The 2018 CREWES VSP survey: FWI of the accelerometer and straight DAS fiber datasets

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CREWES Sponsors Meeting
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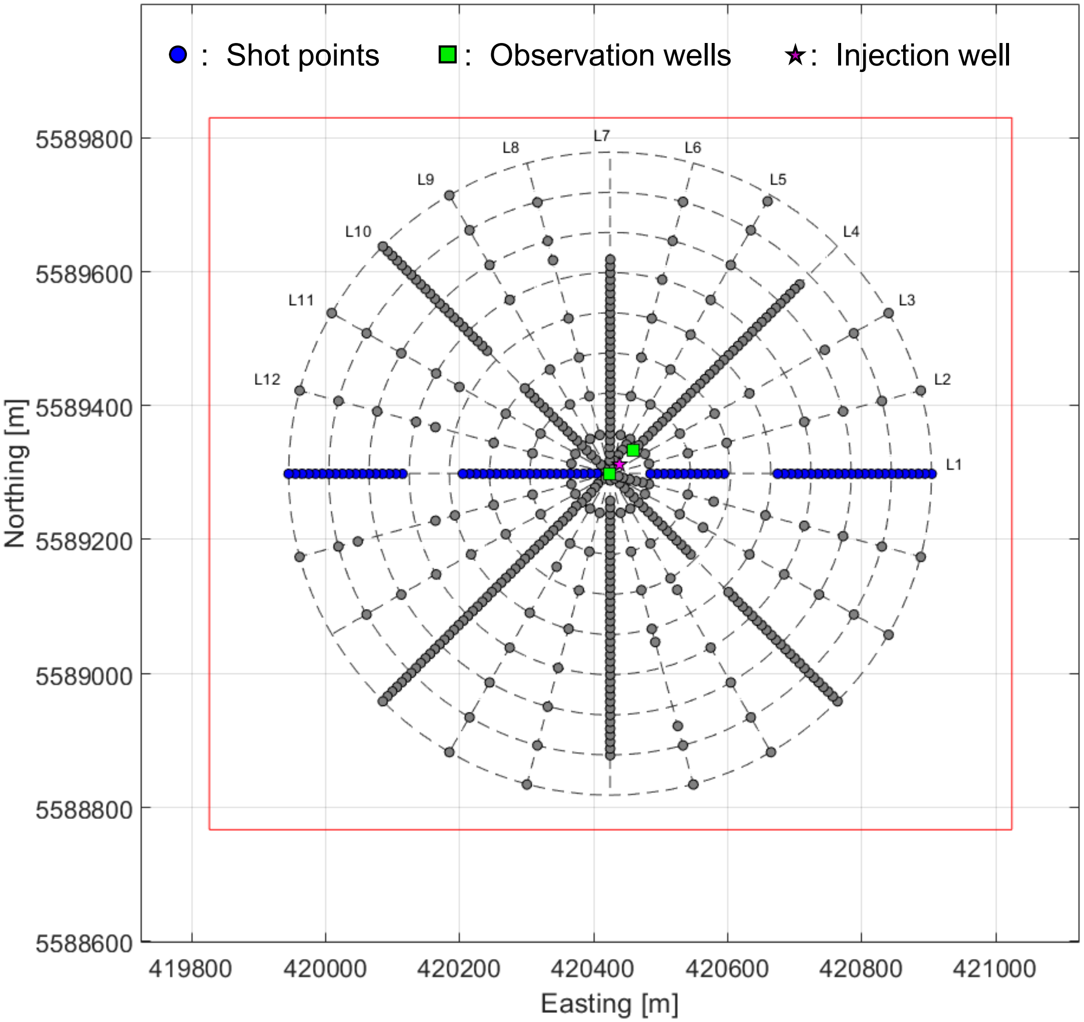
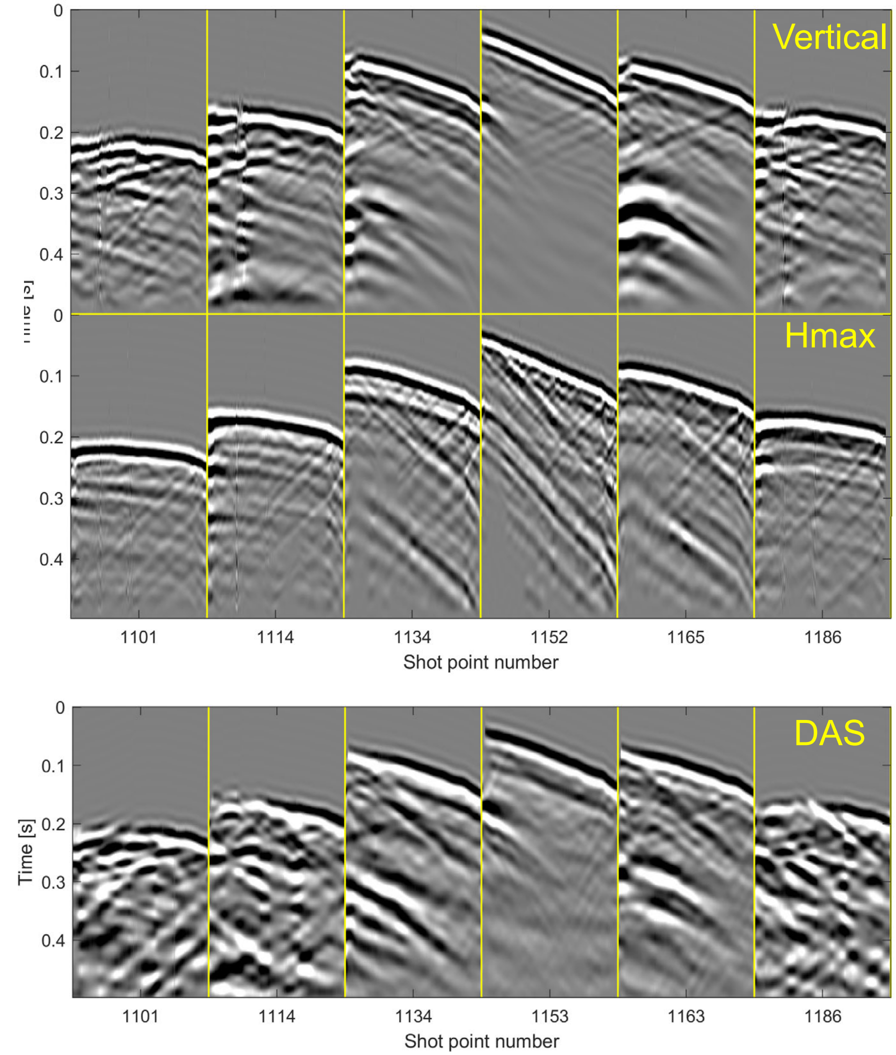
NSERC CRSNG
UNIVERSITY OF CALGARY
FACULTY OF SCIENCE
Department of Geoscience

