Journal of
Marine Science and Engineering

MDPI

Correction

Correction: Knobler et al. Wave Height Distributions and Rogue Waves in the Eastern Mediterranean. *J. Mar. Sci. Eng.* 2021, *9*, 660

Sagi Knobler [1,2,*], Daniel Bar [1,2], Rotem Cohen [2] and Dan Liberzon [1,3]

[1] The Interdisciplinary Program for Marine Engineering, The Technion—Israel Institute of Technology, Haifa 3200003, Israel; daniel.bar@campus.technion.ac.il (D.B.); liberzon@technion.ac.il (D.L.)
[2] CAMERI—Coastal and Marine Engineering Research Institute LTD, Haifa 3200003, Israel; cohen.rotem@technion.ac.il
[3] Faculty of Civil and Environmental Engineering, The Technion—Israel Institute of Technology, Haifa 3200003, Israel
* Correspondence: sagikn@campus.technion.ac.il

Figure Legend

In the original publication [1], there was a mistake in the legend for Figure 3. The caption text was missing the statement (H/H_s above 2). The correct legend appears below:

Figure 3. Crest to trough symmetry of waves; detected rogue waves datasets (H/H_s above 2) are marked in accordance with the threshold definition as standard definition $H \geq 2Hs$ denoted by +; crest height $\eta_c \geq 1.25Hs$ denoted by ♢; STD of the instantaneous water elevation fluctuations $H \geq 8\sigma_\eta$ denoted by Δ; corresponds to all three threshold definitions denoted by ☆; datasets not answering on any of the rogue thresholds are denoted by red dot sign.

In the original publication, there was a mistake in the legend for Figure 7. The caption text requires edits listing the new highest wave on the record date. The correct legend appears below:

Figure 7. (A) Models fit comparison of the cumulative wave height distributions for the high sea event of 4–9 December 2017; (B) Linear models fit comparison of the cumulative wave height distributions for the high sea event of 4–9 December 2017; (C) Mean square error of the cumulative wave height distributions for the high sea event of 4–9 December 2017.

In the original publication, there was a mistake in the legend for Figure 9. The caption text was missing the statement (H/H_s above 2). The correct legend appears below:

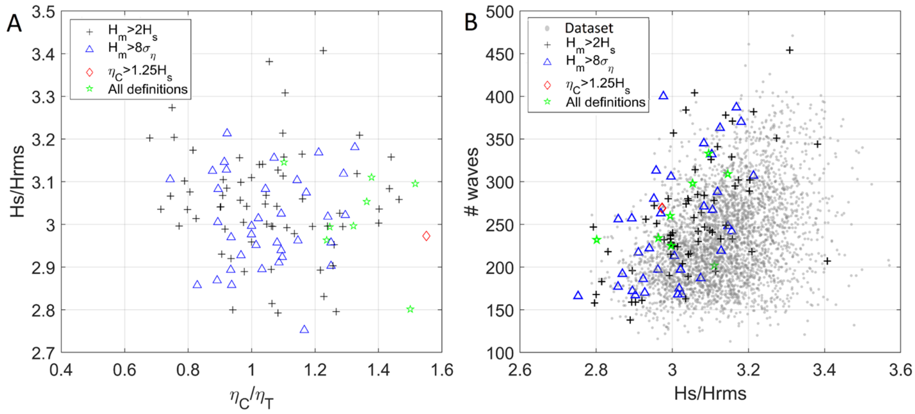
Figure 9. (A) Rogue waves (H/H_s above of 2) crest vs. trough heights distribution as a function of H/Hs. (B) Rogue waves crest vs. trough heights distribution. Thresholds are denoted by: standard definition $H \geq 2Hs$ is denoted by +; crest height $\eta c \geq 1.25Hs$ denoted by ♢; STD of the instantaneous water elevation fluctuation $H \geq 8\sigma_\eta$ denoted by Δ; corresponds to all three threshold definitions denoted by ☆.

