Developing Regional Climate Change Scenario and Dilemma in Climate Change Adaptation Planning

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Abstract: *Long term climate projection at high resolution is fundamental dataset for climate change study, especially assessing impact of climate change at local scale. This future climate projection, which shows future climate of Southeast Asia countries at resolution of 20x20km up to the end of 21st century, is result of dynamic downscaling process using regional climate model from Hadley Centre, The Met Office of United Kingdom, to simulate high-resolution climate data for the region based on dataset from global circulation model ECHAM4 GCM - A2 greenhouse gas emission scenario. Result from regional climate model shows that wide coverage of Southeast Asia region tends to be warmer and duration of warm period will extend substantially in the future, especially in the latter half of the century. Even though, the warming up of temperature is detected for both daily maximum temperature and daily minimum temperature, but daily minimum temperature tends to have higher trend. Precipitation tends to fluctuate in the first half of century but shows increasing trend with higher intensity, which will be clearly seen in latter half of the century where there will be higher precipitation throughout the region. Data from this future climate projection can be used to assist climate change adaptation planning; however, it has to be used in the context of future climate scenario in order to avoid dilemma in planning process.*

Keywords: climate change, Southeast Asia, regional climate model, PRECIS, ECHAM4

INTRODUCTION

Climate change, which is induced by global warming effect, has become a global concern as it may have many consequences on various systems and sectors that may threaten human wellbeing (IPCC, 2001). Understanding climate change would be foundation for proper planning on adaptation measures to cope with future risk. However, global warming is a slow process and it would need rather long-term future climate projection to be able to clearly detect the change in future climate pattern (IPCC, 2007), therefore, long-term future climate projection is ground rule for assessment of climate change impact on certain sector in specific area, particularly at the local scale. Global circulation models (GCMs) were developed and have been used to simulate future climate condition, but most of the simulations, especially those GCMs that were used in the IPCC Assessment Report 4, were conducted in coarse scale due to limitation in the technology which is not quite effective for the use in climate change impact assessment at local scale and high resolution future climate data is required. Typically, there are three types of technique for obtaining high resolution regional climate change projections: statistical, dynamical and hybrid (statistical-dynamical) techniques. The use of Regional Climate Model or RCMs falls into the dynamical category. A regional climate model (RCM) is a downscaling tool that adds fine scale (high resolution) information to the large-scale projections of a global general circulation model (GCM). GCMs are typically run with horizontal scales of few hundred kilometers; regional models can resolve features down to much smaller scale, e.g. 50km or less. This makes for a more accurate representation of many surface features, such as complex mountain topographies and coastlines (Jones et al, 2004). This paper discusses approach and result of dynamic downscaling of GCM data using regional climate model to develop high resolution future climate change scenario for mainland Southeast Asia countries over the 21st century. Moreover, the discussion also cover the proper use of future climate projection data for climate change adaptation planning in proper context in order to avoid dilemma in planning process.

CLIMATE CHANGE SCENARIO DEVELOPMENT METHODOLOGY

The high resolution climate projection for the mainland Southeast Asia countries was developed based on dynamic downscaling technique by using regional climate model (RCM) namely; PRECIS. PRECIS is a regional climate model that was developed by Hadley Centre for Climate Prediction and Research, The Met Office, UK. It can be used as downscaling tool that adds fine scale (high resolution) information to the large-scale projections of a global general circulation model (GCM). It has been ported to run on a PC (under Linux) with a simple user interface, so that experiments can easily be set up over any region. PRECIS was developed in order to help generate high-resolution climate change information for as many regions of the world as possible. These scenarios can be used in impact, vulnerability and adaptation studies. (Simson et al, 2006)

The GCM dataset which was used as initial dataset for the simulation was ECHAM4[1] model from the Max-Planck-Institute for Meteorology (MPI), Germany. It was based on SRES A2 Greenhouse Gas (GHG) scenario, which represents the scenario that atmospheric greenhouse gas would increase at relatively high rate (IPCC, 2000). Period of simulation covers the years 1970 – 2100. The simulation provides output with daily timestep throughout the simulating period. The downscaling process was set to resolution of .22º and output was rescaled to 20x20km resolution. Domain coverage is lat. 0-35ºN and lon. 90º-112ºE (see Figure 1).

