# Sensitivity of different physics schemes using WRF model in Typhoon Damrey (2017) over the Indochina region

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**Abstract**. To reduce the tropical cyclone impact of lives and economics, the precise forecast of the event is required. The typhoon Damrey (2017), which caused ravaging of the strong wind, heavy precipitation, flash flood and storm surge over the Indochina region, was simulated by Weather Research and forecasting (WRF) model. The simulated duration was 8 days starting from 31 October 2017 00 00 UTC to 8 November 2017 00 00 UTC. The NCEP 6-hour global FNL (final analysis) data at 1-degree resolution is provided for initial condition. The WRF model was run in a single domain of 20 km horizontal resolution bounded 0 to 20 N and 96ºE to 124ºE. The different physics schemes, which are the microphysics schemes, the planetary boundary layer schemes and cumulus parameterization schemes, were emphasized to examine the suitable schemes in tropical cyclone simulation over the Indochina region. To evaluate the reliability of the simulation of tropical cyclone, the track-position is correlated with the Japan Meteorological Agency (JMA) observation. The results show that the typhoon simulation forced by Belts-Millers-Janjic cumulus, WSM6 microphysics was suitable for simulating of typhoon Damrey.

## 1. Introduction

One of the most changeable weather events that effects to human lives, constructions, economy system, etc. is tropical cyclone event. The characteristic of tropical cyclone is lowest pressure at center over tropics. Tropical cyclone brings a heavy rain, storm surge and flash flood [1]. Reducing the social and economic impacts and the cost of forecasting, the precise tropical cyclone research is required. Typhoon Damrey (2017) was chosen in this work because it was the second deadliest storm of the 2017 Pacific typhoon season. It developed in the South China Sea and moved to Indochina and Thailand.

The Weather Research and Forecasting (WRF) Model is a mesoscale numerical weather prediction system including a non-hydrostatic process [2]. In this study, the options of parameterization schemes are recognized which the physics parameterization is a strong influence in model including track position and intensities, i.e., wind speed, central pressure, precipitation [3].

## 2. Analysis

In this study, the WRF model has been configured one-way nested domain bounded by 0 -24 N and 96-124 E with 20-km resolutions. The initial and boundary conditions were forced by NCEP 6 hourly final analysis (FNL). The NCEP FNL is reliable as it includes all of accessible observed data. There are 160 x 120 grid points overall selected domain. The simulation was applied with 32 vertical levels.

The main aim in Typhoon Damrey simulation was to recognize the physics parameterization impacts on tropical cyclone simulation. Thus, the combinations of three physics parameterizations, i.e., microphysics, planetary boundary layers, and cumulus parameterization schemes, are employed to perform the sensitivity of physics options. The experiment design was showed in table 1. The Kain-Frinsth cumulus, Kessler microphysics and Yonsei university are frequency appeared since there are many worldwide tropical cyclone researches especially over Asia as [4–7].

**Table 1.** The experiment design for typhoon Damrey simulations.

| Simulation no. | Cumulus scheme | Microphysics scheme | PBL scheme |
|---|---|---|---|
| 1 | Kain/Fristch | Kessler | YSU |
| 2 | Belts-Millers-Janjic | Kessler | YSU |
| 3 | Grell-Freitas | Kessler | YSU |
| 4 | New Grell | Kessler | YSU |
| 5 | Kain/Fristch | WSM3 | YSU |
| 6 | Kain/Fristch | Ferrier | YSU |
| 7 | Kain/Fristch | WSM6 | YSU |
| 8 | Kain/Fristch | Kessler | MYNN |

## 3. Results and discussion

The WRF model is simulated the 12-hour track position from 31 October 2017 06.00 UTC to 4 November 2017 18.00 UTC using different physics parameterizations, the follow results are presented.

### *3.1. Cumulus schemes*

Cumulus parameterization including the shallow and deep cumulus cloud that effects to the vertical heat, moisture and momentum. Cumulus schemes involve tendencies of moisture and momentum and shallow convection. Each schemes have different options as shown in table 2. Moreover, parameterization of cumulus scheme significantly impacts on tropical cyclone track position and intensities with coarser resolution.

