ISSN 2187-9486

NIES Annual Report 2018

AE - 24 - 2018

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Foreword

This annual report is the official record of activities at the National Institute for Environmental Studies (NIES) in Fiscal Year 2017 (FY2017: April 2017 to March 2018) which marks the second year of our Fourth NIES Five-Year Plan (FY 2016-FY2020).

NIES established its Fukushima Branch in the Research Building of Fukushima Prefectural Centre for Environmental Creation as a collaboration hub to conduct environmental emergency research in 2016 along with the seven research centers in Tsukuba Headquarters – the 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 April 2017, Lake Biwa Branch Office was established located inside Lake Biwa Environmental Research Institute.

Each research center undertook basic research on various aspects of environmental issues whereas issue-driven research has been jointly carried out under five *Issue-Oriented Research Programs* - low carbon; sustainable material cycles; harmonization with nature; health and environmental safety; and environment-economy-society integration. Besides these research programs, three *Environmental Emergency Research Programs* - environmental recovery; environmental renovation; and environmental emergency management - have been undertaken in the aftermath of the Great East Japan Earthquake. Starting from the preceding five-year plan period, NIES also continued the activities to support and promote broad range of environmental research by updating and offering various type of tools and data: various type of monitoring activities; a greenhouse gas emissions inventory; environmental as well as biological specimen banking; reference laboratory functions; and various environmental databases.

Activities closely associated with NIES' research have been categorized as Research Project, which are to meet the increasing society's demands to make full use of research outcomes. These included observation of earth-level GHGs by Greenhouse Gases Observing Satellite (GOSAT) and a nation-wide birth cohort study by the Japan Environment and Children's Study (JECS), showing firm progress and generating achievements. In addition, several Collaboration Offices have been organized to serve as the primary promotion body of these projects and to facilitate smooth collaboration within and/or outside NIES.

The society's needs for environmental research such as analyzing and predicting climate change and its effects, designing adaptation measures for this, and achieving Sustainable Development Goals (SDGs) are steadily increasing. Here, challenge for NIES is to figure out how effectively we could give back and implement these research outcomes to the community. Thus, while focusing on its primary mission as a research institute, NIES will also strive to focus on activities that emphasize being in touch with the society and holding social dialogues.

NIES furthers advance and research networks domestically and globally. NIES has research agreements with more than 50 foreign institutes and universities, and 14 research projects were conducted under the Science and Technology Cooperation Agreements between the governments. Furthermore, NIES contributes to various kinds of global initiatives including Intergovernmental Panel on Climate Change

(IPCC), Global Climate and Health Alliance (GCHA), and Future Earth. To promote research collaborations in Asia, NIES, together with National Institute of Environmental Research (NIER; Korea) and Chinese Research Academy of Environmental Sciences (CRAES; China), hosted the 14th Tripartite Presidents Meeting in Tsukuba and exchanged views for future collaborations. NIES also held the 3rd NIES International Forum to discuss with Asian research communities in Kuala Lumpur, Malaysia.

We hope that this report will help facilitate a greater understanding of our institute's activities, and we invite your full and frank feedback and opinion about these activities.

Watanabe, Chiho
President
October, 2018

Contents

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.

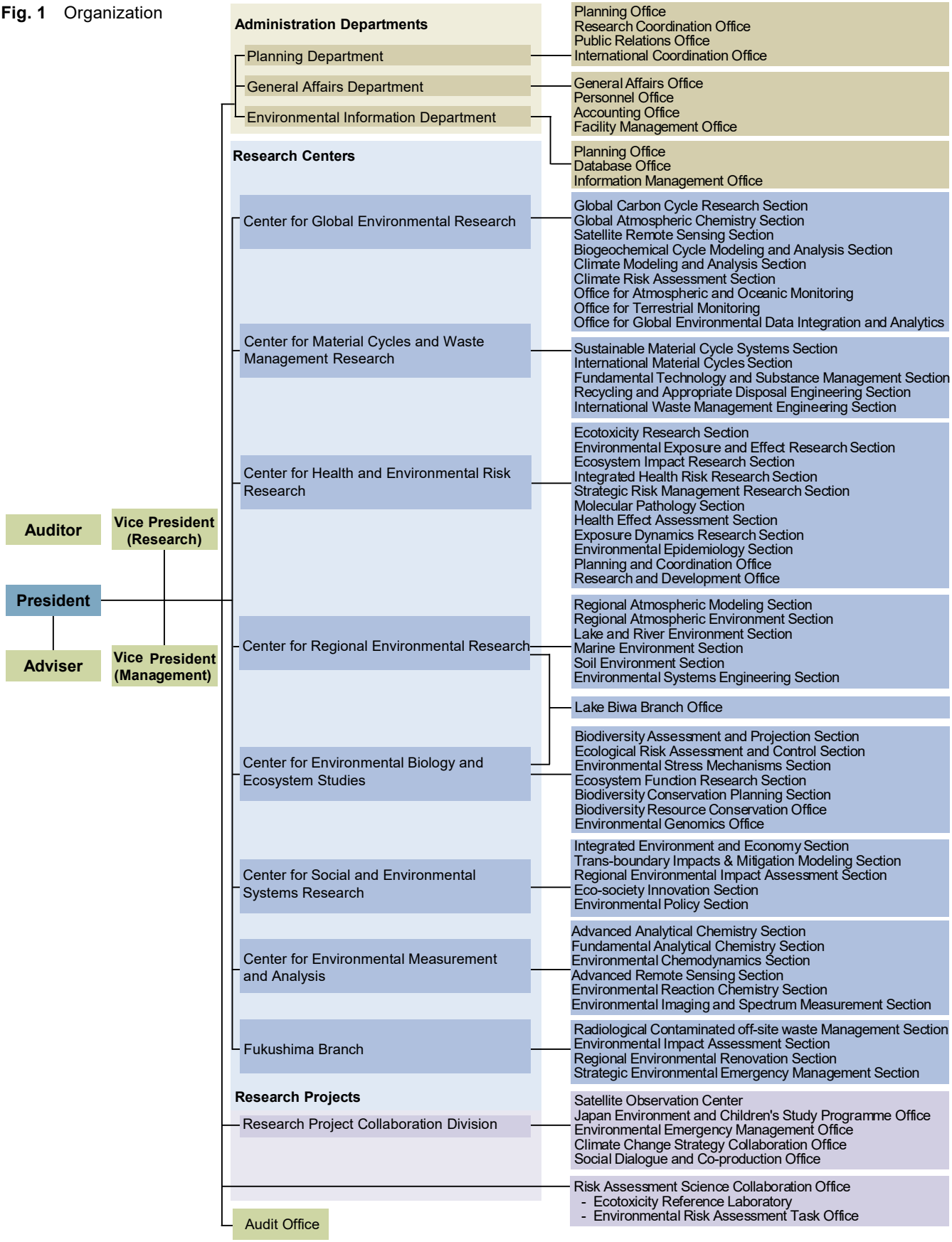
During the two decades following the establishment of NIES, rapid technological progress, structural changes in industry, and lifestyle changes, created additional issues for environmental science to confront. Moreover, global environmental problems such as climate change; depletion of the stratospheric 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 issue-oriented research programs for this plan's term, and will pursue them in an integrated manner that transcends individual fields. NIES has established Fukushima Branch, where it is running Environmental Emergency Research Programs. Also in April 2017, Lake Biwa Branch Office was established

Fig. 1 Organization



located in Lake Biwa Environmental Research Institute where developed research for water environmental protection is jointly conducted. Additionally, to produce scientific findings on environmental protection, 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, 2018, there are 275 NIES permanent staff and 491 non-permanent researchers (Table 1; Figs. 2 to 5). The total budget for FY2017 was 15,476 million yen (Table 2).

Table 1 Numbers of permanent staff

Administration Departments	58
Research Centers	212
Executives and Advisers	5
Total	275

(As of April 1, 2018)

Table 2 Budget for the fourth five-year plan

(Unit: million yen)

	Category	2016–2020 Budget (5 years)	Fiscal Year 2017 Budget
Revenue	Grants for Operating Costs	62,668	12,216
	Subsidies for Facilities	1,662	317
	Commissioned Work	17,786	3,557
	Total	82,116	16,090
Expenditure	Project Costs	44,609	8,541
	Facility Improvements	1,662	317
	Expenses for Commissioned Work	17,786	3,557
	Personnel Expenses	16,025	3,216
	General Administrative Expenses	2,034	458
	Total	82,116	16,090

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	:	58	
Research Centers	:	212	(4)
Executives and Advisers	:	5	
Total		275	(4)

Notes:
1. Data is as of April 1, 2018.

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

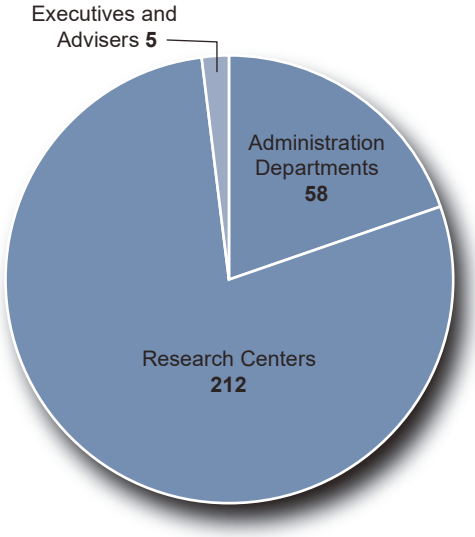


Fig. 2 Permanent staff breakdown

Basic Sciences (Physics, Chemistry, Biology)	:	83	41.09%
Engineering	:	66	32.67%
Agricultural Sciences	:	29	14.36%
Medical Sciences	:	10	4.95%
Pharmaceutical Sciences	:	4	1.98%
Fisheries Sciences	:	1	0.50%
Economics	:	4	1.98%
Sciences	:	3	1.49%
Law	:	1	0.50%
Veterinary Medicine	:	1	0.50%
Total		202	

Notes: Data is as of April 1, 2018.

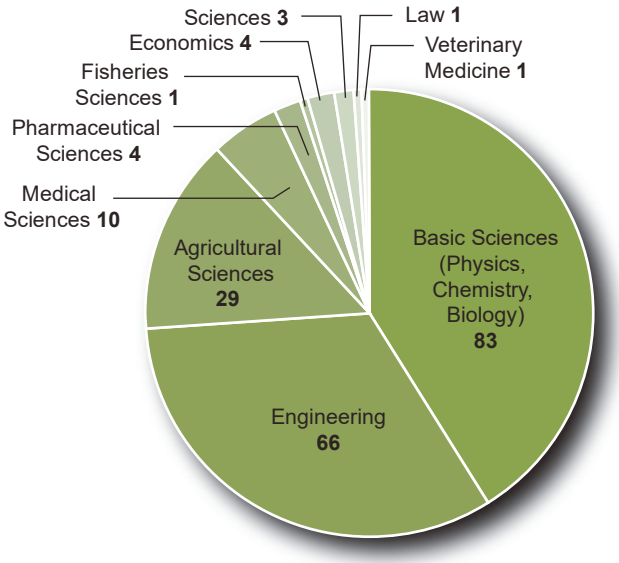


Fig. 3 Fields of expertise（Researchers holding doctorates（96.0%））

Senior Fellow	:	1	
Fellow	:	16	
Research Associate	:	87	(23)
Junior Research Associate	:	9	(1)
Research Assistant	:	31	(10)
Specialist	:	184	(6)
Assistant Staff	:	302	(1)
Senior Staff	:	5	
Senior Research Associate	:	6	
Total		641	(41)

Notes:
1. Data is as of April 1, 2018.

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

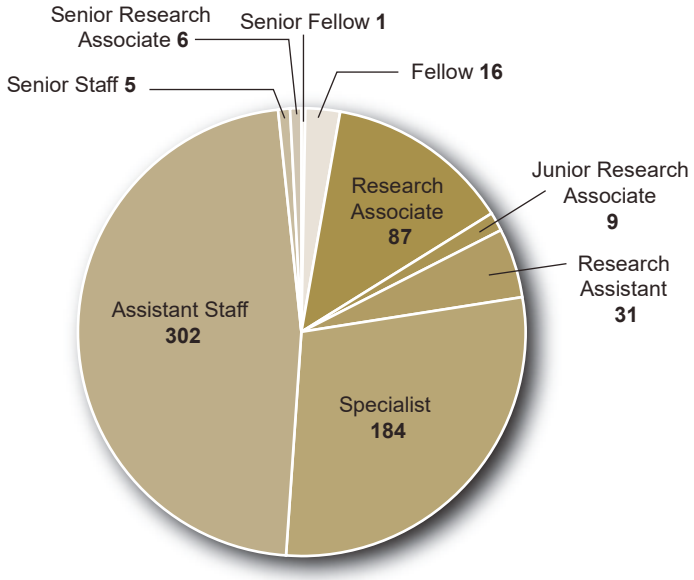


Fig. 4 Contract Staff Breakdown

Visiting Researcher	219	(10)
Research Student	49	(19)
Collaborative Researcher	73	(15)
Total	341	(44)

Notes:

1. Data is the total number accepted in FY2017.

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 this 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 2018, 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.

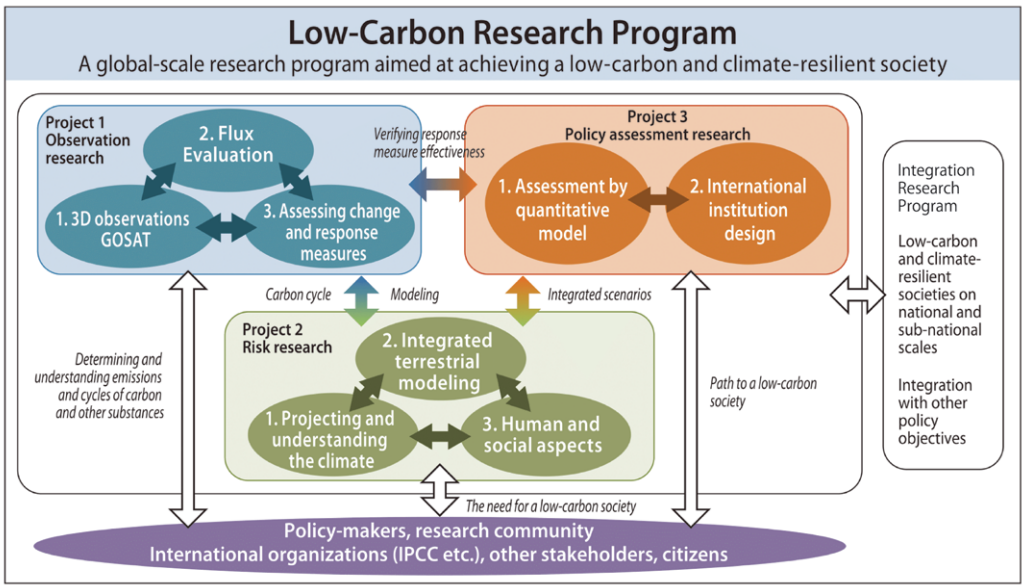


Fig. 1 Structure of the Low-Carbon Research Program. The three projects interact with each other and with society.

1. Study of a multi-scale 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 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 2017, we continued to expand the number of our ground stations for atmospheric GHG monitoring in Southeast Asia—especially in Indonesia, where data coverage had been limited. To quantitatively estimate anthropogenic emissions from the megacity of Jakarta, we started measuring GHGs and air pollutants in the city of Bogor, in Serpong (a Jakarta suburb), and in Cibeureum (a mountainous area). We also started measuring GHGs and related tracers at Tokyo Skytree, the tallest tower in Japan. The concentrations of CO_2, CH_4, CO, and oxygen are monitored in situ at the Skytree, and the isotopic ratio of $^{13}CO_2/^{12}CO_2$ and $^{14}CO_2/^{12}CO_2$ in the sampled air is also analyzed in a NIES laboratory. Simultaneous analysis of carbon isotopes and oxygen was used to partition CO_2 emitted from the biosphere and from the burning of fossil fuels. This was done to improve the accuracy of regional GHG budget estimations—particularly anthropogenic emissions from Asia's megacities.

We also conducted intensive estimations of the emissions from tropical peat forests in southeast Asia. Although tropical peat forest occupies only 0.25% of the globe's surface area, it accounts for 3% of Earth's soil organic carbon. Recently, the area of tropical peat forest has been rapidly decreasing because of fire and the development of plantations, and this has resulted in large carbon losses. Remote sensing is a useful tool for evaluating forest loss at regional scale. In this study, we developed maps of forest loss for every 3 months including forest fire by using MODIS data. We also estimated forest biomass by using the random forest method and evaluated carbon emissions by multiplying the forest loss area by biomass and by emission factors.

We estimated the area of forest loss in Borneo island from 2001 to 2015 (Fig. 2). Tropical forests on the island of Borneo have been disappearing at a rate of 1.7%/year, and half of the forests on peat and 14% of the non-peat forests were lost in this period. CO_2 emissions caused by the loss of peat forests accounted for 25% of the total loss of forests, although peat forests cover only 10% of the total forested area. Most of the forest loss has occurred in central Kalimantan (on the southern part of the island) and Sarawak (in the mid-west of the island). Forests have been mainly converted to oil palm plantations in the Sarawak region, whereas the forests have been lost through fire in Central Kalimantan.

We also examined yearly changes in CO_2 emissions caused by forest fire (Fig. 3).

CO_2 emissions from fires in peat forests accounted for 60% of emissions across the total forested area. Large carbon emissions occurred in 2002, 2006, and 2015 in association with El Niño events. El Niño triggered serious droughts in the region, which caused devastating forest fires. Because emissions from peat forests in Borneo contribute substantially to global carbon emissions, we need to protect peat forests in the region and keep monitoring emissions.

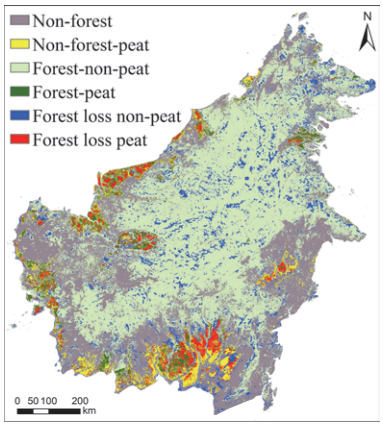


Fig. 2 Map of forest loss in Borneo from 2001 to 2015

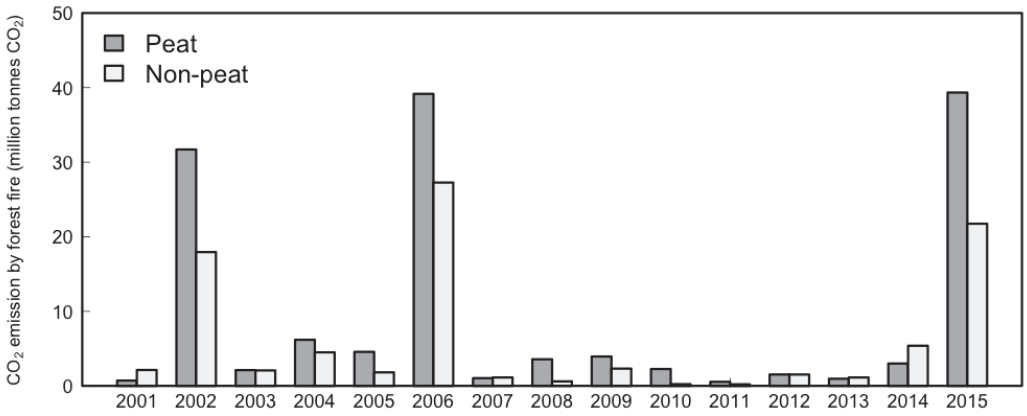


Fig. 3 CO_2 emissions caused by forest fires

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.

Sub-theme 1 is contributing to the development of climate change risk scenarios

by projecting the future climate and increasing our understanding of past climate changes. Specifically, we are aiming at informing the IPCC 6th Assessment Report and also the Special Report on the impacts of global warming of 1.5 °C (SR1.5). This fiscal year, we used a reduced-form integrated assessment model to examine the consistency between temperature- and emission-based targets of the Paris Agreement, namely stabilization of global warming at well below 2 °C above pre-industrial levels, with aims to further constrain this warming to 1.5 °C (temperature based), and reduction of net anthropogenic GHG emissions to zero, during the second half of this century (emission based). We found that net zero GHG emission is not necessarily required to remain below 1.5 °C or 2 °C, assuming that either target can be achieved without overshoot (Fig. 4 ii, iv). With overshoot, however, the emissions goal is consistent with the temperature targets, and substantial negative emissions are associated with reducing warming after it peaks (i, iii). Temperature targets are put at risk by late achievement of emissions goals (vi, vii).

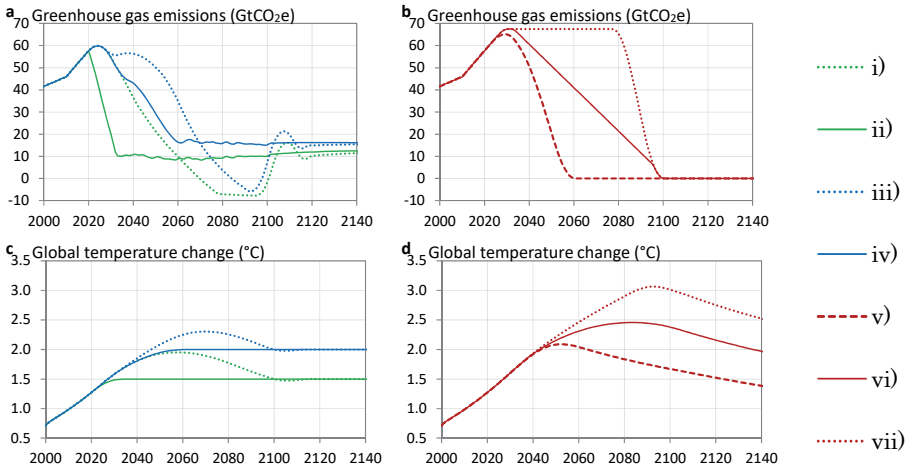


Fig. 4 GHG emissions (a, b) and global temperature changes (c, d) under various scenarios:
i) 1.5 °C (overshoot),
ii) 1.5 °C,
iii) 2 °C (overshoot),
iv) 2 °C,
v) zero emissions by 2060,
vi) zero emissions by 2100 (gradual), and
vii) zero emissions by 2100 (last minute)

We also conducted numerical simulations for the IPCC SR1.5 with a global climate model and found considerable differences in the simulated climate between the 1.5 °C warming and the 2.0 °C warming cases, specifically in terms of extremes of high temperatures, drought risk, and mid-latitude atmospheric circulation.

In sub-theme 2, we have developed an integrated terrestrial model that includes land use, water resources, ecosystems, and agriculture. We have assessed the impact of BECCS (bioenergy with CO_2 capture and storage) deployment scenarios on land systems, including land use, water resources, and ecosystem services. Specifically, we assessed three land-use scenarios to achieve a total emission reduction of 3.3 Gt C year^{-1} [the annual negative emission level required for the IPCC's RCP (Representative Concentration Pathway) 2.6] by growing bioenergy crops, which requires the global use of huge amounts of agricultural and forest land and water. Our study showed that the conversion of food croplands on a vast scale into rainfed bio-crop cultivation would result in

considerable loss of food production.

In sub-theme 3, we have been analyzing climate policies through the integrated utilization of climate impact models and mitigation assessment models. For example, the economic cost of climate change impacts on labor productivity has been estimated by linking a global economic-trade model and a global impact model on labor productivity; we have found that the global annual GDP will decrease by 2.6% to 4.0% by the end of the century if we don't implement any mitigation policies. On the other hand, if we can achieve the 2 °C target of the Paris Agreement then the decrease in GDP will be limited to less than 0.5%.

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 in the Environment-Economy-Society Integration 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 2017 in each sub-theme.

In sub-theme 1, AIM/Enduse [Global] was used to evaluate several scenarios for the mitigation of SLCPs (short-lived climate pollutants) and air pollutants that can become precursors of SLCPs (Fig. 5). We assessed the effects of synergies and tradeoffs of various combinations of air-pollutant control measures and decarbonization measures that can influence the emission profiles of SLCPs and air pollutants. We found that, even if the CO_2 emission pathways of several mitigation scenarios in our study were all similar in achieving the 2 °C target, SLCP and air pollutant emission pathways and mitigation potentials would be largely influenced by combinations of some of the key mitigation measures. By considering both direct SLCP-reduction effects [i.e. mitigating BC (black carbon) and CH_4 (methane) emissions] and indirect SLCP-reduction effects [i.e. mitigating NOx (nitrogen oxide), CO (carbon monoxide), and NMVOC (non-methane volatile organic compound) emissions to reduce tropospheric O_3 (ozone) generation and atmospheric CH_4 concentrations], we assessed combinations of the following actions as effective SLCP-mitigation scenarios: widespread promotion of renewable energies; intensive electrification of the transport, residential, and commercial sectors; using biofuels in a high proportion of the transport sector; and deployment of devices to remove air pollutants such as NOx, SOx, and BC.

As part of sub-theme 2, we utilized a set of indicators to examine countries' efforts to curb global GHG emissions towards the Paris Agreement's long-term target of 2 or 1.5 ºC. We selected G20 countries because they are responsible for

around 80% of global emissions. Four intermediate goals were chosen to examine their efforts. (1) Decarbonization of energy: almost all countries are heading towards decarbonization, but some emerging economies such as India and Brazil are directed towards increasing carbon intensity. (2) Improvement of energy efficiency: all countries are shifting towards improvement, although some relatively wealthy countries (in terms of GDP per capita), such as Saudi Arabia and Russia, are not making many improvements. (3) Reduction of demand for energy services: by and large, little improvement is being observed. Slow progress is being made in developed countries, and many emerging economies have set emission targets that are expected to reflect increasing energy demands up to 2030. (4) Use of non-CO_2 GHGs and sequestration by forests: methane emissions remain untouched in many countries. Forest coverage has improved in many countries that have implemented sound policies aiming at afforestation.

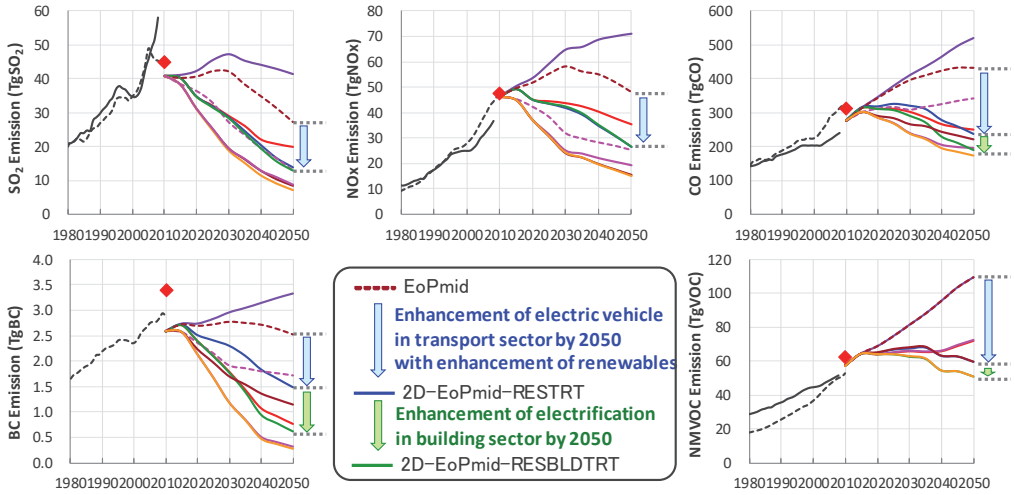


Fig. 5 SO_2, NOx, BC, CO, and NMVOC emission pathways in Asia within global emissions pathways under a number of different mitigation scenarios

	Key measures for mitigating GHGs, SLCPs and air pollutants					
	Enhancement of end-of-pipe technology	2 ℃ target	Enhancement of carbon capture & storage (CCS)	Enhancement of renewable energy	Intensive electrification in building	Intensive electrification in transport
Reference						
EoPmid	mid					
EoPmax	max					
2D-EoPmid-CCSBLD	mid	✔	✔		✔	
2D-EoPmax-CCSBLD	max	✔	✔		✔	
2D-EoPmid-RESTRT	mid	✔		✔		✔
2D-EoPmax-RESTRT	max	✔		✔		✔
2D-EoPmid-RESBLDTRT	mid	✔		✔	✔	✔
2D-EoPmax-RESBLDTRT	max	✔		✔	✔	✔

EDGER4.2 REAS HTAP

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 a consumption-based perspective (Research Project 1)

Because successful achievement of the United Nations' sustainable development goals and implementation of the Paris Agreement will require technologies that utilize vast quantities of a wide range of minerals, global resource governance will be required for sustainable development. Knowledge about the flow of substances is fundamental to reducing natural resource consumption and controlling material cycles. Material flow analysis (MFA) is an excellent tool for quantifying material balances in specific areas for resource and waste management. This project identified (1) apparent consumption of materials (Fe, Cu, and Ni), and (2) the role of primary processing in risks to the supply of critical metals (Co, Pt, and Nd) as a global systematic phenomenon.

In terms of rates of consumption of materials, Asia has already become the largest world user of iron, copper, and nickel, and economic growth in China has accelerated the rapid rise in worldwide demand for these resources. Per-capita apparent consumption of iron in Asia has already reached that of North America and Western Europe, and the per-capita apparent consumption of copper and nickel is following a similar path. The world's population is projected to increase, with much of that growth concentrated in Asia and Africa (Fig. 1). This situation demonstrates the potential for greatly increased demand for materials as a result of population and economic growth in Asia and Africa.

We quantified the supply risks for three critical metals in the first post-mining stage in the context of Japan's economy. By applying the "footprint" concept and a multiregional input–output model, we quantified the direct and indirect vulnerability of the Japanese economy to such risks. Considering the supply risks associated with primary processors, we have found that Japanese final consumers are exposed to higher supply risks for neodymium than for cobalt and platinum.

Our study showed that the primary processing stage of a metal's supply chain may contribute substantially to the overall supply risk, suggesting that this stage should be taken into account in understanding and mitigating supply-chain vulnerability through, for example, supplier diversification and the development of alternative materials.

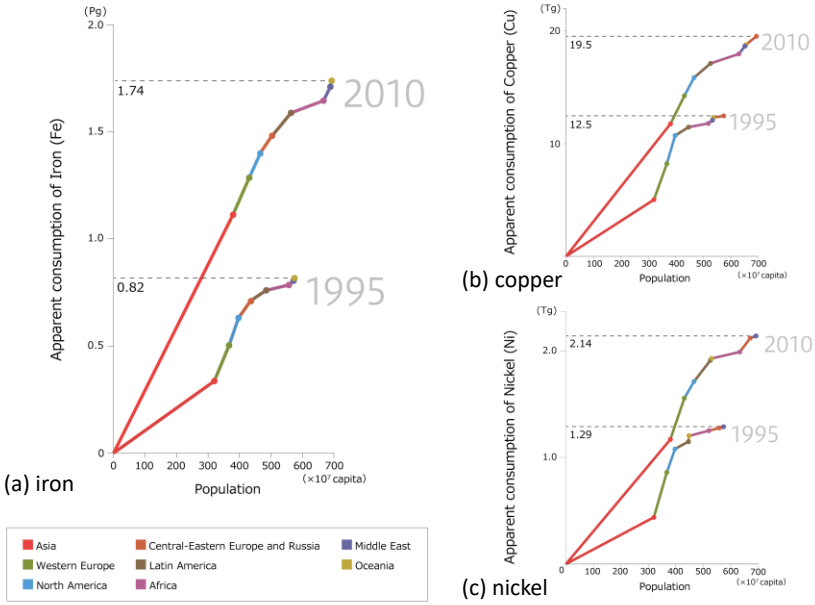


Fig. 1 Distribution of population and apparent consumption of substances in 1995 and 2010; (a) iron, (b) copper, and (c) nickel Reference: Nakajima K., Daigo I., Nansai K., Matsubae K., Takayanagi W., Tomita M., Matsuno Y. (2018) Global distribution of material consumption: Nickel, copper, and iron. Resources, *Conservation and Recycling* 133:369–374

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

We estimated the contents of 16 kinds of metals targeted by the Japanese PRTR (pollutant release and transfer register) system in incinerated industrial waste based on the metal content analysis of incineration residue samples and mass balance information from incineration facilities. The results showed that specific waste categories were dominant in the transfer of metals to waste incineration: for example, sludge and waste acids/alkalis were the dominant sources of heavy metals. Therefore, to accurately estimate environmental emissions, the types of waste predominantly processed by each incineration facility must be considered. We also determined the concentrations of the 16 metals in the exhaust gases at the facilities. The concentrations ranged over two or three orders of magnitude; we attributed this wide range to differences among the types of waste predominantly processed and the types of exhaust-gas treatment systems at the facilities investigated. These characteristics of the incineration facilities must be considered to accurately estimate emission factors.

