Database setup for non-repeatability studies for 4D FWI

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Abstract

Reservoir changes resulting from hydrocarbon production and fluid injection are essential information to optimize oil production. Full Waveform inversion (FWI) has recently been widely applied to time-lapse seismic data as a reservoir monitoring tool. However, non-repeatability (NR) issues between baseline and monitor surveys cause artifacts in the FWI recovery model, leading to misinterpreted 4D changes. Therefore, evaluating non-repeatability effects in the 4D data is a helpful tool to differentiate artifacts from 4D changes in the inversion process. We generated a monitor database using four different NR scenarios to understand the characteristics of the NR effects on seismic data. In this work we simulate seismic acquisitions with different non-repeatability problems, by using a wave propagator that solves the second order wave equation by using the finite difference method. We simulate non-repeatability effects in four scenarios.

In the first scenario, we simulated the perfect repeatability between the baseline and monitor survey. In the second scenario, we modeled the NR position, where the positions of sources and receivers are not the same for baseline and monitor surveys. We shifted laterally the positions of shots and receivers using a random distribution. As the variations of the sources and receiver positions not necessarily coincides with finite difference grid, we use the sinc interpolation to interpolate the outgrid positions. In the third scenario, we simulated the situation where the velocity of the water layers varies between the surveys. To do that, we modified the top of the velocity model by a linear perturbation. Finally, in the last scenario, we combined the second and third NR effects to create a more complex scenario. We used a typical Brazilian pre-salt model to model the baseline data and to simulate a 2D Ocean Node Bottom acquisition (OBN). To create the 4D anomaly, we add a Gaussian perturbation in the reservoir area, simulating a velocity variation caused by fluid injection. We also generate a synthetic dataset containing 24 monitor surveys for machine learning training from those four NR scenarios. For this, we combined different position errors and layer water velocity perturbations.