iJournals: International Journal of Software & Hardware Research in Engineering (IJSHRE)
ISSN-2347-4890
Volume 9 Issue 4 April 2021

MONSUNAL REGIONAL WEATHER MODEL FOR EXTREME DYNAMIC ANALYSIS OF CLOUD IN SUKABUMI WEST JAVA INDONESIA

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ABSTRACT

The use of the WRF (Weather Research and Forecast) model to simulate most of the dynamics of the atmosphere as well as cumulus parameterization and simulation of cumulus rainfall conditions during the September 2020 floods in Sukabumi, West Java.

The result of this research is a numerical simulation of the dynamics of rain clouds, especially in the Sukabumi area of West Java, which is important in finding flood mitigation solutions, especially in the Sukabumi area of West Java. Evaluation of convection patterns in the Sukabumi area of West Java based on existing observational data, especially high-resolution satellite imagery, is expected to provide an understanding of the change patterns of convection clouds that cause heavy rain and cause flooding in the area. Sukabumi area, West Java.

Keywords: Floods, cloud dynamics and satellite imagery, rainfall data.

1. INTRODUCTION

Based on data from the Regional Disaster Management Agency (BPBD) for the DKI Jakarta and Sukabumi regions, several areas affected by flooding due to rain in September 2020 covered several districts and resulted in 1,107 people in Sukabumi being flooded, 18 houses washed away and washed away. 85 roads were inundated, while in the DKI Jakarta area 31 roads were inundated. The occurrence of this flood can be caused by several factors including high rainfall [1, 2, 3]

This decade changes in atmospheric anomalies due to rainfall, the distribution of rainfall in Sukabumi Regency, West Java with a maximum rainfall period of 21 September 2020. The largest rainfall is termed 'extreme rain'. Rainfall anomaly events can be caused by changes in the atmosphere either caused by synoptic factors or local factors. Since this tropical rainfall cycle involves large-scale increases in the latent heat of evaporation and energy, the equatorial region becomes the general circulation generator in the atmosphere [4].

In this paper, a preliminary study has been carried out to evaluate the tropical climate and obtain the mechanism and numerical simulation of cloud dynamics against the extreme rain phenomenon in the 2020 years west Java Sukabumi flood.

2. METHODOLOGY

The study of convection patterns in the Sukabumi area of West Java was carried out based on existing observational data, especially high-resolution satellite imagery which is expected to provide an understanding of the growth patterns of convection clouds that occur producing heavy rains and causing flooding in the Sukabumi area of West Java. Analysis of atmospheric changes from local factors, namely cloud type based on visible satellite data obtained from data centers (http://www.ssec.wisc.edu/datacenter/) University of Wisconsin-Madison Space Science and Engineering Center (SSEC) and AVN Data

(Aviation Run) at (http://dss.ucar.edu) DSS Research Data Archives [5, 6].

The Application and validation of the WRF model for dynamic analysis of rain clouds in Sukabumi, West Java, where the WRF model has developed a next-generation model for forecasting mesoscale assimilation systems to assist in understanding and forecasting mesoscale rain systems. Where the WRF model is applied in various problems, including physical analysis (Skamarock et al., 2005):

- Microphysics
- Cumulus cloud parameterization

The WRF model requires input, namely NCEP global analysis (AVN) data, and terrain data. There are subsequent programs, which are required to create a domain (boundary) of the research area in both the WPS program (WRF Pre-Processing System) and the WRF program with the Ndown.exe menu in the Namelist program editor. As shown in Figure 2, the program flow diagram is combined into two programs, namely WPS and WRF, and then the output of the WRF results is obtained. Then the output is processed with the convert to GrADS program, to get the expected numerical results [7, 8, 9].

The WRF model is a Numerical Weather Prediction (NWP) model developed by the United States Atmospheric and Oceanic Agency (NOAA) in collaboration with the National Weather Service (NWS), Forecast Decision Training Branch (FDTB), and the Science Operations Officer and Training Resource Center (SOO) / STCR). For weather forecasting the WRF-EMS model is considered a complete and state-of-the-science product model of the NWP and is a combination of two dynamic models commonly used in modeling, namely Advanced Research WRF (ARW) developed by the National Center for Atmospheric Research (NCAR) and the Non-Hydrostatic Mesoscale Model (NMM) developed by the National Center for Environmental Prediction (NCEP). All the features contained in these two binaries are incorporated into the WRF-EMS model and have been simplified from installation, configuration, and execution so that the use of this model can be easily carried out [7].

