THE UTILIZATION OF WEATHER RESEARCH FORECASTING (WRF) MODEL OF 3DVAR (THREE DIMENSIONAL VARIATIONAL) AND HIMAWARI-8 SATELLITE IMAGERY TO THE HEAVY RAIN IN PALANGKARAYA (CASE STUDY: APRIL 27, 2018)

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ABSTRACT

On April 27, 2018 heavy rain was occurred in Palangkaraya. Based on surface data observations at Tjilik Riwut Meteorological Station, the peak of rain occurred between 18-21 UTC, which 54 mm within 3 hours. As a result, the flood inundated on the following day. This research purposed to discover the cause of heavy rain used the WRF model of 3DVar technique that assimilated with AMSU-A satellite which used the tropical physic suite parameterization scheme and Himawari-8 Satellite (IR-1 data), processed by Python Programming. Based on the results, the WRF of the 3DVar model is not representative enough in total rainfall results. However, several weather disturbances show the potency for severe weather occurrence from WRF 3DVar modelling. These are indicated by the shear line and eddy circulation at 18 and 21 UTC, and the time series of air pressure decreases with a 0.5 Mb tendency between 15 to 18 UTC. Moreover, the cloud top temperature graph from Himawari-8 Satellite data shows a drastic reduction in temperature to -61.4323 at 18.20 UTC, which supports the heavy rain process. The weather analysis above show that WRF 3DVar is not representative enough for total rainfall result, but appropriate for other weather aspects (shear line, eddy, and air pressure). Therefore, the heavy rain is caused by shear line and eddy condition, air pressure and low temperature of the cloud top.

Keywords: WRF 3DVar, Himawari-8, Python Programming, Flood, Heavy Rain

1. Introduction

The ability of a model to predict weather conditions, not only depends on the resolution of the model and the accuracy of physical and dynamic processes, but also depends on initial or initial conditions [1]. Therefore, a data assimilation program is needed and valuable for entering observation data into numerical calculations. This program can be used to update initial conditions for computing WRF [2]. The variational approach that makes us consider all observations around the world simultaneously is called the 3DVar method. This 3DVar implementation is helpful for improving performance on the WRF (Weather Research and Forecasting) model. The 3DVar system is applied to multiresolution domain forecasting systems [3]. Research example that using the WRF 3DVar method are ever done by Paski (2017) [4], Yang et al (2018) [5], Hastuti et al (2019) [6], Sagita et al (2016) [7], and Ismail et al (2018) [8]. Therefore, this research will use WRF 3DVar to modeled the heavy rain event.

This research was conducted in Palangkaraya on April 27, 2018, when heavy rain caused the flood. The heavy rain-soaked dozens of resident's houses in several villages in Palangkaraya. The heavy rain occurred between 18-21 UTC based on Observations data at Tjilik Riwut Meteorological Station in Palangkaraya, which is 54 mm in 3 hours. According to BMKG, the criteria for heavy rain is 10-20 mm/hour or 50-100 mm/day, so that it can be categorized as heavy rainfall.

The research about utilize WRF-ARW in Palangkaraya has been done by Swastiko and Rifani (2016) [9], which use 20 parameterization schemes. Therefore, to improve the heavy rain analysis and result, this research will utilize the WRF of 3DVar technique, which assimilated with the AMSU-A satellite with the tropical physic suite parameterization scheme, where WRF 3DVar technique and tropical physic suite parameterization scheme has never been done before in Palangkaraya.

In addition to analyzed the causes of heavy rain, a comparison of rainfall results based on WRF-ARW output and WRF 3DVar techniques will be analyzed and compared. Moreover, the result of IR-1 data from Himawari-8 satellite is used to knowing the cloud top temperature condition when rain occurred. It will be processed using Python Programming.

