Outline

- Motivation
- Theory
- 2D and 3D reflection WEMVA kernels
- Conclusions and future work

Motivation

- Accurate wave propagation in large angles with respect to vertical

- Efficient wave extrapolation and imaging

One-way VTI extrapolation using implicit finite difference (Shan 2006)

Theory

$$\min \sum_{S_r} \left(\sqrt{\frac{1-(1+2\delta)S_r^2}{1-2\eta(2\delta+1)S_r^2}} - \left(1 - \sum_{i=1}^{n} \frac{\alpha_i S_r^2}{1-\beta_i S_r^2}\right)\right)^2$$

Exact dispersion relation

Approx. dispersion relation

$$S_z = \frac{k_z}{w/v_v},\ S_r = \frac{k_r}{w/v_v} \text{ and } k_r = \sqrt{k_x^2 + k_y^2}$$

w : temporal frequency

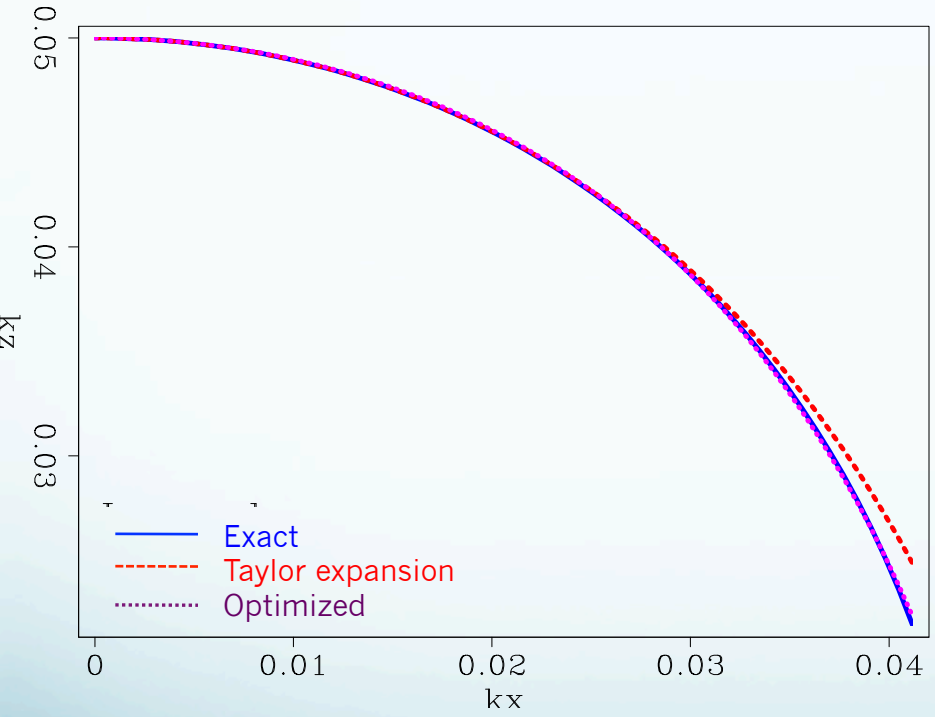
v_v : vertical velocity

η, δ: Thomsen parameters

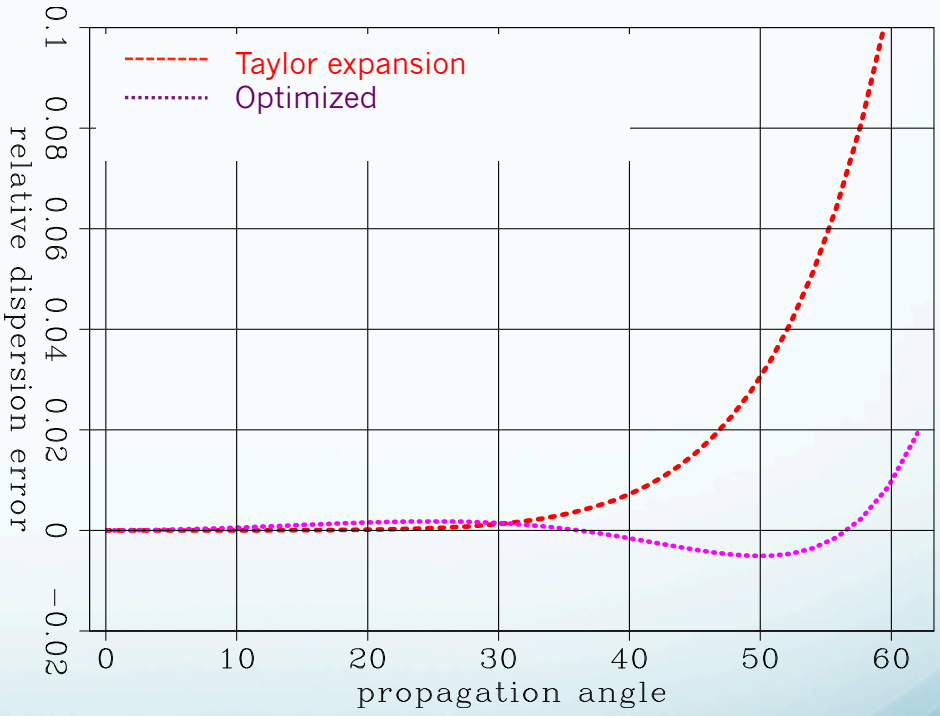
k_x, k_y, k_z: Spatial wavenumber

Theory

Dispersion relation



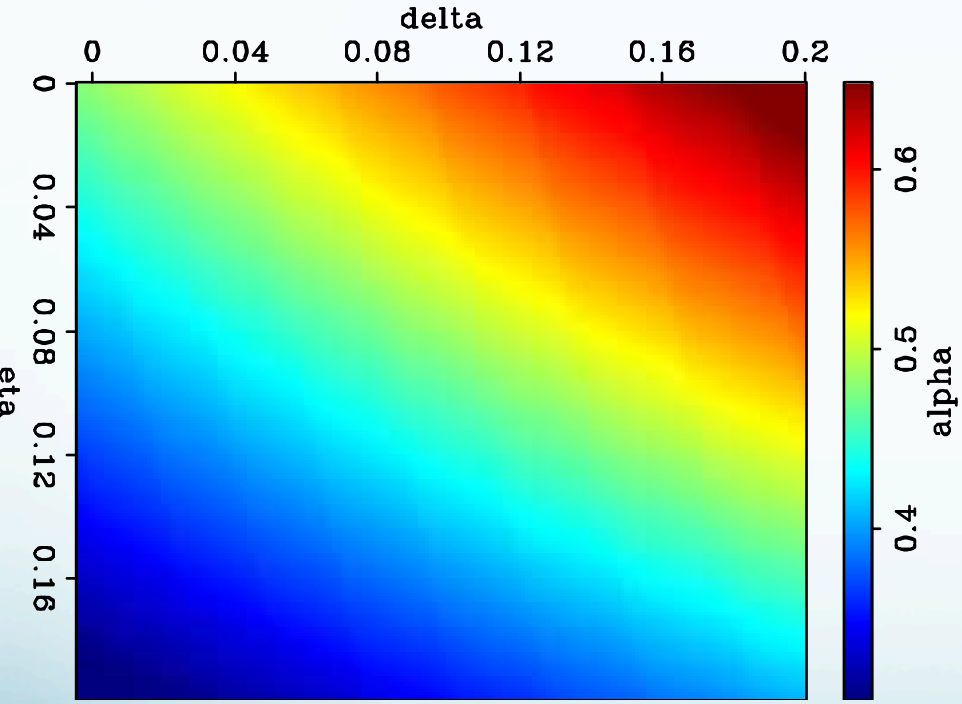
Relative dispersion error



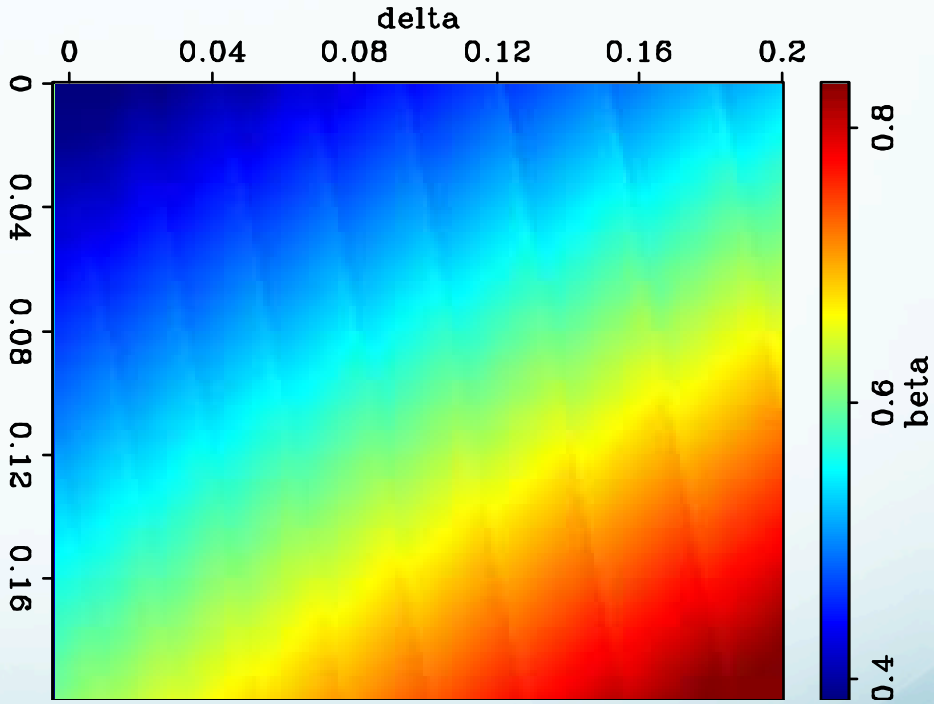
$\eta = 0.09; \ \delta = 0.02$

Theory

Optimized α



