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Nonstandard finite-difference scheme for three-dimensional viscoelastic waves

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Finite-difference Time-Domain (FDTD) is a popular method for modeling seismic wave propagation. The main drawback of the standard FDTD, especially for models that are much larger than the wavelength, is phase error due to grid dispersion. In large scale modeling, hence long propagation distances, the phase error due to the grid dispersion becomes very severe. There have been several attempts to reduce grid dispersion and anisotropy of FDTD. Among them the nonstandard scheme which was originally proposed in computational electromagnetics, is one of the most successful schemes to reduce grid dispersion and anisotropy. We have developed a nonstandard finite-difference time-domain (NSFDTD) in two dimensions (fourth-order accurate in space and second-order accurate in time) for highly accurate computation of elastic wave propagation with low numerical dispersion and grid anisotropy (JafarGandomi & Takenaka, 2009, GJI, in press), and extended the nonstandard scheme to three dimensions (JafarGandomi & Takenaka, SSJ Fall Meeting, 2008). However, our scheme could not significantly reduce numerical dispersion errors of both of P and S waves at the same time. Since we focused on improvement of S wave to optimize the parameters for the nonstandard scheme, computational errors for P wave was almost equal or a little better than those for the standard FDTD scheme. We then proposed a new nonstandard scheme which gives highly accurate solutions both for P and S waves (Takenaka & JafarGandomi, SSJ Fall Meeting, 2008).

In this study we apply our nonstandard scheme to modeling of three-dimensional (3D) viscoelastic waves. We then implement the scheme to 3D viscoelastic modeling of seismic wavefields excited by kinematic and dynamic sources.