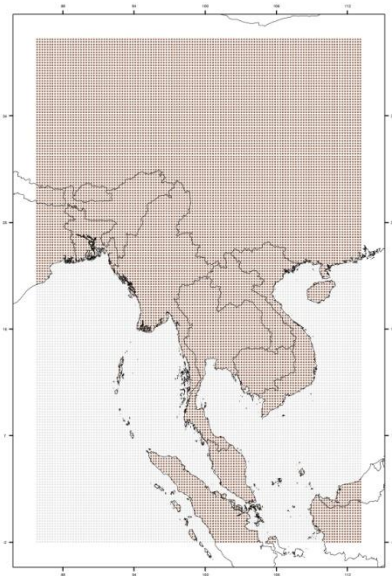


Figure1: Domain of the future climate projection

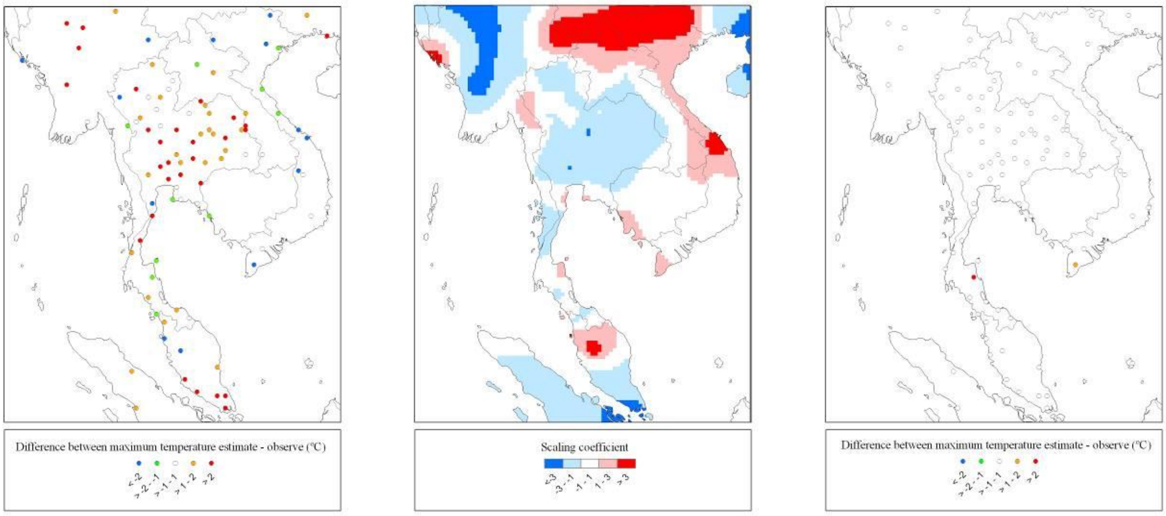
The results from PRECIS regional climate model were verified by comparing against data from observation stations and the period of 1980s was selected as baseline for verification. The comparison shows that the result of RCM is somewhat differ from the observed weather data.

1 ECMWF Atmospheric General Circulation Model coupled with University of Hamburg Ocean Circulation Model (http://www.ipcc-data.org/is92/echam4_info.html)

PRECIS model tends to overestimate temperature and underestimate precipitation in many areas. "Rescaling" technique was developed and applied to the simulation result from PRECIS model in order to adjust the simulated data to better match real condition based on observation data.

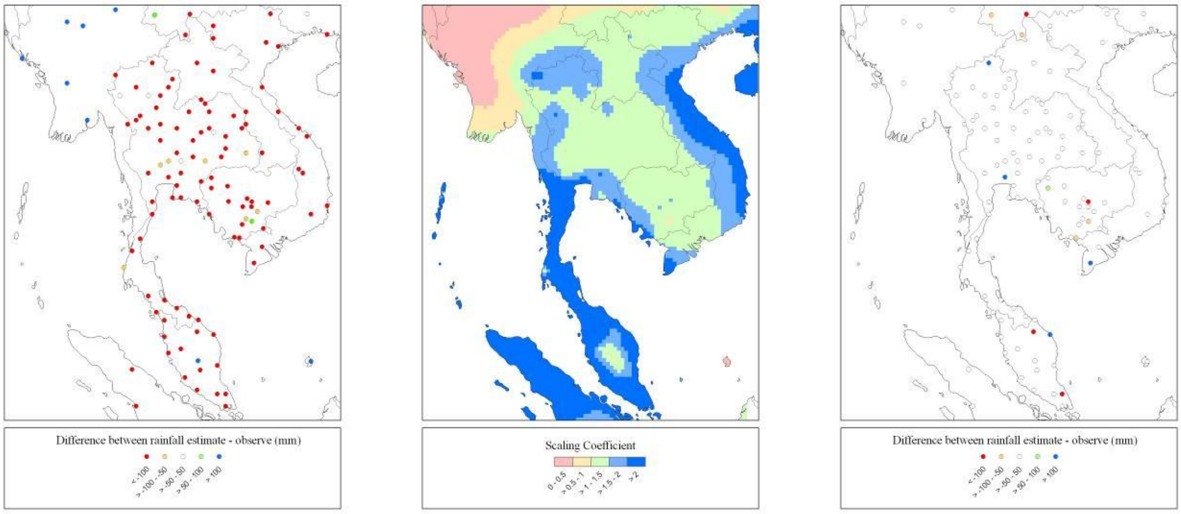
Rescale technique, which was developed and used in this study, is based on the analysis in the difference of key climate parameters, i.e. temperature and precipitation, between simulated and observation data from 130 weather observation stations in Thailand, China, India, Myanmar, Lao PDR, Vietnam, Malaysia and Indonesia. The rescaling process is the process to 'suppress' and 'lift' the simulated data throughout the simulation domain by using coefficient value that was calculated from different of average values of key weather parameters between simulated and observation data during 1980s at number of station grids in the simulation domain and those values at the station grids were interpolated using kriging technique to get the coefficient value for every grids that will be used to rescale the simulated result of each climate grid throughout the simulation domain over the period of the simulation.

