Japan Geoscience Union Meeting 2014
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MIS31-01 Room:511 Time:May 2 09:00-09:15

Extensions of RCP2.6/4.5 with zero emission after 2100: as 2K/3K stabilization scenarios for MIROC-ESM

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Focusing that MIROC-ESM (an earth system model, no atmospheric chemistry version) output around 2K/3K rise in global mean surface air temperature in 2100 with the Representative Concentration Pathways (RCP) 2.6 and 4.5, we extend the experiments with zero-emission after 2100, as 2K/3K stabilization scenarios for the model. As MROC-ESM is a "pessimistic" (with high climate sensitivity and small ecosystem carbon uptake) model, stabilization for this model means large chance of stabilization for many other models. The experiment, with fixed land use and other non-CO_2 forcing after 2100, is designed to 2300,and we are now just after 2200.

In the 2K stabilization scenario, RCP2.6 followed with zero emission, temperature rise from the pre-industrial state (PI) is slightly over 2K in 2100, and slowly decreased after the zero-emission period starts, and is just below 2K at 2200. Atmospheric CO_2 concentration (pCO_2) is 421ppm at 2100 and around 400ppm at 2200. On the other hand, in the 3K stabilization scenario, RCP4.5 followed with zero emission, temperature rise from PI is just over 3K, and then decreased after that slightly more rapidly than 2K stabilization scenario and is around 2.8K at 2200. pCO_2 is 540ppm at 2100 and just below 500ppm at 2200.

Looking at air temperature after stabilization (i.e., 2100), the 2K stabilization scenario have temperature rise in and around Antarctica, in Siberia and in Greenland, and decrease in Amazon and in northern lands. The 3K stabilization scenario has similar pattern, but with relatively small rise in and around Antarctica, and no significant increase in Greenland. Some increase in Siberia, and with significant decrease in Arctic Sea. Precipitation decreases in Western Pacific and increases in a part of Eastern Pacific and around Indian Ocean for 2K stabilization scenario. For 3K stabilization scenario, precipitation is decreased in some areas in southern Pacific.

Keywords: Representative Concentration Pathways, zero emission, stabilization, Earth system model

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MIS31-02 Room:511 Time:May 2 09:15-09:30

Parallel and integrated processes of climate-impact-socioeconomics for climate research

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The need to take mitigation measures in order to hold the increase in global average temperature below 2 degree C above pre-industrial levels are recognized in international negotiations of the United Nations Framework Convention on Climate Change (UNFCCC). According to the fifth assessment report (AR5) by the Working Group (WG) I of Intergovernmental Panel on Climate Change (IPCC) which was published last September, attaining the temperature goal with a probability of 50% will require cumulative CO2 emissions from all anthropogenic sources to stay approximately 300 GtC from the present. If the current level of anthropogenic CO2 emission, 10 GtC yr-1, continues, the cumulative emissions will reach this upper limit in only 30 years. If we will seriously pursue the goal of temperature increase below 2 degree C, global CO2 emission should be turned to decline as soon as possible, and to be reduced at nearly zero by around the end of this century.

A great deal of research on climate change impacts and mitigation measures exist; however, large uncertainties remain in their overall pictures. So far, nobody can grasp clearly risks for human society and ecosystem associated with global warming exceeding "2 degree C", and risks for socioeconomics due to severe emission reductions of greenhouse gases. Furthermore, the risks will be realized in different ways by country, region, generation, and social attribution, and therefore, either if no specific response measures are conducted or if strong measures are conducted, a part of people in the world will have benefits and another part of people will make a loss. Climate change impact is not just an issue on benefits and losses of each person; but it relates to issues how we feel distress on risks for ecosystem, developing countries, and future generations. It relates to different value judgment among people.

Climate research plays a role to provide scientific information to help the societal decision making process of such an uncertain, complex and ambiguous risk problem. To pursue it, there has been a serious international activity to promote interaction across the three research communities, that is, climate, impact and socioeconomics (corresponding to the WG I, II and III of IPCC, respectively). I will look back the idea of parallel and integrated processes of the three research communities, that was attempted during the discussion of Representative Concentration Pathways (RCP) around 2010, from the present where IPCC AR5 was released, and discuss its progress and future prospects.

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

MIS31-03 Room:511 Time:May 2 09:30-09:45

Development of the climate model MIROC and initialization system using LETKF for the next IPCC report

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We have been updating the climate model MIROC and developing a data assimilation and initialization system based on the local ensemble transform Kalman filter (LETKF) for reconstructing global centennial climate, understanding of mechanisms of climatic periodic changes, regime shifts, and extreme events, and improving skills in seasonal-to-decadal climate predictions. For the previous fifth assessment report of IPCC-AR5, decadal climate forecasts and retrospective predictions taking into account both of the global warming due to increase of anthropogenic green house gases and intrinsic variability of the climate system were performed using a series of MIROC with various resolutions and physics. As a result, for example, the mid-latitude SST signals in the North Pacific associated with the Pacific decadal oscillations, the abrupt stepwise climate shift occurred in the late 1990s, and the tropical cyclone activity over the western North Pacific are suggested to be predictable for a few to several years. After the experiments for IPCC-AR5, we additionally performed retrospective climate predictions on seasonal-to-interannual timescales focusing ENSO. Prediction skill of the equatorial SST in MIROC is as high as those in climate models of operational centers over the world. However, because MIROC has remarkable systematic climate biases of stronger equatorial trade winds and resultant deeper thermocline, more subtropical clouds in the lower troposphere and relating colder SST, weaker mid-latitude westerly jets, warmer SST and larger precipitations around Antarctica than observations, so-called anomaly assimilation technique is used in initializing the climate model, and thus the seamless climate predictions cannot be performed by the present system. Therefore, our modeling group is devoting effort to reduce the model biases and to realize the seamless predictions by MIROC based on full field assimilation. In my talk, recent update of MIROC will be introduced along with preliminary results from a newly developing initialization system.

