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Effect of higher order nonlinearity, directionality and finite water depth on wave statistics: Comparison of laboratory experiments, field data and numerical simulations.

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This research is focused on the study of nonlinear evolution of irregular wave fields in water of arbitrary depth by comparing laboratory experiments, field measurements and numerical simulations. It is now well accepted that modulational instability, known as one of the main mechanisms for the formation of rogue waves, induces strong departures from Gaussian statistics and second order based statistics. However, whereas non-Gaussian properties are remarkable when wave fields follow one direction of propagation over an infinite water depth, wave statistics only weakly deviate from Gaussianity when waves spread over a range of different directions. Over finite water depth, furthermore, wave instability attenuates overall and eventually vanishes for relative water depths as low as $kh = 1.36$ (where k is the wavenumber of the dominant waves and h the water depth). Recent experimental results, nonetheless, seem to indicate that oblique perturbations are capable of triggering and sustaining modulational instability even if $kh < 1.36$. In this regard, the aim of this research is to understand whether the combined effect of directionality and finite water depth has a significant effect on wave statistics and particularly on the occurrence of extremes. For this purpose, laboratory experiments in a large wave basin, numerical experiments solving the Euler equation of motion with the Higher Order Spectral Method (HOSM) and field experiments at the Lake George experimental site (Australia) have been compared to assess the role of third order nonlinearity, and particularly modulational instability, on wave statistics. Herein, we present a comparative analysis of the statistical properties (i.e. density function of the surface elevation and its statistical moments skewness and kurtosis) between laboratory experiments, simulations and in-situ data which provides a confrontation between the numerical results and real observations in laboratory and field conditions.