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Nonlinear Properties of Random Gravity Waves in Water of Finite Depth

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ABSTRACT

The weakly nonlinear theory for a stationary and homogeneous field of random gravity waves in water of finite depth is developed to the third order. This describes the second-order nonlinearities as a bound wavefield that can be expressed in terms of the freely propagating first-order waves. Expressions are obtained for the second-order spectrum and for the first nonlinear correction to the free-wave phase velocity. Calculations of these nonlinearities are made for a specified spectral form (the TMA spectrum) and also for some spectra derived from measurements. Three influences are considered: (i) the directional distribution, which spreads the interacting waves and, if narrow, will enhance the bound-wave contribution to the spectrum; (ii) the growth stage, or maturity, which is quantified by the ratio of the phase velocity at the peak frequency to the surface friction velocity and, if small, will increase the nonlinearity considerably; and (iii) the depth. Although the nonlinearity increases for shallower water, the second-order spectrum is only enhanced sufficiently to produce a secondary spectral peak if the peak–wavenumber by depth product is less than about 0.6. Further, the directional distribution of the second-order spectrum is shown to imitate that of the first-order spectrum. As growth stage and depth influence the contributions of bound nonlinear waves to the spectrum at high frequencies, they also affect the specification of a spectral form in this range.

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