APN
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Scientific Capacity Building & Enhancement for Sustainable Development in Developing Countries

Final Report
Project Reference Number: CBA2014-02NMY-Singhruck

Strengthening the Adaptive Capacity of Local Agricultural Communities Through the Development of Seasonal Climate Prediction System

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REGIONAL CENTER

Project Reference Number: CBA2014-02NMY-SINGHRUCK:

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OVERVIEW OF PROJECT WORK AND OUTCOMES

Non-technical summary

Agricultural production in many developing countries is still highly susceptible to various forms of climate variability. In Thailand, recent evidence shows that its agricultural sector has experienced adverse climate-related impacts resulting in tremendous losses and posing a great risk to socio-economic development and livelihood. Local agricultural communities are the most vulnerable due to their limited adaptive capability. Hence the ability to anticipate climate fluctuation and make proper adjustment accordingly to reduce the impacts is greatly desirable. This project aimed to build the capacity on seasonal climate prediction that is tailored to meet the requirements of local agricultural communities in decision-making at farm level. The area of study was in the northeast of Thailand where agricultural production relies solely on monsoon rain. To bridge the gap between climate scientists and end-users, the project adopted a participatory approach in developing the seasonal prediction system to ensure the relevancy and accessibility of climate information to end-users. Lesson-learned from the project suggested that the uptake by the farmers of the seasonal prediction was dependent on the accessibility, accuracy and relevancy of the information. Integrating climate prediction with local wisdoms as well as proper farm management advisory could further enhance the uptake.

Keywords

Capacity building, seasonal prediction, agricultural communities

Objectives

The main objectives of the project were:

1. To build the scientific capacity on seasonal climate prediction tailored for local agricultural communities
2. To facilitate a dialogue between climate information providers, scientists and end-users in the development of seasonal climate prediction products

Amount received and number years supported

The Grant awarded to this project was:
US$ 40,000 for Year 1 (2014-2015)

Activity undertaken

The project employed a participatory approach in developing the seasonal prediction system. A series of workshop was organized consisting of a user-need consultation workshop, a scientific training workshop on seasonal forecasting for scientists, and mini-workshops to train the users on the use of climate information.

1. User needs consultation workshop

The inception workshop was held on 21 August 2014 at Ubon Ratchathani University in Ubon Ratchathani Province. The first objective of the workshop was to introduce the project to stakeholders including smallholder farmers, local government and non-government officers, and project core members. The second objective was to create a dialogue between climate information provider and user communities to co-design the seasonal climate prediction system. There were sixty-two smallholder farmers from six communities in three northeast provinces (i.e. Ubon Ratchathani, Amnat Charoen, and Yasothon) participated in the workshop. The participants identified climate information requirement and potential ways for information dissemination. The dialogue showed that the farmers recognized potential benefit of using climate prediction in farm management. But the main constraints that prevented them from fully exploit the information included lacking of local context in the information and lacking of accessibility to the products. The user consultation workshop highlighted the essential features of the planned seasonal climate prediction products. In order for them to be useful in decision making and planning in agricultural production, the products must have detail spatial resolution and location specific, be available in accessible formats (e.g. mobile phone SMS, radio broadcast, website, etc.), be easy to understand by the users, and be provided with sufficient lead time to be actionable especially during weather-sensitive growing activities such as sowing and reaping. In addition to seasonal rainfall total, timing of rainfall and onset and length of wet season were also identified as beneficial information.

2. Scientific training workshop on seasonal climate prediction

As part of the scientific capacity building component of the project, a five-day training workshop titled "Seasonal Forecasting Using the Climate Predictability Tool (CPT)" was held from 12 to 16 January 2015 at the training center of the Geo-Informatics and Space Technology Development Agency (GISTDA), Bangkok, Thailand. The workshop was primarily funded by the Asia-Pacific Network for Global Change Research (APN). The Thailand Research Fund (TRF) co-sponsored the workshop. The Center of Excellence for Climate Change Knowledge Management (CCKM), Chulalongkorn University, provided logistics arrangement. The training was conducted by Dr. Simon Mason, International Research Institute for Climate and Society (IRI), USA. The objective of the training workshop was to increase the capacity on seasonal climate prediction. There were forty-eight participants from government agencies dealing with climate services, water resources, agriculture, disaster management, as well as participants from research institutions and universities taking part in this workshop. The training consisted of lectures and hands-on exercises on the principles of seasonal forecasting, the uses of empirical methods as diagnostic and forecasting tools and forecast verification. The participants learned how to use the Climate Predictability Tool (CPT) developed by IRI to construct seasonal climate forecast models, perform model validation and produce a forecast for the coming season. Overall, the participants evaluated the workshop execution and learning experience as highly satisfactory and anticipated to incorporate knowledge and methods on seasonal forecasting in their institutions' ongoing works.

3. Mini-workshops on the use of climate information in selected communities

Mini-workshops on the use of climate information were carried out during 18-20 February 2015, 29-31 March 2015 and 27-30 April 2015 in selected communities in three provinces (i.e. Ubon Ratchathani, Amnat Charoen, and Yasothon). The objective of these mini-workshops was to create informal dialogue between the climate information providers and the users on the use of climate information. Researchers visited villages and discussed with community leaders about the outcome of the seasonal forecast research, weather and climate information as well as information dissemination protocols. Due to the low predictability of the newly-developed product at seasonal timescale, other forecast products at shorter timescales available from operational institutions were introduced to assist farmers in decision-making. These products consisted of a 5-day forecast from Thai Meteorological Department (TMD) and a daily forecast from weather forecasting model by Hydro and Agro Informatics Institute (HAII). The climate information dissemination were agreed to be delivered regularly via mobile phone messages and LINE.

4. Development of seasonal prediction system

Research and development together with the training workshop were activities contributing toward the first objective of the project in building the scientific capacity on seasonal climate prediction tailored for local agricultural communities. The seasonal prediction system focused on the area of study in northeast Thailand in particular, but information was also available for the whole country. Six statistical models were constructed by using canonical correlation analysis (CCA) of different variables as predictors. Two models were based on historical relationship between tropical

Pacific sea surface temperature and local rainfall. Four models were based on downscaling of global circulation model (GCM) rainfall hindcast for the period of 1982-2010 from the North American Multi-model Ensemble (NMME) project. The predictive skills of six model constructions were assessed using cross-validation method. The final products consisting of seasonal rainfall forecast and associated predictive skills of each model construction were publicly available and updated monthly via the project's website: http://www.cckm.or.th/CCKM/Seasonal_Prediction/Home.html For users in local communities, targeted forecasts were translated to easily understandable messages and disseminated directly to them via mobile phone messages.

Results

The project has created the seasonal climate prediction system for Thailand and therefore enhanced the national capacity in seasonal climate prediction. Skill assessment of the six constructed models showed that during wet monsoon season, predictability of rainfall over Thailand was quite modest compared with other parts of the Asia-Pacific region, such as the maritime continents. Nation-wise, the northeast part of Thailand had some predictive skills compared to other regions of the country. The model skills also varied in time being moderate in the beginning of the season, becoming high during the peak season and dropping to virtually none during the latter part of the season. In general, downscaled GCM rainfall hindcast showed enhancement in predictive skills over statistical models using sea surface temperature as predictors. Overall the skill assessment suggested that seasonal prediction of rainfall over the study area was quite challenging. The small predictability had repercussion on providing seasonal prediction to local agricultural communities. The uptake of the seasonal prediction by farmers indicated that the accuracy of the forecast was a critical factor. In such uncertain circumstance, farmers also used local wisdoms such as observation of certain species of insects, lizards and plants and other ancestral experiences in decision-making. It was also essential to provide recommendations in agricultural practices together with climate information.

Although the developed system showed modest predictive skill over the study area and hence rendered it to be less useful in risk management in agriculture, it is important to highlight the other dimensions which the project had accomplished including:

- The project had facilitated a dialogue between climate scientists and end-users in co-designing the seasonal climate prediction system for agricultural application.
- The project raised the awareness of farmers of the benefit of incorporating climate information in decision making

Relevance to the APN Goals, Science Agenda and to Policy Processes

The project was highly relevant to the APN's Goal 2 and Science Agenda through the identification of information needs from the end-users and the development of a tool for improving the effectiveness of scientific knowledge transfer to non-science user communities. It contributed to the APN's Scientific Capacity Development at local community and national levels. The project's goals were also in line with the United Nations Framework Convention on Climate Change (UNFCC)'s priority in reducing vulnerability of the most vulnerable farmer communities to climate-related impacts. The project tackled the issue of sustainable development by promoting the use of scientific knowledge and technology to manage the risks related to climate. It contributed to Rio+20 "The Future We Want" which affirms the importance of creating greater opportunities for all, empowerment of people in vulnerable situations, including removing barriers to opportunity, enhancing productive capacity and developing sustainable agriculture.

Self-evaluation

Initially the project was planned for two-year period and had four objectives in total. The two additional objectives were

3. To evaluate the benefits of seasonal climate prediction system in enhancing the capacity of local agricultural communities to adapt to climate variability and change
4. To communicate with policy-makers on the prototype of seasonal climate prediction system for agricultural communities

However, the result of the research in the first year of the project which used well-recognized statistical tool as well as state-of-the-art NMME models indicated that the predictability at seasonal timescale for the study area was modest. Consequently, it was deemed challenging to evaluate the benefits of using seasonal climate information in agricultural management and communicate with policy-makers on the prototype of the prediction system given the lack of predictability. The project team believed that further advancement on global climate models is required before seasonal forecast can provide useful information to farmers. Therefore the project team, in mutual agreement with the APN, decided not to continue into the second year. Nevertheless, the project had accomplished the first two objectives which were to build the capacity on seasonal climate prediction and to facilitate a dialogue between climate scientists and end-users.

Potential for further work

Lesson learned from the project suggested further work which can be beneficial for the development of climate service for agriculture.

1. The full cycle of system development of seasonal prediction for agriculture consisting of user needs assessment, system development, system's predictive capability assessment and evaluation of the benefits of using seasonal climate prediction for risk management should be explored in areas where there are some demonstrable predictive skills.
2. Further improvement on seasonal forecast accuracy should be explored using various techniques such as GCMs, dynamic downscaling, and statistical post-processing.
3. It was found that farmers need a continuum of timescales of climate information. Hence further work should also explore the provision of climate information at short-, medium- and long-ranged timescales and integrate them with crop calendar.
4. Integrating local wisdoms such as observation of certain species of insects, lizards and plants and other ancestral experiences with scientific forecast was found to enhance the uptake of climate information by farmers and therefore should be compiled and evaluated.
5. It was found that providing climate information together with recommendations on agricultural practices enhanced the uptake of climate information and therefore should be further compiled and evaluated.

Publications

Singhruck, P., Limsakul, A., Rakwatin, P. and Snidvong, A. (2015) Strengthening the adaptive capacity of local agricultural communities through the development of seasonal climate prediction system. In: Boonjawat, J., Stevenson, L. A., & Tupas, L. (Eds.). *APN Science Bulletin (5).* Asia-Pacific Network for Global Change Research. p. 66.

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Acknowledgments

The project team sincerely acknowledges generous support for the project from Asia-Pacific Network for Global Change Research (APN). The team gratefully acknowledges the following institutions and individuals for collaboration and support; Healthy Public Policy Foundation, EFFU, Ubon Ratchathani University and Ms. Pannee Samerpak (EFFU) for local communities engagement; Thailand Research Fund for additional financial support for the training workshop; Geo-Informatics and Space Technology Development Agency (GISTDA), Southeast Asia START Regional Centre (SEA START RC) and Center of Excellence for Climate Change Knowledge Management (CCKM), Chulalongkorn University for in-kind support; International Research Institution for Climate and Society (IRI, USA) for Climate Predictability Tool (CPT) and Dr. Simon Mason (IRI, USA) for professional guidance as the resource person. The team is thankful for additional forecast products from Thai Meteorological Department (TMD), Hydro and Agro Informatics Institute (HAII, Thailand), and the North American Multi-Model Ensemble (NMME).

TECHNICAL REPORT

Preface

This report describes the rationale, methodology and outcomes of the development of seasonal climate prediction system for agriculture in Thailand. The project aimed to build the capacity on seasonal climate prediction tailored to meet the requirements of local agricultural communities in decision-making at farm level. The area of study was in the northeast of Thailand where agricultural production relies solely on monsoon rain. The project adopted a participatory approach in developing the seasonal prediction system. It involved scientific capacity development as well as user engagement activities.

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1. Introduction

Seasonal forecast has the potential impact on agricultural practice in providing information for risk management (Hansen, 2002; Hansen et al., 2011; Huda and Packham, 2004; Sivakumar and Hansen, 2007). For many parts of the world, seasonal forecast demonstrated useful skills. The source of seasonal predictive skill comes from slowly-varying sea surface temperature in the tropics mainly related to El Nino-Southern Oscillation (ENSO) (Mason and Goddard, 2001; Stockdale et al., 2010). In the Indo-Pacific region, previous studies have shown encouraging results. He and Barnston (1996) found that for the tropical western Pacific Islands, seasonal rainfall prediction showed moderate skills during northern winter while modest skills were realized for other seasons of the year. Juneng and Tangang (2008) found that Malaysia seasonal rainfall predictive skills were higher during northern winter compared with northern summer and that the skills were higher over East Malaysia on Borneo Island compared with peninsular Malaysia. These studies highlighted that seasonal rainfall predictive skills vary in places and times.

Seasonal forecasting approach can be categorized into two broad methods, statistical method and dynamical method (Goddard et al., 2001). Statistical method uses historical relationship between predictors and predictands in forecast model construction. Canonical Correlation Analysis (CCA) which finds patterns that maximize the correlation between time series of predictors and predictands were often used in seasonal forecast (e.g., He and Barnston, 1996; Juneng and Tangang, 2008). An advantage of statistical method is the comparatively small computing resource requirement in producing the forecast.

Dynamical method provides a physically consistent prediction derived from interaction among various components of ocean and atmosphere in the general circulation model (GCM) and hence require intensive computing resources. Recently dynamic forecasts provided from large research institutions and operational centres are becoming available. However GCMs still have deficiency which may arise from parameterization of processes at sub-grid scales. In applying GCMs forecast for local area it is often required to apply statistical downscaling methods to account for systematic biases. This approach is called Model Output Statistics (MOS). Juneng et al. (2010) showed that downscaling of GCM forecast for the peninsular Malaysia provided some skill enhancement compared with purely statistical method.

Thailand depends on agriculture sector, which is very sensitive to climate-related stressors. Recent evidence shows that agricultural sector has already experienced adverse impacts of various forms of climate variability and change and extreme weather events, resulting in tremendous loss and posing a great risk to socio-economic development and rural livelihoods. Local agricultural communities are ones of the most vulnerable groups, due to their heavily dependent on climate-sensitive sectors. Hence the ability to anticipate climate fluctuations in advance and the capacity to make adaptive management under the face of uncertainty are the keys to reduce climate risk and vulnerability of the most vulnerable farmer communities.

