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The Condition of Significant Wave Height and Wind Velocity in Makassar Strait during 2017

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Abstract

This study aims to look at the conditions and characteristics of significant wave height and its relationship to wind velocity in the Makassar Strait in 2017. The data used in this study are bathymetry data from GEBCO with a resolution of 30 seconds, significant wave height data (Hs) with a resolution of 0.25 x 0.25 as well as wind velocity and direction with a resolution of 0.25 x 0.25 which are secondary data results from the European Center for Medium-Range Weather Forecasts (ECMWF) with a span of one year in 2017. The method used in this research is an analysis of the energy spectrum of significant wave height using Fast Fourier Transform. In addition, wind velocity and direction are processed by using GrADS software to see the visual conditions. Based on this study, it can be concluded that wind velocity is strongly associated with significant wave height values. This can be seen at each sample point in the Makassar Strait, where when the value of wind velocity is high, the value of significant wave height has the same conditions, and vice versa. The wind velocity value has a maximum value in the Makassar Strait during the east season with a value of more than 4.5 m/s. The highest energy spectrum occurs at point 3 in the Makassar Strait, which is 7303 m^2 with a period of 6 months.

Keywords: significant wave height, wind velocity, energy spectrum, significant wave period

1. Introduction

The Makassar Strait is the main line of Indonesian cross-currents that carry warm water masses from the Pacific Ocean to the Indian Ocean through Indonesian waters (Ffield et al, 2000). Water conditions in the Makassar Strait are strongly influenced by seasonal conditions and ENSO (Gordon, et al. 1999). Monsoon wind is the wind that blows throughout the year and reverses direction twice a year. Monsoon wind is divided into two, namely the Northeast Monsoon determines the season in the North Indian Ocean at the time of the Northern Hemisphere (BBU) experiences summer (December - March) and Southwest Monsoon determines the climate in the North Indian Ocean during summer BBU (June - September) (Tomczak and Godfrey, 2001). Based on research conducted by Ffield et al (2000), transport volume in the Makssar Strait is integrally related to the thermocline temperature field. In addition, the incidence of ENSO strongly determines internal transport energy conditions in the Makassar Strait (Ffield, et al, 2000).

Table 1. Distribution of water depth

Type	Criteria	Fast Speed
Deep	$\frac{h}{L} > \frac{1}{2}$	$C_d = \sqrt{g\frac{Ld}{2\pi}}$
Shallow	$\frac{h}{L} < \frac{1}{20}$	$C_d = \sqrt{gh}$
Medium	$\frac{1}{20} < \frac{h}{L} < \frac{1}{2}$	$C_d = \sqrt{\frac{gL}{2\pi} \text{TAN } 2\pi\frac{h}{L}}$

During the El Nino peak, which was in 1997/1998, from September 1997 to mid February

1998, the average flow rate in the Makassar Strait was reduced, which was to be 4.6 Sv (Susanto and Gordon, 2005). Based on research from Gordon et al (1999) and Susanto et al (2000), tides in the Makassar Strait are predominantly diurnal and semidiurnal with fortnightly modulation. In addition to ENSO, IOD (Indian Ocean Dipole) also has an effect on significant wave height and sea surface temperature (SST), ie when IOD is negative, Hs and SST values have increased (Cai et al, 2012; Weller and Cai, 2013; Qiu et al, 2014 in Khoirunnisa et al, 2017; Lubis and Daya 2017).

Research in the Makassar Strait was also carried out by Shinoda et al (2012), where seasonal variations greatly influenced the condition of the waters in the Makassar Strait. Besides that, the wind speed in the Makassar Strait has a very important role. This study will discuss the relationship of wave height and wind speed in the Makassar Strait during 2017, as well as the energy spectrum of significant wave heights in the Makassar Strait.

2. Data and Method

2.1 Data

This study used bathymetric data, significant wave height data in the Makassar Strait and wind data in the Makassar Strait in 2017. The Makassar Straits bathymetry data was obtained from General Bathymetric Chart of the Oceans (GEBCO) with a resolution of 30 seconds. Ocean bathymetry refers to the depth of the seabed. Since 1903 initiations have been carried out for mapping the world's marine bathymetry by GEBCO. In 1973 GEBCO established a program under the International Hydrographic Organization (IHO) and the Intergovernmental Oceanographic Commission (IOC). GEBCO has launched GEBCO_2014, a global bathymetry model with a grid resolution of 30 seconds. This GEBCO_2014 data source is from SRTM30_PLUS for gridded bathymetric datasets.

Data on significant height of wave and wind direction were obtained from the assimilation data and downloaded through the European Center for Medium-Range Weather Forecasts (ECMWF) site with a span of one year in 2017. Significant wave height data, u10, and v10 have a grid resolution of 0, 25x0.25. While the significant wave period obtained based on the Sverdrup Munck Bretschneider (SMB) method.

