Climate Change in Southeast Asia

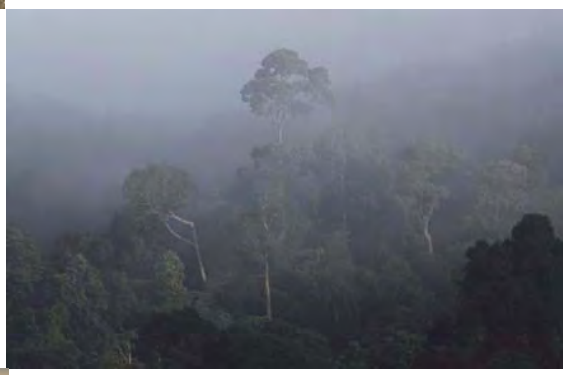
Outputs from GCM

環境省
Ministry of the Environment

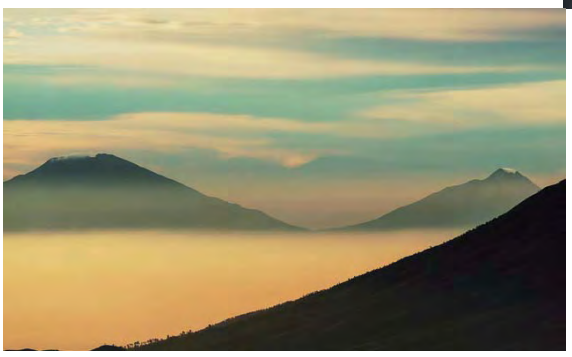
Vietnam/Rice terrace

Laos/Mekong river

Cambodia/Ancient ruin in tropical forests



Indonesia/Tropical forests in Borneo



Indonesia/Cloud sea in Java island

1. Outline

1.1 Climate change projections and the need for adaptation

In the 40th session of the International Panel on Climate Change (IPCC) held in October 2014, the Synthesis Report of the Fifth Assessment Report (AR5) of the IPCC was published. In the report, the importance of coping with risks of future climate change was once again pointed out, and it was demonstrated that both mitigation and adaptation measures are essential. A climate change projection dataset (CMIP5) based on a number of climate change projection models was used for the AR5, and the data have served as an important information source for quantitative projections and assessments of uncertainties.

In climate change projections, as well as impact assessments and adaptations performed and undertaken by each country in response to global approaches, the importance of quantitative assessments based on projection data has been increasing. For that reason, each country is using the above-mentioned CMIP5 data after downscaling them, or by establishing its own projection data.

Although climate change is affecting various sectors, the degree of certainty and the time scale of impacts vary from sector to sector. To establish appropriate adaptation strategies in such a situation, it is important to perform risk assessments and cost-benefit analyses, by appropriately handling and analyzing quantitative projection data.

1.2 Outline of global climate change projection data and its intention

Outline of the data

The Ministry of the Environment, with the cooperation of Japan Meteorological Agency, created a climate change projection dataset with a view to performing impact assessments and drawing up adaptation measures in Japan. This dataset is composed of two types of model output: global climate model outputs and regional climate model outputs. The global climate model outputs (hereinafter referred to as “GCM data”) are the results of calculations using an atmospheric model covering the entire world with an image resolution of about 60 km. The periods covered by the data are “20 years of the present climate” and “20 years of the future climate” (the end of the 21st century).

The most important feature of the dataset is that the results of calculations based on multiple cases are provided. We performed calculations on three cases for the present climate, and on three cases each for RCP2.6, RCP4.5 and RCP6.0 scenarios with different emissions scenarios, and on nine cases for RCP8.5 scenario, totaling 21 cases. The reason for performing calculations on multiple cases for the same scenario is to take into consideration uncertainties associated with future sea surface temperature patterns and a simulation method (which is called the “cumulus convection scheme”) of climate change projection models.

Intention of the data

Although the data is created mainly for performing impact assessments required to establish the climate change adaptation plan in Japan, the GCM data is based on projections covering the entire world. Therefore, basically the data are available in any countries.

The GCM data has the following features, compared to the results of other existing climate change projections.

- The GCM data has higher image resolution, compared to that of CMIP5’s global model outputs. The purpose of increasing image resolution is to enhance the reproducibility of orographic meteorological phenomena and tropical phenomena such as tropical cyclones.
- While model outputs by many organizations are available on CMIP5, the GCM dataset is based on projection results by a single model. However, multiple cases are calculated in the dataset in considearation of uncertainties, therefore, it is possible to assess uncertainties to a certain degree by the GCM data only.

2. Overview of climate change and its impacts in Southeast Asia

We briefly review climate conditions and observed climate change and its impacts in Southeast Asia as below, based on reports prepared by Indonesia[1], Vietnam[2], Laos[3], and Cambodia[4].