Previous studies of seasonal forecasting in Thailand have shown potential predictive skills. Singhrattana et al. (2005) used statistical model for wet-season rainfall prediction over the central plain of the country and found relationship between rainfall and ENSO. Kang et al. (2007) found good skill for rainfall prediction in Bangkok region by applying statistical downscaling of APEC Climate Center (APCC) multi-model ensemble (MME) output. It is still unclear whether such predictive skills exist over the northeast Thailand which is the main area of this study. The region deserves detail study since agriculture practice in this area relies mainly on rainfall and irrigation system is not very extensive as in the central plain. The objective of this report is to assess the seasonal rainfall predictive skills over the northeast Thailand. Forecast model construction uses two techniques, CCA of historical relationship between sea surface temperature and rainfall and statistical downscaling of GCMs rainfall prediction.

2. Methodology

2.1 Project Framework

The project was developed on the basis of the science-social framework that strengthens participation of scientists, end-users and policy makers as key stakeholders in the interlinked processes of building capacity, developing seasonal climate forecast system and translating forecast products into detailed information tailored for local agricultural communities. The system was developed through a series of scientific capacity and user consultation. The system was then evaluated through participatory approaches in the selected communities, and improved by incorporating the recommendations from consultation with end-users including agricultural producers and extension agents. Communication with policy-makers on the prototype of seasonal climate forecast system and its products is also an important part of this framework. This ensures its long-term sustainability for further integrating the system into the decision making process of agriculture. The overall framework of this proposed project is shown in Figure 1. The project can be divided into four elements which begin with scientific capacity on seasonal climate forecast, followed by scientific work on development of seasonal climate forecast system through a dialogue between science and end users. The third element involves evaluation of usefulness and benefit of seasonal climate forecast information via participatory actions in the selected agricultural communities. The feedback from end users will be used to improve the seasonal climate forecast system before communicating with policy makers.

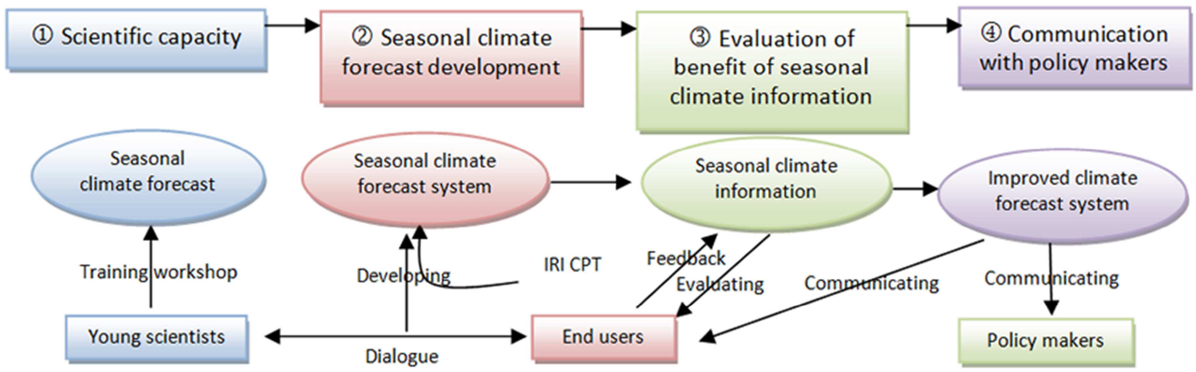
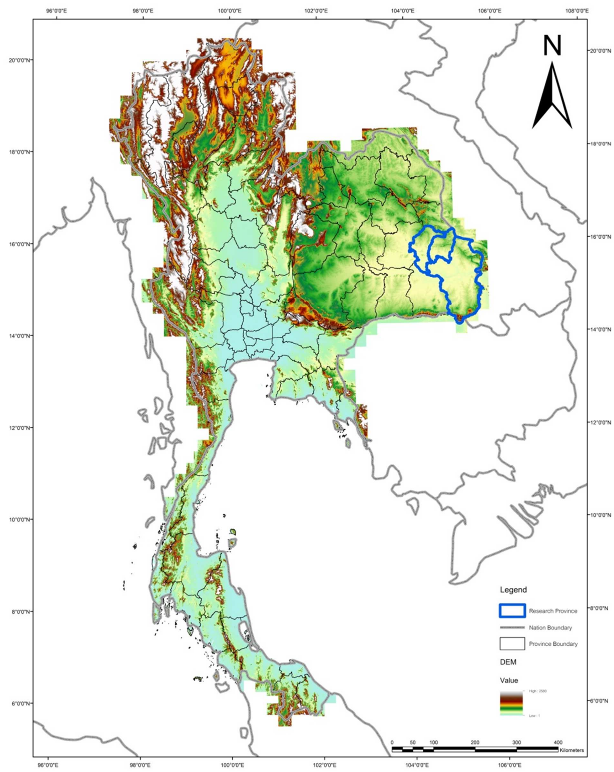


Figure 1 Conceptual framework of the Project

2.2 Study area

This study focuses on the area of 3 provinces in the northeast Thailand namely Ubon Ratchathani, Yasothon, Amnat Charoen (Figure 2). Climatic pattern of the area is characterized by southwest monsoon wet period from May to October and northeast monsoon dry period from November to April. Figure 3 shows average monthly and seasonal rainfall distribution from meteorological station in Ubon Ratchathani province. The study assesses the seasonal predictive skill over six 3-month run on seasons during wet period starting from April to June (AMJ), May to July (MJJ), June to August (JJA), July to September (JAS), August to October (ASO), and September to November (SON). Note that peak rainfall amount occurs during JAS. The area also gets occasional passages of westward-moving low pressure systems during wet monsoon period. These low pressure systems were tropical depressions or tropical storms that weaken from typhoons developed in the western Pacific and the South China Sea.

a)



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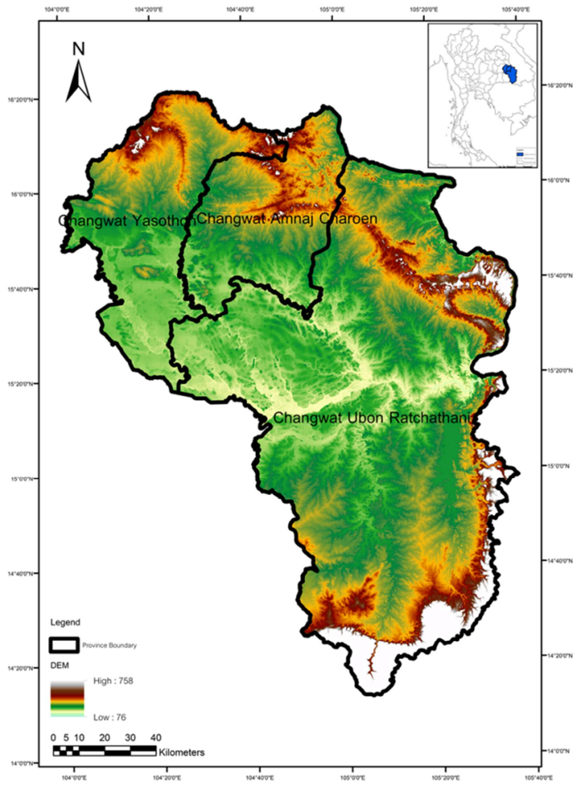
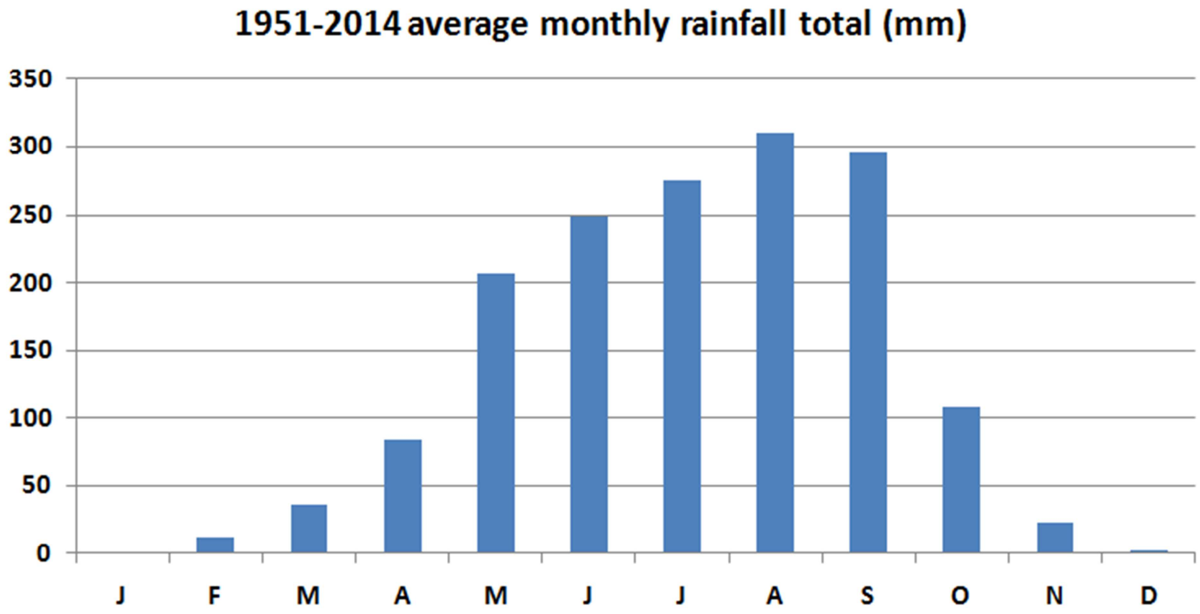


Figure 2 Study area in the northeast Thailand is delineated by blue lines.

a)



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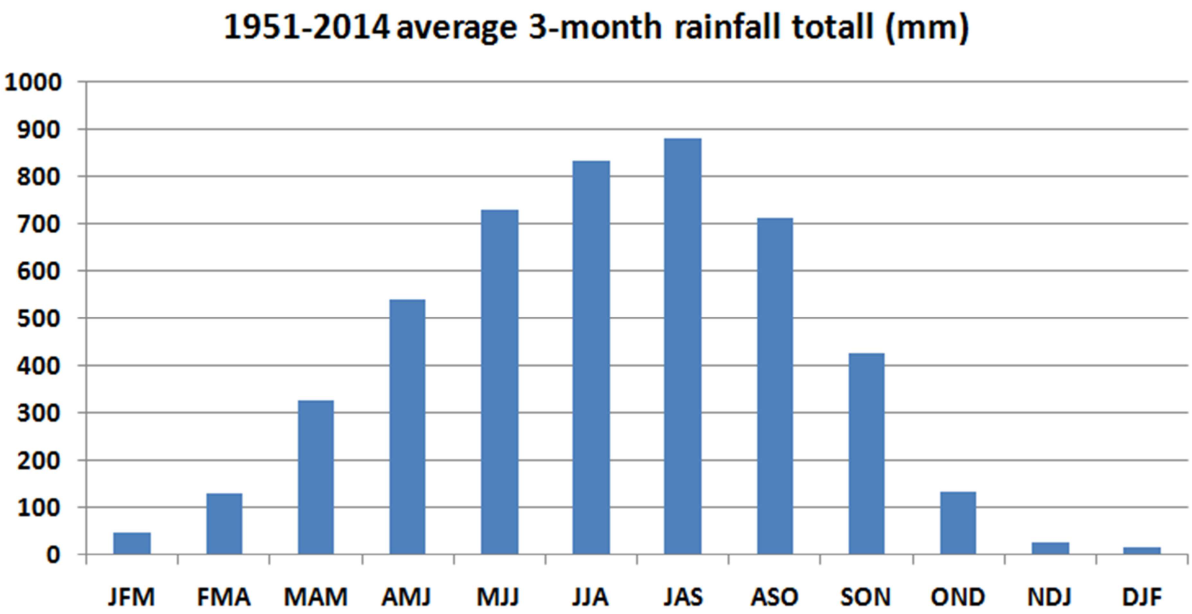


Figure 3 Average monthly (a) and 3-month run on seasons (b) rainfall distribution from meteorological station in Ubon Ratchathani province (Data source: Thai Meteorological Department)

2.3 Development of seasonal climate prediction system

2.3.1 Observation data

Monthly rainfall data from meteorological station in Ubon Ratchathani province and other stations nationwide were obtained from Thai Meteorological Department. The data were available from 1951-2014. In order to assess rainfall predictive skills at the regional scale, global gridded monthly precipitation CRU TS3.21 (Haris et al., 2014) available from 1901-2012 were also used. The dataset is a gridded product at 0.5x0.5 degree resolution based on weather station records. Sea surface temperature (SST) from NOAA ERSST v.3 (Smith et al., 2008) monthly gridded product at 2x2 degree from 1854-2015 were used as predictors in statistical model. Nino 3.4 index was computed from ERSSTv.3b for the area between 5oN-5oS and170-120oW. The analysis of all observation data was done for the period of January 1982 to December 2010 to be consistent with the availability of GCMs data.

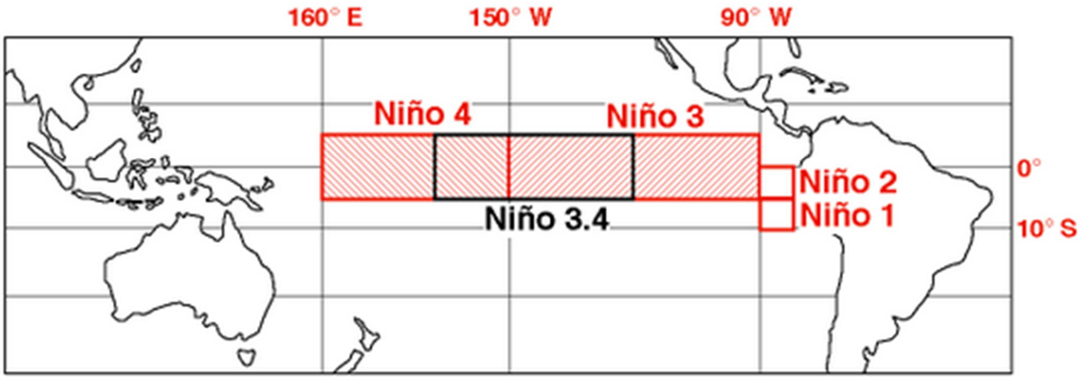


Figure 4 Nino 3.4 region

2.3.2 GCMs data

Hindcast data from GCMs that participated in the North American Multi-Model Ensemble (NMME) (Kirtman et al., 2014) were used in statistical downscaling approach. Only 4 out of the 11 NMME models were selected for this study based on the availability of real-time forecast outputs. Details of selected models are provided in Table 1. GCMs variables that are available across all models are total precipitation and SST at various lead times. For this analysis, data at one-month lead time were used. For example to downscale rainfall for AMJ seasons, GCM forecast that was initialized in March was used. The analysis was done by averaging all ensemble members for each model over the period of January 1982 to December 2010.

