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Undular bores in the presence of a vertically sheared current

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The evolution of two-dimensional undular bores travelling on a vertically sheared current of constant vorticity is investigated. Considering Euler equations, in the shallow water approximation, hyperbolic equations for the surface elevation and the horizontal velocity are derived. Using Riemann invariants of these equations, that are obtained analytically, a closed-form nonlinear evolution equation for the surface elevation is derived. A dispersive term is added to this equation using the fully linear dispersion relation. The heuristic introduction of dispersion allows the study of strongly nonlinear two-dimensional long gravity waves in the presence of constant vorticity.
Within the framework of the model derived from Riemann invariants with the addition of dispersion we have considered the problem of non breaking undular bores. An undular bore is formed when a sudden discharge of water at rest of depth $h(1 + \Delta)$ is initiated into a still water of depth h. To consider non-breaking undular bore, the initial relative difference in water level, Δ, is chosen less than 0.28. Favre (1935) showed experimentally that beyond this value undular bores evolve to breaking. To consider the effect of the vorticity on the height of the leading wave, h_{max}, we have run a series of numerical simulations. The height of the leading wave was recorded at 100 depths. For a fixed value of Δ, we found that negative vorticity amplifies, h_{max} whereas positive vorticity reduces the maximal height. This finding is in full agreement with the results of Touboul & Kharif (2016) who investigated the effect of vorticity on rogue waves due to dispersive focusing.