2018 Vertical Seismic Profile





Inclusion of DAS data in FWI

Receiver matrix

Observed data

$$\phi = \frac{1}{2}\|\mathbf{Ru} - \mathbf{d}\|_2^2$$

Modeled wavefield

Back-propagated adjoint wavefield

$$\frac{\partial \phi}{\partial \mathbf{m}} = \left\langle \frac{\partial S}{\partial \mathbf{m}}\mathbf{u}, \lambda \right\rangle$$

Forward propagated wavefield

<u>Forward wavefield propagation</u>

$$S\mathbf{u} = \mathbf{f}$$

<u>Reverse wavefield propagation</u>

$$S^{\dagger}\lambda = \mathbf{R}^{\mathrm{T}}(\mathbf{Ru} - \mathbf{d})$$

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Elastic land-base FWI challenges

- Unknown source characteristics and complex near surface wave propagation are challenging to model.
- How can prior subsurface information be included in the model parameterization?
- Regularization that improves convergence but is geologically reasonable.

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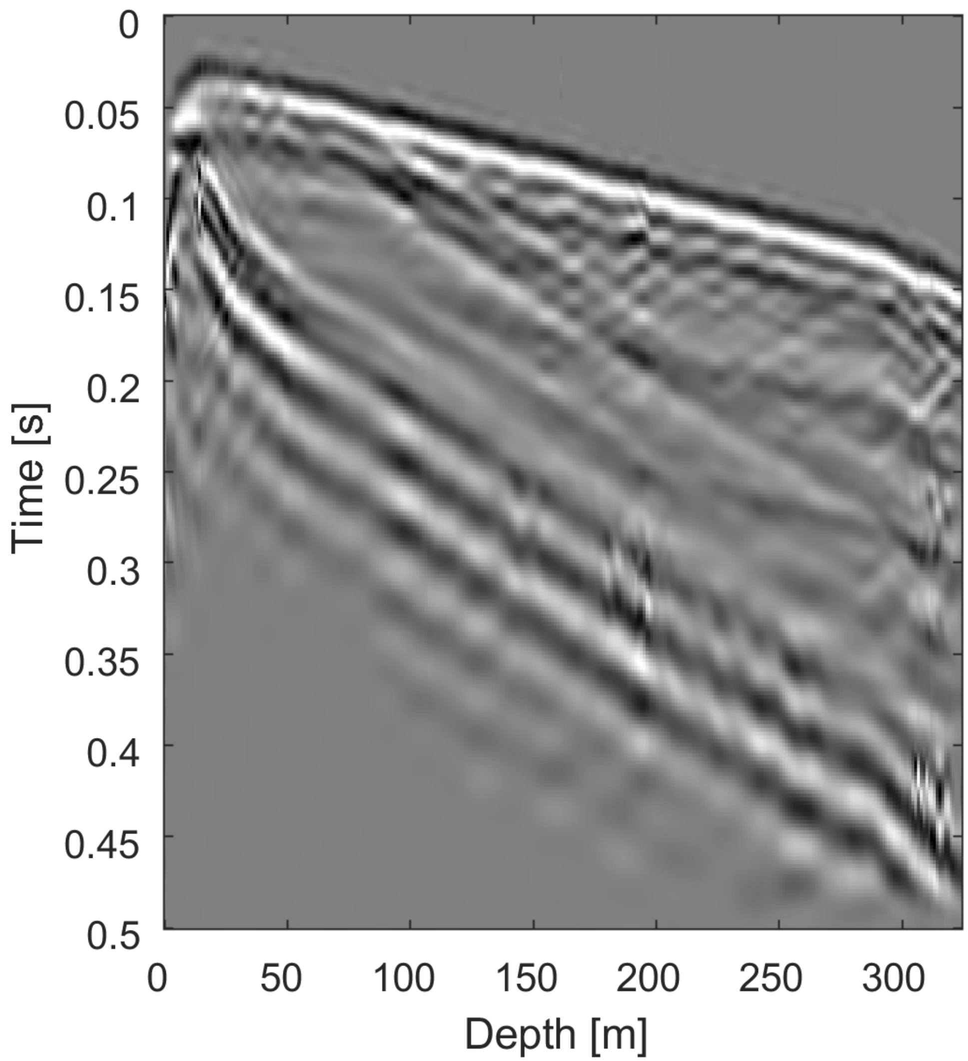
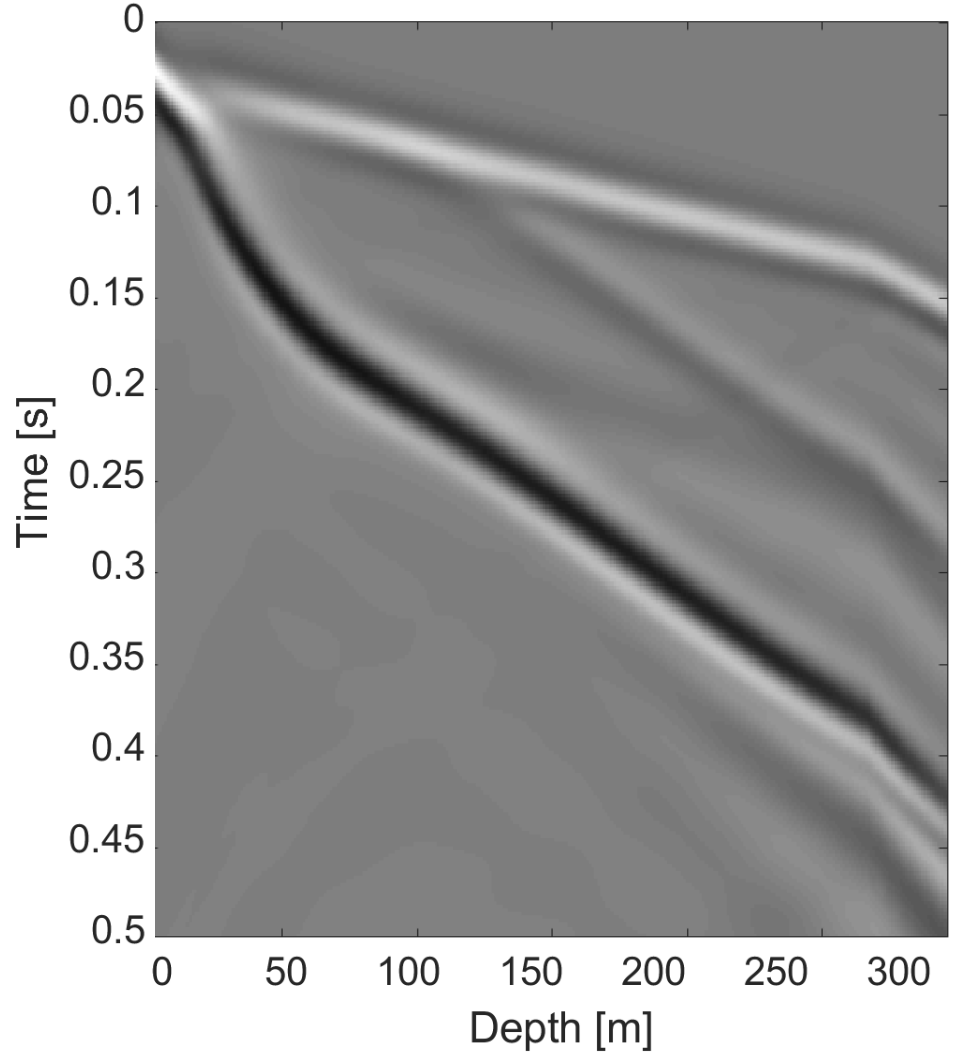
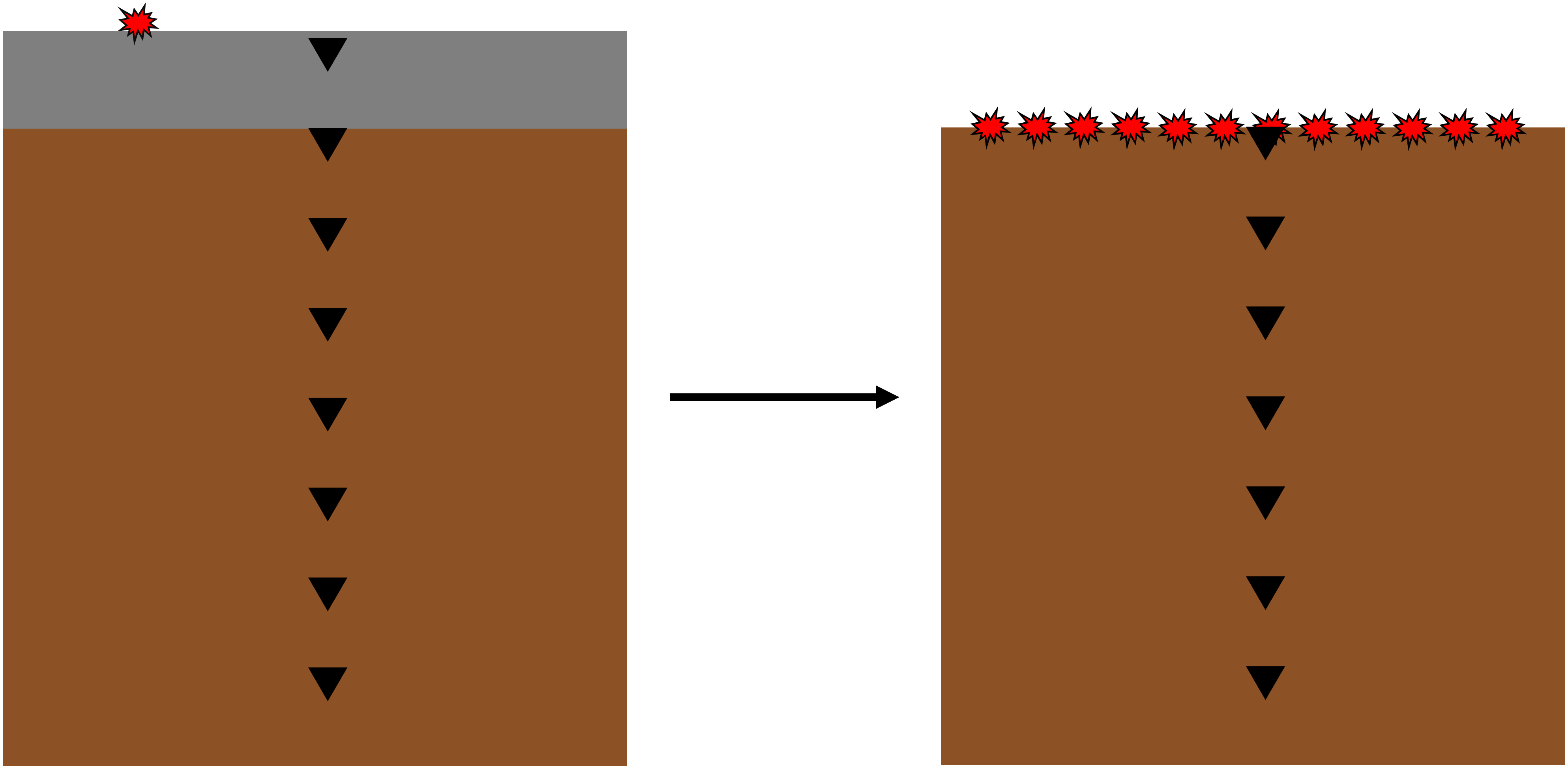
Shot record, 20 m offset