Table 1 GCMs from NMME project used in this study

Model name	Institution	Ensemble size
CMC2-CanCM4	Canadian Meteorological Center (CMC) - Canada	10
COLA-RSMAS-CCSM4	National Center for Atmospheric Research (NCAR) – United States	10
NCEP CFSv2	National Center for Environmental Prediction (NOAA/NCEP) – United States	24
GFDL-CM2p5-FLOR-A06	Geophysical Fluid Dynamics Laboratory (NOAA/GFDL) – United States	12

2.3.3 Statistical model construction

The statistical model construction was done by using the Climate Predictability Tool (CPT). The tool was developed by International Research Institute for Climate and Society (IRI). Six statistical models using different variables as model predictors were developed (Table 2). The predictands were 3-month rainfall total. The Nino 3.4 and SST-CCA cases use statistical relationship between historical Pacific Ocean SST and rainfall over Southeast Asia and Thailand. The CanCM4, CCSM4, CFSv2 and GFDL cases are MOS forecasting model constructed by using CCA. The difference of MOS from CCA is the use of GCM precipitation forecast as predictors in the model. This downscaling technique also accounts for systematic biases in the GCMs.

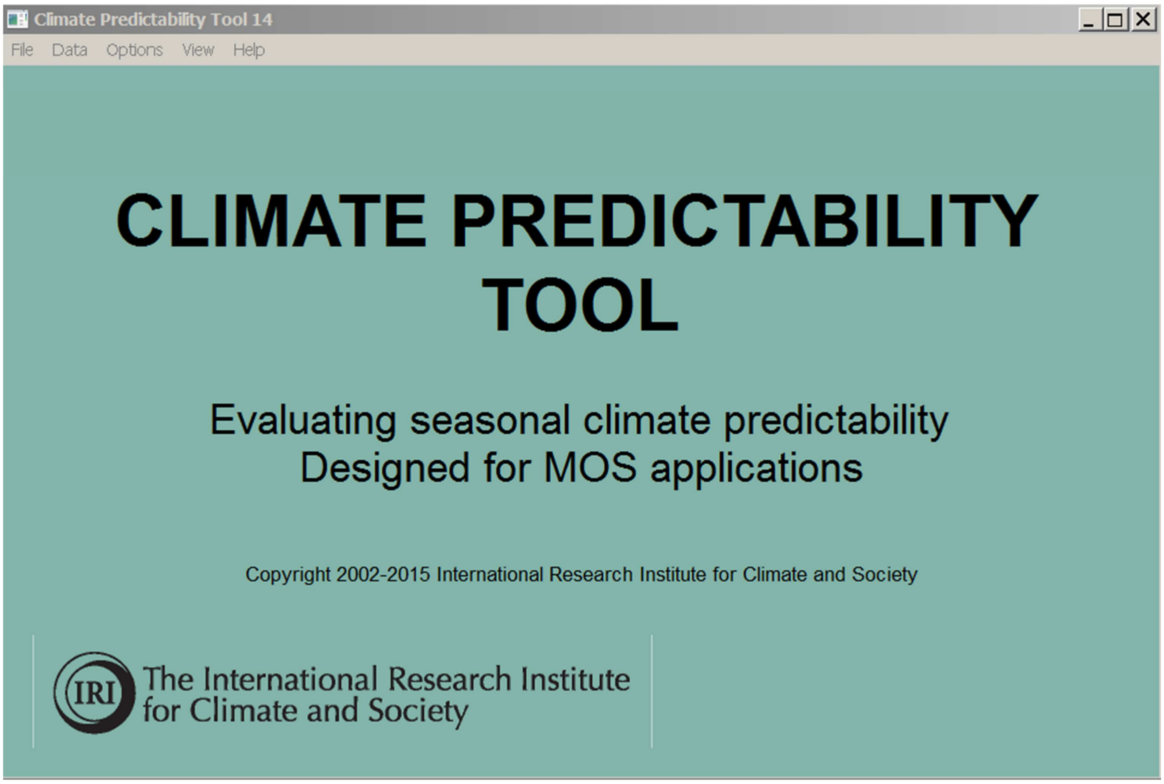


Figure 5 Climate Predictability Tool (CPT)

a) b)

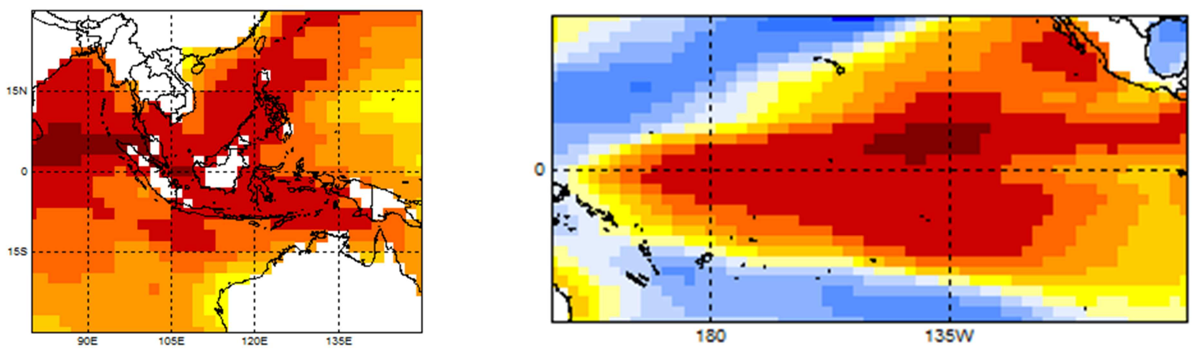


Figure 6 SST CCA regions

Table 2 Summary of statistical models construction

Case	Statistical method	Predictors
Nino 3.4	Multiple linear regression	1-month lead Nino3.4
SST-CCA Indo-Pacific	Canonical correlation analysis (CCA)	1-month lead SST in Eastern Indian Ocean and Western Pacific (30^{o}N-30^{o}S and 80^{o}E -150^{o}E)
SST-CCA Pacific	Canonical correlation analysis (CCA)	1-month lead SST in Pacific Ocean (30^{o}N-30^{o}S and 150^{o}E -90^{o}W)
CanCM4	GCM downscaling by CCA	3-month southeast Asia precipitation (40^{o}N-10^{o}S, 80-140^{o}E)
CCSM4	GCM downscaling by CCA	3-month southeast Asia precipitation (40^{o}N-10^{o}S, 80-140^{o}E)
CFSv2	GCM downscaling by CCA	3-month southeast Asia precipitation (40^{o}N-10^{o}S, 80-140^{o}E)
GFDL	GCM downscaling by CCA	3-month southeast Asia precipitation (40^{o}N-10^{o}S, 80-140^{o}E)

2.3.4 Forecast quality assessment

To prevent overestimation of model skill arising from using in-sample data during model construction, cross-validation technique was used in the skill assessment. The analysis spans the period of 1982-2010 resulting in 29 years of cross-validation samples. Forecast quality was assessed using two scores. Pearson's correlation coefficient which measures the association between the model forecast and the observation was used. In addition, the relative operating characteristic (ROC) curves (Mason and Graham, 1999) which provides information on the model ability in event discrimination was also used. ROC is one of the measures recommend by WMO for verification of long-range forecast. The ROC curve is constructed by plotting the hit rate versus the false alarm rate for categorical forecast, i.e. below-normal and above-normal rainfall. The area beneath the curve gives the measure of discrimination between an event and non-event. A score higher than 0.5 shows that model has better skill to successfully predict below-normal or above-normal seasons from other seasons as compared to a random guessing.

3 Results & Discussion

3.1 User-need assessment

Farmers expressed their needs of climate information across a wide spectrum of time scales ranging from daily weather forecast, weekly forecast, monthly forecast and seasonal forecast. The most important variable is precipitation. Additional useful variables are temperature, winds and storms. In addition to seasonal rainfall total, seasonal onset and length are also very useful. The information is used in planning crop calendar (Figure 7). They required information that has enough spatial resolution and location specific, at least at district (Amphur) scale, if the information at village scale is not viable. The timing of forecast is also very critical especially during weather-sensitive growing activities such as sowing and reaping. They suggested that providing historical climate information in their areas would be very useful in planning crop calendar. They recommended that the information provider should communicate the level of confidence in the forecast.

Farmers recommended potential ways to disseminate the forecast including mobile phone SMS, local community radio broadcast and communication through community leaders. For those who can access the internet, receiving forecast information via website and social network was also suggested. An outlook forum before the beginning of the rainy season was also mentioned. Climate information should be presented in an easy to understand language and format such as graphs, color figures with short description. Categorical forecast i.e. above normal, near normal, below normal, was perceived as easier to understand and thus preferred over probabilistic forecast. Training farmers on how to interpret the forecast was agreed as a crucial activity. They also emphasized the important of inclusion of local wisdom with scientific information.

Apr	May	Jun	July	Aug	Sep	Oct	Nov
Land preparation		seeding	transplanting			Harvesting	Drying

Figure7 Rice production calendar for the study area

3.2 Assessment of model forecast skills

3.2.1 Seasonal rainfall forecast skills

The skill of seasonal rainfall prediction models were assessed over Southeast Asia by using CRU gridded monthly precipitation as predictands. Figure 3 to Figure 8 shows Pearson's correlation skill maps for 3-month seasons from SST-CCA, downscaled CanCM4, downscaled CCSM4, downscaled CFSv2 and downscaled GFDL models respectively. It was clear that predictability of rainfall over Thailand during wet monsoon period were quite modest and varied over evolving seasons. All models showed comparatively higher predictive skill (Pearson's correlation greater than 0.3) during the beginning of wet period in AMJ. The skills markedly dropped as the seasons progress to mid monsoon period in MJJ, JJA and JAS, although there were some locations which showed some skills. All models showed no useful skill (negative correlation) during late monsoon seasons in ASO and SON.

Comparatively high rainfall predictive skills were found over Indonesia archipelagos for all seasons except MJJ for all models. In Thailand, the northeast part which includes the study area showed some predictive skills compared with other part of the country especially in AMJ, MJJ, JJA and JAS seasons. Comparison between CCA-SST model and downscaled GCMs model shows that GCM downscaling provides enhancement in the predictive skill especially during peak monsoon period in JJA and JAS. Consistent findings were obtained when using rainfall from meteorological stations instead of gridded precipitation (Figure 9)

3.2.2 Categorical forecast skills

The previous section shows that the model predictive skills were not very high (correlation 0.01 to 0.41) for Ubon Ratchathani station during AMJ, MJJ, JJA and JAS seasons and even show negative correlation between model hindcast and observation for ASO and SON seasons. Given uncertainty in deterministic forecast, it is useful to assess the model ability to successfully predict categorical forecast. This section evaluates whether the model demonstrate any skill in discrimination between below- or above normal- seasons from other seasons. A ROC score higher than 0.5 shows that model has better skill than random guessing to successfully predict an event from non-event.

Figure 9 shows the ROC scores for below-normal and above-normal rainfall categories from six forecasting models. The results showed that model skills varied with time over the wet monsoon period consistent with correlation analysis. In ASO only downscaled GFDL model provided better skills than guessing while during SON no predictive model showed useful skill. For early part of the wet seasons in AMJ, using synchronous Nino 3.4 index provided skills for prediction of dry years similar to all four GCMs downscaling. For wet years, only downscaled CFSv2 and CCSM4 showed good skills. In MJJ season, for which correlation coefficient showed near zero value (not shown), ROC scores suggested that the downscaling of four GCMs had 60% to 70% chances of correctly predict above-normal years. Hence useful information could be obtained from the models by considering above-normal categorical forecast despite low correlation. However this was not true for forecast of below-normal category in MJJ. For JJA season which is in the peak of the monsoon period, all model showed high probability of correctly forecast above-normal rainfall events, while for below-normal rainfall events, the skill slightly dropped. For JAS season, SST models and downscaled GCM models showed high probability of correctly forecast below-normal rainfall, while for above-normal events, only downscaled GCM model show high confidence.

Seasonal rainfall prediction skills during wet monsoon season of Thailand and of study area in particular were assessed. Both statistical models and downscaled GCM models demonstrated some useful prediction skills in early and middle parts of the wet period while for the later part of the monsoon season, all models showed no skill. Generally, downscaled GCM rainfall hindcast provided enhancement in predictive skills over statistical models using SST as predictors. Despite modest predictive skill over the area of study, assessment of categorical forecasts showed moderate confidence in discriminating below-normal or above-normal seasons from other seasons during early and middle parts of rainy season.

