Utilization of Wavewatch III Model Output Data for High Wave Analysis

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Abstract

This study discusses the occurrence of extreme waves in North Sulawesi waters from 17 to 24 June 2016 using Wavewatch III (WW3) model output data with resolution 0.125° x 0.125° extracted from MIDAS-BMKG. The extracted WW3 data is mapped using ArcMap and presented in graphical form. Based on the results of the study, the significant wave height is in the range of 0.0 to 1.0 m and the average wind speed ranges from 0 to 15 knots in the early phase of 17-19 June 2016. Significant wave increases in the peak phase of 20-22 June 2016 that reaches 1.5-2.0 m and average wind speeds reach 25 knots. The average wind speed and the significant wave height decreased after June 23, 2016. The high of the significant wave are influenced by the low-pressure circulation in the atmosphere near the Sangihe-Talaud Islands. Further study can be done as a comparison of this study e.g. using wave data from altimeter satellites or comparing with other parameters such as the influence of swell and wind sea.

Keywords: *Significant wave height, wind, Wavewatch III (WW3)*

Introduction

Indonesia is an archipelagic country that stretch from Sabang to Merauke (Karsidi, 2014). As an archipelagic country, marine transportation becomes an important vehicle for the mobility of passengers and goods inter island, including North Sulawesi waters. Sea transportation becomes a solution that can transport passengers and more goods than using air transportation (Rildo *et al*., 2016). The waters around North Sulawesi have long been used as a shipping and trade route (Kaunang *et al*., 1999).

One of the aspects which determine the smoothness of sea and air transportation is weather condition (Oktaviani, 2014). High wave information of sea, wind and other weather parameters is needed by ships that will make the voyage (Rustendi, 2015). High winds and high waves can increase the risk of shipwrecking crashes, especially on relatively small ships (Suwardjo, *et al*., 2010).

The problem studied in this study is what kind of sea wave conditions that could cause natural disasters in the Sangihe Islands in mid-June 2016 and how the mapping results use Wavewatch III output data. This study aims to test the data extraction model Wavewatch III in understanding the conditions of winds and waves during extreme weather that could cause natural disasters in this region.

Wavewatch III (WW3) is a 3rd generation marine wave model developed by Marine Modeling and Analysis Branch (MMAB) at the Environmental Modeling Center (EMC) at the National Centers for Environmental Prediction (NCEP) (Tolman, 2014). WW3 produces a significant wave height that has good conformance with buoy observation data and altimetry satellite data (Ramdhani, 2015). WW3 can be used to simulate waves in deep waters and in shallow waters (Ortiz-Royero and Mercado-Irizarry, 2008). The wave studies using WW3 should pay attention to some inputs such as wind and bathymetry in order to produce a better calculation (Eshleman *et al*., 2007; Zijlema, 2010; Sofian, 2012). Output data of WW3 will be used in this research to analyze high wave incidence in Sangihe Islands Waters.

Materials and Methods

The research area is in position 118°E–128°E and 7°N–1°S which includes the Sulawesi Sea,

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Sangihe-Talaud Waters and the Maluku Sea (Figure 1). The sample point is taken at eight points on the coordinates A1 (220°E,4°N), B1 (222°E,4°N), C1 (224°E,4°N), D1 (226°E,4°N), A2 (220°E,2°N), B2 (222°E,2°N), C2 (224°E,2°N) and D2 (226°E,2°N). Software that is used for data processing was ArcMap 10.3.

WW3 model output data sourced from the Meteorology Climatology and Geophysics Agency of Indonesia (BMKG, 2016) which is a hindcast data of wind and wave height with a resolution of 0,125° x 0,125°. The WW3 data is then extracted and stored into a readable format as data having dimensions x, y and z (longitude, latitude and wave height). Then the data is sorted to take eight sample points at the specified coordinates. The data are then displayed in the form of two graphs each representing latitude 4°N (line 1) and latitude 2°N (line 2) and explained descriptively.

