Reply to the comments from anonymous referee#1:

We sincerely thank referee#1 for the valuable feedback that we have used to improve the quality of our manuscript. The referee's comments are laid out in *italicized font* and the comments have been numbered in the authors' response. Our response is given in normal font and changes/additions to the manuscript are given in blue text. The authors' response can be found in the attachment.

Sincerely Yours,
Dr. Jiang Xingjie

Authors' Response:

This manuscript aims at providing a systematic approach that allows a convenient and quantitative comparison of non-Gaussianity of real-world wave fields through the corresponding wave spectra. The newly proposed approach includes: i) a set of pre-calculated references representing the relation of non-Gaussianity to spectral geometries, and ii) an approach to introduce arbitrary 2D spectra into the references. Since the occurrence of rogue waves is closely related to the two issues: spectral geometries and non-Gaussianity of sea states, we applied this approach to some rogue events occurred in real oceans. The results confirmed with the existing theories and conclusions, and provided a quantitative support regarding the topic of "explaining formation of rogue waves without modulational instabilities" in wind-sea dominated sea states. Apparently, the newly proposed approach is operational and can be used in more studies related to rogue wave sea states.

Comment 1: *This manuscript should clarify its novelty in comparison with previous studies.* And *"Line 58-60: With regard to …, Ribal et al. (2013) derived criterion of the modulational instability for JONSWAP spectra", "Even if HOSM is necessary,…. Is not the result of Xiao et al. (2013) insufficient?",* and *"The conclusion of this manuscript is fairly similar to that of Fedele et al. (2016)".*

Response: We must admit that the statement "it remains difficult …" in the original manuscript was a bit ambiguous and the following example was not proper. As mentioned in the referee's comments, there are existed theories and approaches to obtain the non-Gaussianity indicators through the three geometries, and some of the approaches can even be applied to operational rogue wave forecast systems. However, these 'operational' indicators are not suitable to assess the severity of the deviation from Gaussianity for a real sea state, this is because:

1) The operational non-Gaussianity indicators, especially dynamic kurtosis, were first obtained from theoretical models derived under the narrowband assumption in an environment with near-unidirectional wave propagation. The original expression of those indicators cannot be applied to the real sea conditions with broad bandwidth and directional spreading.
2) In the rogue wave forecast systems, specific parameters representing the geometries were selected and undermined parameters were introduced to calibrate the indicators to adapt the real wave environment. However, calibrations were conducted based on the final forecast results, i.e., the exceptional maximum wave/crest height, rather than the skewness/kurtosis observed in real environment. The skewness/kurtosis of wave surface depends on the number of waves involved

in the statistics, and the scope of the statistical sea surface and the length of the statistical time can hardly be defined. Therefore, the number of waves is a quantity that cannot be accurately estimated in real wave fields. Furthermore, the number of waves is also an important factor determines the exceptional wave/crest heights forecasted, together with the skewness/kurtosis indicators in the forecast systems. (And that is the "additional complicated factors").

Details of introducing and calibrating the operational non-Gaussianity indicators can be found in Barbariol et al. (2015; 2017) for the WWIII-STE system, and in ECMWF Technical Memorandums (Janssen, 2017; Janssen and Bidlot, 2009) for the ECMWF-IFS system. (Barbariol et al., 2015, 2017; Janssen, 2017; Janssen and Bidlot, 2009)

In this study, we used HOSM to simulate the wave field. The HOSM can adopt arbitrary 2D wave spectra as initial conditions without any limitation of spectral shape. To avoid the impact of the number of waves on the statistics of skewness/kurtosis, the number of waves was set to be almost the same (25.5*25.5) in the initial field of each HOSM simulation (see Sect. 2.1), and the ratios denoted as $R_{\mu 3}$ and $R_{\mu 4}$ were introduced (see Eq. (8) in Sect. 2.3) to represent the non-Gaussianity obtained under these similar experimental environments.

