ROSE meeting

ROSE
Rock Seismic Research Project

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25.04.2016, Trondheim

Anisotropy parameters from diving waves

Objectives:

1 Better understanding of the feature of diving wave in a factorized VTI medium

2 Imaging moveout approximation of the diving wave

3 Estimate the anisotropy parameters through semblance analysis

Outline

- 1 Diving wave in a factorized VTI medium

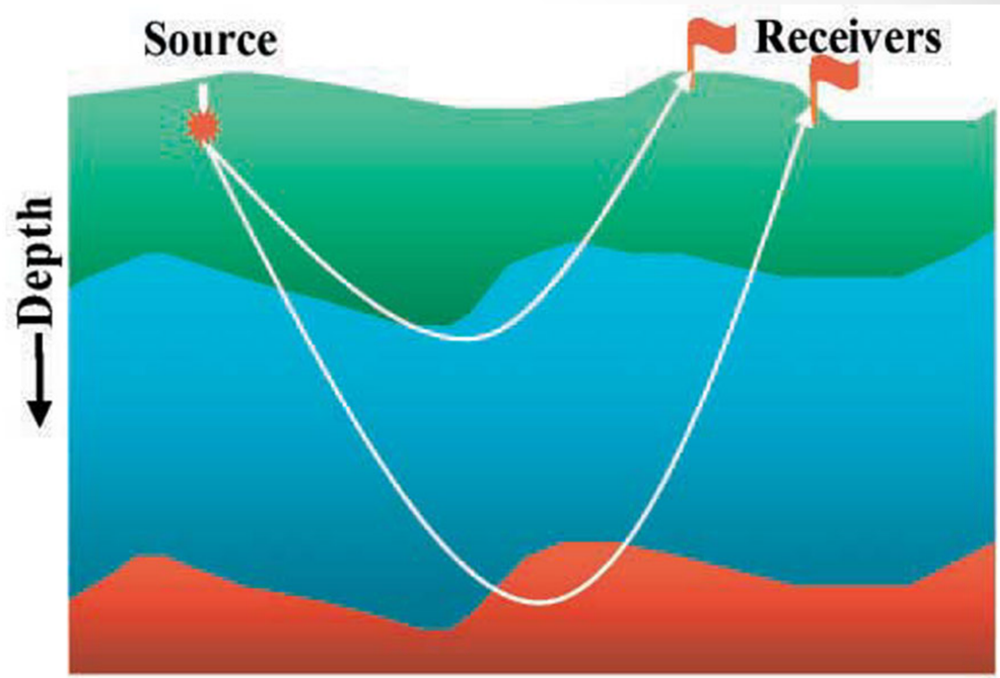
  2 The image moveout approximation

  3 Semblance analysis & anisotropy estimation

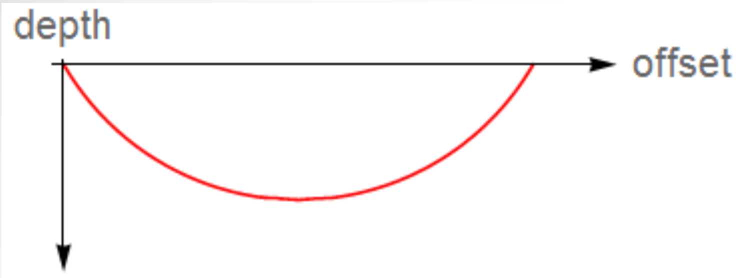
  4 Numerical examples & different parameterization

