Integrated migration and internal multiple elimination

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• Creating a virtual source from reflection data
• Imaging scheme, accounting for internal multiples
• Conclusions
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Upgoing field below deepest reflector (obtained by one-way extrapolation)
Sources

Receivers

Target (e.g. a reservoir)

Seismic interferometry
Sources

Receivers

Virtual source

Target (e.g. a reservoir)

Seismic interferometry
Creating a virtual source from reflection data

Sources and receivers

Virtual source

Target (e.g. a reservoir)
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Virtual sources and receivers

Target (e.g. a reservoir)

Data-driven redatuming
Sources and receivers

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Upgoing field below deepest reflector (obtained by data-driven redatuming)
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Creating a virtual source from reflection data
Background


Convolve with reflection response and sum over all sources
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Convolve with reflection response and sum over all sources
Superposition

\[ p(x, t) = p^+(x, t) + p^-(x, t) \]
Superposition

\[ p(x, t) = p^+ (x, t) + p^- (x, t) \]

Add time-reversed field

\[ p(x, t) + p(x, -t) \]
\[ p(x, t) + p(x, -t) \]
$G(x, x_{VS}, t) * s(t)$
Directly modeled response

\[ G(x, x_{VS}, t) \ast s(t) \]
Summary:
Measured reflection response at surface, plus estimate of primary virtual source response, gives full virtual-source response.
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decomposition
decomposition + reciprocity

\[ G^{-}(\mathbf{x}, \mathbf{x}_S, t) \ast s(t) \]

\[ G^{+}(\mathbf{x}, \mathbf{x}_S, t) \ast s(t) \]
\[ G^-(\mathbf{x}, \mathbf{x}_S, t) \ast s(t) \quad G^+(\mathbf{x}, \mathbf{x}_S, t) \ast s(t) \]
\[ G^- (x_R, x_S, t) * s(t) = \]

\[
\int R(x_R, x', t) * G^+ (x', x_S, t) * s(t) dx'
\]
Resolve

\[ R(x_R, x', t) \]

by MDD, etc.

\[ G^{-}(x_R, x_S, t) \ast s(t) = \]

\[ \int R(x_R, x', t) \ast G^{+}(x', x_S, t) \ast s(t) dx' \]
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Data-driven virtual-source retrieval requires:
• Reflection data at the surface
• Estimate of primary traveltimes
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• Reflection data at the surface
• Estimate of primary travel times

Consequences:
• Virtual-source response, including internal multiples
• Basis for imaging, accounting for internal multiples
• Stable w.r.t. small errors in the estimated primaries
• Non-recursive, hence no error accumulation
• No adaptive prediction and subtraction
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To be investigated:
• Limitations, due to finite acquisition aperture, triplications, errors in traveltimes, head waves, fine-layering, etc.
• Elastodynamic extension
Related presentations “beyond interferometry”:

Already presented:
• Snieder et al., Developments in seismic interferometry: Time-lapse monitoring and autofocusing of internal multiples: Recent Advances and the Road Ahead (yesterday).
• Broggini et al., Creating a virtual source inside a medium from reflection data: A stationary-phase analysis: Imaging and Migration session (today).

To be presented:
• Broggini et al., Focusing inside an unknown medium: This session, 4:25
• Behura et al., Newton-Marchenko-Rose imaging: SPMI 5 New Implementations, Thursday 11:00, Breakers F