Effects of wave-current interactions on suspended-sediment dynamics during strong wave events

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Wave-current interactions are crucial to suspended-sediment dynamics but the roles of the associated physical mechanisms, the depth-dependent wave radiation stress, Stokes drift velocity, vertical transfer of wave-generated pressure transfer to the mean momentum equation (form drag), wave dissipation as a source term in the turbulence kinetic energy equation, and mean current advection and refraction of wave energy, have not yet been fully understood. Therefore, in this study, a computationally-fast wave model developed by Mellor et al. (2008), an FVCOM hydrodynamics model and the sediment model developed by the University of New South Wales are two-way coupled to study the effect of each wave-current interaction mechanism on suspended-sediment dynamics nearshore during strong wave events in a tidally dominated and semi-closed bay, Jiaozhou Bay, China, as a case study. Comparison of Geostationary Ocean Colour Imager data and model results demonstrates that the inclusion of just the combined wave-current bottom stress in the model, as done in most previous studies, is clearly far from adequate to model accurately the suspended-sediment dynamics. The effect of each mechanism in the wave-current coupled processes is also investigated separately through numerical simulations. It is found that, even though the combined wave-current bottom stress has the largest effect, the combined effect of the other wave-current interactions, mean current advection and refraction of wave energy, wave radiation stress and form drag (from largest to smallest effect), are comparable. These mechanisms can cause significant variation in the current velocities, vertical mixing and even the bottom stress, and should obviously be paid more attention when modelling suspended-sediment dynamics during strong wave events.