



Band-limited scattered wavefield reconstruction beneath complex overburdens using the Marchenko method

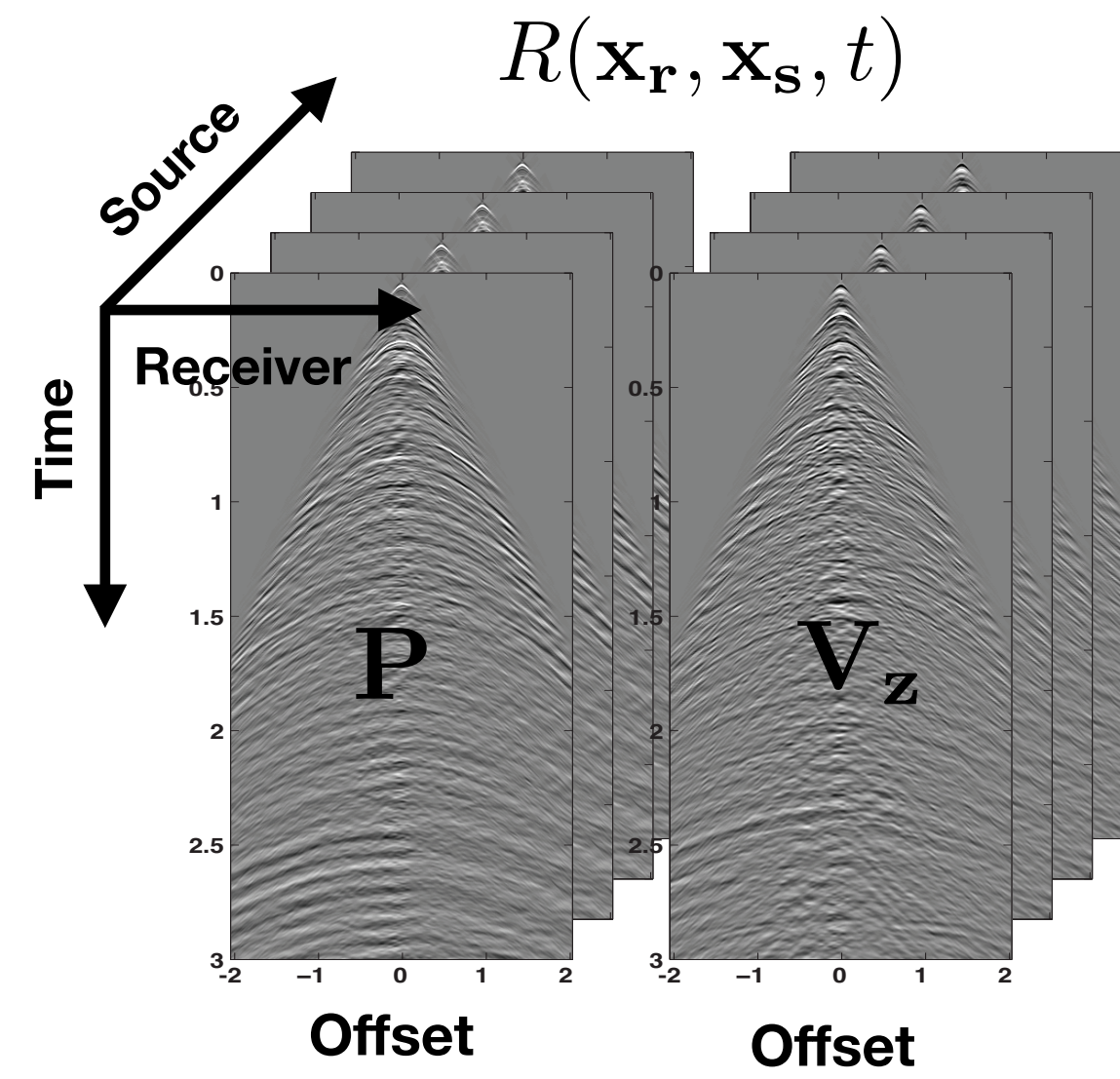
David Vargas¹, Ivan Vasconcelos¹, Matteo Ravasi²,