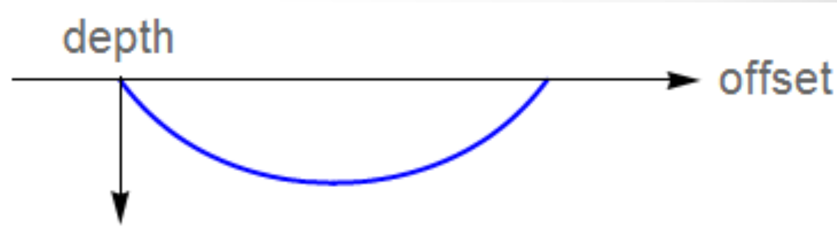
  5 Conclusions

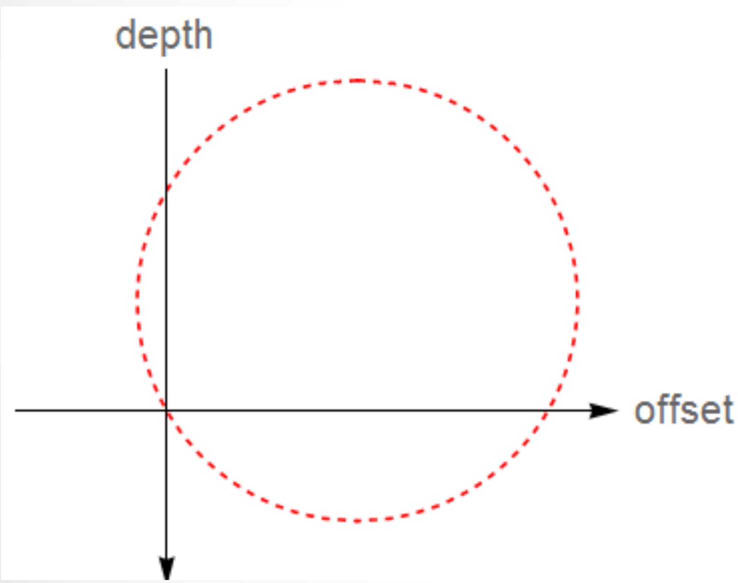
Diving wave

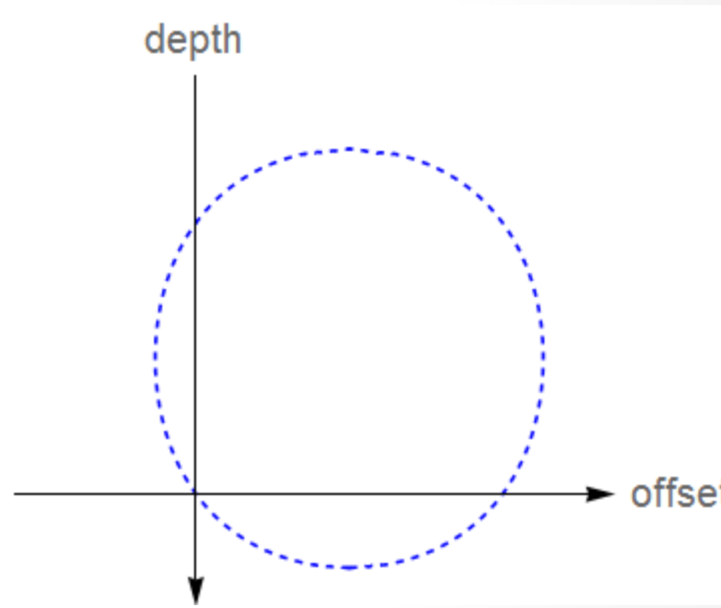


Diving wave in anisotropic medium









Constant-gradient isotropic model

$$v(z) = v_0 + Gz \quad \varepsilon = \delta = 0$$

Constant-gradient anisotropic model

$$v(z) = v_0 + Gz \quad \delta = 0.2, \eta = 0.1$$

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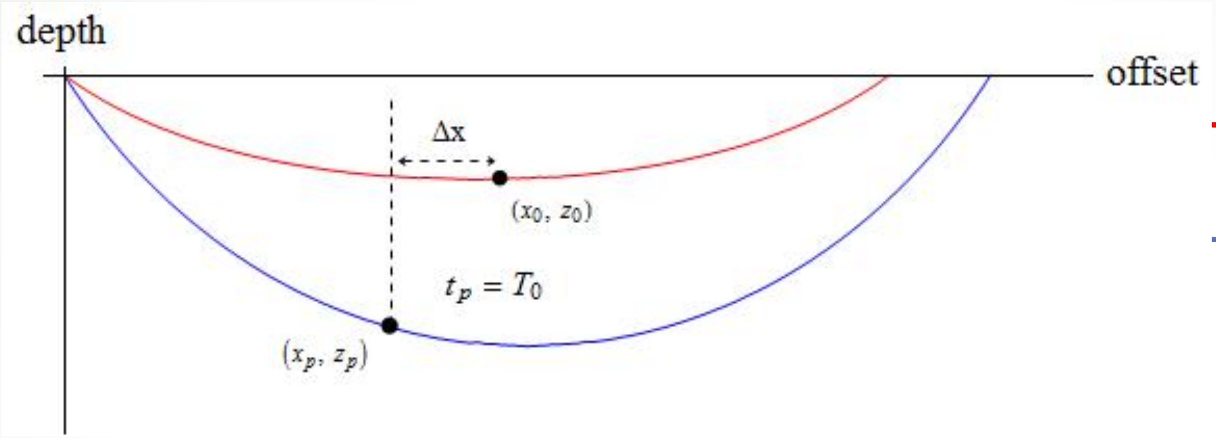
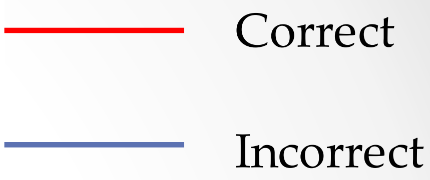
Imaging moveout





Isotropic traveltime expression

$$t_p = \frac{1}{G}\log\left(\frac{v(z_p)}{v_0}\frac{1+\sqrt{1-p^2v_0^2}}{1+\sqrt{1-p^2v^2(z_p)}}\right)$$

Anisotropic traveltime from source to the turning point T_0

Apply for isotropic constant gradient model $t_p = T_0$

"Turning point"

$x_p(\varepsilon,\eta), z_p(\varepsilon,\eta)$

$$\Delta x_p(z_p) = x_0 - x_p$$

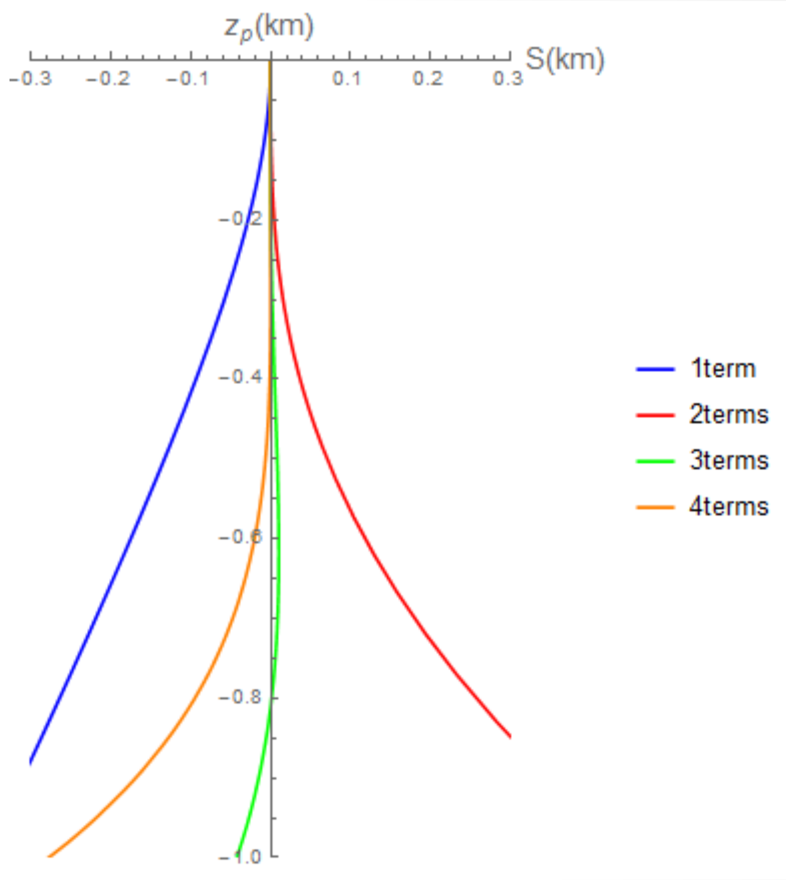
The image moveout approximation_(A) Taylor series

