Review Report
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P.G. Petrova and C. Guedes Soares:
Nonlinear probability distributions of wave heights in bimodal following and crossing seas generated in laboratory experiments

1 General Comments

The manuscript is submitted for a special volume of *Natural Hazards and Earth System Sciences* addressing extreme seas and ship operations. The topic of the paper is analysis of basin generated waves of mixed seas in order to identify conditions for the occurrence of extreme waves, and this should be relevant for the journal. However, the present version is in a draft form which needs refinements in language and exposition in order to be acceptable.

One objection is the title of the paper. *Nonlinear probability distributions* do not exist. Of course, a proper (but too long) title could be *Probability distributions of wave and crest heights of nonlinear waves in bimodal...*

The data set consists of recordings from the Marintek basin in Norway. The generated sea states are all bimodal wave fields, where each component is *unidirectional* (long-crested) waves with a JONSWAP frequency spectrum. This is a special situation never occurring for real waves (apart from a case with two very long-crested swells, which is not what is to be considered here). There is therefore no discussion in the paper about wave directionality and its significant effects on the occurrence on abnormally high waves as discussed in, *e.g.* Gramstad and Trulsen, 2007. The relevance of the modelled sea states and the overall conclusions of the research to real seas may be questioned. In fact, if directional data have been available, any development in the directional spectrum over the basin would have been quite interesting to observe.

In general, the paper is careful to cite and present overviews of the relevant literature. In particular, the analysis is heavily based on work by Tayfun and others. This analysis focuses on non-spectral properties like skewness and kurtosis and brings in mixed moments of the elevation and the Hilbert transform of the elevation records. It is however somewhat hard to understand the physical relevance of the mixed moments. As a side issue, the authors could have observed that the (vertical) skewness of the Hilbert transform relates directly to the *horizontal* (back-front) skewness of the original waves. This additional analysis could easily have been included in the present case. The manuscript has a serious typo in the definition of Λ, where the correct second term is $2\lambda_{22}$ instead of $3\lambda_{22}$ stated the paper. Fortunately, the tables seem to apply the correct definition for Λ.

The presentation in the paper is very descriptive. This works well for summarizing the literature, but is not so good for discussions of the results. Lengthy comparisons of empirical distributions to distributions from the literature gets rather boring and do not shed much new light on the field. The tables present several obscure parameters of which only the regular skewness and kurtosis have an obvious meaning to this reviewer. Why should Λ be more interesting than λ_{40}? Most of the time, λ_{40} is larger than λ_{04} and λ_{22} is even smaller.

Knowing the significance of λ_{03}, it could be pertinent to ask what interesting property of the waves relates to λ_{04}?

As a general conclusion, the paper is too long and descriptive. The generated sea states consisting of two unidirectional wave fields are special, and the relevance for real wavefields is questionable. However, some of the findings are interesting, like the final section dealing with removing the second- and third-order bound wave effects from the surface profile.

The authors are encouraged to consider the objections in the review and submit a trimmed version of the manuscript, also pointing out shortcomings of laboratory waves contrary to real waves.

2 Specific Comments

In the following, P∗ ∗ ∗∗ L∗ ∗ ∗∗ defines the location in terms of page and line numbers in the discussion manuscript.

P5405 L1–2: May be write ...*seem to indicate*. However, recall that there is a clear difference between linear wave theory and the narrow band (NB) distributions for the wave height.

P5406 L14–16: Try to improve the sentence.

P5407 L21–24: This is very hard to read. Try splitting the sentence.

P5408 L11–13: This may cause some confusion: Later analysis is carried out using 15 minutes segments of data. In this full scale or lab scale? On some of the figures, a number N is stated without any obvious definition. Is this the number of waves or the number of data points? Please state what is meant.

P5408 L15–20: Also state the rest of the parameters in the spectra and the notation for the spectra introduced in Table 1 (may be not necessary).

P5409 L25–6: Why is the spectrum first estimated with 400dof and afterwards averaged over 101 points (corresponding to 202dof). Explain better.

P5410 L 27–8: Wave breaking should be discussed with reference to ε.

P 5412 L 12–13: Explain *self-focusing* (probably in frequency and not in direction?).

P5412 L20–3: Explain better the need of the λ-parameters (apart from λ_{30} and λ_{40}). The use of the HT for the horizontal skewness has not been addressed and I find no discussion of the kurtosis of the HT compared to the kurtosis of the original data record. Apart from the use of Λ as a parameter needed in the Gram-Charlier-based distributions like Eq. 9 and 10, and later distributions, it is hard to say what information Λ gives us which could not have been obtained directly from λ_{40}.

P5413 L3–4: What happened to λ_{13} and λ_{31}?

P5413 L21. How many waves do 15 minutes correspond to?

P5415 L 4–5: May be say something about the time variation of $\xi(t)$ and $\theta(t)$?

P5415 L 8–12: These arguments are difficult to follow, but the conclusions are well known.

P5416 L4–5: It is somewhat strange to call μ a steepness parameter, but probably OK?

P5417 L23: Shouldn't a lower bound be stated with an inequality sign?

P5419 L14–21. These definitions should be put earlier in the text since they have been used previously.

P5421 L9: If $\lambda_{40} \approx \lambda_{30}^2$ follows from NB theory it should be stated so. Clearly $\lambda_{40} \approx \lambda_{30}^2$ does not imply that NB theory holds!

P5421 L 22: "...*but fails to predict the crests exceeding 4* σ*, which keeps for all gauges over the second half*" What does this mean?

P5422 L25– : This looks strange. Does "*these differ*" refer to the height distributions? Difference depending on up- or down-crossing waves? This is strange, and it is questionable to average two heights in the statistics. The height defined as the average vertical distance from the crest to the two nearest troughs on each side will be a different stochastic variable than the one-sided heights, and one would be doubtful about the conclusions in Sec. 5.2.

P5428 L3: "Λ *hardly reaches* 0.6" . Could instead say "Λ *never exceeds* 0.6". The behaviour of Λ is described but far from explained.

Several pages: It would help the reading if the runs were identified with better names than 8228 - 8235, e.g. F1 – F4 for following waves, and C1 – 3 for crossing waves, or even some additional code for identifying the height and periods of wind sea and swell.

3 Minor Technical Corrections

P5406 L13: The correct name of the cruise ship is *Louise Majesty*

P5407 L27: State location and country for Marintek.

P5407 L27: Rather write ".. *and adjustable bottom set to* 2m"

P5411 L4: Use "*tends to defocus*". But what does that really mean?

P5417 L7: Define GC here since it has not been mentioned before.

P5435: The column *Spectrum* just shows ″2P J3/J3" without any explanation. Should it be omitted?

P5441: The wave gauges are sketched as about 8 meter long crossing bars. Does this reflects the size of the gauges?

P5442: Spectra for crossing seas are not shown, why?

P5443: Indicate the covariance function and its envelope on the graph.

P5443: This is not shown for crossing seas, why?

P5445 and 5446: Enlarge letters for the text on the axes.

P5446: Typo in caption: (c) not (d).

P5448: Caption very incomplete. Define N. Caption needs to be complete in at least one of this and the following figures. Enlarge letters for the text on the axes.