2.1. Climate change and its impacts in Indonesia

Climatic conditions

Indonesia is the world' s largest archipelagic state, with a coastline of 81,000 km and 13,667 islands. The country is considered to be vulnerable to climate change. People of Indonesia often suffer from climate extremes such as El Nino and La Nina. In years of El Nino, they are exposed to the risk of drought, and in years of La Nina they are exposed to the risk of heavy rains and floods.

Observed climate change

Surface temperature increases during the 20th century is considered not to have exceeded 1℃, although it is difficult to make an accurate estimate because observation data is not complete for Indonesia. Regarding changes in annual mean precipitation, it has increased in Sumatra Island, but it has decreased in some other places of the country. Therefore, the trend of precipitation in Indonesia is not homogeneous.

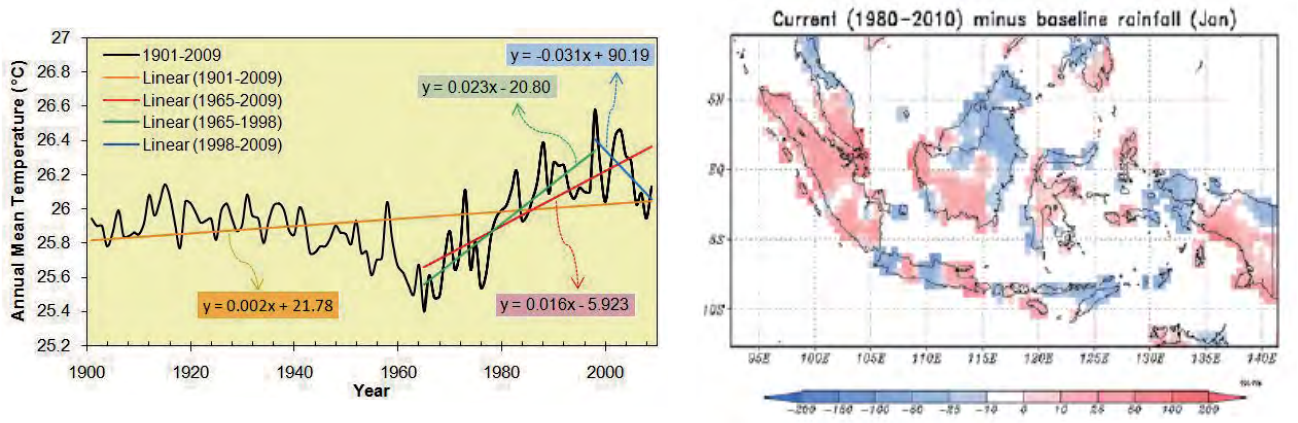


Fig. 1 Changes in annual mean temperature (left) and annual mean precipitation (right) in Indonesia (National Action Plan for Climate Change Adaptation, 2013, p.4-5)

Climate change impacts

- Impact on agriculture: Due to longer dry seasons caused by El Nino, significant damage is caused to farm products.
- Impact on water resources: It is predicted that the ratio of municipalities without sufficient water supplies will increase from the present 14% to 19% in 2025 and 31% in 2050 (under the SRES B1 scenario).
- Impact on coastal areas and the ocean: There are concerns about coral bleaching caused by El Nino and coastal erosion by sea level rise and high waves.
- Impact on health: There are concerns about the increase and spread of vector borne diseases such as dengue fever, malaria, and diarrhea.

1 Descriptions about Indonesia are based on the following literature.
"National Action Plan for Climate Change Adaptation (RAN-API): Synthesis Report", Ministry of Environment (2010),
"Indonesia Second National Communication Under The United Nations Framework Convention on Climate Change", Republic of Indonesia (2013)

2 Descriptions about Vietnam are based on the following literature. "National Strategy on Climate Change", Government of Vietnam (2011), "Vietnam's Second National Communication to the United Nations Framework Convention on Climate Change", Ministry of Natural Resources and Environment (2010)

3 Descriptions about Laos are based on the following literature.
"The Second National Communication on Climate Change: Submitted to The UNFCCC", Laos PDR (2013)

4 Descriptions about Cambodia are based on the following literature. "Cambodia's Initial National Communication", Ministry of Environment (2002)

2.2. Climate change and its impacts in Vietnam

Climatic conditions

Vietnam has a large land area extending north to south with a long coastline, and is exposed to serious risks associated with weather and climate change. Because of its vulnerability, various measures have been taken to mitigate the impacts of drought, floods, and rainstorms. For the past 50 years since 1960, the sea level rise of approx. 20cm was observed in Hon Dau Oceanographical station.

