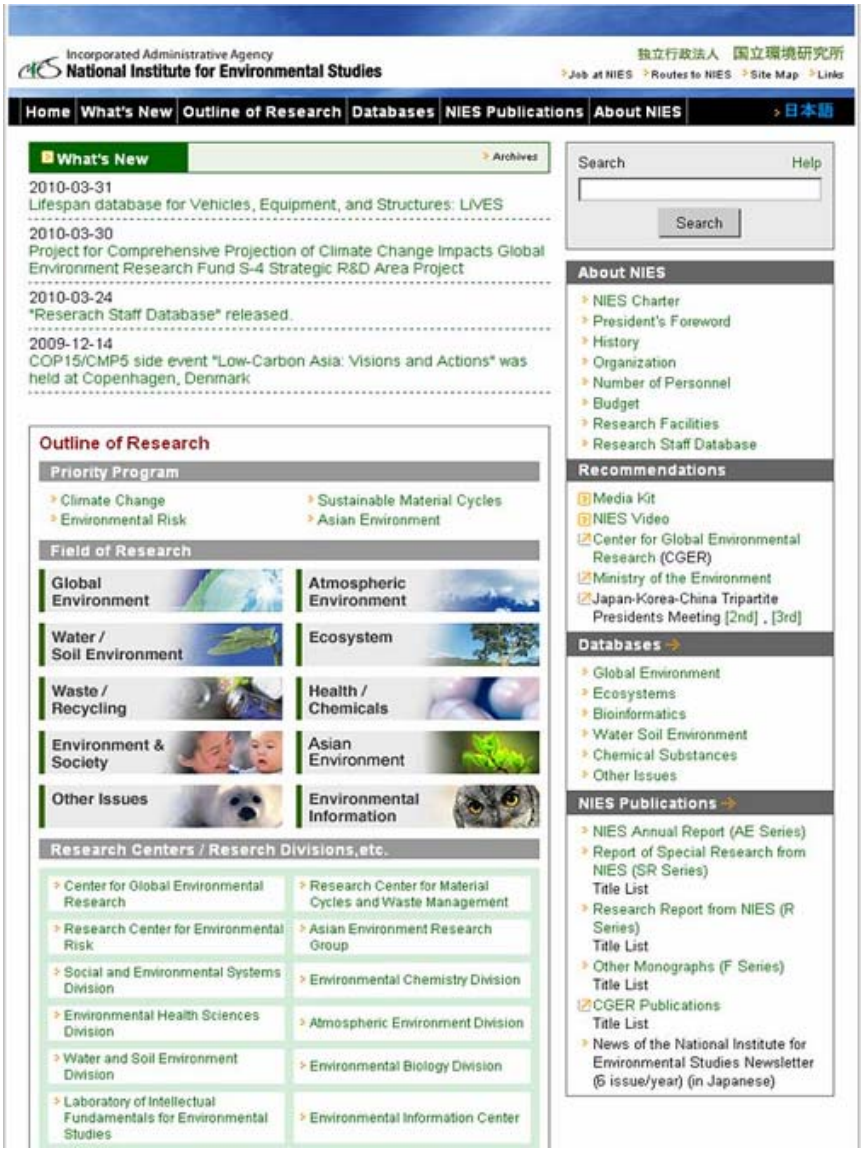
Library facilities include separate rooms for reading books, journals, indexes and abstracts, reports, maps, and microfiches.

2. NIES public relations activities

The Center manages the NIES website. 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 second 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 on 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

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 system).

Environmental Research and Technology Portal

The Center opened the Environmental Research and Technology Portal (http://ecotech.nies.go.jp/) in October 2007. The portal provides a variety of content, such as news on environmental research and technology from domestic and foreign news sources, reports on key topics in environmental technology, and information on seminars and events in environmental research and technology. Additionally, new content for environmental learning was launched in January 2009. 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 collected by local government and reported to MOE. These processed data can be accessed through the database on the NIES website. Duplication and lending services are also available.

Provision of environmental information via GIS

The Center, with the cooperation of MOE, 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 2009, in tasks commissioned by MOE, GIS was used to evaluate the following five datasets against quality standards:

- a nationwide car noise survey
- living environment data, covering noise, vibration, and offensive odors
- a survey of the concentration distributions of hazardous air pollutants
- a dioxin-monitoring survey.

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.

IDB (International Day for Biological Diversity) Symposium 2009"Invasive Alien Species – Causes and Impacts"

May 22, 2009
U Thant Hall, 3F United Nations University Headquarters
Tokyo, Japan

The international symposium for the International Day for Biological Diversity, entitled "Invasive Alien Species – Causes and Impacts", was held at the United Nations University. Keynote speeches were given by Mr. M. Yoshino, the Vice Minister of the Environment, Dr. Konrad Osterwalder, the President of UNU, and Dr. Ahmed Djoghlaf, the President of the Convention on Biological Diversity (CBD). These were followed by 8 presentations on the ecological impacts and control of invasive alien species by international and Japanese speakers. Notably, the speakers were not only scientists but also included representatives from NPOs working to eradicate naturalized alien species, and a company selling alien species as biological agents. The symposium closed with a panel discussion between the speakers, which was also joined by Drs. Junko Shimura of CBD (from NIES) and Naoki Adachi of Response Ability, Inc., a company which educates other companies about biodiversity. Topics including reasons why invasive alien species are produced in Japan and in the world were discussed from ecological, sociological and economic viewpoints. The symposium was attended by over 300 participants.

7th Workshop on GHG Inventories in Asia (WGIA7)

July 7-10, 2009
Hotel Mayfield, Seoul, the Republic of Korea

The Ministry of the Environment of Japan (MoEJ) and the National Institute for Environmental Studies (NIES) convened the "7th Workshop on Greenhouse Gas Inventories in Asia (WGIA7)" on July 7 - 10 in Seoul, Republic of Korea. The workshop was attended by a total of 100 participants including government and research representatives from eleven countries (Cambodia, Indonesia, Japan, Lao, P.D.R., Malaysia, Mongolia, Myanmar, Philippines, Republic of Korea, Thailand, and Vietnam), in addition to the representatives of two international organizations, the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat and the Technical Support Unit of the IPCC National Greenhouse Gas Inventories Programme (IPCC-NGGIP TSU), and also the members of the Regional Capacity Building Project for Sustainable National Greenhouse Gas Inventory Management Systems in Southeast Asia (SEA GHG Project).

The participants reaffirmed the importance of inventory as a key tool for promoting mitigation actions in a measurable, reportable and verifiable (MRV) manner.