Taylor expansion

$\Delta x_p(z_p)$

$$\Delta x_p = a_1 z_p + a_2 z_p^2 + a_3 z_p^3 + a_4 z_p^4,$$

$$\hat{S}(z_p) = S\{\Delta x_{exact}(z_p) - \Delta x_i(z_p)\}$$



$$V_0 = 2\ \text{km/s}, G = 1.5\ \text{s}^{-1}, \varepsilon = 0.22, \eta = 0.1$$

The image moveout approximation_(B) Pade approximation

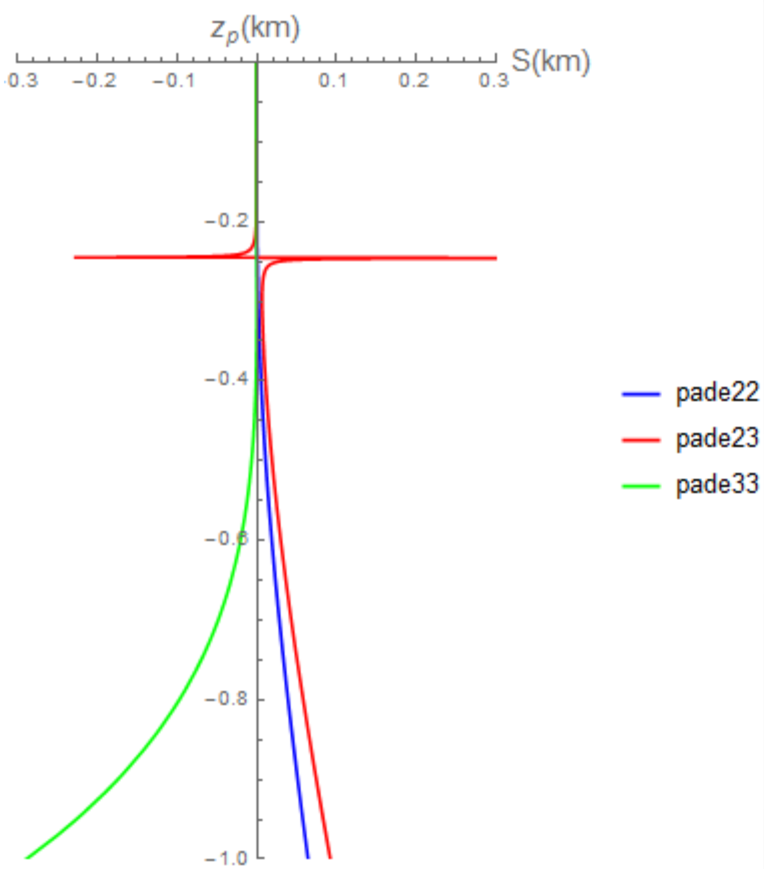
Pade approximation

$$f(z_p) = \Delta x_p = a_1 z_p + a_2 z_p^2 + a_3 z_p^3 + a_4 z_p^4,$$

$$f(z_p) = R_{L,M}(z_p) + O(z_p),$$

$$R_{L,M}(z_p) = \frac{\sum_{k=0}^{L} p_k z_p^k}{1 + \sum_{k=0}^{M} q_k z_p^k}$$

$$R_{2,2}, R_{2,3}, R_{3,3}$$



$$V_0 = 2\ \mathrm{km/s}, G = 1.5\ \mathrm{s}^{-1}, \varepsilon = 0.22, \eta = 0.1$$

The image moveout approximation_(C) rational approximation

Rational approximations

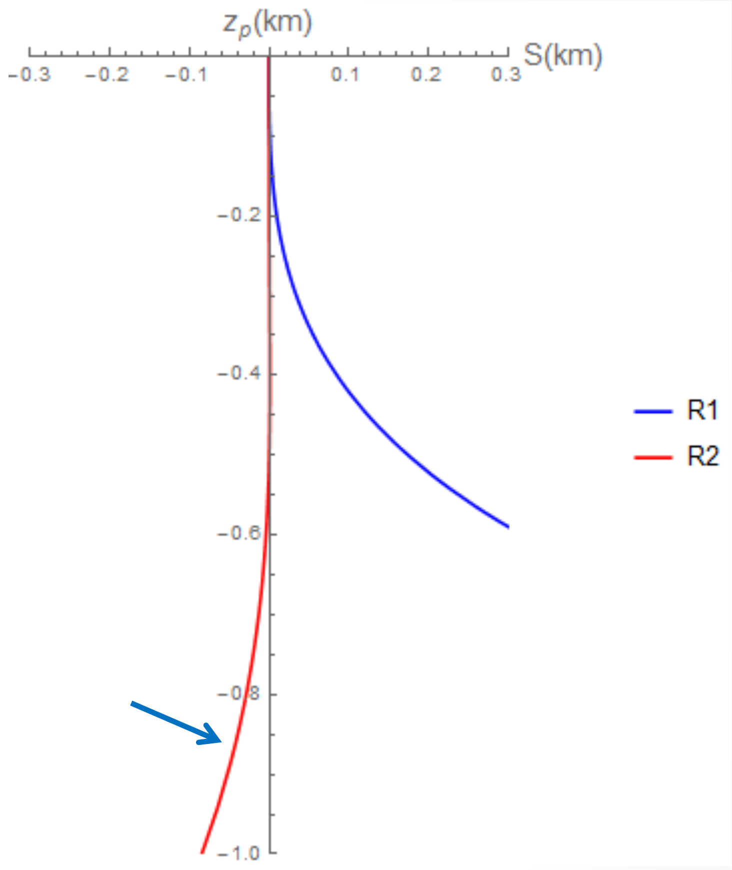
$$R(z_p) = \frac{\sum_{k=0}^{L} p_k z_p^k}{1 + \sum_{k=0}^{M} q_k z_p^k}$$

