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The Performance Rainfall Simulation over Thailand by using WRFROMS Coupling Model

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Key words: WRF, WRFROMS coupled model, rainfall, Thailand, TRMM

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Abstract: In this study, the Weather Research and Forecasting (WRF) model and the Coupling model between Weather Research and Forecasting with Regional Oceanic Model Systems (WRFROMS) model simulated rainfall over Thailand. The period time simulation was on the month of rainfall seasonal in 2015 and 2016. A sensitivity test was conducted to examine the performance of two different single moment microphysics schemes (Lin scheme and WSM6 scheme) for the rainfall simulation. The simulations were compared with the Tropical Rainfall Measure Mission (TRMM) grid data. The domain resolution for simulation was 15×15 km and covered the Thailand area. The results of rainfall simulation from WRF and WRFROMS given by the two microphysics schemes can be compared with the trend of rainfall spatial distribution from the TRMM data. On the spatial pattern, the WRF model both Lin scheme and WSM6 scheme were shown overestimation rainfall than observation data. On the other hand, the coupled model WRFROMS both Lin scheme and WSM6 scheme decreased rainfall closely TRMM observation than the WRF model. The overall results of the WRFROMS with the WSM6 scheme supported the lowest RMSE and MAE value than another scenario. However, in this study, the rainfall prediction cases were concluded the WRFROMS coupled model that can be used to simulate rainfall and SST over Thailand and gave a better performance that only the WRF model.

INTRODUCTION

Thailand is located in the tropical area between latitudes at 5°37-20°27´N longitudes at 97°22-105°37´E. The total area is 513,115 km^2 or around 200,000 square miles as shown in Fig. 1. According to the climate pattern and meteorological conditions, Thailand may be divided into 5 parts, i.e., Northern, North-Eastern, Central, Eastern and Southern Parts. The boundaries of Thailand with near areas are Myanmar and Laos in the Northern part of Thailand. The Eastern part of Thailand is near Laos, Cambodia and the Gulf of Thailand. The Southern part of Thailand is near Malaysia and the western part of Thailand is near Myanmar and the

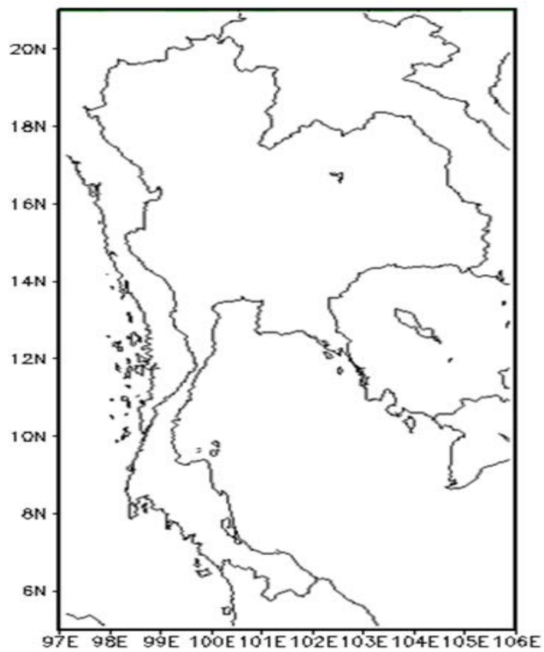

Fig. 1: Thailand is located in the tropical area between latitudes at 5°37-20°27´N longitudes at 97°22´N-105°37´E

Andaman Sea. The climate of Thailand is under the influence of monsoon winds of seasonal character, i.e., Southwest monsoon and Northeast monsoon. The Southwest monsoon which starts in May brings a stream of warm moist air from the Indian Ocean towards Thailand causing abundant rain over the country, especially, the windward side of the mountains. The Northeast monsoon which starts in October brings the cold and dry air from the anticyclone in china mainland over major parts of Thailand, especially the Northern and Northeastern Parts which are higher latitude areas. In the Southern part, this monsoon causes mild weather and abundant rain along the Eastern coast of the part[1, 2].

The meteorological point of view of the climate of Thailand may be divided into three seasons. The first season is summer or pre-monsoon season to begin the middle of February to the middle of May. This is the transitional period from the Northeast monsoon to Southwest monsoons. The weather becomes warmer, especially in upper Thailand and April is the hottest month. The second season is rainy or Southwest monsoon season to begin the middle of May to the middle of October. The Southwest monsoon prevails over Thailand and abundant rain occurs over the country. The wettest period of the year is from August to September. The exception is found in the Southern Thailand East Coast where abundant rain remains until the end of the year that is the beginning period of the Northeast monsoon and November is the wettest month. The third season is winter or Northeast monsoon season to begin the middle of October to the middle of February. This mild period of the year with quite cold in December and January in upper Thailand but there is a great amount of rainfall in Southern Thailand East Coast especially during October to November[3, 4].

