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NIES Annual Report 2017

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National Institute for Environmental Studies
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Foreword

The Fiscal Year 2016 (FY 2016: April 2016 to March 2017) marks the beginning of the Fourth NIES Five-Year Plan (FY 2016 – FY 2020). We have seven research centers this year at Tsukuba Headquarters- centers for global environment; material cycles and waste management; health and environmental risk; regional environment; environmental biology and ecosystems; social and environmental systems; and environmental measurement and analysis. In addition, we established Fukushima Branch located in the Research Building of Fukushima Prefectural Centre for Environmental Creation, Miharu town, Fukushima Prefecture in April 2016. Another Branch Office was established and opened in April 2017, located in Lake Biwa Environmental Research Institute of Shiga Prefecture at the lakeside of the largest lake in Japan.

Major activities of these research units (centers, branch and branch office) are classified into several categories. While all units undertake basic research in their respective fields, five issue-oriented research programs - low-carbon; sustainable material cycles; harmonization with nature; health and environmental safety; and environment-economy-society integration have been carried out as joint activities of two or more units to tackle issue-driven environmental problems. In addition, three environmental emergency research programs are undertaken in the aftermath of the Great East Japan Earthquake in 2011- environmental recovery; environmental renovation; and environmental emergency management, which are mainly conducted in our Fukushima Branch.

Maintenance of medium to long-term initiatives in step with the sustainment and furtherance of environmental research is another important category of NIES' activities. This refers to observation and analyses of atmospheric carbon cycle using commercial aircraft or commercial ship, updating of the GHG inventory, and long-term storage and provision of environmental specimens. The final purpose of these activities is to develop research tools and facilities to be utilized by environmental research/non-research communities.

Activities related to NIES' research with more emphasis on practical or policy implementations have been organized under research project collaboration division. Activities in this division are the global-scale monitoring of GHGs by GOSAT and the establishment of a national birth cohort study by Japan Environment and Children's Study (JECS) which involves 100,000 parent-child pairs. Both research projects have been achieving firm progresses. Offices have been newly established under this division to facilitate communication within NIES as well as with outside organizations.

Increasing societal needs for the studies on environmental issues, such as climate change, its impact and future prediction, strategic planning of the countermeasures, and adaptation, require NIES to give feedback and implement its research outputs to society/policy makers. Establishing the branch and branch office in Fukushima and Lake Biwa as well as the collaborative offices is a part of NIES' responses to such societal needs. While promoting its research activities as the fundamental core of its responsibility, NIES is also expanding the activities, which emphasize interaction and communication with the society in general.

This report intends to convey our activities as explained above to the readers with more details. Your feedback, comments, and frank opinion regarding the current and future direction of our institute would be most appreciated.

Watanabe, Chiho
President
October, 2017

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During the 1950s and 1960s, Japan experienced serious environmental pollution problems accompanying rapid economic growth. The Environment Agency was established in 1971 as part of the Japanese government to develop measures to counteract serious problems associated with environmental pollution, such as Minamata disease, which was caused by poisoning from organic mercury in factory wastewater, and chronic bronchitis and asthma caused by sulfur oxides from factories in large industrial complexes. 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, in 1974. It is now Japan's primary institute for comprehensive research in environmental science.

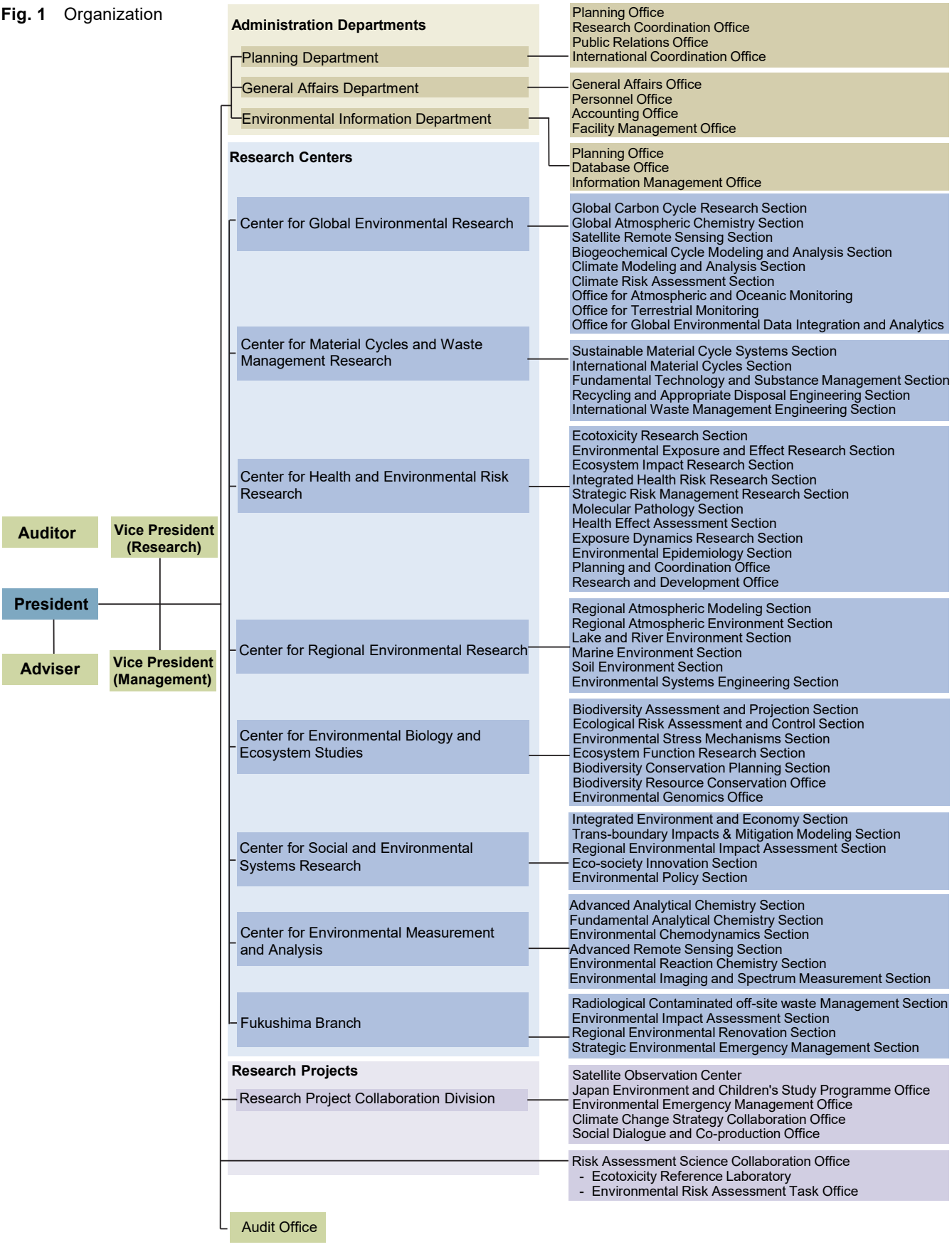
During the two decades following the establishment of NIES, rapid technological progress, structural changes in industry, and lifestyle changes, created additional issues for environmental science to confront. Moreover, global environmental problems such as climate change; depletion of the stratospheric ozone layer; acid deposition; destruction of tropical rain forests; desertification; and decreasing biodiversity, attracted greater concern worldwide. NIES subsequently underwent a major reorganization in 1990, including the establishment of the Center for Global Environmental Research, to enable it to conduct more intensive research on conservation of the natural environment and on global environmental changes and their effects.

January 2001 saw the transition of the Environment Agency into the Ministry of the Environment as part of structural changes within the Japanese government, and the establishment of a Waste Management Research Division at NIES. That year also marked the establishment of NIES as an Incorporated Administrative Agency, giving it a degree of independence from the national government. The change in the administrative status of the institute allows more prompt and flexible responses to societal demands. Concurrently, NIES prepared a five-year plan (2001–2005) in line with the objectives of the Ministry of the Environment.

Following the second five-year plan (2006-2010), the third five-year plan (2011–2015) was adopted in 2011. During the third five-year plan, research was carried out under eight fundamental fields of environmental research. Research activities to respond to and recover from the Great East Japan Earthquake have also been ongoing since the direct aftermath of the disaster. In March 2013, the five-year plan was revised following a directive of the Minister of the Environment and NIES relaunched as a National Research and Development Agency from April 2015.

April 2016 marks the beginning of the forth medium-and-long-term plan (2016-2020). NIES established five problem-solving research programs for this plan's term, and will pursue them in an integrated manner that transcends individual fields. NIES has also established a Fukushima Branch, where it is running a Disaster Environment Research Program. Additionally, to produce scientific findings on environmental protection,

Fig. 1 Organization



NIES will carry out research projects that include consolidating the institute's research foundation through basic research, data acquisition and analysis, preservation and provision of environmental samples, and other efforts.

As of April 1, 2017, there are 273 NIES permanent staff and 476 non-permanent researchers (Table 1; Figs. 2 to 5). The total budget for FY2016 was 15,476 million yen (Table 2).

Table 1 Numbers of permanent

Administration Departments	54
Research Centers	214
Executive	5
Total	273

(As of April 1, 2017)

Table 2 Budget for the third five-year plan

(Unit: million yen)

	Category	2016–2020 Budget (5 years)	Fiscal Year 2016 Budget
Revenue	Grants for Operating Costs	62,668	11,695
	Subsidies for Facilities	1,662	223
	Commissioned Work	17,786	3,557
	Total	82,116	15,476
Expenditure	Project Costs	44,609	8,041
	Facility Improvements	1,662	223
	Expenses for Commissioned Work	17,786	3,557
	Personnel Expenses	16,025	3,222
	General Administrative Expenses	2,034	432
	Total	82,116	15,476

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

Administration Departments	:	54	
Research Centers	:	214	(5)
Executives	:	5	
Total		273	(5)

Notes:
1. Data is as of April 1, 2017.

2. Figures in parentheses indicate number of non-Japanese.

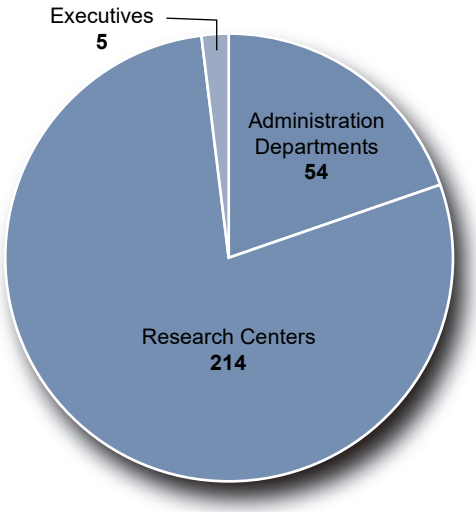


Fig. 2 Permanent staff breakdown

Basic Sciences (Physics, Chemistry, Biology)	:	83	40.89%
Engineering	:	67	33.00%
Agricultural Sciences	:	31	15.27%
Medical Sciences	:	10	4.93%
Pharmaceutical Sciences	:	4	1.97%
Fisheries Sciences	:	1	0.49%
Economics	:	2	0.99%
Sciences	:	3	1.48%
Law	:	1	0.49%
Veterinary Medicine	:	1	0.49%
Total		203	

Notes: Data is as of April 1,2017.

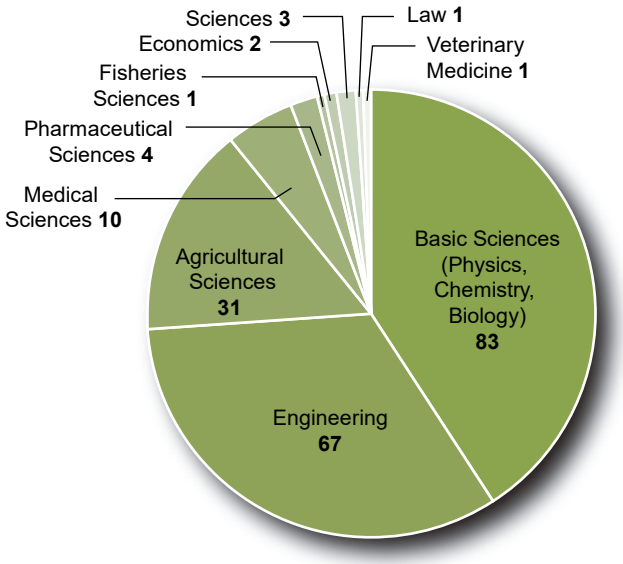


Fig. 3 Fields of expertise（Researchers holding doctorates（96.6%））

Senior Fellow	:	1	
Fellow	:	15	
Research Associate	:	79	(19)
Junior Research Associate	:	10	
Research Assistant	:	25	(10)
Specialist	:	178	(7)
Assistant Staff	:	254	
Senior Staff	:	6	
Senior Research Associate	:	4	
Total		572	(36)

Notes:
1. Data is as of April 1,2017.

2. Figures in parentheses indicate number of non-Japanese.

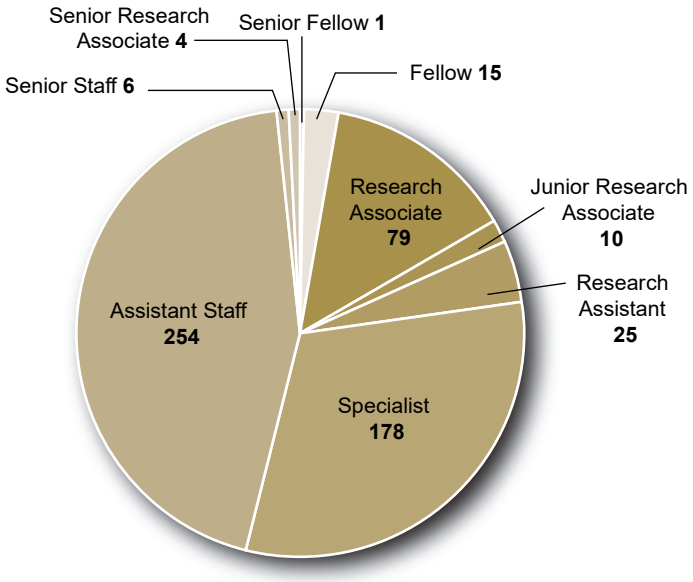


Fig. 4 Contract Staff Breakdown

Visiting Researchers	222	(7)
Research Students	55	(15)
Collaborative Researchers	65	(11)
Total	342	(33)

Notes:

1. Data is the total number accepted in FY2016.

2. Figures in parentheses indicate number of non-Japanese.

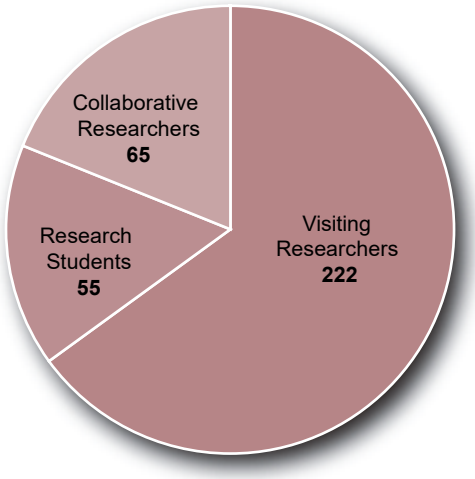


Fig. 5 Visiting and Collaborative Researchers and Research Students

Issue - Oriented Research Programs

Low-Carbon Research Program

The concept behind this program is to build a scientific foundation that society can use to tackle the goal of keeping the global mean surface temperature increase below 2 °C relative to pre-industrial levels. In the program we will conduct observations, mainly in the Asia-Pacific region, to assess the balances of the greenhouse gases (GHGs) that cause global warming, as well as climate change impacts and control measures. To accomplish this, we will use surface and aerial observations, and an observation satellite to be launched in 2017, to develop a highly reliable three-dimensional global-scale GHG monitoring system. Furthermore, we will combine climate change projection models, impact assessment models, and integrated socioeconomic assessment models and use them to discuss the need for, and feasibility of, building a sustainable, low-carbon society along the path indicated by this comprehensive research program.

The program consists of three research projects: (1) Study of a multi-scale system for observing and evaluating GHG variation and mitigation; (2) Global-scale climate risk research based on integrated assessment of climate projections, impacts, and response options; and (3) Policy assessment research toward a global low-carbon society (Fig. 1). Each project and its research highlights are described below.

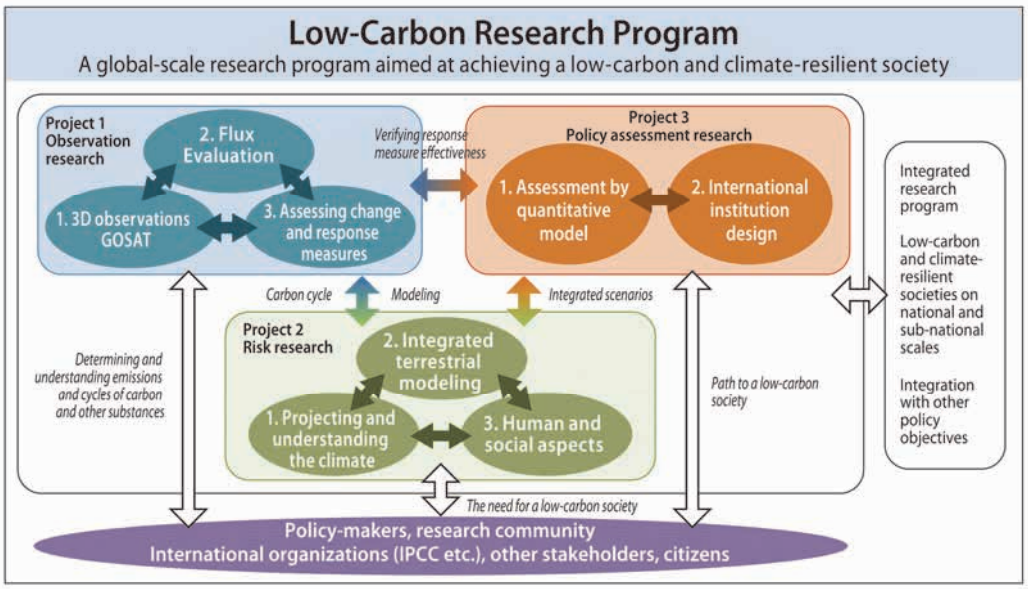


Fig. 1 Structure of the Low-Carbon Research Program. The three projects interact with each other and with society.

1. Study of a multi-scale evaluation system for observing and evaluating GHG variation and mitigation

This project aims to develop a multi-scale observation and analysis system for

estimating spatial and temporal variations in the atmospheric concentrations of GHGs and their surface fluxes, including fluxes in GHGs from, and to anthropogenic and natural sources and sinks. The system is essential for analyzing a variety of climate change mitigation and adaptation policies and evaluating their effectiveness. The project comprises three sub-projects: (1) Evaluation of GHG budgets at different spatial scales, from global to local; (2) Estimation of oceanic and terrestrial GHG budgets and their upscaling; and (3) Assessment of climate change impacts and climate change mitigation policies.

In FY 2016, we expanded the number of our ground stations in Southeast Asia—especially in Indonesia, where the data coverage had been quite limited. This was done to improve the accuracy of regional GHG budget estimations. We also effectively updated the estimation of ocean surface carbon dioxide partial pressure (pCO_2) distributions by using global pCO_2 datasets (Surface Ocean CO_2 Atlas: SOCAT), to which NIES makes essential contributions in the Pacific Ocean. First, we successfully reproduced monthly pCO_2 distributions from 2001 to 2013 and investigated temporal changes due to the El Niño Southern Oscillation (ENSO). Figure 2 shows mean pCO_2 distributions from October to December in the El Niño period in 2009 and in the La Niña period in 2010. As seen in the figure, the ENSO affected the eastward transport of water mass with a high pCO_2 (over 400 µatm) in the equatorial region by changing the strength of the trade wind. We then estimated the mean anthropogenic trend in increase in pCO_2 due to oceanic CO_2 uptake in the Pacific Ocean to be about 1.6 µatm year^{-1} and the apparent spatiotemporal mean pCO_2 trend, which is a combination of the anthropogenic and biogeophysical trends, to be about 1.8 µatm year^{-1}; much of the difference of 0.1 to 0.2 µatm year^{-1} between the apparent trend and the anthropogenic trend was caused by biogeophysical changes. The results clearly suggested that climate change effects such as global warming would affect future oceanic CO_2 uptake.

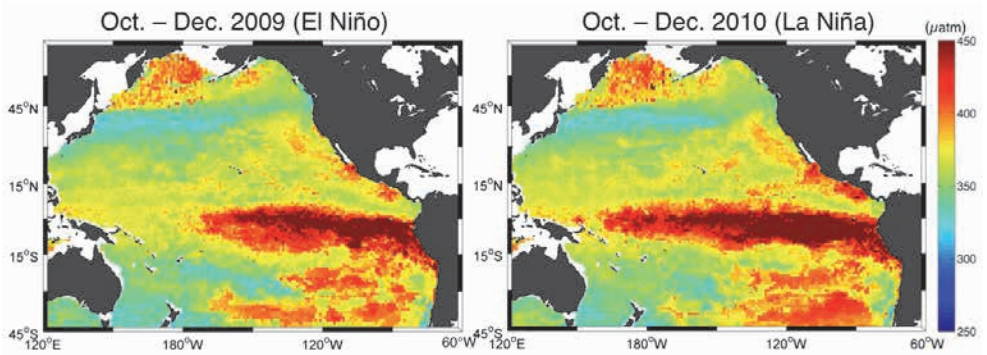


Fig. 2 Mean pCO_2 distributions from October to December in the Pacific Ocean in 2009 (El Niño period) and 2010 (La Niña period)

2. Global-scale climate risk research based on integrated assessment of climate projections, impacts, and response options

In this project, we are developing a comprehensive modeling approach in which

models for climate projections, impact assessments, and assessments of response options at a global scale are used in an integrative manner. With this approach, we aim to describe synthetic scenarios of climate change risk. This project consists of three sub-themes: (1) Projection and interpretation of climate change; (2) Synthetic assessment of low-carbon scenarios based on an integrated terrestrial model; and (3) Assessment of climate impacts, adaptation, and mitigation from the human and social perspectives.

In sub-theme 1, we are helping to develop a climate model MIROC (Model for Interdisciplinary Research on Climate) and contributing to Phase 6 of the Coupled Model Intercomparison Project (CMIP6). We are also using climate simulations to analyze uncertainties in future climate change projections and to interpret past climate change. One of the results focused on extreme events. We compared historical and non-warming (counterfactual) climate simulations with the observed data to investigate the human influence on historical changes in the numbers of record-breaking hot-day events (Fig. 3). The results suggested that human activity has already had statistically significant impacts on the number of record-breaking hot days worldwide.

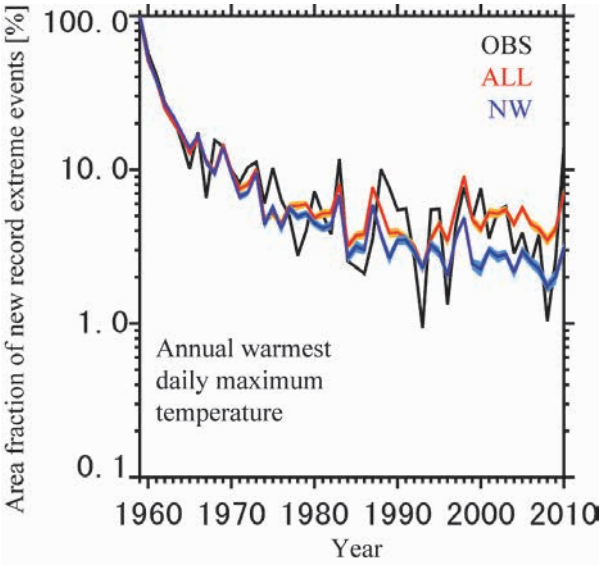


Fig. 3 Temporal evolution of the fraction of the global area where record-breaking hot-day events have occurred. Shown are observational data (OBS, black), historical (ALL, red), and non-warming simulations (NW, blue) (%). By definition, all the grids had new records at the first year of the analysis period. The frequencies of record-setting events are expected to decrease as observations accumulate over time. The global warming made the decline rate slower.

In sub-theme 2, we have developed an integrated terrestrial model that includes land use, water resources, ecosystems, and agriculture. The water resource and ecosystem models are also used to analyze the impacts of climate change, land use, and other human influences through our participation in the Inter-Sectoral Impact Model Intercomparison Project (ISI-MIP). In sub-theme 3, we have used the results from sub-theme 2 and our collaboration with experts from other institutes and universities to complete a synthetic assessment of global and long-term climate risks. We have comprehensively assessed the risk implications of setting a 1.5-, 2.0-, or 2.5-°C temperature goal. We use process-based impact

models for multiple sectors to make future projections of impacts, whereas we use multiple integrated assessment models to assess the portfolios of mitigation options and the economic impacts associated with achieving the emission pathway for each goal. Our results suggest that, given the uncertainties of climate sensitivity, "net zero GHG emissions in the second half of this century" is a more actionable goal for society than the 2- or 1.5-°C temperature goals themselves. If climate sensitivity is relatively high, then the temperature goals won't be met, even when the net zero emission goal is achieved. If this is proven to be the case, then the options left are: a) accepting or adapting to a warmer world; b) boosting mitigation; or c) climate geo-engineering, and any combination of these. In this case, decisions should be made based on deeper discussions of the risks associated with each option in society, using the latest knowledge of the scientific and moral aspects of those risks.

3. Policy assessment research toward a global low-carbon society

The aim of project 3 is to provide scientific knowledge from the perspectives of modeling and analysis, scenario development, and negotiation processes, in order to achieve a global low-carbon society. National- and local-scale analyses toward a low-carbon society are implemented as an integrated research program. Project 3 of the Low-Carbon Research Program consists of two sub-themes: (1) Assessment by using quantitative models; and (2) International institution design. The following are the main results obtained in FY 2016 in each sub-theme.

In sub-theme 1, we have been developing a global enduse model for the Asia-Pacific Integrated Model, named AIM/Enduse [Global]. A new module for assessing air pollution measures has been introduced in AIM/Enduse [Global], and both GHG and air pollutant emissions are quantified under the various climate targets (Fig. 4). In addition, a simple mitigation action tool based on these results has been developed for use in discussing the appropriate actions with policy-makers on GHGs and air-pollutant emission pathways.

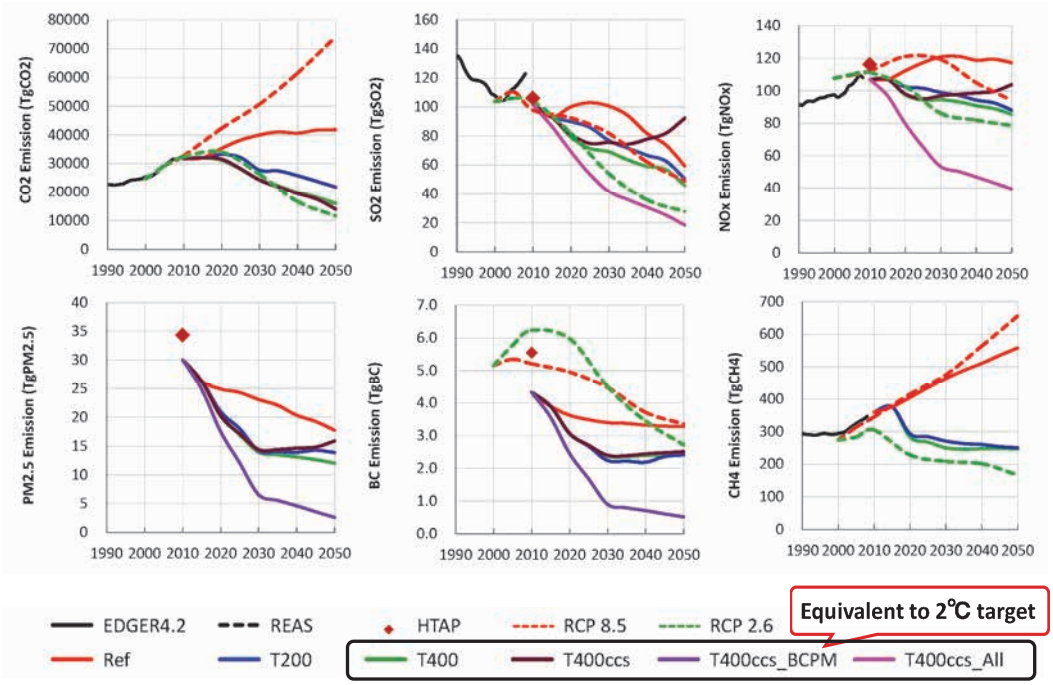


Fig. 4 Global emission pathways of CO2, short-lived climate pollutants, and other air pollutants under the various targets of AIM/Enduse [Global].

In sub-theme 1, we also contributed to research collaboration between Japan and France through participation in the Low-Carbon Society Research Network (LCS-RNet). Many European countries, including France, have used stakeholder dialogues to help develop their own GHG mitigation targets. Through collaborative research, we have started assessing methods of developing new scenarios that reflect stakeholders' opinions.

As part of sub-theme 2, titled International institution design, this fiscal year we conducted a comparative study of the political processes used to set mid-century, long-term low GHG emission development strategies in each country. Countries are to develop mid-century low emission strategies and communicate them to the UNFCCC secretariat by 2020. Currently, some European countries, including France, Germany, and the United Kingdom, have set ambitious GHG emission targets or energy consumption targets, or both, for 2050, but Japan has only begun discussing its mid-term target. We conducted a literature review and interview surveys in these countries to examine the political and economic factors that enabled them to set these targets. The following factors proved effective in setting long-term targets: (1) two types of committee—one for scientific experts and another for various stakeholders— had been set up and were independent of each other; (2) several models were used to compare emission mitigation costs under different assumptions; (3) the poor received co-benefits through policies such as improvement of housing insulation; and (4) business communities had considered investment in low-carbon technologies as new opportunities rather than simply as expenses.

Sustainable Material Cycles Research Program

To help realize the future vision for an international material cycle strategy, this program will clarify supply chain structures and the factors that shape those supply chains. Measures toward a sustainable material-cycle-based society will be proposed on the basis of an assessment of resource and environmental conservation and future social change.

The program will develop and evaluate measures for the advancement of sustainable, integrated waste management systems in Japan and the broader Asian region. It will also be used to propose the fundamental technologies and social systems needed for waste prevention or minimization, reuse, and recycling in harmony with a low-carbon footprint society and other initiatives.

1. Designing a sustainability strategy for global resource networks from the consumption-based perspective (Research Project 1)

In today's globalized economy, each country has indirect flows supporting its economic activities, and natural resource consumption through supply chains influences environmental impacts far removed from the place of consumption. One way to control environmental impacts associated with the consumption of natural resources is to identify the consumption of natural resources and the associated environmental impacts through the global supply chain. In this study, we used a global link input–output model (GLIO, a hybrid multiregional input–output model) to detect the linkages between national nickel consumption and mining-associated global land-use changes. We focused on nickel, the global demand for which has risen rapidly in recent years, as a case study.

The estimated area of land-use change around the world caused by nickel mining in 2005 was 1.9 km^2, and that induced by Japanese final demand for nickel was 0.38 km^2 (Fig. 1). Our modeling also revealed that the areas of greatest land-use change associated with nickel mining were concentrated in only a few countries and regions far removed from the places of consumption. For example, 57.7% of the world's land-use changes caused by nickel mining were concentrated in five countries in 2005: Australia, 13.7%; Russia, 12.9%; Indonesia, 12.5%; New Caledonia, 10.4%; and Colombia, 8.2%. The mining-associated land-use change induced by Japanese final demand accounted for 19.5% of the total area affected by land-use change caused by nickel mining. The top three countries affected by mining land-use change induced by Japanese final demand accounted for 70.6% (Indonesia: 47.0%; New Caledonia: 16.0%; and Australia: 7.7%), and the top five accounted for 82.4% (Philippines: 7.5%; and Canada: 4.3%, in addition to the top three countries and regions).

Fig. 1 Distribution of the 25 countries and regions with the largest areas of land-use change associated with nickel mining in 2005. a) Land-use change caused by nickel mining around the world. b) Land-use change caused by nickel mining induced by Japanese final demand.

Reference: Nakajima K., Nansai K., Matsubae K., Tomita M., Takayanagi W., Nagasaka T. (2017) Global land-use change hidden behind nickel consumption. *Science of the Total Environment*, 586, 730–737.

2. Assessment of resource efficiency and environmental impact in the cycles of recyclable materials and accompanying substances (Research Project 2)

To gain an understanding of the flows of chemicals in waste treatment streams, we analyzed the chemical transfer data reported by the Japanese Pollutant Release and Transfer Register (PRTR) system. The results showed that, in general, a large part of the PRTR-targeted inorganic chemicals was transferred to incineration and melting processes, crushing and compressing processes, and landfills, whereas most of the PRTR-targeted organic chemicals were transferred to incineration and melting processes. The results also showed that the main wastes that contained PRTR-targeted chemicals were waste acid or sludge (in the case of inorganic chemicals) and waste oil (in the case of organic chemicals in general).

At an e-waste-processing site in a village in northern Vietnam, we started assessing exposure to hazardous substances derived from e-waste. As a first step in the exposure assessment, the concentrations of hazardous substances such as heavy metals, brominated and phosphorus-containing flame retardants, and dioxin-like compounds were measured in indoor dust and surface soils collected in or around the e-waste-processing workshop and open-burning area. We then developed an in vitro assay to assess, with high reproducibility, the gastric and intestinal bioaccessibility of ingested hazardous substances in indoor dust and surface soils (Fig. 2).

We used a population balance model to estimate the generation of e-waste and ELV (End-of-Life Vehicles) in Asian countries for the period through 2030. We found that China was a dominant contributor in the case of many items. Appropriate collection of refrigerant fluorocarbons from air-conditioners was important in reducing GHG emissions.

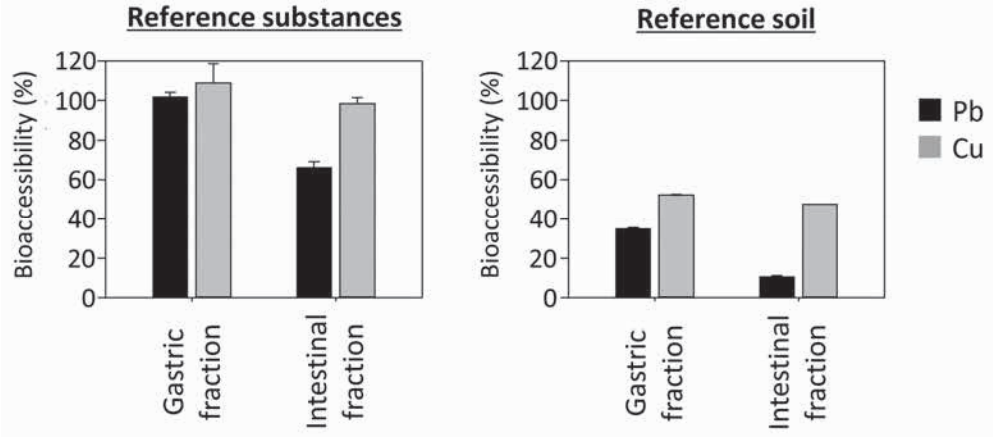


Fig. 2 Bioaccessibility of Pb and Cu from a reference substances solution (XSTC-331) and a reference soil (NIST SRM 2710a Montana Soil) in gastric and intestinal fractions. Experiments were performed independently at least three times.