Optimized β



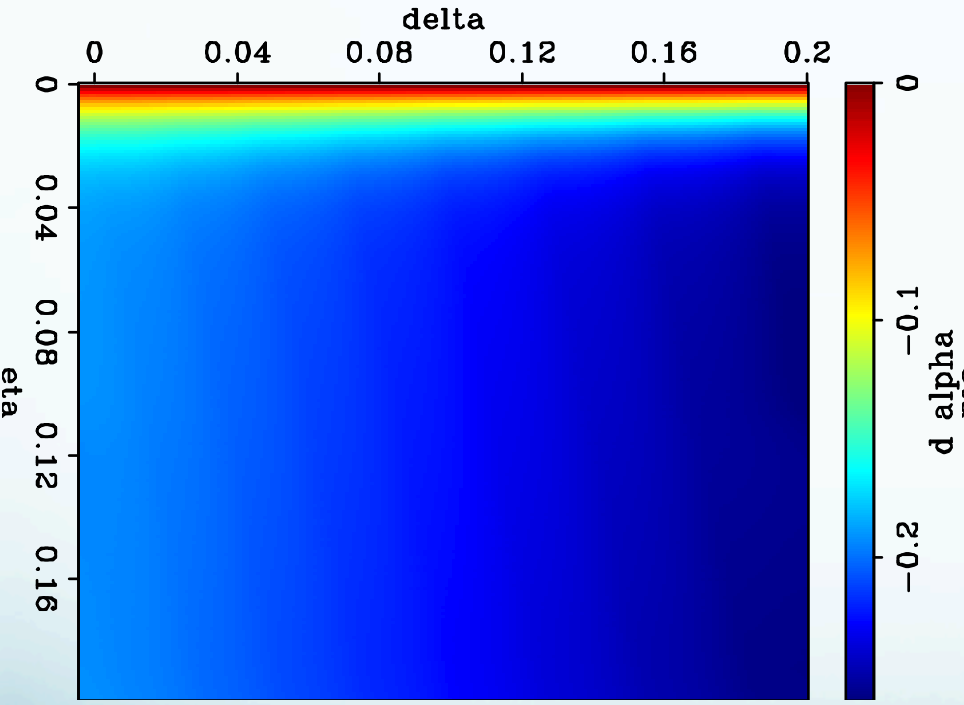
Theory

$$\frac{\partial k_z}{\partial v_v} = -\frac{w}{v_v^2}\left(1 + \alpha\frac{k_r^2}{(w/v_v)^2} + 3\alpha\beta\frac{k_r^4}{(w/v_v)^4}\right)$$

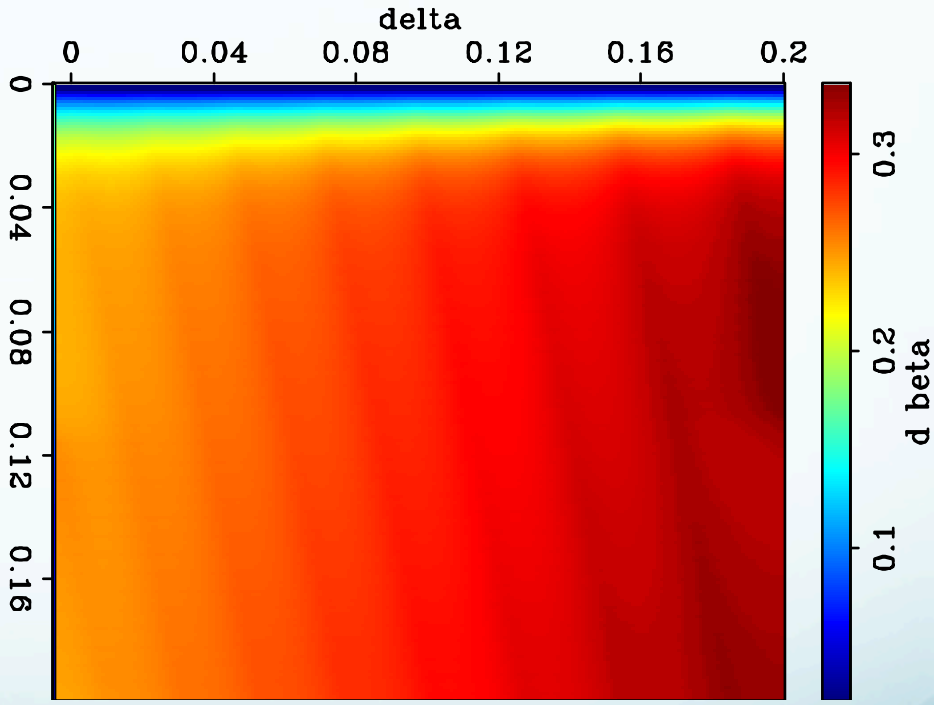
$$\frac{\partial k_z}{\partial \eta} = -\frac{w}{v_v}\left(\frac{\partial \alpha}{\partial \eta}\frac{k_r^2}{(w/v_v)^2} + \left(\frac{\partial \alpha}{\partial \eta}\beta + \alpha\frac{\partial \beta}{\partial \eta}\right)\frac{k_r^4}{(w/v_v)^4}\right)$$

