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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Time-frequency analysis of the sea state with the "Andrea" freak wave" *by* Z. Cherneva and C. Guedes Soares

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(1) "The introduction is very general and offers a long historical description of time-frequency spectra. However, it lacks is a clear description as to why the Wigner spectrum should be used for the analysis of ocean waves. Compared with e.g. wavelets, what can the Wigner spectrum offer to improve time series analysis? Furthermore, I do not understand what the main purpose of this analysis is. Apart from applying the Wigner spectrum to one time series, what do the authors expect to discover or demonstrate?"

We decided to use the Wigner time-frequency k spectrum because it gives an opportunity for more detailed investigation of the higher-order properties of the measured

waves in one point. Other time-frequency distributions (including e.g. wavelets) have not this peculiarity. The referred work of Cherneva and Guedes Soares (2008) is a first effort to use that features of the Wigner time-frequency spectrum of order k in investigation of the freak waves.

(2) "In section 2.1, there is reference to the carrier wave frequency ïĄůïĂř(t). It is stated that the carrier wave frequency is different from the peak frequency. This is not at all clear. Why the frequency of the carrier wave is different from the peak frequency? Does the carrier wave refer to the individual group? Also there is a reference to a local frequency. What is that?"

The carrier frequency and the peak frequency have different methods for estimation. The frequency spectrum shows the distribution by frequencies of the energy of a given sea state and the peak frequency shows in which frequency the spectrum has maximum. As it can be seen in section 2.1 the carrier frequency is estimated using the phase function. These two frequencies characterize the series but obviously their estimation will give different values. It should be a big surprise if these values coincide. It is shown in the text and also for details are given references of the dispute on the same problem that had place more than 30 years before.

(3) "Section 2.2 describes the Wigner spectrum. As it is written, it looks as Wigner spectrum is a linear tool like the FFT. It is mentioned that equation (5) allows the estimation of high order time frequency spectra. How? What does high order spectra mean? What sort of nonlinearity can be detected? Only referring to (Cherneva and Guedes Soares 2008) is not enough. Considering that the Wigner spectrum is the main tool used for the present study, a much more detailed description is expected."

It is known that spectrum (even usual frequency spectrum) is not a linear tool like FFT. It is a FFT transform of the series and after that multiplication of the result by its complex conjugated taking into account products with equal phase. Because of that the usual stationary frequency spectrum is phase blind. The frequency spectrum is of second

order to the surface elevation. But the spectrum shows the linear correlations between components. Bi-spectrum shows the second order correlations between the components. The high-order stationary spectrum of order k shows a correlation of order (k-1) between the components. In the works of Fonolosa and Nikias (1993, 1994), referred in our paper, it was made a step further from the stationary high-order spectra and the authors introduced time-frequency high-order spectra. These works have motivated us to use the Wigner time-frequency k spectrum because it gives an opportunity for more detailed investigation of the higher-order properties of the measured waves in one point. Other time-frequency distributions (including e.g. wavelets) have not this peculiarity. The referred work of Cherneva and Guedes Soares (2008) is a first effort to use that features of the Wigner time-frequency spectrum of order k in investigation of the freak waves.

(4) Section 2.3 describes Benjamin-Feir Instability. Honestly, I do not understand the reason why this section is presented. Is there any connection with the Wigner spectrum? Can these higher order spectra detect BFI? Also, there is no further mention to BFI in the rest of the manuscript.

We described the Benjamin-Feir Instability as a possible mechanism of generation of freak waves. These waves are the subject of the present investigation. Because of that we briefly gived an account of the mechanism of the Benjamin-Feir Instability.

(5) There is reference to tank experiments. What experiments do the authors refer to? Why are they not described? Also there is reference to real sea states (line 19, page 1491). What are these sea states?

The answers of the questions one can find in our previous studies referred in the paper. We add once more the references of our works to avoid eventual lack of understanding.

(6) Spectral downshifting generated by BFI takes some time to develop. I do not quite understand the downshifting of energy showed in individual wave group (Fig. 3, for example). The time window is far too short for nonlinear mechanisms to develop.

The stationary spectrum downshifting really takes some time and distance to develop. The history of the freak wave measured at Andrea is unknown for us and it is impossible to create it. The calculation of the wave before and after the measurement (in time or distance) will be a real speculation. We have only a short time series with already formed freak wave. Here we show a downshifting in time existing of one group of waves. Everywhere in the paper we highlight it. Similar works for downshifting during the time interval of one group are referred too.

(7) The statement in the paragraph between page 1491 and page 1492 is unclear. Also, statement like ". . .,possibly it will transform to a short group similar to that of the New Year Wave after several wavelength" is speculative. How can the author prove this?

We see this in the tank and it is explained in our work - Cherneva and Guedes Soares (2011b, 2012) where all is shown in detail. The reason for our assumption is that experiment. We highlight that it is only an assumption.

(8) Again, the statement "It can be suggested that the complicated time-frequency spectrum picture of the group III from Fig. 1b possibly is a result of interaction of wave components coming from separate directions" is speculative. There is no mention to directional property. How can this statement be supported?

As we had already said we have only the time series measured in one point at Andrea platform and the comment of Magnusson and Donelan (2013) that 40 min before the measurement it was registered a start of a new wind increase from a new and slightly different direction. Because of that we make only a suggestion.

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