Error in Figure/Table

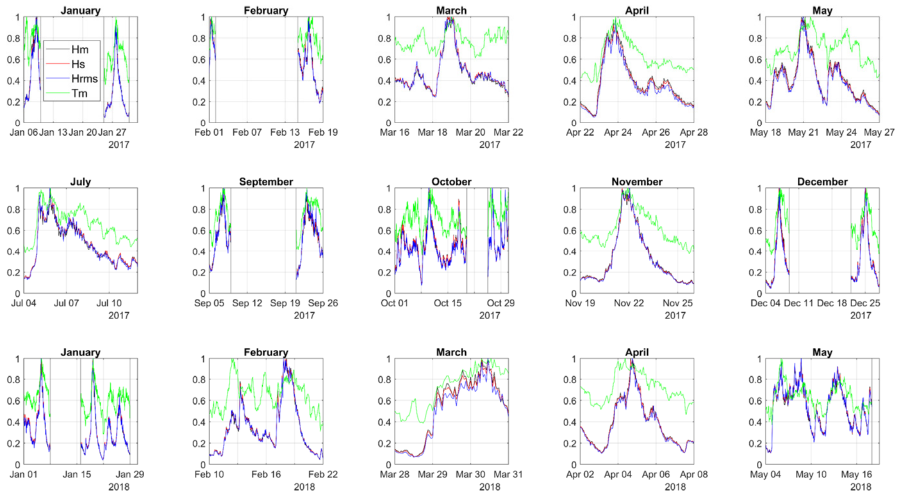
In the original publication, there was a mistake in Figure 3 as published. The authors have discovered an error in some of the raw data files recorded by the buoy; these datasets contained negated values of the surface elevation fluctuations. The contents of this figure are updated to reflect the results using the corrected surface elevation time series. The corrected Figure 3 appears below.

Citation: Knobler, S.; Bar, D.; Cohen, R.; Liberzon, D. Correction: Knobler et al. Wave Height Distributions and Rogue Waves in the Eastern Mediterranean. *J. Mar. Sci. Eng.* 2021, *9*, 660. *J. Mar. Sci. Eng.* **2022**, *10*, 482. https://doi.org/10.3390/jmse10040482

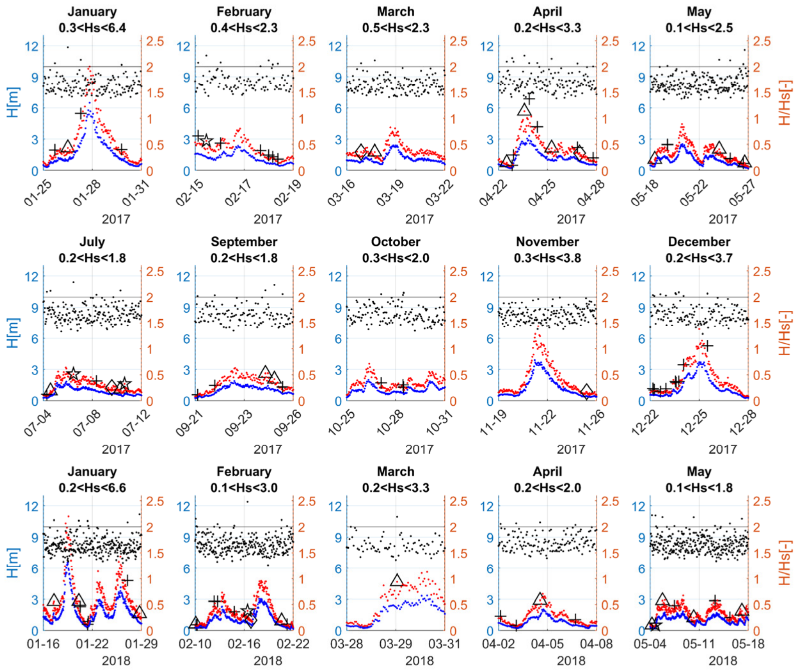
Received: 13 January 2022
Accepted: 19 February 2022
Published: 31 March 2022



