Simulation the Impact of Typhoon Maria (2018) in Taiwan

Chia-hung Huang and Horng-syi Shen

Department of Environmental Information and Engineering, Chung Cheng Institute of Technology, National Defense University

ABSTRACT

Typhoon Maria was the 8th typhoon in 2018. Under proper atmospheric condition, it reached severed typhoon on July 6. The intensity dropped due to the replacement of eye wall. On July 8, the intensity reached to severe after rapid intensification (RI). The colder sea surface temperature (SST) weakened the intensity of Maria. On July 10, Maria impacted Japan and Taiwan, made landfall over China on July 11 and then dissipated the next day.

This study focus on the typical Northwest typhoon as it developed on the east side of Taiwan and channeled by the wind flow of higher pressure. However, the center of typhoon was deflected to north and thus didn't develop into a Northwest typhoon. It moved through the northern sea and made landfall over China. The heavy rainfall and strong Northwest wind induced by Typhoon Maria caused heavy rainfall to northern Taiwan. Jhuzihu reached torrential rainfall of 306 mm. The purpose of this study is to simulate the track and heavy rainfall of Typhoon Maria.

WRF 3.9 was conducted in this case study. Simulation started from 0000 UTC 10, July and processed for 48 hours, ended on 0000 UTC 12, July. Maximum rainfall simulated by 3 microphysic schemes in 24 hours (WSM5, WSM6 and ETA) were close to observation. Accumulated rainfall over 130 mm over mountainous area in North Taiwan was successfully simulated. Furthermore, the surface pressure simulation was also close to observation.

Keyword: Typhoon rainfall, model simulation

1. INTRODUCTION

Typhoon Maria didn't make direct landfall over Taiwan. The extreme rainfall still caused damage to northern Taiwan on 1000 UTC, July 10 to 1000 UTC, July 11. The system impacted northern Taiwan while approaching Taiwan and interacted with local terrains. After Maria moved toward China, strong convective was developed and caused instability to norther Taiwan.

According to Central Weather Bureau, the total rainfall over Jhuzihu was over 300 mm and over 200 mm over Yangmingshan. Heavy rainfall in a short amount of time was the main characteristic of typhoon Maria.

The purpose of this case study is to discuss the results of numerical simulation, which make better understanding of the impact of typhoon Maria.

Below in section 2, the synoptic analysis from observation data are presented. The simulation results are displayed in section 3. Finally, the conclusions are given in section 4.

2. SYNOPTIC ANALYSIS

JMA upgraded the tropical depression to a tropical storm and assigned the international name Maria at around 1200 UTC, and JTWC also upgraded it to a tropical storm. Six hours later, when the storm struck Guam directly, surface observations at Andersen Air Force Base recorded one-minute maximum sustained winds at 50 knots and a minimum pressure at 984 hPa, indicating a rapidly consolidating system.

At around 0110 UTC on July 11, Maria made landfall over Fujian, China, with ten-minute maximum sustained winds at 155 km/h (100 mph) and a central pressure of 955 hPa. Afterward, Maria rapidly weakened overland, before dissipating on July 12.

Figure 1 shows the surface weather map by CWB on 1800 UTC, July 10. We can see that Maria was a severe typhoon. The lowest center pressure was 930 hPa and the maximum wind speed near center was approximately 58 m/s. The interactions with local topography and the outer circulation of typhoon Maria brought heavy rainfall to northern Taiwan, which is worth noticing.

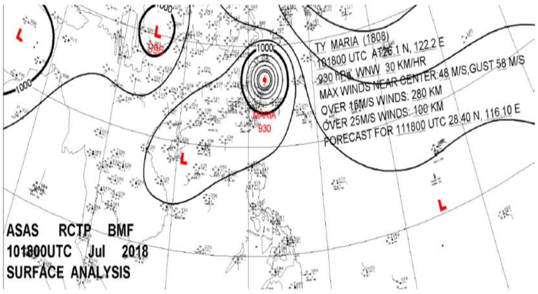


Figure 1. 10 July weather map by CWB.

Figure 2 is satellite map by CWB on July 10. We can see that Maria was located on the northeastern part of Taiwan. The main cloud was distributed on the southern part of typhoon Maria. Indicating heavy rainfall over northern Taiwan.

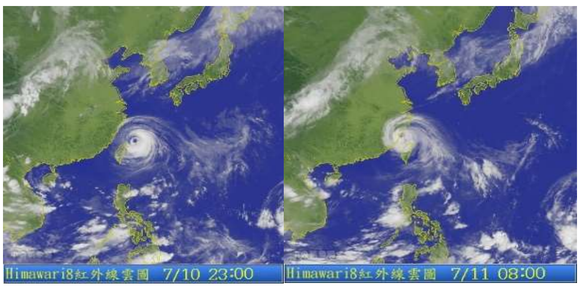


Figure 2. Satellite image by CWB.