Effective Sources



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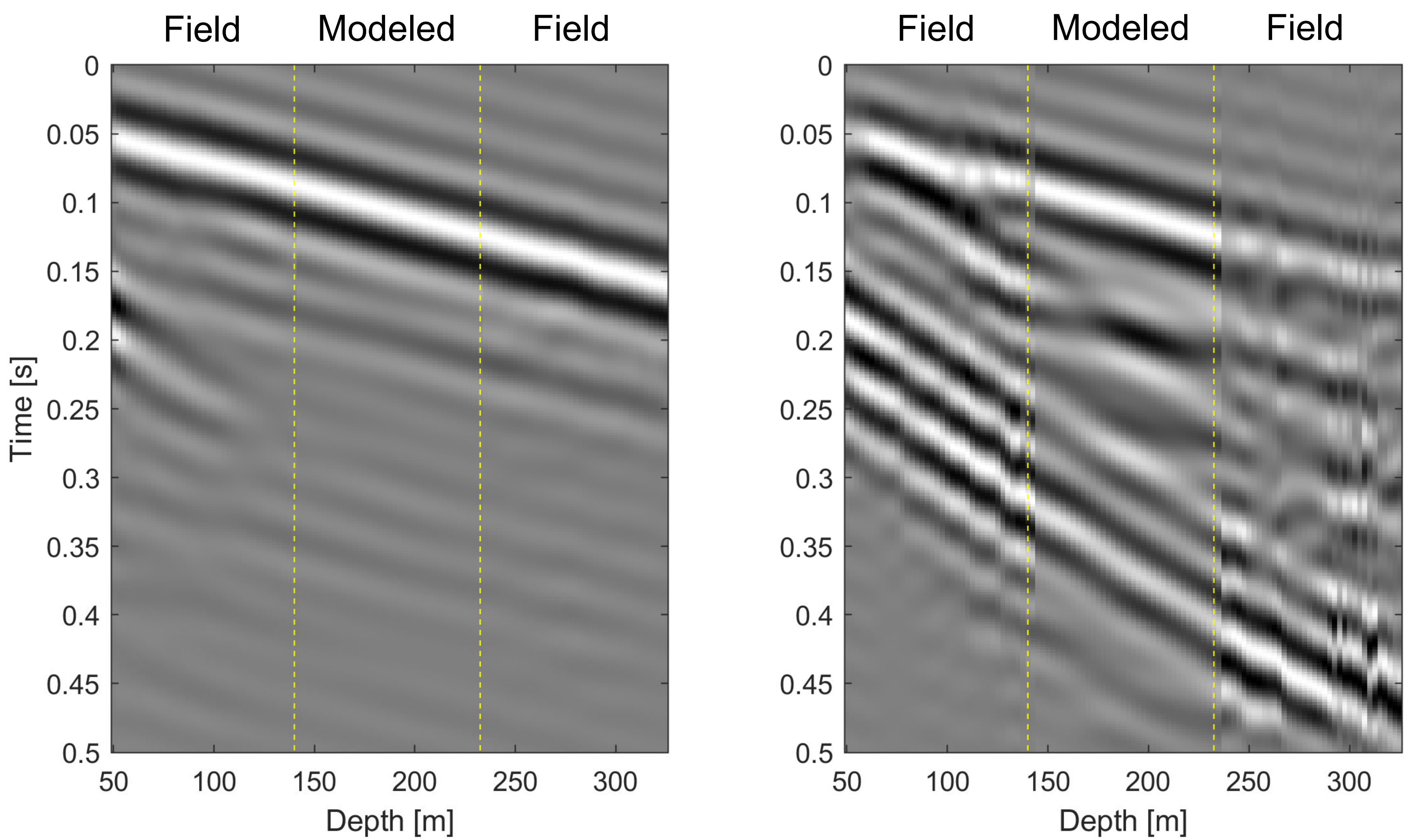

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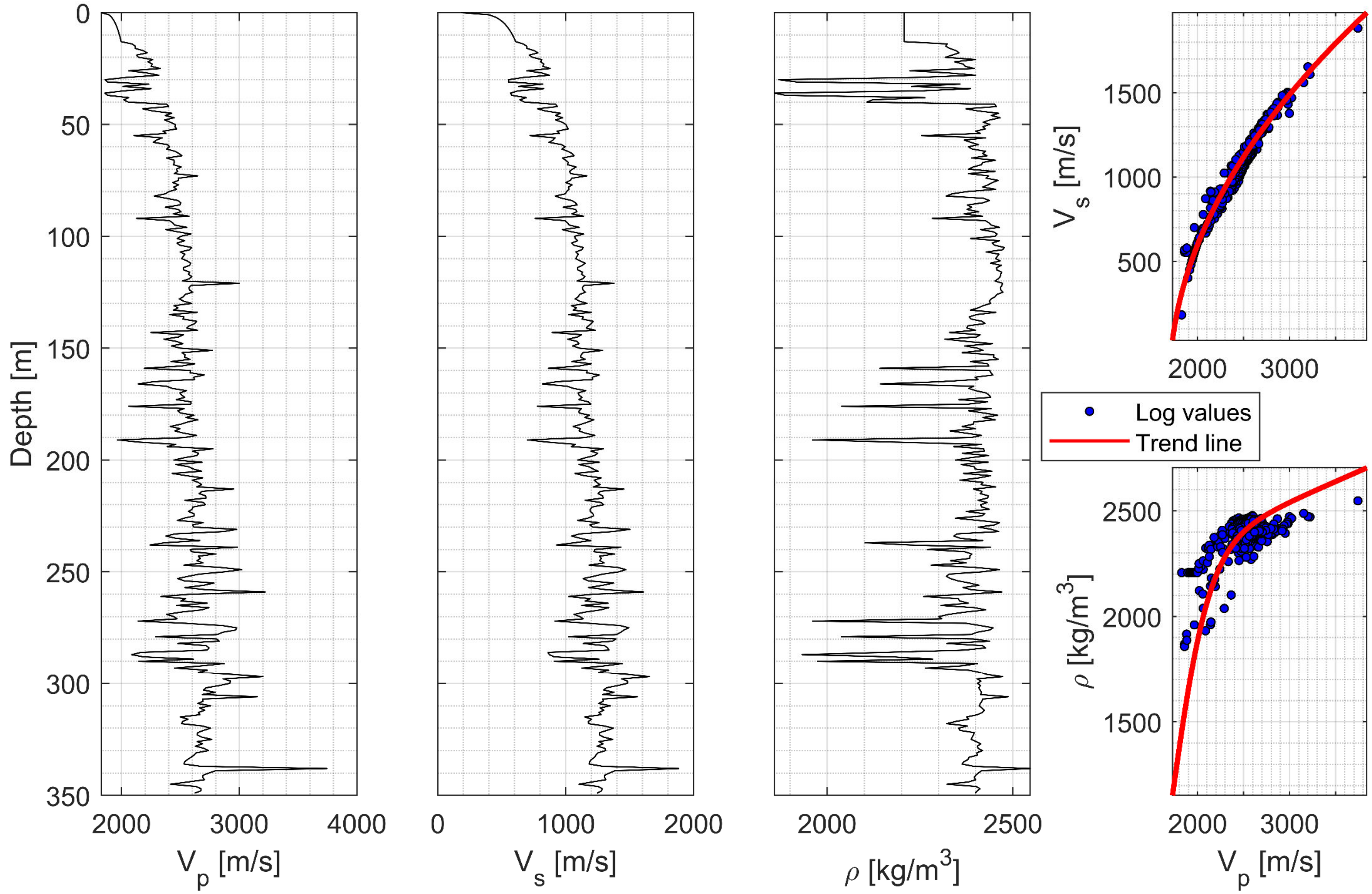
Model parameterization

