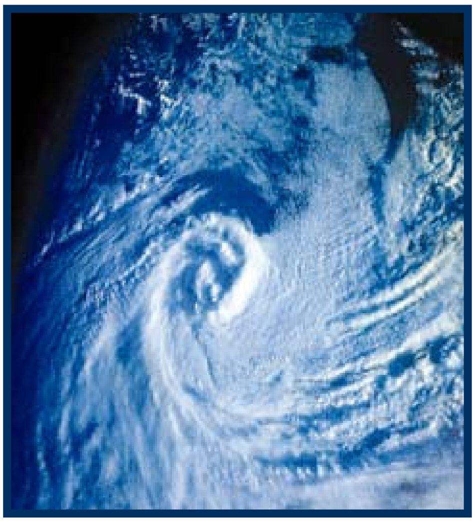
SOUSEI

Program for Risk Information on Climate Change



MEXT

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

Progress of the Climate Change Research Projection

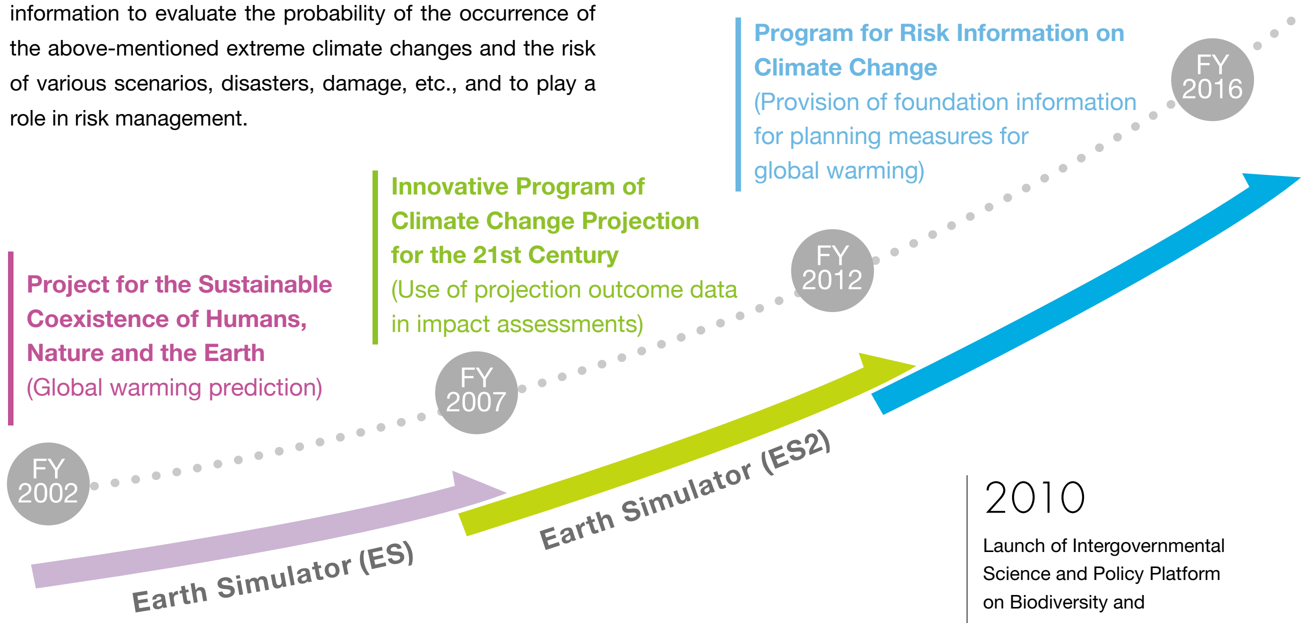
A project is underway to prepare for the conceivable scenario and to enable risk evaluation at the highest level!

On the Japanese archipelago which is mountainous and long north to south, there is significant variation among the regions in temperature, precipitation, and wind. Since the islands are surrounded by the ocean, they are often hit by typhoons during the summer and fall. Moreover in recent years, extreme weather phenomena have become frequent occurrences, including concentrated heavy rainfall, unusually high temperatures near 40 degrees Celsius (104 degrees Fahrenheit), and tornadoes strong enough to destroy houses. These types of abnormal weather phenomena threaten our daily lives and are capable of causing immense damage to society and the economy.

The Program for Risk Information on Climate Change (SOUSEI) carries on the work of the Innovative Program of Climate Change Projection for the 21st Century (KAKUSHIN) (FY2007-FY2011). The aim of this program is to generate information to evaluate the probability of the occurrence of the above-mentioned extreme climate changes and the risk of various scenarios, disasters, damage, etc., and to play a role in risk management.

This project began in FY2012 and will continue for five years. The project's specific research is divided into five themes which are being pursued concurrently, as follow. Theme A: Prediction and diagnosis of imminent global climate change, Theme B: Climate change projection contributing to stabilization target setting, Theme C: Development of basic technology for risk information on climate change, Theme D: Precise impact assessments on climate change, and Theme E: Promotion for climate change research and linkage coordination.

By developing the highest level of research technology in the world, we expect to play a role in climate change risk prediction not only in Japan but also in countries around the world including Southeast Asia.



2001
Intergovernmental Panel on Climate Change (IPCC)
IPCC's Third Assessment Report (TAR)
"There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."

2002
Earth Summit 2002
Adoption of Framework Convention on Climate Change

2007
IPCC's Fourth Assessment Report (AR4)
"Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG (greenhouse gas) concentrations."
IPCC receives the Nobel Peace Prize.

2009
3rd World Climate Conference (TWCC)
Adoption of plan for Global Framework for Climate Services (GFCS)

2010
Launch of Intergovernmental Science and Policy Platform on Biodiversity and Ecosystem Services (IPBES; the biodiversity version of IPCC)

2012
Earth Summit 2012
Action Guidelines for Sustainable Development

2013-2014
Formulation of IPCC's Fifth Assessment Report (AR5) Scheduled

Introduction

SOUSEI

Reduction of the uncertainty of climate change projection and usage of "risk information" in the real world

A quarter of a century has already passed since global warming due to industrial activities was noted. The response heretofore has been mainly to hold discussions on saving energy and on regulating emissions of greenhouse gases such as carbon dioxide. Now we are beginning to see the frequent occurrence of concentrated heavy rainfall, large typhoons, and the flooding that goes along with those. We have reached the point where it is necessary to devise specific answers to questions such as "how high should the levees be?" and "how strong should houses and high-rise buildings be to withstand the wind?," for the adaptation strategies for global warming.

The major mission of the Program for Risk Information on Climate Change is to further boost the basic technology for climate change projection, predict the probability of the occurrence of extreme concentrated heavy rainfall, etc., and conduct the risk evaluation research of the associated damage.

Themes constructed in a nested fashion

This research program is arranged with a multilayered structure. Theme A is the lowest-level layer. On top of that is Theme B, followed by Theme C and Theme D.

Theme A focuses on the development of the basic model that is the basis of this program. In this program's precursor, the Innovative Program of Climate Change Projection for the 21st Century, research on the basic model was also driving the overall program, but in the current program, we aim to strengthen the basic model itself and to add more advanced functions.

Theme B has a sibling relationship with Theme A. It adds elements such as the environmental biogeochemical cycles and biological activity to the basic model, develops a more detailed earth system model, and studies target levels for stabilization of the climate.

The aim of Theme C is to extract more detailed prediction information and to describe the "conceivable scenario" including the probability of a particular scenario occurring, such as Isewan Typhoon (Typhoon Vera). In response, Theme D aims to produce risk projections and assessments to provide adaptation strategies to minimize the impact to natural hazards, water resources and ecosystem and biodiversity under climate change.

What are needed are scientific grounds and reliability

We are already at the point of no return with regard to global warming, but when it comes to "climate change risk," its perceived seriousness varies greatly depending on one's generation and location. For instance, having experienced the tsunami and the nuclear accident following the Great East Japan Earthquake, we in Japan understand that even a disaster with the extremely small probability of "once in 1,000 years" causing exceedingly massive damage may actually occur.