Keywords: climate model, initialization, seamless climate prediction

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MIS31-04 Room:511 Time:May 2 09:45-10:00

Climate projections using high-resolution MRI-AGCM

MIZUTA, Ryo[1*] ; OSE, Tomoaki[1] ; MURAKAMI, Hiroyuki[2] ; ARAKAWA, Osamu[3] ; YOSHIDA, Kohei[1] ; NAKAEGAWA, Toshiyuki[1]

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A high-resolution atmospheric general circulation model of the Meteorological Research Institute (MRI-AGCM), with a horizontal grid size of about 20 km, have been developed, and applied to climate projections for extreme weather events such as tropical cyclones and heavy precipitation. Given the observational sea-surface temperature (SST) as the lower boundary condition, the model can simulate not only global-scale climate of temperature and precipitation, but also climatic characteristics of small-scale phenomena such as geographical distribution and intensity of tropical cyclones, and seasonal march of the East Asian monsoon.

Under the KAKUSHIN program (2007-2012; sponsored by MEXT), giving SST changes from atmosphere-ocean coupled models, time-slice experiments with this model have been performed to investigate detailed and localized changes as a consequence of global warming. The uncertainty of the change has been also evaluated, using many ensemble experiments with 60 km version of the model. The simulation results has been used for many purposes, including impact accessments of disasters, water resources, and agriculture, as well as analyses from meteorological point of view. The results has been also provided to the researchers worldwide, for the researches of regional climate changes of their own countries. Over Japan area, dynamical downscaling experiments have been performed using a regional climate model with horizontal grid sizes of 5km and 2km.

Under the SOUSEI program (2012-2017; sponsored by MEXT), in order to evaluate and reduce the uncertainty of the climate projections, ensemble experiments with the 20-km model with different geographical patterns of SST changes are being performed, using results of CMIP5 coupled models.

Keywords: global warming, atmospheric general circulation model

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Earth system modeling - a brief history and future direction

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A brief history of Earth system modeling will be outlined, and its future direction will be discussed.

Keywords: Earth system model

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Findings in climate change and global carbon cycle from model inter-comparison analyses

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Interactions between climate and carbon cycle are essential for making long-term climate projection, since some part of carbon cycle processes in land and ocean display slow responses to environmental change in a longer timescale, with giving feedbacks on climate. Climate-carbon cycle models, sometimes referred as "Earth system models (ESMs)", have been developed and utilized for the long-term climate projection. Recent model inter-comparison analyses have revealed some problems in the models, and provided new findings on climate-carbon cycle relationships. For example, a new index "TCRE" is introduced in the latest IPCC report. This index can capture the entire response of global climate-carbon cycle system to anthropogenic CO2 emission, with suggesting some useful political messages. In this presentation, new findings on climate-carbon cycle system such as TCRE will be reviewed, based on the results from model inter-comparison analyses.

Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

MIS31-07 Room:511 Time:May 2 10:30-10:45

Cyber Earth: A new technical approach for global studies of Earth

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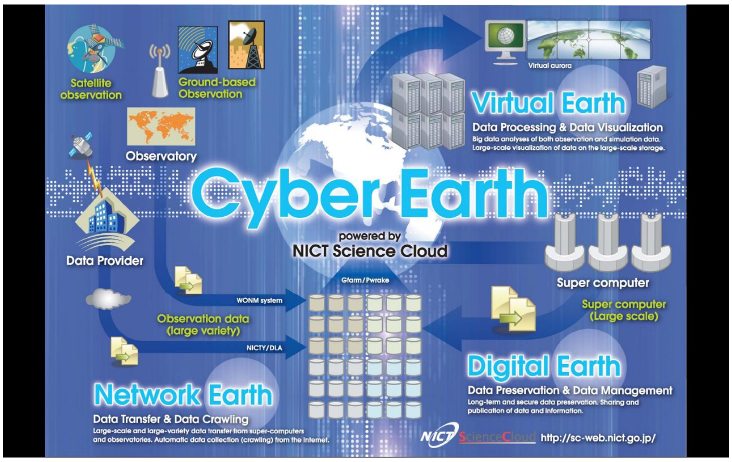
[1]NICT

In the present paper, the author proposed a concept of the Cyber Earth as a basic approach for the global understanding of the Earth system. In order for our global understandings from a variety of observation and simulation data of Earth sciences, we need a methodology to analyze huge size of big science data. The Cyber Earth is a concept to declare that, for our global understandings, mash-up of information and communication technologies for big data plays an important role. This concept is based on several technological ideas, such as data centric/intensive science, the fourth paradigm, science cloud, big-data science. All of the data, observation data and simulation data, are once transferred and stored on a science cloud system. Data preservation and data stewardship is important since most of the data is so precious that they are never observed again at the observed time and location. Big data processing, including visualization, is also important. The data processing must be applicable for any types of digital data from either Earth observation or simulation. Integrated data processing technology for such variety of data type is preferable.