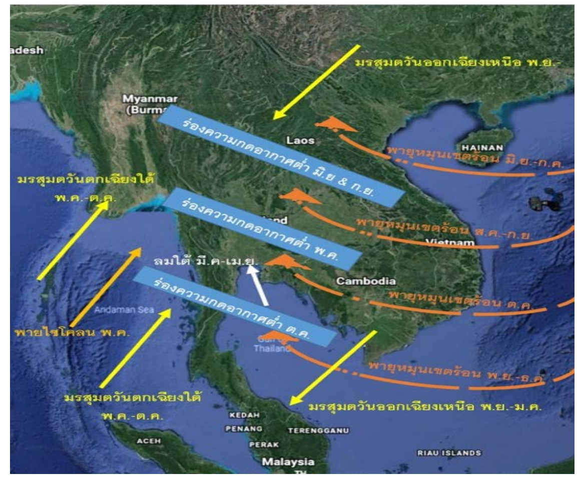

Fig. 2: The monsoon system and all tropical was occurred in annual year over Thailand

The Southwest monsoon event, Northeast monsoon event and all tropical cyclone were occurred in annual year as show in Fig. 2. The climate of Thailand is under the infuence of monsoon winds of seasonal character, i.e., Southwest monsoon and Northeast monsoon. The Southwest monsoon which starts in May brings a stream of warm moist air from the Indian Ocean towards Thailand causing abundant rain over the country, especially the windward side of the mountains[1-3].

Rainfall during this period is not only caused by the Southwest monsoon but also by the Inter Tropical Convergence Zone (ITCZ) and tropical cyclones which produce a large amount of rainfall. May is the period of firrst arrival of the ITCZ to the Southern Part. It moves Northwards rapidly and lies across Southern China around June to early July that is the reason of dry spell over upper Thailand. The ITCZ then moves Southerly direction to lie over the Northern and North-Eastern Parts of Thailand in August and later over the Central and Southern Part in September and October, respectively[4, 1]. Since, Thailand is located between East Pacifc Ocean and East Indian Ocean. It was accepted many effects from ENSO and IOD phenomenon. Such as drought and flood event on monsoon season over Thailand. The South West monsoon or rainy season in Thailand is one season that was affected from ENSO and IOD phenomenon. The South west monsoon prevails over Thailand occur from the middle of May to the middle of October in very year. When the ENSO and IOD was occurred. In case drought event, that occurred on the Northern part, North-Eastern part, Central, Eastern part and Western part of Thailand. While in case food event occur on the Southern part, Northern part and Central of Thailand. The South West monsoon prevails over Thailand occur from the middle of May to the middle of October. Therefore, in this study was focused on rainy season (June-July-August) on 2015-2016. The objective of this study is simulated rainfall in case standalone regional atmospheric model (WRF) and case regional coupled model system (WRF-ROMS) over Thailand and neighbour country especially on (June-July-August) on 2015-2016.

MATERIALS AND METHODS

Domain configuration: The domain of atmospheric part of coupled model in seasonal prediction. The domain was used in this study. This domain has 179×179 grids spacing covering at latitude -10.86-45.89° North and longitude 68.65-131.35° East. The model domain is covers over Thailand and neighbour with horizontal grid spacing of 15 km, 28 layers in vertical levels and the model top of 50 hPa. The oceanic model domain is the same as the regional atmospheric model. The horizontal grid spacing is 15 km. But the vertical level of oceanic model is 41 levels. The model domain is shown in Fig. 3.

In Fig. 4, the processes were shown step of the sensitivity simulation in rainfall seasonal prediction case. The first step was created the domain configuration. The grid points of domain have 179×179 grid points. Second step, to prepare the initial data for simulation. The initial condition was used the National Climate for Environment Prediction Final Operational Global Analysis data or (NCEP-FNL) for Atmospheric model and used National Centers for Environmental Prediction (NCEP) Climate Forecast System Version 2 (CFSV2) for oceanic model. Third step, to select the physics parameterization scheme. But in this study was focused on the high-resolution rainfall case. The selected microphysics parameterization schemes were Lin scheme[5] and WSM6-class scheme[6]. It contained prognostic equations for cloud water, rain, water, ice, snow and graupel and hail mixing ratios. On the other hand, the different microphysics parameterization schemes, the same model configuration was fixed. The other physics options that were used in this study; Betts-Miller-Janjic (BMJ) cumulus parameterization[7], Dudhia shortwave radiation[8], Rapid Radiative Transfer Model (RRTM) long-wave radiation[9], the Yonsei University planetary boundary layer (YSU) scheme[10] and the unified Noah land-surface model. The

