Review

on the manuscript "Numerical investigation on spectral geometries and their relation to non-Gaussianity in sea states with occurrence of rogue waves: wind-sea dominated events" by Xingjie Jiang, Tingting Zhang, Dalu Gao, Daolong Wang, submitted for publication in NHESS.

This work is dedicated to the study of the rogue wave phenomenon, aiming at solving the problem of forecasting the occurrence of such waves. In the article, the set of spectral parameters, the wave steepness, the frequency bandwidth and the directional spreading, is used for determining the probabilistic properties of the wave field in terms of skewness and kurtosis. The relation between the spectral and statistical parameters is estimated using the direct numerical simulations within the HOSM for irregular waves with the JONSWAP spectrum and the $\cos^2$ spreading function. The obtained relation is applied to the sea conditions observed during the occurrence of widely known rogue waves, such as the New Year Wave, the Andrea Wave and some others. The sea state conditions were reproduced by the WWIII model; they turn out to be characterized by broad frequency and directional spectra. The authors make use of the possibility to control the order of nonlinearity of the HOSM to show the dominant contribution of the second-order nonlinearity to the third statistical moment (skewness); and that the fourth statistical moment (kurtosis) is small and the 4-wave interactions do not lead to its increase. They conclude that in these particular sea states the effect of the modulation instability is negligible.

The idea of the work is generally understood and reasonable; in the literature there have already been some attempts to tackle the problem following similar approaches (some references are present in the manuscript). However, there is a long list of uncertainties on the way to the final outcomes; not all the conclusions sound convincing. On the other hand, the work represents a new serious attempt to reconstruct the realistic wave conditions within numerical simulations. Unfortunately, the work is lacking in discussion and comparison with previously reported results on similar problems, even though the publications are mentioned. In particular, the BFI parameter is not mentioned in the work at all, although it seems to be a most promising characteristic of the extremality of sea states. The in-situ extreme events considered in the article have already been analyzed earlier, but the new results are not discussed against the already reported. Such a discussion should be added to the revised version of the manuscript before it is accepted for publication. The text is generally not easy-to-read due to the numerous notations, which are not always obvious. Some particular issues listed below should be clarified as well.

1. Line 228. "*It should be noted that $R_{\mu4}$ could take a negative value with some combinations of (ε, γ, Θ), which could be attributable to two factors.*" I have doubts about the negative values of kurtosis for rather small directional spreading. It could be seen from Fig. 3(c,d) that the negative values of kurtosis are observed for small wave steepness (looking at the figure, I cannot estimate the kurtosis value for larger ε). I think this may be due to insufficient statistics of waves for the initial conditions, when a Gaussian field is constructed. If the number of random waves is insufficient, the kurtosis will be less than zero (see negative dynamic kurtosis in Fig. 5a in [Slunyaev A. V. Effects of coherent dynamics of stochastic deep-water waves. Phys.Rev.E, 101, 062214, 2020]). Note however that the total kurtosis is positive, though the directional spreading is large and the steepness is relatively small). If the subsequent evolution of the waves of small steepness is practically linear, then the wave statistics may remain almost unchanged.
   Secondly, such negative values might be a result of the high-frequency cut-off. The similar effect of kurtosis underestimation is discussed in the recent preprint [Kokina, T. Dias, F. Influence of the Wave Spectrum on Statistical Wave Properties. Preprints 2020, 2020110421]. Please indicate

the rate of the energy loss during the simulation (within the last 170 periods) caused by the wave breaking suppression.