We evaluated human exposure to bioaccessible hazardous chemicals derived from waste electrical and electronic equipment (WEEE). To do this, we investigated the bioaccessibilities of heavy metals, brominated flame retardants (BFRs),

phosphorus-containing flame retardants (PFRs), and dioxin-related compounds (DRCs) in artificial gastrointestinal fluids. The compounds were sourced from the floor and from dust settled on surfaces in an indoor working environment for WEEE recycling; ingestion of contaminants from such sources is an important exposure pathway. The bioaccessibilities of heavy metals (lead and cadmium) and PFRs in the gastric and intestinal phases tended to be higher than those of BFRs and DRCs in the intestinal phase. Elution testing of these chemicals in soil samples collected from around the WEEE recycling facility and an open-burning area is ongoing.

Taking into consideration material cycles and the global warming potential in Asian countries by 2030, we estimated the numbers of end-of-life household air-conditioners per year and the amount of refrigerants they would contain. We found that the absolute increase and percentage share of air-conditioning units and refrigerants in China, compared with Asia as a whole, were marked. A cost-effectiveness analysis of several fluorocarbon-mitigation scenarios suggested that a scenario of appropriate recovery and decomposition of fluorocarbons after transportation from China to Japan compared favorably with other global warming mitigation measures.

From that perspective, we are analyzing trade statistics and national reports under the Basel Convention in an effort to compile a database of transboundary movements of electronic scrap and other recyclable resources with the aim of appropriate management at a whole-of-Asia scale.

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.

We have developed a model to estimate waste flows in Japan on the basis of a bottom-up approach, in which municipal solid waste (MSW) management data for each municipality are used and aggregated to the national level. First, we focused on food waste recycling (composting) and estimated its contribution to changes in the rate of recycling of MSW at the national level. The statistical data on MSW management in Japan suggested that 149 municipalities had collected food waste separately and had produced compost. Analysis of municipalities with more than 354 m^2 of farmland per capita revealed that 961 municipalities would

be able to initiate food waste composting.

We then conducted an interview survey and systems analysis of seven cases in which integrated treatment of food waste and sewage sludge had been achieved with the aim of efficient material cycling and waste management. The results showed that the costs and CO_2 emissions of integrated treatment had been successfully reduced in all seven cases, primarily by reducing the number of facilities.

Thirdly, we used MSW data from the Ministry of Environment to analyze trends in the rates of operation of incinerators. We observed a decreasing trend in the operation rate of incinerators since about 2000; this suggests that it will be difficult to operate incinerators efficiently in the future, and that we need to evaluate the consolidation of such facilities.

To further investigate Japans' future adaptation to an aging society, we published an online guideline for municipalities to cope with issues related to waste disposal by the elderly. Our guideline includes principles, procedures, and practical advice on introducing policies. We also published a case report that introduces 12 good practices for supporting waste disposal by the elderly.

Finally, we reviewed cases that enhance the quality of material circulation. For greater resource efficiency, we also developed a product lifespan model that explicitly considers the effects of product longevity on lifespan distribution and applied it to the case of motor vehicles.

4. Establishment of a robust, sustainable, and integrated waste management system for 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, including mechanical–biological treatment, constructed wetlands for landfill leachate, landfills with reduced long-term pollution flux, energy saving/generating using 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 2017.

We demonstrated a typical cause of uncertainty of the MSW management data in developing countries. MSW generation per capita was estimated by using statistical population and MSW-generation data for 50 districts of Bangkok, Thailand. Per-capita MSW generation in Bangkok has tended to increase over the last 10 years and was estimated at 1.68 kg/capita/day in 2015. When the population not registered for waste collection service was assumed to be 50% of the registered population (i.e. the population for which we had statistical data),

the daily MSW generation per capita was estimated at 1.12 kg/capita/day.

We evaluated the qualities of the solid recovered fuel (SRF) and residues produced by the mechanical biological treatment (MBT) of MSW in Thailand. The lower calorific value of the SRF was lower than that of SRF traded internationally. This indicates that MBT drying and sorting processes need to be improved. Instability of quality can lead to the need for additional SRF treatments or rejection of the SRF by users. Residues included degradable organics with a low carbon to nitrogen ratio. This is a concern if residues are to be disposed of in landfills. To see if landfilling of MBT residues could be avoided, we applied biomass carbonization by pyrolysis to the residues. The product had a higher specific surface area and may be able to be used as a pollution purification material for treating intermediate cover soils and leachates.

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

To maximize biomethane recovery from organic wastes generated in urban commercial areas, we investigated the optimal lipids to total solids (L/TS) ratio in anaerobic digestion. The results of a continuous experiment using anaerobic bioreactors at different L/TS ratios ranging from 0.20 to 0.70 suggested that a maximum methane yield of 0.74 L/g-VS (volatile solids), with stable digester operation and no serious inhibition, was obtained at a ratio of 0.55. However, further increasing L/TS ratio to 0.70 caused the process to fail, as indicated by a poor methane yield and a drop in the pH to below 6.5. Thus, an L/TS ratio of 0.55 was the upper limit for the co-digestion of food waste and oily waste. Co-digestion had an obvious advantage in terms of enhancing biomethane recovery under a properly controlled L/TS ratio.

In a study of the behavior of organic pollutants such as POPs (persistent organic pollutants), we investigated the concentrations of pollutants in each medium (such as biogas and effluent) in biogas production facilities that used different wastes as feedstocks. Differences in the feedstock affected the concentration of these pollutants in the fermentation residue. Furthermore, we developed a numerical model for predicting concentrations and have begun to evaluate its reliability.

As part of the development of a thermal treatment technology, we investigated the elemental balance during incineration of woody biomass in a biomass power generation facility, and we clarified the behavior of various elements from fuelwood tips to grate ash, bottom ash, and fly ash. In addition, as a resource recycling method for MSW incineration ash, we proposed a draft method in which metallic particles are separated by using an air-table sorting apparatus and aging of the separated ash residue is accelerated by ventilation with a gas enriched with carbon dioxide.

In a study of the appropriate treatment of wastes containing nanomaterials, we selected titanium oxide and carbon nanotubes as target materials as a result of a prior study of the state of use and health effects of several nanomaterials. We investigated analytical techniques for monitoring them. We revealed that these nanomaterials could be uniformly dispersed in water without their aggregation if suitable dispersing agents were used; the number of nanomaterials in the prepared samples could therefore be counted by transmission 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).

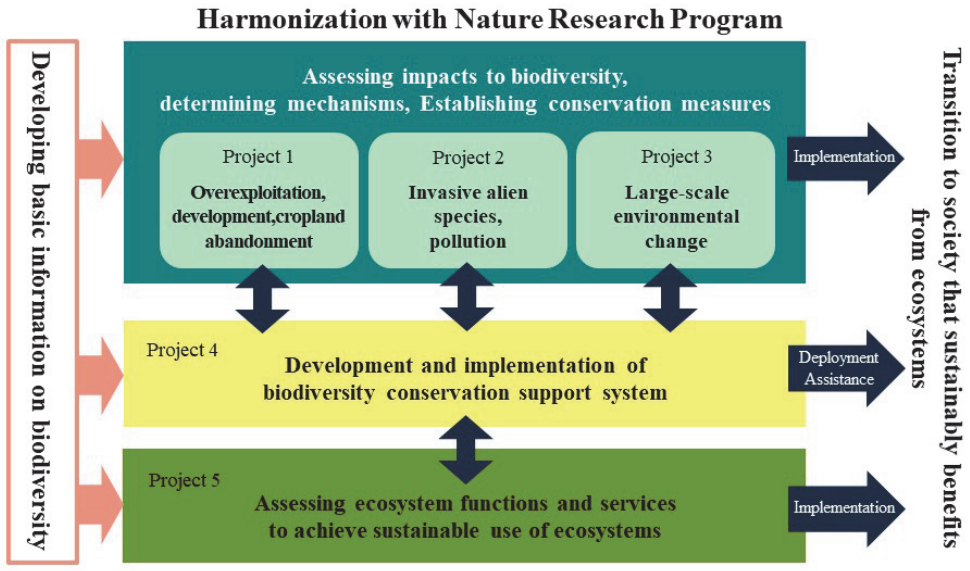


Fig. 1 Research framework of the Harmonization with Nature Research Program

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. Specifically, we quantified forest area change at 30-m resolution globally and are starting the assessment of biodiversity impacts by overlaying range maps provided by International Union for Conservation of Nature (IUCN) for more than 10,000 endangered species on the forest change rate map.

1.2 Effects of land-use abandonment on biodiversity

We surveyed abandoned settlements to estimate the effects of land abandonment on butterfly communities, and we developed a method of using species traits to evaluate the spatial distribution of the impact of land abandonment on species richness. The occurrence of butterflies at each settlement was explained by using the binary explanatory variable, “abandoned or not,” and other factors such as climate via a hierarchical model that considered a trait-species hierarchy. The results indicated that the habitat traits of butterflies were good predictors of species-specific responses to land abandonment. A trial run of spatial evaluation of impacts was conducted (Fig. 2).

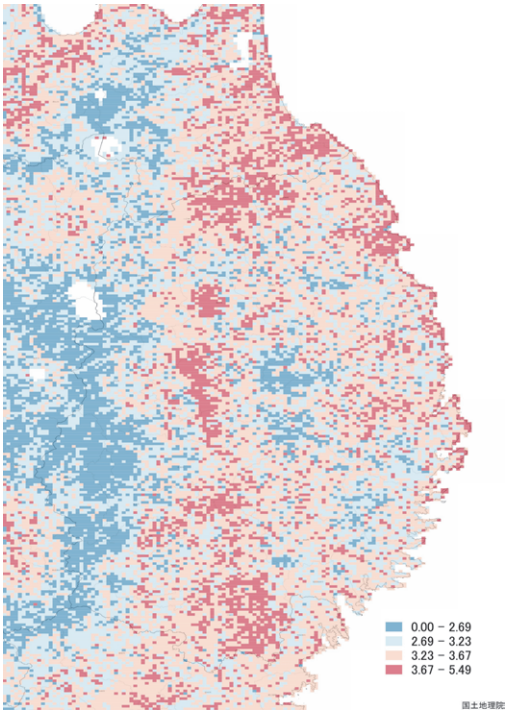


Fig. 2 Example of a map showing the negative impacts of land abandonment on the species richness of butterflies in Iwate Prefecture The value in the map shows the summed species-specific sensitivity to land abandonment over all species.

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

Since the Alien Species Act was enacted, top priority of Ministry of the Environment (MOE) has been to control, and ultimately eradicate, invasive alien species established in Japan, while also preventing new alien species introductions. In developing eradication methods to support the national policy, we have conducted invasive alien species risk assessment and research.

To determine the success of eradication of an invasive species, we need a way to decide when its risk of reoccurrence has become acceptably low. In Japan, the area populated by the Argentine ant, *Linepithema humile* (Mayr), is expanding, and eradication via chemical treatment is ongoing at various locations. One such

program in Tokyo was apparently successful, because the ant population decreased to undetectable levels within a short time. However, construction of a population model for management purposes was difficult, because the probability of detecting ants decreases rapidly as the population collapses. To predict the time when the ant was eradicated, we developed a multinomial mixture model for chemical eradication based on monthly trapping data and the history of pesticide applications. We decided when to declare that eradication had been successful by considering both "eradication" times, which we associated with eradication probabilities of 95% and 99%, and an surveillance stopping time based on a "minimum expected economic cost" that considered the possibility that surveys were stopped too soon. By applying these criteria, we retroactively declared that Argentine ants had been eradicated 38 to 42 months after the start of treatments (16 to 17 months after the last sighting) (Fig. 3).

Since the first detection of the fire ant, *Solenopsis invicta*, in Japan in June 2017, both MOE and NIES have promoted the emergency control of this newly invasive ant. As it is important to detect ant invasions as soon as possible, we have developed a molecular technique to identify the presence of the fire ant by using DNA barcoding and LAMP (loop-mediated isothermal amplification) methods (Fig. 4). Furthermore, we are constructing a chemical control strategy for the ant in collaboration with private companies developing insecticides. To advance these fire ant countermeasures, MOE and NIES are planning to establish an Invasive Alien Ant Control Program for the Asian area.

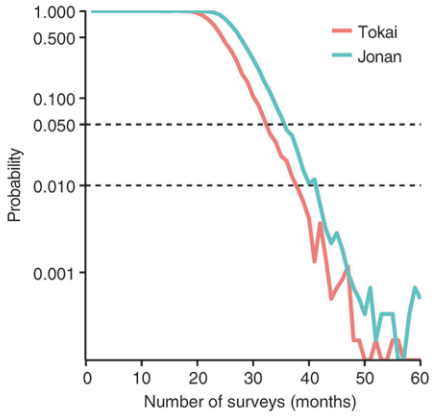


Fig. 3 Posterior probabilities of the estimated occurrence of Argentine ants versus the number of surveys at the Tokai and Jonan sites. Dashed lines indicate posterior probabilities of 0.01 and 0.05.

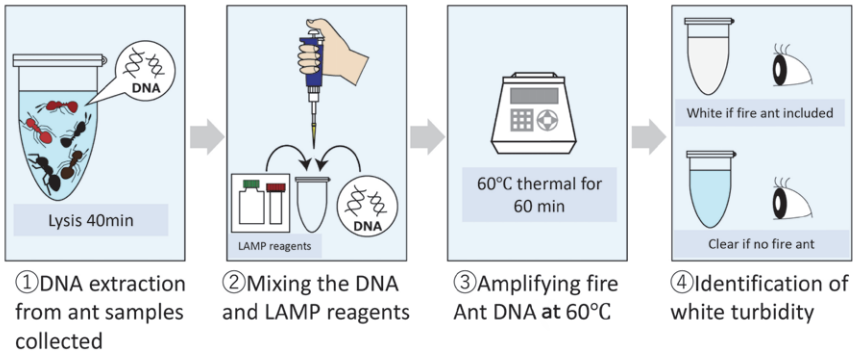


Fig. 4 Concept of the LAMP method for identification of fire ants

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.

In our study of Japanese coastal ecosystems, we constructed a database of occurrence records that includes corals, macroalgae, and herbivorous fishes. Our prediction model incorporating not only ocean warming but also current transport and herbivorous impact explained the ongoing community shift from temperate macroalgae to tropical corals over the past few decades in Japan well. Furthermore, we developed a high-resolution prediction model for coral bleaching by refining the thermal indices and light and other environmental factors (Fig. 5).

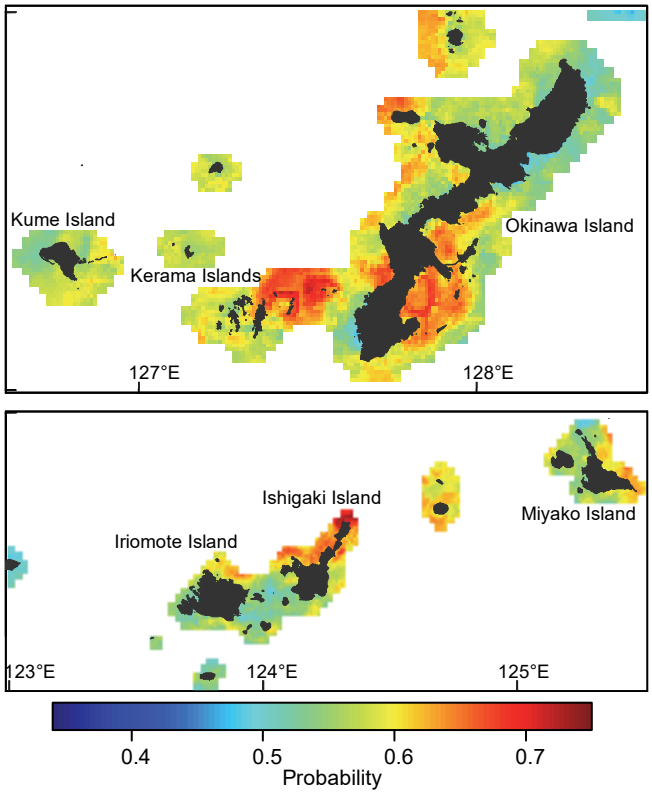


Fig. 5 Predicted probability of coral bleaching in the Ryukyu Islands, Japan, mean of 2008–2010, 2013, and 2016 (Kumagai et al. 2018 PeerJ6:e4382)

In our study of the mechanisms of biotic responses to air pollutants, experiments were continued in mutant lines of *Arabidopsis thaliana*, a model plant. Arabidopsis mutant lines with deficiencies in photorespiratory enzymes such as glycolate oxidase and hydroxypyruvate reductase were sensitive to ozone under high light intensity (Fig. 6A). Ion leakage—an indicator of damage to the cell membrane—from the leaves of ozone-damaged plants started to increase 1 h after the beginning of ozone exposure, and during the next 2 h about 50% of the ions leaked out (Fig. 6B). Therefore, photorespiration appears to be involved in protection against photooxidative stress caused by ozone. Excess reducing equivalents/energy can lead to enhanced reactive oxygen species (ROS)

production through photosynthetic electron transport under high light. When this ROS production in chloroplasts adds to the apoplastic ROS burst derived from ozone, the cell death program may be activated, resulting in severe phenotypes such as leaf chlorosis and necrosis. The buffer effect of photorespiration against excess electrons can reduce ROS production by photosynthesis and can consequently contribute to ozone tolerance. These results and hypothesis were reported in an international journal (Saji et al. 2017). The photorespirration system can be classified on the basis of plant function type (i.e., C3 or C4 plants); therefore, by using our knowledge of photorespiration it should be possible to use molecular mechanisms to assess the impacts of air pollutants on plant growth.

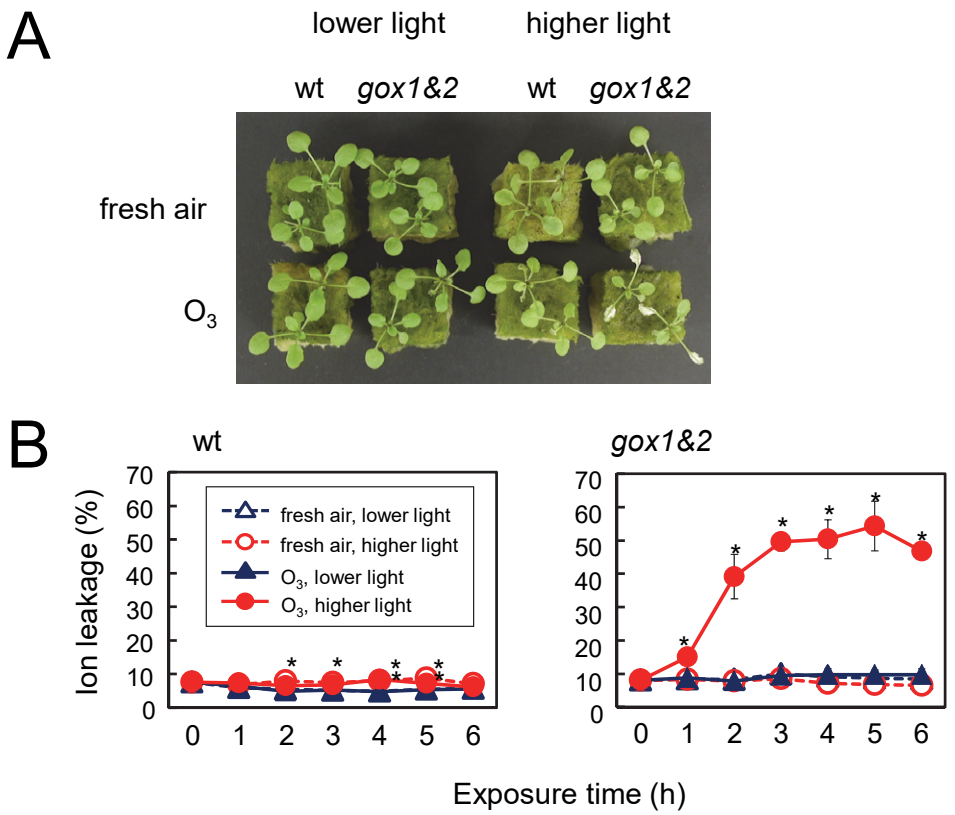


Fig. 6 Ozone sensitivity of the gox1&2 mutant. (A) Images of wild-type (wt) and gox1&2 mutant plants exposed for 4 h to fresh air or to ozone at 0.2 μL L^{-1} under continuous irradiation at low (100 μmol photons m^{-2} s^{-1}) or high (350 μmol photons m^{-2} s^{-1}) light intensity. The plants were kept in fresh air under the same light conditions for an additional 20 h and then photographed. (B) Ion leakage from leaves, measured at various times after the onset of exposure of the wt and the gox1&2 mutant to fresh air or to ozone at 0.2 μL L^{-1} under continuous irradiation at low or high light intensity. Averages and standard deviations are shown (n = 6).

Reference:

Kumagai, N. H., Yamano, H., Sango-Map-Project, C. (2018). High-resolution modeling of thermal thresholds and environmental influences on coral bleaching for local and regional reef management. PeerJ, 6, e4382. DOI: 10.7717/peerj.4382

Saji S., Bathula S., Kubo A, Tamaoki M., Aono M., Sano T., Tobe K., Timm S., Bauwe H., Nakajima N., Saji H. (2017) Ozone-sensitive arabidopsis mutants with deficiencies in photorespiratory enzymes. *Plant Cell Physiol.* 58(5):914–924

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

This research project aims to contribute to effective and integrative conservation planning to satisfy a variety of needs related to biodiversity conservation and sustainable use of ecosystem services.

National parks are major conservation areas for both biodiversity and ecosystem services, and it is essential to incorporate strategies for adaptation to climate change into their management plans, especially in mountainous and marine areas, which can be particularly vulnerable to climate change. We collected information on existing frameworks for assessing the effects of climate change on biodiversity and ecosystem services in national parks. We listed essential components for such frameworks, including identification of the types of climate change and quantification of its intensity; key ecological characteristics for species-level assessment to determine vulnerability to climate change; methods of integrated assessment of multifaceted effects; and feasible options for adaptation strategies. By taking into account these components and ecosystem services, including recreational use (which is being evaluated in other projects of this program), we developed a scheme for both assessing climate change impacts and assisting with adaptation planning by using estimated species distributions based on ecological characteristics.

We then applied the scheme to the alpine vegetation in a national park in the mountains. We predicted the future distribution of alpine vegetation and competing vegetation (subalpine forest and *Sasa* bamboo, respectively; Fig. 7) by using species distribution models that took into account snow accumulation. Then we constructed a flow chart to suggest management options based on the predicted distributions.

Fig. 7 Landscape in Daisetsu National Park (left), and alpine vegetation in the park (right). *Sasa* bamboo (top of the photo at right) is intruding into the alpine vegetation.

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, enabling us all to enjoy the sustainable benefits of nature.

5.1 Interactions among multiple ecosystem services in the Lake Kasumigaura watershed

We divided the whole watershed of Lake Kasumigaura into 50 sub-watersheds and quantified 10 ecosystem services, including crop production, surface water quality, flood regulation, and carbon storage, in each sub-watershed. We also investigated the spatial distribution of freshwater fishes by using eDNA (environmental DNA) and evaluated the richness of native fish species. We conducted a factor analysis to identify spatial synergies and trade-offs among ecosystem services and native fish diversity. Our factor analysis clearly identified synergies among carbon storage, net primary production, flood regulation, climate regulation, and habitat diversity (i.e., synergies among regulating and supporting services), and trade-offs between crop production and surface water quality (i.e., trade-offs between provisioning and regulating services). We successfully visualized these synergies and trade-offs on a watershed map (Fig. 8). We found that the spatial correlations between native fish diversity and any ecosystem service were low. This result suggests that ecosystem services and biodiversity targets should be treated independently in the management of this watershed.

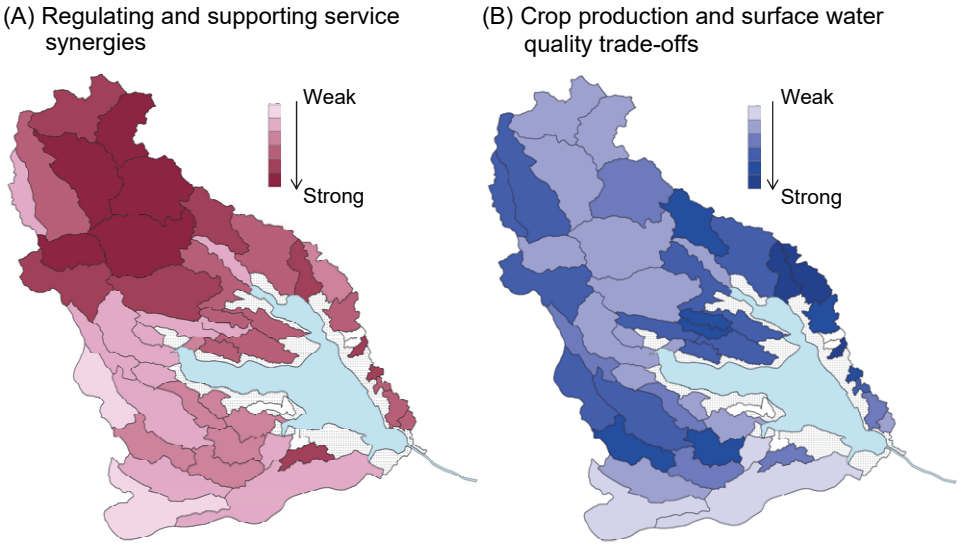


Fig. 8
A: Map of regulating and supporting service synergies in the Lake Kasumigaura watershed.
B: Map of crop production and surface water quality trade-offs

5.2 Sustainability of ecosystems on the Ogasawara Islands

In the first half of 2017, a serious drought hit Chichi-jima, an island in the Ogasawara Islands. Our field survey revealed that the species diversity in freshwater ecosystems on Chichi-jima had declined severely. We are monitoring freshwater ecosystems on Chichi-jima and trying to determine the process of

recovery of freshwater ecosystems in the wake of this serious drought. Mitochondrial COI (cytochrome c oxidase I) sequences were obtained for 18 animal species collected from freshwater on Chichi-jima. We confirmed that genes of fish (e.g., the endemic freshwater goby, *Rhinogobius* sp.) could be detected by eDNA analysis.

We also conducted a content analysis of the local monthly newsletter for residents of the Ogasawara Islands and revealed changes in the long-term provision of information on cat management in the islands. A paper on this study has been published in the *European Journal of Wildlife Research*. We conducted a computer simulation of species deletion from a model Ogasawara ecosystem and suggested that an extinction cascade is likely to occur when invasive goats and rats are removed.

5.3 Ecosystem functions, services, and connectivity in basin ecosystems between rivers and sea

In this project, our aim is to recover the linkages between forests, *satoyama* (the border zones between mountain foothills and arable flat land), rivers, and sea by restoring the habitats of freshwater migratory fish. The main target is the Anguillidae, including the Japanese eel (*Anguilla japonica*). The endangered Japanese eel is a symbolic indicator species that links marine ecosystems to watershed ecosystems via rivers. Unfortunately, the abundance of the resources used by the Japanese eel has decreased dramatically in Japan since the 1970s. The main reasons for this drastic decrease in the watershed are habitat degradation in the riparian zone and migration obstruction by river structures.

We estimated spatiotemporal changes in habitat potential for Japanese eel living in Japanese watersheds (Fig. 9). Additionally, we used a statistical data analysis and GIS procedure to try to discover the cause of the decrease in the freshwater eel resource. The approaches of our research are as follows: 1) Construction of nationwide-scale GIS databases on the long-term eel habitat distribution, fisheries statistics, and artificial river structures. 2) Analysis of spatiotemporal changes in the eel's habitat and their relationship to watershed structure. 3) GIS mapping to determine the present status of Japanese eel populations and to detect potential sites for eel habitat restoration. Through these analyses, we are gaining an understanding of long-term changes in the eel's habitat, and we are detecting some areas of marked habitat loss and degradation. We are also investigating candidate sites for restoration of the Japanese eel's habitat in an effective and efficient manner.

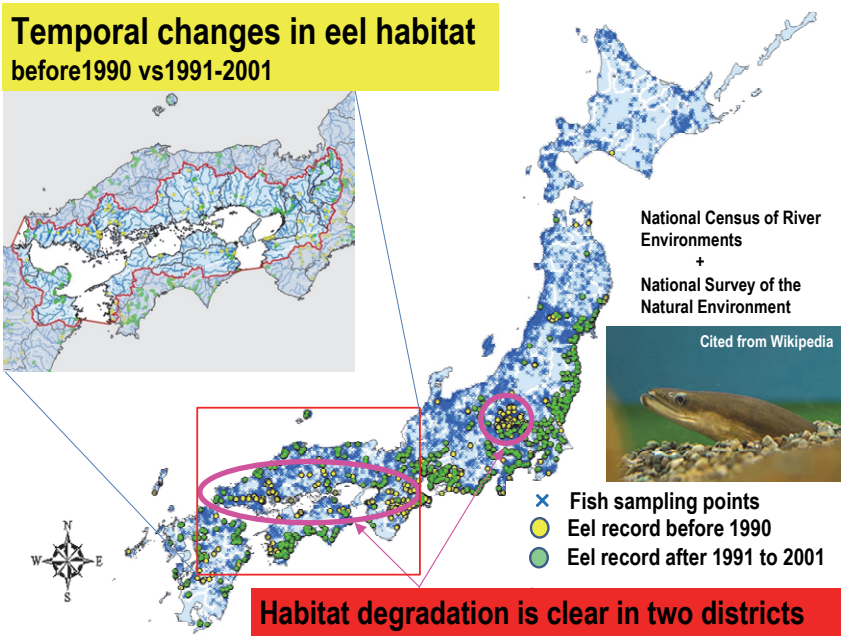


Fig. 9 Changes in the habitat of the Japanese eel between before 1990 and 1991–2001. Upper left map shows the Seto Inland Sea area, where the eel's habitat is shrinking drastically.

Health and Environmental Safety Research Program

To ensure the establishment of a Safe and Secure Society, as described in the Fourth Basic 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 in the Low-carbon, Sound material-cycle, and Natural-symbiosis fields. The aim of this research program is to provide scientific support to establish a safe and secure society 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 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, as well as 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. The projects are described below (Fig. 1).

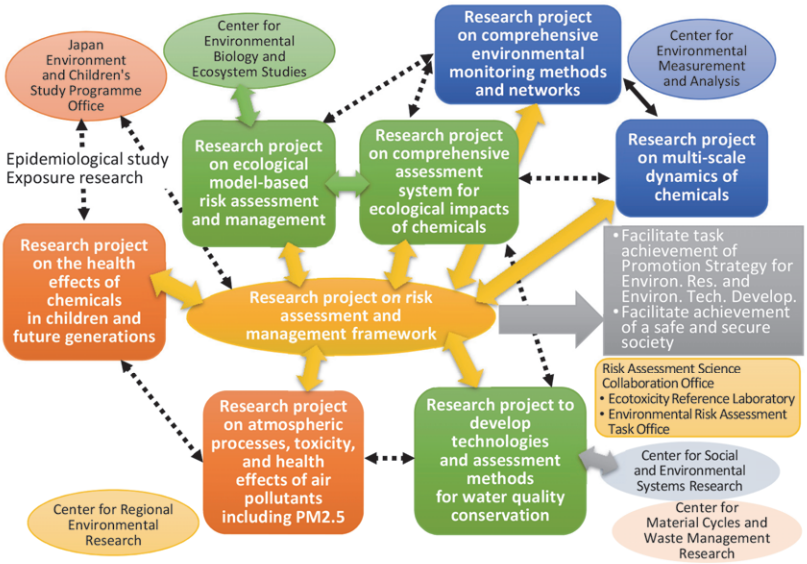


Fig. 1
The Health and Environmental Safety Research Program consists of eight research projects. The projects' outcomes are integrated to establish a general scientific basis for a safe and secure society.

