MEXT-Program for The Advanced Studies of Climate Change Projection(SENTAN)

MEXT
MINISTRY OF EDUCATION,
CULTURE, SPORTS,
SCIENCE AND TECHNOLOGY-JAPAN

Program
Overview

About MEXT-Program for the Advanced Studies of Climate Change Projection (SENTAN)

Across the planet, there have been numerous extreme weather events and disasters in recent years, and their frequency and severity are projected to increase under climate change. Working Group I contribution to the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) (Climate Change 2021: The Physical Science Basis) concluded that it is unequivocal that human influence has warmed the Earth. The report, released in August 2021, is more categorical than its predecessors and highlights the urgent need to address climate change globally and collaboratively. It is therefore important that Japan contributes actively to international efforts, such as the upcoming Seventh Assessment Report (AR7) cycle and the development of the Sustainable Development Goals (SDGs) for 2030, and advance the field of climate change science and technology.

In Japan, various legislations, plans, and activities related to climate change have been put into place. These include the Climate Change Adaptation Act, which came into force in 2018 and diverse practical measures taken by municipalities and private companies. The importance of scientific information as a basis for decision-making is growing; for example there is increasing demand for science-based predictions to support activity planning. However, the practical application of climate change research has remained limited because prediction accuracy and data usability and availability are insufficient to meet the high demand of users. Climate change research needs to be adapted to provide information that can meet the needs of the society.

Thus, in this program, we build on and expand the Integrated Research Program for Advancing Climate Models (2017-2021 FY), and collaborate closely on four study themes under a unified research framework. We aim to improve our understanding of climate change mechanisms, reduce uncertainties, and create highly accurate climate change projections that can be used as the scientific basis for the development of climate change adaptation and mitigation measures. Our goal is to conduct application-oriented research to meet the needs of different users and contribute to the realization of a decarbonized society.

Greeting

Message from the Program Director

Humankind is trying to take a major step toward the realization of a decarbonized, recycling-based society to address climate change, which the IPCC has determined to be unequivocally caused by human activities. On numerous occasions, national leaders have demonstrated their unwavering determination for change and have referred to the 10 years leading up to 2030 as the decisive decade. There is no doubt that increase in atmospheric greenhouse gas concentrations will result in a mean global temperature rise, but what are the regional and seasonal changes and natural disaster risks? In many cases, it is not self-evident about what measures should be taken by the different sectors of the society and to which extent and by when measures should be taken. We are aware that scientific evidence forms the basis for humankind's major decisions on climate change. Therefore, detailed scientific knowledge of various aspects of climate change and especially climate change projections and evidence are much needed to ensure the success of major decisions and changes. We will make every effort to implement the advanced climate change projection program that has been entrusted to us. Many aspects of the natural climate system remain unknown, which makes understanding the behavior of the climate system under anthropogenic forcing a formidable task. We will communicate our research results to the general public and provide quantitative estimates of the uncertainties as far as possible despite the challenges of translating science into plain language and the limitations of scientific research in providing answers to all our questions. We would like to contribute toward supporting decisive actions to address climate change at individual and collective levels. The research groups that are involved in this program have been working on the promotion of climate change science in Japan for more than 20 years, but to widen the scope of our research, we intend to collaborate with researchers in related disciplines in and outside Japan and engage in stakeholder dialogues. We look forward to receiving your honest opinion and encouragement.

PD Program Director

Masahide Kimoto

Special Advisor to MEXT
National Institute
for Environmental Studies
President

PO Program Officer

Toshiki Iwasaki

Special Advisor to MEXT
Graduate School of Science, Tohoku University
Emeritus Professor

PO Program Officer

Eiichi Nakakita

Special Advisor to MEXT
Disaster Prevention Research Institute, Kyoto University
Professor and Director

Advisor

Akimasa Sumi

Special Advisor to MEXT
Project Professor and Professor Emeritus of the University of Tokyo

Area Theme 1 — Predictive understanding of Earth system changes based on physical evidence