By applying this technique, simulated data of key climate parameters from the simulation were rescaled to be closer to the observation value. The figures below show the comparison of maximum temperature (Figure 2) and precipitation (Figure 3) between PRECIS RCM simulation and observation at various locations where observation stations are located (A), the coefficient value for rescaling (B) and comparison after the rescaling process (C).



A **B** **C**

Figure 2: Maximum temperature rescaling process - (A) Comparison between simulation result and observation, (B) scaling coefficient from interpolation of values from comparison in (A), (C) Comparison between rescaled simulation result and observation.

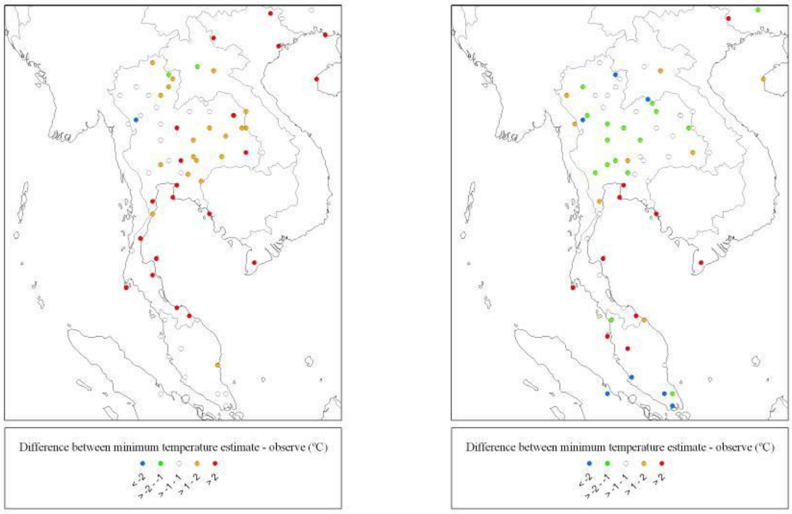


A **B** **C**

Figure 3: Annual precipitation rescaling process - (A) Comparison between simulation result and observation, (B) scaling coefficient from interpolation of values from comparison in (A), (C) Comparison between rescaled simulation result and observation.

Output from rescaling process, as shown in Figure 2 and Figure3, shows improved comparison result between rescaled simulation result and observation data. The rescaled maximum temperature is more realistic when compare to observed data, which the different from the observation falls into the range of +/- 1ºC and different in annual precipitation falls within the range of +/- 50mm per annum. This rescale coefficient pattern was used to rescale future maximum temperature throughout the simulation period.

The regional climate model also overestimates minimum temperature and rescale process was also applied to the minimum temperature simulation data. However, the rescale process for minimum temperature is based on the rescaled result of maximum temperature. The different value between simulated maximum and minimum temperature of each grid from regional climate model output was applied to the rescaled result of maximum temperature to get rescaled minimum temperature. The rescaled minimum temperature is still slightly underestimated in some area, especially in the in-land area of the simulation domain, and overestimated in the area near the coastline. See Figure 4.



A **B**

Figure 4: Minimum temperature (A) Comparison between simulation result and observation and (B) Comparison between rescaled simulation result and observation.