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

To evaluate the health effects of chemicals in children and future generations, this

project is examining the risks caused by chemicals to higher-order biological functions (e.g., immune system, metabolic/endocrine system, and central nervous system) and multi- or trans-generation by using animal models and cultured cells. Our main research outcomes in FY 2017 are as follows.

We found that oral exposure to bisphenol A (BPA) aggravates allergic asthma in mice. Histopathological and molecular biological analyses revealed that administration of BPA (9 μg/kg/day) with allergen enhanced eosinophil and lymphocyte accumulation in the lungs and goblet cell hyperplasia in the bronchial epithelium compared with allergen alone (Fig. 2). These changes were accompanied by increased mRNA levels of interleukin-33 and Muc5ac. Levels of BPA substitutes (bisphenol S, bisphenol F, bisphenol AF, and tetramethyl bisphenol F) in the drinking water were below the quantitation limits, meaning that there was no contamination of the breeding environment with BPA substitutes.

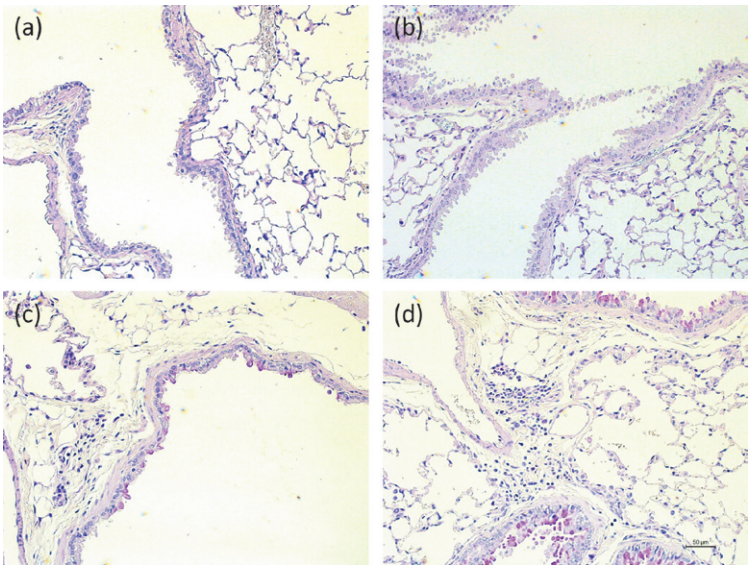


Fig. 2 Histological changes in the lungs of mice were investigated 48 h after final intratracheal instillation. Goblet cell differentiation and mucus hypersecretion in the bronchial epithelium was evaluated by using periodic acid-Schiff staining. (a) Vehicle group, (b) bisphenol A (BPA) group, (c) allergen (ovalbumin; OVA) group, (d) OVA+BPA group

Developmental exposure of animals to chemicals such as neonicotinoids and neuroendocrine disruptors produced abnormal social behaviors and hyperactivity, accompanying by changes in related gene expression and gliosis in the brain. We developed an automated and three-dimensional animal behavior analysis system and a method for evaluating blood-brain-barrier permeability. We also established a method for administering chemicals into the egg yolk vein of birds in a novel fertilized-egg culture system. We differentiated and induced neurons from human and mouse iPS cells, and we studied the development of an *in vitro* evaluation system.

We previously found that gestational exposure of F0 C3H mice to arsenite increases the incidence of hepatic tumors, not only in male offspring in the F1 generation but also in the F2 generation. This year, we investigated the phenotypic changes in the primary hepatocytes and found that their adhesion abilities were significantly reduced in both F1 and F2 offspring by F0 arsenite

gestational exposure. Using hepatic cell lines and primary hepatocytes, we also investigated the involvement of changes of DNA methylation and miRNA composition, which were recently detected in the livers of F2 offspring of the arsenic group, in tumorigenesis. The results suggested that several epigenetic pathways were implicated in tumor augmentation in F2 offspring of the arsenic group.

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 second year of the Project—we conducted the following studies.

For 65 of the 143 substances that show human estrogen-receptor (ER)-binding activity, we started investigating an automatic on-line analysis system. A system in which a molecularly imprinted polymer (MIP) that specifically captures ER-binding-active substances (ER_MIP) is used as a pre-concentration column. An environmental water sample is passed through the column, eluted with a solvent, and then introduced into a separation column. For this system, we are also developing a rapid-flow ER_MIP. Confirmation of recovery rates and reproducibility is a future task.

In addition, we performed a simultaneous analysis of water-soluble organic arsenic as a method of speciation of organometallic compounds. The chemical structures of unidentified arsenic compounds without standard products were estimated by using, in a complementary manner, mass spectrometry (MS)—for example, by LC/MS(/MS). We undertook high-sensitivity speciation of mercury compounds by GC/ICP/MS, and next fiscal year we will attempt to establish an analytical method by using a stable and relatively inexpensive derivatization reagent.

We applied non-target analysis by GC×GC-TofMS to river water monitoring and detected about 2000 components as chromatogram peaks; we selected 80 components and evaluated them statistically to investigate the stability and detection power of the method. Kruskal-Wallis testing revealed that it was possible to detect differences among samples, even though the within-sample variation was relatively large. However, to enhance the sensitivity and reliability of difference detection among samples, the reproducibility and stability of the wet analysis needs to be improved.

We have also developed a new piece of software that shows the differences between “sample” and “blank” chromatograms. In Figure 3, blank and sample respectively refer to water upstream and downstream of a source of

contamination—for example, water before and after an accident. This software deconvolutes chromatograms and presents them as bar graphs, making it easy to see which are the causative chemicals in complex chemical mixtures (red arrows in Figure 3(c); arrow length represents the significance of the difference between the peaks in the sample and blank chromatograms).

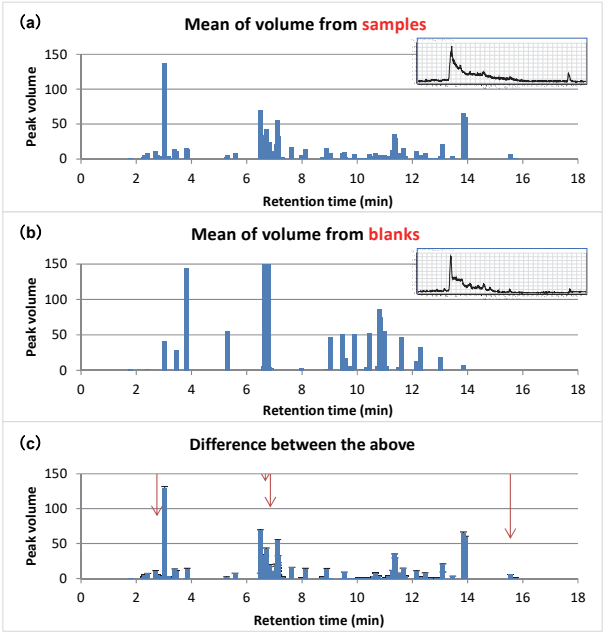


Fig. 3
Bar graphs of chromatograms after deconvolution (with a peak ratio threshold of 1000 or more). (a) sample, (b) blank, (c) difference between sample and blank

Furthermore, as a high-throughput method for detecting pollutants in air and water environments, we prepared a bioassay battery including eight types of human-cell-based *in vitro* bioassays, and we have been evaluating the usefulness of this battery by using reference compounds. This year, we used the bioassay battery to evaluate 33 substances regulated under Japanese Law.

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

Many countries have established water quality criteria for Ni by using laboratory toxicity tests. However, the results of laboratory toxicity tests are of limited accuracy for predicting the direct responses of organisms in an aquatic ecosystem. In Japan, a standard for the protection of aquatic species from nickel toxicity has not yet been established. Moreover, no studies have yet assessed the effect of nickel at various concentrations on the structures of benthic invertebrate communities in Japanese rivers. Here, we conducted a field survey at 45 sites that were approximately equal in terms of flow velocity, water depth, and riverbed structure. After the field survey, we also selected 32 sites where the toxic effects of Ni were dominant. We then estimated the relationship between nickel concentration and benthic invertebrate community structure at the 32 sites by using a 90th quantile regression model. EPT (*Ephemeroptera*, *Plecoptera*, and *Trichoptera*) richness, wet biomass, taxonomic richness, and the abundances of grazers and filter-feeders were negatively associated with dissolved nickel

concentration. We estimated the 5% effect concentrations (EC_5s) from the dissolved nickel concentration when these five indicators decreased by 5% in each 90th quantile regression model. The estimated EC_5 values were 2.1 µg/L for EPT richness, 1.9 µg/L for wet biomass, 2.6 µg/L for taxonomic richness, and 1.7 µg/L for abundance of filter-feeders. As a next step, we have started estimating the causal relationships between benthic invertebrate community structure and nickel concentrations to derive optimal management plans.

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

We continued to investigate long-term tests, such as multi-generation tests in fishes and crustaceans, with various endpoints focusing on specific life stages, for the purpose of chemical management under Japanese laws such as the Chemical Substances Control Law and Agrochemicals Control Act. Furthermore, we developed a draft algorithm to select a test battery based on the physicochemical properties of a compound or its potential effects. We also continued to develop other new test methods for evaluating chemical compounds with unique properties, such as endocrine-disrupting chemicals. These tests were conducted by using reference chemicals to investigate the possibility of implementing them as part of a chemical management system for 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 results of the *in silico* analyses; they included the determination of quantitative activity–activity relationships and a categorical approach for potential use in chemical management in Japan.

From January 2013 to June 2017 we conducted trawl surveys of the community structure and spatiotemporal changes of megabenthos (fishes, crustaceans, mollusks, and echinoderms) off coastal Fukushima, Japan, in the wake of the March 2011 earthquake, tsunami, and nuclear disaster. The surveys covered three latitudinal transects along the coast—off Soma (north), off Fukushima Daiichi Nuclear Power Plant (central), and off Iwaki (south)—and three depths (10, 20, and 30 m) at each transect. Total abundance and biomass fluctuated among years, primarily because of temporary increases in the abundance or biomass of small shrimp and squid or abundance or biomass variations in mid-sized fishes (i.e., puffers and flatfishes) and large elasmobranchs. Decreases in echinoderm abundance and biomass were observed in all areas. Extremely low crustacean abundance and biomass were evident in the central and southern offshore transects. Factors affecting changes in megabenthic communities should be elucidated in relation to environmental conditions.

Finally, river water samples were collected from more than 20 metal-contaminated sites, and we continued to conduct short-term chronic toxicity tests using the water flea *Ceriodaphnia dubia* (Fig. 4). An apparent

increase in toxicity was found downstream of a metal-discharging industry. The total metal concentration was adjusted on the basis of the concentration of dissolved organic carbon (DOC) and other metal concentrations, and we found significant attenuation of the toxicity from the sites at relatively high DOC concentrations. We also continued to investigate the ecotoxicity of chemical mixtures of metals, pesticides, and surfactants. Compensating effects of mixtures of Cd and Zn and synergistic effects of mixtures of Cd and Cu were observed on the reproduction of *C. dubia*. In the case of pesticide and surfactant mixtures mostly additive effects were observed.

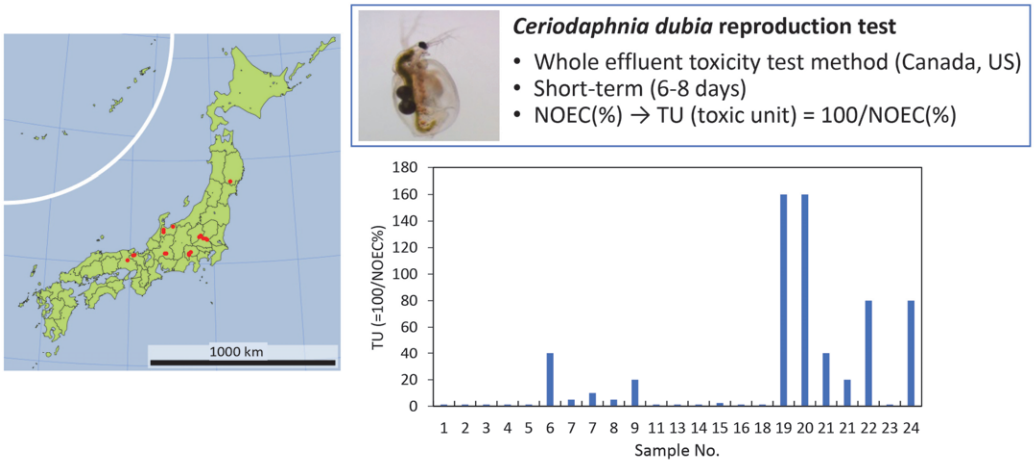


Fig. 4
Results of *Ceriodaphnia dubia* reproduction tests of for water samples collected from selected rivers in Japan (NOEC: no observed effect concentration)

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.

Mercury (Hg) in lacustrine sediments generally undergoes extensive methylation to form neurotoxic methylmercury (MeHg). We established an analytical technique for determining ultra-trace levels of MeHg in water samples in Lake Kawaguchi and Lake Yamanaka. Approximately 25 to 79 pg/L of MeHg in the bottom waters were detected in summer; no MeHg was detected in the surface waters or in the bottom waters in other seasons. The presence of MeHg in the bottom waters corresponded to the timing of the development of an oxygen minimum zone in the bottom waters.

We improved the deposition scheme of our global multimedia model for mercury (FATE-Hg) by implementing dry deposition related to sea-salt aerosol formation in the marine boundary layer. Also, we updated the input geogenic emission data for FATE-Hg by compiling global data from mercury mines and submarine volcanoes. We performed a 30-year simulation (1981–2010). The improved model could generally simulate the global distributions of elemental mercury in

the lower troposphere and the upper ocean (Fig. 5).

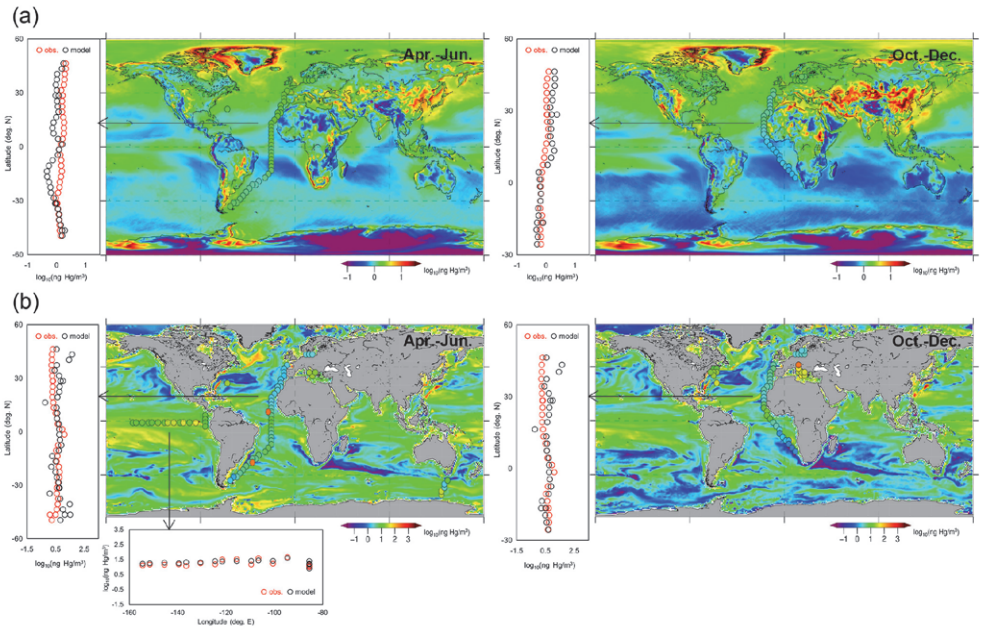


Fig. 5
Validation results for concentrations of (a) gaseous elemental mercury (Hg^0) in the atmospheric boundary layer and (b) dissolved Hg^0 in the ocean mixed layer. Observed concentrations (circles) are plotted on tri-monthly mean modeled concentrations, with comparison between values from cruise observations (obs.) and modeled (model) concentrations.

We have been constructing geographic information system (GIS) data on sewage collection areas and points of effluent from sewage treatment plants. We made a simple model to calculate chemical concentrations in rivers on the basis of these data and other GIS data used in a multi-media fate model, G-CIEMS. We also confirmed the good representativeness of this simple model by comparing the calculated concentrations of biochemical oxygen demand (BOD) and chemical oxygen demand (COD) in river water with the observed ones in Hiroshima Prefecture.

As part of a study of the indoor-scale dynamics of chemicals, we are modeling the transfer of the flame retardant hexabromocyclododecane (HBCD) from curtains to attached dust, and we are measuring the emission rate of HBCD from polystyrene products by using the micro-chamber method. We also measured the isomer-specific vapor pressure of HBCD; this property is essential in the modeling and analysis of emission rates but is not available in the literature.

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 modeling system and are conducting *in vitro* toxicity studies and epidemiological studies. In the second year of this project, we obtained the following two main sets of results:

1) To improve current aerosol models, we evaluated the gas-particle behaviors of organic compounds (Fig. 6). (i) We modified an emission inventory to include condensable particulate matter (PM) from stationary combustion sources and found that emission rates of organic aerosol (OA) increased by a factor of seven over Japan. Consideration of condensable PM from stationary combustion sources improved model estimates of OA in winter but caused overestimation of OA concentrations in summer. (ii) We simulated the evaporative behaviors of secondary organic aerosol (SOA) from α-pinene ozonolysis by using an aerosol model with processes of kinetic gas-particle partitioning, formation/dissociation between monomers and dimers, and particle-phase diffusion limitation. We found that low-volatility compounds were important contributors to SOA and that slow evaporation rates during the dilution experiment could be reproduced by assuming slow bulk diffusion or by assuming oligomer formation.

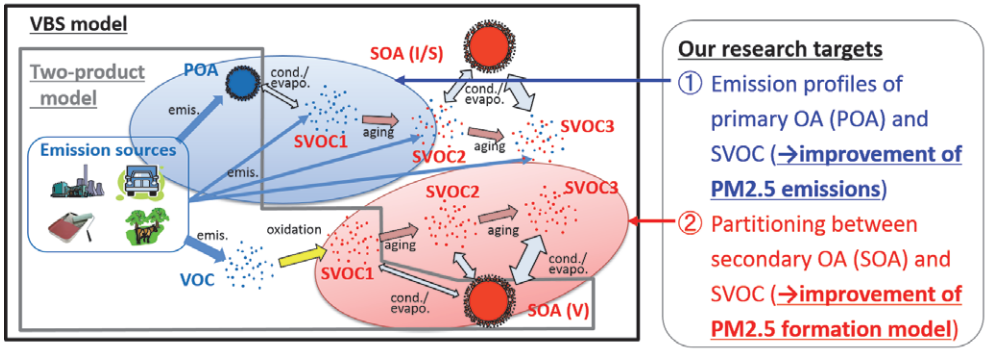


Fig. 6
Diagram of aerosol models and our research targets. OA, organic aerosol; SOA, secondary organic aerosol; VOC, volatile organic compound; SVOC, semi-volatile organic compound

2) We prepared a reporter gene assay system that is sensitive and high-throughput to examine several types of biological responses to PM2.5 (Fig. 7). CHO-K1 cells were transfected with a vector that containing a firefly luciferase (*luc2P*) reporter gene with sequences of an NFκB-responsive element (NFκB-RE), antioxidant responsive element (ARE), xenobiotic-responsive element (XRE), or metal responsive element (MRE). We exposed these cells to water or to organic extracts of PM2.5 collected at Tsukuba in winter 2017. We found that the water-soluble fraction of several PM2.5 samples contained more ARE-reactive chemicals than its organic-solvent-extractable counterpart. Using this assay, we may be able to narrow down candidate source-specific PM2.5 to evaluate health effects.

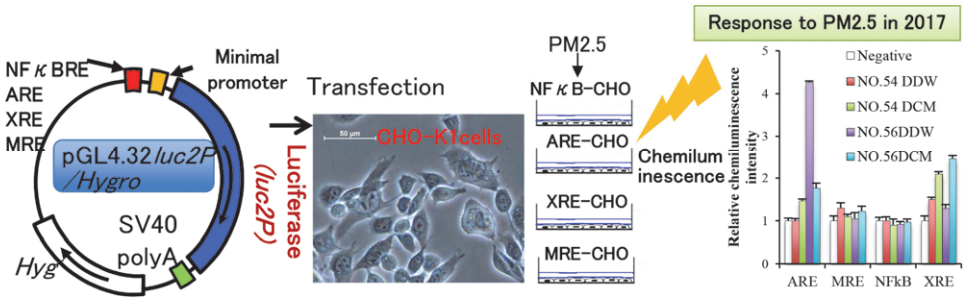


Fig. 7
Reporter gene assay system for PM2.5

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.

This project comprises two sub-projects. The first is the development of appropriate wastewater treatment technologies. Reducing the energy (operational cost) of the treatment system promotes the dissemination of technology. This year, we conducted a performance evaluation of an aerobic trickling-filter system for domestic wastewater treatment in Bangkok, Thailand. The aerobic trickling-filter system was superior to the existing treatment system in terms of not only effluent water quality but also power consumption (50% reduction) and installation space (65% reduction). On the basis of the superior results of the demonstration experiment, a full-scale treatment system (capacity 40 to 60 m^3/day, 450 persons) was installed in August 2017 in company housing in an industrial estate in Thailand (Fig. 8).

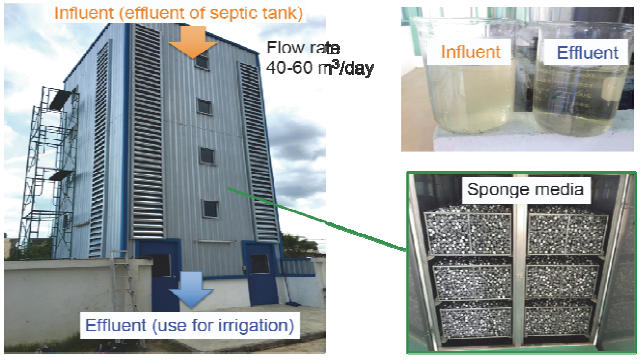


Fig. 8
Overview of the full -scale aerobic trickling-filter system installed in company housing

In the second sub-project, we investigated the influence of inflow of effluent from a domestic wastewater treatment plant into Lake Kasumigaura, Japan.

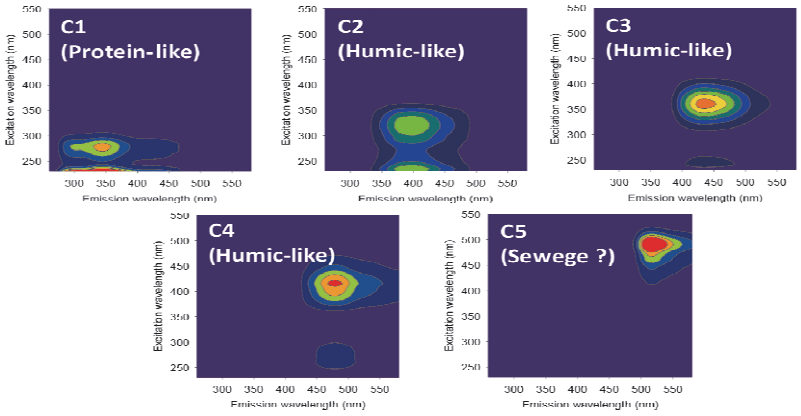


Fig. 9
Five fluorescent components of effluent, as determined by EEM-PARAFAC analysis

Especially in winter (January 2017), an artificial thermocline was clearly observed, even at a site 200 m from the outlet of the wastewater treatment plant. The difference in temperatures between the surface and bottom was about 7 °C at the effluent discharge point. This was evidence of the effluent's widespread diffusion and effect on the water quality of the lake. Also, dissolved organic matter in the effluent was decomposed into five components (C1 to C5) by fluorescence analysis (EEM-PARAFAC: excitation emission matrices and parallel factor analysis) (Fig. 9). The presence of C5 in the surface layer of the above-mentioned artificial thermocline was confirmed. These results suggest that it may be possible to use the C5 component as a tracer of effluent in aquatic environments.

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 continued to study a new direction for incorporating the precautionary approach into chemical risk management on the basis of both the scientific and the social nature of chemicals. We re-evaluated several pollution incidents, including the one that caused Minamata disease, to explore how preliminary observations that may not be scientifically sufficient can be used to trigger precautionary actions. Also, we have established new category-based structure–activity relationships for the ecotoxicological nature of chemicals. We confirmed that the method was good at forecasting the ecotoxicological nature of a wider range of chemicals than can be forecast with the current quantitative structure–activity relationships methodologies.

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 sustainable 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.

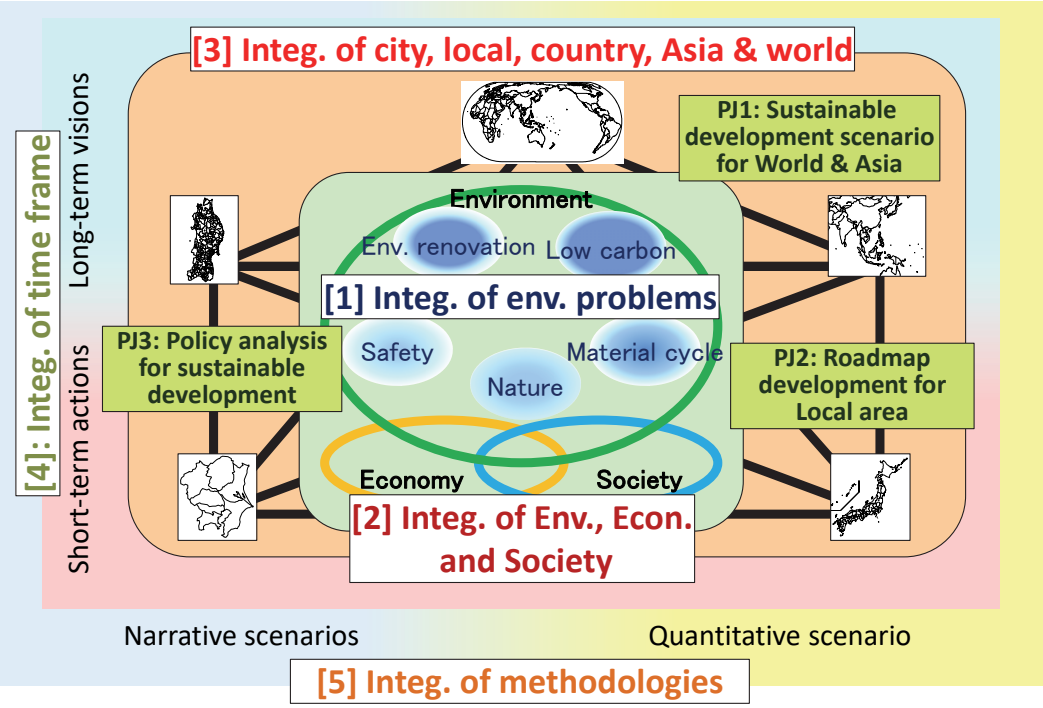


Fig. 1 Framework of the Environment-Economy-Society Integration Research Program. Shown are the three projects (PJs) and the five numbered aspects of the Program.

1. Sustainable development scenarios for the world and Asian countries

This project is developing integrated assessment models (IAMs) for analyzing sustainable 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 sustainable development scenarios, and sub-theme 2 provides national sustainable 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, as part of the development of global sustainability scenarios, we have improved global IAMs and analyzed the future impacts of GHG mitigation policy on food security through this century. We have also examined additional policies for simultaneously achieving two global goals, namely climate stabilization and food security improvement. Climate change mitigation to achieve the Paris Agreement's "well below 2 °C" and "1.5 °C" goals for global warming relies on large-scale deployment of land-related measures (e.g., afforestation or bioenergy production). This could also increase food prices and hence could raise food security concerns. On the basis of our model analyses, we have shown how the use of an inclusive policy design can avoid these adverse side-effects. Food-price support through international aid, a bioenergy tax, or domestic reallocation of income can shield impoverished and vulnerable people from the additional risk of hunger caused by the economic effects of single-minded climate policy.

We also used a global land-use allocation model that we developed in FY 2016 to develop global spatial land-use scenarios based on shared socioeconomic pathways (SSPs). SSPs are socioeconomic scenarios recently developed through the international coordination of research communities for common use in climate change research. The land-use scenario dataset contains maps showing the area shares of 18 land-use types (11 food cropland types, plus bioenergy crops, afforestation, settlement, ice and water, forest, pasture, and other natural vegetation) for each grid cell at a 0.5° spatial resolution. The dataset is now publicly available on our website (http://www-iam.nies.go.jp/aim/data_tools/aimssp/aimssp.html) to support climate research inside and outside Japan.

In sub-theme 2, we have improved our IAMs to assess GHG mitigation and sustainable development actions in Asian countries such as China, India, and Indonesia. To take into account barriers apart from costs in our end-use model, the concept of energy transition—changes in energy types in accordance with economic development—was introduced. Figure 2 shows the results of modeling of energy demand by the residential sector in urban and rural areas of China. In urban and rural areas, the demand for coal and traditional biomass, respectively, is overestimated by the model under Intended Nationally Determined Contribution (INDC) conditions if energy transition is not introduced.

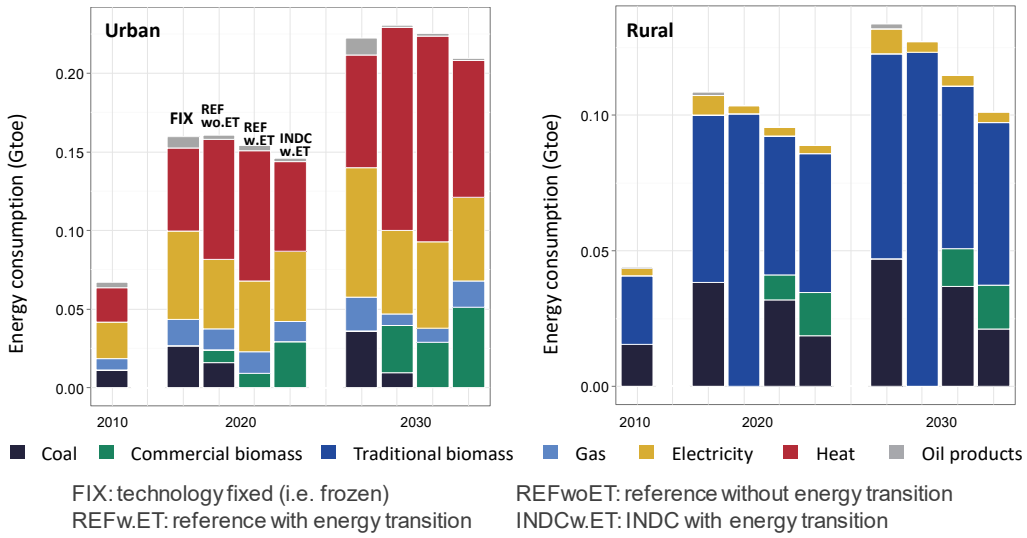


Fig. 2 Modeled energy demands in the residential sector in urban and rural areas of China. Gtoe, gigatonnes of oil equivalent. INDC, Intended Nationally Determined Contribution

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

Sub-theme 1 of project 2 is "Development of an Environmental Impact Assessment Model for Regions and Cities." As a leading research institute for "Research into the Development of Technologies for the Assessment of Climate Change Impacts," which is theme 3 of the Ministry of Education, Culture, Sports, Science, and Technology's Social Implementation Program on Climate Change Adaptation Technology (SI-CAT), we intend to develop an evaluation model covering multi sectors in multi-scale targeting of the entire country and its cities. For this purpose, we have been developing the technologies to support local governments with the scientific knowledge they need for climate change impact assessment and examination of adaptation measures. Also, to develop an integrated assessment platform, we made a prototype of a projection model of land-use change by using a cellular automaton. We applied the model to the city of Tsukuba this fiscal year. We conducted a projection of land-use status of 2011 by using data on land-use change from 2006 to 2009 as learning data. We then compared the accuracy of the model by comparing land-use status for the projected time period, as obtained by interpolating the data on land-use change from 2009 to 2014, with the projection result.