Mapping is processed spatially using ArcMap 10.3. Significant wave heights are mapped in color gradations at intervals of 0, 0.5, 0.75, 1, 1.25, 1.5, 2, 2.5, 3, 3.5, 4, 5, 6, 7 in meters (m). Wind speed is mapped with intervals of 0, 2, 4, 6, 8, 10, 15, 20, 25, 30, 35, 40, 50, 60 in knots. The determination of the color gradient and the interval follows the wind and wave mapping issued by BMKG (BMKG, 2017). The mapping results are analyzed by looking at the relationship between wind speed and significant wave in the three phases of the initial phase of 17-19 June 2016, the peak phase of 20-22 June 2017 and the final phase of the date of 23 to 24 June 2016.

Results and Discussion

Based on reports from several sources, extreme weather that caused high waves in the region of Sangihe Archipelago, North Sulawesi occurred on Tuesday, June 21, 2016 (Hidayat and Hari, 2016; Srisurya, 2016; BBC Indonesia, 2016). The analysis of air pressure released by the Bureau of Meteorology (BOM) shows the presence of low pressure areas in the northeast of the Sangihe-Talaud Islands at coordinates of 129°E and 06°N at that date. (Figure 2.). Circulation systems of low pressure areas can trigger extreme weather. (As-syakur, 2007)

In general, the average wind velocity in North Sulawesi waters in the early phase (17-19 June 2016) is in the range 0-15 knots and the significant wave height is in the range 0-1.0 m (Figure 3.). At peak phase (20-22 June 2016) the average wind speed reached 25 knots in the waters of the Sangihe-Talaud Islands (Figure 4c.) and significant wave heights reached 2.0 m (Figure 4d.). Average wind speed and wave height decreased in the final phase (23 - 24 June 2016) (Figure 5.).