3. Proposal of transition paths and adaptation measures for a circular society (Research Project 3)

This project aims to propose measures for establishing a circular society that will adapt to a variety of social changes today and in the future; the proposed measures will also enable Japan to integrate resource and waste management with other environmental policies and public policies to advance the quality of resource circulation. To meet these objectives, we conduct case studies, develop material flow models, and analyze current material use and waste treatment under scenarios such as population decline, aging of society, changes occurring in local communities, and self-supply of energy.

In the first year of the project, by employing a brainstorming method, we first discussed and extracted social changes from the present to 2030 and possible consequences in the field of waste management. Changes extracted included the weakening of local communities, financial difficulties within municipalities, changes in work and households, and the need for increased care of the elderly. Future demand for waste management would be diversified, and the government would have to distinguish a minimum level of public services in a circular society and those not.

Second, we analyzed the effectiveness of integrating MSW (municipal solid waste) incinerators, as integration could reduce the financial burdens on municipalities facing population decline. The systems analyzed were three cases of integration in which a municipality integrated its incinerator with one of three neighboring municipalities. Waste management costs were reduced in all three cases and CO_2 emission was reduced in two cases. Thus the integration of MSW incinerators is one possible direction for waste management in Japan.

Third, we conducted seven case studies to clarify the support currently provided to elderly Japanese in discarding their waste. The studies revealed points that need to be taken into account when municipalities introduce this type of support.

Fourth, we investigated the sale of used clothes and use of the profits for social purposes. Our study showed that social values were created by these activities, increasing the motivation of staff and volunteers in the reuse group.

Last, we conducted a questionnaire survey to determine consumer expectations of product lifespan. Products surveyed were vacuum cleaners and mobile phones. We identified several different definitions of expected lifespan; all of the lifespans tended to be shorter than those considered ideal by consumers.

4. Advancement of sustainable and integrated waste management system in Asia (Research Project 4)

To establish a robust, sustainable, and integrated waste management system for Asia, including Japan, we are studying the development and adaptation of several technologies, such as mechanical-biological treatment, constructed wetlands for landfill leachate, landfills with reduced long-term pollution flux, energy saving/generating of decentralized wastewater treatment, and *Johkasou* systems (small-scale wastewater treatment tanks), to suit Asia-specific situations. We are also developing and applying several tools for evaluating waste management in Asia. Below are some of the results we obtained in FY 2016.

We assessed the appropriate management of wastes containing elemental mercury from the perspective of long-term environmental safety. Stabilized and solidified mercury waste had certain features that enabled the mercury to be contained. Control of mercury emissions (at both the highest and average levels) must be achieved by using a combination of sulfur polymer stabilization/solidification (SPSS) and monofill disposal, penetration reduction, or adsorption to delay migration. A bacterial gene involved in mercury alkylation, which yields even more environmentally toxic forms, was detected under landfill conditions, indicating the need for risk management to achieve environmentally sound disposal of mercury waste.

We organized stakeholder meetings on the use of decentralized wastewater treatment facilities in Indonesia so that all stakeholders could reach agreement on our draft method for performance-testing these decentralized facilities. Many pieces of useful advice were given and important issues were raised, regarding not only the draft testing method but also wastewater management, and a basic agreement on the draft was reached among stakeholders. We also investigated the effects of the high wastewater temperatures in Indonesia on pollutant removal rates and sludge production rates in *Johkasou*. We revealed that high BOD (biochemical oxygen demand) reduction rates and low sludge production rates

must be achieved in Indonesia.

5. Development of next-generation technologies for "3R" (Research Project 5)

We newly constructed a small-scale system combining anaerobic digestion and post-treatment for the on-site simultaneous treatment of organic waste and wastewater. Through continuous experimentation in a laboratory-scale system and fluid modeling, we improved the reactor configurations in stages to reduce microbial inhibition by any oils and fats present. At organic loading rates in the appropriate ranges (3 to 5 kg-COD/m^3/day [COD, chemical oxygen demand] for thermophilic anaerobic digestion and 0.1 to 0.5 kg-BOD/m^3/day for post-treatment), the system performed well and the BOD, suspended solids concentration, n-hexane extract levels, and T-NP levels in the effluent met the discharge standard for sewage.

We investigated the behavior of organic pollutants in a normal biogas plant by using Level I and III multimedia fugacity models. First, a phase distribution map of the pollutants in a biogas fermenter was made on the basis of a Level I model and the pollutants' physicochemical properties. Next, we built a prototype Level III model to calculate the emissions of the pollutants from all processes in the biogas plant.

With the eventual aim of demonstrating our proposed dual-biofuel production system (DBPS), we finished designing the main fuel-production equipment and then, with the collaboration of private companies, proposed some demonstration systems.

We investigated the behaviors of useful and harmful metals in municipal solid waste thermal treatment facilities. For example, fluid sand, boiler ash, gas cooling-tower ash, and air-pollution control residue were sampled in a fluidized-bed-type incineration facility and an elemental composition analysis of the samples was then performed. The major components of fluid sand and other types of ash proved not to differ largely, except in the case of volatile elements. We also collected ash samples from each temperature zone of a boiler tower at an incineration facility and analyzed their elemental composition. We used the results of the analysis to derive an advanced method of recovering resources from the boiler ash.

As part of an investigation into appropriate techniques for treating nanomaterial-containing waste, we investigated current best practice in the production, use, and disposal of nanomaterials in order to select nanomaterials for evaluation of their safe treatment. We also started examining analytical methods for determining the number fractions and weight fractions of these nanomaterials in waste samples containing different matrices, as determined by electron microscopy.

Harmonization with Nature Research Program

This program will shed light on the mechanisms by which the four major factors behind the biodiversity crisis (overexploitation/development, cropland abandonment, invasive alien species/pollution, and climate change) affect biodiversity. It will also assess and project the impacts of these factors and develop biodiversity conservation measures and adaptation strategies. Additionally, the program will assess the ecosystem functions and services generated by biodiversity and will propose strategies, such as watershed management in harmony with nature, for sustainably benefiting from ecosystems (Fig. 1).

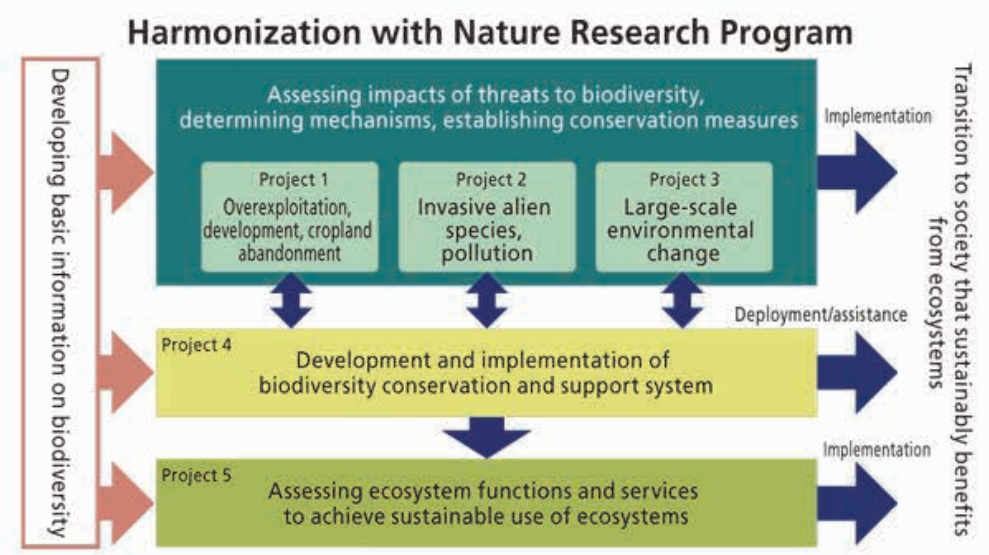


Fig. 1 Research framework of the Harmonization with Nature Program

1. Biodiversity assessment of impacts of large-scale human activities

1.1 Global effects of natural resource exploitation on biodiversity

To quantify the global effects of various types of natural resource exploitation on biodiversity, we surveyed available spatial and temporal datasets on land-use change, resource exploitation, and the distribution of biodiversity. We then conducted geospatial analyses using the collected datasets and overlaid maps of human impacts (e.g., maps of land-use change) on biodiversity (e.g., the distribution of species listed on the IUCN red list: Fig. 2). Our next goal is to develop indicators that summarize the global effects of various types of resource exploitation, such as logging and mining, on biodiversity.

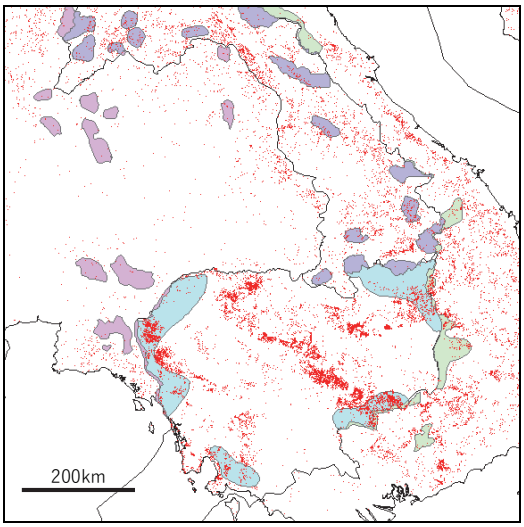


Fig. 2 Example of a map showing endangered species (colored areas) overlaid by deforested areas (red cells) on the Indochina Peninsula.

1.2 Effects of land-use abandonment on biodiversity

We started a national-scale survey of butterflies in abandoned settlements to determine the effects of long-term land abandonment on community composition. As study sites, we chose 34 abandoned settlements and 30 inhabited settlements on Japan's four main islands (Hokkaido, Honshu, Shikoku, and Kyushu) and conducted repeated presence–absence surveys in each settlement. In each survey, a researcher recorded a list of the species found in a 5-min interval. The survey was performed 10 to 16 times in each settlement. We obtained a dataset of 52 species. We intend to conduct a statistical analysis to estimate species-specific susceptibility to land abandonment and its relevance to habitat-use characteristics.

2. Development of intensively control methods for invasive alien species management

Since the Alien Species Act was enacted, the Ministry of the Environment's top priority has been to control, and ultimately eradicate, the invasive alien species established in Japan, while also preventing new alien species introduction. Here, we report on several newly developed methods for the quick detection of invasive alien species introductions and for the eradication of naturalized populations.

We developed a molecular technique to identify the presence of target exotic species by using DNA barcoding and LAMP (loop-mediated isothermal amplification) methods. The areas surrounding bonded warehouses are relevant to exotic species monitoring; plant quarantine data suggest that agricultural products are potential invasion pathways for the Argentine ant and other species.

We successfully controlled the Argentine ant population around Tokyo Bay and then in other parts of the Kanto area by using chemical baits. To establish criteria for ending chemical control, we developed a stochastic model to confirm the eradication of Argentine ant populations on the basis of monitoring data. We also

assessed the ecological impacts of chemical control on non-target species.

In addition, we developed a method for controlling European bumblebee and larval Asian black hornet populations: workers carry pesticides that inhibit larval growth back to the insects' nests. For chemical control, we selected an insect growth regulator insecticide that inhibits larval molting by inhibiting the activity of chitin synthase. We confirmed this method's effectiveness in field tests (Fig. 3).

A control manual for each of these alien insects has been written and distributed to the public.

Fig. 3 Workers of the Asian hornet *Vespa velutina nigrithorax* feed on (a) liquid and (b) solid baits. The graph shows the numbers of adult individuals (workers, new queens, and males) found in treated and control nests.

3. Ecological responses to large scale environmental changes

This project aims to clarify ecosystem responses to human-induced global environmental changes such as climate change and atmospheric pollution. Among the various ecosystems, we are focusing especially on tropical coastal ecosystems and alpine ecosystems from the perspectives of the biodiversity crisis and vulnerability to climate change.

In our study of tropical coastal ecosystems, we are collecting and compiling large datasets on global biotic communities (mangrove plants and coral and macroalgal species) and the ecosystem functions contributing to climate change mitigation (carbon storage) and adaptation (coastal protection). These datasets have enabled us to explore patterns of biotic communities and ecosystem functions in relation to broad-scale variables such as geography, temperature, and other climatic factors. As an example, Figure 4 shows the predicted past, present, and future distribution probabilities of temperate and southern kelps under a climate change scenario (atmosphere-ocean coupled general circulation model MIROC4h). We found different patterns of distribution change between the different species.

In our study of alpine ecosystems, we have been monitoring altitudinal changes since 2006 in plant phenology and major ecosystem functions, including CO_2 and H_2O fluxes, in relation to microclimates along a mountain slope from 4300 to 5200 m at Dangxiong on the Qinghai-Tibetan Plateau. So far, we have found that

plant phenological changes show large variations among different species and altitudes. Furthermore, we are compiling a dataset on the phenotypic traits, including morphological features of the flower, fruit, leaf, stem, and root, of plants all over the plateau. We found that flower features were closely linked to altitude. These results have given us new insights into the effects of our projected climate warming on future variations in the alpine ecosystem.

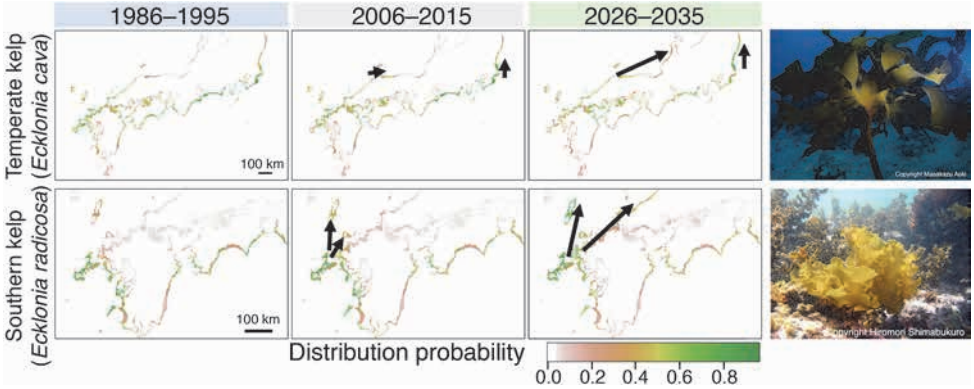


Fig. 4 Predicted distributions of temperate and southern kelp species in past, present, and future climates, based on a climate model (MIROC4h). Arrows represent shifts on the range edge (Kumagai et al. in preparation).

4. Integrated evaluation of biodiversity and development of tools for conservation planning

In this research project, we are developing indexes for the evaluation of multiple aspects of biodiversity and ecosystem services. We are also developing systems for the efficient allocation design of conservation efforts. Achieving biodiversity conservation and sustainable use of ecosystem services is not a simple task. We need to estimate the effects of multiple threats on biodiversity and the cost of different conservation efforts. Furthermore, on the basis of an integrated evaluation of the costs and risks, we need to prioritize threats and areas that must be dealt with.

In our preceding research program on biodiversity conservation, we developed a system to support the prioritization of protected areas while minimizing the risks of extinction of multiple threatened species. The system is based on quantitative data on the changes in local population size of individual species, and such data are not easy to obtain. In our present project, we are developing another prioritization support system for wider use. The concept of this prioritization is shown in Figure 5. The system is applicable when local units of multiple biodiversity components—such as local populations of multiple species—are roughly classified in their priority for conservation. The categories can be of any number. Higher priority may assigned to more threatened local populations that require more protection, or to stable local populations that are more likely to persist in the future and are worth protecting to reduce the risk of global extinction. We expect that the system will aid conservation prioritization in a variety of situations.

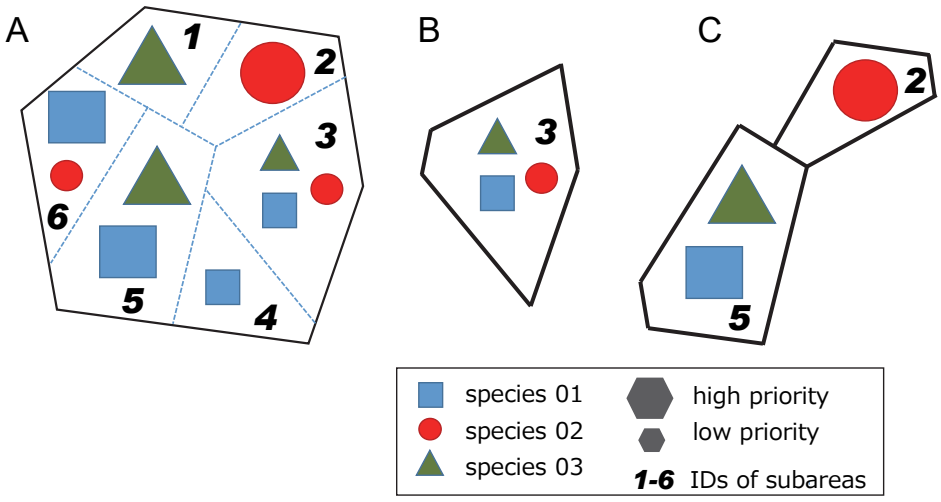


Fig. 5 The concept of protected area prioritization, based on priorities of local units of multiple biodiversity components.
A: Six subareas contain local units of biodiversity components. Different shapes indicate different types. Size differences represent the conservation priority of each local unit.
B: Subarea 3 alone includes all types, but the local units included are of low conservation priority.
C: Subareas 2 and 5 together include high-priority local units of all three types.

5. Evaluation of ecosystem functions and services and their sustainable use

This research project evaluates ecosystem functions and services, taking into account land–sea connections at the watershed or island sale. The results will contribute to the better management of watersheds or islands on the basis of biodiversity conservation so that we will all be able to enjoy sustainable benefits from nature.

5.1 Interactions among multiple ecosystem services in the Lake Kasumigaura watershed

In this project, we aim to identify the spatial and temporal synergies and tradeoffs among multiple ecosystem services in watersheds containing lakes. We focused on the watershed of Lake Kasumigaura, the second largest lake in Japan, which includes a variety of landscapes, including croplands, forests, paddy fields, urban areas, and rivers. We divided the watershed into 50 sub-watersheds and mapped and tried to quantify ecosystem services such as crops, livestock, surface water quality, flood regulation, and carbon sequestration and storage. Our preliminary analysis showed that there were some tradeoffs among the ecosystem services. For example, there was a significant negative correlation between the proportion of cropland area and the NO_3- concentration, suggesting that there was a tradeoff between agricultural production (provisioning service) and surface water quality (regulating service). In this project, we are also seeking to understand the relationship between ecosystem services and biodiversity. We are surveying the distribution of freshwater fishes by using an eDNA (environmental DNA) method, which is an emerging, high-throughput, potentially cheaper, vastly more sensitive, and less invasive method of successfully detecting the presence of aquatic species. We will then examine the relationships between fish diversity and ecosystem services.

5. 2 Sustainability of ecosystems on the Ogasawara Islands

The major industry on the Ogasawara Islands is tourism, which depends on the unique ecosystem of this registered world natural heritage site. To sustain Ogasawara's society in harmony with nature, the islands' unique ecosystem must be sustainable. Although the local ecosystem is legally designated a protected area, it suffers continually from a variety of changing pressures, such as climate change and alien species (both existing and new). In this project, we are using a field survey to gain an understanding of the current status of the ecosystem. Valuable samples obtained from the field survey are preserved in the Time Capsule at NIES. We are also trying to develop new technologies for future ecosystem monitoring using eDNA analysis. In addition, we are conducting computer simulations on the behavior of the Ogasawara ecosystem and a sociological analysis of tourism demand. By integrating these results, we intend to propose an ecosystem management method that will sustain Ogasawara society in harmony with nature.

5. 3 Ecosystem functions, services, and connectivity in basin ecosystems between rivers and sea

In this research, we aim to propose a management approach for conserving biodiversity and the sustainable use of ecosystem services in anthropogenically modified current basin ecosystems. In the first year, we investigated the effects of floodgate construction in the downstream part of the Ohta River where it discharges into the Seto Inland Sea on biodiversity and ecosystem services. We also examined the mechanisms of these effects.

In the main stream of the Ohta River, flow mass is decreased by closure of the floodgate under normal conditions, resulting in the formation of healthy sandy tidal flats with high potential for the reproduction of Japanese littleneck clams in the estuary. In contrast, the floodgates on the tributaries flowing into the center of the city of Hiroshima are fully open under normal conditions. In the tributaries, rough sandy tidal flats with a highly active Japanese basket clam fishery have formed just below the gates. Muddy tidal flats have also formed in the middle and fine sandy tidal flats at the river's mouth. Our findings suggested that these distributions are influenced by retention, sedimentation and circulation, which are biogeochemical features in estuaries.
Although floodgate control is aimed at disaster prevention, our results indicate that anthropogenic modification to obtain these ecosystem services can supply different ecosystem services, such as current biodiversity conservation and marine fisheries and leisure activities.

Health and Environmental Safety Research Program

To ensure the establishment of the Safe and Secure Society described in the 4th Environment Plan of the Ministry of the Environment, we need to address current environmental concerns about chemical contamination and ensure that major environmental pollution events, such as the outbreak of Minamata disease in Japan, do not happen again. This is the basis for the establishment of all other sustainable goals of Low-carbon, Sound material-cycle, and Natural-symbiosis fields. The aim of this research program is to provide scientific support through new findings on hazards, analytical technologies, fate processes and models, and abatement technologies, as well as advanced risk assessment methodologies and management frameworks for environmental chemicals. To achieve this aim, the program is using a multi-faceted, systematic approach to gain new insights into health and environmental hazards and develop methods both for assessing the health and environmental risks posed by environmental chemicals and abatement technologies for those risks. The program is examining the effects of chemicals on higher-order biological functions and multi- or transgenerational impacts. It is developing new systems for assessing the ecological impacts of chemical bioaccumulation and advanced high-throughput chemical analyses to give us a more comprehensive understanding of the dynamics of environmental chemicals. In addition, the program is examining the atmospheric processes and adverse health effects associated with exposure to PM2.5 and other air pollutants, and it is developing advanced methods for conserving regional aquatic environments (Fig. 1).

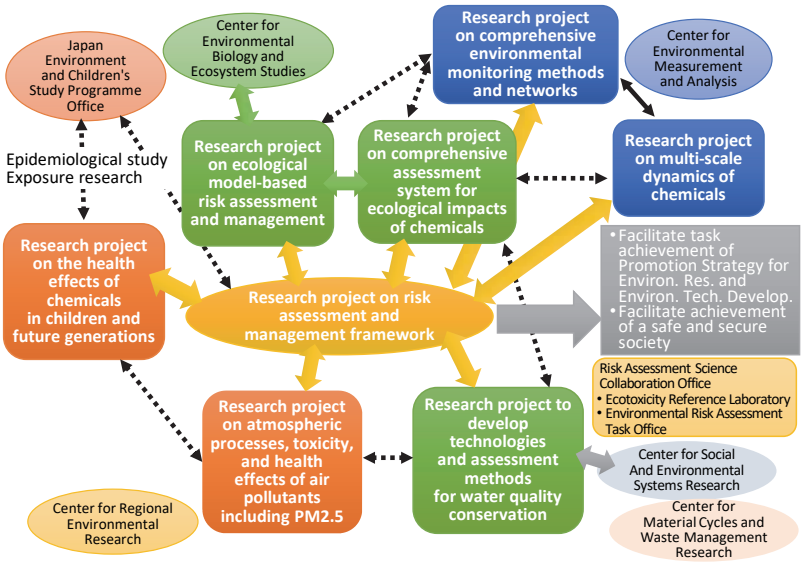


Fig. 1
The Health and Environmental Safety Research Program consists of eight research projects. Each project works to elaborate its scientific achievements; the projects' outcomes are integrated to establish a general scientific basis for the safe and secure society.

1. Research project on the health effects of chemicals in children and future generations (Project 1)

To evaluate the health effects of exposure to chemicals in children and future generations, we have been using animal models and cultured cells to examine the

effects of chemicals on the development of immune and metabolic diseases, developmental neurotoxicity, and multi- or transgenerational epigenetic inheritance. Our main research outcomes in FY 2016 were as follows.

We have started investigating the effects of oral exposure to bisphenol A (BPA) at low doses relevant to human exposure in a mouse model of allergic asthma. First, we improved the breeding environment to minimize background BPA exposure because BPA was detected in the general environment of our breeding animals. Then, mice were exposed to BPA in the diet and sensitized by an allergen during the juvenile period of development. We observed that dietary administration of BPA aggravated allergen-induced lung inflammation, allergen-specific immunoglobulin production, and activation of immune cells in the mediastinal lymph nodes.

Through the detection of emotional, mnemonic, and hyperactivity disorders in animal models developmentally exposed to chemicals such as pesticides and flame retardants, we established methods for evaluating developmental neurotoxicity. In parallel, we established fundamental techniques for analyzing the blood–brain barrier and the transfer of chemicals into the brain. We also promoted alternatives to the use of experimental animals in testing for developmental neurotoxicity by using avian embryos and mammalian embryonic stem (ES)/induced pluripotent stem (iPS) cells (Fig. 2).

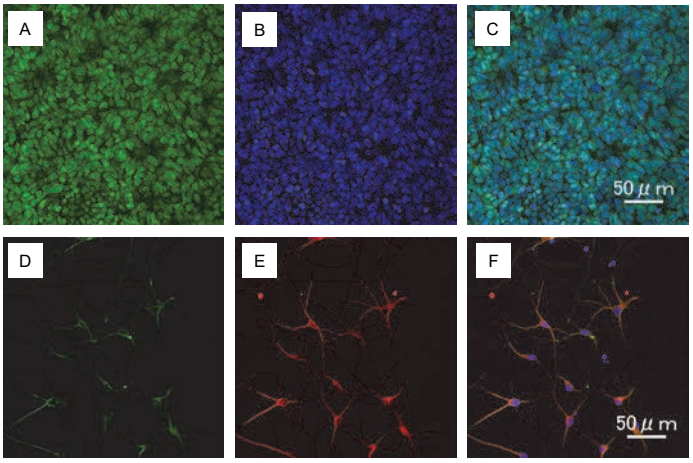


Fig. 2 Induction of neural progenitor cells from human iPS cells. Human iPS cells were differentiated into neural progenitor cells (NPCs) by using a monolayer culture protocol and then visualized by immunofluorescence staining with PAX6 (A, green) and DAPI (B, blue). These cells showed a typical morphological characteristic of NPCs (rosette formation), and almost all of them expressed PAX6, a representative marker of NPC (C). NPCs were further differentiated into neuronal cells, which expressed immature and mature neuronal markers (TUBB3 [D, green] and MAP2 [E, red], respectively). Almost all cells were double positive for these two neuronal markers (F).

Recently, we found that exposure of C3H mice to arsenite during gestation increased hepatic tumor incidence, not only in the F1 generation but also in F2 male offspring. To identify the factors involved in the arsenic-induced increase in hepatic tumorigenesis in both the F1 and the F2, we conducted a DNA microarray analysis of isolated hepatocytes and detected several genes with altered expression in common in both the F1 and the F2. We focused on sperm-borne small RNA as one of the carriers enabling the paternal transmission of multigenerational epigenetic effects, and we established conditions for the preparation of RNA from pure sperm cells collected from the cauda epididymis of

mice. We are now building an *in vitro* system to detect the effects of changes in sperm-borne small RNA on the development of embryos.

2. Research project on comprehensive environmental monitoring methods and networks (Project 2)

The purpose of this project is to develop advanced comprehensive analytical methods and networks to monitor environmental chemicals that affect human health and the environment. This year—the first year of the Project—we conducted the following studies.

We developed a simultaneous analytical method for 143 chemicals positive for human estrogen receptor (ER)-binding activity. For 123 of these compounds, we determined the multiple reaction monitoring conditions in an LC/QTofMS (liquid chromatography/quadrupole time-of-flight mass spectrometry) system and prepared a highly accurate method of identification by using cleavage patterns. For compounds for which this system was not sensitive enough we used an LC/MS/MS (liquid chromatography–tandem mass spectrometry) method, and for compounds that were difficult to ionize by using the electrospray ionization method we used GC/MS/MS (gas chromatography–tandem mass spectrometry). Individual analytical methods were prepared for substances that were difficult to measure. In addition to using the above approaches, we started developing a molecularly imprinted polymer (MIP) that can selectively collect ER-active substances (Fig. 3). In addition, as a method of chemical speciation of organometallic compounds, we investigated conditions for separating organoarsenicals for the simultaneous analysis of water-soluble organic arsenic in environmental samples including both animals and plants materials. To improve the accuracy of evaluation of mercury exposure, we also established a method for the simultaneous analysis of organic mercury compounds with a relatively wide dynamic range by using GC-CVAFS (gas chromatography–cold vapor atomic fluorescence spectrometry).

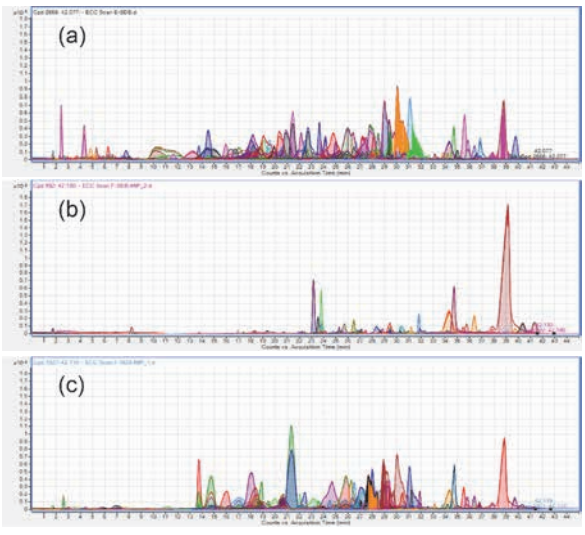


Fig. 3
Evaluation of the selectivity of MIP prototype cartridges by using environmental waters.
(a) Sample before passing through MIP cartridge,
(b) the fraction adsorbed onto the MIP cartridge, and (c) the fraction passed through the MIP cartridge.

The adsorbed fraction (b) was purified from the original sample (a) ; the activities of the two fractions were nearly the same.

As a basic method of non-target monitoring by using GC×GC/TofMS, we optimized methods of sampling air and water, including the process of preparation for measurement. Magnetic solid phase extraction of compounds was employed for non-target monitoring of water. Various compounds, including persistent organic pollutants, pesticides, and other compounds with an octanol–water partition coefficient ranging from 0.72 to 7.4, were recovered from water samples after the addition of 20% (w/w) NaCl and 10% (v/v) acetone. We have started non-target monitoring of river and effluent waters in the Kanto region. In addition, we have begun developing software that detects different peaks by comparing TofMS measurement results between different sample groups. Furthermore, for the early detection of pollution in air and water environments by using a human-cell-based *in vitro* bioassay, we are listing candidate chemicals and promoting the introduction of a reporter gene assay system that can detect these chemicals.

3. Research project on ecological model-based risk assessment and management (Project 3)

To predict changes in biodiversity under habitat-disturbed conditions, we have been exploring theoretical models to gain an understanding of the mechanisms by which species diversity is maintained in biological communities. Two contrasting hypotheses, namely the deterministic and neutral theories, have been proposed to explain species diversity in a community. The deterministic theory considers deterministic factors such as interspecies competition and niche differentiation as the main drivers in the formation of community species structure. On the other hand, neutral theory incorporates a stochastic process as the major factor in community composition without any deterministic factors. The debate over these hypotheses is still ongoing, partly because of the absence of powerful neutrality tests in community ecology. Here, we have been developing a new neutrality test using simple demographic data. By using a formula to analyze demographic statistics, we can suggest a procedure for testing neutrality. We are also developing deterministic models and demonstrating the performance of the test. We found that our method was efficient enough to reject neutrality. We then applied the test to tropical tree communities in Pasoh, Malaysia (Fig. 4), and the test rejected the neutrality of the communities. This indicated that deterministic factors are important for the maintenance of species diversity in tropical rain forests. This year we also collected tropical forest community data in a fragmented forest landscape in Sarawak, Malaysia. We established 19 inventory plots in eight forests and found more than 3000 trees—500 species in total. The information gathered will be used as empirical data to develop methods of detecting the effects of environmental disturbances such as habitat fragmentation on biodiversity.

Fig. 4 A tropical rain forest in Pasoh Forest Reserve, Malaysia. More than 800 tree species coexist in a 50-ha plot.

4. Research project on comprehensive assessment system for ecological impacts of chemicals (Project 4)

We investigated long-term and multi-generation tests, such as multi-generation tests in fishes (Fig. 5) and crustaceans, with various endpoints focusing on specific life stages, for the purpose of chemical management in Japan. Furthermore, we developed a draft algorism to select whether a test should be based on the physicochemical properties of a compound or its potential effects. We also developed some other new test methods for evaluating chemical compounds with unique properties, such as endocrine disrupting chemicals and neonicotinoids. These tests were conducted by using reference chemicals to investigate the possibility of implementing a chemical management system in Japan. We also investigated the development of an adverse outcome pathway for a model compound with a relatively clear mechanism of action. Additional studies were conducted to clarify the *in silico* and *in vitro* tests used in chemical management outside Japan.

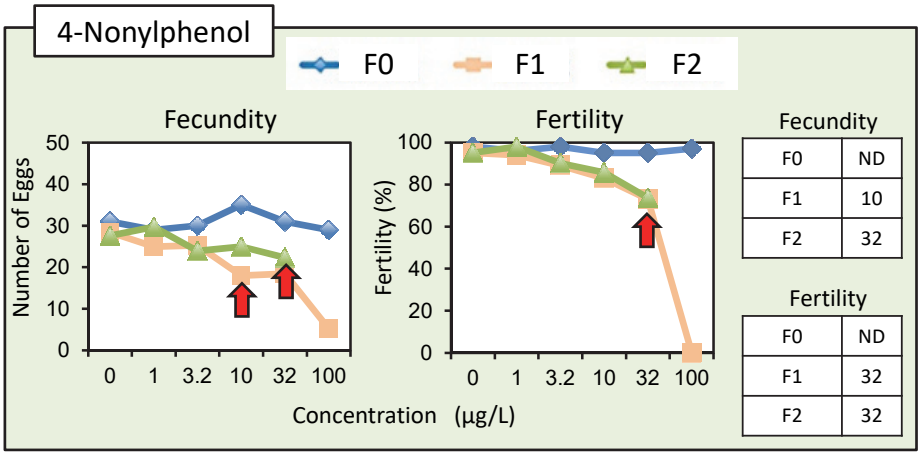


Fig. 5
Part of the results of the MEOGRT (medaka extended one-generation reproduction test) of 4-nonylphenol. Red arrows and right hand side tables indicate the lowest observed effect concentrations.

We conducted a seasonal survey that included a physicochemical analysis of environmental factors and trial trawling at 20 sites in Tokyo Bay. Temperature, salinity, dissolved oxygen, and nutrients were measured, and the population and

biomass of fishes, crustaceans, mollusks, and sea urchin species, among benthic organisms, were investigated. A decrease in population and biomass per unit effort was observed between the 1970s and 2000s, mainly because of a decrease in abundance of the bivalve *Arca boucardi*. The abundance of large fish species such as sharks and rays was found to be decreasing. Hypoxia developed in the northern part of the bay in summer, depleting it of organisms, whereas in the southern part of the bay hypoxia was not well developed and some organisms were present. Hydrogen sulfide levels were relatively high in the sediments of the northern part of the bay (0.1 or 0.8 mg/L in the over-bottom water); this was a potentially source of lethality to sulfide-sensitive species such as the shrimp *Metapenaeus ensis*. Since October 2012, we have been investigating spatial and temporal variations in the population and biomass of benthic organisms in the coastal area (10 to 30 m deep) of Fukushima Prefecture in the wake of the East Japan Earthquake and the accident at the Fukushima Dai-ichi Nuclear Power Plant. We continue to analyze the data.