In order to take specific action under the current difficult circumstances which include a declining birthrate, an aging society, and less-than-abundant funds, we must have reliable risk assessments based on scientific grounds. Those of us involved in this project intend to scientifically question and ascertain the matters which seem certain and the matters which are still not well understood. We are pushing forward with research to obtain reliable results that will serve as grounds for every person to think and make decisions.

Program Director (PD) Akimasa Sumi (special advisor to MEXT)

President, National Institute for Environmental Studies (NIES)

Outline

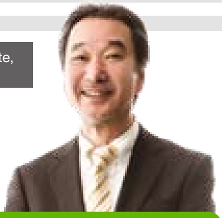
PD supervises the program so that it is carried out efficiently and effectively, and he handles the overall coordination of the program. A PO (program officer) is assigned to each theme to assist the PD in managing the progress of research topics and adjusting research plans, etc.

Akimasa Sumi, PD (Program Director)
Special Advisor to MEXT
President
NIES

Tatsushi Tokioka, PO
Special Advisor to MEXT
Team Leader
Research Institute for Global Change, JAMSTEC

Fujio Kimura, PO
Special Advisor to MEXT
Program Director
Research Institute for Global Change, JAMSTEC

Hideo Harasawa, PO
Special Advisor to MEXT
Vice President
NIES



Theme A: Atmosphere and Ocean Research Institute, the University of Tokyo (AORI)

Prediction and diagnosis of imminent global climate change

Representative: Masahide Kimoto
Vice Director/Professor, AORI, the University of Tokyo

The coming global warming is unavoidable, and all segments of society are seeking ways to adapt to it. In an effort toward providing climate change risk information and contributing to building a society highly adaptive to climate change, this theme develops a climate prediction system that enables verification using observation data on various timescales and provides climate projection information with high reliability. We aim to improve the reliability of projections of future climate changes through analyzing major contributing factors, verifying hindcasts, and assessing the impacts of anthropogenic factors associated with past climate changes involving severe weather and extreme events. In addition, we attempt to reduce the uncertainty in climate projection due to physical processes controlling climate sensitivity through verification using observation data, which is a yardstick of climate system responsiveness to external forcing such as that caused by changes in concentration of carbon dioxide.

【Research Topics】

Understanding mechanisms of climate variability and change

- Studies on prediction and predictability of climate variability from interannual to decadal time scales (AORI)
- Towards reducing uncertainty in model-based estimation of climate sensitivity (National Institute for Environmental Studies: NIES)
- Reduction of uncertainty in climate models relevant to climate sensitivity (JAMSTEC)

Development of an integrated prediction system for global climate studies

- Development of a seamless prediction system for seasonal-to-decadal time scales (Meteorological Research Institute JMA: MRI)
- Development of data assimilation technology for optimizing initial and boundary conditions (JAMSTEC)

Theme B: JAMSTEC

Climate change projection contributing to stabilization target setting

Representative: Michio Kawamiya
Project Manager, JAMSTEC

Uncertainty in the projection of carbon dioxide concentration, together with uncertainty concerning climate sensitivity, is a major obstacle to predicting the future climate. In this research theme, we are developing an earth system model that handles the environmental biogeochemical cycles including the carbon cycle and the nitrogen cycle as well as changes in land use. These are critical for more accurately predicting changes in the balance of carbon dioxide and changes in ecosystems and agriculture, etc. When developing our research, we study, from a scientific standpoint, the socio-economic scenarios that form the preconditions on which the projection experiment is premised. In studying targets for carbon dioxide, it is important to understand phenomena that may occur in the future but must be avoided as well as the impact of methods we could use to avoid them. This is why we work to create new scientific knowledge concerning the impact and effects of violent changes (tipping elements) which may arise when the degree of anthropogenic environmental changes exceed a certain threshold as well as methods to lower the average temperature of the earth artificially so as to suppress the damage due to warming (geoengineering).

【Research Topics】

Long-term global change projection based on diverse scenarios

- Development of an earth system model dealing with variations of greenhouse gases, land use change, etc. (JAMSTEC)
- Information gathering and examination on socio-economic scenarios toward stabilization target setting (JAMSTEC)
- Integrated assessment on climate projection experiments and socio-economic scenarios (Central Research Institute of Electric Power Industry:CRIEPI)

Obtaining scientific perceptions on large-scale variations and modifications of climate

- Development of technologies for numerical investigations on tipping elements and irreversibility of environmental changes (ice sheet collapse, etc.) (JAMSTEC)
- Development of technologies for numerical investigations on geoengineering (stratospheric aerosol injection, etc.) (JAMSTEC)

Theme C: University of Tsukuba

Development of basic technology for risk information on climate change

Representative: Izuru Takayabu
Head of the Second Laboratory, Atmospheric Environment and Meteorology Research Department, Meteorological Research Institute (MRI)

In recent years, climate change impact assessments and development of countermeasures have been undertaken around the world. However, there is currently no standard downscaled data that can simultaneously address various demands (from changes in the mean field to hazard analyses). In this research theme, we aim to produce probability data that enables hazard analyses related to both high-frequency phenomena and low-frequency phenomena (typhoons, heavy rainfall, etc.) in the region of Japan. For this purpose, we are further refining the existing super high-resolution atmospheric model and applying statistical methods on model results to generate data on the probability of climate change predictions in the Asian monsoon region, including Japan. We aim to prepare a standard dataset (climate scenarios) together with data concerning the uncertainty in basic variables in climate prediction, which can be used in different applications of prediction data.

【Research Topics】

Probabilistic climate prediction for risk assessment

- Efficient approach for climate ensemble experiment (National Research Institute for Earth Science and Disaster Prevention: NIED)
- Development of statistical methodology of ensemble data on climate change (The Institute of Statistical Mathematics:ISM)
- Improvement in cost-efficiency of dynamical downscaling for ensemble data (AORI)

Producing a standard climate scenario by using super high resolution models

- Development of quantification method for reliability and uncertainty of climate change information (University of Tsukuba)
- Downscaling of the change in future weather extremes by using high-resolution models (MRI)
- Development of a coupled ocean-atmosphere non-hydrostatic model for typhoon research (Hydrospheric Atmospheric Research Center, Nagoya University: HyARC)

Theme D: Disaster Prevention Research Institute, Kyoto University (DPRI-KU)

Precise impact assessments on climate change

Representative: Eiichi Nakakita
Professor, DPRI, Kyoto University

To generate information that contributes to climate change risk management, it is important to perform a more detailed assessment of the impact, together with specifying the risks and understanding the probabilities. In this research theme, we are performing a quantitative impact assessment from a variety of perspectives including natural hazards, water resources, and ecosystems and biodiversity, using climate change prediction information as well as prediction information produced in this program. We are also performing a variation estimate of the expected risk value, an estimate of the uncertainty of that estimate, and an impact assessment on the worst-case scenario of a natural hazard. Next, using these figures, we perform a variation estimate of the socio-economic risk and aim to compile the basic information for adaptation strategies. With regard to natural hazards, in conjunction with proposing various basic approaches to the adaptation strategies, we aim to study assessment methods for comprehensive disaster mitigation measures that can alleviate a disaster to some degree when external forces occur that exceed the existing facilities plan, as part of the worst-case scenario. We also aim to construct a methodology for the economic assessment.