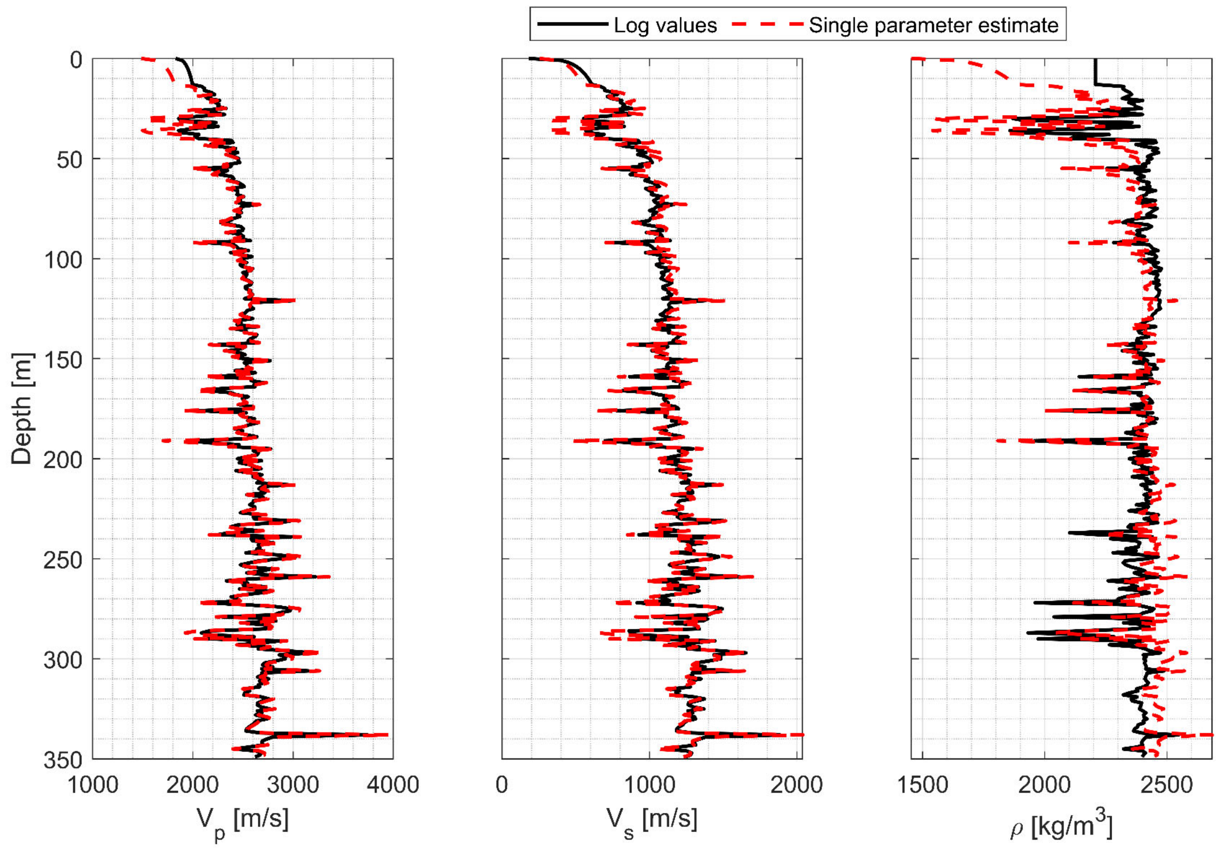


Model parameterization

- Strong interparameter relations suggest subsurface can be characterized by single parameter.

- Metric chosen is distance along the three parameter trendline computed through nonlinear regression.

- More parameters could be used to encapsulate more variance or describe CO_2 induced changes.



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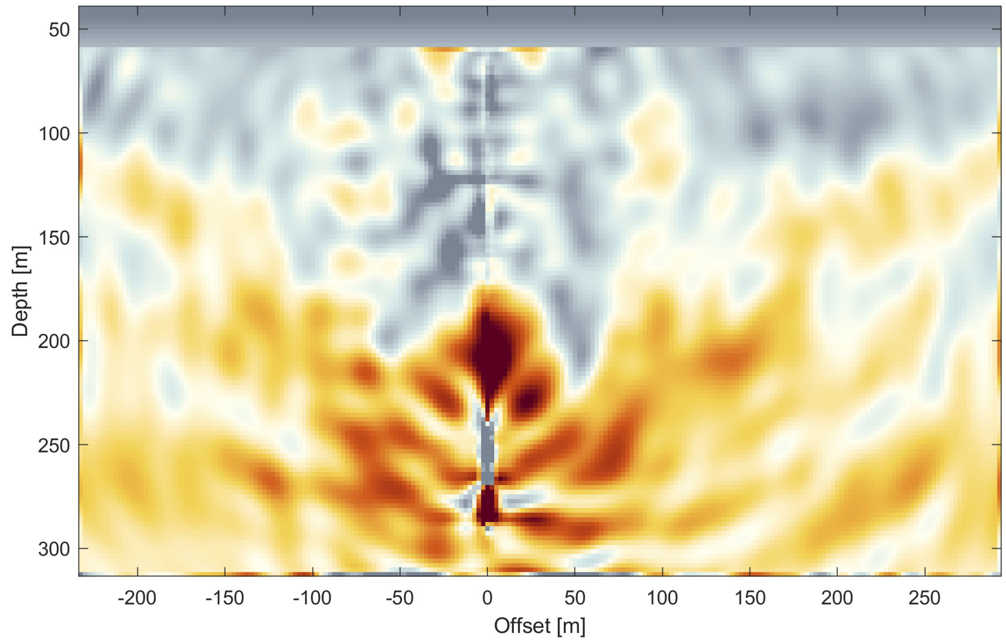
Accelerometer data inversion

Strong data influence makes region around well disproportionately sensitive

Source and receiver-related artifacts can occur if data fit is only inversion criterion

We introduce a layer-promoting regularization term as an additional inversion objective