Finally, river water samples were collected from more than 10 sites, mainly in eastern Japan, to conduct short-term chronic toxicity tests using daphnia. We also investigated the ecotoxicity of chemical mixtures of metals and pesticides to evaluate additive, synergistic, and antagonistic effects.

5. Research project on multi-scale dynamics of chemicals (Project 5)

In this project, we are examining the dynamics of chemicals at various spatiotemporal scales by using state-of-the-art analytical techniques and constructing mathematical models to better understand and predict the concentrations and dynamics of environmental chemicals.

Atmospheric Hg is a major source of the mercury in most aquatic ecosystems. We determined the seasonal variations in Hg concentrations in Lake Motosu to evaluate the timing and magnitude of atmospheric Hg deposition. Hg concentrations in the lake's surface water increased from 0.06 to 0.14 ng/L during summer and autumn (Fig. 6), a timing that corresponds with a typical rainy season in Japan. Wet deposition of Hg has an important influence on lake water Hg concentrations.

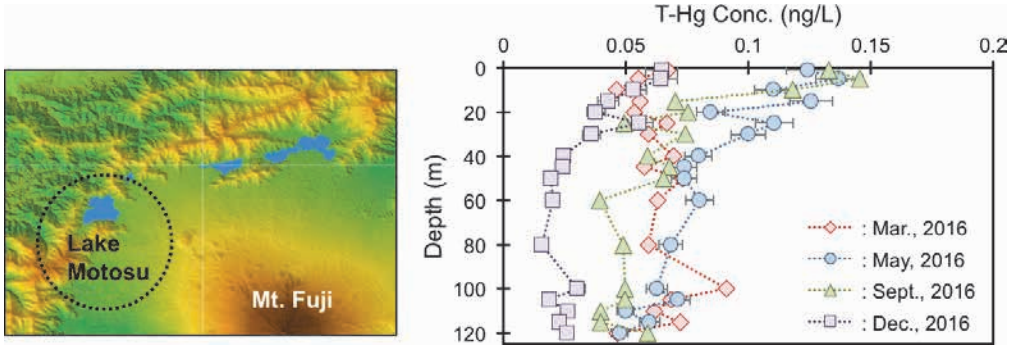


Fig. 6
Generalized map of Lake Motosu and seasonal variations in total mercury (T-Hg) concentrations (ng/L), plotted against the sampling water depth (m).

We improved our global multimedia model for mercury (FATE-Hg) by implementing a new module that describes Hg processes in and across the atmosphere, ocean, sediments, and marine organisms. We evaluated the improved FATE-Hg by using compiled monitoring data on Hg concentrations. The results of our validation showed that our model could simulate the levels, distributions, and seasonal variations of Hg in the surface atmosphere and the surface ocean.

To improve a multi-media environmental fate model, G-CIEMS (Grid-Catchment Integrated Environmental Modeling System), for regional-scale estimations over more extensive areas, we reconstructed GIS data on coastal river-basins, which are not considered in the present version of G-CIEMS, and upgraded the basic rules for a river-networking structure. We also considered a new method for calculating the river flow rates for each river segment that were used in the default dataset of this model.

As part of a study of the indoor-scale dynamics of chemicals, we experimentally measured the transfer of the flame retardant hexabromocyclododecane from curtains to attached dusts for 196 days and found that there were different levels of transfer for different types of curtains and dusts. We modeled the transfer processes. We also worked on measuring, developing new measurement methods for, and estimating the relevant physicochemical properties of flame retardants.

6. Research project on atmospheric processes, toxicity, and health effects of air pollutants including PM2.5 (Project 6)

Rapid economic growth in East Asia has resulted in a marked increase in energy consumption, leading to increased emission of air pollutants. High concentrations of PM2.5 have been reported in Japan, and their adverse health effects are now a major public concern. To control air pollution, to collect evidence of its adverse health effects, and to construct alert systems for air pollution, we are developing an integrated air quality model system and are conducting *in vitro* toxicity studies and epidemiological studies. In the first year of this project, we obtained the following two main results.

1) To improve the current PM2.5 model [the volatility basis-set (VBS) model], we evaluated the volatility distribution of biogenic and anthropogenic secondary organic aerosol (SOA) by using a laboratory chamber (Fig. 7). The volatility distribution of SOA was measured by using a heat method, chemical analysis, and a dilution method. The SOA consisted of not only compounds with a saturated concentration (C^*) of 10^0 to 10^3 μg/m^3, which are already considered in the current model, but also of compounds with a C^* of less than 10^0 μg/m^3, which are not considered in the current model. Our analyses using these different methods revealed that these previously unconsidered low-volatility compounds would be formed from oligomerization of monomer products. We have proposed revisions to the current model on the basis of these experimental results.

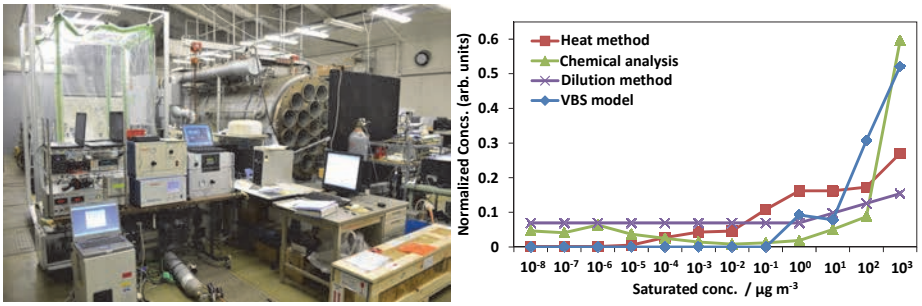


Fig. 7
Laboratory chamber (left) and volatility distributions of secondary organic aerosol (right); VBS, volatility basis set.

2) The main objective of our epidemiological studies is to accumulate evidence of the adverse health effects associated with the mass and chemical compositions of PM2.5 and to present the current status of these adverse health effects in highly susceptible populations. Last year, our target population was pregnant women. We examined the association between exposure to air pollutants and complications during pregnancy—in particular, placental abruption (an emergency complication during pregnancy). Our hypothesis was that a short-term increase in air pollutant exposure is a potential trigger of placental abruption.

We received data for the Kyushu–Okinawa districts from the Japan Perinatal Registry Network database, which is managed by the Japan Society of Obstetrics and Gynecology. Between 2005 and 2010, we identified 821 singleton pregnant women with placental abruption. Daily concentrations of air pollutants, including nitrogen dioxide [NO_2], suspended particulate matter [SPM], photochemical oxidants [Ox], and sulfur dioxide [SO_2], at the monitoring station nearest to the delivery hospital of each woman were used. We constructed an analytical dataset based on a time-stratified case-crossover design, and we applied a conditional logistic regression model to estimate odds ratios (ORs) and their 95% confidence intervals (CIs) per 10-unit increase in the concentration of each pollutant. We observed that exposure to NO_2 two days before delivery was associated with a risk of placental abruption (OR = 1.4, 95% CI = 1.1–1.8) (Fig. 8). There was no association between exposure to SPM, Ox, or SO_2 and placental abruption. We did not explore the association between PM2.5 exposure and placental abruption, because PM2.5 concentration was measured only in limited areas during the study period (2005–2010). The goal of our next investigation is, therefore, to analyze the outcome data after 2010, when routine measurement of PM2.5 at ambient air-pollution monitoring stations began.

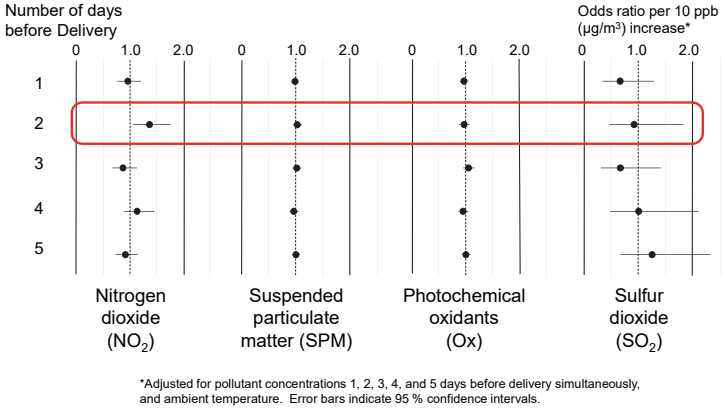


Fig. 8
Association between exposure to air pollutants and placental abruption.

7. Research project to develop technologies and assessment methods for water quality conservation (Project 7)

In provincial cities domestically and in developing countries in the Asian region, the introduction of water-environment conservation technologies has been delayed because of economic constraints. The aim of this project is to develop technologies to conserve the water environment and evaluate the effectiveness of conservation projects so that water quality can be managed effectively in areas under economic constraints.

This project comprises two sub-projects. The first is the development of appropriate technologies to conserve aquatic environments. Reducing the energy required for the treatment system (i.e. the operational cost) promotes the dissemination of technology. Also, introducing decentralized treatment of domestic wastewater is an effective immediate contamination countermeasure. Therefore, this year, we started the experimental demonstration of an aerobic trickling-filter system for domestic wastewater treatment (Fig. 9) in cooperation with a local municipality (Bangkok Metropolitan Administration, Thailand). The aerobic trickling-filter system was superior to the existing treatment system (an activated sludge process) in removing ammonia nitrogen (NH_4-N) and coliform bacteria.

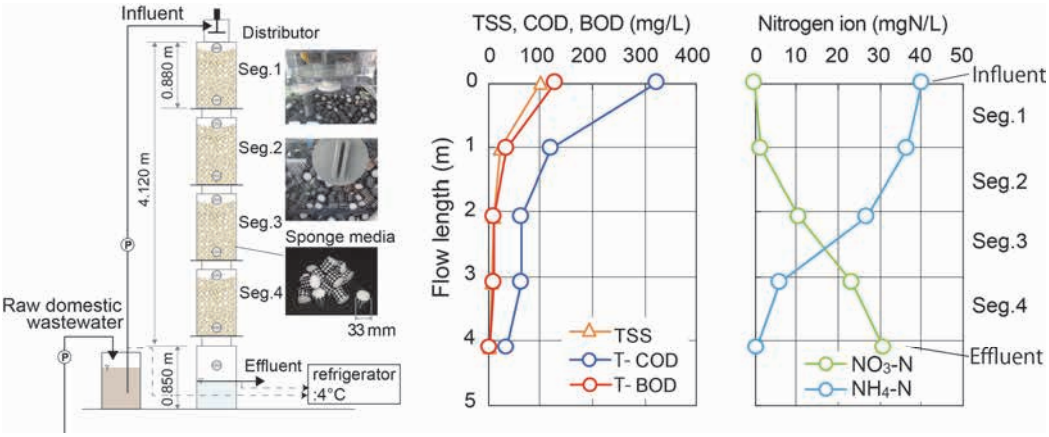


Fig. 9
Overview of the aerobic trickling-filter system for domestic wastewater treatment and the water-quality profile along flow length.

In the second sub-project, we are developing methods to evaluate the water environment and its conservation technology by using various groups of indicators. To evaluate and select a water environment conservation technology (i.e. a wastewater treatment technology) suitable for social implementation, we collected domestic wastewater inventory data on the target area (Bangkok).

Also, we conducted a comprehensive next-generation sequencing analysis of 16S rRNA genes in multiple samples of canal waters in Bangkok with different degrees of contamination. 16S rRNA clones of the genus *Arcobacter* (family *Campylobacteraceae*) were detected more frequently than those of *Escherichia*

coli (family *Enterobacteriaceae*). Characterization of dissolved organic matter by fluorescence analysis (EEM-PARAFAC: excitation emission matrices and parallel factor analysis) of domestic wastewater showed that it was possible to use this process to investigate the behavior of treated waters in the environment.

8. Research project on risk assessment and management framework (Project 8)

A sound management framework to manage the risks posed by environmental chemicals to human health and the environment can be established by integrating the social context, public concerns, and accumulated social and natural scientific knowledge. The aim of this inter-disciplinary project is to develop a robust framework for managing environmental chemicals that reflects both the social context and the latest outcomes of Projects 1 to 7. To achieve this aim, this project is developing risk assessment and management strategies that are acceptable to the public and incorporate the latest scientific information on the impacts of environmental chemicals on human health and the environment. Furthermore, the project is developing an ecological management framework based on the comprehensive characterization of ecotoxicity by using a newly developed system of testing protocols. It is also developing a system for the environmental management of coastal, oceanic, atmospheric, and aquatic pollution that will incorporate new technologies as they become available, and a management approach that incorporates comprehensive monitoring methodologies to assess new chemicals as they arise from technological development. Our aim is for Project 8 to summarize the scientific outcomes of all the other projects into the context of sound chemical management in our society.

This year we studied a new direction for incorporating the precautionary approach to chemical risk management on the basis of both the scientific and the social nature of chemicals. Our assumption is that risk-based and precaution-based approaches can be integrated in a complementary way, and we have been discussing this possibility with a wide range of experts. We have also been developing new category-based structure–activity relationships of the ecotoxicological nature of chemicals to strengthen the management of a wide range of target chemicals that are currently appearing in the chemical industry and are produced at low rates.

Environment-Economy-Society Integration Research Program

Starting with integration of the mitigation of, and adaptation to, climate change, this program develops multilayered models that quantitatively analyze solutions to environmental problems, including those related to socioeconomic activities and the need for sustainable material cycles, harmonization with nature, and health and environmental safety, on a variety of scales from urban and regional to national and global. From the perspectives of environmental, economic, and societal sustainability, the program conducts quantitative and qualitative analyses pertaining to the future visions of stakeholders at each scale. It also designs and evaluates the international and local or urban policies needed to realize these intended future visions. The program will establish a system to support the implementation and realization of proposed policies, countermeasures, and innovative green technologies. Figure 1 illustrates the framework of the program and five aspects of the research integration. The program consists of three projects: Project 1 provides sustainability development scenarios for the world and Asian countries; Project 2 develops a local environmental sociologic integration roadmap focusing on climate change mitigation and adaptation; and Project 3 evaluates policies for an environmentally sustainable society.

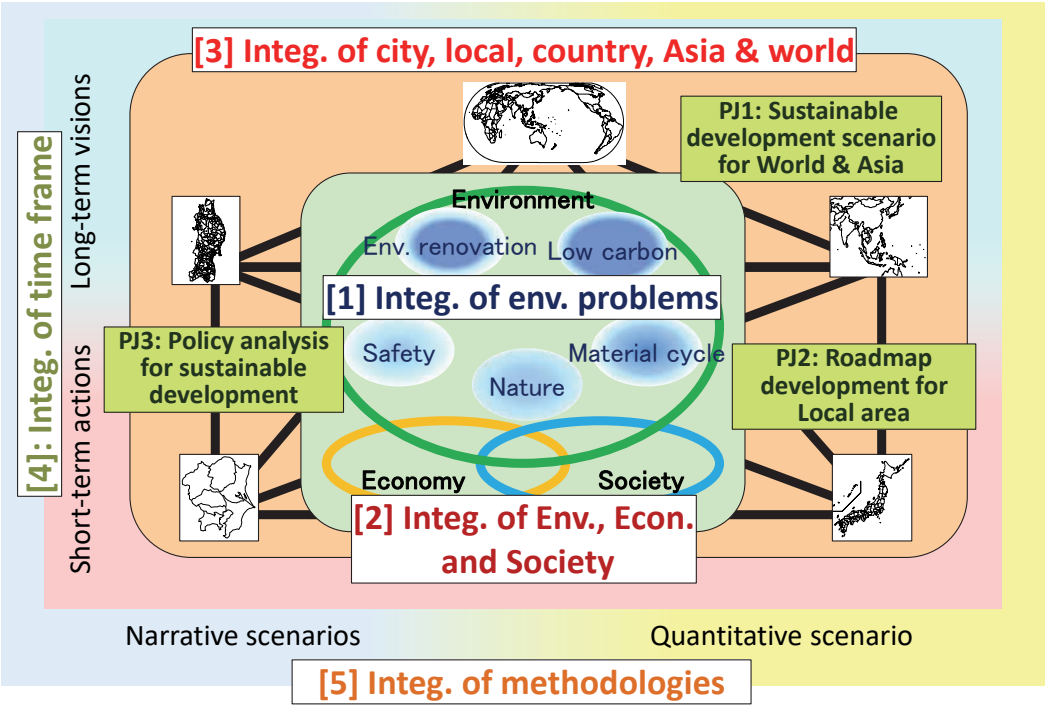


Fig. 1 Framework of the Environment-Economy-Society Integration Research Program. The bracketed numbers list the five aspects of the program.

1. Sustainability development scenarios for the world and Asian countries

This project is developing an integrated assessment model for analyzing sustainability development scenarios that pursue the simultaneous attainment of global or regional societal goals such as a low carbon society, resource recycling, natural symbiosis, and safety from various risks. The project consists of two

sub-themes. Sub-theme 1 provides global sustainability development scenarios, and sub-theme 2 provides national sustainability development scenarios for Asian countries. Sub-theme 1 will also develop methodologies for downscaling global socioeconomic scenarios and will provide spatial socioeconomic scenarios with a resolution appropriate for supporting regional or national scale analyses conducted in the research program.

In sub-theme 1, we have contributed to the internationally coordinated process of developing the shared socioeconomic pathways (SSPs) that are expected to be in common use across climate research communities in the near future. These SSPs consist of five scenarios representing different socioeconomic development pathways in the future. The NIES team has quantified a marker scenario (a representative scenario among the multiple scenarios developed by different models) for SSP3 (regional rivalry), under which the world is expected to face strong challenges in terms of both mitigation and adaptation. This scenario is characterized by its assumptions of high population, slow economic growth, and slow technological improvements. The quantified scenario depicts a world in the 21st century with a decrease in forest cover accompanied by a large expansion of cropland and pasture land, high levels of air pollutant emission associated with weak implementation of air quality legislation, a high level of coal dependency, and a continuous increase in GHG emission.

In sub-theme 1, we have also developed a global land-use allocation model that can be linked to economic module of integrated assessment models (IAMs) with a coarser spatial resolution (Fig. 2). By using the model, we downscaled the IAMs' regional aggregated land-use projections to obtain a spatial land-use distribution, which could subsequently be used by Earth system models for global environmental assessments of ecosystem services, food security, and climate policies. A comparison of the emissions estimated with and without downscaling suggested that the land-use downscaling would help capture the spatial distribution of carbon stock density and the regional heterogeneity of carbon emissions caused by cropland and pasture land expansion.

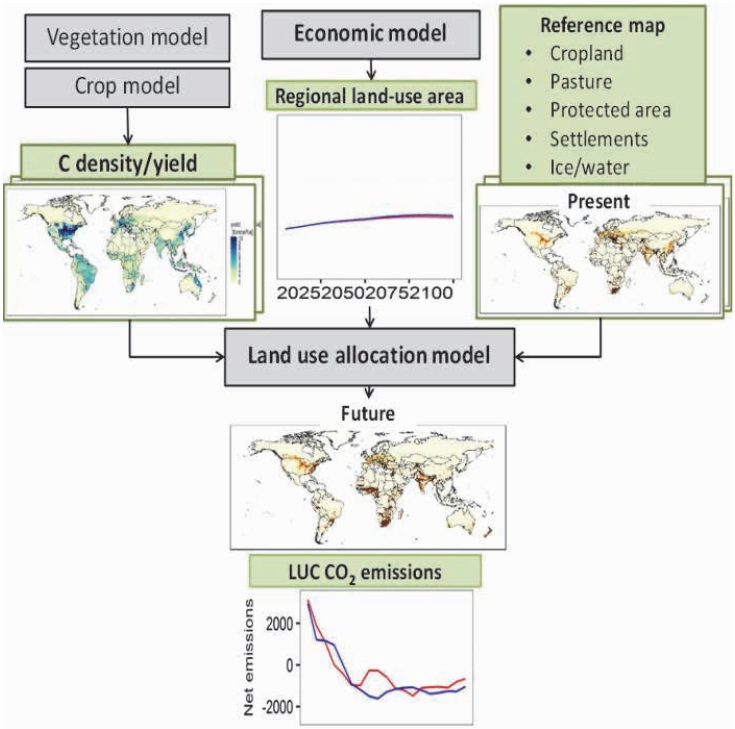


Fig. 2 Overall framework of the land-use allocation methodology. LUC: land-use change.

In sub-theme 2, we have developed IAMs to assess GHG mitigation and sustainable development actions in Asian countries such as China and Indonesia. To assess the impacts of ozone on the macro-economy of China, we have integrated a computable general equilibrium model that can treat the provinces in China, an atmospheric transportation-chemistry model for air pollutants, and a human health impact model. Although the economic impacts of ozone will be smaller than those of PM2.5, the gross domestic product loss in China in 2030 will be 0.04% as compared with the baseline scenario. In addition, we have assessed energy service demands in the residential sector of Chinese urban and rural areas.

2. Research into a regional environmental sociologic integration roadmap focusing on climate change mitigation and adaptation

To support local governments with the scientific knowledge needed to assess climate change impacts and deliberate adaptation measures, sub-theme 1 of this project has started to consider the model development specifications of climate change impact assessment by sectors that can potentially use multiple adaptation measures. During these considerations, we reviewed in detail the specifications of climatic variables on land and in the sea and the spatial resolutions needed for these variables to enable us to develop impact assessment models. Furthermore, we have started to investigate the specifications of land-use models so that we can collaborate with other projects, project groups, and sub-themes to ultimately develop a kind of regional environmental sociologic integration roadmap for climate change mitigation and adaptation. We have been reviewing the

specifications of the models to be developed in this project from the perspectives of 1) the objectives of model development, 2) methods, 3) the possibility of data utilization, 4) definitions of land-use classification, 5) the scope of application, 6) spatial resolutions, and 7) time scales. We have now started to develop a prototype based on a cellular automaton for which we have more than 6000 case studies.

In sub-theme 2, to analyze the integration roadmap focusing on climate change mitigation, we developed a regional-scale model that can comprehensively assess the industrial, consumption, and transportation sectors. To do this, we enhanced nation-scale models to cover municipalities in order to analyze low carbon scenarios for units of cities or towns while taking regional characteristics into account. In this analysis, we set up two cases: one does not consider any CO_2 emission reduction targets (no-target case), and the other has a target of 80% reduction in 2050 from the amount in 2005 (80% reduction case), which is the same as the current national target. Moreover, by clearly incorporating the transport sector as an analysis object of the model, we were able to explain increasing electricity demand for electric vehicles and others and the need to facilitate low-carbon measures such as photovoltaic systems for homes and gas-engine cogeneration systems. We also began to develop a general model framework for analyzing energy system networks. This framework enables us to assess the allowances for power and thermal energy inside and outside an area, which becomes important in analyses of energy systems, particularly in rural areas. We then performed some experimental calculations to verify the effectiveness of the model; the whole of Japan was the subject of the calculation.

In sub-theme 3, we considered the improvement of monitoring devices to enable us to effectively understand energy consumption and analyze data. We also examined the development of efficient networks for heat and power from industrial or waste treatment plants, in addition to the establishment of a collaborative framework among government, industry, and academia to promote monitoring of resource circulation and related activities that contribute to low carbonization. As part of low-carbon measures for industrial estates and surrounding towns, we assumed that the establishment of an energy network for heat from incineration for industrial use and cogeneration by gas from thermal power plants would be accelerated. We also scrutinized the requirements for the network by interviewing staff from local government and industry bodies, namely both suppliers and consumers. Furthermore, a committee involving government, industry, and academia was established to construct a monitoring system that will enable resource-recovery and associated low-carbon measures to be proposed, controlled, and verified for efficiency. This will be done by enhancing energy-consumption-survey technology that applies the Internet of Things and other advancing technologies. As of FY 2016, more than 30 organizations had joined the committee, including universities, research institutes, local governments, waste disposal contractors, distributors, and electronics companies.

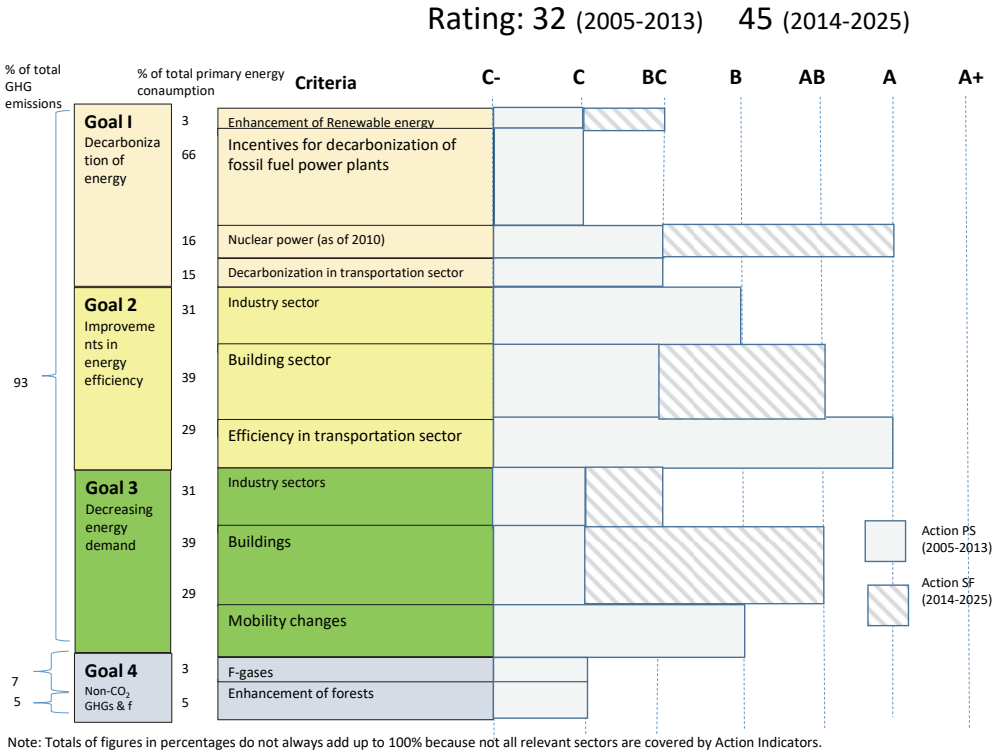
3. Evaluation of policies for an environmentally sustainable society

Project 3 aims to elucidate effective policy and planning for an environmentally sustainable society. In sub-theme 1, sustainable visions for various regions and lifestyles are designed and assessed, and the planning approaches and tools to accomplish these visions are developed. In sub-theme 2, national and regional laws and policies are evaluated and submitted from the perspective of their effectiveness and validity. Below are the main results for FY 2016.

To design sustainable regions and lifestyles, our estimations of the carbon emissions from household sectors in municipalities at the grid and building scales were revised by using a combination of building point data and statistical data at the prefecture scale. A series of presentations were organized to exchange information among research programs as to how detailed population distributions were being considered in each issue-oriented research program. Various environmental loads from different types of regions and families were evaluated as basic data for designing sustainable regions and lifestyles.

We proposed a “sustainability nexus indicator framework” that is structured in terms of ends and means. The intended use of this framework is to monitor the state of development and reveal the interlinkages and nexuses of complex human–environment systems. To evaluate Japan’s current status, statistical data on 48 indicators were collected, and a website was set up with selected 22 indicators so that anyone can check the trends of these indicators in Japan.

We also developed a Climate change mitigation Policy Progression Indicator (C-PPI) to assess countries’ efforts to reduce their respective GHG emissions. The C-PPI consisted of two sets of indicators, namely action and outcome indicators. The action indicator included 37 policy elements, and the outcome indicator included 6 elements. Five countries, namely the United States, Germany, the United Kingdom, China, and Japan, were evaluated by using the C-PPI, and each country’s policy package was assessed accordingly (Fig. 3).



Note: Totals of figures in percentages do not always add up to 100% because not all relevant sectors are covered by Action Indicators.

Fig. 3 Evaluation of Japan's climate mitigation policies by using action indicators.

Environmental Emergency Research Programs

Environmental Emergency Research Programs

Immediately after the Great East Japan Earthquake and Fukushima nuclear disaster, NIES undertook disaster-related environmental research. This research has helped in the environmental restoration and recovery of the devastated areas. By using the accumulated outcomes of this research, and with the NIES Fukushima Branch, which was established in the Fukushima Prefectural Centre for Environmental Creation, as a research hub, this program conducts Environmental Recovery research, Environmental Renovation research, and Environmental Emergency Management research in collaboration with Fukushima Prefecture, the Japan Atomic Energy Agency, other related institutions in Japan and abroad, stakeholders, and other entities. In addition to contributing to environmental recovery in the devastated areas, the Environmental Emergency Research Program delineates paths leading to environmental restoration and creation and is helping to create a disaster-resilient society based on the lessons of the Great East Japan Earthquake and other major disasters. Below, we outline the major projects conducted under the three sub-programs in FY 2016.

1. Environmental Recovery Research Program

This program is conducting research into, and development of, volume-reduction and other technologies for the intermediate storage and final disposal of radioactively contaminated off-site waste. This is an urgent task of the highest priority for our nation. The program will also conduct research and development of technological solutions to problems related to the treatment and disposal of designated wastes and other contaminated wastes. Additionally, from a long-term perspective, the program will study the environmental fate of radioactive substances remaining in forests, water bodies, and other environments. Furthermore, it will apply long-term environmental risk-management methods to secure a livelihood platform to enable people to live safely and free of concern, and it will implement an ecosystem assessment that will include ecosystem services.

1.1 Development of management systems for radioactively contaminated off-site wastes

The Fukushima Daiichi Nuclear Power Plant accident resulted in the grave problem of solid waste contamination by radioactive substances. To help solve this problem as expediently as possible, in collaboration with central and local governments we are performing various types of urgent research into appropriate waste management.

Our research has been reflected in various measures, including technical guidelines from the Ministry of the Environment (MOE), discussions by an MOE panel, and the passing of the Act on Special Measures Concerning the Handling

of Pollution by Radioactive Substances.
Our recent areas of interest are: (1) volume-reduction technologies for radioactively contaminated off-site wastes; (2) management and optimization of material flows through recycling and disposal of radioactively contaminated off-site wastes; and (3) optimization and long-term management of processes in the final disposal of contaminated off-site wastes and interim storage of removed soil. Below are representative results of these studies in FY 2016.

1.1.1 Behavior of radiocesium during incineration of two different contaminated wastes, and development of two types of melting technologies

We investigated the behavior of radiocesium in two incineration facilities, one dealing with decontamination waste and one with demolition wood. The behavior of radiocesium during decontamination waste incineration differed from that reported in our previous investigation in terms of the leachability of radiocesium from fly ash. Similarly, the behavior during incineration of the demolition wood differed markedly: radiocesium leachability from the fly ash and radiocesium distribution to the fly ash were much higher than those during decontamination waste incineration. This difference was due to the generation of more gaseous radiocesium compounds during waste incineration in the presence of a higher chlorine content.

We developed ash-melting and gasification melting process technologies to produce slag from incineration residues and decontamination waste, respectively. Our aim was to decontaminate the waste and reduce its volume. In developing the former technology, we clarified the elemental composition of various incineration residues. In a laboratory-scale experiment we then investigated the relationship between the addition of reagents to promote radiocesium evaporation and the amount of gaseous radiocesium evaporated from the slag. Finally, we suggested optimum conditions for effectively removing radiocesium from the slag. In the developing the latter technology, we examined the distribution of radiocesium between fly ash and slag in a commercial shaft-type gasification melting facility. Furthermore, we investigated the effect of adding $CaCl_2$ on the distribution. We showed that even adding a small amount lowered the activity of radiocesium in the slag by one order of magnitude compared with the activity in slag without $CaCl_2$.

1.1.2 Technology for interim storage of removed soil

In Fukushima, soil removed as part of decontamination work will be stored in an interim storage facility. To design a leachate treatment facility and predict the environmental impact of this facility, we set up two lysimeter test sites, each 2 m wide, 2 m deep, and 2 m high. Five years after the Fukushima incident, radioactively contaminated soil and sediments removed from an agricultural reservoir were used as test samples. The radioactivity of both soil samples was

approximately 3000 Bq/kg. Artificial precipitation (10 mm/day) was applied to accelerate seepage, and the time-series changes in leachate quality and gas emissions were monitored. The monitoring results during the first few months are summarized below. The initial biochemical oxygen demand and chemical oxygen demand were hundreds of mg/L, but these concentrations rapidly decreased during the first few weeks. The suspended solids concentration depended on the fine particle content of the parent material and fluctuated during the first few weeks. The colloidal particle concentration was unexpectedly high (tens of mg/L). Methane and carbon dioxide gas emissions were very low (0 and about 0.2 L m^{-2} h^{-1}, respectively). Monitoring of the lysimeters will continue, because we have not yet had enough time to determine the long-term behaviors of the leachates and the emissions.

1.2 Analysis and prediction of the behavior of radioactive substances in multimedia environments

1.2.1 Radiocesium transfer in forest insect communities

To understand radiocesium transfer in forest insect food webs, we investigated the activity concentrations of radiocesium in forest insects in Fukushima and Ibaraki prefectures about 1.5 to 2.5 years after the FDNPP accident. We analyzed 34 species of insects sampled from 4 orders (Coleoptera, Hemiptera, Lepidoptera, and Orthoptera) and 4 feeding functional groups (herbivore, carnivore, omnivore, and detritivore). We used a generalized linear mixed-effects model (GLMM) to assess whether insect ^{137}Cs activity concentrations differed across feeding functional groups. The GLMM analysis revealed that herbivores (moths, herbivorous flying beetles, stinging bugs, and grasshoppers) had significantly lower ^{137}Cs activity concentrations than carnivores (ground-dwelling beetles), omnivores (crickets) and detritivores (carrion-feeding Coleopteran beetles, including dung beetles). ^{137}Cs activity concentrations were especially high in detritivorous and omnivorous species that fed on forest litter and fungi. Radiocesium activity concentrations in any given species reflected the degree of contamination of their primary diet, because radiocesium activity concentrations were found to be the lowest in leaves and grass and the highest in litter, bark, and fungi. This study confirmed that litter and other highly contaminated forest components such as fungi, decaying wood, bryophytes, and lichens serve as sources of ^{137}Cs transfer into the forest insect community.

1.2.2 Multimedia fate modeling

We aimed to simulate the multimedia fates of radioactive substances by coupling atmospheric, oceanic, and terrestrial environment models using appropriate geographic resolutions. In our atmospheric modeling, we analyzed the results of seven atmospheric models to improve our simulations of atmospheric ^{137}Cs concentrations during March 2011. In our terrestrial modeling, we analyzed ^{137}Cs

behavior in an urban area on the basis of concentrations in sewage sludge. In our oceanic modeling, we simulated sedimentary ^{137}Cs behavior in Matsukawaura Lagoon, Fukushima, Japan, for about 4 years after the Fukushima accident (Fig. 1). The long-term simulation indicated that 75% of total sedimentary ^{137}Cs as of the end of 2015 was derived from atmospheric deposition or Pacific water inflow in the initial 3 months after the nuclear accident; the influence of river runoff over the 4 years was quite small.