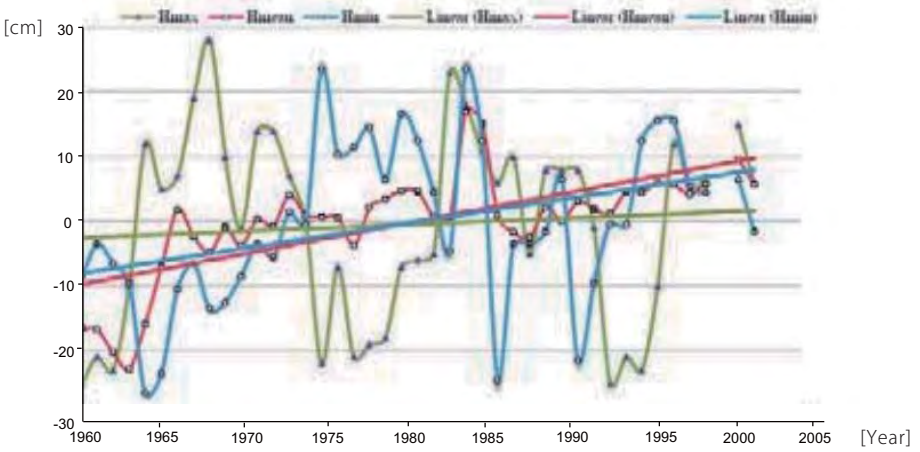


Fig. 2 Changes in sea level at Hon Dau Oceanographical station (Vietnam' s Second National Communication, 2010, p.60)

Observed climate change

The mean temperature has increased 0.5-0.7℃ during the past 50 years, and the sea level has increased 20 cm during the same period. The country has been suffering serious damage from El Nino and La Nina events. It is said that the country had 9,500 fatalities during the 10-year period 2001-2010 and lost 1.5% of its GDP due to natural disasters such as floods, landslides and droughts.

Climate change impacts

- Impact on agriculture: Since the scale of agricultural land is generally small and most of the land is located in low coastal areas, there are concerns about damage to farm products by the intrusion of salty water due to sea level rise.
- Impact on water resources: There are concerns about a deterioration of water quality and water shortages resulting from increased occurrences of drought due to climate change.
- Impact on aquaculture: There are concerns about the impact on aquaculture of frequent rainstorms and sea level rise. There are also concerns about occurrences of epidemics associated with water temperature increases.

2.3. Climate change and its impacts in Laos

Climate change impacts

In Laos, the mean temperature has increased 0.05℃ every year for the past 40 years. Regarding the rainfall pattern of this country, a larger difference in total precipitation between the rainy season and the dry season has been observed. The most frequent natural hazard is floods, and this is considered to be the cause of diseases such as dengue fever, cholera, and diarrhea.

2.4. Climate change and its impacts in Cambodia

Climate change impacts

Due to the monsoon climate, this country has two distinct seasons: a rainy season (May-October) and a dry season (November-April). As the country is surrounded by mountains, it seldom suffers serious damage from typhoons, etc. However, there are concerns that increase of flood frequency due to climate change will lead to the impact on the cultivation of rice, which is the main farm product in the Mekong River basin.

3. Climate change projections in Southeast Asia

Based on the GCM data, we calculated future changes in temperatures and precipitation in Southeast Asia.

3.1. Projections of temperature

Fig. 3 shows changes in temperatures in the area of Southeast Asia. Temperature has an increasing tendency in all scenarios and cases. There is little local difference in patterns of temperature increase, and temperature is increasing uniformly, by and large.

Fig. 4 shows changes in average temperatures in Indonesia, Vietnam, Cambodia, and Laos. Changes during the period 2080-2100 for each case are shown. In every scenario, there is a clear tendency of temperature increase. In the case of the RCP8.5 scenario, in which emissions are the largest, the magnitude of temperature increase is about 3-5℃. (For reference, the increase in global mean surface temperature based on the same data is about 3.5-4℃.)

3.2. Projections of precipitation

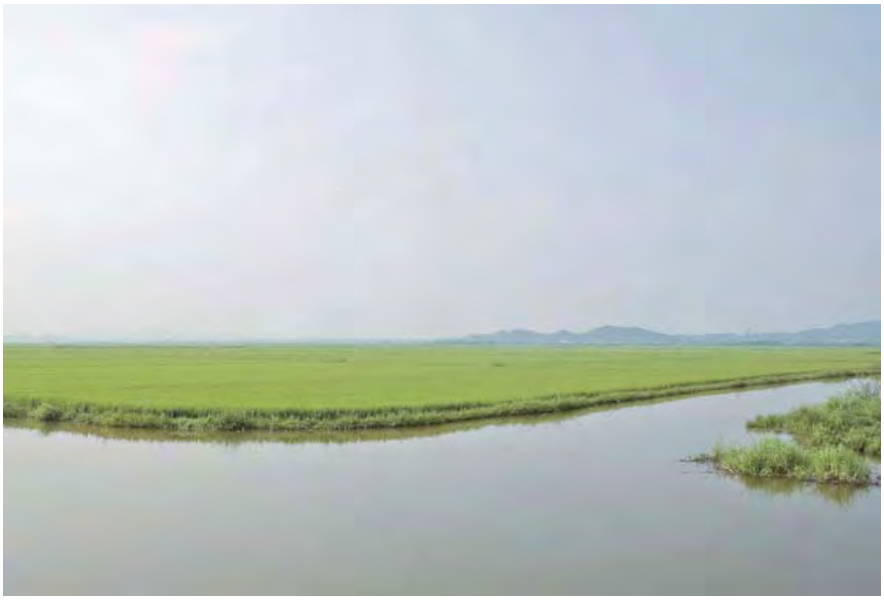
Fig. 5 shows changes in the annual precipitation in the area of Southeast Asia. Changes are expressed by the ratios against the present climate. Unlike the case of temperature, there are both areas where the amount of precipitation shows an increasing tendency and where that shows a decreasing tendency; also, there are many areas with high uncertainties (areas where no meshing is provided on the map).