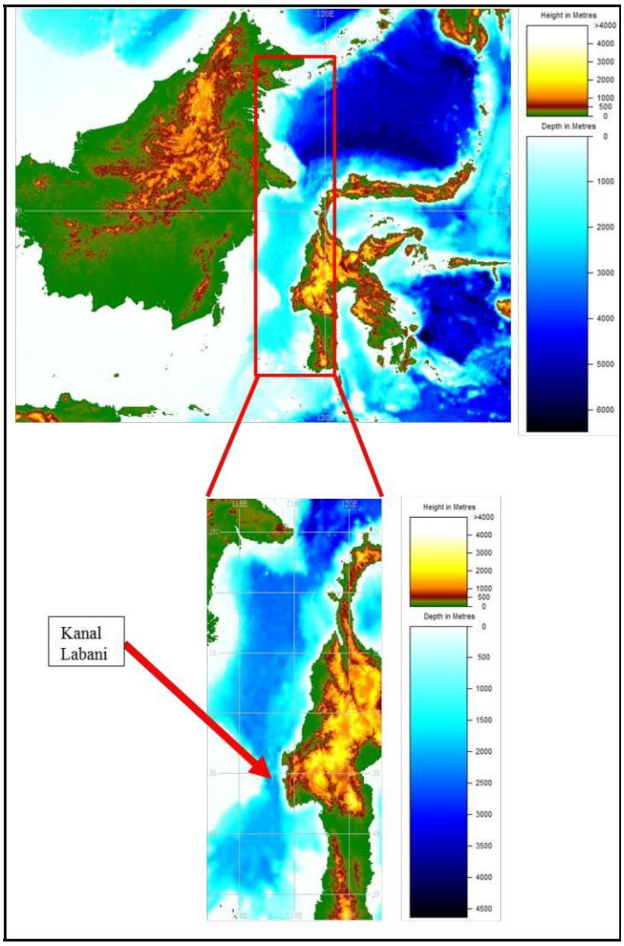


Figure 1. Makassar strait bathymetry (Source: Gebco, 2014).

2.2 Method

Wind data consists of direction and speed, can be visualized by using The Grid Analysis and Display System (GrADS) software. GrADS software can read data in netcdf format. In addition to visualizing wind data, GrADS can also combine wind data with Hs data. The original development of GrADS was funded by the NASA Advanced Information Systems Research Program. The development of the GrADS Data Server was funded by SIESIP grant from NASA's Earth Science Information Partnerships.

The next method is to determine the value of the energy spectrum of Hs during 2017 in the Makassar Strait. The method used is Fast Fourier Transform (FFT). The FFT method is used to change the time domain to frequency.

4. Result and Discussion

The Makassar Strait is located at the coordinates 1°55'37"N and 120 °59'56" –5°43'21"S and 117°42'02"E. The deepest conditions in the Makassar Strait are located at coordinates 119,3542 E and 1.4542N with a value of 4629 m. The Makassar Strait has an average depth of 650 m. The area around the Labani Canal has a fairly deep bathymetry, which is around 1700 – 2100 m (Figure 1).

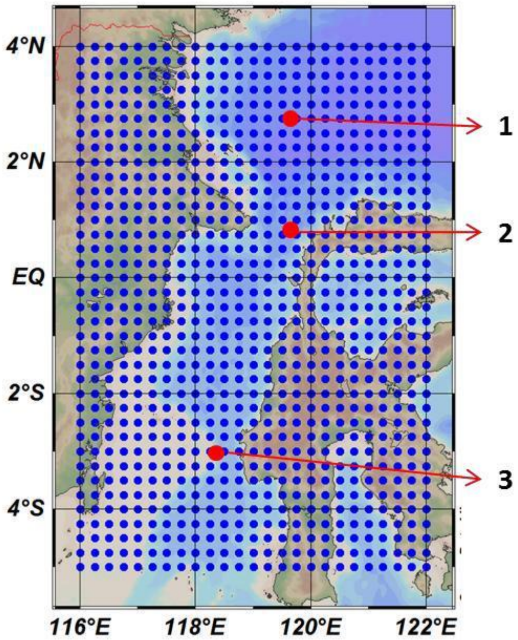


Figure 2. The observed locations in Makassar Strait.

Based on Figure 3, it can be seen that the maximum wind speed occurs during the east season, which is more than 4.5 m / s. The wind blows from the south of the Makassar Strait during the east season. This is consistent with wave height conditions during the east season, where the highest significant wave height occurs during the east season (Figure 4).

Figure 4 shows the significant wind and wave height conditions throughout 2017. Data on significant height of wave and wind direction are obtained from the assimilation and downloaded data from the European Center for Medium-Range Weather Forecasts (ECMWF) site. Significant wave height data, u10, and v10 have a grid resolution of 0.25x0.25. Then the data is processed using the Grid Analysis and Display System (GrADS) to describe the spatial conditions. Based on the picture, it is seen that in January the wind conditions entered the Makassar Strait from the north. Whereas in July it was seen that the direction of the wind was moving in the opposite direction. This shows that monsoon conditions affect wind speed and wave height conditions.