2. Methods

Data. (1) Final Analysis (FNL) data. FNL data is a model input data of WRF-ARW, and it is available on https://rda.ucar.edu. It is 24 hours FNL data with 0,250 x 0,250 resolution. (2) Global Data Assimilation System (GDAS) Data for AMSU-A Satellite. The data to be assimilated is AMSU-A satellite data. Satellite data can be obtained from www.rda.ucar.edu/datasets/ds735.0/[10]. (3) Infrared channel of Himawari-8 satellite data. The data is available on ftp://202.90.199. (4) Rainfall data from AWS Digi Palangkaraya Meteorological Station. AWS data is obtained from the BMKG AWS center. Rainfall data is used to verification the results of one-point rainfall on the WRF 3DVAR output model.

Method. The method in this research is to verificate WRF-ARW and WRF 3DVAR rainfall results on rainfall from AWS Digi Palangkaraya Meteorological Station. Also, the output of the WRF 3DVar model will be reviewed and analyzed descriptively. The output will be processed with GrADS (The Grid Analysis and Display System). Moreover, the domain and spatial resolution that used in this research is based on Swastiko and Rifani (2016) [9], which was used in previous research in Palangkaraya. Meanwhile, the IR-1 channel of Himawari- 8 satellite data will be processed with Python programming to obtained the cloud top temperature value on April, 27 2018.

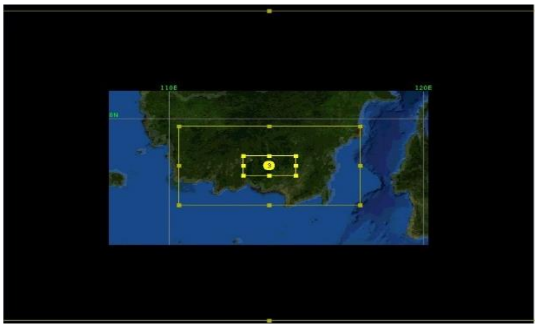

Figure 1. Map or Domain in this research

Table 1. WRF 3DVar Configuration Model in this research

Configuration	Domain 1	Domain 2	Domain 3
Centre-lat	$-2,21^0$		
Centre-lon	$113,92^0$		
e_we	100	88	76
e_sn	60	46	34
Spatial Resolution	27 km	9 km	3 km
Parameterization scheme	Tropical Physics Suite		
Time step	162		

3. Result and Discussion

Rainfall and The Verification. Based on the WRF-ARW model and the WRF 3DVar model output, which used the tropical physics suite parameterisation scheme, that model is not responsive enough to captured the heavy rain moments. This can be indicated by the big difference in rainfall between the WRF-ARW model, the WRF 3DVar model and rainfall data from AWS Digi Palangkaraya Meteorological Station. Therefore, for heavy rain events on April 27, 2018, the WRF-ARW model and the WRF 3DVar model did not represent to capture the heavy rain events. Moreover, tropical physics suite parameterization scheme is not suitable to detect the heavy rain in Palangkaraya. The same thing also happened in previous research [11], where the tropical physics suite parameterization scheme was not able to capture heavy rain events. Therefore, this scheme has mismatches in some areas to detect heavy rain moment.

Table 2. Rainfall (mm) from WRF-ARW output, WRF 3DVar output, and AWS Digi Palangkaraya Meteorological Station

April 27, 2018	WRF-ARW	WRF 3DVAR	AWS Digi Palangkaraya
00-03 UTC	0	0	0
03-06 UTC	0	0	0
06-09 UTC	0	0,17	0
09-12 UTC	0	0	0
12-15 UTC	0	0	0
15-18 UTC	0	0,1	0
18-21 UTC	0	1,38	54
21-24 UTC	0	0	9,4
Daily Rainfall	0	1,65	63,4

