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Accurate 3D Bathymetry Representation in Low-Dispersion Finite Differences

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Abstract

When performing seismic modeling using a finite-difference approach, the domain is usually modeled using a regular Cartesian grid. While this method is often computationally faster and easier to implement than other modeling solutions, it presents some disadvantages when compared to methods that use unstructured meshes, such as finite-element or finite-volume. One drawback is that Cartesian grids struggle when they must conform to a non-flat interface, like a free surface with topographic features or an ocean floor with bathymetry. In the case of the bathymetry, the strong impedance between water and sediments generates complex wavefields, which, if modelled with the staircase approach on a Cartesian grid, generate high-amplitude spurious diffractions. This usually leads to dispersion errors in the simulated interface/refracted waves. We present a method to overcome this issue, based on the deformation of a fully staggered grid to accommodate grid points to interfaces between a top water layer and a bottom sediment layer. This method extends the solution for free surface and topographic features presented in de la Puente et al. (2014), by adapting the grid to arbitrary bathymetry. The resulting scheme solves spatial derivatives with high order, thus resulting in a low dispersion scheme. In addition, we show that this solution can be easily generalized to simulate any number of interfaces between sediment layers. Finally, we present the results of a comparison between this method and a simple staircase-like approximation of the water-sediment interface to quantify the differences in dispersion error between the two solutions.