Theory

$\mathrm{d}\alpha / \mathrm{d}\eta$



$\mathrm{d}\beta / \mathrm{d}\eta$

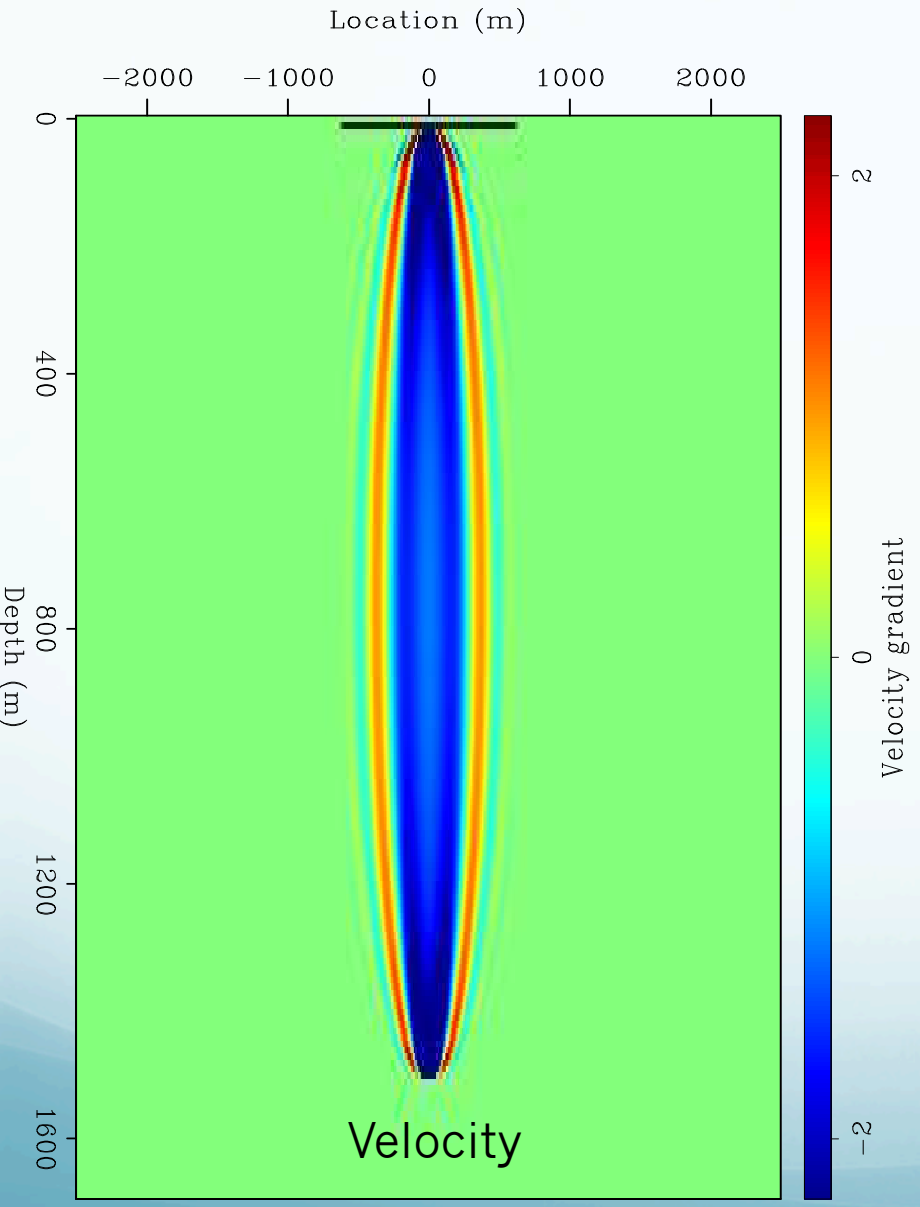


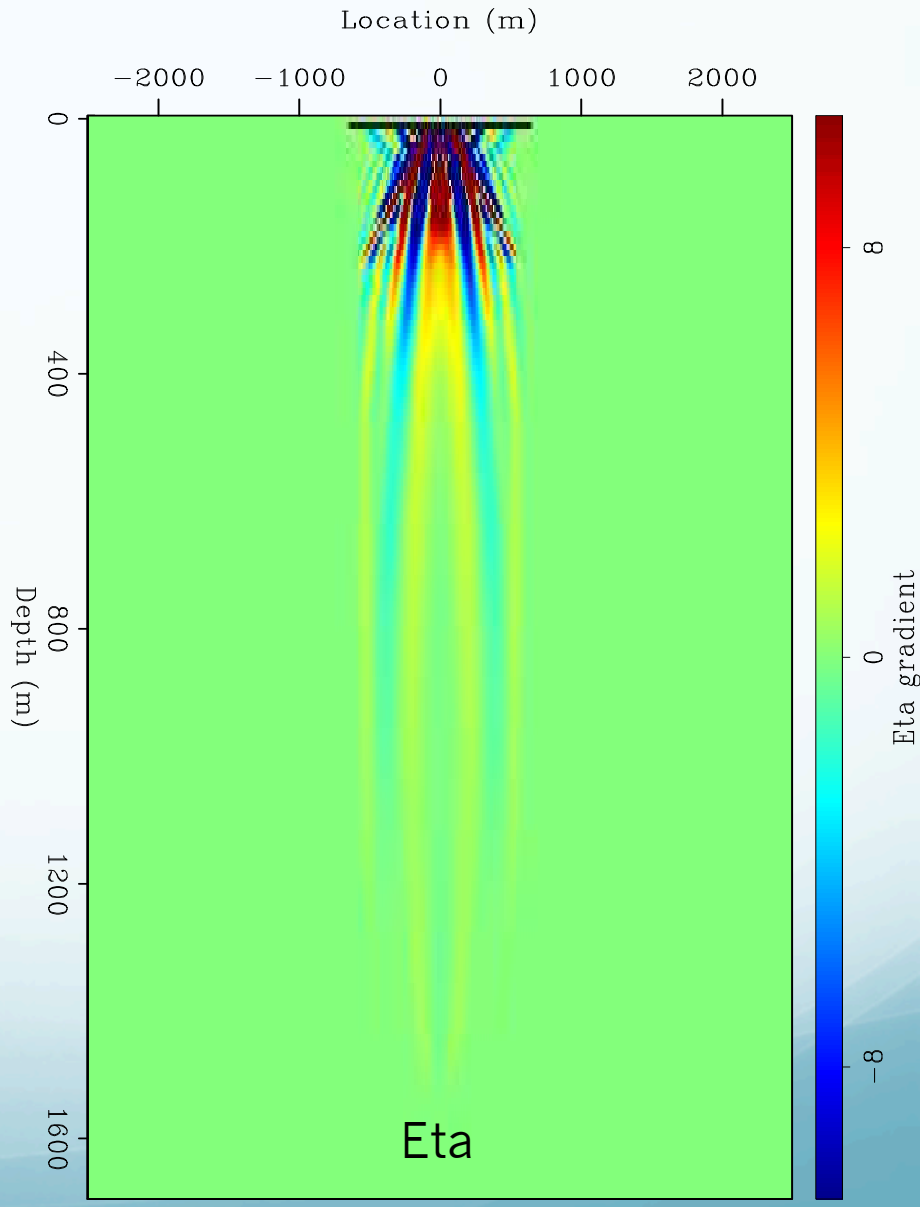
Sensitivity kernels for AnisoWEMVA

- Background model:
  - Homogenous Vv = 2000m/s, η =0.09, δ =0.02
  - Flat reflector at z=1500m

