Investigation the effect of total solar eclipse March 9, 2016 on tidal elevation study cases: Bangka and Belitung islands

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Abstract. Tidal elevation is generating primary by the gravitational forces between earth with moon and solar. Since the sun plays an important role on generating the tidal sea level then the effect of total solar eclipse (TSE) March 9, 2016 on surface water level has been analysed from real time one-minute tide gauge station from Geospatial Information Agency. Two stations was selected to observe the impact of TSE i.e. in coastal of Bangka Island where totally path of TSE was detected and the other is in the coastal Belitung Island, located near to Bangka Island. We compare the observed sea level with the predicted sea level from 9 constituents using Tidal Model Driver (TMD). The result shows that during the TSE in Bangka Island, the observed tidal phase is shifted and observed sea level is higher compare with the prediction one. But in Belitung Island, there is no pattern change of tidal phase and with small increasing sea level compare with the prediction.

1. Introduction

A total solar eclipse (TSE) took place on March 9, 2016 was visible along across 11 provinces of Indonesia. The TSE started in Western Indonesia and moved to Eastern Indonesia and ended in northern Pacific Ocean. TSE occurs when moon is directly in front of the earth and the moon’s shadow falling on the earth completely hides the solar surface and thereby cuts off direct rays of sunlight from observer.

On the other hand we know tides or ocean tides is a phenomenon that affected by the gravitational attractive force of moon and sun. Tides is an alternating high and low sea level. Tides on the Earth are primary generating by the gravitational pull of both the moon and the sun with tides from the Moon being larger because the moon is so much closer. Tides occur in different positions and alignments of Sun, Earth and Moon. When the Earth, Moon and Sun are aligned then the resultant gravitational force exerted on Earth's water is strongest at these moments and we called the spring tides. Spring tides can only occur during full and new moon. Therefore, the TSE occurs during the new moon and the relation of on tidal elevation should be an interesting matter to study. So far there is no previous studies about the relation between eclipse and tide elevation that located in Indonesia area.

The aim of this research is to investigate the effect of TSE March 9, 2016 on the surface water level or tidal elevation from tidal movement point of view. In simple way, we will show the difference between the real time one minute tide data with the prediction one. We assumed the prediction one is a normal condition. We choose two tidal stations in the western part of Indonesia that passed by the TSE path.
2. Data and method

Two tide stations in western part of Indonesia were selected as the research area i.e. Muntok in Bangka Island and Tanjung Pandan in Belitung Island as seen in figure 1. Since we know that the path of TSE started at western part of Indonesia from Palembang and moved to eastern part of Indonesia. We choose the tidal station that passed by the TSE path. That is why both tide gauge stations is an ideal location. The tidal elevation data provided by the Geospatial Agency of Indonesia. The real time one-minute observed data was obtained from the tide gauge located in this two stations. We picked out the data from 1 to 16 March 2016, so we can cover the spring and neap tidal phases.

To see the effect of tide on TSE and normal events, we compare the observation results and prediction. We used the user friendly tidal model namely Tidal Model Driver (TMD) developed by [2] to predict the tidal elevation. There are 9 major tidal constituent considered in the TMD. The model was running with the same time with the observational one. We simulated also the tidal elevation in the same time in 2015.

![Figure 1. The location of two tide observation stations (Muntok and Tanjung Pandan). The station indicated by the blue circle. (Courtesy to Google Earth, 2016)](image)

3. Results

The observation tidal elevation in Bangka and Belitung Islands on March 1-16, 2016 can be seen in figures 2 and 3. The tide type in both stations is fully diurnal tide, where in one day there is one time highest water level and one time lowest water level. This result confirmed with research from [3]. The spring tide is happened around the first week indicated by higher water level. After that around the second week, the neap tide which occurs indicated by the lower water level occurs. In both stations, it is clearly demonstrated that the TSE happened during spring in new moon phase. The observation tidal range in Bangka during spring tide and neap tide is about 2.4m and 0.5m respectively, while in Belitung is about 1.7m and 0.5m. If we compare the observational data with the prediction then we can find in general the same pattern between both results. In Belitung station, the observational and prediction tide range and phases slightly similar. But in Bangka the observational magnitude tide is bigger than the predictions, especially during spring tide, and also there is about one hour phase different, where the prediction one is earlier. After the TSE we can see the pattern is not similar for both station. The pattern and tidal elevation between the observation 2016 and prediction seem differs especially in the magnitude of tide. In both locations the predicted tidal range is smaller.
Further we will focus the analyses during the TSE phase in figures 4a and 4b. From the report it is known that the duration of maximum eclipse is just a short time i.e. 1-2 minutes (www.terangi.com). But the total process from sun rise is about 1-2 hour. So, we will investigate from 06.30 to 08.30. From figure 4a, in Bangka coastal, during this period the high water is going to low water, but after that increase about 1 hour and go down again. We can assume that during TSE the low water becomes lower (the absolute magnitude is higher), it means the tide become stronger. That is why the curve is not smooth in this short interval time. The curve prediction in 2015 and 2016 is smooth but the magnitude is very small for 2015. There is also shifted phase between observation and prediction.

In Belitung station, the sea level is moving from high water to low water for both observation and prediction (figure 4b). Tide range and phase pattern slightly similar but the curve line of observation data is more negative (the magnitude is higher) compare to the prediction. It is maybe because of stronger force. But we need more detail and advanced investigation on math and physical analysis to conclude it.
4. Conclusions
The conclusions are concluded from a simple research method. We can conclude that during the TSE 9 March 2016, the water level is moving from high tide to low tide and tidal phase is in new moon phase in spring tide in both stations. The tidal level is higher and there is shifted tidal phase between observation and prediction in Bangka Island. The magnitude of tidal level is higher during TSE time compare with the prediction in Belitung Island.

This research gives just preliminary results. We know that there is still lot of remain questions that need to answer and debatable results to proofs in more detail point of views. Therefore, it should be some interesting multi-disciplinary research to be conducted.

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