Analysis of wide-azimuth angle decomposition

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Outline

- Extended imaging condition based angle decomposition method
- Resolution and range analysis of angle-domain common-image gathers
- Example: SEG/EAGE 3D salt dome model
Wave equation migration

wavefield reconstruction

- $U_s(x, \omega)$: source wavefield
- $U_r(x, \omega)$: receiver wavefield

conventional imaging condition

$I(x) = \sum_\omega U^*_s(x, \omega) U_r(x, \omega)$
Wave equation migration

wavefield reconstruction

- $U_s(x, \omega)$: source wavefield
- $U_r(x, \omega)$: receiver wavefield

conventional imaging condition

$$I(x) = \sum_{\omega} U_s^*(x, \omega) U_r(x, \omega)$$
Wave equation migration

wavefield reconstruction

- $U_s(x, \omega)$: source wavefield
- $U_r(x, \omega)$: receiver wavefield

extended imaging condition

$$I(x, \lambda) = \sum_{\omega} U^*_s(x + \lambda, \omega) U_r(x - \lambda, \omega)$$
Angle decomposition

\[ l(x_0, y_0, z, \lambda_x, \lambda_y) \rightarrow l(x_0, y_0, z, \theta, \phi) \]

\[ \theta = \theta(\lambda_x, \lambda_y) \]

\[ \phi = \phi(\lambda_x, \lambda_y) \]
Reflection geometry
Reflection angle $\theta$
Azimuthal angle $\phi$
\[ \theta \]

- 30°
- 60°
- 90°
Work flow

\[
\begin{align*}
I(x, y, z, \lambda_x, \lambda_y) \\
\downarrow \\
I(x_0, y_0, z, \lambda_x, \lambda_y) \\
\downarrow \\
I(x_0, y_0, k_z, k_{\lambda_x}, k_{\lambda_y}) \\
\downarrow \\
I(x_0, y_0, z, \theta, \phi)
\end{align*}
\]
2D mapping equation

\[
\tan \theta = \frac{k_{\lambda_x}}{k_z}
\]

\(k_{\lambda_x}\): space-lag wavenumber

\(k_z\): depth wavenumber
$I(z, \lambda_x)$
$l(k_z, k_{\lambda x})$
$l(k_z, \theta)$
$I(z, \theta)$
$I(k_z, \theta)$
2D mapping equation

\[ \tan \theta_{\text{max}} = \frac{k \lambda_{x_{\text{max}}}}{k z_{\text{max}}} = \frac{d_z}{d \lambda_x} \]

angle domain range

\~ (lag-domain resolution)^{-1}
3D mapping equation

\[ \tan \theta = \frac{\sqrt{k_{\lambda x}^2 + k_{\lambda y}^2}}{k_z} \]

\( k_{\lambda x} \): space-lag wavenumber

\( k_{\lambda y} \): space-lag wavenumber

\( k_z \): depth wavenumber
Parameter relationships

angle-domain resolution

\[\uparrow\downarrow\]

lag-domain range

angle domain range

\[\uparrow\downarrow\]

lag-domain resolution
SEG/EAGE 3D salt dome model
$\theta = 30$

$\phi = 350$
Conclusions

- limited range of accurately recovered angles

- range bounds controlled by
  - space-lag sampling interval
  - depth sampling interval
Acknowledgments

Center for Wave Phenomena
Colorado School of Mines

StatoilHydro