¹Utrecht University,

²King Abdullah University of Science and Technology,

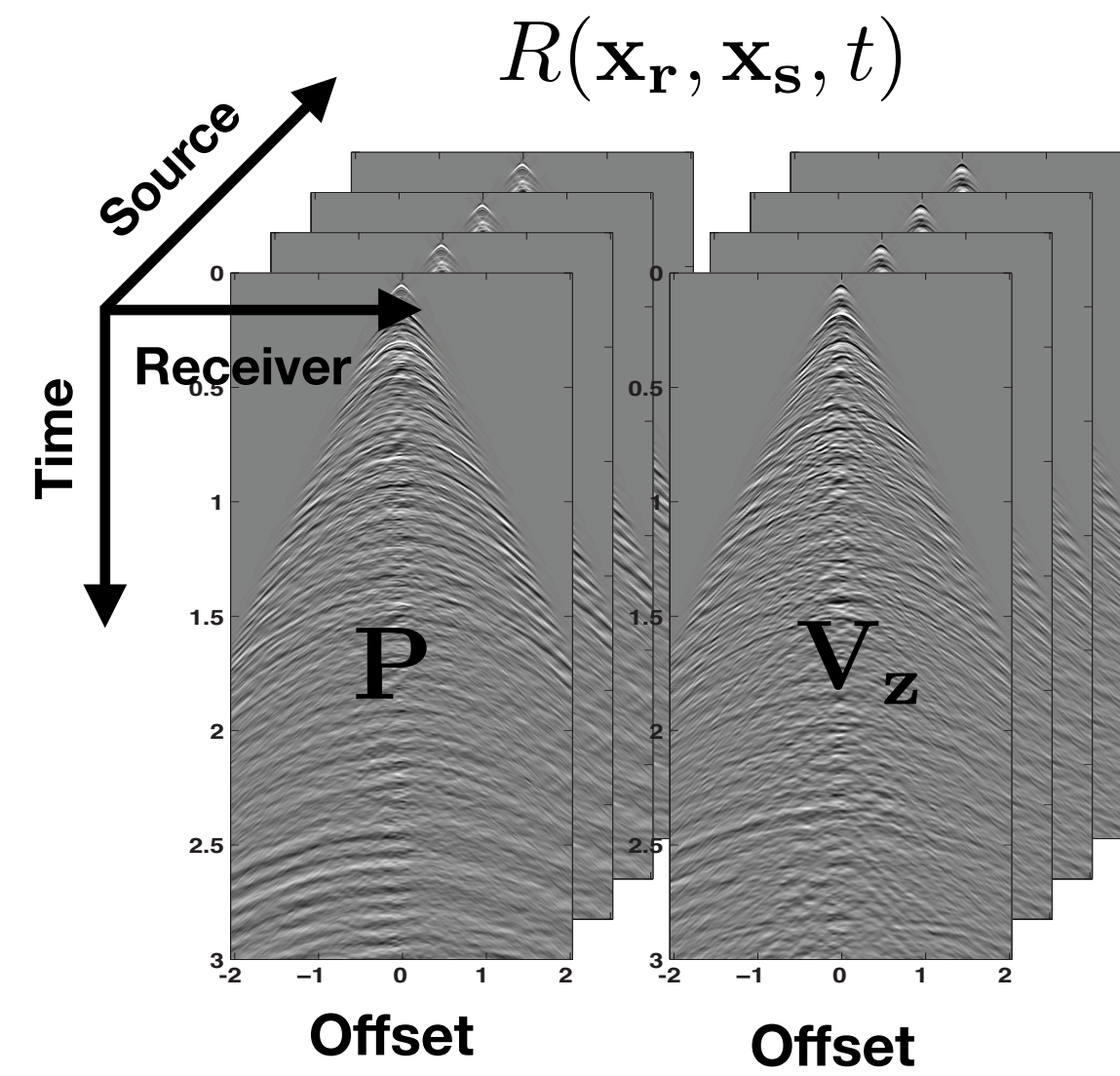
Outline

- *Band-limited reflection data*

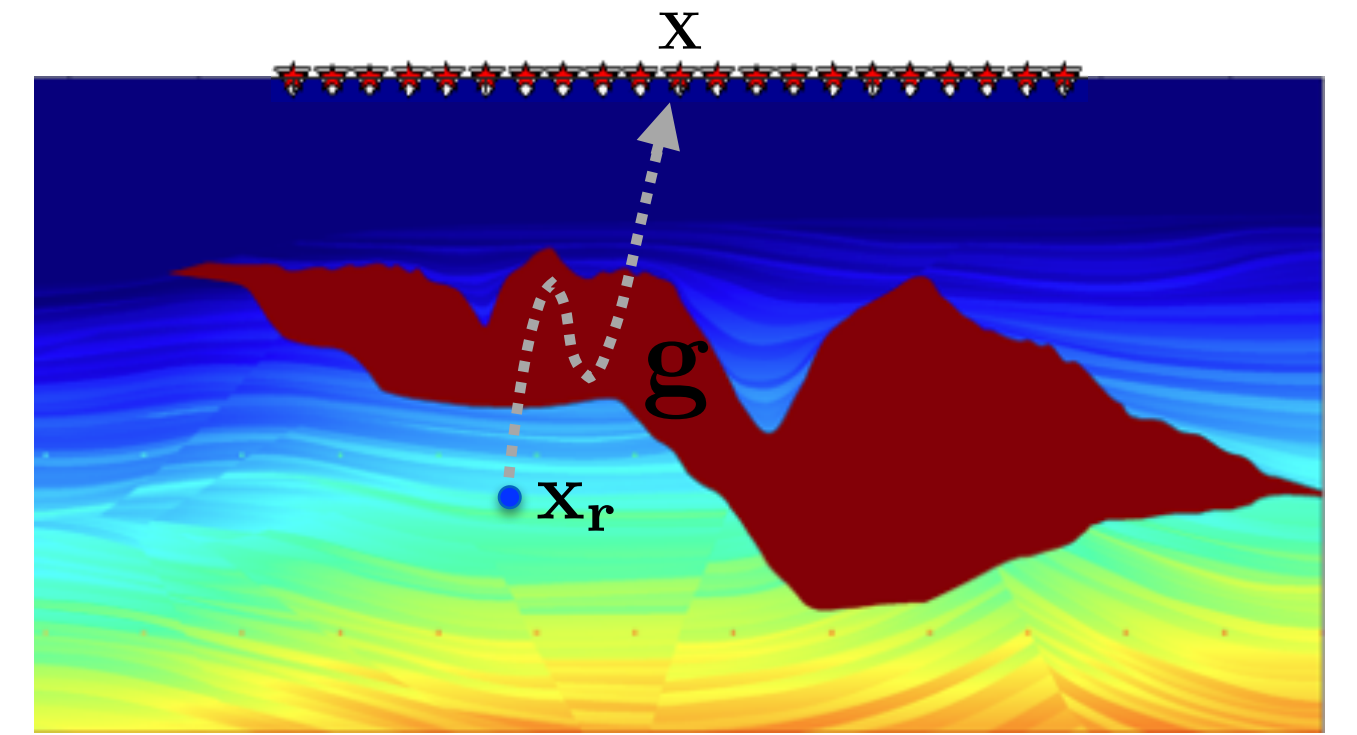


Outline

- *Band-limited reflection data*

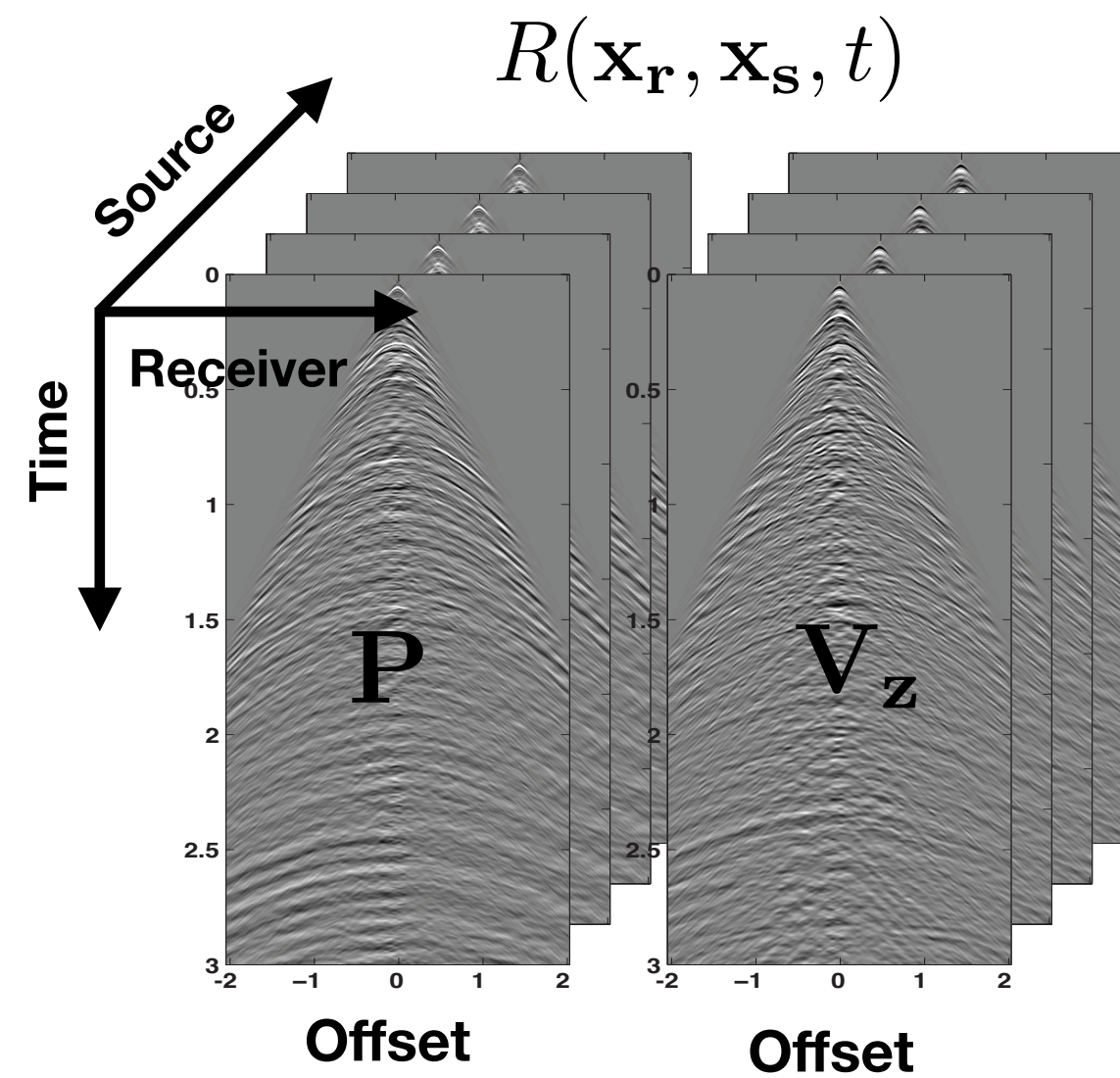


- *Complex overburdens*

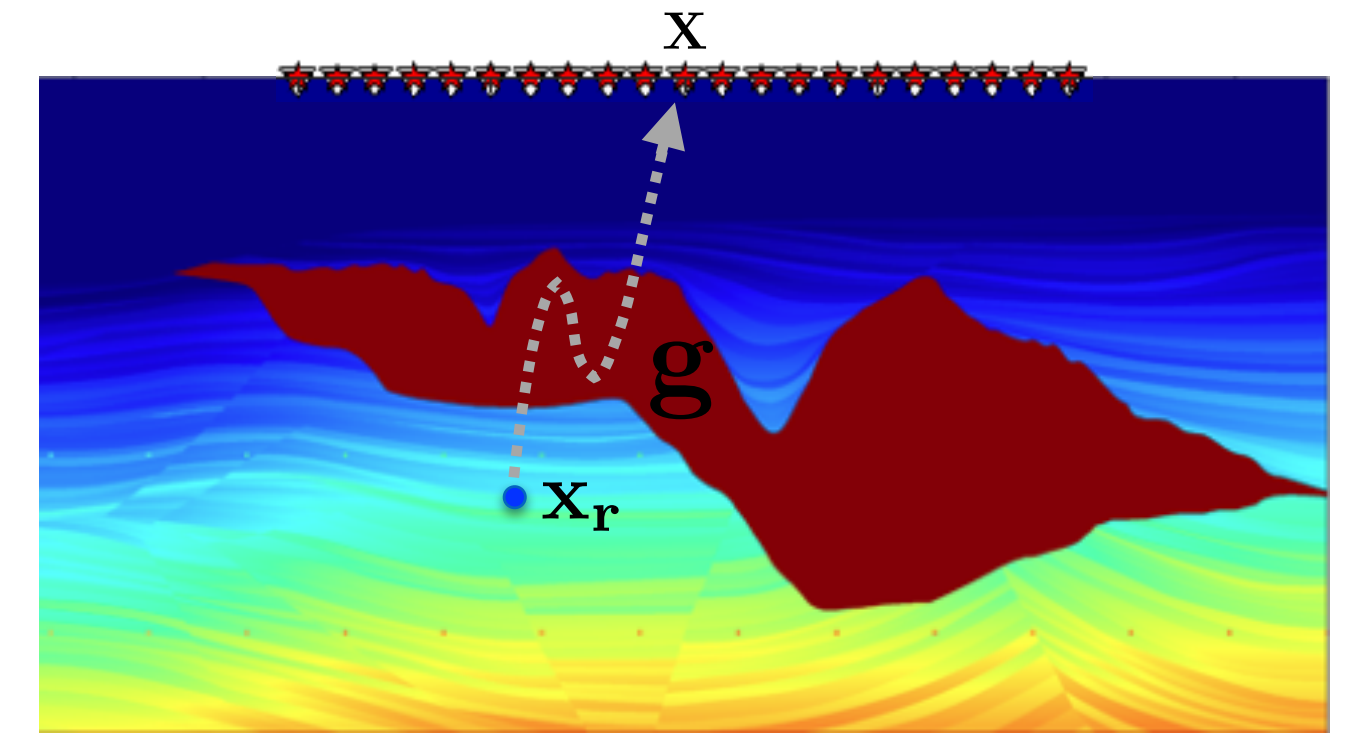


Outline

