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THE PERFORMANCE RAINFALL DURING RAINY SEASONAL OVER THAILAND BY USING PRELIMINARY REGIONAL COUPLED ATMOSPHERIC AND OCEANIC (WRF-ROMS) MODEL

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ABSTRACT: A coupled regional climate between atmosphere-ocean coupled model systems is developed using the regional model Weather Research and Forecasting (WRF) and Regional Ocean Modeling System (ROMS) to simulate performance rainfall during the rainy season over Thailand. The processes of the atmospheric model are provided to the ocean model. The wind (Uwind, Vwind), the atmospheric pressure (Patm), the relative humidity (RH), the atmosphere surface temperature (Tair), the cloud fraction (Cloud), precipitation (Rain), the short wave (SW), the long wave (LW). The processes of the oceanic model provide sea surface temperature (SST) to atmosphere model. The simulation period is during June-July-August (JJA) in 2014, and the results are compared with rainfall gauge station from Thai Metrology Department (TMD). The results show a good trend performance rainfall and can capture large amount rainfall in June, July and JJA 2014. The average rainfall and Mean Absolute Error (MAE) showed good value in June, July and JJA 2014, especially in June was shown good value average (236.25 mm) and MAE (4.389) than other months.

Keywords: Coupled Model, Rainy Season, Regional Ocean Modeling System (ROMS), Thailand, Weather Research and Forecasting (WRF)

1. INTRODUCTION

Seasonal prediction of the Asian Monsoon System (ASM) rainfall in advance with high spatial resolution is a major challenge due to influence of multiple factors, including the topography of the subcontinent and the impact of the surrounding oceans [1]. The ASM is regarded to be separate into two subsystems the Indian Ocean monsoon system and the East Asian Monsoon System (EAMS) [2]. The two main points of AMS has impacted over Thailand, that regimes are the northeast monsoon (winter season) during November to March and the southwest monsoon (summer season) during mid-May to mid-October. The one important feature of climate in Thailand is rainfall. It is the main source of fresh water on the earth and is a major component of the hydrologic cycle on the earth's surface. Hence, in every annual year, the southwest monsoon (summer season) is blown wet air from the Indian Ocean to over country. So it makes the rainfall over Thailand in this period. Sometimes the rainfall events occurred in Thailand producing breaking flash flood and an enormous amount of property damage. Therefore we can say, the rainfall is the main factor for agriculture, industrial, irrigation and etc. in Thailand. However a good simulation and bold, justified, and First Characters of Each Word are in Capital font. Leave one blank line both before forecasting rainfall are the main factor for improving water management. Because a good water management can prevent and decrease the damage from the natural disasters.

A majority of the Atmospheric General Circulation Model (AGCMS) has difficulty in simulating the mean well as the intra-seasonal variability of monsoon rainfall mainly due to the lack of air-sea interactions [3]. On the other hand, coupled models are powerful tools for enhancing the skill of seasonal simulation and forecasting. It's providing realistic simulation and forecasting over tropical phenomenon [4].

However, the researchers in Thailand are based on rainfall event. They were used AGCM and standalone regional model to simulation rainfall events that were neglected of air-sea interactions. In this study, to use a regional couple modeling system by the Coupled Ocean Atmosphere Wave Sediment Transport (COAWST) to simulate rainfall in the rainy season of Thailand. The simulation period was during June, July and August (JJA) in 2014. The results were basic compared with rainfall gauge station from Thai Metrology Department (TMD) data.

2. METHODOLOGY

2.1 The atmospheric model part

The atmosphere part of the coupled model is the Weather Research and Forecasting model (WRF). This model was developed by the National Center for Atmosphere Research (NCAR). The model is contained with a terrain following sigma coordinate in the vertical coordinate, Arakawa C-grid staggering for the horizontal grid, initial conditions, boundary condition, multiple-nested domain and a full set of physical parameterisation options. The more detailed description of WRF in [5]. The physics parameterizations used in this study that is: WSM3-class scheme for microphysics scheme, the Betts-Miller-Janjic (BMJ) for cumulus scheme, the Rapid Radiative Transfer Model (RRTM) for long wave radiation scheme, the Duhia for short wave radiation scheme, the Noah Land-Surface Model for surface and the Yon-Sei University (YSU) Planetary Boundary Layer (PBL) scheme PBL scheme. The model domain covers over Thailand and neighbors with a horizontal grid spacing of 30 km, 28 layers in vertical levels and the model top of 50 hPa.

