Future Climate Projection for Thailand and Surrounding Countries: Climate change scenario of 21st century

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Abstract: *Climate change, which is induced by global warming, is a slow and complex process. It needs long term projection to detect the direction, magnitude and pattern of change. This study focused on the projection of future climate for Thailand and surrounding countries upto the end of 21st century based on dynamic downscaling of global climate change scenarios generated by ECHAM4 GCM A2 scenario by using PRECIS regional climate model from Hadley Centre, The Met Office of United Kingdom. The preliminary analysis on the result of the regional climate model shows that the regional climate model tends to underestimates precipitation and overestimates the maximum temperature for the region. The rescaling technique, which uses the observed weather data to rescale the result from regional climate model, was applied in the post-processing stage. Rescaled result of regional climate model shows that Southeast Asia region tends to be slightly warmer, but the duration of warm period will extend much longer in the future, especially in the latter half of the century. The warming up of temperature is detected for both daily maximum temperature and daily minimum temperature. In addition, the area that will be warmer will also expand to wider coverage. Precipitation tends to be fluctuating in the first half of century but shows increasing trend, which will be clearly seen in latter half of the century where there will be higher precipitation throughout the region.*

Keywords: climate change, Thailand, regional climate model, PRECIS, ECHAM4

1. 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) have been developed and are used to simulate future climate condition, but most of the simulation results available today were conducted in coarse scale due to limitation in the technology and is not quite effective for the use in climate change impact assessment at local scale. Therefore, regional climate change projection in high resolution is developed based on various techniques to serve the requirement in climate change impact assessment process. 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 (Jones et al, 2004). This paper discusses the approach in dynamic downscaling of GCM data using regional climate model to develop future climate projection for Thailand and surrounding countries over the 21st century.

2. METHODOLOGY

2.1 Dynamic downscaling using regional climate model

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 hundreds kilometers; regional models can resolve features down to much more 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. It also allows small islands and peninsulae to be represented realistically, where in a global model their size would mean their climate would be that of the surrounding ocean. RCMs are full climate models, and as such are physically based. They represent most if not all of the processes, interactions and feedbacks between climate system components represented in GCMs. They produce a comprehensive set of output data over the model domain. This study used regional climate model called PRECIS for downscaling coarse scale GCM to get the climate change scenarios for Thailand and surrounding countries. (Jones et al, 2004)

PRECIS is a regional climate model that was developed by Hadley Centre for Climate Prediction and Research and is based on the Hadley Centre's regional climate modelling system. 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)

As key influence of global warming is the increasing of atmospheric GHG in the future, this study used PRECIS RCM to downscale ECHAM4[1] GCM data, which is based on SRES A2 GHG scenario (IPCC, 2000). 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. Period of simulation covers baseline condition during 1970-1999 and future projection during 2010-2100. The simulation provides output with daily timestep throughout the simulating period.