The Cyber Earth is composed of three methodologies; the Network Earth, the Digital Earth and the Virtual Earth. The Network Earth is a concept that role of network is important for data transfer and collection to the cloud. For global monitoring we often build up global observatories on the Earth. Integrated operations and easy management of the remote sites are significant for labor-saving. The Digital Earth is a concept that long-term data preservation is one of the most expected functions to a science cloud. Data files must be saved and managed under DR (disaster recovery) environment. Easy data publication should be functionally synchronized with data preservation. The Virtual Earth is a concept that every digital data must be processed or visualized to be shown on the same framework with other data. Inter-disciplinary data preview, in space and/or in time, makes our global and functional understanding of the Earth system. Immersive visualization may work effectively to understand or discover any interactions between data.



Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

MIS31-08 Room:511 Time:May 2 11:00-11:15

Current trends of international assessments of greenhouse gas emission mitigation scenarios

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The IPCC 5th Assessment Report (AR5) are scheduled to be completed in 2014. The Working Group III assesses mitigation options and the report "Climate Change 2014: Mitigation of Climate Change", will be released in April 2014 after the approval in the 39th Session of IPCC. Scenario analysis and modeling exercise by the integrated assessment model (IAM) provide a key element in the AR5 report. A number of international inter-model comparison projects are formulated mainly in the United States and EU countries in an effort to make contribution to the IPCC AR5 report.

This paper introduces that the current trends of international assessments of greenhouse gas (GHG) emission mitigation scenarios with the key points which have been described in the AR5 and the key outcomes of the international IAM comparison projects. In addition, international research cooperation activities for harmonizing socioeconomic scenarios for the future IAM assessments, which is named SSPs (Shared Socioeconomic Pathways), will be introduced.

The Fourth Assessment Report (AR4) of IPCC WGIII which was published in 2007 provided six categories for broad ranges of several emission pathways provided by IAM estimations. The lowest level of GHG concentration stabilization is 445-490 ppm CO2eq and the emission pathways correspond to 85-50% reductions of global emission by 2050 relative to the 2000 level. The report summarized that the emission pathways will be expected to the equilibrium global mean surface temperature of 2.0-2.4C increase relative to pre-industrial level. The assessment had a strong impact on the international climate change negotiations and domestic measures of climate change response. Long-term target of 2C and halving global emissions by 2050 have been widely discussed in international negotiations such as UNCCC/COP and G8 after the release of AR4, while IPCC never recommends a specific target and policy.

A lot of assessments for emission reduction scenarios by IAMs particularly for deep emission reduction scenarios such as 450 ppm CO2eq, have been conducted after the AR4. The assessments also include many overshoot scenarios which are temporally over 450 ppm CO2eq and then achieve 450 ppm CO2eq in 2100 as well as 450 ppm stabilization scenarios, because current global emission increases are large due to the increases in developing countries, and it is difficult to develop emission reduction pathways with reality in near-term emissions for 450 ppm CO2eq stabilization without overshoot.

One of the inter-model comparison projects, AMPERE (Assessment of Climate Change Mitigation Pathways and Evaluation of the Robustness of Mitigation Cost Estimates) project which was funded by the European Commission provided the feasibility of significant emissions reduction for a variety of mitigation technology portfolios. The project assessed that the feasibility for deep emission reductions such as 450 ppm CO2eq and the emission reduction costs under several conditions of technology unavailability and the near-term emissions locked into by the Cancun pledges. With significant emission reduction until 2030, the required annual emission reduction to meet 450 CO2eq target diverges from the historical rates of change. If the emissions pathways are locked into the low ambitious Cancun pledges to 2030, further improvement is required after 2030. There are many infeasible results to meet the stringent target in model calculation, if there are technological constraints in the availability of CCS, nuclear and renewable energy particularly under the near-term emissions locked in. The emission reduction costs are also very high and almost double or more compared with the idealistic conditions. These assessments which consider realistic conditions in IAMs are one of the progresses after the AR4.

The AR5 of IPCC will includes such new assessments will make impacts on international climate policies after the release.

Keywords: climate change, global warming mitigation, emissions scenarios, IPCC, integrated assessment model

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Integrated assessment model structure and linkage with climate model

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1. History and basic structure of integrated assessment model

Integrated assessment model (IAM) has been developed as a tool to analyze climate change countermeasures. Edmonds-Reilly model in 1980s was the one of initial trials to indicate the importance of the relationship between climate change and energy issues, through explicit analysis of energy CO_2 and global warming. Since 1990s, model development has been active to evaluate comprehensive measures from interdisciplinary knowledge in climate change, energy system, land use, etc. The new keywords of the models developed are 'interdisciplinary', 'large scale', 'very long-term dynamics', 'scale integration'. These models are called IAMs because their scope is very wide in time, space and disciplines. For example, GRAPE model, developed by the GRAPE development team, consists of modules dealing with energy, climate, land use, macroeconomics and environmental impacts. Intergovernmental Panel on Climate Change (IPCC) working group III reviewed IAM intercomparison results such as economic impacts of Kyoto Protocol, multiple GHGs mitigation including non-CO_2 gases mitigation potential and its effects in the past assessment reports.