2.2 The oceanic model part

The oceanic part of the coupled model is the Regional Ocean Modeling System (ROMS). This model is a general class free-surface, a terrain following a numerical model that solve the three dimensional Reynolds-averaged Navier-Stokes equations using the hydrostatic and Boussinesq approximations. This model is based on primitive equation ocean model and uses finite-difference approximations on the Arakawa-C staggering in the horizontal with on a vertical stretched terrain-following coordinate. The basic ideal case study the values of thetas, thetab and Tcline in this study are 3.0, 0.4, and 50.0 respectively. The initial values of u wind (wind direction from east to west), v wind (wind direction from south to north), temperature, and salinity before transfer in the coupled model are 0, 0, 35, and 18 respectively. The oceanic model domain is the same as the regional atmospheric model. The horizontal grid spacing is 30 km. But the vertical level of the oceanic model is 21 levels. The model domain is shown in Fig.1.

2.3 The coupled and experiment configuration

In this study was used the Coupled Ocean Atmosphere Wave Sediment Transport (COAWST) model system. The COAWST model system is an agglomeration of open source modeling components that has been tailored to investigate coastal processes of the atmosphere, ocean, waves and coastal environment [6]. The coupler is the Model Coupling Toolkit (MCT) that allow the transmission and transformation of various distributed data between component models using parallel coupled approach. MCT is a program written in Fortran90 and works with the MPI communication protocol. In this study used the COAWST coupled model to simulate WRF-ROMS over the rainy season in 2014 year. In the processes of the atmospheric model is provided to the ocean model. The wind (Uwind, Vwind), the atmospheric pressure (Patm), the relative humidity (RH), the atmosphere surface temperature (Tair), the cloud fraction (Cloud), precipitation (Rain), the short wave (SW), the long wave (LW). In the processes of the oceanic model provides sea surface temperature (SST) to atmosphere model [6]. The Fig.2 represents a transfer parameter between atmosphere model and an ocean model.

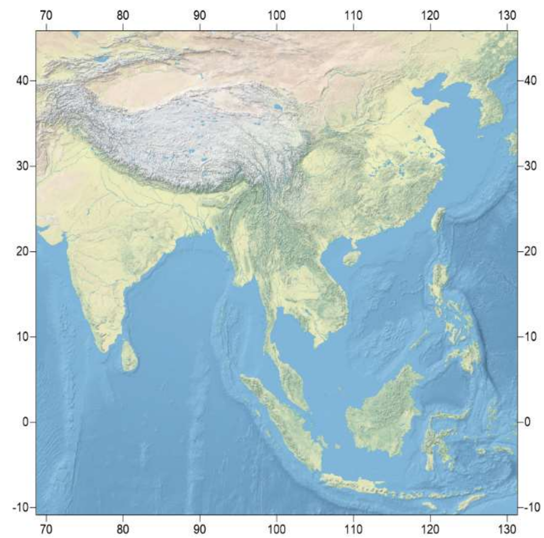


Fig. 1 The domain was used in this study. This domain has 179×179 grids spacing covering at latitude -10.86 degree north to 45.89 degrees north and longitude 68.65 degrees east to 131.35 degrees east.

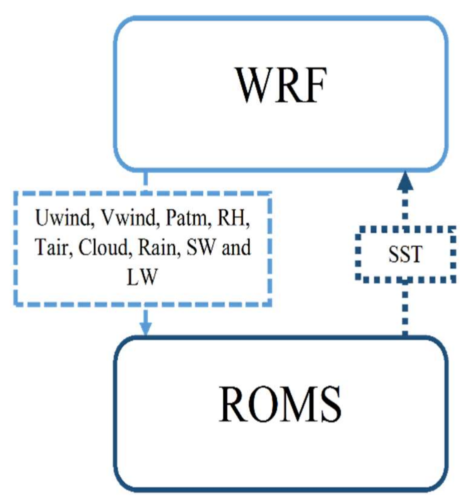


Fig. 2 The application was showed configurations of data exchanged WRF and ROMS model.