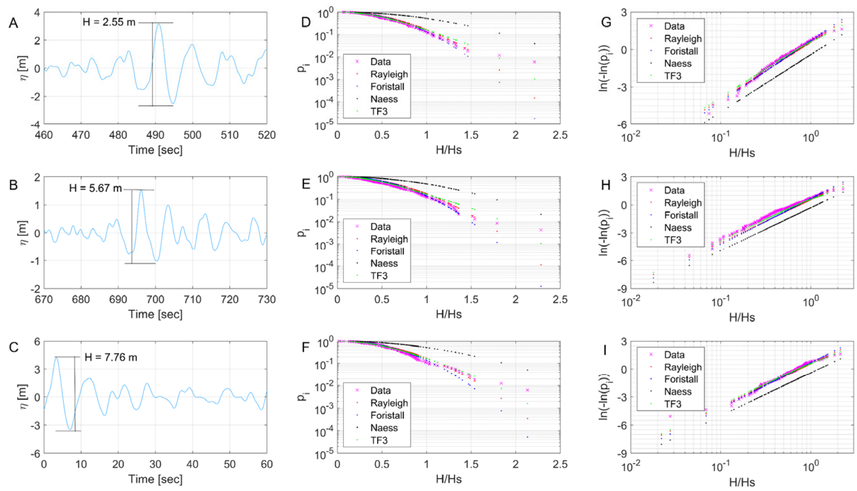
In the original publication, there was a mistake in Figure 4 as published. The authors have discovered an error in some of the raw data files recorded by the buoy; these datasets contained negated values of the surface elevation fluctuations. The contents of this figure are updated to reflect the results using the corrected surface elevation time series. The corrected Figure 4 appears below.



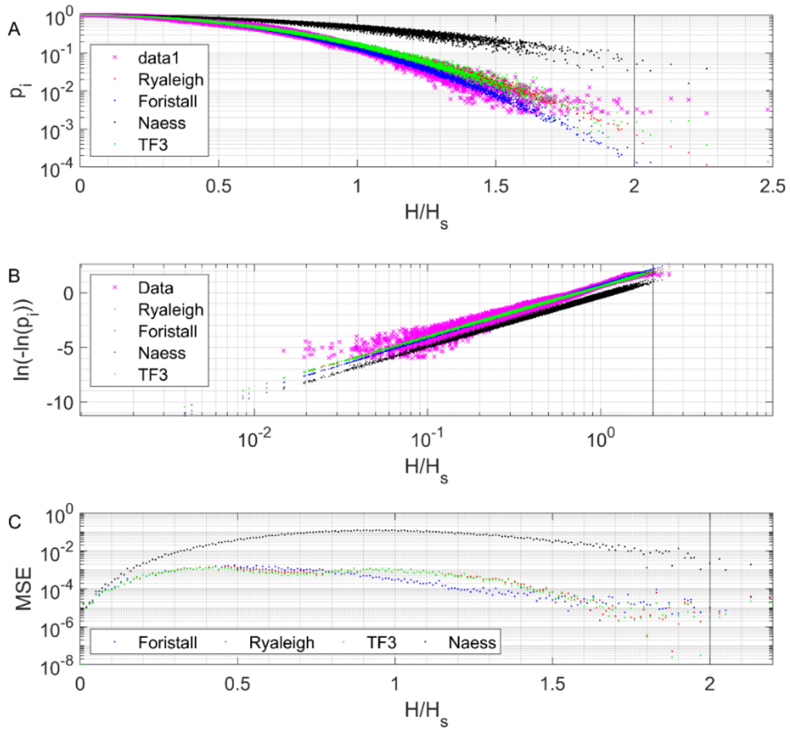
In the original publication, there was a mistake in Figure 5 as published. The authors have discovered an error in some of the raw data files recorded by the buoy; these datasets contained negated values of the surface elevation fluctuations. The contents of this figure are updated to reflect the results using the corrected surface elevation time series. The corrected Figure 5 appears below.