When the west monsoon, which is in December – January, the significant height of the waves is greater in the northern part of the Makassar strait, which is around 0.7 – 0.8 m. Whereas for the southern part of the Makassar strait has a wave height of 0.6 – 0.45 m. When the east monsoon, the southern condition of the Makassar Strait has a fairly high wave height compared to other regions. It can be seen that there is a strong relationship between wind speed with wave height, namely the faster the wind blows, the higher the significant waves in the Makassar Strait.

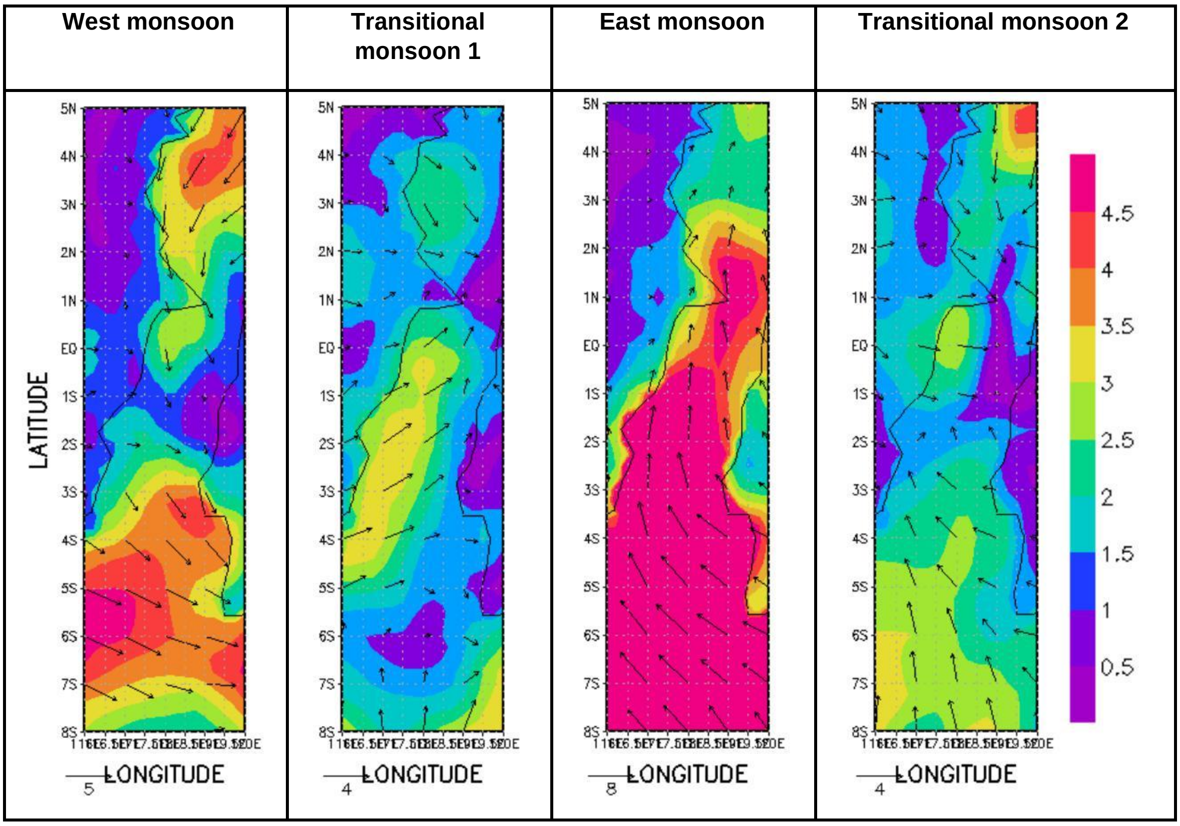
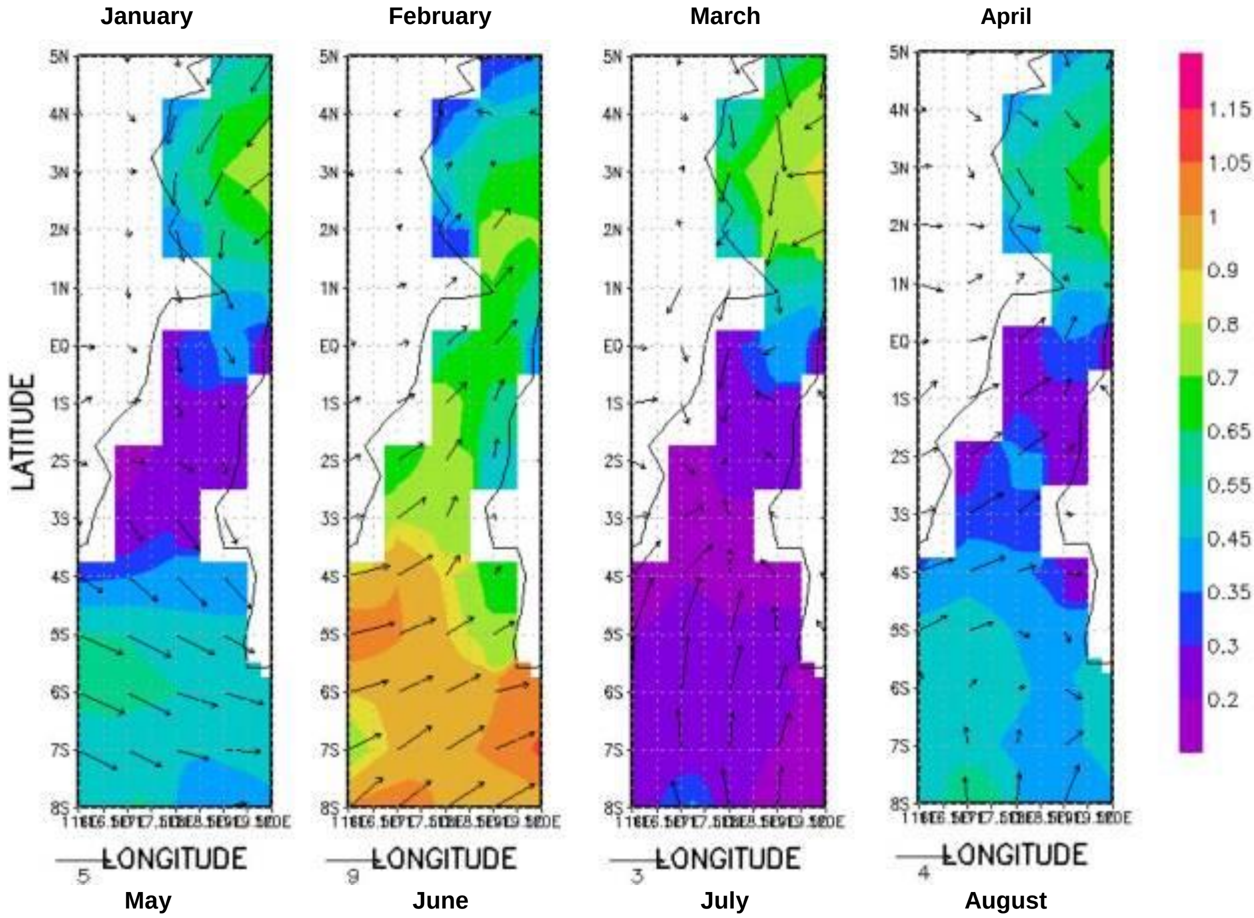


