Single-source rapid-repeat time-lapse elastic FWI based on the DAS-VSP data

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Abstract

Last year, to track the transient changing levels of CO_2, we employed elastic full waveform inversion (EFWI) to identify anomalies in single-source rapid-repeat time-lapse VSP data. The time-lapse EFWI inversion outcomes, relying on differences in data norms, have demonstrated their ability to identify and assess changes in time-lapse data caused by the injection of CO_2. However, the data norm difference response only in the geophone data instead of the distributed acoustic sensing (DAS) data. In theory, the injection of CO_2 into the formation is expected to change the elastic parameters, resulting in noticeable changes in the difference between the shot gathers before and after the injection. This change typically manifests as distinct upgoing wavefield data. Therefore, we develop an inversion strategy that relies on the difference of upgoing DAS data. This strategy aims to determine whether it can effectively detect transient changes based on DAS data during the injection of CO_2.

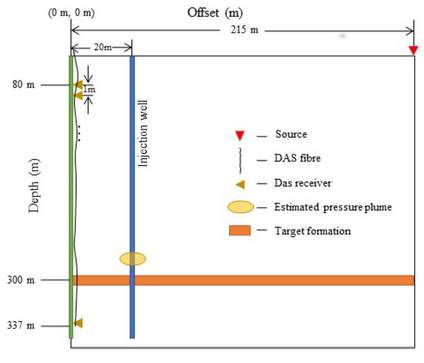

Figure 1: (a) The schematic diagram for the upgoing and downgoing wavefields based on the Tiny bubble geometry.

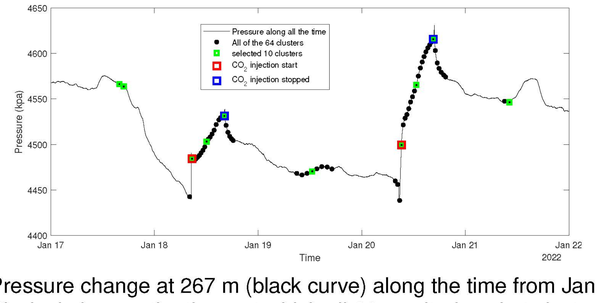

Figure 2: Pressure change at 267 m (black curve) along the time from Jan 17 to Jan 22, 2022. Black circles are the times at which all 64 monitoring shot clusters occurred. Red squares and blue squares indicate the start and end of CO_2 injection, respectively.

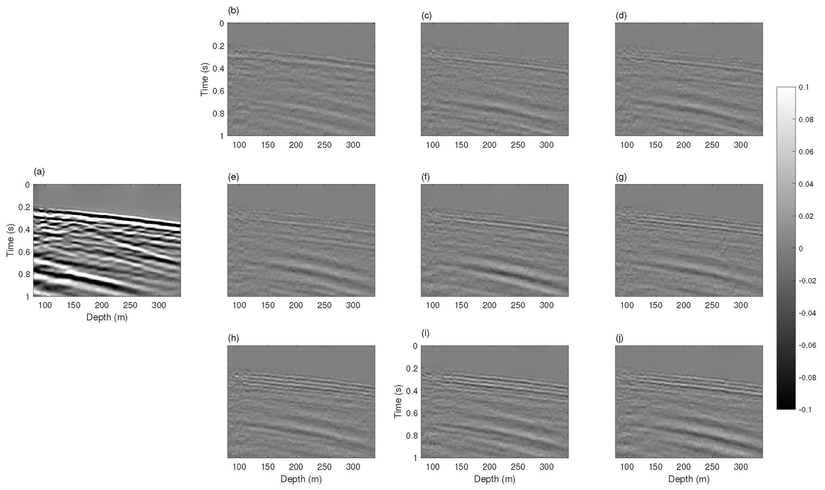

Figure 3: (a) The processed baseline cluster 1 data. (b)-(j) represents the data difference between clusters 3, 5, 13, 22, 31, 39, 47, 56, and 64 compared to the cluster 1 baseline.

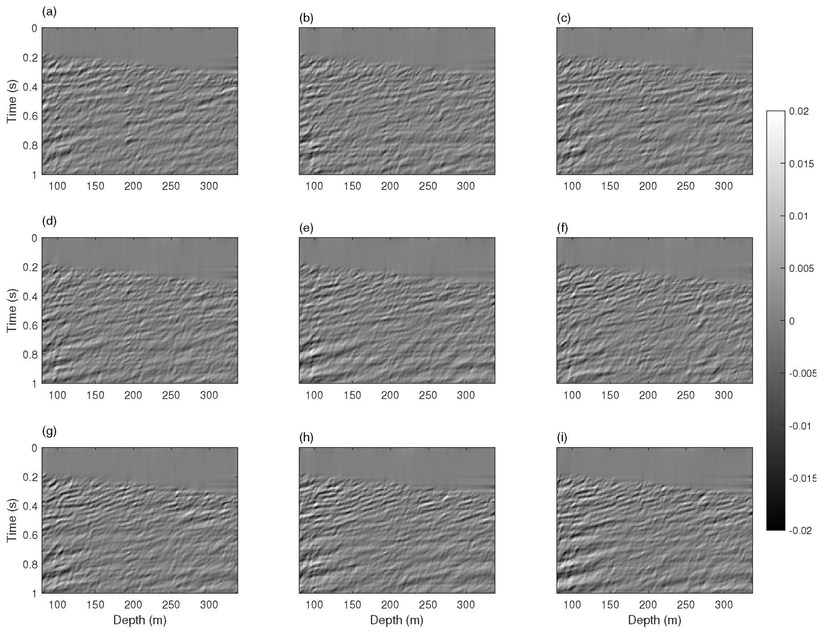

Figure 4: (a)-(i) represents the separated upgoing wavefields difference between clusters 3, 5, 13, 22, 31, 39, 47, 56, and 64 compared to the cluster 1 baseline data.