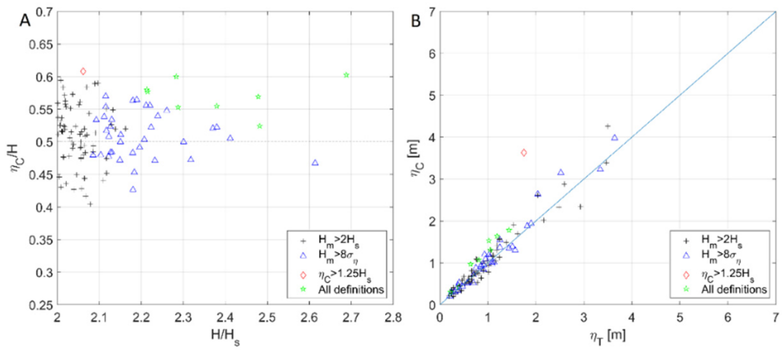
In the original publication, there was a mistake in Figure 6 as published. The authors have discovered an error in some of the raw data files recorded by the buoy; these datasets contained negated values of the surface elevation fluctuations. The contents of this figure are updated to reflect the results using the corrected surface elevation time series. A different wave is now identified as the highest on the record, shown in panels (C, F, I). The corrected Figure 6 appears below.



In the original publication, there was a mistake in Figure 7 as published. The authors have discovered an error in some of the raw data files recorded by the buoy; these datasets contained negated values of the surface elevation fluctuations. The contents of this figure are updated to reflect the results using the corrected surface elevation time series. A different wave is now identified as the highest on the record, occurring at different time in the record. The corrected Figure 7 appears below.



In the original publication, there was a mistake in Figure 9 as published. The authors have discovered an error in some of the raw data files recorded by the buoy; these datasets contained negated values of the surface elevation fluctuations. The contents of this figure are updated to reflect the results using the corrected surface elevation time series. The corrected Figure 7 appears below.



In the original publication, there was a mistake in Table 1 as published. The authors have discovered an error in some of the raw data files recorded by the buoy; these datasets contained negated values of the surface elevation fluctuations. The contents of this table are updated to reflect the results using the corrected surface elevation time series, including corrected dates of three of the storm events, corrected various wave height values, and a corrected count of the detected rogue waves. The corrected Table 1 appears below.

Event Dates	Max. H_s (m)	Max. H (m)	Max. Wind Magnitude (m/s)	Max. Wind Gusts (m/s)	Mean Wind Direction (Deg)	Total Number of Rogue Waves Detected by Threshold $H \geq 2H_s$	Total Number of Rogue Waves Detected by Threshold $H \geq 8\sigma_\eta$	Total Number of Rogue Waves Detected by Threshold $\eta_c \geq 1.25H_s$
6–10 January 2017	4.31	7.85	15.7	20.3	230	-	2	-
25 January–2 February 2017	6.10	10.01	18.2	23.6	280	3	1	-
15–18 February 2017	2.36	4.00	13.4	16	300	6	-	1
16–22 March 2017	2.38	4.12	13.4	16.3	350	-	1	1
22–28 April 2017	3.32	6.86	10.7	13.2	0	5	3	-
18–27 May 2017	2.51	4.45	9.4	11.7	280	3	3	-
4–12 July 2017	1.84	3.19	7	8.1	300	2	2	2
5–9 September 2017	1.89	3.84	8	9.4	350	2	2	-
21–26 September 2017	1.88	3.13	6	7.3	330	3	2	-
1–20 October 2017	1.87	3.7	8.9	10.4	350	6	6	1
25–31 October 2017	2.00	3.56	10.3	12.5	0	3	-	-
19–26 November 2017	3.89	7.18	10.8	14.9	230	-	-	-
4–9 December 2017	4.03	7.76	12.8	17.8	290	4	2	1
22–28 December 2017	3.71	6.88	13.5	17.3	270	9	-	-
1–8 January 2018	5.04	8.35	17.7	22.3	235	2	-	1
16–29 January 2018	6.62	10.99	15.9	22.1	230	4	3	-
10–22 February 2018	3.03	4.77	15.4	19.4	265	6	2	1
28–31 March 2018	3.36	5.63	14.6	18.9	0	-	1	-
2–8 April 2018	2.02	3.53	10	11.9	95	3	1	-
4–18 May 2018	1.82	3.37	9.7	11.8	10	4	4	1
	Total count					**65**	**35**	**9**