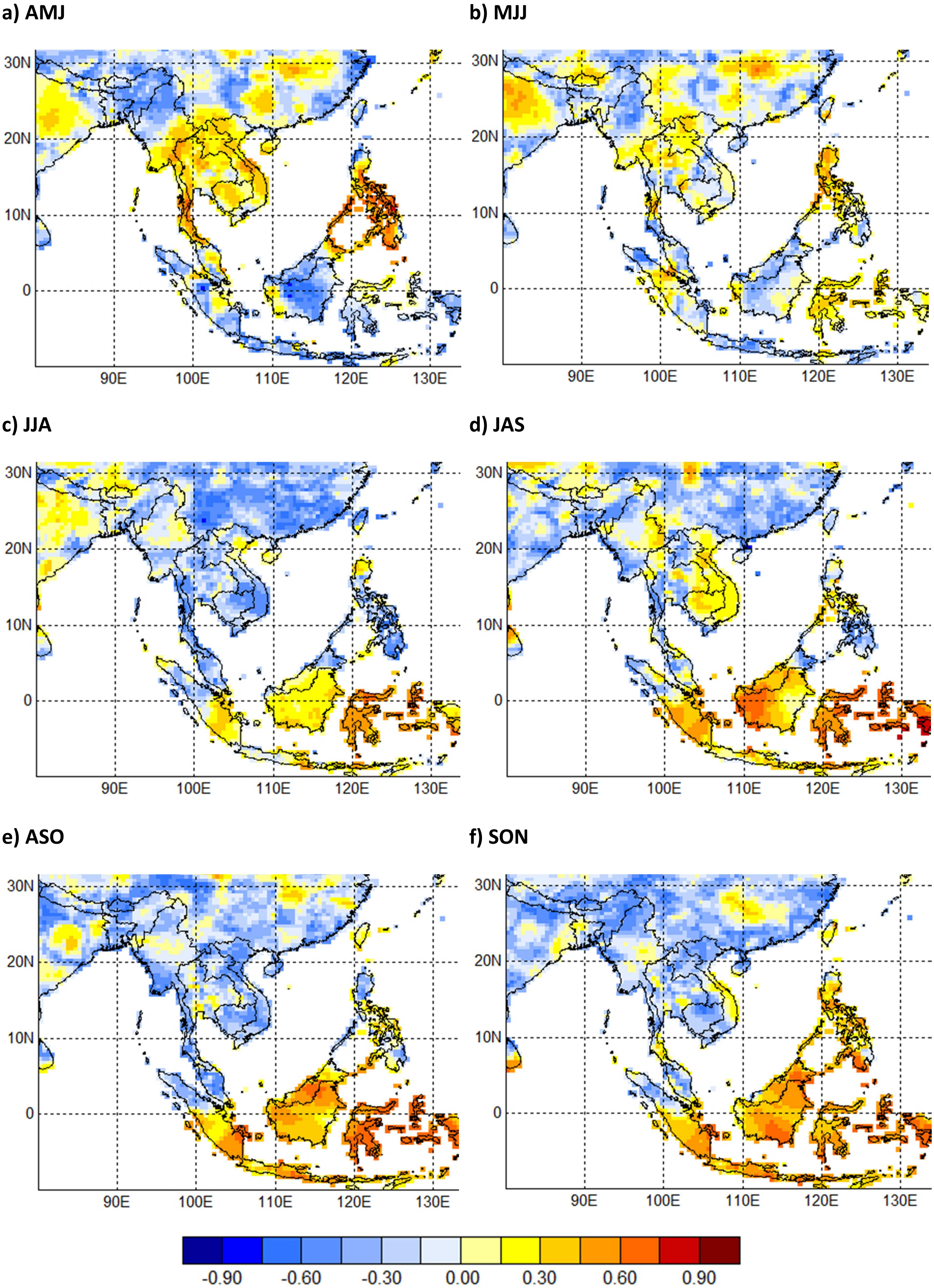


Figure 8 Pearson's correlation skill maps of 1-month lead Nino3.4 SST model for predicting 3-month seasonal rainfall

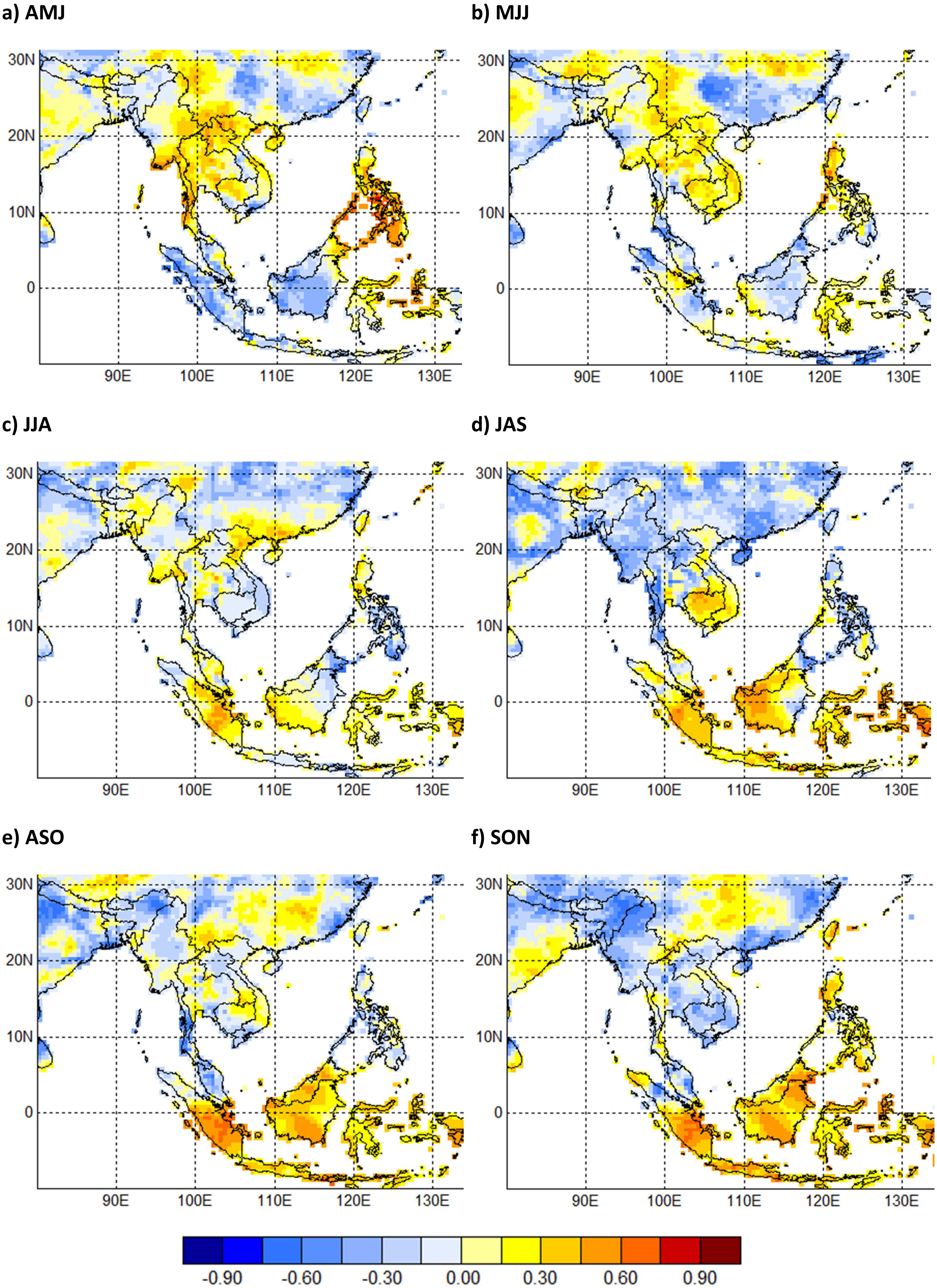


Figure 9 Pearson's correlation skill maps of 1-month lead Indo-Western Pacific SST CCA model for predicting 3-month seasonal rainfall

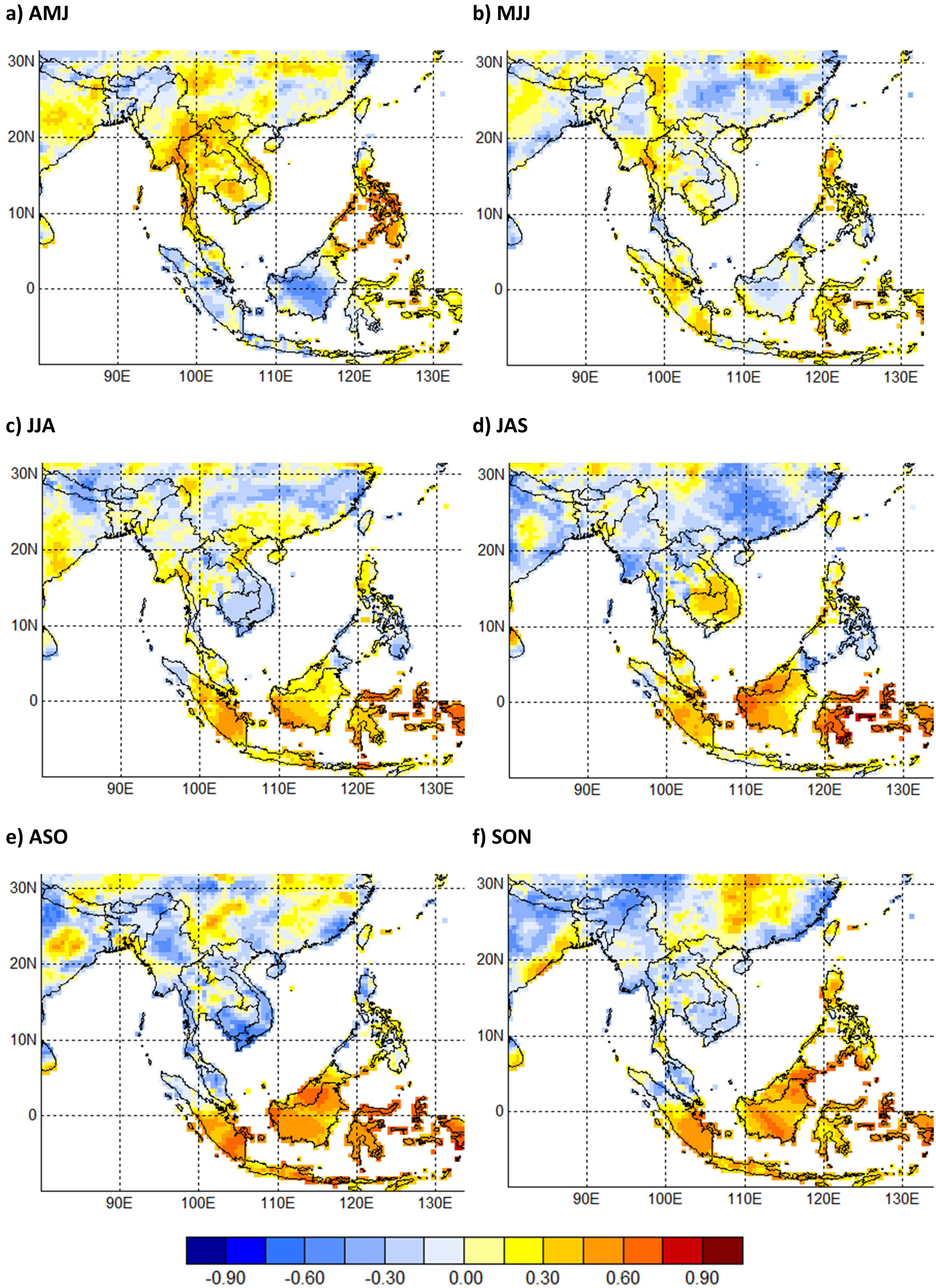


Figure 10 Pearson's correlation skill maps of 1-month lead Pacific SST CCA model for predicting 3-month seasonal rainfall

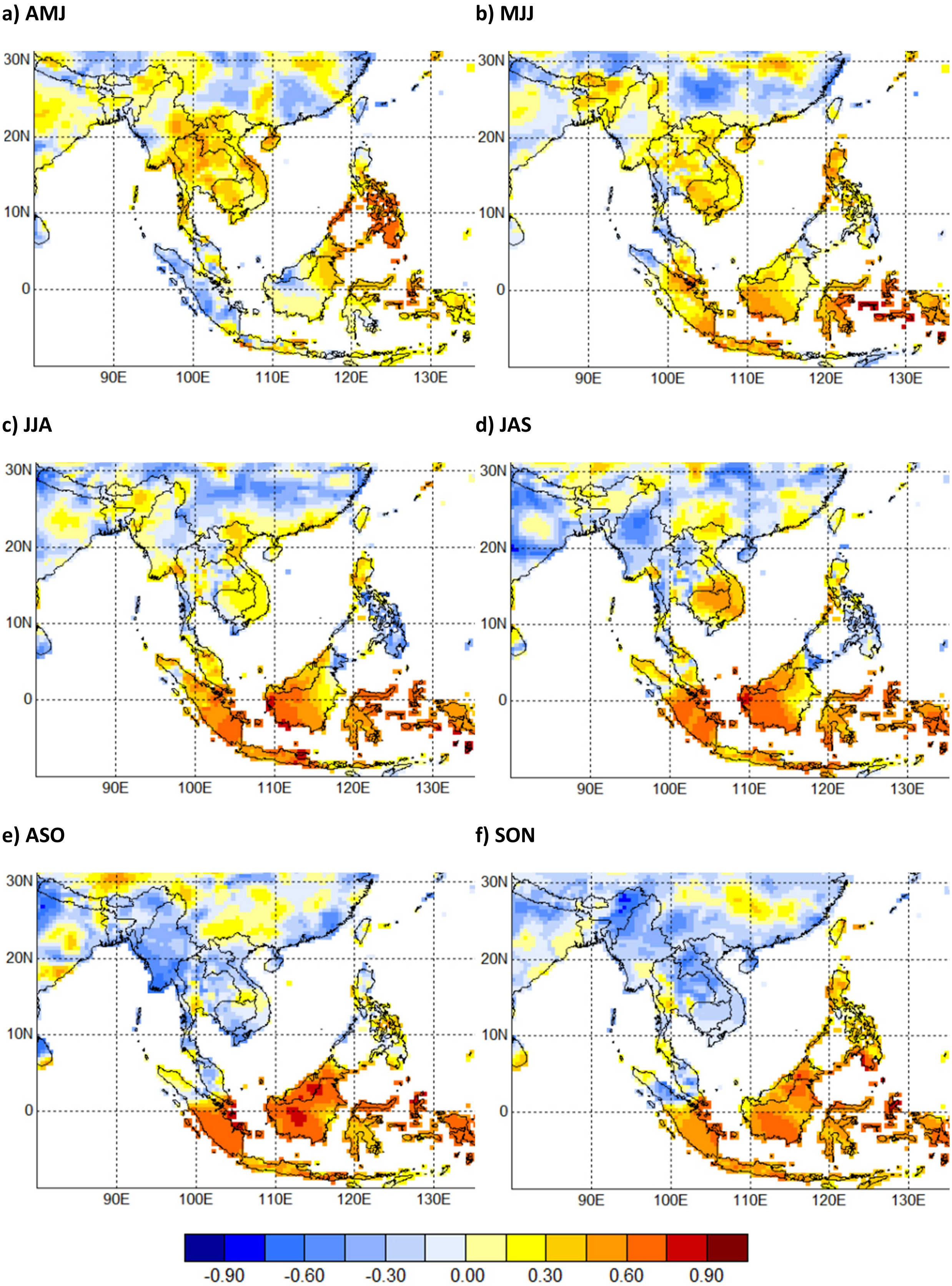


Figure 11 Pearson's correlation skill maps of downscaled GFDL prediction model for 3-month seasons

