



**Preliminary
investigation on the
coastal rogue waves of
China**

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Preliminary investigation on the coastal rogue waves of Jiangsu, China

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Abstract

As an eye-catching issue, rogue waves have been undergoing different stages from theory to practice gradually, whose occurrence always brings about severe threat to not only ships and sailors but also coastal structural integrity. Due to the scarce wave observations in coastal zone and meager study in Mainland China, the discussion specifically aimed at observed coastal rogue waves in China was at elementary stage. Based on the measured data from Xiangshui station of Jiangsu, China, the characteristics including occurrence probability and nonlinearity are investigated, which is a supplement to the previous research works. Surprisingly, the outcomes tend to refute rather than confirming some of the traditional conceptions about rogue waves. A new concept for the classification of coastal rogue waves is proposed afterwards.

1 Introduction

The concept of rogue waves or freak waves was put forward by Draper (1965) for the first time to delegate an abrupt surface gravity wave with tremendous wave height and often poses severe hazardous effect because of its giant energy. The typical and always be used definition of rogue wave is a wave with wave height exceeds twice the significant wave height. As a quite special kind of disastrous waves, rogue waves have drawn more attentions all over the world in recent years. With the continuous emerging of the achievements associated with the dynamic and kinematic characteristics of rogue wave phenomenon, various academic discussion and debate was also derived from the advancements on the new and controversial issue.

Nowadays, the study methods on rogue waves mainly concentrate upon theoretical analysis (Onorato et al., 2006a, b; Osborne, 2010), numerical simulation, physical experiment (Toffoli et al., 2010, 2011) and field observation. Some key advances were reviewed by Dysthe et al. (2008) and Kharif et al. (2009). Among all the approaches, field measurement is necessary and efficient for seeking the nature of rogue waves,

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since there are still no unifying concepts towards rogue waves. However, since the occurrence of rogue waves is full of random and chance, it is very difficult to develop actual measurement work specifically for the rogue waves. Most of the related studies based on observed data are only by-products of the regular wave analysis.

It is found that the research works aiming to probe the characteristics of rogue waves depending on observed data or historical wave data are mainly in five water areas in the entire world: the Atlantic Ocean, the Indian Ocean, the North Sea, the Sea of Japan and the sea around Taiwan Island, China. Pinho et al. (2004) mentioned that the occurrence probability of rogue waves in the Campos Basin in the South Atlantic Ocean is higher than the probability given by Rayleigh distribution. Liu et al. (2008) mentioned that the occurrence likelihood of rogue waves in the Indian Ocean is also higher than Rayleigh distribution. Stansell (2004) held the opinion that Rayleigh distribution considerably under-predicts the occurrence probability of the extreme crest heights, but only slightly over-predicts the occurrence probability of extreme trough heights in North Alwyn situated in the North Sea. Yasuda and Mori (1997) believed that the occurrence probability of giant rogue waves on the Pacific Ocean side is almost the same as Rayleigh distribution, while the probability on the Japan Sea side is fairly less than it. Mori et al. (2002) pointed out that the wave height distribution is in line with the Rayleigh distribution in the sea area 3000 m away from the Yura Fishing Port in Japan. Tseng et al. (2011) found that the probabilities of dangerous rogue waves in the sea around Taiwan are lower than the Rayleigh distribution.

It could be discerned from the above that the majority of the studies on the rogue waves based on in situ measurements merely concentrate on the open seas rather than near shore areas, although the rogue waves in shallow water have also attracted the attentions (Sergeeva et al., 2011; Didenkulova et al., 2010, 2011). Chien et al. (2002) once reported about 140 freak wave events in the coastal zone of Taiwan Island in the past 50 yr (1949–1999), which claims the existence of freak waves off the deep water areas. Kharif and Pelinovsky (2003) mentioned that the data of marine observations as well as laboratory experiments both demonstrate that freak waves may appear in

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deep and shallow waters. Didenkulova (2006) used to select nine cases of true freak wave events from a total number of 27 events reported by mass media or described by eyewitnesses. Of the nine examples, three events correspond to open-sea cases, while the six others occurred near shore. Soomere (2010) believed that most of the processes resulting in the formation of unexpectedly high surface waves in deep water (such as dispersive and geometrical focusing, interactions with currents and internal waves, reflection from caustic areas, etc.) are also active in shallow areas. Thus, besides rogue waves in the open seas, which are always the subject of investigations, the problem of coastal freak wave events need to be emphasized as well.