Text Correction

(1) Following the discovery of negated surface elevation records in the raw data of buoy records and their correction, the text of the Abstract was edited to list the correct new highest wave and its height.

A correction has been made to Abstract:

There is a lack of scientific knowledge about the physical sea characteristics of the eastern part of the Mediterranean Sea. The current work offers a comprehensive view of wave fields in southern Israel waters covering a period between January 2017 and June 2018. The analyzed data were collected by a meteorological buoy providing wind and wave parameters. As expected for this area, the strongest storm events occurred throughout October–April. In this paper, we analyze the buoy data following two main objectives—identifying the most appropriate statistical distribution model and examining wave data in search of rogue wave presence. The objectives were accomplished by comparing a number of models suitable for deep seawater waves. The Tayfun–Fedele third-order model showed the best agreement with the tail of the empirical wave height distribution. The examination of different statistical thresholds for the identification of rogue waves resulted in the detection of 109 unique waves, all of relatively low height. The characteristics of the detected rogue waves were examined, revealing that the majority of them presented crest-to-trough symmetry. This finding calls for a reevaluation of the crest amplitude being equal to or above 1.25, the significant wave height threshold which assumes rogue waves carry most of their energy in the crest.

(2) A typo in Equation (3) was corrected by removing the $/H_s$ on the left-hand side of the equation.

A correction has been made to Equation (3):

$$p_R(H) = \exp\left(-\frac{H^2}{8\sigma_\eta^2}\right).$$

(3) Following the discovery of negated surface elevation records in the raw data of buoy records and their correction, the text of paragraph four of the Results was edited to reflect the corrected wave heights values and the newly identified highest rogue wave.

A correction has been made to paragraph four of the Results section:

In Figure 6 pane A, a relatively low sea condition is observed, characterized by H_s = 1.11 m, and a small rogue wave of H = 2.55 m was detected on 6 July 2017 at about 11:00 a.m. This wave answers all three rogue wave threshold definitions. In Figure 6 pane B, a higher sea condition is observed, characterized by H_s = 2.56 m, and a rogue wave of H = 5.67 m was detected on 23 April 2017 at about 2:00 p.m. This wave answers both (9) and (10) thresholds. In Figure 6 pane C, on 6 December 2017, at about 20:00 a.m., the event was characterized by H_s = 3.63 m and the highest of all detected rogue waves was of height H = 7.76 m.

(4) Following the discovery of negated surface elevation records in the raw data of buoy records and their correction, the newly identified highest rogue wave was listed in paragraph six of the Results section.

A correction has been made to paragraph six of the Results section:

To further examine the performance of each distribution model, we fit all the empirical wave height distribution data during the high sea period with the highest detected rogue wave, the 4–9 December 2017 event. The models were used to fit all the wave height empirical distributions from this storm, and Figure 7 presents the cumulative results. Again, we notice that the Tayfun–Fedele third-order model performance showed the best fit at the tail of wave heights distributions, followed by the Rayleigh and Foristall models.