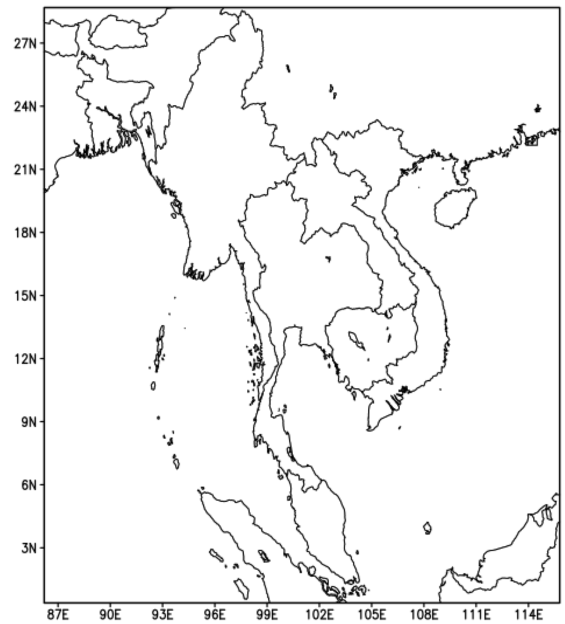

Fig. 3: The domain configurations used a one domain grid resolution of 15-km for seasonal prediction rainfall case

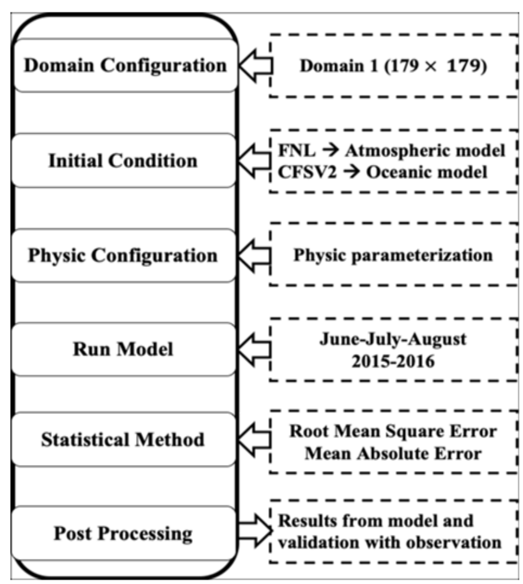

Fig. 4: The flow chart of the rainfall simulation in this study

vertical mixing layer of oceanic model was General Large Scale (GLS) to use in this study. Fourth step was the run model process by standalone atmospheric model and coupled atmospheric and oceanic model. The simulation of two cases were complete. The results from two cases simulation were compared with the TRMM gridded observation data[11, 12]. Three statistics method was used in this study. That is RMSE and MAE respectively that was shown in fifth steps. The last step was post processing. This step was summary and discuss the results for high resolution on seasonal rainfall prediction over Thailand and neighbour country.

RESULTS AND DISCUSSION

Rainfall Simulation on June-July-August 2015: On June 2015, the monthly mean rainfall prediction was shown in Fig. 5 TRMM observation data, WRF Lin scheme, WRF WSM6 scheme, WRFROMS Lin scheme and WRFROMS WSM6 scheme. The monthly mean rainfall from TRMM was shown extreme rainfall over Northern Vietnam. The monthly mean rainfall of WRF Lin scheme and WRF WSM6 scheme were similar rainfall spatial pattern that shown extreme rainfall over Eastern and Southern Myanmar. But this case, the WRF Lin scheme was shown more extreme rainfall over Eastern Myanmar than WRF WSM6 scheme. In case, the monthly mean rainfall of WRFROMS Lin scheme and WRFROMS WSM6 scheme were similar rainfall spatial pattern that shown extreme rainfall over Andaman Sea nearly Eastern Myanmar and South China Sea. But the both results from WRFROMS were decreased than only the WRF model.

