A Comparative Analysis of the Wind and Significant Wave Height on the Extreme Weather Events (TC Cempaka and TC Dahlia) in the Southern Sea of Java, Indonesia

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Abstract. The tropical cyclones (TCs) are a serious danger to marine and coastal areas in the tropics because they cause strong winds and extreme sea wave height. The combination of these two parameters will be dangerous for shipping safety. The purpose of this study was to investigate the effect of Tropical cyclone on significant wave heights and surface winds in the southern sea of Java with case studies of TC Cempaka (21-29 November 2017) and TC Dahlia (26 November-4 December 2017). The relationship between two parameters was also discussed in this paper. Both of these tropical cyclone events are interesting to study because they occurred in the southern sea of Java and in adjacent time periods. Special attention was paid to the southern sea of Java because it had high shipping traffic where 8 locations were used as case studies. Significant wave height and wind conditions were evaluated using data obtained from the European Mid-Term Weather Forecast Center (ECMWF) with 6 hourly temporal resolution (time UTC 00.00, 06.00, 12.00, 18.00) and 0.5 x 0.5 degrees spatial resolution. The obtained results showed that the influence of TC Dahlia on significant wave height and surface wind appears stronger than the influence of TC Cempaka. During TC Dahlia, the strongest relationship between wind and significant wave height was in the southern sea of Central Java 01 and Yogyakarta 01 with correlation coefficients of 0.84 and 0.81, respectively. While the frequency of extreme wave height of 55.56% appeared to occur in the southern seas of West Java 01 and Central Java 01.

1. Introduction
The territory of Indonesia is geographically located in the tropics which covers between 6°N to 11°S and 95°E to 141°E, with an area of mostly sea (70%). This causes the Indonesian territory also known as the maritime continent [1]. Various activities carried out by the Indonesian people at sea include sea transportation, fishing, exploitation of marine resources, design of structures in the waters and sea defense and security.

Sea transportation activities in the form of shipping is one of Indonesia's economic sectors. In general, the causes of marine accidents are caused by human error factors, force majeure factors, and other factors. Based on data from the Ministry of Transportation [2] states that during 2007 - 2011 there were 140 ship accidents with various causes in the territory of Indonesia, where 60% of the accident occurred in the western part of Indonesia. While the number of maritime court decisions on factors
causing ship accidents shows that 26 cases in the 2007-2011 period or the frequency of around 18.57\% of the ship accidents were caused by force majeure (natural) factors.

Frequently high sea accidents must be a concern of all parties, both shipowners, the government in this case, relevant agencies and the community. Although there is a tendency to decrease the number of accidents that occur each year, but the Government of Indonesia should remain focused to improve shipping safety in Indonesia.

Natural factors in the form of extreme weather conditions at sea, especially because high sea waves are generally one of the factors that greatly affect sea activity. Therefore, weather information and sea wave height need attention. The World Meteorological Organization (WMO) states that information about waves is the most important part that must be present in any type of marine information [3]. Meanwhile WMO [4] also states that sea level waves are the result of forces acting at sea. The dominant natural forces are pressure or pressure from the atmosphere (mainly through wind), earthquakes, earth's gravity and celestial bodies (moon and sun), Coriolis strength (due to earth's rotation) and surface tension. The other study [3] states that the wave phenomenon in the sea is the result of energy manifestation due to the disturbance from the deep waters leading to shallow waters. These disturbances can come from the wind, the attraction of astronomical objects (moon and sun), plate movements and so on.

Tropical Cyclone (TC) are a form of extreme weather disturbances. The growth of tropical cyclone is caused by high sea surface temperatures and causes the formation of intensive low pressure centers above the ocean. Thus triggering the process of convection and intensive cloud formation. This TC can also have an impact, among others, on the increase in wind speed and sea wave height. Tropical cyclones have long been recognized [6, 7]. Climatologically, tropical cyclones develop only over warm oceans with SSTs of 26\(^\circ\)C or higher. The TC is the most devastating weather phenomenon in nature with strong storm events occurring when large and severe TCs land along the coastline. In the southern regions of Indonesian waters, tropical cyclones generally occur in the Indian Ocean (south of Java and Nusa Tenggara [8]. Tropical cyclone events usually begin in October and last until March of the following year.