Sub-theme 2, "Development of an Integrated Evaluation Model of Economy, Society, and Technology for Countries, Regions, and Cities," is aimed at integrated roadmap analysis focusing on mitigation. We expanded the model so that it can evaluate low-carbon effects from a spatial perspective. We applied it to local cities and evaluated technical countermeasures, such as switching to highly efficient equipment, and the low-carbon effects of introducing renewable energy and regional energy business through aggregation of urban functions. The results of the analysis (Fig. 3) showed that, because of the consolidation of residential

and business facilities in base districts, as specified by the targeted cities, the introduction of photovoltaic power generation would be promoted among renewable forms of energy; moreover, the profitability of regional energy business would be secured through the accelerated introduction of photovoltaic power generation. An expected effect would be a 200,000t reduction in CO_2 emissions, corresponding to 22.7% of CO_2 emissions in the target area; this would be the sum of a 100,000t CO_2 reduction through the introduction of solar power generation (renewable energy in Fig. 3) and a 100,000t CO_2 reduction from the implementation of a regional energy project (the integration effect scenario in Fig. 3). Because this reduction effect is larger than the 70,000t CO_2 reduction expected if technical countermeasures alone were implemented (i.e., switching to highly efficient equipment; standalone technology in Fig. 3), it is likely that the effect of land-use consolidation is important in examining low-carbon scenarios in urban areas. There is a particular need to evaluate the appropriateness of introducing regional energy projects.

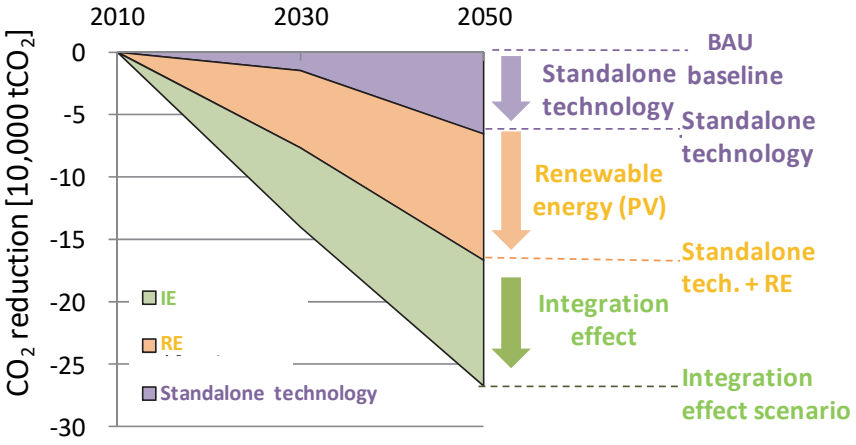


Fig. 3 CO_2 emission reductions modeled from specific countermeasures. BAU, business as usual. PV, photovoltaic. RE, renewable energy

We also developed a model for macro-frame outlooks (e.g., in terms of GDP) by using econometric methods and analyzed the outlook by 2050 for Japan. We estimated the labor force on the basis of data on the "estimated future population in Japan" released by the National Institute of Population and Social Security Research, and we set total factor productivity on the basis of the annual average rate of change from 2005 to 2015. We found that real GDP would rise at an annual rate of 0.5% from 2015 to 2030 and would continue to rise by 0.2% a year until 2030. Average growth per capita would be 1.0% through until 2050. Also, if the private consumption ratio and the government consumption ratio were at the same levels as in 2015, private consumption expenditure in 2050 would be about 350 trillion yen and government consumption expenditure would be about 120 trillion yen.

Sub-theme 3 is "Research into Social Implementation Support Measures and Society Monitoring for Sustainable Society Measures." We are developing a technology assessment system that comprehensively calculates the effects of a

regional transportation system and a construction stock management system in addition to a regional energy system under future land-use scenarios in urban areas. We developed the scenario on the basis of case studies of Tokyo and Kitakyushu, focusing mainly on countermeasures such as the energy and economic effects of changes in land-use patterns (including the industrial use of heat from the incineration of municipal waste, and the residential use of industrial low-temperature waste heat), and we evaluated the effects on CO_2 emission reduction and cost change. In addition, to develop research tools that will help to the verify the results of these regional studies, we promoted the development of monitoring equipment and social implementation research so as to efficiently gain an understanding of energy consumption.

We developed a projection formula for power consumption by using an auto-regressive exogenous model (mainly for buildings such as residences, offices, commercial facilities, and factories in Fukushima and Indonesia), and we successfully simulated the measured values, with the relative mean square error yielding an accuracy of about 20%. Moreover, by adding more samples and statistical data from a questionnaire survey to monitoring data with a limited number of samples, we started to create a methodology for estimating energy consumption and future low-carbon potential at the urban and regional levels. As a method of comprehensively diagnosing the energy-saving performance of buildings in terms of both equipment and structure, we analyzed the heat balance of buildings on the basis of the power consumption of air-conditioners.

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 2017.

To design sustainable regions and lifestyles, our estimations of the carbon emissions from household sectors in municipalities and the vacant house ratio at the residential block scale were revised by using a combination of building point data and statistical data at multiple scales. To achieve low carbonization in the residential sector by providing highly insulated houses without increasing the number of vacant houses, 20% of the stock, in addition to the already planned 30%, needs to be insulated through retrofitting by 2030.

We utilized the Climate change mitigation Policy Progression Indicator (C-PPI)—an indicator that we developed last fiscal year to assess countries' efforts to reduce their respective GHG emissions—to evaluate the climate change mitigation efforts of G20 countries. The C-PPI proved useful for examining the

relationship between policy efforts to reduce GHG emissions and actual emission trends. The indicator was also suitable for pinpointing those policies that were effective in many G20 countries. For instance, the setting of targets for share of renewable energy, total energy consumption, and afforestation area was effective in motivating governments to increase policy efforts so as to achieve such targets. We also investigated the relationships among mass media coverage and public perception of climate change issues from 2005 to 2017. Our results showed that public perceptions of climate change changed directly in response to changes in mass media coverage (Fig. 4).

Reference:

Sampei Y and Aoyagi-Usui M (2009) Mass-media coverage, its influence on public awareness of climate-change issues, and implications for Japan's national campaign to reduce greenhouse gas emissions. Global Environmental Change, 19:203–212

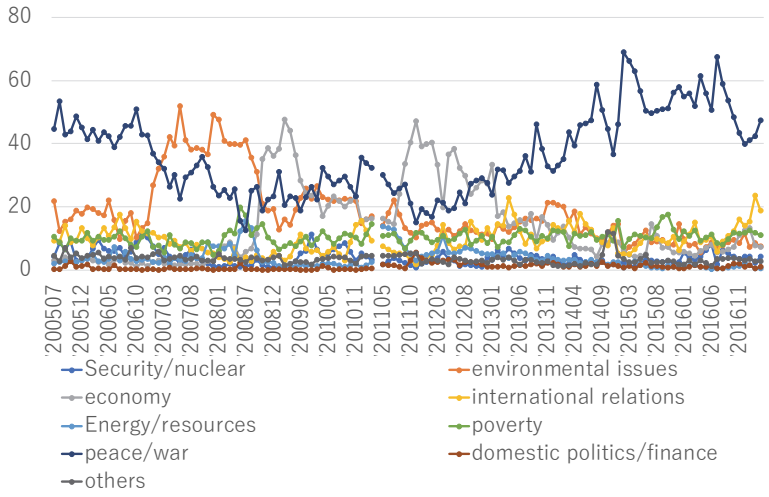


Fig. 4 Changes in public perceptions of global issues from July 2005 to November 2016.
Recent trends show that "peace/war" (including terrorism) is receiving much more attention than other issues. However, among other issues, environmental issues ranked higher than the rest. These changes are closely related to changes in mass media coverage of targeted issues (Sampei and Aoyagi, 2009).

Environmental Emergency Research Programs

Environmental Emergency Research Programs

Immediately after the Great East Japan Earthquake and the Fukushima Daiichi Nuclear Power Plant (FDNPP) accident, 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 at the Fukushima Prefectural Centre for Environmental Creation in April 2016) as a research hub, this program conducts Environmental Recovery research, Environmental Renovation research, and Environmental Emergency Management research in collaboration with the government of 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 on the basis of the lessons of the Great East Japan Earthquake and other major disasters. Below, we outline the major projects conducted under the three sub-programs.

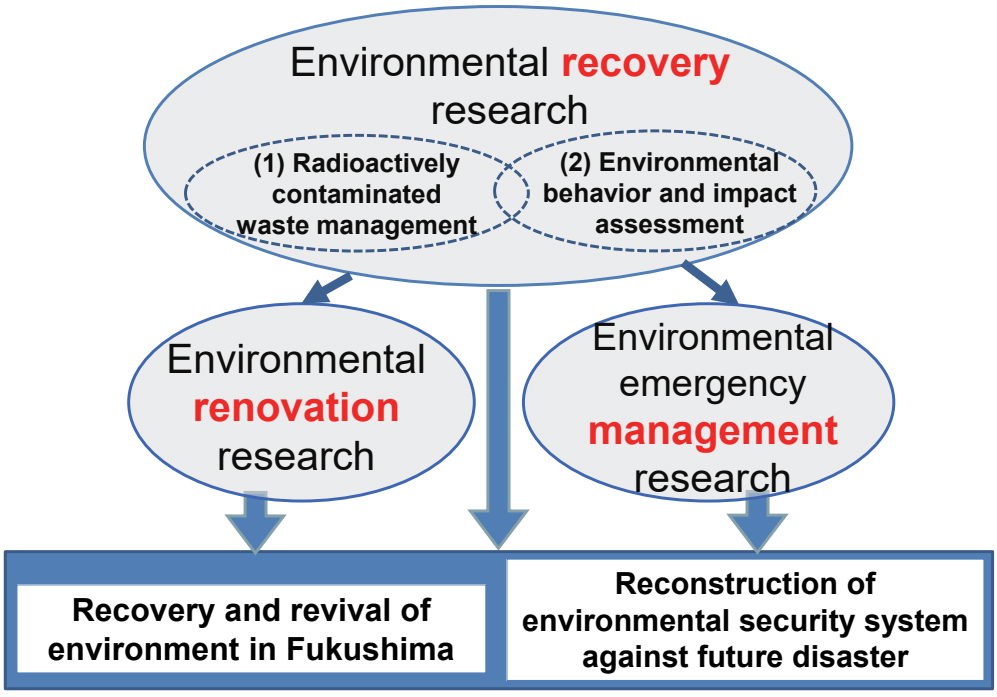


Fig. 1 Outline of the Environment Emergency Research Programs

1. Environmental Recovery Research Program

This program is conducting research on the 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 research and develop 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 (Project 1)

The FDNPP accident resulted in serious radiocesium contamination of solid wastes and soil. We are performing various types of emergency response research into appropriate waste management. We are collaborating with central and local governments in the practical implementation of our research. Our research results are being reflected in various measures, including technical guidelines published by the Ministry of the Environment (MOE), discussions by an MOE panel, and implementation of the Act on Special Measures Concerning the Handling of Pollution by Radioactive Materials.

The above Act specifies waste management as follows. Municipal solid waste (incineration ash, etc.) and industrial waste (sewage sludge, its incineration ash, etc.) around Fukushima were contaminated by highly condensed radiocesium. Waste in which the radiocesium concentration is 8000 Bq/kg or less is landfilled in municipal solid waste landfills. Other waste (more than 8000 Bq/kg), which is called specified waste, is landfilled in specified landfills after cement solidification. Large amounts of removed soil and decontaminated wastes such as branches and leaves were generated by the decontamination work. These were treated by using the following procedure: (1) Removed soil and decontamination waste are temporarily stored in stockpiles located near the decontamination areas. (2) The removed soil is transferred to a landfill-type interim storage facility. (3) The decontaminated waste is incinerated at temporary incineration facilities. (4) The incinerated ash, which includes high levels of radiocesium, is stored in an interim storage structure. (5) Removed soil with low radiocesium concentrations is recycled as a geomaterial. (6) The volume of removed soil and waste with high radiocesium concentrations is reduced by thermal treatment. (7) Disposal of the reduced waste at a final disposal site outside Fukushima Prefecture will be accomplished within 30 years.

The target of our current research is to develop appropriate methods for managing the contaminated waste and storing the removed soil. In addition, we are focusing on recycling of the removed soil and the final disposal technologies following the interim storage period. Figure 2 outlines our research, and the research topics under this project are summarized below.

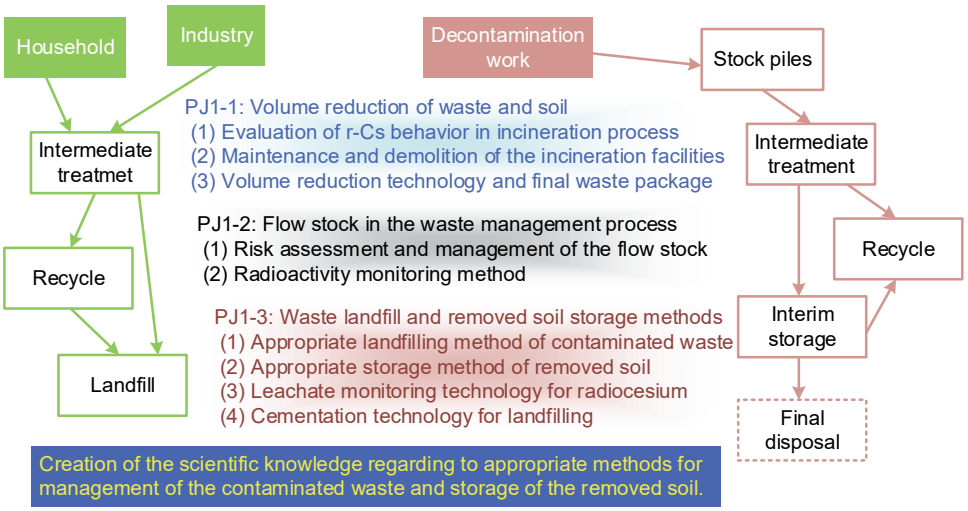


Fig. 2 Outline of research project on development of management systems for radioactively contaminated off-site waste

Project 1-1: Volume reduction of waste and soil

(1) We intend to investigate radiocesium (r-Cs) behavior during the incineration process and determine the distribution ratio of r-Cs between bottom ash and fly ash. A numerical simulation model based on a multizonal equilibrium calculation method proposed in 2012, representing the fate of r-Cs and other elements, will be developed.

(2) We will study the accumulation of r-Cs in refractory materials inside the furnaces and gas cooling towers of incineration facilities with the aim of reducing occupational radiation doses to workers during plant maintenance or plant demolition.

(3) We will develop thermal treatment technologies such as ash-melting, gasification-melting, and cement-kiln treatment to remove radiocesium and produce clean slag and cement from contaminated incineration residues, soil, and waste. Furthermore, we will develop a method of reducing the volume of the final waste package to ensure final disposal outside Fukushima Prefecture.

Project 1-2: Flows and stocks in the waste management process

(1) We intend to build a database of flows and stocks of radiocesium concentrated wastes and by-products generated from contaminated areas. We are collecting the data by surveying waste management facilities and official registers (manifests) of waste. We will provide the information to waste management authorities to enable the selection of safer methods of treatment, storage, recycling, and landfilling at an acceptable risk level of exposure dose.

(2) We will develop and verify monitoring methods for alpha- and beta-emitting nuclides in waste and soil—not just gamma-emitting nuclides such as r-Cs. These methods may be required when we process wastes located near the nuclear power plant.

Project 1-3: Waste landfills and storage of removed soil

(1) We will develop appropriate methods of landfilling radioactively contaminated municipal solid waste and industrial waste to ensure containment of

the radiocesium in landfills.
(2) We will develop appropriate storage methods of large amounts of removed soil by focusing on organic pollutants and radiocesium.
(3) We will create a semi-continuous monitoring system for leachate to detect low concentrations of radiocesium as an early warning sign.
(4) When specified wastes with high concentrations of radiocesium need to be landfilled, we will evaluate concrete/cementation technology to isolate the waste from the environment.

The best available technology for each treatment process is not always the same as the best solution for the whole treatment system. We will research and develop optimum technologies for the whole system from a broad perspective.

1.2 Environmental behavior and impact assessment (Projects 2 to 4)

As part of another effort to support the early environmental recovery of disaster areas contaminated with radioactive substances from the FDNPP accident, we are conducting comprehensive research consisting of three projects: analysis and prediction of the behavior of radioactive substances in multimedia environments (Project 2), impacts on organisms and ecosystems (Project 3), and assessment of human radiation doses (Project 4) (Fig. 3). The overall goals of these projects are to assess long-term environmental impacts in zones to which evacuees are allowed to return, develop methods to manage the risks in the living environment, and conduct assessments on ecosystems, including ecosystem services. Through these activities, we intend to develop long-term monitoring plans for the water environment and terrestrial ecosystems; we will provide scientific outcomes, not only for evacuees to make decisions about whether to return to former exclusion zones, but also to support people's everyday safety and security after they return. Furthermore, we will attempt to schematize the lessons learned from research conducted after the FDNPP accident.

1.2.1 Analysis and prediction of the behavior of radioactive substances in multimedia environments (Project 2)

To quantitatively evaluate and predict the migration and accumulation of radioactive cesium in river catchments, soon after the FDNPP accident we began conducting intensive field measurements and modeling in the watersheds of the main rivers in the northern coastal region of Fukushima Prefecture. In this 5-year plan, we are focusing especially on clarifying how bioavailable forms of radioactive cesium behave in highly contaminated mountainous river systems now and in the future. Our research is especially motivated by local residents' anxiety about ongoing radioactive contamination of forests and fresh water ecosystems. To summarize the results obtained in the past 2 years, it is clear that contaminated accumulated organic matter strongly influences the cycle of radioactive cesium in forest ecosystems and the behavior of dissolved radioactive cesium in rivers. Moreover, it is becoming clear that there is substantial elution of radioactive cesium from the bottom sediments of dam reservoirs; this might be

closely related to the observed radioactive cesium contamination of the food chain in freshwater ecosystems.

1.2.2 Research into impacts on organisms and ecosystems (Project 3)

After the FDNPP accident, wild animals and plants were left behind in a high-radiation-dose area and are still being exposed to radiation. It is, therefore, of great concern whether any adverse effects are being found in wild organisms in the Fukushima area as a result of long-term, low-dose exposure to radiation. Moreover, there was massive-scale, long-term human evacuation from the area that received a high radiation dose. It is likely that changes in land use due to the cessation of daily activities such as agricultural work will substantially affect wild organisms and ecosystems in these areas. Therefore, we have conducted the following experiments to elucidate the direct and indirect impacts of radiation on wild organisms and ecosystems in Fukushima. (1) Evaluation of the reproduction ability of wild rodents inhabiting forested areas, and estimation of the accumulation of DNA mutations by using transgenic plants that can detect DNA damage by radiation. (2) Monitoring of terrestrial biodiversity inside and outside the evacuation zone (started in 2014). In this project, population indices of mammals, insects, birds, and frogs have been recorded at about 50 monitoring sites.

1.2.3 Preparation for environmental emergencies by modeling of human radiation and chemical contaminant doses (Project 4)

To better inform residents about their options to reduce exposure, we need to estimate radiation doses as accurately as possible. We aimed to estimate current and future doses and to provide information about possible measures to reduce exposure to radiation from the FDNPP disaster. We also intend to study possible exposure to harmful chemicals that may be released in future disasters.

In this study, we have combined modeling and monitoring techniques to achieve these goals. We have been conducting estimations of respiratory inhalation doses during the first few weeks after the incident, and of long-term doses, by using an exposure model. We have also been continuously monitoring radioactive cesium in outdoor air and indoor dust and its sources and evaluating the efficiency of self-cleaning of residents' indoor house environments and its effect on radiation exposure.

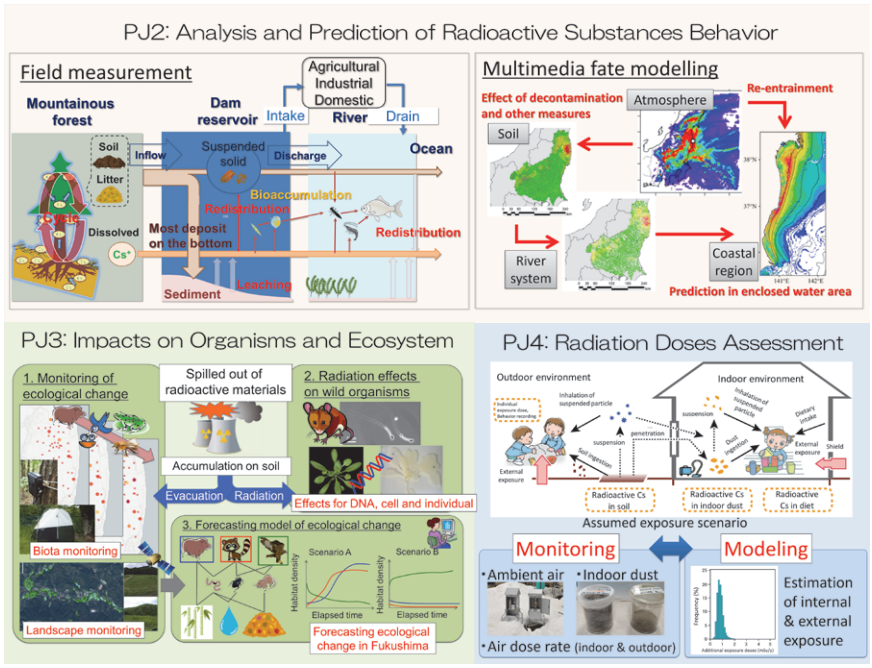


Fig. 3 Outline of research projects on environmental behavior and impact assessment

2. Environmental Renovation Research Program

This program is working with staff of 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 re-creation in post-disaster regional environments. It also studies the use of these methods to provide support for policymaking by local governments. Moreover, we are considering such items as global warming countermeasures and resource recycling strategies tailored to the characteristics of affected areas, and we are conducting practical research aimed at building regional environmental resource and energy systems and formulating quantitative eco-city policy targets and roadmaps for achieving those targets. Figure 4 presents the framework of our Environmental Renovation Research Program.

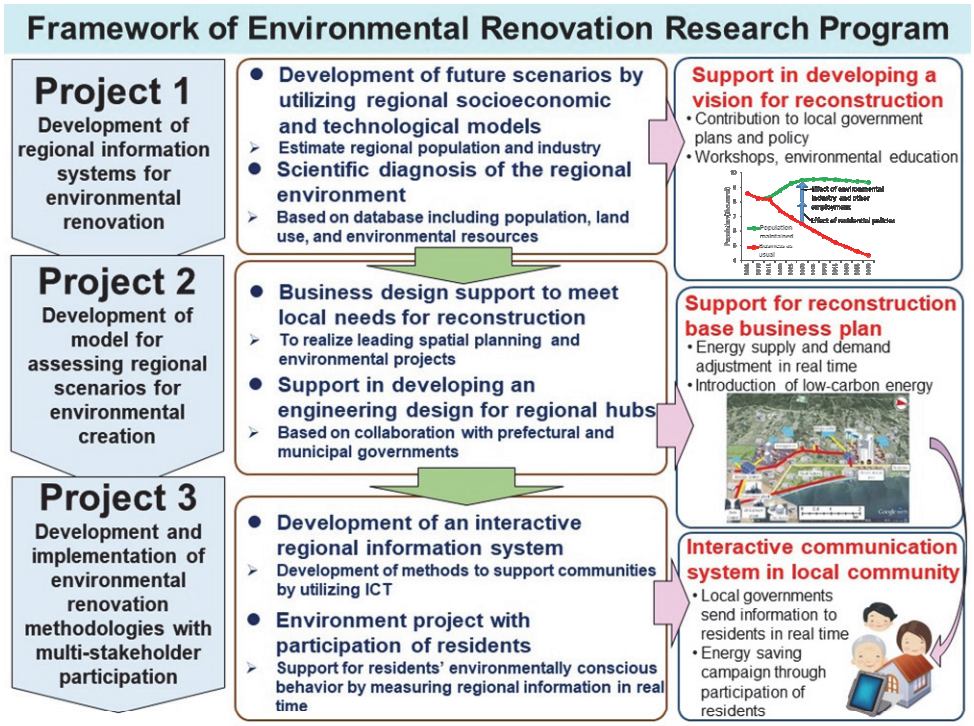


Fig. 4 Outline of the Environmental Renovation Research Program

2.1 Development of regional information systems for environmental renovation (Project 1)

A spatial regional database has been developed as a common information base for environmental renovation research. It includes information on time-series land-use and land-use change; population and other socioeconomic data; roads and other infrastructure; building stocks; zoning for urban planning; energy demand distribution; industrial activities; and potential for use of renewable energy. Some of the information contains time-series data from the past three decades, making it possible to analyze climate change impact and adaptation studies. By using these data, to enhance communication with stakeholders, a 3-D projection mapping system of Fukushima Prefecture was newly developed and disclosed in NIES's outreach activities in Fukushima Branch and other places.

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 consider evacuation after the disaster in describing population dynamics, the models explicitly treat migration between cities and towns. The framework and models were applied to Fukushima Prefecture. They combine a macroscopic economy and population dynamics model, an urban spatial distribution model, a local transport model, and a building energy-system model. In the city of Koriyama and north of the Hamadori region, we analyzed

different spatial development patterns considering differences in population dynamics, building stock management, and local transport systems such as car-sharing. The methodology was also applied to the city of Kitakyushu in Fukuoka Prefecture with the aim of generalizing the methodology that we developed. The results of future simulations by using the above models—including for future urban structure, GHG emissions, and analyses of emission reduction potential—were provided for the current process of formulating an urban spatial plan for the town of Shinchi. In addition, long-term population scenarios for Shinchi were developed. One of the scenarios, the "Population maintained scenario" showed the policy intervention that would be needed to stop the decreasing trend in the town's population.

A series of outreach actions were also conducted. In Shinchi, the results of the above-described modeling were spread via the town's newspapers and in workshops. The town government and NIES invited the mayor of the town of Saerbeck, Germany, to visit and organized an international workshop to share experiences of local and renewable energy development. The results of the integrated modeling were provided to the Fukushima prefectural government for revision of their climate change action plan. The knowledge and experience from this project were also provided to the city government of Koriyama and the Fukushima Branch of the Bank of Japan upon request, and the future potential of collaborative research was discussed with them.

2.2 Development of a model for assessing regional scenarios for environmental creation (Project 2)

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 designing a distributed energy system from the perspective of mathematical optimization problems. This year, sensitivity analyses were conducted on woodchip price and scale of demand to evaluate policy effects. The conditions required to achieve the introduction of BCHP (Biomass Combined Heat and Power) systems were examined. Analysis confirmed that BCHP systems have an advantage when the FiT (feed-in tariff) system is flexibly applied; this advantage is expected to promote their introduction in the current situation. There is concern, however, about a potential increase in the social cost. Additionally, system selection responds flexibly to the price of woodchips. BCHP and biomass boilers could be introduced within the range of actual price fluctuations without the support of institutions or other appropriate systems, and biomass use would thus be promoted. Refinement of these research results should contribute to the following environmental policies. Previous manuals and other documents provided by the national government have introduced a thermal load per hectare of 4.2 TJ or more; this is the standard to allow regional energy use as the basis of autonomous and distributed energy systems. However, this standard may be affected by various factors, such as the unused heat inventory, other energy supply conditions, and the electric and heat demand balance in the district.

Introduction standards can be elucidated by examining the relationship between boundary conditions and the effects of introduction beyond the demand side. Furthermore, land-use planning and policy-guidance target identification can be facilitated by local government.

In the quest to mitigate global warming, forest ecosystems that are well managed and efficaciously utilized are effective systems for carbon sequestration. The effective carbon sequestration rate (ESR) is defined as the net sequestration rate in both ecological and social systems, excluding carbon emissions from woody biomass combustion owing to its carbon neutrality. We assessed the dynamics of the ESR by using a biomass-integrated model (BaIM). The BaIM considers a dynamic forest ecosystem and includes a forest ecosystem model, woody biomass production cost model, and carbon sequestration model. The ESR was estimated for different processes under different harvest intensities in the western region of Fukushima Prefecture, Japan. A total of four consumption scenarios were evaluated for ideal assessment: standard (carbon sequestration by ecosystem only), energy use of woody biomass, construction use of harvested wood products, and cascade use (waste wood consumed as fuel). Under a well-planned forest management system, production of forest resource is sustainable and its cost has decreased sufficiently to supply a small-scale biomass power plant. The reduction in carbon emissions from the use of woody biomass for energy was the largest among the four scenarios evaluated. Finally, the study suggested that a framework needs to be developed to plan for the best combination of energy-use woody biomass and construction materials so that forest ecosystems can be managed well while contributing to the regional economy.

2.3 Development and implementation of environmental renovation methodologies with multi-stakeholder participation (Project 3)

We continued to develop a local ICT (information and communications technology) system that acts as a residential interface for a community energy project; it is presently at the phase of a social demonstration experiment in the town of Shinchi. We conducted several updates, such as connection of a smart-meter in each house, function expansion of a local information map, and multi-device (home PC, smartphone, tablet PC, etc.) implementation. With these updates, the system was opened for use with typical PCs and smartphones in addition to distributed tablet terminals.

By analyzing electricity consumption data from the local ICT system, we evaluated the pattern of residential power consumption. We were thus able to clarify the patterns of variation in characteristics and differences according to different household attributes. By using this local ICT system, we conducted the 6th community energy conservation campaign in Shinchi, helping to improve awareness of energy conservation and make the community more active.

Furthermore, as an example of measures for balancing social community

activation with low-carbon measures, we constructed six typical models to compare and assess forest biomass utilization systems. The results revealed various characteristics of the respective systems, including the high performance of wood-stove systems in terms of CO_2 emission reduction per subsidy and the high contribution of biomass power-generation systems to regional employment.

3. Environmental Emergency Management Research Program

Our Environmental Emergency Management Research Program (Fig. 5) 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 the communities within them.

This program will devise technologies and systems for integrated disaster waste management aimed at achieving smooth and appropriate management of these types of 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 an 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.

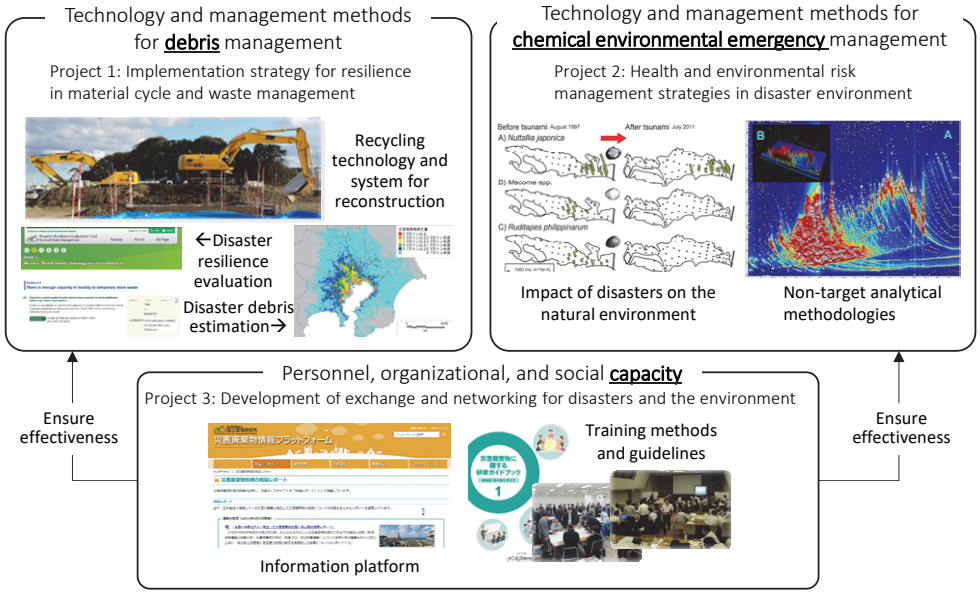


Fig. 5 Outline of the Environmental Emergency Management Research Program

3.1 Establishment of disaster-resilient waste management systems and strategies (Projects 1 and 3)

This fiscal year, to improve the disaster resilience of waste management systems, we conducted research into organizational management (Project 1) and capacity development (Project 3) for smooth and appropriate disaster waste management.

