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Short-crestedness of fully nonlinear potential waves

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In the oceanographic literature, short-crestedness of waves is often assumed to be the same feature as directionality, as opposed to long-crested waves which are unidirectional. Indeed, superposition of linear long-crested waves will create an interference pattern of modulated long crests. Lateral modulation of the long crests, however, is also a nonlinear phenomenon which for nonlinear waves occurs naturally even if the waves are unidirectional. These two contributions have different physics and metrics involved and have to be separated.

Here, we investigate short-crestedness of three-dimensional fully-nonlinear potential deep water waves whose initial spectrum is assumed to be of Pierson-Moskowitz type with directional distribution given by cosine to the power from 2 to 64. The analysis is based on the results of long-term wave simulations performed using a numerical scheme based on solving a full three-dimensional potential equation in a rectangular domain. To characterise the wave surface properties we introduce the concept of three-dimensional steepness as the vector whose magnitude is equal to the average steepness calculated along the vector direction in a horizontal plane. The results are compared with the analysis of a linear superposition of sinusoidal waves with identical directional spectra.