A kinetic model for rain falling on water waves

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We present a model for estimating the momentum flux from water drops falling onto a moving free surface. The theory is based on a kinetic approach whereby individual drops are modeled as point particles with mass and velocity, and are described collectively by a distribution function f(t; x; v; r). We show that the resulting momentum flux can be readily incorporated in free surface Navier-Stokes and Euler models. As an illustration of this approach we examine the interaction between rainfall and linear deep water surface waves. This particular application is not fundamentally different from study of Le Mehaute & Khangaonkar (1990), but our methodology is more general and is novel in its use of a kinetic approach with an all-purpose drop distribution function. The applicability of the model to linear surface waves is found to be valid for surface wave wavelengths approximately ranging from 3 m to 250 m. We further show that rainfall modifies the usual wave dispersion relationship and induces wave amplification, or damping, depending on the rain rate, the rain impact angle, and the wavelength of the surface wave. We solve for the amplification and damping rates analytically and show, among other results, that rain falling vertically will always damp the surface waves.