New methods to detect extreme waves in quality controlled in-situ measurements

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Summary
Waves measured by wave rider buoys typically contain measurement errors with outliers as the most prominent ones. In the research project RAVE Offshoreservice, a novel parameter is applied to distinct extreme waves from spikes by using the HILBERT Transformation and its instantaneous parameters.

1. Motivation

Within the scope of the research project RAVE Offshoreservice, funded by the Federal Ministry for Economic Affairs and Energy (BMWi), an extensive in-situ measurement program is carried out to collect oceanographic, meteorological, and structural data in the German offshore wind park alpha ventus in the North Sea and, thus, enhance the knowledge of the marine conditions with regard to construction and operation in offshore regions [1]. One main goal of the project is to adapt the data quality control to the state-of-the-art and, where necessary, develop own quality control tests.

2. Method & Results

Regarding quality control tests for waves, comprehensive literature can be found in, e.g. [2], [3], and [4]. In this project, wave measurements are carried out, inter alia, with a directional wave rider buoy (DWR-MkIII) by Datawell. Typical measurement errors pertain to the value range, outliers (spikes), and flat lines. Especially, the distinction between extreme waves and spikes is a challenging task. Commonly, data points exceeding four times the standard deviation of the time series are defined as outliers. In this project, a more sophisticated method is applied, which also considers the deformation of an extreme wave and its behaviour in the time-frequency domain. The instantaneous steepness $s_Z(t)$, a novel parameter developed by [5], is introduced, see Eq. (1):

$$s_Z(t) = 2 * a(t)/L(t) \qquad (1)$$

with the instantaneous amplitude *a*(t) and the so-called instantaneous wavelength *L*(t), which is determined based on the instantaneous frequency *f*(t), which is computed with the HILBERT Transformation. In Fig. 1, the normalised water surface displacement of an extreme wave is shown, and compared with its geometrical steepness s_Z=H/L and instantaneous steepness $s_Z(t)$. It can be observed, that the geometrical steepness does not behave in a distinct way, in contrast to the instantaneous steepness, which captures the unique feature of an extreme wave, namely the fast and extreme deformation of the water surface.

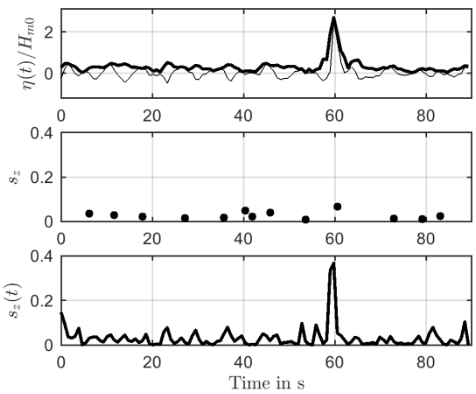

Fig. 1: Extreme wave, measured with a directional wave rider buoy, and its geometrical and instantaneous steepness.

3. References

[1] The research at alpha ventus (rave) project website. [Online]. Available: http://www.rave-offshore.de.
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