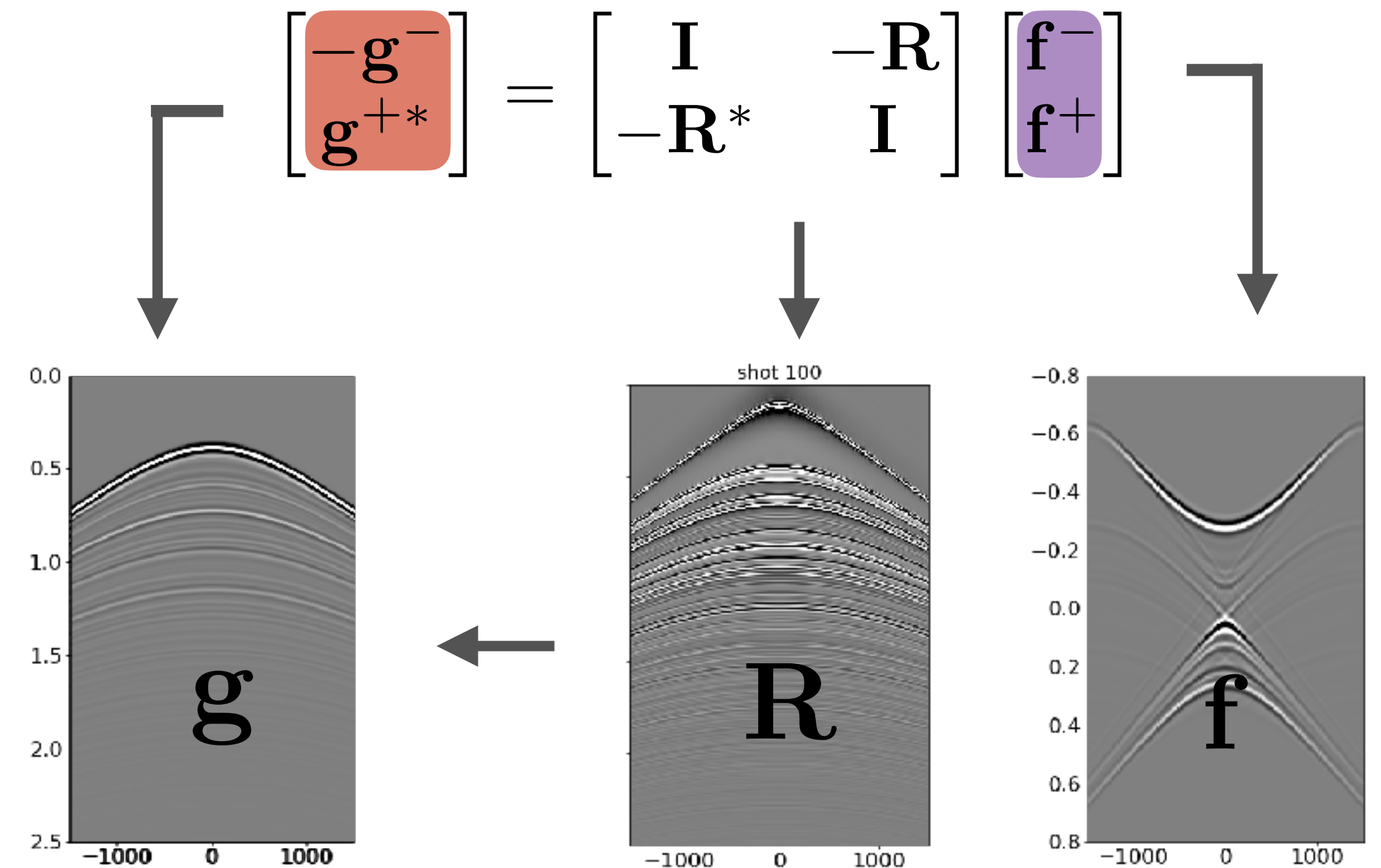
- *Band-limited reflection data*



- *Complex overburdens*

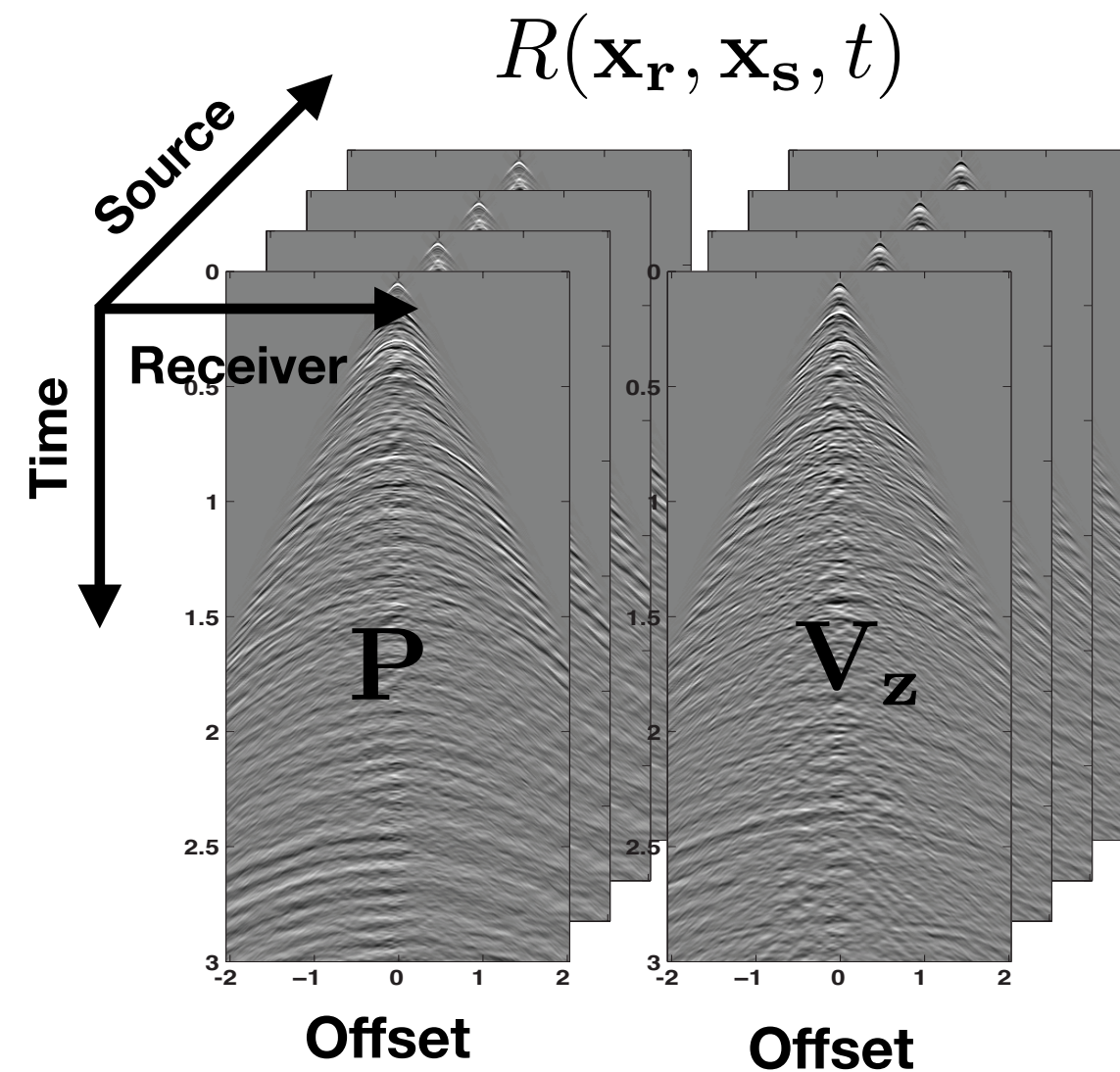


- *Marchenko redatuming*



Redatuming

- *Band-limited reflection data*

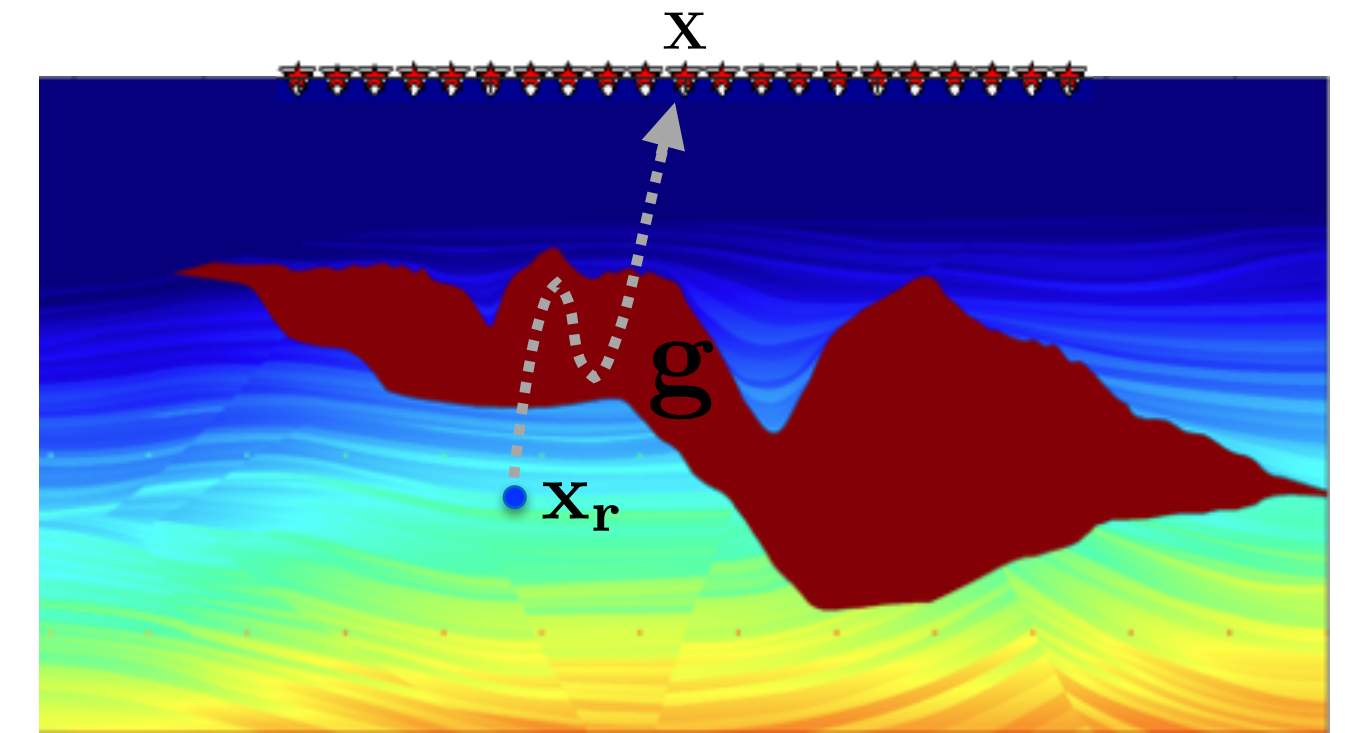


- *Scattered wavefields*

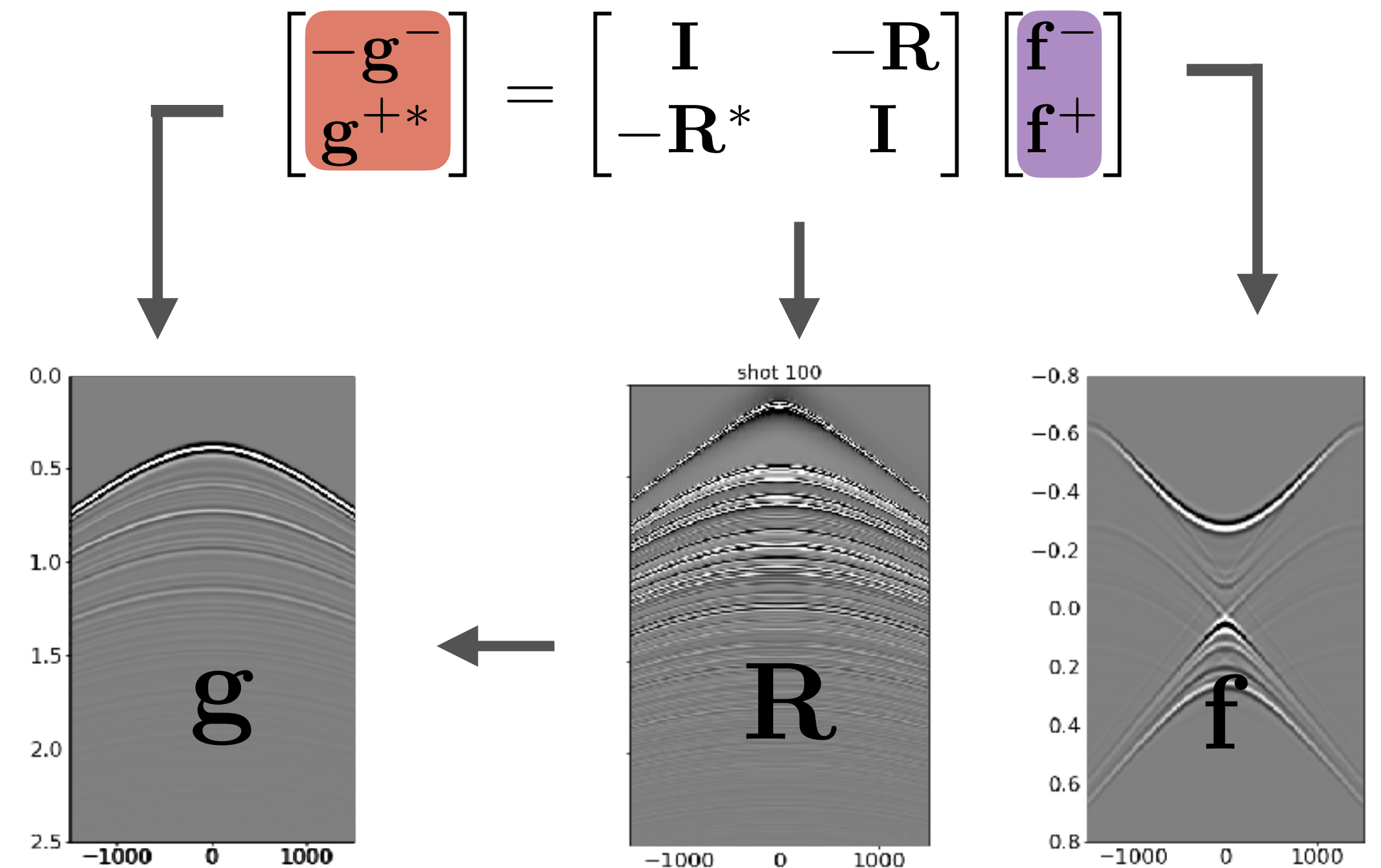
$$\mathbf{p} = \delta\mathbf{p} + \mathbf{p}_0$$

