

Multi-parameter elastic full-waveform inversion based on the time-lapse VSP Snowflake data

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Abstract

Vertical seismic profile (VSP) is one of the technologies for monitoring hydrocarbon production and CO₂ geosequestration. We present a workflow of three-parameter elastic full-waveform inversion (EFWI) applied to VSP field data to identify and estimate time-lapse changes introduced by injection of CO₂ at 300 m depth. Application of this workflow to the Snowflake field data shows that EFWI is able to detect and quantify the time-lapse anomaly in P wave velocity with the magnitude of 130-210 m/s.

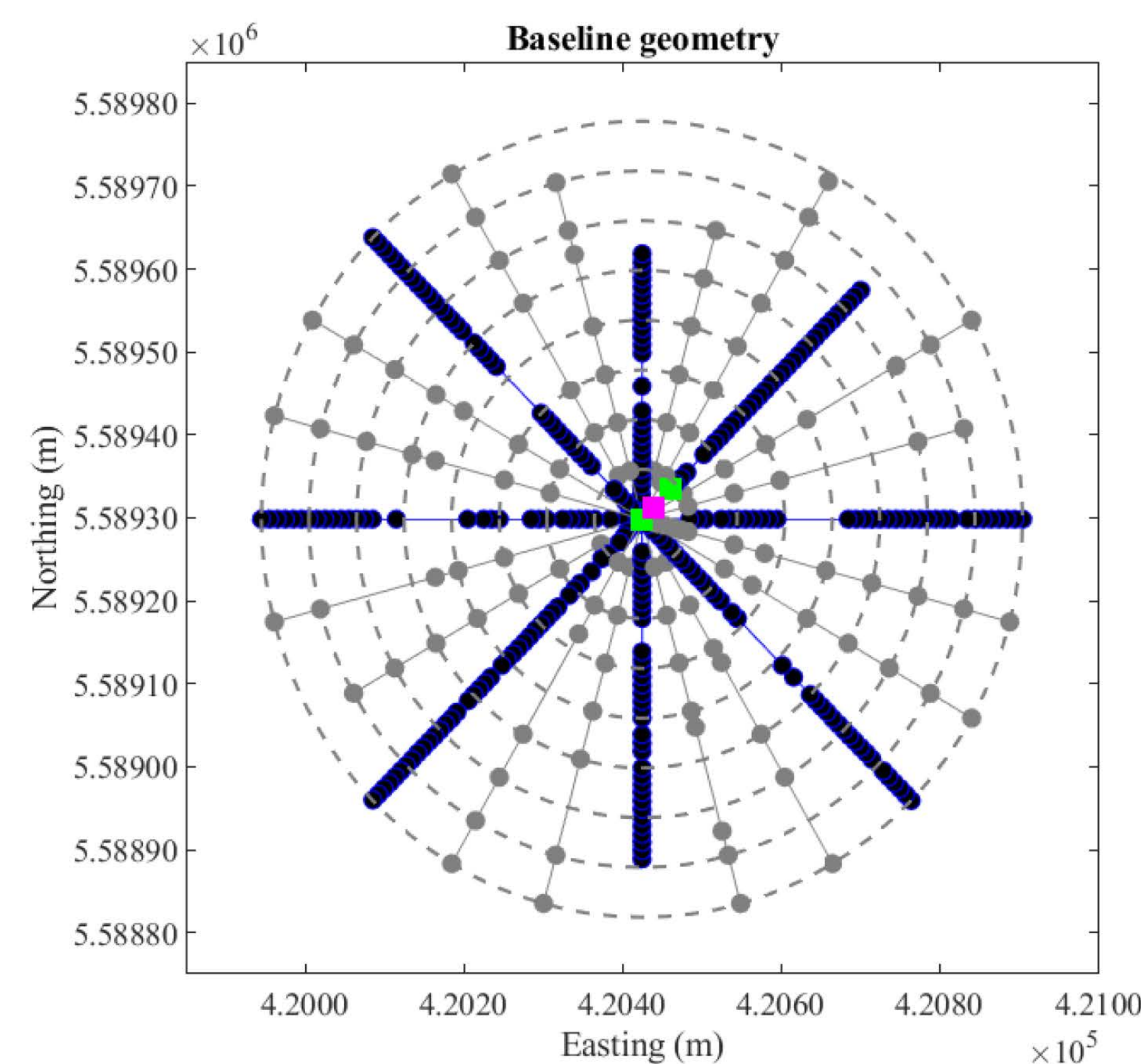


Figure 1: Baseline shots geometry.