【Research Topics】

Climate change impacts on natural hazards

- Risk assessment of meteorological disasters under climate change (DPRI-KU)
- Risk assessment of water-related disasters under climate change (Kyoto University Graduate School of Engineering)
- Risk assessment of coastal disasters under climate change (DPRI-KU)
- Measuring socio-economic impacts of climate change and effectiveness of adaptation strategies (DPRI-KU)
- Development of risk assessment and adaptation strategies for water-related disaster in Asia (Public Works Research Institute:PWRI)

Climate change impacts on water resources

- Assessment of socio-economic impacts on water resources and their uncertainties under changing climate (DPRI-KU)
- Assessment of climate change impacts on the social-ecological systems of water resources and hydrological cycles (Institute of Industrial Science, University of Tokyo:IIS)

Climate change impacts on ecosystem and biodiversity

- Assessment of climate impacts on ecosystem and biodiversity (Tohoku University)
- Economic evaluation of ecosystem science (Tohoku University)
- Eco-climate system in northeastern Eurasia and southeastern Asian tropics: impacts of global climate change (Nagoya University)
- Assessment of multiple effects of climate change on coastal marine ecosystem (Hokkaido University)

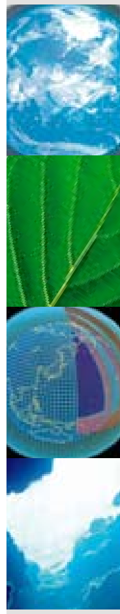
Theme E: JAMSTEC

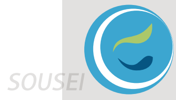
Promotion for climate change research and linkage coordination

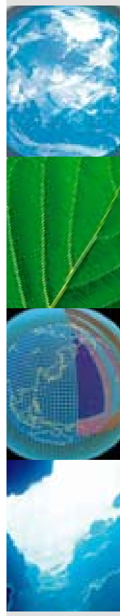
Representative: Michio Kawamiya
Project Manager, JAMSTEC

Promotion for effective researches on climate change

- Support for program implementation and outreach
- Support for forming common recognition on climate change risk information
- Establishment of a system required for providing information and advice on climate change risk







We provide a research basis for climate prediction so that we can perform prediction experiments over various spatiotemporal scales

We develop a system that can predict climate changes over broad timescales, from El Niño over a half year to global warming over 10 years or 100 years. We aim to provide to the world "more specific prediction levels" that can be used for risk assessment.

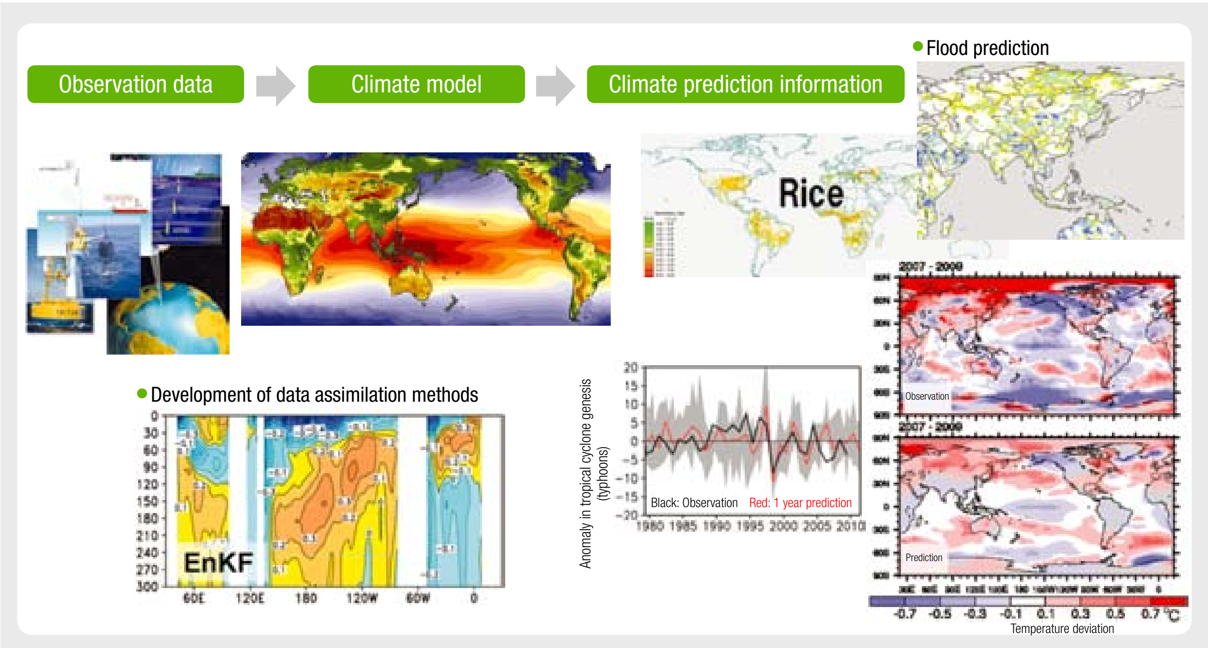
Weather forecasts and precipitation probabilities, which are indispensable in our daily lives, have been remarkably improved in the past few decades. This is due to the appearance of supercomputers capable of rapidly performing massive and complex calculations and the development of atmospheric models that can reproduce the atmospheric circulation, precipitation, and the generation and extinction of clouds. Recently, a "coupled atmosphere-ocean general circulation model" which is composed of an ocean model together with the atmospheric one has been developed, and it is used to predict the occurrence of El Niño a half year to one year in advance and to predict global warming 10 years in the future. In general, we face a larger uncertainty in longer term climate predictions, and actually, the present climate change predictions contain such a large uncertainty that we cannot estimate adequate levels for the height of levees and the strength of buildings.

Theme A, prediction and diagnosis of imminent global climate change, aims to develop the models and the technology to serve as the research basis for the Program for Risk Information on Climate Change. We are endeavoring to improve the present models and the prediction systems so that we can more reliably verify the past extreme events and apply them to future predictions.

Seamless prediction, from weather to El Niño and global warming

Theme A is divided into two sub-themes: (1) understanding mechanisms of climate variability and change and (2) development of an integrated prediction system for global climate studies.

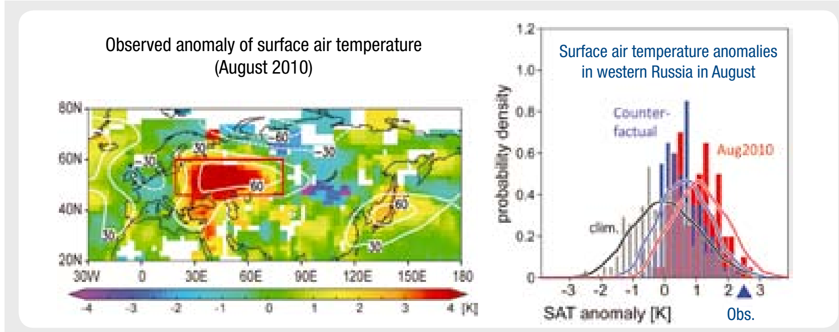
In the former, i.e., understanding mechanisms of climate variability and change, we have three goals. The first goal is to further develop the "near-term climate prediction system with initialization" that was developed by KAKUSHIN and to provide information for seamless prediction, from the occurrence of El Niño up to a half year in advance to the prediction of global warming 30 years in the future. "Initialized prediction" is regarded here as making forecasts by starting with the realistic atmospheric, oceanic, and land conditions, based on observation data. In addition to the long-term tendency of global warming, we predict the future natural changes in the atmosphere and oceans.



Theme A aims to develop a system capable of seamless climate prediction from weather fluctuations a few months ahead to global warming several decades ahead. For this, not only will we improve the accuracy of climate models, but we will also develop data assimilation methods that initialize the model using the observation data. We will verify hindcast skills for the past climate changes and provide prediction information for applied studies.

The second goal is to estimate the contribution from anthropogenic warming to the past extreme events such as heat waves and abnormally low temperatures.

The third goal is to clarify the factors that cause the wide range of predictions, such as "a temperature increase of 1.5 degrees to 4 degrees in 100 years" to improve the present prediction models. In particular, we aim to reduce the uncertainty of climate sensitivity by focusing on what approach to employ for "cloud behavior" in the models.

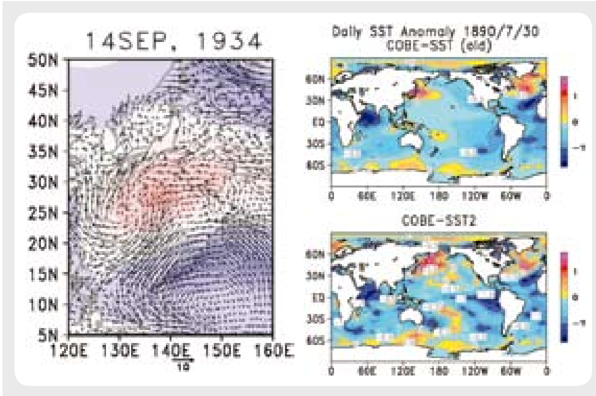


The prediction system is also used to estimate the contribution of global warming to the past extreme events toward risk assessment. Our simulation using the observed ocean condition revealed that the heat wave over Russia in August 2010 appeared to be a rare natural fluctuation (event probability 3.3%) (left panel). In a counterfactual simulation that removed the contribution of global warming, the event probability was less than one-fifth.

