## Abstract

The largest set of field measurements published to date, comprising of 200 million waves and 1 million sea states, has been employed within the present study to produce crest elevation and wave height statistics. The accuracy of the dataset has been ensured by applying a thorough quality control (QC) process. A new improved automated QC method has been proposed within the present study whose novel approach automatically forms an accurate database while increasing the number of waves and minimising the degree of manual checks.

The wide range of sea states involved in this large database allows for the detailed examination of the influence of individual parameters on the wave distributions. The present study conclusively demonstrates that the Forristall (2000) model underpredicts crest elevations in steep sea states within the field and that non-linear effects beyond second-order cannot be ignored for design simulations. The Tayfun & Fedele (2007) model has been shown capable of capturing these effects to some extent however it is severely conservative. For wave heights, the Boccotti (1989) model is in very good agreement with the field measurements, adequately accounting for changes in bandwidth.

The influence of directionality on wave statistics has also been examined by analysing co-located recordings of the water surface elevation and directional spreading. It was concluded that long-crested seas result in amplifications above the Forristall (2000) model, whilst wave height predictions are in good conservative agreement with the Forristall (1978) model regardless of the degree of directional spreading within a sea state. Additionally, the Adcock & Taylor (2009) method for extracting directional spreading information from single-point measurements, such as wave radars was examined. Its application on $8,095$ sea states recorded in the field (more than 20 times the number of the previous largest study) concluded that the method provides accurate predictions of the mean directional spreading value to within $\pm 20\%$.

Finally, the influence of non-linear wave-structure interactions due to a single,

vertical, bottom-mounted, surface-piercing cylinder (representative of a monopile of fixed offshore wind turbines) was considered. Based on the findings it is recommended that a higher-order crest elevation model (such as the Tayfun & Fedele (2007) or the Latheef (2014) distributions) is adopted in design along with a safety factor that takes into account the additional amplifications due to non-linear wave-structure interactions. Specifically, it is suggested to use an amplification factor of 1.189 and to increase it to 1.709 if run up is additionally considered. Finally, the Boccotti (1989) distribution is recommended for wave height predictions along with an amplification factor 1.3 and to increase it to 1.553 should run-up be considered.