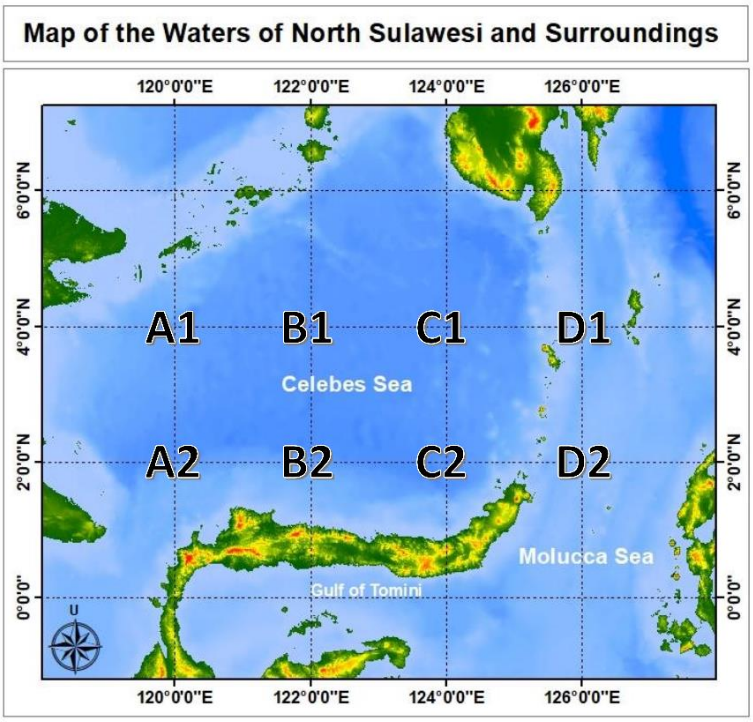

Figure 1. Map of the Water of North Sulawesi and Surroundings

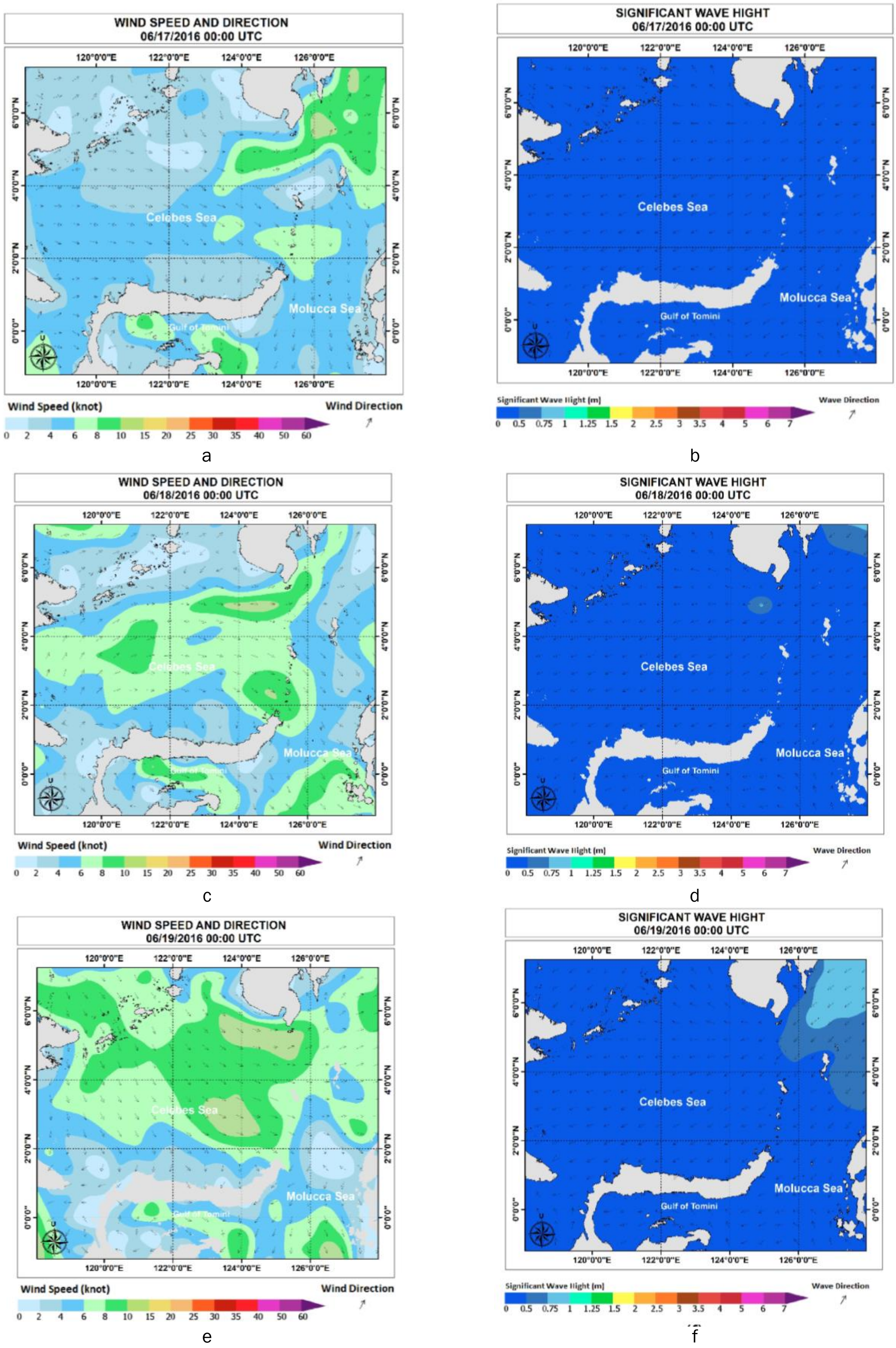

Figure 3. Analysis map of wind and significant wave in the initial phase (17-19 June 2016)