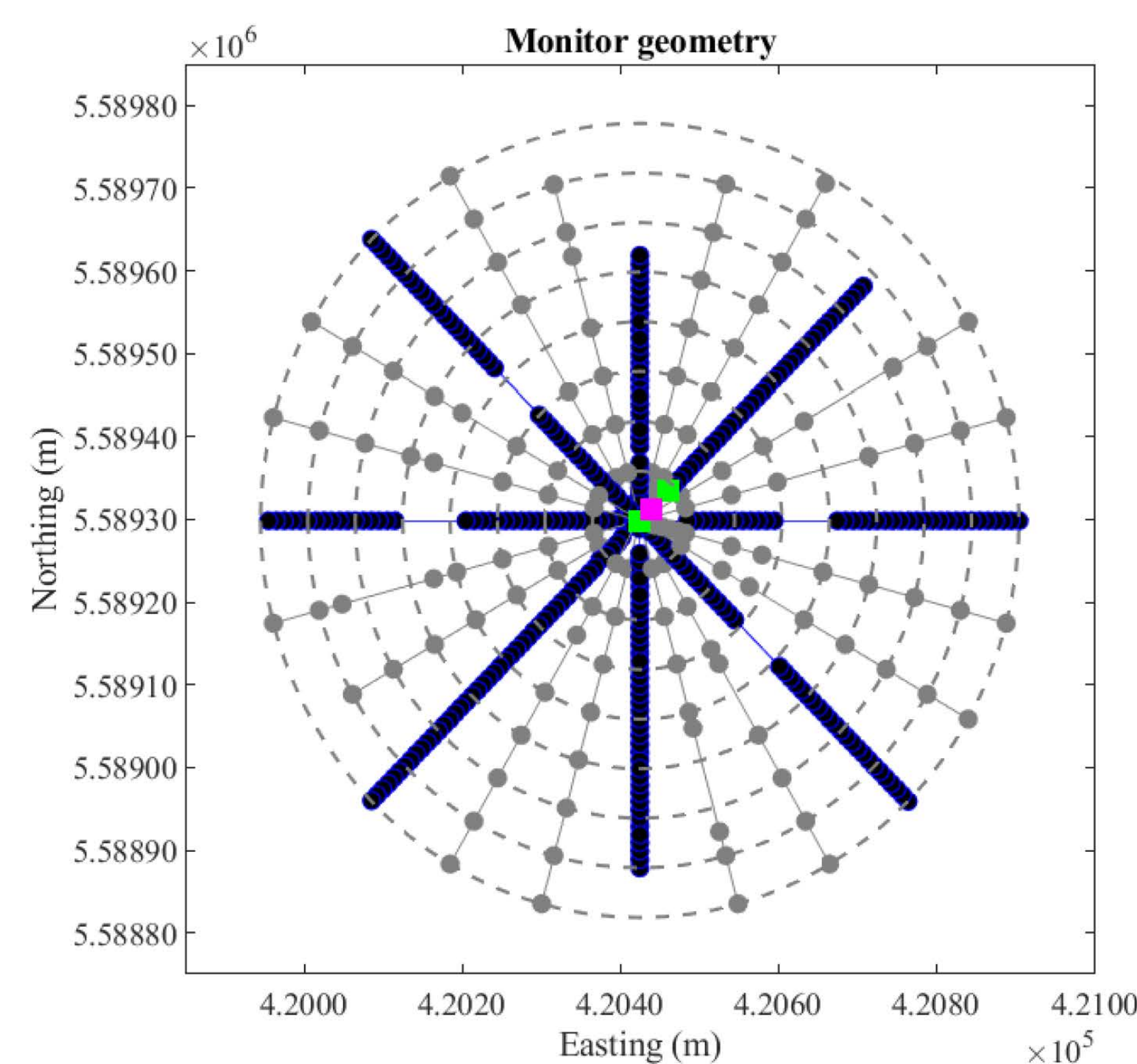


Figure 2: Monitor shots geometry.