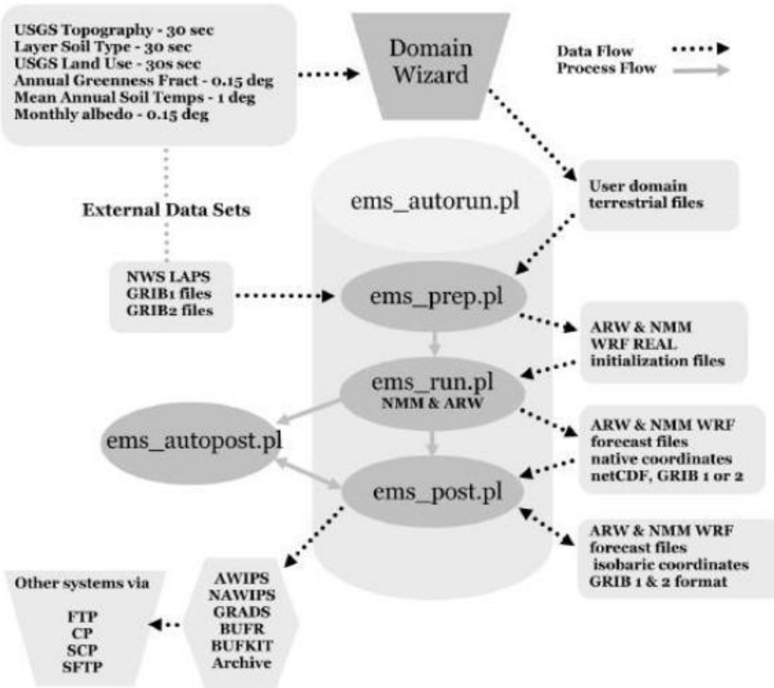


Figure 1. WRF-EMS flow chart [7].

The basic difference between WRF and WRF-EMS is the routine system (Automatic Scripting Language), that each software has used. The use of the WRF-EMS model consists of 3 main commands, namely ems_prep which functions to determine data configuration and running time, ems_run to run the model, and ems_post as the last step to determine the output model. The process carried out on the WRF-EMS software system can be seen in Figure 1. The diagram illustrates the initial ems_prep process starting with inputting the data to be used, selecting domains, configuring time, selecting cores, and setting other external datasets. This preparation process is continued by running the model on ems_run then doing post_processing using the ems_post command. The advantage of the WRF-EMS system is the additional commands ems_autorun.pl and ems_autopost.pl. These two commands make it easy for users to set the system to run automatically. Also, the data output formats are available in the form of GRIB 1, GRIB 2, and NetCDF [9].

3. RESEARCH OF DATA

Research methods

The data used in this study are:

1. Daily rainfall data for BMKG, ARG, and AWS stations in the Sukabumi West Java region on 21 September 2020.
2. Re-analysis of WRF model FNL data with a spatial resolution of 18 km.
3. Himawari-8 image dated 21 September 2020.
4. Weather radar image for 21 September 2020.

The data is processed using WRF-EMS and GrADS software, and then the output of the software will be analyzed and compared with climatological conditions, global conditions, and regional conditions.

As in Figure 2. Displays the hourly rainfall pattern on September 21, 2020, in Sukabumi, West Java [10].