The model runs were initialized at 0000 UTC 1 May 2014 and ended at 0000 UTC 31 August 2014 for a three month simulation. The first month simulation (May 2014) was regarded as model spin-up and excluded from comparison with observation, as shown in Fig. 3.

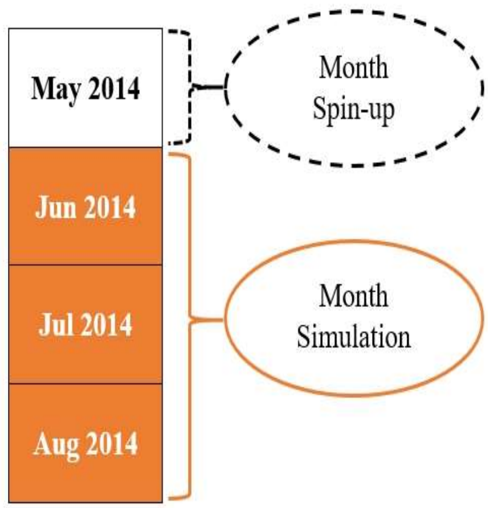


Fig. 3 The period month spin-up and month simulation in this study.

In this study was used the National Centers for Environmental Prediction (NCEP) Final Operational Global Analysis (FNL) data for initial data. The NCEP-FNL product is from the Global Data Assimilation System (GDAS). The grid spacing data are in 1-degree by 1-degree and 6-hourly intervals. The period of data during 1800 UTC 30 July 1999 to the present and the surface area covered longitude 180 degrees east to 180 degrees west and latitude 90 degrees south to 90 degrees north. Table 1 was concluded the physics parameterization schemes and scenario configuration.

The observation data used to verify the results from the model. In this study are measurements made at 118 gauge stations from the Thai Meteorological Department (TMD). The location of 118 gauge stations is covered Thailand, as shown in Fig 4.

3. RESULTS AND DISCUSSION

Fig 5 shows the month accumulate rainfall from TMD station data and month accumulate rainfall simulation from WRF-ROMS coupled model in June 2014.

The TMD station data show the rainfall distribution (in the rage of 0 mm to 400 mm) almost over the country. But the rainfall distribution with large amounts rainfall is (more than 500 mm) over Ubon Ratchathani and Nakhon Phanom province in northeastern Thailand, Trat province in the coast eastern Thailand and Ranong province in southern Thailand, as shown in Fig 5(a).

Table. 1 The physics parameterization schemes and scenario configuration.

Physics	Details
Cumulus scheme	BMJ
Microphysics scheme	WSM3
Short wave radiation scheme	RRTM
Long wave radiation scheme	Duhia
Planetary boundary Layer scheme	YSU
Land surface	Noah
Run period	3 Mon (JJA)

