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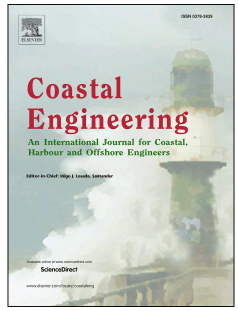

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Abstract

This study investigates the chaotic behavior of breaking waves by laboratory experiments and numerical modeling. Repeated laboratory runs with different initial velocity perturbations show that the wave profile before the wave breaks can be accurately reproduced, but the subsequent breaking process varies among runs, indicating the lack of repeatability of breaking waves in reality. Numerical simulations based on the Smoothed Particle Hydrodynamics method are further carried out to examine the repeatability of wave breaking process. Consistent with the laboratory observation, multiple numerical simulations with variations in initial conditions present highly repeatable velocity field and free surface profile in the potential flow region but considerable variation at the breaking and post-breaking processes. Comparison also shows that 3D vortex structures induced by breaking waves are different among cases. Analysis of particle trajectory reveals that there is a similar trajectory thus a minor trajectory divergence among particles that are initially located at the pre-breaking region and the flume bottom, which are not directly impacted by the breaking process. However, a much more significant particle trajectory divergence is observed among particles that are initially located at the wave-splash region and the bore propagation region. The rate of divergence of particle trajectory under breaking waves is further examined by computing the Lyapunov exponent, a widely used indicator of chaos. This study reveals that different initial velocity perturbations lead to

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