$$\Delta x_p = a_1 z_p + a_2 z_p^2 + a_3 z_p^3 + a_4 z_p^4,$$

$$a_\infty = \lim_{z_p \to \infty} \left(\frac{\Delta x_p}{z_p}\right),$$

$$R_1(z_p) = \frac{p_1 z_p + p_2 z_p^2}{1 + q_1 z_p}$$

$$R_2(z_p) = \frac{P_1 z_p + P_2 z_p^2 + P_3 z_p^3}{1 + Q_1 z_p + Q_2 z_p^2}$$

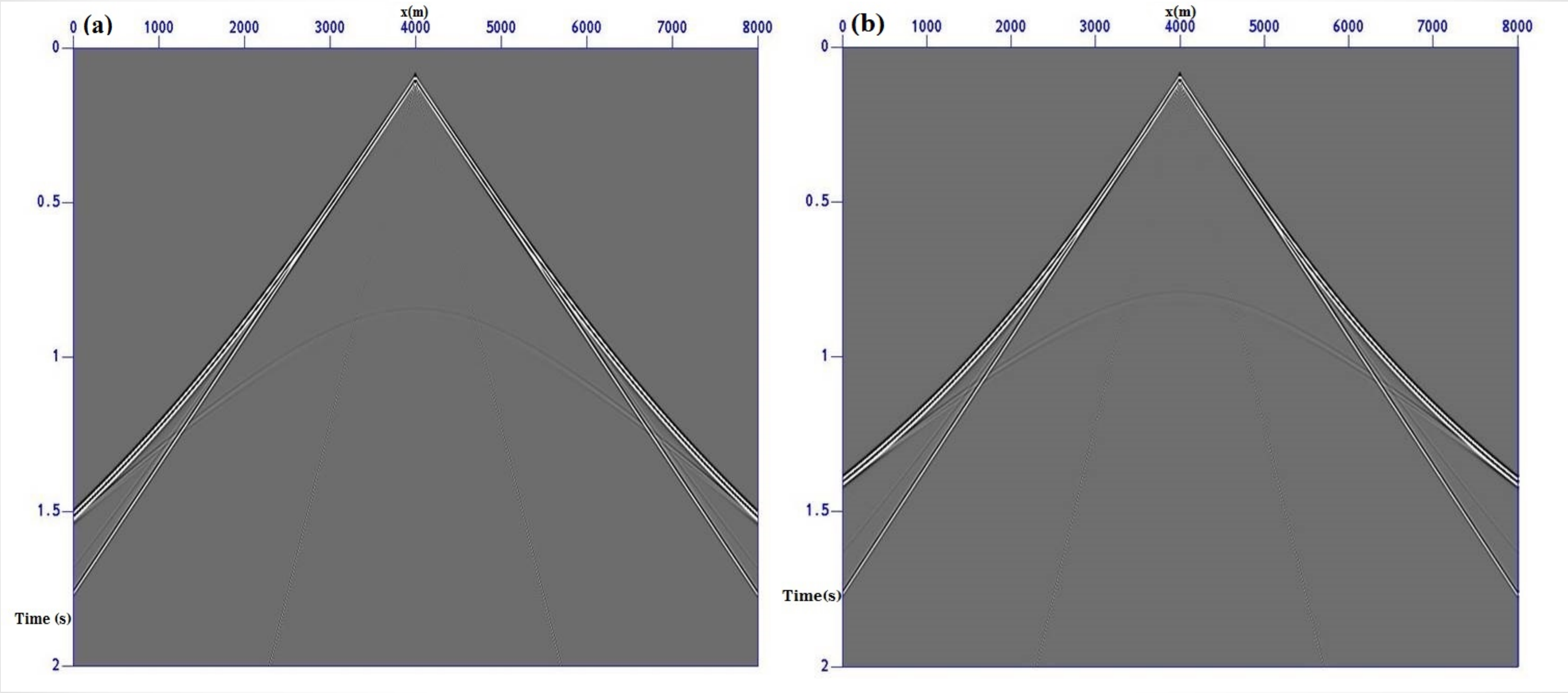


$$V_0 = 2\ \text{km/s},\ G = 1.5\ \text{s}^{-1},\ \varepsilon = 0.22,\ \eta = 0.1$$

