Wavefield Reconstruction Inversion for Ambient Seismic Noise

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Full Wavefield Recordings

De Ridder et al., EGU 2020
wave field only known at recordings and subject to noise

velocity unknown

De Ridder et al., EGU 2020
do not care about the wave equation

pseudo sources & sinks

obey wave the equation + observations

do not care about the wave equation

De Ridder et al., EGU 2020
Wave Equation

\[ c^2 \nabla^2 u - \partial_t^2 u = 0 \]
Wave Equation

\[ c^2 \nabla^2 u - \partial_t^2 u = 0 \]

Discrete Linear in Wave Field

\[
\begin{bmatrix}
\text{diag}\{m\}L - D_{tt}
\end{bmatrix} u = 0
\]

Discrete Linear in Velocity

\[
\begin{bmatrix}
\text{diag}\{Lu\}
\end{bmatrix} m - D_{tt}u = 0
\]
Wave Equation

\[ c^2 \nabla^2 u - \partial_t^2 u = 0 \]

Discrete Linear in Wave Field

\[ \left( \text{diag}\{m\}L - D_{tt} \right)u = 0 \]

Discrete Linear in Velocity

\[ \left( \text{diag}\{Lu\} \right)m - D_{tt}u = 0 \]
Wavefield Reconstruction Inversion

**Wave Equation**

\[ c^2 \nabla^2 u - \partial_t^2 u = 0 \]

**Discrete Linear in Wave Field**

\[ \left[ \text{diag}\{m\} L - D_{tt} \right] u = 0 \]

**Discrete Linear in Velocity**

\[ \left[ \text{diag}\{Lu\} \right] m - D_{tt} u = 0 \]
Wave Equation Inversion

Wave Equation
\[ c^2 \nabla^2 u - \partial_t^2 u = 0 \]

Discrete Linear in Wave Field
\[ \left[ \text{diag}\{m\} \mathbf{L} - \mathbf{D}_{tt} \right] \mathbf{u} = 0 \]

Discrete Linear in Velocity
\[ \left[ \text{diag}\{\mathbf{L} \mathbf{u}\} \right] \mathbf{m} - \mathbf{D}_{tt} \mathbf{u} = 0 \]
Step Function Model

Poisson Solid Medium

$V_\omega = 92\% \, V_s$
True Wavefield (unknown)

Fully Elastic Modelling

Poisson Solid Medium

$V_\omega = 92\% V_s$

De Ridder et al., EGU 2020
Sampled Wavefield (known)

Recorded data

175 m

De Ridder et al., EGU 2020
Sampled Wavefield (known)

Recorded data

De Ridder et al., EGU 2020
• Fully elastodynamic modelling
• Sampling spacing 175m
• Neglect P, S waves and higher-mode surface waves
• Poisson Solid Medium $\omega = 92\%$ $V_s$

Sampled Wavefield (known)

Recorded data

Starting Velocity Model

De Ridder et al., EGU 2020
• Fully elastodynamic modelling
• Sampling spacing 175 m
• Neglect P, S waves and higher-mode surface waves
• Poisson Solid Medium $v_\omega = 92\% \; v_s$

De Ridder et al., EGU 2020

Retrieved after 45 iterations

Recovered Wavefield

Recovered Velocity Model
Retrieved after 45 iterations

De Ridder et al., EGU 2020
Dispersion Match

- Fully elastodynamic modelling
- Sampling spacing 175m
- Neglect P, S waves and higher-mode surface waves
- Poisson Solid Medium
  \[ \nu = 92\% \]

Recovered Velocity Model

True Dispersion Images

De Ridder et al., EGU 2020
Stay Well, Safe & Sane

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