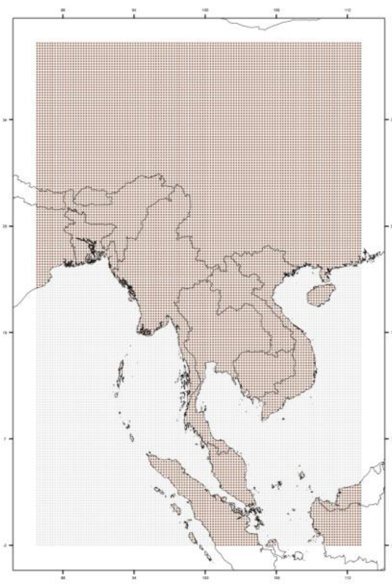


Figure1: Domain of the future climate projection

2.2 Rescaling regional climate model output

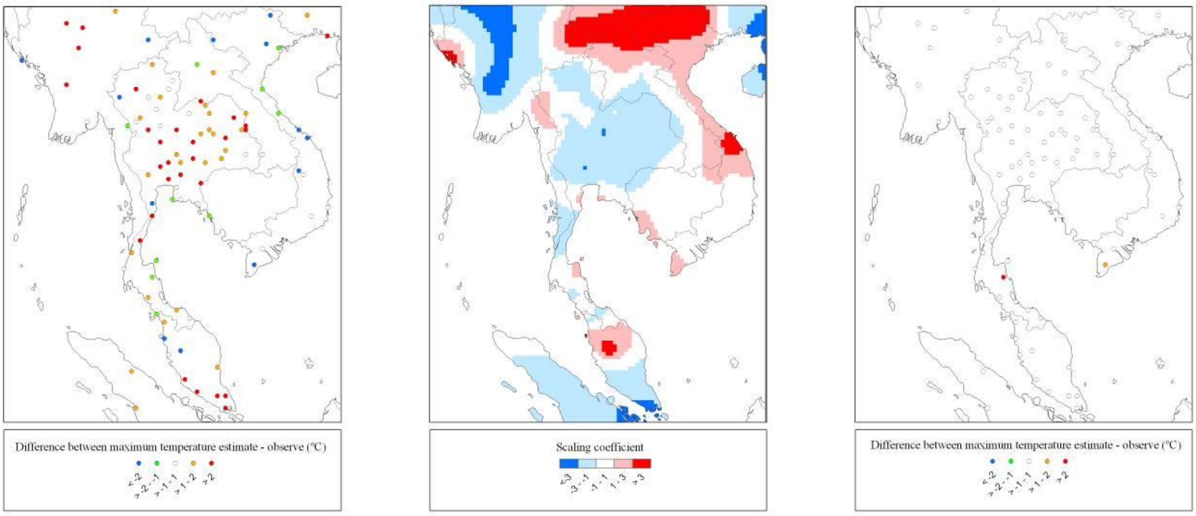
The results from PRECIS regional climate model were verified by comparing against data from observation stations and the period of 1980s was selected as baseline for verification. The comparison shows that the result of RCM is somewhat differ from the observed weather data. PRECIS model tends to overestimate 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 difference of key climate parameters, i.e. temperature and precipitation, between the 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

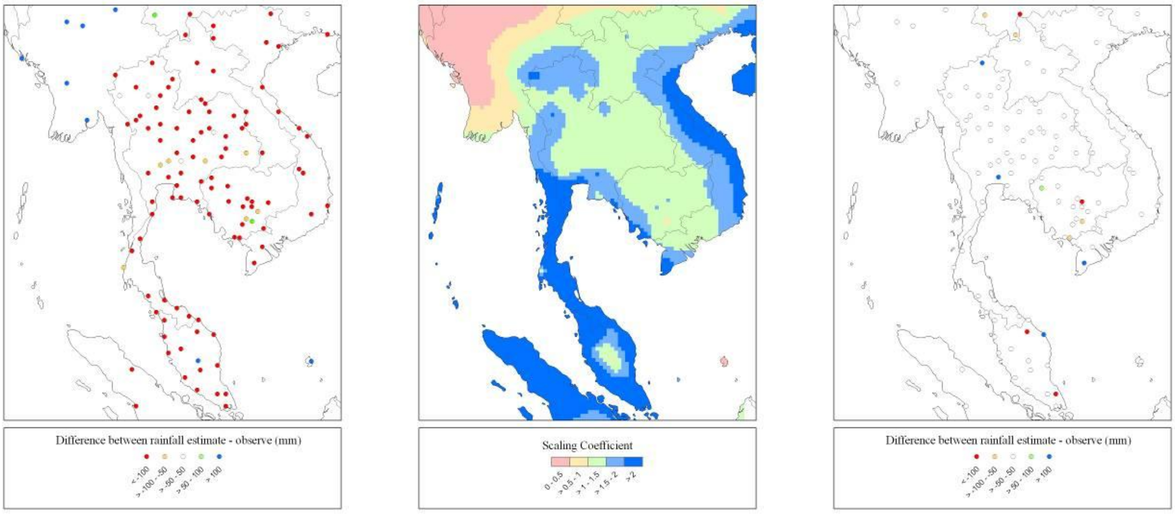
[1] ECMWF Atmospheric General Circulation Model coupled with University of Hamburg Ocean Circulation Model (http://www.ipcc-data.org/is92/echam4_info.html)

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.