Participants agreed upon the importance and necessity of keeping this momentum to further improve their inventories continuously and efficiently, even after completion of the National Communications (NC), national reports on the implementation of the United Nations Framework Convention on Climate Change to be submitted to the Conference of the Parties (COP) by the Parties to the Convention, currently under preparation:

(1) implementation of uncertainty assessment, developing time-series estimates, awareness-raising;
(2) collection of activity data (AD) using the guidance from the IPCC 2006 Guidelines (GL);
(3) application of new (updated) Emission Factors (EF) developed in each country, the 2006 GL and the WGIA-Emission Factor Database (EFDB);
(4) submission of a proposal for Global Environmental Facility (GEF) funding prior to completing NCs, and exploration of funding sources;
(5) trial of the mutual inventory review.

Participants expressed their interest in expanding the WGIA activities to enhance the utility of the inventory (e.g. activities to link GHG inventories to mitigation planning).

Hands-on training of techniques to fill data gaps was implemented and welcomed by participants.

Workshop on Chemistry in the Earth's Atmosphere -Crosscutting Aspects of Molecular Science and Atmospheric Chemistry-

September 7-8, 2009
Tokyo Tech Front, Tokyo Institute of Technology
Tokyo, Japan

The workshop was organized by the Interactive Research Center of Science, Tokyo Institute of Technology and NIES. A total of 11 invited papers including the Morino Lecture by Dr. Ravishankara (NOAA) were presented in the oral sessions and 30 in the poster sessions. More than 100 participants attended the workshop. Topics covered include spectroscopy of radicals and complexes relevant in the atmosphere, atmospheric free radical reactions, oxidation of volatile organic compounds and its impact on ozone and aerosol, and properties and distribution of atmospheric particles.

Annual Meeting of Integrated Assessment Modeling Consortium (IAMC)

September 15-16, 2009
Tsukuba International Congress Center
Tsukuba, Ibaraki, Japan

The meeting began with a presentation by Dr. Jae Edmonds who gave a brief introduction on the principles of operation and participation of the IAMC, including its members, aims, governance, committee and council. It was followed by a discussion on the Representative Concentration Pathways (RCPs) developed for the IPCC 5th Assessment Report. In the afternoon session of the first day, following the video presentation by Dr. R.K. Pachauri, IPCC chair, discussions centered around the exchange of scientific information, communication and coordination between the IAM (Integrated Assessment Model), CM (Climate Model), and IAV (Impact, Adaptation and Vulnerability) communities, the corresponding IPCC WGs and experts from other scientific fields, including video and telephone conferences with IPCC co-chairs (T. Stocker, C.Fields, O.Edenhofer). In the morning session of the second day, the Panel on Future IAM community made presentations on proposed research agendas such as modeling renewable energy technologies in IAMs, Asian modeling exercises, energy security, bio-energy and burden sharing. In the afternoon of the second day, further discussions on the remaining issues of scenario process and the interaction of IAMC with the CM and IAV communities were held. Remaining discussions focused on the following issues: i) refinements on several remaining issues of RCP scenarios process, ii) extending RCP scenarios beyond 2100 up to 2300, iii) the pros and cons of providing storyline for RCP, and iv) the preparation of databases and templates for sharing RCP scenarios with IAMC and others.

NIES Commemorative Lectures by the Blue Planet Prize Winners

October 23, 2009
National Institute for Environmental Studies
Tsukuba, Ibaraki, Japan

Dr. Hirofumi Uzawa, winner of the 17th Blue Planet Prize for outstanding achievements in providing solutions to global environmental problems, gave a special lecture to NIES researchers and local residents of Tsukuba.

AsiaFlux Workshop 2009

October 27-29, 2009
Conference Hall, Hokkaido University
Sapporo, Hokkaido, Japan

The 8th AsiaFlux Workshop was held on 27-29 October, 2009 at Hokkaido University in Sapporo, Japan. The workshop was sponsored by the Japan Society for Promotion of Science, the National Natural Science Foundation of China, the National Research Foundation of Korea, the Global COE Program (Establishment of Center for Integrated Field Environmental Science)-MEXT- Japan, Japan Aerospace Exploration Agency (JAXA), NIES, LI-COR Biosciences, Meiwafosis Co. Ltd., Campbell Scientific Inc., and Sapporo International Communication Plaza Foundation, and organized in cooperation with the Society of Agricultural Meteorology of Japan, iLEAPS Japan, and Japan Long-Term Ecological Research Network. The workshop was organized to explore the advantages of collaborations between the flux research community and various other research communities specializing particularly in long-term ecological research, remote-sensing, and social science in order to 1) deepen our knowledge about ecosystems, 2) extend our knowledge to broader regions, and 3) extend the knowledge to society. The following special sessions featuring collaborations with other networks, such as remote sensing fields, iLEAPS and ILTER were held; Bridges between Ecosystem Observation and Remote Sensing, Global Biogeochemical Cycles, and Interfaces between Carbon Science and Society. During the two-day meeting, more than 180 scientists and students from 16 countries and regions participated in the workshop, and 36 oral and approximately 100 poster presentations were made.

International Symposium on Cities and Carbon Management: Towards Enhancing Science-Policy Linkages

November 16, 2009
Tokyo International Forum (Hall D7)
Tokyo, Japan

The 22 international speakers were grouped into three categories- 10 leading scientists in the urban carbon field; city policy makers from five global cities Chicago, London, Tokyo, Jakarta and Delhi; and the community that facilitates research policy bridging, such as the World Bank, Asian Pacific Network for Global Change Research, United Nations Economic and Social Commissions for Asia and the Pacific, Institute for Global Environmental Strategies and International Council for Local Environmental Initiatives. The symposium was attended by over 150 people from academia, local governments, NGOs, research institutions, and the public.

The 6th Meeting of the Tripartite Presidents Meeting among NIES, NIER and CRAES

November 25-27, 2009
Lotte Hotel
Seoul, the Republic of Korea

The Tripartite Presidents Meeting among NIES, NIER and CRAES (TPM) has worked to expedite joint efforts in environmental research among Japan, Korea and China, while seeking further cooperation on issues of common interest. At the TPM6, three presidents exchanged information on the recent developments in each institute and shared the view of the global challenges faced. They agreed to strengthen cooperation to address the issues including climate change, realization of low carbon society, resource recycling and waste management.

