Finite-difference wave equation migration

René-Edouard Plessix, Wim Mulder

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Abstract

Accurately imaging the earth is one of the major challenges in the hydrocarbon industry. Over the last three decades, imaging techniques (migration) based on the high frequency approximation of the wave equation (ray theory) have been very successfully developed in two and three dimensional spaces. However, when the medium is very complex, with strong lateral velocity variations and heterogeneities, the so-called ray-based migration techniques reach their limits. There is a need to develop imaging techniques based on a finite-difference discretization of the wave equation to avoid the high frequency approximation. In three dimensional spaces, it is still too expensive to solve the wave equation either in the frequency domain or the time domain for imaging purpose on an area on several tens of kilometer square. Currently the hydrocarbon industry is using the so-called one-way or paraxial approximation. In two-dimensional spaces, we have developed frequency domain migration algorithms based on the solution of the (full) wave equation with a direct solver. It is not possible to directly extend this approach in three dimensional spaces because the wave equation cannot be solved with a direct solver and the current iterative solvers are not good enough. A more efficient iterative solver is then required to solve the wave-equation in the frequency domain. In this presentation, we will briefly explain the current imaging techniques and will discuss the computational issue of the migration based on the finite-difference solver of the wave equation.