In addition to the five sea areas mentioned earlier in the article, the sea around Mainland China is also one of the prone sea areas. From the reports in the recent years, shipwreck accidents caused by burst rogue waves were not rare. Tao (2007) found 6 cases that caused serious damage during 2005 to 2006 in the mainland of China through searching the official news. The latest serious event raised by rogue waves was in 28 November 2012. *Liaodajinyu81073* was capsized in the Heidao sea area near the Xingshutun fishing port in Dalian, China. It was reported that there existed 8-level fresh gale and giant waves in the incident area. Except for the case in Dalian, the 2 November Wenchang shipwreck accident also attracted great attention in 2010. The *Qionghaikou03052* sank in the sea area near the Qizhou fishing ground in the city of Wenchang in Hainan, China when encountering with the burst giant waves. It could be concluded that the rogue waves might not be rare in Chinese Coastal water.

Therefore, the basic characteristics of observed rogue waves in coastal sea areas around China need to be properly answered. In order to improve the understanding on the occurrence of rogue waves in the Chinese nearshore water and to solve the above-mentioned problems, wave records in Xiangshui station in Jiangsu, China in 2011 are applied and analyzed in this paper.

2 Wave data

The wave data used here are from a self-developed wave buoy SBF3-1 wave buoy (Fig. 1), which is deployed by the Coastal Monitor Center of Hohai University from 2010 in Jiangsu coastal sea area, China (Fig. 2). The buoy SBF3-1 is currently the popular instrument for wave measurement in mainland China, at coastal ocean or in the deep sea. A strapped-down acceleration meter is installed in a buoy for motion measurement and assumed as the water particle track. Surface movement is inverted from displacement spectrum that transferred from acceleration spectrum. The uncertainty of the measurement comes from the response of the buoy with sea surface. The SBF3-1 buoy telemetry system was designed by Shandong Institute of Instrumentation (SDIOI) in China. According to the two tests comparison with MARK II Wave-Rider buoy (Netherlands) and the WAVESCAN buoy (Norway) in 2005 and 2007, the results showed that the measured data of SBF3-1 wave buoy was reliable. The SBF3-1 buoy consists of the buoy system on the sea and the receive-process system on the land. The wave height measuring range was from 0.2 m to 25 m, and the limits of measurement of wave period was from 2 s to 30 s. The resolution is 0.1 m and measurement accuracy is $\pm(0.1 + 5\%H)$.

Buoy size, mooring line and the sea state are the factors of wave following capability. Small buoy like used in this study has better wave following motion in moderate or calm seas. Mooring line drag in strong currents is significant. Drag increases with square of current speed and exposed area of the mooring line. For small buoy, we used rubber cord for mooring in order to have better wave following capability. In addition, we deploy the buoy with 40 m mooring line length that is 4 times of the water depth of buoy location. Actually the tidal current at the buoy location is between 0.1 to 0.6 m s⁻¹, showing the current drawing effect is relative small. The sampling rate is increased to 4 Hz comparing to typical designed 2 Hz. This is to increase the capability of recording an entire wave profile for rogue wave study. Corresponding approaches have been carried out to reduce the uncertainty of buoy measurement on individual wave shape. Baschek and

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Imai (2011), Cavaleri et al. (2012), Pinho et al. (2004), Divinsky et al. (2004), Doong et al. (2010), Lee et al. (2011), Liu et al. (2009), Liu and Pinho (2004) all used buoy data for rogue wave studies.

The latitude and longitude of the buoy position was $34^{\circ}26.2' N$ and $120^{\circ}06.0' E$ respectively. The waves were recorded intermittently for 17.067 min (1024 s) per hour sampled at 4 Hz. The SBF3-1 buoy telemetry system consists of the buoy system on the sea and the receive-process system on the land. The average sea level is about 9 m and the tidal range here is about 3 m.

Since the original wave data contained long period components and waves lower than 0.2 m because of the zero drifting of the sensor, they should be pre-processed to guarantee the rationality of the results. In this paper, the Finite Impulse Response (FIR) high-pass filter design was chosen to remove the futile signals (cut-off period = 15 s) from the original data sequence. The processed wave surface elevation was shown in Fig. 3.

When dealing with the processed data, the zero-up crossing method was applied to define the wave height and wave period. After dividing the processed wave data into individual waves, the widely accepted criterion $H/H_s \geq 2$ was employed in this study to determine the rogue waves, in which H denotes the maximum trough to crest wave height, and H_s represents the significant wave height.

3 Occurrence probability

In the Xiangshui station, 40 rogue waves were found among 218 657 waves in January 2011. The occurrence probability of rogue waves in January was approximately 0.0180 %. In the whole year, the occurrence probability of rogue waves mainly fluctuated between 0.0150 % and 0.0261 %. The results are listed in Table 1. The last column of Table 1 is the average significant wave height of all the wave series with the presence of rogue waves.

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coincides with the results of the symmetry of rogue wave portraits as discussed above. And the waves in this sea area are not strong since the broad silt bottom slope. Even the wave heights of rogue waves are also not huge as shown in Fig. 7. Most of the wave heights are less than 3.5 m, except only one case of 4.5 m which is captured in typhoon stage. However, the paradox of nonlinearity characterization in the coastal waters still needs reasonable explanation in the future.