Fig. 6 shows changes in precipitation in each of Indonesia, Vietnam, Cambodia, and Laos. The range of changes for the period 2080-2100 for each case are shown. In every scenario, the degree of uncertainty is high, and in the case of the RCP8.5 scenario, precipitation has an increasing tendency in three countries except Laos.

Fig. 7 shows the tendency of changes in precipitation by season under the RCP8.5 scenario. It is observed that the increasing and decreasing tendencies are reversed by the seasons.

3.3. Reference: Reproducibility of the present climate

To verify the validity of the climate model, we compared the mean temperature and precipitation at the present period to an observation data (Fig. 8). Relative tendencies within the Southeast Asian region seem to be reproduced well generally, however there are some differences in the local scale.



Paddy fields in Vietnam

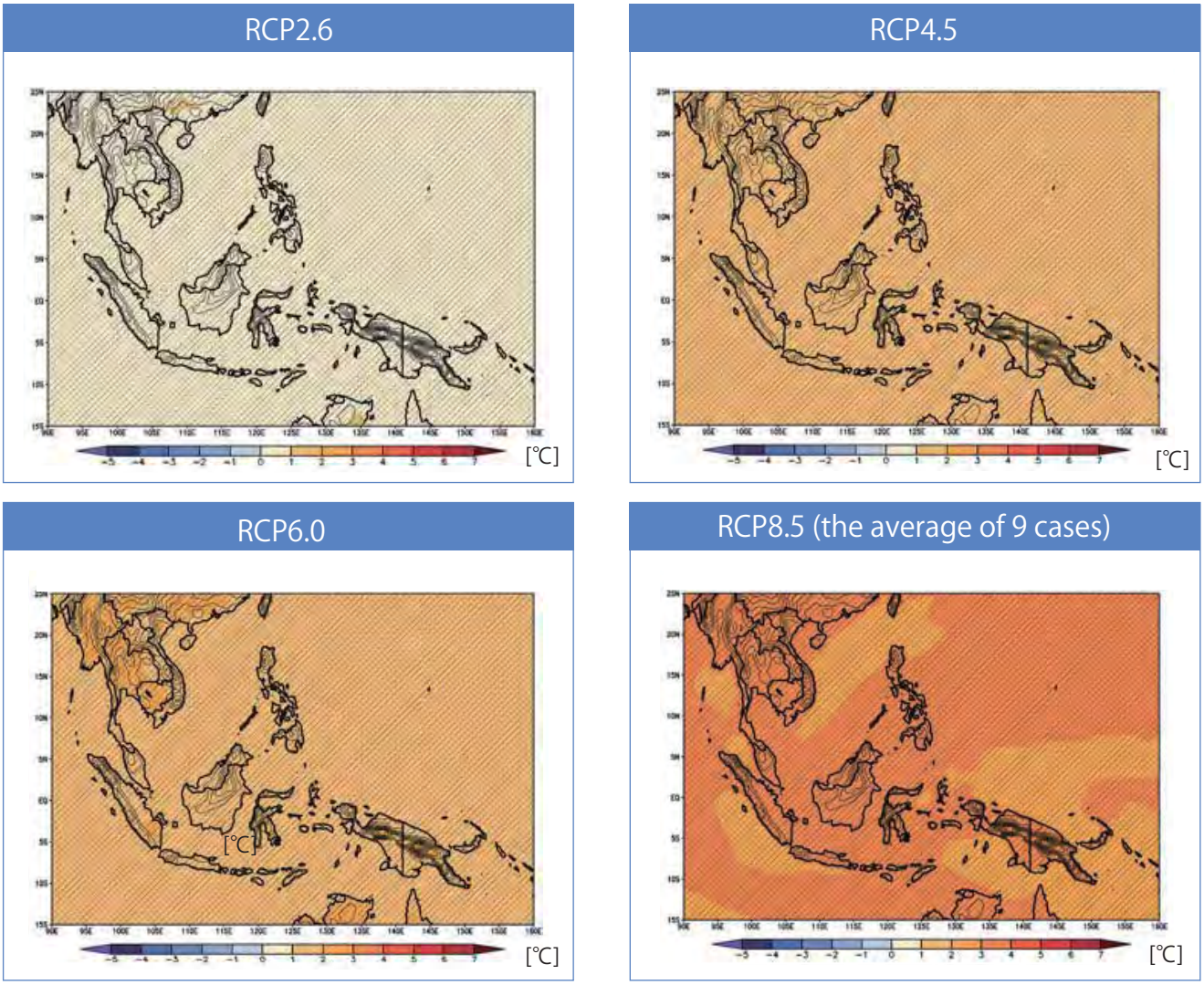


Fig. 3 Changes in annual mean surface temperatures (℃) in Southeast Asia under each RCP scenario
