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Broadband FAZ Land Data: an Opportunity for FWI

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Summary

There are very few applications of full waveform inversion (FWI) on land data. This is commonly attributed to data-specific challenges. However, modern broadband full-azimuth (FAZ) land surveys offer an extraordinary opportunity for applying FWI. They have dense surface and offset sampling X and Y directions, and contain very low frequencies down to 1.5 Hz. We demonstrate in this study and in other real data examples from the Sultanate of Oman that it is possible to benefit from the broadband spectrum of modern land acquisitions to obtain a high resolution velocity model reliably using FWI.

Introduction

Compared to marine data, there are very few applications of full waveform inversion (FWI) on land data. This is commonly attributed to data-specific challenges associated with elastic effects and near surface heterogeneities, as well as noise from industrial or human activity. However, modern broadband full-azimuth (FAZ) land surveys offer an extraordinary opportunity for applying FWI. They have dense sampling in terms of shot and receiver distribution and in both X and Y directions (hence the FAZ denomination), benefit from long offsets, and contain very low frequencies down to 1.5 Hz (Mahrooqi et al., 2012). We demonstrate in this study and in other real data examples from the Sultanate of Oman that it is possible to benefit from the broadband spectrum of modern land acquisitions to obtain a high resolution velocity model reliably using FWI.

One of the key points of our land FWI applications is a dedicated data pre-processing sequence tailored to enhance data quality especially at low frequencies and long offsets as well as removing surface related noise and mitigating elastic effects. The critical aspect of the broadband pre-processing sequence consists of tuning of processing parameters at each frequency octave (Retailleau et al., 2014).

We obtain a high resolution velocity model (up to 13 Hz) using reflected waves in addition to diving waves (Sedova et al., 2017). For the estimation of anisotropy, we promote the use of joint first-break and reflected wave tomographic inversion, which effectively solves the trade-off between anisotropic and velocity parameters (Allemand et al., 2017). We also demonstrate that by using Optimal Transport FWI (Poncet et al., 2018) we are able to exploit more of the low-frequency content of the data to mitigate local cycle skipping issues and obtain geologically consistent velocity model (Sedova et al., 2018).

References

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