Principal Investigator: Masahiro Watanabe (Professor, Atmosphere and Ocean Research Institute, The University of Tokyo)
Representative organization ▶Atmosphere and Ocean Research Institute, The University of Tokyo
Partner organizations ▶JAMSTEC, National Institute for Environmental Studies, Japan Meteorological Business Support Center

(i) Advanced studies for global climate simulations
- **Hiroaki Tatebe** Group Leader, Japan Agency for Marine-Earth Science and Technology
- **Kentaroh Suzuki** Professor, Atmosphere and Ocean Research Institute, The University of Tokyo
- **Kei Yoshimura** Professor, Institute of Industrial Science, The University of Tokyo

(ii) Attributing and Predicting Earth System Variability
- **Tomoo Ogura** Head, National Institute for Environmental Studies
- **Yu Kosaka** Associate Professor, Research Center for Advanced Science and Technology, The University of Tokyo
- **Yukiko Imada** Investigator, Japan Meteorological Business Support Center

Area Theme 2 — Biogeochemical modeling and climate simulations for carbon budget assessment

Principal Investigator: Michio Kawamiya (Director, Japan Agency for Marine-Earth Science and Technology (JAMSTEC))
Representative organization ▶Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
Partner organizations ▶National Institute for Environmental Studies, Central Research Institute of Electric Power Industry

(i) A hierarchical approach to advancing Earth system modeling
- **Tomohiro Hajima** Deputy Group Leader, Japan Agency for Marine-Earth Science and Technology
- **Junichi Tsutsui** Associate Vice President, Central Research Institute of Electric Power Industry

(ii) Development of an integrated framework for Earth system research
- **Hiroaki Tatebe** Group Leader, Japan Agency for Marine-Earth Science and Technology

(iii) Earth-human system interaction and future scenario analysis
- **Kaoru Tachiiri** Group Leader, Japan Agency for Marine-Earth Science and Technology
- **Tokuta Yokohata** Chief Senior Researcher, National Institute for Environmental Studies

(iv) Technical and clerical support for inter-theme cooperation
- **Michio Kawamiya** Director, Japan Agency for Marine-Earth Science and Technology

Area Theme 3 — Increasing the sophistication of climate change projections around Japan

Principal Investigator: Izuru Takayabu (Principal Investigator, Japan Meteorological Business Support Center)
Representative organization ▶Japan Meteorological Business Support Center (JMBSC)
Partner organizations ▶Hokkaido University, Tohoku University, JAMSTEC, Nagoya University

(i) Development of projection system and analysis of mechanism for climate change around Japan
- **Hiroyuki Tsujino** Investigator, Japan Meteorological Business Support Center
- **Ryo Mizuta** Investigator, Japan Meteorological Business Support Center
- **Hiroaki Kawase** Investigator, Japan Meteorological Business Support Center
- **Hideyuki Nakano** Investigator, Japan Meteorological Business Support Center
- **Yoichi Ishikawa** Director, Japan Agency for Marine-Earth Science and Technology
- **Hirokazu Endo** Investigator, Japan Meteorological Business Support Center

(ii) Creating climate change projection information and elucidating extreme event mechanisms for promoting regional and basin scale adaptation measures
- **Tomohito Yamada** Professor, Faculty of Engineering, Hokkaido University
- **Kazuhisa Tsuboki** Professor, Nagoya University
- **Hiroaki Kawase** Investigator, Japan Meteorological Business Support Center
- **Takeshi Yamazaki** Professor, Graduate School of Science, Tohoku University

(iii) Creation of high-accuracy climate projection datasets for vulnerable regions in the world
- **Akihiko Murata** Investigator, Japan Meteorological Business Support Center

← Promotion of projection products use and user communication

Toshiyuki Nakaegawa
Investigator, Japan Meteorological Business Support Center

Area Theme 4 — Development of an integrated hazard projection model

Principal Investigator: Nobuhito Mori (Professor, Disaster Prevention Research Institute, Kyoto University)
Representative organization ▶Kyoto University
Partner organizations ▶Hokkaido University, Public Works Research Institute ICHARM, National Agriculture and Food Research Organization