2. In the numerical experiments by HOSM (section 2.1), the spatial sampling was about 10 points per a wavelength. To the best of my knowledge, it is not sufficient to describe accurately the wave features, what may lead to artifacts of processing. A greater resolution was used in, particular, [Xiao, W., Liu, Y., Wu, G. and Yue, D. K. P. Rogue wave occurrence and dynamics by direct simulations of nonlinear wavefield evolution, J. Fluid Mech., 720, 357–392, 2013]. The issue of sufficient spatial resolution was particularly considered in [Slunyaev A., Kokorina A, Account of occasional wave breaking in numerical simulations of irregular water waves in the focus of the rogue wave problem. Water Waves, 2, 243-262, 2020], where about 20 points per wave was used as the minimum.
3. The statistical moments are calculated by averaging over a remarkably long period of 170 after the start of the simulation. It is well-known that the transition of modulationally unstable wave systems to a quasi-stationary state takes a couple of tens wave periods (e.g., [Shemer L. and Sergeeva A. An experimental study of spatial evolution of statistical parameters in a unidirectional narrow-banded random wave field. J. Geophys. Res., 114, C01015, 2009; Shemer L., Sergeeva A., Slunyaev A. Applicability of envelope model equations for simulation of narrow-spectrum unidirectional random field evolution: experimental validation. Phys. Fluids, 22, 016601(1-9), 2010]). Therefore the averaging over 170 wave periods will most likely completely hide the effects of the modulational instability. It is well seen in Fig. 9 (Alwyn-r2, for example) that during the first 10-20 T_p both the skewness and kurtosis increase rapidly and then oscillate around some steady-state value. For steeper waves this effect will be more pronounced. It may be more reasonable to consider a shorter time period (and to simulate a greater number of realizations). Anyway, it would be instructive if the maximum attained values of skewness and kurtosis for the given spectral parameters are plotted in e.g. Fig. 8,9 in line with the averaged ones.
4. In Sec. 3.2 the values of the skewness and kurtosis which characterize the Draupner wave and the Andrea wave seem to be rather different from the results of a similar analysis performed in [Fedele, F., Brennan, J., Ponce de León, S., Dudley, J. and Dias, F. Real world ocean rogue waves explained without the modulational instability., Sci. Rep., 2016]. Please discuss possible reason of this disagreement.

Some other remarks:

Line 114. What is "*a relevant parameter n=4*"?

Line 121. Please clarify what "*pseudo-spectra*" means? The same question about "*pseudo-spectral space*" in Table 1.

Line 138-140. In Eq. (4) should be β instead of *B*.

Line 143. The writing $\cos^2 x$ should be probably used in Eq. (5).

Line 185. It should be μ_3 in the expression for the skewness, Eq. (8).

Line 215. "*It can be seen in Fig. 3c and 3d that within the range where Θ is extremely narrow (e.g., $\Theta \leq 20°$), $R_{\mu 4}$ decreases markedly as Θ widens; when Θ is beyond the extremely narrow range, the value of $R_{\mu 4}$ reaches a much lower level and decreases markedly more slowly in comparison with the situation when Θ widens within the extremely narrow range.*" The surfaces in Figs. 3 are probably not the best way to present the data, since the non-monotonic change of kurtosis is hardly seen. I suggest using contour plots or something similar (the top-view with a color coding, etc.).

Line 221 "…in *a normal sea state (Annenkov and Shrira, 2014)*".Do you mean "Gaussian sea state" or "typical sea state"?

Line 231. "*Negative $R_{\mu4}$ values represent sea states with less possibility of finding rogue waves; thus, they would not influence identification of MI-triggering combinations*." Please explain what you mean.

Line 256. The subscripts *i* of the characteristics ε γ Θ are not defined.

Line 301. "*It can be seen from Fig. 7 and Table 3 that the parameters indicating SP are very similar at the times of occurrence of the selected events, i.e., they are almost all within the range of 0.035–0.040*." The meaning of the sentence is not clear. Please paraphrase.

Table 2. Please add to Table 2 the information about T_p and the local water depth.

Figure 2. The blue colors look similar, therefore the lines are poorly readable. Please change.

Figure 3. Please, swap the figures c) and d) to be consistent with a) and b).

Figure 4. Please, correct the colorbar (depth, meter). The scale of the depths does not allow to estimate the bathymetry in the vicinity of the locations of measurements. Please indicate the depths of the measurement locations.

Figure 7. The absence of the red curves in the upper panel looks confusing. You could use different line widths or line styles to show the curves which coincide. A new undefined notation *Spr* appears in the bottom figure. Please change the scale of the left vertical axis – the red lines are poorly read.

Figure 8. The figure is impossible to read. I can see only two horizontal lines corresponding to the averaged values. I suggest the authors to use different colors and line widths.

Figure 9. I would expect that the blue dashed lines show the averaged values of the dependences shown with the red curves. However, the plots are inconsistent with this. Could you please explain the relation between the curves in the figure. Please, give the values of $B_{\mu3}$ and $B_{\mu4}$ on the graph.

In Figures 9, 10 the axis tick labels are too dense and even overlap. Please, improve.