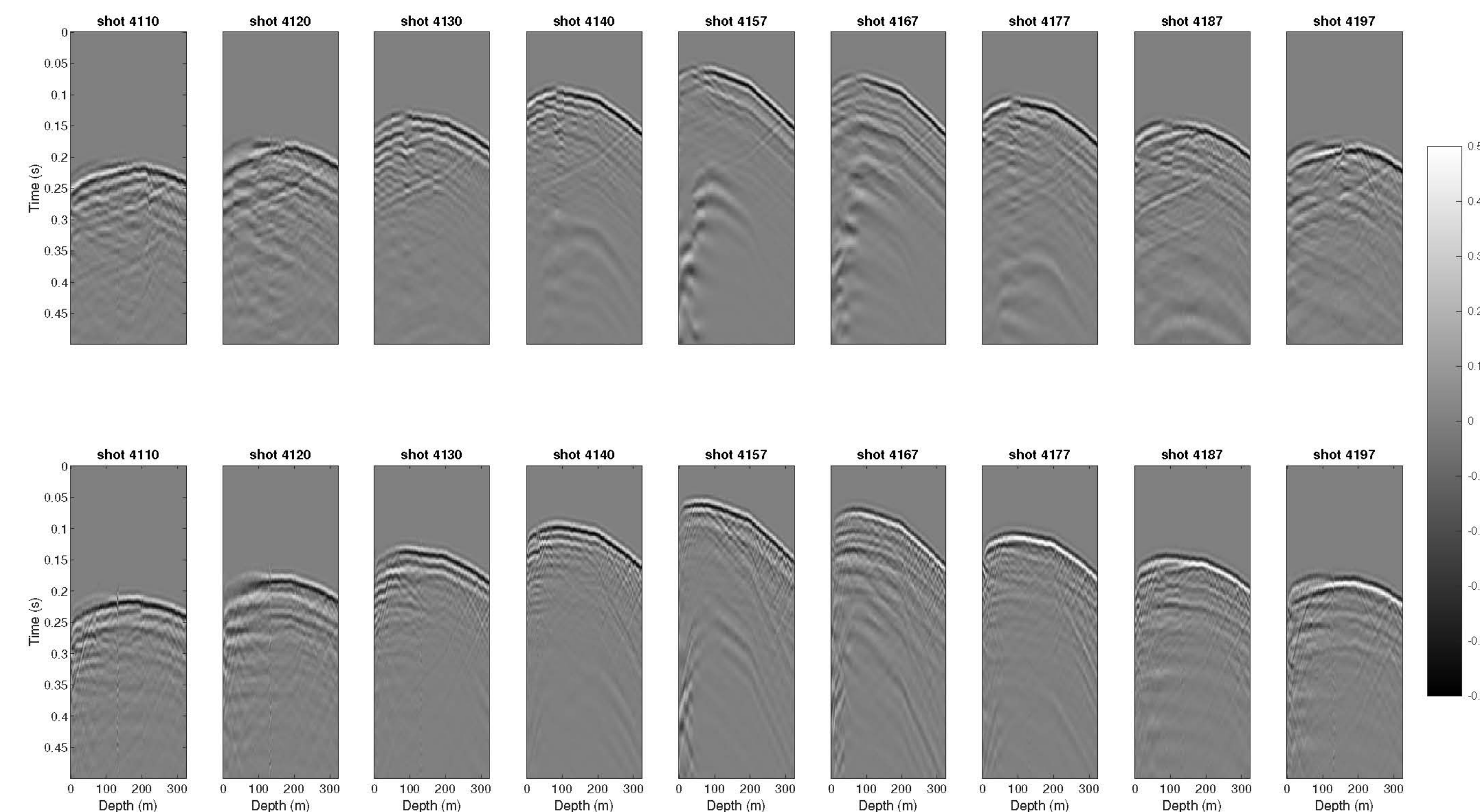


Figure 3: The processed baseline data acquired in 2018: vertical component (top row) and Hmax component (bottom row).