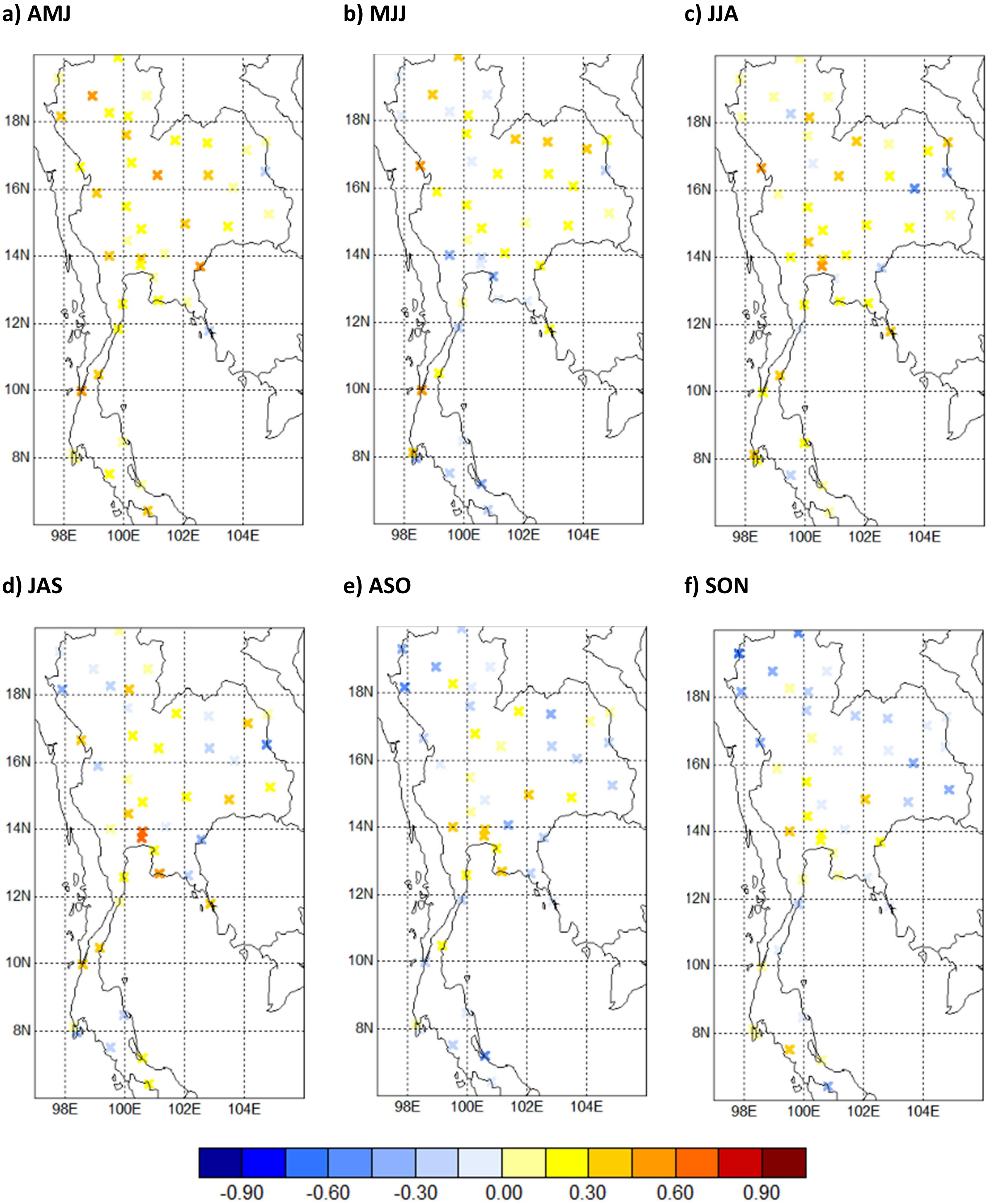
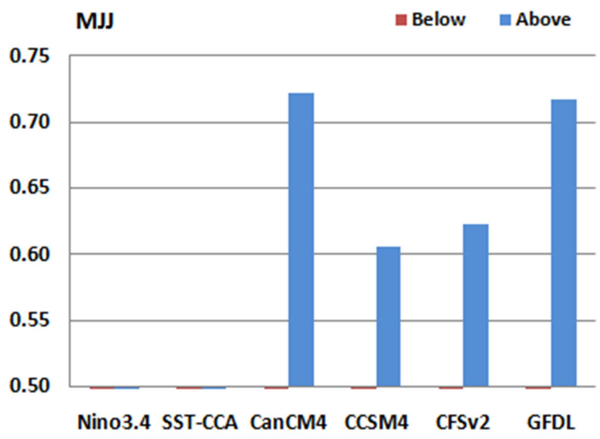


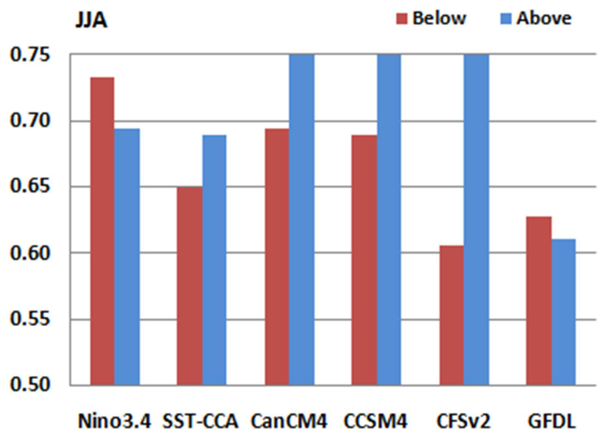
Figure 12 Pearson's correlation skill maps of downscaled GFDL prediction model for 3-month seasons at TMD stations

a) AMJ

b) MJJ



c) JJA



d) JAS

e) ASO

f) SON

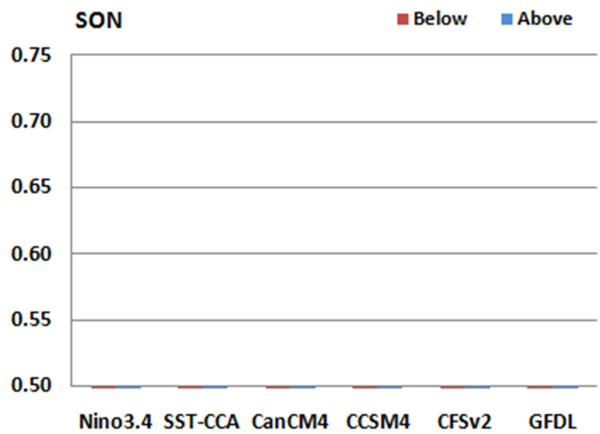
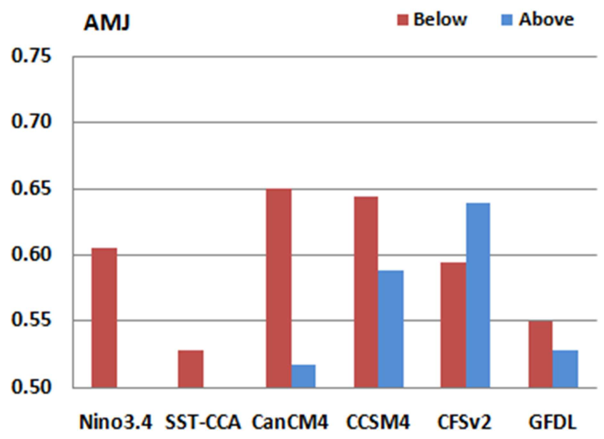
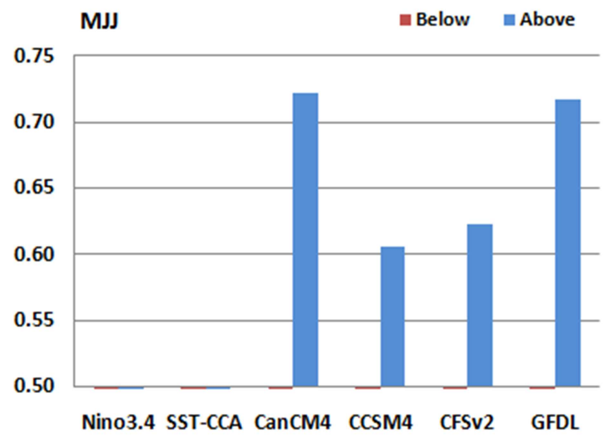


Figure 13 Pearson's correlation coefficient of downscaled statistical models and MOS for Ubon Ratchathani station

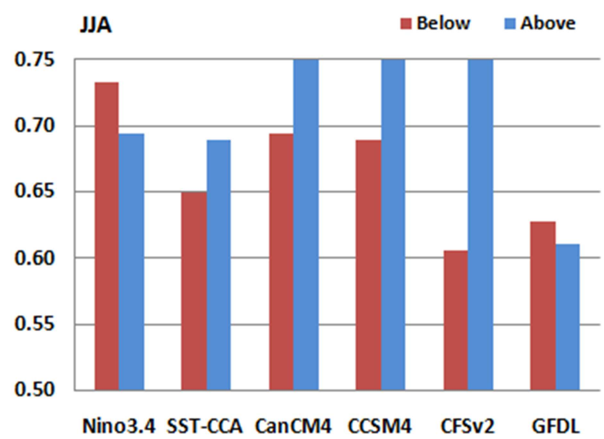
a) AMJ



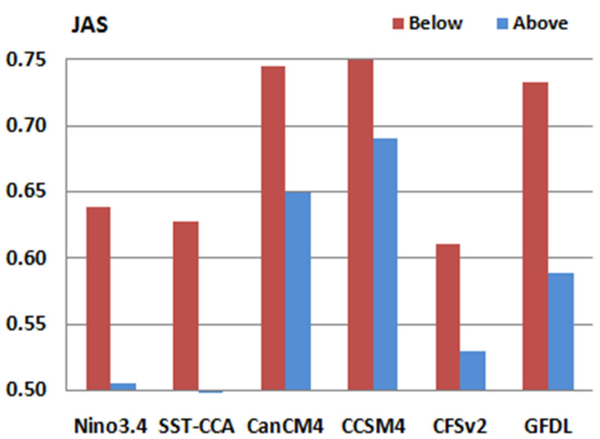
b) MJJ



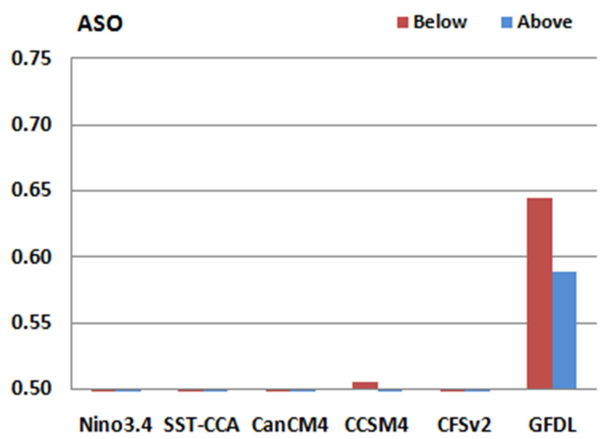
c) JJA



d) JAS



e) ASO



f) SON

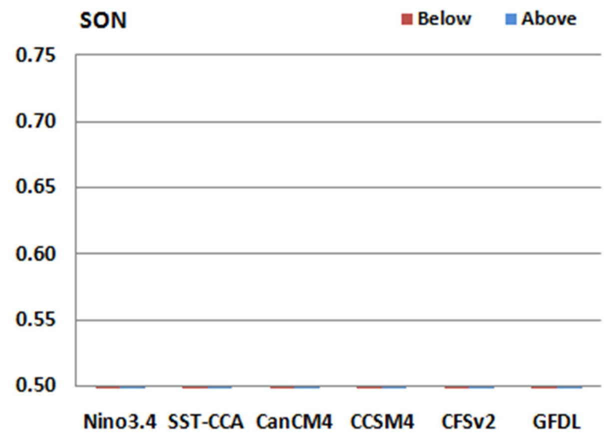
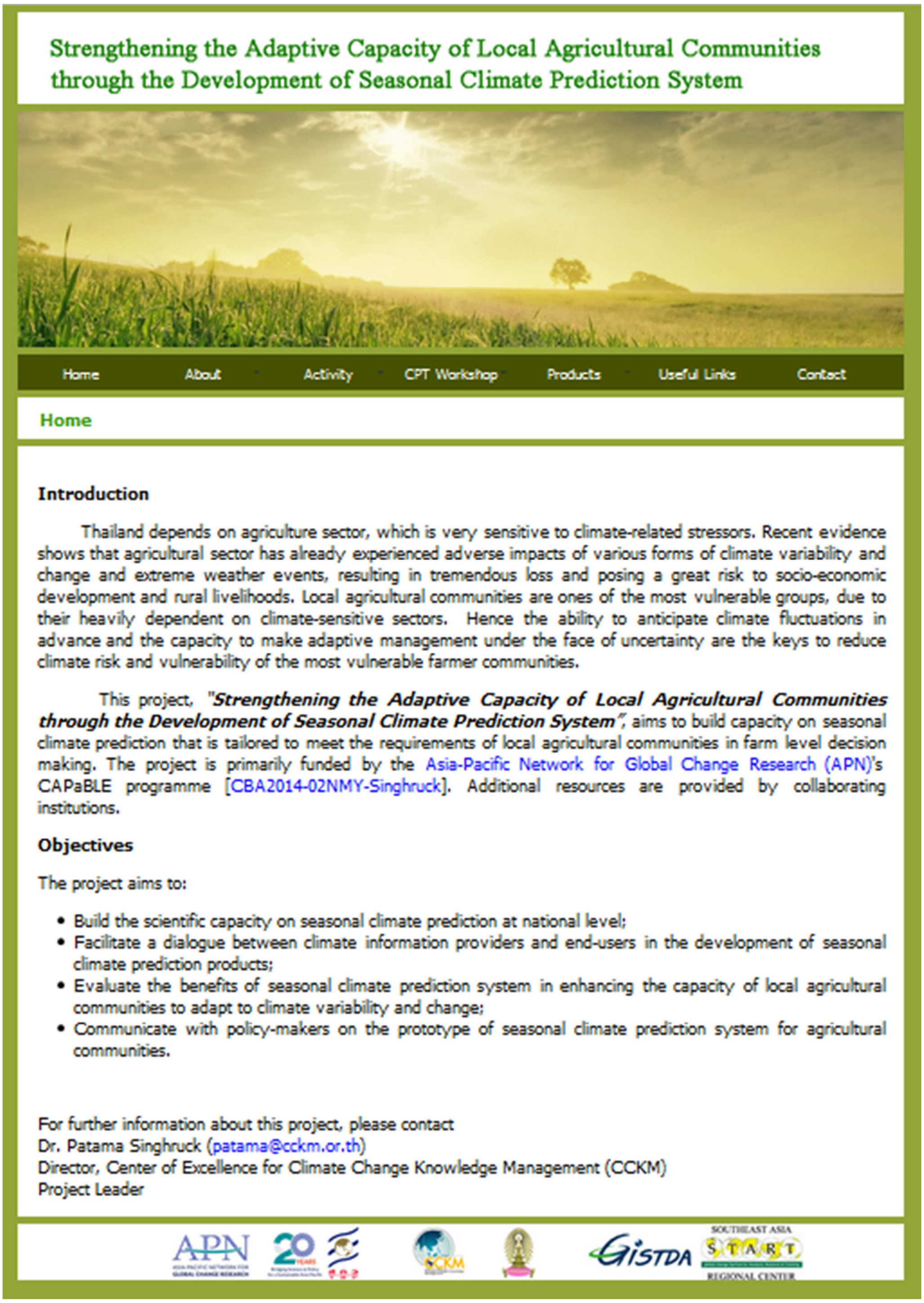


Figure 14 ROC scores for below-normal and above-normal rainfall categories for Ubon Ratchathani station

3.3 Seasonal climate prediction system

Research and development together with the training workshop were activities contributing toward the first objective of the project in building the scientific capacity on seasonal climate prediction tailored for local agricultural communities. The seasonal prediction system focused on the area of study in northeast Thailand in particular, but information was also available for the whole country. Six statistical models were constructed by using canonical correlation analysis (CCA) of different variables as predictors. Two models were based on historical relationship between tropical Pacific sea surface temperature and local rainfall. Four models were based on downscaling of global circulation model (GCM) rainfall hindcast for the period of 1982-2010 from the North American Multi-Model Ensemble (NMME) project. The predictive skills of six model constructions were assessed using cross-validation method. The final products consisting of seasonal rainfall forecast and associated predictive skills of each model construction were publicly available and updated monthly via the project's website: http://www.cckm.or.th/CCKM/Seasonal_Prediction/Home.html
For users in local communities, targeted forecasts were translated to easily understandable messages and disseminated directly to them via mobile phone messages.