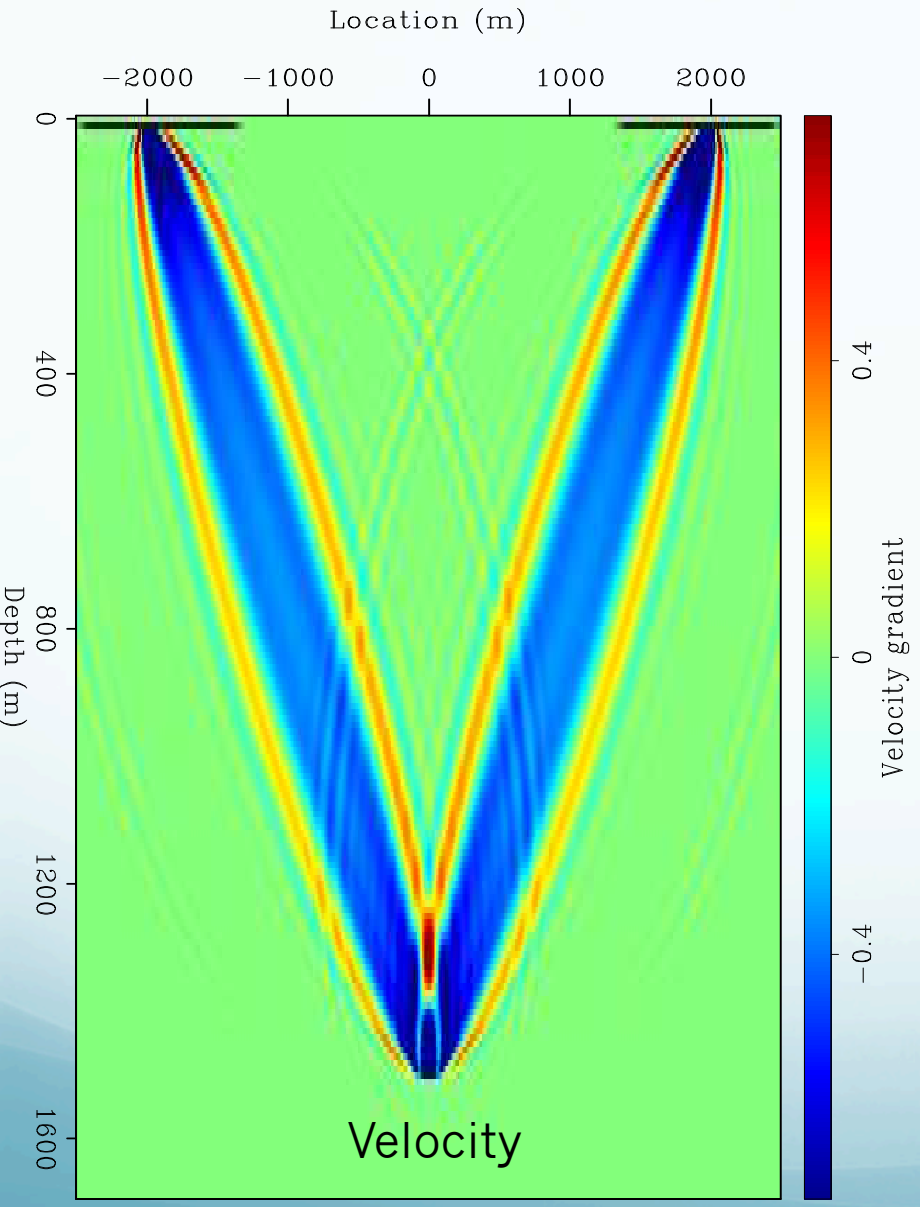
- Impulse image perturbation
  - $\Delta I = \delta(x,y,z=1500)$

