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Stochastic 3D Lagrange waves, asymmetry properties and consequences for marine safety

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In the stochastic Lagrange model for ocean waves the vertical and horizontal movements of surface water particles are modeled as correlated Gaussian processes. In this paper we investigate the statistical properties of wave characteristics related to wave asymmetry in the 3D Lagrange model. We present a modification of the original Lagrange model that can produce front-back asymmetry both of the space waves, i.e. observation of the sea surface at a fixed time, and of the time waves, observed at a fixed measuring station. The results, which are based on a multivariate form of Rice's formula for the expected number of level crossings, are given in the form of the cumulative distribution functions for the slopes observed either by asynchronous sampling in space, or at synchronous sampling at up-crossings and down-crossings, respectively, of a specified fixed level. The theory is illustrated in a numerical section, showing how the degree of wave asymmetry depends on the directional spectral spreading and on the mean wave direction. It is seen that the asymmetry is more accentuated for high waves, a fact that may be of importance in safety analysis of capsizing risk in connection with extreme waves.