$$\delta\mathbf{V}_z^\pm = \mathbf{V}_z^\pm - \mathbf{V}_{0,z}^\pm$$

- *Complex overburdens*



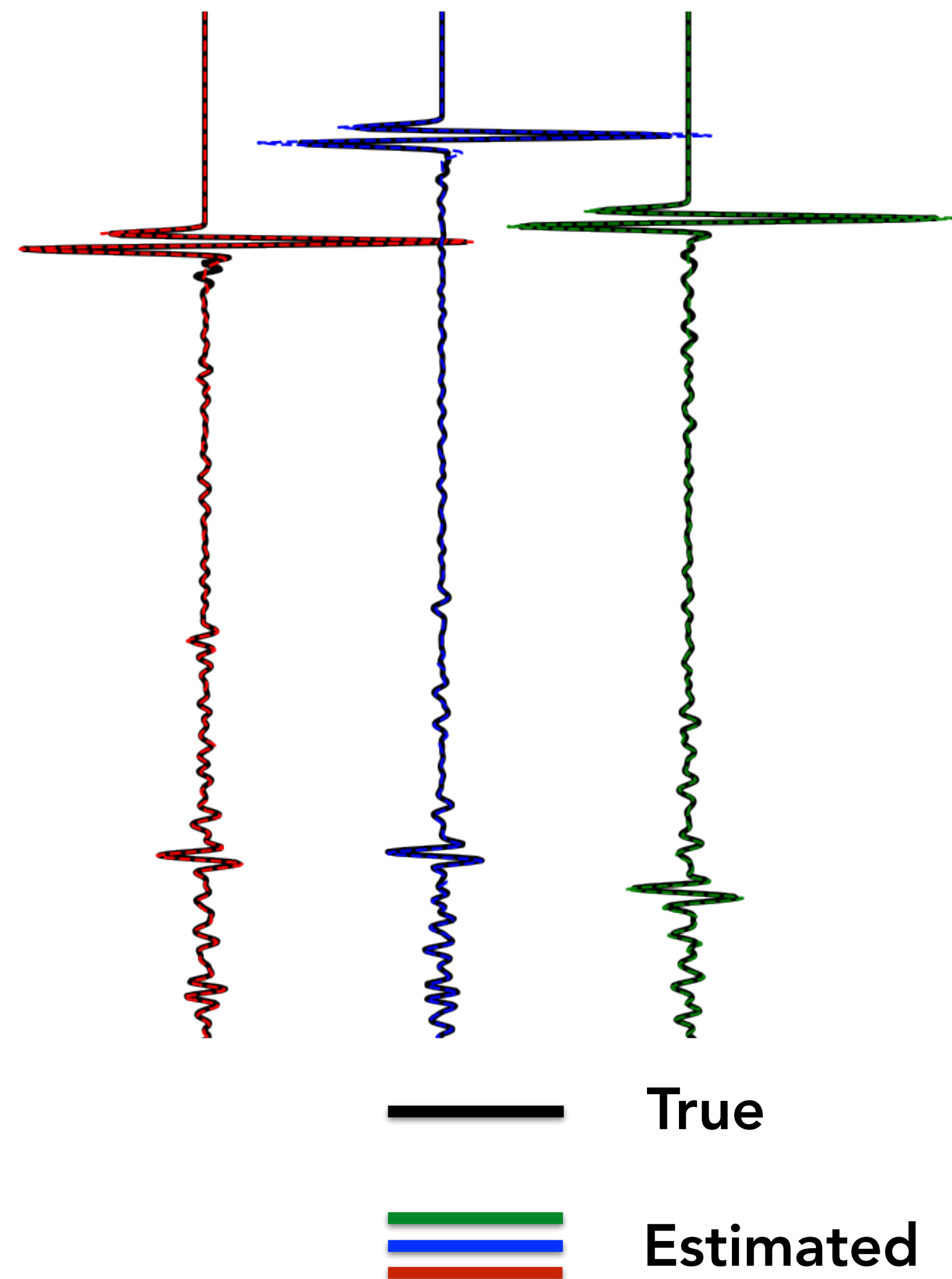
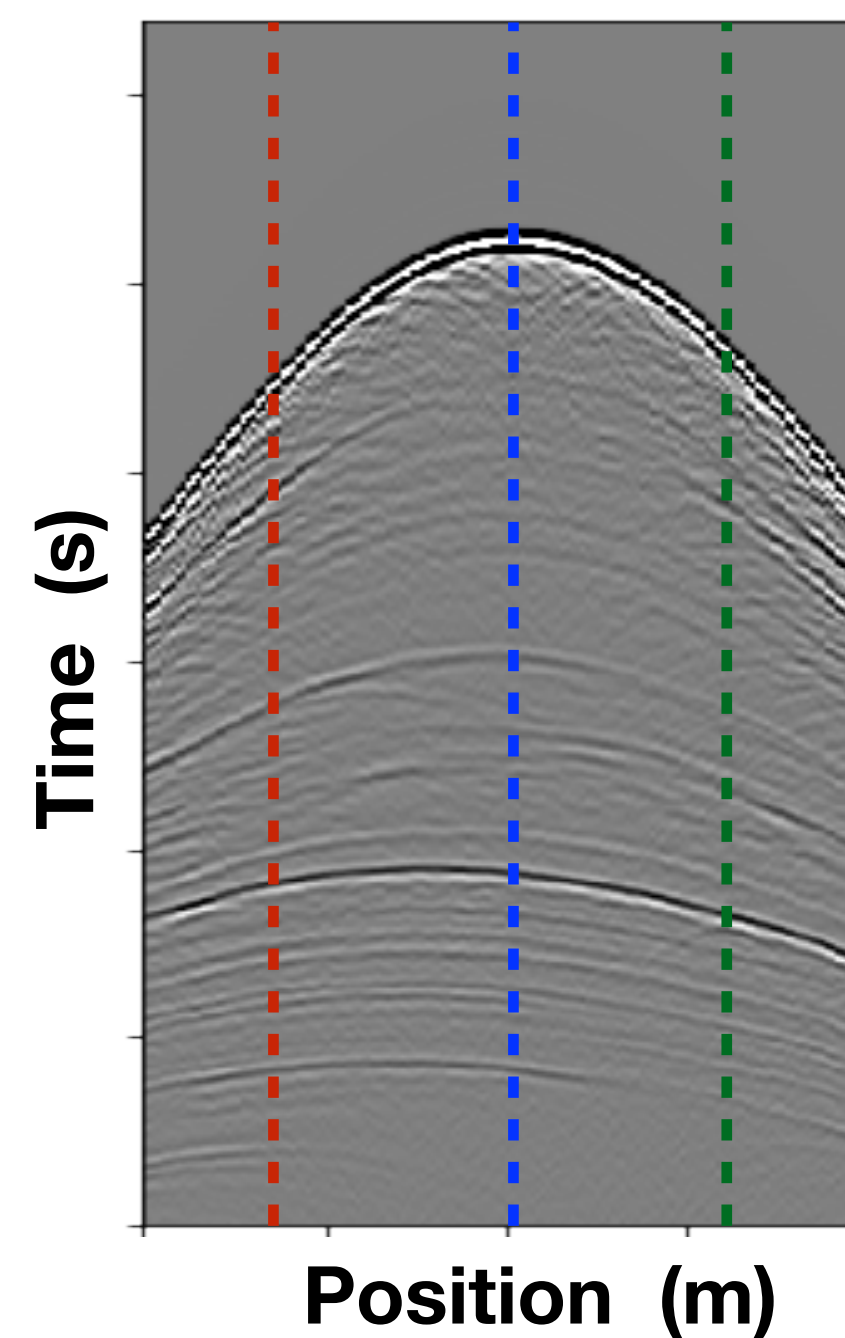
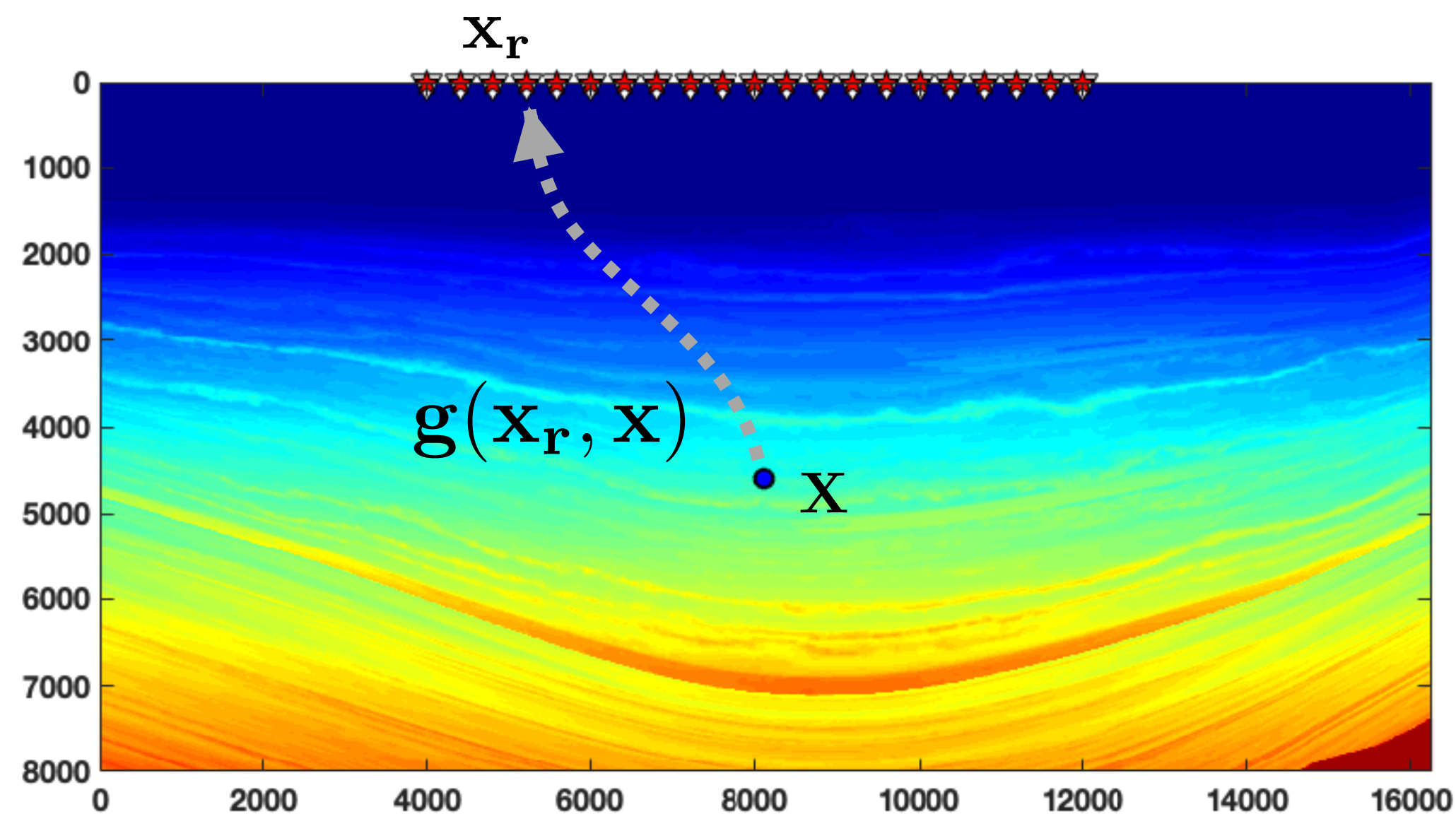
- *Marchenko redatuming*



