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Absorbing Boundary Conditions for 3D Tilted Transverse Isotropic Media

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ABSTRACT

The construction of Absorbing Boundary Conditions (ABCs) for elastic media is an issue that has been widely studied in the isotropic case, but the case of general elastic media remains an open problem. Besides, a realistic representation of the Earth must include anisotropy and in most of cases, subsurface layers are Tilted Transverse Isotropic (TTI). Applying Perfectly Matched Layers to this kind of media generally induces instabilities, which prevents us from using this popular technique which is highly efficient for isotropic media. That is why we propose here a new low-order ABC for TTI media, that is constructed from the geometry profile of the slowness curves. We thus avoid technical issues that make the construction of ABCs impossible. A rigourous methodology for the construction of ABCs is based on the diagonalization of the elastodynamic system. This approach has been proposed by Enquist and Majda [2] for strongly hyberbolic systems. It also provides a very elegant process for the derivation of ABCs on arbitrarily shaped boundaries [1]. Nevertheless, in practice, it can quickly become uneasy to use because of coupling terms between P-waves and S-waves that are difficult to handle in the first stage of the diagonalization. The coupling results indeed in eigenvalues which are difficult to exploit for the construction of efficient ABCs. A possible approach consists then in uncoupling these waves and constructing ABCs for each of them. By this way, we can construct ABCs for Vertical Transverse Isotropic (VTI) media, which are particular TTI media where the anisotropy possess a symmetry along the vertical axis. Next, the P-waves and S-waves VTI ABCs can be mixed in order to form unsplitted PS-waves low-order VTI ABCs. Unfortunately, considering the TTI case, even the splitting of the PS-waves into P-waves and S-waves does not help anymore. This is due to the characteristic angles of rotation of the symmetry axis that prevent from obtaining a local ABC. In this work, we propose a new TTI ABC that includes any characteristic of the media providing this anisotropy is elliptic. The construction of the new ABC is then based on a change of coordinate that transforms a rotated ellipsoid, representing the slowness curve of the TTI P waves, into a sphere, representing the slowness curve of the isotropic P-waves. The ABC is then obtained by applying the inverse coordinate change to the isotropic ABC. Finally, the P-waves and S-waves ABCs are mixed in order to obtain unsplitted PS-waves low-order TTI ABCs for elliptic anisotropic media. Numerical results assess the efficiency of the proposed ABC and illustrate the fact that the ellipticity hypothesis is not restrictive, so that the ABC can applied to general TTI media.

REFERENCES

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