As mentioned in the comment, Fedele et al. (2016) produced similar results. In fact, HOSM could be very cumbersome if it is applied to every spectrum obtained in the time duration of interest. As the HOSM simulations were carried out 50 times for each spectrum, Fedele's work only focused on three spectra which represented the sea states where and when the events of Draupner, Andrea and Killard occurred. In this study, thanks to the pre-calculated references and the introducing approach, non-Gaussianity indicators $R_{\mu 3}$ and $R_{\mu 4}$ could be obtained very conveniently. Then, the evolution of non-Gaussianity within concerned wave fields and time durations can be presented, as exhibited in Fig. 8. Non-Gaussianity evolution shown in Fig. 8 is a unique production of this study, through Fig. 9 exhibited similar results as Fedele's work. (Fedele et al., 2016)

Previous research like Ribal et al. (2013) (Ribal et al., 2013) and Xiao et al. (2013) (Xiao et al., 2013) have provided criterions containing the three geometries for MI. And these criterions were derived based on spectrum models that conform to the characteristics of real wave environment, like the JONSWAP spectrum with the Ad-type distribution (Babanin and Solov'yev, 1987; Babanin and Soloviev, 1998). However, the usage of these criterions in real cases was not specified in their research. There is still a lack of a way to introduce arbitrary 2D wave spectra into the criterions, and it is still unknown how effective these criterions are in practical applications. Moreover, in the spectrum models mentioned above, the triggering of MI is a sudden change, depending on whether a certain criterion (a certain combination of the three spectral geometries) is met. In fact, the effect of MI—kurtosis is a quantity that varies gradually and continuously with the change of the geometries, as reflected in the non-Gaussian references. From the perspective of the kurtosis indicator $R_{\mu 4}$, the influence of spectral geometries and MI on the possibility of triggering rogue waves can be more intuitively presented.

All the explanations above have been added into the revised manuscript, please see the blue texts in the sections of introduction and discussion.

Comment 2: *What are "additional complicated factors"?*

Response: Please see the Response for Comment 1.

Comment 3: *"...although the range of DS might become narrower as the waves become more developed", please cite some references or show some evidences.*
Response: This phenomenon can be observed in the Alwyn events, and it also has been studied in previous research (Babanin and Soloviev, 1998). According to the A_d-type distribution proposed by Babanin and Soloviev (1998) (the reference has been added to the revised manuscript):

$$A_d(f)^{-1} = \int_{-\pi}^{\pi} K(f,\theta)\mathrm{d}\theta \text{ and } \int_{-\pi}^{\pi} A_d(f)K(f,\theta)d\theta = 1,$$

higher values of A_d correspond to narrower directional distributions. The dependence of the parameter A_d on wave development stage U/c_m at peak frequency f_m is shown in the figure below (which is cited from Fig. 5 in Babanin and Soloviev (1998)):