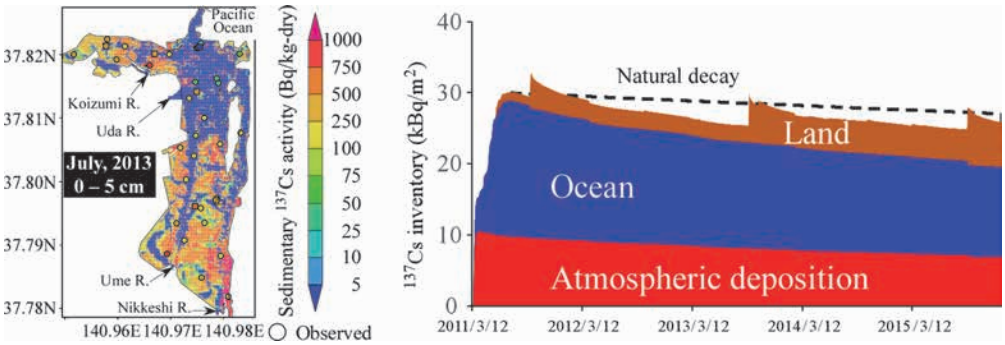


Fig. 1 Results of a simulation of sedimentary ^{137}Cs in Matsukawaura Lagoon. (Left) Spatial distribution of ^{137}Cs activity in surface sediment (0 to 5 cm layer) in July 2013. (Right) Temporal variation in total sedimentary ^{137}Cs derived from atmospheric deposition, Pacific water inflow, and river runoff.

1.3 Developing open data on mammal assemblages inside and outside the evacuation zone

The Fukushima accident resulted in the evacuation of about 81,000 people from the evacuation zone, which suffered high levels of radioactive contamination. Large-scale and long-term land abandonment can cause changes in species assemblages, and hence in ecosystem function. Despite the abundance of global attention given to the issue, our open and spatially explicit datasets of mammal fauna from Fukushima are in fact quite limited. We therefore established a continuous monitoring protocol inside and outside the evacuation zone by using camera traps for mammals, and we made the dataset openly available online as a data paper (refer to Fukasawa *et al.* 2016. Ecol. Res. 31, 493). These data represent the monitoring results from 46 camera traps from May 2014 onward, including the location and actuation time of each camera, and the information recorded, such as species, camera, and date. After the publication of this initial data paper, we intend to continue monitoring until 2023, and the datasets will be hereafter updated by the addition of new observations. Users can download the datasets via the Internet under Creative Commons (CC) attribution license CC-BY 4.0 International (as used for the above-mentioned paper by Fukasawa *et al.* 2016).

We also launched a website for mapping the mammal monitoring data through the Web-GIS system Biodiversity Web Mapping System (BioWM) (http://www.nies.go.jp/biowm/contents/fukushima.php; Fig. 2). Users can browse the camera-trap survey data for mammals inside and outside the evacuation zone designated after the Fukushima accident. The capture rates (= number of captures/number of days of camera survey) calculated from the data extracted by species name and duration are plotted on a map (NIES, Japan Biodiversity

Information Facility 2015: East Fukushima Wildlife, BioWM, created by the Center for Environmental Biology and Ecosystem Studies, NIES, Japan, under CC-BY 4.0. Map tiles are by CartoDB under CC-BY 3.0, and the Chiriin tiles [blank] are by the Geospatial Information Authority of Japan. Map data are by OpenStreetMap under Open Database License ODbL; Fig. 2).

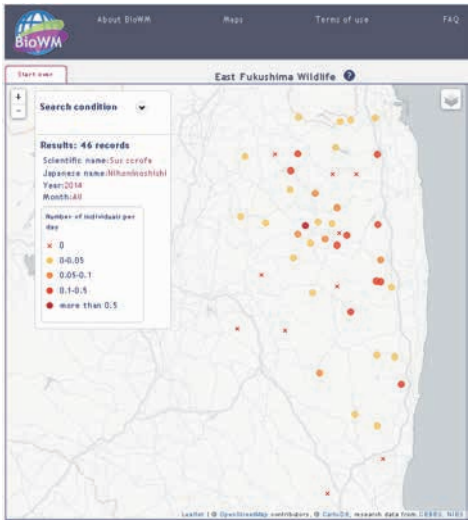


Fig. 2 Web interface of BioWM.

1.4 Ambient monitoring of radiation doses

To estimate inhalation radiation doses from the Fukushima incident, we measured radiocesium concentrations in the ambient air in the village of Iitate, 40 km from the power plant (Fig. 3). In 2016, the peak from May to June at site A was speculated to be associated with the presence in the air of fine soil particles from decontamination work around the site. At site B, no marked peak was detected in 2016. The majority of the ambient air samples from the two sampling sites in 2016 did not exceed 0.001 Bq/m^3, which is equivalent to an estimated inhalation dose for adults of 0.00004 mSv/year. We also assessed the inhalation dose during cleaning of the interior of a house in Iitate. The ^{137}Cs concentration in indoor air was less than the detection limit (0.006 Bq/m^3), which indicated that the inhalation dose was less than 0.001 mSv/year (assuming 1 h of cleaning a day × 365 days). The distribution of radionuclides (mainly radiocesium) on the top of a dropped ceiling in the house was not uniform (Fig. 4).

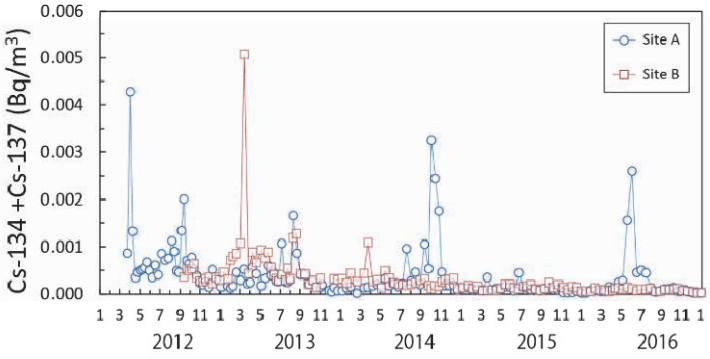


Fig. 3 Temporal changes in radiocesium concentrations in ambient air collected in the village of Iitate in Fukushima Prefecture.

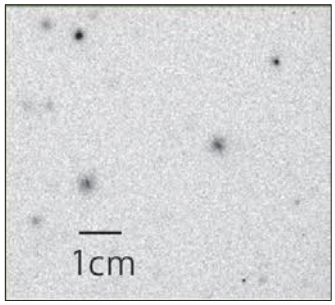


Fig. 4 Distribution of radionuclides (mainly r-Cs) on the top of a dropped ceiling in an house in Iitate (Imaging plate; black dots are high activity spots).

2. Environmental Renovation Research Program

This program will work with the Fukushima Prefecture municipalities of Shinchi and Mishima, where reconstruction is under way, to develop research theory and methods for supporting the process of restoration and environmental creation in post-disaster regional environments. It will also study the use of these methods to provide support for policymaking by local governments. We will also consider such items as global warming countermeasures and resource recycling strategies tailored to the characteristics of affected areas, and we will conduct practical research aimed at building regional environmental resource and energy systems and formulating quantitative eco-city policy targets and roadmaps for achieving those targets.

2.1 Urban revitalization-planning-support system based on regional energy characteristics

In FY 2016, we updated spatial information on land use, population density, zoning of urban planning, and building stocks to the regional spatial database. We also developed a framework for integrated assessment models. The framework consists of three layers, namely a socioeconomic macro-model, a spatial land-use model, and sector-specific element models. Adopting this approach makes it possible to integrate formal models such as those for population and economy, local transport, resource recycling, and industrial symbiosis; thus the models can be used to analyze social and environmental systems consistently. To take into account evacuation after the disaster in describing population dynamics, the models explicitly treat migration between cities and towns. By using this framework, we developed several scenarios for population, land use, transport, and energy. We then assessed the low-carbon effect of local transport systems (such as car sharing) and local energy systems (such as combined heat and power supplies), as well as the impact of their spatial distributions, in the Naka-dori region of Fukushima Prefecture. We discussed the application of these methodologies in the prefectural planning process with the prefectural government.

2.2 Scenario and model analysis for environmental renovation after recovery from the Fukushima disaster

Because of recent social and economic changes, the design of energy systems has become recognized as a regional issue. In this study, we modeled the process of design of a distributed energy system from the perspective of mathematical optimization problems. In the case of energy supply to basic facilities (hot bath facilities) in the Aizu region of Fukushima, through the optimized selection of energy systems, we evaluated the impacts of such factors as regional conditions, the social system, and business-based behavioral norms on indicators such as cost, CO_2 emissions, and resource consumption. An example of an optimal system design is shown in Figure 5. The results indicated that, in the current situation, it is possible to popularize a distributed energy system utilizing local woody biomass, although additional social costs are likely to be incurred. Furthermore, we used a sensitivity analysis of demand scale and fuel price changes to discuss the standards required for system installation.

We developed BaIM (biomass-integrated model), which models the dynamics of carbon sequestration by ecosystems and social systems, to assess the potential supply of, and demand for, woody biomass in the Aizu region of Fukushima. The model consists of a dynamic forest ecosystem and production model, a forestry cost model, and a carbon sequestration model. The characteristics of the local woody biomass for production, along with transportation, are often suggested to be issues that are problematic for the sustainable production and consumption of woody biomass. Four consumption scenarios were used to determine the ideal scenario: standard (carbon sequestration by the ecosystem only), use of woody biomass for energy, use of harvested wood for construction, and cascade use (consumption of waste wood as fuel). Carbon sequestration for different processes was compared, and its implications under different harvest intensities in the western region of Fukushima Prefecture were discussed. The reduction in carbon emissions from the use of woody biomass for energy was the largest among the four scenarios. Under well-planned forest management, the production cost would be cheap enough to supply materials to a biomass power plant. We suggested that we need to develop a framework to plan the best mix of energy-use woody biomass and construction materials to achieve a sustainable regional society.

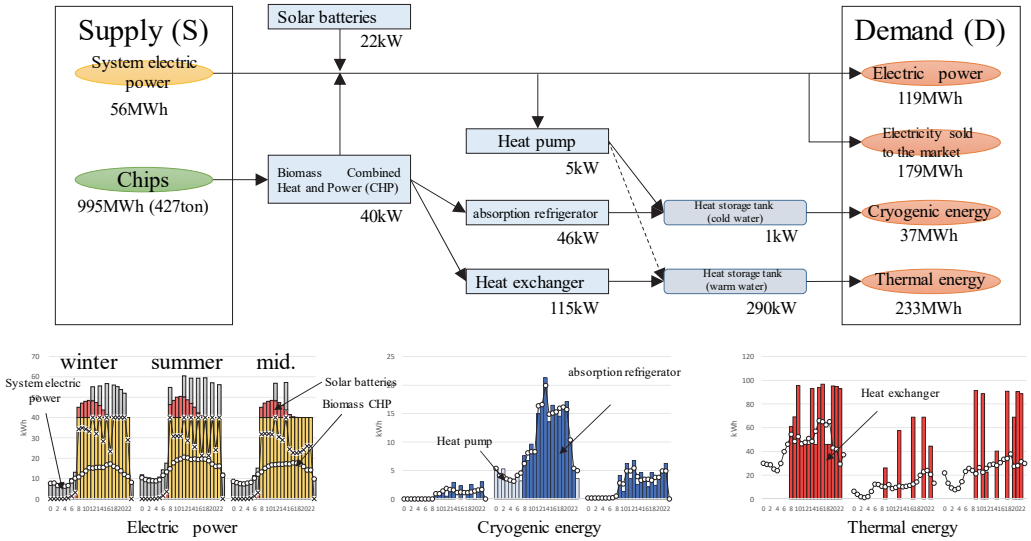


Fig. 5 Example of optimal system design.

2.3 Development of a local planning support system through multi-stakeholder communication development

We conducted a continuing verification test of the local ICT (information and communication technology) system, which was developed in the town of Shinchi, in Fukushima Prefecture, in 2014 by NIES. Seventy-five households are now participating in the test. With this system, users can view various types of local information via a tablet. We held a workshop to support the installation and use of the system. To resolve system problems related to cost, we proposed a new method by which the system can now collect electricity data directly from smart meters.

We also started collaborative research with the town of Mishima in Fukushima Prefecture. We introduced a local ICT system to seven new houses in Mishima, and we intend to start collecting and analyzing a variety of data.

We interviewed woody biomass stakeholders and used the results to classify the flows of wood, costs, and money. In addition, we conducted a questionnaire survey of woody biomass vendors to determine and analyze the current status of use of this product.

3. Environmental Emergency Management Research Program

Our Environmental Emergency Management Research Program aims to establish practical management systems and technologies for handling disaster waste during and after disasters. It also aims to develop a strategy for environmental and health risk management in times of emergency to create more resilient social environmental systems and foster associated communities.

This program will devise technologies and systems for integrated disaster waste

management aimed at achieving smooth and appropriate management of disaster wastes. Additionally, to create a strategy to manage the environmental and health risks associated with disasters, the program will investigate approaches to setting risk management targets when disasters strike and methods and organizational arrangements for emergency environmental surveys. Furthermore, to build a research hub for the environmental emergency research network, the program will design and develop an information platform and capacity-development system for environmental emergencies. This research will be pursued in collaboration with NIES's Environmental Emergency Management Office.

3.1 Establishment of disaster-resilient waste management systems and strategies

This financial year, to improve the disaster resilience of waste management systems, we conducted research into organizational management and capacity development for smooth and appropriate disaster waste management.

As part of our research into organizational management, we developed a prototype standard workflow for disaster waste management in the early response phase, to be used by local authorities for preparedness planning. This was done by investigating actual workflows in three different recent disaster-waste management cases (landslide, flooding, and earthquake/tsunami). The results highlighted the importance of multitasking and personnel management. We also developed an online self-evaluation tool that can be used to identify the disaster resilience or vulnerability of a waste management system. Moreover, we started a research project aimed at reducing flood risks through appropriate waste management in South East Asia along with local collaborators.

In our research into capacity development, we held a table-top exercise in collaboration with the government of Hyogo Prefecture to develop participatory training methods for disaster waste management. The table-top exercise aimed to enhance the capacity of waste management officers to respond to disaster wastes effectively in the early response phase by placing them in hypothetical disaster situations in which various waste management tasks were assigned one after the other. The results showed that this participatory training method was effective in terms of enhancing understanding of disaster waste management tasks and spontaneous learning. Nevertheless, challenges remain in acquiring management skills.

To support organizational management and capacity development, we restructured our online information platform to improve the ability of users to access the disaster waste management information they need. For this, we studied the structure of the information needed to prepare for, and respond to, disaster wastes. This work was done in an integrated manner with NIES's Environmental Emergency Management Strategy Facilitation Office, where the study results

were implemented and the data used for the research was gathered.

3.2 Health and environmental risk management strategies in disaster environments

Health and environmental risk assessment and management of hazardous chemicals are currently general practices when such chemicals are used in normal environments. However, the risks posed by the accidental release of hazardous chemicals in disaster environments have not yet been sufficiently evaluated or managed.

This research project focuses on establishing a risk assessment and management methodology for the accidental release of hazardous chemicals in disaster environments. The project consists of several sub-themes (Fig. 6), namely, sub-theme 1: Setting target control levels for chemical contamination in disaster environments; sub-theme 2-1: Establishing comprehensive analytical technologies and emergency response teams for contaminant chemicals on the basis of collaboration and cooperation among the national, prefectural, and private sectors; sub-theme 2-2: Establishing non-target analytical methodologies and sampling technologies for emergency contamination; and sub-theme 2-3: Clarifying the long-term impacts of emergency contamination events on coastal ecosystems in the field. The project aims to integrate the achievements of these sub-themes to demonstrate comprehensive strategies for managing the health and environmental risks posed by hazardous chemicals in a variety of disaster environments.

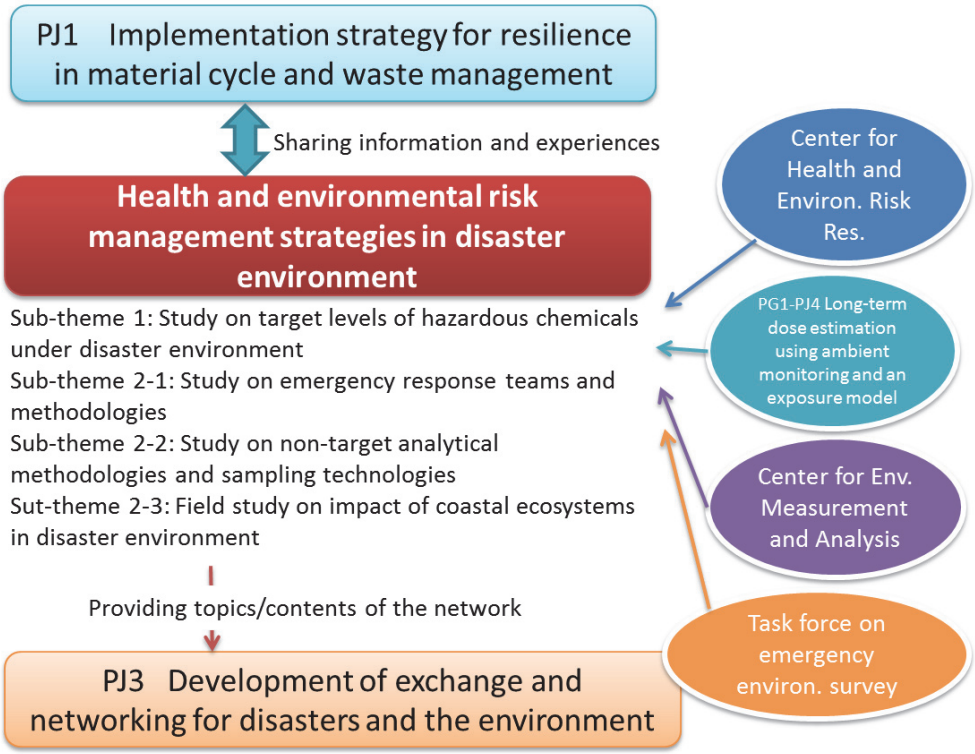


Fig. 6 Outline of health and environmental risk management strategies in disaster environments.

Rsearch Projects

Satellite Observation Center

The Center contributes to improved scientific understanding of the carbon cycle, more accurate prediction of the future climate, and climate-change-related policy making by the Ministry of the Environment (MOE) through activities that use data from the Greenhouse Gases Observing Satellite (Ibuki/GOSAT, launched in 2009) and the satellite that will succeed it (GOSAT-2, to be launched in FY 2018). Activities include developing and operating data-processing systems for GOSAT and GOSAT-2. These systems are being used to calculate the concentrations and fluxes of greenhouse gases (GHGs) and to verify, archive, or distribute GOSAT or GOSAT-2 products. The Center will also conduct a scientific review of the Earth observation satellites to succeed GOSAT-2, including GOSAT-3. GOSAT and GOSAT-2 projects are jointly promoted by MOE, the Japan Aerospace Exploration Agency (JAXA), and NIES.

Major achievements of the Satellite Observation Center in FY 2016 are as follows:

1. GOSAT

Operational data processing for GOSAT, which is currently in space, was continued, and the generation, validation, and distribution of GOSAT data products, such as the concentrations and fluxes of carbon dioxide (CO_2) and methane, were conducted. Concentration products up to February 2017 are freely available from the newly developed data distribution website (GOSAT Data Archive Service, GDAS; https://data2.gosat.nies.go.jp). Maintenance and operation of the GOSAT Data Handling Facility (GOSAT DHF), which is the computer system necessary for these activities, were also done.

2. GOSAT-2

Critical design and manufacturing of a dedicated data processing system for GOSAT-2, namely the GOSAT-2 Data Processing System (G2DPS), were conducted, and computers and other equipment required for G2DPS were procured. Studies of, and preparations for, data processing algorithms for GOSAT-2 were conducted. In addition, a new validation site for GOSAT-2 products was established in the Philippines in December with the support of MOE. Bi-monthly meetings of the GOSAT-2 Science Team and its Calibration Working Group were held.

3. GOSAT-3

Studies of the functional requirements of GOSAT-3, mostly from a scientific perspective, were conducted with input from external experts.

4. Hosting of meetings

A number of meetings and events were co-hosted with MOE and JAXA. The 12th International Workshop on Greenhouse Gas Measurements from Space and the 8th GOSAT Research Announcement Principal Investigator Meeting were hosted in Kyoto in June to deepen collaboration with domestic and foreign researchers and extend the use of GOSAT data. An expert meeting was held in Tokyo in September to obtain comments about GOSAT and GOSAT-2 from domestic researchers. A symposium and exhibition for the general public were also hosted in Tokyo in September as outreach activities for GOSAT and GOSAT-2. An expert meeting was held in Tokyo in February to discuss the utilization of satellite GHG concentration data to verify national GHG emission inventories; experts from developed and developing countries were invited.

5. Participation in international events

To promote the use of GOSAT data in Earth science- and climate-change-related policy making, the Satellite Observation Center participated in the following international events and conducted presentations, lectures, and exhibits:

• Group on Earth Observation 13th Plenary Session (GEO-13, November, Russia)

• United Nations Framework Convention on Climate Change 22nd session of the Conference of the Parties (UNFCCC COP22, Morocco, November).

6. Press releases

The following press releases were issued jointly with MOE and JAXA:

6.1 Whole-atmospheric monthly CO_2 concentration tops 400 ppm (May)

A recent provisional analysis of GOSAT observational data showed that the global atmospheric monthly mean CO_2 concentration observed vertically through the whole atmosphere exceeded 400 ppm in December 2015 for the first time since GOSAT was launched in 2009.

6.2 Whole-atmospheric monthly CO_2 concentration with average seasonal cycle removed tops 400 ppm: preliminary GOSAT monitoring results (October)

A recent provisional analysis of GOSAT observational data up to May 2016 showed that the monthly mean CO_2 concentration derived after removing the average seasonal cycle (CO_2 trend) exceeded 400 ppm in February 2016 for the first time since GOSAT was launched in 2009.

6.3 Detecting anthropogenic CO_2 emissions from mega-city regions from space by using "Ibuki" (GOSAT) (December)

We used data from GOSAT (also known as 'Ibuki") to analyze anthropogenic CO_2 concentrations in mega-cities, including the Tokyo metropolitan area, for the 5.5 years from June 2009 to December 2014. We found that the anthropogenic CO_2 concentrations estimated from the GOSAT data generally agreed with those estimated by using inventory data on fossil fuel emissions in Japan (Fig. 1). The results indicated that satellite observations from space could be useful for monitoring and verifying the CO_2 emission rates aggregated and published by all nations under the framework of the Paris Agreement.

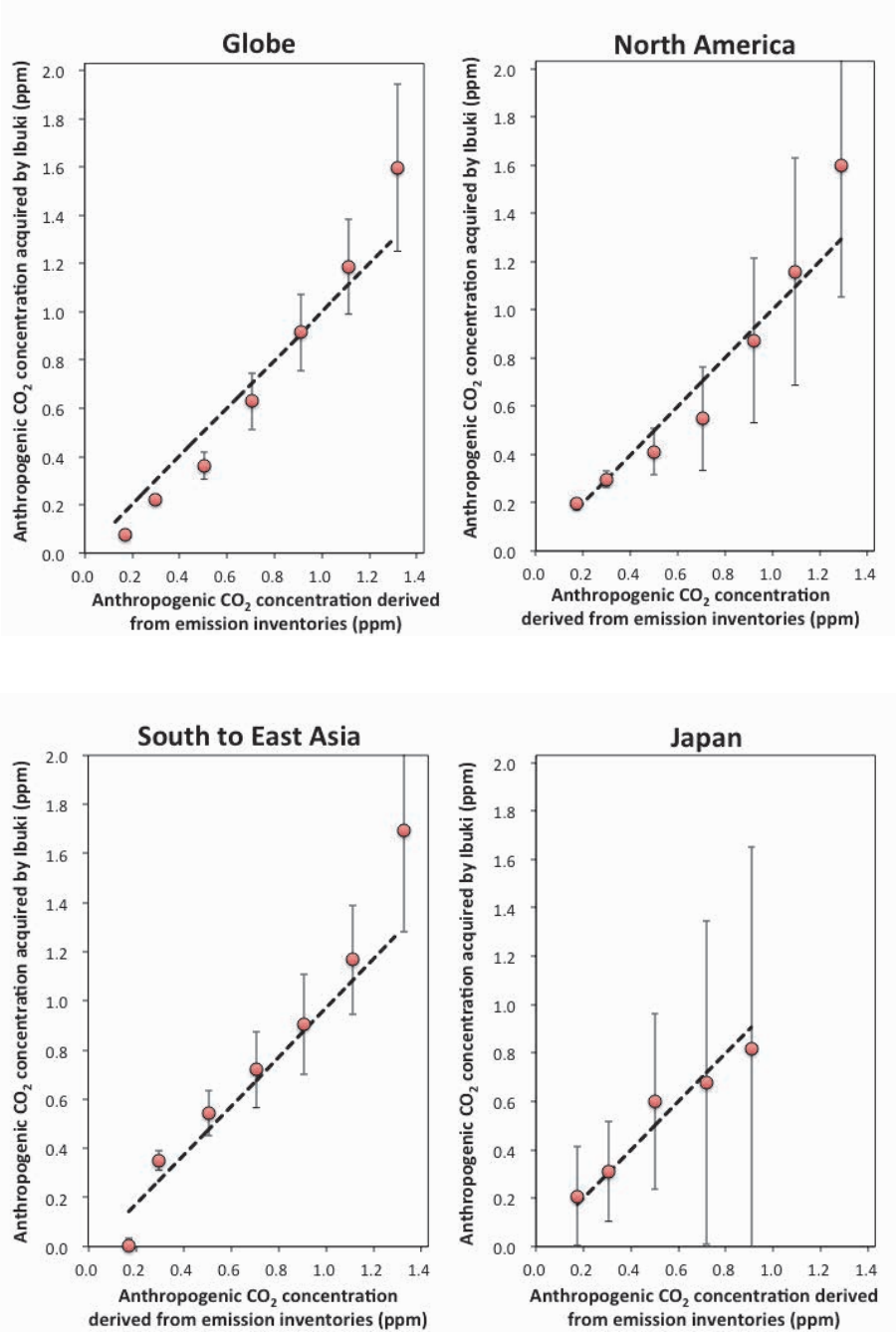


Fig. 1 Relationships between anthropogenic CO_2 concentrations derived from emission inventories and those acquired by GOSAT for the globe, North America, South and East Asia, and Japan. Broken lines show the 1:1 relationship between the concentrations from the inventories and those from GOSAT.

Japan Environment and Children's Study

The Japan Environment and Children's Study (JECS) is a large-scale birth cohort study that aims to investigate the impact of the environment on children's health and development. NIES serves as the JECS Programme Office, supporting the Regional Centers that conduct the survey in 15 study areas throughout Japan in cooperation with the Medical Support Center situated in the National Center for Child Health and Development, which provides medical expertise.

1. Aim

The aim of JECS is to identify environmental factors that affect children's health to develop better environmental risk management policy. Specifically, JECS focuses on the effects of exposure to chemical substances during the fetal period or in early childhood. JECS gives priority to five major health domains: Reproduction and pregnancy complications, congenital anomalies, neuropsychiatric/developmental disorders, allergy and immune system disorders, and metabolic and endocrine system dysfunction. The environment is defined broadly as the global or ambient environment, including chemical substances and physical conditions, the built environment, behaviors and habits, socioeconomic factors, family and community support, and genetic factors.

2. Study design and subjects

The participants of the Main Study are pregnant women, their children, and the children's fathers (when accessible). We recruited pregnant women between 2011 and 2014, and the number of participating mother–child pairs now exceeds 100,000. JECS began to collect the data when the mothers were pregnant and plans to follow their children until they reach 13 years of age. For the Main Study, JECS acquires information about participants' health and development, as well as potentially relevant environmental factors, by administering questionnaires twice a year. The Sub-Cohort Study of 5,000 children randomly selected from the participants of the Main Study is also being conducted to investigate environmental factors and outcome variables more thoroughly. It includes extensive assessment through home visits, ambient air measurements, psycho-developmental testing, and examinations by pediatricians.

3. JECS study organization and role of the Programme Office

For appropriate data collection and analysis, the JECS Programme Office plays key roles, including developing standard operation procedures; accumulating data collected by the 15 Regional Centers (Fig. 1); operating the data management system; maintaining a repository of biological and environmental specimens; performing exposure measurements, including chemical analyses, on specimens; and performing exposure measurements, including chemical analyses, on

specimens. The Programme Office also performs administrative tasks; provides administrative and technical support for the Regional Centers, and is responsible for risk management and public communications. The Programme Office strives to play a leadership role in facilitating collaboration among different research groups conducting environmental birth-cohort studies, both in Japan and in other parts of the world, working as a platform for information exchange among researchers.

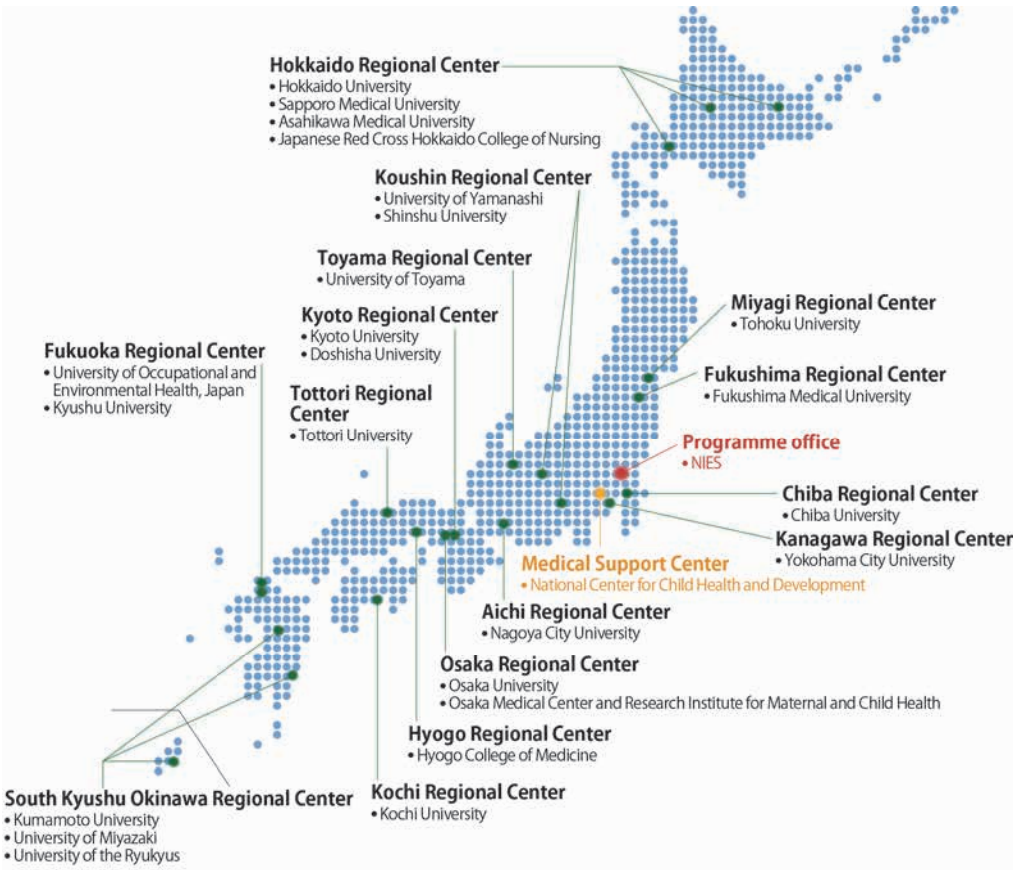


Fig. 1 JECS organizations.

4. Study protocols

The study protocols of JECS are demonstrated in the following papers:

1. Kawamoto T, Nitta H, Murata K, Toda E, Tsukamoto N, Hasegawa M, Yamagata Z, Kayama F, Kishi R, Ohya Y, Saito H, Sago H, Okuyama M, Ogata T, Yokoya S, Koresawa Y, Shibata Y, Nakayama S, Michikawa T, Takeuchi A, Satoh H and Working Group of the Epidemiological Research for Children's Environmental Health. Rationale and study design of the Japan Environment and Children's Study (JECS). *BMC Public Health* 2014;14:25 (doi: 10.1186/1471-2458-14-25).

2. Michikawa T, Nitta H, Nakayama SF, Ono M, Yonemoto J, Tamura K, Suda E, Ito H, Takeuchi A, Kawamoto T: Japan Environment and Children's Study Group.

The Japan Environment and Children's Study (JECS): A preliminary report on selected characteristics of approximately 10 000 pregnant women recruited during the first year of the study. *J. Epidemiol.* 2015;25(6):452–8. (doi: 10.2188/jea.JE20140186).

5. Activity report in FY 2016

The Main Study child participants reached the ages of 3 to 6 years in FY 2016. We administered questionnaires to their parents or guardians to collect a wide range of information, including details of the children's health and development, socioeconomic status, social capital, and exposures. The Sub-Cohort Study of 5,000 children continued. Home visits were made to members of the 3-year-old Sub-Cohort to collect indoor and outdoor air samples and house dust samples. Volatile organic compounds, aldehydes, acidic gases, and particulate matter were measured in the Sub-Cohort houses. House dust samples were analyzed for mite allergens and endotoxins. We completed the analyses of metal elements (mercury, lead, cadmium, manganese and selenium) in the mothers' blood samples (~100,000) and of a nicotine metabolite in the mothers' urine (75,000). The Programme Office also worked on coordinating developmental tests, pediatrician's examinations, and blood collection and testing of 2-year-old Sub-Cohort participants in cooperation with the Medical Support Center and the Regional Centers.

Risk Assessment Science Collaboration Office

The Risk Assessment Science Collaboration Office provides domestic leadership for the promotion of regulatory science with the aim of achieving a safe and secure society. The office consists of the Ecotoxicity Reference Laboratory and the Environmental Risk Assessment Task Office. The Laboratory conducts ecological toxicity research, international collaboration for the development of advanced testing methods, and standardization of test implementation. The Task Office conducts projects to assess environmental risks scientifically in collaboration with other organizations; it also constructs databases and disseminates knowledge and technical methodologies (Fig. 1).

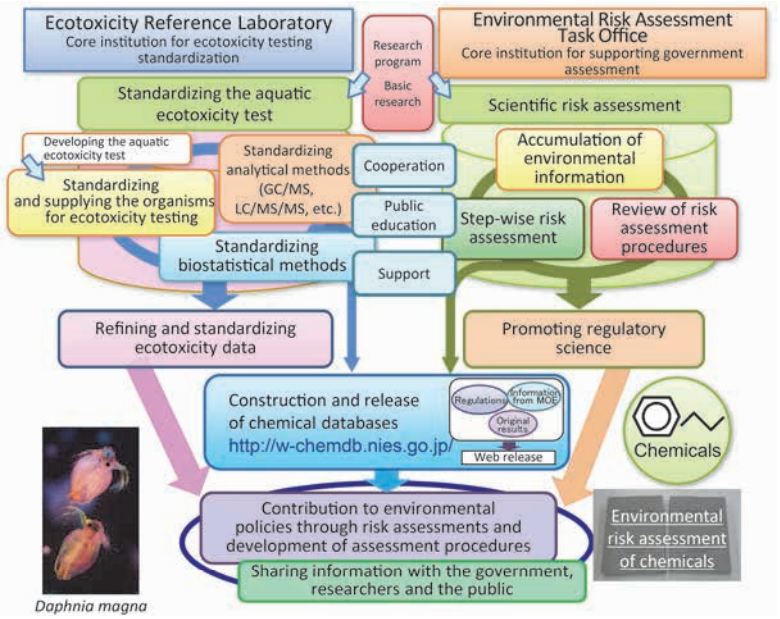


Fig. 1
The Ecotoxicity Reference Laboratory and Environmental Risk Assessment Task Office work in collaboration in regulatory risk assessment science through ecotoxicological testing, scientific risk assessment, and database development.