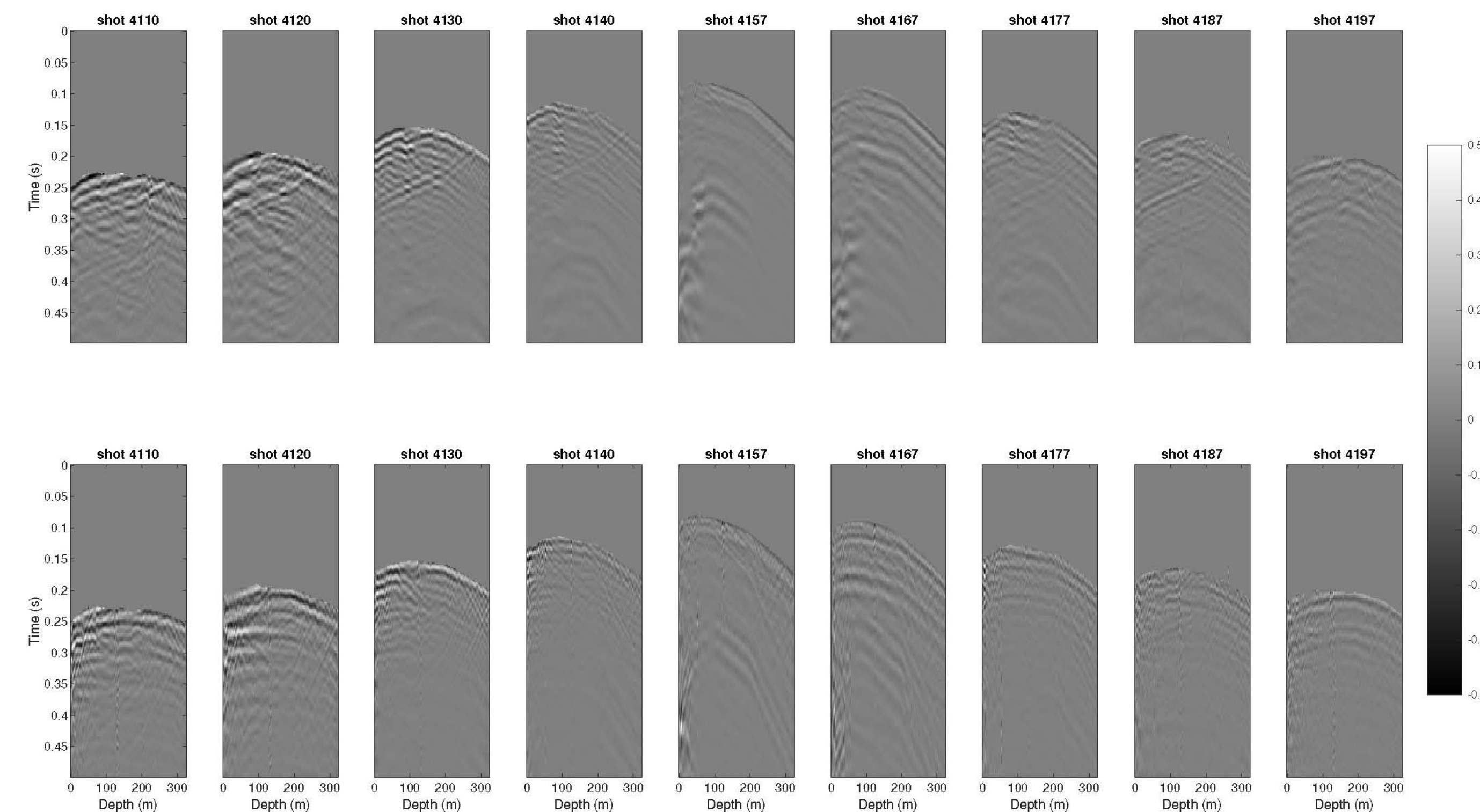


Figure 4: The difference between monitoring data and baseline data: vertical component (top row) and Hmax component (bottom row).