As part of our research into organizational management, we are developing a 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 several 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 by local governments in South East Asia as well as Japan to identify the disaster resilience or vulnerability of a waste management system. Moreover, along with local collaborators, we are conducting a research project in South East Asia aimed at reducing flood risk through appropriate waste management.

In our research into capacity development, we held several table-top exercises 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; this was done by placing the officers 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, boosting spontaneous learning, and 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, the production of disaster wastes. This work was done in an integrated manner with NIES's Environmental Emergency Management 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 (Project 2)

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, namely, Project 2-1: Setting target control levels for chemical contamination in disaster environments; Project 2-2-1: 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; Project 2-2-2: Establishing non-target analytical methodologies and sampling technologies for emergency contamination; and Project 2-2-3: Clarifying the long-term impacts of emergency contamination events on coastal ecosystems in the field. This year the project established a preliminary list of priority chemicals on the basis of general hazard and production information (Project 2-1); developed a rapid and comprehensive analytical screening method (Project 2-2-1); created a rapid sample-preparation method (Project 2-2-2); and performed a field survey after the impact of a disaster on a coastal ecosystem (Project 2-2-3). Through these achievements, 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.

Research 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 2017 are as follows:

1. GOSAT

Operational data processing for GOSAT, which is currently in space, 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 2018, CO_2 flux products up to October 2015, and CH_4 flux products up to September 2013 are freely available from the 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

Manufacturing and testing 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. The operation of a new validation site for GOSAT-2 products in the Philippines was started in April with the support of MOE. Bi-monthly meetings of the GOSAT-2 Science Team and its Calibration Working Group were held. Also, a GOSAT-2 New Product Validation Working Group meeting was held.

3. GOSAT-3

Information on plans for foreign GHG observation satellite projects were gathered at international conferences and websites, and discussions on GOSAT-3 with MOE and JAXA were continued.

4. Collaboration with other organizations

A meeting among NIES, the Finland Ministry of the Environment, and the Finnish Environment Institute (SYKE) was held in June in Helsinki, Finland, to discuss possible research collaboration between NIES and SYKE.

Agreements were signed in December with JAXA, the European Space Agency (ESA), the Centre National d'Etudes Spatiales (CNES), and the German Aerospace Center (in German, Deutsches Zentrum für Luft- and Raumfahrt, abbreviated DLR) to promote cooperation in the remote sensing of GHGs and related missions.

5. Hosting of meetings

A number of meetings and events were co-hosted by NIES with MOE and JAXA. The 10th GOSAT Research Announcement (RA) Principal Investigators (PI) Meeting was held in Helsinki, Finland, in June. Preparations for hosting the 15th International Workshop on Greenhouse Gas Measurements from Space and the 11th GOSAT RA PI Meeting in 2019 in Japan were started. The 2nd 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 both developed and developing countries were invited.

6. 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 14th Plenary Session (GEO-14, October, US)

• United Nations Framework Convention on Climate Change 23rd session of the Conference of the Parties (UNFCCC COP23, November, Germany).

• 54th Session of the Scientific and Technical Subcommittee, United Nations Committee on the Peaceful Uses of Outer Space (February, Austria)

7. Press release

Whole-atmosphere monthly mean methane concentration data derived from

GOSAT observations were publicly released from the website of the NIES GOSAT Project. The concentration of methane—the second most important greenhouse gas in the Earth's atmosphere—has been increasing since the launch of GOSAT in 2009 (Fig. 1). In January 2017 it reached the record-high concentration of about 1815 ppb. Its long-term trend suggests that its growth ratio increased in 2015–2016, partially because of the intense El Nino event that occurred in the same time period.

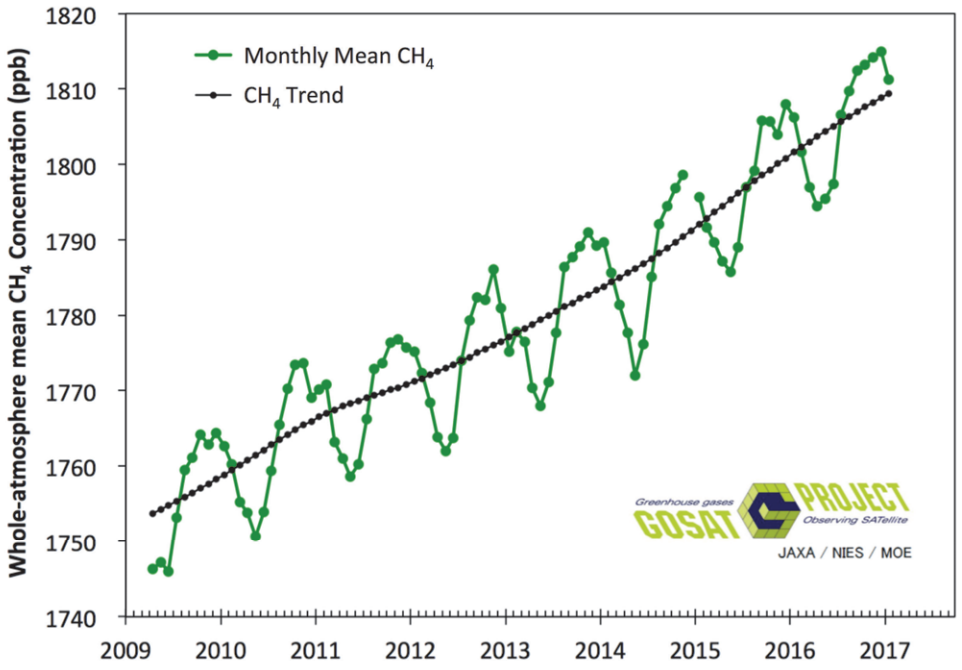


Fig. 1 Time-series data on whole-atmosphere monthly mean methane concentrations, derived from GOSAT observations since 2009

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 surveys in 15 study areas throughout Japan in cooperation with the Medical Support Centre 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 policies. 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

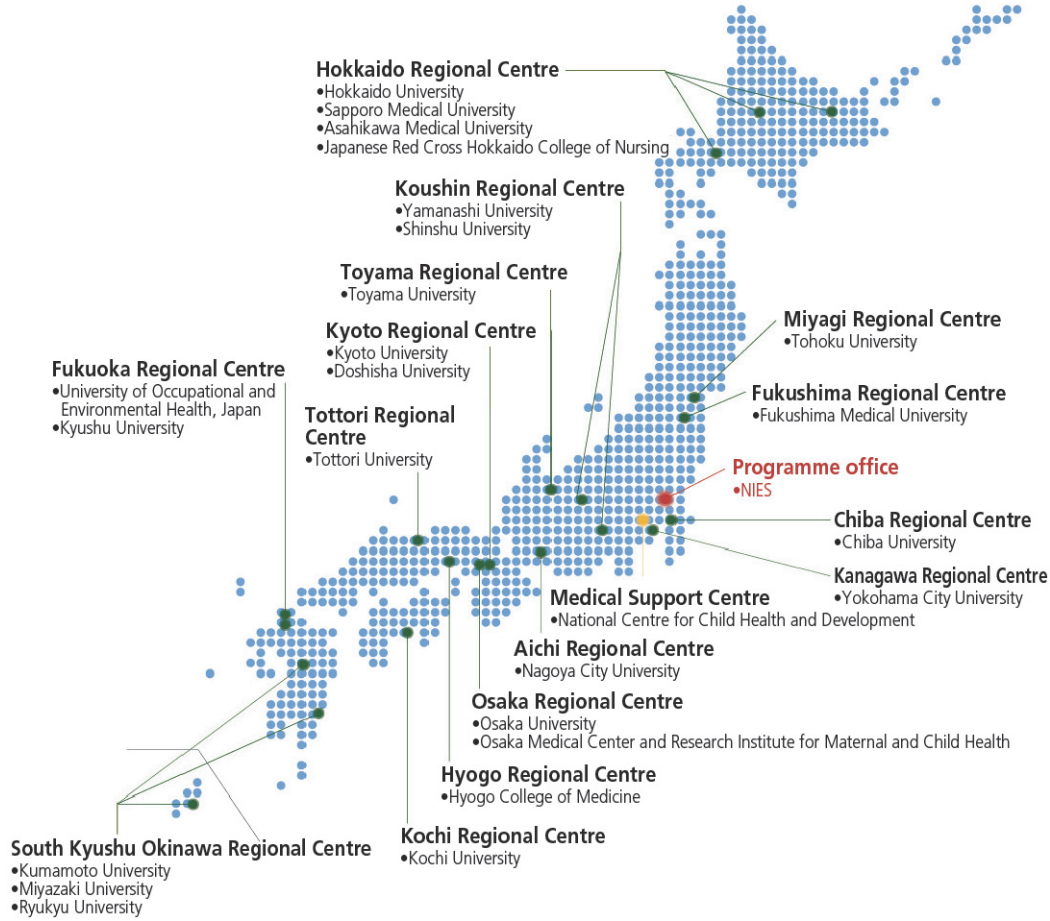
We started the participant recruitment in January 2011. The recruitment continued until March 2014. Recruited participants were pregnant women and their partners (when accessible). The number of participating mothers reached 103,099. JECS began to collect data when the mothers were pregnant and plans to follow their children until they reach 13 years of age. For the Main Study, JECS acquires information about participant health and development and potentially relevant environmental factors by administering questionnaires twice a year. The Sub-Cohort Study, which involves 5,000 children selected randomly among participants in 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 Programme Office plays key roles, including developing standard operation procedures; accumulating the data collected by the 15 Regional Centers (Fig. 1); operating the data management system; maintaining a repository of biological and environmental specimens; and performing exposure measurements, including chemical analyses of biological samples, questionnaire administration, and environmental measurements. The

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

Fig. 1 JECS organizations



4. Study protocol

Details of the study protocols of JECS can be found 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 2017

The children participating in the Main Study reached the ages of 4 to 7 years in FY 2017. We continued to administer questionnaires to participants to collect a wide range of information on the children's health and development and exposure to environmental factors. The Sub-Cohort Study involving 5,000 participants selected from the Main Study continued. Home visits to the 3-year-old Sub-Cohort were completed, resulting in the collection of 4,702 pairs of indoor and outdoor air samples and house dust samples. Volatile organic compounds, aldehydes, acidic gases, and particulate matter in the samples were quantified. House dust samples were analyzed for mite allergens and endotoxins. We completed analyzing a nicotine metabolite in urine samples from about 100,000 mothers. A total of 25,000 maternal blood samples were analyzed for poly- and per-fluorinated alkyl substances. Developmental testing, examination by a pediatrician, blood collection and testing, and urine collection in 4-year-olds were performed as part of the Sub-Cohort study.

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).

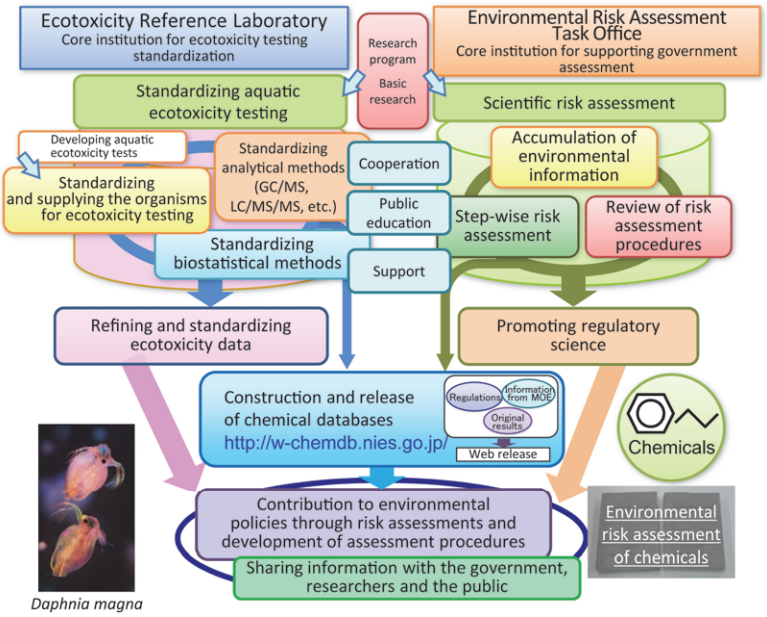


Fig. 1
The Ecotoxicity Reference Laboratory and Environmental Risk Assessment Task Office work in collaboration in regulatory risk assessment science through ecotoxicological testing, scientific risk assessment, and database development.

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 (juvenile medaka anti-androgen screening assay: JMASA) and a simple method of detecting juvenile-hormone-like chemicals by using *Daphnia magna* (juvenile hormone short-term screening test: JHSST), were proposed by our laboratory in the previous year for the OECD (Organisation for Economic Co-operation and Development) and reported additionally at the meeting of the OECD's Validation Management Group for Ecotoxicity testing (VMG-eco) this year for approval next year. 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 to personnel in Japan, both outside and inside NIES, for ecotoxicity testing. Two additional marine and estuarine invertebrates were added in the current list, which includes only freshwater fishes and invertebrates.

The Laboratory held an education seminar on ecotoxicity test techniques in FY 2017. The seminar covered test methods using a crustacean and an alga, and it was attended by about 20 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).

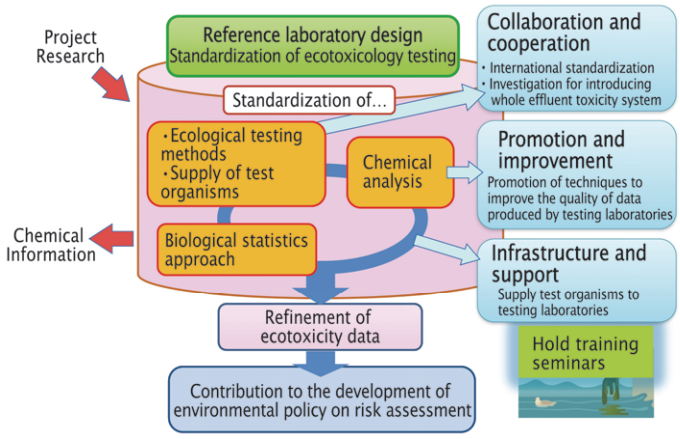


Fig. 2
The Ecotoxicity Reference Laboratory functions as a core organization for the standardization of ecotoxicity testing, both domestically and internationally.

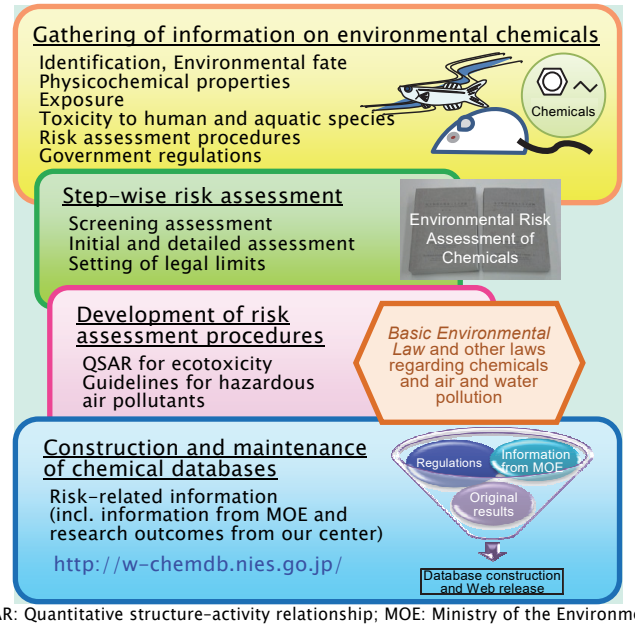
2. Environmental Risk Assessment Task Office

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 Office collects a variety of information on environmental chemicals and assesses their risks to support the risk assessments conducted under the laws enacted by 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 2017, as part of a screening assessment, we evaluated the credibility of the classification of 49 chemicals in terms of the hazards they pose to the aquatic environment. We also collected and evaluated information on hazards to the aquatic environment of 17 chemicals

under Risk Assessment I and 14 chemicals under Risk Assessment II. MOE publishes an "Initial Environmental Risk Assessment of Chemicals" every year. In FY 2017, the Task Office supported the initial ecological risk assessment of 12 chemicals. To support the registration of withholding standards for agricultural chemicals on the basis of the *Agricultural Chemicals Regulation Law*, information on the toxicity to the aquatic environment of 47 substances was collected and their credibility was 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. On 29 March 2018, we released KATE 2017 on NET beta version (https://kate.nies.go.jp/). Although this is still a beta version, it is an update of the current formal version of KATE 2011 on NET. 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 MOE; amounts of chemical substances manufactured and imported; volumes of agricultural chemicals shipped into each prefecture; PRTR (Pollutant Release and Transfer Register) information; and the results of risk assessments performed by several organizations. The EnvMethod database contains details about the analytical methods developed by MOE for environmental surveys in Japan.

Climate Change Strategy Collaboration Office

The National Plan for Adaptation to the Impacts of Climate Change was endorsed by the Cabinet in 2015 to comprehensively and systematically promote measures within the whole of government for coherent adaptation to a variety of climate change impacts. On the basis of this plan, the Climate Change Strategy Collaboration Office (The Office) has been operating and enhancing the Climate Change Adaptation Platform (A-PLAT) launched on 29 August 2016, in accordance with the Policy on Scientific Knowledge and Climate Risk Information to Promote Climate Change Adaptation Measures (interim report) formulated in March 2017. The Office established a web page to promote cooperation between the Office and the Regional Adaptation Consortium project launched by the Ministry of the Environment (MOE). Moreover, as a result of the decision by MOE to develop an adaptation measures implementation platform for Asia-Pacific Regions in response to the Paris Agreement, the necessary preparations were made to develop the Asia-Pacific Climate Change Adaptation Platform (AP-PLAT), which will be fully developed by FY 2020. The prototype was released at COP23 (the 23rd United Nations Climate Change Conference, held in Bonn, Germany) in November 2017.

To implement the sharing of information related to climate change and promote the use of such information, the Office supported the operation of a Steering Committee composed of representatives of 22 institutions, namely MOE; the Cabinet Office; the Ministry of Internal Affairs and Communications; the Ministry of Education, Culture, Sports, Science, and Technology; the Ministry of Agriculture, Forestry, and Fisheries of Japan (MAFF); the Ministry of Economy, Trade, and Industry; the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT); the Japan Meteorological Agency; the Forestry Agency; the Fisheries Agency; the Japan Coast Guard; Geospatial Information Authority of Japan and 10 research institutes, including NIES. The Office also supported the operation of Scientific Advisory Board, which provides scientific advice to the Steering Committee. Moreover, the Office operated a Working Group for the Climate Change Adaptation Platform (WG for A-PLAT); it examines important issues, such as observations of global warming areas, from a scientific perspective. Three teams were established in FY 2017: a Review team for promoting the observation and monitoring of climate change impacts (Review team for observation and monitoring), a Review team for promoting cooperation between climate change projection and impact assessment (Review team for projection), and a Review team for promoting international initiatives for progress in observing greenhouse gases (Review team for international initiatives).

To promote climate change adaptation research at NIES, the Office organized a kick-off symposium and accumulated information on climate scenarios and research progress. It also organized nine Climate Change Adaptation Seminars.
With regard to the activities of the Low-Carbon Research Program and the

Environment-Economy-Society Integration Research Program, researchers and policymakers from Bhutan, Vietnam, Thailand, and Malaysia, as well as young researchers from Sri Lanka, China, and Vietnam, were trained in model use so that they can help make a roadmap toward realizing nationally determined contributions (NDCs) in their respective countries.

1. A-PLAT (Climate Change Adaptation Platform)

The A-PLAT portal website was opened on 29 August 2016 and redesigned on 31 March 2017 to load WebGIS, which enables the download of information on observed data and present impacts, future prediction by using several models and scenarios, and comparisons with multiple views. To enhance the content of the website, not only the results of research obtained from the S-8 Project, "Comprehensive Study on Impact Assessment and Adaptation for Climate Change," implemented by the Environment Research and Technology Development Fund of MOE, but also the results of Global Warming Prediction Information Vol. 9 of the Japan Meteorological Agency, were added in February 2018.

To collect information on global observation and climate change adaptation and determine the need for such information, Office staff attended meetings and research project symposiums organized by relevant Ministries and Agencies. Staff submitted a total of 37 reports of needs surveys to MOE, and the information obtained was referenced to enhance the A-PLAT portal website. On the A-PLAT portal website, news and event information, adaptation planning information for local governments, and examples of private sector adaptations were renewed and updated and posted as needed.

As part of the transmission of information and enlightenment of the public through interactive communication, survey research was conducted by using a questionnaire board at the Eco-Life Fair in June, at the NIES Open Day in July, and at the Tsukuba Science Collaboration 2017 in November. A total of about 2500 responses were obtained over 5 days. Some of the results were added to the A-PLAT portal website. In addition, to enhance the content for individual users, links to documents, databases, and monitoring sites were added to help users to understand climate change, with cartoon-style explanations added to facilitate comprehension.

Fig. 1 One of the cartoon characters on the pages designed for individual users of the A-PLAT website

To introduce efforts to formulate adaptation planning and examples of adaptation measures by local governments, the Office conducted interviews with the government of Tokushima Prefecture in August and of Hyogo Prefecture in September, and 10 articles regarding these interviews were added to the A-PLAT portal website. To develop tools to assist communities with adaptation activities, we also conducted research into five tools that have been developed and operated in foreign countries; we conducted a survey of local governments' needs for such tools, and we developed a prototype.

Fig. 2 One of the articles used to introduce local government efforts toward adaptation

To help the private sector with its adaptation efforts, reference materials and documents on adaptation efforts were added to the website, and the development of an index of adaptation efforts and guidelines to assist the private sector was considered, using examples from guidelines developed in foreign countries to help the private sector adapt. A Workshop on Advancing Climate Change Adaptation by the Private Sector was held on 1 November 2017, with more than 100 participants. A preliminary questionnaire was conducted, and needs for climate change adaptation were surveyed.

To introduce the government's efforts, links to the adaptation pages of related Ministries and Agencies were set up, and a list of references collected by the five Sectoral Working Groups, which were established toward the Next Term Climate Change Impact Assessment, was added. The contents of the Climate Change Impact Statistics portal site, which started operating in FY 2011 on the basis of The Basic Plan on Establishing Official Statistics, endorsed by the Cabinet in March 2009, were reclassified into seven sectors of climate change adaptation and

examined and added to the A-PLAT portal website with the goal of integrating the two web portals.
Members of the Office attended meetings, including meetings of the National Steering Committee and Regional Conference, which were held a total of 12 times (twice in each of six regions), to cooperate with the Regional Adaptation Consortium Project. Web pages that were compiled exclusively for participants and other relevant persons and require an ID and password were opened to share documents and conference notes from the National Steering Committee and Regional Conference. In addition, pages for the public were opened to introduce the Project to the public. These pages are designed to be easily viewed; lead sentences refer to regional characteristics, icons are used to show sectors, and research summaries are supplied in PDF format.

The portal website had received more than 320,000 page views in FY 2017 as of 31 March 2018; over the last two fiscal years, it has received 470,000 page views—a gain of 1000 page views a month since the site opened. These numbers greatly exceed 10,000 page views a year—an item in the Fourth medium- and long-term Goal.

2. AP-PLAT (Asia-Pacific Climate Change Adaptation Platform)

A structural plan for the AP-PLAT portal website was created, and yearly plans until FY 2020 were made. Examples of impact assessment and adaptation efforts in the Asia-Pacific region and reports of bilateral cooperation for adaptation with countries in the Asia-Pacific regions supported by MOE were analyzed and a prototype portal was developed. This prototype was released at the side event "Building scientific knowledge to enhance the effectiveness and efficiency of adaptation planning and its action" at COP23 in November, and news of this event was added to the A-PLAT portal website.

3. Coordination of Steering Committee and Working Groups

The Steering Committee held its first meeting on 20 October 2017. The following items were reported on and approved: the activity report of JACCO (the Japanese Alliance for Climate Change Observation) for FY 2017; the future renewal, progress, and development of the A-PLAT website; three Review teams established as a new initiative; and the yearly schedule for FY 2017. The Scientific Advisory Board convened its first meeting on the same day as the Steering Committee. Advice was provided in regard to items reported by the Steering Committee. The Steering Committee held its second meeting on 7 March 2018. An activity report for FY 2017, a progress report on the A-PLAT portal website, and a planning draft for FY 2018 were reported on and approved.

4. WG (Working Group) for A-PLAT, Review team for observation and monitoring, Review team for projection, and Review team for international initiatives

Meetings of WG for A-PLAT were held twice, on 31 July 2017 and 15 January 2018. At the first meeting, participants exchanged opinions about the renewal, management report, future development, and problems of the A-PLAT portal website, and about the issues involved in developing AP-PLAT. At the second meeting, the content and status of operation of the A-PLAT portal website were reported on and their future development were discussed.

Meetings of the Review team for observation and monitoring were held twice, on 8 September 2017 and 4 December 2017. At the first meeting, participants held a discussion to share details of the current status and problems regarding observation of climate change and its impacts. At the second meeting, participants discussed problems and measures for improving the observation of climate change and its impacts, and they shared information on the current status of each point observed.

Meetings of the Review team for projection were held twice, on 1 September 2017 and 15 December 2017. At the first meeting, participants discussed their understanding of the present situation and its problems and the need for cooperation in the projection and impact sectors. At the second meeting, participants discussed ideas for approaching problems with cooperation and actions that could be used. Not only these issues, but also improvement plans and ideas for approaching problems were summarized into documents for the 18th Central Environmental Council's Climate Change Impact Assessment Subcommittee meeting, held on 20 March 2018.

Meetings of the Review team for international initiatives were held three times, on 23 June and 20 November 2017 and 7 March 2018. At the first, preliminary, meeting, a course of action was confirmed and activities were reported on by representatives of the attending agencies. At the second meeting, the agencies' activities and progress of the IPCC report were reported on, and the need for participating agencies to compile an activity report was emphasized. At the third meeting, activities and future plans were reported on by staff of the attending agencies. The status of the activity report was discussed, and it was confirmed that the report would be completed in about October 2018 in coordination with the relevant Ministries and Agencies.

5. Climate change adaptation research at NIES

A kick-off symposium was held on 10 July 2017 on the climate change adaptation research conducted at NIES, in collaboration with the members of the Climate Change Strategy Collaboration Office, Fukushima Branch, and five Research

Centers, with a total of 43 participants. The current situation of research was shared among the participants, and vigorous discussions were conducted to promote advancement of the research. Climate Change Adaptation Seminars were newly organized and were held nine times from June 2017 to March 2018. After each meeting, newsletters were published and uploaded with the presentation materials to the NIES File Exchange Server with the aim of advancing climate change adaptation research at NIES. In addition, two participants under the suggested research theme of climate change adaptation research at NIES were accepted after review to foster young researchers; the progress of their research was reported at the Climate Change Adaptation Seminar in February 2018.

6. Asia-Pacific Integrated Model (AIM) Project and Enhancement of Partnership with Indonesia

NIES held a training workshop for the Extended Snapshot Tool, the AIM/Enduse model, and the AIM/CGE (Computable General Equilibrium) model at Thammasat University, Thailand, in FY 2016, and researchers from 10 Asian countries had the opportunity to share their opinions. As a result, it was decided to do concrete assessments of the emission reduction target in the NDCs already submitted by Bhutan and Vietnam. NIES was asked for support with analysis of the models. As it is expected that the same NDC assessments will need to be done in Thailand and Malaysia, researchers and policymakers from the four countries were invited to NIES for 6 weeks from September 2017 to attend a training workshop on the theory of the AIM/CGE model, data, programming, and utilization of results. Moreover, NIES invited young researchers from Sri Lanka, China, and Vietnam for a 1-week training workshop on the AIM/Enduse model in October 2017; NIES contributed to the development of the AIM/Enduse model, which is the basis of a roadmap toward the realization of NDCs in each country. Including in this fiscal year, this project has trained a total of more than 100 people since its launch in 1997. At the 23rd AIM International Workshop, held at NIES in November 2017, the project's outcomes and efforts were shared, and discussions were held on the future of research cooperation in Asia.

Furthermore, as part of the MOE project, "Development for Innovative Technology in Measurement, Reporting and Verification (MRV) systems in Indonesia for Promotion of the Joint Crediting Mechanism (JCM) 2017," NIES advanced the development of a social monitoring system for urban and industrial activities by using information and communications technology (ICT), and it discussed cooperation with Bogor Agricultural University, the Institut Teknologi Bandung, Udayana University, the Indonesian Ministry of Environment and Forestry and Ministry of Industry, and the Bogor City government. Development and maintenance of a system for energy consumption and behavior analysis of residences and work and commercial facilities were promoted and a questionnaire survey was conducted, in cooperation with the Bogor City government, to acquire the data needed to estimate the low-carbon effect at a regional scale. By using

these monitoring results, NIES made progress in a scenario analysis of future low-carbon planning in Bogor City with Bogor Agricultural University. Using results from the monitoring of industrial facilities, an energy consumption projection model was developed and applied to facilities in the factories, and data on energy consumption reduction potential were extracted in coordination with the Institut Teknologi Bandung. These research outcomes were shared at international meetings hosted and co-hosted by NIES.

The LoCARNet 6th Annual Meeting was held in Bangkok, Thailand in November 2017, and the research outcomes were shared and research cooperation was promoted. The 3rd International Forum on Sustainable Future in Asia (3rd NIES International Forum) was hosted by NIES in Malaysia in January 2018. Discussions on measures for making a transition to decarbonizing and resilient regions were held; at these discussions, the importance of collaborating in adaptation and mitigation, considering adaptation technology and policy to implement more sustainable adaptation measures, and implementing these measures in society was emphasized.

On the domestic front, cooperation was promoted at various opportunities, including the International Forum on regional energy in Shinchimachi in Fukushima Prefecture in September; the Kitakyushu Research Complex Program in August; the Eco-model Cities project in Oguni in Kumamoto Prefecture; and the Innovation Coast Policy Consideration 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 environmental monitoring systems centered on regional environmental research institutions.

This year, we have made an especially 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 waste management after the northern Kyushu region heavy rain disaster

The heavy rainfall experienced in the northern Kyushu region (545 mm in 24 h rainfall in the city of Asakura, in Fukuoka) in early July 2017 caused a series of devastating landslides. This resulted in the generation of large amounts of disaster waste and driftwood (Fig. 1).

Our office immediately sent an expert on site to investigate conditions in the affected area. The expert stayed for several weeks to support the local government 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 manage waste at temporary waste storage sites, and

b) how to estimate the amount of disaster waste.

Fig. 1 Disaster waste collected in the city of Asakura after the 2017 floods (left), and driftwood scattered across the city (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, including a tabletop exercise, for personnel from Hyogo Prefecture. The trainees were able to virtually experience actual responses in disaster waste management (Fig. 2). By participating in the program, trainees were able to gain a better perception of the issues and tasks required in an emergency.

In addition, we advised other prefectural governments, such as Saitama, Mie, and Kanagawa prefectures, on how to design and run effective tabletop exercises appropriate to their needs. We also co-hosted an on-site training program, which we have run at actual damage sites in Kumamoto Prefecture.

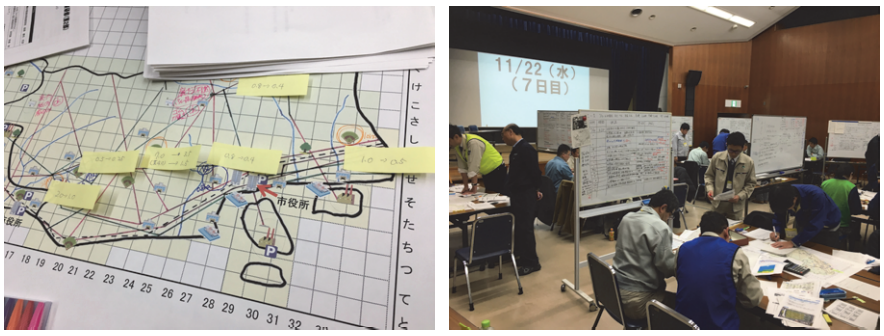


Fig. 2 Scenes at a disaster waste management training program held in Hyogo Prefecture

3. Implementing a disaster waste information platform

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

This year, the following information was newly provided from the platform:

a) lessons learned from local government responses to past disasters (in Iwate Prefecture), and preparedness actions in normal situations,
b) disaster waste management plans and records issued by local government,
c) guidebooks explaining the principles and processes of designing effective training programs, and
d) a relay-style self-introduction essay for stakeholders in disaster waste management.

