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Investigation of steepness-limited current-induced wave breaker

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A number of mechanisms could lead to wave breaking, including depth-induced, dispersive focusing, modulational instability, wind-wave, wave-current, and wave-structure interactions. Among them, the current-induced wave breaking is one of the least understood breaking mechanisms.

Using a Reynolds-Averaged Navier-Stokes (RANS) flow solver with a Volume of Fluid (VOF) surface capturing scheme, this study investigates the phenomenon of wave breaking and blocking due to strong opposing currents. The model predictions are compared with the theoretical results for wave propagation over a submerged bar in an opposing current, and a novel experiment of wave blocking solely by the spatially varying current. In the presence of a spatially varying opposing current, the wave shoals and then breaks at a much lower limiting wave steepness than that for a deepwater Stokes wave. For the two current gradients considered, only spilling breaker was observed, which is apparently more common for current-induced breaking waves. It was found that the wave radiation stress gradient due to the wave shoaling and breaking together with the pressure gradient arising from the current-induced surface tilting, determines the mean water level. Some of the characteristics of current-induced breakers are similar to those of surf zone spilling breakers. Unlike the surf zone breaker, however, the turbulence and vorticity generated by the broken wave crest are advected downstream, interact with those generated by the following wave and current, which leads to more complicated temporal and spatial variation of turbulence and vorticity.