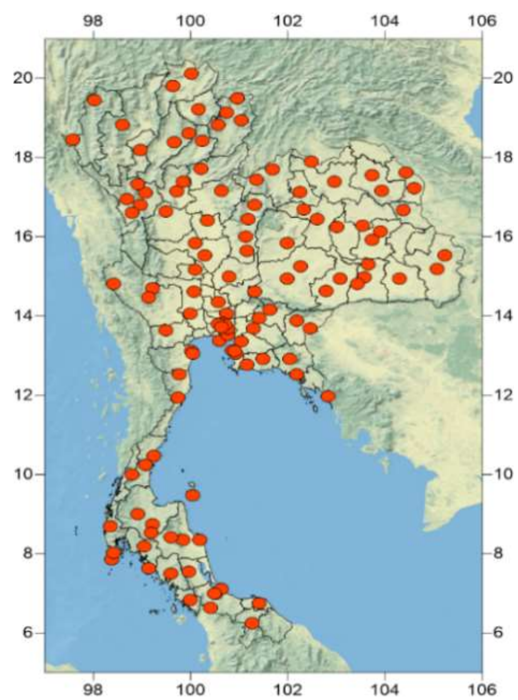


Fig. 4 The station locations used for model evaluations

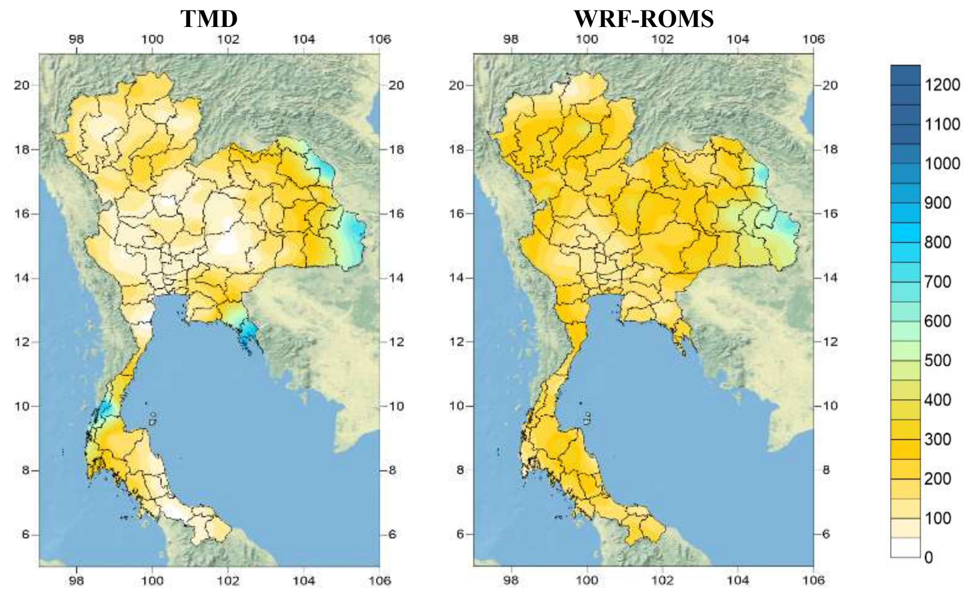
The WRF-ROMS coupled model shows the rainfall distribution (in the range of 0 mm to 400 mm) almost over the country. But the rainfall distribution with large amount rainfall is (more than 500 mm) over Ubon Ratchathani and Nakhon Phanom province in northeastern Thailand, as shown in Fig 5(b).

Fig 6 shows the month accumulate rainfall from TMD station data and month accumulate rainfall simulation from WRF-ROMS coupled model in July 2014.

The TMD station data show the rainfall distribution (in the rage of 0 mm to 400 mm) almost over the country. But the rainfall distribution with large amounts rainfall is (more than 500 mm) over Ubon Ratchathani, Bung Kan and Nakhon Phanom province in northeastern Thailand, Trat province in the coast eastern Thailand and Ranong province in southern Thailand, as shown in Fig 6(a).

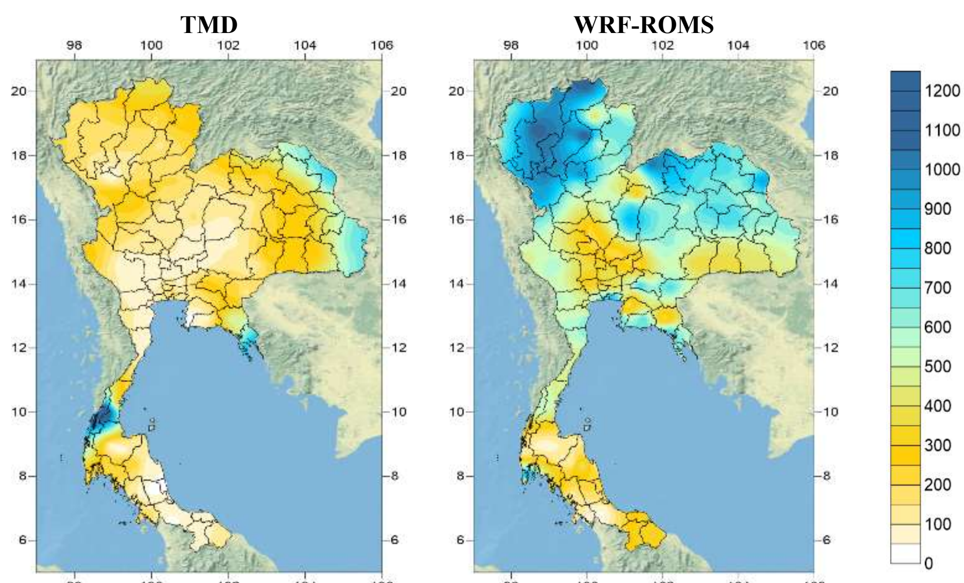
The WRF-ROMS coupled model shows the rainfall distribution (in the range of 0 mm to 400 mm) over center, lower northeastern and lower southern Thailand.