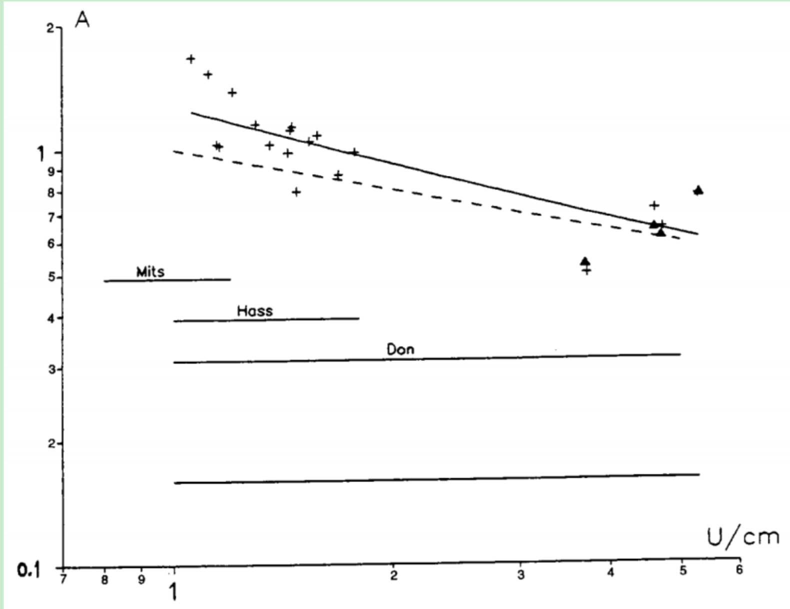

Fig. 5. Dependence of parameter A on wave development stage U/c_m at peak frequency f_m. Dashed line is the dependence of the parameter A on parameter U/c if directional spectra at all frequencies f are taken into account. Level of isotropic directional spectra is shown at the bottom as well as data ranges of the parameterizations of Mitsuyasu *et al.* (1975), Hasselmann *et al.* (1980) and Donelan *et al.* (1985). Triangles show positions of the theoretical spectra (31) with $a = 2.6 \times 10^{-3}$.

Parameter U/c_m represents the wave age, where U is the wind speed and c_m is the wave velocity at peak frequency. Lower values of U/c_m denote more developed wave fields. It is observed in the figure shown above, as parameter U/c_m reduces, larger values of A_d can be found, indicating narrower distribution of wave energy, i.e., narrower DS.

Comment 4: *the latter (the red lines) is several times larger than the former (the bule lines) in all cases of Alwyn, actually. Some explanation on this discrepancy are needed.*
Response: First of all, we need to apologize that the additional HOS simulations performed on the Alwyn_r2–Alwyn_r8 events incorrectly used the spectrum of Alwyn_r1 as initial conditions. Therefore, the black and red lines shown in the Alwyn panels in Fig. 9 appear to be at the same level, whereas blue dashed lines were getting lower and lower through Alwyn_r2–Alwyn_r8, conforming to the smaller and smaller values of $R_{\mu3}$ and $R_{\mu4}$ shown in Table 3 (Table 4 in the revised manuscript, see the Response to Comment 5 below). And that's why the red lines are obviously

larger than the blue ones in all the cases of Alwyn. We sincerely thank referee#1 for pointing out our mistakes. The additional HOS simulations were conducted again on all the 8 Alwyn events with the correct initial conditions, and Fig. 9 was redrawn in the revised manuscript. The newly drawn Fig. 9 proves the inactivity of MI in the Alwyn events, and better goodness of the fit of the blue dashed lines to the red lines can be found in the redrawn figure.

Comment 5: *The infinite water depth was adopted for HOSM simulation (line 125) in this study, but was this assumption valid for these sites (of Draupner, Andrea, and Alwyn)?*
Response: Water depth (d) at the sites of Draupner, Ekofisk Field, and Alwyn platforms are about 70m, 74m, and 126m (see the newly added column *Depth*(m) in Table 2), and the values of parameter $k_p d$ simulated at the times of the occurrences are listed in Table 3. The values of $k_p d$ shown in Table 3 are all greater than the well-known 1.363, indicating that it was not the water depth that restricted the nonlinear focusing caused by MI in those events (Benjamin and Hasselmann, 1967; Janssen and Onorato, 2007; Whitman, 1974).

A new table (Table 2) was added into the revised manuscript, and an explanation corresponding to this response was added at the end of Sect. 3.4.

Comment 6: *The title is a bit long*
Response: We will seriously consider this comment.

Comment 7: *Typesetting issues:*
Response: The wrong fonts in "Abstract" and "Conclusion and Discussion" have been fixed. The incorrect line spacings in sections 3.x have been fixed too. The changes mentioned above were NOT marked in blue text.

Reference:

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Whitman, G. B.: Linear and nonlinear waves., , doi:10.4249/scholarpedia.4308, 1974.
Xiao, W., Liu, Y., Wu, G. and Yue, D. K. P.: Rogue wave occurrence and dynamics by direct simulations of nonlinear wave-field evolution, J. Fluid Mech., 720, 357–392, doi:10.1017/jfm.2013.37, 2013.