5 A suggestive classification of rogue waves

The numerical simulation works done by other researchers have shown that the ratio of maximum wave height and significant wave height has a relationship with the degree of wave mutation. The ratio shall change with the increase of the value of kurtosis. By analyzing the measured data in Jiangsu coastal sea area, it was found that ratio of H/H_s was relevant to the value of kurtosis, as shown in Fig. 8.

In Fig. 8, it was revealed that there exists proportional relationship between the ratio of maximum wave height and significant wave height and the kurtosis. When the ratio is between 1.5 and 2.5, the slope of the tendency is about 0.6, while when the ratio is larger than 2.5, the trend reflects a steeper shape. Liu (2004) once brought up a new classification for rogue waves in the South Indian Ocean based on the analysis on the observations offshore from Mossel Bay, South Africa. He decided to call the cases that satisfy the condition of $2 < H/H_s < 4$ “typical rogue waves”, while for the cases when the value is 4 or even higher, he named them “uncommon rogue waves”.

The correlation of largest wave height and the significant wave height in Xiangshui station was illustrated in Fig. 9.

It could be perceived from Fig. 8 that the ratio of largest wave heights and related significant wave heights of most waves are distributed between 1.5 and 2. When the ratio goes up to 2, the waves are considered as rogue waves. In combination with the above analysis on the relationship between H/H_s and kurtosis, the rogue waves in Xiangshui station could also be divided into different groups. For the cases of $2 < H/H_s < 2.5$,

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which embody most of the available data, the waves here are called “common rogue waves” as well, while for the cases of $2.5 < H/H_s < 3.5$, the waves are regarded as “special rogue waves” in this area since they may be caused by different reasons. While the samples of the second kind of rogue waves are so limited, more data need to be analyzed to confirm this concept.

The “special rogue waves” were taken for individual analysis herein trying to look into the generation mechanism of this kind of rogue waves. For example, the rogue wave in September was presented in Fig. 10. The kurtosis of the 17 min wave sequence was 5.6575, the highest of the whole year, and the ratio of wave height and significant wave height of the 17 min was 3.41 ($H = 1.1133$ m, $H_s = 0.3266$ m), highest all over the year synchronously. The Meteorological Center of Yancheng released coastal gale warning at 2 September 2011. And news report at that time stated that there might be coastal sea waves higher than 1.5 m and 5–6 levels of breezes off the coast. Thus, it could be reckoned that the occurrence of the rogue waves might be related to the coastal gale. More measured data are required in the future works to explore whether the sea area could generate rogue waves matching the condition of $H/H_s > 3.5$.

6 Concluding remarks

In this study, based on the measured data, some research works have been done to advance the knowledge of rogue waves in the sea area of mainland Jiangsu, China, which laid emphasis on the coastal observed rogue waves rather than open-sea cases. The occurrence probability of rogue waves in Jiangsu coastal waters is calculated. It is showed that rogue waves are rare events in this region. The occurrence probability of rogue waves here is lower than the probability given by the Rayleigh distribution.

The horizontal symmetry, vertical symmetry, wave steepness, skewness, kurtosis and the BFI indicator are discussed. Through the analysis on the wave pattern characteristics of rogue waves, the opinion that rogue waves have asymmetry and solitary-like shape is challenged, which might indicate weak nonlinearity of waves. While the

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calculated results of steepness, skewness and kurtosis manifest the non-Gaussian characteristics. Taking into account the BFI indicator, which could stand for the impact of wave modulation instability, the nonlinear properties of rogue waves are investigated with the evolution of BFI indicator. The results reveal that rogue waves in this area are the consequence of linear superposition rather than modulation instability.

Finally, according to the calculation results of the skewness and kurtosis, a suggestive sorting scheme of rogue waves in Jiangsu Coasts was presented. It is suggested that there should be two different types of rogue waves here in combination with the research on the relationship between occurrence of rogue waves and the kurtosis from a statistical point of view. The first kind of rogue waves, which meet the condition $2 < H/H_s < 2.5$, should be the consequence of linear composition, while the second category of coastal rogue waves, whose ratio of wave height and significant wave height is between 2.5 and 3.5, or even higher, could be evoked by other contributors, such as the meteorological factor, modulation instability and so on, since the wave pattern of the second type of rogue waves demonstrated asymmetry waveform different from the first one.

Acknowledgements. This research work is funded by the Youth Project of National Natural Science Fund (41106001), the National Key Technology Research and Development Program (2012BAB03B01), the 111 Project (B12032), the Qing Lan Project of Jiangsu Province, the 333 Project of Jiangsu Province (BRA2012130), the Scientific Research Fund for the Returned Overseas Chinese Scholars of the State Education Ministry([2012]1707), as well as the Open Research Project of the Korea Ocean Research and Development Institute (2011555712).

