Time-lapse full-waveform inversion: how wrong are we and how do we find out?

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Multiple seismic data sets are often recorded to monitor changes in Earth properties. The first survey acquired over a field is called a baseline survey and all the following surveys are called monitor surveys. Thus far, Full Waveform Inversion (FWI) has been efficiently used to image changes in Earth properties between surveys. The goal of FWI is to deliver a velocity model of Earth properties by using measured and predicted seismic data. As in any other measurement, uncertainty is very important particularly as we are often looking for small changes inside a reservoir.

To determine how errors in the model translate into errors in the final image, we are using a method called Alternating Full Waveform Inversion (AFWI). In AFWI we use the differences in how baseline and monitor models converge to determine a set of weights. These weights are then used to constrain the final joint inversion for changes in material properties, highlighting areas that have been identified as having the highest probability of changes.

In this study we use a simple 2D numerical model of two horizontal reflectors where the distance between them changes from the baseline to monitor model. We create one hundred noise realizations and add them to the velocity models. We then apply AFWI to determine the final time-lapse change image. For each of these images the distance between the two recovered reflectors Δz is calculated and then plotted on a histogram.

Our results follow a normal distribution with most concentrated around the mean value, which is the true change in this simple model. This outcome opens the possibility of calculating the absolute errors. Current and future work is focused on addressing this.

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