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Efficient New Approach for Solving the Dispersive Tsunami Equations

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For simulations of real earthquake tsunamis propagating over deep-sea area the linear dispersive wave (LDW) equation is commonly used, which consists of "two" equations of motion and "one" continuity equation. The dispersive terms are involved in the equations of motion. The time integration of the equations of motion is then computed with an implicit scheme, which is implemented with a Poisson solver, while the time integration of the continuity equation is calculated by an explicit scheme. In non-dispersive cases, i.e. the linear long wave (LLW), all the three equations are solved by an explicit scheme such as the leap-frog method. Implicit time integration requires much computation time than explicit one. For example, a LDW computation may takes about 50 times longer time than the corresponding LLW computation. In this study we propose a new simple approach to efficiently solve the LDW equation. The dispersive terms in the equations of motion are transferred into the continuity equation by replacing the flow rate variables to the new ones. Then, since we can solve the equations of motion using an explicit time scheme and the continuity equation using an implicit one, the computation time is generally at least four times faster than the previous procedure. We have implemented this approach into finite-difference codes for near-field and far-filed tsunami simulations to demonstrate the effectiveness of the new approach. The near-field tsunami code employs Cartesian coordinates, while the far-filed tsunami code uses the spherical coordinates and includes the Coriolis force terms. For the implicit time integration, we use the ICCG method as Poisson solver. We have also developed a PML (perfect matched layer) scheme for efficiently realizing the radiation condition at sides of computational domain. In this presentation, we show the actual numerical schemes based on the finite-difference method and illustrate their efficiency through several computational examples.

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