Several previous studies generally examined the impact of TC on increasing rainfall around the Indonesia region [9-11]. Research [9] shows that TC contribute to increasing rainfall in Indonesia, especially those located close to the center of TC. Likewise, research [10] states that the TC Cempaka was one of the TC that had an indirect impact in the form of very high rainfall in the region of Yogyakarta and other southern Java close to the center of the TC Cempaka. Another recent study [11] mentioned that the tropical cyclone Lili had a very damaging impact on the Tanimbar Islands region in the form of heavy rains and sea waves above 7 meters and damage to the coastal areas. Tropical cyclones (TCs) were one of the most destructive natural hazards. TCs can generate strong surface waves induced by the associated winds. TC-induced surface waves can reach a height of more than 10 m, which may damage offshore platforms and vessels, erode coastlines, threaten the coastal area, and cause economic and human life losses [12].

In general, the characteristics of ocean waves are represented by significant wave heights (SWH). SWH is defined as the average height of the highest one-third waves in a wave spectrum [13, 14]. SWH is the average of the highest one-third (33\%) of waves (measured from trough to crest) that occur in a given period. We should be aware that many individual waves will probably be higher. This is measured because the larger waves are usually more significant than the smaller waves. For instance, the larger waves in a storm cause the most beach erosion, or the larger waves can cause navigation problems for mariners [15]. Several studies based on wind and SWH parameters have been done before. Analysis of monthly wind and SWH variability based on ERA-Interim data for several locations in Indonesia has also been conducted [16]. Based on the wave spectrum model data [17] has conducted an analysis of the characteristics of sea waves in Western Indonesia.

The Center of Atmospheric Science and Technology - Indonesian National Institute of Aeronautics and Space (PSTA - LAPAN) is developing the SEMAR DSS (DSS “Sistem Embaran Maritim”) which is a decision support system related to shipping safety and increased capture fisheries production. This
project is a collaboration between LAPAN and the Marine and Fishery Office of Yogyakarta Province (DKP DIY).

In 2017, there have been two phenomena of tropical cyclones namely TC Cempaka (21 to 29 November 2017) and TC Dahlia (26 to November to 04 December 2017). These two TCs events are interesting to study because they occurred in the southern sea of Java and in adjacent time periods. In addition special attention was paid to the southern sea of Java as the domain of this study because it had quite high shipping traffic related to captured fisheries production and tourism activities.

Therefore this study was conducted with the aim of investigating the impact of the two TC phenomena on Significant Wave Heights (SWH) and surface winds in the southern sea of Java. and knowing the relationship between the two parameters also discussed in this paper. This research was conducted in an effort to complement some previous research with a focus on the impact of tropical cyclones on SWH and surface winds in the southern sea of Java. References relating to this are rarely found in Indonesia, so this research needs to be done. This research is also expected to contribute to a scientific study to support the development of the SEMAR DSS, specifically related to shipping safety.

2. Data and Methods

For Indonesia region, in-situ wave data coverage is very rare because of the high expense of the installation and maintenance of wave measuring instruments. So, this study used the ERA-Interim data from the European Mid-Term Weather Forecast Center (ECMWF) for significant wave height and wind 2m parameters with 6 hourly temporal resolution (time UTC 00.00, 06.00, 12.00, 18.00) and 0.5 x 0.5 degrees spatial resolution.

A validation study was carried out by comparing ERA-Interim data with buoy data [18]. The research [18] found that ERA-Interim data generally underestimate the wave height with lower standard deviations in comparison to observations, but it maintains slightly better error metrics. Some studies around the globe have been conducted on the correction of the reanalysis product [19]. The ERA-Interim data are very good and reliable data for the study of atmospheric circulation and surface waves [20]. These data have better spatial resolution than ERA-40 to analyze SWH in the North Sea [20].

The method used in processing the SWH and WIND spatial data is to use the GrADS (The Grid Analysis and Display System) application. GrADS is an application tool for visualizing data, as a tool that can handle climate mapping problems developed by the Atmospheric Science Community and recommended by WMO [21]. As for processing timeseries and statistics, the Microsoft Excel application is used.

