

## **THE OCCURRENCE OF WAVE HEIGHT INCREASING AROUND BALI ISLAND**

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*Recently there was reported by local news both online and printed about the wave height increasing phenomena around the southern part of Bali. According to portal online some tourists were hit by high wave while they were sightseeing at Pasih Uug Beach, Nusa Penida, Klungkung on 2/6/2016<sup>[1]</sup>. While they were enjoying the natural pool of Angel's Billabong, a sudden large wave hit them and two tourist were separated and dragged into the sea. There also has been reported about the increasing sea surface level along Kuta beach since 5/6/2016 which has made flooding around its surrounding. Until this article has been written (6/6/2016) there has still been reports that sea water rose towards to the streets around the coast. Therefore many people are curious about what phenomena made these cases occur in Bali?*

### **SEA WAVE: WHAT AND HOW?**

Actually sea wave is one of the natural occurrences about the moving up and down of sea water perpendicular to the sea surface level in sinusoidal graph/curve form <sup>[2]</sup>. The sea wave can be classified based on its trigger <sup>[3]</sup>. The main trigger are caused by meteorological factors e.g. wind and astronomical events such the change of the moon phase, which is more well-known as wind waves and tidal waves.

Wind waves occur because of wind blowing along the sea at surface level frequently hence the strength of wind waves depend on the wind factor e.g. wind speed, wind duration, and fetch. Fetch is the area where waves are still influenced by wind constantly in the same direction. Higher wind speed, longer wind duration and fetch, tend to be a higher wind wave. There is also one occurrence can trigger the increasing wave height in one area is called the swell, a sea wave that comes from other area. The swell can enhance the wave height when it is triggered by weather disturbance such as pressure low area (L) and storms.

Frankly, there is no real record data about wave height which is triggered by wind waves in Indonesia since there are no observations at sea unless predicted using wind data, the result of buoys and ship observations, and utilizing satellite data. Therefore BMKG meteorologist forecast wave height by using some wave models e.g. windwave, inaWaves, etc. which are usually presented as significant wave height map, the most common wave height product.

According to Tom Ainsworth's article about 'Significant Wave Height' a closer look at wave forecast <sup>[4]</sup>, the significant wave height is defined as the average height value of the highest one-third waves. It was resulted by the equation of all recorded wave heights from ship observations. Since wind waves are formed even more than thousand times with different height from different directions and speeds, thus it was decided to use the equation which has the most probable wave occurrence, it is significant wave height ( $H_s$ ) while Height Maximum ( $H_m$ ) is two times of  $H_s$ .

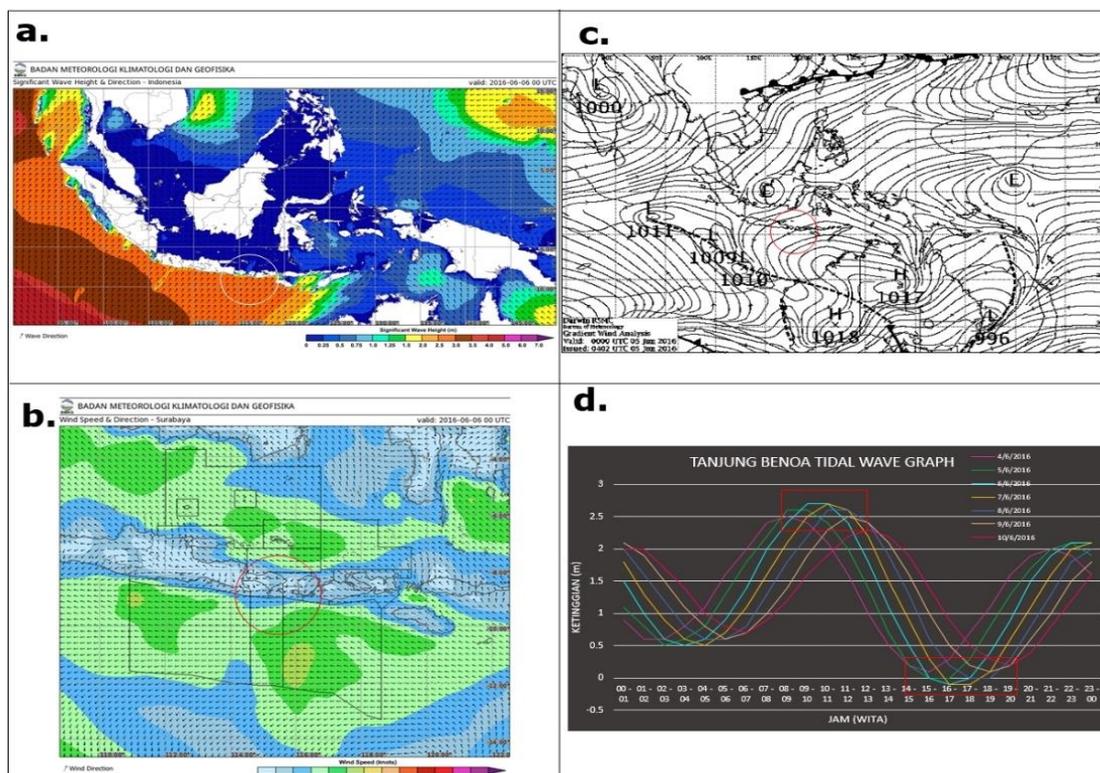
Different from wind waves, tidal waves are easier to predict since it is calculated by using astronomical data such as latitude and longitude of one point location. The height of a tidal wave depends on the attractive force between the moon and the sun that related to the Earth's, Moon's, and Sun's position. If they are parallel to each other, the wave height will be the highest on high tide and be the lowest on low tide. It usually occurs in the new or full moon phase, more well-known as a spring tide. On the other hand, when they are perpendicular to each other, the height of the wave will be lower during the high tide and higher on the low one, commonly known as a neap tide which occurs in the first and third quarter of the moon phase.

