CHAPTER 1 INTRODUCTION

1.1 Rationale

The Weather Research and Forecasting (WRF) model is a famous dynamical atmospheric model, which has many microphysics parameterization options including a single-moment parameterization predicting only the particle mixing ratios or specific humidity and double-moment parameterization predicting both of the particle mixing ratio and the particle number concentration (Morrison**,** H. and Thompson, 2008). The bulk microphysics parameterization occurs for the microscale, and includes the specific humidity of seven different forms of water: water vapor, cloud water, cloud ice, snow, rain, graupel, and hail involving cloud and precipitation processes. The processes of microphysics parameterization are as follows: cloud droplets, rain drops, ice crystals, aggregates of ice crystals, snowflakes, rimed ice particles, graupel particles, and hail stones. The certain processes of microphysics parameterization are condensation, accretion, evaporation, ice and snow aggregation, accretion by frozen particles, vapor deposition, melting, and freezing (Warner, 2011, Morales, 2012). The options microphysics parameterization is different in calculation processes. However, microphysics parameterization impact of increased natural or anthropogenic aerosols in the atmosphere of a modified climate should be represented in a model because it can change precipitation efficiency (Warner, 2011). Therefore microphysics parameterization is an important for precipitation simulation for the small scale. There are many studies using the WRF model focusing on rainfall simulation for Thailand. But study about microphysics didn't receive a great deal of attention studies emphasizing on microphysics, and is not completed to investigate rainfall over Thailand given by microphysics parameterization option. Because the location of Thailand is in the tropical area near the equator line, it has a different regional rainfall regime prevailing in dry (North and East) and wet (South and west). The rainy season due to the southwest monsoon prevails over Thailand and the wettest period of the year during August to September, the summer season due to the pre-monsoon prevails over Thailand and the hottest period of the year is April, the winter season due to the northeast monsoon prevails over Thailand and cold period of the year during December to January (Thai Meteorological Department, 2013).

In this study, we used the WRF model version 3.4 to simulate rainfall over Thailand with different microphysics parameterization options. The results of precipitation simulation will compare with rainfall of observation data from Tropical-Rainfall Measure Mission (TRMM). These aim to provide information for improvement of rainfall simulation of Thailand.

1.2 Precipitation

Precipitation is deference in shape and size such as liquid and solid form. The liquid form falls from bases of clouds and reach the earth surface such as rainfall and drizzle, while in solid form such as snow, grain, pellet, hail and graupel. It must be remembered that rain, snow, grain, pellet, hail, dew, frost, mist, and fog also contribute to produce moisture in earth's surface. Its lies in Tropical region and rainfall often occur in this country. Therefore, In this study estimate about rainfall over Thailand using microphysics parameterization of WRF models version 3.4 and also to select the microphysics parameterization scheme which appropriate for simulating rainfall over Thailand.

1.3 Physical Parameterization

Physical processes are parameterized for a reason, the small scales involved make it too computationally expensive to represent a process directly, the complexity of a process makes it too computationally expensive to represent directly, and there is insufficient knowledge about how a process work to explicitly represent it mathematically (Warner, 2011). The physics parameterization available in the WRF model categories are cumulus parameterization, microphysics parameterization, radiation, land-surface, and planetary boundary layer (PBL) (Skamarock, 2008). This study will focus on microphysics parameterization. Bulk microphysics parameterizations describe the processes by which water and ice particles grow and precipitate within a cloud (Morales, 2012). Bulk microphysics parameterization impacts of increased natural or anthropogenic aerosols in the atmosphere of a model climate must be represented in a model because this change precipitation efficiency (Warner, 2011). In this study used microphysics parameterization available in WRF model version 3.4 and selected microphysics scheme proper for simulating rainfall over Thailand

1.4 Literature Review

In this study examines operation of the 16 microphysics parameterization scheme available in WRF model for simulate rainfall over Thailand. There are Kessler scheme, Lin scheme, WSM 3 - class simple ice scheme, WSM 5 - class scheme, Eta scheme, WSM 6 - class graupel scheme, Thompson graupel scheme (2 - moment scheme), Milbrandt - Yau 2 - moment scheme, Morrison 2 - moment scheme, SBU - YLin 5 - class scheme, WRF double moment 5 class scheme (WDM5), WRF double moment 6 - class scheme (WDM6), NSSL 2 - moment (NSSL), NSSL 2 - moment with CCN prediction scheme (NSSL+CCN) respectively.

Chotamonsak, C. et al., (2012) used two nested domain with the inner domain of 20 km in the WRF model for downscale region over Thailand, pointing on simulated precipitation using different convective parameterization schemes. They used 4 convective cumulus parameterization schemes Betts-Miller-Janjic scheme (BMJ) Grell-Devenyi scheme (GD) improved Grell-Devenyi scheme (G3D) and Kain-Fritsch scheme (KF) with and without nudging applied to the outermost nest. The results are compared with station dataset and gridded dataset. The results of this study were very well in Betts-Miller-Janjic scheme is cumulus parameterization scheme with nudging yields over Thailand.