On July 2015, the monthly mean rainfall prediction was shown in Fig. 6. TRMM observation data, WRF Lin scheme, WRF WSM6 scheme, WRFROMS Lin scheme and WRFROMS WSM6 scheme. The monthly mean rainfall from TRMM was shown extreme rainfall over Southern Myanmar. The monthly mean rainfall of WRF Lin scheme and WRF WSM6 scheme were similar rainfall spatial pattern that shown extreme rainfall over Southern Myanmar. In case, the monthly mean rainfall of WRFROMS Lin scheme and WRFROMS WSM6 scheme were similar rainfall spatial pattern that shown extreme rainfall over Andaman Sea nearly Eastern Myanmar and South China Sea. But the both results from WRFROMS were decreased than only the WRF Model. On July 2016, the monthly mean rainfall prediction was shown in Fig. 7-10; TRMM observation data, WRF Lin scheme, WRF WSM6 scheme, WRFROMS Lin scheme and WRFROMS WSM6 scheme. The monthly mean rainfall from TRMM was shown extreme rainfall over Andaman Sea, Myanmar and Northern Thailand. The monthly mean rainfall of WRF Lin scheme and WRF WSM6 scheme were similar rainfall spatial pattern that shown extreme rainfall over Northern Myanmar. But this case, the WRF WSM6 scheme was shown more extreme rainfall over Eastern Myanmar than WRF Lin scheme. In case, the monthly mean rainfall of WRFROMS Lin scheme and WRFROMS WSM6 scheme were similar rainfall spatial pattern that shown extreme rainfall over Andaman Sea nearly Eastern Myanmar. But the both results from WRFROMS were decreased than only the WRF model. On August 2015, the monthly mean rainfall prediction was shown in Fig. 7. TRMM observation data, WRF Lin scheme, WRF WSM6 scheme, WRFROMS Lin scheme and WRFROMS WSM6 scheme. The monthly mean rainfall from TRMM was shown extreme rainfall over Andaman Sea nearly Southern Myanmar. The monthly mean rainfall of WRF Lin scheme and WRF WSM6 scheme were similar rainfall spatial pattern that shown extreme rainfall over Andaman Sea nearly Southern Myanmar. In case, the monthly mean rainfall of WRFROMS Lin scheme and WRFROMS WSM6 scheme were similar rainfall spatial pattern that shown extreme rainfall over Andaman Sea nearly Eastern Myanmar and South China Sea. But the both results from WRFROMS were decreased than only the WRF model.

Rainfall Simulation on June-July-August 2016: On June 2016, the monthly mean rainfall prediction was shown in Fig. 8. TRMM observation data, WRF Lin scheme, WRF WSM6 scheme, WRFROMS Lin scheme and WRFROMS WSM6 scheme. The monthly mean rainfall from TRMM was shown extreme rainfall over Andaman Sea. The monthly mean rainfall of WRF Lin scheme and WRF WSM6 scheme were similar rainfall spatial pattern that shown extreme rainfall over Andaman Sea, Eastern and Southern Myanmar. But this case, the WRF WSM6 scheme was shown more extreme rainfall over Eastern Myanmar than WRF Lin scheme. In case, the monthly mean rainfall of WRFROMS Lin scheme and WRFROMS WSM6 scheme were similar rainfall spatial pattern that shown extreme rainfall over Andaman Sea nearly Eastern Myanmar and South China Sea. But the both results from WRFROMS were decreased than only the WRF model.

On July 2016, the monthly mean rainfall prediction was shown in Fig. 9. TRMM observation data, WRF Lin scheme, WRF WSM6 scheme, WRFROMS Lin scheme and WRFROMS WSM6 scheme. The monthly mean rainfall from TRMM was shown extreme rainfall over Andaman Sea, Myanmar and Northern Thailand. The monthly mean rainfall of WRF Lin scheme and WRF WSM6 scheme were similar rainfall spatial pattern that shown extreme rainfall over Northern Myanmar. But this case, the WRF WSM6 scheme was shown more extreme rainfall over Eastern Myanmar than WRF Lin scheme. In case, the monthly mean rainfall of WRFROMS Lin scheme and WRFROMS WSM6 scheme were similar rainfall spatial pattern that shown extreme rainfall over Andaman Sea nearly Eastern Myanmar. But the both