References

- Baschek, B. and Imai, J.: Rogue wave observations off the US West Coast, *Oceanography*, 24, 158–165, 2011.
- Cavaleri, L., Bertotti, L., Torrisi, L., Bitner-Gregersen, E., Serio, M., and Onorato, M.: Rogue waves in crossing seas: the Louis Majesty accident, *J. Geophys. Res.-Oceans*, 117, C00J10, doi:10.1029/2012JC007923, 2012.

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- Mori, N., Liu, P. C., and Yasuda, T.: Analysis of freak wave measurements in the sea of Japan, *Ocean Eng.*, 29, 1399–1414, 2002.
- Olagnon, M. and Magnusson, A. K.: Sensitivity study of sea state parameters in correlation to extreme wave occurrences, in: Proceedings of the 14th International Offshore and Polar Engineering Conference (ISOPE), Toulon, France, 2004.
- 5 Onorato, M., Osborne, A. R., Serio, M., Cavaleri, L., Brandini, C., and Stansberg, C. T.: Extreme waves, modulational instability and second order theory: wave flume experiments on irregular waves, *Eur. J. Mech. B-Fluids*, 25, 586–601, 2006a.
- Onorato, M., Osborne, A. R., and Serio, M.: Modulation instability in crossing sea states: a possible mechanism for the formation of freak waves, *Phys. Rev. Lett.*, 96, 014503, doi:10.1103/PhysRevLett.96.014503, 2006b.
- 10 Osborne, A.: Nonlinear Ocean Waves and the Inverse Scattering Transform, access online via Elsevier, available at: <http://www.sciencedirect.com/science/article/pii/B9780126137606500000>, 2010.
- 15 Pinho, U. F., Liu, P. C., and Ribeiro, C. E. P.: Freak waves at Campos Basin, Brazil, *Geofizika*, 21, 53–67, 2004.
- Sergeeva, A., Pelinovsky, E., and Talipova, T.: Nonlinear random wave field in shallow water: variable Korteweg-de Vries framework, *Nat. Hazards Earth Syst. Sci.*, 11, 323–330, doi:10.5194/nhess-11-323-2011, 2011.
- 20 Soomere, T.: Rogue waves in shallow water, *Eur. Phys. J.-Spec. Top.*, 185, 81–96, 2010.
- Stansell, P.: Distributions of extreme wave, crest and trough heights measured in the North Sea, *Ocean Eng.*, 32, 1015–1036, 2005.
- Tao, A., Yan, Y., and Wang, J.: Researching on disastrous rogue waves in China, in: Proceedings of 4th International Conference on Asian Pacific Coasts (APAC 2007), Nanjing, China, 255–258, 2007.
- 25 Toffoli, A., Gramstad, O., Trulsen, K., Monbaliu, J., Bitner-Gregersen, E., and Onorato, M.: Evolution of weakly nonlinear random directional waves: laboratory experiments and numerical simulations, *J. Fluid Mech.*, 664, 313–336, 2010.
- Toffoli, A., Bitner-Gregersen, E. M., Osborne, A. R., Serio, M., Monbaliu, J., and Onorato, M.: Extreme waves in random crossing seas: laboratory experiments and numerical simulations, *Geophys. Res. Lett.*, 38, L06605, doi:10.1029/2011GL046827, 2011.
- 30 Tseng, L. H., Chang, F. S., Doong, D. J., and Tao, A. F.: Probability of ocean freak wave occurrence, in: Proceedings of the 5th East Asian Workshop on Marine Environments, 2011.

Yasuda, T. and Mori, N.: Occurrence properties of giant freak waves in sea area around Japan, J. Waterw. Port C.-ASCE, 123, 209–213, 1997.

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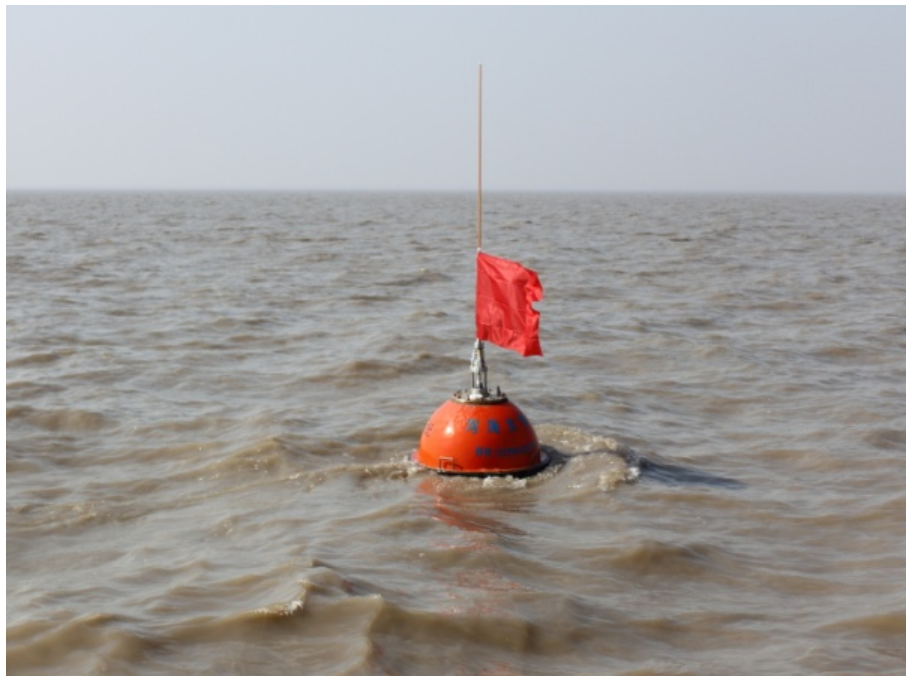