SUMMARY OF CLIMATE CHANGE SCENARIO FOR MAINLAND SOUTHEAST ASIA

Simulation result from PRECIS regional climate model, after rescaling process, shows that average maximum temperature as well as average minimum temperature in Southeast Asia region in the future will increase which tend to be more prominent from the middle of the century onward. The trend of warming temperature is clearly seen in the central plain of Thailand and most part of Cambodia as well as Malaysia peninsular. See Figure 5 & 6.

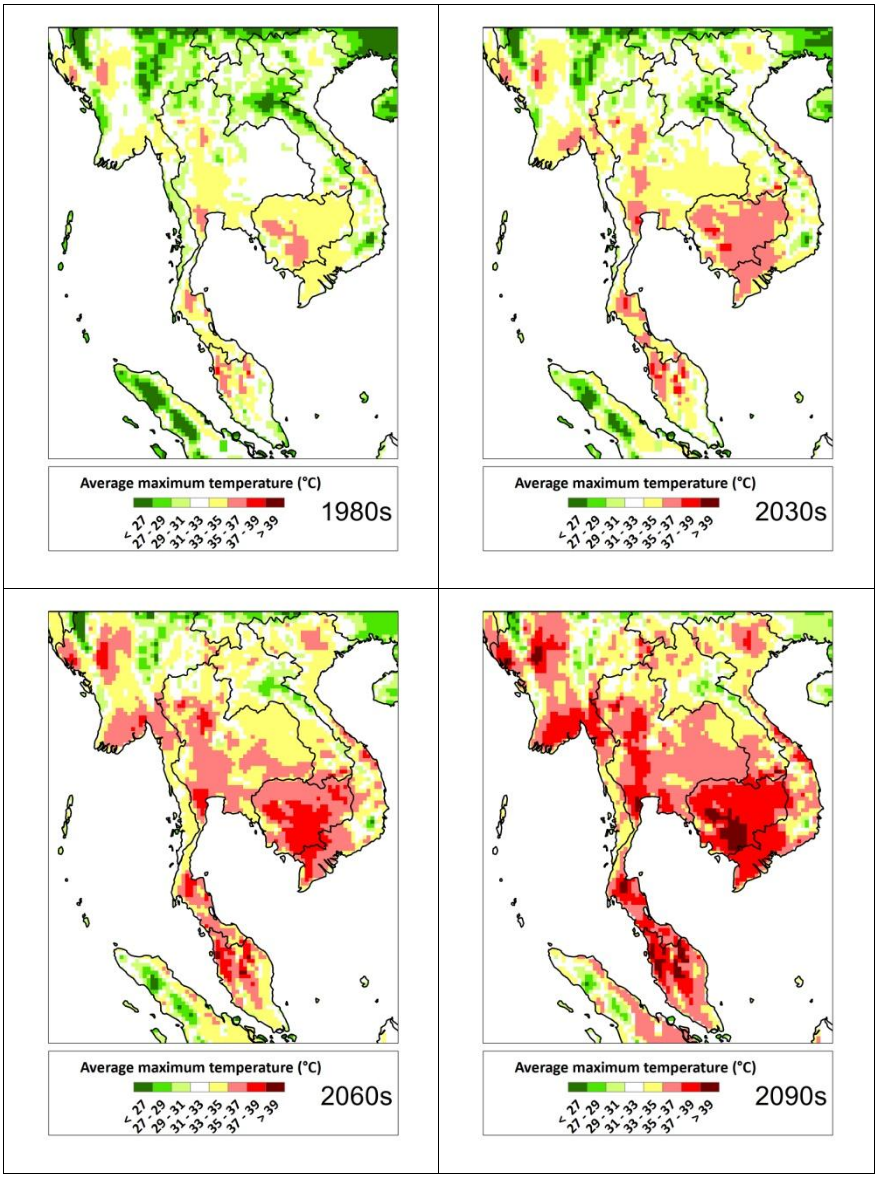


Figure 5: Average daily maximum temperature

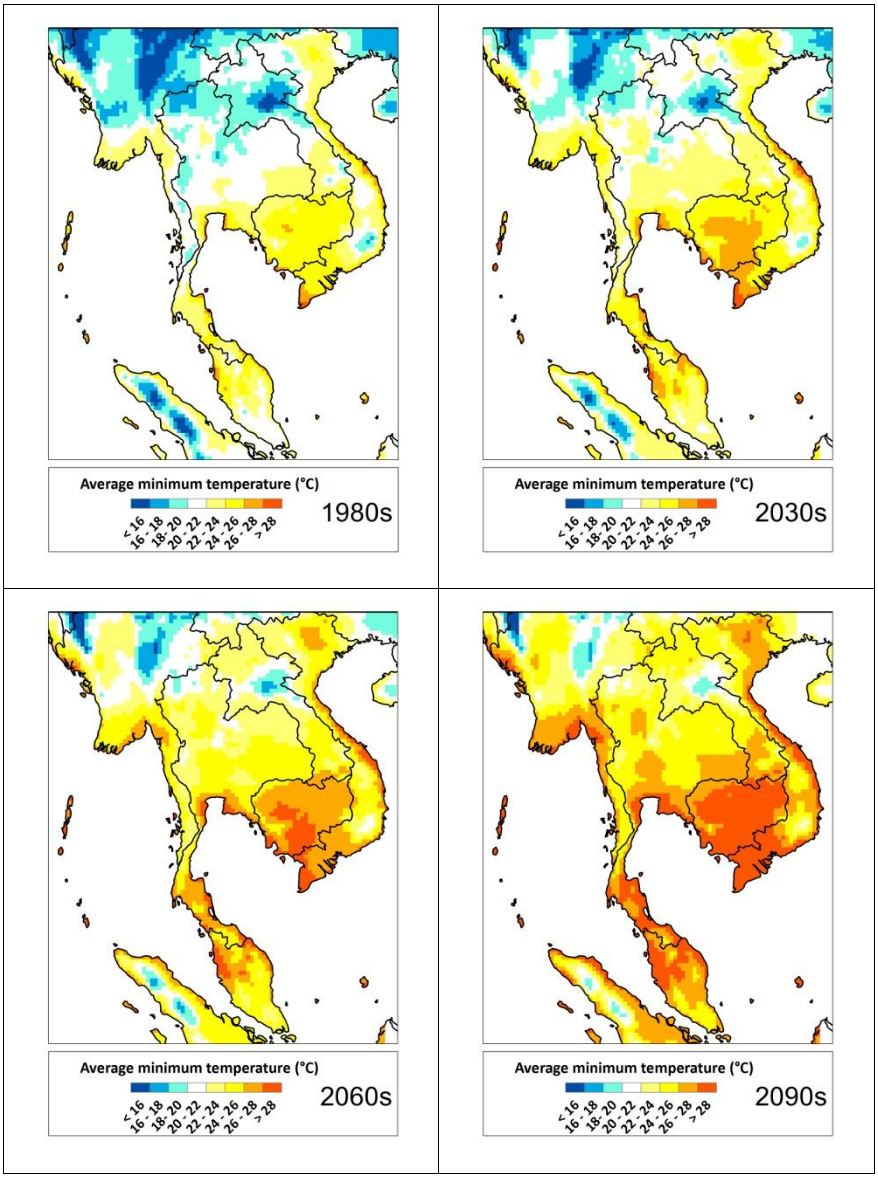


Figure 6: Average daily minimum temperature

In addition to the changing in magnitude aspect, change in future temperature also occurs in temporal aspect. Southeast Asia region tends to have longer hot period over the year. This changing in temporal aspect can be seen in the change of number of hot day in a year, or in other words the length of summertime, i.e. the number of 'hot day' or as defined in this study is the day with maximum temperature is 35ºC or higher will increase in the future, which could be longer by a few months in a year. See Figure 7. On the other hand, PRECIS result also shows slight trend of change on the 'cool period', or number of days in the year that the minimum temperature is 16ºC or below. Cool period, or in other word - wintertime, in the Southeast Asia countries will become shorter than baseline climate pattern, even though not as prominent as the trend of change on the 'hot period'. See Figure 8.