But the rainfall distribution with large amount rainfall is (more than 500 mm) over northern, upper northeastern, western, Rayong and Trat province over coast eastern Thailand, as shown in Fig 6(b).



(a) (b)

Fig. 5 Spatial rainfall pattern of month accumulate rainfall (mm) in June 2014: a) TMD and b) WRF-ROMS.



(a) (b)

Fig. 6 Spatial rainfall pattern of month accumulate rainfall (mm) in July 2014: a) TMD and b) WRF-ROMS.

Fig 7 shows the month accumulate rainfall from TMD station data and month accumulate rainfall simulation from WRF-ROMS coupled model in August 2014.

The TMD station data show the rainfall distribution (in the rage of 0 mm to 400 mm) almost over the country. But the rainfall distribution with large amounts rainfall is (more than 500 mm) over Mae Hong Son in northern and Trat province in the coast eastern Thailand and Ranong province in southern Thailand, as shown in Fig 7(a).

The WRF-ROMS coupled model shows the rainfall distribution (in the range of 0 mm to 400 mm) almost southern and center of Thailand. But the rainfall distribution with large amount rainfall is (more than 500 mm) over northern, Bung Kan, Sakon Nakhon, Nong Khai and Udon Thani province in northeastern, Sa Kaeo province in coast eastern and Kanchanaburi province in western Thailand, shown in Fig 7(b).

Fig 8 shows the month accumulate rainfall from TMD station data and month accumulate rainfall simulation from WRF-ROMS coupled model in June-July-August (JJA) 2014.

The TMD station data show the rainfall distribution (in the rage of 0 mm to 400 mm) almost over the country. But the rainfall distribution with large amounts rainfall is (more than 500 mm) over Ubon Ratchathani and Nakhon Phanom province in the northeastern, Trat province in the coast eastern Thailand and Ranong province in southern Thailand, as shown in Fig 8(a).

The WRF-ROMS coupled model shows the rainfall distribution (in the range of 0 mm to 400 mm) almost southern and center of Thailand. But the rainfall distribution with large amount rainfall is (more than 500 mm) over almost northern, Loei, Nong Bua Lamphu, Amnat Charoen, Yasothon, Nakhon Phanom and Udon Thani province in northeastern Thailand, as shown in Fig 8(b).