1. Ecotoxicity Reference Laboratory

As a leading reference laboratory for ecotoxicological research, the Ecotoxicity Reference Laboratory helps realize a safe society by proactively promoting regulatory science. Two kinds of new ecotoxicity test methods, namely a method of detecting antiandrogens by using medaka and a simple method of detecting juvenile-hormone-like chemicals by using *Daphnia magna*, were proposed by our laboratory this year for the OECD (Organisation for Economic Co-operation and Development). We performed a number of processes required for the acceptance of the two test methods as OECD guidelines. The two methods contribute to the EXTEND (Extended Tasks on Endocrine Disruption) 2016 project of the Ministry of the Environment (MOE), namely "Future correspondence regarding the endocrine-disrupting action of chemical substances."

The Laboratory continuously supplies stable test organisms for ecotoxicity testing in Japan. This year the homepage (http://www.nies.go.jp/kenkyu/yusyo/index.html),

which gives detailed information on how organisms are supplied, was further enhanced.

The Laboratory held two education seminars on ecotoxicity test techniques in FY 2016. The seminars covered test methods using fishes and crustacea, and each was attended by about 30 people from universities, local environmental laboratories, and private enterprise.

In collaboration with universities, local environmental laboratories, and private enterprise, the Laboratory also promotes ecotoxicity testing and performs scientific risk assessments (Fig. 2).

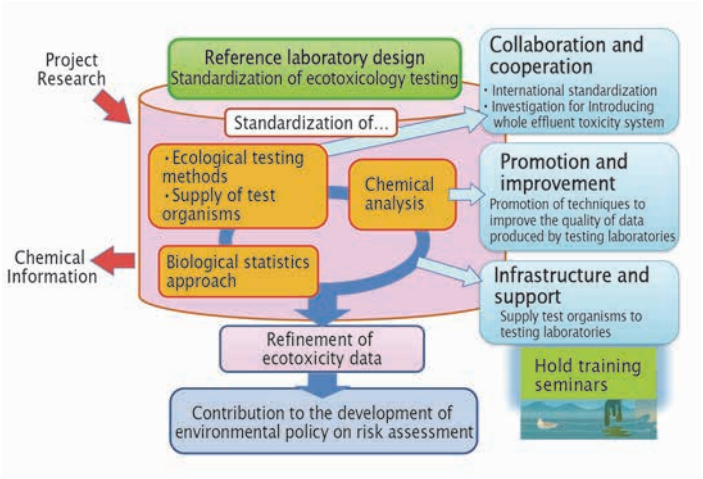


Fig. 2
The Ecotoxicity Reference Laboratory functions as a core organization for the standardization of ecotoxicity testing, both domestically and internationally.

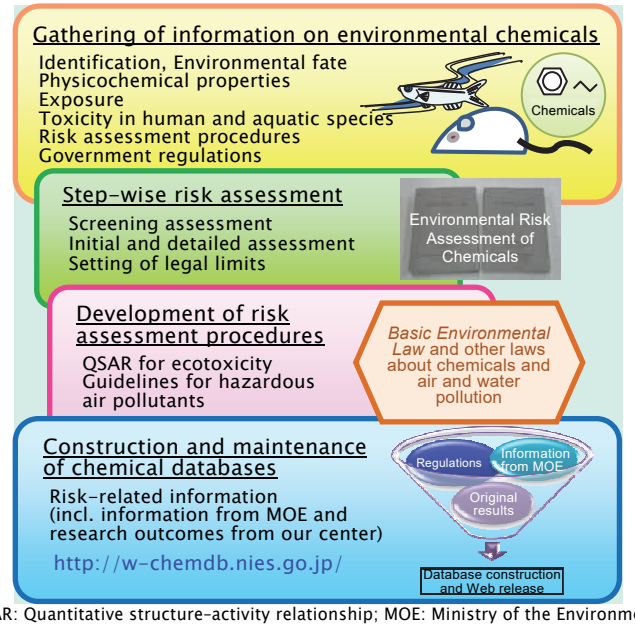
2. Environmental Risk Assessment Task Office

The Environmental Risk Assessment Task Office promotes research to support assessment and management of the risks posed by environmental chemicals. It also provides risk-related information to government and the public. The Task Office collects a variety of information on environmental chemicals and assesses their risks to support the risk assessments conducted under the laws enacted by the MOE. Our activities are outlined in Figure 3.

Under the revised *Chemical Substances Control Act*, all chemical substances, including existing chemical substances, must be screened to determine whether or not they need more detailed risk assessment (such as Risk Assessment I or II under the Act). The Task Office supports the implementation of screening assessments and more detailed assessments. In FY 2016, we evaluated 59 chemicals for screening. We also collected and evaluated information on the hazardous properties of 9 chemicals for Assessment II and 16 chemicals for Assessment I. The MOE publishes “Initial Environmental Risk Assessment of Chemicals” every year. In FY 2016, the Task Office supported the initial ecological risk assessment of 15 chemicals. To support the registration of withholding standards for agricultural chemicals on the basis of the *Agricultural*

Chemicals Regulation Law, toxicity information on 46 substances was collected and evaluated.

Fig. 3
Activities and research projects of the Environmental Risk Assessment Task Office.



QSAR: Quantitative structure-activity relationship; MOE: Ministry of the Environment

We have been improving the Kashinhou Tool for Ecotoxicity (KATE) as a QSAR (quantitative structure–activity relationship) model. External validation of KATE using about 200 new chemicals was performed in FY 2016. We have been continually updating our chemical substance databases and the related two websites in Japanese. The Webkis-Plus database contains information on about 10,000 substances, including their physicochemical properties; laws and regulations related to environmental pollution; environmental concentrations from surveys performed by the MOE; amounts of chemical substances manufactured and imported; volumes of agricultural chemicals shipped into each prefecture; PRTR (Pollutant Release and Transfer Register) info; and the results of risk assessments performed by several organizations. The EnvMethod database contains details about the analytical methods developed by the MOE for environmental surveys in Japan.

Climate Change Strategy Collaboration Office

As part of a climate change observation data project, to enhance the functions of the Secretariat of the Japanese Alliance for Climate Change Observation (JACCO) and promote the sharing and use of climate change observation information, the Climate Change Strategy Collaboration Office supported the operation of a Steering Committee composed of representatives of a wide range of Japanese agencies, namely the Ministry of the Environment (MOE); Japan Meteorological Agency; Cabinet Office; Ministry of Internal Affairs and Communications; Ministry of Education, Culture, Sports, Science, and Technology; Ministry of Agriculture, Forestry, and Fisheries (MAFF); Forestry Agency; Fisheries Agency; Ministry of Economy, Trade, and Industry; Ministry of Land, Infrastructure, Transport, and Tourism (MLIT); Geospatial Information Authority of Japan; Japan Coast Guard; and other 10 research institutes, including independent administrative institutions such as NIES. The Office also helped operate the Scientific Advisory Board, which provides scientific advice to the Steering Committee. Moreover, the Office has been operating the Scientific Working Group for Climate Change Adaptation Platform (WG for A-PLAT), which examines important issues such as observations of climate change from a scientific perspective, and the Scientific Working Group for the Standardization of Greenhouse Gas Observational Data (WG for GHG).

As part of a project to support an action plan for adaptation, in cooperation with WG for A-PLAT, the Office examined the development of tools to promote responses to climate change. As a result of this, a portal website named Climate Change Adaptation Platform (A-PLAT) was launched on 29 August 2016 (For more details see below.). A-PLAT is based on the National Plan for Adaptation to the Impacts of Climate Change, which was endorsed by Cabinet in 2015 to comprehensively and systematically promote coherent measures for adapting to a variety of climate change impacts within the whole government. A-PLAT provides a foundation for promoting adaptation efforts by municipalities, businesses, and members of the public working with the relevant ministries and agencies.

As an activity of the Low-Carbon Research Program and the Environment-Economy-Society Integration Research Program, young researchers invited from Indonesia and Thailand were trained in climate change model utilization. Models were introduced or improved to suit the circumstances in each country. In the second half of this fiscal year, the Office invited researchers from more than 10 Asian countries to share their results on the development and installation of models for mitigation and adaptation to realize a low-carbon society.

1. A-PLAT (Climate Change Adaptation Platform)

After exploring the development of tools to help improve the distribution and

convenience of Earth observation data and measures to counter climate change, the Office established A-PLAT as a project commissioned by MOE.

This portal website transmits information about adaptation to climate change impacts in an integrated way for the purpose of supporting local government, the private sector, individuals, and communities to take action. Its main contents are pages that introduce national and local adaptation plans and adaptation measures with respect to each area of impact; provide accessible and downloadable data sorted at the national and prefectural levels, such as observed climate data, future climate predictions, and projections of future impacts through several climate models; and collect documents on climate change impacts. Moreover, A-PLAT provides "Municipal Adaptation to the Impacts of Climate Change—Planning Guidelines" for local governments as a reference for their adaptation planning, and tips for individuals and communities on how to adapt lifestyles to climate change.

The S-8 project entitled "Comprehensive Study on Impact Assessment and Adaptation for Climate Change" is implemented by the Environment Research and Technology Development Fund of the Ministry of the Environment, Japan. In cooperation with participating research institutions, we have compiled a Project web page of National/Local Information showing the results of assessments of the impacts of climate change on agriculture, forests and forestry, water resources, natural disasters, and health. These data are provided in downloadable form.

At the time of the establishment of the portal website, MOE hosted a Climate Change Adaptation Platform Opening Symposium, "The Future Created by Adaptation—How to Adapt to Climate Change," co-hosted by NIES in Tokyo (Fig. 1). Along with officers responsible for the climate change adaptation of MOE, MAFF, and MLIT, Saitama Prefecture, which had been used as a model for the Local Government Support Project for Impact Assessment of Climate Change and Adaptation Planning (implemented by MOE in 2015), together with NEC Corporation, as a representative of the private sector, made presentations about adaptation measures to climate change impacts in each of the sectors defined in the Support Project. Next came an integrated discussion on the theme of "How to Adapt to Climate Change," in which one of the panelists, Dr. Yasuaki Hijioka, the Office leader, delivered a presentation on the adaptation measures implemented domestically and abroad with the introduction of A-PLAT. Despite bad weather

Fig. 1
There was a wide range of speakers at the Climate Change Adaptation Platform Opening Symposium, "The Future Created by Adaptation—How to Adapt to Climate Change."

conditions caused by the rapid approach of typhoon No. 10 toward the main island, 343 people attended the symposium.

The English version of the portal website was opened on 10 November, coinciding with the holding of the United Nations Framework Convention on Climate Change Conference of the Parties (COP)22. WebGIS was added on 31 March to provide map data in an easily understood way.

As of the end of March—7 months after its opening—the portal website (Fig. 2; http://www.adaptation-platform.nies.go.jp/en/index.html) had received 143,127 page views.

Fig. 2
The A-PLAT website.

2. Coordination of Steering Committee, Scientific Advisory Board, and working groups

The Steering Committee held its first meeting on 1 June 2016. Amendments to its opening procedure were approved in response to the proposed enhancement of the activities of JACCO after FY 2016. At the meeting, opinions were exchanged on efforts related to JACCO's activities this fiscal year, particularly with regard to A-PLAT. Moreover, measures associated with the adaptation of relevant ministries and agencies to climate change were introduced. At the second meeting, convened on 2 March 2017, an activity report on FY 2016 and a planning draft for FY 2017 were discussed. During this consultation, a number of projects, including the application and improvement of A-PLAT, the establishment of a new working group for observing and monitoring climate change and its impacts and promoting predictions, and preparations for the launch of the Asia Pacific Adaptation Platform were adopted.

The Scientific Advisory Board convened its first meeting on 14 June 2016. Efforts related to JACCO's activitie—in particular, the development of tools to support climate change adaptation measures and the mid- and long-term issues faced by A-PLAT—were discussed. The second meeting was held on 22 February 2017. A report was presented on activities this fiscal year, and a debate was held on the

Asia Pacific Adaptation Platform, which will be constructed in about 2020.

3. Asia-Pacific Integrated Model (AIM) Project and enhancement of partnership with Indonesia

In Indonesia and Thailand, NIES has conducted assessments by using models to examine the emissions reduction targets stated in the Intended Nationally Determined Contribution (INDC) submitted last year. To support these assessment efforts, four young researchers from Bogor Agricultural University and Bandung Institute of Technology (Indonesia) and Thammasat University (Thailand) were invited to NIES in July and trained in how to use the models. The models were introduced or improved to suit the circumstances of each country. Also, in January 2017, NIES held a training workshop for 23 participants from eight Asian countries at Thammasat University. To date, this project has trained more than 100 people since its launch in 1997.

As part of its international cooperation with domestic research institutes, NIES formed a consortium with the University of Tokyo (as a leading institute), Ibaraki University, and Nippon Koei to conduct an MOE contract job named "Support for climate change impact assessment with the purpose of provincial adaptation plan development in Indonesia." As part of its research into assessing climate change impacts, the consortium selected representative impacts of climate change in target areas (North Sumatra and East Java) and then implemented impact assessments regarding selected items. For example, to formulate and apply crop yield models, average observation and prediction data for temperature and precipitation, disaggregated for each regency, were prepared for both target areas. The 22nd AIM International Workshop was held at NIES in the second half of the fiscal year, from 9 to 11 December 2016. About 50 participants, including 25 researchers invited from more than 10 (mainly Asian) countries, attended the Workshop. The participants shared their achievements in developing and using comprehensive assessment models over the past year as part of mitigation and adaptation measures for realizing a low-carbon society. They discussed their research activities in relation to the upcoming IPCC report, titled "Global Warming of 1.5 ºC: an IPCC special report on the impacts of global warming of 1.5 ºC above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty."

Furthermore, as part of the MOE project, "Innovative Modeling and Monitoring Research toward a Low Carbon Society and Eco-Friendly Cities and Regions, 2016," our Office advanced the development of a social monitoring system for urban and industrial activities by using ICT (information and communication technology), and it discussed cooperating with Bogor Agricultural University, the Bandung Institute of Technology, the Indonesian Ministry of Environment and Forestry and Ministry of Industry, and the Bogor City administration. We

promoted the development and maintenance of a system for analyzing the energy consumption and behavior of residences, workplaces, and commercial facilities. We also obtained the cooperation of the city government to provide traffic information to the public through traffic monitoring by using GPS. NIES, in cooperation with Bogor Agricultural University, used the results of this monitoring to perform a scenario analysis of future low-carbon planning. Monitoring of industrial facilities was also launched in coordination with the Bandung Institute of Technology.

These research outcomes were communicated at international meetings hosted and co-hosted by NIES. In July, NIES, the University of Tokyo, and Bogor Agricultural University co-hosted an Environmental Innovation Research Workshop on the promotion of adaptation and mitigation action plans in Indonesia. Dr. Tsuyoshi Fujita, the director of the NIES Center for Social and Environmental Systems Research, delivered a presentation titled “The role of an innovative MRV [measuring, reporting, and verification] system to promote low carbon city development.” He explained the progress and future development of research into the construction of MRV systems in Indonesia, and he made recommendations on the research approach to analyzing mitigation actions that will meet local needs. Moreover, at the abovementioned Workshop, Professor Kensuke Fukushi of the University of Tokyo gave a presentation on integrated mitigation and adaptation measures and Professor Rizaldi Boer of Bogor University gave a presentation on a framework for international cooperative research into adaptation and mitigation. Research presentations were made at the STS (Science and Technology in Society) forum in Kyoto in October, at the 8th Meeting of the Regional Action on Climate Change (held the day before the forum), and at the Asia-Pacific Eco-Business Forum in Kawasaki in February. Through overseas meetings such as the 5th Annual Meeting of the Low Carbon Asia Research Network in Bandung, Indonesia, and the International Conference on Chemical Engineering at the Bandung Institute of Technology, NIES was able to promote cooperation in research.

Furthermore, at the 2nd International Forum on Sustainable Future in Asia, organized by NIES and held in Indonesia in January, our Office facilitated a session on “Synergizing Adaptation and Mitigation Actions” and delivered a presentation on technical and political approaches to promoting adaptation and mitigation measures.

NIES representatives have had a series of discussions with the Climate Change Agency of the Ministry of Environment and Forestry, Indonesia, to outline the efforts of Bogor as a model low-carbon city. We have also been furthering our consultations with the Indonesian Ministry of Industry on industry monitoring and our discussions with experts in factory operation in the industrial parks around Jakarta.

Back home, we have had a variety of opportunities to promote cooperation on climate change mitigation and with other organizations, including in the Kitakyushu Research Complex Program in August; at the German–Japanese Energy Local Government Symposium in Shinchimachi, Fukushima in November; in the Eco-model Cities project in Oguni, Kumamoto; and in the Action plans of local governments in Fukushima Prefecture.

Environmental Emergency Management Office

Through research collaboration with relevant organizations in Japan, this office implements projects aimed at supporting effective and efficient environmental emergency management by emergency response personnel. This includes building and operating institutional and information network systems that serve as a foundation for developing environmental emergency management strategies, training personnel to develop practical expertise in environmental emergency management, providing on-site support for disaster responses, setting up research hubs for environmental emergency management, and training researchers.

More specifically, this office is establishing a new platform for enabling domestic institutions to cooperate in collecting and organizing the experiences and lessons gained from tackling environmental issues caused by past disasters, and in efficiently and effectively organizing new knowledge derived from environmental emergency management research. The office will focus in particular on the smooth management and operation of the central government's Disaster Waste Treatment Support Network (D.Waste-Net), and on building emergency environment monitoring systems centered on regional environmental research institutions.

This year, we have especially made a great effort to establish a system of contributing to efficient and effective disaster-waste management. Below are the main results of our efforts.

1. Provision of on-site support for disaster responses in the Kumamoto earthquake

The Kumamoto earthquakes (Fig. 1) struck in April 2016, including a main shock with an intensity of 7 on the Japanese seven-stage seismic scale. The quake caused extensive damage to many buildings and has resulted in the generation of huge amounts of disaster waste, estimated at about 3 million tonnes.

Our office immediately sent an expert on-site to investigate the situation in the affected area. We kept the expert on-site for several months to support the local government's disaster waste management responses. Our support was conducted in cooperation with the Ministry of the Environment under D.Waste-Net.

Examples of the support given were advice on:

a) How to separate many kinds of waste at a short-term waste storage site.
b) How to make a plan for implementing disaster waste management.
c) How to perform environmental monitoring for asbestos.

Fig. 1 Houses damaged by the Kumamoto earthquake (left) and a short-term waste storage site (right)

2. Training local government personnel to develop practical expertise

Human resources are key to properly enhancing our potential to manage disaster waste in real, unexpected disaster situations. Our office provides training programs for local government personnel to develop practical expertise. This year we offered a special training program for personnel from Hyogo Prefecture in which the trainees could virtually experience actual responses in disaster waste management (Fig. 2). The program was developed on the basis of our research. By participating in the program, trainees were able to gain an abundance of knowledge and know-how on how to properly implement the tasks required in an emergency.

In addition, we advised other local governments, such as Saitama, Mie, Shizuoka, and Nara prefectures, on how to design and run an effective training program appropriate to their needs.

We also designed an on-site training program, which we have run at actual damage sites. This year we ran the program in Kumamoto Prefecture, where the large earthquake took place. Many trainees from other local government areas participated. They were able to learn the realities of disaster waste management by touring relevant facilities and talking to personnel from the damaged local government area.

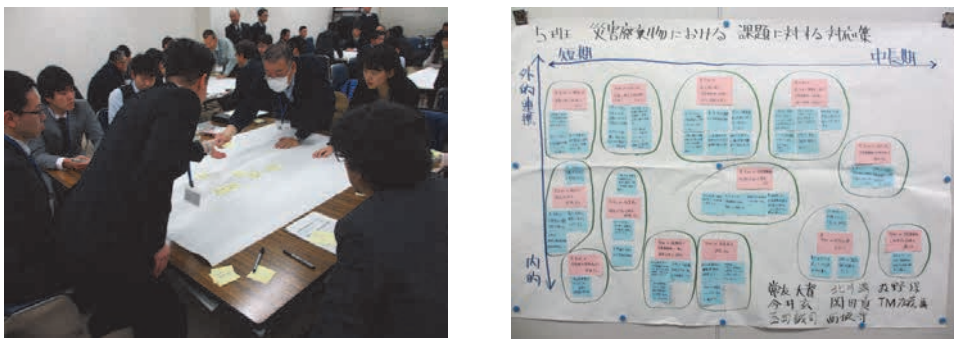


Fig. 2 Scenes of a training program held in Hyogo Prefecture

3. Implementing a disaster waste information platform

We have established a disaster waste information platform and provide a lot of useful knowledge and information to relevant stakeholders, such as local government and relevant private companies (Fig. 3). The platform has been utilized not only by local government to plan their disaster waste management but also by relevant consulting companies to provide support for local government.

The following types of information are provided from the platform:

a) Lessons and strategies learned from central and local government responses to past disasters.
b) Appropriate technologies adopted and applied in past disasters.
c) Data useful for making disaster waste management plans.
d) A movie explaining basic information on disaster waste management for e-learning.

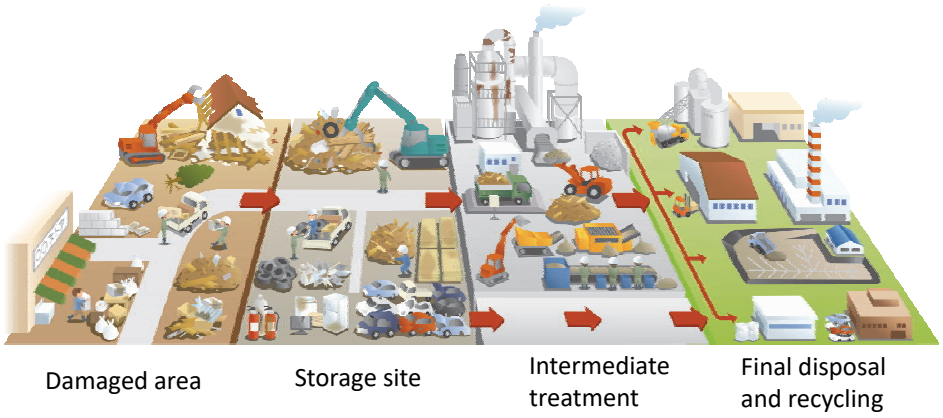


Fig. 3 Schematic illustration of disaster waste management flow

Social Dialogue and Co-production Office

1. About

To encourage dialogue between members of society and NIES about awareness of environmental problems and the current state of environmental research, the Social Dialogue and Co-production Office (DaC) will accumulate and analyze our communication experiences to date and will develop new content for interacting with the public by using social media and other means. Furthermore, DaC will hold events such as stakeholder meetings and science cafés on NIES activities. Through these communication opportunities, it will get feedback from participants on NIES research activities. DaC will use these means to build a relationship of mutual trust between society and environmental researchers (Fig. 1)

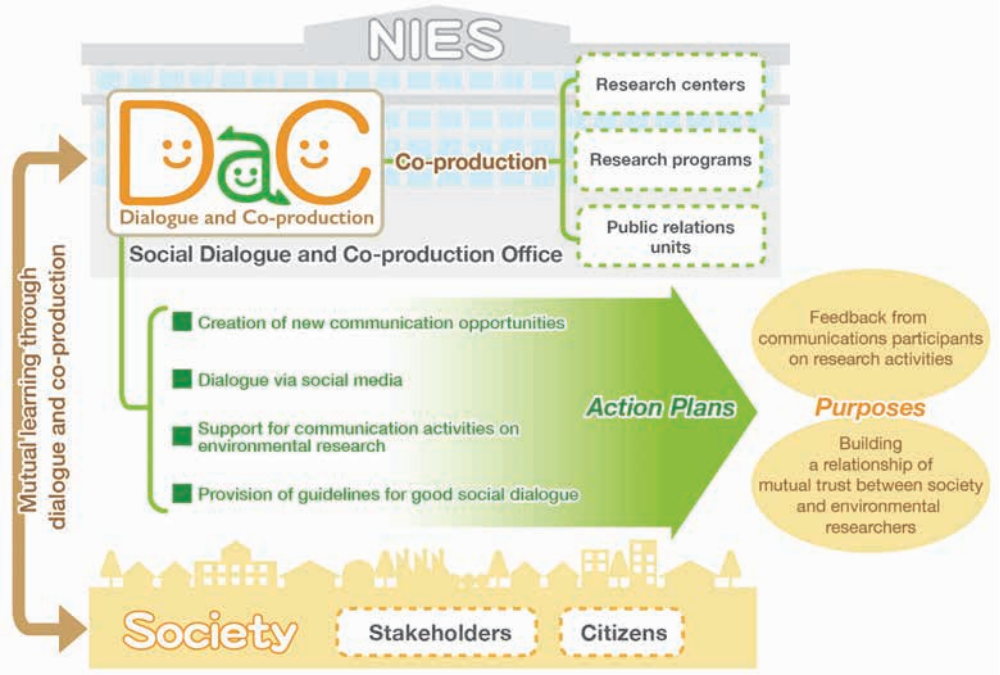


Fig. 1 Action plans and purposes of DaC. There are four activities that involve mutual learning between NIES and members of society. Through these activities, DaC can accomplish its purposes, namely to get feedback from society on NIES research activities and to build a relationship of mutual trust between society and environmental researchers.

2. Major activities in 2016

2.1 Creation of new communication opportunities

DaC held two kinds of social dialogues, namely a stakeholder meeting to which we invited outside experts and science cafés where researchers and members of the public could talk frankly with each other.

2.1.1 Stakeholder meeting

To exchange views with researchers on NIES activities and environmental issues, five stakeholders from sectors like business, media, and civil society were invited. They expressed the following opinions:
(1) There are gaps between scientific research and policy-making, and between policy-making and social action. NIES should address how to overcome these gaps and promote pro-environmental thinking and actions in society.
(2) It is important to design ways to utilize feedback from society in our research activities.

2.1.2 Science cafés

DaC held four cafés as one of the programs during the NIES Open House (Fig. 2). The themes were "Low-carbon," "Material cycles," "Biodiversity," and "Environmental risks" and were drawn from the issue-oriented research programs started in FY 2016. Two researchers gave presentations at each café, and a total of about 80 people participated. DaC and NIES researchers were thereby able directly to take the public reaction to these NIES activities.

Fig. 2 About 80 members of the public participated in the science cafés and enjoyed talking with researchers.

2.2 Support for communication activities

DaC supported communication activities in other research centers or programs at NIES, such as the following.

2.2.1 Science café at Fukushima Branch

A science café was held to mark the establishment of the Fukushima Branch in July. DaC supported the café from planning to implementation. Two researchers from the branch talked about their environmental emergency research activities with more than 40 local residents of the Fukushima area.

2.2.2 Communications seminar for NIES staff

DaC invited one of the office's advisors, Soichi Ueda, to lecture at a seminar held for NIES staff on social communications. It was a good opportunity for participants to learn how to deliver their messages to the public effectively.

2.3 Accumulation of communication experience at NIES

To create guidelines for good social dialogue, DaC plans to create opportunities to accumulate and analyze staff members' communication experiences at NIES. As a first step, DaC held a workshop so that staff could listen to each other's experiences. A variety of difficulties—especially in dialogue with non-academic people—were revealed, and some researchers with a lot of experience gave advice on good communication.

3. Future issues

Over the past year DaC has been preparing to use social networking services (SNS) to interact with many more members of the public. It will start contributing to SNS sites in 2017.

It is also important to strengthen internal cooperation between DaC and the public relations units at NIES. To do this, DaC will not only maintain a number of information resources on NIES research activities but will also help NIES units to interactively communicate with stakeholders more effectively.

Basis for Environmental Research

Center for Global Environmental Research

The global environment is essential for human life. Climate change, including global warming caused by increasing atmospheric greenhouse gas (GHG) concentrations, together with changes in the stratospheric ozone layer, has serious impacts on all ecosystems and also on humans. Considering the seriousness of the predicted impacts, it is vital that we take measures to conserve the global environment towards establishing a sustainable society with lower emissions of GHG-related materials. Because it takes a long time for the environmental impacts of human activities to manifest, it is essential that we adopt a long-term perspective and recognize the importance of mid- and long-term continuous research.

For these reasons, the Center for Global Environmental Research (CGER) conducts strategic environmental monitoring across the atmospheric, oceanic, and terrestrial domains and distributes the resulting data through environmental databases. CGER also implements proactive and predictive research on the global environment, develops new technologies, and conducts pioneering and fundamental research, especially in the field of climate change. CGER supports collaborative studies among domestic and international organizations, disseminates the various scientific findings, and facilitates mutual understanding to raise public awareness of global environmental problems.

1. Long-term monitoring of GHGs and other trace gases

Atmospheric GHGs (e.g. CO_2, CH_4, and N_2O) and other trace gases (e.g. CO, NOx, and SOx) are monitored from various platforms to determine the long-term variations in their concentrations and their 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 eastern Hokkaido). Commercial ships operating between Japan and Australia, New Zealand, North America, and Asian countries are used to observe the latitudinal or longitudinal distributions of GHGs and the partial pressures of CO_2 in the surface waters of the Pacific. Routine samplings are conducted from aircraft over three sites in Siberia to measure the vertical distributions of GHGs. UV-A and UV-B on the ground are monitored, and real-time UV indexes obtained at 15 sites in Japan are available to the public via our web page. To detect the effects of global warming on the marine environment, the distributions of tropical reef corals and the DNA clades of the symbiotic algae Zooxanthellae around Japan are monitored.

Fig. 1
Mt. Fuji Weather Station, where our CO_2 system is installed.

A battery-operated CO_2 measurement system was developed and has been used since 2009 to monitor atmospheric CO_2 concentrations at the summit of Mt. Fuji (3776 m a.s.l.) (Fig. 1). The seasonal variations on Mt. Fuji were almost the same as those observed by the CONTRAIL (Comprehensive Observation Network for Trace Gases by Airliner) project (Fig. 2). Therefore, we concluded that the summit of Mt. Fuji was a suitable location for sampling free troposphere air throughout the year. The seasonal amplitude of CO_2 concentrations on Mt. Fuji was about 18 ppm higher than that at Mauna Loa observatory (MLO) in Hawaii (Fig. 2). This is because, in both summer and winter, the air at the summit of Mt. Fuji is influenced more by events over the Eurasian continent than is the air at MLO.

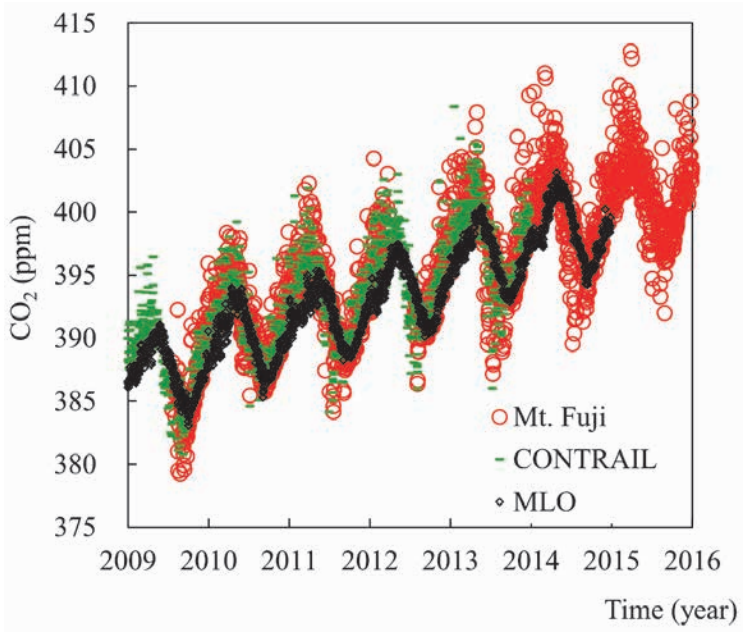


Fig. 2 Daily average CO_2 concentrations observed on Mt. Fuji, by aircraft (CONTRAIL) and at Mauna Loa observatory (MLO) in Hawaii.

2. Ozone layer research project

The objectives of this project are to investigate changes in the ozone layer due to increases or decreases in the levels of ozone-depleting substances and GHGs in the atmosphere, their effects on climate, and the interaction between ozone change and climate change, thus contributing to Earth environmental research. To achieve these objectives, we analyze global meteorological data and ozone concentration data observed by satellites and ground-based instruments, and we have developed numerical models that can project future ozone and climate changes and simulate past ones. These models are the chemistry–climate model and the chemical transport model.

Topics from this project include the simulation and analysis of a low total ozone event at Rio Gallegos, Argentina (51.6°S, 69.3°W) in November 2009. This year, we have focused on the processes of interaction between this low ozone event in the stratosphere and the dynamic field in the troposphere. Figure 3 indicates that there was an ozone hole advection (polar vortex advection) toward the South American continent in November 2009. Accordingly, there was an anomalously large blocking in the troposphere to the west of the South American continent, as indicated by the large positive geopotential anomalies in the panel at right. A wave activity flux analysis indicated that large wave fluxes were emitted from the blocking region in the troposphere and propagated to the stratosphere over South America in association with the ozone hole advection. These kinds of process studies of past events may be useful for increasing the reliability of numerical predictions or projections of low ozone events over South America in the future by using chemistry–climate models.

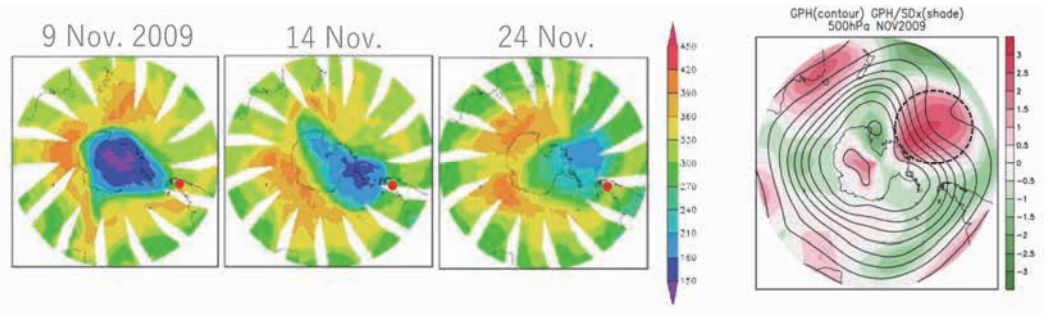


Fig. 3 (First three panels from left to right) Polar map of total ozone distribution in the Southern Hemisphere on 3 days in November, as observed by Total Ozone Mapping Spectrometer. Color scale is in Dobson Units. Rio Gallegos (51.6°S, 69.3°W) is indicated by the red dot. (Right panel) The 500-hPa geopotential height anomaly from the 1979–2015 mean in the Southern Hemisphere in November 2009, as calculated from ERA-Interim reanalysis data. The anomaly is indicated as a ratio to the standard deviation in each grid. The blocking region is indicated by the black-dotted circle to the west of the South America continent. GPH, geopotential height.