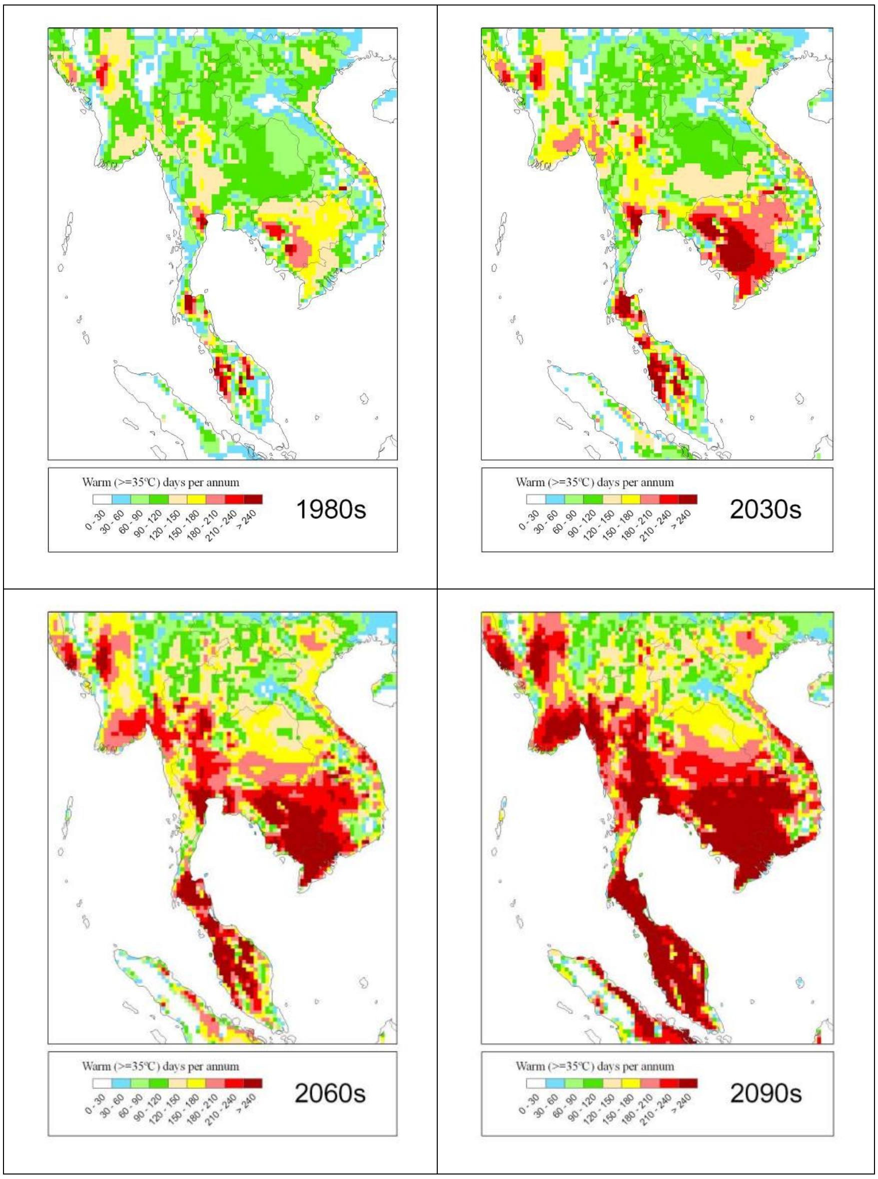


Figure 7: Length of hot period over the year - number of days with maximum temperature >35ºC