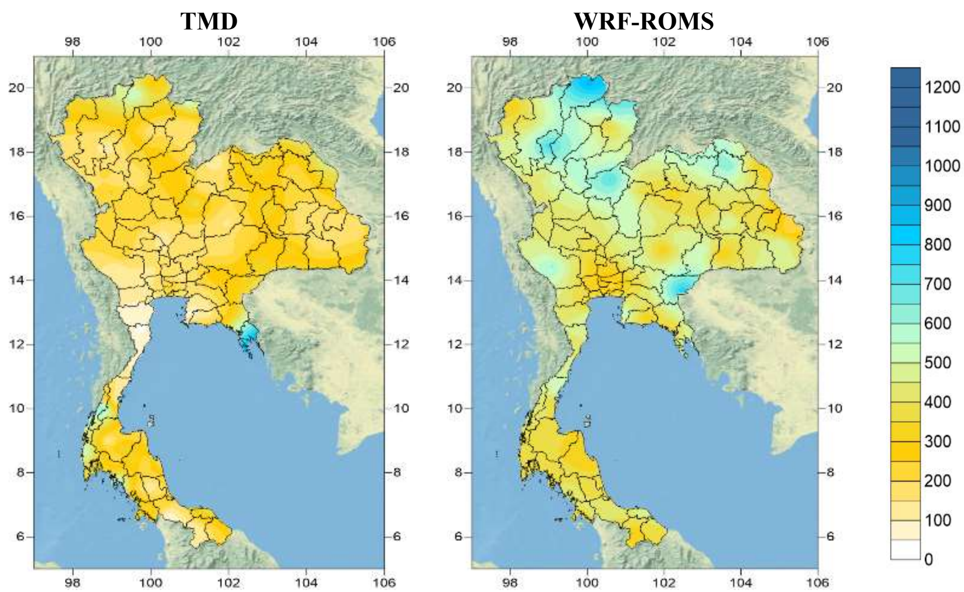


Fig. 7 Spatial rainfall pattern of month accumulate rainfall (mm) in August 2014: a) TMD and b) WRF-ROMS.

Table 2 was shown the average rainfall. It was shown overestimate average rainfall than the TMD data in all cases. The Mean Absolute Error (MAE) was shown good performance in June (4.389). But show a more MAE value in July (12.126). In summary, the results were overestimated in average rainfall and the MAE results shown good performance with TMD data.

Fig. 10 shows the temporal MAE over Thailand. It's shown less significant (more than 12) over Chiangmai, Lamphun, Lampang, Phetchabun and Chiangrai in northern, Loei in northeastern, Trat in eastern, Ranong and Phang Nga in southern Thailand. However, the overall of temporal MAE was shown good performance (less than 12) in many parts of Thailand. For example over central, western, lower southern and northeastern Thailand.

4. CONCLUSION

In this research used a preliminary coupled model between atmospheric model WRF and Oceanic model (Regional Ocean Modeling System (ROMS)) to simulation performance rainfall during the rainy season over Thailand.

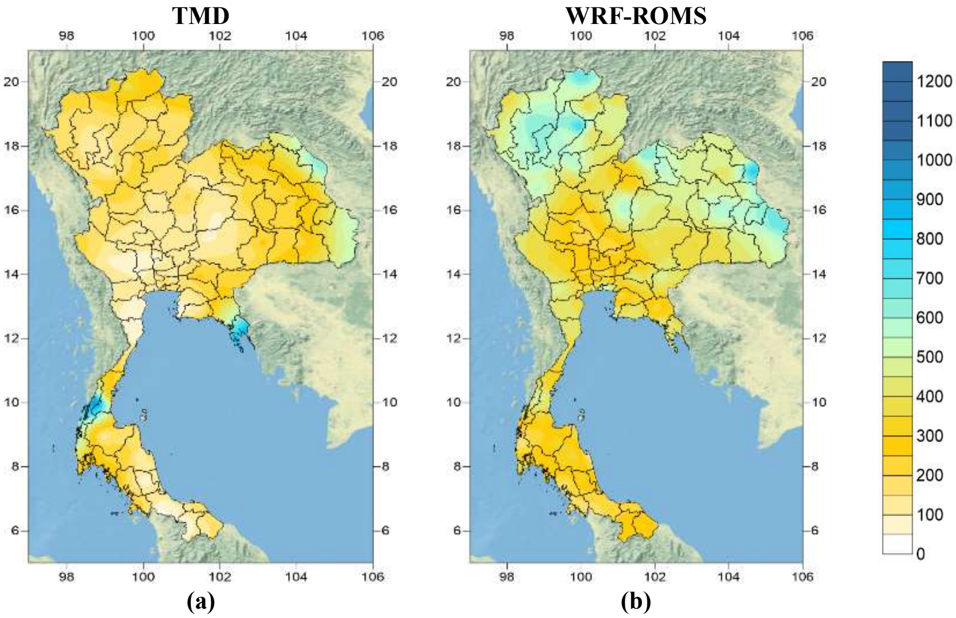


Fig. 8 Spatial rainfall pattern of month accumulate rainfall (mm) in JJA 2014: a) TMD and b) WRF-ROMS.