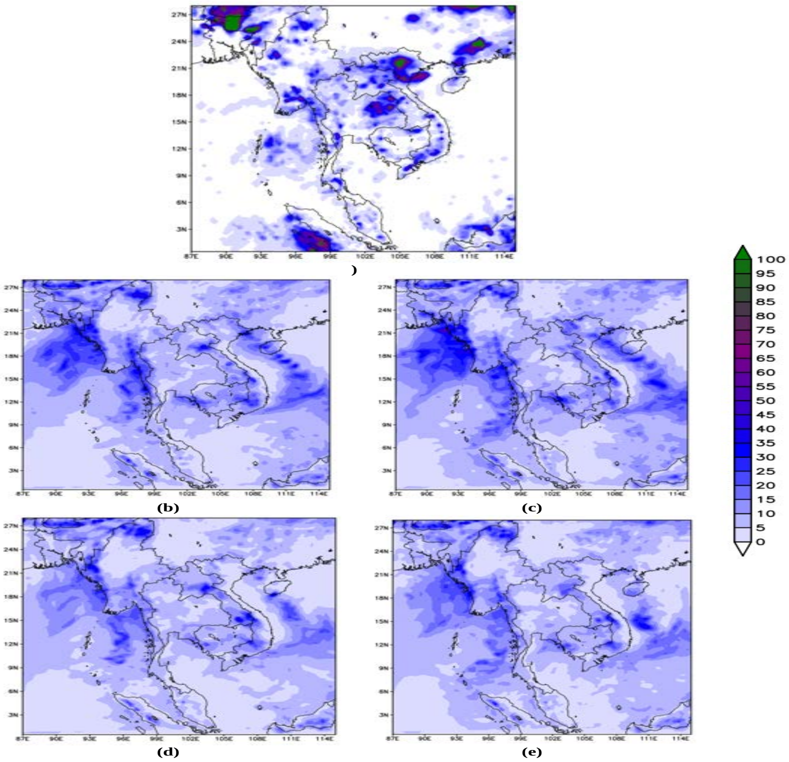

Fig. 5: Monthly mean rainfall prediction on June 2015: (a) TRMM observation data, (b) WRF Lin scheme, (c) WRF WSM6 scheme, (d) WRFROMS Lin scheme and (e) WRFROMS WSM6 scheme

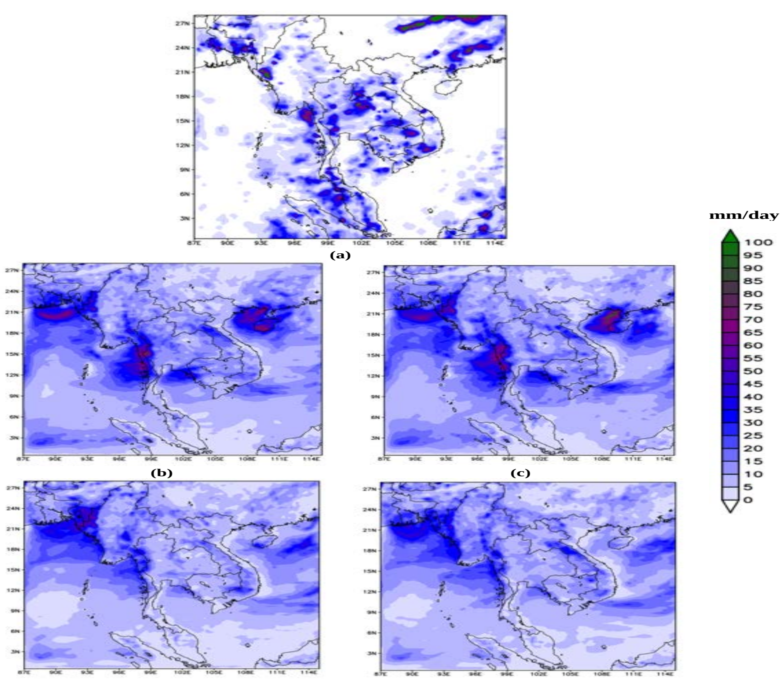

Fig. 6: Monthly mean rainfall prediction on July 2015: (a) TRMM observation data, (b) WRF Lin scheme, (c) WRF WSM6 scheme, (d) WRFROMS Lin scheme and (e) WRFROMS WSM6 scheme

