Wavefield tomography without low frequency

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Waveform inversion

\[
\min_{m} J = \| d_{\text{obs}} (x_r, t) - d_{\text{pre}} (x_r, t, m) \|^2
\]

- \textit{d}: data
- \textit{m}: model
- \textit{x}_r: receiver coordinates
- \textit{t}: observation time
in phase
off phase
off phase

[Graph showing waveforms and color-mapped data with labels for time frequency and phase difference]
off phase
off phase
off phase
off phase
off phase
off phase
off phase
off phase
off phase
off phase
off phase
off phase
off phase
off phase
in phase
wavefield tomography: definition

A procedure for estimating the earth model using seismic wavefield discrepancies.
\[ u_s(e, x_s, t) \]

\[ u_s(e, x, t) \]

\[ L(m)[u_s(e, x, t)] = u_s(e, x_s, +t) \]

*forward time propagation*
\[ L(m) [u_r(e, x, t)] = u_r(e, x_r, -t) \]

backward time propagation
data domain WT
$D(e, x, t) = u_s(e, x, t) - u_r(e, x, t)$
\[ J_d (v) = \sum_e \| K_r (e, x) D (e, x, t) \|^2 \]

\[ D (e, x, t) = u_s (e, x, t) - u_r (e, x, t) \]
$C(e, x, \tau) = \sum_t u_s(e, x, t - \tau) u_r(e, x, t + \tau)$
$$J_d(v) = \sum_e \| P(\tau) K_r(e, x) C(e, x, \tau) \|^2$$

$$C(e, x, \tau) = \sum_t u_s(e, x, t - \tau) u_r(e, x, t + \tau)$$
correlation
image domain WT
\[ C(e, x, \lambda, \tau) = \sum_t u_s(e, x - \lambda, t - \tau) u_r(e, x + \lambda, t + \tau) \]
\[ R(x, \lambda, \tau) = \sum_e C(e, x, \lambda, \tau) \]
$J_i(v) = \| P(\lambda, \tau) K_i(x) R(x, \lambda, \tau) \|^2$
WT objective functions

\[ J_d(v) = \sum_e \| K_r(e, x)D(e, x, t) \|^2 \]

\[ J_i(v) = \| P(\lambda, \tau)K_i(x) \sum_e C(e, x, \lambda, \tau) \|^2 \]
difference

local minima
correlation

global minimum
difference

high resolution
correlation

low resolution
difference & correlation
Marmousi example
correct model
shot gather
data spectrum
starting velocity
objective functions
starting velocity
image-domain WT + data-domain WT
conclusion

We don’t really need low frequencies!
acknowledgments