Improving prediction accuracy for the world

In the latter, i.e., development of an integrated prediction system for global climate studies, we aim to develop the optimization technology for applying analysis methods simultaneously to various spatiotemporal scales, obtaining initial and boundary values and improving computer processing.

To enhance the case studies and verify the prediction system, it would be desirable to compile reanalysis data of the atmosphere and ocean states for the past 100 years, yet this is difficult even with the supercomputer Earth Simulator which is the pride of Japan. Since the capacity of the supercomputer places a major limit on research progress, Theme A poses challenging goals. More accurate prediction of near-term climate changes will enable us to provide "more specific figures" for risk assessments to the world. In other words, it will become possible to calculate where we should place priority, how much budget is necessary and where it is necessary, and how many years will be required until preparations are complete.



At present, observation data for only 50 years are available to verify the prediction of decadal climate changes and extreme events. We attempt to reconstruct climate variability during the recent 100 years by using advanced data assimilation methods. The left panel represents a reconstructed weather chart at the time of the 1934 Muroto typhoon, and right panel represents the reconstructed sea surface temperatures at the end of the 19th century.

Key phrases: Reduction of uncertainty in climate predictions, detection and attribution of anthropogenic climate changes, seamless prediction of climate change, development and improvement of climate models, improvement of data assimilation system

Structure

JAMSTEC

NIES

AORI

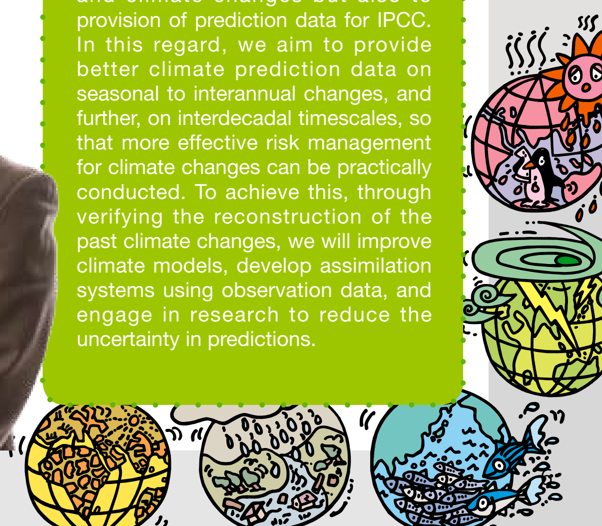
and others

Representative: Masahide Kimoto

Vice Director/Professor, AORI,
the University of Tokyo

Representative: Masahide Kimoto

We have developed MIROC, the Model for Interdisciplinary Research on Climate, and have contributed not only to research on climate systems and climate changes but also to provision of prediction data for IPCC. In this regard, we aim to provide better climate prediction data on seasonal to interannual changes, and further, on interdecadal timescales, so that more effective risk management for climate changes can be practically conducted. To achieve this, through verifying the reconstruction of the past climate changes, we will improve climate models, develop assimilation systems using observation data, and engage in research to reduce the uncertainty in predictions.



Theme B: Climate change projection contributing to stabilization target setting

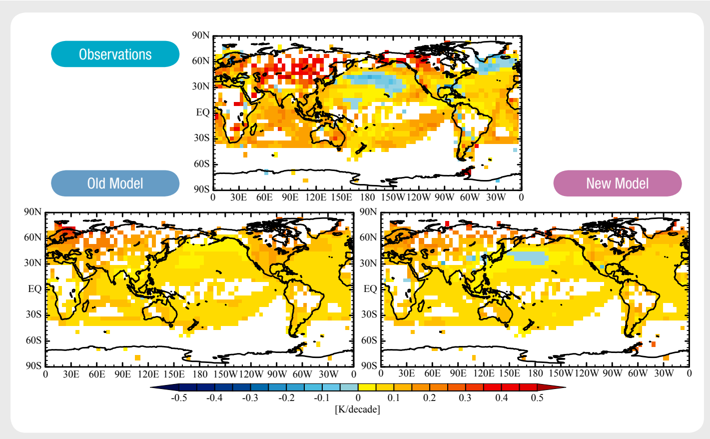
We are building a high-precision earth system model to contribute to global warming countermeasures and socio-economic scenarios

We aim to contribute to the setting of target levels to stabilize the climate and the building of more reliable socio-economic scenarios by constructing a climate system model that incorporates biological activities such as photosynthesis and environmental biogeochemical cycles for carbon dioxide and methane, etc., on a global scale.

Starting in the latter half of the 20th century, emissions of greenhouse gases including carbon dioxide surged due to industrial activities, and now attention is being called to the risks of global warming. It is clear from the observation data that the average temperature increased by 0.74 degrees Celsius (1.33 degree Fahrenheit) in the past 100 years, and there is no doubt that the earth is undergoing a warming trend.

The rise in temperature will cause negative effects including a rise in ocean levels due to melting ice sheets, an increase in massive typhoons and concentrated heavy rainfall, and extinction of living things, but the problem is that it is not easy to predict the climate change and the impact that will actually occur. Global warming has occurred repeatedly during the earth's 4.6 billion year history, but this is the first time that the human element has played a role.

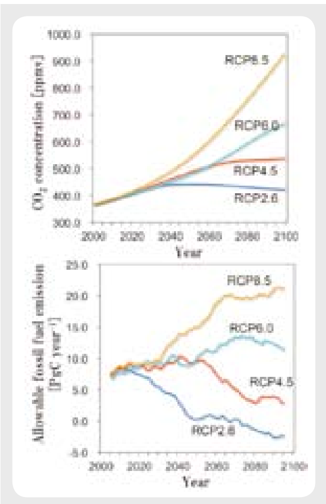
Four major themes spanning diverse research areas



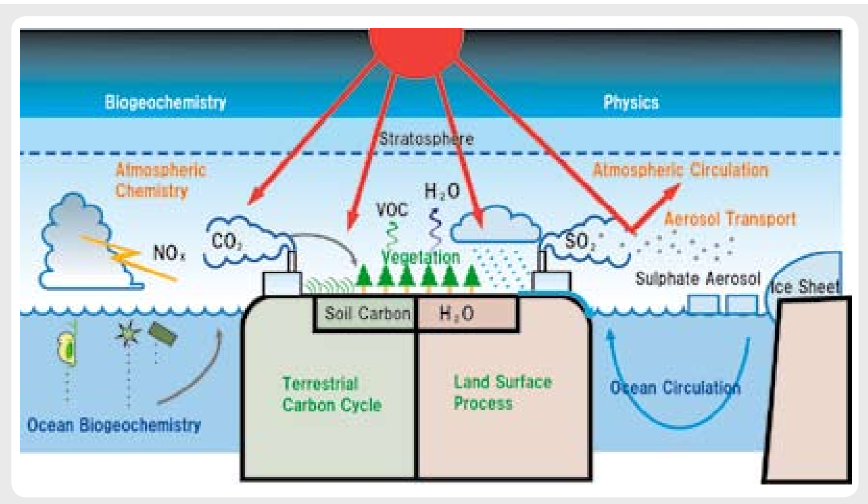
Improvement of the climate model: We are pursuing efforts to improve the climate model, which is the foundation for the earth system model. We are also improving the reproducibility of past climate changes.

Given these conditions, the four sub-themes under Theme B are "development of an earth system model," "study of socio-economic scenarios," "development of prediction models for tipping elements (sudden climate changes)," and "development of technologies for numerical investigations on geoengineering (climate engineering)" which should enable achievement of Theme B's objective, "climate change prediction contributing to stabilization target setting."

In charge of "development of an earth system model" are JAMSTEC, AORI, and NIES. We aim to enable dynamic analysis of the entire planet by incorporating environmental biogeochemical cycles and biological activity in the existing "earth system model," and to apply it to the issues at hand in this project. Researchers from a variety of backgrounds are participating in this project, not only those who specialize in meteorology and physical oceanography but also those in ecology and chemistry.



