Instabilities in Ocean Wave Fields

A.V. Babanin

Swinburne University, Melbourne, Australia

Abstract.

While routine wave modelling/forecast concentrates on mean wave properties, rare extreme events are also of utmost practical interest. Such rare events are usually transient short-lived waves caused by instabilities in the wave trains/fields.

We would expect such instabilities to depend on a) whether the waves are at the spectral peak or at the tail; b) on wave spectrum and mean steepness in the wave field; c) on the directional distribution of the peak waves; d) on whether the waves are in deep water, in intermediate depth or in shallow water; e) on wave breaking; f) on the wind, particularly if it is very strong, and on the currents if they have suitable horizontal gradients. It is argued that probability distributions of rare wave events in the different circumstances according to these groups of conditions should be different, and by combining them together the inevitable scatter is introduced. The scatter and the accuracy will not improve by increasing the bulk data quality and quantity, and it hides the actual distribution of extremes. The groups have to be separated and their probability distributions treated individually.

We suggest to proceed systematically through the available data sets, by using physical understanding rather than the bulk statistical approach. If the wave trains/fields in the wave records are stable, distributions for the second-order waves should serve well. If modulational instability is active, rare extreme events not predicted by the second-order theory should become possible. This depends on wave steepness, bandwidth and directionality. Mean steepness also defines the wave breaking and therefore the upper limit for wave heights in this group of conditions. Under hurricane-like circumstances, the instability gives way to direct wind forcing, and yet another statistics is to be expected. In case of changing sea levels, whether short-term (surge) or long-term (climate), probability of extreme surface elevation will be affected greatly.