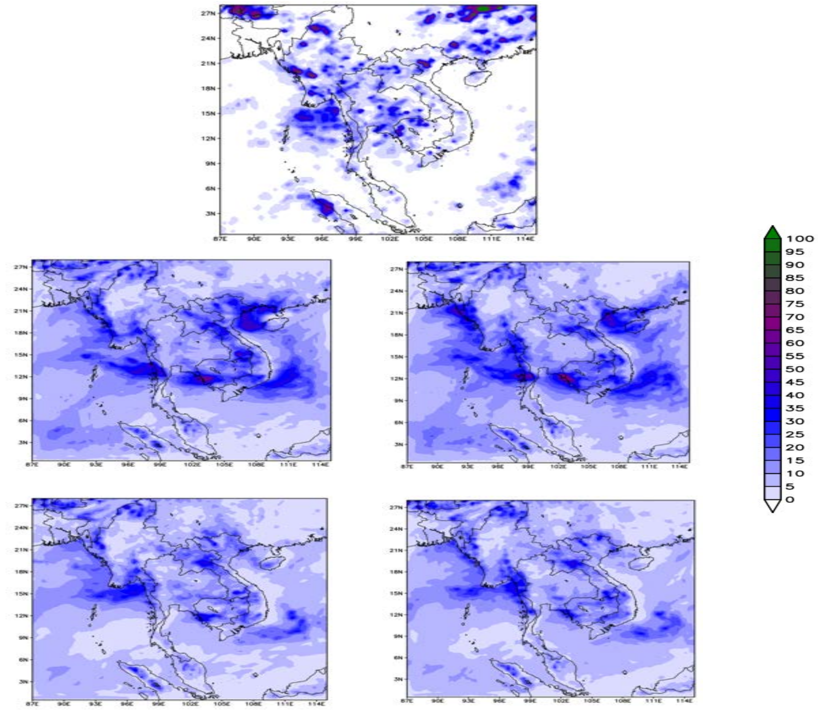

Fig. 7: Monthly mean rainfall prediction on August 2015: (a) TRMM observation data, (b) WRF Lin scheme, (c) WRF WSM6 scheme, (d) WRFROMS Lin scheme and (e) WRFROMS WSM6 scheme

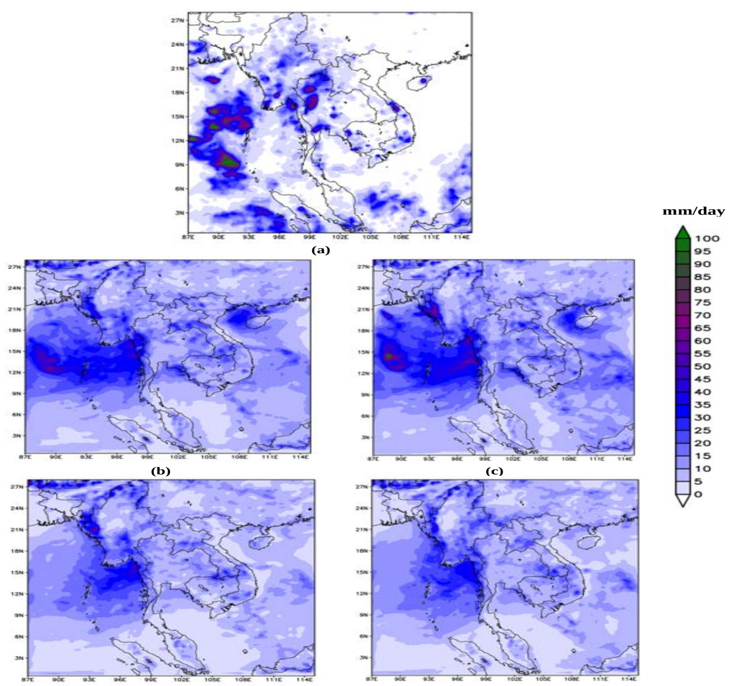

Fig. 8: Monthly mean rainfall prediction on June 2016: (a) TRMM observation data, (b) WRF Lin scheme, (c) WRF WSM6 scheme, (d) WRFROMS Lin scheme and (e) WRFROMS WSM6 scheme