The 6th NIES Workshop on E-waste

December, 9 2009
Hyakunen-kinen Kaikan (Centennial Hall), Hokkaido University
Sapporo, Hokkaido, Japan

Thirty participants from seven countries (Indonesia, Korea, Nigeria, the Philippines, USA, Vietnam and Japan) attended the workshop, which consisted of three sessions and a panel discussion. In the first session, three speakers made presentations on estimating e-waste generation and the current recycling situation and technology in Asia. Statistical data limitations, the unclear definition of e-waste, and different behaviors connected to discarding e-waste were identified as obstacles to drawing precise descriptions of material flows of e-waste in Asian developing countries. In the second session on resource recovery efficiency and possible harm from e-waste recycling processes, three speakers presented data on environmental contamination and results of assessment of human exposure to persistent toxic substances in e-waste recycling sites in India and Vietnam, a case study of gold recovery from e-waste components in Indonesia, and the categorization of Waste Electrical and Electronic Equipment (WEEE) as secondary resources. In the third session, there were three presentations about the comparison of e-waste recycling systems in Japan and Europe, and recommendations for e-waste recycling schemes in Asian developing countries. During the panel discussion, participants discussed future research plans and necessary policies and recognized the importance of identifying which recycling processes cause significant impacts on the environment and human health.

International Symposium on Role of Environmental Stressors in the Developmental Origins of Disease

December 7-10, 2009
Lowes Hotel, Miami Beach
Florida, USA

The fetal and infant stages have been conceptually recognized as being the stages in the human life cycle most susceptible to environmental chemicals, but the toxic mechanisms of environmental chemicals in these stages have yet to be identified. This symposium discussed how subtle effects of chemicals during development can lead to functional deficits and increased disease risk later in life. Invited lectures and poster presentations were held on topics relating to cancer, obesity/diabetes/metabolic syndrome, reproductive diseases and neurobehavioral deficits. Scientists from US, Europe and other regions were invited as chairpersons; From Japan, Drs. Ken Takeda (Tokyo University of Science), Keiko Nohara (NIES) and Yasunobu Aoki (NIES) were nominated. In each session, presentations were selected equally from experimental studies, in which adverse effects of chemicals on fetal development in pregnant animals were examined based on the latest molecular biology and physiology research, and epidemiological studies, in which health effects of chemicals on individuals were examined in the real world. The studies presented in this meeting showed exciting results. On-going epidemiological studies which are surveying children's health, such as the National Children's Study in the US, were also introduced. The outline of the Japan Environment and Children's Study organized by Ministry of the Environment was presented by Dr. Fujio Kayama from Jichi Medical University.

COP15/CMP5 Side Event: Low-Carbon Asia: Visions and Actions

December 10, 2009
Copenhagen Congress Center
Copenhagen, Denmark

The official side event during UNFCCC COP15/CMP5 "Low-Carbon Asia : Visions and Actions" focused on sustainable low-carbon society visions and roadmaps for Asian countries and cities such as Jilin in China, Ahmedabad in India, Iskandar in Malaysia, and Shiga prefecture and Kyoto city in Japan. The panel presented possible drastic GHG emissions reductions while realizing a high quality of life through our research collaboration. The event was jointly organized by the Institute for Global Environmental Strategies (IGES) and the Japan Center for Climate Change Actions (JCCCA) and attended by about 200 people.

International Symposium "International Institution on Climate Change: Assessment by Major Economies of Outcome of COP15"

January, 19 2010
KKR Hotel
Tokyo, Japan

The symposium invited speakers from the United States, the European Union, China, Russia, and Indonesia (on behalf of the G77 group). Each speaker talked about the country's positions and decision making up to COP15, held in December 2009 in Copenhagen, and how those countries perceive the outcome of the meeting. This symposium was attended by about 120 observers. The Q & A session between the panelists and the floor resulted in fruitful exchanges of views among the participants.

COUNTRY
No.Title
Collaborating institution
NIES Research Division (as of latest review meeting)

CANADA

1. Monitoring of the atmosphere-ocean carbon dioxide exchange rate
   Center for Ocean Climate Chemistry, Institute of Ocean Sciences
   Center for Global Environmental Research

CHINA

1. 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
2. Advanced wastewater treatment processes for China
   Research Institute for Environmental Engineering & Department of Environmental Engineering, Tsinghua University
   Research Center for Material Cycles and Waste Management
3. 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
4. Research on the development of water pollution control techniques for the Taihu Lake in China by bio/eco engineering
   Chinese Research Academy of Environmental Sciences
   Research Center for Material Cycles and Waste Management
5. Development of eco-engineering technologies for the control of eutrophication in the drainage area Hongfeng Lake and Baihua Lake in China Guizhou
   Guizhou Provincial Environmental Protection Bureau
   Research Center for Material Cycles and Waste Management
6. 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
7. Research on VOCs and ammonia emissions in China
   Chinese Research Academy of Environmental Sciences
   Atmospheric Environment Division
8. Environmental impact assessment of dams & floodgates and river ecosystem restoration in Huai River, China
   Key Laboratory of Water Cycle and Related Land Surface Processes, Institute of Geographical Science and Natural Resource Research, Chinese Academy of Sciences
   Asian Environment Research Group
9. Establishment of early observation network for the impacts of global warming
   Institute of Geographic Science and Natural resources Research
   Asian Environment Research Group

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
   French National Center for Scientific Research
   Environmental Biology Division

KOREA

1. Study on monitoring of long range transported air pollutants and acid deposition in the Northeast Asia region
   National Institute of Environmental Research
   Asian Environment Research Group
2. Analysis of environmental changes by corals distributed around Japan and Korea
   Korea Ocean Research and Development Institute
   Center for Global Environmental Research
3. Korea–Japan information exchange and cooperative survey on invasive alien species in both countries
   National Institute of Environmental Research
   Research Center for Environmental Risk
4. Establishment of real-time data exchange system of Asian dust observations between Korea and Japan (Joint research on the monitoring of Asian dust using a LIDAR system)
   Korea Meteorological Administration
   Atmospheric Environment Division
5. Evaluation on organotin pollution and its effects on marine organisms in Korea and Japan
   National Fisheries Research & Development Institute
   Risk Center for Environmental Risk

RUSSIA

1. Measurement of methane emission rates from permafrost areas
   Permafrost Institute
   Center for Global Environmental Research
2. Modeling of methane emission rates from natural wetlands
   Institute of Microbiology
   Center for Global Environmental Research
3. Airborne measurement of greenhouse gases over Siberia
   Central Aerological Observatory
   Center for Global Environmental Research
4. Measurements of greenhouse gases affected by Siberian ecosystems
   V.E. Zuev Institute of Atmospheric Optics, SB RAS
   Center for Global Environmental Research
5. Greenhouse gases budget of land ecosystems in Siberia
   Winogradsky Institute of Microbiology, Russian Academy of Sciences
   Center for Global Environmental Research
6. Conservation of genetic resources on wild animals in Khabarovsk region

Russian Federation Ministry of Ecology and Natural Resources Bolonsk y Nature Reserv
Laboratory of Intellectual Fundamentals for Environmental Studies

SWEDEN

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

USA

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, NASA
   Center for Global Environmental Research

Notes:

1. The number of projects is subject to change, as the adoption of certain projects is still under discussion.
2. Names of collaborating institutions are shown as they were at the time of approval of the joint research project.