Wavefield vs Marchenko extrapolation

CASE 1

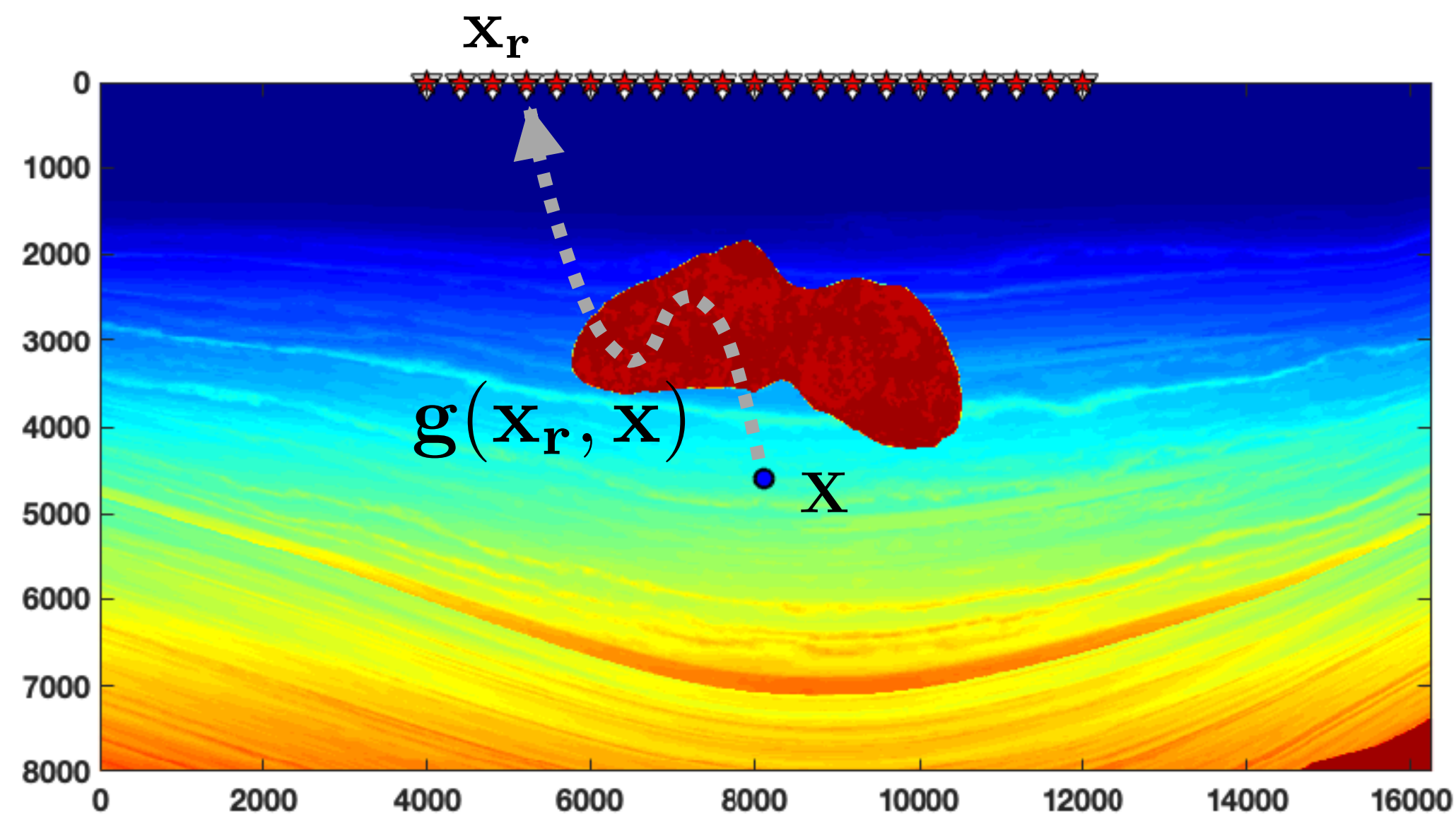
2



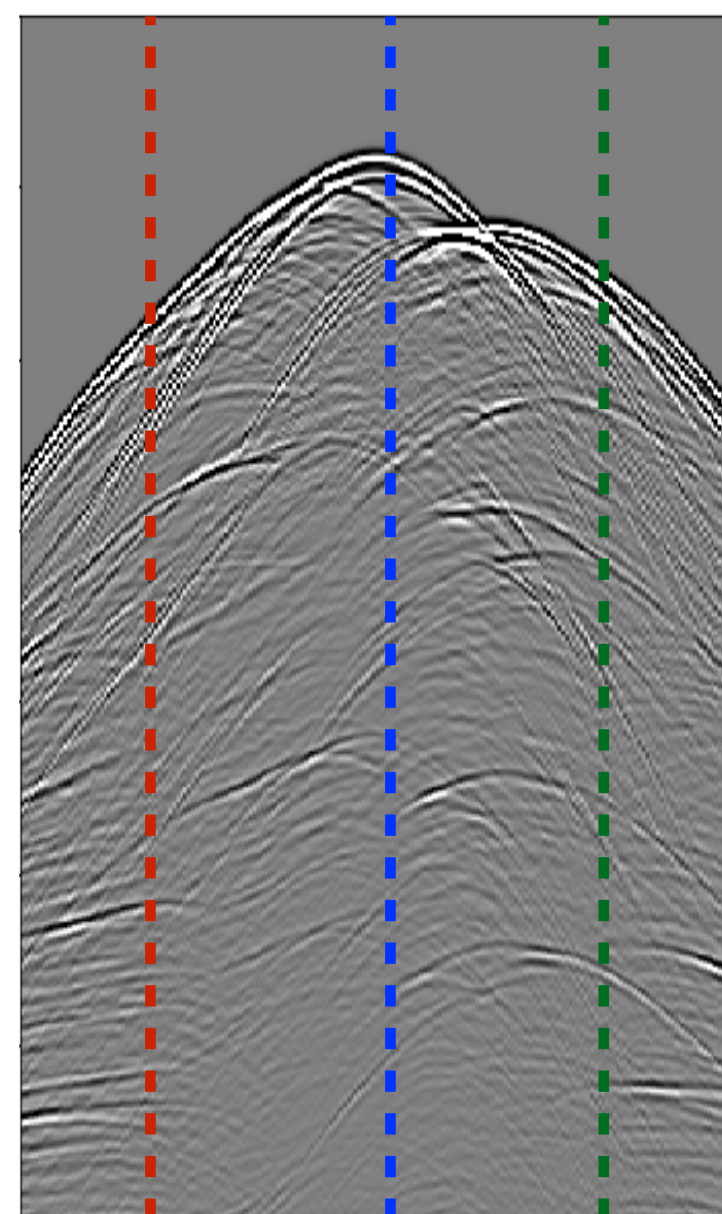
Wavefield vs Marchenko extrapolation

CASE 2

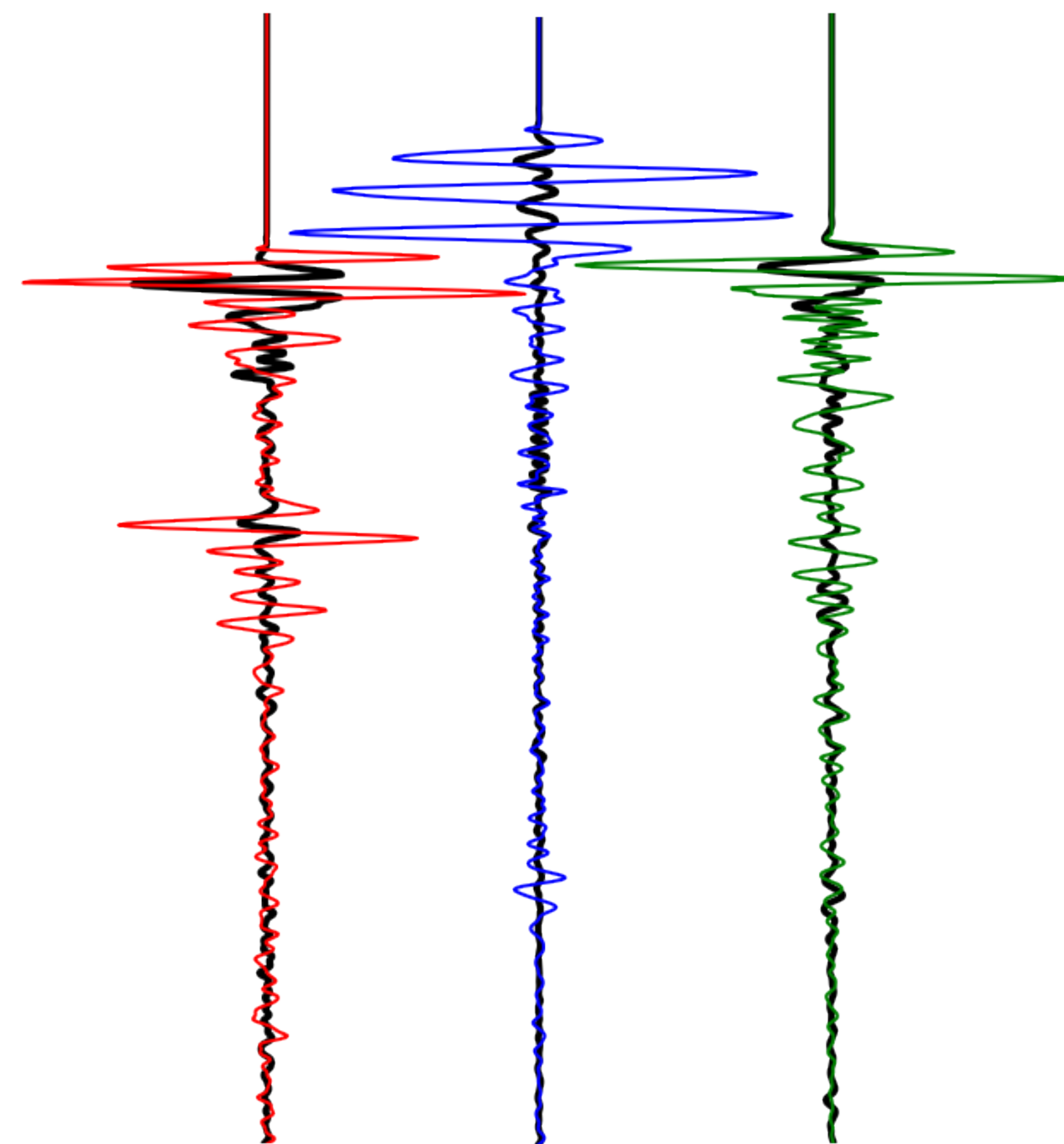
2



Time (s)



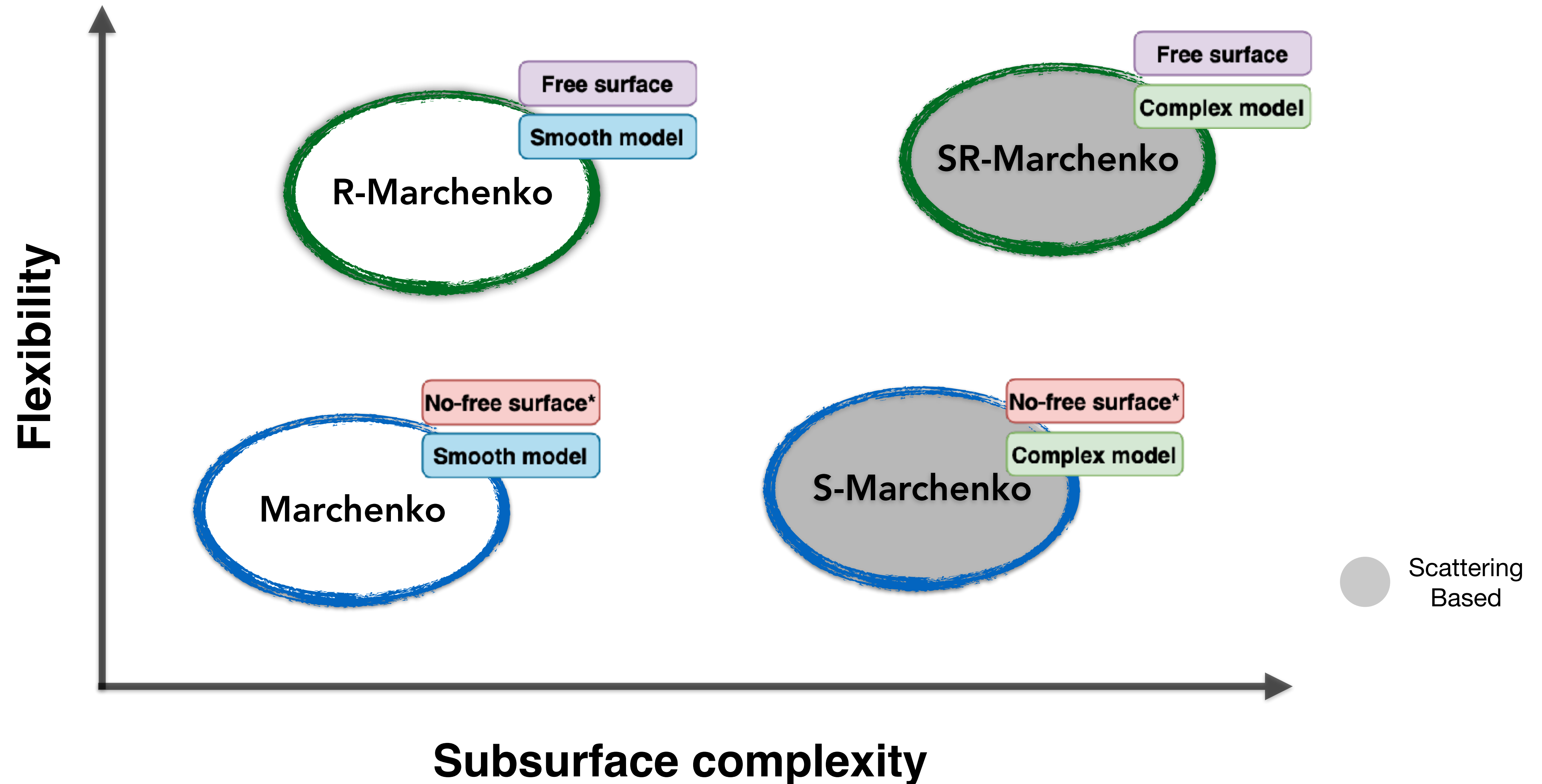
Position (m)