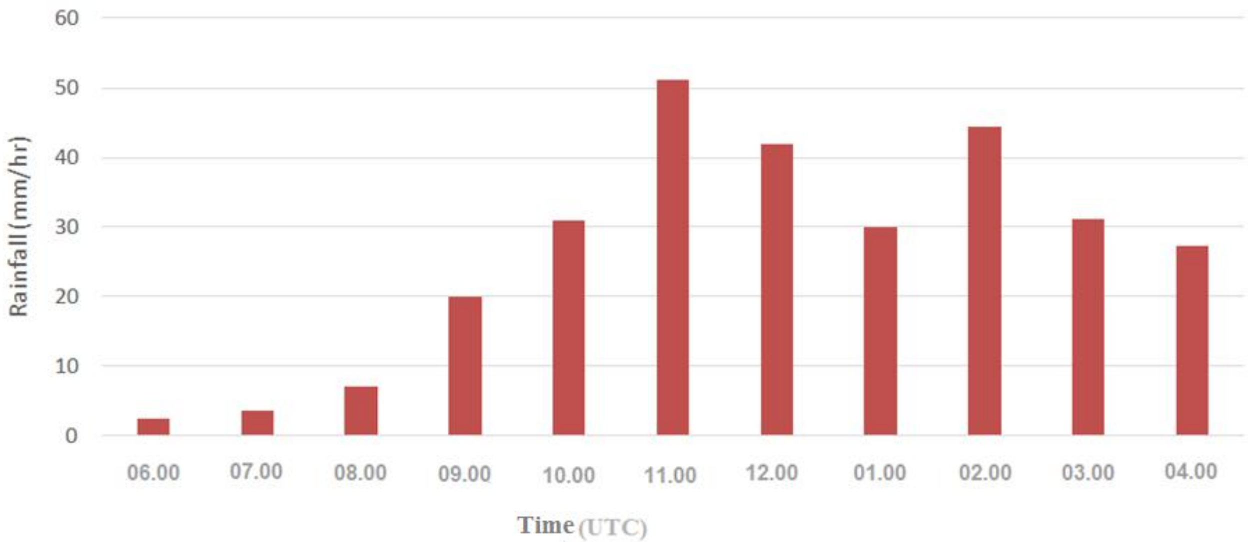


Figure 2. Rainfall data areas in Sukabumi 21 September 2020 [10].

4. RESULTS AND DISCUSSIONS

4.1 Analysis of measurement data

The phenomenon of extreme rain, if analyzed based on cloud dynamic patterns (IR1 temperature data) as in (Figure 4, 5, 6) in Sukabumi, West Java, the cloud growth pattern starts on September 21, 2020 which occurs at 16.00 and 18.00 UTC (23.00-100 WIB). Further studies in this study will be analyzed from AVN data on September 21, 2020, in the Sukabumi area of West Java, including wind divergence, Absolute Vorticity, for flood events for the 2020 period obtained from NCEP / NCAR data.

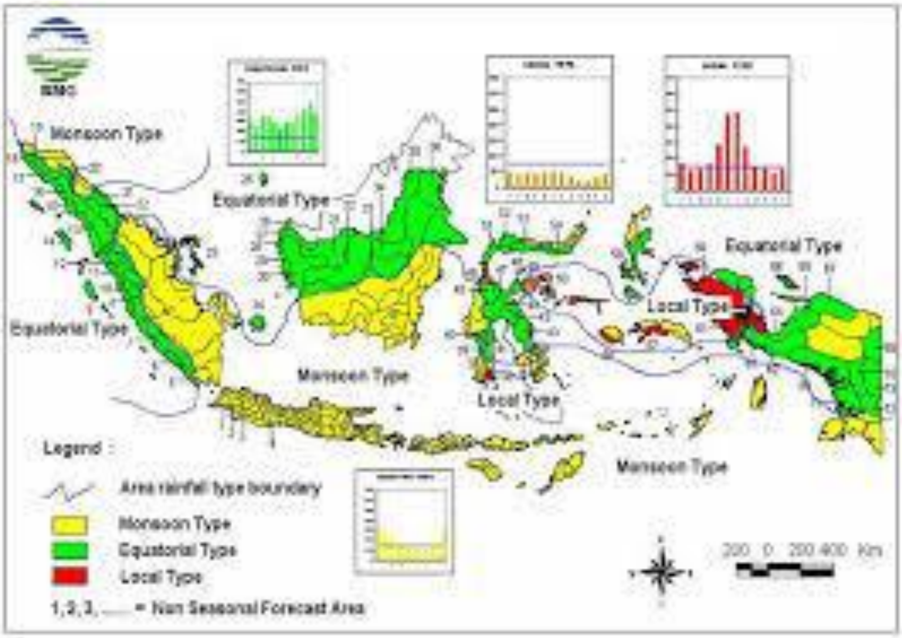


Figure 3. The division of the three rainfall areas in Indonesia [10, 11]

In general, Indonesia can be divided into three main climatic patterns by looking at the rainfall pattern for one year. This is supported by the research of [12] on the classification of Indonesia's climate into three rainfall patterns. The three patterns are the Seasonal Pattern, the Equatorial Pattern, and the Local Pattern (Anti-Seasonal) Figure 3.[13].

