

Seismic imaging combining active and passive sources using distributed acoustic sensing

Florian Faucher¹, Maarten V. de Hoop² and Otmar Scherzer¹

¹Faculty of Mathematics, University of Vienna

²Rice University, Houston, Texas

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Der Wissenschaftsfonds.

Motivation: Introduction of fiber-optic sensors in geophysics (distributed-acoustic sensing, DAS) that provide additional data-sets. We assume measurements of the displacement $\mathbf{u}$ and of the normal stress σ , for frequency ω and source $\mathbf{f}_k$:

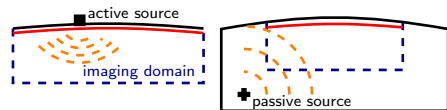
$$\mathcal{F}_\omega(\mathbf{m}, \mathbf{f}_k) = \left\{ \left\{ \mathbf{u}(\mathbf{x}_1, \mathbf{f}_k), \dots, \mathbf{u}(\mathbf{x}_{n_{rcv}}, \mathbf{f}_k) \right\}; \left\{ \sigma(\mathbf{x}_1, \mathbf{f}_k) \cdot \mathbf{n}, \dots, \sigma(\mathbf{x}_{n_{rcv}}, \mathbf{f}_k) \cdot \mathbf{n} \right\} \right\}.$$

Full Reciprocity-Gap Waveform Inversion (FRgWI):

Minimization of misfit $\mathcal{J}_R$ with respect to physical properties,

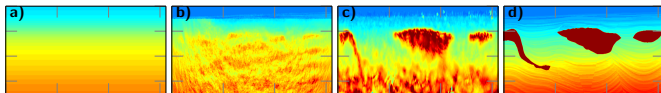
$$\mathcal{J}_R = \frac{1}{2} \sum_k \sum_j \left\| \mathbf{d}_\sigma(\mathbf{g}_j)^T \mathcal{F}_\mathbf{u}(\mathbf{f}_k) - \mathbf{d}_\mathbf{u}(\mathbf{g}_j)^T \mathcal{F}_\sigma(\mathbf{f}_k) \right\|^2.$$

- * Combinations of data $\mathbf{d}$ with simulation using the different components,
- * Sources of the simulation can be **arbitrarily chosen** ($\mathbf{f}$ vs. $\mathbf{g}$),
- * We can use observed data from sources of unknown position.



Elastic 2D experiment combining active and passive-source data-sets

- * FRgWI enables using data without knowing the sources position and function;
- * The data from passive-sources contain the low-frequency missing in the active acquisition.



P-wave speed (a) initial model, (b) reconstruction using the active source data-set only, (c) reconstruction using passive and active sources data-sets with FRgWI, (d) true model.

References:

Faucher, de Hoop and Scherzer. *Reciprocity-gap misfit functional for Distributed Acoustic Sensing, combining data from passive and active sources*, Geophysics, 2020.
Faucher, Alessandrini, Barucq, de Hoop, Gaburro and Sincich. *Full Reciprocity-Gap Waveform Inversion, enabling sparse-source acquisition*, Geophysics, 2020.