This helps restrict consideration to more reasonable models



Accelerometer data inversion – Regularization

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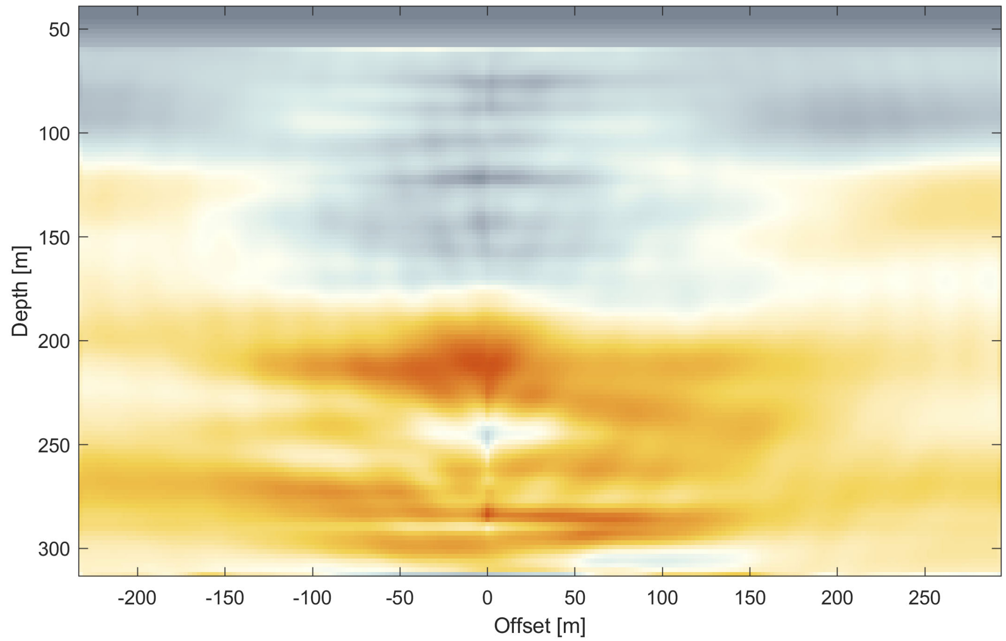
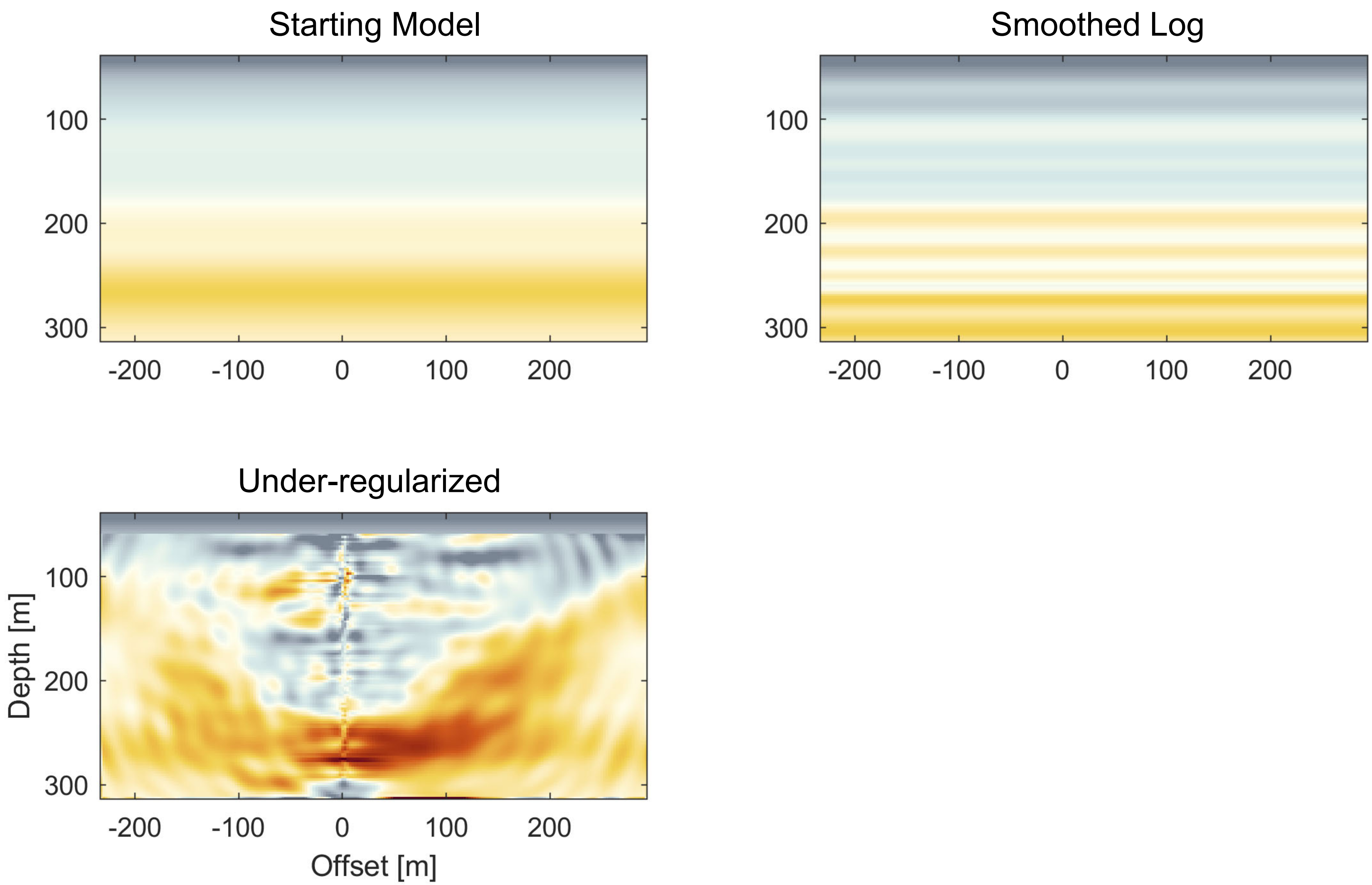


