FINITE-DIFFERENCE NUMERICAL SIMULATION OF SEISMIC WAVES PROPAGATION IN MODELS WITH COMPLEX BOUNDARY GEOMETRIES

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The Finite-difference method (FDM) is widely used for seismic wave numerical simulation in complex velocity models due to its efficiency and intuitive mathematical principle. A traditional mindset of FDM is that it was only used with Cartesian grids thus was not able to accurately simulate seismic wave propagation in regions with surface topography, which is not true. The true requirement relating to the grids for higher-order FDM is a structural grid, i.e., the points along grid lines can be ordered sequentially, but the grid lines could be curvilinear to conform with the boundary topography. Besides the curvilinear grids, we also need a stable free surface boundary condition implementation with enough accuracy on curvilinear grids and a FD scheme suitable for the velocity-stress equation in a general curvilinear coordinate.

In this work, I will discuss some progresses about key components of the curvilinear grid finite-difference method (CGFDM) for complex geometries, including 1) FD schemes: staggered FD with interpolation, Lebedev FD with explicit filtering, mimetic scheme, collocated-grid central FD with explicit filtering, MacCormack-type scheme with inherent dissipation, and pseudo-spectral operator; 2) Free surface boundary condition implementations: vacuum approach, one-sided FD operator, traction-image approach, and characteristic boundary condition; 3) algorithms for complex geometries: overset grid, multi-block grid, and Adaptive Mesh Refinement (AMR).