Figure 3. The wind veocity and wind direction in Makassar Strait during 2017. (Source: ECMWF, 2018).



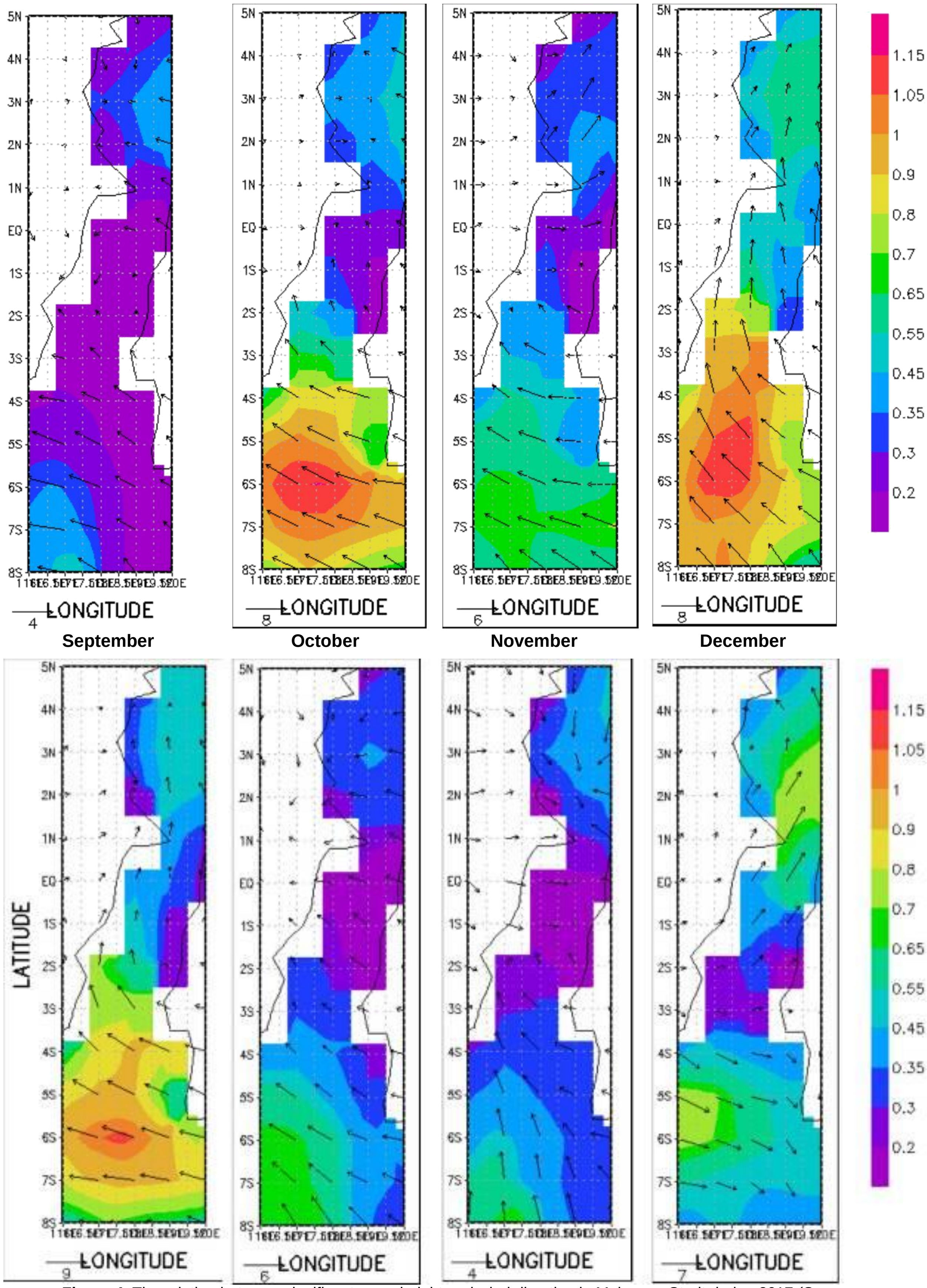


Figure 4. The relation between significant wave height and wind direction in Makassar Strait during 2017 (Source: ECMWF, 2017).

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Table 2. The observed locations in Makassar Strait with its wind velocity, significant period, and significant wave height.

No	Location	Averaged wind velocity (m/s)	Averaged significant period (s)	Averaged significant wave height (m)
1	2,75^{O}N and 119,75^{O}E	3,340466	2,402205	0,583811
2	0,75^{O}N and 119,5^{O}E	2,961115	2,079552	0,358851
3	3^{O}S and 118,5^{O}E	3,081811	2,179889	0,39673

The relationship between wind speed and significant wave height can be seen from table 2. The maximum significant wave height value when the wind speed is maximum. In table 2 it can be seen that point 1 has the highest wind speed value compared to Point 2 and Point 3. Significant period of wave has a positive correlation with significant wave height. The results of this study indicate that the highest significant wave period occurs at Point 1 of the Makassar Strait.

Based on Figure 5, it is seen that the highest energy spectrum at point 1 of the Makassar Strait in 2017 is 3299 m2 with a period of 6 months. Whereas for periods under 5 days, the highest energy spectrum of significant wave height is 468 m2 with a period of 4.5 days.

Based on Figure 6, it can be seen that the highest energy spectrum at point 1 of the Makassar Strait in 2017 is 2400 m2 with a period of 6 months. Whereas for periods under 5 days, the highest energy spectrum of significant wave height is 253 m2 with a period of 4.5 days.

Figure 7 shows the significant wave height energy spectrum for 2017 at point 3 of the Makassar Strait. The highest spectrum value for point 3 is 7303 m2 for a period of 6 months. While for periods under 5 days, the highest energy spectrum of significant wave height is 238 m2 with a period of 4 days. Based on the results above, it can be concluded that in the Makassar Strait there is a long wave propagation with a period of 6 months (semiannual). Based on research conducted by Susanto et al (2012), it is evident that the presence of Kelvin wave intrusion from the south with a portion of 45% of the total transport in the Makassar Strait. Based on Figure 8, the significant wave height in 2017 in the Makassar Strait is highest in around January - February and September - October.