Fig. 1. Snapshot of the SBF3-1 buoy set in the Xiangshui station.

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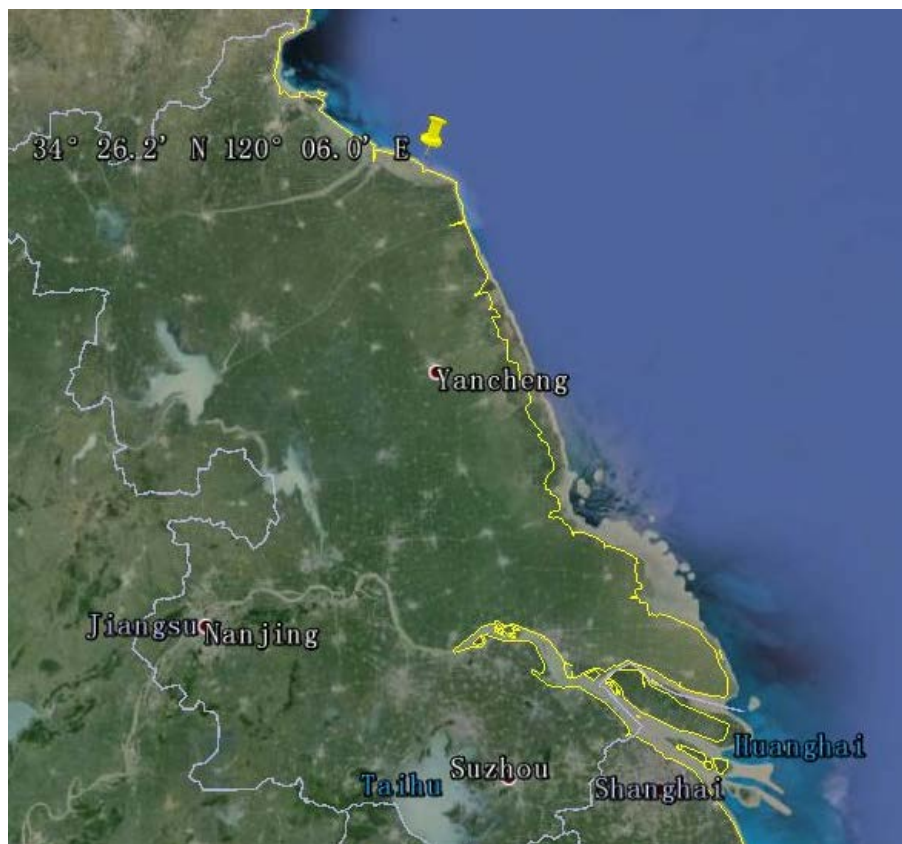


Fig. 2. Geographic scheme of buoy position in Xiangshui station (snapshot from Google earth).

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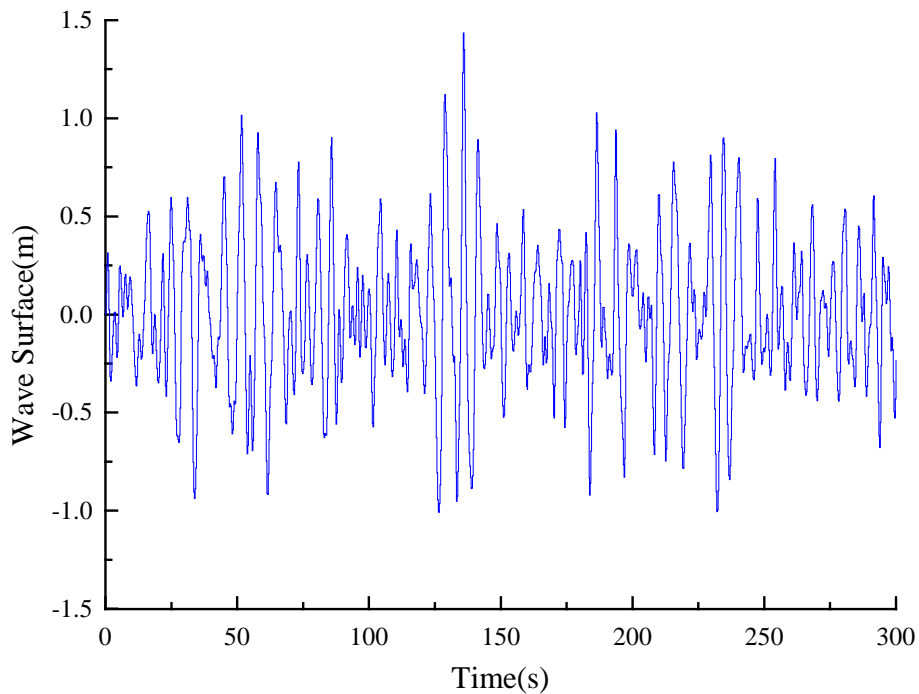


