Variable grid, finite-difference, viscoelastic seismic modeling including surface topography

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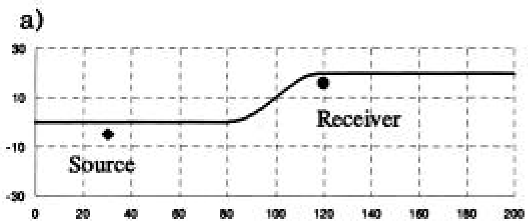
We have developed a two-dimensional viscoelastic finite-difference modeling method for highly complex surface topography and subsurface structures. Realistic modeling of seismic wave propagation in the near surface region is complicated by many factors, such as strong heterogeneity, topographic relief and large attenuation. In order to account for these complications, we use a velocity-stress staggered grid and employ an O(2,4) accurate viscoelastic finite-difference scheme. The implementation includes an irregular free surface condition for topographic relief and a variable grid technique in the shallow parts of the model. Numerical tests indicate that approximately ten grid-points per shortest wavelength with the variable grid method results in accurate calculations.



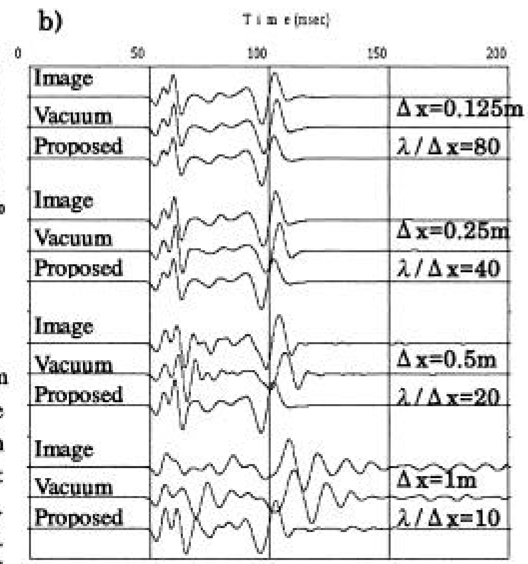
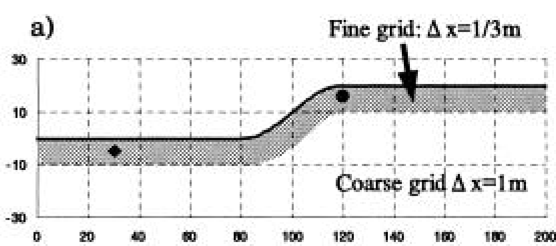


Fig. 1. a)The model used in numerical test. P-velocity=2000m/s, S-velocity=1155m/s, Dencity=1000kg/m3, Qp=10000, Qs=10000, P-wave source with a 110 Hz Ricker wavelet, Minimum wavelength(S-wave) is approximately 10m b)Time series collected at the receiver. Particle velocity perpendicular to the free surface with various grid sizes are plotted. Δx : grid size. λ : minimum wave length(approximately 10m) . Image : Robertsson's generalized image method. Vacuum : Vacuum formulation. Proposed : Proposed method.



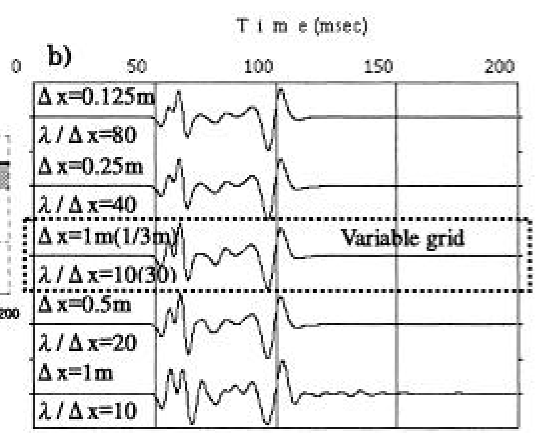


Fig. 2. a)The area of the fine grid. The grid size is 1/3m in the fine grid, and 1m in the coarse grid.

b) The comparison of the waveform calculated by proposed method with the various grid sizes.