— True
— Estimated

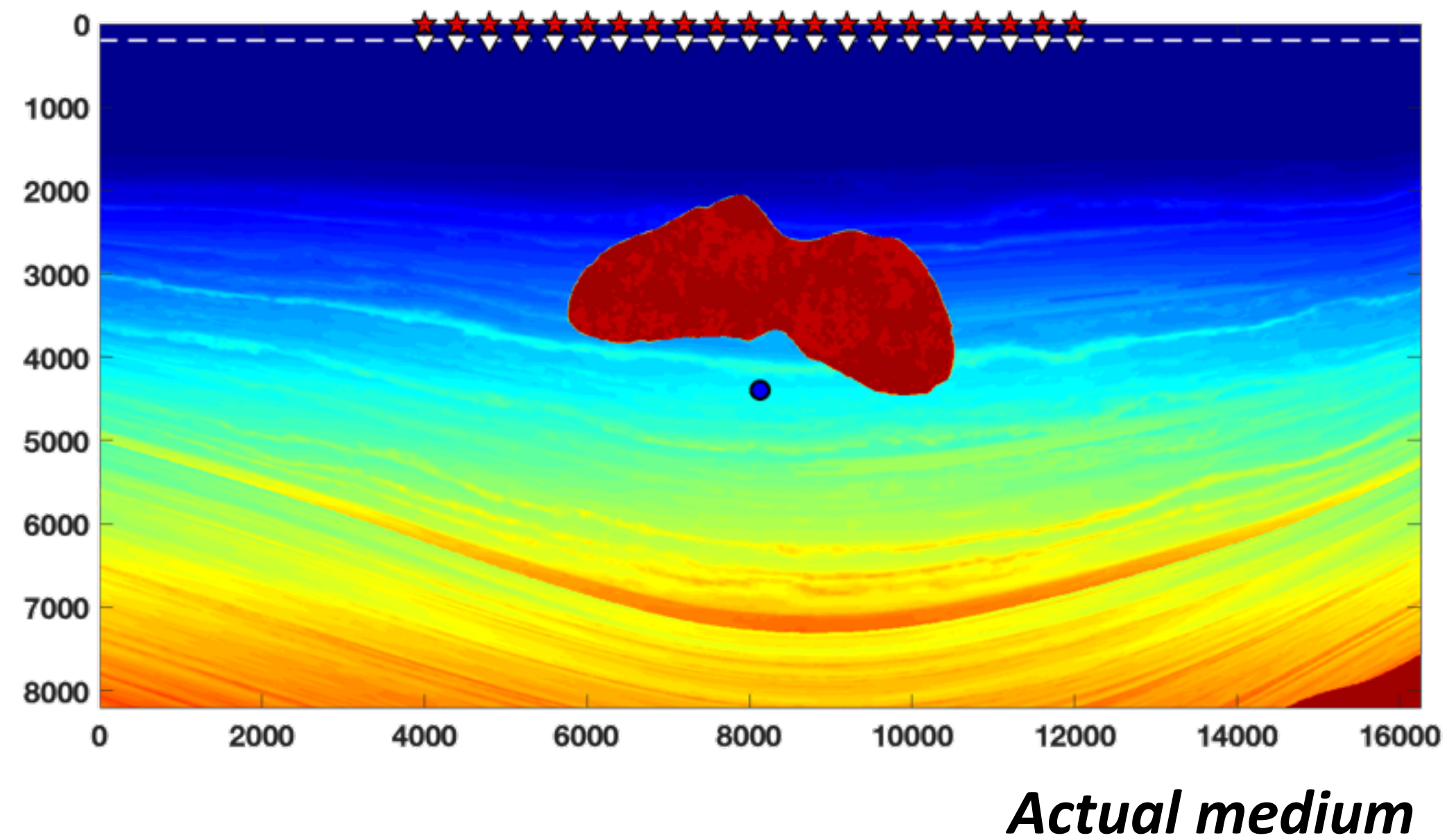
Schematic comparison

3



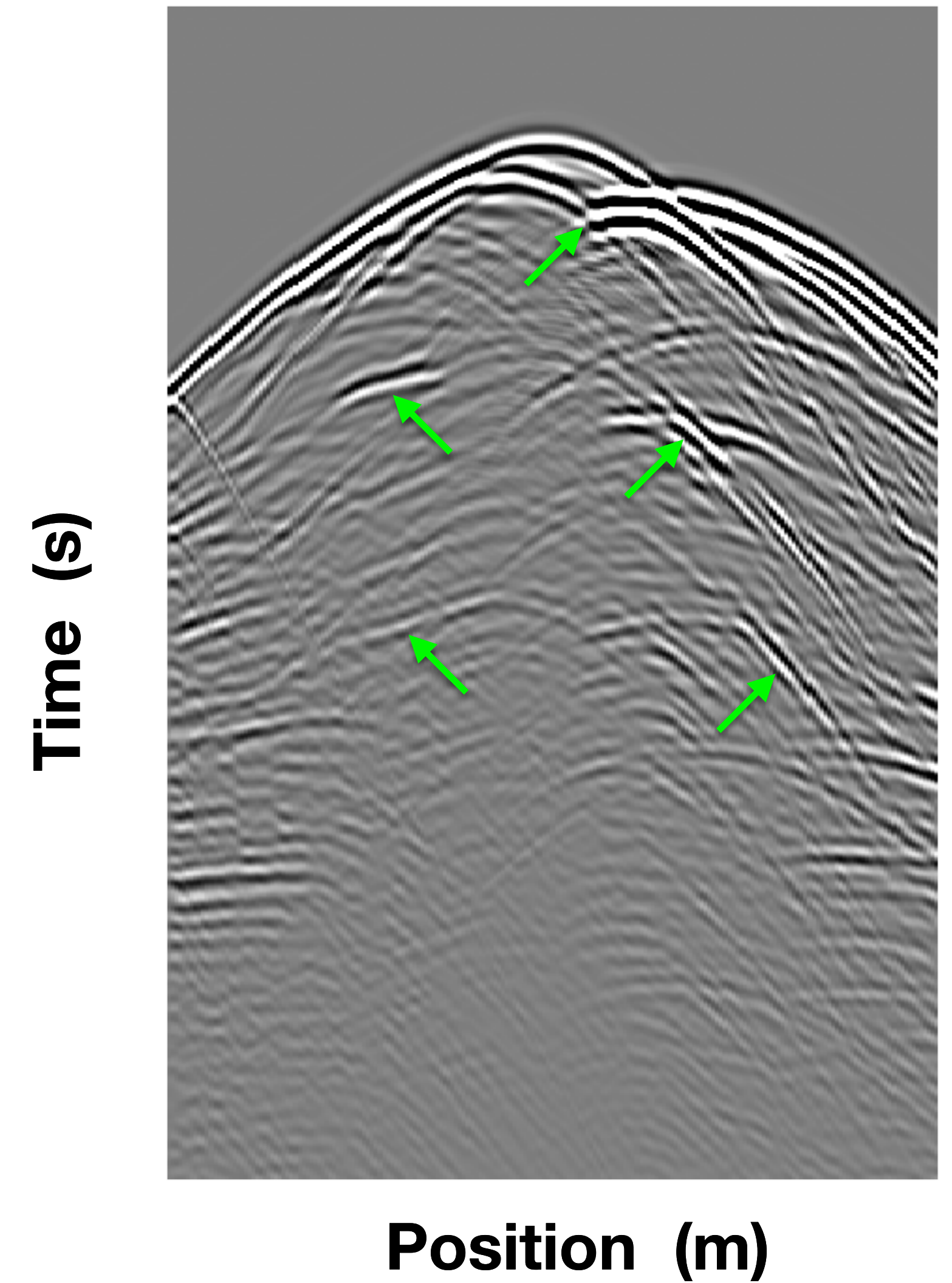
Rayleigh Marchenko

R-MARCHENKO



(Ravasi, 2017, Geophysics)

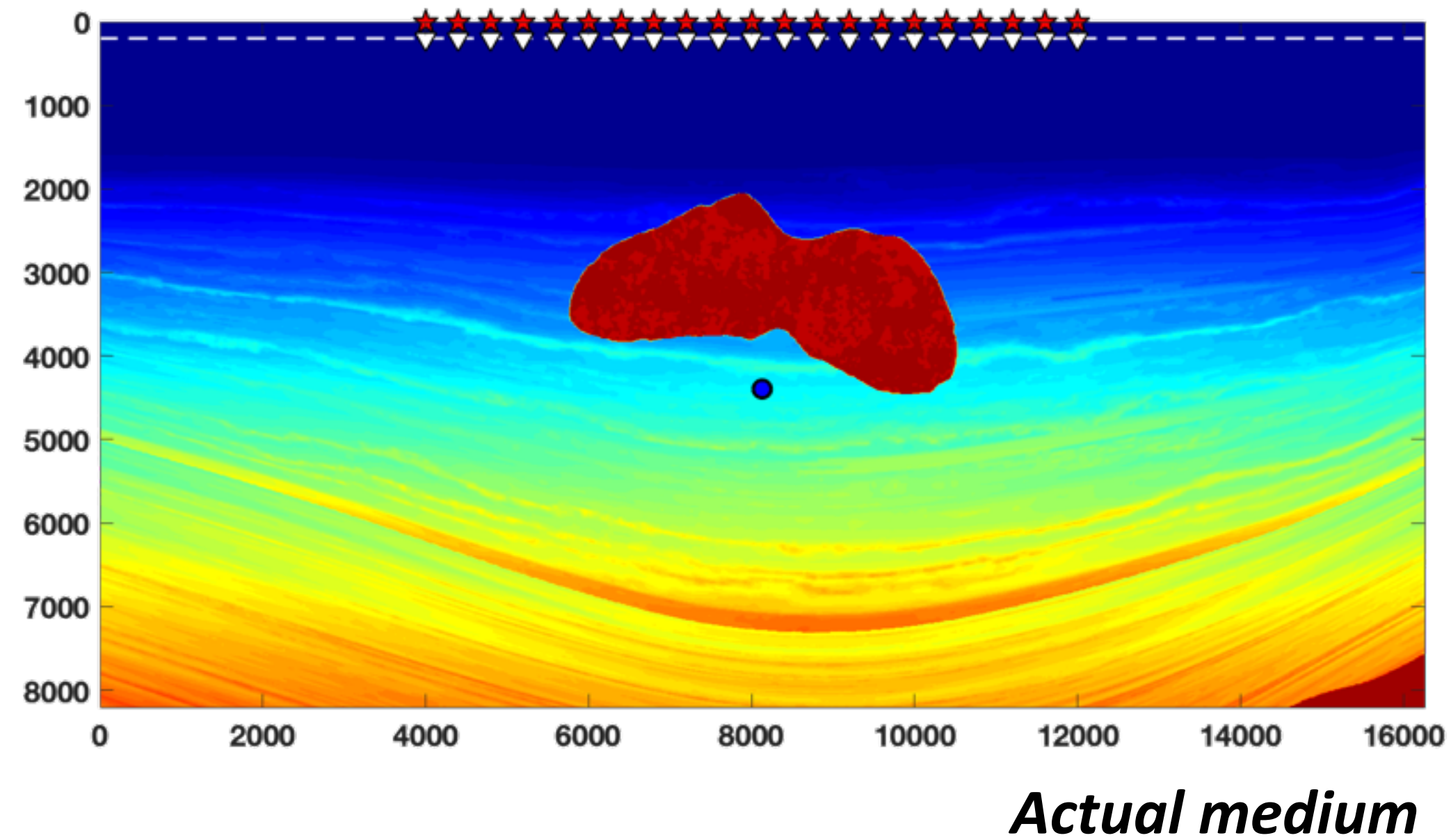
Benchmark



Rayleigh Marchenko

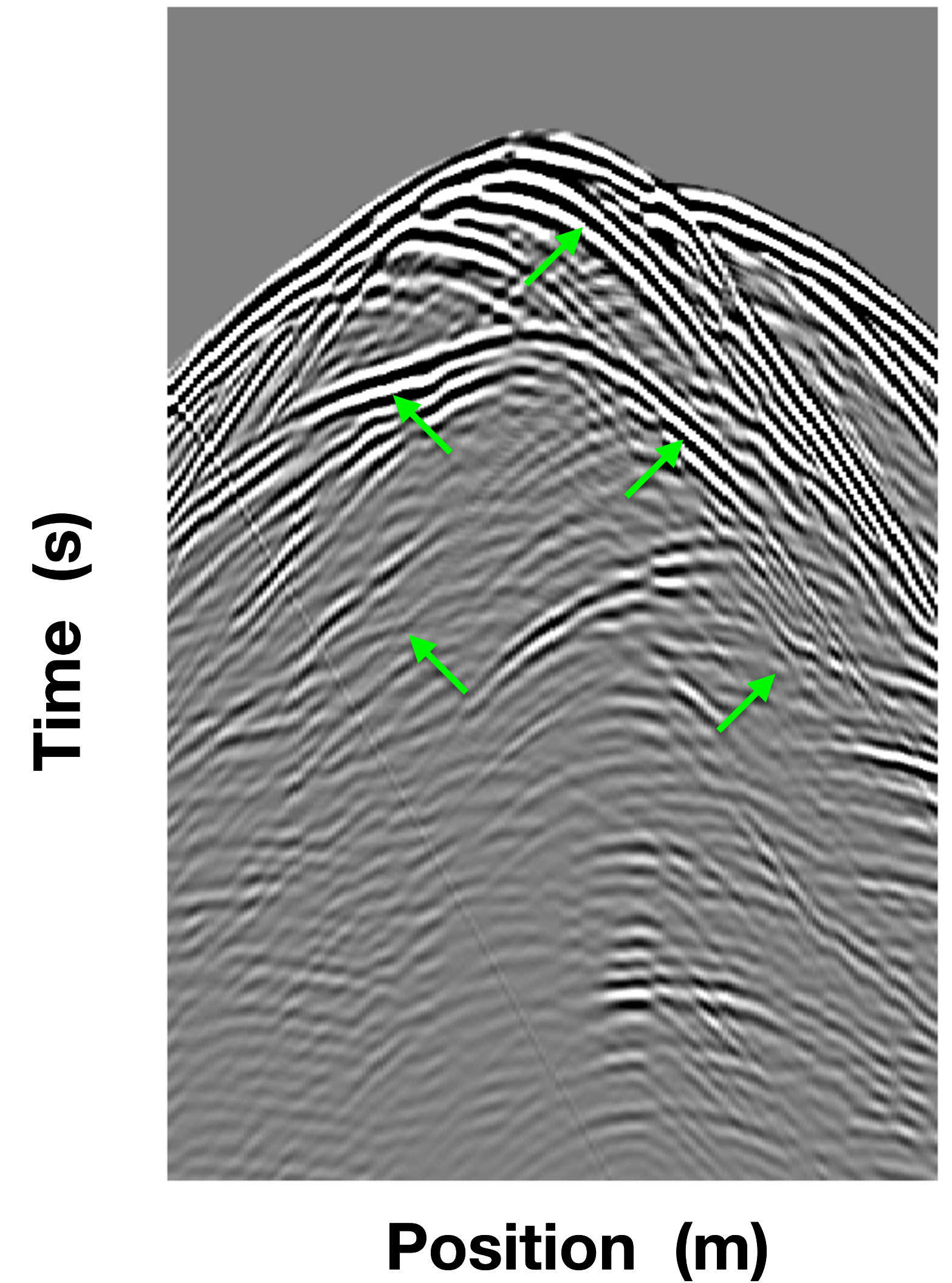
4

R-MARCHENKO



(Ravasi, 2017, Geophysics)