Differences in temperatures between present climate (1984-2004) and future climate (2080-2100) are shown. Colors indicate average values of the three cases under the RCP2.6, 4.5, and 6.0 scenarios, as well as those of the nine cases under the RCP8.5 scenario, and the meshing indicates the areas where the tendency of future changes agrees among all cases (areas with high confidence). For reference, the topography of the climate model is shown with contour lines (the topography is modeled; therefore, it may differ from the actual topography).

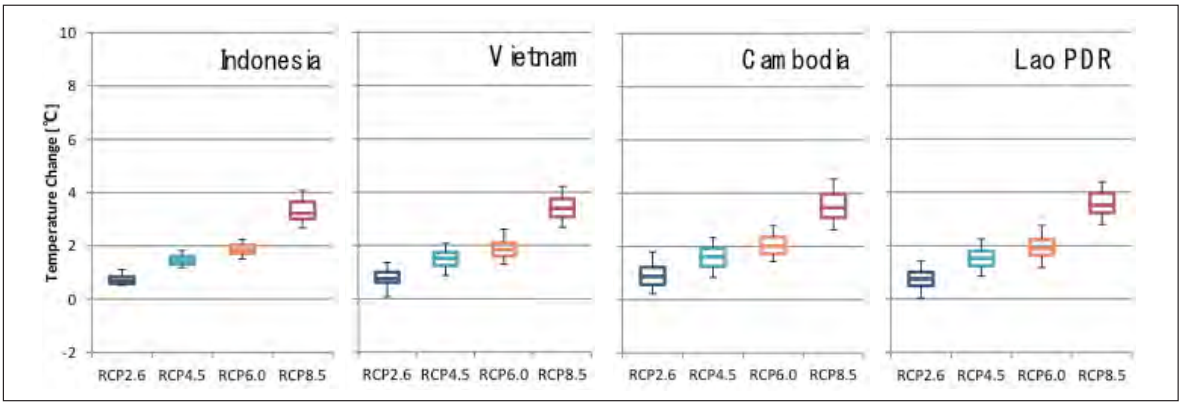


Fig. 4 Changes in annual mean surface temperatures (℃) under each RCP scenario in Indonesia, Vietnam, Cambodia, and Laos
Summary of the magnitude of temperature increases for each RCP scenario. Box plots indicate 25-75 percentile ranges and central values, and error bars indicate 5-95 percentile ranges. The magnitude of temperature changes is indicated by the difference from the mean temperatures of the present climate (1984-2004). For each RCP scenario, aggregations are made for all years and for all cases.