(i) Integrated hazard modelling and nationwide future projections
- **Takahiro Sayama** Associate Professor, Disaster Prevention Research Institute, Kyoto University

(ii) Elaborate hazard model development and hazard mechanism elucidation
- **Kenji Tanaka** Professor, Disaster Prevention Research Institute, Kyoto University
- **Masahiko Fujii** Associate Professor, Faculty of Environmental Earth Science, Hokkaido University

(iii) Quantification of climate change factors in extreme hazards
- **Tetsuya Takemi** Professor, Disaster Prevention Research Institute, Kyoto University

(iv) International cooperation for hazard and risk assessments in the Asia-Pacific region
- **Yasuto Tachikawa** Professor, Graduate School of Engineering, Kyoto University

(v) Flexible adaptation strategies to the future changes in hazard and society
- **Toshio Fujimi** Associate Professor, Disaster Prevention Research Institute, Kyoto University

As head of the project, the Program Director(PD) will be responsible for overall program coordination and the efficient and effective management of the program.
A Program Officer (PO) will be assigned to each study theme to assist the PD, e.g., by monitoring progress of research activities and coordinating research plans.

Research Area 1

Predictive understanding of Earth system changes based on physical evidence

Predictive understanding of Earth system changes based on physical evidence

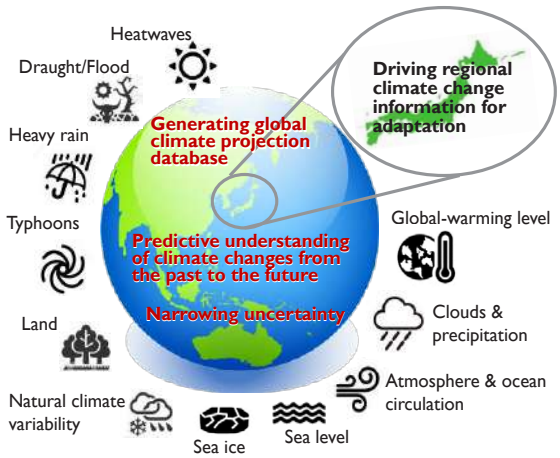
The Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC), issued in August 2021, concluded that human influence has unequivocally warmed the climate system. Global surface temperature has risen by 1.1°C since the preindustrial era, and is likely contributing to global increases in the frequency and intensity of extreme weather. In many developed countries, including Japan, both climate change adaptation and mitigation measures have been put in place. Mitigation is necessary to achieve carbon neutrality and the target of the Paris Agreement to limit global warming to below 1.5 or 2°C.

All climate change policies and actions are ideally based on scientific knowledge and evidence. Robust explanations of the cause of observed warming and future climate projections consistent with our understanding of past climate changes provide the basis for policies and actions. They can be obtained from climate simulations using physically-based global climate models (GCMs). Over the past 20 years, our group has led the climate modeling efforts in the MEXT research program. We developed an in-house GCM, MIROC, and have used it to simulate climate change on the Earth Simulator, generating large amounts of data publicly available. On the basis of these data, our group has also published a number of world-class research papers and contributed to the past three IPCC assessment cycles. In Research Area 1 of the SENTAN program, we intend to upgrade MIROC by using satellite products for validation. We plan to contribute to the IPCC Seventh Assessment Report (AR7) and advance our understanding of the causes of Earth system changes, particularly those aspects that were associated with low confidence levels in AR6. We will produce a database of near-term climate and greenhouse gas prediction based on an initialization technique implemented to MIROC. Our research will further improve our understanding of the mechanisms of large-scale climate change and variability, attributions of observed changes, constraints on future projections, and estimates of human influence on individual extreme weather events, also known as event attribution.

Principal Investigator

Masahiro Watanabe

Professor,
Atmosphere and
Ocean Research Institute (AORI),
The University of Tokyo



Climate phenomena examined in Research Area 1 are indicated by the black symbols and the expected outcomes (data and knowledge) are indicated in red. Research Area 1 focuses on climate change on global and large scales, and produces data that will be downscaled to create regional climate projections in Research Area 3. We will generate near-term Earth system predictions in collaboration with Research Area 2. We aim to produce actionable climate science and provide evidence-based climate change information for decision makers and the general public to support their decisions and changes in relation to climate change.