Fig. 3. Portrait of the processed wave surface elevation.

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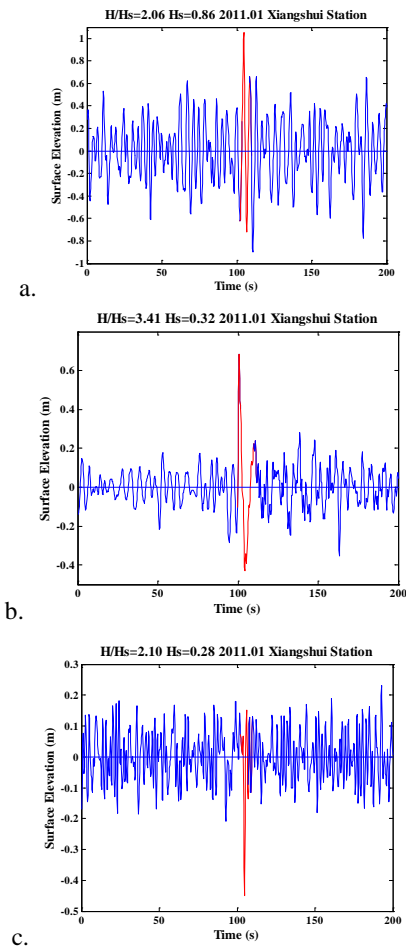
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**Fig. 4.** Typical portraits of rogue waves in Xiangshui station.

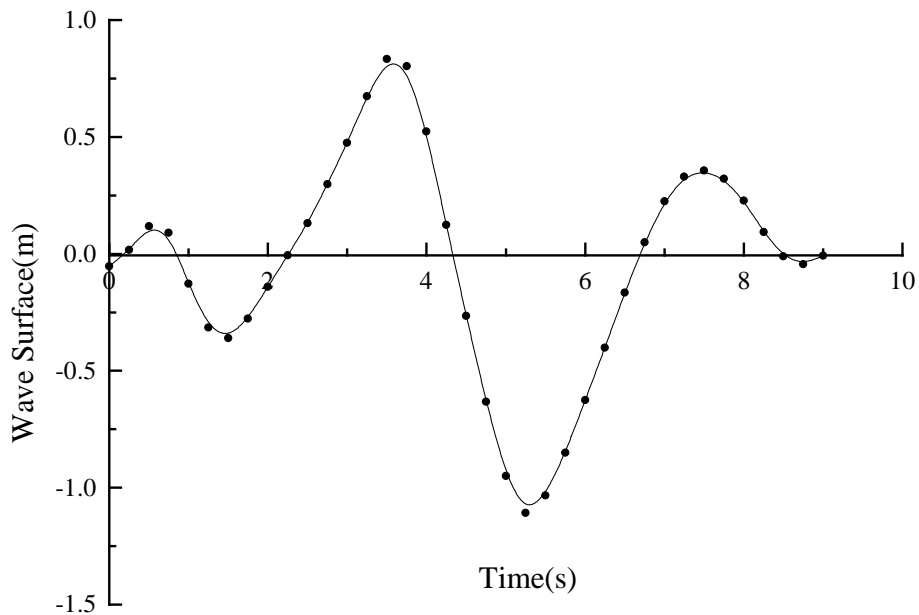


Fig. 5. Symmetry of the rogue waves.

