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Rogue waves, rogue events and extreme wave kinematics in spatio-temporal sheets of simulated sea states

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An approach to study rogue wave occurrence in numerical simulations of unidirectional surface waves is suggested. The spatio-temporal wave data is obtained by means of frequent acquisition of wave fields from the simulated periodic domain. The irregular waves are characterized by the JONSWAP spectrum; and the time-evolution is simulated within the strongly nonlinear solver for the Euler equations (HOSM with M = 3, M = 6) with a short-wave damping. As a result, sheets of irregular wave data of the size 20 min x 10 km with a good resolution in time and space are obtained. This data is used to visualize the dispersion relation for nonlinear waves, where wave components (free, bound and counter-directional modes) are naturally separated. The data is used for statistical analysis with the particular focus on rogue waves.

Having the complete wave data enables us to capture rogue wave surface shapes, to consider the evolution of rogue waves and to conduct a statistical analysis. Most of the simulated rogue waves have very high crests and shallow long troughs, or sign-variable shapes. “Holes in the sea”, characterized by deep troughs, are found in the simulation data as well. We assemble recurrent rogue wave accidents, which are localized close in space and time, into rogue events and then estimate the life-times. Though the life-time of a continuous rogue wave is relatively short, the life time of a rogue event may be significantly longer (dozens of wave periods).

The relation between extreme wave kinematics and kinematics of rogue waves in the stochastic simulation is discussed, and compared versus the third-order Stokes theory. Though in general the significant amount of data well corresponds to each other, some difference between kinematics of extreme waves and extreme kinematics is emphasized. Rogue waves are typically characterized by large values of velocities, but high velocities do not necessarily correspond to rogue waves.