A UNIFORM-GRID FINITE-DIFFERENCE MODELLING OF SEISMIC WAVEFIELDS AROUND A VACUUM CAVITY

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A uniform-grid finite-difference (FD) modelling of seismic wavefields around a vacuum cavity still poses a non-trivial problem because the traction-free condition has to be satisfied at a curved interface between the vacuum and elastic/viscoelastic solid. We present an algorithm that we have developed using the immersed-interface approach.

We use a staggered-grid FD scheme, 4th-order accurate in space and 2nd-order accurate in time, SGFD (4,2), at all grid points except those at or near the boundary of the cavity. At those points we apply SGFD (2,2). A near-grid point means that for updating wavefield at this point, the FD stencil needs at least one grid point inside cavity. We calculate the wavefield at the grid points inside cavity using an immersed-interface method in order to account for the vacuum-solid boundary conditions. That is, we apply a special extrapolation inside a 9x9x9 grid-point cube centred at the near point. Calculation of the 9x9x9 coefficients can be performed just once – when preparing a grid model. Effectively, the FD simulation itself is then only about 10% slower compared to the case of the same model without cavity. For calculating the coefficients we use subroutines generated by the Mathematica software. The key for using Mathematica is an appropriate parameterization of the interface.

We verified our FD algorithm by comparing the FD simulations with the finite-element simulations. We have not encountered any problem with accuracy or instability even for long time windows (we tested windows up to 25 000 time levels). The level of agreement is excellent.

We have applied the developed FD algorithm for simulating seismic wavefields in the medium modified by an underground nuclear explosion.