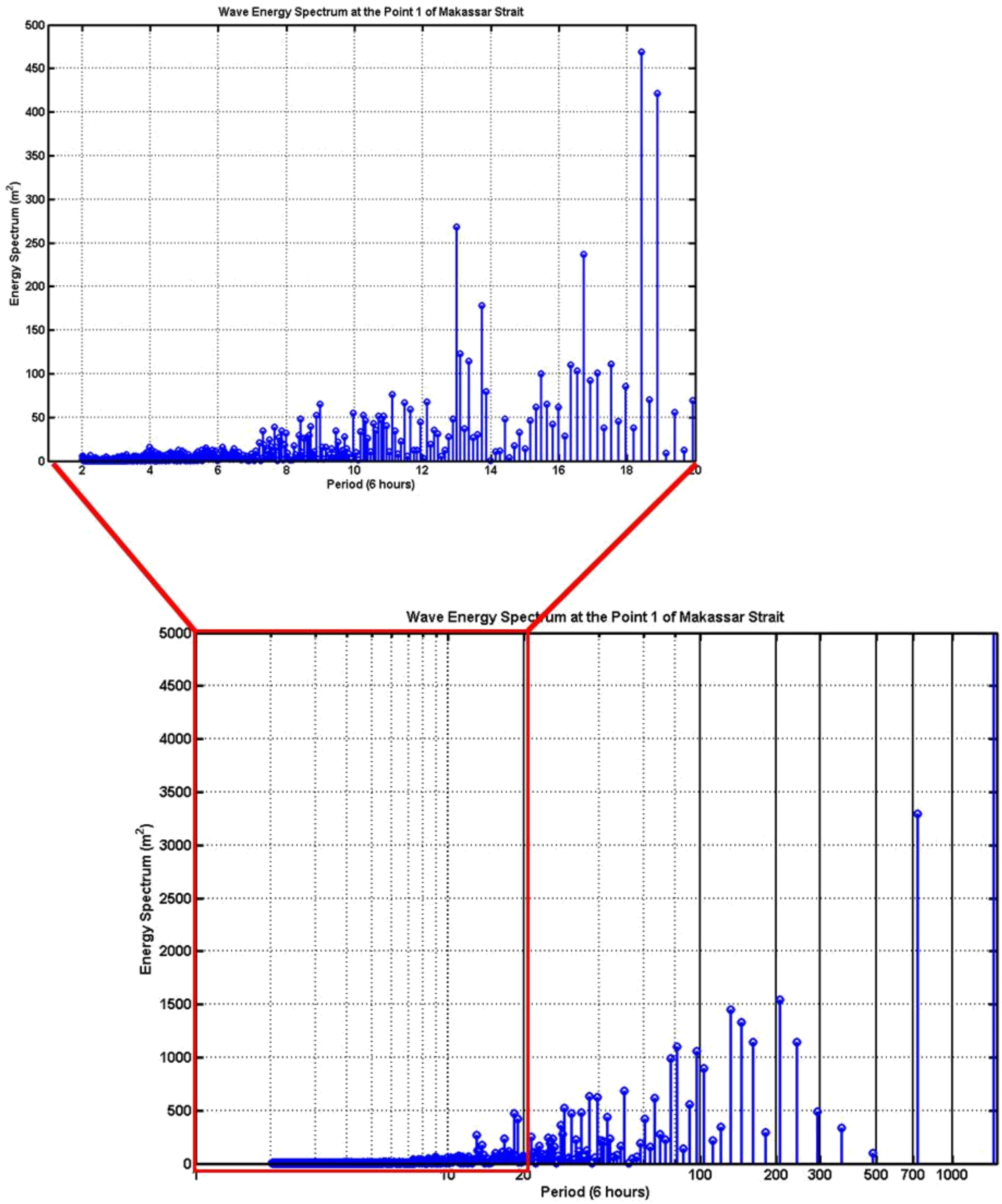

Figure 5. The Hs energy spectrum during 2017 at point 1 of Makassar Strait.