CO_2 emission path calculation: We can use the earth system model to answer the question of "How much do we need to reduce emissions to bring CO_2 concentration below 450 ppm in order to restrain global warming?"

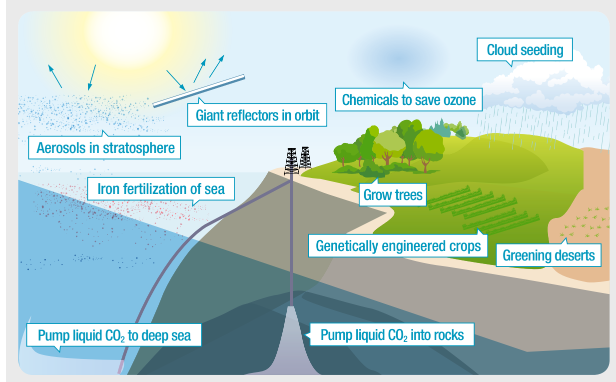


Structure of the earth system model. We are developing this model by adding biological and chemical processes to the atmospheric and ocean general circulation models that have been used for conventional global warming predictions.

Participating in the "study of socio-economic scenarios" are economics researchers who specialize in global warming countermeasures from the University of Shiga Prefecture and CRIEPI, in addition to researchers from AORI and from NIES. Heretofore, development of socio-economic scenarios was in the category of economics, but in this project, we have arranged for collaboration with the field of climate change analysis with the aim of building a future image of the world that is based on scientific data.

"Development of prediction models for tipping elements (sudden climate changes)" and "development of technologies for numerical investigations on geoengineering" are both handled by JAMSTEC, AORI, and NIES. In the former, our activities include the building of a prediction model for "changes in the outermost edges of the south polar ice sheet as it collapses," which has not been studied until now as well as verification with mathematical models of "how suddenly the melting of permafrost could occur" and "the volume of organic carbon that will melt and decompose."

In the latter, we carry out numerical investigations on development of technology to artificially control the climate and also calculate the expense, predict the effects, and predict the side effects of that. For example, we use Earth Simulator to "chill the earth by spraying fine particles in the stratosphere" and "promote photosynthesis by scattering iron in the ocean and increasing the plankton."

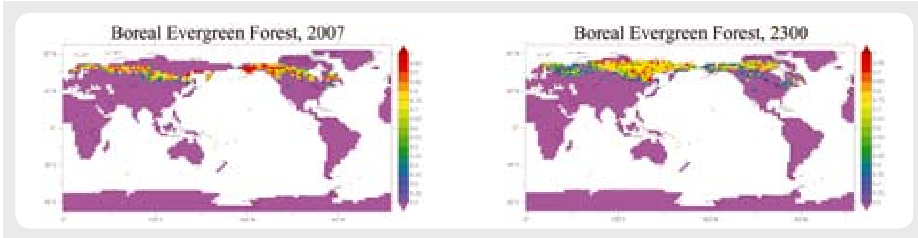


Proposed methods of geoengineering. Of these, in this program, we are working to verify the feasibility of "aerosols in stratosphere" and "iron fertilization of sea."

Producing results that contribute to society

Development and verification of a climate model depend largely on the development of supercomputer technology, but in Theme B overall, we would like to achieve an improved version of our earth system model by the fourth year of the project. Moreover, when building emission scenarios for carbon dioxide, not only do we plan to have researchers in the field of socio-economics produce estimates as has been done heretofore, but also to fully integrate knowledge and information from the natural science fields, such as the carbon cycle.

Prediction of changes in vegetation distribution: As global warming continues, the distribution of vegetation may change significantly. By using the earth system model, we can gain information about the changes in vegetation distribution.



Key phrases	Development of an earth system model, study of socio-economic scenarios, tipping elements, geoengineering

Structure

CRIEPI

The University of Shiga Prefecture ▶ JAMSTEC

and others

Representative: Michio Kawamiya

Project Manager, Research Institute for Global Change, JAMSTEC

Representative: Michio Kawamiya

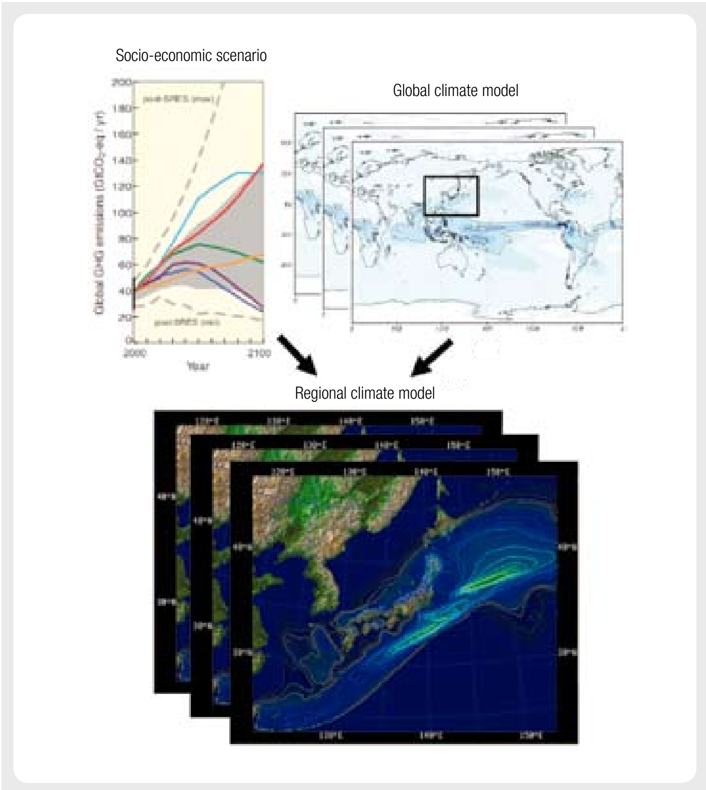
While the question of "How much should we reduce carbon dioxide emissions in the future so that the earth is not massively harmed?" is a socio-economic question, it is also a natural science question that we need to tackle using an earth system model. We believe that we must engage in generating the future image of society while encouraging communication, which has been sparse, between researchers in both fields and taking on issues that have not been researched to a large extent until now, such as verification of achievability of geoengineering.

We aim for technological development that will enable us to employ a statistical approach for everything from inter-annual variability to extreme climate phenomena and to produce detailed evaluations for each region

Our objective is to develop statistical methods for analyzing and evaluating, for instance, the inter-annual variability of seasonal changes which affects the timing of the northward movement of the cherry blossom front ("Sakura-Zensen") or the southward movement of the autumnal-colored front ("Kouyou-Zensen"), or extremely rare weather phenomena such as the Isewan Typhoon (Typhoon Vera). We also aim to create a picture of the "conceivable scenarios," including the probability of a particular scenario occurring. The research results will be useful when devising countermeasures for future disasters, etc., of the nation and municipalities.

The Isewan Typhoon made landfall at Cape Shionomisaki in September 1959 and wreaked tremendous damage in almost all regions of Japan. Approximately 5,000 people lost their lives, and the economic damage due to high tides and floods was 551.2 billion yen, equivalent to three times the annual national budget at the time. This type of extreme weather event occurs only rarely, about "once in 20 to 50 years." However, when it does occur, many people's lives are endangered, and significant social and economic damage and chaos ensue.

Theme C, development of basic technology for risk information on climate change, will focus on these types of extreme weather conditions that rarely occur. Ultimately, we aim to achieve detailed regional evaluations by employing a statistical approach to extreme precipitation, ocean wave height, and wind speed. Broadly speaking, there are two specific research sub-themes. One is "probabilistic climate projection for risk assessment," and the other is "producing a standard climate scenario by using super high resolution models."



Ensemble numerical experiments to generate probability data for weather scenarios

Here, in addition to assessment of the uncertainty in a global climate model by using ensemble experiments, etc., we use downscaling techniques to obtain detailed climate information for each region. Downscaling is a method for obtaining the distinctive changes in each region in Japan from low resolution information such as the computation results from a global coupled atmosphere-ocean general circulation model. Here, we employ a dynamical downscaling method that uses various regional climate models like those used for daily weather prediction.