Strengthening the Adaptive Capacity of Local Agricultural Communities through the Development of Seasonal Climate Prediction System

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Introduction

Thailand depends on agriculture sector, which is very sensitive to climate-related stressors. Recent evidence shows that agricultural sector has already experienced adverse impacts of various forms of climate variability and change and extreme weather events, resulting in tremendous loss and posing a great risk to socio-economic development and rural livelihoods. Local agricultural communities are ones of the most vulnerable groups, due to their heavily dependent on climate-sensitive sectors. Hence the ability to anticipate climate fluctuations in advance and the capacity to make adaptive management under the face of uncertainty are the keys to reduce climate risk and vulnerability of the most vulnerable farmer communities.

This project, *"**Strengthening the Adaptive Capacity of Local Agricultural Communities through the Development of Seasonal Climate Prediction System**"*, aims to build capacity on seasonal climate prediction that is tailored to meet the requirements of local agricultural communities in farm level decision making. The project is primarily funded by the Asia-Pacific Network for Global Change Research (APN)'s CAPaBLE programme [CBA2014-02NMY-Singhruck]. Additional resources are provided by collaborating institutions.

Objectives

The project aims to:

- Build the scientific capacity on seasonal climate prediction at national level;
- Facilitate a dialogue between climate information providers and end-users in the development of seasonal climate prediction products;
- Evaluate the benefits of seasonal climate prediction system in enhancing the capacity of local agricultural communities to adapt to climate variability and change;
- Communicate with policy-makers on the prototype of seasonal climate prediction system for agricultural communities.

For further information about this project, please contact
Dr. Patama Singhruck (patama@cckm.or.th)
Director, Center of Excellence for Climate Change Knowledge Management (CCKM)
Project Leader

Figure 15 The main webpage for the Project

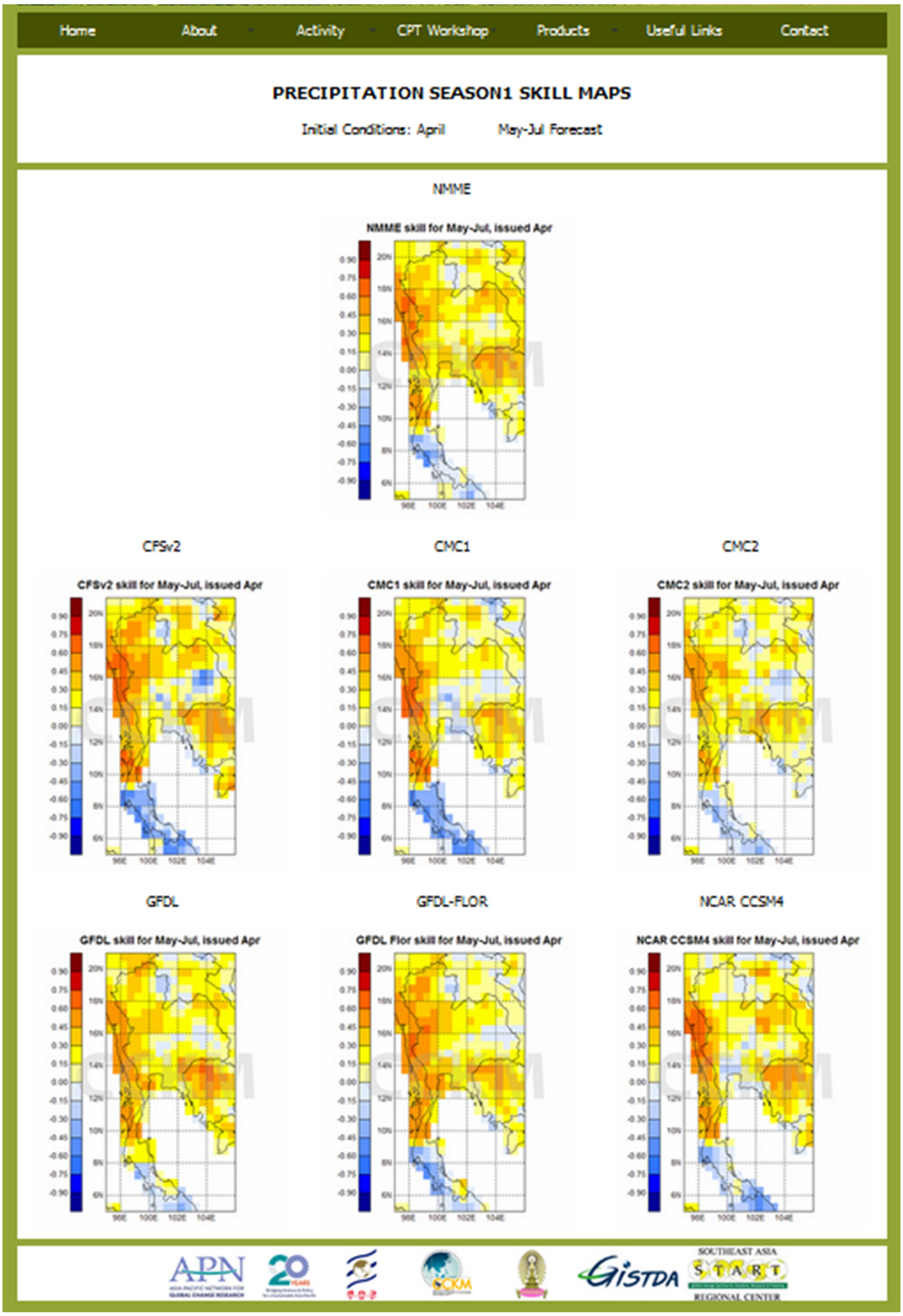

Figure 16 Webpage providing skill maps of seasonal forecast models

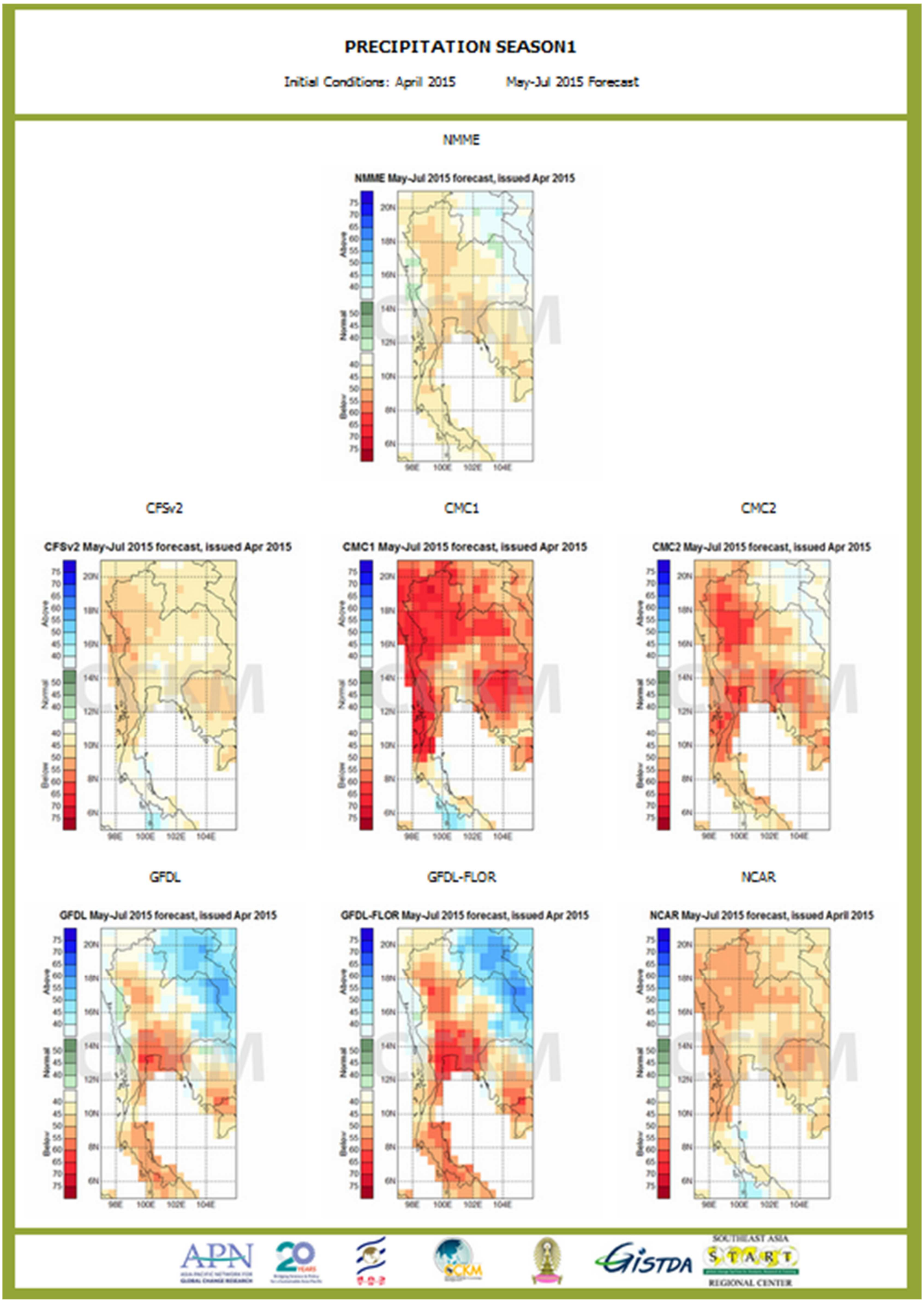

Figure 17 Webpage providing seasonal rainfall forecast maps

3.4 User interaction with climate information

3.4.1 Indigenous knowledge

The uptake of the seasonal prediction by farmers indicated that the accuracy of the forecast was a critical factor. In such uncertain circumstance, farmers also used local wisdoms such as observation of certain species of insects, lizards and plants and other ancestral experiences such as the empirical association between late monsoon onset dates in lunar calendar leap years.

3.4.2 Incorporation of management options with seasonal climate information

It was also essential to provide recommendations in agricultural practices together with climate information. For example, if the dry condition is forecasted for the beginning of growing season, the advisory may include adaptive practices such as shifting growing calendar. Adaptive production options for different climate conditions should be compiled and included with climate information dissemination.

3.4.3 Continuum of timescales

Farmers expressed their needs of climate information across a wide spectrum of timescales ranging from daily weather forecast, weekly forecast, monthly forecast and seasonal forecast. Sufficient lead time is critical during weather-sensitive growing activities such as sowing and reaping. Due to the low predictability of the newly-developed product at seasonal timescale, other forecast products at shorter timescales available from operational institutions were introduced to assist farmers in decision-making. These products consisted of a 5-day forecast from Thai Meteorological Department (TMD) and a daily forecast from weather forecasting model by Hydro and Agro Informatics Institute (HAII). The inclusion of weather prediction and seasonal prediction enhanced the awareness of farmers of the benefit of incorporating climate information in decision making

4. Conclusions

The study assessed the seasonal rainfall predictive skills in wet monsoon seasons of Thailand and of the study area in northeast Thailand in particular. Six statistical models were constructed using different variables as predictors. Two models were based on historical relationship between tropical Pacific SST and local rainfall. Four GCM rainfall hindcast for the period of 1982-2010 from NMME project were downscaled to local rainfall using canonical correlation analysis (CCA). Predictive skills of the models were assessed by two skill scores from cross-validation, i.e., Pearson's correlation coefficient and ROC scores. Result showed that during wet monsoon season, predictability of rainfall over Thailand is quite modest compared with other parts of the region, for example, the maritime continents. Nationwide, the northeast part of Thailand have some predictive skills compared to other region of country. The model skills also varied in time being moderate in the beginning of the season, becoming high during the peak season and dropping to none during the latter part of the season. In general, downscaled GCM rainfall hindcast showed enhancement in predictive skills over statistical models using SST as predictors. Assessment of model confidence in discriminating below- or above- normal rainfall seasons showed that during the early and middle part of the rainy season, models tended to showed high probability of successfully predict below- or above- normal seasons. However, in the later part of the season, model showed no better skill in discriminating the events than guessing.

5. Future Directions

While the successful application for the area chosen was not realized due to low predictability achieved from the forecasting system, it was clear that other part of Thailand showed potential predictability. In this study, the area of study was chosen based on the needs of local communities for climate information. However, the successful application depends critically on the predictive skills of the model. Hence the full cycle of system development of seasonal prediction for agriculture consisting of user needs assessment, system development, system's predictive capability assessment and evaluation of the benefits of using seasonal climate prediction for risk management should be explored in areas where there are some demonstrable predictive skills. In addition, further improvement on seasonal forecast accuracy should be explored using various techniques such as GCMs, dynamic downscaling, and statistical post-processing.

It was found that farmers need a continuum of timescales of climate information. Hence further work should also explore the provision of climate information at short-, medium- and long-ranged timescales and integrate them with crop calendar. Integrating local wisdoms such as observation of certain species of insects, lizards and plants and other ancestral experiences with scientific forecast was found to enhance the uptake of climate information by farmers and therefore should be compiled and evaluated. It was found that providing climate information together with recommendations on agricultural practices enhanced the uptake of climate information and therefore should be further compiled and evaluated.

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Appendices

A. Inception Workshop: User Needs Consultation

Ubon Ratchathani, Thailand

21 August 2014

Executive summary

The inception workshop was held on 21 August 2014 at Ubon Ratchathani University, Ubon Ratchathani Province. The first objective of the workshop was to introduce the project to stakeholders including smallholder farmers, local government and non-government officers, and project core members. The second objective was to create a dialogue between climate information provider and user communities to co-design the seasonal climate prediction system. There were sixty-two smallholder farmers from six communities in three northeast provinces participated in the workshop. Farmers in breakout groups according to their geographical settings identified necessary contents of climate information, dissemination strategies and the processes of information interpretation. Result from the dialogue showed that farmers recognized potential benefits from using seasonal climate product in farm management. However, the main constraints prevented them from fully exploit the information arose from lacking of local context in the information as well as lacking of accessibility to the product. Hence, to make seasonal climate information more useful in decision making and planning at community level, the product must have detail spatial resolution, is available in accessible format (e.g. mobile phone SMS, radio broadcast, website, etc.), understandable to the users, and provided with sufficient lead time to be actionable. In addition to seasonal rainfall total, decision making at farm level also requires information on timing of rainfall and season onset or length. The results from this consultation process will be incorporated in the development of seasonal climate prediction product.