Outline

Semblance analysis & anisotropy estimation

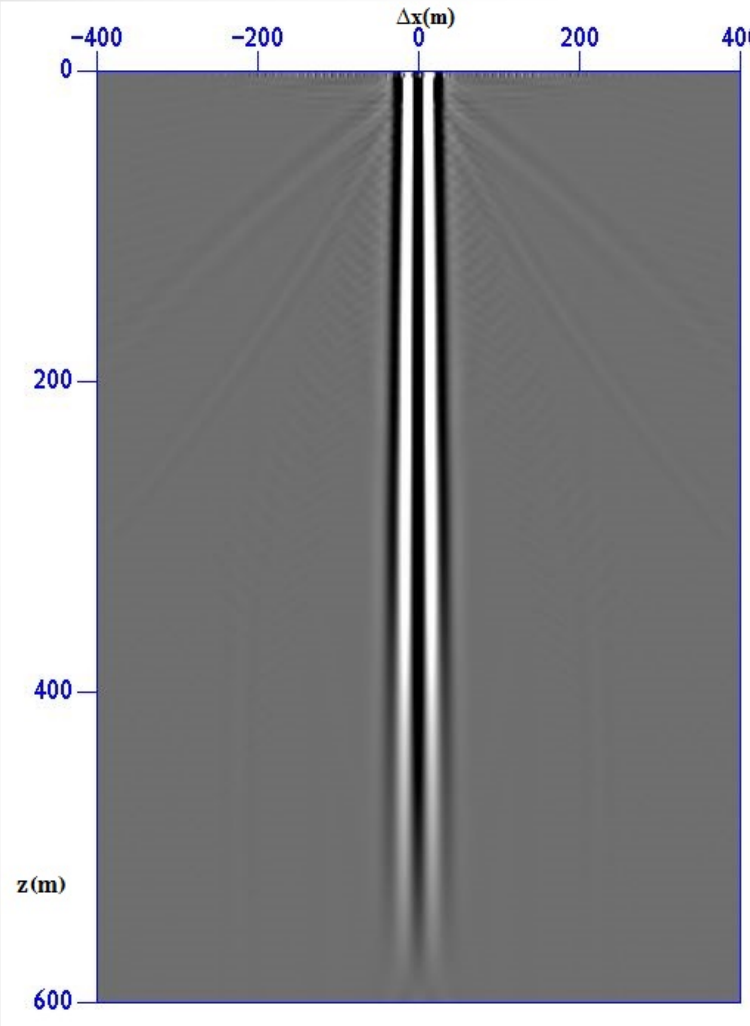
Smaller $G = 1.5\,\mathrm{s}^{-1}$ Larger $G = 2\,\mathrm{s}^{-1}$



Anisotropic modeling

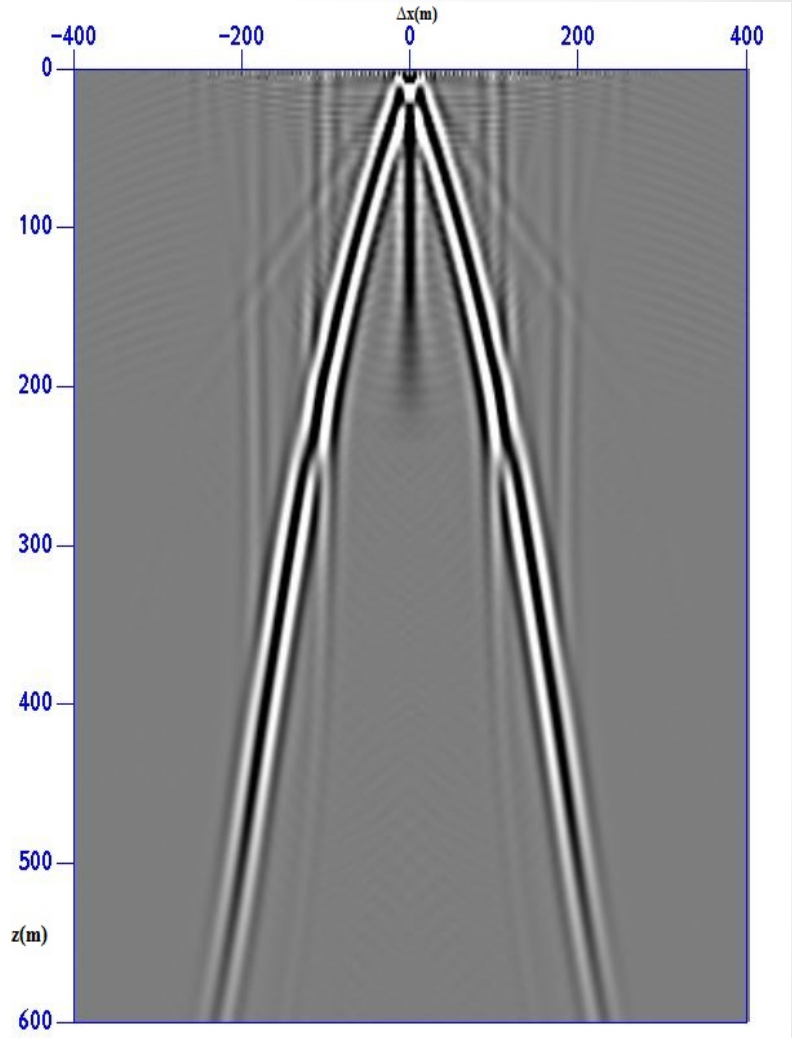
$$V_0 = 2\ \mathrm{km/s},\ \varepsilon = 0.22, \eta = 0.1$$