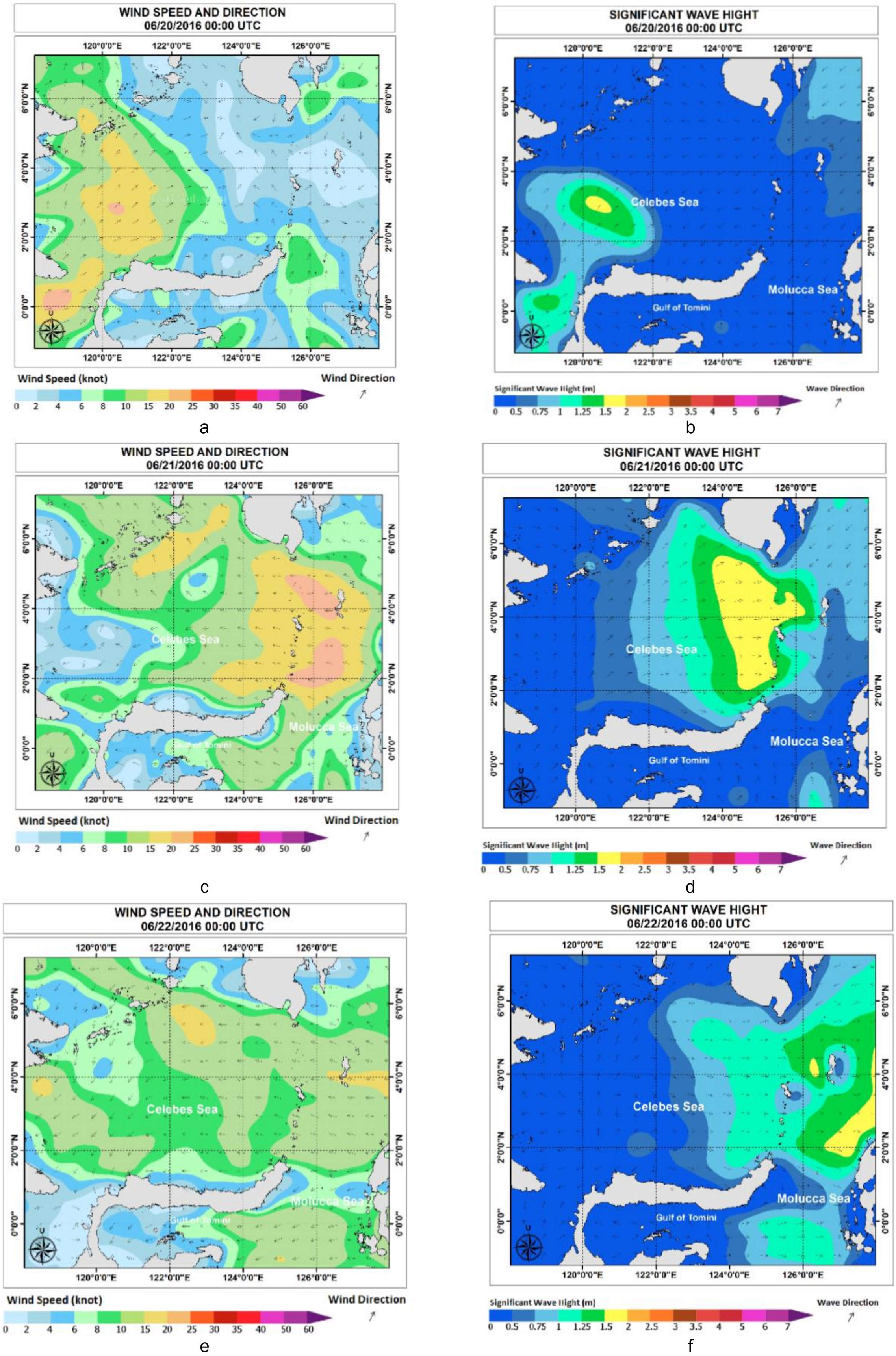

Figure 4. Analysis map of wind and significant wave in the peak phase (20 - 22 June 2016)

