Abstract

A new set of laboratory experiments to examine the short-term statistics of crest elevation and wave heights has been undertaken. Sea states with a range of steepness and directional spreading have been considered. Comparisons between these data and a number of widely adopted short-term statistical models exhibit clearly defined departures.

For a given sea state, the extent of these departures is directly proportional to the sea state steepness and inversely proportional to the directional spread. With directional spreading identified as a critical parameter, a detailed study of how best to describe, define and model it has been undertaken. The key finding of this study is that the average directional spread in the steepest sea states reduces. In addition, it has also been shown that on average the largest waves in these steep sea states are more uni-directional when compared to the sea state as a whole.

Further consideration of the data show that the two physical mechanisms leading to the alteration of the statistics are nonlinear amplification (leading to increases above second-order) and the dissipative effect of wave breaking. Quantification of the effects arising from these two competing mechanisms has been undertaken based on additional simulations (both numerical and experimental) of focused wave groups.

For uni-directional sea states, a classical expansion (truncated at a third order of wave steepness) of the increased surface elevation obtained in a fully nonlinear uni-directional focused wave group has been used to quantify the effect of amplification in the crest height statistics. Similarly, the dissipative effect of wave breaking on crest elevations has been quantified based on the reduction in crest elevations in focused wave groups with linear amplitude sum larger than the limit at which incipient spilling first occurs. These reductions are calculated as the difference in the maximum crest elevation in a breaking wave event and that predicted by the third-order power series used for the quantification of nonlinear amplificiation. Overall the two methods employed in quantifying the effect of nonlinear amplification and wave breaking yield good agreement with the original (random) laboratory data.

Finally, directionality is incorporated into these predictions based on the linear

reduction in the wave front steepness with increasing directional spread. Both the nonlinear amplification and the dissipative effect of wave breaking are calculated based on this reduced steepness for the directional sea states. The predicted crest heights from this simplified procedure compare well with the laboratory data; the predictions remaining conservative throughout.