To quantify the selected models' performance, a mean square error (MSE) of the fits was calculated as:

$$\text{MSE} = \frac{1}{n}\sum (P_i - P_d)^2, \tag{12}$$

where P_d is the EDF of the empirical data, and all models' MSE are presented in Figure 7, panel C as average errors over all datasets of this high sea event. MSE values summarizing the models' performance over the full 18-month period of measurements are presented in Figure 8, also as averages over all available 20 min long ensembles. The Naess model showed errors larger by a few orders of magnitude and therefore was excluded.

(5) Following the discovery of negated surface elevation records in the raw data of buoy records and their correction, the newly identified highest rogue wave was listed in paragraph seven of the Results section.

A correction has been made to paragraph seven of the Results section:

In both the December 2017 first event and cumulative MSE of all events in our data, a similar trend was observed. The Tayfun–Fedele third-order and the Rayleigh models demonstrated the smallest MSE in the range of $\text{H/Hs} \leq 0.8$, while the Forristall model provided a much better fit for the range of $0.8 \leq \text{H/Hs} \leq 1.5$. Above the ratio of 1.5 and in the distribution tail, the Tayfun–Fedele third-order model performed the best for our data.

(6) Following the discovery of negated surface elevation records in the raw data of buoy records and their correction, the text of paragraphs 9–12 of the Results section is corrected, removing the description of a previously erroneously detected rogue wave of much larger trough. The original publication's typos in cross-reference to Figure 9 were also corrected.

A correction has been made to paragraphs 9–12 of the Results section:

Finally, we re-examined the crest height-based threshold for the identification of rogue waves. As noted earlier, the threshold $\eta_c \geq 1.25\text{H}_s$ assumes that most of a rogue wave water mass is contained above the mean water level, or in other words, most of its energy is carried by the crest. On the right pane of Figure 9, a distribution of all detected rogue wave crest vs. trough heights is plotted. Most of the rogue waves are tightly distributed along the one-to-one line. On the left pane of Figure 9, the ratio η_c/H of all detected rogue waves is presented. The waves are marked in accordance with the threshold to which they correspond, and a 50% ratio signifying equal height crest and trough is marked by a horizontal dashed line. Here, we can note that the majority of the detected rogue waves are distributed within a 40–60% range. Both plots show that among the vast majority of the detected rogue waves there is no preference to crest or trough height.

The crest-to-trough symmetry found in almost all waves identified as rogue by the several commonly used thresholds is not a trivial finding. While comparison with previous reports from the area of the Eastern Mediterranean is currently impossible due to the lack of such reports, which was one of the motivations of this study, our findings are in clear contradiction with the available reports on rogue wave characteristics available from other parts of the world [7–22]. The rogue waves are commonly reported as having a high crest-to-trough amplitude ratio, indicating strong nonlinearity. Being a statistical rarity, the identification and analysis of rogue waves naturally require large ensembles of waves, hard to achieve in open sea conditions. The here reported results are based on rather small ensembles of 100 to 500 waves (Figure 3). However, the absence of a clear trend or correlation between the ensemble size and the identification of rogue waves, and the lack of observable dependence of the calculated statistical parameters of wave height distribution on ensembles size reassure us that the findings are statistically trustworthy. The disagreement with previous reports cannot be attributed to insufficient ensemble size and different reasoning must be considered.

One such reasoning is the relatively low energetic state of the sea during the here analyzed storms in the East Mediterranean, an area not known for extreme storms. Detected by statistical thresholds, the rogue waves are hence of small height, generally posing no threat to the local maritime transport and rigs. Close examination of Figure 9B shows a slowly increasing trend in rogue wave asymmetry as the wave height increases. As in most cases, a very energetic sea state is chosen in works seeking evidence of rogue wave occurrences; our results call for analyzing existing low sea state data and the deliberate acquisition of new data at similar conditions. Accumulating enough evidence supported by properly quantified statistical parameters will potentially prove further understanding of the trends between sea state and the apparent asymmetry of the rogue waves.