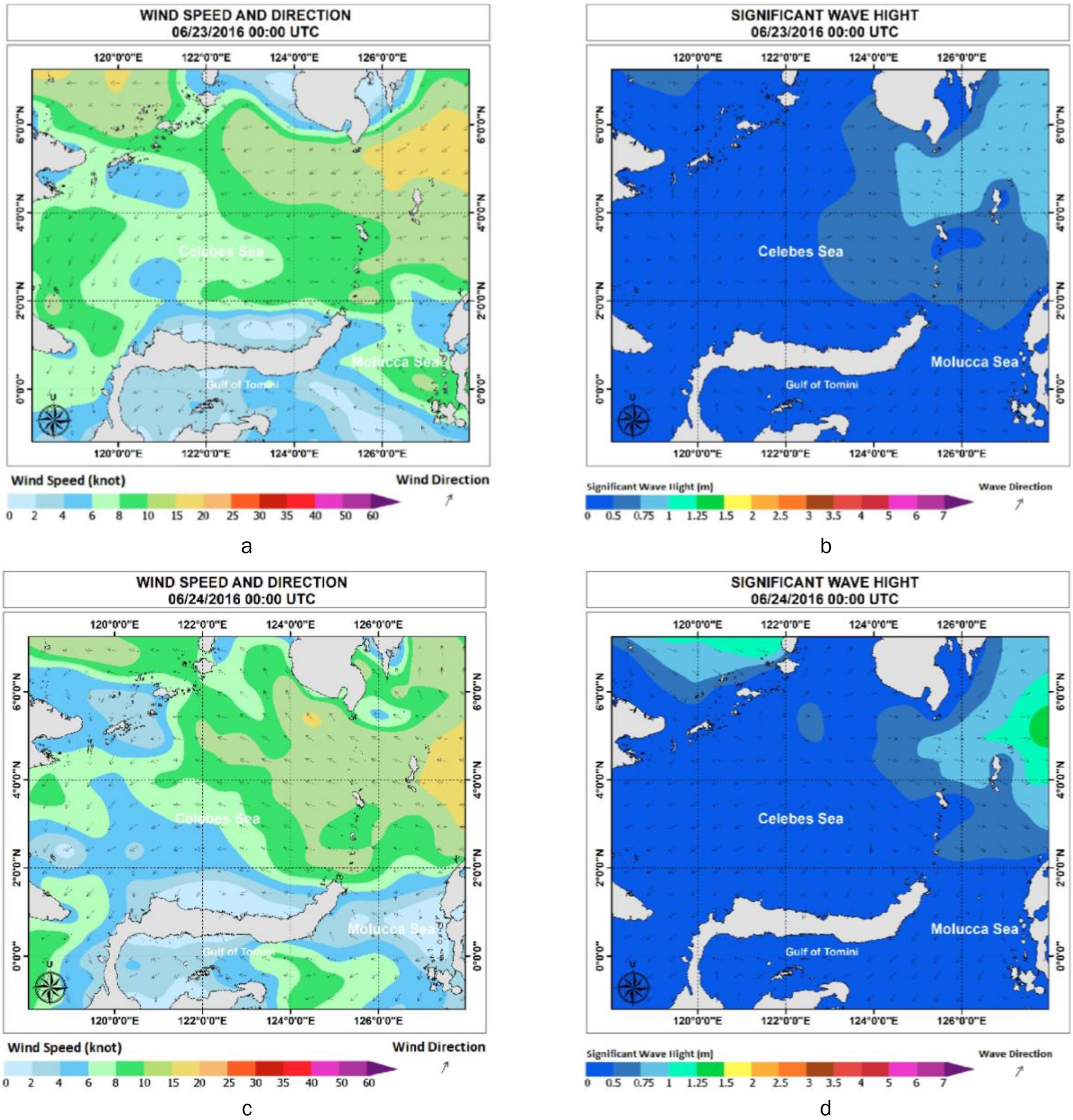

Figure 5. Analysis map of wind and significant wave in the final phase (23 - 24 June 2016)