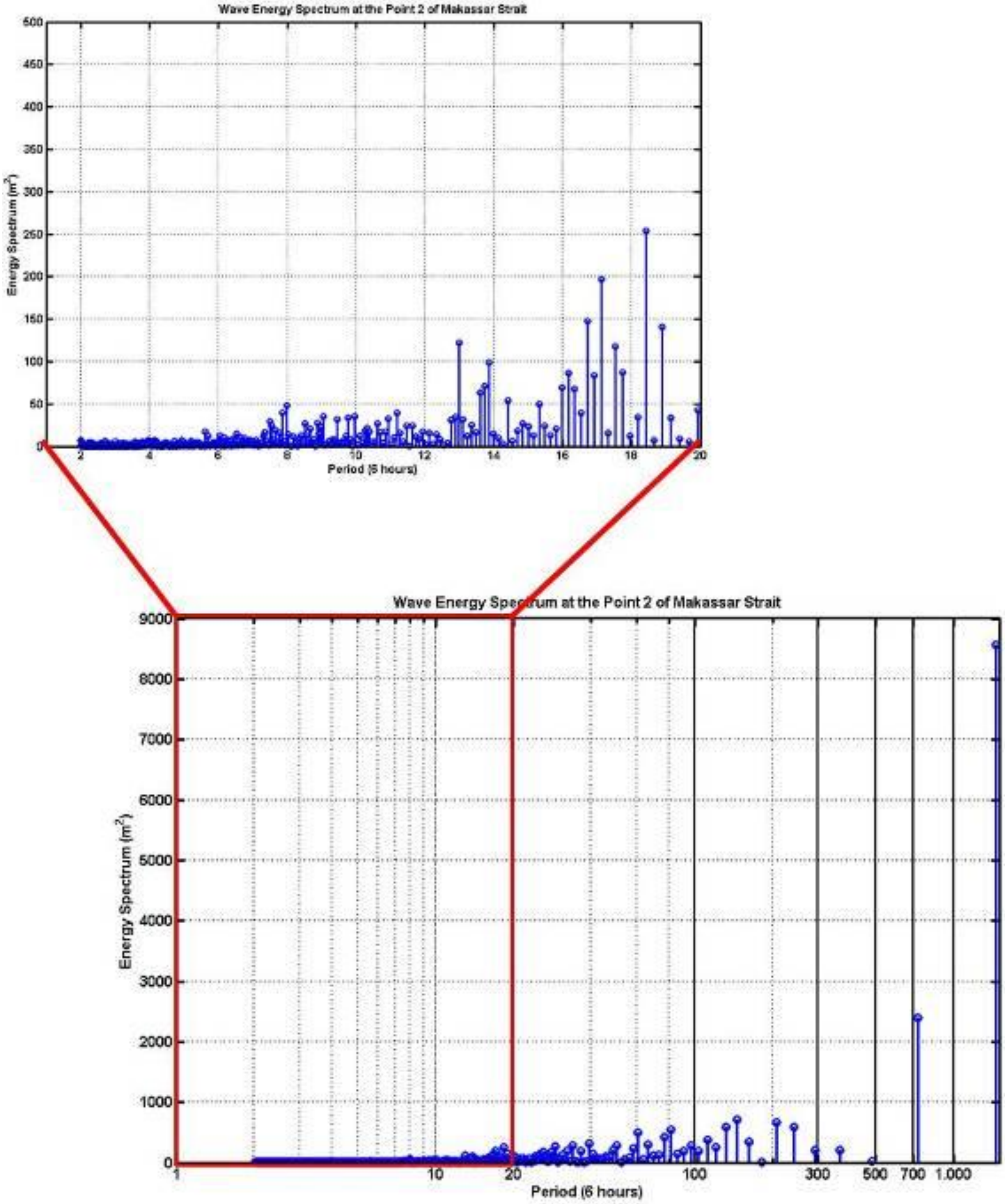

Figure 6. The Hs energy spectrum during 2017 at point 2 of Makassar Strait.