2. Linkage with climate model

There are various types of linkage of climate model in IAMs. Major categories are 'hard-link' and 'soft-link'. The former includes all equations and variables of climate module in the entire model structure, while the latter exchanges the information (e.g. GHG emissions) between climate module and other parts of the model.

DICE model, one region global model, is the one of initial famous IAMs. It uses hard-link optimization methodology and simple one-dimension climate model with two ocean layers and one atmospheric layer. Radiative forcing of CO_2 is calculated endogenously but other aggregated forcing values are exogenously provided. After obtaining the global mean temperature, macroeconomic damage feedback is assessed as the function of temperature rise.

It is great challenge to include large scale climate model in the hard-link type IAMs. Because of climate system nonlinearity and many constraints including inequalities, it is quite difficult to get solutions especially under dynamic climate constraints such as long-term forcing stabilization. Climate module of GRAPE includes carbon cycle representation of one-dimensional version of the ISAM, one of the reference model in IPCC WG I third assessment report. Global carbon stock is distributed to the atmosphere, ocean, and terrestrial biospheres. The ocean part has 40 deep layers and terrestrial biosphere has six boxes. Energy exchange among atmosphere and ocean layers are also modeled.

Recently, coupled analyses combining earth system model and IAMs are in progress in the area of climate impact assessment with fine mesh-scale, or climate feedback of energy consumption level, etc. Climate information is quite useful and essential in these assessments.

3.Future issues and summary

GHG reduction would not be on the track to avoid potential dangerous impacts to global climate change because it is difficult to get consensus in global climate policy. Adjustment to climate condition (i.e. 'adaptation') could be the realistic solution in the short to medium term. Vulnerability to climate change varies by region and economic condition, and climate information in the future is important to design regional adaptation policies.

'Geoengineering', such as solar radiation management (SRM) and carbon dioxide removal (CDR), is included in the IPCC working group I fifth assessment report sentences. Negative emission feasibility through implementation of CDR needs further considerations with low GHG emissions scenarios with assistance of climate models.

IAM has close and essential linkage with climate model from initial development stage, and more interaction are crucial to resolve global and regional agenda in the future.

Keywords: Integrated Assessment Model, Climate Model

MIS31-10 Room:511 Time:May 2 11:30-11:45

Integration of climate and economic modeling studies

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So far, there have not been many studies which integrate climate modeling and economic modeling research. The purpose of this presentation is to show one way to integrate climate and economic studies with regard to climate change issues. Here, we present an example of the integration of these two areas, which analyzes socioeconomic impact of achieving a specific radiative forcing level considering the uncertainties of Earth system models using a computable general equilibrium (CGE) model.

Although much uncertainty exists in climate system and simulations of future climate profiles with Earth system models (ESMs), it has not been evaluated in relation to socioeconomic aspects. In this study, we analyze the socioeconomic impact (including that on energy) of three emission pathways, all of which possibly achieve 4.5 W/m^2 of radiative forcing in the year 2100 within uncertainties estimated by an ESM of intermediate complexity (EMIC) tuned for full ESMs using a CGE model, a type of economic models. The model used here is a multi-regional and multi-sectoral recursive dynamic CGE model on a global scale, with energy and environmental components. Thus, the model is also called an integrated assessment model or IAM.

The emission pathways considered in this study are allowable emission pathways obtained by using an EMIC with the Representative Concentration Pathway 4.5 scenario. Here, we analyze the emission pathways of the 5th (lower bound), 50th (mean), and 95th (upper bound) percentiles of the weighted ensemble members in the parameter perturbation experiment. Different pathways are derived from different physical and biogeochemical properties. The global CO_2 emissions in 2100 and the cumulative CO_2 emissions in this century in the upper bound case are 5.1 GtC/yr and 917.6 GtC, while those in the mean case are 3.0 GtC/yr and 764.9 GtC respectively, and those in the lower bound case are 0.91 GtC/yr and 619.7 GtC respectively.

The results indicate that the socioeconomic impacts are larger in the lower bound emission pathway to achieve 4.5 W/m^2 as expected, although the economy and energy demand (both primary and final energy demand) increase continuously in this century. For example, the global gross domestic product (GDP) in each emission pathway is $212 trillion in the lower bound case, $217 trillion in the mean case, and $221 trillion in the upper bound case in 2100 ($30 trillion in 2001), which are 4.2 – 8.1% smaller than that of the reference scenario ($230 trillion in 2100). On the other hand, the global primary energy demand in 2100 in the lower bound case is slightly larger than in the mean case; this can be interpreted because biomass energy with carbon capture and storage technology is enhanced to achieve very low carbon dioxide emissions in the lower bound case. In a comparison between the upper bound and lower bound emission pathways, the carbon price of the latter is approximately three times higher in 2100. The GDP in the latter is 4.1% smaller than that in the former in 2100, which is equivalent to only a 0.042% decrease in the annual GDP growth rate. Thus, the socioeconomic impacts caused by ESM uncertainties, here evaluated by GDP and energy demand, are not insignificant but are smaller than the differences in the emission pathways to achieve 4.5 W/m^2.