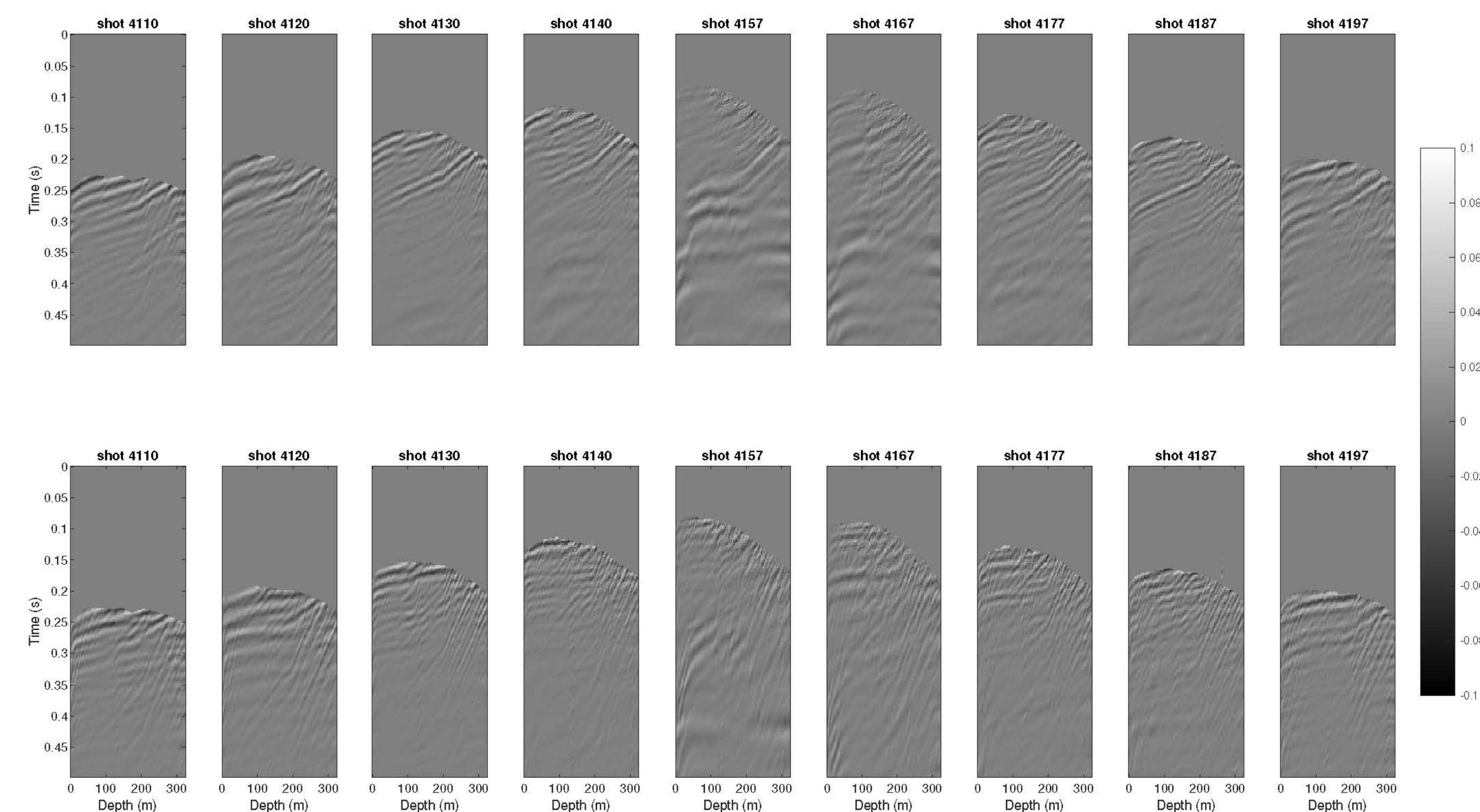


Figure 5: The separated difference upgoing wavefield between monitoring data and baseline data: vertical component (top row), and Hmax component (bottom row).