Agenda

Thursday 21 August 2014	
9.00 – 9.30	**Registration**
9.30 – 9.45	**Welcome and opening remarks** Assistant Professor Dr. Inthira Sahee, Vice President for Research and Social Engagement, Ubon Ratchathani University
9.45 – 10.00	**Workshop introduction** Ms. Pannee Samerpak, Project Manager, Empowering Farmers for Food security and climate change adaptation in Ubon Ratchathani Province (EFFU)
10.00 – 10.20	**Development of seasonal climate prediction system for smallholder farmers in northeast provinces** Dr. Patama Singhruck, Director, Center of Excellence for Climate Change Knowledge Management (CCKM)
10.20 – 10.40	**Adaptation to climate variability and change in farming communities** Mr. Bhumrindra Tauvarotama, Researcher, Center of Excellence for Climate Change Knowledge Management (CCKM)
10.40 – 12.00	**Breakout group discussion: Identification of climate information needs** facilitated by Ms. Pannee Samerpak (EFFU) Mr. Nawin Sophapoom (Healthy Public Policy Foundation) Dr. Atsamon Limsakul (Department of Environmental Quality Promotion)
12.00 – 13.00	Lunch
13.00 – 14.30	**Breakout group discussion: Strategy for climate information dissemination** facilitated by Ms. Pannee Samerpak (EFFU) Mr. Nawin Sophapoom (Healthy Public Policy Foundation) Dr. Atsamon Limsakul (Department of Environmental Quality Promotion)
14.30 – 15.00	**Summary of breakout group discussion and the way forward** Dr. Patama Singhruck, Director, Center of Excellence for Climate Change Knowledge Management (CCKM)
15.00 – 15.15	**Closing**

Summary of user needs

1. Identification of climate information needs

Farmers expressed their needs of climate information across a wide spectrum of time scales ranging from daily weather forecast, weekly forecast, monthly forecast and seasonal forecast. The most important variable is precipitation. Additional useful variables are temperature, winds and storms. In addition to seasonal rainfall total, seasonal onset and length are also very useful. The information is used in planning crop calendar. They require information that has enough spatial resolution and location specific, at least at district (Amphoe) scale, if the information at village scale is not viable. The timing of forecast is also very critical especially during weather-sensitive growing activities such as sowing and reaping. They suggested that providing historical climate information in their areas would be very useful in planning crop calendar. They recommended that the information provider should communicate the level of confidence in the forecast.

2. Strategy for climate information dissemination

Farmers recommended potential ways to disseminate the forecast including mobile phone SMS, local community radio broadcast and communication through community leaders. For those who can access the internet, receiving forecast information via website and social network was also suggested. An outlook forum before the beginning of the rainy season was also mentioned. Climate information should be presented in an easy to understand language and format such as graphs, color figures with short description. Categorical forecast i.e. above normal, near normal, below normal, was perceived as easier to understand and thus preferred over probabilistic forecast. Training farmers on how to interpret the forecast was agreed as a crucial activity. They also emphasized the important of inclusion of local wisdom with scientific information.

Participants

Personnel from participating institutions

No.	Name	Organization
1.	Assistant Professor Dr. Inthira Sahee	Ubon Ratchathani University
2.	Ms. Kritaya Udtho	Ubon Ratchathani University
3.	Mr. Pratai Kenleam	Ubon Ratchathani University
4.	Mr. Ukrit Boonna	Ubon Ratchathani University
5.	Ms. Walailuck Srila	Ubon Ratchathani University
6.	Ms. Pannee Samerpak	EFFU, Ubon Ratchathani University
7.	Asst. Prof. Dr. Boontiam Lertsupawitnapa	EFFU, Ubon Ratchathani University
8.	Mr. Boontiwa Sangaklod	EFFU, Ubon Ratchathani University
9.	Ms. Uthaiwan Phewphan	Mahidol University Amnatcharoen Campus
10.	Mr. Supawasan Wongthanu	Ubon Ratchathani Rajabhat University
11.	Mr. Suchai Charoenmookayanan	Ubon Ratchathani Provincial Agriculture
12.	Ms. Chantraporn Pratan	Bureau of Argiculture Development
13.	Ms. Wariya Krongyut	Ubon Ratchathani Rice Research Center
14.	Mr. Piyawat Homkuntod	Bank for Agriculture and Agricultural Cooperatives
15.	Ms. Chanatip Akesiri	Sangsook Foundation, Ubon Ratchathani
16.	Mr. Aniwat Suwan	Sangsook Foundation, Ubon Ratchathani
17.	Mr. Rapin Yeunyao	Civil Foundation, Ubon Ratchathani
18.	Mr. Nawin Sophapoom	Healthy Public Policy Foundation
19.	Mr. Atsamon Limsakul	Department of Environmental Quality Promotion
20.	Ms. Naritsara Sakphoo	Center of Excellence for Climate Change Knowledge Management (CCKM), Chulalongkorn University
21.	Ms. Maneewan kwankaew	Center of Excellence for Climate Change Knowledge Management (CCKM), Chulalongkorn University
22.	Mr. Pongsit Polsomboon	Center of Excellence for Climate Change Knowledge Management (CCKM), Chulalongkorn University
23.	Mr. Bhumrindra Tauvarotama	Center of Excellence for Climate Change Knowledge Management (CCKM), Chulalongkorn University
24.	Ms. Patama Singhruck	Center of Excellence for Climate Change Knowledge Management (CCKM), Chulalongkorn University

Smallholder farmers

No.	Name	District (Amphoe)	Province (Changwat)
1.	Mr. Surat Wannachat	Sai Mun	Yasothon
2.	Ms. Warunee Madkhao	Kut Chum	Yasothon
3.	Mr. Prajong Srimanta	Kut Chum	Yasothon
4.	Ms. Buatong Boonsri	Kut Chum	Yasothon
5.	Mr. Mun Polchai	Kut Chum	Yasothon
6.	Mr. Padung Veruwanarat	Kut Chum	Yasothon
7.	Mr. Suthipong Polchai	Kut Chum	Yasothon
8.	Mr. Saisamorn Waiwong	Pa Tio	Yasothon
9.	Mr. Amnui Pongkan	Pa Tio	Yasothon
10.	Mr. Wanna Kaewklom	Mueang Amnat Charoen	Amnat Charoen
11.	Ms. Chindaporn Boonklom	Mueang Amnat Charoen	Amnat Charoen
12.	Mr. Siwa Boonruang	Mueang Amnat Charoen	Amnat Charoen
13.	Mr. Lodtong Kongtong	Mueang Amnat Charoen	Amnat Charoen
14.	Mr. Sangwan Boonjung	Mueang Amnat Charoen	Amnat Charoen
15.	Mr. Wichit Butri	Senangkhanikhom	Amnat Charoen
16.	Mr. Sirisak Tongkaew	Senangkhanikhom	Amnat Charoen
17.	Mr. Sayan Tonglor	Senangkhanikhom	Amnat Charoen
18.	Mr. Wilai Puwong	Senangkhanikhom	Amnat Charoen
19.	Mr. Suwan Wamaloon	Hua Taphan	Amnat Charoen
20.	Mr. Suthipong Wamaloon	Hua Taphan	Amnat Charoen
21.	Mr. Wichai Tayatham	Hua Taphan	Amnat Charoen
22.	Mr. Tongdee Hongsa	Hua Taphan	Amnat Charoen
23.	Mr. Sompong Jarujit	Hua Taphan	Amnat Charoen
24.	Mr. Somkid Laitong	Hua Taphan	Amnat Charoen
25.	Mr. Kasemsan Saengsingkaew	Phana	Amnat Charoen
26.	Mr. Somrit Chaoranong	Phana	Amnat Charoen
27.	Mr. Songkorn Somrak	Phana	Amnat Charoen
28.	Mr. Sawan Lohkam	Phana	Amnat Charoen
29.	Mr. Samai Pakdee	Phana	Amnat Charoen
30.	Mr. Sawit Cheablaem	Phana	Amnat Charoen
31.	Ms. Samrueng Roobsuay	Na Tan	Ubon Ratchathani
32.	Mr. Dokdam Suebkam	Na Tan	Ubon Ratchathani
33.	Mr. Amphorn Wonglang	Na Tan	Ubon Ratchathani
34.	Mr. Bin Kongton	Pho Sai	Ubon Ratchathani
35.	Mr. Samai Laoma	Pho Sai	Ubon Ratchathani
36.	Mr. Niratsai Khantong	Pho Sai	Ubon Ratchathani
37.	Mr. Prasit Chantachalee	Pho Sai	Ubon Ratchathani
38.	Mr. Somjit Tongmalee	Mueang Ubon Ratchathani	Ubon Ratchathani
39.	Mr. Kowit Tongmalee	Mueang Ubon Ratchathani	Ubon Ratchathani
40.	Mr. Paitoon Sripradap	Mueang Ubon Ratchathani	Ubon Ratchathani
41.	Mr. Utan Chaitong	Mueang Ubon Ratchathani	Ubon Ratchathani
42.	Mr. Soontorn Wansilp	Mueang Ubon Ratchathani	Ubon Ratchathani
43.	Ms. Nampetch Kanwipat	Mueang Ubon Ratchathani	Ubon Ratchathani
44.	Mr. Champee Sattham	Warin Chamrap	Ubon Ratchathani
45.	Mr. Banchong Tongbutr	Warin Chamrap	Ubon Ratchathani
46.	Mr. Pabud Nawaboonniyom	Warin Chamrap	Ubon Ratchathani

47.	Mr. Tongyim Pimkot	Tan Sum	Ubon Ratchathani
48.	Ms. Chom Satho	Tan Sum	Ubon Ratchathani
49.	Mr. Malai Santaweesuk	Tan Sum	Ubon Ratchathani
50.	Mr. Poom Wongyen	Tan Sum	Ubon Ratchathani
51.	Ms. Tongdee Poomchan	Phibun Mangsahan	Ubon Ratchathani
52.	Ms. Sombai Weesee	Phibun Mangsahan	Ubon Ratchathani
53.	Ms. Saeng-aroon Boonlom	Phibun Mangsahan	Ubon Ratchathani
54.	Mr. Paopong Suma	Phibun Mangsahan	Ubon Ratchathani
55.	Mr. Anan Nonsiri	Phibun Mangsahan	Ubon Ratchathani
56.	Mr. Panya Sitthichai	Phibun Mangsahan	Ubon Ratchathani
57.	Mr. Promma Panich	Det Udom	Ubon Ratchathani
58.	Mr. Prasert Pudpa	Det Udom	Ubon Ratchathani
59.	Ms. Pikun Kuakoon	Det Udom	Ubon Ratchathani
60.	Mr. Pae Sritong	Det Udom	Ubon Ratchathani
61.	Mr. Uthai Sankammeun	Det Udom	Ubon Ratchathani
62.	Mr. Kamsao Roythamkui	Det Udom	Ubon Ratchathani


การพัฒนาระบบคาดการณ์ลักษณะอากาศรายฤดูกาล
เพื่อสร้างขีดความสามารถในการปรับตัวต่อ
ความแปรปรวนของภูมิอากาศ สำหรับชุมชนเกษตรกรรม
APN

การสัมมนาเปิดโครงการ





B. Training Workshop: Seasonal Forecasting Using the Climate Predictability Tool

Bangkok, Thailand

12 – 16 January 2015

Executive summary

As part of the scientific capacity building component of the project CBA2014-02NMY-SINGHRUCK, “Strengthening the Adaptive Capacity of Local Agricultural Communities through the Development of Seasonal Climate Prediction System”, a five-day training workshop on Seasonal Forecasting Using the Climate Predictability Tool (CPT) was held during 12-16 January 2015 at the training center of the Geo-Informatics and Space Technology Development Agency, (GISTDA), Bangkok, Thailand. The workshop was primarily funded by the Asia-Pacific Network for Global Change Research (APN). The Thailand Research Fund (TRF) co-sponsored the workshop. The Center of Excellence for Climate Change Knowledge Management (CCKM), Chulalongkorn University, provided logistics arrangement. The training was conducted by Simon Mason, International Research Institute for Climate and Society (IRI).

The objective of the training workshop was to increase the capacity on seasonal climate prediction at national level. There were 48 participants from government agencies dealing with climate services, water resources, agriculture, disaster management, as well as participants from research institutions and universities taking part in this workshop. The training consisted of lectures and hands-on exercises on the principles of seasonal forecasting, the used of empirical methods as diagnostic and forecasting tools and forecast verification. Participants learned how to use the Climate Predictability Tool (CPT) developed by IRI to construct seasonal climate forecast models specific to their region of interests, perform model validation and produce a forecast for the coming season. Overall, participants evaluated the workshop execution and learning experience as highly satisfactory and anticipated to incorporate knowledge and methods on seasonal forecasting in their institutions’ ongoing work.