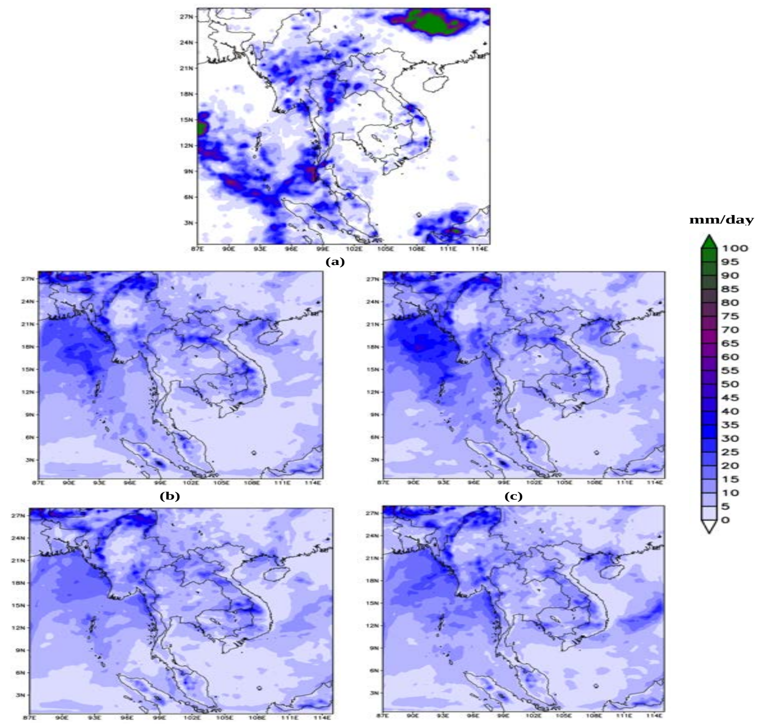

Fig. 9: Monthly mean rainfall prediction on July 2016: (a) TRMM observation data, (b) WRF Lin scheme, (c) WRF WSM6 scheme, (d) WRFROMS Lin scheme and (e) WRFROMS WSM6 scheme

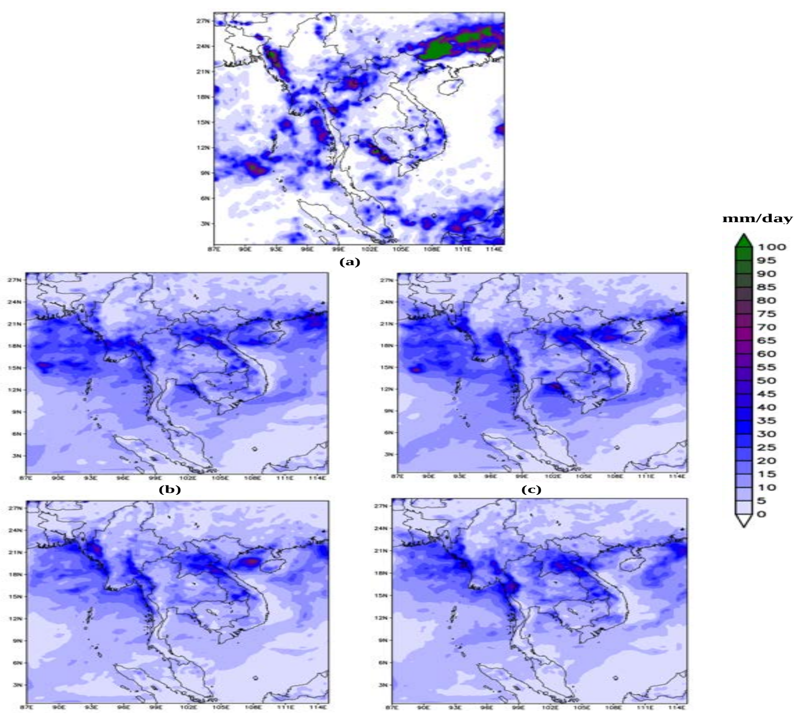

Fig. 10: Monthly mean rainfall prediction on August 2016: (a) TRMM observation data, (b) WRF Lin scheme, (c) WRF WSM6 scheme, (d) WRFROMS Lin scheme and (e) WRFROMS WSM6 scheme

Table 1: The results of RMSE comparison between rainfall result from model and observation data (Unit: mm)

Years	WRF-Lin	WRF-WSM6	WRFROMS-Lin	WRFROMS-WSM6
June				
2015	16.25	15.82	15.50	15.40
2016	13.96	13.57	13.60	13.69
July				
2015	16.25	15.82	15.50	15.40
2016	13.96	13.57	13.60	13.69
August				
2015	13.98	13.83	12.54	12.40
2016	20.32	20.05	19.81	19.67

Table 2: The results of MAE comparison between rainfall result from model and observation data (Unit: mm)

Years	WRF-Lin	WRF-WSM6	WRFROMS-Lin	WRFROMS-WSM6
June				
2015	10.91	10.04	9.608	9.17
2016	12.11	11.45	10.130	10.01
July				
2015	13.8	13.13	11.660	11.52
2016	12.24	11.63	11.690	11.39
August				
2015	12.02	11.39	9.540	9.19
2016	13.52	13.05	12.170	12.00

Table 3: The results of RMSE comparison between SST result from model and observation data (Unit: oC)