Table 2 Comparison TMD and WRF-ROMS

	Average (mm/month)		
Month	**TMD**	**WRF-ROMS**	**MAE**
Jun	186.45	236.25	4.389
Jul	214.77	540.04	12.126
Aug	237.98	416.32	7.150
JJA	213.07	397.54	7.201

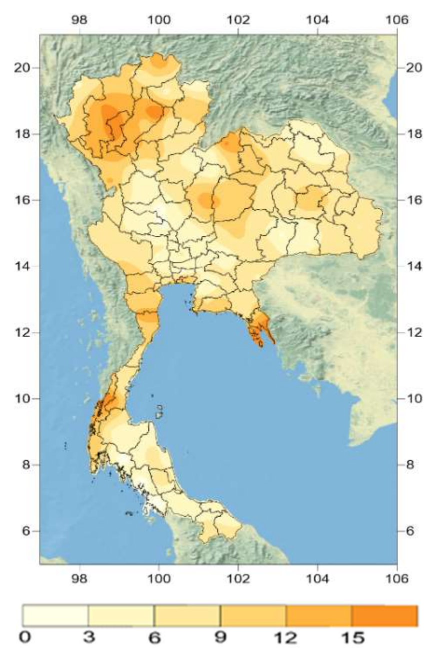


Fig. 10 The temporal MAE in JJA 2014 over Thailand.

The simulation period is during June-July-August (JJA) in 2014. The results from coupled models were shown overestimate accumulate rainfall in June, July, and August 2014. Table 2, the average rainfall was confirmed the coupled model overestimating in all cases.

However, it can capture the large amount rainfall similarly TMD data. In June 2014, the coupled model can capture large amount rainfall similar TMD over Ubon Ratchathani and Nakhon Phanom province in northeastern. In July 2014, the coupled model can capture large amount rainfall similarly TMD over Ubon Ratchathani and Nakhon Phanom province in northeastern and Trat province in eastern. In June-July-August (JJA) 2014, the coupled model can capture large amount rainfall similar TMD over Ubon Ratchathani and Nakhon Phanom province in northeastern.

Therefore, the WRF-ROMS coupled model performed overestimate in simulating spatial distribution, compared with the TMD. However, the results show a good trend performance rainfall and can capture large amount rainfall in June, July and JJA 2014. When comparison rainfall gauge stations by using MAE method over Thailand. The MAE showed the relation between TMD and the coupled model similar average rainfall value. The temporal MAE was shown good performance over Thailand. Future work, we will improve the result from the coupled model (WRF-ROMS). We will update the initial boundary condition from ideal case to real case in Oceanic model (ROMS).

5. ACKNOWLEDGEMENT

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6. REFERENCE

[1] Salama BK, Nagaraju C, Banerjee S, Kaginalkar A and Dalvi M, "Study of the Indian summer monsoon using WRF-ROMS regional coupled model simulation", Atmospheric science letters, Vol. 14, Aug. 2012, pp. 20-27.

[2] Pokhrel S, Chaudhari HS, Subodh KS, Dhakate A, Yadav RK, Salunke K, Mahapatra S, Suryachandra AR, "ENSO,IOD and Indian Summer Monsoon in MCEP climate forecast system", Clim Dyn, Vol. 39, Mar 2012, pp. 2143-2165

[3] Rajendran K, Kitoh A and Arakawa O, "Monsoon low-frequency oscillation and ocean-atmosphere coupling over the Indian Ocean", Geophysical Research Letters, Vol. 31, Jan 2004 L002210, DOI:10.1029/2003GL019031

[4] Kristma KK, Hoerling M, Rajagopalan B, "Advancing dynamical prediction of Indian monsoon rainfall", Geophysical Research Letters, Vol. 32, Apr 2005, L0874, DOI:10.1029/2004GL021979.

[5] Skamarock WC, Klemp JB, Dudhia J, Gill DO, Barker DM, Duda MG, Huang XY, Wang W, and Powers JG, A description of the Advance Research WRF Version 3. National Center for Atmospheric Research, Boulder, Colorado, 2008.

[6] Warner JC, Armstrong B, He R, and Zambon, JB, "Development of a Coupled Ocean-Atmosphere-Wave-SedimenTransport (COAWST) modeling system", Ocean Modeling, Vol. 35, July 2010, pp. 230-244.