This research was conducted based on several stages of work where the first stage was data collection based on the period in which two tropical cyclones appeared (TC Cempaka, 21-29 November 2017 and TC Dahlia, 26 Nov to 04 Dec 2017). The second step was to do the data cropping according to the specified domain study. The domain of this study is the southern sea of Java, which includes 04°-22°S and 102°-118°E, as shown in the red box in Figure 1a. The third stage was processing the spatial data to accumulate 6 hours of data into daily data to understand the average daily distribution patterns of SWH and WIND in the southern part of Java. The fourth step is processing spatial data to determine changes in the distribution patterns of SWH and WIND from locations around 8°S to 22°S in the southern waters of Java Island by making averaging latitude using the Hovmoller plot. While the fifth stage is extracting 6-hour data for eight (8) case study locations (shown in Figure 1b) and then processing the time series data with statistical calculations. The selection of eight (8) case study sites was based on the consideration that these location was closest to the port and shipping activities were also quite high in each province on Java (see Table 1 for locations).

The next stage was an analysis of the results obtained. The first step was to analyzed the impact of TC on the daily average distribution pattern of the SWH and WIND distributions. The second stage, analyzed the impact of TC on changes in the average latitude of SWH and WIND in the waters of southern Java over time using the Hovmoller diagram. The third step is to analyze the results of timeseries data processing and also the correlation between SWH and WIND with statistical calculations using linear regression equations.
Figure 1. The study area covers 8°-22°S; 102°-118°E as shown in the red box (a) and the eight (8) case study locations in southern Java as indicated by a red dot (b).

Table 1. The case study locations and the names of the nearest port.

| No | Case study location based on Province | Lat  | Lon   | Name of the nearest port                  |
|----|--------------------------------------|------|-------|-------------------------------------------|
| 1  | West Java_1                          | 09°S | 106.50°E | Port of Ratu                               |
| 2  | West Java_2                          | 10°S | 106.50°E |                                            |
| 3  | Central Java_1                       | 09°S | 108.99°E | Port of Tanjung Intan, Cilacap             |
| 4  | Central Java_2                       | 10°S | 108.99°E |                                            |
| 5  | DLYogyakarta_1                       | 09°S | 110.80°E | Port of Sadeng                             |
| 6  | DLYogyakarta_2                       | 10°S | 110.80°E |                                            |
| 7  | East Java_1                          | 09°S | 114.40°E | Port of Ketapang, Banyuwangi               |
| 8  | East Java_2                          | 10°S | 114.40°E |                                            |

3. Results and Discussions
In 2017, the Tropical Center Warning Center (TCWC Jakarta - BMKG) recorded 2 tropical cyclones that grew very close to the southern coast of Java Island which resulted in changes in extreme weather patterns around its trajectory. The TC Cempaka, was named by the Indonesian meteorological agency (BMKG) overnight on 27 November, and was currently located south of the Indonesian island of Java. TC Cempaka was embedded in a weak tropical trough which extended to a second tropical low further to its west. This second low was forecasted to merge with Cempaka and slowly strengthened as it moved in a southerly direction. Current forecasts back then suggested this system may tracked towards the far western coast of Western Australia at tropical cyclone strength. On 29 November, the TC Cempaka in south Java had weakened to become a tropical depression which was moving towards the Southwest away from Indonesian waters. Meanwhile, on November 29 12:00 UTC, a tropical cyclone seedling in Southwest Bengkulu also saw an increase in strength to a tropical cyclone. The tropical cyclone was given the name TC Dahlia which was in the position of 8.2°S and 100.8°E with a movement towards the Southeast away from the territory of Indonesia.