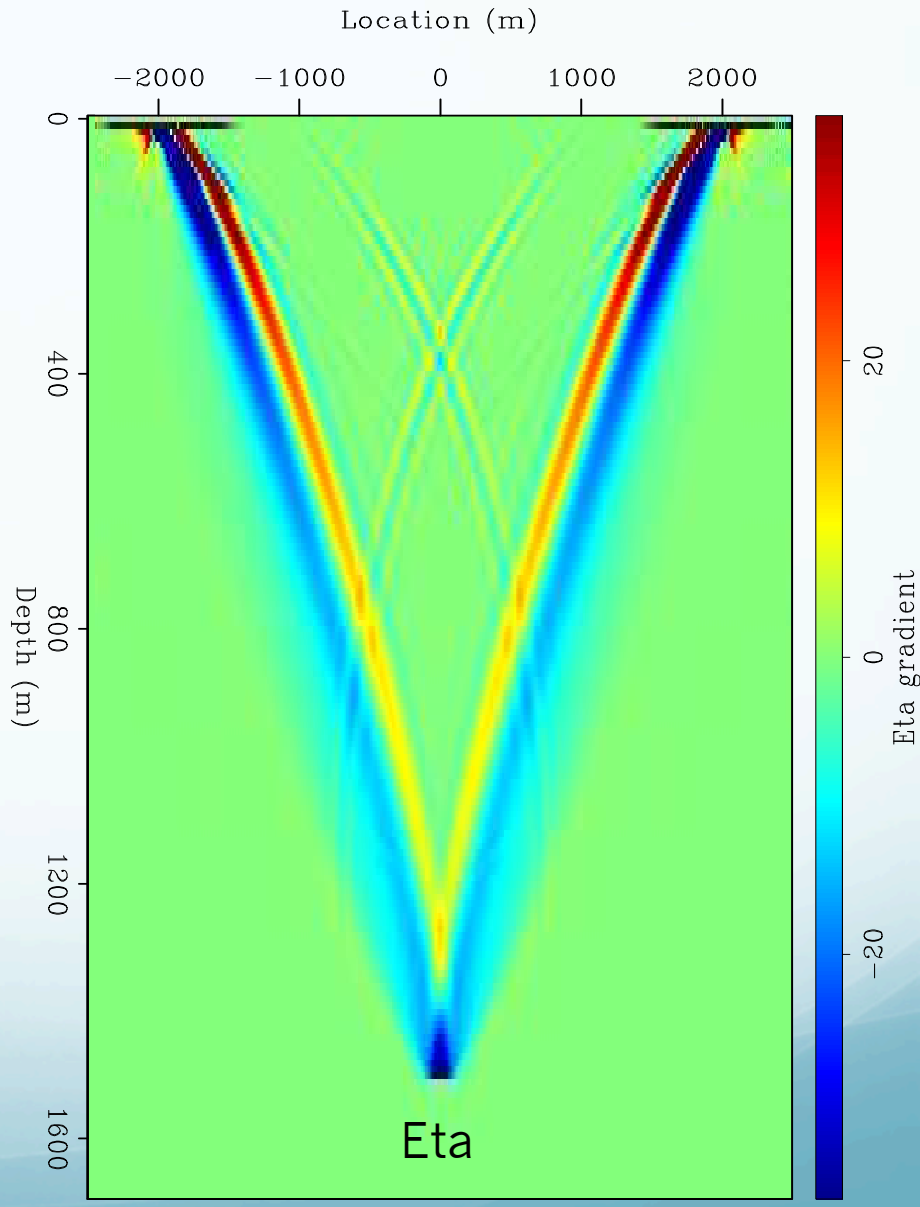
2D sensitivity kernels – Zero offset



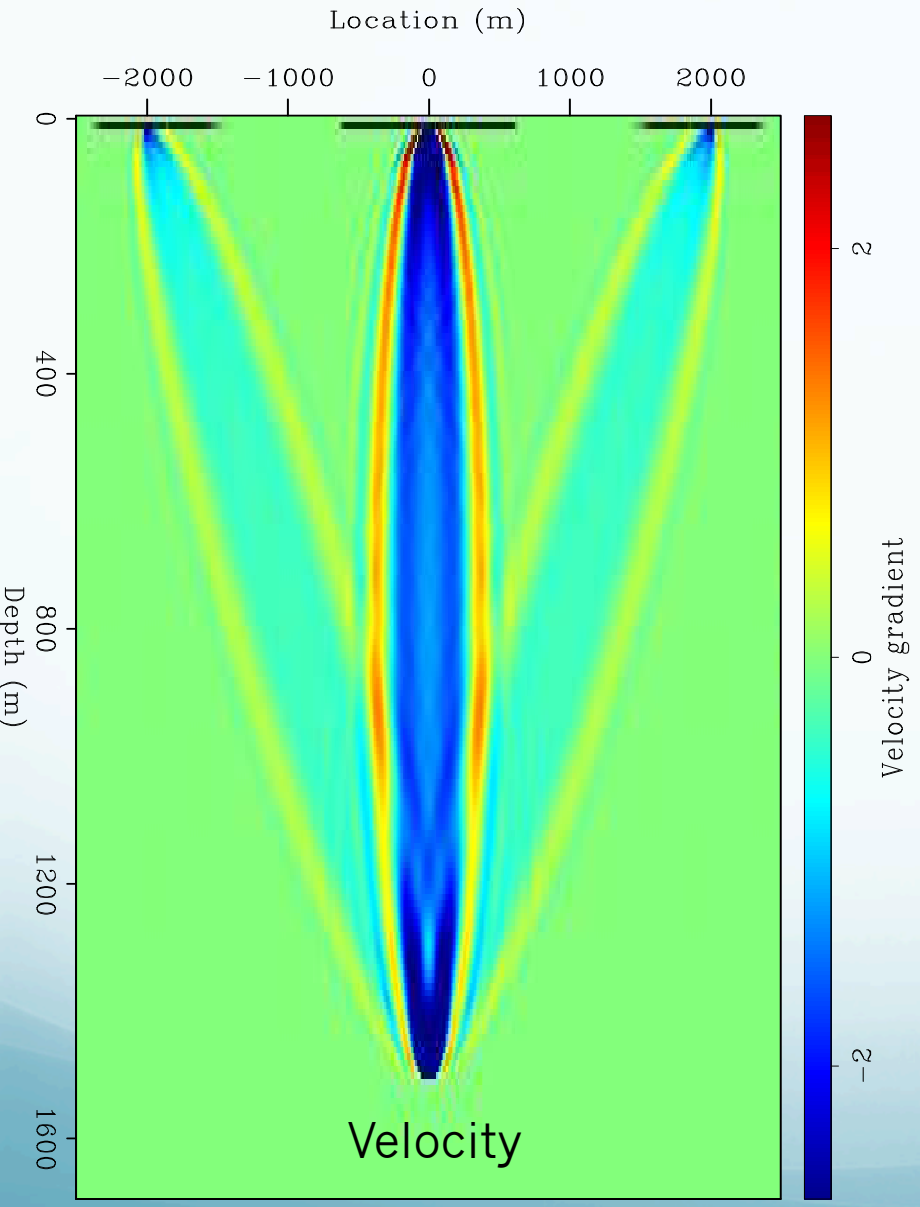


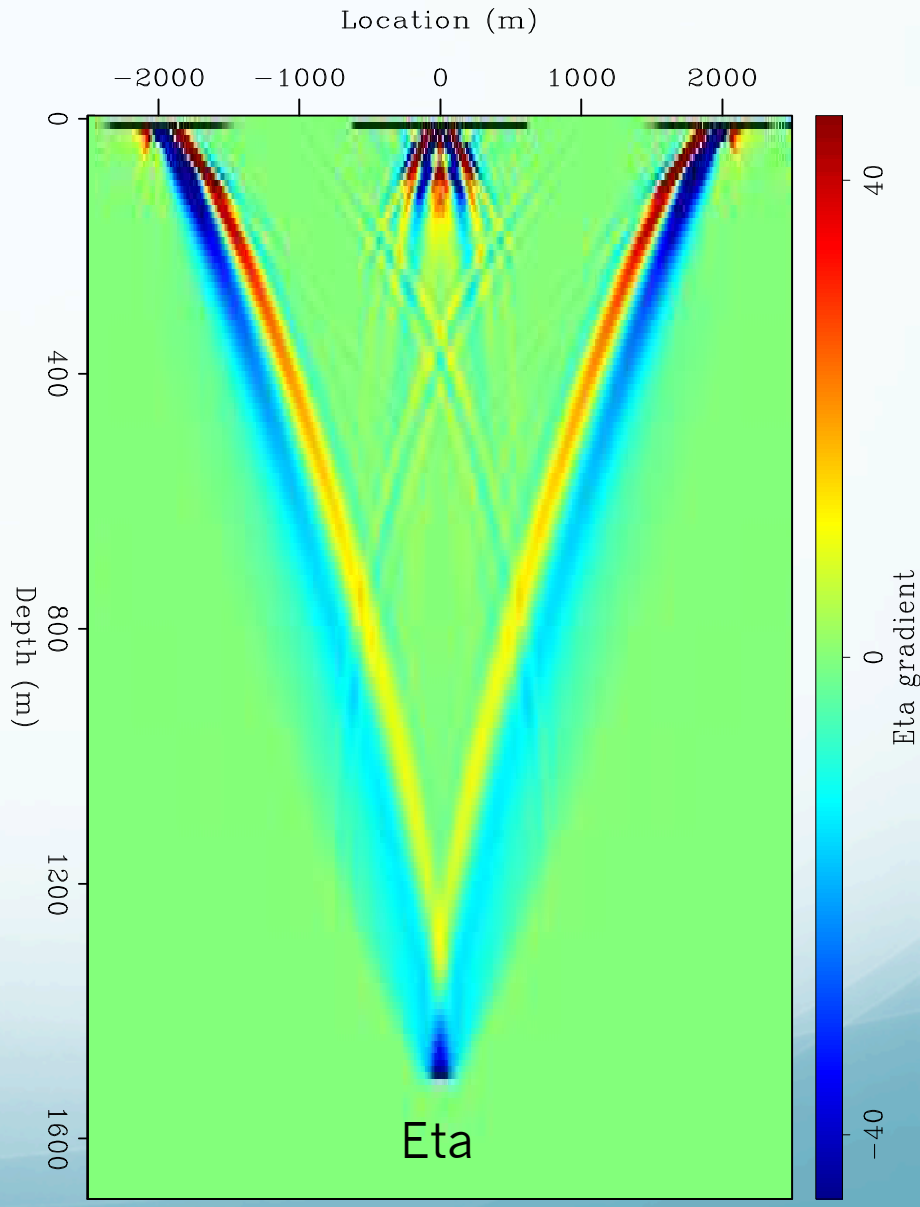
2D sensitivity kernels – 4km offset



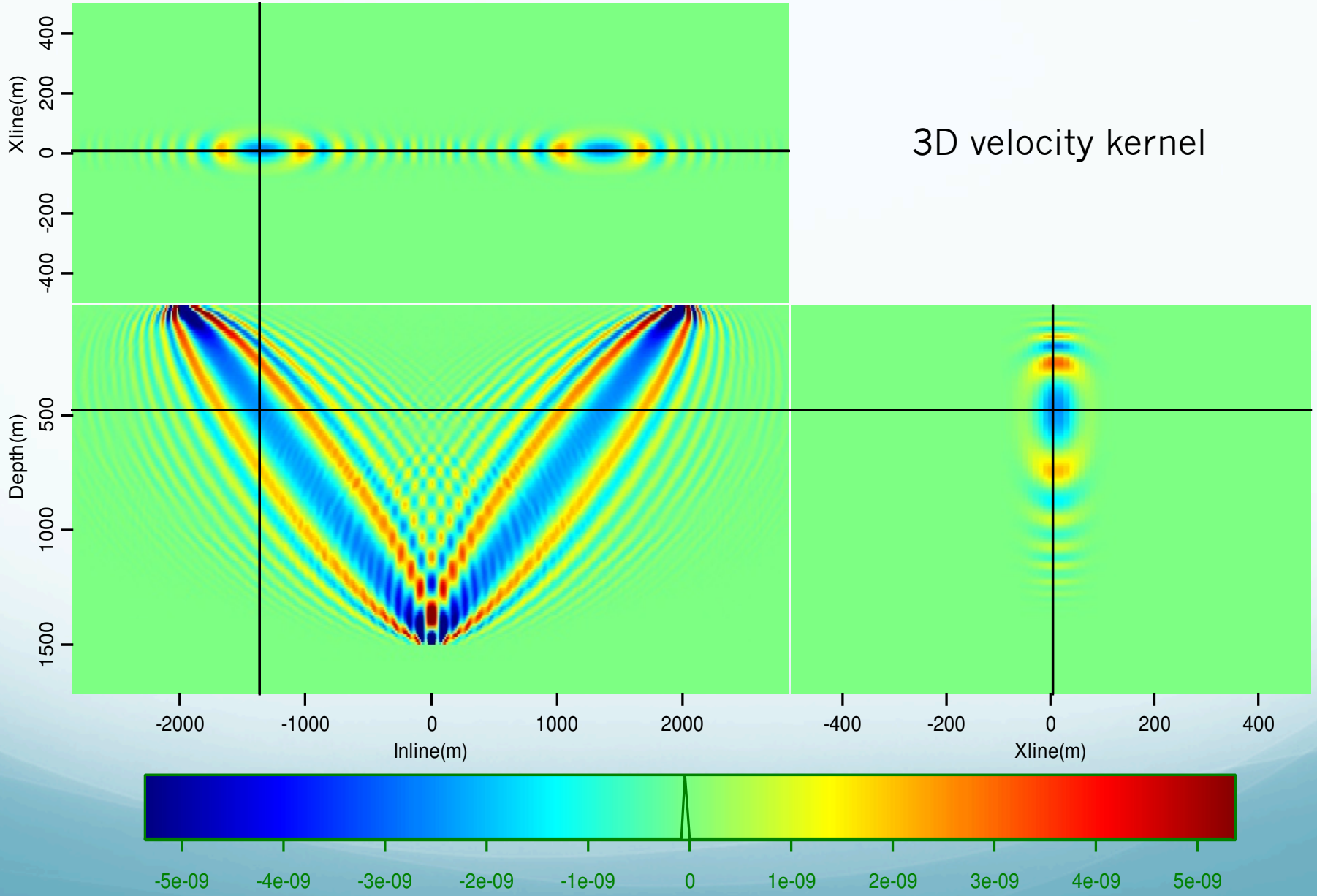


2D sensitivity kernels – Sum of both