R-Marchenko



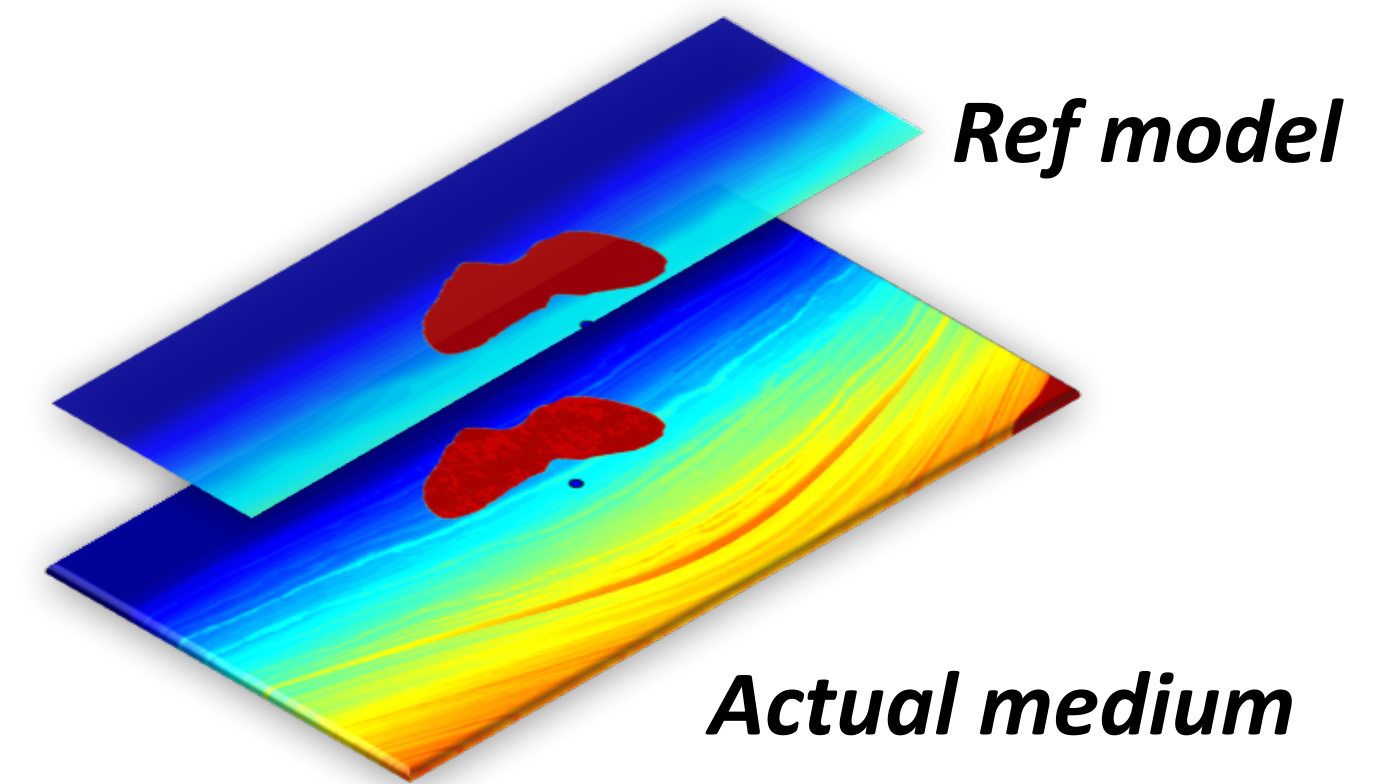
Scattering-based Marchenko

R-MARCHENKO

$$\begin{bmatrix} -\mathbf{p}^- \\ \mathbf{p}^{+*} \end{bmatrix} = \begin{bmatrix} \mathbf{V}_z^+ & \mathbf{V}_z^- \\ \mathbf{V}_z^{-*} & \mathbf{V}_z^{+*} \end{bmatrix} \begin{bmatrix} \mathbf{f}^- \\ \mathbf{f}^+ \end{bmatrix}$$

SR-MARCHENKO

$$\begin{bmatrix} -\delta\mathbf{p}^- \\ \delta\mathbf{p}^{+*} \end{bmatrix} = \begin{bmatrix} \mathbf{V}_z^+ & \mathbf{V}_z^- \\ \mathbf{V}_z^{-*} & \mathbf{V}_z^{+*} \end{bmatrix} \begin{bmatrix} \delta\mathbf{f}^- \\ \delta\mathbf{f}^+ \end{bmatrix} + \begin{bmatrix} \mathbf{0} & \delta\mathbf{V}_z^- \\ \delta\mathbf{V}_z^{-*} & \mathbf{0} \end{bmatrix} \begin{bmatrix} \mathbf{f}_0^- \\ \mathbf{f}_0^+ \end{bmatrix}$$

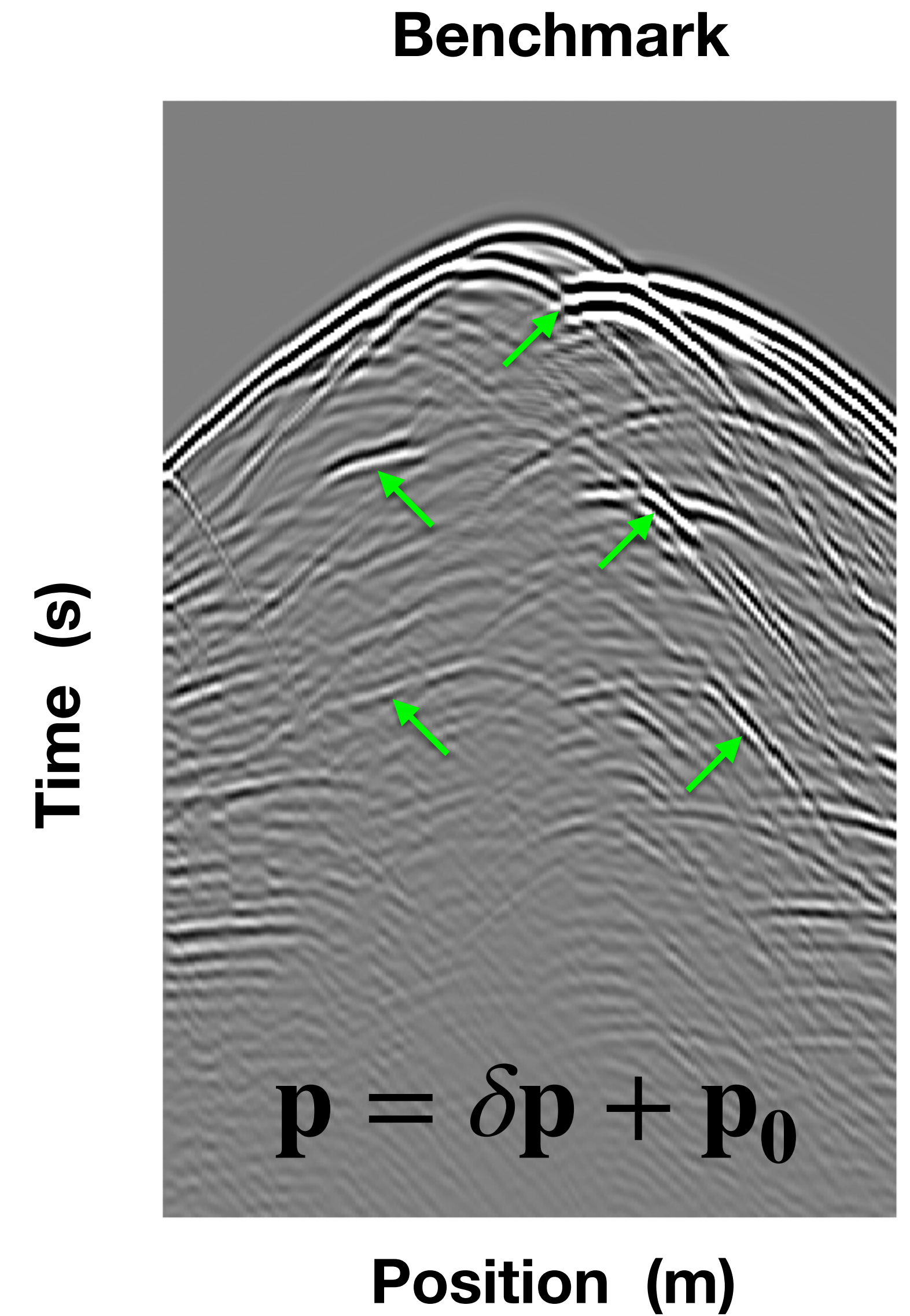
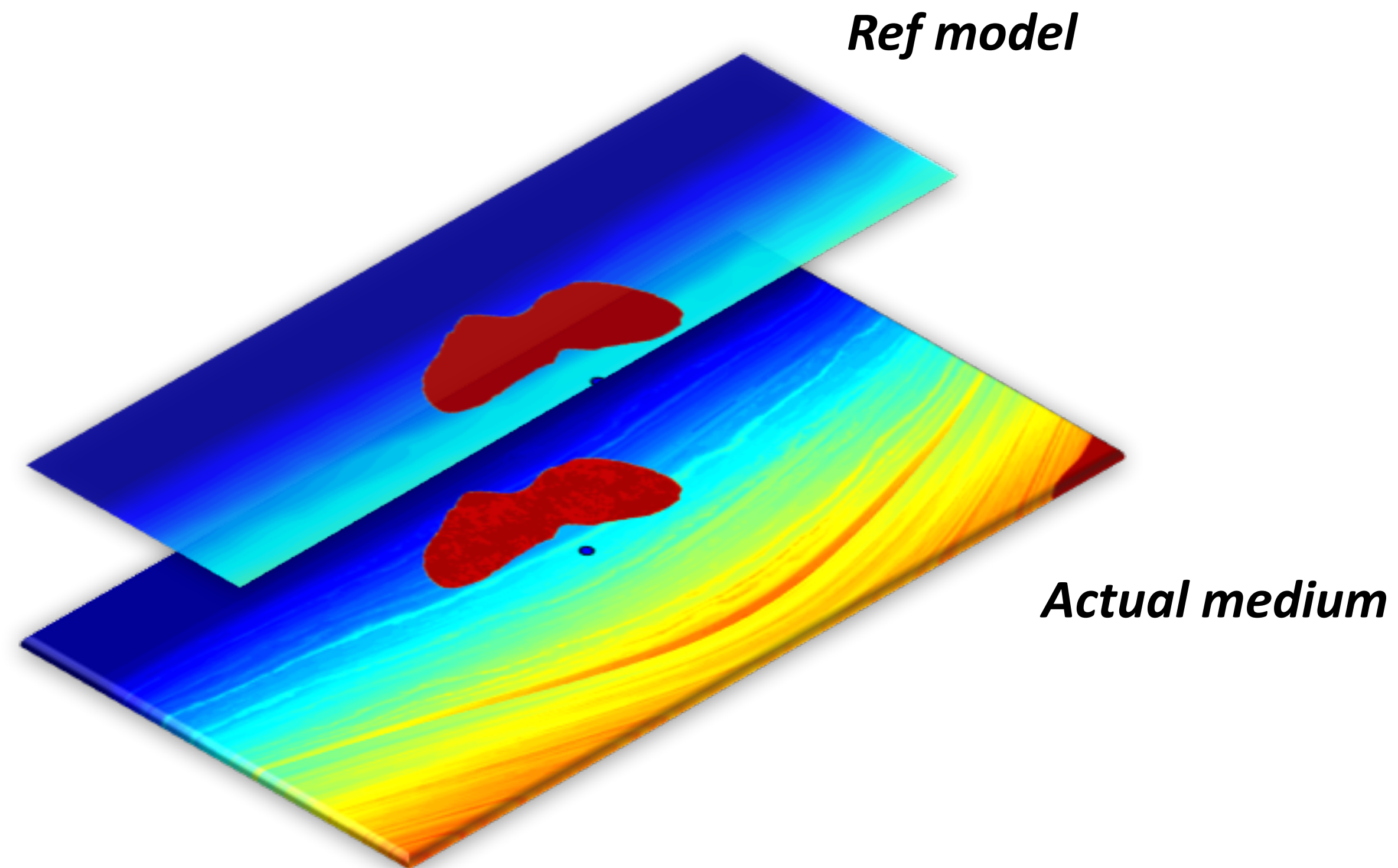


- ✓ Band-limited data
- ✓ SRM -> Included
- ✓ Wavelet -> Included
- ✓ $\delta\mathbf{V}_z^\pm$ -> naturally scaled

	Reflection	Redatumed
<i>Ref model</i>	$\mathbf{V}_{0,z}^\pm$	$\mathbf{p}_0^\pm$
<i>Perturbation</i>	$\delta\mathbf{V}_z^+ = \mathbf{0}$ $\delta\mathbf{V}_z^- = \mathbf{V}_z^- + \mathbf{R}_0\mathbf{V}_z^+$	$\delta\mathbf{p}^\pm = \mathbf{p}^\pm - \mathbf{p}_0^\pm$
<i>Medium</i>	$\mathbf{V}_z^\pm$	$\mathbf{p}^\pm$