Keywords: earth system model, computable general equilibrium model, climate change

MIS31-11 Room:511 Time:May 2 11:45-12:00

Model Inter-comparison projects of Integrated Assessment Models and the Collaboration with Impact Assessmemts

FUJIMORI, Shinichiro[1*] ; HANASAKI, Naota[1] ; TAKAHASHI, Kiyoshi[1] ; MASUI, Toshihiko[1] ; KAINUMA, Mikiko[1] ; HIJIOKA, Yasuaki[1] ; HASEGAWA, Tomoko[1]

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This presentation talks about two topics; namely model inter-comparison projects (MIP) of integrated assessment models (IAM) and the collaboration with impact assessments.

MIP of IAM is carried out by sharing main themes, assuming model conditions and parameter settings, and comparing results. The themes dealt with the last couple of years were, for example the influence of the technological availability (e.g. nuclear) and mitigation starting year on the mitigation cost. The outcomes are eventually summarized as special issues of international journals. The harmonization of the scenario assumptions is generally quite limited to narrative story. The numerical future socioeconomic conditions are dependent on individual models. This intends to encourage as many as IAMs participating MIPs since IAMs have several types and some variables which are exogenous parameters for some IAMs can be endogenous variables for others. The activities relevant to model validation have become much more important than before and some MIPs treat such themes. The activities are ongoing now and model documentations, development of model diagnostics protocol and comparison hind-casting with historical observation are discussed. In regard to the collaboration with Impact, Adaptation and Vulnerability (IAV) assessment, we can classify two types according to the way how the IAM is used. First is the case where IAMs are used as a provider of socioeconomic conditions to IAV. RCP (Representative Concentration Pathways) and SSP (Shared Socioeconomic Pathways) are well known such information. Hanasaki, et al. is an example and AIM/CGE provided information to the water assessment model H08. They assessed the water scarcity. Second is the case where IAMs assess climate change impacts by themselves. Hasegawa, et al. is an example and crop productivity model GAEZ calculated a potential crop productivity change and it is fed into AIM/CGE. They assessed a risk of hunger. The fields of water and agriculture overlap with the IAM coverage through land use and energy supply. We expect one of the possibilities for the further studies would incorporate transactions between them. All studies are made by the combination of emissions scenarios and the outcome of the Earth System Models (ESM). The release of SSP would encourage much more IAV studies.

Meanwhile, several issues might remain even after SSP processes are completed. Here we show two issues. First, SSPs exclude information relevant to climate mitigation and the case with climate mitigation would be different from the case without climate mitigation. The combination of the RCP and CMIP5 (Coupled Model Intercomparison Project Phase 5) is not consistent for such case. Second, we would face the case where the stabilization targets other than existing four RCPs needed to be assessed. The accuracy of the pattern scaling would be the key point. If the pattern scaling had an accuracy which is acceptable for IAV, the existing RCP and CMIP5 are available with the pattern scaling. Otherwise, a set of new climate scenarios is required. However, multi-model ensemble examination similar to CMIP5 takes extra a few years and it would be unrealistic for IAV. Hence, a specific combination of IAM and ESM in Japan (e.g. AIM/CGE and MIROC) associated with the new set of emissions scenarios might be one of the solutions. Although it would take many efforts in order to achieve it, we might be able to identify the usefulness for society and scientific novelty. We hope that this presentation would be one of the indications for such discussions.

Hanasaki, N. et al. A global water scarcity assessment under Shared Socio-economic Pathways ? Part 1: Water use. Hydrol. Earth Syst. Sci. 17, 2375-2391, doi:10.5194/hess-17-2375-2013 (2013).

Hasegawa, T. et al. Climate Change Impact and Adaptation Assessment on Food Consumption Utilizing a New Scenario Framework. Environmental science & technology 48, 438-445, doi:10.1021/es4034149 (2014).

Keywords: Integrated Assessment Models, Impact, Adaptation and Vulnerability, Model inter-compasion projects, Scenarios

MIS31-12 Room:511 Time:May 2 12:00-12:15

Climate and socioeconomic scenarios for climate change impact and adaptation assessments in Japan

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[1]National Institute for Environmental Studies

In order to assess the overall impacts of climate change on a nation and investigate effective adaptation measures, it is important to collect scientific understanding beyond academic disciplines, because impacts of climate change emerge every aspect of the society. Modeling is a widely accepted method to assess future climate change impacts: develop climate and socioeconomic environment assumptions in the future (scenarios), run statistical or process based models using the scenarios, and simulate the future situation for each subject and discipline. If a large number of modelers conduct simulations using a set of common scenarios, one can obtain a multidisciplinary national perspective of climate change impacts and potential adaptation strategy.