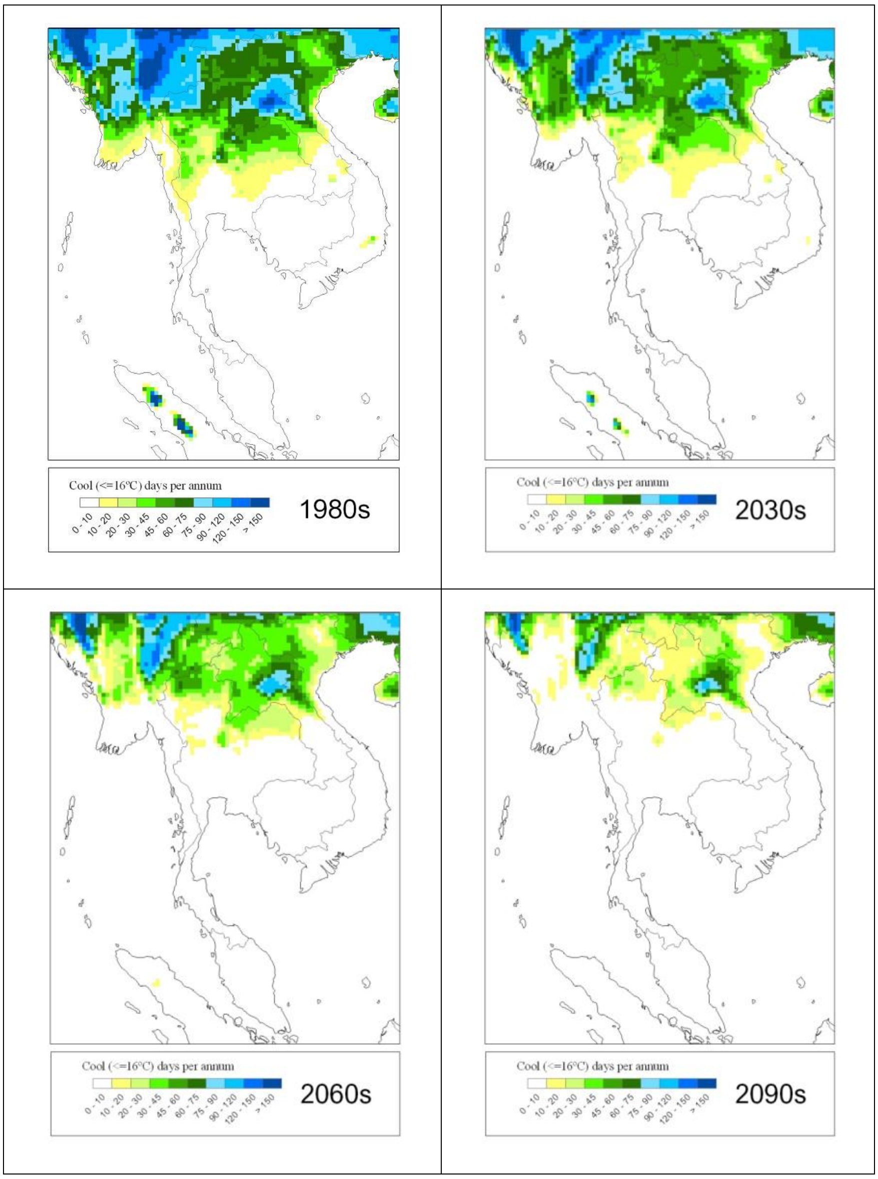


Figure 8: Length of cool period over the year - number of days with minimum temperature <16ºC

Annual total precipitation may fluctuate in the early decades of the century, but simulation result shows trend of higher precipitation throughout the Southeast Asia region in the future, especially toward the end of the century, which could be around 25% - 50% in some areas. See Figure 9.

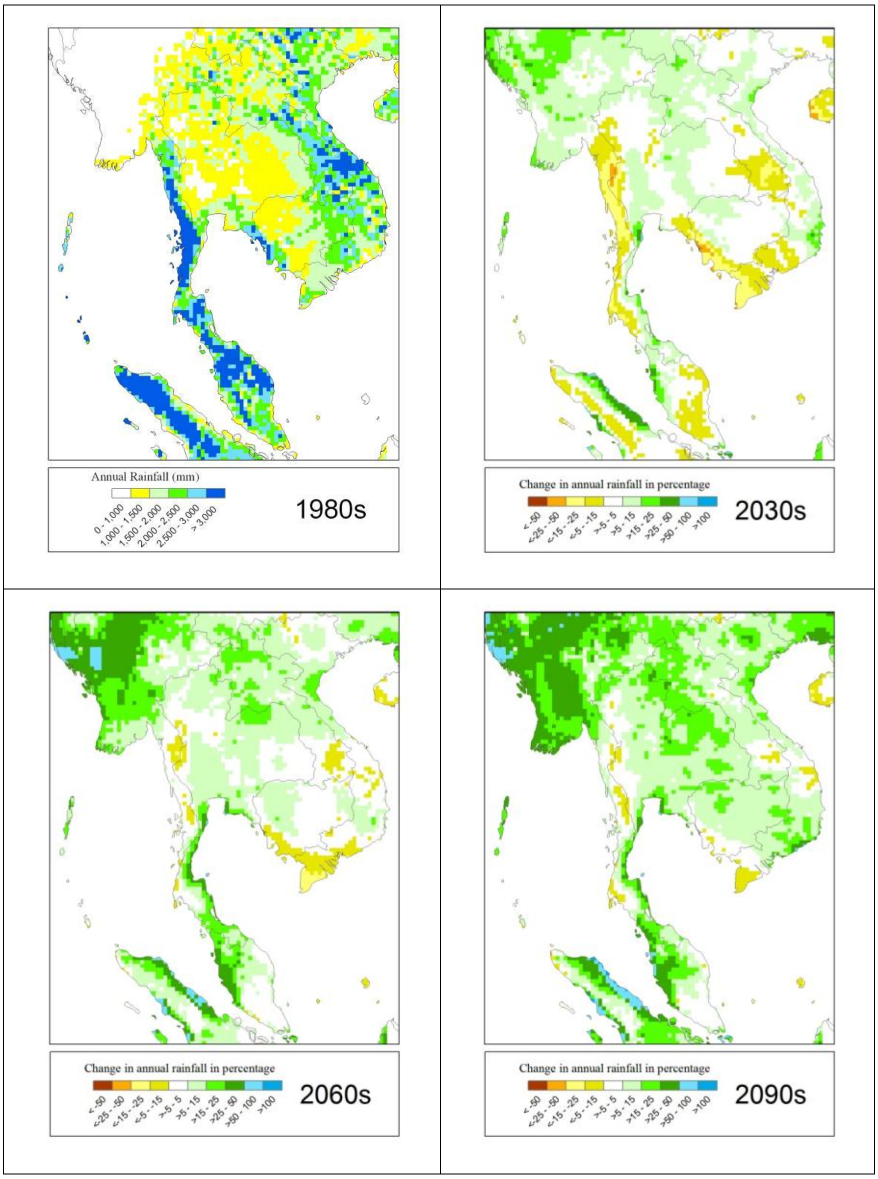


Figure 9: Annual precipitation (mm) and future change compare to 1980s (%)

