Tsunami generation, propagation, and run-up with a high-order Boussinesq model

In this work we extend a high-order Boussinesq-type (finite difference) model, capable of simulating waves out to wavenumber times depth $kh < 25$, to include a moving sea-bed, for the simulation of earthquake- and landslide-induced tsunamis. The extension is straightforward, requiring only an additional term within the kinematic bottom condition. As first test cases we simulate linear and nonlinear surface waves generated from both positive and negative impulsive bottom movements. The computed results compare well against earlier theoretical, numerical, and experimental values. Additionally, we show that the long-time (fully nonlinear) evolution of waves resulting from an upthrusted bottom can eventually result in true solitary waves, consistent with theoretical predictions. It is stressed, however, that the nonlinearity used far exceeds that typical of geophysical tsunamis in the open ocean. The Boussinesq-type model is then used to simulate numerous tsunami-type events generated from submerged landslides, in both one and two horizontal dimensions. The results again compare well against previous experiments and/or numerical simulations. The new extension compliments recently developed run-up capabilities within this approach, and as demonstrated, the model can therefore treat tsunami events from their initial generation, through their later propagation, and final run-up phases. The developed model is shown to maintain reasonable computational efficiency, and is therefore attractive for the simulation of such events, especially in cases where dispersion is important.

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