Fig. 3 Relay-style essay (left) and the disaster waste management plan database (right) provided in our information platform

4. Development of an expert network on disaster waste management

We developed a list of waste management experts willing to support disaster waste management and preparedness actions undertaken by local government. We also distributed a questionnaire survey to academic members of the Japan Society of Material Cycles and Waste Management asking about the kinds of support members could provide and the necessary conditions for providing such support. We also started a discussion on an effective system for utilizing this list to support local government disaster waste management activities.

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) has accumulated and analyzed our communication experiences to date and developed new content for interacting with the public by using social media and other means. Furthermore, DaC has held events such as stakeholder meetings and science cafés on NIES activities. Through these communication opportunities, we get feedback from participants on NIES research activities. DaC will use these means to build a relationship of mutual trust between society members and environmental researchers (Fig. 1)

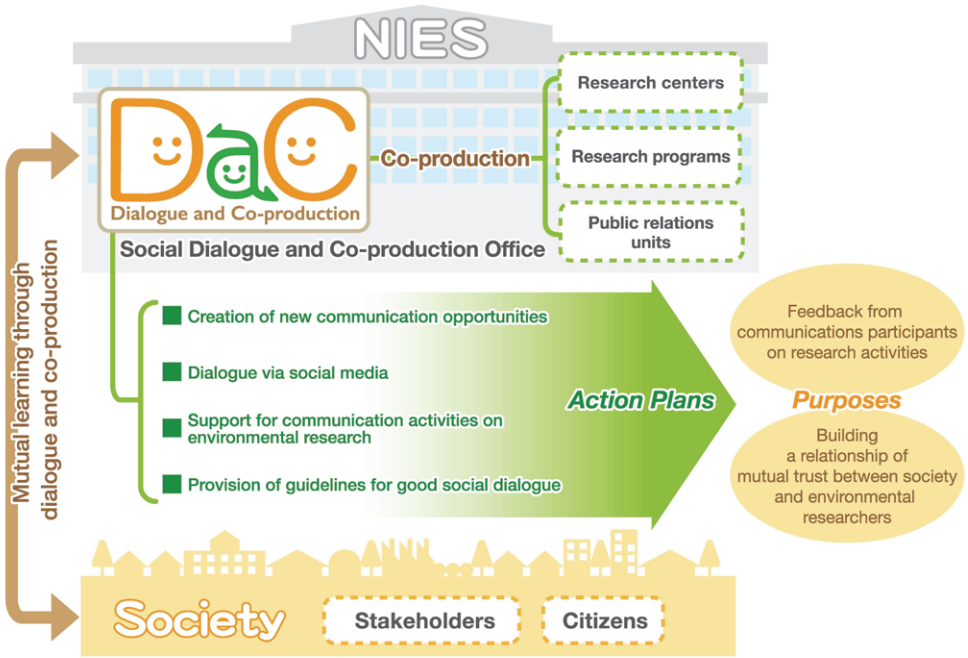


Fig. 1 Action plans and purposes of DaC. There are four activities that involve mutual learning between NIES and members of society. Through these activities, DaC can accomplish its purposes, namely to get feedback from society on NIES research activities and to build a relationship of mutual trust between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

2. Major activities in FY 2017

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, DaC organizes a stakeholder meeting once a year. This year's theme was "Adaptation to climate change." Four stakeholders from business, consulting, the media, and local government sectors were invited and held discussions with NIES researchers about an adaptation research project.

2.1.2 Science cafés

DaC held science cafés as part of the Spring and Summer NIES Open House programs (Fig. 2). DaC and NIES researchers used these opportunities to directly gauge the public's reaction to NIES's activities.

Fig. 2 About 50 members of the public participated in the science cafés and enjoyed talking with researchers at the Summer Open House.

2.2 Dialogue via social media

DaC has opened Twitter (Fig. 3) and Facebook sites this fiscal year so that we can interact with many more members of the public on the Internet. By supplying timely information in response to social topics via social media, we can encourage a greater diversity of people to become interested in NIES's activities. DaC is also concentrating its efforts on enriching its online articles, which the public can read easily and which encourage people to think about environmental issues.

Fig. 3 Examples of Tweets. By contributing catchy topics or visuals, DaC attracts public interest in environmental issues.

2.3 Support for communications activities

DaC supported the communications activities of other research centers or programs at NIES, including the following.

2.3.1 Science café at Fukushima Branch

A science café was held at the Fukushima Branch in July. DaC supported the café from planning to implementation.

2.3.2 Communications seminar for NIES staff

DaC invited one of the office's advisors, Mikihito Tanaka, and his colleague to lecture at a seminar held for NIES staff about science communications on social networking sites.

2.4 Provision of guidelines for good social dialogue

To create guidelines for good social dialogue, DaC holds a workshop every year to gather and analyze staff members' communication experiences at NIES. This year, staff discussed the best ways to convey research results or activities to the mass media.

3. Future issues

DaC has been exploring how to evaluate the effectiveness of communications activities and mutual trust between society and NIES. For effective dialogue it is important that we have a clear picture of communications counterparts and methods. It is also important to think about how we should get and use social feedback to improve NIES research activities.

Basis for Environmental Research

Center for Global Environmental Research

Global environmental change is an essential threat to a sustainable society and human life. Climate change, including global warming caused by increasing atmospheric greenhouse gas (GHG) concentrations, together with changes in the stratospheric ozone, is having serious impacts on all ecosystems and on humans. Considering the predicted impacts, it is vital that we take measures to conserve the global environment towards establishing a sustainable society with lower emissions of GHGs. Because it requires a lot of time for the effects of climate change mitigation options to manifest, we must 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 scientific findings, and facilitates mutual understanding to raise public awareness of global environmental problems.

1. Decreasing trend in vertical gradient of CH_4 concentrations over West Siberia; monitoring of a reduction in anthropogenic CH_4 emissions from Europe

We have been performing monthly flask sampling using aircraft at an altitude range of 0 to 7 km over the boreal wetlands in Surgut (61°N, 73°E) since 1993 and in a pine forest near Novosibirsk (55°N, 83°E) since 1997; both locations are in the West Siberian Lowland (WSL). The temporal variation of methane (CH_4) concentrations at all altitudes at both sites exhibited an increasing trend with stagnation from 2000–2006, as observed globally from ground-based networks. In addition to a winter maximum, as seen at other remote sites in northern mid- to high latitudes, another seasonal maximum was observed in summer, particularly in the lower altitudes over the WSL; it was likely attributable to emissions from the wetlands. Our measurements suggest that the vertical gradient at Surgut has been decreasing; the mean CH_4 difference between 5.5 km and 1.0 km changed from 64 ± 5 ppb during 1995–1999 to 37 ± 3 ppb during 2009–2013 (mean ± standard error) (Fig. 1). No clear decline in the CH_4 vertical gradient appeared at Novosibirsk. Simulations using an atmospheric chemistry-transport model captured the observed decrease in the vertical CH_4 gradient at Surgut when CH_4 emissions from Europe decreased. At Novosibirsk, the influence of the European emissions was relatively small. Our results also suggest that regional emissions around the WSL did not change significantly over the period of our observations.

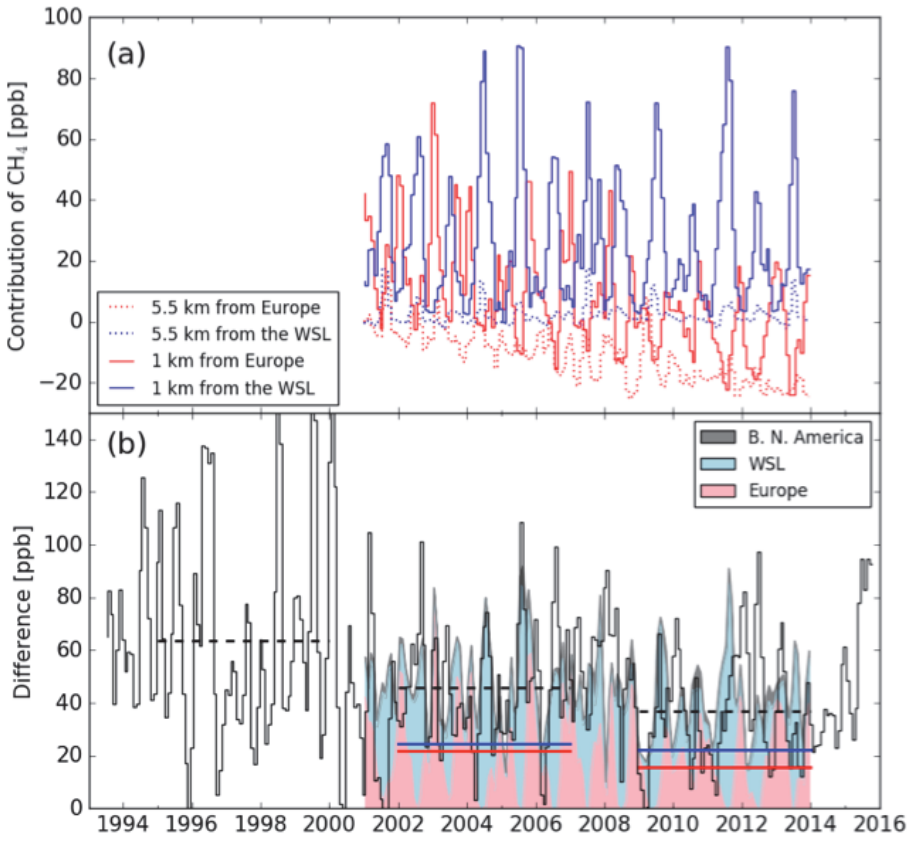


Fig. 1
(a) Temporal variation in monthly mean contributions of tagged simulations from Europe (red) and the West Siberian Lowland (WSL) (blue) to the concentration of CH_4 at 1 km (solid lines) and 5.5 km (dotted lines) over Surgut. The monthly means were produced by using the fitting method and offset by the first value at 5.5 km from each region.
(b) Temporal variation in the vertical difference between 1 km and 5.5 km in monthly mean values of CH_4 over Surgut, produced by using the fitting method. Horizontal dashed lines indicate mean values for 1995–1999, 2002–2006, and 2009–2013. Vertical gradients calculated for emissions from Europe (pink), the WSL (light blue), and Boreal North (B.N.) America (gray) are shown. Horizontal red and blue lines indicate mean values for Europe and the WSL, respectively, during 2002–2006 and 2009–2013. (Sasakawa et al., 2017)

Reference:

Sasakawa M., Machida T., Ishijima K., Arshinov M., Patra P.K., Ito A., Aoki S., Petrov V. (2017) Temporal characteristics of CH_4 vertical profiles observed in the West Siberian Lowland over Surgut from 1993 to 2015 and Novosibirsk from 1997 to 2015. *J. Geophys. Res. -Atmos.,* 122, 11261-11273, 10.1002/2017 JD026836.

2. Sea-to-air flux of dimethyl sulfide in the South and North Pacific Ocean, as measured by proton transfer reaction-mass spectrometry coupled with the gradient flux technique

Dimethylsulfide (DMS) is produced from phytoplankton and is ubiquitous in the surface ocean. Once DMS is emitted into the marine atmosphere, it is oxidized to sulfur dioxide, sulfuric acid, and sulfate aerosols. These acidic compounds influence atmospheric chemistry and contribute to the formation of cloud condensation nuclei, as well as to the growth of existing particles. The particles derived from DMS affect the Earth's radiation budget by directly scattering sunlight and indirectly influencing cloud physics and albedo. We developed a novel instrument combining the gradient flux (GF) technique with the proton transfer reaction-mass spectrometry (PTR-MS) system (PTR-MS/GF), and we succeeded in measuring the DMS fluxes between the surface ocean and the lower atmosphere at the platform of an ocean-going research vessel. We deployed the PTR-MS/GF system and observed vertical gradients of atmospheric DMS just above the sea surface in the subtropical and transitional South Pacific Ocean and the subarctic North Pacific Ocean (Fig. 2). In total, we obtained 370 in situ profiles, and of these we used 46 data sets to calculate the sea-to-air flux of DMS. The DMS flux determined was in the range of 1.9 to 31 μmol m^{-2} day^{-1} and increased with wind speed and biological activity, in reasonable accordance with previous observations in the open ocean. When atmospheric conditions were highly stable during the daytime in the subtropical ocean, the PTR-MS/GF observations captured a daytime vs. nighttime difference in DMS mixing ratios in the surface air overlying the ocean. The difference was due mainly to sea-to-air DMS emissions and the stable atmospheric conditions, thus affecting the gradient of DMS. This indicates that the DMS gradient is strongly controlled by diurnal variations in the vertical structure of the lower atmosphere above the ocean surface.

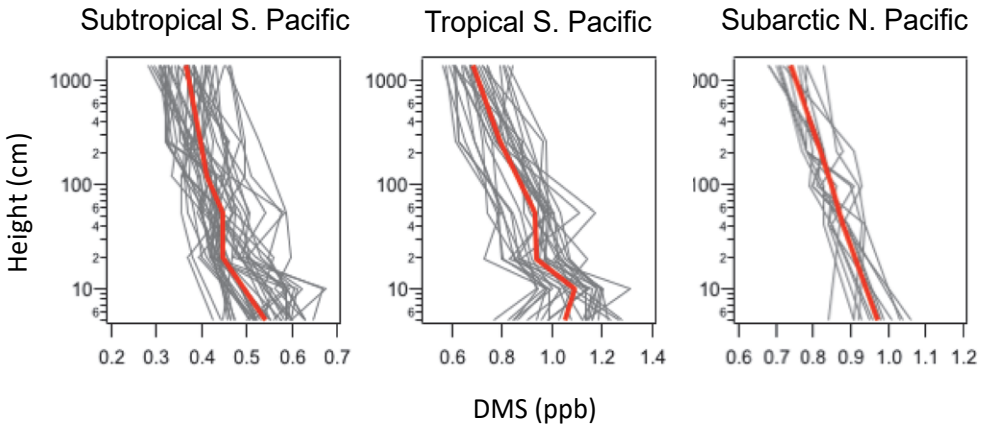


Fig. 2
Vertical profiles of dimethylsulfide (DMS) above the sea surface, observed by using the PTR-MS/GF system in three ocean regions: the subtropical and transitional South Pacific and the subarctic North Pacific Ocean (Omori et al., 2017).

Reference:
Omori Y., Tanimoto H., Inomata S., Ikeda K., Iwata T., Kameyama S., Uematsu M., Gamo T., Ogawa, H., Furuya K. (2017) Sea-to-air flux of dimethylsulfide in the South and North Pacific Ocean as measured by Proton Transfer Reaction-Mass Spectrometry coupled with the Gradient Flux (PTR-MS/GF) technique. *J. Geophys. Res.-Atmos.*, doi:10.1002/2017JD026527

3. Impact of inland water on the global carbon cycle

Previous research on the global carbon cycle has generally considered the accumulation of carbon in terrestrial ecosystems without the effect of inland waters explicitly. Therefore, the effect of inland waters has been implicitly included within the uncertainty range in the global carbon cycle of Earth systems consisting of land, oceans, and atmosphere. To quantify the role of inland waters, an advanced model coupling eco-hydrology and biogeochemical cycles [National Integrated Catchment-based Eco-hydrology (NICE)-BGC] was developed to incorporate complex coupling of hydrologic-carbon cycles in terrestrial–aquatic linkages and interplay between inorganic and organic carbon during the whole process of carbon cycling. The new model can (i) simulate both horizontal transport to the ocean and vertical fluxes; and (ii) include aquatic metabolism and terrestrially derived carbon together in major rivers. These are potential improvements from previous models and will help to identify some hotspots of CO_2 evasion, like the Amazon River basin, on a global scale (Nakayama, 2017a).

The model was also used to evaluate seasonal variations in the carbon cycle and improved on previous studies, confirming that: (i) whereas there is a clear relationship between runoff and carbon export, soil temperature has some effect on carbon transport by the biologic process responsible for carbon production; (ii) there is high runoff from April to June and a large DOC (dissolved organic carbon) and POC (particulate organic carbon) flux from January to March on hillslopes; (iii) CO_2 evasion peaks from January to June, primarily because of changes in Amazon River flows; and (iv) sediment storage is greatest from July to September in Asian and North American rivers. The model results showed that there is great variability in DOC, POC, and DIC (dissolved inorganic carbon) transport to the ocean, reflecting variations in biologic and hydrologic processes and CO_2 degassing, which is affected by both terrestrially derived CO_2 and CO_2 production through aquatic metabolism (Fig. 3). Because these items have usually been evaluated separately in previous studies, the model is a great improvement. Nevertheless, we still need to reduce the uncertainty ranges of the simulation results and analyze their biases more strictly in each process (Nakayama, 2017b).

References:
Nakayama T. (2017a) Development of an advanced eco-hydrologic and biogeochemical coupling model aimed at clarifying the missing role of inland

water in the global biogeochemical cycle. *J. Geophys. Res. Biogeosci.* 122:966–988

Nakayama T. (2017b) Scaled-dependence and seasonal variations of carbon cycle through development of an advanced eco-hydrologic and biogeochemical coupling model. *Ecol. Model.* 356:151–161

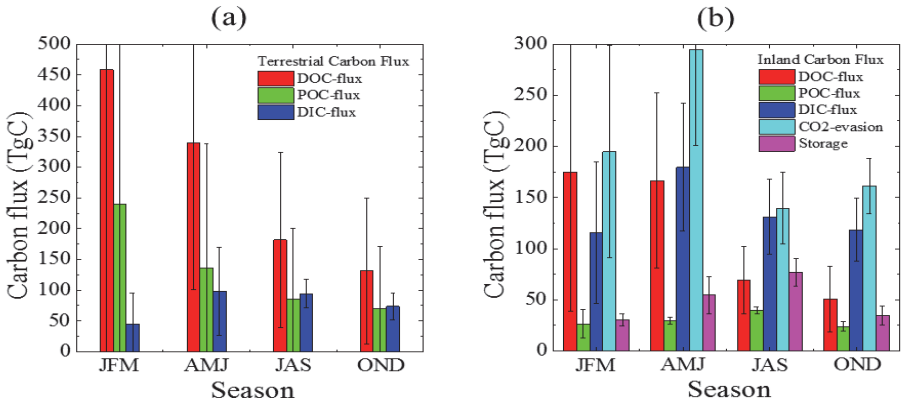


Fig. 3
Seasonal variations in global carbon flux simulated by NICE-BGC, (a) from terrestrial into aquatic ecosystems; and (b) in inland waters (reprinted from Nakayama, 2017b). Error bars show standard deviations of seasonally averaged values simulated by the model.

Center for Material Cycles and Waste Management Research

The Center for Material Cycles and Waste Management Research conducts a variety of research to establish a political and academic base in the fields of materials cycling and waste (Fig. 1). Currently our focus is the present 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.

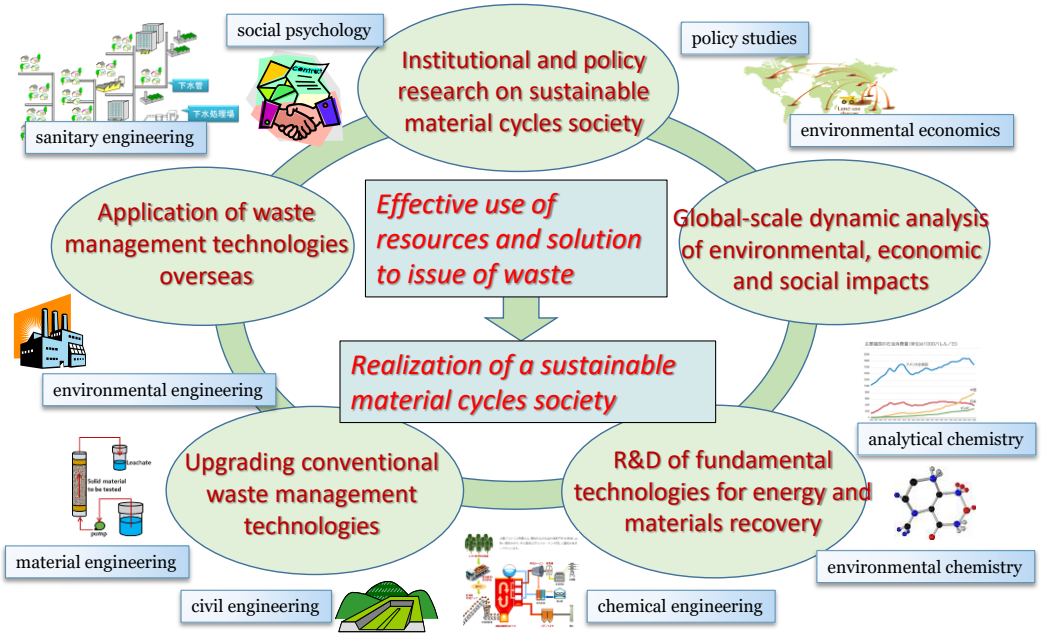


Fig. 1 Outline of flows of fundamental research for material cycles and waste management

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

As part of research into behavioral change, we conducted interview surveys in addition to the household surveys we conducted in Vietnam and Thailand the previous year. We also interviewed housing developers and found that there was considerable demand for the building of apartments and condominiums with private capital in Hanoi and for plumbing work to install air-conditioners. In urban areas of Chiang Rai, many people already live in modern houses and the installation of two or more air-conditioners per household is already common. With the aim of transforming regional energy systems, we developed a collective behavior model and started analyzing determinants of the collective behavior of

people participating in activities to promote such regional energy systems.
As part of policy research, we compared recycling systems for waste electrical and electronic equipment (WEEE) in Sweden, Japan, and China. This study analyzed how WEEE management systems emerged and how governance mechanisms worked within each system. Data obtained on perceptions of extended producer responsibility (EPR) from our international questionnaire survey were statistically analyzed further, and perceptional issues underlying Japanese EPR policy were discussed.

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

In an analysis, we modified trade volumes by commodity and improved the metal contents of the commodities and the recycling rates of metals to enhance the accuracy of estimation of global metal flows and stocks in each country. The time series of global metal flows was extended to 2013. We began building a database of webpages to make these material flow data publicly available; this will also provide visualization tools applicable to web browser environments to help database users to understand the dynamics of metal flows and stocks year by year.

In 2015, in response to the Paris Agreement, the Japanese government committed itself to reducing greenhouse gas (GHG) emissions by 26% below 2013 levels by 2030. In the same year, the government also committed itself to overcoming the barriers to economic growth imposed by an aging society with a low birth rate by implementing socioeconomic policies. To achieve these two national targets, we examined the extent to which increases in the total fertility rate and the number of double-income households would affect the domestic carbon footprint (CF) associated with household consumption in 2030. Our findings showed that the total household CF in 2030 would range from 683 to 815 Mt-CO_2eq/year, depending on the consumer preferences resulting from implementation of the socioeconomic policies. This implies that, compared with a business-as-usual scenario, the GHG emissions associated with household consumption would need to be reduced by more than 7.8% to 29% to meet the CF target set by using the CF for 2009 and the reduction target proposed in the Paris Agreement.

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

We used model gastric juice and intestinal fluid to develop two types of chemical leaching tests to assess the ingestion of chemicals contained in products. We then applied the tests to recycled materials from e-waste. In addition, we began to develop another leaching test for assessing the intake of chemicals via inhalation exposure.

In a continuing study of the behavior of new POPs in recycling facilities, we

investigated the behavior in recycling facilities in addition to those we had already investigated. We developed an on-site screening method to sort high-impact polystyrene products, whereby decabromodiphenyl ether is incorporated at concentrations of more than 5%. We applied the process to waste TV-casings collected from an actual home appliance recycling facility. Furthermore, we determined the volatilization flux of hexabromocyclododecanes (HBCDs) from recycled materials to evaluate their emission to the environment before and after the recycling of HBCD-containing waste.

In a study of the appropriate treatment of building material waste containing asbestos, we estimated the amount of waste asbestos generated across Japan in FY 2014, and we analyzed the effects of local characteristics, such as population and number of demolition works, on waste generation.

To realize our previously developed lifetime improvement technology for secondary batteries without the use of high pressure, we suggested the use of a viscous electrolyte solution. We estimated the viscosity of solvent mixtures and then selected appropriate solvents for this modification.

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

By microscopic observation, we examined the stability of framboidal pyrite in marine sediments against water, hydrochloric acid, or hydrogen peroxide water with the aim of establishing a method for determining the natural or artificial origin of contaminated soils.

To make effective use of waste gypsum, we proposed methods of evaluating the leaching of heavy metals, pH, and generation of hydrogen sulfide. These methods were presented in a draft recycling guideline.

We developed a new method of calculating the mechanism of neutralizing high-pH leachate at landfill sites on the basis of the difference between the equivalent concentrations of cations and anions that do not contribute to pH neutralization among constituent ions.

We performed a demonstration test (width 2.5 m, length 30 m) with a full drainage structure aimed at early abolition of an off-shore landfill site. We confirmed that use of a total drainage layer could suppress the pH rise of the leachate water to a maximum of around 9.0. This pH was lower than the value predicted by numerical analysis; the effect of carbonation was considered as a potential cause of this finding.

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

We are studying fundamental technological issues associated with the improvement of waste management systems in Japan and Asia.

In FY 2017 our studies included the following. To specify hazardous chemical flows in waste management, we estimated the concentrations of PRTR designated chemicals in industrial wastes for each waste item and each type of industry.

From the perspective of the declining population of our society, we started experimenting with the appropriate operation of *Johkasou* systems with extremely low user numbers.

We also estimated the costs of using captured harmful wildlife for food and the costs of disposing of such wildlife under several scenarios, considering the time from capture to implementation of each disposal strategy, the equipment and labor required, and the results of volume-reduction experiments.

We investigated changes in leachate quality and quantity with the introduction of a semi-aerobic landfill system and a leachate recirculation system. Moreover, we changed the carbon to nitrogen ratio of waste by segregation at source and the removal of resources and pretreatment before landfilling; these actions affected the behavior of materials in landfill.

We obtained information on nitrous oxide generation under conditions of carbon shortage and its equilibrium between the dissolved state and the gas state. Also, we proposed a microbial ecological control mechanism for reducing the emissions of methane from landfill by using methane oxidation bacteria and sulfate reduction bacteria.

To control microbial films in the microbiological treatment of waste and wastewater, we established a monitoring system that senses the amount of film deposited.

6. Waste management research collaboration and research into practice projects with Asian countries

6.1 Project for appropriate solid-waste management toward flood risk reduction in tropical Asian urban areas by restoring drainage functions

We surveyed the composition of the waste accumulated in Bangkok’s canals. We also examined the attitudes of residents in Bangkok in Thailand and Hue in Vietnam toward their discharge of wastes.

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

As part of the activities of the committees for ISO/TC 297 (Waste management vehicle) and ISO/TC 300 (Solid recovered fuel), we advised the national mirror committees and, as technical experts, proposed and negotiated new standards for international technical committees.

6.3 Formulation of an ASEAN project on integrated decentralized domestic wastewater management

A proposal for a Japan–ASEAN Integrated Fund policy dialogue project was submitted to the ASEAN Secretariat. The project is expected to start in mid-2018. Policy advisories will be provided to ASEAN member states to promote decentralized domestic wastewater management.

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 fish chronic toxicity prediction models and performed external validation of daphnia chronic toxicity prediction models by using QAAR (quantitative activity–activity relationship) and QSAAR (quantitative structure activity–activity relationship). QSAAR is based on daphnia acute toxicity, chemical structure descriptors, and physicochemical properties. Test methods were also developed for the amphipod *Hyalella azteca*, and in a daphnia multi-generation test, the toxicities of mixtures of chemicals were examined to help standardize and upgrade risk assessment under the Chemical Substances Control Law (CSCL) and the Agrochemicals Control Act. Various methods of preparing aquatic solutions of hydrophobic chemicals were compared in terms of toxicity testing and the maintenance of aqueous concentrations close to the aqueous solubility limit. An adverse outcome pathway was also investigated for daphnia juvenile hormone agonists. Finally, we quantitatively analyzed error rates in the hazard classification of environmental chemicals by evaluating the derivation flow of Predicted no effect concentration (PNEC) under the CSCL in Japan. Moreover, we proposed an algorithm for efficient ecotoxicity testing of new chemicals under the CSCL 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 year, we continued research on the establishment of detection methods for mutagens, carcinogens, biological macromolecules, and receptor-binding chemicals. Specifically, we examined exposure assessment methods for mutagenic compounds derived from cooking or burning and for

endocrine-disrupting chemicals. In addition, the causal relationship between the level of exposure to aromatic hydrocarbon receptor (AhR) ligand and neurodevelopmental effects was studied by using active AhR-binding substances such as benzopyrene and dioxin. Furthermore, we held an International Conference on Environmental Health and Environmental-related Cancer Prevention 2017: Assessing Low-doses and Cumulative Effects of Exposure to Chemical Mixtures, and we discussed on how to approach the next-generation analysis of chemical exposure and its influence.

3. Radiocesium in seawater, sediments, and marine biota in the coastal waters off Fukushima after the Fukushima Daiichi Nuclear Power Plant accident

In bottom-sediment samples collected in October 2012 from a coastal strip (about 30 × 120 km) near the Fukushima Daiichi Nuclear Power Plant (FDNPP), radiocesium activity concentrations were generally higher south of the FDNPP, with patches of high activity concentration in the north. In periodic surveys conducted at nearshore sites from October 2012 to June 2016, no clear temporal trends were observed in radiocesium activity concentrations in seawater or bottom sediments, and activity concentrations were higher in fish than in invertebrates. From October 2012 to July 2014, radiocesium activity concentrations tended to decrease in fish, but from October 2012 to January 2013 in the south, some increases were observed. Radiocesium activity concentrations were significantly higher in some fish species (e.g., the skate *Okamejei kenojei*) directly offshore and south of the FDNPP than to the north. Activity concentrations in fish stomach contents were significantly correlated with those in muscle tissue, suggesting that the consumption of contaminated prey contributed greatly to radiocesium contamination of demersal fish.

4. Basic study for strategic risk management

We are studying the factors that are 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; the behavior of chemicals by using multimedia environmental fate models; the emission of flame retardants from products; environmental monitoring and risk management 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 the management of 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 determined the respiratory uptake and depuration kinetics of perfluorooctanesulfonate in a marine polychaete sandworm species. The estimated respiratory absorption efficiency was 11% of that of oxygen, and the estimated depuration half-life was 15 days. The bioconcentration factor was 470.

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.
We have made progress in developing an *in vitro* air–liquid interface exposure system for studying inhalation toxicity (Fig. 1). We have simulated the most appropriate conditions for applying electrostatic force to enhance deposition efficiency, with homogeneous deposition of airborne particulate matter of various sizes on the cell surface at the bottom of the culture well. We can simulate deposition efficiencies as a function of applied voltage. As shown in Figure 1, although the deposition efficiency was high at voltages over 1 mV, the deposited particles were concentrated near the center of the cell culture insert. On the other hand, the distribution was even at 0.1 mV. At this applied voltage, the whole deposition efficiency (10.3%) was higher than that with normal usage (i.e., without electrostatic force) (0.19%). In this way, we found the optimal conditions for operation of the *in vitro* air–liquid interface exposure system.

