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Approximate calculation of group velocity of anisotropic media in the shortest path method

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Shortest path method calculates travel times between sources and receivers by searching the shortest travel time path connecting nodes distributed in the target area. In order to apply this method to anisotropic media, group velocity between two nodes should be calculated. The other part of program is almost same as in isotropic media. In the anisotropic media, phase velocity and group velocity is different. Phase velocity vector and group velocity vector are also different. In weak anisotropic media, the differences are negligible and the difference of ray path due to it is also neglected in general. In this study, we take the difference into account.

At each media node, we calculate group velocity vectors as well as phase velocities in many directions around the node by solving Christoffel equation. We assume six planes around the node. Two components of unit direction vector at the node, parallel to the plane, are two local coordinates on the plane. Grid points are distributed at cross points of the local coordinates. The direction vector is obtained by the group velocity vector, not the phase velocity vector. We fit the group velocities with spline function on each plane and interpolate group velocities at the grid points. The interpolated group velocities are stored and group velocity at the node in arbitrary direction is obtained by linear interpolation of the stored data. In strong anisotropic media, the fitting fails, so that we cannot use this approach.

We add this process into our shortest path method program and apply it to the anisotropic velocity structure of the low velocity layer of PREM model. We get travel times at receivers in horizontal and vertical directions from the source location. The travel tines are same as theoretically expected. The ray paths are little deviated from those in isotropic media. The reason will be that the anisotropy of the PREM is weak.

Keywords: shortest path method, anisotropy, group velocity