

The Effect of Directionality on the Nonlinear Behaviour of Extreme Transient Ocean Waves

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The present investigation is concerned with nonlinear focused wave groups with an energy distribution both in frequency and directional domains. Focused wave groups have been investigated both experimentally and numerically from near linear crest heights to the limit of incipient wave breaking.

A wide wave basin has been calibrated. For small amplitude focused wave groups, measured surface elevations and velocity profiles are in close agreement with linear theory. The wave basin transfer function remains accurate for strongly numerate wave groups.

A nonlinear numerical model has been developed. The numerical formulation is in close agreement with experimental data for directional wave groups very close to the breaking limit.

The extremal statistics of a Gaussian wave field have been investigated theoretically and verified against random linear time domain simulations of empirical ocean spectra. A method of providing a deterministic nonlinear correction to isolated extreme storm events is proposed.

It has been found that large deviations between linear theory and observations are caused by rapid changes in wave components which very nearly satisfy the linear dispersion relationship. If free wave components can be modelled accurately, very steep wave groups can be modelled relatively accurately by free waves and second order bound harmonics.

If the linear crest height is kept constant, the effect of introducing directionality is to reduce nonlinear wave-wave interaction significantly. A reduction of the nonlinear crest height of more than 40% has been observed as a direct result of the wave field directionality. However, the maximum crest height which may be generated before breaking occurs increases with increasing directionality. A 20% increase in the limiting crest height due to directionality has been observed.

Nonlinear calculations on isolated events using an empirical ocean storm spectrum and the appropriate external statistics suggest that second order theory describes the wave field very accurately even for large events.