Improving finite difference grid dispersion and anisotropy by using a nonstandard scheme for seismic wave simulation in 2D

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Finite-difference in time-domain (FDTD) is one of the most common techniques used for simulation of elastic wave propagation. This algorithm is popular because it is simple and easy to program. In the FDTD, the numerical solutions do not coincide with the theoretical solutions unless the temporal and spatial discretization steps are sufficiently fine. The Nonstandard FDTD (NS-FDTD) is a technique for obtaining the theoretical solution with rather coarse temporal and spatial discretization steps by replacing them with a correction function. The main objectives of the nonstandard scheme are to reduce numerical dispersion and anisotropy. The high accuracy nonstandard versions of the FDTD algorithms are only slightly more complicated, and existing computer programs can easily be modified to run the nonstandard algorithms. The nonstandard schemes are widely used in computational electromagnetics. In this paper we show that even the nonstandard schemes are very efficient for narrow-band simulations, but they keep their efficiency also for seismic wave simulation in a rather wide-band. We have investigated the dispersion and stability of NS-FDTD. Also our results show that the nonstandard scheme improves numerical dispersion and anisotropy very efficiently. By deriving the stability condition we show that in the case of nonstandard scheme the time step can be about 20 percent larger than the one in FDTD. Also by improving numerical phase accuracy it is possible to get accurate simulation using larger grid spacings.