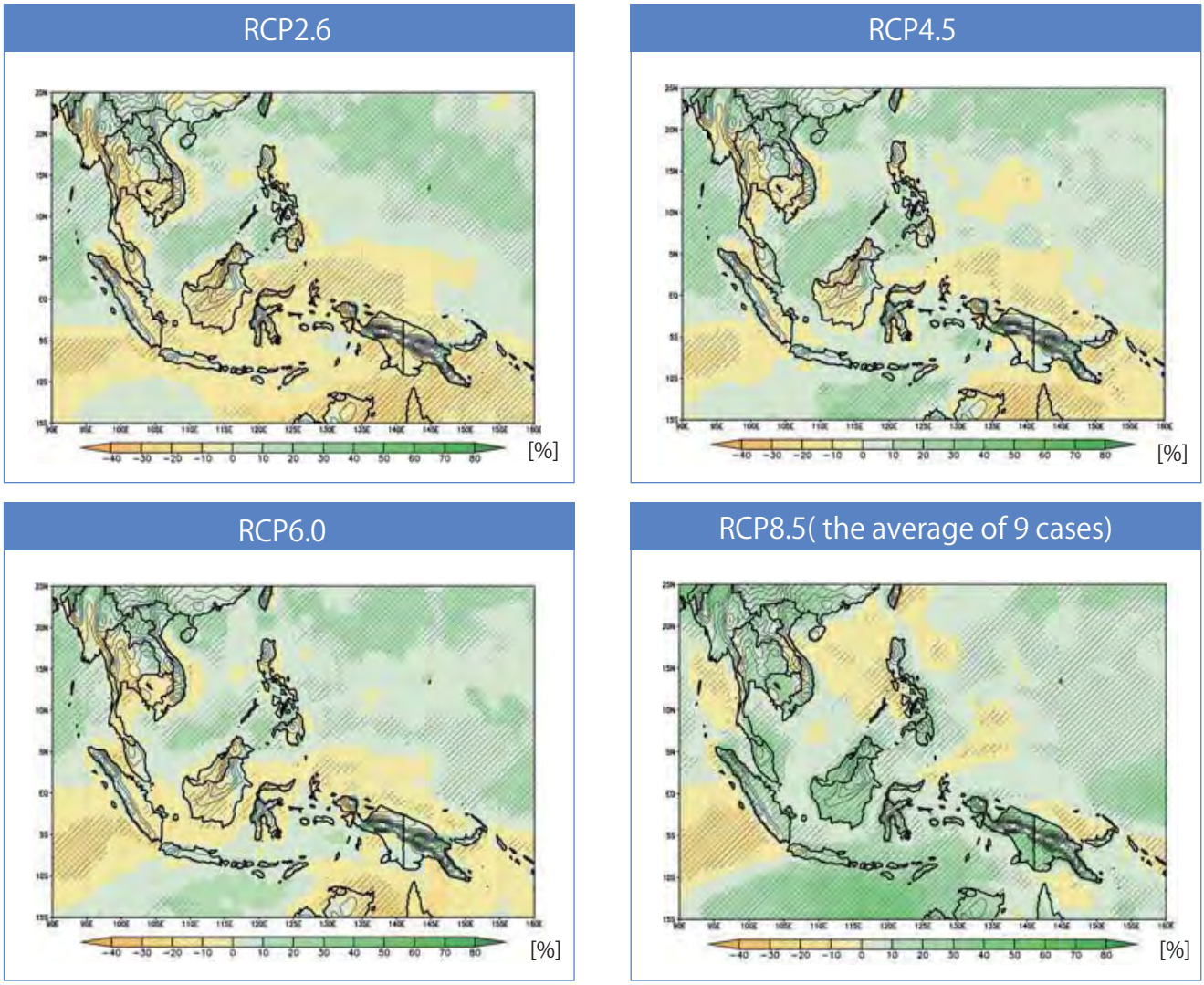


Fig. 5 Changes (%) in annual mean precipitation under each RCP scenario in Southeast Asia
Differences in precipitation between present climate (1984-2004) and future climate (2080-2100) are shown. Colors indicate average values of the three cases under the RCP2.6, 4.5, and 6.0 scenarios, as well as those of the nine cases under the RCP8.5 scenario, and meshing indicates the areas where the tendency of future changes agrees among all cases (areas with high confidence). For reference, the topography of the climate model is shown with contour lines (the topography is modeled; therefore, it may differ from the actual topography).

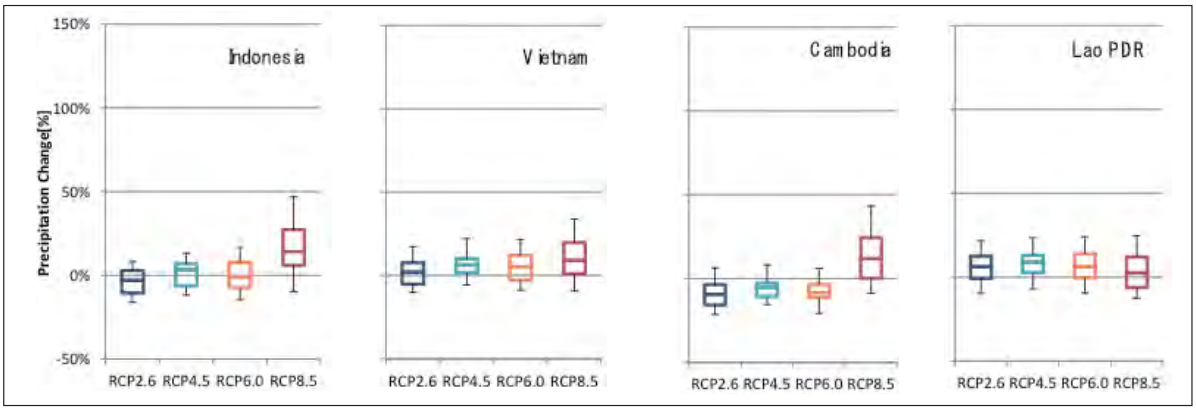


Fig. 6 Changes (%) in annual mean precipitation under each RCP scenario in Indonesia, Vietnam, Cambodia, and Laos
Summary of the changes in annual mean precipitation for each RCP scenario. Box plots indicate 25-75 percentile ranges and central values, and error bars indicate 5-95 percentile ranges. The magnitude of precipitation changes is indicated by the difference from the mean precipitation of the present climate (1984-2004). For each RCP scenario, aggregations are made for all years and for all cases.