AUSTRALIA	Consultancy Agreement between National Institute for Environmental Studies (NIES) and the University of Wollongong (2008)
CANADA	Agreement between NIES and the Institute of Ocean Sciences (1995)
CHINA	Memorandum of Understanding (MoU) on Cooperation in the Field of Environmental Protection between NIES and the Sino–Japan Friendship Center for Environmental Protection of the State Environmental Protection Administration of the People's Republic of China (2006)
	Agreement for Cooperative Study on Water Resources and Water Environment Management in Haihe River Basin (2006)
	MoU for Cooperative Research on Adaptive Management for the Marine Ecological Environment and Biological Resources of East China Sea between NIES and Zhejiang Ocean University (2007)
	Implementation Plan for a Water Quality Automatic Monitoring System and Watershed Environmental Management Modeling in the Middle and Low Reaches of the Hanjiang River (2007)
	Implementation Agreement for "Establishment of an Early Observation Network for Global Warming Impacts", a Cooperative Project of the Sino–Japanese Science and Technology Joint Committee (2008)
	MoU on Joint Research on the Characteristics of Aerosol Pollution in Northern China during the Dust and Sandstorm Season between NIES and the Sino–Japan Friendship Center for Environmental Protection (2008)
	MoU on Joint Research on Integrated Assessment of Water Environment in Liaohe Watershed between NIES and Lioning Academy of Environmental Sciences (2008)
	Joint Research Agreement on the Observation and Modeling of Water and Biogeochemical Cycles in Subtropical Rice Paddy Ecosystems between the Asia Water Environment Research Group, NIES and Taoyun Experimental Station for Agricultural Ecosystems, Institute of Subtropical Agriculture, Chinese Academy of Sciences (2008)
	General Agreement on International Collaborative Research on Environmental Resources and Related Fields between NIES and Institute of Geographic Science and Natural Resources Research, Chinese Academy of Sciences (2009)
	MoU for Collaborative Research on Development of Rural Wastewater Treatment Technology between NIES and North Research Center for Rural Wastewater Treatment Technology, Ministry of Housing and Urban-Rural Development (2009)
	General Agreement International Collaborative Research on Environmental Conservation and Related Fields between NIES and East China Normal University, China (2009)
	MoU for the Establishment of a Cooperative Program of Academic and Scientific Exchange between NIES and the Institute of Applied Ecology, Chinese Academy of Science, Shenyang (2009)
GERMANY	Contract for the Research Support between NIES and University of Bremen (2008)
INDIA	MoU for Collaborative Research on Atmospheric Science between NIES and Anna University, Chennai (2006)

KOREA	Implementing Agreement to Establish Cooperative Framework regarding the Environmental Protection Technologies between NIES and the National Institute of Environmental Research of the Republic of Korea (1994)
MALAYSIA	MoU for collaborative research on Tropical Forest Ecology and Biodiversity between NIES and Forest Research Institute Malaysia (FRIM), University Pertanian Malaysia (UPM) (1991)
MONGOLIA	MoU on 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 between NIES and The National Agency for Meteorology, Hydrology and Environment Monitoring (2007)
NEW ZEALAND	Independent Contractor Agreement between NIES and the National Institute of Water and Atmospheric Research Limited (2008)
RUSSIA	Agreement on Cooperative Research Projects between NIES and the Central Aerological Observatory, Committee for Hydrometeorology and Monitoring of Environment, Ministry on Ecology and Natural Resources of the Russian Federation (1992) Agreement on Cooperative Research Projects between NIES and the Institute of Microbiology, Russian Academy of Sciences (1994) Agreement on Cooperative Research Projects between NIES, Environment Agency of Japan, and Institute of Atmospheric Optics, Russian Academy of Sciences (1997) MoU on Joint Research concerning the Evaluation of Genetic Diversity and Cell Preservation of Rare Birds between NIES and Bolonski State Nature Reserve (BSNR) (2009)
SWEDEN	MoU on Joint Research on Product and Waste Oriented Environmental Management and Policy between NIES and International Institute for Industrial Environmental Economics at Lund University (2008) Contract for Joint Research Project on The Collection and Recycling System of Used Mobile Phones and Actors engaged in Such Systems between NIES and the International Institute for Industrial Environmental Economics at Lund University (2009)
TAIWAN	MoU on Joint Research to the Application of Chicken Primordial Germ Cells for Protein Production between NIES and ABNOVA corporation (2009)
THAILAND	MoU on Research on Appropriate Landfill Operations in Thailand between NIES and Kasesart University （2009） MoU on Research on Appropriate Landfill Operations at Laemchabang Landfill between NIES and Laemchabang Municipality (2009) MoU on Joint Research on Development of Co-benefit Treatment System of Molasses-based Waste Water between NIES and Khon Kaen University (2009) MoU on Research on Greenhouse Gas Emissions from Solid Waste Disposal Sites and Waste Management between NIES and The Joint Graduate School of Energy and Environment, Kings's Mongkut University of Technology Thonburi (2009) MoU between NIES and Ubon Rajathanee University, Thailand on Joint Research

on Alternative Dam Construction Schemes and Their Effects on Freshwater Fish Diversity in the Mekong (2009)

MoU on Joint Research related to the Cryo-phoenix Project between NIES and Kasetsart University (2010)

MoU between NIES and Asian Institute of Technology (2010)

UK Collaboration Agreement "Towards Constructing a Consistent Dataset of Atmospheric CO_2 Concentrations from the New Generation of Satellite Instruments to Improve Estimates of Carbon sources and Sinks" between NIES, The University of Leicester, and The University of Edinburgh (2008)

USA Implementing Agreement on Joint Research on Analyses of Marine Productivity and Oxygen Cycle in the Pacific and Tasman Sea, between NIES and Princeton University (2008)

Technical Assistance Agreement between NIES and the California Institute of Technology at the Jet Propulsion Laboratory (2008)

Technical Services Agreement between NIES and the California Institute of Technology (2008)

MoU Agreement between NIES and Advanced Global Atmospheric Gas Experiment (AGAGE) (2009)