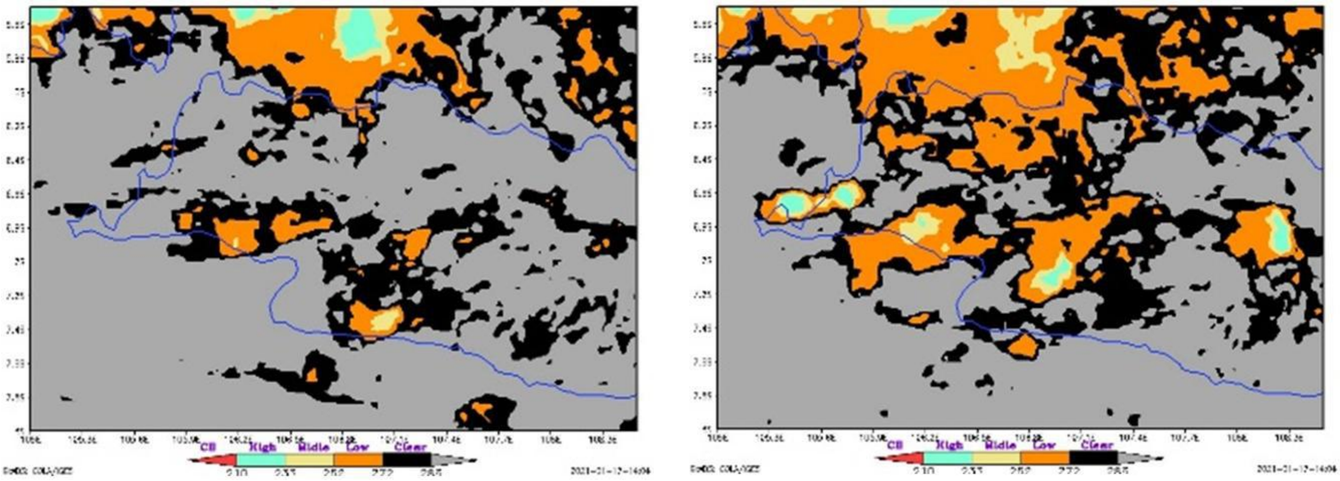


Figure 4. Himawari-8 Satellite Data As of September 21, 2020 [10].

4.2 Numerical data analysis

The study of cloud dynamics in Indonesia will be carried out based on the application of the numerical weather model Weather Research and Forecasting, which is open-source software developed by the National Center for Atmospheric Research (NCAR) in the United States [7]. This numerical study is a simulation to explain the extreme rainfall event on September 21, 2020, in the Sukabumi flood, West Java. This study uses WRF Modeling System version 2, a regional scale model of non-hydrostatic or mesoscale weather designed by Pennsylvania State University. /

National Center for Atmospheric Research (PSU / NCAR) as described by [7, 14].

