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Multilayer HySEA granular flow and tsunami model improves results over single layer models: sensitivity analysis, benchmarking against flume experiments, and implications for field scale models.

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Granular avalanches that enter a body of water present a hazard to coastal communities via their ability to generate tsunami waves. By improving the accuracy of model estimates of tsunami severity and quantifying the error of said models, we can improve the accuracy of tsunami hazard assessments. Sensitivity analyses were performed of the hybrid finite-difference finite-element model HySEA to changes in the number of vertical layers used to discretize the water column (from a single layer up to 5 layers), non-hydrostatic vs hydrostatic fluid pressures, different friction rheological laws (*Pouliquen* and *μ(I)*), and various friction coefficients. Flume experiments with matching conditions were used to benchmark simulations. An improved fit between simulation and experiment wave heights and wave frequencies, as well as improved model stability was found with 3 to 5 vertical water discretization layers compared to using a single water layer. We also demonstrate an improved fit between simulation and experiment wave heights, speeds, and form with non-hydrostatic versus hydrostatic conditions, although most simulations performed here did not accurately estimate wave speeds. Only minor changes in fit were observed between the *Pouliquen* and *μ(I)* friction laws. We demonstrate that multilayer HySEA can reliably estimate tsunami wave heights with a reasonable certainty (< 38% error) without any fitting across different granular mass volumes, grain sizes, and slopes of flow and can reach errors < 2% with only limited fitting. Furthermore, we detail how to improve model fit using additional rheological information (e.g., grain size, slope, volume of mass) and friction coefficients.