UNEP MoU referring to the establishment and operation of a GRID-compatible Center in Japan (1991)

MoU on Joint Research on Global Energy – Economic Modeling between NIES and UNEP Risø Centre on Energy, Climate and Sustainable Development, Denmark (2007)

VIETNAM MoU on Joint Research on Development of Future Visions for Municipal Solid Waste Management Systems in Vietnam between NIES and Institute of Science for Environment Management (2009)

MoU on Joint Research on Accumulation of Municipal Solid Waste Data in Vietnam between NIES and Institute for Urban Environment and Industry of Vietnam (2009)

GOSAT-Research Announcement Joint Research Agreements

CANADA Validation of GOSAT Measurements Using Ground-Based and Satellite Data (2008)

Evaluation of Applicability of GOSAT Data for Monitoring of Green House Gases (GHG) Emissions from Tailing Ponds and Upgrader Operations in the Oil Sands Production Area, Alberta, Canada (2008)

Chemical Data Assimilation and Inverse Modeling of Atmospheric CO_2 (2009)

CHINA Analysis of Spatial and Temporal Relationship between Greenhouse Gases and Landuse/Landcover in China (2008)

FRANCE Geophysical Parameters Derived from TANSO/FTS and CAI Data (2008)

Correlative TIR, SWIR, and NIR Measurements for GOSAT (2008)

Quality Control of Radiances, Validation of Greenhouse Gas Products, and Study of CO_2 Diurnal Cycle (2009)

Estimation of CO_2 and CH4 Surface Fluxes (2009)

GERMANY	Cloud Remote Sensing using GOSAT Instruments (2008)
	Towards Consistent Long-term SCIAMACHY and GOSAT Greenhouse Gas Data Sets (CONSCIGO) (2008)
	Distributions of CO_2 and CH_4 over Eurasia between 30°N and 90°N (2008)
	Non-standard Cloud, Aerosol, and Albedo Products (2008)
	Quantification of the Carbon Cycle in Europe and Western Africa by the Top-down Method (2008)
	Validation of TANSO CH_4 Columns and Profiles by Ground-based Solar Absorption FTIR (2008)
	Validation of GOSAT Methane, Carbon Dioxide, and Water Vapor at the Ground-Truthing Facility Garmisch / Zugspitze (2009)
NETHERLANDS	Retrieval of Methane, Carbon Dioxide, and Water Vapor from GOSAT Near-infrared Spectra (2008)
	Intercomparison of CO_2 Fluxes Estimated using Inverse Modeling of GOSAT and OCO Measurements (2008)
	Study of Aerosol and Cloud Properties by using Polarization of the O_2A band (2008)
	Retrievals of Atmospheric CO_2 from GOSAT Observations Based on Accurate Vector Radiative Transfer Modeling of Scattering Atmospheres (2009)
NEW ZEALAND	Southern Hemisphere Validation of GOSAT XCO_2 and XCH4 from TCCON Solar FTS Measurements in Australia and New Zealand (2008)
RUSSIA	Simulation of Cirrus Clouds and Humidity in UTLS by using a Coupled Cirrus/Trajectory Model, and Modification of the Transport Models used for the Purposes of Greenhouse Gas Inversion (2008)
	Development of Methods and Software for Retrieval of CO_2 and CH_4 Spatial Distributions from TANSO-FTS and TANSO-CAI Sensor Data, and Application of these Methods to Analysis of the Atmosphere over Western Siberia (2008)
	Development of Radiative Transfer Technique for Arbitrary 3K Geometry with Consideration of Polarization Effects (2008)
	Development of Column Amounts and Concentration Profiles for Retrieving Algorithms for CO_2 and CH_4 from Satellite Data using A Priori Information (Neural Network Approach) (2008)
UK	Application of GOSAT Data in a 4D-Var Data Assimilation System, in Combination with Other Greenhouse Gas Observations, to Better Estimate CO_2 and CH_4 Fluxes (2008)
	The UK Universities' Contribution to the Analysis of GOSAT L1 and L2 Data: Towards a Better Quantitative Understanding of Surface Carbon Fluxes (2008)
	Validation of TANSO FTS Spectra Using RFM Line-by-Line Model (2010)
	Using Envisat MERIS MTCI to Characterize the Response of the Terrestrial Biosphere to Spatio-temporal Variability in Atmospheric Carbon Dioxide as Measured by GOSAT FTS (2009)
	Using GOSAT to Help Improve the Representation of Wetlands and Associated CH_4 Cycle in the next Generation Global Land Surface Models (2009)

USA Early Detection of Leakage from Siberian and Alaskan Gas Pipelines (2008)
Infrared Validation and Mid-tropospheric CO_2 from the FTS GOSAT Sensor (2008)
Trace Gas Remote Sensing using Near IR and Longwave IR (2008)
Validation of a Lidar System for the Measurement of CO_2 (2008)
Evaluation and Validation of GOSAT CAI Vegetation Index Products using MODIS, AVHRR, and In Situ Data over the Conterminous United States and Hawaii (2008)
Assessment of GOSAT TIR FTS Absolute Calibration through Validation (2008)
Validation of GOSAT Data Products (2009)
GOSAT and Oceanographic Observations of CO_2 and CH_4 on the Laptev and East Siberian Shelf Seas (2009)
Comparison of GOSAT CH4 and CO_2 with NOAA/NESDIS Operational Trace Gases Products Retrieved from AIRS, IASI and CrIS and Use of CAI Aerosol Product for NOAA Synergy Studies of Using Satellite Data for Air Quality Applications (2009)
Assessment of GOSAT Radiance Responses to the Lower Atmospheric CO_2 Concentration Change and Impact of Aerosols and Clouds on CO_2 Concentration Retrievals (2009)
Comparison of GOSAT Retrievals of the CO_2 and CH_4 Column Mole Fractions with In-Situ Data and Estimates Produced by the Carbon Tracker Data Assimilation System (2009)
Application of GOSAT/TANSO-FTS to the Measurement of Volcanic CO_2 Emissions (2009)
Global Analysis of Carbon Sources and Sinks with a Comprehensive Model Optimized with GOSAT/TANSO Observations (2009)

Host Division

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

Center for Global Environmental Research

Valsala, Vinu Krishnapillai, INDIA, 2007.10.1～2009.9.30
A robust estimation of the ocean-atmosphere exchanges of carbon dioxide (CO_2) (Maksyutov, S.)

Kim, Heon-Sook, KOREA, 2008.10.24～2010.3.31
Application of atmospheric transport and inverse modeling in global methane flux estimation and GOSAT product evaluation (Maksyutov, S.)