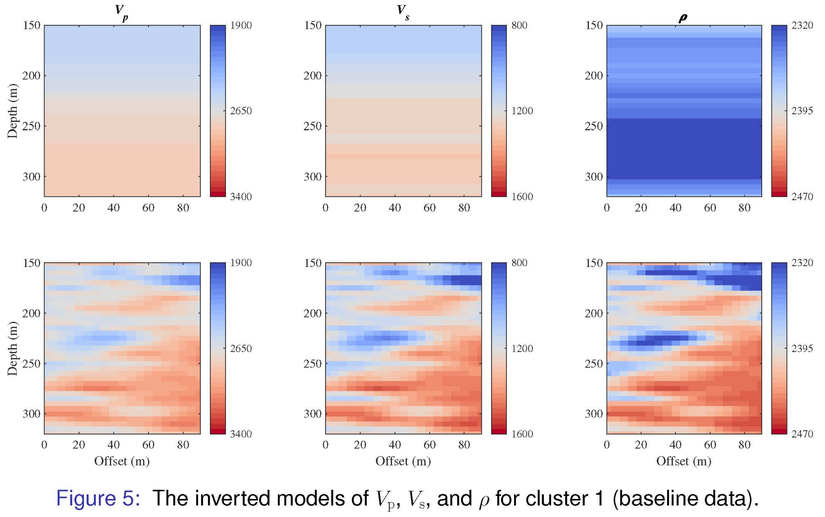

Figure 5: The inverted models of V_{p}, V_s, and ρ for cluster 1 (baseline data).

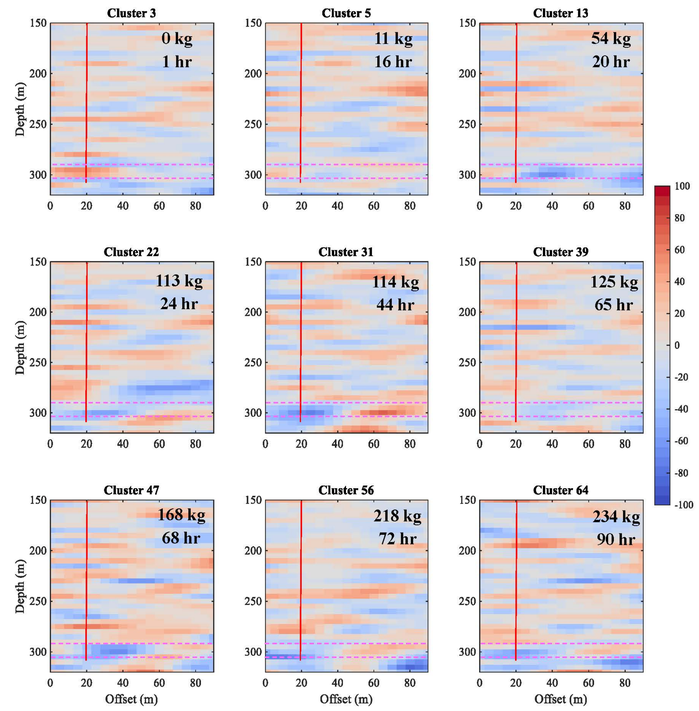

Figure 6: The inverted V_{p} models difference between the 9 monitor data and baseline.

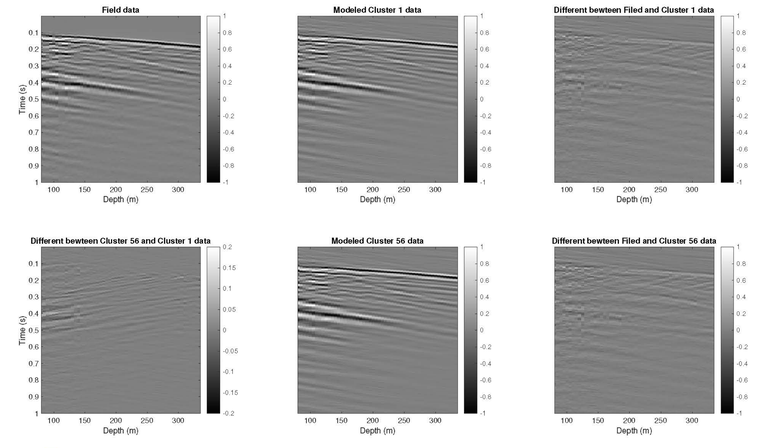

Figure 7: The comparison between the inverted offset VSP gathers and the field data in the time domain.

Conclusions

- The DAS-VSP EFWI could achieve high-resolution models depicting the subsurface's physical properties.
- The challenge arises with the single-source rapid-repeated time-lapse DAS-VSP EFWI detecting anomalies in parameters.
- It is hard to identify the location and trends of anomalies by the DAS-VSP data compared with last year's combined geophone and DAS data.

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