Acknowledgments

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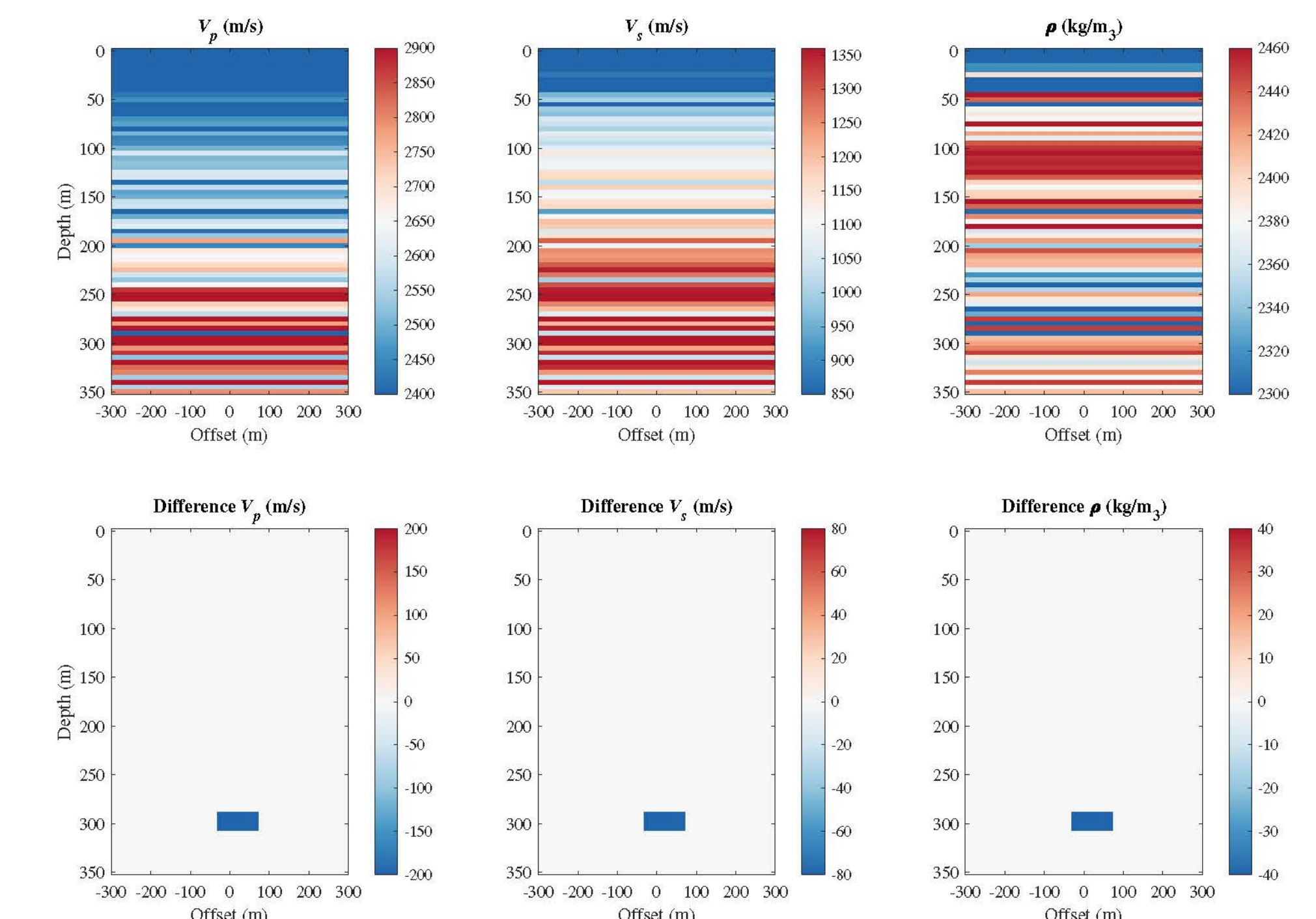


Figure 6: The synthetic true model and time-lapse true model.