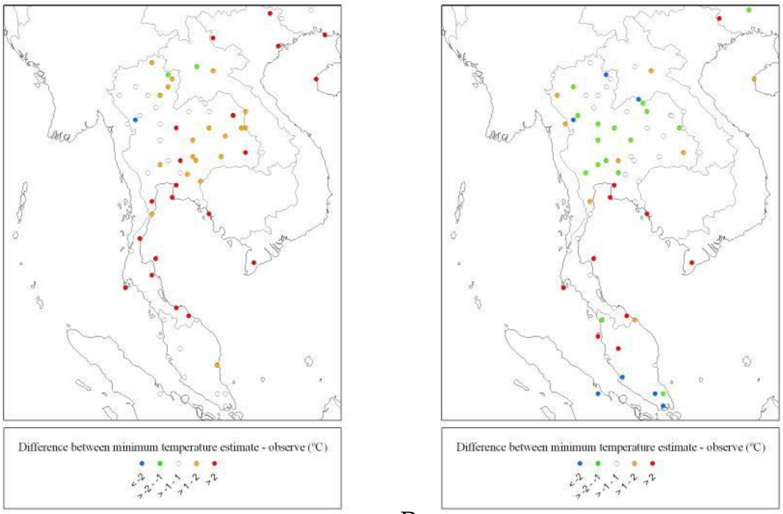


A B C

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.

3. RESULTS AND DISCUSSION

3.1 Climate change in Thailand and surrounding countries in 21st century

Simulation result from PRECIS regional climate model, after rescaling process, shows that average maximum temperature as well as average minimum temperature in Thailand and 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. Range of temperature increase in the future is approximately 2-3ºC during the middle of the century and increasing trend continue till the end of the century when most part of the region will be warmer. See Figure 5 & 6.