**Table 2.** Cumulus schemes [2].

| Scheme no. | Scheme name | Moisture tendencies | Momentum tendencies | Shallow Convection |
|---|---|---|---|---|
| 1 | Kain/Fristch | $Q_c$ $Q_r$ $Q_i$ $Q_s$ | no | yes |
| 2 | Belts-Millers-Janjic | - | no | yes |
| 3 | Grell-Freitas | $Q_c$ $Q_i$ | no | no |
| 5 | New Grell | $Q_c$ $Q_i$ | no | yes |

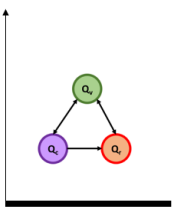
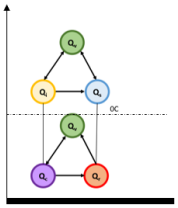
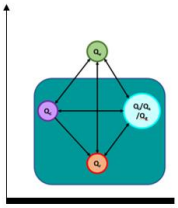
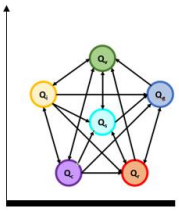
The location of low surface pressure indicated the track of typhoon Damrey. It shown in figure 1 that the typhoon originally located over the South China Sea and moved toward to Vietnam,

Cambodia, Laos and Thailand also. Difference of cumulus scheme sensitivity shows 2-4° northward compared to the observed track of Japan meteorological agency. It implied that cumulus scheme effects to tropical cyclone track position. In this experiment, the simulation with Belts-Millers-Janjic cumulus scheme nearly shows the closet track to the observation, approximately 0.2° southward for first 48 hours and 0.2-0.4 degree southward later.

*3.2. Microphysics schemes*

Microphysics parameterizations provide the atmospheric heat and moisture tendencies which are major parameters in regional weather. There are different number of hydrometeors and interactions for the processes in microphysics schemes [3] as shown in table 3.

**Table 3.** Microphysics schemes [2, 3].

| Scheme name | Kessler (mp=1) | WSM3 (mp=3) | Ferrier (mp=5) | WSM6 (mp=6) |
|---|---|---|---|---|
| hydrometeors and interactions |  |  |  |  |

The KF cumulus and YSU planetary boundary layer schemes are selected because these schemes are applied for WRF model in various tropical cyclone studies [4]. From figure 2, the sensitivity of microphysics shows approximately 0.2 -1° differences from the observation. After 48 hours, the simulation with Kessler and Ferrier moved northwestward meanwhile its WSM3 moved southwestward. The selection of WSM6 microphysics performs tracking position of the tropical cyclone closer than Kessler, WSM3 and Ferrier microphysics schemes, with approximately 0.2° differences. Furthermore, several studies indicate the WSM6 microphysics scheme is perceptive to tropical cyclone track forecasting over Asia and western north Pacific [5-6].

*3.3. Planetary boundary layer schemes*

The Planetary boundary layer parameterization provides the profiles of vertically temperature and moisture and horizontally momentum in the atmosphere. The upper air swirling, the precipitation and the transport of energy and moisture are influenced by these Planetary boundary layer schemes. The YSU planetary boundary layer scheme is a typical nonlocal scheme meanwhile MYNN planetary boundary layer scheme is a local turbulent kinetic energy schemes [7,8].

The track position of early simulation with YSU planetary boundary layer scheme is similar to its MYNN PBL scheme and there is approximately 0.2° difference from the observation as shown in figure 3. After 48 hours, the track position of the simulations moved northward about 1-2°from observation. The track position analysis reveals that the simulation with YSU scheme similar to its MYNN 2.5 level planetary boundary layer schemes. Although the 5 tropical cyclones simulation over the Bay of Bengal showed that the YSU made a minimum track position error [7].

**4. Conclusion**

The sensitivity of different physics parameterizations was studied in typhoon Damrey simulation using WRF model. The simulated track position is compared to Japan Meteorological Agency observed data. The results shown that the simulation with Belts-Miller cumulus scheme and WSM6 microphysics scheme perform the best ability in tracking position of typhoon Damrey. Meanwhile, both planetary

boundary layer schemes similarly effect to the tropical cyclone simulation. Furthermore, the statistical tests, i.e., track position error, root mean square error, etc., is required for validation of tropical cyclone simulation in future work.

