seismic imaging without accurate velocity

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surface seismic information

Claerbout, 1984, Imaging the Earth’s Interior

information from surface seismic

low \quad medium \quad high

spatial wavenumber
surface seismic information

Claerbout, 1984, Imaging the Earth’s Interior

information from surface seismic

knowable unknowable knowable

spatial wavenumber
the questions:

1. how does the unknowable model impact imaging?

2. how can we reduce these effects?
conventional imaging

\[ V_{\text{low}} \]
velocity

\[ V_{\text{high}} \]
reflectivity
conventional imaging

$V_{low}$  $V_{medium}$  $V_{high}$

velocity  does not matter!  reflectivity
conventional imaging
conventional imaging

\[ U(y, t) = \int d\mathbf{x} \ D(\mathbf{x}, t) \ast_t G(\mathbf{x}, y, t) \]

I.C.

\[ R(y) = U(y, t = 0) \]
conventional imaging
conventional imaging
correct mapping
incorrect mapping
medium-scale effects

random fluctuations due to the unknowable velocity
medium-scale filtering

W.R.  FLT  I.C.

low  medium  high
medium-scale filtering

**statistically** reduce the effects of the mid-scale (unknowable) velocity perturbations

- Dussaud & Symes (2005)
- Sava & Poliannikov (2007)
- ...
Wigner distribution functions


Definition
time-frequency transformations of complex signals

\[ U(x, t) \leftrightarrow W(x, t, k, \omega) \]


\[ W(x, t, k, \omega) = \int d\xi \int d\tau \ U\left(\frac{x - \xi}{2}, t - \frac{\tau}{2}\right) U\left(\frac{x + \xi}{2}, t + \frac{\tau}{2}\right) e^{-i(k\cdot\xi + \omega\tau)} \]

- \( U(x, t) \): wavefield
- \( W(x, t, k, \omega) \): WDF
\[ W(x, t) = \int d\xi \int d\tau U \left( x - \frac{\xi}{2}, t - \frac{\tau}{2} \right) U \left( x + \frac{\xi}{2}, t + \frac{\tau}{2} \right) \]

- \( U(x, t) \): wavefield
- \( W(x, t) \): pseudo-WDF
wavefield
interferometric imaging condition

Sava & Poliannikov (2007)
interferometric imaging condition
Sava & Poliannikov (2007)

W.R. \[ U(y, t) = \int dx \ D(x, t) \ast_t G(x, y, t) \]

WDF \[ W(y, t) = wdf[U(y, t)] \]

I.C. \[ R(y) = W(y, t = 0) \]
statistical stability

images do not change with model realization
conclusions

medium-scale velocity impacts imaging

modified imaging conditions attenuate artifacts
acknowledgment

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