BMKG stated that tropical cyclones of Cempaka and Dahlia had an impact on increasing heavy rainfall, high sea waves, strong winds, and the potential for lightning in several regions in Indonesia. Figure 2 shows the trajectory map of TC Cempaka (a) and TC Dahlia (b) events. In Figure 2 it appears that the duration of activity of each of the tropical cyclone is the same, namely 9 days where TC Cempaka 21 to 29 November 2017 while TC Dahlia 26 November to 4 December 2017. This shows normal conditions as [22] stated that the duration the incidence of tropical cyclones varies from a few hours to 14 days with an average of 6 days from the phase of cyclone formation to the phase of cyclone death as it moves towards the mainland or veers into the subtropics.
TC Cempaka's activities occur at sea around the area located between 8°-11°S and 110°-112.5°E or generally appear in the sea south of the Ngiyep coast of Malang (East Java) to the southern waters of the Cilacap coast (Central Java). Based on the Bureau of Meteorology Tropical Cyclone data it appears that the peak activity of TC Cempaka took place on 27 November 2017 18:00 UTC to 28 Nov 2017 18:00 UTC with a minimum air pressure of 998hPa and a maximum wind speed of 18m/s (35kt). While the TC Dahlia activity that appeared early formed in the area between 5°-17.5°S and 90°-115°E or in general, emerging tropical ocean cyclones that develop from southwest Bengkulu and move north of Christmas Island eventually weakened well off the coast of Western Australia. On 30 Nov 2017 06:00 UTC TC Dahlia with intensity 1. The intensity continued to strengthen reaching the peak with intensity 2 on 01 Dec 2017 12:00 UTC to 01 Dec 2017 18:00 UTC. At the peak time, the minimum air pressure was 985hPa and the maximum wind speed reached 25m/s (50kt). Furthermore tropical cyclones began to weakened with intensity 1 on 02 Dec 2017 00:00 UTC and disappeared on 4 December 2017 12:00 UTC.

**Figure 2.** The trajectory map of TC Cempaka (a) and TC Dahlia (b) events.

Based on the spatial data processing, obtained the maximum daily distribution pattern of SWH and WIND in the southern sea of Java for the occurrence of each TC period. Figure 3a shows the daily average pattern of SWH distribution during the TC cempaka period, where a very significant SWH increase was seen on November 22, which reached a maximum of more than 3.2 m at latitude 22°S, whereas in the southern waters of Java Island up to 16°S the distribution of SWH varies from 1.8 m to 2.6 m. In fact, on June 23, 2017, it appears that the increase in the value of SWH varies between 2.2 m to 2.6 m which is very significant with a wider affected area. Likewise, the daily average pattern of WIND distribution also reached a maximum speed (10 m / s) with the dominance of winds from the southeast-south direction on November 22, 2017 in the southern sea of Java, especially for areas around 11°-22°S. However, on November 23, 2017 the wind appeared to be getting weaker with the dominance of variations between 6 m/s to 8 m/s, as shown in Figure 3b.

The very significant impact of the TC Dahlia event on the increase in the average daily distribution of SWH in the southern seas of Java was shown in Figure 3c. It appears on November 30, 2017 the value of SWH varies between 1.8 m to 3.2 m, with a peak occurring around southern Lampung, southern waters of West Java and Central Java. Whereas on December 1, 2017, SWH movements with high values were seen heading eastward along the waters in southern Central Java and Yogyakarta. Likewise, the impact of TC Dahlia on the daily average pattern of the WIND distribution appears to be very significant in the southern waters of Java, where the maximum SWH location also shows the maximum
WIND speed reaching 14 m / s. Even on December 1, 2017 it was seen forming a WIND vortex pattern following the TC Dahlia track as shown in Figure 3d.

Figure 3. Patterns of daily average distribution of SWH (a) and WIND (b) during the TC Cempaka period and SWH (c) and WIND (d) during the TC Dahlia period

In this study, it appeared that the analysis of TC Dahlia impact on increasing SWH and WIND in the southern sea of Java is stronger than when TC Cempaka. This is caused by TC Dahlia's intensity criteria which are also stronger than TC Cempaka's intensity. This study supports previous research [23] where for the TC Quang event which formed on April 28, 2015 in the waters of the Indian Ocean. Using data based on the Windwaves-05 model, research [23] show that TC Quang had an impact on oceanographic parameters around Indonesia, where wind speeds, maximum waves, and surface currents show an increase in value and then decrease with the weakening of TC Quang activity and further away from the waters of southern Java. Whereas, research [24] the impact of TC on WIND and SWH in Central Bengal Bay from 1979 to 2012 was based on ECMWF ERA-re-analysis data from a temporary data set. They found that higher peaks in wind speed and SWH during certain years were mainly due to TC influence in the area. The highest annual maximum SWH (5.66 m) observed during 1996 was due to the proximity of the typhoon path to the study site.

