# Full Waveform Inversion (FWI)

Service: Time-lapse/4D | Seismic Tomography | Elastic

Brief Summary: I have developed a localized FWI algorithm in which iterative modeling is performed locally, allowing us to extend inversions for higher frequencies with little computation effort.

## Motivation

Seismic full-waveform inversion (FWI) is a powerful method used to estimate the elastic properties of the subsurface. To mitigate the nonlinearity and cycle-skipping problems, in a hierarchical manner, one first inverts the low-frequency content to determine long- and medium wavelength structures and then increases the frequency content to obtain detailed information. However, the inversion of higher frequencies can be computationally very expensive, especially when the target of interest, such as oil/gas reservoirs and axial melt lens, is at a great depth, far away from source and receiver arrays.

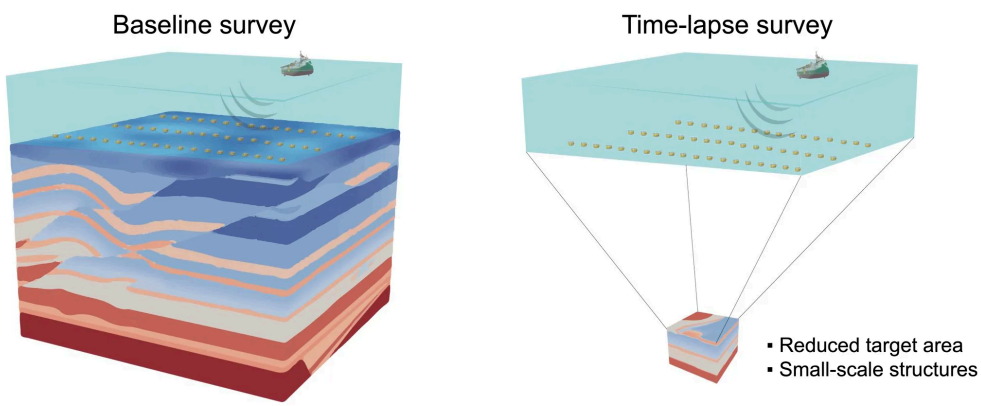


Figure 1. Target-oriented full waveform inversion.

## Method

To address this problem, we have developed a localized FWI algorithm in which iterative modeling is performed locally, allowing us to extend inversions for higher frequencies with little computation effort. Our method is particularly useful for time lapse seismic, where the changes in elastic parameters are local due to fluid extraction and injection in the subsurface. In our method, the sources and receivers are extrapolated to a region close to the target area (Figure 1), allowing forward modeling and inversion to be performed locally after low-frequency full-model inversion for the background model, which by nature only represents long-to-medium wavelength features. Numerical tests show that the inversion of low-frequency data for the overburden is sufficient to provide an accurate high-frequency estimation of elastic parameters of the target region.

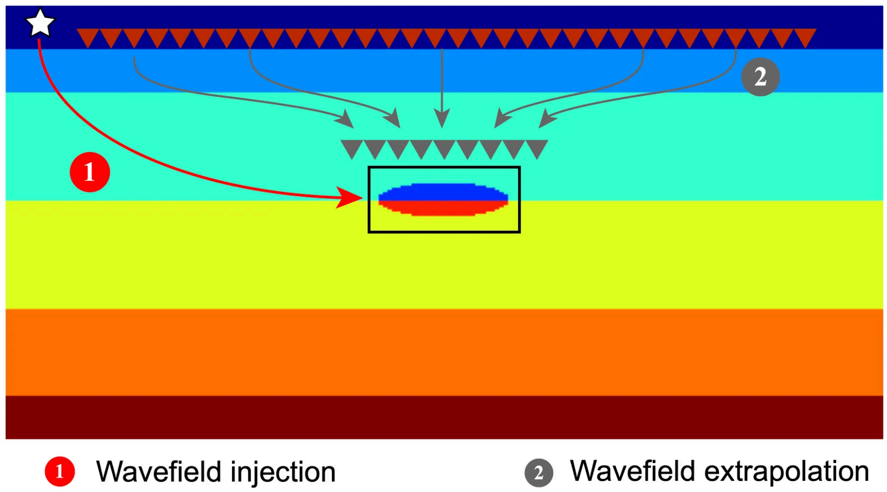


Figure 2. A schematic illustration of the proposed localized inversion in a layered model. White star denotes the physical source. Red and blue triangles denote physical and virtual receivers, respectively.

In Figure 2, we schematically illustrate how we conduct the proposed high-frequency localized waveform inversion for time-lapse surveys. We start from the low-frequency baseline full-model FWI aiming at retrieving the long- and medium-wavelength structures (Figure 2a). The inverted models are then interpolated to enable the high-frequency localized FWI. The Green's functions and injection sources (boundary wavefield) are precalculated and stored in preparation for the receiver-side of wavefield extrapolation and source-side injection, respectively, based on the inverted and interpolated baseline models (Figure 2b). In the following section, we explain and verify these processing sequences with various numerical
examples.

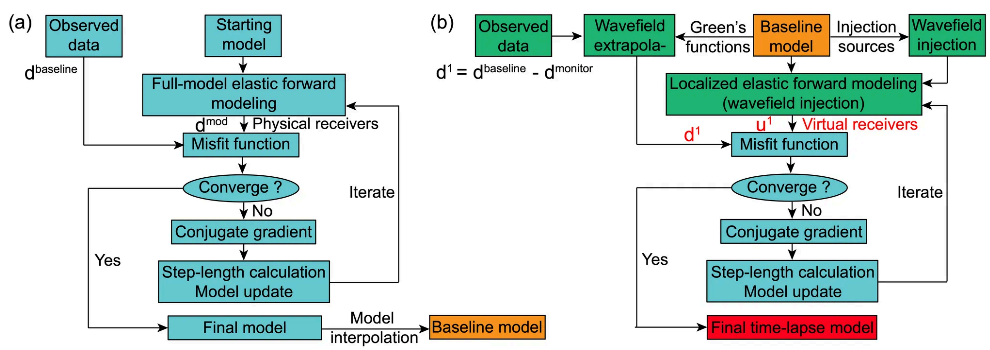


Figure 3. Processing sequences of the proposed high-frequency localized waveform inversion. (a) First, low-frequency full-model elastic waveform inversions to achieve the baseline model. Inverted baseline models are then interpolated to enable the high-frequency localized inversion. (b) Second, the high-frequency localized inversion after wavefield extrapolation and injection based on the interpolated baseline models.

## Presentation

Towards localized waveform inversion with seismic translation, rotation and s...

## References


- Yuan, S., Fuji, N., Singh, S., & Borisov, D. (2017). Localized time-lapse elastic waveform inversion using wavefield injection and extrapolation: 2-D parametric studies. *Geophysical*