We have been conducting a strategic research project funded by the Ministry of Environment, which is named 'Comprehensive research on climate change impact assessment and adaptation policies' (Abbr.: S-8 project; Period: FY2010-2014; Project leader: Prof. Nobuo Mimura, Ibaraki University). In S-8 project, we are working on quantitative analyses of climate change impact on various sectors and adaptation in Japan for the purpose of supporting adaptation policy makings as well as of evaluating possibility of the society that can adapt to the anticipated climate change. The sectors covered in the project include water resource, coastal, disaster prevention, natural vegetation, agriculture, and human health. In S-8 project, climate and socioeconomic scenarios for Japan were discussed for climate change impact assessment and adaptation measures investigation by reviewing earlier literature and latest research activities. Based on the discussion, with keeping in step with the research schedule of the project, sets of scenarios were developed twice covering the whole Japan (the 1st version: March 2011, the 2nd version: November 2013), utilizing information available at the respective timings.

For the 2nd version of the S-8 scenario set, we used the climate projection of four climate models and three radiative forcing scenarios of the Coupled Model Intercomparison Project Phase 5 (CMIP5). We utilized the results of dynamical downscaling using a regional climate model which is consistent with the global scenarios after applying bias-correction techniques. Regarding the population projection scenarios, we developed nine scenarios taking into account not only uncertainty range of the total numbers but also uncertainty in its spatial distribution. We also proposed land use scenarios compatible with the population projections.

In the JPGU session, as a case of multidisciplinary collaboration, we will introduce the background and procedure of the S-8 scenarios development. We will also mention future challenges, which have been found in the scenario development process.

Keywords: climate change, climate change impact, adaptation, scenario

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Introduction to global climate change impact assessment

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In this presentation, a typical methodology used in modern climate change impact assessments is introduced. Some latest research activities to tackle key problems are discussed as well. This presentation mainly focuses on water resources sector at global scale, but the contents can be broadly applicable to other sectors and scales.

Climate change impact assessment requires scenarios on future climatic and socio-economic conditions and a model which quantitatively describes how the system of interest responses to those changes. In this presentation the latest scenarios namely CMIP5, RCP, and SSP are introduced. Then, a global water resources model H08 is explained which delineates the water cycle and water use of the globe.

Climate change impact assessment typically takes three steps. First, a model of interest is prepared and a simulation is conducted using the present climatic and socio-economic conditions. Second, some simulations are conducted using various future scenarios. Third, the differences in outputs between the future and present are examined since these are considered the impact due to climatic and socio-economic change. In this presentation, the geographical spread of water stressed regions and the number of affected population are discussed under 10 different future scenarios.

A number of challenges remain unsolved on climate change impact assessments. Two international research activities are highlighted to address some of the challenges. The first item is quantification of uncertainties in assessments caused by models. Although the models used in climate change impact assessment basically reproduce the present conditions well, none of them is perfect and outputs include errors. An ongoing international research project termed ISI-MIP is introduced which conducts climate change impact assessment by using a set of common scenarios and multiple models. ISI-MIP analyzes the variations in results and reasons. The second item is implementation of adaptation options. Although humans are expected to take adaptation measures when the impacts of climate become intolerable, adaption is seldom implemented in earlier simulations. Some pioneering works including adaptation are reviewed and future research directions are discussed.

Keywords: climate change, impact, global, water resources

MIS31-14 Room:511 Time:May 2 12:30-12:45

Impact assessment of natural disaster due to global warming

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Climate changes in give significant impacts on natural disasters such as typhoon, river flooding, storm surge, landside and etc. The different natural disasters require different forcing from GCMS. The spatial and temporal resolutions of forcing also give significant impact on the impact assessment of natural disasters. This study summarize current activity of impact assessment of natural disasters by SOUSEI program in Japan and discuss importance of cooperative research between GCM modelers and IAM group.

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Downscaling in Climate Information and applications

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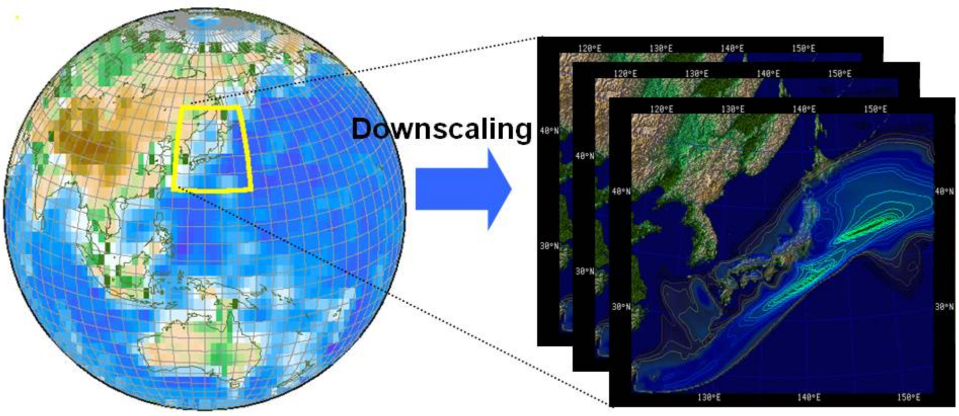
Climate effects caused by human activities will continue for centuries and natural climate influences have always been a risk. Mitigation is a complex, uncertain approach and will need at least several decades. It is necessary, therefore, to put adaptation together immediately. The impacts and potential applications of interest to the stakeholders are mostly at regional and local scales as the essential resources of water, food, energy, human health, and ecosystem function respond to regional and local climate. Climate information and services for Impacts, Adaptation and Vulnerability (IAV) Assessments are of great concern.