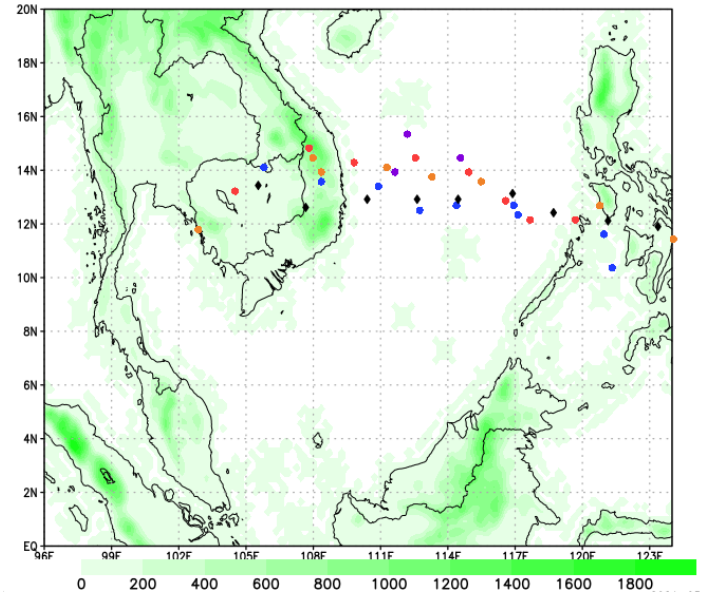



**Figure 1.** 12-hourly track position of typhoon Damrey including observation (black), Kain-Frinsth (red), Belts-Millers-Janjic (blue), Grell (orange) and new Grell (purple) cumulus scheme.

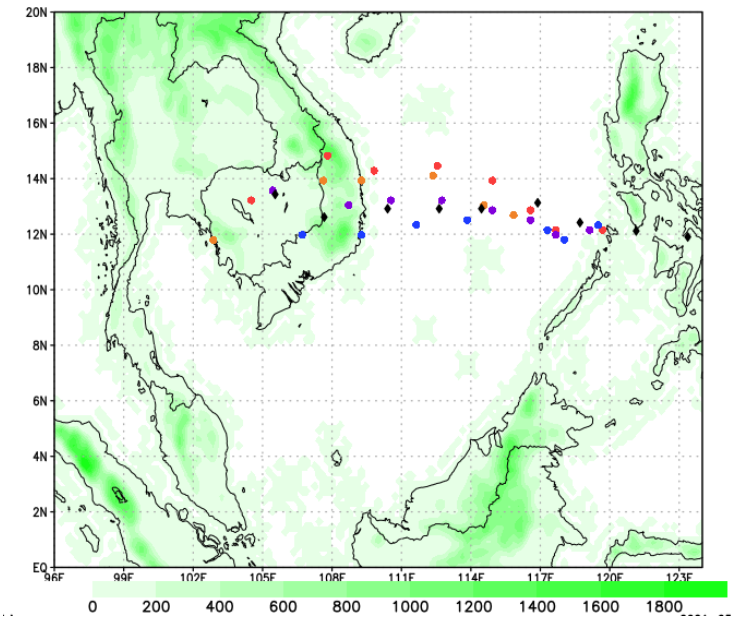



**Figure 2.** 12-hourly track position of typhoon Damrey including observation (black), Kessler (red), WSM3 (blue), Ferrier (orange) and WSM6 (purple) microphysics scheme.

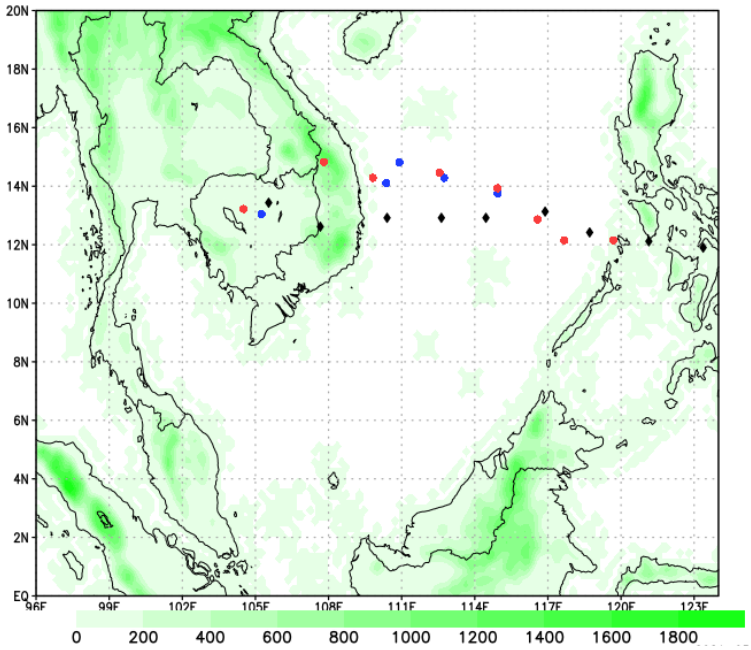



**Figure 3.** 12-hourly track position of typhoon Damrey including observation (black), Yonsei university (red) and MYNN 2.5 level (blue) PBL scheme.

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