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Some Aspects of Numerical Simulation of Seismic Wave Propagation

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Over the last decades, numerical simulation of seismic wave propagation has become an important tool to better understand the characterization of wave propagation and rock properties. It also plays a significant role in seismic data processing and interpretation [1]. Here, several important aspects of seismic numerical modeling of wave propagation will be mentioned, such as numerical algorithms for solving partial differential wave equations, absorbing boundary condition and high performance computing techniques.

Numerical modeling of wave propagation has been used in the most types of wave equations in time and frequency domains [2,3], for example, acoustic, elastic, poroelastic and viscoelastic equations. Several numerical algorithms such as finite difference, finite element, spectral element and pseudo-spectral methods have been used to solve those wave equations [2,4-6]. These numerical algorithms have different numerical precisions due to grid dispersion and numerical approximation.

To model seismic wave propagation in an unbounded medium, many absorbing boundary conditions have been developed for suppressing the artificial reflections at the edges of the truncated medium, for instance, paraxial conditions [7], continued fraction conditions [8] and sponge absorbing conditions [9]. Currently, widely applied boundary conditions are the perfectly matched layer (PML) [10,11] and modified PMLs such as Convolutional perfectly matched layer (CPML) and nearly perfectly matched layer (NPML) [2,12]. These PMLs, originally proposed to the first-order electromagnetic (EM) wave equations, were applied to first-order seismic wave equations with velocity-stress forms. Soon after, some PMLs are developed to second-order displacement wave equations in acoustic and elastic media [13,14].

Due to needs of large model space and computational memory, high performance techniques have received more and more attention on the development of seismic numerical modeling. After the early 90s, parallel computing techniques were fast developed based on conventional message passing interface (MPI) and open multi-processing (OpenMP) [15]. Currently, modern graphics processing unit (GPU) and GPU cluster have the tendency toward replace the conventional parallel computing techniques [16].

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