Schutgens, Nicolaas Alexander Johannes, NETHERLANDS, 2009.4.1～2010.3.31
Development, improvement and validation of an aerosol transport model for the GOSAT data processing (Yokota, T.)

Go, Ensyun, CHINA, 2009.4.1～2010.3.31
Visualization and assessment of policies towards low carbon societies (Kameyama,Y.)

Li, Zhidong, CHINA, 2009.5.27～2010.3.31
Development of support systems for Asian low-carbon society scenarios (Fujino J.)

Bloom, Alexis Anthony, GREECE, 2009.6.24～2009.8.24
Large scale constrains on methanogenesis inferred from satelite measurments of methane and gravity
(Maksyutov, S.)

Cai, Guo t ian, CHINA, 2010.1.28～2010.2.28
Finding appropriate solutions for forming a set of relatively comprehensive energy strategy research systems suitable for Guangdong Province (Fujino, J.)

Research Center for Material Cycles and Waste Management

Li, Yu-you, CHINA, 2009.4.1～2010.3.31
Studies on the development of the technology for hydrogen and methane fermentation from biomass (Xu, K.)

Lu, Xi-wu, CHINA, 2009.4.1～2010.3.31
Studies on development of appropriate treatment technology for decentralized liquid wastes (Xu, K.)

Kong, Hai-nan, CHINA, 2009.4.1～2010.3.31
Studies on advanced treatment and energy recovery from liquid wastes using Bio-eco technology (Xu, K.)

Easter, Lautua Siatua Adrian, SAMOA, 2009.10.1 ～ 2009.12.31
Investigation of landfill technologies for the Asian region (Endo, K.)

Ju, Mun-sol, KOREA, 2009.11.1～2010.3.31
Analysis of the environmental impact due to changes in consumer behavior in food lifecycle systems (Osako, M)

Hori, Mitsue, BRAZIL, 2009.12.14～2010.2.12
Recycling process and related costs of reverse logistics of electric and electronic products waste (Terazono, A.)

Research Center for Environmental Risk

Li, Chunmei, CHINA, 2007.4.5～2009.4.4
Effects of diesel exhaust with enrich-nanoparticles on reproductive and endocrine function (Suzuki, A.)

Adu-kumi, Sam, GHANA, 2008.9.16～2009.11.7
Exposure assessment of lindane in Ghana (Suzuki, N.)

Yang, Linqing, CHINA, 2009.4.1～2009.8.31
Study on molecular effects of nuclear receptor ligands on carcinogenesis and aging (Sone, H.)

Pak, Jeong-Che, KOREA, 2009.6.1～2010.3.31
Analysis of causal factors for the declining star-spotted dogfish population in Tokyo Bay (Horiguchi,T.)

Kim, Hyun-Young, KOREA, 2010.1.7～2010.2.18
Study of effects of new persistent organic pollutants on differentiation of neuronal cell lineages derived from mouse ES cells (Sone, H.)

Asian Environment Research Group

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.)

Zou, Chunjing, CHINA, 2008.6.24～2010.3.31
Comparative analysis on eco-physiological characteristics among ecotypes grown in semi-arid regions (Shimizu, H.)

Koolkalya, Sontaya, THAILAND, 2009.4.1～2010.3.31
Effects of constructed barriers such as dams on freshwater fishes in the Mekong River and rivers in eastern Thailand (Fukushima, M.)

Tang, Changyuan, CHINA, 2009.4.1～2010.3.31
Degradation of ground water resources in river basins (Murakami, S.)

Social and Environmental Systems Division

Welch, Eric Wayne, USA, 2009.3.27～2009.5.24
Study on the effectiveness of the voluntary approach (Hibiki, A.)

Lee, Huey-Lin, TAIWAN, 2009.7.12～2009.9.9
Study on the effect of trade liberalization on the environment (Hibiki, A.)

Glenk, Klaus, GERMANY, 2009.9.5～2010.3.31
Comparative study on policies to drive a shift to a low carbon society (Okagawa, A)

Xu, Yan, CHINA, 2009.9.5～2010.3.31
Comparative study on policies to drive a shift to a low carbon society (Okagawa, A)

Choi, Hyo-Ji, KOREA, 2010.1.7～2010.2.18
Study on economic evaluation of flood risk (Hibiki, A.)

Kim, Min-Jeong KOREA, 2010.1.7～2010.2.18
Vertical variation of horizontal wind energy resources distribution using clustering analysis (Ichinose, T.)

Environmental Health Sciences Division

Bao, Jinhua, CHINA, 2009.6.1～2010.3.31
Studies on epigenetic effects of arsenic (Nohara.K.)

Atmospheric Environment Division

Xing, Jia-hua, CHINA, 2009.4.1～2010.3.31
Studies on variability of stratospheric processes and uncertainties in the prediction of future changes in stratospheric ozone (Imamura, T.)

Environmental Biology Division

Saghar, Zarenezhad, IRAN, 2008.6.2～2010.3.31
Molecular phylogenetic study of toxic cyanobacteria

Cylindrospermopsis raciborskii (Kawachi, M.)

Cho, Kyoungwon, KOREA, 2009.4.1～2010.3.31
Study on evaluation of effects of high temperature and ozone on rice by analysis of molecular markers in panicles and seeds (Kubo, A.)

Rakwal, Randeep , INDIA, 2009.4.22～2010.3.31
Comprehensive analysis of molecular responses of a model plant to high temperatures and ozone (Kubo, A.)

Kovács-Bokor, Éva HUNGARY, 2009.11.12～2009.11.25
Studies on environmental conservation in wetland ecosystems such as lakes, ponds, brackish-water regions, tidal flats and rivers (Nohara, S.)

Abe M., Shiogama H., Hargreaves J. C., Annan J. D., Nozawa T., Emori S., 2009, Correlation between inter-model similarities in spatial pattern for present and projected future mean climate, SOLA, 5, 133-136.