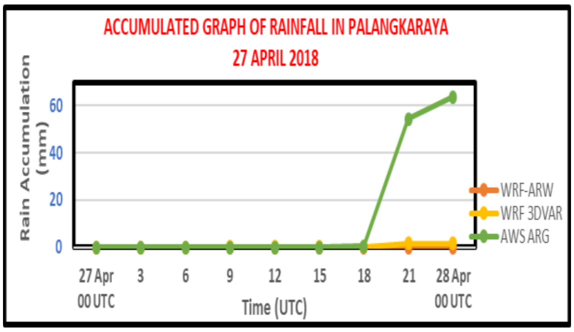

Figure 2. Accumulated graph of WRF-ARW, WRF 3DVar, and AWS Digi Palangkaraya

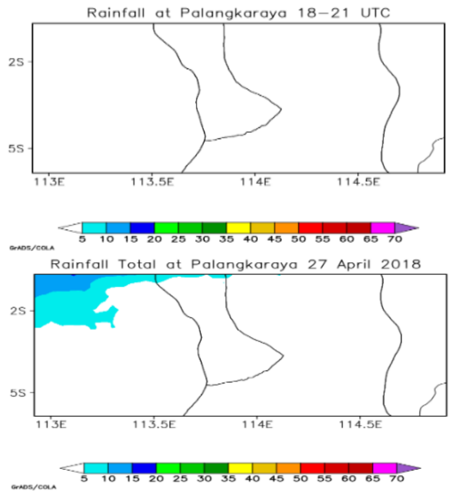

Figure 3. Rainfall at Palangkaraya, which obtain from WRF-ARW model output.

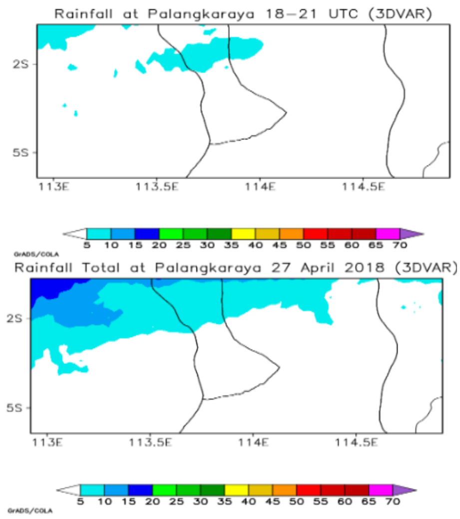

Figure 4. Rainfall at Palangkaraya, which obtain from WRF 3DVar model output

Wind Pattern Analysis. The stream line from the WRF 3DVar model below shows that there is significant wind pattern at 18 and 21 UTC. At 18 UTC, the wind forms the strong and tight convergence with shear line in Palangkaraya. Thus, increasing the cloud cumulation, which caused heavy rain. Meanwhile, there is an eddy circulation at 21 UTC, which gave the big impact to produced heavy rain that caused the flood. Additionally, the strong convergence, tight shear line and eddy circulation were in one situation that across Palangkaraya. Therefore, WRF 3DVar model using tropical physics suite parameterization scheme or the wind pattern output can illustrate significantly the cause of heavy rain in Palangkaraya.

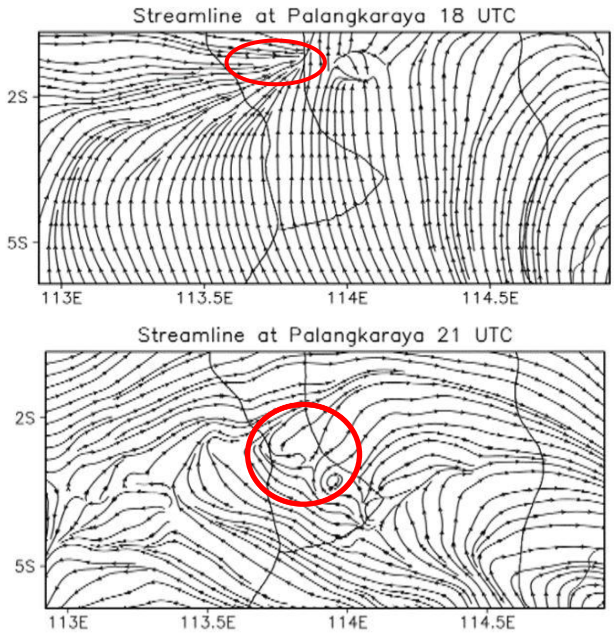

Figure 5. Streamline in Palangkaraya, which obtain from WRF 3DVar model output

Surface Air Pressure. Based on the WRF 3DVar model output or surface air pressure output, it can be seen that air pressure decreases with a tendency of 0.5 Mb between 15 UTC and 18 UTC (air pressure tendency for 3 hours). At 18.00 UTC, the heavy rain occurred which caused flood. The air pressure reduction contributed to produce heavy rain in Palangkaraya, because it is indicated that there is a probability of bad weather occurrence. Therefore, air pressure is one of the indicators that can give indication of bad weather occurrence [12].