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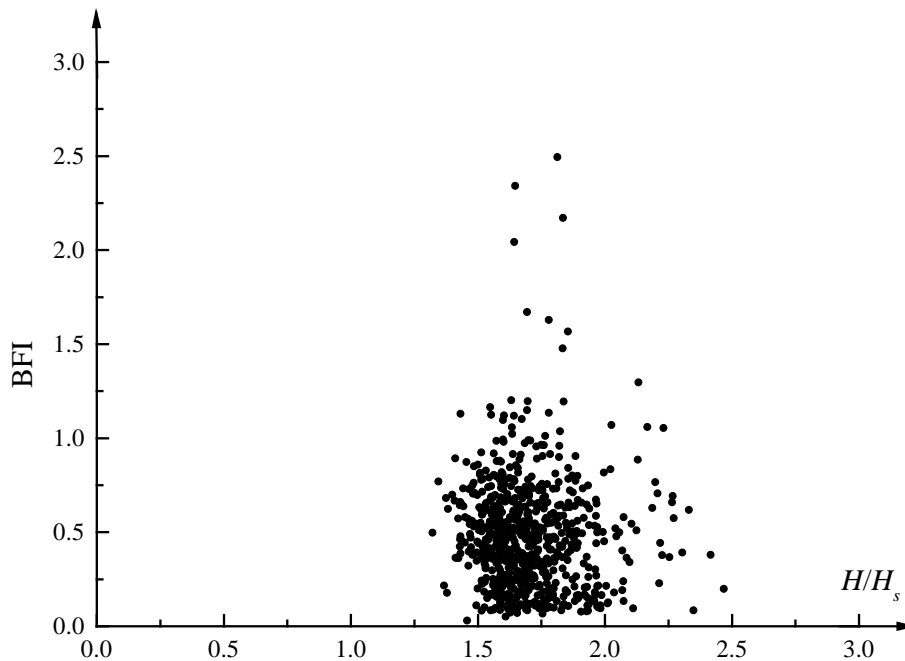
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**Fig. 6.** Relationship between BFI indicator and H/H_s .

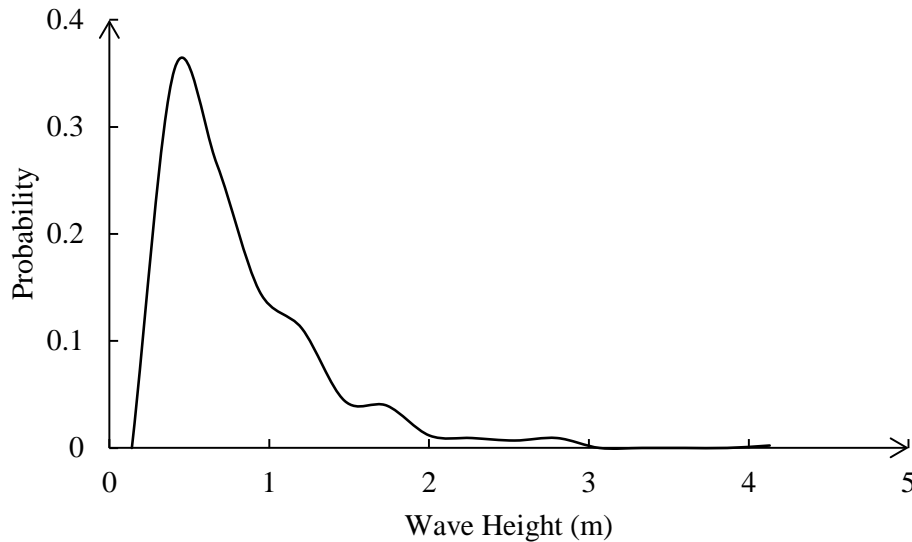


Fig. 7. Probability distribution of wave heights of rogue waves of Jiangsu Station in 2011.

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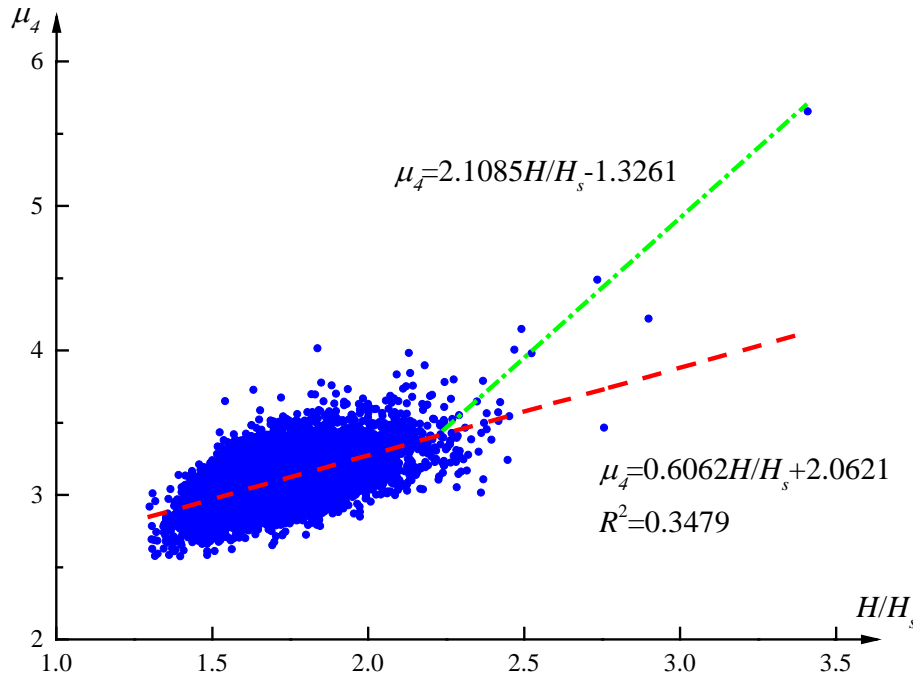
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**Fig. 8.** Relationship between H/H_s and kurtosis.