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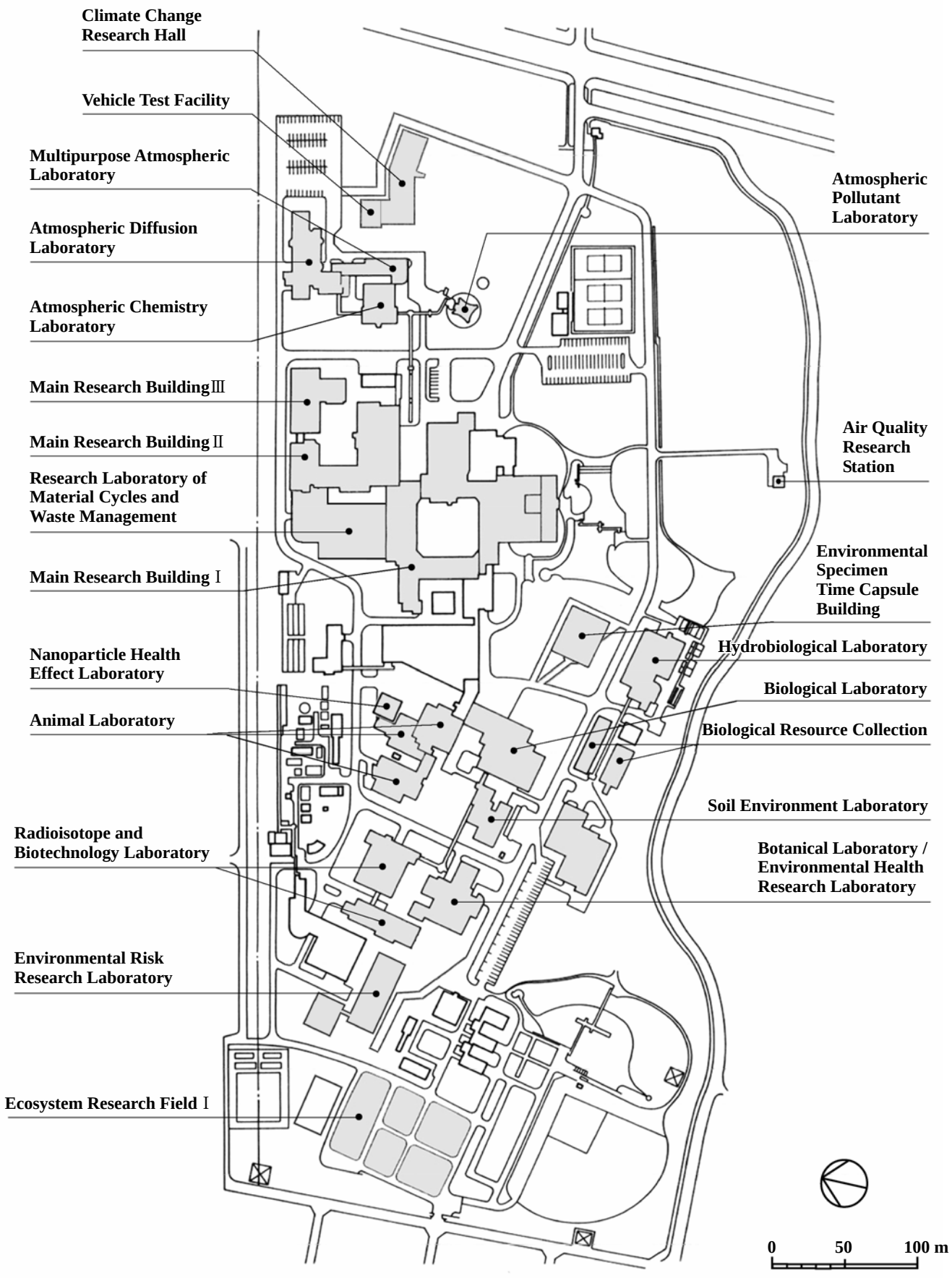
Climate Change Research Hall
Vehicle Test Facility
Multipurpose Atmospheric Laboratory
Atmospheric Diffusion Laboratory
Atmospheric Chemistry Laboratory
Main Research BuildingⅢ
Main Research BuildingⅡ
Research Laboratory of Material Cycles and Waste Management
Main Research BuildingⅠ
Nanoparticle Health Effect Laboratory
Animal Laboratory
Radioisotope and Biotechnology Laboratory
Environmental Risk Research Laboratory
Ecosystem Research FieldⅠ
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 eight atmospheric constituents (NO_x, SO_2, O_3, methane and non-methane hydrocarbons, suspended particulate matter and PM2.5, 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. The stability and accuracy of the automated measurements and the factors that interfere with them have been studied. The monitoring results are made available to NIES researchers as fundamental data for various studies, and simplified processing data are also opened in the NIES Home page.

Animal Laboratory

The animal laboratory has three controlled-environment facilities. Facility I has complex gas or diesel exhaust particle (DEP) exposure chambers for investigating the health effects of $PM_{2.5}$ and DEPs. Facility II has a conventional laboratory animal breeding unit and laboratories for studying the effects of chemicals, including dioxins and heavy metals. Facility III was built in 2004 as a nanoparticle health effects research facility; it has exposure chambers and two diesel engines for generating nanoparticles. Research on the health effects of nanoparticles began in FY 2005 using experimental animals.

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 locations 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 the 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 2700 strains of microalgae, protozoa, and endangered macroalgae. Among them, 2225 strains are available to researchers inside and outside NIES. In FY 2009, researchers were supplied with 1114 strains.

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. The hall also contains 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 they 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 qualitative and quantitative analysis of environmental chemicals and a confocal laser scanning microscope for cell biology.

Environmental Specimen Time Capsule Building

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 tree growth periods. After the felling of a natural forest of coniferous and broad-leaved 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, near Tomakomai, in 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 monitoring 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 home page and the World Data Centre 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

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.

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 6.5×10^4 and that of the second is 5×10^3. Ions selected by the first MS are passed through the collision cell, where they 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 MV (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) processes GOSAT data. The facility's tasks include data acquisition from JAXA (the Japan Aerospace Exploration Agency), 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 that contribute to the overall function. After the successful launch of GOSAT on January 23, 2009, GOSAT DHF has been operating to perform the taskes mentioned above. The level 1 data products (spectral data and terrestrial images) have been released to the general users since October 30, 2009. The level 2 data products (column abundances of carbon dioxide and methane) have been released to the general users since February 18, 2010.

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

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 km × 1 km). The AVHRR facility of NIES was able to receive these 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 a part of the CGER Global Environmental Database. 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. There are four whole body inhalation chambers designed for chronic toxicological studies on environmental nanoparticles and one nose-only inhalation chamber designed to investigate acute toxicity of carbon nanotubes.

Oku-Nikko Field Research Station
After a plan to overhaul the use of the field research station at Oku-Nikko in Tochigi Prefecture in March 2009, the station was used as the research field base for preparation, analysis and staying to accomplish the researches related to forest and river ecosystems. The station was used, for example, to check the performance of newly developed devices and systems for environmental measurement under field conditions; to clarify the influence of deer feeding on natural tree regeneration; and to monitor the succession of vegetation on rotten woods in relation to micro-environmental factors.

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
NIES established this laboratory in March 2002. The 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 to restore polluted sites.