Semblance analysis & anisotropy estimation



Anisotropic RTM

$$\varepsilon = 0.22, \eta = 0.1$$

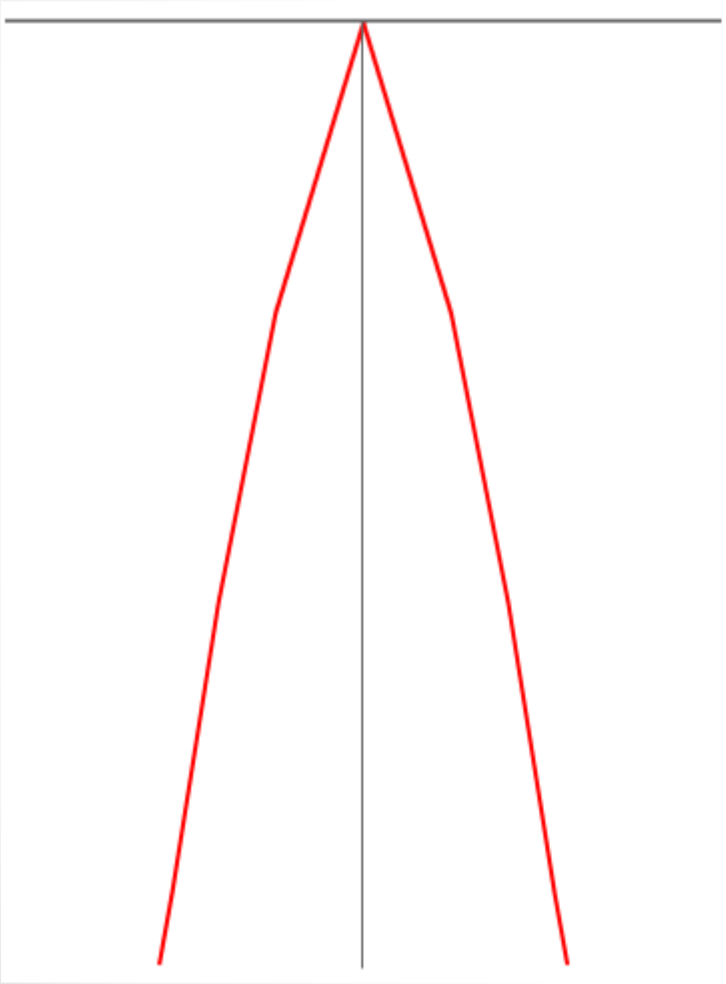


Isotropic RTM

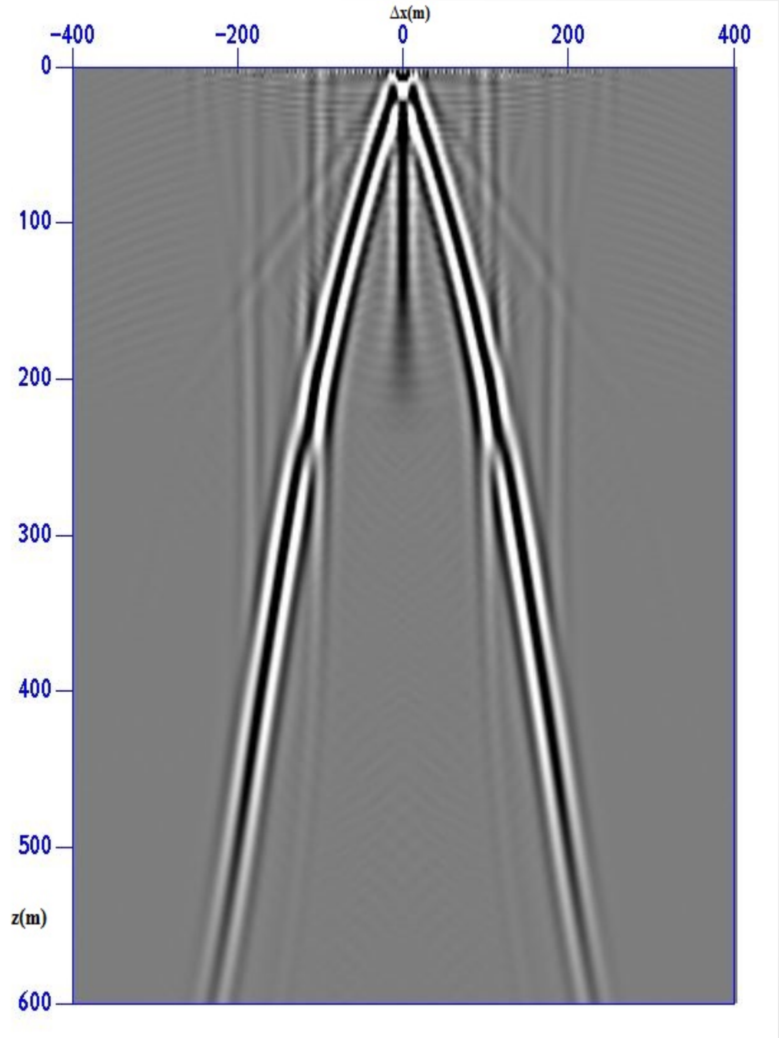
$$\varepsilon = 0, \eta = 0$$

Semblance analysis & anisotropy estimation

Rational approximation



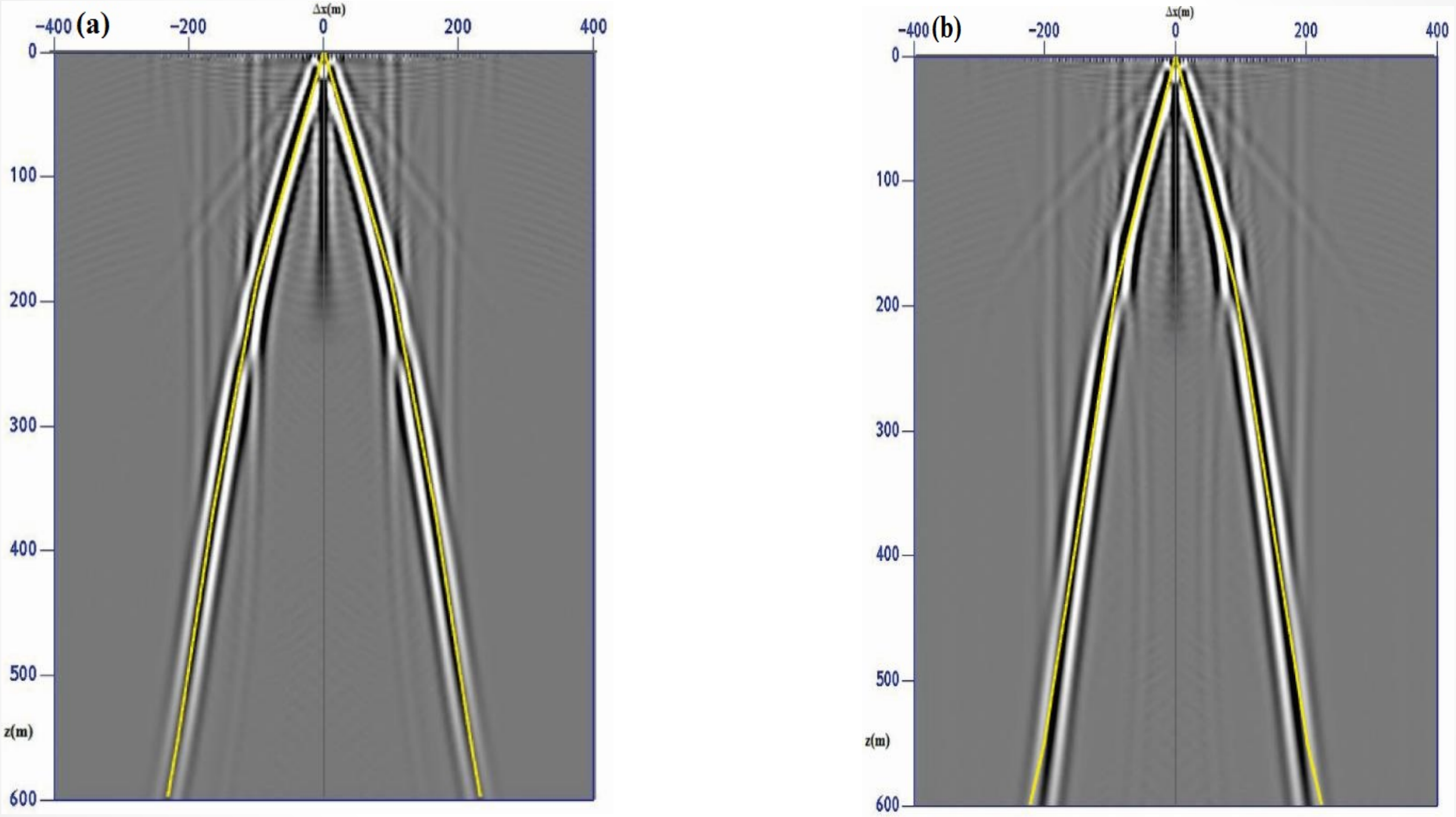