Probabilistic climate prediction for risk assessment

The first sub-theme, probabilistic climate prediction for risk assessment, is handled by NIED, ISM, and AORI. Here, for the purpose of climate change risk assessment, we study the statistical expression of uncertainty in detailed regional climate change scenarios using a climate model, and we study how to sample efficiently and evaluate statistically the extremely rare weather phenomena.

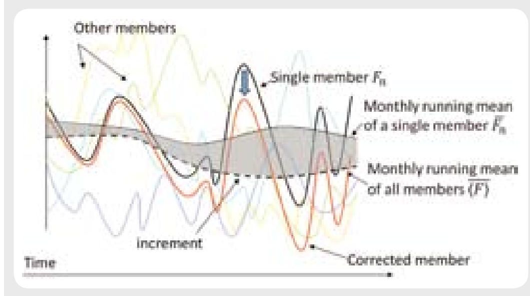
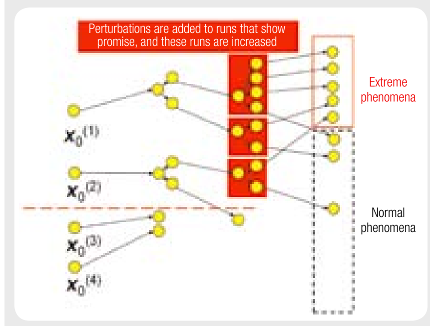


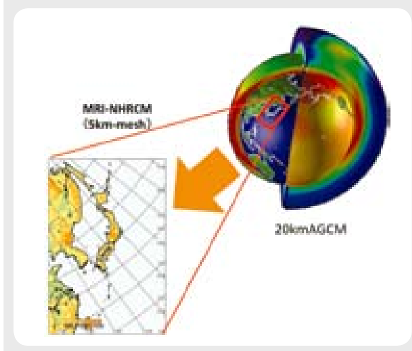
Illustration of the single member correction method which is an efficient method of dynamical downscaling from the ensemble prediction results. This figure shows the correction using the same method for forecast variables (from black line to red line).

Sampling of extreme phenomena. We simultaneously begin multiple runs with different initial conditions or initial values (the four ◯ arranged vertically on the left). If a run is determined to have no chance of reaching an extreme phenomenon by a given point in time (i.e., it is below the red dotted line), then the time integration is halted. If the run is considered to have a chance (◯ above the red dotted line), we continue the time integration after adding perturbations to that value, assigning new tasks to the computing unit which has already halted the time integration before. Through these operations, it is possible to prioritize the assignment of computation resources to extreme phenomena.



Producing a standard climate scenario by using super high resolution models

The second sub-theme, producing a standard climate scenario by using super high resolution models, is handled by University of Tsukuba, MRI, and HyARC. Using a super high-resolution atmospheric model, we generate detailed climate change scenarios for Japan that are useful in assessing climate change risk. A coupled model will be developed to assess accurately the interaction between ocean and typhoon and will be used to quantitatively project the typhoon intensity in the future climate.



Schematic diagram of a dynamical downscaling experiment using 5-km mesh regional climate model (lower left) from a 20-km mesh general circulation model (upper right)

A super typhoon in a global warming climate predicted by a cloud resolving atmospheric model with a 2km horizontal resolution. The clouds of the simulated typhoon are shown in 3D. When this typhoon is over the Pacific Ocean, it maintains a central pressure of 870 - 860 hPa and a maximum wind speed of 70 - 80 m/s for four days, and it makes landfall at nearly the same intensity.

Key phrases	Climate scenario, ensemble experiments for climate change, downscaling, statistical evaluation, typhoon intensity estimate

Structure

ISM
HyARC, Nagoya University
University of Tsukuba
NIED
MRI
AORI
and others

Representative: Izuru Takayabu

Head of the Second Laboratory, Atmospheric Environment and Meteorology Research Department, MRI

Representative: Izuru Takayabu

The key to the success of this theme is "collaboration" across a variety of fields although the dynamical downscaling technique used in this theme is based on a field of meteorology. This time, experts in statistics are also involved for the first time, and we are pursuing research together with scientists from various applied fields. To communicate smoothly with researchers from different fields, including agreeing on definitions of basic terminology, a number of years are required. We believe that we must strive, at times with perseverance, for good communication.

How will global warming change typhoons and ecosystems? We tackle oncoming problems that affect all of us

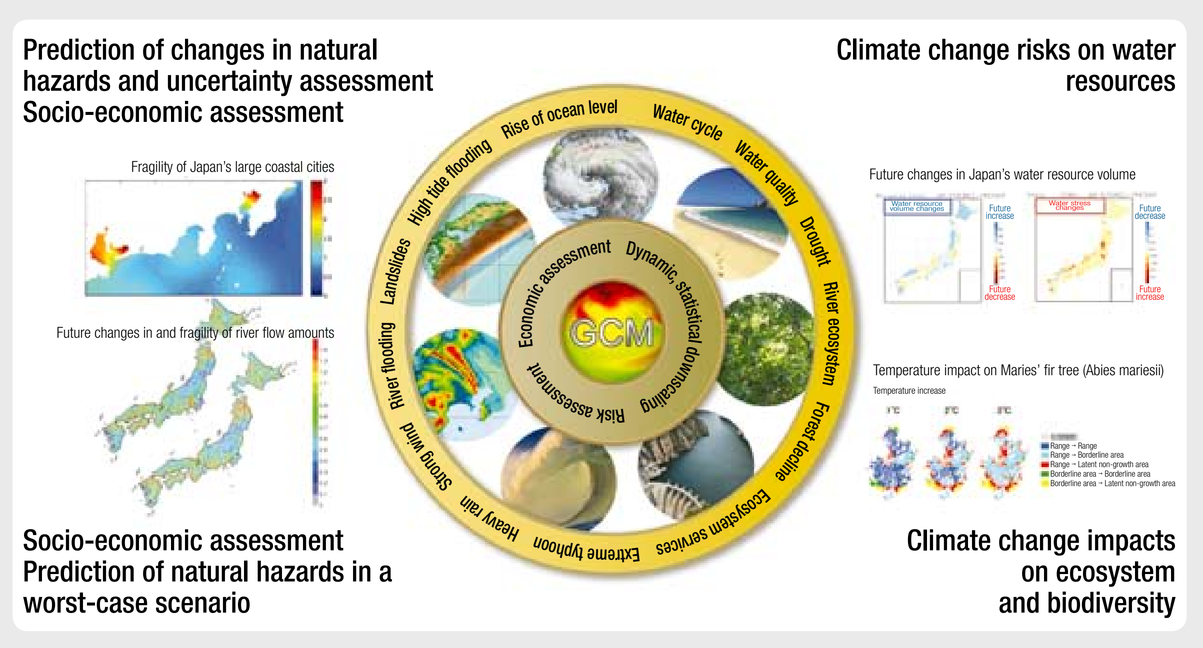
How will global warming change typhoons, floods, landslides, and river flows as well as the forests and oceans? By producing specific predications, we promote adaptation to oncoming problems that affect all of us.

Not long ago, there was a great deal of careful discussion on whether or not global warming is related to extreme weather phenomena such as the large typhoons and localized heavy rainfall that have been increasing recently. However, Japan experienced any number of close brushes with, and direct hits from, large typhoons and frequent occurrence of strong winds, floods, overflowing rivers, high tides, high waves, and landslides. Concern has spread that these disasters may intensify as global warming progresses.

Theme D, precise impact assessments on climate change, aims to scientifically demonstrate the connection between the aforementioned increase in natural disasters and global warming and to look 100 years into the future to see how serious it may become. The research results are to be presented as "actual figures" and are expected to be used as data for the government and municipalities to consider how to protect the lives of people in urban and rural areas, coastal areas, and river areas.

A "100 year impact assessment" was proposed by this program's antecedent, KAKUSHIN, but this is the first attempt to produce an actual figure for "the maximum predicted amount of future rainfall." To generate this kind of specific figure, detailed data with a high degree of precision is required. Even with all the data that we can collect, the sample size and precision are still inadequate. So, in Theme D, we take on the challenge of developing an assessment model that can produce predictions even given the data limitations, and we endeavor to assess extreme phenomena.