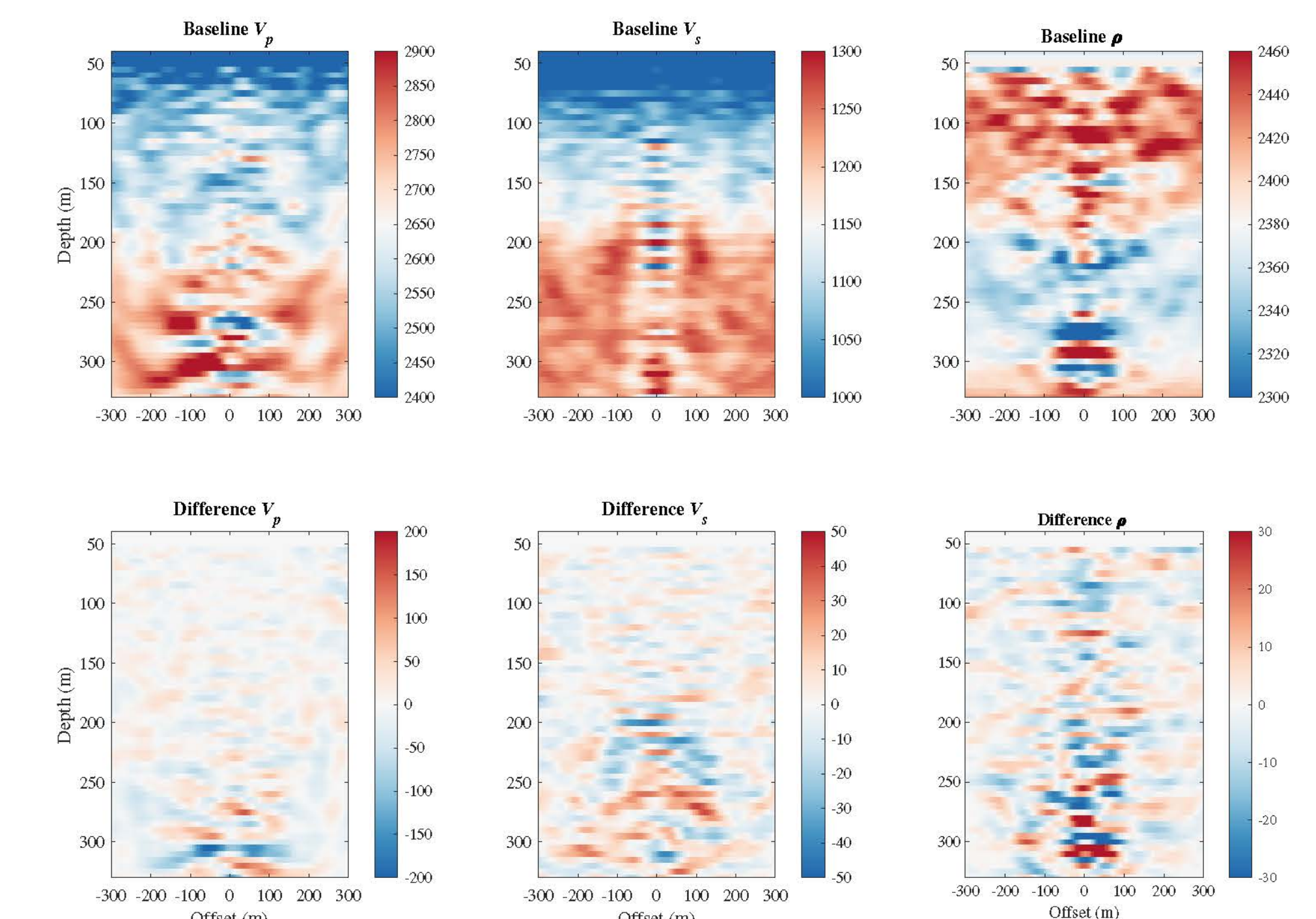


Figure 7: The inverted baseline V_p , V_s , and ρ , models, and the inverted time-lapse V_p , V_s , and ρ , models.