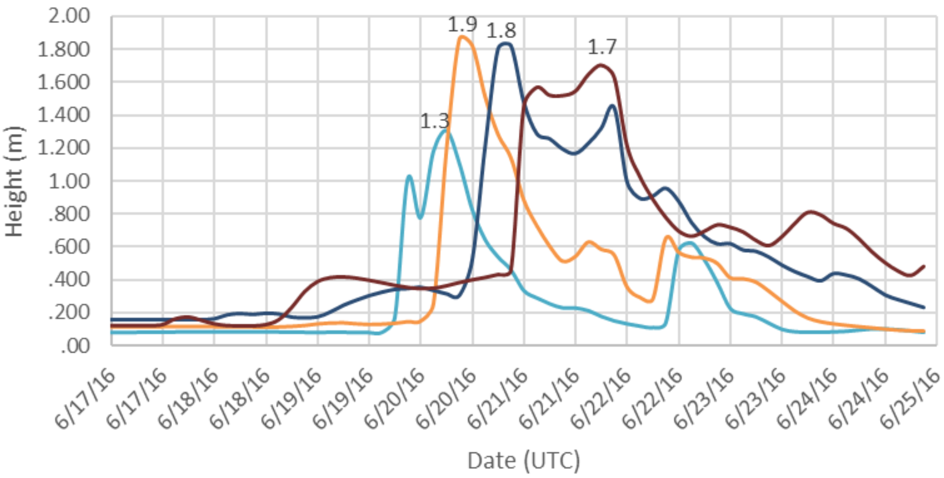

Figure 6. Graphs of Significant wave height on line 1

Note : —— A1=220E,4N; —— B1=22E,4N; —— C1=224E,4N; —— D1=226E,4N

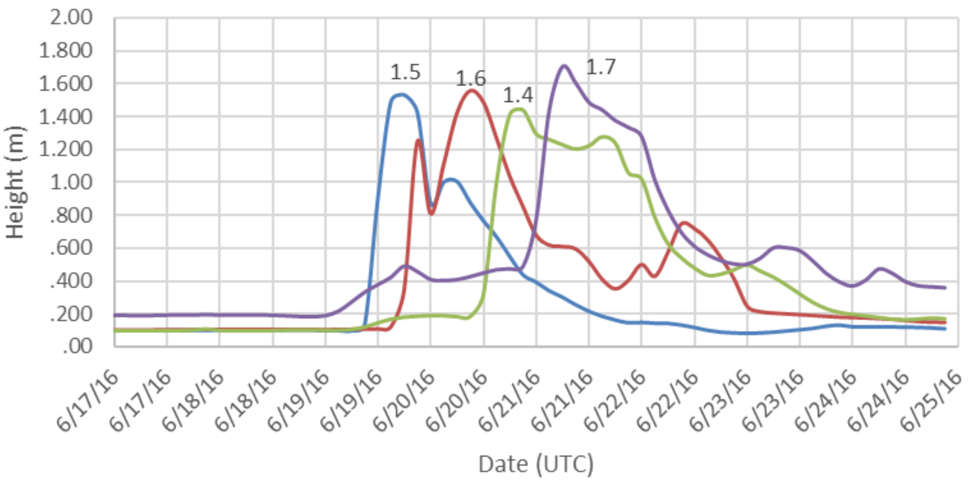

Figure 7. Graphs of Significant wave height on line 2
Note : A1=220E,4N; B1=22E,4N; C1=224E,4N; D1=226E,4N

Significant wave conditions on line 1 (A1, B1, C1, D1).

Figure 6 is a high-wave graph line 1 at four sample points at 4°N latitude. In the initial phase the significant wave height at all four points on line 1 is in the range 0.1-1.0 m. The highest of significant wave heights in sequence at point A1; B1; C1 and D1 are 1.0; 0.1; 0.3 and 0.4 m. Significant wave height at peak phase is in the range 0.1-1.9 m. At this phase the highest significant wave height is sequentially at point A1; B1; C1 and D1 are 1.3; 1.9; 1.8 and 1.7 m. Then the wave height decreases in the final phase (23 - 24 June 2016) that is in the range 0.1-0.8 m, the highest significant wave height sequence at point A1; B1; C1 and D1 are 0.2; 0.4; 0.6 and 0.8 m.

Waves at point A1 rise first compared to other points (B1, C1 and D1). This shows that the high wave area moves from west to east i.e. from point A1 to B1 to C1 then to D1. This condition can also be seen in Figure 4.

Significant wave conditions on line 2 (A2, B2, C2, D2)

The wave conditions in line 2 are not much different from the wave conditions in line 1. The graph in Figure 7 shows that the high wave area also moves from west to east ie from point A2 to B2 to C2 then to D2.

Significant wave heights at all four points are in the range of 0.1-1.5 m in the initial phase. In sequence of the highest significant wave height at point A1; B1; C1 and D1 are 1.5; 1,2; 0.2 and 0.5 m. Significant wave height increased in peak phase that is in the range 0.1-1.7 m. High The highest significant wave in this phase sequentially at point A1; B1; C1 and D1 are 0.9; 1.6; 1.4 and 1.7 m. The wave height decreases in the final phase ie in the range 0.1 - 0.8 m, and the highest significant wave heights successive at point A1; B1; C1 and D1 are 0.1; 0.2; 0.5 and 0.6 m.

Conclusion

The low-pressure circulation system near the Sangihe-Talaud Archipelago triggers the extreme weather resulting in high winds and high waves in the region. The high wave area moves from west to east ie from the western Sulawesi Sea to the Waters of the Sangihe-Talaud Islands. The increase in significant wave height is proportional to the increase in wind speed. Wavewatch III model output data can be used for high-wave analysis.

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