Seismic waveform modelling and inversion with velocity-deviatoric stress-isotropic pressure formulation

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In waveform inversion, most of the existing adjoint-state methods are based on the second-order elastic wave equations subject to displacement. The implementation of the acoustic-elastic coupling problem and free-surface in this formulation is not explicit, especially for arbitrary boundaries. The formulation of velocity-deviatoric stress-isotropic pressure can tackle the above issue. We firstly review the difference between velocity stress equations and velocity-deviatoric stress-isotropic pressure equations. Then the adjoint state of the velocity-stress equations are derived, decomposing stresses into their deviatoric and isotropic parts. To simulate the unbounded wavefield, perfectly matched layers (PML) are embedded into the system of equations. It is modified for cheap computation, which avoids PML-related memory variables by applying complex coordinate stretch to three Cartesian axes in parallel.

A 3D velocity-deviatoric stress-isotropic stress formulation is implemented with the staggered finite-difference method for several synthetic models (including anisotropic models). And inversions are then performed to reconstruct the model parameters, which is followed by a sensitivity analysis.

This method has the potential to be used with real data, both for active and passive seismics. However, in its current form, since it does not treat fluid/anisotropic solid interfaces correctly, it is limited to fluid or isotropic solid problems.