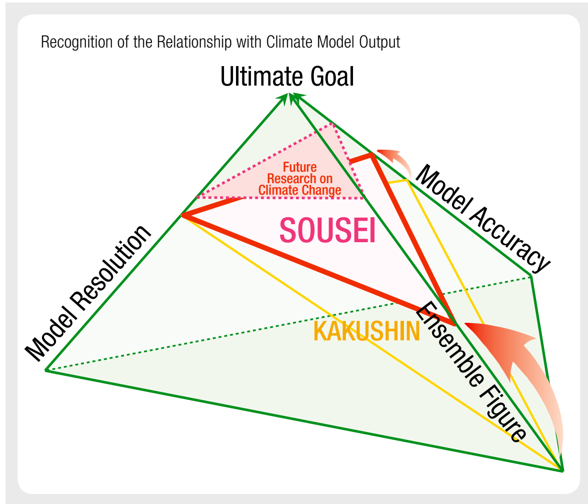
Broadly speaking, there are three specific research sub-themes. They are "climate change impacts on natural hazards," "climate change impacts on water resources," and "climate change impacts on ecosystems and biodiversity."



Climate change impacts on natural hazards

The first sub-theme, climate change impacts on natural hazards, is handled by DPRI-KU, together with Global Centre of Excellence for Water Hazard and Risk Management (ICHARM/PWRI). We aim to produce predictions for scenarios including worst-case particularly in the case of typhoons, which cause the most serious weather-related damage in Japan, concerning the frequency, scale, accompanying precipitation, strong winds, high tides, and high waves, including during the Baiu season.

There are approximately 25 typhoons annually, and around 10 of those approaches or make landfall in Japan. The number of typhoons is not large, but it is known that a small alteration in the path of a typhoon can have an extremely large impact on the amount of wind and rain Japan receives, and as a result, cause immense damage. We will predict and assess how the frequency of "once in 100 years" type disasters and worst-case damage will change during the coming 100 years, and we will use this information to understand the impact on society and for national planning.



When generating impact assessments and adaptation strategies, the ultimate ideal is to boost the model's accuracy and to generate many possibilities (ensembles) with finer time and space resolutions, but this ideal is not achievable. So, what can be done? This challenge is one of the highlights of climate change impact assessment.

Climate change impacts on water resources

The second sub-theme, climate change impacts on water resources, is handled by DPRI and IIS. When the climate changes due to global warming, the rain amount and rain patterns change significantly. It is also possible that what formerly fell as snow will change into rain. In Japan which has many mountainous regions, it is anticipated that this would cause a great change in the "pattern of water flowing into rivers."

So, the Kyoto University team of this group will predict and assess the changes in the flow and supply of water in the main rivers in Japan, the impact on rice farming, etc., and the need for flood control such as dams, etc. Similar prediction and assessment will be pursued for the world' s major rivers, including in Asia. The University of Tokyo team will predict and assess how the actual water cycle will change on a global scale with the addition of artificial modifications. This team will also study the effectiveness of adaptation strategies.

Key phrases	Assessment of impact 100 years in the future, application to the East Asian region, actual condition of global warming and impact assessment as well as countermeasures, prediction of climate on a regional scale

Structure

- DPRI, Kyoto University
- NIES
- National Agriculture and Food Research Organization (NIRE/NARO)
- Hokkaido University
- Tohoku University
- ICHARM / PWRI
- Tokyo Institute of Technology
- Nagoya University
- IIS, the University of Tokyo
- and others

Representative: Eiichi Nakakita

Professor, DPRI, Kyoto University

Representative: Eiichi Nakakita

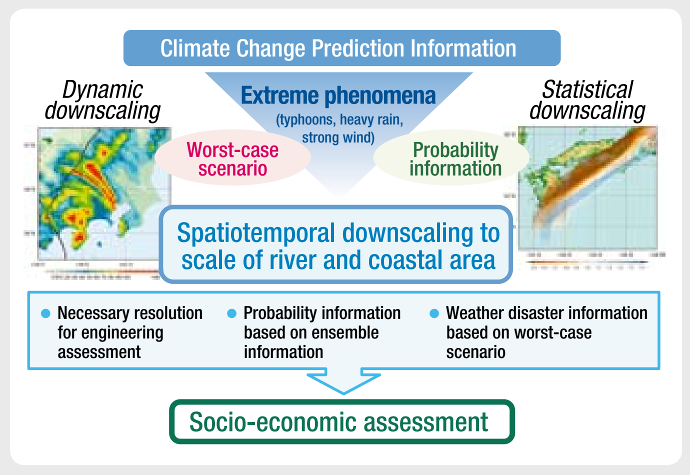
This area deals with a wide field. It focuses on phenomena that are the entryway for the research project (from natural hazards and water resources to ecosystems) and the exit target (adaptation strategies). It is extremely important to understand the entry phenomena as well as to know the society, people, and living things involved in the exit. Consequently, I believe that, compared to the other areas, we will be able to pursue our research with many researchers in an enjoyable and lively manner.

Climate change impacts on ecosystem and biodiversity

The third sub-theme, climate change impacts on ecosystem and biodiversity, is supervised primarily by Graduate School of Life Sciences at Tohoku University, and other participants include Nagoya University, Hokkaido University and NIES. We aim to predict and assess whether ecosystems are capable of changing abruptly due to global warming, taking as models the forests of northeastern Japan and the marine life in the ocean near Japan.

The Tohoku University team will conduct predictions and assessments concerning whether global warming will cause the extinction of alpine plants, the impact of strong wind on forests, the purification effects of forests, and changes in tourism resources. The Nagoya University team will conduct predictions and assessments on how climate change alters forest vegetation and then whether the altered forest vegetation affects the climate. The main research sites will be Asian rainforests and the eastern boreal Siberia. The team will study the changes in the major forests in the world, such as the tundra forest.

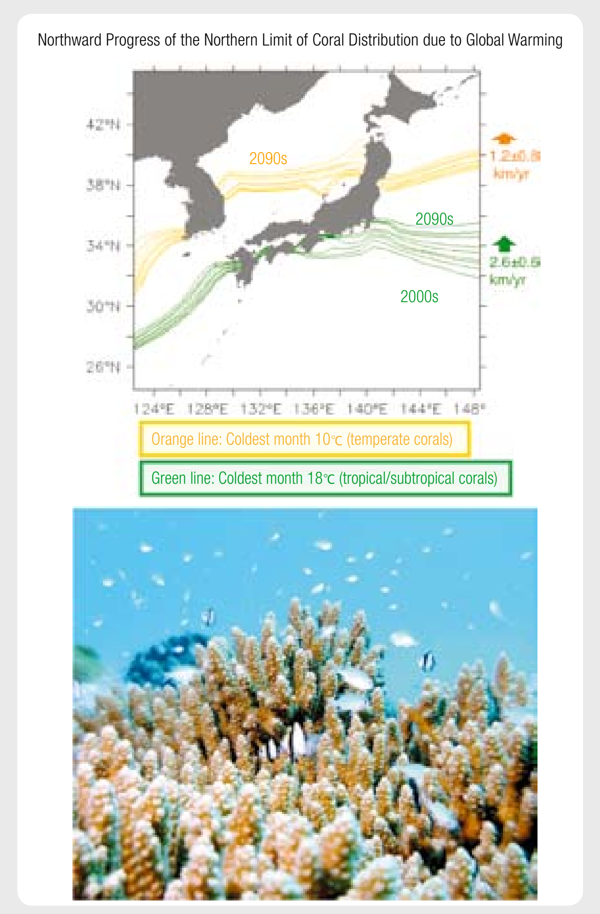
The team composed of Hokkaido University and NIES focus on ocean acidification which occurs when more anthropogenic carbon dioxide dissolves in seawater. The team will predict and assess what sorts of changes will occur in coastal marine ecosystem such as coral reefs and seaweed forests due to global warming and ocean acidification.