Users of climate scenarios produced by global climate models with coarse grid-spacing involve an inadequate mismatch of spatial scale. Downscaling technique is used to obtain the regional climate scenarios, especially in regions of complex topography, coastlines, and in regions with highly heterogeneous land surface covers where those results are highly sensitive to fine spatial scale climate processes. Dynamical and statistical downscaling techniques available for generating regional climate information have the respective strengths and weaknesses. To produce useful climate assessments for dicision-making, interaction between the downscaling community and the IAV community are necessary.

To facilitate its interaction, author will present,

- Overview of downscaling techniques in particular for regional climate modelling.
- current International activities (WCRP-CORDEX, etc.)
- Applications of downscaling in Japan from the ”REsearch program on Climate Change Adaptation (RECCA)” and the ”Program for Risk Information on Climate Change (SOUSEI)” sponsored by the Ministry of Education, Culture, Sports, Science and Technology(MEXT)

Keywords: Downscaling, Regional Climate Model, Climate Change, CORDEX, RECCA, SOUSEI



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Pattern scaling approach for generating regional projections of future extreme events associated with tropical cyclones

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The assessment of a wide range of greenhouse-gas-emission scenarios in climate change studies employs a simple climate model and pattern scaling based on ensemble projections with complex climate models for a few representative scenarios. The simple climate model deals with the global mean surface temperature as a prediction variable, and the pattern scaling specifies the spatial distributions of different climate variables with prescribed spatial patterns that do not depend on specific scenarios and time points. Although mean temperature and precipitation are typical variables specified by pattern scaling, the present study applies the concept of pattern scaling to extreme events, which are essential for assessing the impact of climate change. An example shown here is a scheme to assess changes in the minimum sea-level pressure and precipitation extreme of the most intense class of tropical cyclones that make landfall in Japan.

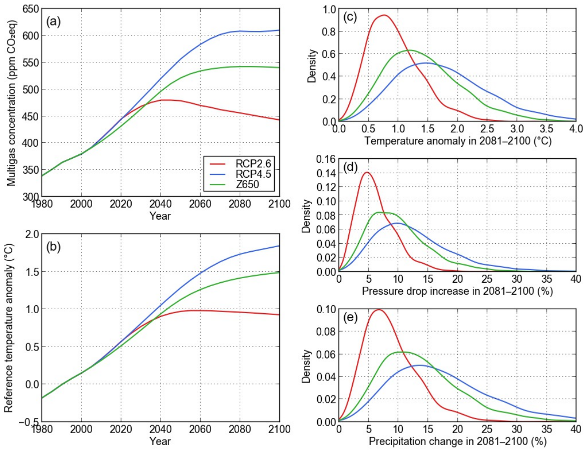
This scheme is based on the theory of potential intensity of tropical cyclones and general precipitation extremes. Although real tropical cyclones do not necessarily attain their potential intensities because of various environmental restrictions, the annual cycle of the lower limit of observed minimum sea-level pressures is well represented by climatological potential intensity. An extremely strong tropical cyclone with high societal impact forms only occasionally, within large fluctuations of natural climate variability, regardless of background warming. It is generally difficult to assess relatively small background changes in the intensity of such a rare event by observation statistics or numerical climate projections. The scheme overcomes this difficulty by focusing on large-scale thermodynamic conditions alone, with no consideration of the dynamic conditions that dominantly control the frequency of tropical cyclones. The thermodynamic conditions are scaled with global mean surface temperature anomalies by referring to results (patterns) of ensemble climate model experiments, and reflected in changes in the potential intensity of a target tropical cyclone. Then, the formulation of precipitation extreme incorporates the dynamic effect associated with the intensification of the target tropical cyclone by scaling the vertical structure of the base updraft with that potential intensity change, in addition to thermodynamic change in the amount of water vapor.

Figure 1 shows the assessment results for three different scenarios. The scheme formulates changes in the pressure drop and precipitation extreme of a target tropical cyclone as a function of global mean surface temperature anomaly. The temperature anomaly is calculated using a simple climate model, which has been developed separately, for 3000 cases for each scenario, taking the uncertainty of climate sensitivity into consideration. The computation load of the scheme is negligible, which enables the assessment of many scenarios with different conditions. The scheme also incorporates another uncertainty, not shown here, associated with the amplification of the upper-air temperature anomaly in the troposphere, which greatly affects the minimum sea-level pressure. Thus, the combination of a simple climate model and pattern scaling handles different types of uncertainties in a distinctive way, which is one of the advantages of this approach.

Figure 1: Probabilistic analysis of a target tropical cyclone for three different scenarios labeled RCP2.6, RCP4.5, and Z650. (a), (b): Secular change in the atmospheric multigas concentration and reference global-mean surface temperature anomaly, (c)-(e): Probability density function of the temperature anomaly, increase in pressure drop, and increase in precipitation extreme in 2081-2100 relative to 1981-2000.