Synthetic seismic data



$$V_0 = 2\ \text{km/s}, G = 1.5\ \text{s}^{-1}, \varepsilon = 0.22, \eta = 0.1$$

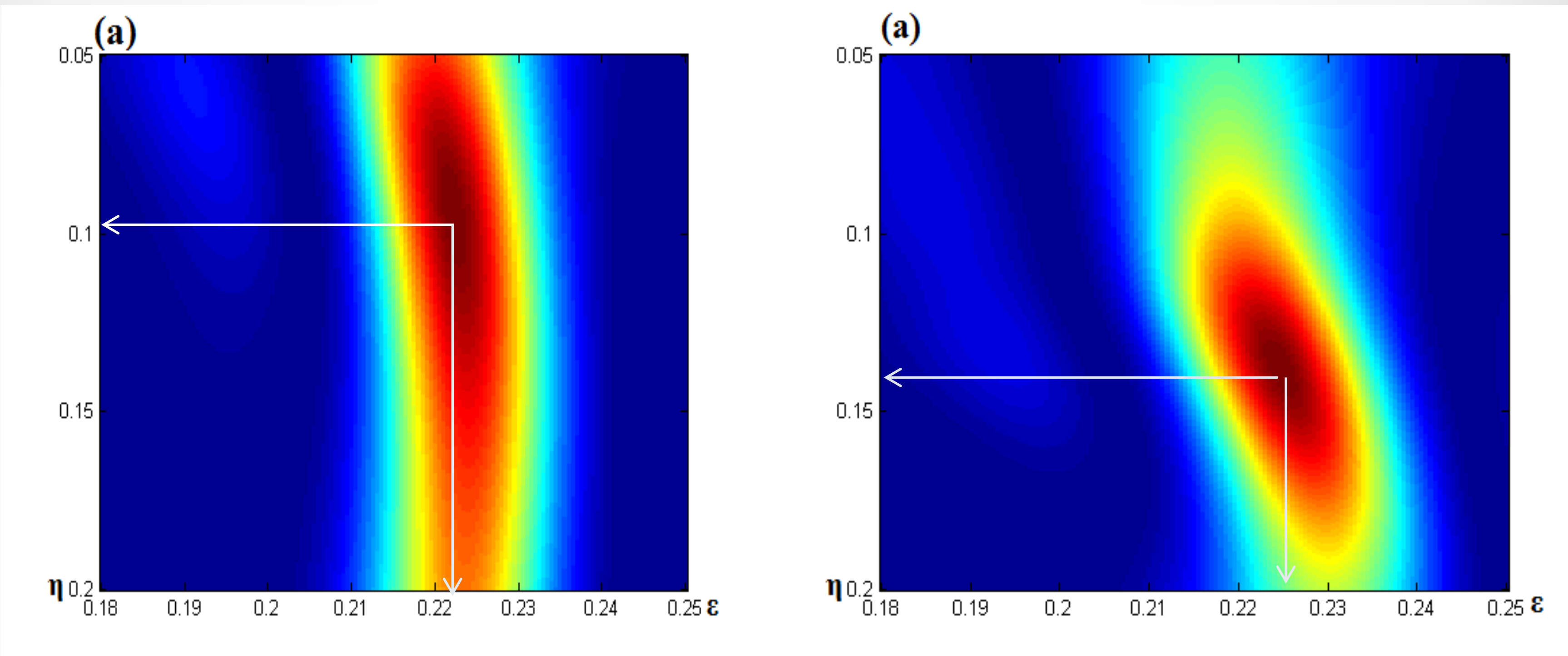
Semblance analysis & anisotropy estimation

$G = 1.5\,s^{-1}$ $G = 2\,s^{-1}$



Semblance analysis $SB = \dfrac{\sum_{j}^{nz} A_{i(j),j}^2}{(\sum_{j}^{nz} A_{i(j),j})^2},$