Spatial analysis to determine changes in patterns of SWH and WIND along latitude 8°-22°S for the southern waters of West Java (at longitude 106.50°E), along latitude 8°-22°S for the southern waters of Central Java (at longitude 108.99°E), along latitude 8.5°-22°S for the southern waters of Yogyakarta (at longitude 110.80°E), and along latitude 9°-22°S for the southern waters of East Java (at longitude 114.40°E). The results obtained in the hovmoller diagram illustrate the time vs latitude distribution for the SWH parameters (Figure 4a) and wind (Figure 4b) in the southern sea of Java during the TC Cempaka period. It can be seen in Figure 4a that there was a similarity of sea wave height patterns in general in the southern waters of Java during the TC period. Extreme weather conditions where SWH was greater than 2 m to 3 m appear to occur almost along the latitude of 8°-19°S waters in southern Java around 21 November 2017 00:00 UTC to 24 Nov 2017 06:00 UTC, except in the southern waters of East Java that appear SWH lower which was around 2 m to 2.6 m. While the movement of the waves appears increasingly to the south of Java, which is around the location of 19°-22°S, it seems that the height reaches more than 3m. Subsequently, around SWH decreased to around in the southern waters of
West Java and Central Java (1.4m to 1.6m) while in the southern waters of Yogyakarta and East Java it seemed to be getting smaller than 1.4 m. However, there appears to be an increase in SWH in the southern waters of Java up to 29 November 2017, where the highest is seen in the southern waters of West Java. This showed the influence of TC Dahlia which began to form in the southwestern part of Bengkulu on increasing SWH in the southern waters of West Java.

The wind speed patterns formed along the 8°-22°S latitude during the Cempaka TC period also appeared to have similarities in the southern waters of West Java, Central Java, Yogyakarta and East Java (Figure 4b). Wind speeds in the waters around the southern coast of Java generally range from 2 m/s to 6 m/s. The further south, the stronger the wind speed reaches 10 m/s. However, an interesting thing appeared throughout the day on 21 November 2017 00:11 UTC to 22 Nov 2017 00 UTC The wind blows with a stronger speed generally between 10 m/s to 14 m/s in the southern waters of West Java (location 8°-11°S), Java Central (location 8°-13°S) and East Java (location 9°-11.5°S). Even in the southern waters of Yogyakarta there is a maximum wind speed that exceeds 16 m/s. This is due to the position of the southern waters of Yogyakarta which is the closest position to the position of TC Cempaka formation. On 27 November 2017 00:00 UTC to 27 Nov 2017 18:00 UTC it appears that strong wind speeds generally 10 m/s to 14 m/s also occur in the southern waters of West Java and Central Java.

![Figure 4. Plot Hovmoller diagram of the 6-hourly SWH (a) and WIND (b) during TC Cempaka period.](image)

How the SWH and WIND conditions in the southern sea of Java during the TC Dahlia period are shown in Figure 5a and Figure 5b, respectively. During the TC Dahlia period there were generally high sea waves occurring in the southern part of the Java sea. Based on the results of data processing it appears that the southern territorial waters of West Java experienced the most severe extreme conditions where the wave height of more than 2 m even reached a maximum of more than 3.2 m which occurred on 30 Nov 2017 18:00 UTC to 01 Dec 2017 12:00 UTC around 8°-14°S latitude position. It can be seen from Figure 3a that the further east the influence of TC Dahlia decreases. This is indicated by the smaller SWH value. in the southern waters of East Java the sea waves appear lower, which is generally around 1.4 m to 2 m. However, when TC reaches the maximum intensity there also appears to be an increase in the range of 2.4 m to 2.8 m which occurs around the latitude of 9° to 14°S.
Figure 5. Hovmoller diagram of the 6-hourly SWH (a) and WIND (b) during TC Dahlia period.

Likewise, the wind pattern that looks similar to the high wave pattern in the southern waters of West Java in Figure 3b is that in the TC period Dahlia strong winds generally blow between 10 m/s to 12 m/s which predominantly occur along the 14°S to 22°S, whereas further north approaching Java, which is along the positions of 8°-14°S, it appears that the domination of the wishful tighter is between 12 m/s to 14 m/s and in some locations it can reach 16m/s.

