Elastodynamic equation and finite-difference solution for seismic plane-wave responses of vertically heterogeneous media

Hiroki Tanaka[1], Hiroshi Takenaka[2], Takeshi Nakamura[3], Xiaofei Shi[4]

[1] Earth and Planetary Sci.,Kyushu Univ, [2] Dept. Earth & Planet. Sci., Kyushu Univ., [3] Earth and Planetary Sci,Kyushu Univ, [4] CS&S Network Technology Co., Ltd.

Plane-wave responses of vertically heterogeneous structure models (1-D media) are often computed in seismology. For horizontally layered media, they can be calculated by semi-analytical methods, such as propagator matrix method. However, for the gradient velocity or randomly heterogeneous structures, we have to use numerical methods such as the finite-difference method. The conventional codes for the 2-D or 3-D finite-difference method require huge computer memory and long computation time even for calculating plane-wave responses of 1-D media. In this study we propose a procedure to calculate plane-wave responses of any 1-D media using the finite-difference method.

We first derive an elastodynamic equation of plane-wave incidence problem for vertically heterogeneous media by applying the Snell's law to 3-D elastodynamic equation. We then discretise the velocity-stress formulation of the derived elastodynamic equation by a staggered-grid finite-difference scheme fourth-order accurate in space and second-order accurate in time. We have made a Fortran code based on them.

In this study we also investigate schemes for stress-free surface condition, and perform stability check of the code.