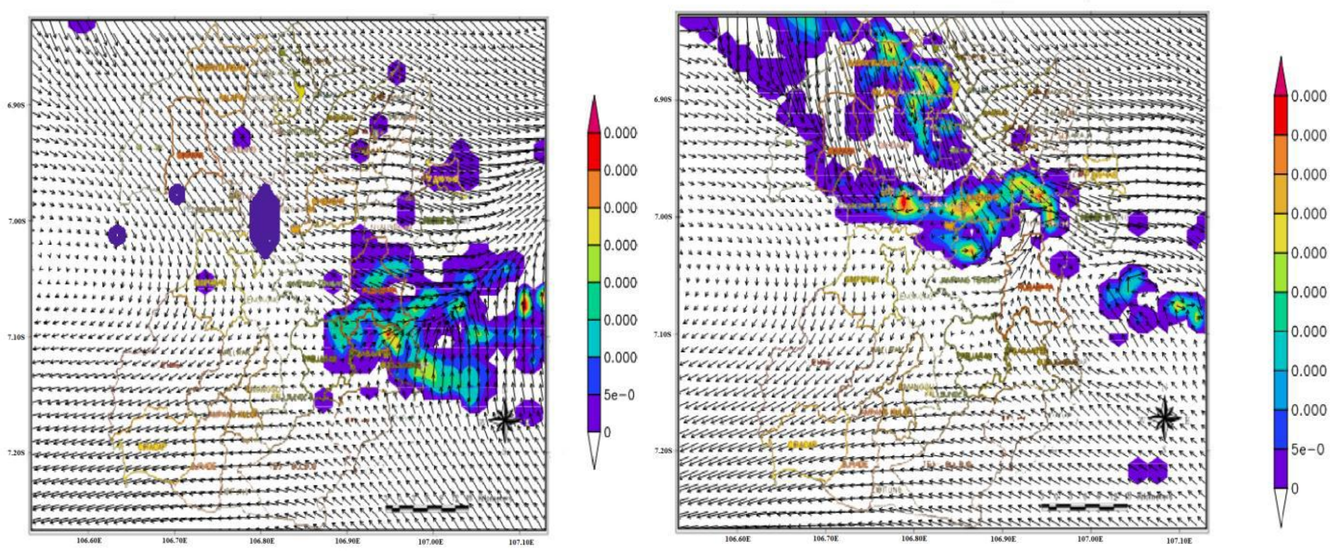
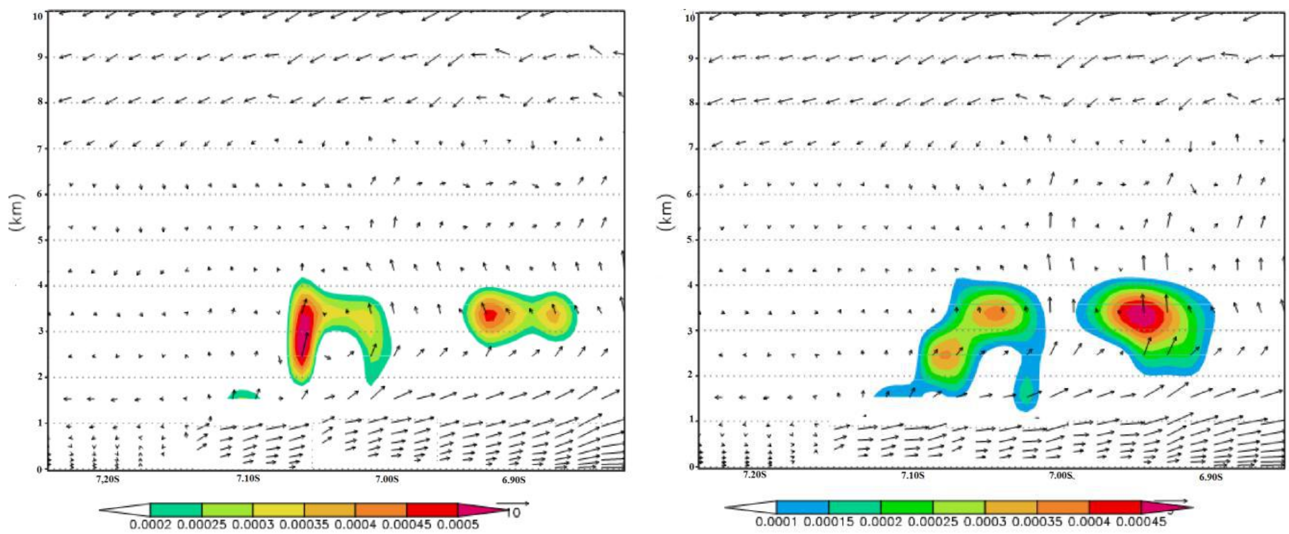


Figure 5. Numerical simulation results with WRF model for horizontal cloud distribution.

As in Figures 5 and 6, a comparison of the results of AVN data on September 21 2020 at 00 UTC (Universal Time Coordinate) with the simulation results of the WRF model for cloud cover patterns occurs convective cloud growth which is physically a storage process. the total energy in the atmosphere, then released simultaneously to produce a very large energy pulse. Energy pulses, in this case in the form of very high rainfall. Based on this, the extreme rainfall that causes flooding in Sukabumi, West Java is more dominated by local factors that play an active role in changing regional and global factors [15, 16].