Tidal waves usually occur along the coastlines that has a diurnal phase, it can occur once, twice, or mixed in a day while sea waves are more common in high seas without any time limit. The height of the wave table around Indonesia is legalized and provided by Indonesia Hydrology Agency (DISHIDROS) which are presented into some points for each province. Bali is just represented by Tanjung Benoa's point at  $8.74^\circ$  S;  $115.21^\circ$  E.

#### *THE INCREASING WAVE HEIGHT AROUND BALI*

Generally in the past, starting from early June 2016, the wave height of southern Bali increased up to 4 meters. It happened because of Australia monsoon has begun in some parts of Indonesia including Bali. The air pressure gradient between low Asia and high Australia caused winds blowing from Australia to Asia through Indonesia thus its direction is almost uniform from east to southeast. It is famous as a dry season that commonly happened in June – July – August (JJA).

The persistence of wind direction can possibly form constructive waves that make them higher than the transitional season which has a chaotic vector direction. It is strengthened by Rony Kurniawan's paper that said during the JJA period high wave events in the south sea of Indonesia such as the Indian Ocean, Timor Sea, Arafuru Sea, and Banda Sea is quite common <sup>[5]</sup>. Geographically the location where the two tourists were hit by the wave was adjacent to the Indian Ocean which was possibly influenced by the high waves in the Indian Ocean.



Picture 1. Height Wave (a.), Wind Speed and Direction (b.), Streamline (c.) Analysis on 6/6/2016 at 08.00 LT; Height Tidal Wave Graph between 4 and 10/6/2016 (Source: <http://peta-maritim.bmkg.go.id/2.0> ; <http://www.bom.gov.au/australia/charts/>; and DISHIDROS)

It is rather differ if it is compared with the flooding event in Kuta on 6/6/2016 because the Kuta's coastlines are located little bit far from the Indian Ocean and it surrounded by mainland. It may also be influenced by high sea waves because of the wind persistence, yet most of them would be decreased after reaching the seashore. There must be another factor which enhanced the increasing wave height in Kuta because high wave happened several days ago, even in early June, but the flooding was reported only on 5 – 6 June 2016 in the morning. Hence, some pictures have been displayed in relation to analyze what factors possibly influenced Kuta's flooding.

As shown in Picture 1b it can be seen that there was a part on the Indian Ocean which had wind speeds up to 20 knots and blew uniformly from the southeast. Thus, it was possible to form strong sea waves towards Bali. It was proven by a height wave analysis in picture 1a where the southern part of Bali was surrounded by

a 3-meter high wave. That event was got worse by the presence of three low pressure areas around the Indian Ocean which could trigger some storms e.g. strong winds, heavy rain, and high waves (Picture 1c.). It couldn't affect Bali directly but it could be the source of high waves which resulted by the movement of swells toward Bali, thus the sea waves would be higher than a day without weather disturbance.

We also have to notice that high waves around coastlines is not only influenced by sea waves but also tidal waves. As presented by the height fluctuation of the tidal wave graph on Picture 1d. From that picture it can be seen that the height of the tidal wave reached its maximum on 6/6/2016 at 9 – 11 Local Time (LT) and on 7/6/2016 at 10 – 11 LT up to 2.7 meters. On the same day, the lowest value of -0.1 to 0 meter occurred at 16 – 18 LT. It means that the highest tide was at high tide and the lowest one at low tide. Therefore it could be concluded that spring tide was the other factor of the increasing height of the waves around Kuta's coastline even when the time matched between the real occurrence and the temporal tidal wave graph in the morning. The spring tide was occurred since the day of Kuta's flooding coincided with the beginning of Ramadhan month or it was close enough to the new moon phase.

In the general final analysis, it can be said that the increasing wave height around Bali is caused by the wind persistence in relation to the dry season. The wave can be higher when there are other factors, for example in Kuta's localized flooding case, it was caused by the spring tide and swelling because of weather disturbance. Thus people should be aware of the possibility of high waves since the wind persistence may happen until August. The information of high waves is frequently provided by BMKG through warnings and weather forecasting disseminations, since wave height reached 2 meters or more is one kind of extreme weather characteristic.

#### REFERENCE:

- [1]. Detik.com. *Berwisata ke Angel's Bilabong, Dua Wisatawan Bali Terseret Ombak Pantai* (3/6/2016) di akses tanggal 6 Juni 2016
- [2]. Holthuijsen L.H. (2007). *Waves in Oceanic and Coastal Waters*. New York: Cambridge University Press.
- [3]. Nichols, C.R., & Williams R.G. (2009). *Encyclopedia of Marine Science*. New York: Fact on File Inc.
- [4]. Ainsworth, T. '*Significant Wave Height*' a closer look at wave forecast. Online Article: NOAA yang di akses pada 5 Juni 2016