Partner organizations: JAMSTEC, National Institute for Environmental Studies, Japan Meteorological Business Support Center

IPCC: Intergovernmental Panel on Climate Change
AR6: Sixth Assessment Report

※ Working Group I contribution to the AR6 of the IPCC (Climate Change 2021: The Physical Science Basis) was released in August 2021.

Research Area 2

Biogeochemical modeling and climate simulations for carbon budget assessment

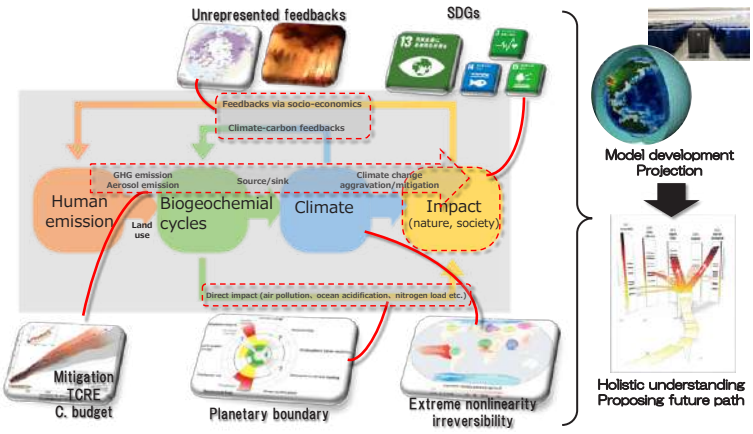
Global model of ecosystems and human activity —Supporting decision-making with respect to climate change measures

The carbon budget refers to the maximum amount of CO_2 emissions that can be allowed under a certain global warming target. Earth System Models (ESMs), which include essential elements of the global carbon cycle such as forests and marine ecosystems, are used to evaluate this indicator critical for estimating the necessary CO_2 emission reductions. The IPCC Sixth Assessment Report (AR6), published in 2021, estimated that the remaining carbon budget for limiting global warming to below 1.5 °C is about 400–650 GtCO2 (33%– 67% likelihood). The quantification of the carbon budget has substantial consequences for the society but has very large uncertainty. Therefore, it is necessary to narrow the uncertainty as much as possible by increasing ESM sophistication and understanding the sources of uncertainty; nitrogen and nutrient cycles, for example, need to be incorporated into the conventional carbon cycle to improve our understanding of the dynamics of all the major greenhouse gases. Furthermore, hydroxyl (OH) radicals play a critical role in determining the lifetime of greenhouse gases such as methane but their past and future changes under the influence of anthropogenic pollutants remain a subject of debate. To advance our understanding of the interactions between society and climate change, we will quantify the carbon budget and explore corresponding emission reduction pathways using a model suite that combines an ESM with a socioeconomic model. We will also focus on outreach, and our research findings can be used as a scientific basis for planning and decision-making, including supporting international negotiations on emission reductions and the Global Stocktake.

Principal Investigator

Michio Kawamiya

Director,
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)



Various processes will be integrated into the Earth System Model (ESM). Research findings will be synthesized to provide the society with a scientific basis for decision-making with respect to future pathways. We will increase model sophistication, e.g., by incorporating methane release from permafrost, and introduce novel elements, including detailed atmospheric chemistry processes and forest fires and combining the ESM with a human activity model. We will also focus on outreach to contribute to decision-making with respect to climate change measures.