The results of the numerical model of the cloud distribution results show that on September 21 2020 at 11.00 UTC the high atmospheric stability index value ranged from 1500-2500 J / Kg. Then the atmospheric stability index value decreased drastically at 06.00 UTC, namely in the range of 0-500 J / Kg. This is following the rainy period known from BMKG data [10]. Where the rain starts to fall on September 21 2020 at 06.00 UTC, this value is quite high and it can be assumed that the potential for convective cloud growth is quite high. So it can be concluded that the energy available for convective cloud growth in the Sukabumi region is in the period September 21, 2020, at 11.00 UTC [17, 18].



5. ANALYSIS AND RESULTS

The application of the WRF model according to [7] first determined the area domain, namely the downscaling of the research area (Figure 6). The model in this study includes the microphysical process, cumulus parameterization, the selection of the research area, which is intended to obtain fairly realistic results that represent actual conditions. In the determination of the boundaries of the study area, three nesting levels were used for global downscaling from the NCEP-FNL data, namely to achieve cloud growth in a horizontal radius of 3 km connecting the smallest areas. The simulation process for domains 1 and 2 is carried out simultaneously in the WRF model system (WPS). The above treatment is expected to obtain optimal results by reducing the need for simulation time without affecting the dynamic mesoscale pattern and fulfilling the boundary representation and initial requirements of the research area.

The application of this model can be done with PC-Cluster technology which allows parallel computing features in the model to be run. The results of this study can be applied as a dynamic cloud model to identify and analyze the physical processes of extreme climatic events. Evaluation of convection patterns in the Sukabumi area of west Java based on existing observational data, especially high-resolution satellite imagery, is expected to provide an understanding of the growth patterns of convection clouds that produce heavy rains and the causes of flooding in the Sukabumi area. The areas in west Java extreme rain in the Sukabumi region of west Java for 2020 flood events based on data analysis and tropical cyclone phenomenon (Vortex), this is a study of the influence of global and regional on extreme rain events in that period [19, 20, 21, 23].

6. CONCLUSION

Whereas for cloud dynamics, it can be seen that the cloud change pattern is from IR1 temperature data in Sukabumi, West Java in the form of maximum cloud growth in the 2020 period, as seen in the cloud growth pattern in Sukabumi Regency, West Java. This is due to local atmospheric circulation factors, which can be seen from the analysis of AVN data when there is extreme rain, the AVN data pattern shows a change in the direction of the effect of convection.

Simulation of the dynamics of flood clouds in Sukabumi, West Java in 2020 using the WRF model (research and weather forecasts) based on satellite observation data and global analysis data, it is found that synoptic conditions are good for convective rainfall where the southern season, winds migration trajectory occurs over the island of Java. The simulation results show that the convective rainfall concentration in Sukabumi, West Java is controlled by a combination of cold advection effects, mixing layer development, and topography. With appropriate data input, regional weather models such as WRF are useful for short-term analysis (short-term prediction; days) needed to anticipate flood events or other extreme weather-related natural disasters.

CONFLICT OF INTEREST

There is no conflict to disclose.

7. REFERENCES

[1] Abidin H.Z., Andreas H., Gumilar I., Wibowo I.R. (2015) On the correlation between urban development, land subsidence, and flooding phenomena in Jakarta. *Proc. IAHS.* 370: 15–20.

[2] Prasetyo Y., Yuwono B.D., Ramadhanis Z. (2018) Spatial Analysis of Land Subsidence and Flood Pattern Based on DInSAR Method in Sentinel Sar Imagery and Weighting Method in Geo-Hazard Parameters Combination in North Jakarta Region. *IOP Conf. Series: Earth and Environmental Science*. 123 012009

[3] Siswanto, Geert J.V.O.B., Gerald V.D.S., Lende R.K., Bart V.D.H. (2015) Trends in High-Daily Precipitation Events in Jakarta and Flooding of January 2014, *Special Supplement to the Bulletin of the American Meteorological Society*. 96(12).

[4] Mori S, Jun-Ichi H, YudiIman T, Yamanaka MD, Okamoto N, Murata F, Sakurai N, Hashiguchi H, Sribimawati T. (2004) Diurnal Land-Sea Rainfall Peak Migration over Sumatra Island, Indonesia Maritime Continent, Observed by TRMM Satellite and Intensive Rawinsonde soundings, *American Meteorological Society*. 2021-2039.