3. Impact of global warming on soil carbon dynamics

To examine the long-term effect of global warming on soil organic carbon (SOC) decomposition in Asian monsoon forests, from the end of 2008 until 2014, we conducted a soil warming experiment in a multichannel automated chamber system (15 chambers) in a 55-year-old warm-temperate evergreen broadleaved

forest in Miyazaki University Forest in southern Japan. To analyze the effect of warming on SOC decomposition, we installed 10 chambers in trenched plot: five chambers were used to measure heterotrophic respiration (R_h), and the other five chambers, which were placed in a warmed trenched plot, were used to measure warmed R_h (R_{hw}). The soil was warmed with an infrared heater above each chamber to increase the soil temperature at 5 cm depth by about 2.5 °C. A stimulatory effect of soil warming on R_h was observed continuously during the 6-year experiment period (Fig. 4). The annual warming effect (the rate of increase in R_h per °C) ranged from +7.1% to +17.8%. Although the warming effect varied among years, the average value of +9.4% $°C^{-1}$ was close to the value of 10.1% that we calculated by using a simple annual temperature–efflux response model. In addition, Q_{10} (the rate of increase in R_h when the soil temperature was raised by 10 °C) in the warmed treatment was 2.92 (range, 2.74 to 3.23); this value was larger than the Q_{10} (range, 1.45 to 2.61) used in CMIP5 (Coupled Model Intercomparison Project phase 5) Earth System Models. Furthermore, the inter-annual warming effect was positively related to the total precipitation in summer, indicating that summer precipitation and the resulting increase in soil moisture level also strongly influenced the soil warming effect in this forest. Our findings imply that the feedback from the terrestrial ecosystem in the Asian monsoon region to global warming might be stronger than expected. Moreover, our results suggest that the strength of SOC–climate feedback may be currently underestimated because of the application of a low Q_{10} in the CMIP5 Earth System Models.

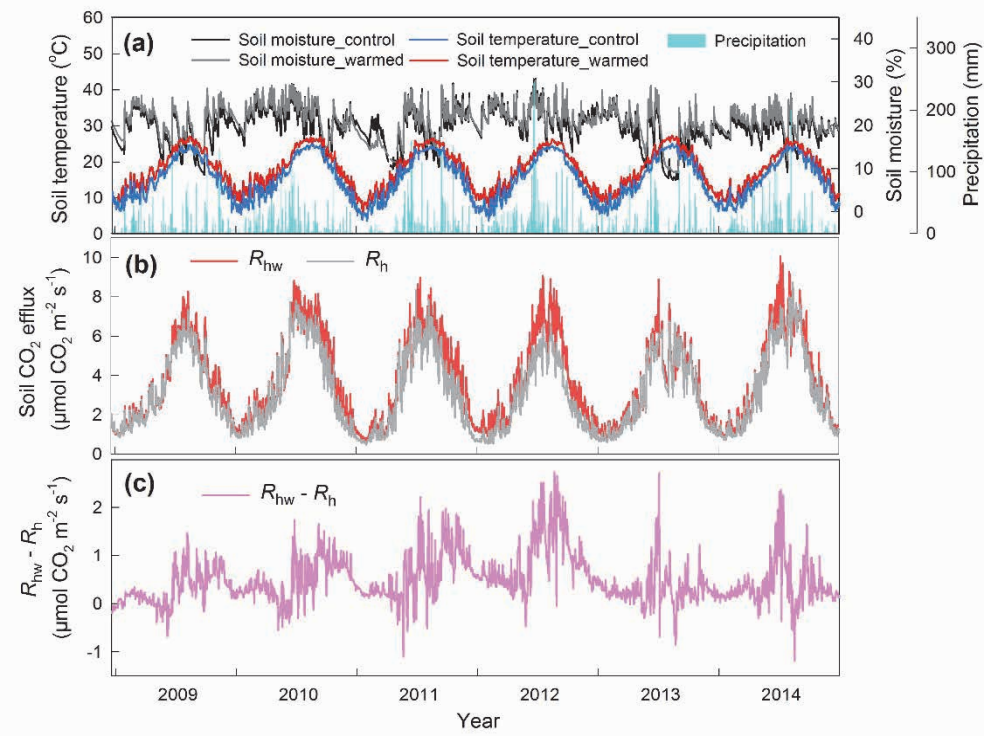


Fig. 4 Seasonal changes in (a) soil temperature (at a depth of 5 cm) and soil moisture content (at a depth of 10 cm); (b) soil CO_2 efflux (heterotrophic respiration (R_h) and warmed R_h (R_{hw})); and (c) the difference in efflux between R_{hw} and R_h.

Center for Material Cycles and Waste Management Research

The Center for Material Cycles and Waste Management Research has conducted a variety of research to establish a political and academic base in the fields of materials cycling and waste. Currently our focus is the current state of, and mechanisms behind, the structure of material flows and the associated environmental burdens imposed by socioeconomic activities at local to international scales.

We intend to propose assessment methods and strategies for shifting to a sustainable, sound material-cycle society. We are also evaluating technologies and systems for treating and recycling waste and recyclable materials in Japan and other countries, and we are developing fundamental technologies for materials recycling and substance control in waste treatment and recycling processes.

1. Institutional and policy research on systems and measures for shaping a sound material-cycle society

Two studies were performed this year as part of our policy research for a sound material-cycle society. The aim of one was to develop a framework of behavioral changes toward such a society. We reviewed existing behavior models and Japanese environmental policy from the 1990s onward and identified three approaches: (1) providing information to influence behavioral intentions, (2) making systemic changes to remove or lower barriers to certain behaviors, and (3) utilizing behavioral intentions other than environmental motives.

The other study examined responsibility in a sound material-cycle society. It included research into extended producer responsibility (EPR) and financial responsibility in waste management. As part of the EPR research, we interviewed experts and knowledgeable stakeholders in Japan and discussed the concept of EPR and underlying differences in their perceptions of the concept. The updated OECD EPR guidance manual was published in 2016, and we translated it into Japanese in collaboration with the Institute for Global Environmental Strategies (IGES) and disseminated a Japanese summary version through the NIES website.

2. Dynamic analysis of international material cycles and assessment of their environmental, economic, and social impacts

We have developed a top-down method to estimate the amount of metal stock in each country in the world. The method first calculates apparent consumption, focusing on the material balance in a country, as determined from mining data and imports and exports of metals through international trade. These data are then converted to the stock of metal, taking into consideration the percentage waste of the metal during manufacturing processes. We have also developed a visual way of describing the dynamics of metal flows and stocks year by year.

We used a regression analysis to examine the socioeconomic drivers of international physical flows of neodymium, cobalt, and platinum. A gravity model of trade, which has been widely employed in economics, was used as the regression specification. We selected explanatory variables based on economic scale, distance, technology, and supply, and we related these to the use of the metals. The regression analysis revealed that gross domestic product per capita, population, and distance between exporter and importer regions were statistically significant in explaining the global flows of these critical metals, and that the impacts of supply- and technology-related variables were substantial. The proposed method, which emphasizes changes in socioeconomic factors, could be used in projections of critical metal flows and to support policymaking initiatives focused on ensuring a stable supply of these metals in terms of the dynamics of the identified drivers.

3. Developmental and survey research on various types of fundamental technologies required for resource recycling and materials management

We developed *in vitro* assays to assess the bioaccessibility of ingested chemicals contained in products and waste as an indicator of subsequent human exposure, and we then evaluated the reliability and validity of the assays by using standard samples.

To implement environmentally sound management of waste containing newly listed persistent organic pollutants (POPs) such as polybrominated diphenyl ethers, polychlorinated naphthalenes, and pentachlorophenol, it is important to gather detailed information on their content in end-of-life products and recycled materials in Japan. Therefore, we conducted field surveys at several plants where waste household electrical appliances were recycled or woodchips were manufactured from waste timber to determine the concentrations of such POPs in recyclable resources.

We investigated an analytical procedure for distinguishing asbestos fibers from cleavage fragments in asbestos-containing building materials by using a scanning electron microscope.

We tried to develop a technology for regenerating nickel-metal hydride (NiMH) secondary batteries by using high pressure. We found that storage of a NiMH battery under high pressure (over 3 MPa) prolonged its lifetime. We also investigated the effects of the pressure value and timing of high-pressure storage during charge–discharge cycles on lifetime improvement of the battery.

4. Advancement of testing and evaluation management systems related landfill disposal and the use of wastes and byproducts as construction materials

We performed microscopic observations of thin specimens of soils originating from marine sediments. We confirmed the presence of framboidal pyrite in the soils and estimated the amount of arsenic accumulated in the pyrite (Fig. 1). We proposed a draft method of judging whether soil arsenic contamination is artificial or natural by observing the microscopic change between before and after exposure to 1 mol/L hydrochloric acid.

We also used microscopic observation to identify secondary minerals formed on the surface of municipal solid waste incinerator ash after aging treatment, and we discussed the possibility that calcium carbonate generated on the ash surface inhibits the leaching of lead.

With the aim of early remediation of offshore landfill sites, we started a demonstration test and established a system for verifying the effectiveness of a full drainage layer on a field scale. It takes about 1 year to obtain clear results; therefore, this financial year we have begun discussing the initial behavior of the landfill site to which the full drainage layer was applied.

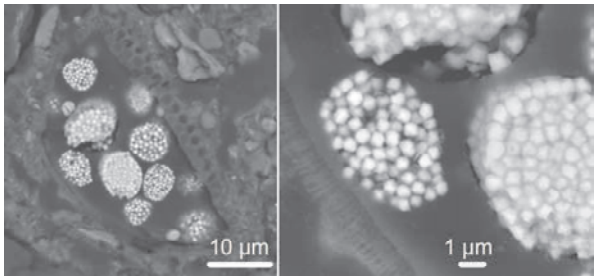


Fig. 1 Framboidal pyrite observed in soil particles originating from a marine sediment and formed in the remains of diatoms.

5. Fundamental research into the application of waste management technologies in Japan and overseas

We are studying fundamental technological issues of improving waste management systems in Japan and Asia.

As an example of our work in FY 2016, we investigated improvements in biological hydrogen production from biomass waste. An electrochemical bioreactor system that converts electrons produced from anaerobic degradation of the organic fraction of municipal solid waste (OF-MSW) into hydrogen was developed (Fig. 2). A semi-continuous experiment using the reactor system demonstrated that the hydrogen yield from OF-MSW was more than 10 times that obtained in fermentative hydrogen production.

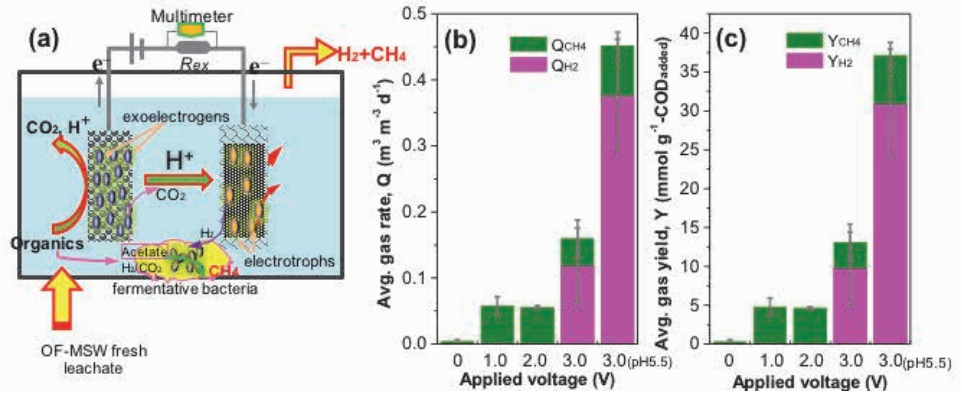


Fig. 2 Schematic diagram of the electrochemical bioreactor (a). The hydrogen production rate *Q* (b) and the yield *Y* (c) at different voltages are shown.

6. Waste management research collaboration and research into practical projects in Asian countries

6.1 Project on Appropriate Solid Waste Management toward Flood Risk Reduction in Tropical Asian Urban Areas through Recovery of Drainage Function

This project has been approved and funded by the APN (Asia-Pacific Network for Global Change Research) from 2016 to 2018. With counterpart researchers in Thailand and Vietnam, we have been conducting field surveys in Bangkok and Hue.

6.2 Expert contributions to waste-management-related technical committees for ISO standardization

We have been actively contributing as experts to the technical discussions of the ISO Technical Committees on waste collection vehicles (TC297) and Solid Recovered Fuels (TC300). We have been studying the European solid recovered fuel (SRF) market situation, SRF production technology, and its related regulation and policies.

6.3 Formulation of an ASEAN project on integrated domestic wastewater management

In identifying a need to achieve integrated domestic wastewater management in ASEAN (Association of Southeast Asian Nations) countries, we, together with the Indonesian Government and the ASEAN Secretariat, have been formulating a multi-stakeholder policy dialogue project under the Japan–ASEAN Integration Fund scheme.

Center for Health and Environmental Risk Research

The Center for Health and Environmental Risk Research conducts research in the Environmental Risk Research Field and Environmental Health Research Field. The two research fields form the basis of two projects administered by the Risk Assessment Science Collaboration Office (RASCO) and the Japan Environment and Children's Study (JECS). The Center leads the Health and Environmental Safety Research Program with other research centers. Here, we report the current outcomes of research in the environmental risk and environmental health research fields.

1. Upgrade of ecotoxicity testing and development of a novel system to evaluate the ecotoxicological effects of chemicals

We developed a daphnia chronic toxicity prediction model by using a QSAAR (quantitative structure activity–activity relationship) based on daphnia acute toxicity, chemical structure descriptors, and physicochemical properties. Test methods were also developed for an amphipod and daphnia multi-generation test, the toxicities of mixtures of chemicals were examined, and methods of preparing aquatic solutions of difficult-to-test chemicals were investigated to help standardize and upgrade risk assessment under the Chemical Substances Control Law (CSCL) and the Agrochemicals Control Act. An adverse outcome pathway was also investigated for daphnia juvenile hormone agonists. In addition, ambient water samples were collected from more than 10 sites, mainly in eastern Japan, and used to conduct short-term chronic toxicity tests using daphnia based on a draft effluent test method published by MOE and NIES in 2013. Finally, an algorithm for efficient ecotoxicity testing of new chemicals under the CSCL was proposed on the basis of IATA (integrated approaches to testing and assessment).

2. Fundamental study of integrated approaches to assessing chemical exposure and environmental effects

In this area of study, we aimed to develop advanced analytical methods for detecting multiple chemical contaminants in environmental media. Our focus was chemicals such as mutagenic or carcinogenic substances, biological macromolecules, or substances with ligand–receptor binding activity, and our goal was to assess the relationships between chemical exposure and effects on organisms and humans. This fiscal year we conducted three studies. The first investigated the relationship between a urinary biomarker of pesticide exposure and menstrual cycles in Japanese women. The second made advances in research into the relationship between genetic alterations caused by chemical exposures at the early life stage and the development of cancer or late effects. In the third study we developed an analytical method to determine dietary acrylamide concentrations and performed a 24-h duplicate diet study to estimate dietary exposure to acrylamide in Japanese adults (Fig. 1). The acrylamide exposure

estimated on the basis of our duplicate diet samples was similar to our previous estimation, obtained last year by using a modeling approach. The diet study also showed that consumption of coffee was an important contributor to dietary exposure to acrylamide in participants.

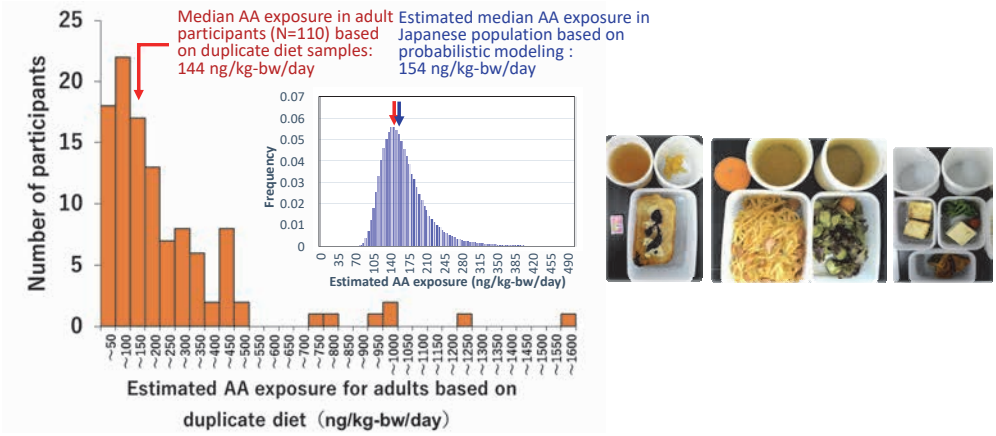


Fig. 1
(Left) Distribution of estimated dietary acrylamide (AA) exposure based on the duplicate diet study. (Right) Examples of duplicate diet samples collected from diet study participants.

3. Investigation of hydrogen sulfide in Tokyo Bay and its possible impacts on benthic organisms

We conducted monthly field surveys in Tokyo Bay from 2014 to 2016 to elucidate the distribution of hydrogen sulfide in the water column and bottom sediment and its possible impacts on benthic communities in the bay. Markedly high concentrations (approximately 80 mg/L at maximum) of hydrogen sulfide were detected in the bottom sediment of the northern part of the bay in summer and autumn. Meanwhile, trace levels (0.1 to 0.8 mg/L) of hydrogen sulfide were detected in the bottom water in the northern part of the bay in September 2016, suggesting release of hydrogen sulfide from the bottom sediment to the water column. To assess the impacts of hydrogen sulfide, as well as hypoxia, on benthic communities, we also performed laboratory experiments with originally designed and manufactured experimental exposure tools, using early-life stages of the Manila clam (*Ruditapes philippinarum*) and greasyback shrimp (*Metapenaeus ensis*). The tolerance of the early-life stages of the two species to hypoxia and hydrogen sulfide differed; generally, the greasyback shrimp was much more sensitive than the Manila clam to hydrogen sulfide, implying that mass mortalities of these crustaceans could occur with extensive occurrences of blue tides (i.e. upwelling of hypoxic water masses containing hydrogen sulfide in shallow coastal areas).

4. Basic study for strategic risk management

We are studying the aspects important for modeling the environmental fate and emissions of chemicals; assessing exposure to, and risks posed by, environmental chemicals; assessing the ecological impacts of environmental disturbances; and

systematically managing the risks to health and the environment posed by environmental chemicals while taking into consideration the many risk factors.

This fiscal year we performed studies on modeling the global fate of mercury; predicting the behavior of radioactive elements in urban environments; modeling the emissions of pharmaceuticals; processes of emission of flame retardants from products; environmental monitoring during and after accidents and natural disasters; the bioaccumulation of chemicals in the aquatic environment; the impacts of chemicals on the community structures of benthic animals in the field; and managing wild mammals in cooperation with local governments. We utilized the results as the basis for research projects in Issue-Oriented Research Programs and for projects related to the strategic management of risks. In the chemical bioaccumulation study, we developed exposure systems and experimental procedures to study the transfer kinetics of perfluoroalkyl acids to a marine polychaete sandworm species, and we conducted a preliminary exposure experiment.

5. Fundamental study of integrated health risk evaluation

This fundamental study aims to develop biomarkers of neurotoxicity, immunotoxicity, reproductive and developmental toxicity, genotoxicity, and inhalational toxicity on the basis of the physicochemical characteristics of harmful environmental substances such as nanomaterials, PM2.5, and metals.

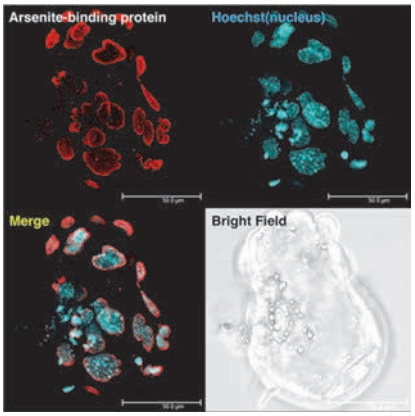


Fig. 2
Representative images of a pre-implantation mouse embryo at about the blastocyst stage, cultured *in vitro*. Subcellular localization of arsenite-binding protein (red) is visualized by immunofluorescence staining. Images were reconstructed as 3-D z-stack images. Scale bars, 50 μm.

We have made progress in developing an advanced method for assessing neurotoxicity by using neurospheres (free-floating clusters of neural stem cells); examining the reproductive toxicity of arsenite in mouse embryos (Fig. 2); analyzing the dynamics of particles undergoing endocytosis; and studying the inhalation toxicity and deposition efficiency of airborne particulate matter by using an *in vitro* air–liquid interface exposure system.

6. Genome-wide analysis of DNA methylation changes in human blood genomic DNA in chronic arsenic exposure in Bangladesh

Naturally occurring inorganic arsenic has been causing serious health problems, such as cancer, in many Asian countries and other areas of the world. We aim to establish epigenetic markers to detect adverse biological effects of arsenic by analyzing the DNA methylation levels of affected genes. Recently, we found that chronic arsenic exposure was inversely associated with LINE-1 (long interspersed nucleotide element 1) methylation. This year, to find other DNA methylation makers, we used Infinium MethylationEPIC BeadChips (Illumina) to perform a genome-wide analysis of DNA methylation changes in the blood DNA of people living in arsenic-endemic and non-endemic areas of Bangladesh. The genome-wide analysis revealed changes in the DNA methylation levels in several regions of the blood DNA of people in arsenic-endemic areas compared with those in people in non-endemic areas. Furthermore, we established experimental conditions for measuring DNA methylation levels in these DNA regions by using pyrosequencing. These regions may be promising new DNA methylation markers to screen for people exposed to arsenic.

7. Fundamental evaluation of the health impacts of environmental factors

This fundamental study aims to develop methodologies for evaluating the neuropathological and social behavioral effects of environmental factors. Its goal is to help identify health-threatening chemicals, reduce the adverse effects of environmental chemicals, and develop precautionary approaches to these threats.

This financial year, we evaluated the effects of organic aerosols and carbon-based particulate matter by using a novel object-recognition test in mice. We also performed highly sensitive measurements of organic chemicals such as diphenylarsinic acid in the rodent brain, evaluated the neurobehavioral toxicities of organic chemicals and new pesticides such as neonicotinoids, and developed novel *in vitro* test methods using differentiated cells to assess the adverse effects of chemicals.

8. Human biomonitoring and exposure factors

Human biomonitoring is a technique that is used widely to characterize our exposure to chemical substances. It employs direct measurements of biological samples, such as blood, urine, hair, and nails, collected from human subjects. Our research focused on the development of new methods to achieve (1) less sample volume requirement, (2) higher throughput, and (3) economic analyses. A method of automated sample preparation followed by liquid chromatography–tandem mass spectrometry measurement was developed to analyze 26 perfluorinated alkyl substances simultaneously in the blood. It requires only 0.2 mL of sample and runs more than 50 samples a day. We also developed a high-throughput

method for the analysis of environmental phenols in urine. These new methods have already been used in large-scale cohort studies.

Exposure factors are essential elements in exposure assessment. Exposure factors enable us to calculate our exposure to chemical substances via a variety of environmental media such as air, water, soil, dust, and diet. We have been conducting research to estimate children's soil and dust ingestion and women's use of personal care products. In our study of soil and dust ingestion, more than 100 preschool children have been investigated. We have developed a simple questionnaire instrument for estimating personal care product use by women of child-bearing age.

9. Adverse health effects of ambient air pollution and meteorological factors

In FY 2016 we examined the association between high and low temperatures and out-of-hospital cardiac arrest (OHCA) of cardiac etiology. We used a case-crossover design. The subjects were 97,500 patients aged 40 years or older with OHCA of cardiac etiology in Tokyo, Osaka, and Fukuoka Prefecture from 2005 through 2012. We used national data with Utstein-style resuscitation registration. Exposure to high temperatures (≥30 ºC) increased the risk of OHCA (OR = 1.11, 95% confidence interval (CI): 1.04–1.18) (Fig. 3). Furthermore, low temperatures (<5 ºC) and relatively low temperatures (5 to 9.9 ºC) were also associated with OHCA (OR = 1.20; 95% CI: 1.16–1.25; OR = 1.10; 95% CI: 1.07–1.13, respectively). The temperature–OHCA association curves were U-shaped or J-shaped, and the association was more prominent among those aged 80 years or older.

We also examined the association between particulate matter and adverse health outcomes. The results of these studies are described in the Health and Environmental Safety Research Program section.

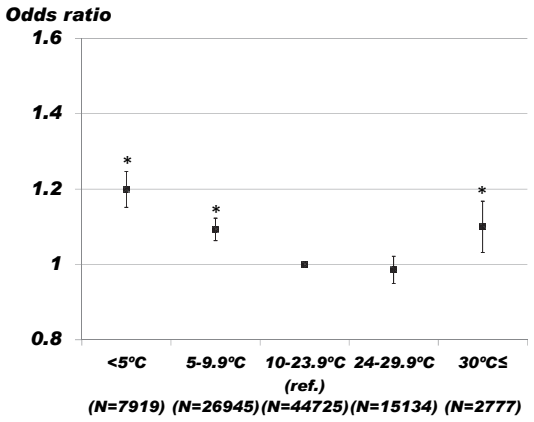


Fig. 3
Odds ratios and 95% confidence intervals for the occurrence of out-of-hospital cardiac arrest of cardiac etiology at different ambient temperatures. Adjustment variables were daily means of relative humidity, atmospheric pressure, and wind speed, and daily amount of precipitation and hours of daylight.
* $P < 0.05$

Center for Regional Environmental Research

Human activities have a substantial impact on both human life and ecosystems through environmental media such as the atmosphere, water, and soil. To provide a sound scientific basis for minimizing the environmental impacts of human activities, the Center for Regional Environmental Research is investigating the mechanisms by which regional environmental issues develop at multiple scales (local, urban, and transboundary) in both Japan and Asia as a whole. Furthermore, we are studying solutions to these regional environmental issues and how to apply them to real-world issues and situations.

The center consists of seven sections (Regional Atmospheric Modeling Section, Regional Atmospheric Environment Section, Lake and River Environment Section, Marine Environment Section, Soil Environment Section, and Regional Environmental Systems Section) and has one Principal Researcher.

In FY 2016, we implemented many research projects covering a wide range of regional environmental issues. Our main research projects were as follows:

・A study of atmospheric behavior and toxicity of particulate matter (PM) from unregulated burning

・A project to implement measuring, reporting, and verification (MRV) and related technological improvements contributing to the Joint Crediting Mechanism (JCM) in Mongolia

・Development and evaluation of technology for amending sediments in coastal seas.

Most of the projects are collaborations with other NIES centers. Additionally, there are two long-term monitoring programs: the Regional Atmospheric Monitoring Program and the GEMS (Global Environment Monitoring System)/Water Program, which is a collaboration with the Center for Environmental Biology and Ecosystem Studies.

Below, we briefly describe some of the important results of the Center's research in FY 2016.

1. Basic Research

1.1 Atmospheric behavior and toxicity study of PM from unregulated burning

Residues of agricultural wastes, including rice straw, are sometimes burned in the open air in Japan. PM from unregulated open burning (UROB) is considered to be one of the main sources of PM in the atmosphere. In this project, we aim to elucidate UROB in the city of Tsukuba and to examine whether the PM from UROB affects local air quality. In addition, we are studying the toxicity of PM

from rice straw.

In autumn 2015 we set up an intensive campaign in Tsukuba, where our institutes are located. The center of the city is a residential area, and paddy fields are in the surrounding area. We used filter samplers to collect PM for analysis of ions, metals, and organic species. Automated chemical analyzers, including an aerosol mass spectrometer (AMS, Aerodyne) and black carbon (BC) monitor (COSMOS, Kanomax), were used for high time-resolution monitoring of the chemicals in PM. We took observations from the beginning of September to the end of October 2015. In the same period, our "watching team" went around the surrounding areas in Tsukuba to watch for UROB and continued through the year. In December 2015, two cameras were set up at the top of Mt. Tsukuba to monitor for UROB.

We often observed high PM2.5 and BC mass events. These types of events happened on days on which UROB was reported by our watching team. Fragments detected with a mass to charge ratio (m/z) = 60 were considered to be levoglucosan from biomass burning. We observed variations in the signals from these m/z = 60 fragments that coincided with variations in the PM2.5 and BC mass concentrations. Thus, the variations in PM2.5 and BC mass concentrations were related to biomass burning from UROB.

We studied the toxicity of PM from biomass burning in the laboratory. Heme oxygenase-1 (HO-1) is measured in response to oxidative stress. We exposed extracts of PM collected from rice straw burning (PM-r) and from wheat straw burning (PM-w) to cells from rats. HO-1 production by cells exposed to PM-w was much greater than that of cells exposed to PM-r, indicating that the toxicities of PM from the burning of biomass of different origins likely differ.

The frequency of UROB in Tsukuba was highest in September and then gradually declined after October. We used the data from our watching team report to construct a UROB model for Tsukuba. We found that UROB occurred on calm (low-wind-speed), fine days. UROB also often happened just before rainy days, no doubt because the fires were naturally extinguished by rain.

1.2 Project to implement measuring, reporting, and verification (MRV) and related technological improvements contributing to the Joint Crediting Mechanism (JCM) in Mongolia (assessment of CO_2 sequestration by rangelands in Mongolia)

We are partly responsible for the project to implement MRV and related technological improvements contributing to the JCM in Mongolia. This project was commissioned by the Ministry of the Environment and presided over by Chuo University, Japan, in collaboration with Hitachi Ltd., and the Japan Research Institute. Our major research objective is to evaluate CO_2 sequestration by rangelands in Mongolia. Our initial aim is to establish ground observation

systems in typical ecosystems both near urban areas and far away from them, in areas with less urban influence. With these systems, we intend to collect data on meteorology, hydrology, vegetation, and CO_2 fluxes. Then, by collecting and analyzing satellite data such as those from the Moderate-resolution Imaging Spectroradiometer (MODIS), we will use an ecosystem model in an effort to evaluate the spatiotemporal distribution of CO_2 absorbed by grasslands. Finally, we expect to help develop an MRV method based on data from the Greenhouse Gases Observing Satellite (GOSAT).

This fiscal year, we first collected CO_2 flux data observed by the eddy correlation method at two sites, one in the Nalaikh area near the city of Ulaanbaatar, Mongolia, and another in the Hustai area far from the city. We found that, in 2015–2016, the amount of CO_2 absorbed by rangelands at the Nalaikh site was greater than that at the Hustai site (Fig. 1).

We then used the MODIS satellite data to develop a set of maps of CO_2 absorption by grasslands in Mongolia and evaluated the seasonal variation in absorption by each type of grassland. We found that the amount of CO_2 absorbed by Forest steppe and Meadow steppe was near twice that absorbed by Dry steppe, and more than three times that absorbed by Semi-desert steppe (Fig. 2).

Finally, we developed a satellite observation dataset (2003–2016) by collecting FOS/SWIR (Flight Operations Segment/Short-Wave Infrared) level 2 data from GOSAT and from the European Space Agency's SCIAMACHY/ENVISAT (Scanning Imaging Absorption Spectrometer for Atmospheric Cartography / European Space Agency Environmental Satellite), and OCO-2 (Orbiting Carbon Observatory 2) data from NASA. We also collected CO_2 ground observation data from 27 TCCON (Total Carbon Column Observing Network) sites. We found that the TCCON ground observation data were well correlated with the XCO_2 trends of both SCIAMACHY and the GOSAT satellite observations. The correlation coefficients between the TCCON data and the GOSAT data were greater than 0.6 at most sites.

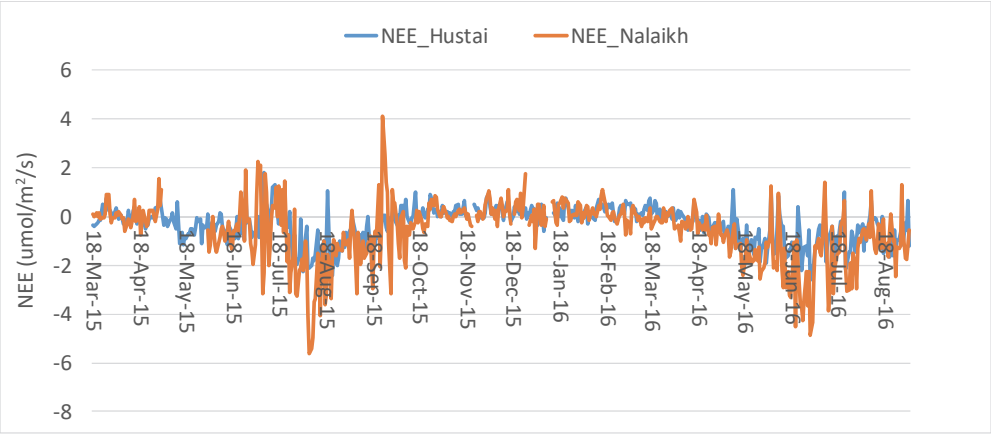


Fig. 1 Net ecosystem exchange (NEE, umol/m^2/s) at the Nalaikh and Hustai sites in Mongolia

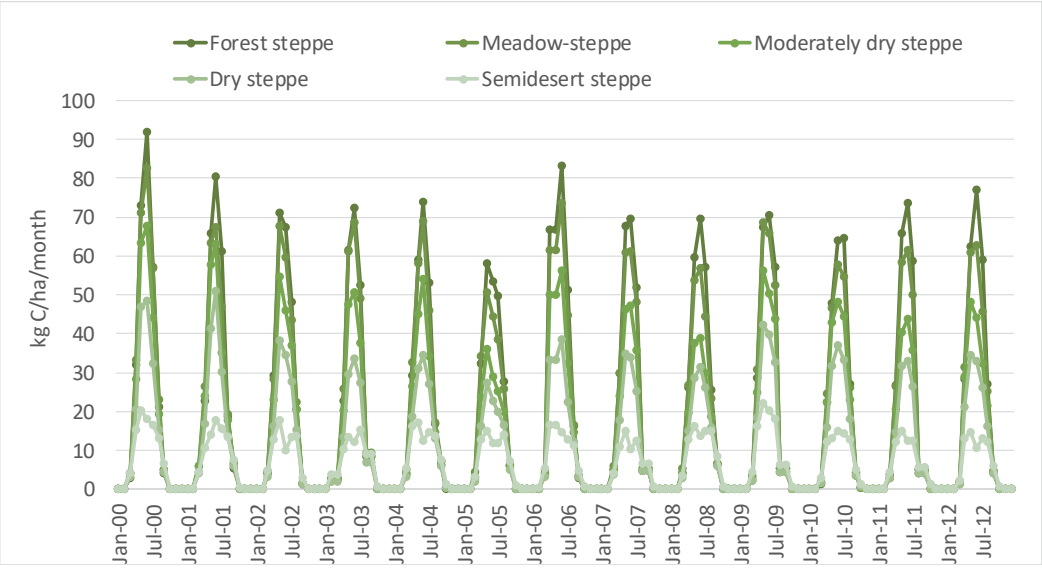


Fig. 2 Amounts of CO_2 absorbed by different types of grassland

1.3 Development and evaluation of a technology for amending sediments in coastal seas: application of a benthic microbial fuel cell to the amendment of sediments in Tokyo Bay

Some coastal seas and estuaries abutting urban areas have been suffering from eutrophication and hypoxia, and consequently their sediment environments are becoming very reductive and unfavorable for benthic fauna. Tokyo Bay is surrounded by about 28 million people and receives enormous volumes of macronutrients. Almost 90% of the coastline of the inner area of the bay has been reclaimed, and immense areas of tidal flats have been lost. This had led to considerable ecosystem deterioration in terms of weakened ability of organisms in the food web to digest and metabolize the excess phytoplankton biomass. Therefore, the inner area of Tokyo Bay suffers chronically from severe hypoxia, and enormous amounts of sulfide have accumulated in the sediments. Microbial fuel cells (MFCs) can generate weak electricity via the anaerobic microbial metabolism of organic substrates and thus have the potential to promote the removal of reductants and organic matter from sediments. We installed and operated a benthic MFC (BMFC; Fig. 3) in the bottom sediments of a shallow channel located in the inner area of Tokyo Bay and tested its ability to amend impaired sediment quality. Electricity began to be generated immediately after BMFC installation (Fig. 4). Circuit resistance was reduced stepwise to obtain maximum electricity generation. As a result, power generation increased by 400% and was maintained for about 4 months. Application of the BMFC significantly increased the redox potential and decreased the soluble sulfide concentration of the interstitial water in the sediments, but it did not reduce sediment oxygen consumption or promote the recovery of benthic fauna (Fig. 5).