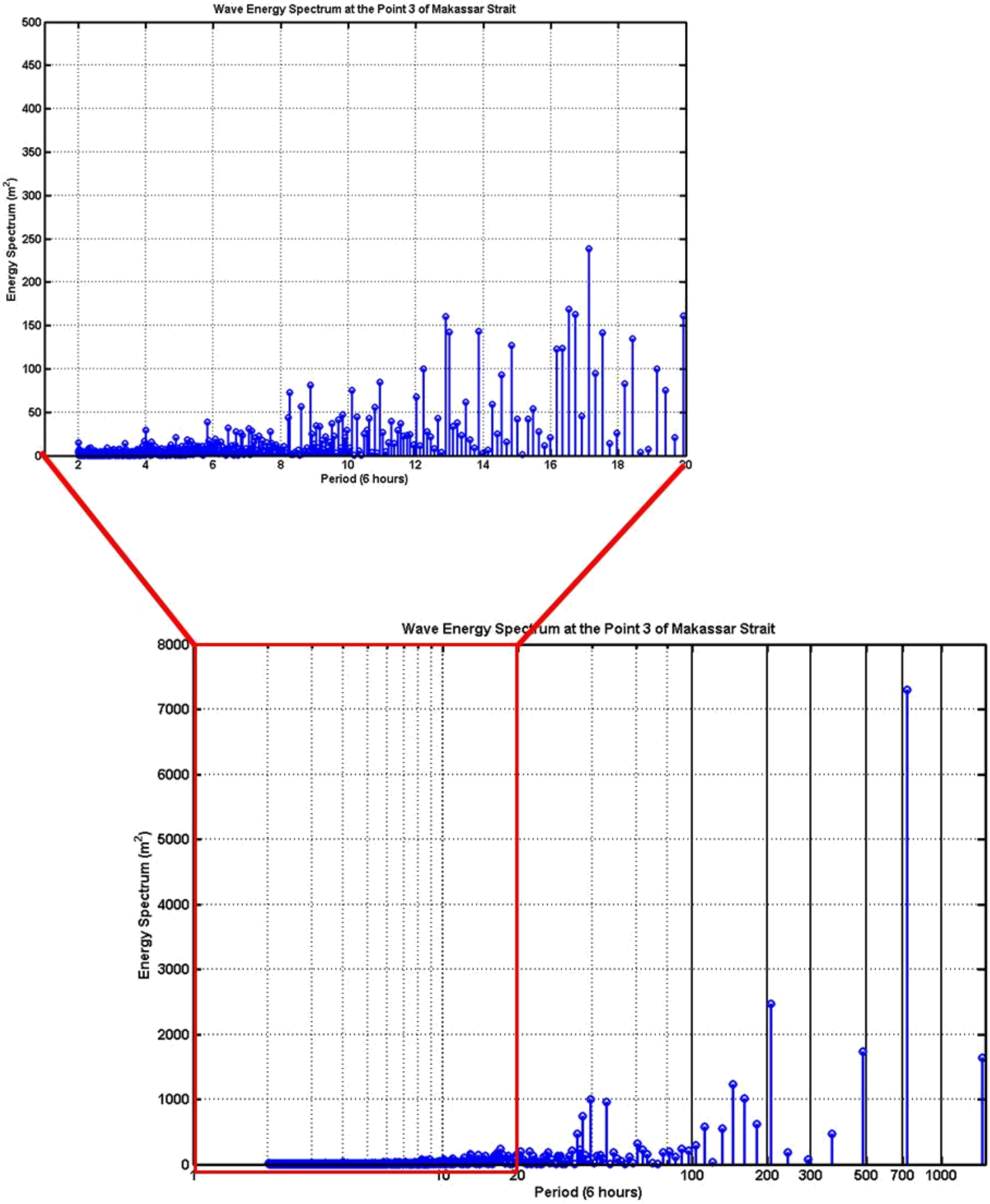

Figure 7. The Hs energy spectrum during 2017 at point 3 of Makassar Strait.

