論文の内容の要旨

Development and validation of a cell-based optimally accurate method for computation of synthetic seismograms for arbitrarily heterogeneous and anisotropic Earth models －Application to spherical coordinates

（セルに基づく最適演算子を用いた任意な不均質媒体における地震波形計算手法の開発、検証、及び球座標系への拡張）

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Methods for accurate and efficient computation of synthetic seismograms in highly heterogeneous, anisotropic three-dimensional (3-D) models are essential for progress in seismology. Presently available computational methods have greatly contributed to research on inferring large scale 3-D Earth structure, but are not fully satisfactory for use in forward and inverse studies of fine scale 3-D Earth structure, because (i) most methods require great effort in setting up the computational mesh along internal boundaries and irregular surface topography; (ii) such irregular grids degrade computational accuracy; and (iii) higher-order methods are well suited for application to large scale heterogeneous models, but not to fine scale heterogeneous models. To make it possible to accurately and efficiently compute synthetic seismograms for arbitrarily anisotropic and heterogeneous fine scale 3-D models, we develop new methods which we call the “cell-based optimally accurate method (C-OPT)” for Cartesian and the “cell-based spherical optimally accurate method (CS-OPT)” for spherical coordinates. In deriving CS-OPT we use a Jacobian transformation of the weak-form of the equation of motion in order to avoid significant additional computational costs. We present several numerical examples of applications of C-OPT and CS-OPT. We confirm their validity by stability and dispersion analyses, including an analytic derivation of the stability limit of a predictor-corrector scheme of for a 2-D infinite, homogeneous, isotropic case. We show that the numerical dispersion of C-OPT is two more order smaller than that of a conventional finite-difference scheme. We also compare the accuracy of the synthetic seismograms computed by C-OPT for 2-D media with those computed using the spectral element method (SEM), which is presently one of the most widely used numerical methods. The performance of C-OPT is better than SEM for fine scale heterogeneous media. These results are also expected to hold for a comparison of CS-OPT to SEM in spherical coordinates.