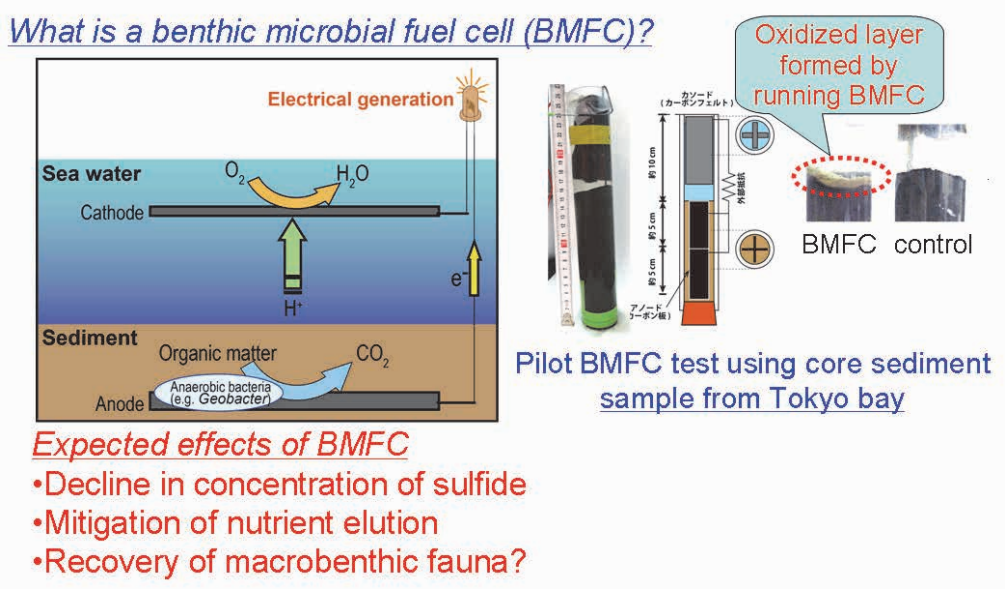


Fig. 3 Principle of the BMFC, and expected effects of the BMFC on sediment quality

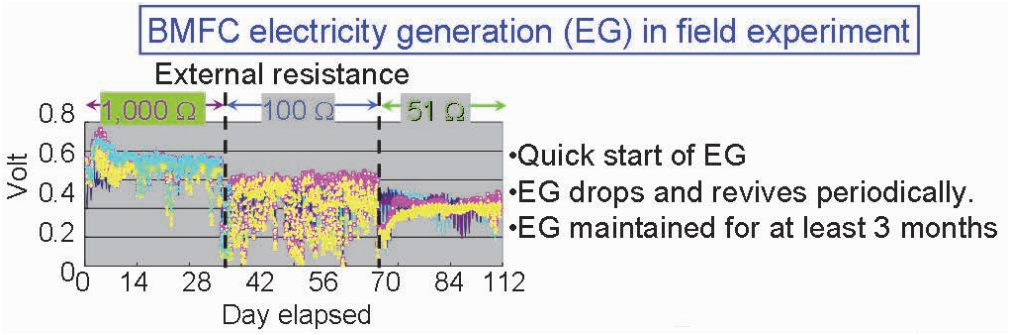


Fig. 4 Power generation via BMFC in the field experiment in Tokyo Bay

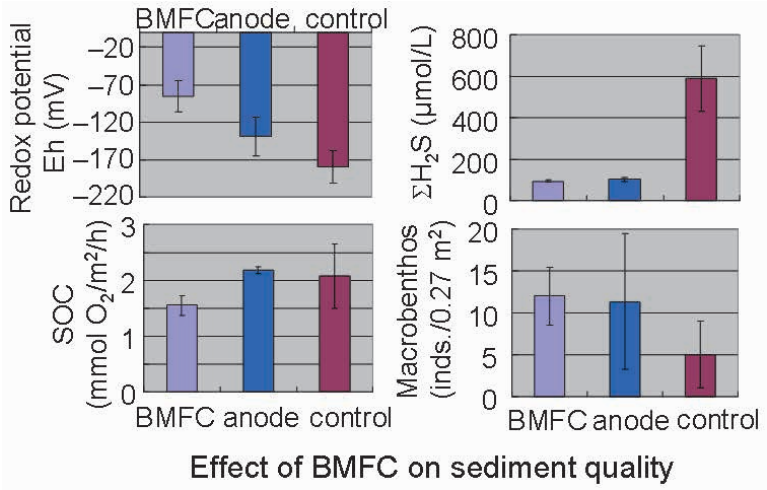


Fig. 5 Effect of BMFC on sediment quality. SOC, sediment oxygen consumption

2. Long-term monitoring

2.1 Long-term monitoring of atmospheric pollutants at Cape Hedo, Okinawa, and Fukuejima, Nagasaki, to monitor air quality in East Asia

Long-term monitoring of atmospheric pollutants, including aerosols and gaseous species, has been conducted by our Center at Cape Hedo Atmosphere and Aerosol Monitoring Station (CHAAMS) on Okinawa Island and at Fukuejima (Fukue Island) Observatory in Nagasaki Prefecture, Kyushu, to observe changes in the atmospheric environment of the East Asian region. Observations of optical, physical, and chemical characteristics, including the scattering coefficient, chemical composition, mass concentration, and vertical distribution of aerosols, have been conducted since spring 2004 at CHAAMS and since autumn 2008 at Fukuejima. The long-term monitoring at Fukuejima has revealed that the severe trans-boundary pollution event that occurred in January 2013 was not a special case but was instead an ordinary, repeatedly observed event. Both the mass of PM2.5 and the aerosol optical thickness associated with the presence of spherical particles—measured by LIDAR (Light Detection And Ranging) at CHAAMS—exhibited peaks in 2006. Since then, the values of both of these parameters have been decreasing. The results of continuous LIDAR observations at Fukuejima have been used in an epidemiological survey conducted by a committee organized by Japan's Ministry of Environment as an index of exposure to Asian dust. Some of these measurement data and a list of peer-reviewed papers are available to the public on the NIES web pages (http://www.nies.go.jp/asia/hedomisaki/home-e.html). Atmospheric mercury has been monitored continuously since 2007 at CHAAMS. The results obtained were used during the negotiations for the International Mercury Treaty. These types of long-term monitoring data contribute to our understanding of the current status and trends of atmospheric pollutants in the East Asian region and of trans-boundary pollution entering Japan.

2.2 Long-term monitoring at Lake Kasumigaura by GEMS-Water

We have been monitoring Lake Kasumigaura, the second largest lake in Japan, monthly for nearly four decades in collaboration with the NIES Center for Environmental Biology and Ecosystem Studies. This lake is registered as a core site of JaLTER (the Japan Long-Term Ecological Research Network). It is also part of the 1000 Monitoring Sites project of the Ministry of the Environment and a trend-monitoring station of the United Nations Environment Programme's GEMS (Global Environment Monitoring System) Water Programme.

We measured selected environmental variables (water temperature, water depth, transparency, dissolved oxygen, pH, and light intensity in the water), water quality (electronic conductivity, chemical oxygen demand, chlorophyll a, suspended solids, particulate organic carbon, particulate organic nitrogen,

particulate organic phosphorus, total phosphorus, dissolved total phosphorus, soluble reactive phosphorus, total nitrogen, dissolved total nitrogen, nitrate nitrogen, ammonium nitrogen), plankton (bacteria, heterotrophic nanoflagellates, ciliates, picocyanobacteria, eukaryotic picoplankton, phytoplankton, rotifers, crustacean zooplankton, mysids), benthos (chironomids and oligochaetes), and primary production. The database of this monitoring program has been released on the following website:
http://db.cger.nies.go.jp/gem/moni-e/inter/GEMS/database/kasumi/index.html.
The progress of some of our research activities has benefited from the monitoring. For example, we have developed a mobile, large-diameter (11 cm) core sampling system to collect sediment cores without compaction, and we have applied this system to research in other lakes. We are also developing rapid in situ methods of using fast-repetition-rate fluorometry (FRRF) to measure primary production by phytoplankton. To assess the validity of the FRRF technique, we compared estimates of primary production rates obtained by FRRF with those regularly measured as part of the monitoring (by the ^{13}C method).

Center for Environmental Biology and Ecosystem Studies

The Center for Environmental Biology and Ecosystem Studies (CEBES) performs various types of research aimed at understanding ecosystem composition and function and the relationships between these two factors, as well as the effects of human activity on biodiversity.

The center is responsible for leading the Biodiversity Research Program (one of the five Priority Research Programs in the third NIES five-year plan), with the aim of helping to implement the Strategic Plan for Biodiversity 2011–2020, including the Aichi Biodiversity Targets of the Convention on Biological Diversity. CEBES is also studying ecosystem management in the Mekong River watershed in partnership with the NIES Center for Regional Environmental Research. Moreover, CEBES conducts long-term ecological monitoring, preserves biological resources, and establishes biodiversity databases. We have also studied the effects of the Great East Japan Earthquake on organisms and ecosystems.

CEBES considers commitment to national and international frameworks and policies to be an important task in the conservation of biodiversity and ecosystem services. During the third NIES five-year plan, four CEBES researchers were selected as experts and participated in the scoping and assessment tasks of IPBES (the Inter-governmental Platform on Biodiversity and Ecosystem Services). We also responded to notifications from the Secretariat of the Convention on Biological Diversity, such as requests for peer-review of documents. Such contributions resulted in the citation of scientific papers by CEBES researchers in the technical report of the 4th edition of *Global Biodiversity Outlook*. In addition, to lead and coordinate participation in these activities by the scientific community in Japan, CEBES set up the Secretariat of the Japanese Biodiversity Observation Network (J-BON) in 2014; its role is to act as an interface between the scientific community and other sectors.

1. Preservation and provision of algal bioresources

The Microbial Culture Collection at NIES (MCC-NIES) has maintained and opened 50 classes, 405 genera, 811 species and 2682 strains of microalgae and threatened macroalgae. The collection covers a variety of algal bioresources, including experimental materials that have been well studied in genomic, molecular, photosynthetic, physiological, and ecotoxicological terms; evolutionarily and taxonomically important species; ecologically significant species; harmful species; and commercially useful strains. Since 2002, the MCC has also been the core facility for algal resources in the National BioResource Project's upgrading of systems for collection, preservation, and provision. As a public culture collection, in FY 2016 the MCC distributed 1555 strains for various purposes and accepted the deposition of 157 strains from researchers. At

least 53 articles on studies performed with our strains were published in FY 2016. The MCC has developed both culture and preservation techniques and successfully cryopreserved 214 strains in liquid nitrogen tanks (Fig. 1, left panel). The MCC has also accumulated useful information on strains, and such information can now be accessed from our website. For example, the compiling of DNA barcoding data for 40 strains, genomic data for 10 strains (including a newly developed strain for ecotoxicological bioassay, Fig. 1, center panel), an occurrence dataset for the Global Biodiversity Information Facility (GBIF) for 100 strains, and fatty acid composition data on 235 strains were completed in FY 2016. During FY 2016, in addition to holding public relations activities such as our summer Open House and guidance for facility visitors, to expand the use of strains, we engaged in trials of new tools to meet customer needs, including periodical mail news distribution, a technical training course, uploading of technical movies to YouTube, and a newly designed homepage (Fig. 1, right panel; http://mcc.nies.go.jp).

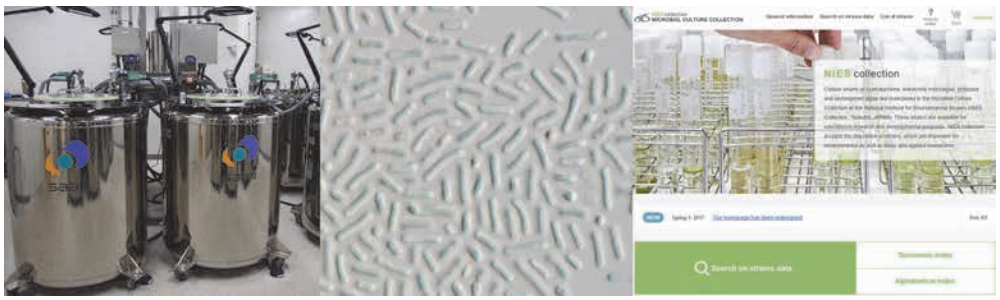


Fig. 1 Liquid nitrogen tanks for cryopreservation of algal strains (left); light micrograph of NIES-981 (center); the newly designed MCC-NIES homepage (right).

2. Long-term lake monitoring

We have been monitoring Lake Kasumigaura and Lake Mashu in cooperation with the Center for Regional Environmental Research and the Center for Environmental Measurement and Analysis. We have provided these monitoring data to the databases of the international observation networks JaLTER (Japan Long Term Ecological Research Network), the United Nations Global Environment Monitoring System (GEMS/Water Programme), and GBIF (Fig. 2). To promote the use of long-term monitoring data, we have published three data papers in an international journal and have renewed our website to make it more user friendly.

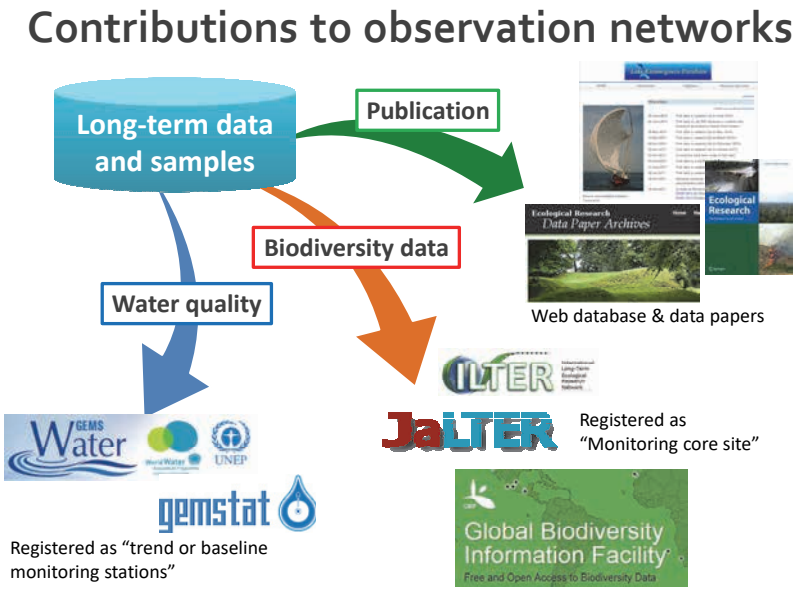


Fig. 2 Contributions of our long-term lake monitoring data to international observation networks

In addition to performing long-term monitoring of the two lakes, we aim to assess the trends and current status of biodiversity in lakes at a national scale. In Japanese lakes, trends in biodiversity have not yet been quantified because data on the distributions of freshwater species are sporadic and not digitized, and nationwide monitoring has not been conducted since the mid-1990s. We developed a research network with 21 regional environmental research organizations, including prefectural research institutes and museums, and we collected an extensive amount of literature on the distributions of strictly freshwater fish and aquatic macrophytes in 19 lakes. We also newly surveyed the presence/absence of fishes in 7 lakes and macrophyte species in 12 lakes. Overall, we found that the native species richness of both fishes and macrophytes has declined from the past (pre-1999) to the current (post-2000) time periods: on average, 25% of fish species and 48% of macrophyte species have disappeared. Many exotic fishes and macrophyte species were found to have invaded the lakes—even those that were very rich in native species. Furthermore, introductions of domestically translocated fish species (native to Japan, but introduced into drainages where they had not historically occurred) were observed in many lakes, and the numbers of these species were about the same as those of exotic fish species. Our study suggests that this research networking with regional environmental research organizations can be effective for broad-scale lake biodiversity assessment.

3. Potential risk of avian influenza A virus infection in three raptor species in Japan

Highly pathogenic avian influenza viruses (HPAIVs) cause lethal infection in poultry and certain species of wild birds. In Japan, HPAIVs have been isolated from over 200 wild birds since 2004. HPAIV-infected wild birds include species

listed on the Red Data List of Japan. Thus, HPAIVs are likely to increase the risk of extinction of endangered birds.

Raptors are susceptible to HPAIV, and spatial risk assessment of such species might be valuable for conservation planning. To conduct a spatial risk assessment, we first constructed potential distribution maps for three raptor species listed on the Red Data List of Japan, namely the mountain hawk-eagle (*Nisaetus nipalensis*), the northern goshawk (*Accipiter gentilis*), and the peregrine falcon (*Falco peregrinus*), by using survey data for the winters from 1996 to 2001. These potential distribution maps for the raptors were then superimposed on the reported avian influenza A virus risk maps of Japan (Moriguchi et al., 2012, Divers. Distrib. 19:78–85). The avian influenza A virus risk maps indicated high-risk areas for the isolation of viruses, including HPAIV, from wild birds. Avian influenza A risk indexes were calculated by using the equation: (avian influenza A risk index) × (habitat suitability index for each raptor). The avian influenza A virus risk map for the mountain hawk-eagle showed that in most regions of Japan this raptor was at low risk for this virus (Fig. 3). In contrast, the distribution maps for the northern goshawk and peregrine falcon showed that high-risk areas for these birds were distributed on the plains along the Sea of Japan and the Pacific coast. We recommend enhanced surveillance and the immediate establishment of inspection systems for each raptor species in the high-risk areas for HPAIV.

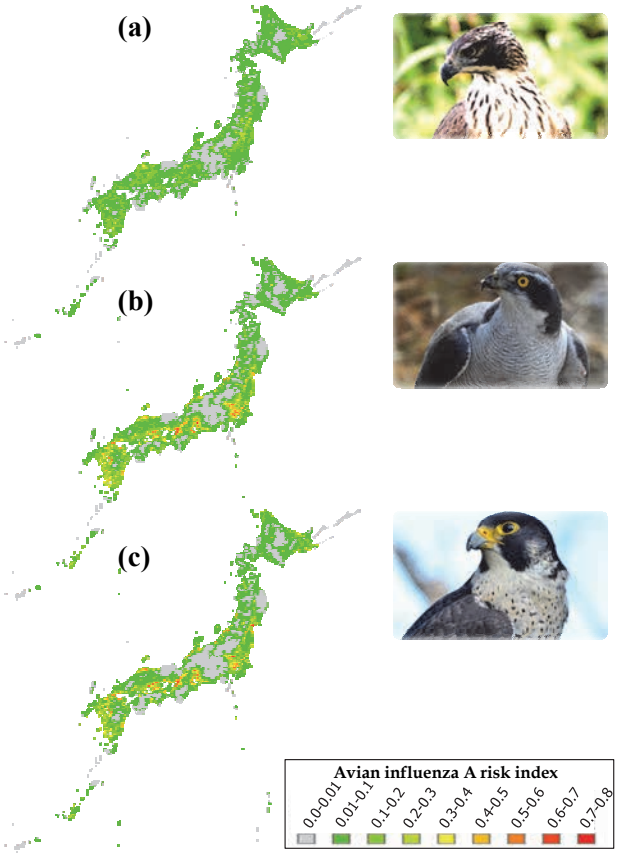


Fig. 3 Avian influenza A virus risk maps for (a) the mountain hawk-eagle (*Nisaetus nipalensis*), (b) the northern goshawk (*Accipiter gentilis*), and (c) the peregrine falcon (*Falco peregrinus*). (Moriguchi et al. 2016)

Center for Social and Environmental Systems Research

The Center for Social and Environmental Systems Research targets linkages between human activities and the natural environment to identify the relationships among socioeconomic systems and environmental issues. The work of the Center results in significant academic findings as well as policy recommendations for environmental issues, covering a broad area, from global environmental issues to local sustainable cities and regions.

The Center consists of five research sections:

1. The **Integrated Environment and Economy Section** analyzes the structure of causes and effects of various environmental problems, considering the inter-relationships among multiple sectors (such as household, government, and enterprises) and multiple scales (including world, country, and city). and explores solutions to these problems.
2. The **Trans-boundary Impacts and Mitigation Modeling Section** develops and utilizes analytical models to quantify the impacts of various environmental changes at transboundary and national scales—including the impact of climate change—and to examine measures for mitigating these changes.
3. The **Regional Environmental Impact Assessment Section** investigates solutions for environmental problems by developing methods and models to assess various environmental impacts at country, local, and city levels.
4. Through social transition research for innovative technological and social systems, the **Eco-society Innovation Section** conducts system design, evaluation, and support for the implementation of environmentally friendly technologies and policies to foster the transition to a sustainable environmental society.
5. The **Environmental Policy Section** aims to elucidate pathways to sustainable social systems by assessing the effectiveness of environmental laws and policies and analyzing the roles and activities of multiple stakeholders.

Research staff at the Center are involved in at least one of two major research programs, namely the Environment-Economy-Society Integration Research Program and the Low-Carbon Research Program. Basic research that supports these project-oriented programs, together with any other research activities, is categorized as part of our Center's research sections. FY 2016 was the first year of the fourth mid-term plan of NIES, and our intention was to extend our research activities to cover a variety of research projects regarded as "seeds" for future studies. Included were those related to data collection for model development, data collection as a foundation for future studies, and policy-relevant studies. Some of our outputs are described below.

1. Global food security under an extreme climate

Future climate variability is a concern for food security but it has rarely been taken into account in actions to secure food in disaster-prone regions. In this

project, we aimed to show how projections of the risk of hunger were affected by potential changes in crop yields under climate variability and other major uncertainties that are expected to occur by the middle of this century. As an adaptation measure, we also presented the total food storage needed under extreme cases in different return periods (i.e. under different probabilities of hunger).

The results suggested that the magnitude of uncertainty increased over time regardless of socioeconomic developments. In 2050, under a once-per-100-year extreme case in the most severe climate change pathway, an additional 0.07 to 0.32 billion people would face the risk of hunger; this accounted for 70% to 80% of the number under the mean climate state (Fig. 1a). The results also suggested that the current global total food storage is quantitatively sufficient but is poorly distributed geographically. For example, a once-per-100-year extreme case under the most severe climate change scenario (RCP8.5) would require 2.2 to 2.3 EJ of food energy to maintain the same consumption level as would occur without extreme climates; this is equivalent to one-fourth of the current global cereal storage (Fig. 1b). However, current food storage locations do not match the locations where food is needed under the extreme case. To fill this gap, a food aid system among countries, or the promotion of food storage in affected regions, is needed so that affected regions will be able to tolerate the worst case.

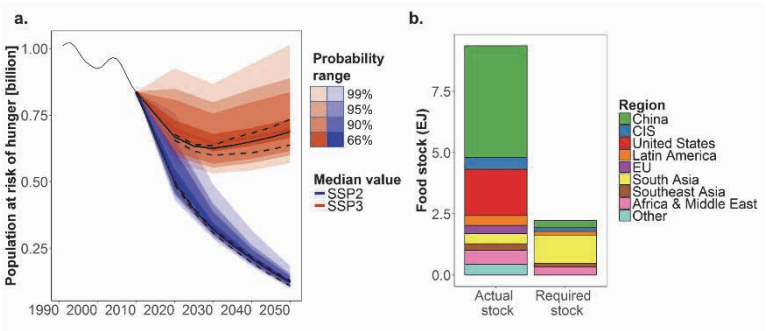


Fig. 1 (a) Probability distribution of the global population at risk of hunger under climate variability. (b) Comparison of the current food storage and the stock required in a once-per-100-year extreme case under SSP2 and the most severe climate change pathway (RCP8.5). Regional codes: EU: European Union, CIS: Commonwealth of Independent States (the former Soviet Union)

Note to Figure 1a: Shown are the results in two socioeconomic scenarios (middle-of-the-road (SSP2) and regional rivalry (SSP3)) by the middle of this century under the most severe climate change pathway (RCP8.5), without considering CO_2 fertilisation effects. Dashed lines show the ranges of effects under mean climate state; black lines show the levels with no climate change. The ranges represent the uncertainty of the inter-annual climate variability, multiple general circulation models, and crop model parameters.

2. Wind tunnel experiments on velocity and temperature fields in a street canyon

Urban configuration is a crucial factor in heat island studies. Here, we used PIV (particle image velocimetry) to investigate the thermal effects of different aspect

ratios (ratio of building height (H) to street width (W)) in a wind tunnel. Under façade-wall heating conditions, the canyon space at around half of the scale model height had the biggest heat load among all aspect ratio cases. This means that paying more attention to the space in the modeled urban canyon at half-height level of the building canopy would result in impressive heat-reduction benefits. Under ground-heating conditions, heat tended to accumulate more in the building's leeward corner when H/W was 1 or 0.67 but more in the windward corner when H/W was 2, because of the change in position of the vortex. When the velocity was 0.5 m/s, after the application of ground-heating, no vortex formed in the canopy and buoyancy flow was the main driver of air flow. When the velocity was 1.5 m/s, surface heating had little influence on the vortex. In addition, another study was conducted to find the relationship between differences in the thermal environment and the wind field (Table 1).

Table 1 Differences in the thermal environment and wind field around a street canyon with winds blowing from different angles.

	Wind angle	
Air temperature decreases. More heat taken away by channeling wind flow, less influence of thermally induced flow	Perpendicular	Influenced mainly by buoyancy flow
	Oblique 67.5°	Similar to perpendicular flow under neutral conditions
	Oblique 45°	Influenced by ground heating in all wind velocity cases
	Oblique 22.5°	Influenced by ground heating only at a wind velocity of 0.5m/s
	Parallel	Building receives more heat in the outlet section. More intense roof heating.

3. Development of a framework for a low-carbon-scenario design workshop by using Japan Low Carbon Navigator

The purpose of this study is to develop a framework for a low-carbon-scenario design workshop and to evaluate its effectiveness in increasing our knowledge of climate change and energy through trial workshops at universities. The workshop consists of three parts: (1) knowledge-sharing about climate change and energy use from exports; (2) discussions regarding future social and energy systems with participants, who may have different views; and (3) scenario simulation and discussion by using the Japan 2050 Low Carbon Navigator (Low Carbon Navigator). We have developed the Low Carbon Navigator in collaboration with the Institute for Global Environmental Strategies (IGES) to facilitate discussions with various stakeholders with different backgrounds and different types of information on the mitigation of climate change.

The workshop has so far been held at three universities, in the Hokuriku area, the Chubu area, and Tokyo. For example, in the Hokuriku area, we organized a workshop for third- and fourth-year undergraduate students. Participants discussed

future visions for Japan based on five 2050 social scenarios (Research and Development society, Made-in-Japan society, Service and Brand society, Resource Independent society, and Sharing society) proposed by the Central Environment Council of the Ministry of the Environment, Japan. Following discussions on possible mitigation actions and technology options, future energy demand, energy supply, and CO_2 emissions were quantified by using the Low Carbon Navigator.

The workshops could advance discussions of, and the formulation of approaches to, long-term low-carbon societal scenarios and strategies. Several issues have already been raised; for example, some participants recognized the word "Service" as relating to the tourism industry, and their discussions would therefore not necessarily have been confined to discussions of a Service and Brand society. We found from the workshop experience that clarifying the definitions of terms and recognizing the participants' levels of understanding of climate change and energy issue are important to the advancement of discussions.

4. Evaluation of electricity-saving actions at NIES and their long-term impacts

The purpose of this study is to quantify the reductions in electricity consumption that have occurred at NIES through the implementation of electricity-saving measures. To achieve a low-carbon society in Japan, we inevitably need to advance GHG emission reduction in the research and development sectors. NIES promotes actions to save electricity. However, because we lack a systematic data collection system, there are many difficulties in planning effective electricity-saving measures and behavioral changes at NIES and in demonstrating their effectiveness in reducing electricity consumption.

Electricity consumption data have been collected in cooperation with administrative departments within NIES. Two types of analysis have been conducted: (1) evaluation of an electricity-saving campaign in each summer since 2011; and (2) long-term trend analysis from 2009 (Fig. 2). In 2016, NIES set a target of 5000 kW for summer electricity use and promoted electricity saving to all staff members. As a result, the maximum electricity consumption per hour was 4080 kWh in July, 4430 kWh in August, and 4250 kWh in September. Although our electricity-saving target was achieved, monthly electricity consumption in September was greater than in the same month in 2015. This increase was considered to be due to the extremely hot weather in 2016, not to reduced awareness by NIES staff of the need to save electricity. Analysis of long-term electricity-saving trends showed that electricity consumption gradually increased before 2013 but has declined since then. These results are provided to research centers and administrative departments and are used as a basis for planning and evaluating electricity-saving actions at NIES.

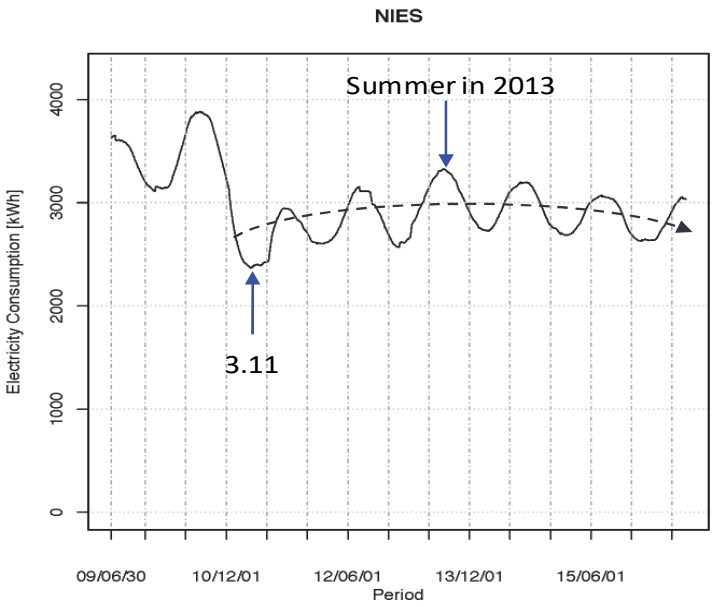


Fig. 2 Long-term trends in electricity consumption at NIES (FY 2009 to FY 2016).

5. Survey of a capacity-building program for local leaders of climate change adaptation actions

Climate change adaptation actions require local leaders that have sufficient scientific knowledge of climate change strategies, in terms of both mitigation and adaptation. This study reviewed five climate change education programs in Japan, one program in Germany (Klimawandel [“Climate Change”] in Baden-Wuerttemberg), and one in Steiermark, Austria, and conducted a comparative study. The study found five aspects that should be reflected in Japanese climate change education programs: (1) setting of competency targets, (2) setting of targets for the capacity of local leaders, (3) reflection of local education systems, (4) course setting to suit the level of development of local leaders, and (5) use of regional data.

6. Development of inter-institutional research collaboration through the establishment of a cross-appointment system with IGES (Institute for Global Environmental Strategies)

In 2015, NIES and IGES established a cross-appointment system in which researchers at either institute could participate in an exchange with those from the other institute for between 1 and 2 years. This new system is an opportunity for researchers at the two institutes to collaborate. The first person to use the exchange system was a member of the Center for Social and Environmental Systems Research, who spent FY 2016 at IGES and will continue to stay there in FY 2017. He is currently in charge of the IGES Sustainable Cities Task Force and has been successful in building networks among local authorities in Japan as well as in other countries in Asia.

Center for Environmental Measurement and Analysis

The goals of the Center for Environmental Measurement and Analysis (CEMA) are to help develop better scientific methodologies that will enable the early detection of environmental issues and changes, give us a deeper understanding of environmental issues, and improve the assessment of current and future environmental concerns. CEMA also helps manage the quality of chemical analyses of environmental samples. Furthermore, we have continued our environmental specimen banking as important work that complements the archiving of environmental changes.

To achieve these goals, the six research sections of CEMA have been conducting a variety of studies. The **Fundamental Analytical Chemistry Section** has been in charge of an environmental specimen banking program; it collects bivalve specimens annually to complete a round sampling from many sites along the Japanese coast. The section has also been preparing and distributing environmental Certified Reference Materials to meet the demand for environmental chemical analysis. The **Advanced Analytical Chemistry Section** has been developing techniques for the comprehensive analysis of organic pollutants; for example, they have coupled a two-dimensional gas chromatograph to a high-resolution time-of-flight mass spectrometer. The **Environmental Chemodynamics Section** has been monitoring the temporal and spatial variation of chemical species in the atmosphere to gain an understanding of the sources and sinks of anthropogenic and natural substances. A microscale radiocarbon (^{14}C) analysis has also been conducted by this section to distinguish the fossil fuel and biogenic sources of carbon-containing materials such as airborne particulate matter. The **Advanced Remote Sensing Section** has been developing advanced techniques for remote sensing, such as lidar (laser radar), to monitor the temporal and spatial distribution of the main aerosol components (e.g., mineral dust, sea salt, and black carbon) in the atmosphere. The **Environmental Reaction Chemistry Section** has been tackling the development of methods to help us understand the mechanisms and efficiency of the production and chemical conversion of atmospheric fine particles—especially organic particles. The **Environmental Imaging and Spectrum Measurement Section** has been involved in the development of non-invasive and non-destructive techniques for monitoring the human brain by using a magnetic resonance (MR) imaging spectrometer. The possibility of utilizing measured MR images as *in vivo* biomarkers has been assessed by this section.

Below are brief accounts of some of the important results of our research in FY 2016.

1. Comprehensive analysis of house dust by using GC×GC/HRToFMS and in-house software

In this study, a comprehensive analysis using GC×GC/HRToFMS (two-dimensional gas chromatography–high-resolution time-of-flight mass spectrometry) and original software was applied to a house dust sample. First, the ability of the system to detect compounds was evaluated by using a standard solution. Second, persistent organic pollutants (POPs) such as polychlorinated biphenyls (PCBs), the concentrations of which had been certified by NIST (the National Institute of Standards and Technology, United States), in an extract of a certified house dust sample (NIST SRM 2585) were automatically quantified by using an automatic peak sentinel tool, T-SEN. Finally, our original mass spectral deconvolution tool, "NMFwithDBcreator" was used for the non-target analysis of pollutants in the certified house dust sample. A search was made for the deconvoluted exact mass spectra in the NIST library and in an in-house library compiled by measuring several standard compounds, and the elemental composition of the sample was estimated.

The concentrations of PCBs, polybrominated diphenyl ethers (PBDEs), polycyclic aromatic hydrocarbons (PAHs), and chlorinated pesticides in the house dust were automatically quantified by T-SEN, and some were compared with the NIST certified values if published NIST concentrations were available. The concentrations we obtained matched the certified values well. For example, the respective concentrations of PCBs #118, #105, and #206 were 23.3, 10.8, and 2.9 ng/g (this study), compared with 26.3, 13.2, and 3.8 ng/g (certified values). Some compounds not listed in the NIST certification were also found after post-data processing by NMFwithDBcreator (Table 1).