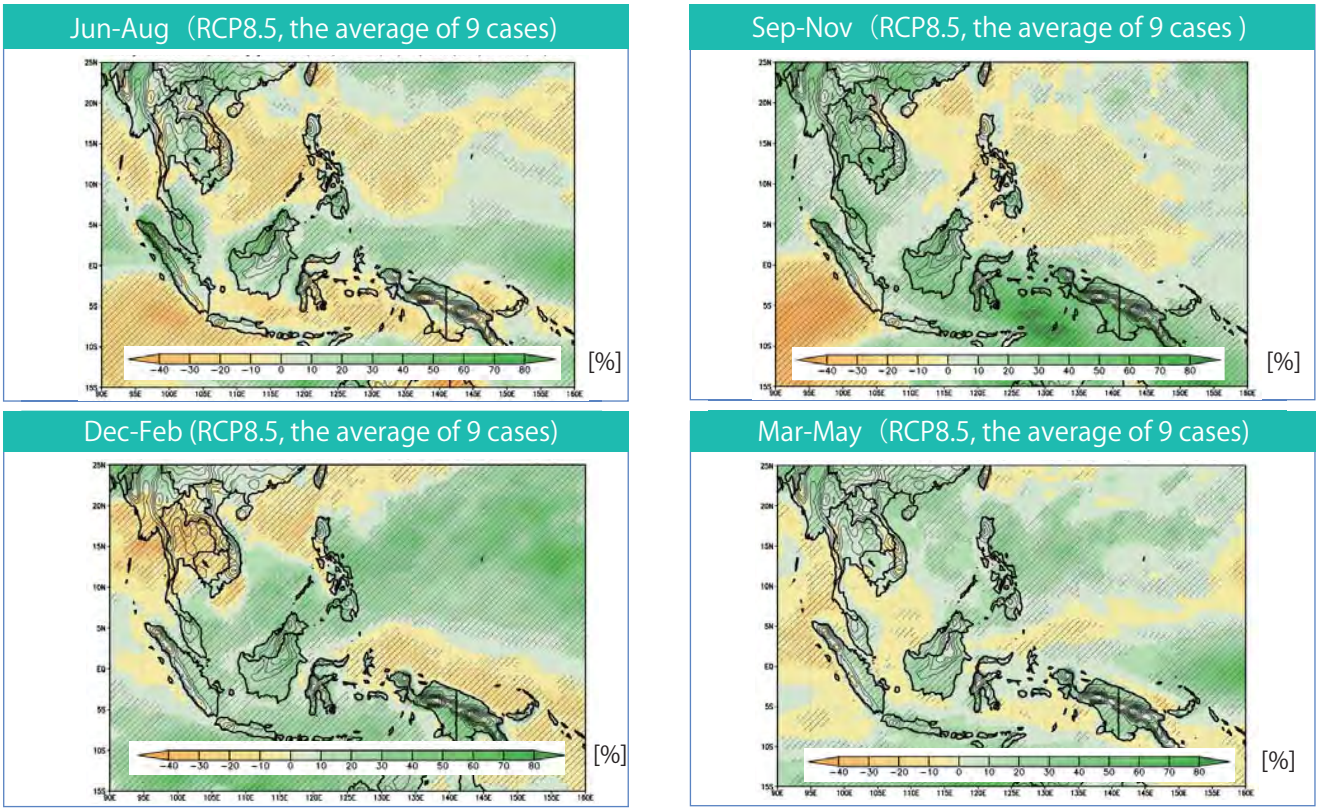


Fig. 7 Changes (%) in precipitation by season in Southeast Asia
Differences between present climate (1984-2004) and future climate (2080-2100) under the RCP8.5 scenario are shown. The meshing indicates the areas where the tendency of future changes agrees among all cases (areas with high confidence). For reference, the topography of the climate model is shown with contour lines (the topography is a modeled and therefore, it may differ from the actual topography).