Partner organizations: National Institute for Environmental Studies, Central Research Institute of Electric Power Industry

Global Stocktake(GST): A process to report and assess each country's collective progress toward the goals agreed under the Paris Agreement.
MEXT: Ministry of Education, Culture, Sports, Science and Technology of Japan

Research Area 3

Increasing the sophistication of climate change projections around Japan

Actionable climate science —Promoting research for a national climate change scenario

The World Climate Research Program (WCRP) strongly advocates actionable climate science, which connects research results with society. In Japan, the national Climate Change Projection Dataset forms the basis for climate change measures; updates will be made on a relatively regular basis starting 2022 and there are demands for different types of data (see figure). In Research Area 3, we aim to create regional climate projections with increased accuracy and diversity and reduced uncertainty to support local government decision-making. Data application will be expanded to include the fields of hydrology and water resources, and our results can be used for the management of water use, fisheries, aquaculture, and flood control. We will develop a model system that includes sophisticated regional climate models, global models with ocean effects, and enhanced ocean information around Japan. In addition, we will focus on regional climate, extreme events, and data application across different domains of the society through the following activities.

(1) To stimulate the application of research results across the society, we will produce information that meets users' needs by increasing model sophistication, generating marine data, and improving reproducibility in the modeling of extreme phenomena and our understanding of climate mechanisms.

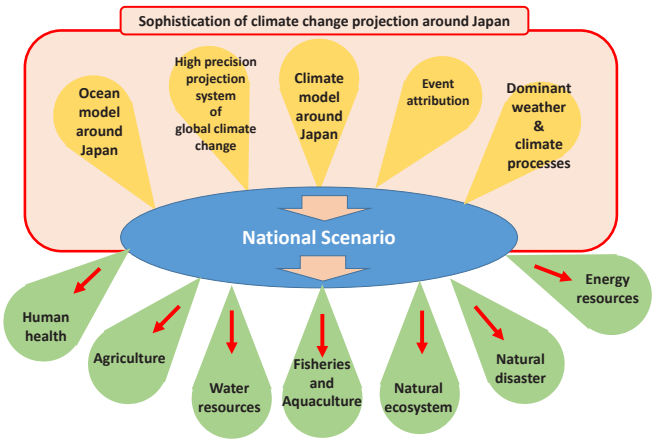
(2) To further facilitate the use of research results, we will engage in two-way communication with users and establish a user-friendly information provision system in cooperation with various domestic organizations, including DIAS, which is responsible for the system.

(3) To contribute to the development and implementation of climate change adaptation measures in vulnerable regions overseas that are similar to Japan and are facing increasing risks of heavy rains, floods, and storm surges, we will create highly accurate climate forecast datasets for these regions in collaboration with researchers in the regions.

Principal Investigator

Izuru Takayabu

Japan Meteorological Business Support Center (JMBSC)



The components of Research Area 3 are enclosed in the red box. Green drops indicate the various sectors that are users of the national scenario.

Partner organizations: Hokkaido University, Tohoku University, JAMSTEC, Nagoya University

Research Area 4

Development of an integrated hazard projection model

Advancing / Integrating weather-related disaster and water resources modeling and projecting future extremes for climate disaster risk information

Research Area 4 focuses on Climatic Impact Drivers (CIDs) following the IPCC Sixth Assessment Report (AR6). Research Area 4 connects WGI (The Physical Science Basis) and WGII (Impacts, Adaptation, and Vulnerability) of the IPCC. We will advance and integrate process models of weather-related hazards, water resources, and major ecosystems targeting the CIDs and produce future projections. Using advanced sub-models, we will integrate hazard models of weather-related hazards and water resources over a wide range of spatial and temporal scales. The compound hazards will be considered based on the integration of hazard models. Furthermore, we will consider extreme risks, including changes in exposure and vulnerability with changes in hazards and water resources. Such a risk assessment will lead to connection to adaptations.