Another reasoning can be found in the discussion regarding the definition of what a rogue wave is. As the name suggests, these waves are also called Freak waves. These are not simply very high waves in the tail end of wave height distribution, but are waves whose characteristics differ significantly from those of the rest of the ensemble. Hence, a somewhat simplistic approach widely adopted for the identification of such unusual waves—a statistical threshold—may not be appropriate to ensure the identified wave is indeed a rogue wave. As mentioned in the Introduction section, very large waves are mostly unaffected by second-order nonlinearities, and hence symmetrical waves at the tail end of wave height distribution will appear symmetric. The empirical evidence analyzed in this study therefore should trigger a reevaluation of the adopted methodology for the identification of rogue waves, to include not only a statistical threshold but also evidence of the wave's strong asymmetry. However, more similar data are needed to initiate the process of reevaluation.

(7) A typo in paragraph one of the Conclusions section was corrected, Eastern Mediterranean was written without capital E.

A correction has been made to paragraph one of the Conclusions section:

Motivated by the lack of sufficient insight and driven by the need for an estimation of possible risks posed by extreme events, the current work provides an overview of the Eastern Mediterranean Sea water wavefield behavior over a period of a year and a half, starting in January 2017. We examined the data provided by a moored buoy, located off the southern coast of Israel. Only the high sea events were analyzed in our search for the best-performing wave height distribution models and to identify and analyze possible rogue wave occurrences. The high sea events were encountered during the winter months, created by the west–southwest storms, as expected in this region.

(8) Following the discovery of negated surface elevation records in the raw data of buoy records and their correction, the results presented throughout the publication were updated with corrected wave parameter values, distribution, detection results, and the count of rogue waves. Following the corrected results, the text of paragraphs three and four of the Conclusions section was edited to accurately reflect the corrected results.

A correction has been made to paragraphs three and four of the Conclusions section:

This is the first known evidence for the possible occurrence of rogue waves in deep water in this area. The findings indicate that rogue waves may occur during storms in the winter months; however, most of them are of relatively low heights, posing no special concern from the engineering point of view. Even the strongest storm of January 2018, identified by the authors of [18] as a once in 10 years storm, produced waves of below 11 m height and no significant rogue waves. Further work is recommended in the future for a full scope of rogue wave occurrences in the Eastern Mediterranean Sea.

Three commonly accepted statistical thresholds were applied to identify rogue waves. A total of 109 unique rogue waves, (9), were identified. All identified rogue waves were of relatively low height, not exceeding 6 m, while the ratio H_s/H_{rms} of the ensembles varied between 2.5 and 3.7. The highest wave identified, H = 7.76 m, was a rogue wave detected during a powerful December 2017 storm during which the wave field's significant height was more than 4 m. A detailed analysis of all identified rogue waves in terms of the crest-to-trough energy distribution revealed that the vast majority of potentially rogue waves exhibited a high level of crest-to-trough symmetry. These findings are in clear disagreement with the widely assumed characteristic of rogue waves as waves with a high crest-to-trough ratio. Moreover, a large number of symmetric, crest-to-trough, waves that crossed the rogue wave threshold at least calls for a reevaluation of the wave crest amplitude-based threshold (11) validity. A slight but steady increase in wave asymmetry at higher sea states stresses the need to conduct a data investigation of low energetic state seas in search of similar evidence. The findings also call for a reevaluation of the commonly accepted rogue wave identification criteria to include not only a simple statistical threshold but also a characterization of wave asymmetry.

The authors apologize for any inconvenience caused and state that the scientific conclusions are unaffected. The original publication has also been updated.

Reference

1. Knobler, S.; Bar, D.; Cohen, R.; Liberzon, D. Wave Height Distributions and Rogue Waves in the Eastern Mediterranean. *J. Mar. Sci. Eng.* **2021**, *9*, 660. [CrossRef]