In summary, future climate in Southeast Asia countries tends to be warmer with longer summertime and higher rainfall intensity during rainy season with higher annual total precipitation. These changes are unlikely to be irreversible and would have impact on various systems and sectors. However, this future climate projection is just one plausible future which was simulated by single climate model and single initial dataset. Additional climate change scenarios need to be further developed to address the uncertainty of the long-term climate projection. Moreover, inter-comparison among other climate models is required to evaluate the result of this experiment that would lead to improvement in future regional climate scenario simulation in the future.

DISCUSSION: USE OF CLIMATE CHANGE SCENARIO TO SUPPORT LONG-TERM PLANNING AND DILEMMA IN CLIMATE CHANGE ADAPTATION PLANNING PROCESS

Data from long-terms climate projection is scenario that can be used to assess impact of climate change in various sectors as well as to support long-term planning, especially climate change adaptation planning. In general, simulation result of climate model gives precise and details data, but even though the simulation result gives daily time-step data of various weather variables, however, such dataset can only represent broad view of future climate change. It has to be used in the proper context of climate change and scenario-based assessment.

Use of climate change scenario

There are concerns in the use of future climate projection data as follows:

- Future climate projection provides data that has to be used in the context of climate. In this regards, user needs to take data into consideration by taking data for analysis that cover long period of time, which has to be long enough to represent climate pattern, e.g. a decade or even a few decades. The simulation result needs to be parameterized to give climate characteristic e.g. average precipitation of the decade in certain area or total precipitation in the wettest year of the decade, etc. One should note that the timestamp on the data, i.e. date / year, only represent estimated weather pattern roughly during such period of time, but not for exact. The precipitation of the simulated year of 2050 is not exactly for the year of 2050 but a year in the middle of the 21st century.
- Using long-term climate projection for climate change adaptation planning to cope with climate change should not only consider change in average of climate variables but also take various aspects of changes in climate pattern into consideration too, especially, change in the extreme value of any climate parameters, e.g. hottest day of the year, and also the temporal aspect of change, e.g. change in the length of season and shifting of season, etc.

Uncertainty of future climate projection and dilemma in planning process

It is important to bear in mind that result of future climate projection is a scenario, which is only plausible future and cannot be taken as long-term forecast or represent truth of the future. It is a precise picture of consequence of a set of assumptions, i.e. the level of atmospheric greenhouse gases in the future. Moreover, the climate models, both global circulations model (GCM) as well as regional climate model (RCM), is yet to be further improved as knowledge on atmospheric physic advances. Being a scenario, we have to accept that there is certain level of uncertainty in the future climate projection, of which may not be able to quantify. The uncertainty of climate scenario raised dilemma in many planning processes, especially when such plan aims for specific action.

The common dilemma is the argument that if the result of future climate projection is not certain, the climate change adaptation plan may not be developed or justified. However, how future in such a long time scale would be pinpointed as many drivers of change are dynamic and may vary in vast directions, and to put it into more complicate condition, independently. This dilemma causes stagnation in climate change adaptation planning in many countries.

Even though, there is certain degree of uncertainty in the simulation result; however, it can still be used for strategic planning purpose. One way to cope with uncertainty of long-term climate projection is the use of multiple scenarios, which are developed using various climate models and/or under different conditions. The use of multiple scenarios is not the matter of putting effort to seek for the 'best' scenario, thus should be selected for the planning exercise; but the planning process should base on wide range of scenarios and to examine whether the plan for the future is resilience to various future conditions under climate change influence or not. By working with multiple climate scenarios, it does not necessary give the probability of chance that such future may occur as per simulation result, however, it will add robustness to the policy and plan as such plan would be tested against various conditions. The use of multiple scenarios in strategic planning or long-term policy planning requires change in thinking paradigm of policy planners to familiarize with the use of multiple climate datasets or multiple conditions in policy planning.

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ANNOUNCEMENT

This dataset of future climate projection for A2 and B2 greenhouse gas emission scenarios is available for download at http://cc.start.or.th/

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