Years	WRF-Lin	WRF-WSM6	WRFROMS-Lin	WRFROMS-WSM6
June				
2015	1.21	1.13	0.61	0.57
2016	1.32	1.25	0.66	0.63
July				
2015	1.52	1.32	0.76	0.66
2016	1.31	1.14	0.66	0.57
August				
2015	1.23	1.03	0.62	0.52
2016	1.34	1.04	0.67	0.52

Table 4: The results of MAE comparison between SST result from model and observation data (Unit: ° C)

Years	WRF-Lin	WRF-WSM6	WRFROMS-Lin	WRFROMS-WSM6
June				
2015	1.67	1.82	0.84	0.91
2016	1.91	2.02	0.95	1.01
July				
2015	2.19	2.30	1.09	1.15
2016	1.94	2.04	0.97	1.02
August				
2015	1.90	2.00	0.95	1.00
2016	2.18	2.25	1.09	1.13

results from WRFROMS were decreased than only the WRF model. On August 2016, the monthly mean rainfall prediction was shown in Fig. 10. TRMM observation data, WRF Lin scheme, WRF WSM6 scheme, WRFROMS Lin scheme and WRFROMS WSM6 scheme. The monthly mean rainfall from TRMM was shown extreme rainfall over South China. The monthly mean rainfall of WRF Lin scheme and WRF WSM6 scheme were similar rainfall spatial pattern that shown extreme rainfall over Southern Myanmar and Laos. But this case, the WRF WSM6 scheme was shown more extreme rainfall over Eastern Myanmar than WRF Lin scheme. In case, the monthly mean rainfall of WRFROMS Lin scheme and WRFROMS WSM6 scheme were similar rainfall spatial pattern that shown extreme rainfall over Andaman Sea nearly Eastern Myanmar. But the both results from WRFROMS were decreased than only the WRF model. In Table 1 and 2 were shown the rainfall results analysis by RMSE and MAE statistical method. The RMSE compared with TRMM observation. On June, July and August 2015-2016, overall results the WRFROMS WSM6 scheme supported the lowest RMSE value. For example, in June the RMSE recorded at 15.40 (June 2015) and 14.15 (June 2016) as shown in Table 1. The MAE results supported the WRFROMS WSM6 scheme that was shown a good result than other cases. For example, in June the MAE recorded at 9.17 (June 2015) and 10.01 (June 2016) as shown in Table 2.

In Table 3 and 4. were shown the Sea Surface Temperature results analysis by RMSE and MAE statistical method. The RMSE compared with OISST observation On June, July and August 2015-2016, overall results the WRFROMS WSM6 scheme supported the lowest RMSE value. For example, in June the RMSE recorded at 0.57 (June 2015) and 0.63 (June 2016) as shown in Table 3. The MAE results supported the WRFROMS WSM6 scheme that was shown a good result than other cases. For example, in June the MAE recorded at 0.91 (June 2015) and 1.01 (June 2016) as shown in Table 4.

CONCLUSION

In this study, investigated WRF model and coupled WRFROMS model simulation in seasonal prediction and short-term rainfall prediction. In case seasonal prediction was selected period over June-July-August during 2015 and 2016. The resolution domain of seasonal prediction was 15×15 km and in resolution. The initial and boundary condition used in this case that was FNL initial condition for atmospheric model and in case oceanic model was used CFSV2 for initial and boundary condition. The physics parameter used in atmospheric model that includes Lin scheme and WSM6 scheme for Microphysics scheme, Betts-Miller-Janjic (BMJ) for Cumulus scheme, RRTM for Long-wave radiation, Dudhai for short-wave radiation Yonsei University planetary boundary Layer (YSU) for PBL scheme and Noah Land-Surface Model for Land Surface scheme. In case oceanic model has an only one physics parameter that is General Large Scale (GLS). The observation was used comparison to find accuracy model that was TRMM observation for rainfall and OISST observation for Sea Surface Temperature.

On the spatial pattern the WRF model both Lin scheme and WSM6 scheme were shown overestimation rainfall than observation data. On the other hand, the couple model WRFROMS both Lin scheme and WSM6 scheme increased rainfall closely TRMM observation than WRF model.

The overall results the WRFROMS with WSM6 scheme supported the lowest RMSE and MAE value. For example, in June the RMSE recorded at 0.57 (June 2015) and 0.63 (June 2016). In case the MAE results supported the WRFROMS WSM6 scheme that was shown a good result than other cases. For example, in June the MAE recorded at 0.91 (June 2015) and 1.01 (June 2016). So, in this study, the rainfall prediction cases were concluded the WRFROMS coupled model that can be used to simulate rainfall and SST over Thailand and gave better performance that only WRF model.

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