G_1=1.5s^{-1} G_2=2s^{-1}



$$\Delta\varepsilon \approx 0.002, \Delta\eta \approx -0.004$$

$$\Delta\varepsilon \approx 0.0075, \Delta\eta \approx 0.0385$$

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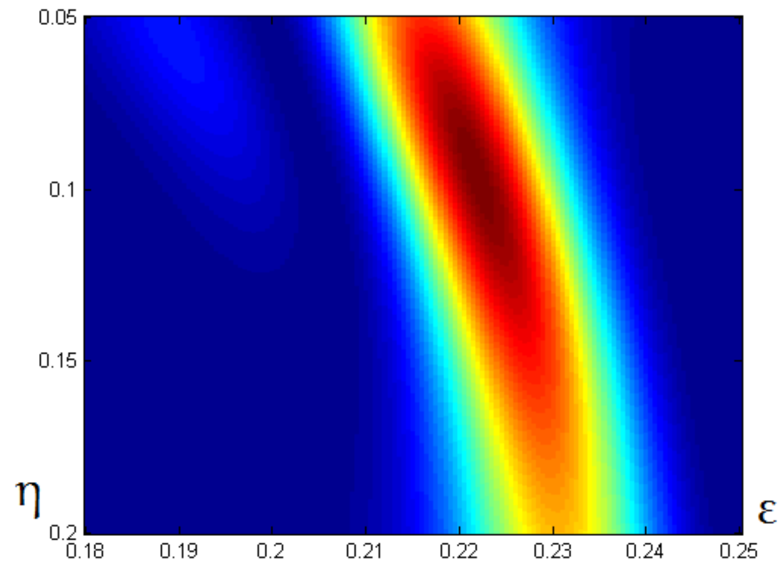
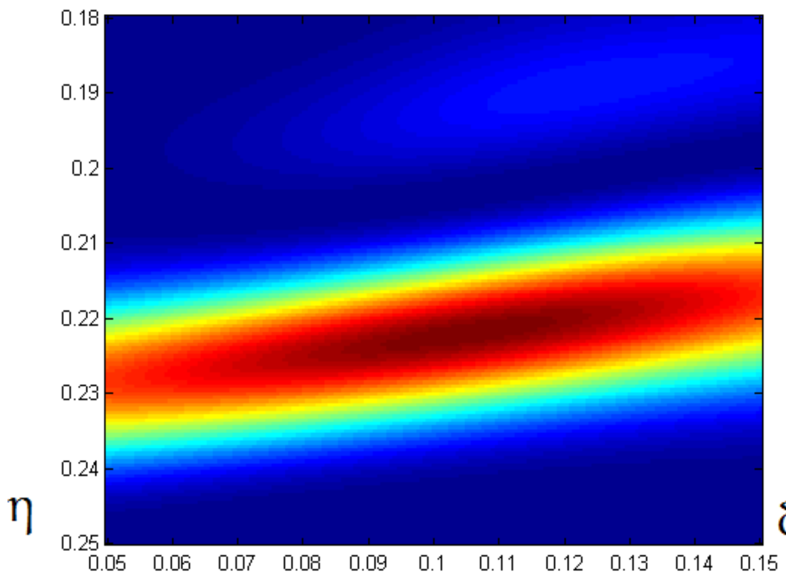
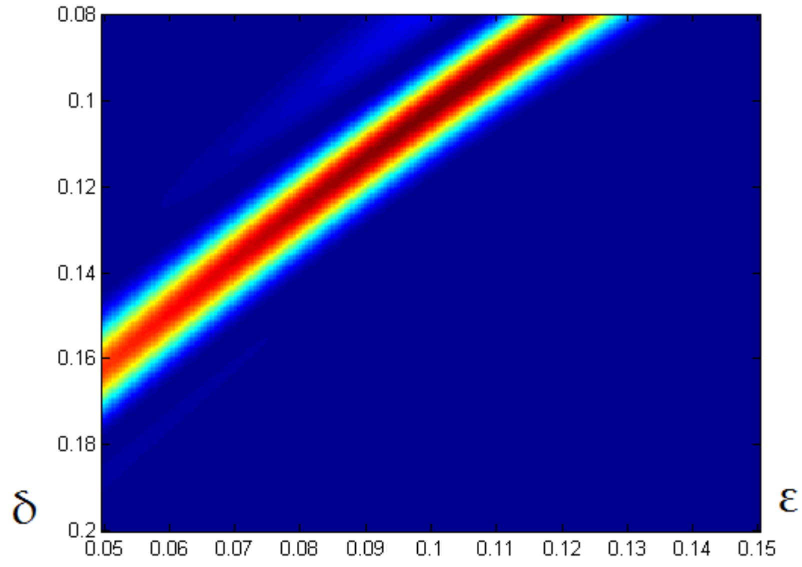
$$\delta, \varepsilon$$

$$\eta = \frac{\varepsilon - \delta}{1 + 2\delta}$$







Different parameterization

$G_1=1.5s^{-1}$		
V_0, ε, η	$\Delta\varepsilon \approx 0.002$	$\Delta\eta \approx -0.004$
V_0, δ, η	$\Delta\varepsilon \approx 0.0015$	$\Delta\eta \approx -0.0055$
V_0, δ, ε	$\Delta\varepsilon \approx 0.002$	$\Delta\eta \approx -0.0035$

$G_2=2s^{-1}$		
V_0, ε, η	$\Delta\varepsilon \approx 0.0075$	$\Delta\eta \approx 0.0385$
V_0, δ, η	$\Delta\varepsilon \approx 0.0080$	$\Delta\eta \approx 0.0385$
V_0, δ, ε	$\Delta\varepsilon \approx 0.0075$	$\Delta\eta \approx 0.045$

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Conclusions

1 We develop the method to estimate the anisotropy parameters from the residual moveout of the diving wave in a factorized velocity model.

2 We analyze different approximations for the imaging moveout, and find that the second order rational approximation is the most accurate one.

3 We estimate the anisotropy parameters from the semblance analysis on residual moveout in the RTM image gathers.

4 The anisotropy estimation using semblance analysis for all parameterizations is reasonably accurate even for large values of velocity gradients.

Discussions

Fix V_0, G

Estimation ε, η

Fix V_0

?

Estimation ε, η, G

End

Thanks for attention!