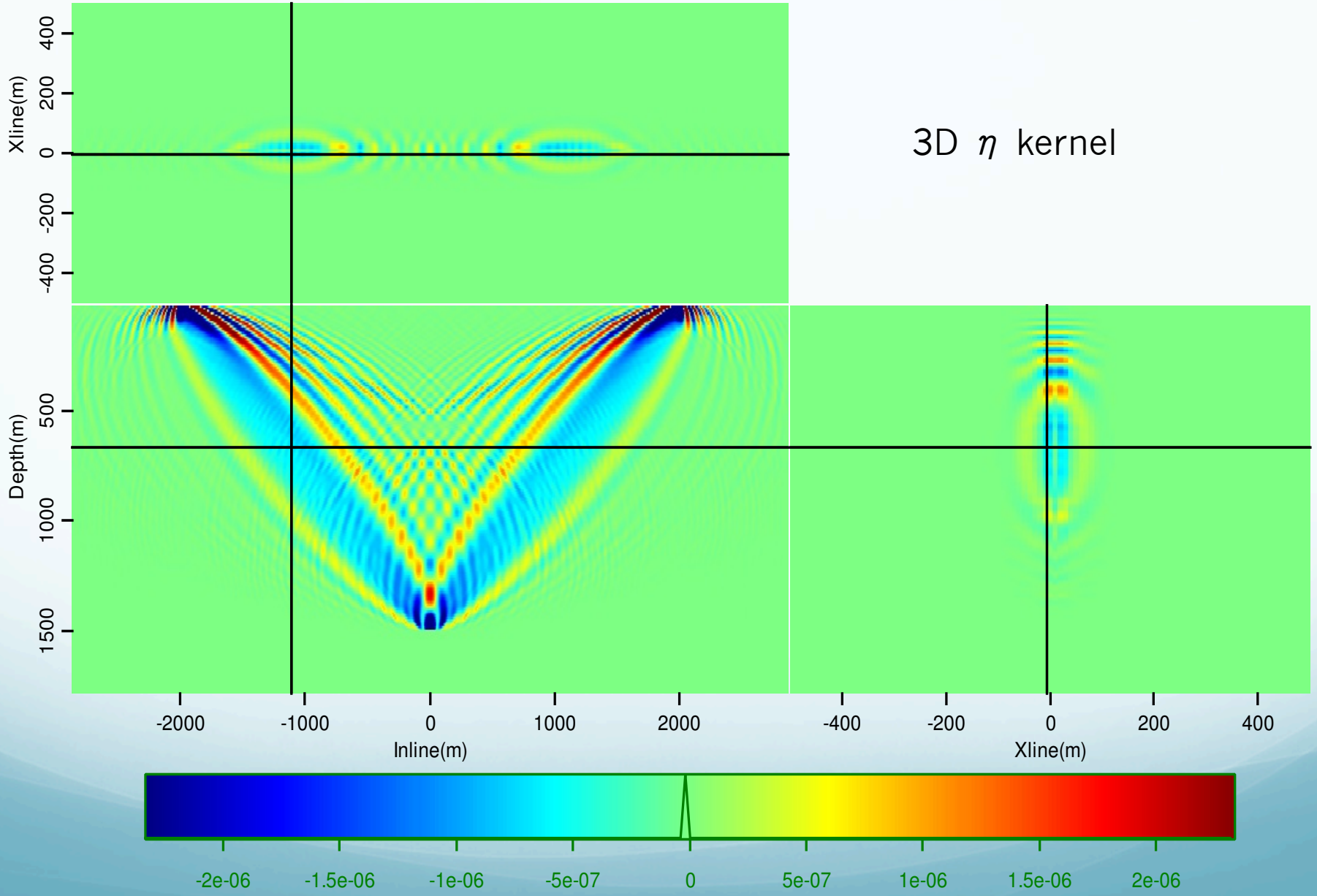




3D sensitivity kernels for AnisoWEMVA



3D sensitivity kernels for AnisoWEMVA



Conclusions and discussions

- Accuracy: up to 60° to the vertical
  - “Right answer to the wrong question?” (Etgen 2009)
  - Joint estimation of the coefficients and their derivatives
- Efficiency: similar cost as isotropic IFD
- 2D kernels:
  - sensitivity test for different parameters using different acquisition geometry
  - editing the gradient with angle
- 3D kernels:
  - code works

Thank you for listening!

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