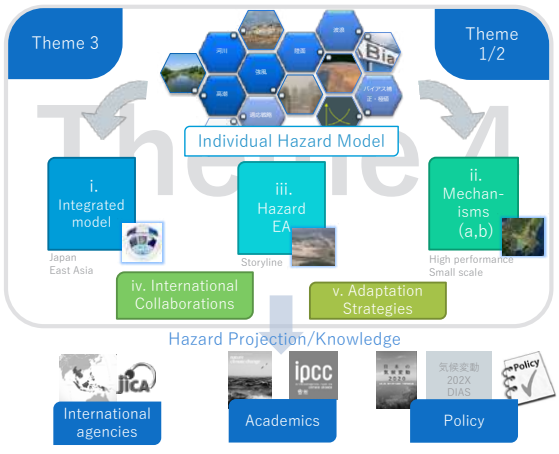
Coordinated future projections of weather-related hazards, water resources, and ecosystems will be generated from the climate projection datasets of Research Areas 1–3. The projection will be analyzed to identify the impacts of future extreme weather events on extreme hazards, water resources, and ecosystems targeting the CIDs in Japan and Southeast Asia. We will analyze hazard changes in response to rising temperatures. We will conduct event attribution and pseudo-global warming studies to estimate and quantify the contribution of warming to hazard projections from past, present, and future extreme weather events. Additionally, we will develop a framework for adaptation policies based on climate disaster prevention information. Impact assessments will be expanded and incorporated into exposure assessments and form the basis of our contribution to the IPCC AR7.

More than 100 researchers from four major institutions and 43 partner institutions, including universities and national research institutes, will work together to conduct research in this area.

Principal Investigator

Nobuhito Mori

Professor,
Disaster Prevention Research Institute,
Kyoto University



Sub-themes 4-i to 4-iii include model development and future projections; sub-theme 4-iv focuses on future projections and their social implementation in Southeast Asia; sub-theme 4-v focuses on the development of adaptation models. Our data and results will be published in research papers and will also be available to support the implementation of domestic and international policies.

Partner organizations: Hokkaido University, Public Works Research Institute ICHARM, National Agriculture and Food Research Organization

CID: Climatic Impact Driver. CIDs are climate system conditions (e.g., mean air temperature and tropical cyclones) that affect society or ecosystems.

Area Theme 1 Predictive understanding of Earth system changes based on physical evidence

Principal Investigator: **Masahiro Watanabe** (Professor, Atmosphere and Ocean Research Institute, The University of Tokyo)
Representative organization: Atmosphere and Ocean Research Institute, The University of Tokyo
Partner organizations: JAMSTEC, National Institute for Environmental Studies, Japan Meteorological Business Support Center

Subject	Representative	
(i) Advanced studies for global climate simulations		
a Advancing prediction systems for near-term climate-carbon cycle changes	**Hiroaki Tatebe**	Group Leader, Japan Agency for Marine-Earth Science and Technology
b Understanding physical processes of climate change with a synergistic use of global models and satellite observations	**Kentaroh Suzuki**	Professor, Atmosphere and Ocean Research Institute, The University of Tokyo
c Understanding and prediction of terrestrial environmental changes	**Kei Yoshimura**	Professor, Institute of Industrial Science, The University of Tokyo
(ii) Attributing and Predicting Earth System Variability		
a Understanding global warming levels and reducing uncertainty in climate projections	**Tomoo Ogura**	Head, National Institute for Environmental Studies
b Mechanism understanding of past climate changes and future projections	**Yu Kosaka**	Associate Professor, Research Center for Advanced Science and Technology, The University of Tokyo
c Deepening and advancement of event attribution studies	**Yukiko Imada**	Investigator, Japan Meteorological Business Support Center

Area Theme 2 Biogeochemical modeling and climate simulations for carbon budget assessment

Principal Investigator: **Michio Kawamiya** (Director, Japan Agency for Marine-Earth Science and Technology (JAMSTEC))
Representative organization: Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
Partner organizations: National Institute for Environmental Studies, Central Research Institute of Electric Power Industry

Subject	Representative	
(i) A hierarchical approach to advancing Earth system modeling		
a Advancing biogeochemical process in Earth system models	**Tomohiro Hajima**	Deputy Group Leader, Japan Agency for Marine-Earth Science and Technology
b Integrating multiple evidence with climate model emulators	**Junichi Tsutsui**	Associate Vice President, Central Research Institute of Electric Power Industry
(ii) Development of an integrated framework for Earth system research	**Hiroaki Tatebe**	Group Leader, Japan Agency for Marine-Earth Science and Technology
(iii) Earth-human system interaction and future scenario analysis		
a Feedback analysis of Earth-human systems	**Kaoru Tachiiri**	Group Leader, Japan Agency for Marine-Earth Science and Technology
b Scenario analysis of Earth-human systems	**Tokuta Yokohata**	Chief Senior Researcher, National Institute for Environmental Studies
(iv) Technical and clerical support for inter-theme cooperation	**Michio Kawamiya**	Director, Japan Agency for Marine-Earth Science and Technology