Hong, S. Y. et al., (2006) examined single – moment – scheme of the Weather Research and Forecasting (WRF) by revising ice - Microphysics of the Hong et al. 2004 In addition to the simple (WRF - Single - Moment 3 - class Microphysics scheme : WSM3) and mixed - phase (WRF - Single - Moment 5 - class Microphysics scheme : WSM5) schemes of the Hong et al. 2004, a more complex scheme with the inclusion of graupel as another predictive variable (WRF -Single - Moment 6 - class Microphysics scheme; WSM6) was developed. They examined three single – moment – scheme for idealized storm case and heavy rainfall event over Korea. The result simulation experiment for a heavy rainfall event, the simulated precipitation with the inclusion of graupel (WSM6) is same to that from the simple (WSM3) and mixed – phase (WSM5) microphysics in a low – resolution grid.

Hong, S. Y. et al., (2008) used same number of prognostic water substances two bulk microphysics schemes, the Weather Research and Forecasting (WRF) Single - Moment 6 - Class Microphysics Scheme (WSM6) and the Purdue - Lin scheme (PLIN), are evaluate for a two dimensional (2D) idealized storm case and for a three dimensional (3D) heavy rainfall event over Korea. The result simulation terminal velocity of WSM6 scheme has smaller than PLIN scheme.

Kirtsaeng, S. et al., (2010) used three nested domain with the inner domain of 5 km in The Weather Research and Forecasting (WRF) model (version 3.0.1) for simulation of weather phenomenon, in the heavy rainfall over Mumbai in India on July 26, 2005. They used the Kian-Fritsch scheme (KF), Betts-Miller-Janjic scheme (BMJ) and Grell-Devenyi ensemble scheme (GD) are cumulus parameterization schemes. The results of precipitation simulation were compared with rainfall observation data from Tropical-Rainfall Measuring Mission (TRMM). The result of this case was very well in Betts-Miller-Janjic scheme (BMJ) is cumulus parameterization scheme for July 25 around Mumbai.

Lin, Y. L. et al., 1983 used a two - dimensional, time - dependent cloud model has been to simulate a moderate intensity thunderstorm for the High Plains region. The result of simulations represent that the inclusion of snow has improved the realism of the results compared to a model without snow. Addition of the snow field has resulted in the inclusion of more diverse and physically sound mechanisms for initiating the hail field, yielding greater potential for distinguishing dominant embryo types characteristically different from warm and cold - based clouds.

Morales A, (2012) used the WRF model for simulate ideal case at "convection - permitting" scale (i.e., without a deep convection parameterization). Four microphysics parameterizations (WSM6 scheme, Thompson scheme, Milbrandt - Yau scheme, and Morrison scheme) available in the WRF model are compared with three different horizontal resolutions (2 km, 1 km, and 250 m). Results represent large increases in surface precipitation with increasing resolution regardless of the microphysics parameterization and WSM6 scheme showed the lowest precipitation in this study.

Rajaeevan, M. et al., (2010) used the WRF model with three nested domain with the innermost of 2 km and used four various microphysical parameterization schemes

Thompson scheme, Lin scheme,WSM6 scheme, and Morrison scheme simulate severe thunderstorm event over Gadanki (13.5 N°, 79.2 E°) over southeast India on 21 May 2008. They have considered the vertical wind measurements made by the Indian MST radar installed at Gadanki by the Doppler Weather Radar at Chennai. The conclusion of this simulation the Thompson scheme simulated surface rainfall spread near to observation

Vaid, B.H., (2012) checked the ability of the WRF version3 model with three nested domain with the inner domain of 3 km to predict the heavy rainfall over Singapore on 16 June 2010. The result of model has a maximum precipitation approximate of 5 cm over changi airport which is very close to observation.

1.5 Research Objective

The objectives of this research were to study and to select the microphysics parameterization scheme of WRF model that appropriated with rainfall simulation over Thailand.

1.6 Scope of Works

1. To compare fourteen difference microphysics parameterization schemes; Kessler scheme, Lin scheme, WRF single moment 3-class simple ice scheme (WSM3), WRF single moment 5-class scheme (WSM5), Eta scheme, WRF single moment 6-class graupel scheme (WSM6), SBU-YLin 5-class scheme, Thompson 2-moment graupel scheme, Milbrandt-Yau 2-moment scheme, Morrison 2-moment scheme, WRF double moment 5-class scheme (WDM5), WRF double moment 6-class scheme (WDM6), NSSL 2-moment (NSSL), and NSSL 2-moment with CCN prediction scheme (NSSL+CCN) of WRF model version 3.4 for rainfall simulation over Thailand on 3 hourly-rainfalls during 0000 UTC 28 March 2011 to 0000 UTC 29 March 2011, 3 hourly-rainfalls during 0000 UTC 10 September 2011 to 0000 UTC 11 September 2011 and 3 hourly-rainfalls during 0000 UTC 23 November 2011 to 0000 UTC 24 November 2011.

2. To select fourteen difference microphysics parameterization schemes of WRF model version 3.4 that appropriated with simulated rainfall simulation over Thailand with

TRMM observation data on 3 hourly-rainfalls during 0000 UTC 28 March 2011 to 0000 UTC 29 March 2011, 3 hourly-rainfalls during 0000 UTC 10 September 2011 to 0000 UTC 11 September 2011 and 3 hourly-rainfalls during 0000 UTC 23 November 2011 to 0000 UTC 24 November 2011.