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Seismic Simulations Using SPECFEM2D: Potential and Limitations of 2D Tomography

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Introduction

This work aims to evaluate the ability of computational seismic tomography to represent geological structures simulated in controlled environments. Using the SPECFEM2D simulator, which is based on the Spectral Element Method (SEM), we modeled the propagation of seismic waves across various two-dimensional mesh configurations. From the simulated data — analogous to what would be recorded by real receivers — we generated tomographic images and compared them visually and structurally to the original models. This comparison is essential to understand the level of fidelity that seismic tomography can offer in capturing the initial features of the mesh, enabling us to assess both its limitations and potential.

Method and/or Theory

The mathematical formulation of seismic waves stems from combining Hooke's Law, which relates stress and strain, with Newton's Second Law of Motion, resulting in the second-order elastic wave equation. By assuming plane wave solutions, it is possible to derive expressions that define the propagation velocities of P and S waves.

For the meshes used in the simulations, dimensions were set to 5000 meters in length and 3000 meters in depth, with a seismic source placed at the center and 20 receivers aligned along the x-axis, all at the same depth as the source.

Results and Conclusions

Using data from incident, reflected, and refracted waves collected by the receivers, it is possible to infer how the sediments are arranged within the mesh. This confirms that the data acquisition method allows for the characterization of basic subsurface properties without the need for direct physical interaction with the medium.