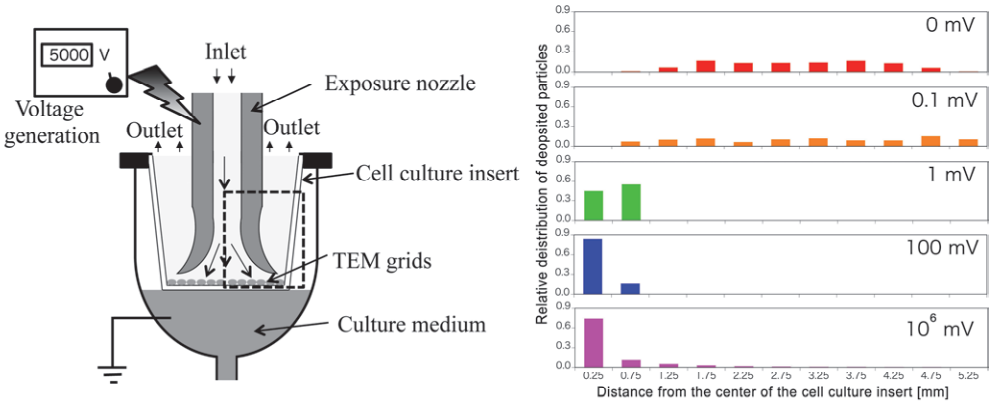


Fig. 1
Left: Schematic diagram of the air–liquid interface cell (exposure chamber). Dotted enclosure indicates simulation field. Right: Distribution of particles (300 nm) deposited at the bottom of the cell culture insert at different applied voltages. TEM, transmission electron microscope

6. Mechanisms of arsenite-induced G0/G1 arrest in mouse B lymphocytes

Chronic arsenite exposure is known to induce immunosuppression, but the mechanisms remain controversial. Previously, we found that the formation of p16-cdk4 complex was increased in mouse A20 B-lymphoma cells by sodium arsenite exposure followed by G0/G1 cell-cycle arrest. Arsenite is known to induce the production of reactive oxygen species (ROS), which are implicated in

inhibition of G0/G1 arrest. However, in contrast to the case with sodium arsenite exposure, exposure to hydrogen peroxide—a major ROS—did not induce p16-cdk4 complex formation or G0/G1 arrest in A20 cells. To investigate the arsenite-specific mode of action in B lymphocytes, we performed a microarray analysis of A20 cells treated with sodium arsenite (10 μM) or hydrogen peroxide (100 μM). The analysis revealed that *Myc* expression was drastically decreased by arsenite exposure, whereas its expression was not changed by hydrogen peroxide exposure. The mRNA expression changes were validated by real-time PCR. Furthermore, siRNA knockdown of *Myc* induced *p16* mRNA expression, suggesting that the reduction in *Myc* expression caused by sodium arsenite exposure caused an increase in *p16* mRNA expression followed by G0/G1 cell cycle arrest.

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 fiscal year, we found a decrease in the level of expression of a social-behavior-related gene and an increase in the production of inflammatory cytokines and oxidative stress markers in the hippocampus of an autism model made in rats by using valproic acid. We also developed a system for evaluating behavioral abnormalities induced by chemical exposure in juvenile animals by using transgenic or wild-type mice (or both) exhibiting autism-like symptoms. We examined the effects of diphenylarsinic acid on extracellular dopamine levels in the striatum of mice by using a microdialysis–HPLC method. To evaluate the toxic effects of airborne particles on the respiratory system, we studied a culture system for a human bronchial epithelium model in which ciliated epithelial cells and goblet cells were differentiated from human normal bronchial epithelium cells under gaseous-phase conditions.

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) a smaller sample volume requirement; (2) higher throughput; and (3) economic analyses. We developed a method for quantifying polychlorinated biphenyls (PCBs) in the blood by using automated sample preparation and gas chromatography–tandem mass spectrometry (GC-MS/MS). It requires 0.1 mL of serum or plasma to achieve sufficient sensitivity to detect major PCB congeners. The GC-MS/MS run time was less than 15 min. Measurements of a standard reference material showed

good agreement with the certified values, indicating that the new method could accurately quantify the target PCBs in a high-throughput manner.

Exposure factors are essential elements in exposure assessment. We studied exposure factors related to the rates of ingestion of indoor dust and soil by preschool children and to the use of personal care products (PCPs) by pregnant women; these factors are not frequently studied in Japan. Median ingestion rates of indoor dust and soils were estimated to be slightly less than, but comparable to, the recommended value for the indoor dust ingestion rate published in the US EPA's Exposure Factors Handbook (EFH). The use of PCPs by women of childbearing age was measured by recording an individual's specific PCP usage; to our knowledge, this was the first attempt to do so in Japan.

9. Adverse health effects of PM2.5 components

Many reports have addressed the health effects of fine particulate matter (PM2.5), although how the components of this complex material affect our health remains unclear. This fiscal year, we examined the association between components of PM2.5 and out-of-hospital cardiac arrest (OHCA) of cardiac etiology. We conducted a case-crossover study. The subjects were 6557 patients in Osaka Prefecture aged 40 years or older who had suffered OHCA of cardiac etiology between September 2011 and December 2012. We used national data with Utstein-style resuscitation registration. The odds ratios of OHCA per unit increment in hydrogen ion, nitrate, sulfate, and water-soluble organic carbon were 1.015 (95% confidence interval [CI]: 0.982–1.048), 1.027 (95% CI: 1.001–1.055), 0.989 (95% CI: 0.973–1.006), and 1.006 (95% CI: 0.982–1.030), respectively. Going forward, we will need to accumulate data on more participants to improve the precision of our analyses.

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 six 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 2017, we implemented many research projects covering a wide range of regional environmental issues. Our main research projects were as follows:

- a study of the 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
- a study of microbial arsenic mobilization for bioremediation of contaminated soil
- a study of the biodegradation and size distribution of dissolved organic matter derived from aquatic macrophytes in Lake Biwa.

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 2017.

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.

We found that the frequency of UROB in Tsukuba was highest in September and then gradually declined after October. We constructed a UROB regression model for Tsukuba by using the data obtained there. The model successfully represented the occurrence of UROB on calm (low-wind-speed), fine days and often just before rainy days.

We then used the regression model to evaluate the emissions from UROB in Japan by using agricultural statistics and meteorological data. We incorporated the emissions from UROB into the existing emissions inventory and then simulated the contribution of UROB to organic carbon (OC) and black carbon (BC) concentrations by using the US EPA's CMAQ (Community Multi-scale Air Quality Model) chemical transport model. The results of the estimations showed that BC and OC from UROB contributed upto several percent to the total BC and OC concentrations, respectively. These estimates are much lower than those estimated from the observations in Tsukuba, in which BC and OC from UROB were estimated at about 20% and 10%, respectively, of the total BC and OC. Because the OC values derived from the simulation tend to be underestimated compared with the observed values and the observation result is just one example from Tsukuba (for September 2015), interpretation of the above results is still under discussion. Nevertheless, we have succeeded in demonstrating one example of a method of estimating the contribution of UROB to atmospheric emissions.

We also investigated the redox activity of atmospheric PM by dithiothreitol (DTT) assay, the results of which reflect oxidative stress in living organisms. Atmospheric PM samples collected during a period of active biomass burning (UROB) in Tsukuba were extracted by using either Tris-HCl buffer or dichloromethane and the solutions were reacted with DTT. Compared with the values obtained in different seasons (i.e. summer and winter) in Tsukuba, the redox activity per PM mass in the buffer extract samples taken in the active biomass burning season was the lowest, whereas that in the dichloromethane extract samples was the highest. This suggests that biomass burning emits highly redox active chemical species that are soluble in dichloromethane.

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 a 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. 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. We will then develop a carbon sequestration model to evaluate the spatiotemporal distribution of CO_2 absorbed by grasslands, considering different grazing densities. Finally, we expect to help develop an MRV method based on data from the Greenhouse Gases Observing Satellite (GOSAT).

This fiscal year, we initially continued to use the ground observation systems to monitor both hydro-meteorological factors and CO_2 fluxes by using the eddy correlation method at two sites, one in the Nalaikh area near the city of Ulaanbaatar and another in the Hustai area far from the city. By analyzing the observation data, we found that the amount of CO_2 absorbed by rangeland at the Nalaikh site was larger than that at the Hustai site over the last 3 years (2015 to 2017).

Next, we analyzed changes in CO_2 concentration in the atmospheric profiles over Mongolia by using the GOSAT data, and we developed a method for estimating its spatiotemporal distribution in the surface layer. As a result, we found that, in the urban area of Ulaanbaatar, CO_2 concentrations in the surface layer showed a marked increasing trend: CO_2 emissions increased year by year from 2009 to 2015 (Fig. 1).

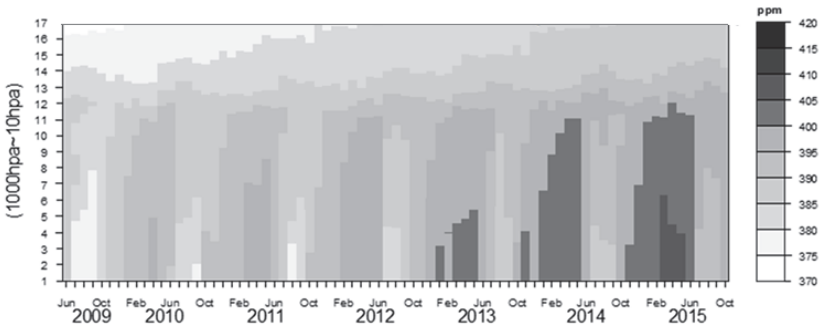


Fig. 1 Profile of CO_2 concentrations in urban Ulaanbaatar, as observed by GOSAT

Finally, we developed a carbon sequestration model that took into account grazing density by coupling satellite data such as MODIS, and we used the model to simulate the spatiotemporal distribution of CO_2 absorbed by grasslands. The primary simulation results showed that carbon loss through grazing (CLG) accounted for 19% to 38% of net ecosystem production (NEP) in the Nalaikh area around Ulaanbaatar, where the grazing density was 1.5 to 2.3 sheep/ha from 2012 to 2016. On the other hand, CLG accounted for only 7% to 20% of NEP in the Hustai area away from Ulaanbaatar, where the grazing density was only 0.4 to 0.6 sheep/ha. This implied that carbon sequestration by the grasslands around

Ulaanbaatar, where the grazing density is high, was much lower than that in the area of low grazing density (Fig. 2).

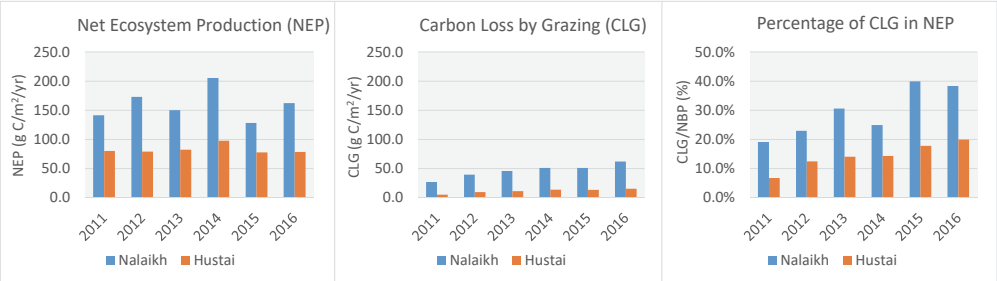


Fig. 2 Carbon loss by grazing (CLG) as a percentage of net ecosystem production (NEP) in the Nalaikh area around the city of Ulaanbaatar and in the Hustai area

1.3 Microbial arsenic mobilization for bioremediation of contaminated soil

Since arsenic (As) contamination of soil has become a worldwide environmental concern, an increasing number of studies have documented the factors affecting As cycling in soils in recent decades. Microbially-mediated arsenate (As(V)) and Fe(III) reduction play important roles in As mobilization in soils. Extracellular redox-active compounds—so-called electron shuttles—allow reduction of Fe(III) without direct contact between cells and minerals, enhancing rates of microbial reduction of insoluble Fe(III). However, their effects on As mobilization within soil microbial ecosystems are largely unknown.

In this study, we conducted microcosm experiments by using arsenic-contaminated soil and microbial communities obtained from several pristine soils. Anthraquinone-2,6-disulfonate (AQDS) was chosen as a common exogenous electron shuttle and riboflavin as an endogenous electron shuttle. Both compounds significantly enhanced reductive dissolution of As and Fe, although the rate and extent differed among microcosms. Accumulation of Fe(II)-bearing minerals was also observed; this can lead to re-immobilization of As after prolonged incubation. Interestingly, 16S rRNA gene analysis revealed that Firmicutes-related bacteria became predominant in all microcosms, but their compositions at the lower taxonomic level differed among microcosms. Analysis of a putative respiratory As(V) reductase gene (*arrA*) revealed that bacteria closely related to a Clostridia group—especially those including the genera *Desulfitobacterium* and *Desulfosporosinus*—may play important roles in As mobilization.

Our results showed that extracellular electron shuttles enhanced the As mobilization capability of natural soil microbial communities by promoting reductive dissolution of Fe(III) minerals. This finding highlights not only the importance of electron shuttles in As mobilization, but also their potential for incorporation into bioremediation strategies for contaminated soils. Furthermore,

diverse taxonomic groups within the Firmicutes could utilize extracellular electron shuttles for Fe(III) reduction, indicating that Gram-positive bacteria play more important roles in As and Fe cycling than was previously suspected. These findings provide new insights towards understanding the biogeochemical processes of As in nature.

1.4 Biodegradation and size distribution of dissolved organic matter derived from aquatic macrophytes in Lake Biwa

Excessive growth of aquatic macrophytes in the southern part of Lake Biwa has raised concern that a substantial amount of dissolved organic matter (DOM) is being eluted from the aquatic macrophytes deposited on the bottom of the lake and may adversely affect the water quality. In this research project, we evaluated the molecular size distribution and optical properties of the lake water and aquatic-macrophyte-derived DOM by using a new type of high-performance size-exclusion chromatography (HPSEC) with UV absorbance, fluorescence, and total organic carbon (TOC) detectors in series.

The aquatic macrophytes collected from Lake Biwa were incubated in lake water in the dark for 14 or 100 days. Molecular size distributions of DOM in the incubated samples were determined by HPSEC. HPSEC eluent was collected separately by a fraction collector (fractions 1 to 5), and the excitation–emission matrix (EEM) of the fractions was measured with a spectrofluorometer.

SEC chromatograms with TOC detection (Fig. 3) clearly showed a substantial change in molecular size with incubation time. The dissolved organic carbon (DOC) concentration increased up to Day 14 and then decreased to the same level as at Day 0, with an alteration in molecular size distribution, indicating that the DOM eluted from the aquatic macrophytes was easily consumed by bacteria and transformed into that having a different molecular size distribution. Analysis of the EEMs of the collected fractions showed that the fluorescence properties of DOM varied closely with variations in the molecular size of DOM; Fraction 2 was considered to have been derived from aquatic macrophytes. These results demonstrated that our method of analyzing DOM should be effective for estimating the origin of DOM.

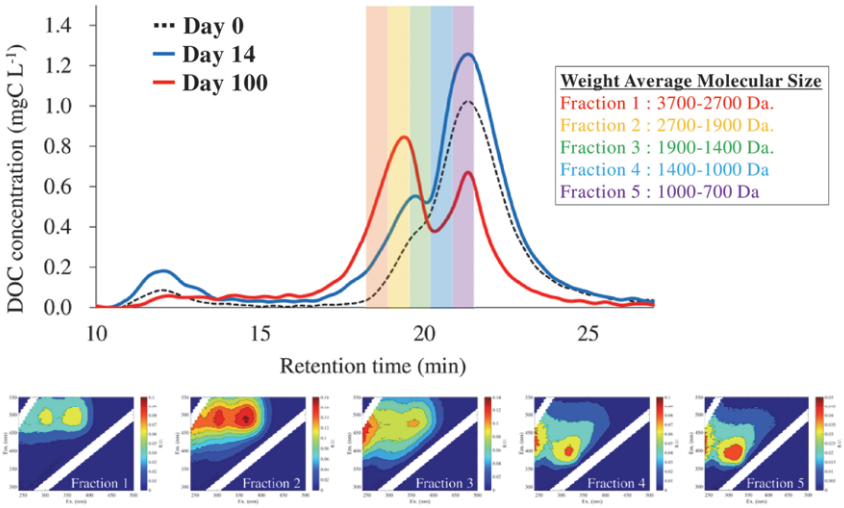


Fig. 3 Size-exclusion (SEC) chromatograms with total organic carbon detection of incubated samples of aquatic macrophytes (top) with increasing incubation time (top panel), and excitation–emission matrix spectra of each molecular-size fraction on day 100 of incubation (bottom panel).

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.

Ultraviolet radiation (UV-A: wavelength 400 to 315 nm; UV-B: wavelength 315 to 280 nm) has been monitored at CHAAMS since 2012 (Fig. 4). No interannual variability was found for either UV. The UV-B value at CHAAMS is slightly lower than that monitored at Hateruma Station, which is located at the south-west end of the Okinawa islands. To confirm the difference, UV monitoring is continuing.

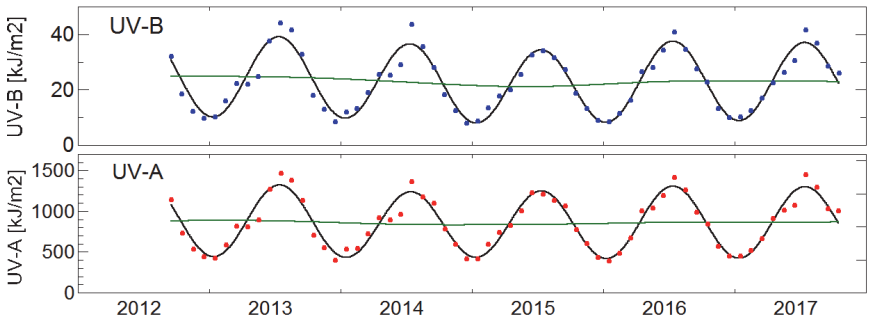


Fig. 4 Observations of ultraviolet radiation at CHAAMS

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 are used to monitor the fate of mercury in East Asia. 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

We have been monitoring Lake Kasumigaura, the second largest lake in Japan, monthly for nearly four decades in collaboration with the 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 Monitoring Site 1000 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 measure 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, and ammonium nitrogen), plankton (bacteria, heterotrophic nanoflagellates, ciliates, picocyanobacteria, eukaryotic picoplankton, phytoplankton, rotifers, crustacean zooplankton, and mysids), benthos (chironomids and oligochaetes), and primary production. The database for 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
As part of the implementation of new and strategic monitoring, we developed a precise observation system by installing an endoscopic instrument for quantifying the dissolved oxygen gradient at the water–sediment interface. We tested the system and successfully collected data from three lakes in Japan (Lake Kojima, Lake Inawashiro, and Lake Kasumigaura). Furthermore, we developed a new simulation model to analyze phosphorus exchange between sediment solids and sediment pore water in Lake Kasumigaura (Shinohara et al. 2017). To expand lake observation networks, this long-term monitoring was introduced and presented at GLEON 19 (the 19th meeting of the Global Lake Ecological Observatory Network, held in the state of New York).

Reference:
Ryuichiro Shinohara, Mikiya Hiroki, Ayato Kohzu, Akio Imai, Tetsunori Inoue, Eiichi Furusato, Kazuhiro Komatsu, Takayuki Satou, Noriko Tomioka, Koichi Shimotori, Shingo Miura (2017) Role of organic phosphorus in sediment in a shallow eutrophic lake. Water Resources Research, 53, 7175-7189.

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 Issue-Oriented Research Programs in the fourth 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. 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. In 2017, we established the Lake Biwa Branch Office in cooperation with the Center for Regional Environmental Research.

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 contributed as lead authors to the assessment reports 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. 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. Studies on conservation and ecosystem management of Lake Biwa

The NIES Lake Biwa Branch Office opened in April 2017 within the building housing the (Shiga Prefecture) Lake Biwa Environmental Research Institute. In its first year of operation, we set up a laboratory for DNA experiments there and collected information on previous and ongoing field studies of the Lake Biwa ecosystem to use as references for future studies. The CEBES group at the branch office aims to restore Lake Biwa's declining native fish populations. For their recovery, conservation and restoration of the emergent plant zone, which consists mainly of reed (*Phragmites australis*), are indispensable, because this zone is used as a spawning site by many native fishes. Although the reed zone (Fig. 1) was once widespread in shallow coastal areas of the lake, its extent has now decreased by 50% through human activity. For effective recovery of the zone and of native fishes, the spawning-site performances of various reed zones, including artificially developed ones, need to be evaluated and monitored adequately. This

year, we started developing a monitoring method. We tried mapping the topography and plant distribution of reed zones (and those of the offshore submerged-plant zones) with the help of remote sensing. In addition, our DNA identification system was improved to enable us precisely to identify the species of eggs, larvae, and environmental DNAs collected from the reed zone. Fish (and benthos) specimens were collected and sequenced to use as reference DNAs.

Fig. 1 Reed zones in the coastal area of Lake Biwa in winter: natural reed zone (left); artificially developed reed zone (right).

2. Digitization of past handwritten records on changes in ecosystems and landscapes

In the visitor centers of national parks, observational records and photos taken by rangers and relating to park ecosystems are stored in large quantities. For example, long-term records are preserved of the timing of spring's first cherry blossoms, the first cicada song of summer, the behavior of animals, and the coloration of autumn leaves. Most of these items have been recorded as handwritten field notes (Fig. 2) or pictures recorded on photographic film, and such non-digitized data cannot be optimally utilized. However, these data can be used to detect changes in the distribution and phenology of plants in the park, and such changes should provide additional knowledge on the vulnerability of park ecosystems. This constitutes important information that should be considered in adaptation planning for national parks.

Therefore, as a case study, we began digitizing records stored in the Sounkyo Visitor Center and Asahidake Visitor Center of Daisetsuzan National Park in Hokkaido. Handwritten notes were digitally scanned and converted into PDF files, and databases were created of the color changes, on a daily basis, of autumn leaves and the days of flowering of alpine plants. Through analysis of these records and past weather data provided by the Japan Meteorological Agency, we developed a model to predict the date when the autumn leaves begin to change color in Daisetsuzan National Park, including when this might occur under conditions of global warming in the future. Thus, digitizing past records not previously utilized made it possible to forecast events.

We are continuing to conduct surveys at national parks nationwide in Japan and to digitize unused records, and we plan to collect more information.

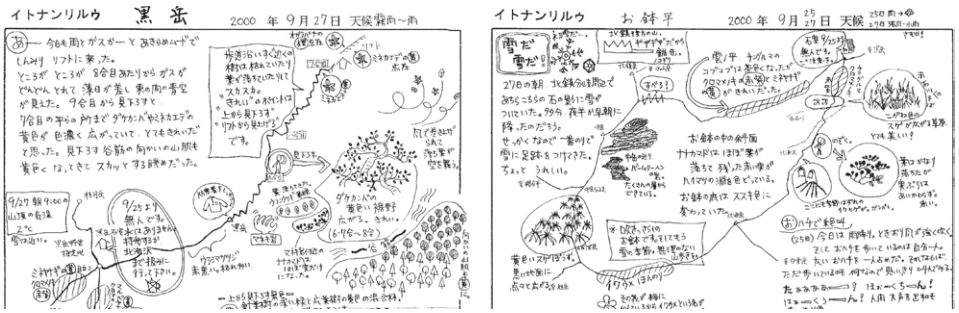


Fig. 2 Sample images of handwritten field notes describing alpine plant distributions

3. Monitoring and Web-GIS-based mapping of avian occurrence in and around the Fukushima evacuation area

A large evacuation area was designated as a result of the accident at the Fukushima Daiichi Nuclear Power plant, and land abandonment has changed the agricultural landscape. The evacuation order has been lifted in places where restructuring of the living environment, for example, through decontamination, has finished. The process of decontamination, including removal of above-ground biomass and topsoil, has created vast areas of bare land. The effects of the drastic environmental change on biodiversity should be monitored to develop a strategy for recovery of the environment and ecosystem services. The dataset obtained by monitoring should preferably be available to the public to achieve transparency and tractability of study.

In 2014, we began avian monitoring at 57 sites inside and outside the evacuation zone (Fig. 3). A digital voice recorder was installed at each site and the species recorded were identified and compiled as occurrence data. Parts of this record were identified with the cooperation of local citizen scientists through an open science event, the “Bird Data Challenge.” In 2017, we published the occurrence record of birds as a data paper. In addition, a Web-GIS-based mapping system for avian occurrence, the KIKI-TORI MAP (http://www.nies.go.jp/kikitori/contents/map/, accessed 3 June 2018; in Japanese), was launched to ensure the dataset was accessible to the public (Fig. 4). The KIKI-TORI MAP has a user-friendly interface, and users can choose the species and year to display. Besides the occurrence map, photographs of species and links to the external website of a pictorial book including birdsong are shown on the web system; these help users learn about a species’ characteristics. The access count for the 5 months after the launch was 18,168.

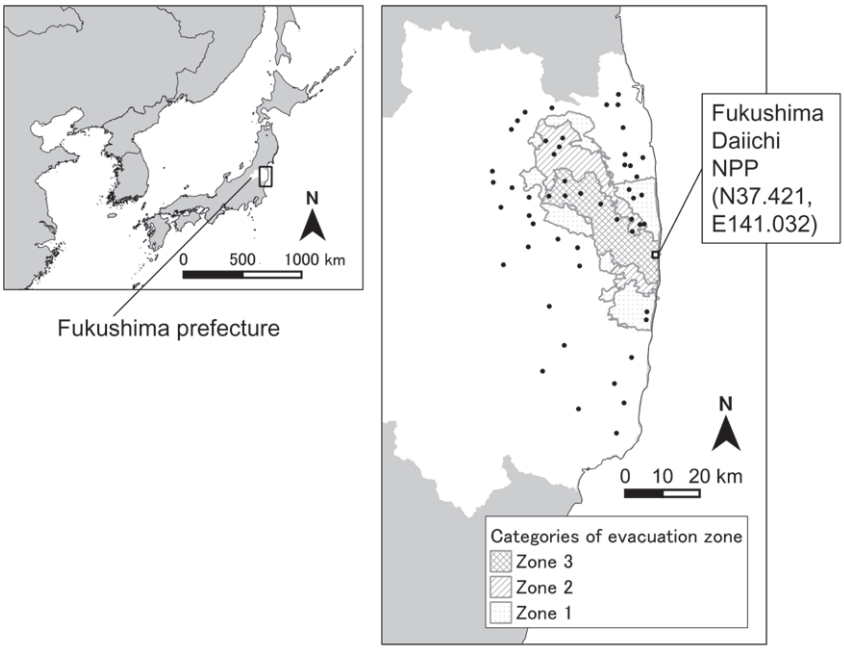


Fig. 3 Locations of avian monitoring sites (black dots) in Fukushima. NPP, nuclear power plant

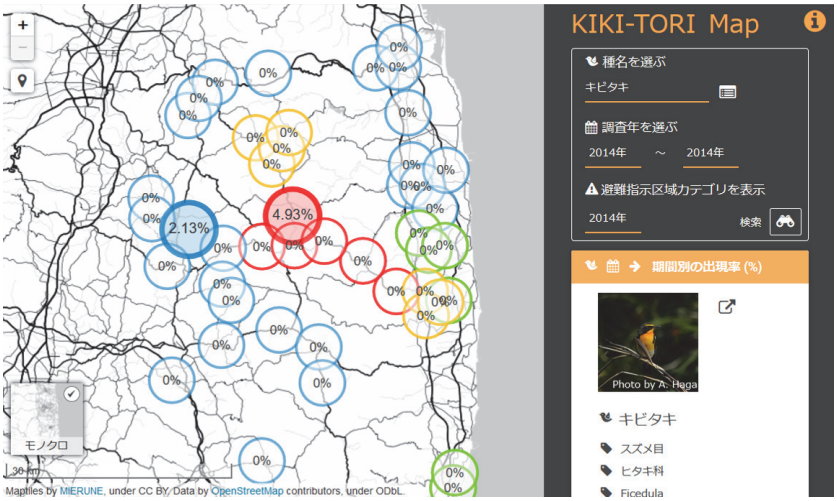


Fig. 4 Interface of the KIKI-TORI MAP of bird occurrences around Fukushima. Size and color of circles on the map correspond to occurrence rate and evacuation category, respectively. (Maptiles by MIERUNE under CC BY. Data by OpenStreetMap contributors under ODbL)

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 enterprise) 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.

Researchers 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. In FY 2017, the second year of the fourth mid-term plan of NIES, our goal 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. Portable environmental monitoring of the climatic environment and human physiological responses by using mobile sensors

To evaluate physiological thermal environments spatially, we attempted portable

environmental monitoring of climatic factors and human physiological responses by using mobile sensors (Fig. 1). The results will be used to develop heatstroke alert systems in urban areas, as well as appropriate health-risk prevention strategies and urban planning that takes thermal comfort into consideration. Remote sensing of ground-surface temperatures from a helicopter (about 5 m resolution) was performed on sunny summer days in rectangular areas across Tokyo. Simultaneously, mobile ground monitoring by sensors attached to human volunteers was performed along four routes that crossed the central business district in an east–west direction. Both surface temperature and air temperature contribute to the development of thermally dangerous areas. Furthermore, large-scale green spaces such as that around the Imperial Palace can have a leeward temperature-reduction effect, although the effect of motor vehicle traffic, which seems to dominate over this green space effect, makes the net effects on carbon dioxide concentration difficult to determine. These field campaigns made it possible to confirm the performance and practicality of each sensor used, although problems with the sensors, such as detachment from the body surface because of sweating, increased communication costs, and instability of data reception, were also revealed.

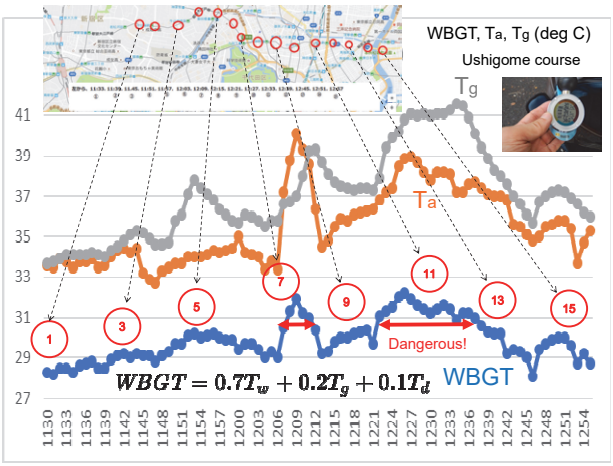


Fig. 1 WBGT (wet-bulb globe temperature) on a mobile monitoring course in Tokyo

Ta: air temperature
Tg: globe temperature

2. Effects of social network services on recruiting volunteers for NPOs

To elucidate the use of social networking services (SNSs) by environmental non-profit organizations (NPOs) and other organizations to recruit volunteers, and to determine the effects of this use, we conducted an interview survey of two types of organizations (Table 1). One was a group of so-called intermediary organizations, which support the activities of many organizations. The other was a group of organizations actually recruiting volunteers. In addition, we used a questionnaire survey to investigate the SNSs used by forest conservation groups to recruit volunteers and their evaluation of SNSs. Few of the organizations felt that SNSs were effective in diffusing information for recruiting volunteers. Most

organizations found that conventional recruitment tools such as leaflets and e-mail newsletters sent directly to individuals were more effective. At the moment, the effect of recruiting volunteers by SNSs is equivalent to that of pull-type information sources such as Home pages.

Table 1 Interviewed organizations.

Intermediary Organization	Activity Organization
Tokyo Voluntary Action Center	WWF Japan
The Nippon Foundation	The Nature Conservation Society of Japan
Okayama Environment Network Foundation	H.I.S.
Okayama NPO Center	Oisca (The Organization for Industrial, Spiritual and Cultural Advancement-International)
Takamatsu Citizens' Activity Center	Greenbird
Japan NPO Center	Earthwatch Japan
Japan Volunteer Coordinators Association	A Seed Japan (Action for Solidarity, Equality, Environment and Development)

3. Contributions in national or local governmental committees

Many of the researchers at the Center for Social and Environmental Systems Research are involved in the environmental policymaking processes of national and local governments. As members of environmental committees and councils of national or local governments, they are often asked by government officials to add inputs to discussions from a scientific perspective. Our research outcomes—especially in regard to climate change mitigation and adaptation actions and urban planning system design—are often utilized by governments to facilitate discussions aimed at establishing sound environmental policies.

4. Continuation 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 exchanges with those from the other institute for several years. This has become an opportunity for researchers at the two institutes to collaborate intensively. The first person to use the exchange system was a member of the Center for Social and Environmental Systems Research, who has spent FY 2016 and 2017 at IGES and will continue to stay there in FY 2018. 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 of 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 (GC) 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 system. 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 2017.

