Uncertainty in 4-D imaging

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Monitoring of an oil field for changes in reservoir parameters during production is important for efficient oil recovery planning. The technique most commonly used to do this is time-lapse (4-D) seismic. Full Waveform Inversion (FWI) is a promising tool for 4-D analysis. The objective of FWI is to deliver a velocity model of the subsurface by iteratively matching modelled and recorded data. FWI iteratively updates the Earth model, and 4-D changes can then be related to changes in elastic properties (e.g., pressure, fluid saturation, density).

Uncertainty is a key component of any measurement, especially in 4D monitoring where we are primarily looking for small changes in a localized region. Current methodologies do not provide a measure of the accuracy of the estimated changes, essential to developing effective production. In this research, we aim to develop a framework for uncertainty quantification, in order to improve the monitoring of fluid movement in time-lapse surveys.

Previous work developed preliminary ideas for assessing uncertainty where the background model is improved by exploiting information from both baseline and monitor datasets, and the time-lapse changes are differentiated from the background, also using both data sets. Here, a confidence map is provided to show how reliable the results are. Others demonstrated a method in which they invert for the baseline and monitor model simultaneously, minimizing in this way unwanted model oscillations that may mask useful production- induced changes. Their observed results showed clear advantages compared to traditional FWI methods.

Using these ideas and methodologies, we are working to provide an appropriate framework for assessing uncertainty. Several numerical experiments will be tested and we will begin to put in place a more rigorous uncertainty assessment. The final goal of this research is a realistic measure of uncertainty in velocity changes within the reservoir.

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