No.	Compound	Formula	Group	MF[1]	RMF[2]	RT I[3] (min)	RT II[4](sec)	Library RI[5]	RI I[6]	RI difference	Exact mass	Matched mass	Mass error (ppm)
1	TNBP(tris(butyl)phosphate)	$C_{12}H_{27}O_4P$	PFRs [a]	639	875	42.82	1.18	1643	1657	14	266.1647	N/D [c]	
2	TCEP(Tris(2-chloroethyl)phosphate)	$C_6H_{12}Cl_3O_4P$	PFRs [a]	650	878	47.02	2.35	1763	1777	14	283.9539	N/D [c]	
3	TClPP(Tris(2-chloroisopropyl)phosphate)	$C_9H_{18}Cl_3O_4P$	PFRs [a]	661	822	47.84	1.75	1790	1801	11	326.0008	N/D [c]	
4	TPHP(triphenyl phosphate)	$C_{18}H_{15}O_4P$	PFRs [a]	718	923	65.45	3.18	2400	2406	6	326.0708	326.0708	0.07
5	TBOEP(tris(2-butoxyethyl)phosphate)	$C_{18}H_{39}O_7P$	PFRs [a]	714	859	65.80	1.56	2410	2420	10	398.2433	N/D [c]	
6	Phosphoric acid, tris(3-methylphenyl) ester	$C_{21}H_{21}O_4P$	PFRs [a]	705	769	71.52	3.12	2664	2656	8	368.1177	368.1180	-0.66
7	TCP(tricresylphosphate)	$C_{21}H_{21}O_4P$	PFRs [a]	602	845	72.10	3.21	2680	2681	1	368.1177	368.1174	1.05
8	Tris(2,4-di-tert-butylphenyl) phosphate	$C_{42}H_{63}O_4P$	PFRs [a]	811	848	90.07	2.42	3582	3589	7	662.4464	662.4410	8.18
9	Pentachlorophenol	C_6HCl_5O	Pesticide	706	818	46.67	1.94	1751	1767	16	263.8470	263.8473	-1.19
10	Diazinone	$C_{12}H_{21}N_2O_3PS$	Pesticide	687	721	47.60	1.65	1791	1794	3	304.1010	304.1004	2.15
11	Carbaryl	$C_{12}H_{11}NO_2$	Pesticide	619	859	51.45	2.99	1901	1913	12	201.0790	N/D [c]	
12	Chlorpyrifos	$C_9H_{11}Cl_3NO_3PS$	Pesticide	739	826	53.44	2.00	1973	1978	5	348.9263	N/D [c]	
13	trans-Chlordane	$C_{10}H_6Cl_8$	Pesticide	843	869	57.05	2.07	2078	2097	19	405.7978	N/D [c]	
14	Hexyl salicylate	$C_{13}H_{18}O_3$	PPCPs [b]	543	765	43.75	2.42	1683	1684	1	222.1256	222.1254	0.78
15	Ethylhexyl salicylate	$C_{15}H_{22}O_3$	PPCPs [b]	792	868	47.95	1.18	1811	1804	7	250.1569	250.1562	2.66
16	Triclosan	$C_{12}H_7Cl_3O_2$	PPCPs [b]	790	879	57.64	2.23	2114	2118	4	287.9512	287.9512	-0.01
17	Diethyltoluamide	$C_{12}H_{17}NO$	Anti-insect agent	736	830	40.14	1.81	1571	1583	12	191.1310	191.1313	-1.38
18	Diphenylamine	$C_{12}H_{11}N$	Stabilization agent	827	892	41.89	2.20	1621	1631	10	169.0891	169.0901	-5.91
19	Styrenated Phenol (Di)	$C_{22}H_{22}O$	Rubber antioxidant	774	777	67.55	2.99	2472	2492	20	302.1671	302.1678	-2.40
20	Styrenated Phenol (Tri)	$C_{30}H_{30}O$	Rubber antioxidant	821	843	79.45	3.72	3006	3019	13	406.2297	406.2282	3.56

Table 1 Identification of compounds in certified NIEST house dust sample (SRM 2585) after mass spectral deconvolution by using our in-house software NMFwithDBcreator.

[a] phosphorus-containing flame retardants; [b] pharmaceutical and personal care products; [c] molecular ions not detected MF, match factor; RMF, reverse match factor; RT I retention time on first gas chromatography (GC); RT II, retention time on second GC; RI, retention index; RI I retention index on first GC

2. Radiostrontium monitoring of bivalves from the Pacific coast of eastern Japan

In early April 2011, radiostrontium was accidentally released from the Fukushima Daiichi Nuclear Power Plant (FDNPP) to the Pacific coast of eastern Japan. This radiostrontium included ^{89}Sr ($T_{1/2}$ = 50.5 days) and ^{90}Sr ($T_{1/2}$ = 28.8 years). We developed a simple procedure to analyze radiostrontium levels in a marine mussel (*Septifer virgatus*) and seawater by using crown ether (Sr Resin; Eichrom). We then used our method to describe the spatial and temporal distributions of radiostrontium in mussels and seawater on the Pacific coast of eastern Japan from 2011–2013 and in 2015. Samples were collected in the coastal areas of Ibaraki, Fukushima, Miyagi, and Aomori prefectures (Fig. 1). Figure 2 shows the activity of ^{90}Sr in mussels and seawater at the sites in Figure 1 in 2011–2013. Activity in mussels and seawater decreased with distance from the FDNPP, and between 2011 and 2013, it tended to be higher in areas south of the FDNPP than to the north of it. Activity also tended to decrease from 2011 to 2013 and by 2015 had reached levels experienced before the Fukushima accident. Our results suggest that radiostrontium discharged from the FDNPP was dispersed by coastal currents in a southerly direction along the Pacific coast of eastern Japan from 2011 to 2013, following which its activity decreased to background levels by 2015.

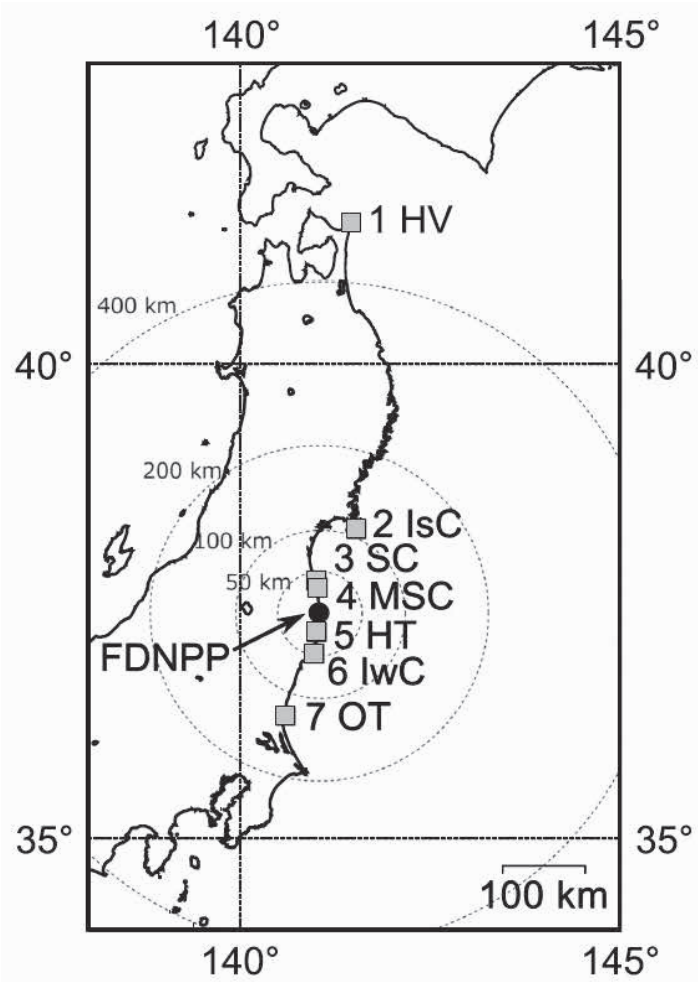


Fig. 1 Map of eastern Japan. Sampling sites (gray squares): 1, Higashidori (HV); 2, Ishinomaki (IsC); 3, Soma (SC); 4, Minami-Soma (MSC); 5, Hirono (HT); 6, Iwaki (IwC); 7, Oarai (OT). The Fukushima Daiichi Nuclear Power Plant (FDNPP) is indicated by the black dot. V, village; T, town; C, city.

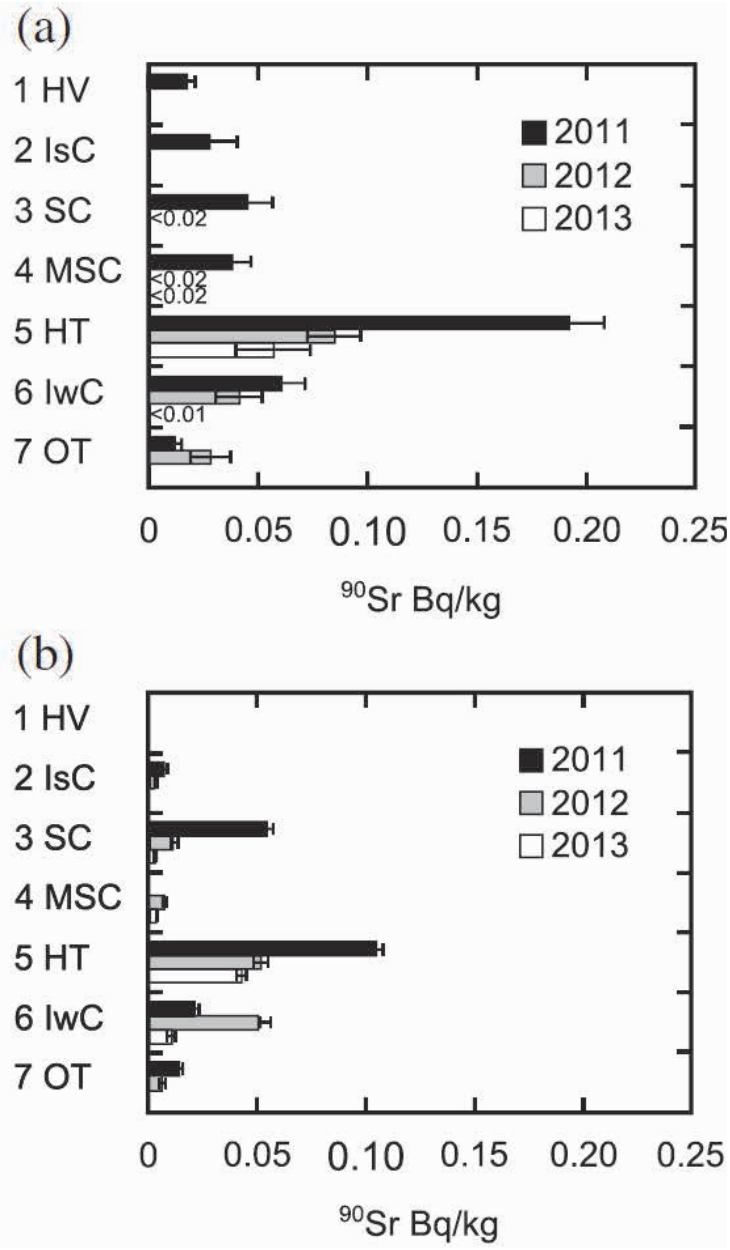


Fig. 2 Spatial and temporal distributions of ^{90}Sr in mussels (a) and seawater (b) by site, from 2011 to 2013

3. Seasonal variations in bromocarbon levels over Hateruma Island, Japan: implications for global sources

Dibromomethane (CH_2Br_2) and bromoform ($CHBr_3$), which undergo photolytic degradation and react with OH to produce inorganic bromine, are major contributors to organic bromine from the ocean to the atmosphere, where it can affect stratospheric and tropospheric ozone chemistry. These naturally produced ozone-depleting substances (ODS) are attracting more interest as concentrations of anthropogenic ODS decrease under the provisions of the Montreal Protocol. However, current estimates of their global emissions have large levels of uncertainty.

We performed high-frequency measurements of CH_2Br_2 and $CHBr_3$ over Hateruma Island, in the subtropical East China Sea, by using automated preconcentration gas chromatography–mass spectrometry. CH_2Br_2 and $CHBr_3$ baseline concentrations in air masses from the Pacific Ocean were 0.65 and 0.26 ppt, respectively, in summer and 1.08 and 0.87 ppt, respectively, in winter. Air masses transported from Southeast Asia were rich in bromocarbons, suggesting that there were strong emissions in that area. The passage of cold fronts from the Asian continent was associated with sharp increases in the observed concentrations of bromocarbons derived from coastal regions of the continent. The relationship between $[CH_2Br_2]/[CHBr_3]$ and $[CHBr_3]$ at Hateruma could be explained by the chemical decay of these compounds in the atmosphere with a fairly consistent $CH_2Br_2/CHBr_3$ initial emission ratio and some additional coastal effects and mixing (Fig. 3). Comparison of the relationships between $[CH_2Br_2]/[CHBr_3]$ and $[CHBr_3]$ in the Hateruma Island data with those in monthly mean data from 14 globally distributed U.S. National Oceanic and Atmospheric Administration ground stations suggested that these gases are produced primarily by a common process on a global scale.

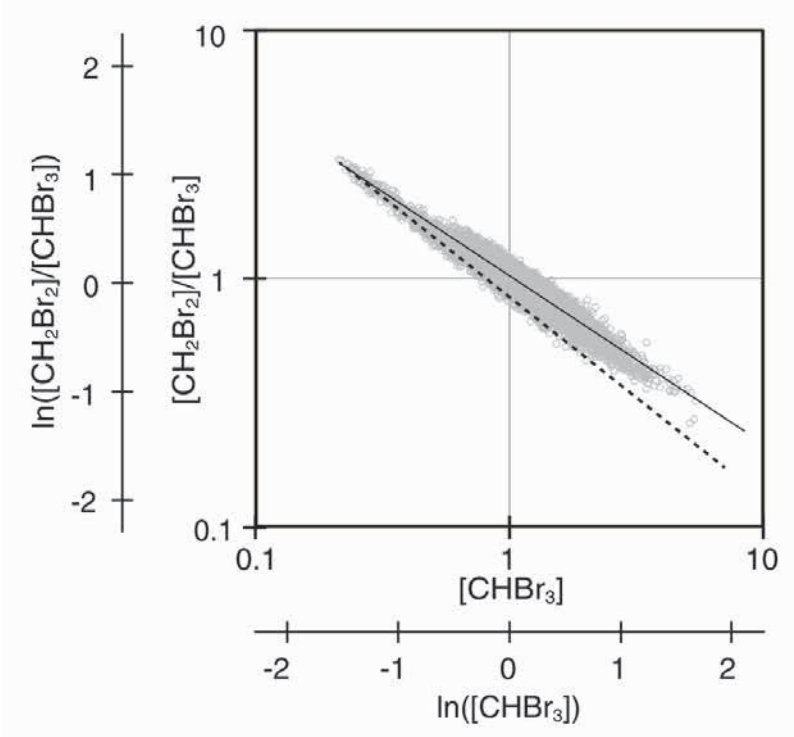


Fig. 3 Relationship between$[CH_2Br_2]/[CHBr_3]$ and $[CHBr_3]$ in individual samples collected at Hateruma. The solid line is the regression line for the complete dataset. The broken line represents possible chemical decay.

4. Improvement of ground-based lidar network observation by introducing Raman lidar technique

We improved two-wavelength polarization Mie-scattering lidars at several main sites in the Asian dust and aerosol lidar observation network (AD-Net) by adding a nitrogen Raman scatter measurement channel at a wavelength of 607 nm. Since 2009 we have been conducting ground-based network observations with the improved Mie-Raman lidars (MRLs) in East Asia. These MRLs provide $1\alpha+2\beta+1\delta$ data at night: the extinction coefficient (α_{532}), backscatter coefficient (β_{532}), and depolarization ratio (δ_{532}) of particles at 532 nm and an attenuated backscatter coefficient at 1064 nm ($\beta_{at,1064}$). Furthermore, we developed a multi-wavelength Mie-Raman lidar (MMRL) providing $2\alpha+3\beta+2\delta$ data (α at 355 and 532 nm; β at 355 and 532 nm; β_{at} at 1064 nm; and δ at 355 and 532 nm) and constructed MMRLs at several main sites of AD-Net (Fig. 4). We identified an aerosol-rich layer and the height of the planetary boundary layer (PBL) by using the $\beta_{at,1064}$ data, and we derived aerosol optical properties (AOPs; for example, α_a, β_a, δ_a, and the lidar ratio (S_a)). We demonstrated that the properties of AOPs could be derived with appropriate accuracy. Seasonal means of AOPs in the PBL were evaluated for each MRL observation site by using 3-year data from 2010 through 2012; the AOPs changed according to each season and region. As shown in Figure 5, marked differences in $S_{a,532}$ and the color ratio of β ($CR = \beta_{at,1064}/\beta_{a,532}$) were observed among seasons, and the seasonal differences varied among observation sites (i.e. among regions). The variations are complicated and may be caused by mechanisms such as external mixing of various aerosol components, internal mixing of these components, and/or water uptake by water-soluble aerosols. By

using the $1\alpha_{532}+2\beta_{532}$ and $1\beta_{at,1064}+1\delta_{532}$ data obtained from the ground-based Raman lidar measurements, we further developed an algorithm to estimate the extinction coefficients at a wavelength of 532 nm for black carbon, dust, sea-salt, and air-pollution aerosols consisting of a mixture of sulfate, nitrate, and organic-carbon substances. With this method, we assumed an external mixture of aerosol components and prescribed an algorithm for the observed data to demonstrate the performance of the algorithm and determine the vertical structure of each aerosol component.

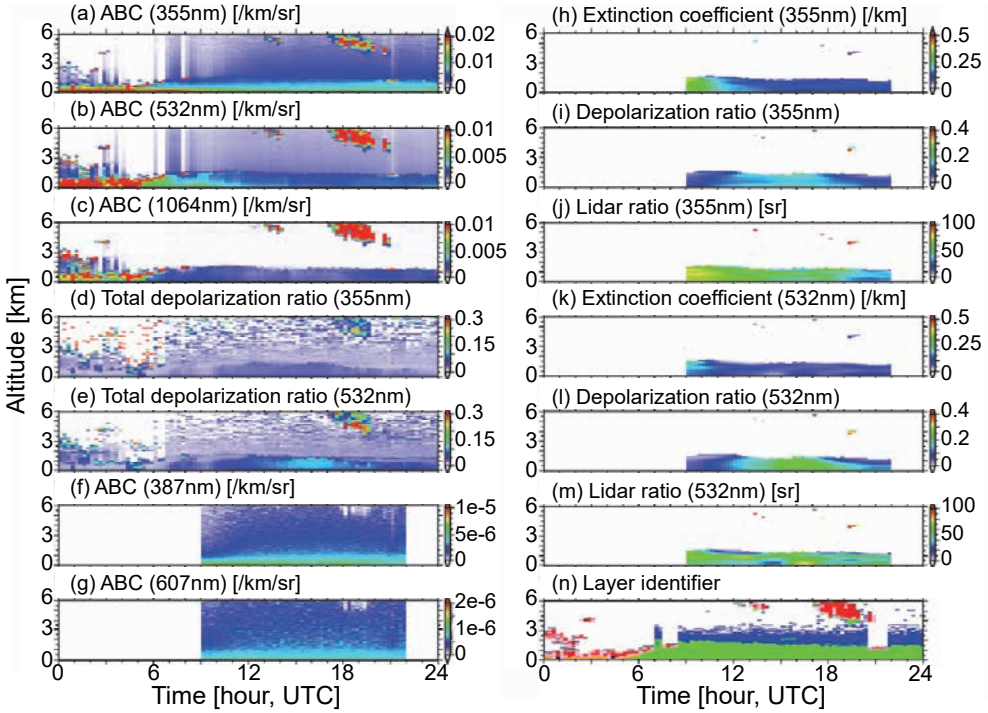


Fig. 4 Time–height cross-sections of measured data for $\beta_{at,355}$ (a), $\beta_{at,532}$ (b), $\beta_{at,1064}$ (c), $\delta_{t,355}$ (d), $\delta_{t,532}$ (e), $\beta_{at,387}$ (f), and $\beta_{at,607}$ (g); aerosol optical properties of $\alpha_{a,355}$ (h), $\delta_{a,355}$ (i), $S_{a,355}$ (j), $\alpha_{a,532}$ (k), $\delta_{a,532}$ (l), and $S_{a,532}$ (m); and layer identifiers (n) for Fukuoka (35.52°N, 130.47°E), Japan, on 6 January 2015. Panel (n) identifies noisy data (white), molecule-rich layer (blue), aerosol-rich layer (green), unknown layer (e.g., heavy aerosol loading or fog), rain, or cloud layer (pink), and cloud layer (red).

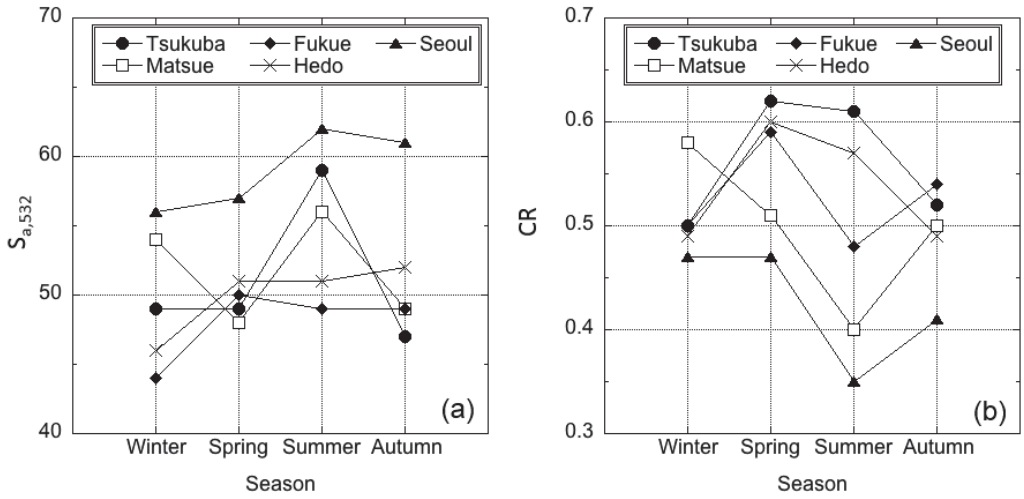


Fig. 5 Seasonal variations in $S_{a,532}$ (lidar ratio at 532 nm) and the color ratio of β (CR) at each observation site. $S_{a,532}$ and CR are seasonal means.

5. Criegee chemistry on aqueous organic surfaces

Criegee intermediates (CIs), which are carbonyl oxides with two charge centers, effectively influence atmospheric HOx cycling and particle formation. The atmospheric fate of gas-phase CIs is determined by their reactions with water molecules. Here, we demonstrated that CIs produced in situ on the surface of water–acetonitrile (W–AN) solutions reacted competitively with millimolar carboxylic acids. In our experiments we have been using online electrospray mass spectrometry to probe CI chemistry on the surfaces of α-humulene and β-caryophyllene in W–AN microjets exposed to O_3(g) for <10 μs. Mass-specific identification lets us establish the progeny of products and intermediates generated in the very early stages of CI reactions with H_2O, D_2O, $H_2{}^{18}O$, or n-alkyl-COOH (n = 1 to 7). Figure 6 shows the negative ion mass spectra from the reaction of α-humulene's CIs with water and hexanoic acid (R_5-COOH). The m/z 305;307 and 403;405 signals correspond to Cl- adducts of α-hydroxy-hydroperoxides (P1) and α-acyloxy-hydroperoxides (P2), respectively. We found that n-alkyl-COOH competes for CIs with interfacial water molecules, their competitiveness being an increasing function of n (chain length). We demonstrated, for the first time, that CIs can react with species other than $(H_2O)_n$ on the surface of aqueous organic aerosols owing to the low water concentrations prevalent in the outermost interfacial layers.

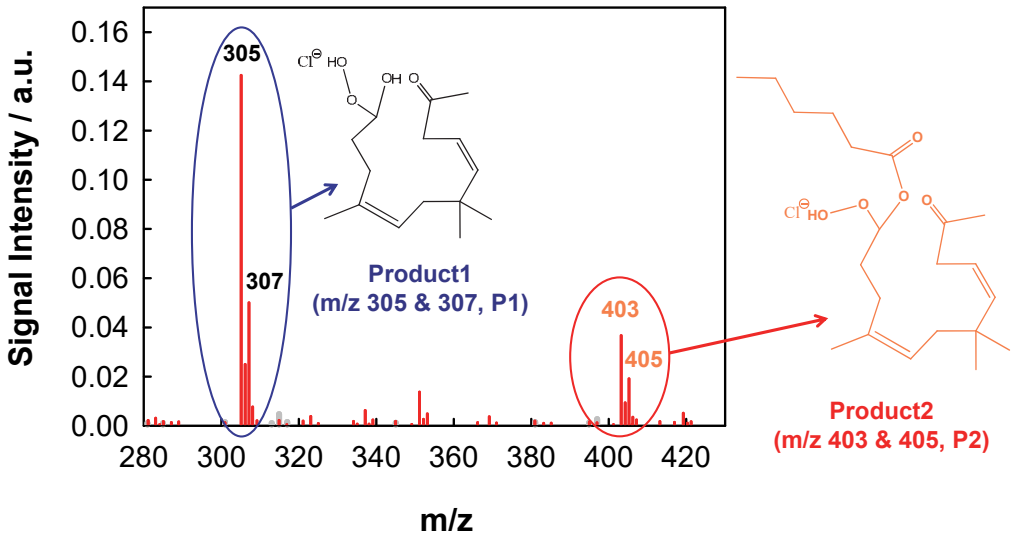


Fig. 6 Negative ion mass spectra from 1 mM α-humulene + 0.2 mM NaCl + 100 mM hexanoic acid microjets in the absence (gray) and presence (red) of O_3(g). The m/z 305;307 signals correspond to Cl adducts of α-hydroxy-hydroperoxides (P1). The m/z 403;405 signals correspond to Cl adducts of α-acyloxy-hydroperoxides (P2).

Fukushima Branch

In April 2016, NIES opened its Fukushima Branch within the research building at the Fukushima Prefectural Center for Environmental Creation (Fukushima CEC) located in the town of Miharu in Fukushima Prefecture. NIES's objective is to promote and maintain rigorous scientific research activities focused on disaster-affected areas. NIES uses its Fukushima Branch as a collaboration hub to conduct environmental emergency research aimed at environmental recovery and renovation in disaster-affected areas. The collaborating partners include various relevant organizations, including the government of Fukushima Prefecture and the Japan Atomic Energy Agency. By providing its environmental emergency research expertise, NIES also extends support to the Fukushima CEC's efforts to collect and disseminate environmental information and to prepare educational, training, and exchange programs. The overall goal is to grow the Fukushima Branch into a globally recognized hub of environmental emergency research.

Fig. 1 Fukushima Prefectural Center for Environmental Creation and NIES's Fukushima Branch

In 2016, Fukushima Branch, along with researchers in the research centers at Tsukuba, began conducting many types of research activities (laboratory work, field measurements, model simulations, and field studies) in the area of environmental emergency research. Researchers at Fukushima Branch took part in an environmental emergency research program, which develops environmental technologies that contribute to environmental recovery, reconstruction, and renovation in devastated areas; on the basis of our experience in the Great East Japan Earthquake and other disasters, they are also involved in creating sustainable regional environments capable of withstanding major disasters. Fukushima Branch is also leading efforts to build an appropriate structure for collaboration among government, industry, and academia in the field of environmental emergency research. Overall, there has been steady progress in the establishment of a research system and a basis for environmental emergency research; the building of a research structure for collaboration with multiple stakeholders; the development of system for widely communicating research results; and the provision of support and cooperation for Fukushima CEC's activities.

Environmental Information Department

Environmental Information Department

The Environmental Information Department provides information technology (IT) support for research and related functions at NIES; supports public relations initiatives (including publishing NIES research reports); and performs miscellaneous other activities, including collecting and processing environmental information and disseminating it to the general public and performing tasks commissioned by the Ministry of the Environment (MOE). These tasks are described in detail below.

1. IT support for research and related activities at NIES

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

1.1 Management and operation of computers and related systems

A new computer system began operation in June 2013. The UNIX-based computing environment consists of a supercomputer system and various subsystems, including a scalar-computing server, a front-end server, and storage devices. Our vector supercomputer (NEC SX-ACE; Fig. 1), 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. NIESNET was upgraded in March 2013. Registered users outside NIES can use the supercomputer system through the Tsukuba wide-area network via the SINET (Science Information Network) connection to the Internet.

Fig. 1 The NEC SX-ACE supercomputer

1.2 Use of IT to improve work efficiency at NIES

The Department provides IT support to the administration and planning divisions 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 website. In FY 2016, the Department supported:

- development of an electronic application and registration system at NIES
- operation of a thin-client PC management system for the administrative section
- development of the NIES research information database
- modification and operation of a database of basic information on each staff member at the Institute.

1.3 Library services

As of March 2017, the NIES library (Fig. 2) held 65,886 books, 909 journals (including electronic resources), and various other technical reports and reference materials. These materials can be searched by using OPAC (Online Public Access Catalog) and a link resolver via the Intranet.

In addition to these resources, researchers at NIES can use abstracts and full-text articles through scientific and technical information databases such as Web of Science (including Essential Science Indicators and Journal Citation Reports) and CiNii.

Library facilities include separate rooms for reading books, journals, and reports.

Fig. 2 The NIES library

2. NIES public relations activities

The Department manages the NIES website. It also edits and publishes NIES reports such as research reports and this *Annual Report*.

2.1 Management of the NIES website

NIES began to provide publicly accessible information on its research activities and results via the Internet (http://www.nies.go.jp/; Fig. 3) in March 1996. In April 2001, the website was completely revamped and improved in step with the restructuring of NIES as an Independent Administrative Institution. The website was again revamped in July 2013. It also provides information on NIES initiatives related to the Great East Japan Earthquake.

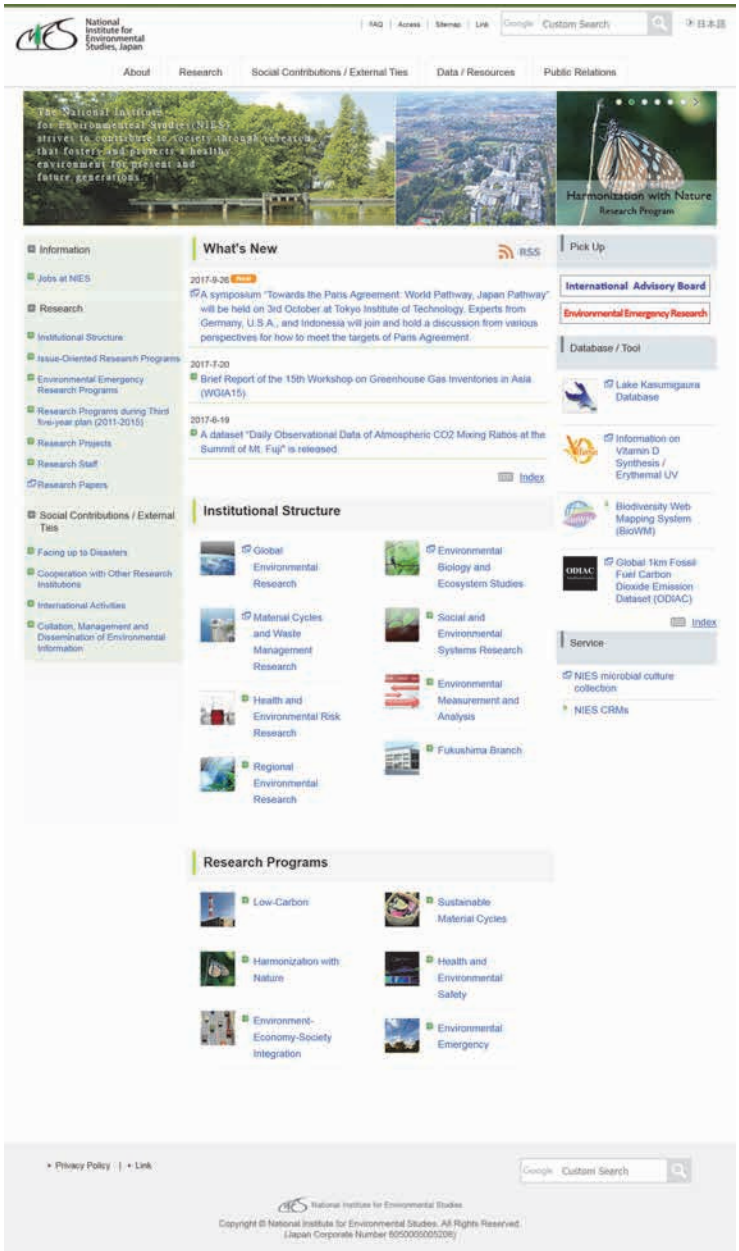


Fig. 3 The NIES website

2.2 Editing and publication of NIES reports

Reports on NIES research activities and outcomes, 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 Department.

2.3 Promoting Open Science

To facilitate the use and application of research resources, prevent the loss of research results, and assure permanent accessibility, we have started attaching digital object identifiers (DOI) to research data. Accordingly, we have set up a system for publishing URLs (metadata) associated with DOIs on the NIES website.

In response to calls for the establishment of a system for promoting open science, we have also started exploring an archive system (an institutional repository) to be created and operated by NIES.

3. Other activities

3.1 Collection, processing, and dissemination of environmental information

One of the major tasks at NIES is “the collection, processing, and dissemination of environmental information.” The Department provides various kinds of environmental information to the public through websites. It also processes and manages environmental information databases and provides environmental information via GIS (Geographic Information Systems).

3.1.1 Environmental Observatory (Information Platform for Environmental Outlook)

The Environmental Observatory (Information Platform for Environmental Outlook) is a multimedia site providing integrated environmental information to promote wider involvement of the public and related institutions in environmental conservation. It gives users broad access to a range of systematically organized environmental information aimed at creating a sustainable society. The site offers a quick search facility to access news updates on such things as environmental issues in Japan and throughout the globe; descriptions of key environmental technologies; information on policies and laws in environmental fields; environmental information via GIS; and other content to aid environmental learning.

3.1.2 Processing and management of environmental information databases

Various environmental data are needed for research, policy decisions, and policy enforcement. We compile and process air-quality and water-quality data collected by local governments and reported to the MOE. These processed data can be accessed through the database on the NIES website. Duplication and lending services are also available.

3.1.3 Provision of environmental information via GIS

The Department, with the cooperation of the MOE, has been using GIS to develop an environmental data provision system. By displaying data on environmental quality and other information on maps, this system helps users to understand the status of the environment easily. The system has been publicly available through the Internet since September 2002 and was revised in March 2011.

3.2 Tasks commissioned by the Ministry of the Environment

In FY 2016, the Department performed the following task, as commissioned by the MOE:

- conversion of hourly values of regular air monitoring data to standard format.

Inquiries:
International Coordination Office
Telephone:＋81-29-850-2827
Facsimile:＋81-29-851-2716
E-mail:international@nies.go.jp

National Institute for Environmental Studies
16-2 Onogawa, Tsukuba, Ibaraki 305-8506, JAPAN
http://www.nies.go.jp/

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