Figure 3 is the radar reflectivity map by CWB on 1400 UTC, July 11. The intensity over 50 dBZ was over northern Taiwan.

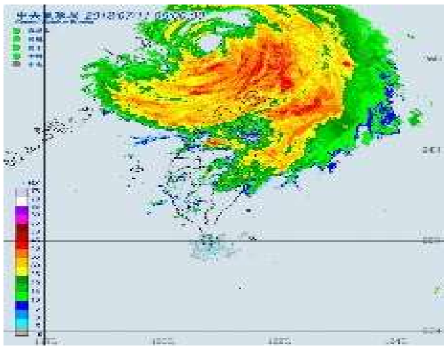


Figure 3. Radar reflectivity map by CWB.

3. SIMULATION RESULTS

The simulation started on 0000 UTC, July 10 and ended on 0000 UTC, July 212. A total of 48 hours until Maria made landfall over China.

First, we compared the simulated track of Maria to observed track and figures are presented as figure 4.

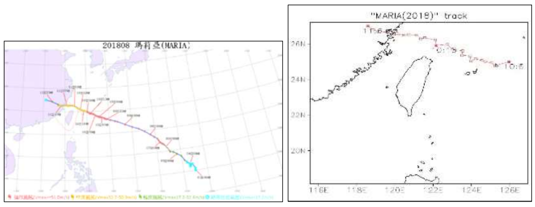


Figure 4. Simulated track and observed comparison.

The result indicated the simulated track was nearly identical to the observation. The simulated track over northern tip of Taiwan was slightly northern than the observation, after making landfall over China, the simulated track began to match with real condition.

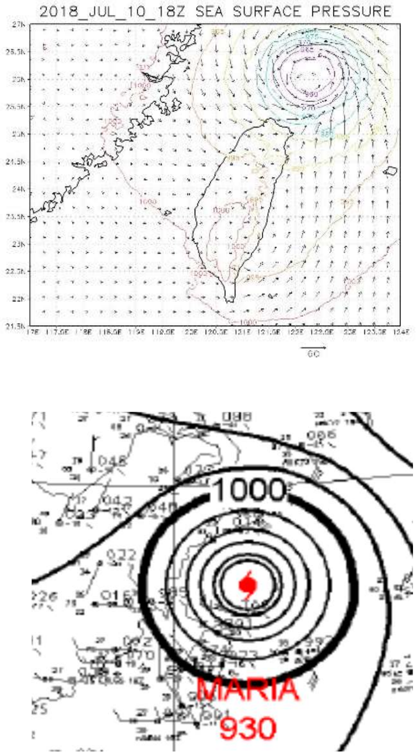
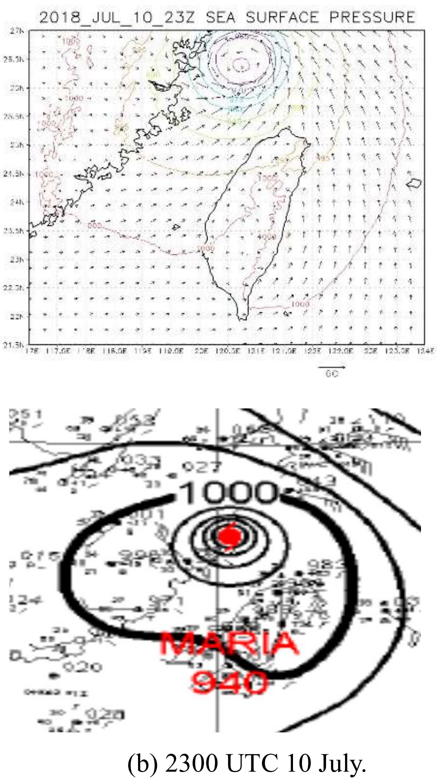


Figure 5. Simulated sea surface pressure and observed comparison.

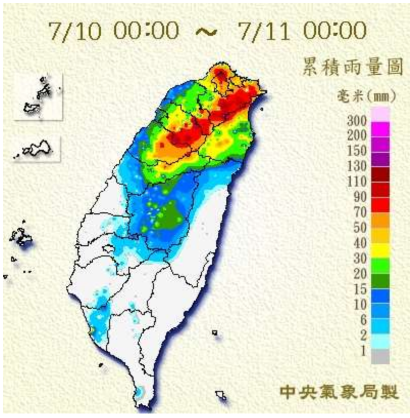
(a) 1800 UTC 10 July.



(b) 2300 UTC 10 July.

Figure 6 (a) indicated the typhoon’s location as well as the pressure of its center (956hPa). Which was slightly higher than observed sea surface pressure on the exact date (930hPa). Figure 5(b) was closed to observed one (940hPa). The outer circulation of typhoon Maria was main reason of heavy rainfall over northern part of Taiwan.