[5] Chaudhry, F.H., Filho A.G.A, Calheiros R.V.(1996) Statistics on Tropical Convective Storms Observed By Radar, *Atmospheric Research.*; 42: 217-227.

[6] Roxana, C., Wajsowicz. (2005) Forecasting extreme events in the tropical Indian ocean sector climate. *Journal dynamics of atmospheres, and ocean*. 1-15.

[7] Skamarock W.C., Klemp J.B., Dudhia J., Gill D.O., Barker D.M., Wang W., and Powers J.G., (2005) A Description of the Advanced Research WRF Version 2, Mesoscale and Microscale Meteorology Division, National Center for Atmospheric Research Colorado USA.

[8] Thompson G, Tewari M, Ikeda K, Tessendorf S, Weeks C, Orkin J, Kong F. (2016) Explicitly-coupled cloud physics and radiation parameterizations and subsequent evaluation in WRF high-resolution convective forecasts. *Atmospherics Research Journal*. 168: 92-104

[9] Hou T., Lei H., Yang J., Hu Z., Feng Q.(2016) Investigation of riming within mixed-phase stratiform clouds using Weather Research and Forecasting (WRF) model. *Atmospherics Research Journal*. 178-179: 291-303.

[10] Meteorology Climatology and Geophysics Council (BMKG), (2020) Climate Analysis.

[11] National Disaster Management Authority (BNPB), Indonesian Disaster Information Data.2000-2020, https://bnpb.go.id/infografis/update-bencana-indonesia-tahun-2020

[12] Roy I., Tedeschi R.G., Collins M. (2019) ENSO teleconnections to the Indian summer monsoon under climate changing. *International Journal of Climatology*. 39(6): 3031-3042.

[13] Diaz, H.F., M.P. Hoerling, and J.K. Eischeid (2001) ENSO variability, teleconnections, and climate change. *Int., J. Climatol*,21, 1845-1862.

[14] Hong S.Y., H.L. Pan. (1996) Nonlocal boundary layer vertical diffusion in a medium-range forecast model, *Mon. Wean. Rev*. 124: 2322-2339.

[15] Gernowo R., Adi K., Yulianto T., (2017) Convective Cloud model for Analyzing of Heavy rainfall of Weather Extreme at Semarang Indonesia. *Advanced Science Letter*. 23(7): 6593-6597.

[16] Sakurai N, Murata F, Yamanaka MD, Mori S, Hamada JI, Hasiguchi H, Tauhid YI, Sribimawati T, Suhardi B.(2005) Diurnal Cycle of Cloud System Migration over Sumatera Island. *Journal of the Meteorological*. 83(5).

[17] Gernowo R., Adi K., Yulianto T., Seniyatis S., Yatunnisa A.A. (2018) Hazard Mitigation with Cloud Model-based rainfall and Convective data. *Journal of Physics: Conference Series*. 1025(1): 012023.

[18] Castellano N.E., Avila E.E., (2004) Sounders CPR.Theoretical Model of the Bergeron-Fiendeisen Mechanism of Ice Crystal Growth in Clouds, *Atmospheric Environment*. 38: 6751-6761.

[19] Cooley D., D. Nychka, P. Naveau. (2007) Bayesian spatial modeling of extreme precipitation return levels. *J. Amer. Stat. Assoc*.102: 824–840.

[20] Masouleh Z.P., Walker D.J., Crowther J.M. (2019) A Long-Term Study of Sea-Breeze Characteristics: A Case Study of the Coastal City of Adelaide. *J. Appl. Meteor. Climatol*. 58(2): 385–400.

[21] Hidayat R., Juniarti M.D., Ma'rufah U. (2018) Impact of La Niña and La Niña Modoki on Indonesia rainfall variability. *IOP Conf. Ser.: Earth Environ. Sci*.149 012046.

[22] Hashiguci H., S. Fukao, T. Tsuda, M.D. Yamanaka, S.W.B. Harijono, H. Wiryosumarto. (1996) An Overview of The Planetary Boundary Layer Observation Over Equatorial Indonesia With an L-Band Clear Air Doppler Radar, Beitr. *Phy. Atmos*. 69: 13-25.