DAS data inversion – Model regularization tests



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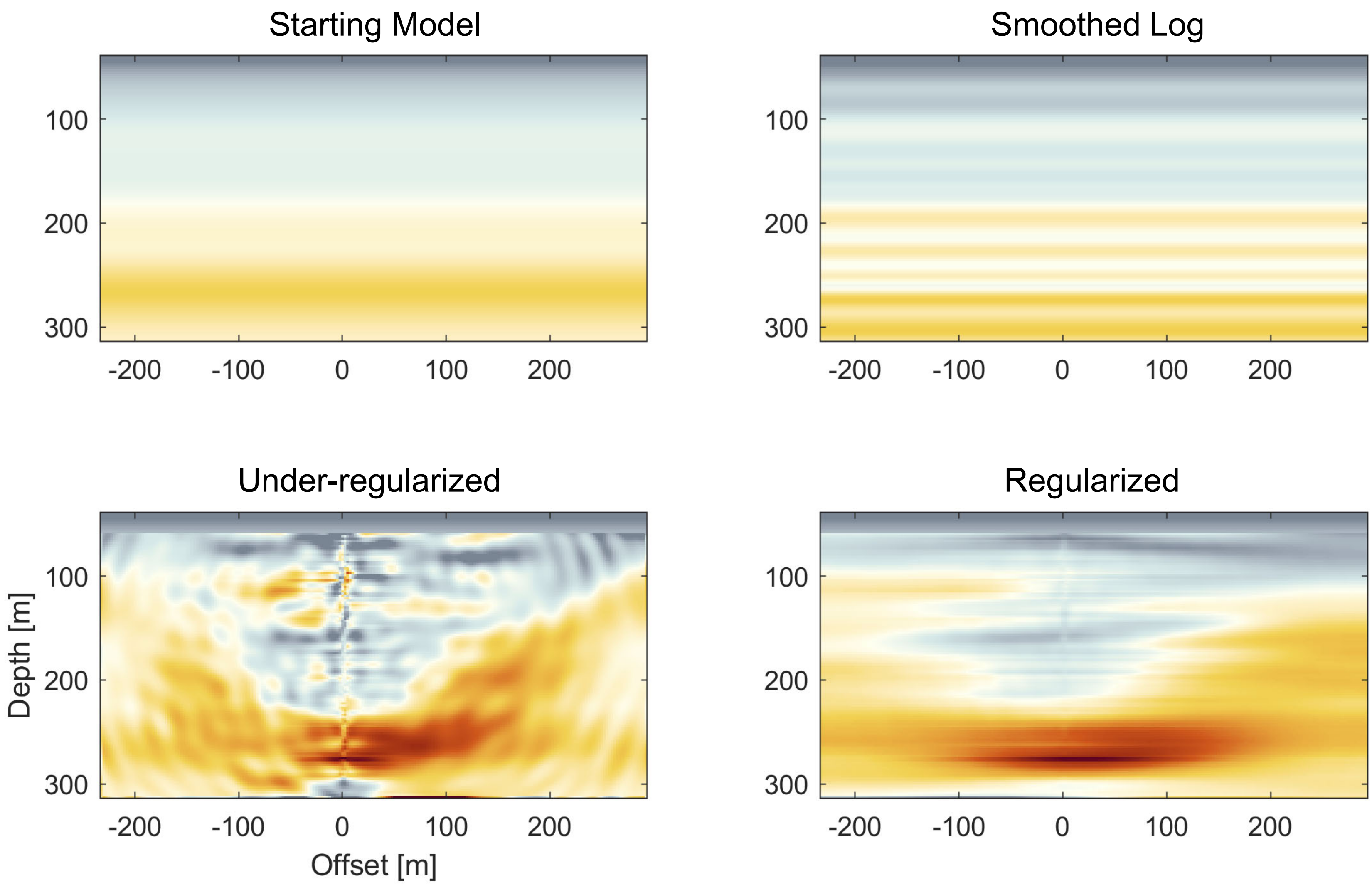
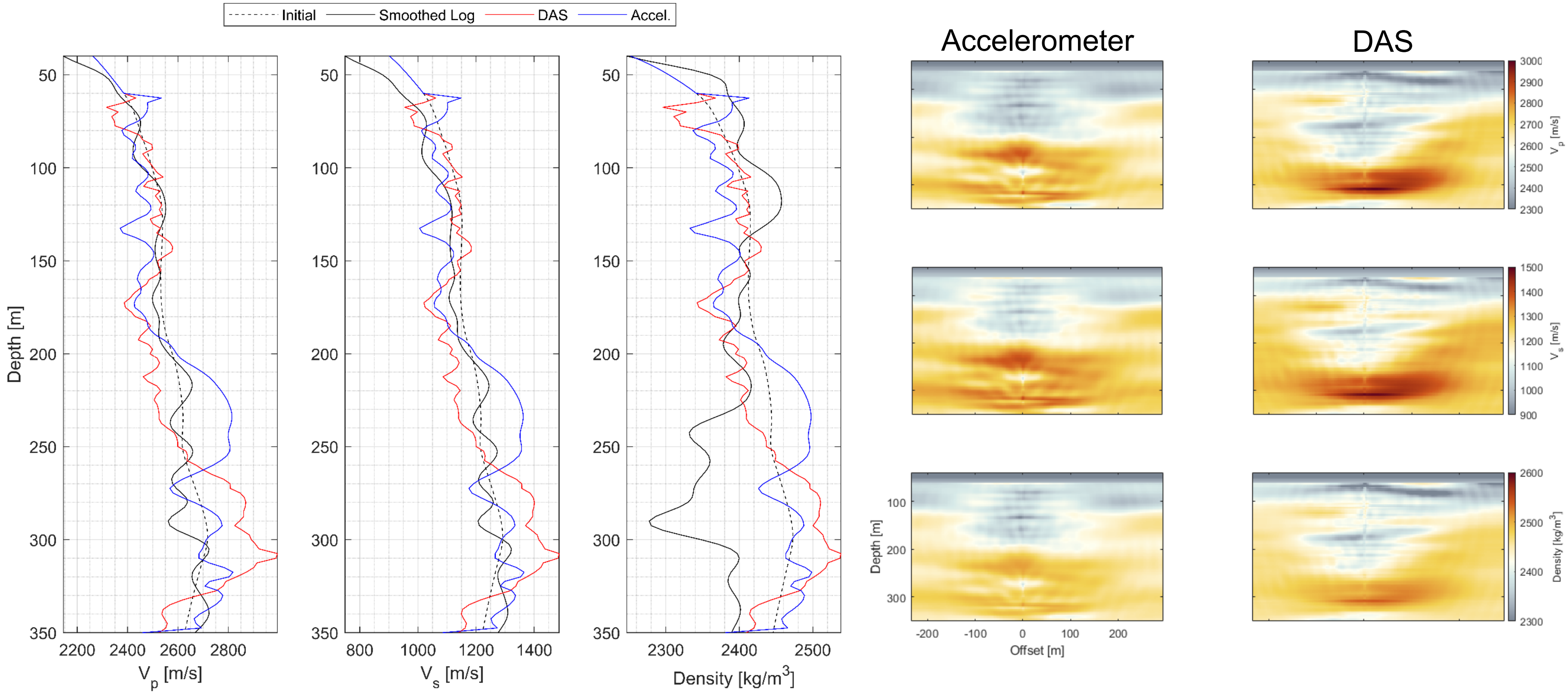