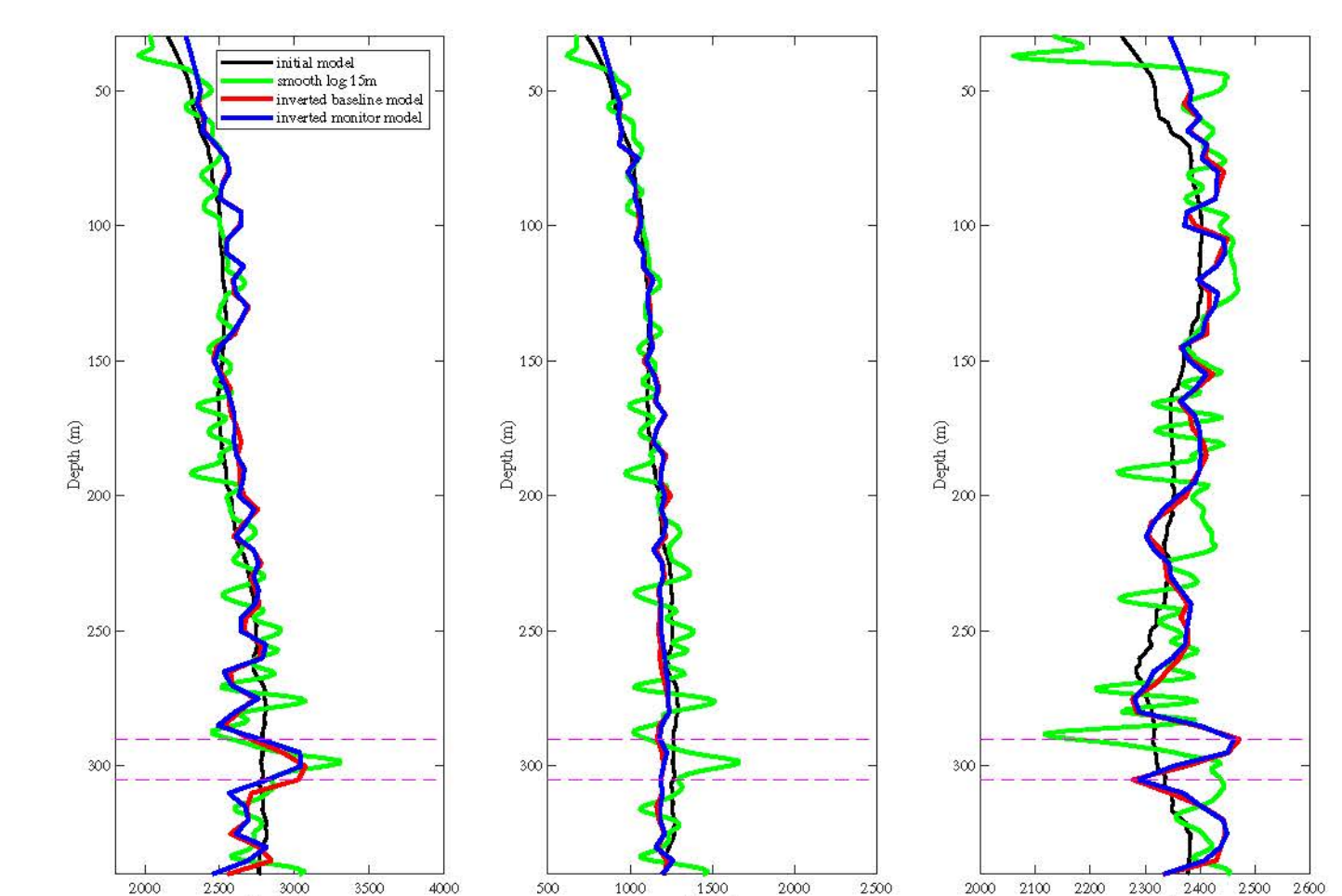


Figure 8: The comparison of the initial and inverted baseline and monitoring velocities with the well logs data.

Conclusions

- The EFWI could effectively identifies and quantifies anomalies within P-wave velocities.
- Our study detected a magnitude of V_p anomaly ranging between 130–210 m/s.
- Upon comparing the field data inversion results with the well log data, it became evident that V_p displays a good match around the target zone.