The accumulated rainfall featuring different micro physics schemes (WSM5, WSM6 and ETA) from July 10 to 11, a total of 24 hours simulation and actual observation are shown as figure 7.



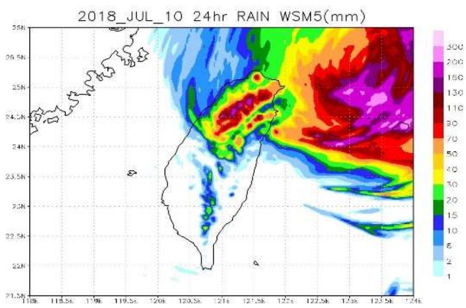
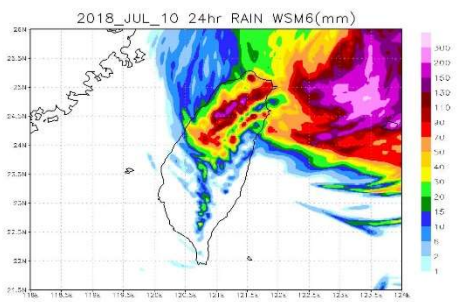
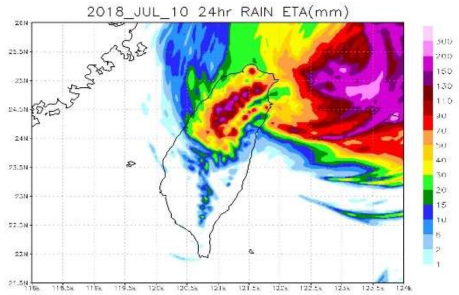


Figure 7. (a) Simulated 24 hours rainfall (WSM5).



(b) Simulated 24 hours rainfall (WSM6).



(c) Simulated 24 hours rainfall (ETA).

As the simulated results indicated, the rainfall pattern of these schemes were very closed to observation. The maximum rainfall over Yangmingshan area was over 200 mm, which was very closed to observation. WSM6 physic over estimated the maximum rainfall over mountain ranges than WSM5 and ETA. Overall, the model captured the heavy rainfall location.

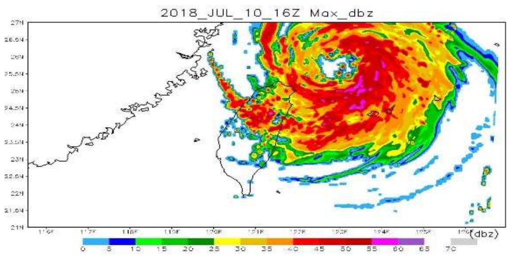


Figure 8. Simulated radar reflectivity on 1600 UTC, 10 July

As the simulated radar reflectivity indicated, the intensity over 50 dBZ was located on the southern part of typhoon Maria, which caused heavy rainfall to northern part of Taiwan.

4. CONCLUSION

Typhoon Maria caused damages and casualties with heavy rainfall mostly on northern part of Taiwan. By using WRF 3.9 to conduct simulation of typhoon Maria, results are listed as following:

The simulated rainfall and observed one were closed, with maximum rainfall over 200 mm in Yangmingshan. However, over forecasting of rainfall on mountain ranges were obvious in WSM6 scheme.

The simulated surface pressures and location on both dates were closed to observed ones, indicating WRF model had captured the system well.

Simulated radar reflectivity over of typhoon Maria indicated strong intensity inside convective rain band.

Acknowledgments

We would highly appreciated CWB for holding this annual symposium.

References

[1] Chen, Y., and M. K. Yau (2001), Spiral bands in a simulated hurricane. Part I: Vortex Rossby wave verification, J. Atmos. Sci., 58, 2128– 2145.

[2] Ryan, B., G. Barnes, and E. Zipser, 1992: A wide rainband in a developing tropical cyclone, Mon. Weather Rev., 120, 431–447.

[3] Schmid, W., H.-H. Schiesser, M. Furger, and M. Jenni, 2000: The origin of severe winds in atornadic bow-echo storm over northern Switzerland. Mon. Wea. Rev., 128, 192-207.

[4] Chang, W.-Y., T.-C. C. Wang, and P.-L. Lin (2009), Characteristics of the raindrop size distribution and drop shape relation in typhoon systems in the Western Pacific from the 2D video disdrometer and NCU C-band polarimetric radar, J. Atmos. Oceanic Technol., 26(10), 1973–1993.

[5] Cesana, G., K. Suselj, and F. Brient, 2017: On the dependence of cloud feedbacks on physical parameterizations in WRF aqua planet simulations. Geophys. Res. Lett., 44, 10762–1077.

[6] Jauregui, Y. R., and K. Takahashi, 2018: Simple physical-empirical model of the precipitation distribution based on a tropical sea surface temperature threshold and the effects of climate change. Climate Dyn., 50, 2217–2237.