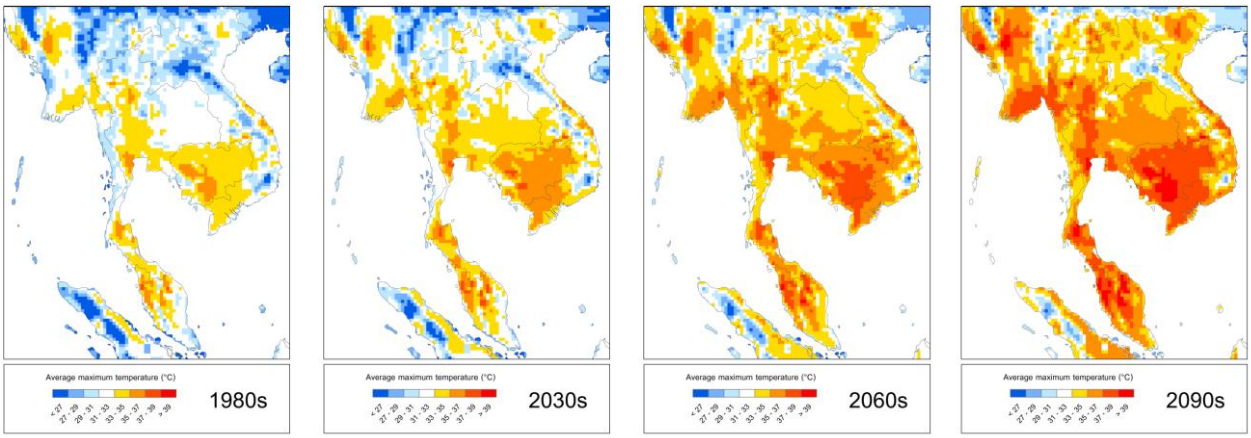


Figure 5: Average daily maximum temperature

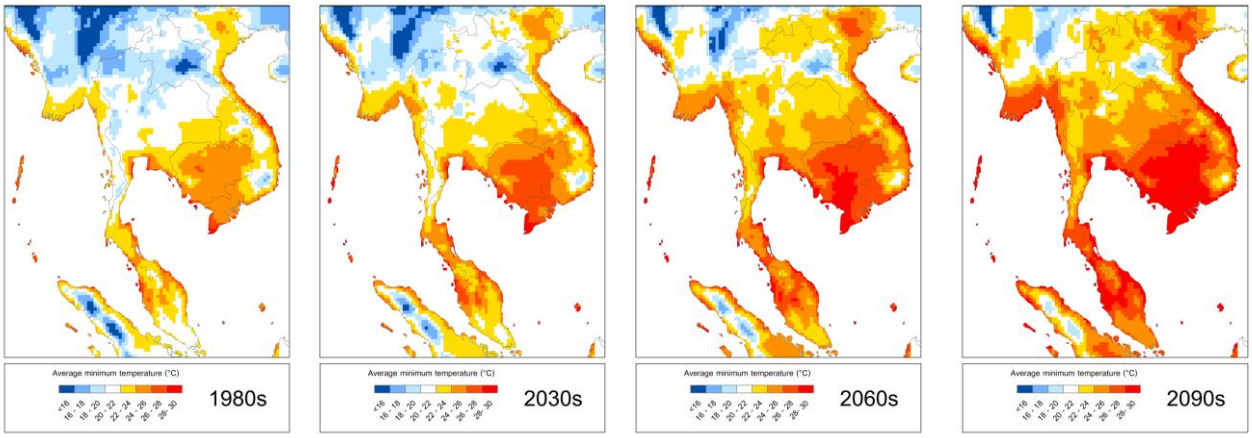


Figure 6: Average daily minimum temperature

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 during the year. This changing in temporal aspect can be seen in the change of number of hot day over the year. The number of 'hot day' or as defined in this study is the day with maximum temperature is 35ºC or higher will be higher in the future. The simulation result from PRECIS model shows that during the baseline period most part of north and northeastern region of Thailand have hot period of 3-4 months over the year, while the central plain and southern region have slightly longer summertime. In the future by middle of this century, hot period over the year would extend longer by a few months in most regions in Thailand as well as other surrounding countries and trend of change will be more prominent at the end of the century when hot period will become even longer. See Figure 7.

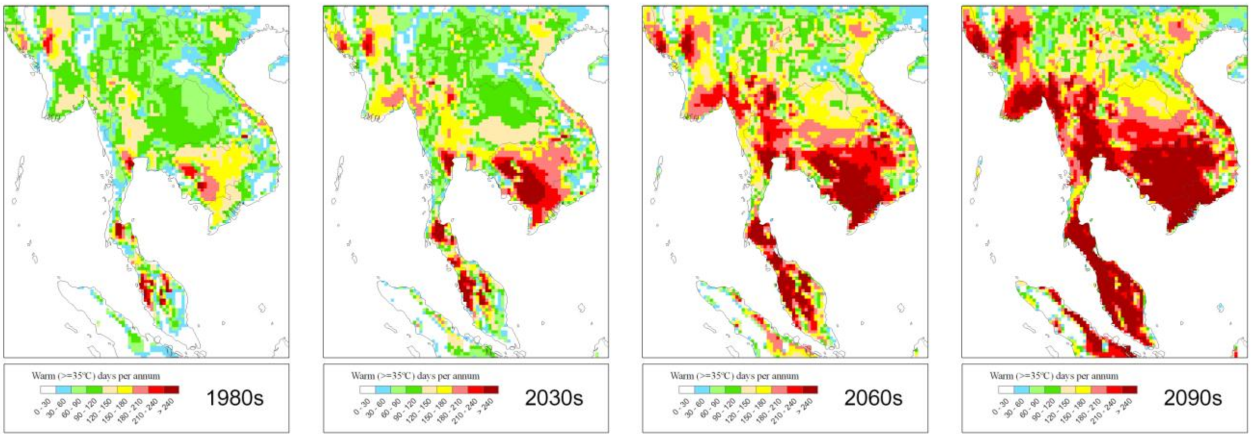


Figure 7: Length of hot period over the year (days): number of days with maximum temperature >35ºC

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 Thailand and surrounding 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.