Table 3. The relation between Hs and wave significant period (Ts) in Makassar Strait at 2017.

	Hs (m)	Ts (s)
Maximum	2,088	10,59229
Minimum	0,26	0,007061
Averaged value	0,5838111	2,402205

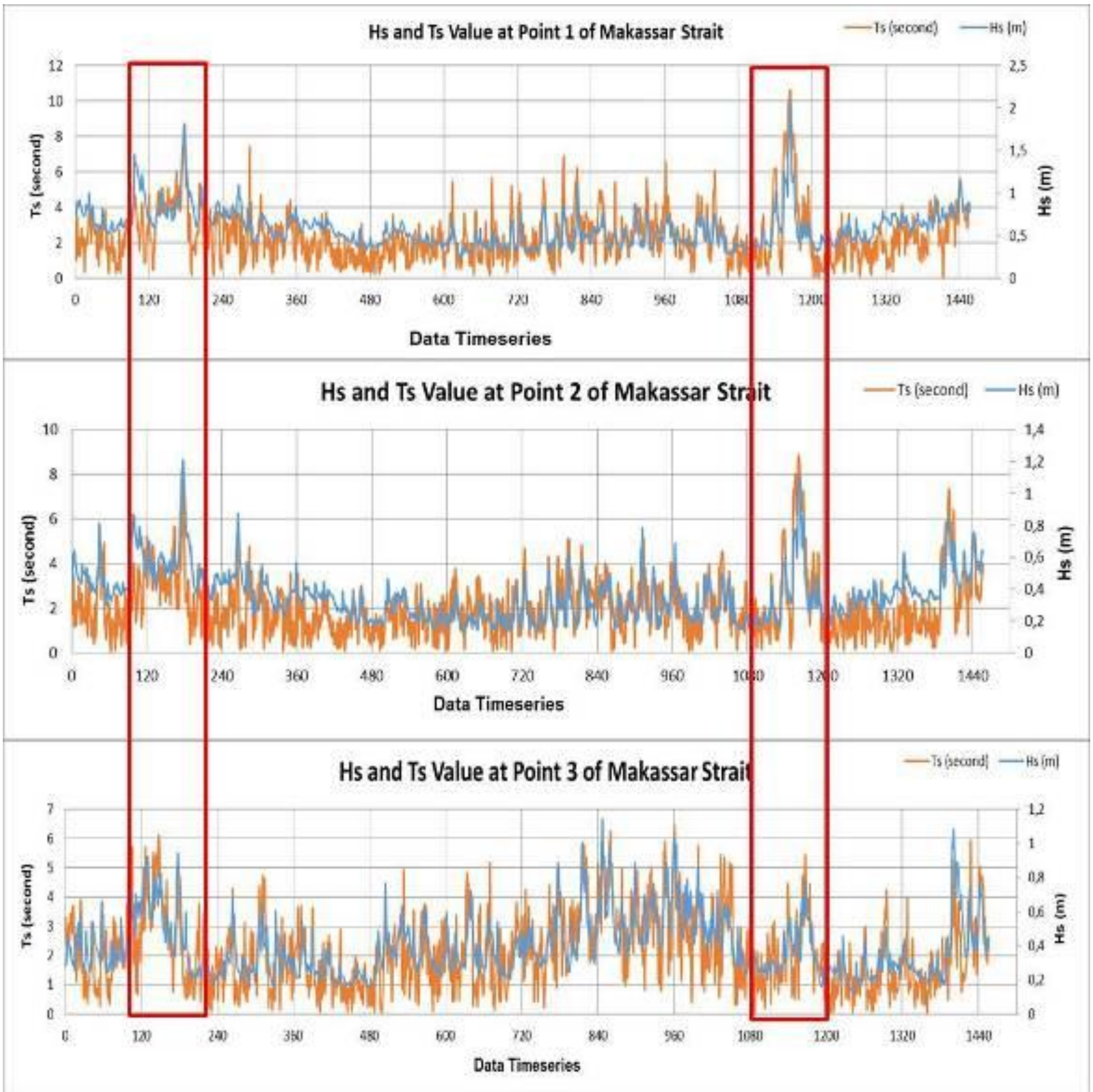

Figure 8. Hs and Ts condition in Makassar Strait at point 1,2, and 3 during 2017.

4. Conclusion

Based on the research above, it can be concluded that wind speed has a correlation with significant wave height. In 2017, the highest wind speed and significant wave height in the Makassar Strait occurred in the eastern season, with values of more than 4.5 m / s and 1.05 m. Wave height in the dominant Makassar Strait has a 6-month (semiannual) wave period, where the highest energy spectrum value occurs at point 3. While the lowest energy spectrum occurs at point 2. In addition, the condition of Hs with Ts has a high correlation. The values of Hs and Ts reach maximum conditions in January - February and September - October in 2017. This study detects the presence of 6 monthly signals in the Makassar Strait. Therefore, further research on the factors that influence the signal is needed.

5. Acknowledgement

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