1. Statistical evaluation of data from SBSE-TD with GC×GC and HRToFMS analysis to detect anomalies in non-target river water monitoring

Our group is focusing mainly on the development of a non-target analytical method for identifying compounds associated with biological effects and improving the method for application to field monitoring. One of the most important goals of non-target analysis is to measure as many compounds as possible so as to minimize the possibility of missing risks. In our previous study, we developed a non-target method of analyzing water samples by using a combination of a stir-bar (SB) coated with polydimethyl siloxane, sorptive extraction (SE) with thermal desorption (TD), comprehensive multidimensional GC, and high-resolution time-of-flight mass spectrometry (GC×GC-HRToFMS).

We applied the non-target analytical method to river water samples under new conditions and then evaluated its usefulness. Six samples collected from a small river on six different days were used for the examination. Each sample was divided into five sub-samples. The sub-samples were separately analyzed by using our method. Finally, we tested for reproducibility of the results from the sub-samples and the possibility of detecting differences among the samples.
About 2000 peaks were detected from each sample, and 80 peaks were picked up for evaluation quantitatively and qualitatively. In our evaluation of the relative standard deviations (RSDs) of the total ion intensities of each peak in the sub-samples, the results for about one-third of the components showed fair reproducibility (RSD <15%), but additional improvement is required. The Kruskal-Wallis test was applied to each of the 80 peaks to investigate whether differences could be detected for each peak among the samples. It was possible to detect differences among the samples, even though the variation among sub-samples was relatively large. To enhance the sensitivity and reliability of difference detection among samples, the reproducibility and stability of the extraction and the measurement need to be improved. The ranges of the relative total ion intensities of three typical components for which we found significant differences among the six samples by the Kruskal-Wallis test are shown in Figure 1. The relative total ion intensity of chk49 changed incidentally with consecutive decreases in that of chk52 or increases in that of chk53.

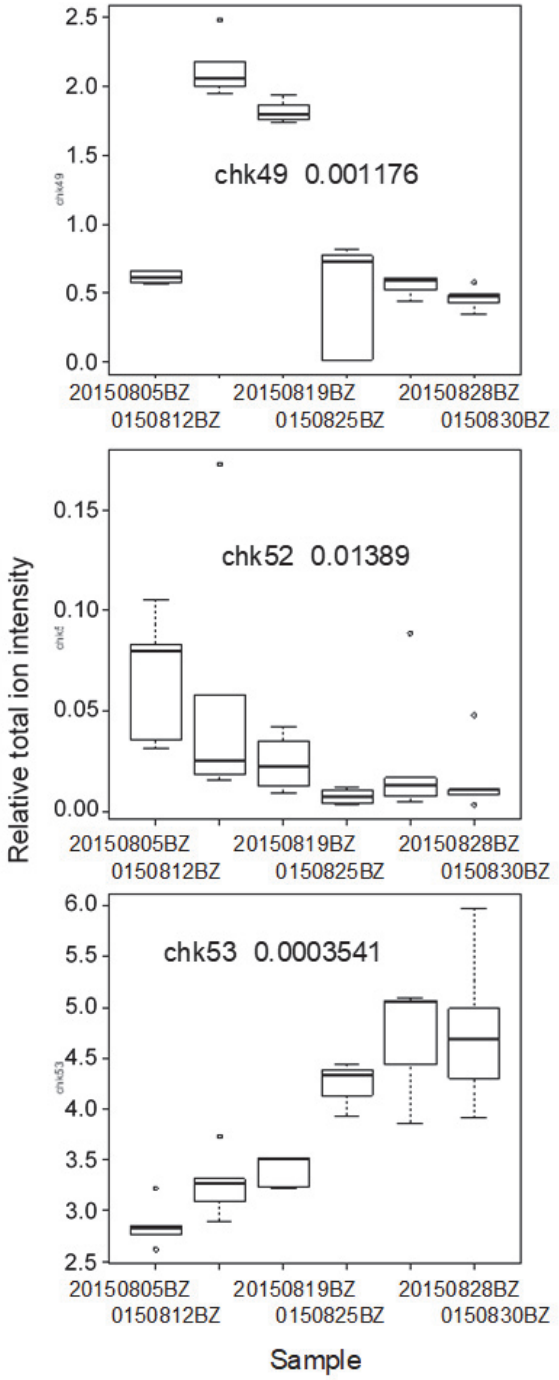


Fig. 1 Non-target river water monitoring. Ranges of relative total ion intensities of three typical components (chk49, chk52, and chk53) for which we found significant differences among six river-water samples by Kruskal-Wallis testing. Values to the right of the component IDs are *P*-values from the Kruskal-Wallis test. Relative total ion intensities were calculated as ratios to ^{13}C-labeled polyaromatic hydrocarbon.

2. Isotopic measurement of gaseous elemental mercury at Misasa, Tottori, and Suzu, Ishikawa

Mercury (Hg) is a toxic heavy metal that exists in various chemical forms in environmental systems. In the atmosphere, Hg exists in three forms: $Hg^0_{(g)}$ (gaseous elemental Hg); $Hg^{II}_{(g)}$ (gaseous oxidized Hg compounds); and $Hg_{(p)}$ (particulate-bound Hg). $Hg^0_{(g)}$, the dominant species of atmospheric Hg, is not easily removed by wet or dry deposition processes. Therefore, the residence time of $Hg^0_{(g)}$ in the atmosphere is relatively long (0.5 to 1 years), allowing long-range transport from mercury emission sources. Because atmospheric Hg has a complex cycle, isotopic measurements of $Hg^0_{(g)}$ have been used to improve our understanding of the associated emission sources and physicochemical processes. Previous studies have demonstrated that Hg isotopes from mass-dependent fractionation (MDF, $\delta^{202}Hg$) and mass-independent fractionation (MIF, $\Delta^{199}Hg$) could be used as tracers of Hg pathways in the atmospheric Hg cycle. In this study, $Hg^0_{(g)}$ was collected at Misasa, in Tottori Prefecture, and Suzu, in Ishikawa Prefecture, and the Hg isotopic compositions were measured by using Nu Plasma II, which is a cold vapor MC-ICPMS (multicollector–inductively coupled plasma mass spectrometer) located at NIES.

Similar seasonal trends were observed for $Hg^0_{(g)}$ collected at Misasa and Suzu, namely (1) negative $\delta^{202}Hg$ and near-zero $\Delta^{199}Hg$ in winter $Hg^0_{(g)}$, and (2) near-zero to positive $\delta^{202}Hg$ and negative $\Delta^{199}Hg$ in summer $Hg^0_{(g)}$ (Fig. 2a). Back-trajectory calculation using the HYSPLIT model (NOAA; US National Oceanic and Atmospheric Administration) showed that the main air mass travelled from China in winter (Fig. 2b). Because low $\delta^{202}Hg$ and near-zero $\Delta^{199}Hg$ have been reported for anthropogenic $Hg^0_{(g)}$ in China (Yu et al., 2016), the $Hg^0_{(g)}$ sources might be associated with anthropogenic emissions in China (e.g. coal combustion). The back-trajectory for summer (Fig. 2c) suggested that the emission sources of the $Hg^0_{(g)}$ were derived locally or regionally.

Reference:

B. Yu, X. Fu, R. Yin, H. Zhang, X. Wang, C.J. Lin, C. Wu, Y. Zhang, N. He, P. Fu, Z. Wang, L. Shang, J. Sommer, J.E. Sonke, L. Maurice, B. Guinot, X. Feng, Environ. Sci. Technol., 2016, 50, 9262-9269.

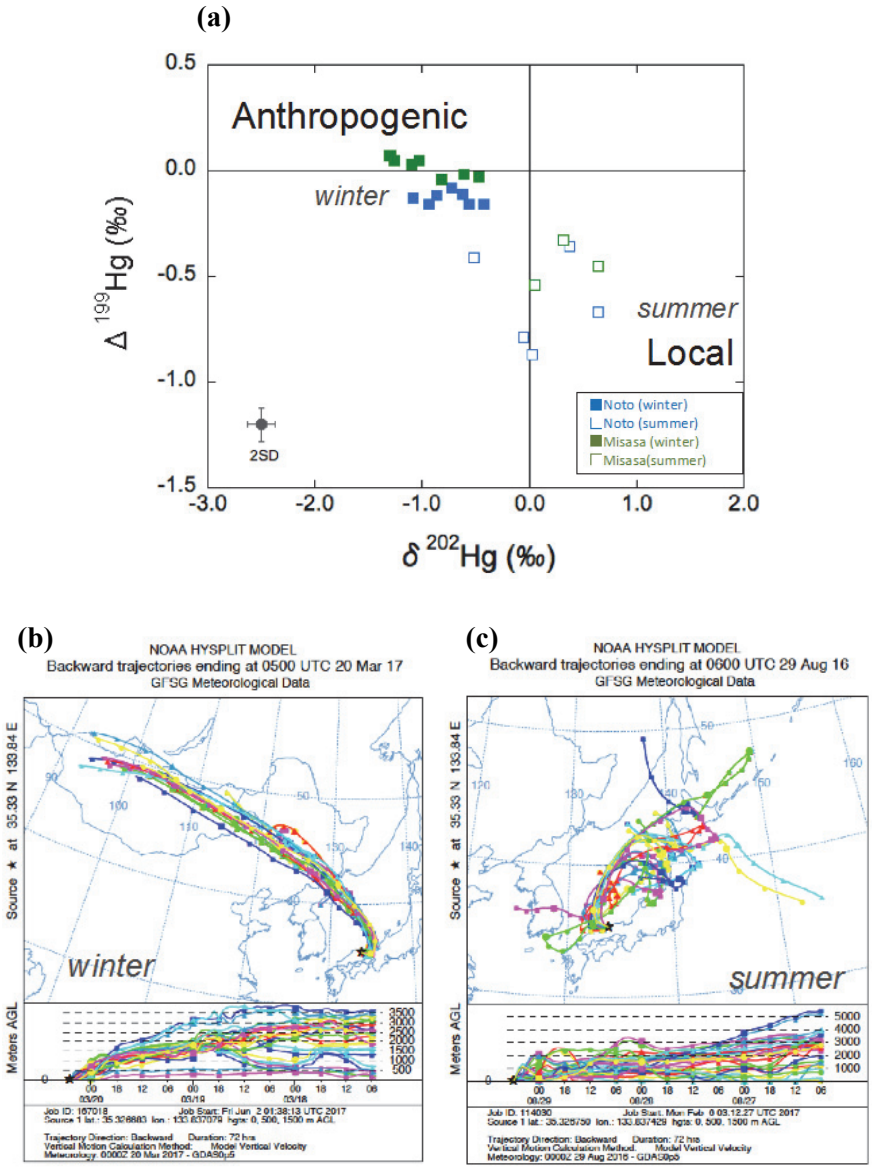


Fig. 2 (a) δ^{202}Hg vs. Δ^{199}Hg of $Hg^0_{(g)}$ (filled squares: winter, open squares: summer; green: Misasa sampling site, blue: Noto site). Back-trajectory calculations are shown for winter (b) and summer (c) at Misasa.

3. Interlaboratory comparison of stable isotopes of atmospheric CH_4 with the aim of merging data sets from different laboratories

There is growing concern about the acceleration of global warming as a result of an increase in atmospheric methane (CH_4) concentrations, because future emissions of CH_4, the second most important anthropogenic greenhouse gas, are potentially increased by both human activities and natural processes. Nevertheless, global CH_4 budgets remain poorly understood in terms of explaining the recent trend toward increasing atmospheric levels of this gas and predicting future levels. Because individual types of CH_4 sources have characteristic isotope signatures, the stable isotope ratios of CH_4 (δ^{13}C-CH_4 and δD-CH_4) have been useful in

constraining the global CH_4 budget. However, the examination of increasing numbers of isotope data has revealed that significant measurement offsets among laboratories limit the usefulness of these data in solving CH_4 budget problems.

Aiming at merging CH_4 isotope data from multiple laboratories, we conducted a worldwide interlaboratory comparison of samples among laboratories that measure stable isotopes of atmospheric CH_4. The offsets among the laboratories were larger than the measurement reproducibility of individual laboratories. To disentangle plausible measurement offsets, we evaluated and critically assessed a large number of intercomparison results, some of which have been documented previously in the literature. The results indicated significant offsets of $\delta^{13}C$-CH_4 and δD-CH_4 measurements among data sets reported from different laboratories; the differences among laboratories at modern atmospheric CH_4 levels were spread over ranges of up to 0.5‰ for $\delta^{13}C$-CH_4 and 13‰ for δD-CH_4 (Fig. 3). The intercomparison results summarized in this study may be of help in future attempts to harmonize $\delta^{13}C$-CH_4 and δD-CH_4 data sets from different laboratories to jointly incorporate them into modeling studies. However, establishing a merged data set that includes $\delta^{13}C$-CH_4 and δD-CH_4 data with desirable compatibility from multiple laboratories is still challenging owing to differences among laboratories in instrument settings, correction methods, traceability to reference materials, and long-term data management. Further efforts are needed to identify the causes of the interlaboratory measurement offsets and to decrease them so as to move towards the best use of available $\delta^{13}C$-CH_4 and δD-CH_4 data sets.

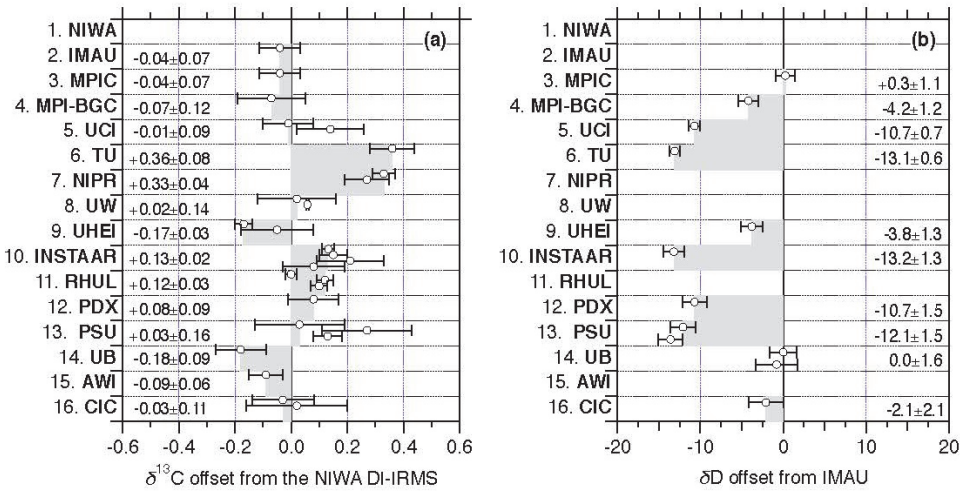


Fig. 3 (a) $\delta^{13}C$-CH_4 offsets of different laboratories compared with measurements made by the dual-inlet isotope-ratio mass spectrometer (IRMS) at National Institute for Water and Atmospheric Research (NIWA), New Zealand. (b) δD-CH_4 offsets of different laboratories compared with measurements made by the gas chromatograph-–IRMS at the Institute for Marine and Atmospheric research Utrecht (IMAU), Utrecht University, the Netherlands.

4. Development of a high-spectral-resolution lidar with a multimode laser and scanning interferometer

A high-spectral-resolution lidar (HSRL) can measure aerosol extinction coefficients independently from aerosol backscattering coefficients. However, a conventional HSRL requires an expensive, single-longitudinal-mode laser. In addition, there are complicated control requirements for the laser and possibly an interferometer. In this study, we proposed a novel HSRL technique. We utilized a low-cost, commercial multi-mode laser widely used for aerosol lidar to develop a durable multi-mode (MM)-HSRL for long-term aerosol extinction measurement during the day and at night with higher sensitivity than that of nighttime Raman lidars.

Conventional HSRL transmits a laser beam with a narrow spectral width to the sky; it separately measures the intensities of light backscattered by aerosols (Mie scatter light), which has a spectral width similar to that of the laser beam, and light backscattered by molecules (Rayleigh scatter light), which has a wider spectral width than the laser beam owing to Doppler broadening. A narrow band filter (high-spectral-resolution filter) such as an interferometer is used to separate the Mie and Rayleigh scatter lights. The extinction and backscatter coefficients of aerosols can be retrieved from the Rayleigh and Mie scatter signals without assumption, unlike in the case of conventional Mie scattering lidar. The MM-HSRL separately measures the signals of the Mie and Rayleigh backscatter lights by using an interferometer in a manner similar to that of a conventional HSRL. However, the MM-HSRL uses a multi-mode laser; therefore, the mode spacing of the interferometer is designed strictly to be the same as the longitudinal modes of the laser to separate the Mie and Rayleigh scatter lights and measure their signals.

We used a Mach-Zehnder interferometer as the high-spectral-resolution filter. Furthermore, we proposed a new way to exclude the need for complicated control of the laser and spectrometer. In conventional HSRL, the laser—and possibly the interferometer—needs to be controlled with a feedback loop so that the laser wavelength matches that at which the transmittance of the interferometer is minimal (or maximal). Our system does not require this control and does not need a feedback loop, because the interferometer is periodically scanned in the span of one fringe to analyze the minimum (or maximum) of interferometer transmittance; the interferometer transmittance and the fringe position are calibrated with the reference signals taken from a portion of the transmitted laser beam.

We constructed the MM-HSRL system at Tsukuba, Japan, and made our observations on 17 February 2017. Figure 4 depicts the backscatter and extinction coefficients of aerosols retrieved from the MM-HSRL measurements in daytime. The signal-to-noise ratio (SNR) of the measured Rayleigh signals (Fig. 4c)

exceeded 1000 in the mixing layer (below 1 km), indicating that the extinction coefficient could be retrieved with sufficient accuracy (Fig. 4b). This retrieval accuracy was comparable to that of nighttime measurements by Raman lidar with specifications (e.g., telescope aperture and laser power) similar to those of MM-HSRL.

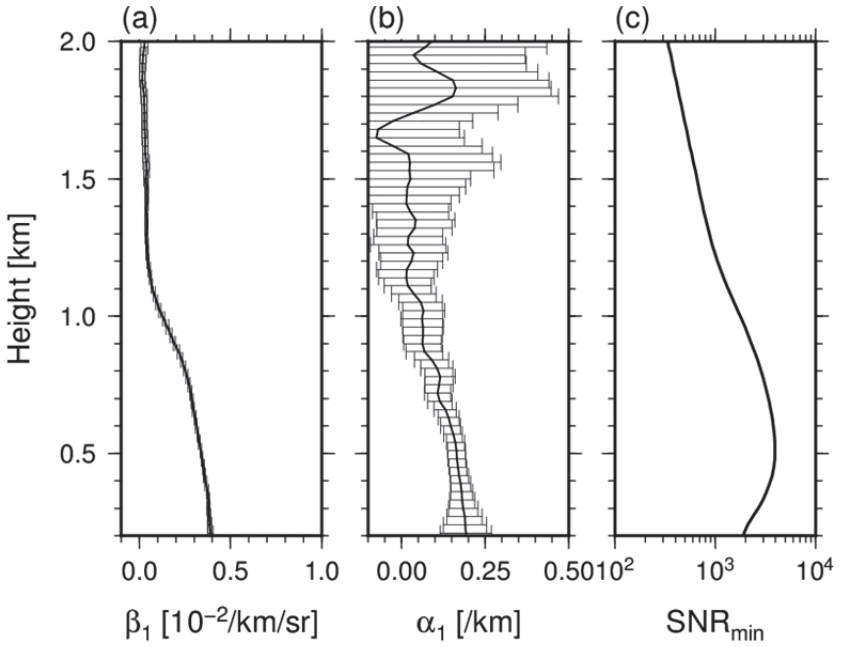


Fig. 4 (a) Backscatter coefficient, (b) extinction coefficient, and (c) signal-to-noise ratio derived from multi-mode high-spectral-resolution lidar signals measured for 15 min from 11:40 a.m. (local time) on 17 February 2017 at Tsukuba, Japan. The error bars in (a) and (b) denote random errors.

5. Direct observation of the formation of new particles competing against the growth of preexisting particles during ozonolysis of small alkenes

Atmospheric aerosols scatter and absorb incoming solar radiation and directly affect the global radiative balance of the atmosphere. If these aerosols are hydrophilic, they can act as cloud condensation nuclei (CCNs) and have an indirect effect on the climate by modifying the properties of clouds. New particle formation through aerosol nucleation is believed to contribute up to half of the global CCN inventory. The nucleation and growth mechanisms of new particles in the atmosphere are therefore topics of study in atmospheric research. We used a 1-nm scanning mobility particle sizer to investigate the formation of secondary organic aerosol (SOA) during the ozonolysis of small alkenes in the presence of seed particles (ammonium nitrate). Analysis of the size distribution of SOAs formed in the range between 1 and 30 nm revealed that particles with diameters smaller than the minimum diameter of the seed particles formed under dry conditions; products formed in the reaction were mostly taken up by the seed particles (Fig. 5a). Under humid conditions, the formation of such particles was substantially suppressed compared with under dry conditions, but particle growth occurred regardless (Fig. 5b). Under humid conditions, the stabilized Criegee intermediates (sCIs) that were generated during the ozonolysis of unsaturated hydrocarbons were strongly scavenged by water vapor. We proposed that

oligomeric hydroperoxides generated from sCIs potentially contribute to the formation of new particles while competing to be taken up onto preexisting particles.

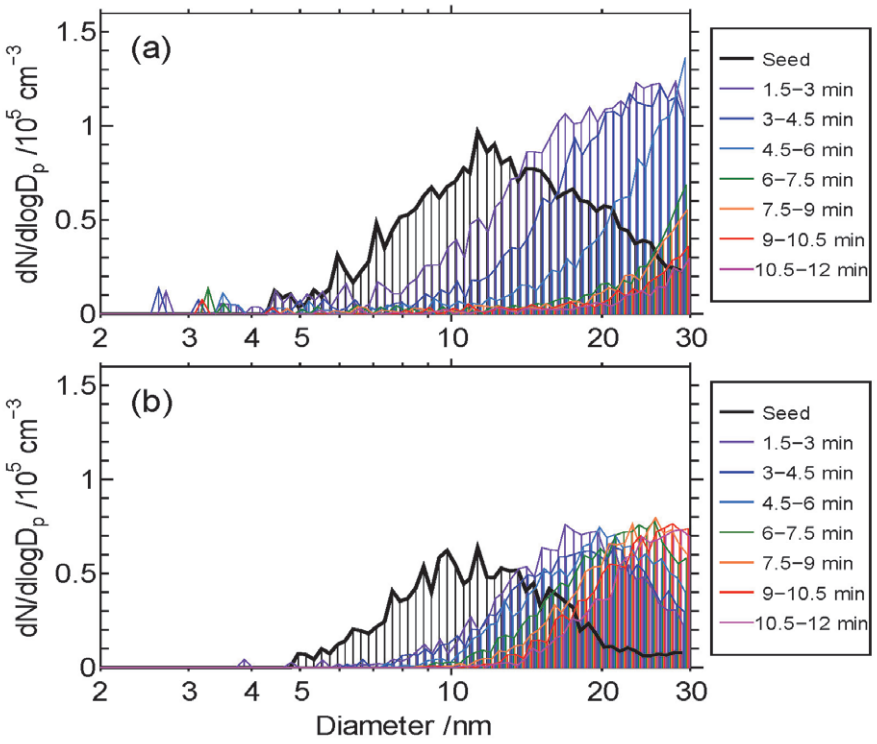


Fig. 5 Temporal variation in the size distribution of secondary organic aerosols formed during ozonolysis of isoprene in the presence of seed particles under dry conditions (a) and humid conditions (b).

6. Correction of quantitation error in *in vivo* metabolite measurement using ^{1}H magnetic resonance spectroscopy

Metabolites in the human brain can be measured *in vivo* by using ^{1}H magnetic resonance spectroscopy (MRS). Quantitation accuracy in ^{1}H MRS improves at higher static magnetic fields. However, difficulties due to chemical shift displacement and stronger inhomogeneity of the radiofrequency magnetic field exist. We evaluated the accuracy of quantitation of the spectra of metabolite mixtures in phantom experiments at 4.7 T. We demonstrated a position-dependent error in quantitation and proposed a method of correction by measuring water signals.

All experiments were conducted on a whole-body 4.7-T MR system with a quadrature volume coil for transmission and reception. We arranged three bottles filled with metabolite solutions of N-acetyl aspartate (NAA) and creatine (Cr) in a vertical row inside a cylindrical phantom filled with water. The peak areas of three singlets of NAA and Cr were measured on three ^{1}H spectra at three volumes of interest (VOIs) inside the three bottles. We also measured a series of water spectra with a shifted carrier frequency and measured a reception sensitivity map.

The ratios of NAA and Cr at 3.92 ppm to Cr at 3.01 ppm differed in peak area among the three VOIs; these differences led to a position-dependent error. The nature of the slope depicting the relationship between the peak area and the shifted frequency value was similar to that between the reception sensitivity and the displacement at every VOI. To decrease the errors of the peak areas of metabolites, we proposed a method of correction by using water signals measured with a shifted carrier frequency. A correction curve was calculated by curve-fitting the relationship between the reciprocal of the peak area in the water spectra and the chemical shift. After correction using this proposed method, we demonstrated that the errors in the peak areas of metabolites decreased.

In conclusion, chemical shift displacement and inhomogeneity of reception sensitivity cause amplitude modulation along the direction of chemical shift on the spectra, resulting in quantitation errors. These errors can be successfully decreased by our proposed method using water signals.

Fukushima Branch

In April 2016, NIES opened its Fukushima Branch in the research building of the Fukushima Prefectural Centre for Environmental Creation (Fukushima CEC), located in the town of Miharu in Fukushima Prefecture. The Institute's objective is to promote and maintain rigorous scientific research 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 (JAEA). NIES, by providing its environmental emergency research expertise, also extends support to Fukushima CEC's efforts to collect and disseminate environmental information and to prepare educational, training, and exchange programs (Fig. 1).

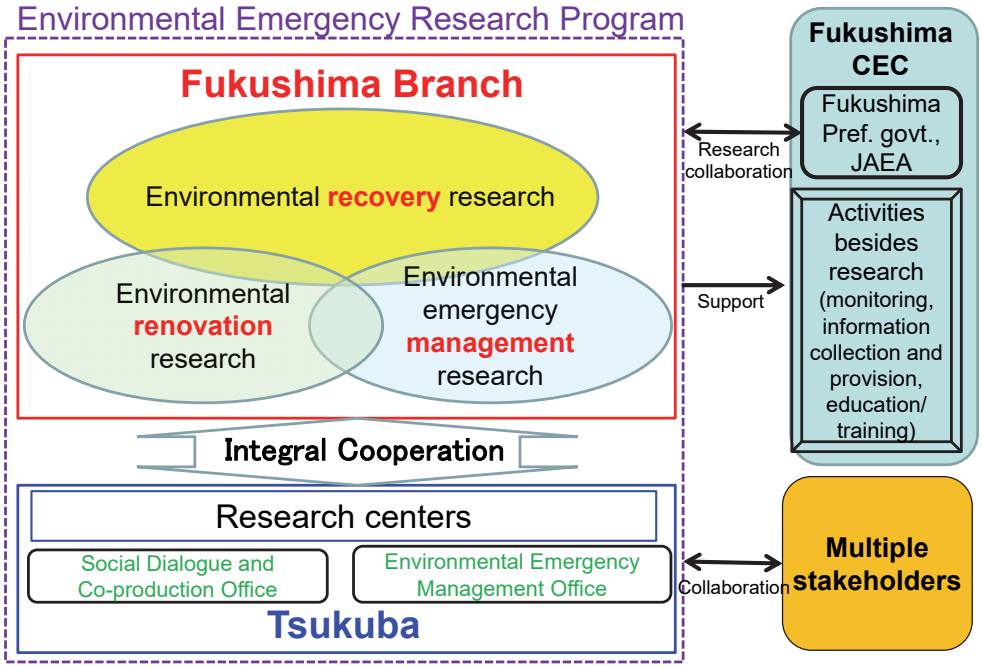


Fig. 1 Outline of environmental emergency research conducted at the NIES Fukushima Branch

In FY 2017, Fukushima Branch continued to conduct many kinds of research (laboratory work, field measurement, model simulation, and field study) in the field of environmental emergency research in collaboration with researchers in the research centers at Tsukuba. Research staff at Fukushima Branch also took part in the environmental emergency research program (see "Environmental Emergency Research Programs" in this report). Fukushima Branch led efforts to build a structure for collaboration among government, industry, and academia in the field of environmental emergency research. It held discussions and cooperated with local people, non-profit organizations, and local governments in Fukushima Prefecture. In addition, Fukushima Branch circulated research outcomes and related information to the public through public lectures, publications, and our website.

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 2017, 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 2018, the NIES library (Fig. 2) held 66,900 books, 897 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.

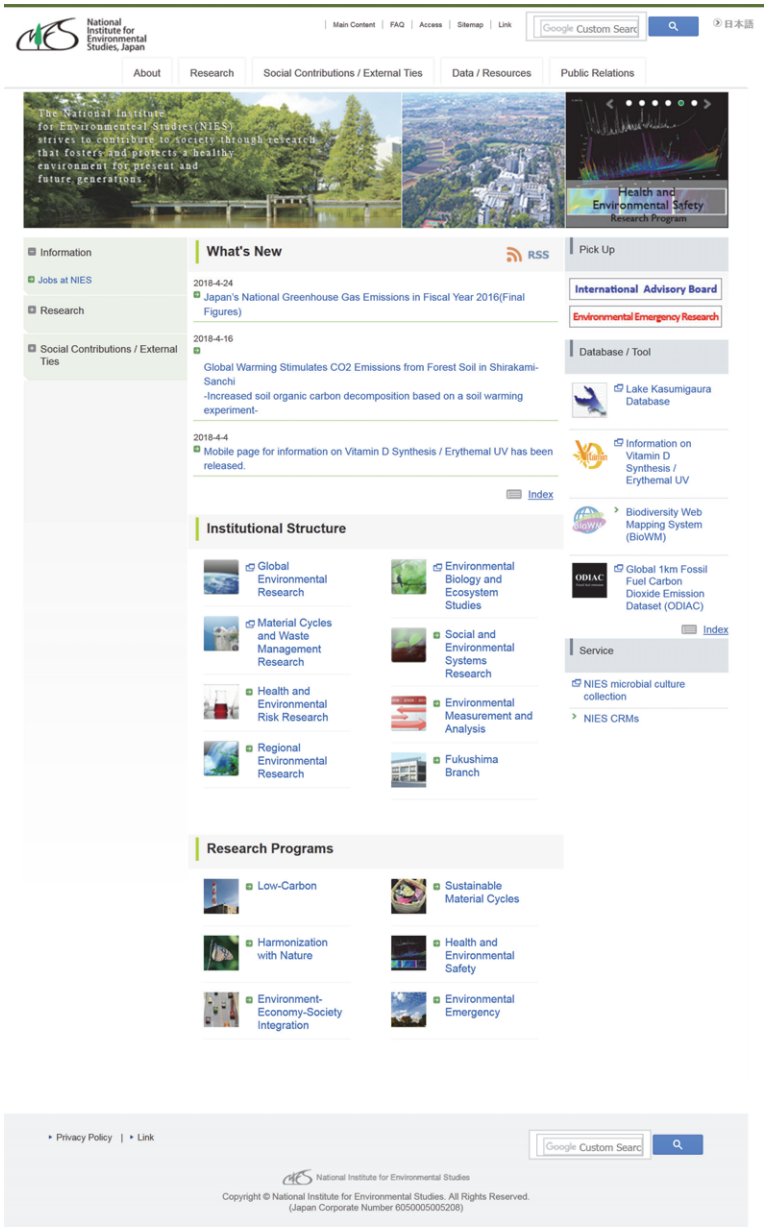


Fig. 3 The NIES website

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. In addition, to estimate the costs of APCs (article processing charges) each year, we conducted a survey of open access activities at 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 relevant 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 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 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 2017, the Department performed the following task, as commissioned by 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/

NIES Publications
http://www.nies.go.jp/kanko/index-e.html

Editorial assistance: MAEDA Printing Co., Ltd.