Several studies on TC Cempaka or TC Dahlia had also been carried out by previous researchers [10, 25, 26]. However, all of these studies were related to the impact of TC events on rainfall parameters. Therefore this research is expected to be able to complete the literature related to the impact of TC Cempaka and TC Dahlia on SWH and WIND in the southern seas of Java. Research [25] reports that TC Dahlia has significantly affected the increase in rainfall in parts of Indonesia which caused flooding. A very large increase in rainfall in Gunungkidul, Yogyakarta region with an increase in rainfall reaching 750% from the historical average. Whereas research [26] has reported spatial analysis to determine the evolution of TC Cempaka, their movements and their effects on rainfall on Java based on cloud brightness temperatures. TC Cempaka influences the weather system in most parts of Java, which significantly increases rainfall intensity in several areas in Java, where Pacitan and Wonogiri were recorded as the regions with the highest rainfall, each at 9 mm/hour and 19.9 mm/hours, and accumulated rainfall reaches 260 mm/3dy.

The next analysis related to the temporal analysis conducted for each of the 8 case study locations. Scatter diagrams for wind and SWH during the TC Cempaka period are shown in Figure 6. Generally, in 8 case study locations show a moderate correlation between wind and SWH. The strongest relationship occurred in the southern sea of West Java-2 with the highest coefficient of determination of 0.4432 and followed by Central Java-2 with $R^2 = 0.4376$. Whereas the other 6 locations have smaller correlation values.

Scatter diagrams for wind and SWH during the TC Dahlia period are shown in Figure 7. There are interesting things that appear during the TC Dahlia period generally showing a strong correlation between wind and SWH. This is indicated by the coefficient of determination ($R^2$) which varies between 0.5155 to 0.7129. Unless the correlation appears to be weak in the southern waters of East Java where the coefficient of determination and the correlation coefficient for the location of the southern waters of East Java-1 and East Java-2 are $R^2 = 0.002$ and $R^2 = 0.0016$, respectively.
Figure 6. Scatter diagrams for the windspeed (m) and SWH (m) at 8 locations during TC Cempaka period.

Figure 7. Scatter diagrams for the windspeed (m/s) and SWH (m) at 8 locations during TC Dahlia period.
Based on statistical analysis between wind speed and SWH shows that a stronger correlation occurred in the southern sea of Java during the TC Dahlia period than the TC Cempaka period. For 6 locations in the southern sea of Java except the southern waters of East Java, the correlation coefficient values very strong, generally varying between 0.72 to 0.84, where the highest correlation coefficient values were seen in Central Java-1 locations. While the correlation coefficient during the Cempaka TC period appears smaller, which varies between 0.33 to 0.67. The results also show conditions in the southern sea of East Java appeared to have a weak correlation for the two tropical cyclone periods. This shows that the influence of tropical cyclones both during the Cempaka and Dahlia periods on wind and SWH in the southern sea of East Java was small and the complete results can be seen in Table 2.

Table 2. The wind and SWH correlation coefficient during TC Cempaka and TC Dahlia periods at eight (8) locations case study.

| Locations | West Java | Central Java | Yogyakarta | East Java |
|-----------|-----------|--------------|------------|-----------|
| Periods   | 1         | 2            | 1          | 2         |
| TC Cempaka| 0.51      | 0.66         | 0.41       | 0.67      |
| TC Dahlia | 0.74      | 0.72         | 0.84       | 0.73      |

The results for wind speed frequencies greater than or equal to 10 m/s during the TC Dahlia period appear to be greater than during the TC Cempaka period. The results for the eight case study locations show a value of less than 20%. Furthermore, an analysis of extreme SWH frequency is carried out with reference to [27] which states that if SWH greater than or equal to 20 m is a criterion of extreme weather conditions. Therefore in this study the SWH extreme frequency values were almost the same in the events of 2 tropical cyclones ranging from 40% to 56%, except in the southern sea of East Java, which is only less than 20% as shown in Figure 8.

Figure 8. The frequency of extreme SWH events during TC Cempaka and TC Dahlia periods
4. Conclusion
Based on the 6-hour data for wind and SWH parameters in this study, it could be concluded that 2 events of tropical cyclones (Cempaka and Dahlia) that occurred in the southern sea of Java had a significant influence on the increase in SWH and wind. The impact of TC Dahlia looked even more severe triggering extreme weather than TC Cempaka. This was also due to the fact that TC Dahlia had a stronger intensity than TC Cempaka. The impact of the tropical cyclone Dahlia on the extreme sea waves was most severe in the southern waters of West Java and Central Java with a frequency of more than 50%. The strongest correlation coefficient between wind and SWH appeared to occur in the TC Dahlia period in the southern seas of Central Java-1 and Yogyakarta-1, respectively 0.84 and 0.81.

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