DAS and accelerometer data inversion – Comparison



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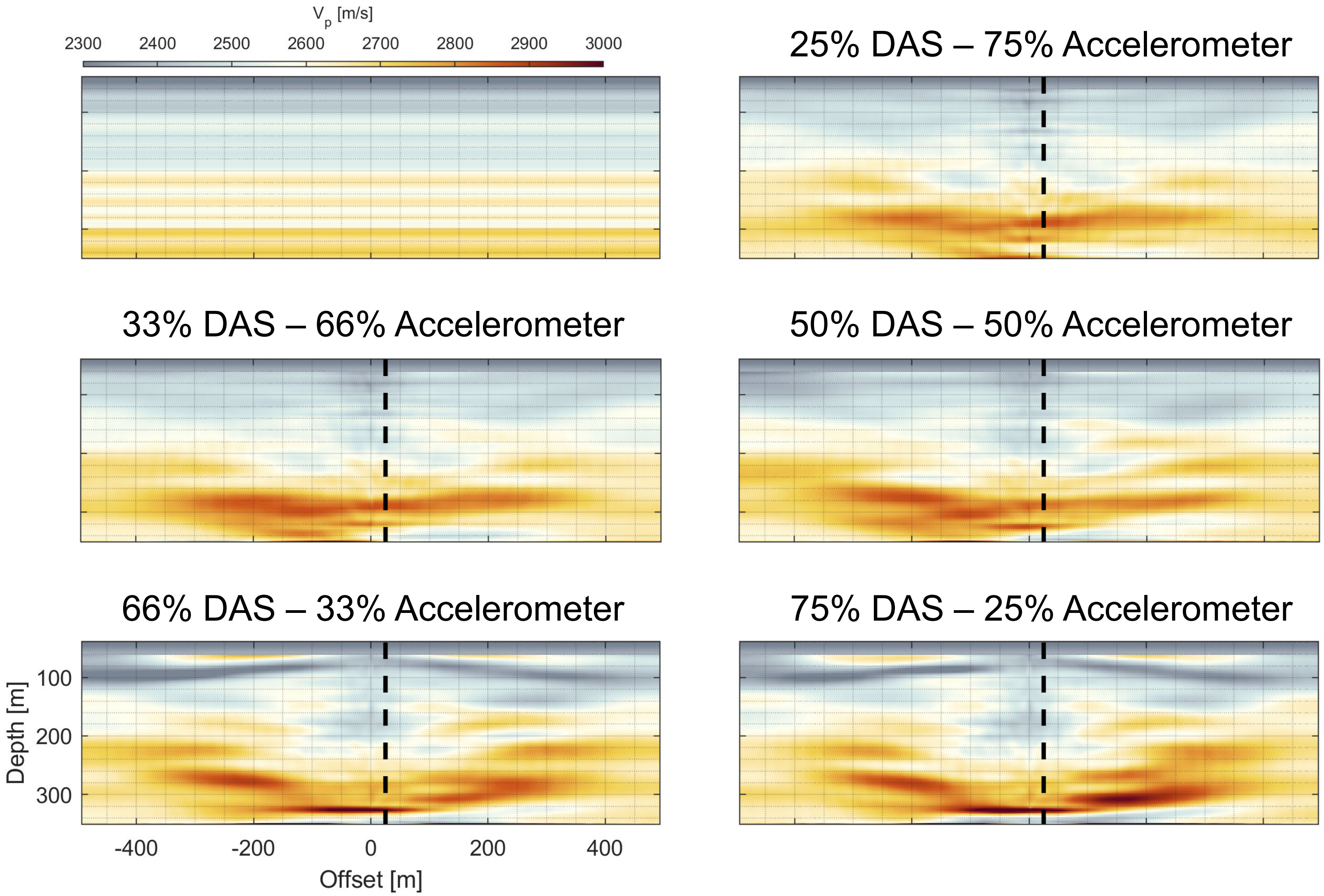
$$\phi = \frac{1}{2}\|\mathbf{T}(\mathbf{R}\mathbf{u} - \mathbf{d})\|_2^2$$

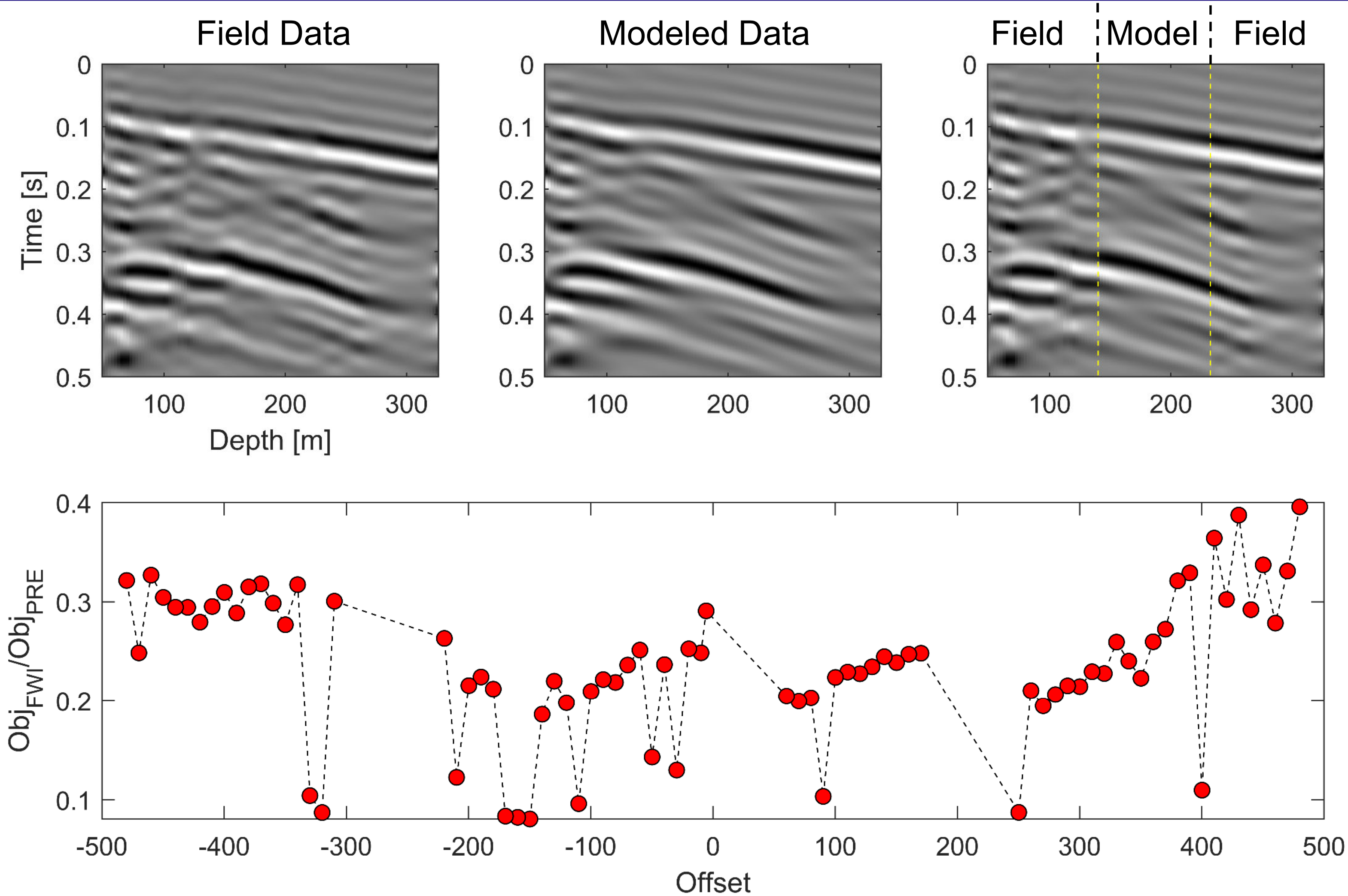
Modeled wavefield

$$T_{ii} = \begin{cases} 1 - \tau_D & for\ accel. \\ \tau_D & for\ DAS \end{cases}$$

FWI DAS-Accelerometer tradeoff results



DAS data inversion – Data fit



Conclusions

- Three key strategies developed for FWI convergence:
  1. Effective source estimation
  2. Log based parameterization
  3. Layer based regularization

- Combined DAS-Accelerometer inversions provide good baseline models and strong data fit.

- Baseline models developed that could support time-lapse FWI at the Field Research Station

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