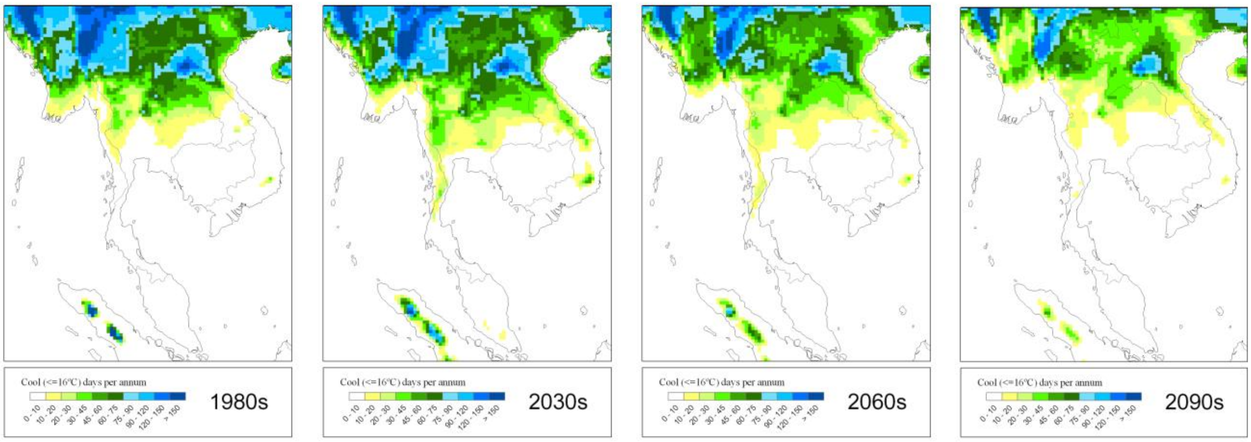


Figure 8: Length of cool period over the year (days): number of days with minimum temperature <16ºC

Annual total precipitation may be 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. Most part of Thailand may have higher precipitation by 25% or as high as 50% in some areas. See Figure 9.

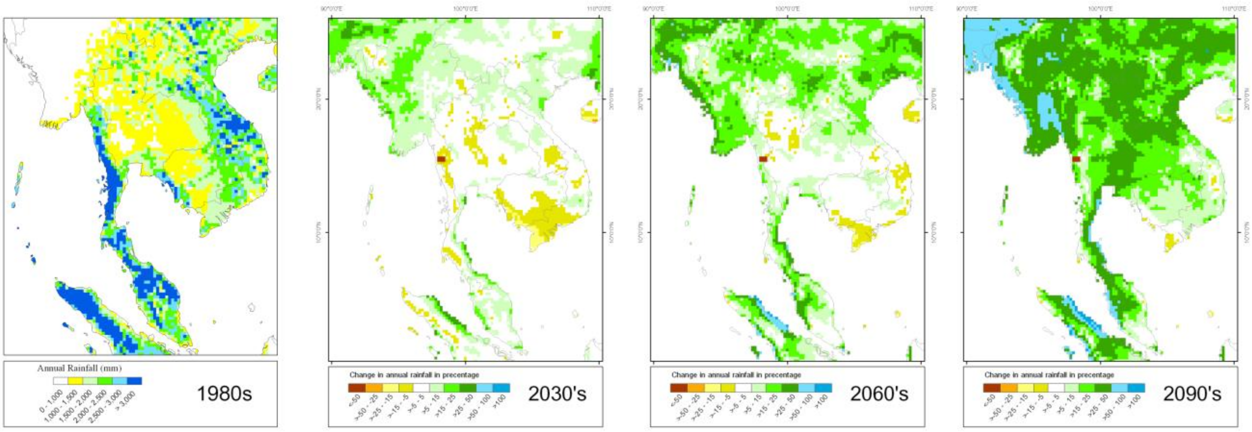


Figure 9: Annual precipitation (mm) and future change compare to 1980s (%)

3.2 Key concerns in using future climate projection: Understanding uncertainty and climate change in multiple dimensions

This long-terms climate projection can be use to assess impact of climate change in various sectors as well as to support many long-term planning. However, it is a scenario and cannot be taken as long-term forecast. 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 in strategic planning or long-term policy planning also requires change in thinking paradigm of policy planners to familiarize with the use of multiple climate datasets for strategic planning. In typical approach of planning that requires climate component, only single dataset which is based on observation data is used. However, the approach in using such dataset may not be applicable in planning process under climate change context, as the future climate may not be the same pattern as it has been in the past due to influence of global warming. Climate scenarios, which are simulated bases on future changes in earth system, should be used as foundation for such planning exercise. 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.

Another concern in using long-term climate projection for strategic planning to cope with climate change impacts is that future changes in climate pattern are in various aspects, of which all of them need to be taken into consideration. In many cases, the change in mean value is used to explain climate change of any region, but that only gives a broad idea on how future climate change might be. In planning process, policy planners need to include changes in other aspects into consideration, especially change in the extreme value of any climate parameters and also the temporal aspect of change, e.g. change in the length of season and shifting of season, etc.

4. CONCLUSION

In brief, future climate in Thailand and surrounding countries tends to be warmer with longer summertime and heavier rainfall 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.

5. ACKNOWLEDGMENTS

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