Agenda

Monday 12 January 2015		
8.30 – 9.00	**Registration**	
9.00 – 9.30	**Welcome** Dr. Patama Singhruck, Director, Center of Excellence for Climate Change Knowledge Management (CCKM) **Introducing resource person: Dr. Simon Mason** International Research Institute for Climate and Society (IRI) by Dr. Patama Singhruck **Opening Remarks** Dr. Anond Snidvongs, Director, Geo-Informatics and Space Technology Development Agency (GISTDA) **Group photo**	
9.30 – 10.30	**Theory**	General introduction to seasonal forecasting: distinction from weather forecasting, sources of predictability, and methods
10.30 – 10.45		-----break-----
10.45 – 12.00	**CPT**	• Introduction of Climate Predictability Tool) CPT) developed by IRI • Multiple linear regression (MLR) as a diagnosis and forecasting tool
12.00 – 13.00		-----lunch-----
13.00 – 14.30	**CPT**	Principal components regression (PCR) as a tool for diagnosing predictability
14.30 – 14.45		-----break-----
14.45 – 16.00	**CPT**	Principal components regression (PCR) as a statistical forecasting tool
Tuesday 13 January 2015		
9.00 – 10.30	**CPT**	Data preparation Canonical correlation analysis (CCA) as a tool for diagnosing predictability
10.30 – 10.45		-----break-----
10.45 – 12.00	**CPT**	Canonical correlation analysis (CCA) as a statistical forecasting tool
12.00 – 13.00		-----lunch-----
13.00 – 16.00	**CPT**	Canonical correlation analysis (CCA) as a general circulation model (GCM) model output statistics (MOS) (break 14.30 – 14.45)
Wednesday 14 January 2015		
9.00 – 12.00	**CPT**	Combining predictors, including multiple GCMs and/or extended empirical orthogonal function (EEOF) predictors

		(break 10.30 – 10.45)
12.00 – 13.00		-----lunch-----
13.00 – 13.30	**Theory**	Probabilistic forecasting
13.30 – 16.00	**CPT**	Forecasting in CPT, including forecast tailoring, probabilities v odds v prediction intervals, standardized precipitation index (SPI) predictions
		(break 14.30 – 14.45)
Thursday 15 January 2015		
9.00 – 10.00	**Theory**	Verification of deterministic forecasts
10.00 – 12.00	**CPT**	Validation - How CPT measures skill of cross-validated forecasts
		(break 10.30 – 10.45)
12.00 – 13.00		-----lunch-----
13.00 – 14.30	**Theory**	Probabilistic forecasts verification Relative operating characteristics (ROC)
14.30 – 14.45		----break-----
14.45 – 16.00	**CPT**	Verification – How CPT measures skill of retroactive forecasts
Friday 16 January 2015		
9.00 – 12.00	**CPT**	Probabilistic forecasts verification
		(break 10.30 – 10.45)
12.00 – 13.00		-----lunch-----
13.00 – 15.00	**Discussion**	Discussion and participant presentations
15.00 – 15.15		-----break-----
15.15 – 16.00	**Closing**	
	Dr. Jariya Boonjawat, Scientific Planning Group (SPG) Member for Thailand and SPG co-chair, Asia-Pacific Network for Global Change Research (APN)	

Course summaries

General introduction to seasonal forecasting

This session introduced the distinction between seasonal forecasting and weather forecasting. Weather forecasting depends on knowing the current state of weather (initial conditions) and how the current state will evolve. Since we do not observe and understand the weather system perfectly, these two uncertainties limit accurate forecast to only a few days in advance. Unlike weather forecasting, seasonal forecasting predicts the statistics of weather over a few months rather than the actual weather at any specific time. Much of the skill in predicting departures from normal seasons comes from slowly-varying sea surface temperature in the tropics notably ENSO. Seasonal forecasting can be done in two possible ways i.e. looking at evidence for influences in the past (empirical forecast) and modeling the processes that cause the effects (dynamical forecast).

Methods in statistical seasonal forecasting

This session introduced commonly used statistical methods in seasonal forecasting available in the Climate Predictability Tool (CPT) which includes multiple linear regression (MLR), principal component regression (PCR) and canonical correlation analysis (CCA). All of these methods use historical relationship between predictors and predictands in constructing the model. Yet, how well we can describe a historical relationship is not the same as how well we can predict future values. Hence we have to test the predictions using independent data. The approach is called cross-validation.

MLR can be used in constructing the model when there is one or very small numbers of predictors. But MLR has multicolineariry and multiplicity problems when there are many predictors. PCR whereby predictors are transformed using principal component analysis prior to constructing the regression model can resolve the multiconlinearity problem and reduce multiplicity problem. When there are lots of predictors and lots of predictands, CCA which finds patterns that maximize the correlation between time series of predictors and predictands is the suitable method. Apart from using CCA as a statistical forecasting tool, it can be used to downscale large-scale predictors from a general circulation model (GCM) output to finer-scale predictands. The approach is called model output statistics (MOS).

In CPT, forecast tailoring can be done in many different ways. Uncertainty in the forecast can be expressed as prediction intervals, probabilities and odds. CPT takes the cross-validated error variance, and the standard errors of the regression constant and coefficient(s) to calculate the prediction error variance. Bootstrapping method is used to determine significant test (P-value, confidence limit).

Evaluating forecast quality

This session introduced methods of assessing the quality of the forecasts. Appropriate metrics are available for different forms of forecast i.e. deterministic or probabilistic forecast for discrete (categories) or continuous variables. In deterministic forecast for continuous variables, we use a measure of association between forecast and observations (e.g. Pearson's correlation, Spearman's correlation, Kendall's tau) or error measures (e.g. mean bias, variance ratio and root-mean-squared error). In deterministic forecast for categorical variables, we consider rates of hits (e.g. hit score, hit skill) and measures of discrimination (2AFC, ROC). Two-alternative forced choice (2AFC) is the probability of successfully identifying warmer/wetter category. Relative operating characteristics (ROC) is the probability of successfully identifying observation in current category.

Probabilistic forecast

This session introduced probabilistic forecast and methods of probabilistic forecast verification. Probabilistic forecast try to give an indication of how confident we are that the specified outcome will occur. Good probabilistic forecast needs to have four qualities i.e. reliability, sharpness, resolution and discrimination. Reliability means the event occurs as frequently as implied by the forecast. Sharpness means the forecasts frequently have probabilities that differ from climatology considerably. Resolution means the outcome differs when the forecast differs. Discrimination means the forecasts differ when the outcome differs. Although a probabilistic forecast can never be wrong, we can assess whether or not the probability is appropriate or fair. In CPT, verification of probabilistic forecast is done by retroactive forecasting. CPT will use an initial training period to cross-validate a model and make predictions for the subsequent year(s), then update the training period and predict additional years, repeating until all possible years have been predicted. Metrics for probabilistic forecast include attributes diagrams, ROC diagrams, skill maps, tendency diagram, ranked hits diagram, weather roulette.

Workshop evaluation

Participants were requested to evaluate the workshop by answering the questionnaire and provide any additional suggestion. Questions are related to the workshop contents and execution, learning experience, and potential benefit to their works. On the whole, participants evaluated the workshop execution and learning experience as highly satisfactory and anticipated high potential in applying acquired knowledge in relation to their works. Suggestions were also offered such as more assisting staffs during hands-on sessions and providing background reading prior to the workshop.

Participants

<u>Trainer</u>

Simon Mason

International Research Institute for Climate and Society, USA

Mason has been involved in seasonal climate forecasting research and operations since the early 1990s. He has published numerous papers on seasonal climate forecasting and verification. His primary areas of research include development of methods for diagnosing the quality of forecasts and of tailoring forecasts to user needs. He has been heavily involved in capacity building activities, including leading the development and support of the *Climate Predictability Tool (CPT)*.

<u>Trainees</u>

No.	Name	Organization
1.	Ms. Patama Singhruck	Center of Excellence for Climate Change Knowledge Management (CCKM), Chulalongkorn University
2.	Mr. Atsamon Limsakul	Department of Environmental Quality Promotion Ministry of Natural Resources and Environment
3.	Mr. Preesan Rakwatin	Geo-Informatics and Space Technology Development Agency (GISTDA)
4.	Mr. Bhumrindra Tauvarotama	Center of Excellence for Climate Change Knowledge Management (CCKM), Chulalongkorn University
5.	Mr. Pongsit Polsomboon	Center of Excellence for Climate Change Knowledge Management (CCKM), Chulalongkorn University
6.	Mr. Thudchai Sansena	Geo-Informatics and Space Technology Development Agency (GISTDA)
7.	Mr. Pakorn Petchprayoon	Geo-Informatics and Space Technology Development Agency (GISTDA)
8.	Mr. Wutthichai Paengkaew	Department of Environmental Quality Promotion Ministry of Natural Resources and Environment
9.	Ms. Aroonrat Insatorn	Thai Meteorological Department Ministry of Information and Communication Technology
10.	Ms. Kannika Jaikham	Thai Meteorological Department Ministry of Information and Communication Technology
11.	Mr. Nuttapong Pantong	Thai Meteorological Department Ministry of Information and Communication Technology

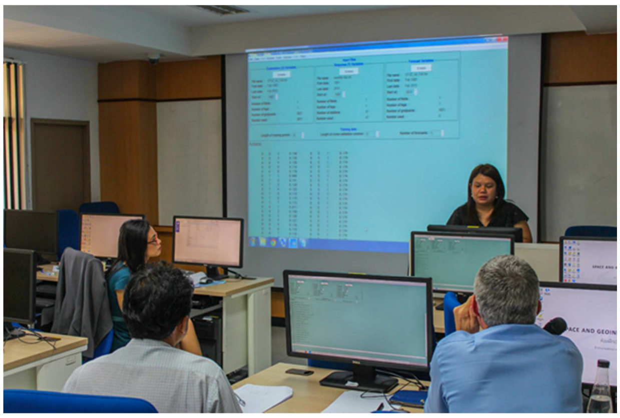
12.	Ms. Jeerapa Teianual	Thai Meteorological Department Ministry of Information and Communication Technology
13.	Mr. Pattara Sukthawee	Thai Meteorological Department Ministry of Information and Communication Technology
14.	Mr. Sukrit Kirtsaeng	Thai Meteorological Department Ministry of Information and Communication Technology
15.	Mr. Somkiat Apipattanavis	Office of Research and Development, Royal Irrigation Department, Ministry of Agricultural and Co-operatives
16.	Ms. Nilobol Aranyabhaga	Office of Water Management and Hydrology Royal Irrigation Department Ministry of Agriculture and Cooperatives
17.	Mr. Kamphol Kesjinda	Department of Royal Rainmaking and Agricultural Aviation Ministry of Agriculture and Cooperatives
18.	Ms. Benjamas Rossopa	Prachin Buri Rice Research Center Bureau of Rice and Development, Rice Department Ministry of Agriculture and Cooperatives
19.	Ms. Duangporn Vuthoonjit	Chai Nat Rice Research Center, Bureau of Rice and Development, Rice Department Ministry of Agriculture and Cooperatives
20.	Ms. Jiraluck Phoomthaisong	Chai Nat Field Crops Research Institute Department of Agriculture Ministry of Agriculture and Cooperatives
21.	Mr. Sapol Kamchamnarn	Department of Disaster Prevention and Mitigation Ministry of Interior
22.	Ms. Naboon Riddhiraksa	Pollution Control Department Ministry of Natural Resources and Environment
23.	Mr. Sunsern Rueangrit	Department of Drainage and Sewerage Bangkok Metropolitan Administration
24.	Mr. Nuttapol Siwthaisong	Department of Drainage and Sewerage Bangkok Metropolitan Administration
25.	Ms. Panyalaln Thawonrat	Department of Environment Bangkok Metropolitan Administration
26.	Commander Viriya Laung-Aram	Hydrographics Department, Royal Thai Navy
27.	Ms. Kanoksri Srinnapakorn	Hydro and Agro Informatics Institute

28.	Ms. Thippawan Thodsan	Hydro and Agro Informatics Institute
29.	Ms. Aisawan Chankarn	Hydro and Agro Informatics Institute
30.	Mr. Watcharapong Noimunwai	Chulalongkorn University
31.	Ms. Pipatthra Saesin	Chulalongkorn University
32.	Mr. Worapong Rerkkliang	Chulalongkorn University
33.	Ms. Usa Humphries	King Mongkut's University of Technology Thonburi
34.	Ms. Sarinya Kirtphaiboon	King Mongkut's University of Technology Thonburi
35.	Mr. Pariwate Varnakovida	King Mongkut's University of Technology Thonburi
36.	Mr. Prem Rangsiwanichpong	King Mongkut's University of Technology Thonburi
37.	Mr. Waranyu Wongsaree	King Mongkut's University of Technology North Bangkok
38.	Ms. Kanchana Nakhapakorn	Mahidol University
39.	Mr. Boonlue Kachenchart	Mahidol University
40.	Ms. Sumaman Buntoung	Silpakorn University
41.	Ms. Korntip Tohsing	Silpakorn University
42.	Mr. Thannob Aribarg	Climate Change and Disaster Center, Rangsit University
43.	Ms. Wachirapond Permpoonsinsup	Pathumwan Institute of Technology
44.	Mr. Danai Tipmanee	Prince of Songkla University, Phuket Campus
45.	Mr. Wirote Laongmanee	Burapha University Chanthaburi Campus
46.	Mr. Attachai Jintrawet	Chiang Mai University
47.	Mr. Rittirong Junggoth	Khon Kaen University
48.	Ms. Uthaiwan Phewphan	Mahidol University Amnatcharoen Campus


GEO-INFORMATICS AND SPACE TECHNOLOGY DEVELOPMENT AGENCY
Training Course on
Seasonal Forecasting using the Climate Predictability Tool (CPT)


APN
GISTDA
Training Course on


Weather prediction



C. Mini-workshops on the use of climate information in selected communities

Ubon Ratchathani, Amnat Charoen, Yasothon, Thailand

29-31 March 2015 and 27-30 April 2015

Summary

Mini-workshops on the use of climate information in selected communities in three provinces were carried out whereby the project's researchers and assistances visited villages and discussed with community leaders about the outcome of the seasonal forecast research, weather and climate information as well as information dissemination protocols. Due to the low predictability at seasonal timescale, we additionally introduced other forecast products at shorter timescales available from operational institutions to assist farmers in decision-making. These products consisted of a 5-day forecast from Thai Meteorological Department and a daily forecast from weather forecasting model by Hydro and Agro Informatics Institute. The climate information dissemination were agreed to be delivered via mobile phone messages.


สำนักงานเครือข่ายวิสาหกิจชุมชน
เกษตรอินทรีย์จังหวัดอำนาจเจริญ
105 หมู่ที่ 3 ตำบลห้วยไร่ อำเภอเมือง จังหวัดอำนาจเจริญ 37000

Funding sources outside the APN

• *Thailand Research Fund (TRF)*	US$ 3,000
• *Geo-Informatics and Space Technology Development Agency (GISTDA)*	*In-kind*
• *Center of Excellence for Climate Change Knowledge Management (CCKM) Chulalongkorn University*	*In-kind*
• *Southeast Asia START Regional Center (SEA START RC)*	*In-kind*
• *Healthy Public Policy Foundation*	*In-kind*
• *EFFU, Ubon Ratchathani University*	*In-kind*
• *Thai Meteorological Department (TMD)*	*In-kind*
• *Hydro and Agro Informatics Institute (HAII)*	*In-kind*

Glossary of Terms

APCC	APEC Climate Center
APN	Asia-Pacific Network for Global Change Research
CCKM	Center of Excellence for Climate Change Knowledge Management
CCA	canonical correlation analysis
CPT	Climate Predictability Tool
ENSO	El Nino-Southern Oscillation
GCM	global circulation model, general circulation model
GISTDA	Geo-Informatics and Space Technology Development Agency
HAII	Hydro and Agro Informatics Institute
IRI	International Research Institute for Climate and Society
MLR	multiple linear regression
MME	multi-model ensemble
MOS	model output statistics
NMME	North American multi-model ensemble
PCR	principal component regression
ROC	relative operating characteristic
SEA START RC	Southeast Asia START Regional Center
SMS	short message service
SST	sea surface temperature
TMD	Thai Meteorological Department
TRF	Thailand Research Fund
UNFCCC	United Nations Framework Convention on Climate Change