Research Station for 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 researchers in universities and private companies as well as in NIES. 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. Actual 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 millimeter-wave radiometer). The aim is to reveal ozone variations in the stratosphere and the effects of 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 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, onboard fuel economy and emission measurement systems, conventional exhaust measurement systems, and devices developed by NIES, including an exhaust gas dispersion chamber and a dilution tunnel with high dilution ratio capacity, to measure and evaluate real-world vehicle exhaust and performance.

Number of personnel

President	1
Executive Director	2
Auditor	2
Planning Division	11
General Affairs Division	32
Audit Section	2
Center for Global Environmental Research	27
Research Center for Material Cycles and Waste Management	18
Research Center for Environmental Risk	23
Asian Environment Research Group	19
Social and Environmental Systems Division	13
Environmental Chemistry Division	13
Environmental Health Sciences Division	18
Atmospheric Environment Division	13
Water and Soil Environment Division	15
Environmental Biology Division	20
Laboratory of Intellectual Fundamentals for Environmental Studies	9
Environmental Information Center	10
Total	248

Fields of expertise

Basic Sciences	70
Engineering	60
Agricultural Sciences	23
Medical Sciences	13
Pharmaceutical Sciences	7
Economics	3
Fisheries Sciences	3
Law	1
Philosophy	1
Veterinary Sciences	1
Total	182

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	Executive Director (Management)	KABURAGI, Yoshiro
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	Deputy Director	TAKIMURA, Akira
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	Principal Research Coordinator (*)	KORESAWA, Yuji
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Research Coordination Office	Chief	MORI, Yasufumi
	Research Coordinator (*)	TASAKI, Tomohiro
	Research Coordinator (*)	ITO, Tomohiro
	Research Coordinator (*)	IWASAKI, Kazuhiro
	Research Coordinator (*)	MURATA, Tomoyoshi
	Research Coordinator	KUME, Hiroshi
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	Special Senior Researcher	YAMAGATA, Yoshiki
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Satellite Remote Sensing Research Section	Chief	YOKOTA, Tatsuya

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Database Section	Chief	KUBO, Tsuneo
Information Management Section	Chief	HIROKANE, Katsunori

(*) Multiple roles

ACLab	Analytical Chemistry Laboratory
ADEOS	ADvanced Earth Observing Satellite
AIM	Asia-Pacific Integrated Model
AMS	accelerator mass spectrometry
API	air pollution index
As	arsenic
B35	polyoxyethylene(23) laurylether
B58	polyoxyethylene(20) cetylether
BDF	biodiesel fuel
BMDCs	bone marrow-derived dendritic cells
BRLab	Biological Resource Laboratory
CBD	Convention on Biological Diversity
CC-LaG	Carbon Cycle and Larch Growth
CGCM	Coupled General Circulation Mode
CGE	computer general equilibrium
CMAQ	Community Multiscale Air Quality
CONTRAIL	Comprehensive Observation Network for Trace gases by AIrLiner
COP	Conference of the Parties
CRMs	Certified Reference Materials
CRT	cathode ray tube
CTMA	cetyltrimethylammonium bromide
DCE	cis-1,2-dichloroethylene
DEP	diesel exhaust particles
DINP	diisononyl phthalate
DNA	deoxyribonucleic acid
DPAA	diphenylarsenic acid
DS	sodium n-dodecylsulfate
EBCs	electric bicycles
ECD	micro-Electron Capture Detector
EMC	electric motorcycle
EPVs	electrically powered vehicles
EV	electric vehicle
FTSs	Fourier transform spectrometers
GC×GC	multidimensional gas chromatography
G-CIEMS	Grid-Catchment Integrated Environmental Modeling System
GERF	global environmental research foundation
GHCN	Global Historical Climatology Network
GHG	Greenhouse Gases
GIO	Greenhouse Gas Inventory Office
GIS	geographic information system
GLU	glucosidase
GOSAT	Greenhouse Gases Observing Satellite
GPCC	Global Precipitation Climatology Centre
GRID	Global Resource Information Database
HR-TOF-MS	high-resolution time-of-flight mass spectrometry
ILAS	Improved Limb Atmospheric Spectrometer
IP	inorganic phosphorus
iPS	induced pluripotent stem
IT	information technology
ITCZ	ntertropical Convergence Zone
KIE	kinetic isotope effect
LAS	sodium n-dodecylbenzenesulfonate
LCS	low-carbon society
MARCO	macrophage receptor with collagenous structure
MC-ICP-MS	multi-collector inductively coupled plasma mass spectrometry
MDD	methyl deficient diet
MeDIP-Seq	methylated DNA immunoprecipitation-sequencing
MIROC	Model for Interdisciplinary Research On Climate
MOE	Ministry of the Environment
MRI	magnetic resonance imaging

mRNA	messenger RNA
MS/MS	quadrapole-type tandem mass spectrometry
MSD	methyl sufficient diet
MWCNTs	multi-walled carbon nanotubes
NAF	northern part of Africa
NC/Nga mouse	a murine mouse model of atopic dermatitis
NEDO	New Energy and Industrial Technology Development Organization
NH	northern hemisphere
NMDA	N-methyl-d-aspartic acid
NOAA	National Oceanic and Atmospheric Administration
Ox	photochemical oxidant
PA	phosphatase
PAHs	polycyclic aromatic hydrocarbons
PCE	tetrachloroethylene
PCM	phase contrast microscopy
PCR	polymerase chain reaction
PGN	peptidoglycan
PLM	polarized light microscopy
PM10	fine particulate matter less than 10 μm in aerodynamic diameter
PM10-2.5	fine particulate matter larger than 2.5 μm and less than 10 μm in aerodynamic diameter
PM2.5	fine particulate matter less than 2.5 μm in aerodynamic diameter
POPs	persistent organic pollutants
Prx	peroxiredoxin
PS	polystyrene
QC	quality control
RCM20	Regional Climate Model 20
RNA	ribonucleic acid
SAM	S-adenosylmethionine
sBM	synthesis of a novel basement membrane substratum
SIMS	secondary ion mass spectrometry
SINET	the Science Information Network
SMS	sound material-cycle society
SPM	suspended particulate matter
SSV	synoptic scale variation
TC	total carbon
TCCON	Total Carbon Column Observing Network
TCE	trichloroethylene
TD	thermal desorption
Th2	T helper type 2
TSLP	thymic stromal lymphopoietin
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WGIA	Workshop on GHG Inventories in Asia
WTO	World Trade Organization
WWW	Worldwide Web
XRF	X-ray fluorescence analysis

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