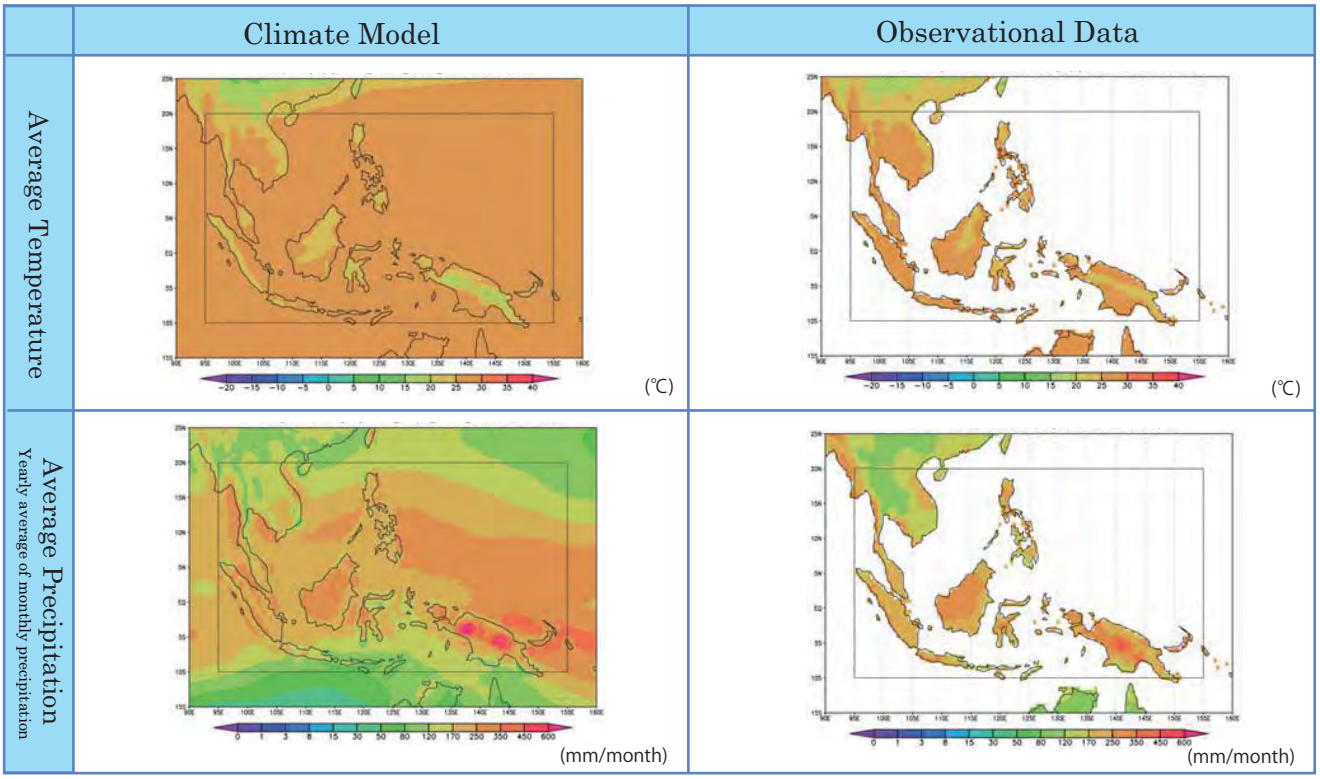


Fig. 8 Reproducibility of temperatures and precipitation in the present climate
Comparison between the average values of the present climate (1984-2004) based on the climate model and observed data during the same period (CRU_TS3.21). There are differences between model altitude data and actual altitude data, but no altitude corrections are made on these maps. Accordingly, we need to note that some differences in temperature may be generated because of such differences in altitude data.

4. Summary

As can be seen from the results in this publication, it is possible to grasp future climate changes in each region based on GCM data. Although the results use only fundamental variables, the dataset contains other variables as well.

The results in this publication do not replace the existing dataset (CMIP5 etc.), but rather can be used complementarily. From the features of the data that resolution is relatively high and multiple cases are studied, we consider that it can be used as a good dataset to grasp the situation of climate change in individual countries, and also as input data for climate change impact assessments.

The Ministry of the Environment Japan (MOEJ) hopes that this dataset will contribute to promoting climate change adaptation planning in all countries in the world.

■ Specifications of GCM data and data access

Specifications of calculation of climate projections

(Published in FY2014)

Item	Content
Name	Global Climate Change Projection Data by MOEJ (in cooperation with JMA)
Model name	MRI-AGCM3.2H
Model type	Atmospheric model
Horizontal resolution	About 60 km
Emissions scenarios	RCP2.6, RCP4.5, RCP6.0, and RCP 8.5
Calculation period	Present climate: September 1984 - August 2004 Future climate: September 2080 - August 2100
Grid points	640 × 320 (horizontal) and 60 layers (vertical)
Cumulus convection scheme	Yoshimura scheme/Kain-Fritsch scheme/ Arakawa-Schubert scheme
Main input conditions	Concentration of greenhouse gasses, ozone, and aerosols, sea surface temperature, sea ice concentration, and sea ice thickness

Data access

■ This dataset is stored in the "Data Integration and Analysis System" (DIAS) implemented by the "Program for Integration and Fusion of Earth Environment and Observation Information" of the Ministry of Education, Culture, Sports, Science and Technology, and is published. Registered users of DIAS can access and acquire data on the following website.

■ Data access website (registration required)
Global Climate Model Calculation Results (dataset ID: GCM60_ADAPT2013

http://dias-dss.tkl.iis.u-tokyo.ac.jp/dl/storages/filelist/dataset:214

Forests of Vang-Vieng in Laos

Mountain region in Vietnam

Agricultural products in South East Asia

Acknowledgements

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Design　：D Japan, Inc.

Climate Change in Southeast Asia

Outputs from GCM

Cover: Tropical rainforest in Borneo (Indonesia)

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