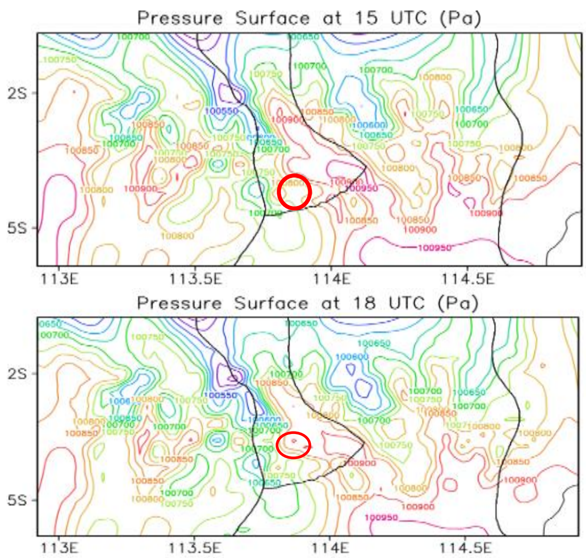

Figure 6. Pressure Surface in Palangkaraya, which obtain from WRF 3DVar model output

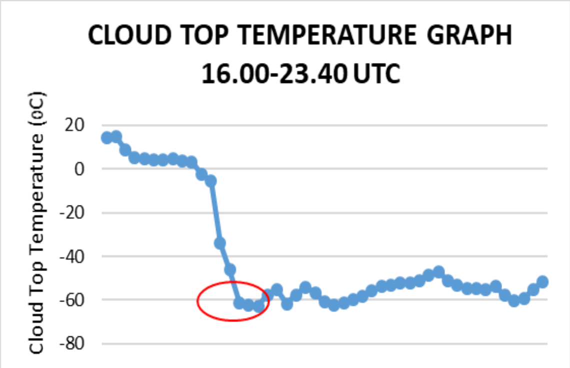

Figure 7. Cloud Top Temperature graph from Infrared (IR-1) channel that processed using Python programming

Himawari-8 Satellite Data (IR-1). Based on the Infrared (IR-1) channel of Himawari-8 satellite data results, which is processed using Python Programming, with coordinates at Palangkaraya Meteorological Station, it is showed that the cloud top has a low temperature, and it drops considerably at 18.30 UTC. Top cloud temperature reaches -61.4323^{0}C at 18.20 UTC shown in Figure 5 (red circle). That temperature shows that Cb clouds in a mature phase and ready in resulting the heavy rainfall in Palangkaraya. Low cloud temperatures persist until 23.40 UTC.

4. Conclusion

Based on the model of WRF 3DVAR technique with tropical physics suite parameterization, the model are not representative concerning to heavy rain events. There is significant difference between the rainfall data from AWS and the models. In addition, wind pattern from WRF 3DVar shows a disturbance in the form of convergence and the sharp shear line, which triggers the cloud cumulation at 18 UTC. Other than that, eddy circulation contributes to give the bad weather in Palangkaraya at 21 UTC.

Moreover, based on the surface air pressure, the WRF 3DVAR output model shows the decreasing of air pressure around 0.5 Mb, which contributes to causing heavy rain in Palangkaraya. Subsquently, based on the Infrared (IR-1) channel of Himawari-8 satellite data results, the top cloud temperature reaches -61.4323^{0}C at 18.20 UTC. That temperature shows that Cb clouds in a mature phase and ready in resulting the heavy rainfall in Palangkaraya. Low cloud temperatures persist until 23.40 UTC.

Therefore, wind pattern, surface air pressure and the top cloud temperature give the essential effect on heavy rain event in Palangkaraya.

Suggestion

In further research, it will be necessary for using WRF 4dvar, the other parameterization schemes and comparisons with the other data such as GSMaP to improve the results of rainfall analysis.

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