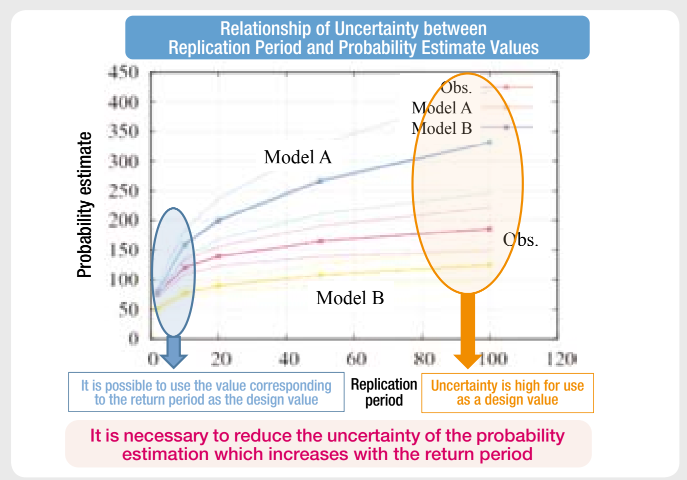


Prediction of Future Changes in Natural Hazards

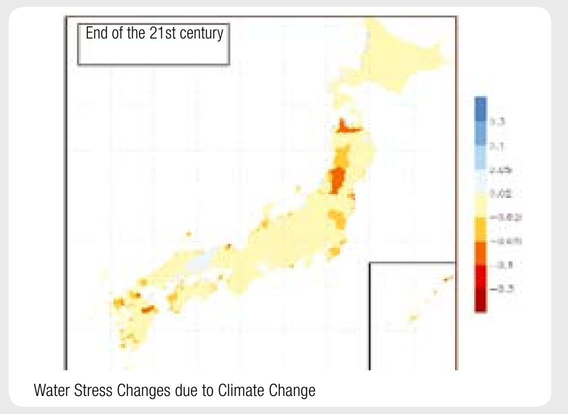
Specific results for input into policy

Of all the themes in this project, the issues examined in Theme D are the most specific and the closest to us. Naturally, work on this theme will enable more accurate prediction of "how climate and meteorological phenomena will change," but the theme will also explore how to utilize the research results in society in order to minimize the lives and assets lost in natural hazards. We look forward to results that enable proposals that will cause a paradigm shift among policymakers.





Relationship between Replication Period and Uncertainty of Probability Estimate



Water Stress Changes due to Climate Change

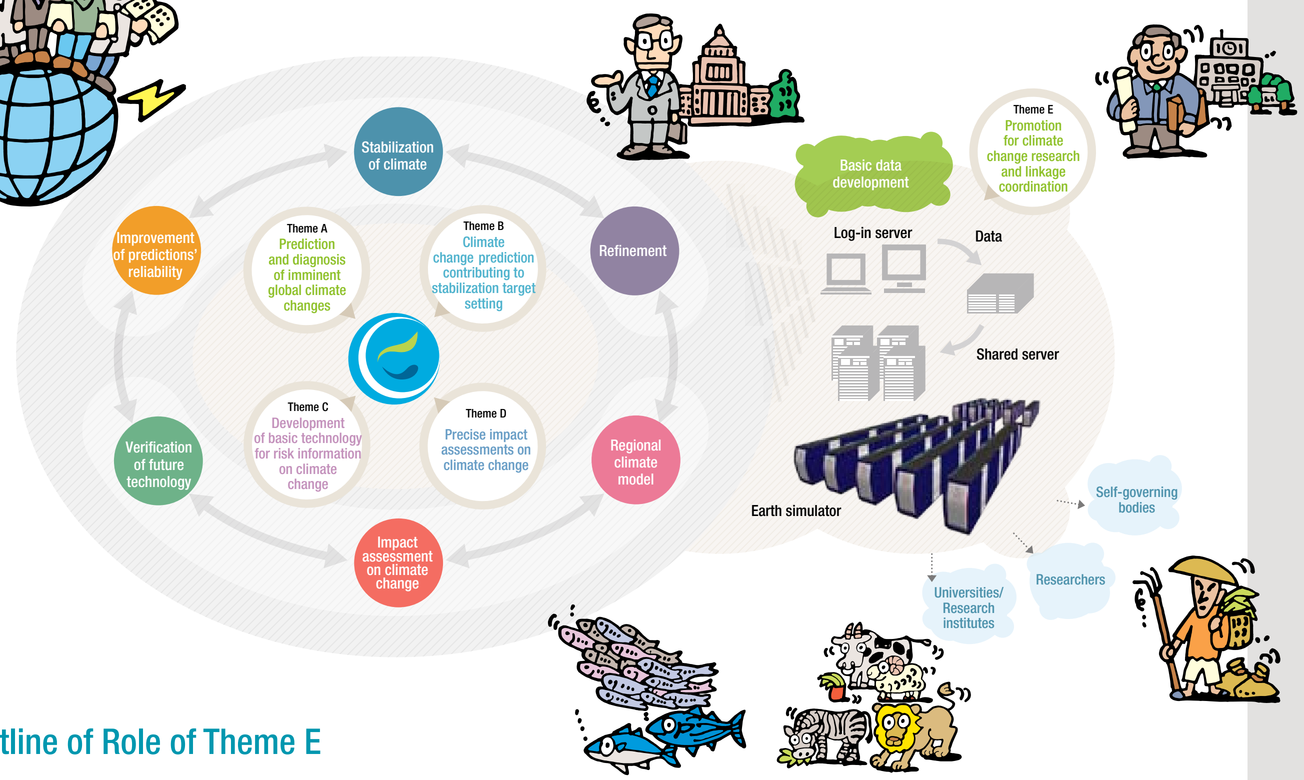
Theme E : Promotion for climate change research and linkage coordination

Summarizing the research result of SOUSEI Program overall and connecting it to society

Theme E plays the role of coordinator

To derive maximum utilization from the results of the Generation Program, we will connect them to the practical aspects of all sorts of disaster-related and preparation-related situations. The role of Theme E is to provide support for coordination, liaison, and information exchange for this purpose.

Theme E will coordinate the linkage of themes A through D and manage the research results in a database in a unified manner. Then, the results will be edited and organized so they can be put to practical use, and using an information network of all the teams and related institutions, a foundation for opportunities to utilize the research results in the real world will be created.



Outline of Role of Theme E

- To fulfill the role of coordinator so as to ensure the utilization of the research results of SOUSEI Program for more accurate and precise weather prediction and disaster prevention.
- To centralize the research results of all the teams in a database and to classify, organize, and provide technological support for efficient utilization of the data.
- To spearhead liaison conferences and information exchanges among themes A through D and to contribute toward the mutual sharing and multilayered utilization of research results.
- To conduct public relations activities so that the this Program becomes widely known, such as holding public symposiums and issuing newsletters.

Related Organizations

Theme A

Atmosphere and Ocean Research Institute, the University of Tokyo

http://www.aori.u-tokyo.ac.jp/english/

- Japan Agency for Marine-Earth Science and Technology
- Center for Global Environmental Research, National Institute for Environmental Studies

Theme B

Japan Agency for Marine-Earth Science and Technology

http://www.jamstec.go.jp/e/

- The University of Shiga Prefecture
- Central Research Institute of Electric Power Industry

Theme C

University of Tsukuba

http://www.tsukuba.ac.jp/english/

- Atmosphere and Ocean Research Institute, the University of Tokyo
- Hydrospheric Atmospheric Research Center, Nagoya University
- Research Organization of Information and Systems, the Institute of Statistical Mathematics
- National Research Institute for Earth Science and Disaster Prevention
- Meteorological Research Institute, Japan Meteorological Agency

Theme D

Disaster Prevention Research Institute, Kyoto University

http://www.dpri.kyoto-u.ac.jp/web-e/

- Hokkaido University Graduate School of Environmental Science
- Field Science Center for Northern Biosphere, Hokkaido University
- Graduate School of Life Sciences, Tohoku University
- Graduate School of Environmental Studies, Tohoku University
- Institute of Industrial Science, the University of Tokyo
- School of Engineering The University of Tokyo
- Graduate School of Information Science and Engineering, Tokyo Institute of Technology
- Hydrospheric Atmospheric Research Center, Nagoya University
- National Agriculture and Food Research Organization
- International Center for Water Hazard and Risk Management under the auspices of UNESCO, Public Works Research Institute
- Center for Environmental Biology and Ecosystem Studies, National Institute for Environmental Studies

Environment and Energy Division
Research and Development Bureau
Ministry of Education, Culture, Sports, Science and Technology-JAPAN

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