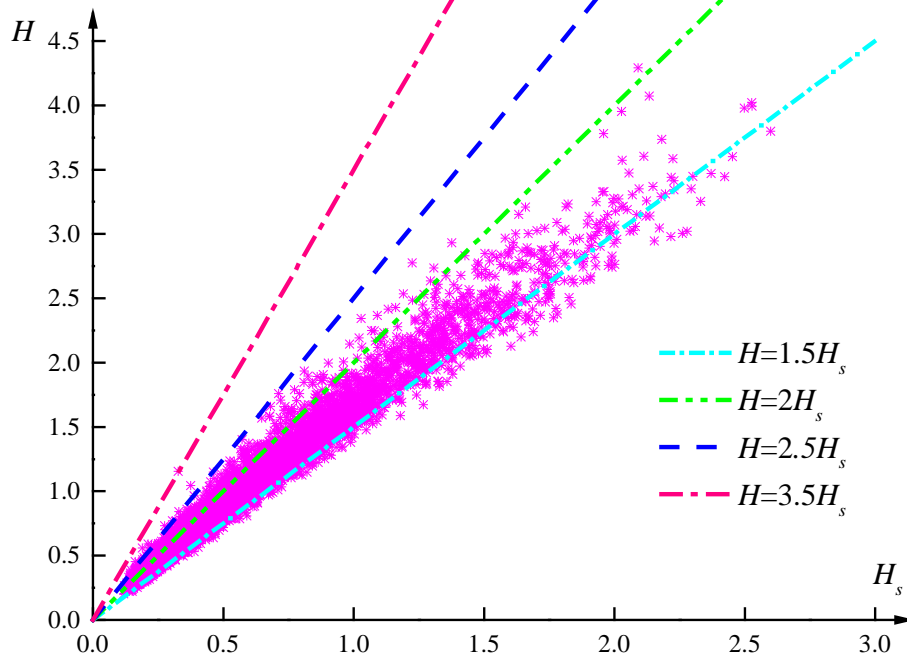


Fig. 9. Correlation plot of largest H and H_s .

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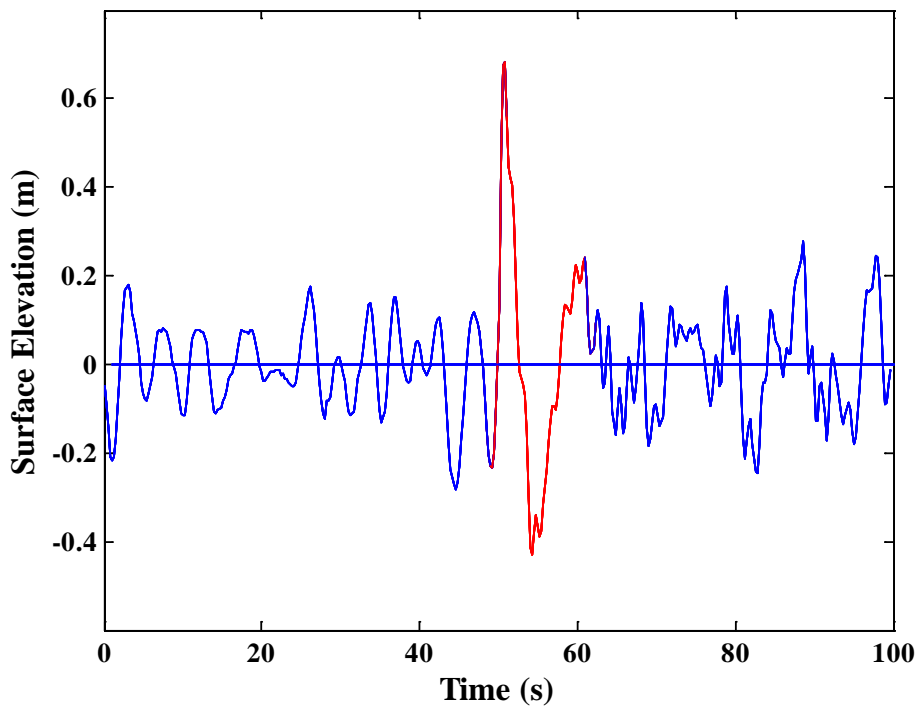


Fig. 10. Rogue wave (Kurtosis = 5.6575, $H/H_s = 3.41$).

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