Keywords: tropical cyclone, potential intensity, precipitation extreme, pattern scaling, simple climate model, emission scenario

MIS31-16 Room:511 Time:May 2 14:30-14:45



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Emission scenario dependency of pattern scaling and linear additivity of climate forcing-response relationship

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Human activities are changing the climate, and the consequent impacts on humans and ecosystems are becoming increasingly serious. It has been recognised that adapting to and mitigating anthropogenic climate change is a matter of immediate concern for the world. To inform adaptation and mitigation policies, it is essential to assess the impact of climatic changes under a wide range of scenarios for the stabilization of emissions of greenhouse gases (GHGs) and anthropogenic aerosols (sulfate, black carbon, and organic carbon aerosols). Impact assessments are based on climate change projections from coupled atmosphere-ocean general circulation models (GCMs). Therefore, uncertainties in climate projection propagate to impact assessments and affect subsequent policy decisions for adaptation and mitigation.

Due to the large computational costs of GCMs, only a limited number of emissions scenarios can be made for GCM simulations. To overcome this difficulty and obtain climate scenarios under a wide range of emissions scenarios, the so-called pattern scaling method is often used. By multiplying climate change patterns per 1K of global warming from an AOGCM (called a scaling pattern) by the global mean warming projections from a simple climate model, this method provides projections of precipitation, as well as other variables, at global and regional scales under many emission scenarios. Although the pattern scaling method is widely used, applicability of pattern scaling has been evaluated by only a few studies, and further investigations are clearly warranted.

The basic assumption of pattern scaling method is that scaling patterns are independent on the emission scenarios. Here I show a robust emission-scenario dependency (ESD) in scaling patterns of annual mean precipitation; smaller global precipitation sensitivities occur in higher GHG and aerosol emission scenarios in all the CMIP3 GCM. Different aerosol emissions lead to this ESD. The ESD of precipitation pattern potentially propagates into considerable biases in water resource assessments via pattern scaling.

It is possible to scale climate response patterns to individual forcing agents to obtain climate scenarios. This 'separated pattern' approach is useful to overcome the influences of the ESD. However, this approach requires care in its use. An important assumption of the separated pattern is that individual climate responses to individual forcing agents can be linearly added to obtain the total climate response to the sum of the forcing agents. We explored whether linear additivity holds in 5-year mean temperature/precipitation responses to various combinations of forcing agents in the 20th century and in a future-emissions scenario at global and continental scales. We used MIROC3 GCM, which includes the first and second indirect effects of aerosols. The forcing factors considered were well-mixed greenhouse gases, the direct and indirect effects of sulphate and carbon aerosols, ozone, land-use changes, solar irradiance and volcanic aerosols (the latter three factors were specified only in the 20th-century runs). By performing and analysing an enormous matrix of forcing runs, we concluded that linear additivity holds in temperature responses for all of the combinations of forcing agents at the global and continental scales, but it breaks down for precipitation responses in certain cases of future projections.

Keywords: Climate scenario, pattern scaling, impact assessment

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Evaluation of the nexus of risks under global climate change

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Climate change caused by the increase in atmospheric greenhouse gas has various impacts on human society and ecosystem. Features of the impacts have a large variety, and most part them is adverse impact (damage), although some part is positive impact (benefit) in some locations. It is very important to have reliable predictions of possible damage and benefit (= risks) under the climate change, in order for us to have effective adaptation and mitigation measures.

Future risks caused by the climate change can happen in various sectors. In addition, the various risks are connected across sectors. Especially, a " nexus " between the water, food and energy sectors is considered to be very important (Hoff 2011, Understanding the Nexus. Stockholm Environment Institute).

In this study, we are going to present our two activities related to the nexus of risks under the climate change. One is the investigation of qualitative feature of the various links of risks caused by the future climate change. We made a comprehensive list of the possible damage and benefit in the human society and ecosystem possibly caused by the future climate change (" item of risk "). This list is generated by the experts of climate, water resources, energy, food, health, security, industry, society, and ecosystem sectors. The experts of these fields in our group members choose all of the possible impacts related to the climate change based on their " expert judgment ". The number of items of risks is about 200 currently, such as " decrease in river runoff ", " decrease in crop productivity ", and " increase in forest fire ". Then, we also made a comprehensive list of the possible causal link between the items of risks as described above (" item of causal link "). This list is also generated by the experts of the various fields as described above. The number of items of causal link is about 400 currently, such as " decrease in river runoff " causes " decrease in crop productivity ". Finally, we visualize all of the causal links based on the network diagram using the Fruchtman & Reingold force-directed layout algorithm. Using the data of item of risks and causal links as well as the network diagram, we are going to discuss the nexus of the risks under the climate change.

The other topic is on the development of a " terrestrial integrated model " of our group. We coupled a global climate model called " MIROC5 " (Watanabe et al. 2010, J. Climate), global water resources model called " H08 " (Hanasaki et al. 2008, HESS), global terrestrial ecosystem model called " VISIT " (Ito and Inatomi 2012, Biogeosciences, and global crop model called " PRYSBI2 " (Iizumi et al. 2013, J. Agricultural Meteorology). The status of our model development and analysis on the nexus of the risks under the climate change as described above are discussed.

Keywords: climate change, risk, water resources, ecosystem, health, society

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Discussion on the challenges for comprehensive global warming studies

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Discussion on the challenges raised.

Keywords: Comprehensive Global Warming Studies