Area Theme 3 Increasing the sophistication of climate change projections around Japan

Principal Investigator: **Izuru Takayabu** (Principal Investigator, Japan Meteorological Business Support Center)
Representative organization: Japan Meteorological Business Support Center (JMBSC)
Partner organizations: Hokkaido University, Tohoku University, JAMSTEC, Nagoya University

Subject	Representative	
(i) Development of projection system and analysis of mechanism for climate change around Japan	**Hiroyuki Tsujino**	Investigator, Japan Meteorological Business Support Center
a Development of projection system for high-resolution global climate change	**Ryo Mizuta**	Investigator, Japan Meteorological Business Support Center
b Development of projection system for regional climate and land surface in Japan	**Hiroaki Kawase**	Investigator, Japan Meteorological Business Support Center
c Development of projection system for ocean change around Japan	**Hideyuki Nakano** **Yoichi Ishikawa**	Investigator, Japan Meteorological Business Support Center Director, Japan Agency for Marine-Earth Science and Technology
d Analysis of mechanism for climate change around Japan	**Hirokazu Endo**	Investigator, Japan Meteorological Business Support Center
(ii) Creating climate change projection information and elucidating extreme event mechanisms for promoting regional and basin scale adaptation measures	**Tomohito Yamada**	Professor, Faculty of Engineering, Hokkaido University
a Developing high-resolution data sets and prediction method using dynamical and statistical methods	**Tomohito Yamada** **Kazuhisa Tsuboki**	Professor, Faculty of Engineering, Hokkaido University Professor, Nagoya University
b Analysis of climate and weather factors causing recent extreme weather events	**Hiroaki Kawase**	Investigator, Japan Meteorological Business Support Center
c Elucidating the mechanism of extreme events considering the risk increase and maximum magnitude at the regional and basin scale	**Takeshi Yamazaki**	Professor, Graduate School of Science, Tohoku University
(iii) Creation of high-accuracy climate projection datasets for vulnerable regions in the world	**Akihiko Murata**	Investigator, Japan Meteorological Business Support Center
Promotion of projection products use and user communication	**Toshiyuki Nakaegawa**	Investigator, Japan Meteorological Business Support Center

Area Theme 4 Development of an integrated hazard projection model

Principal Investigator: **Nobuhito Mori** (Professor, Disaster Prevention Research Institute, Kyoto University)
Representative organization: Kyoto University
Partner organizations: Hokkaido University, Public Works Research Institute ICHARM, National Agriculture and Food Research Organization

Subject	Representative	
(i) Integrated hazard modelling and nationwide future projections	**Takahiro Sayama**	Associate Professor, Disaster Prevention Research Institute, Kyoto University
(ii) Elaborate hazard model development and hazard mechanism elucidation	**Kenji Tanaka**	Professor, Disaster Prevention Research Institute, Kyoto University
a Hazard assessments of wind hazard, water-related disasters and water resources	**Kenji Tanaka**	Professor, Disaster Prevention Research Institute, Kyoto University
b Hazard assessments of forests and coastal ecosystems	**Masahiko Fujii**	Associate Professor, Faculty of Environmental Earth Science, Hokkaido University
(iii) Quantification of climate change factors in extreme hazards	**Tetsuya Takemi**	Professor, Disaster Prevention Research Institute, Kyoto University
(iv) International cooperation for hazard and risk assessments in the Asia-Pacific region	**Yasuto Tachikawa**	Professor, Graduate School of Engineering, Kyoto University
(v) Flexible adaptation strategies to the future changes in hazard and society	**Toshio Fujimi**	Associate Professor, Disaster Prevention Research Institute, Kyoto University

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2022.12