Scattering-based Marchenko

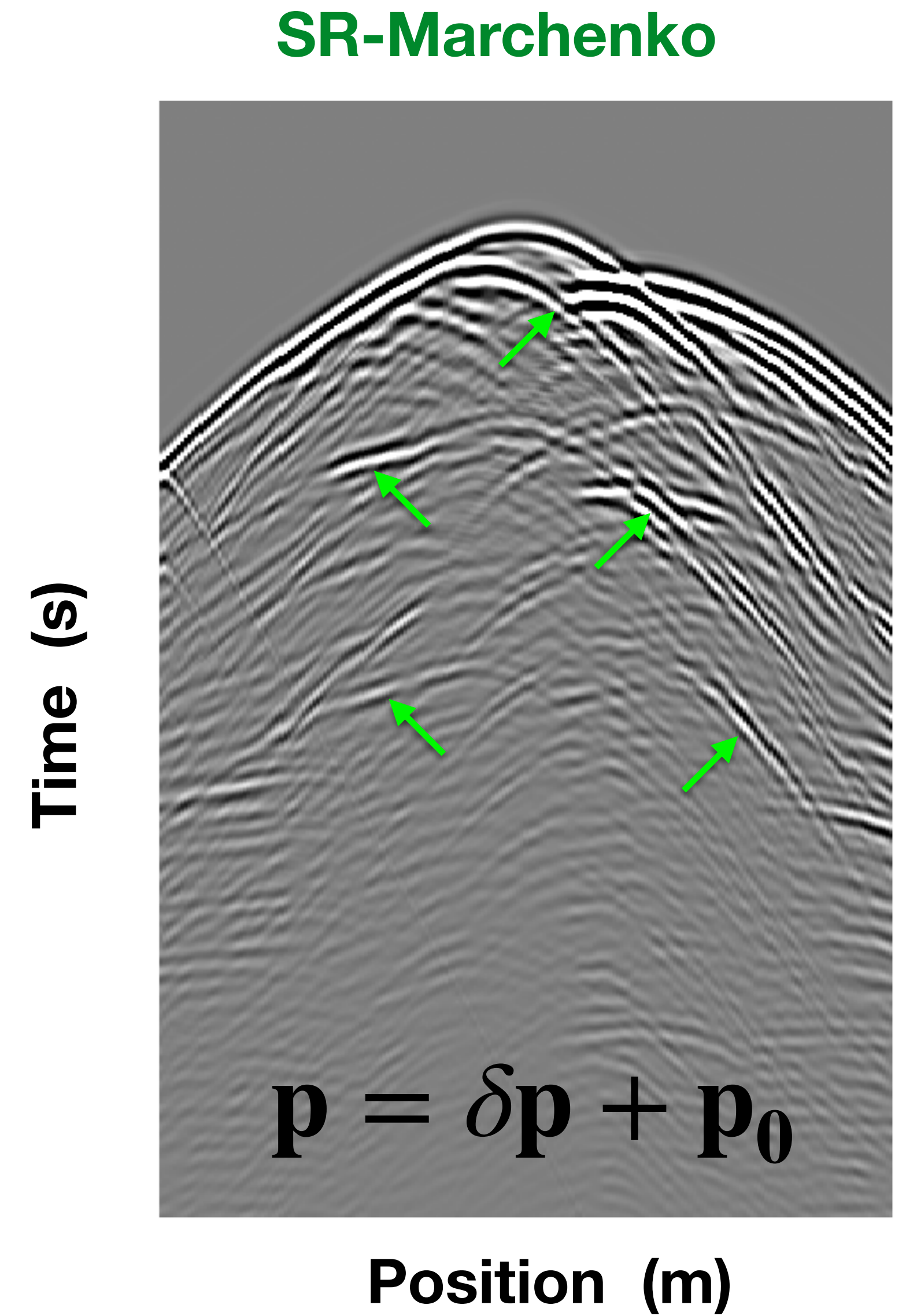
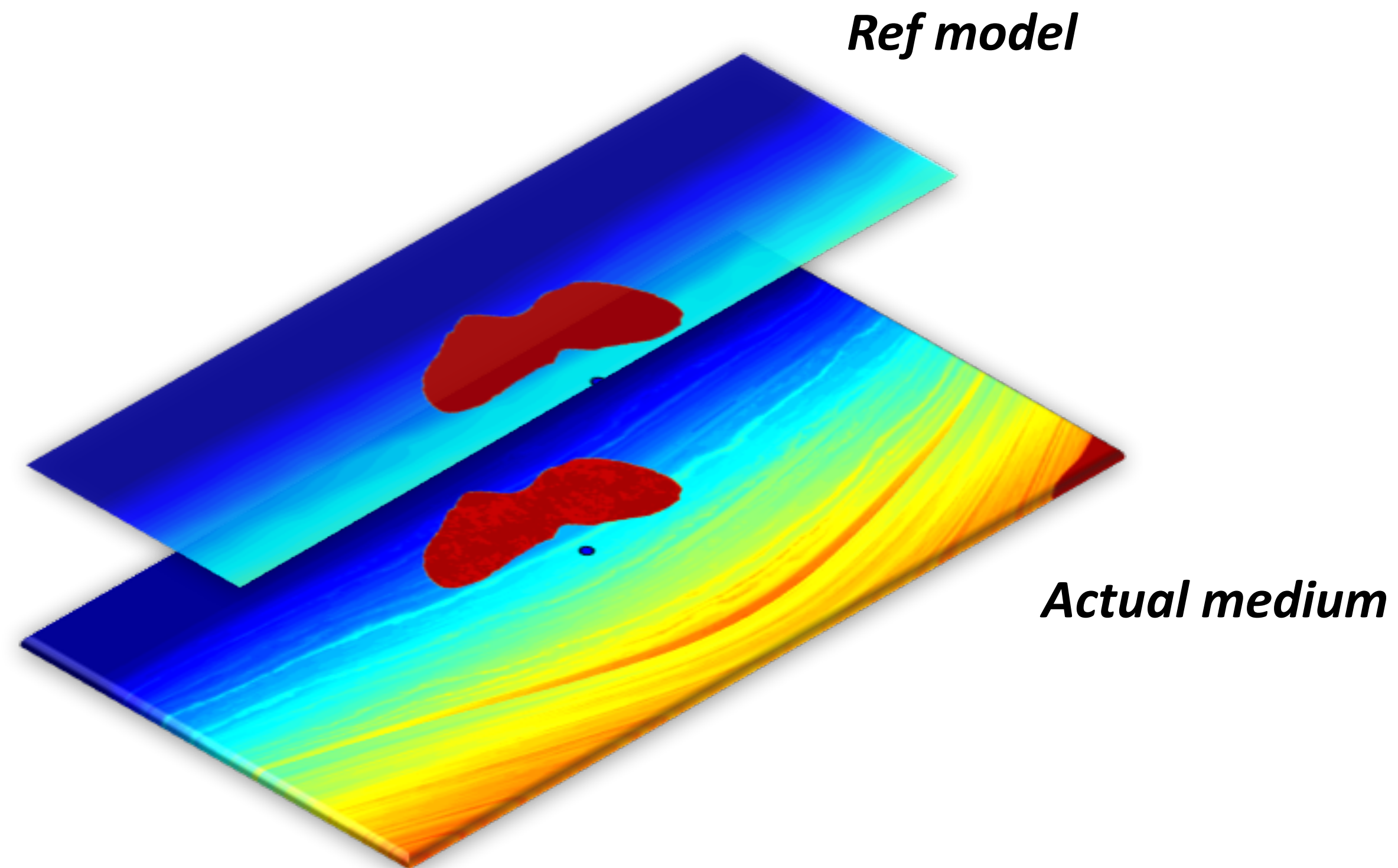
SR-MARCHENKO



Scattering-based Marchenko

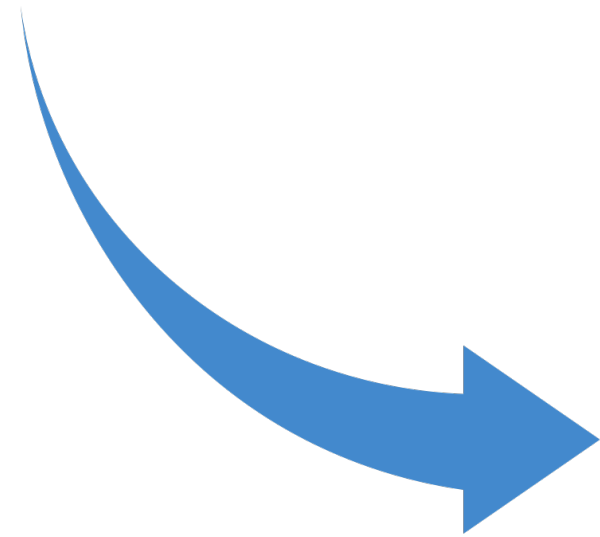
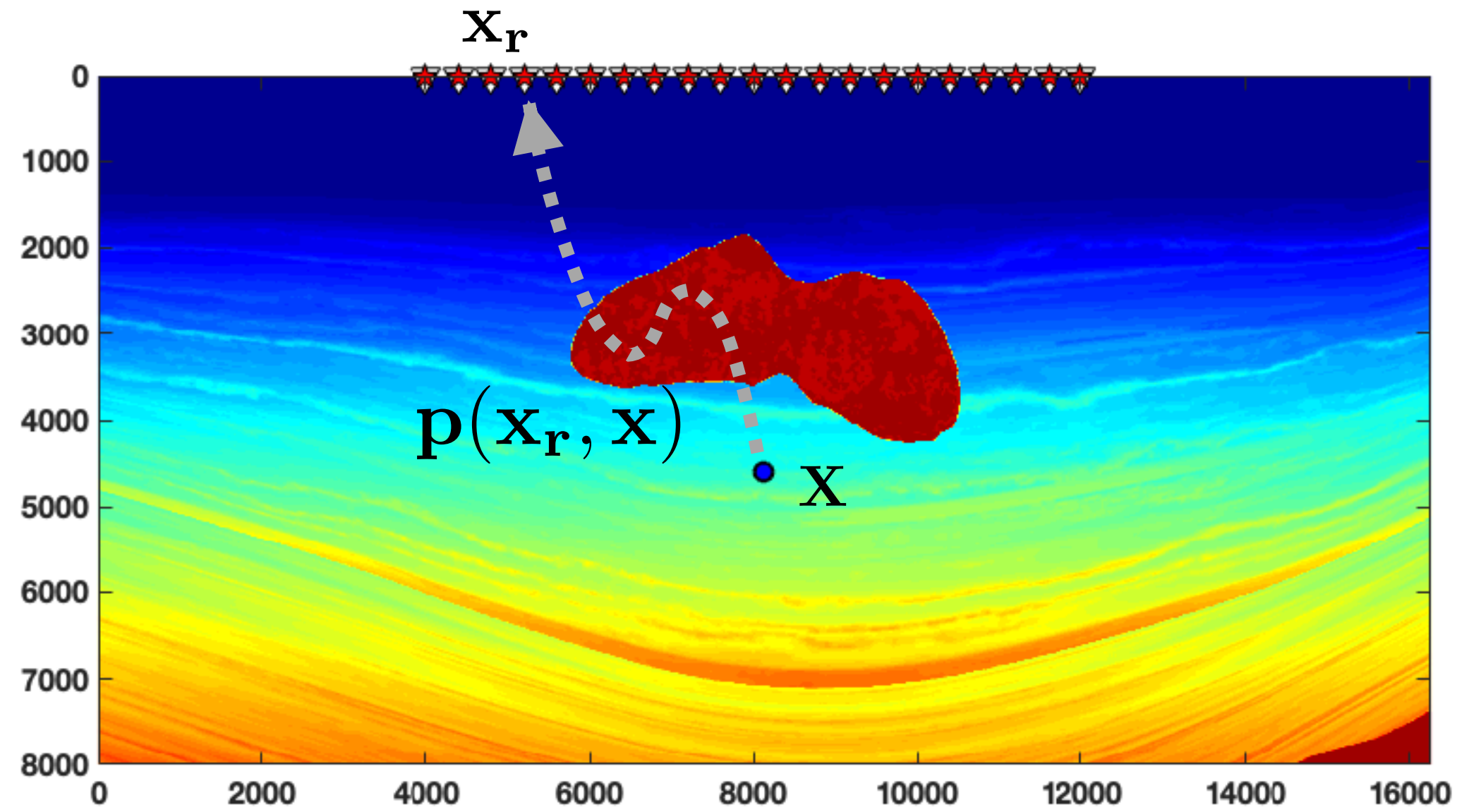
6

SR-MARCHENKO

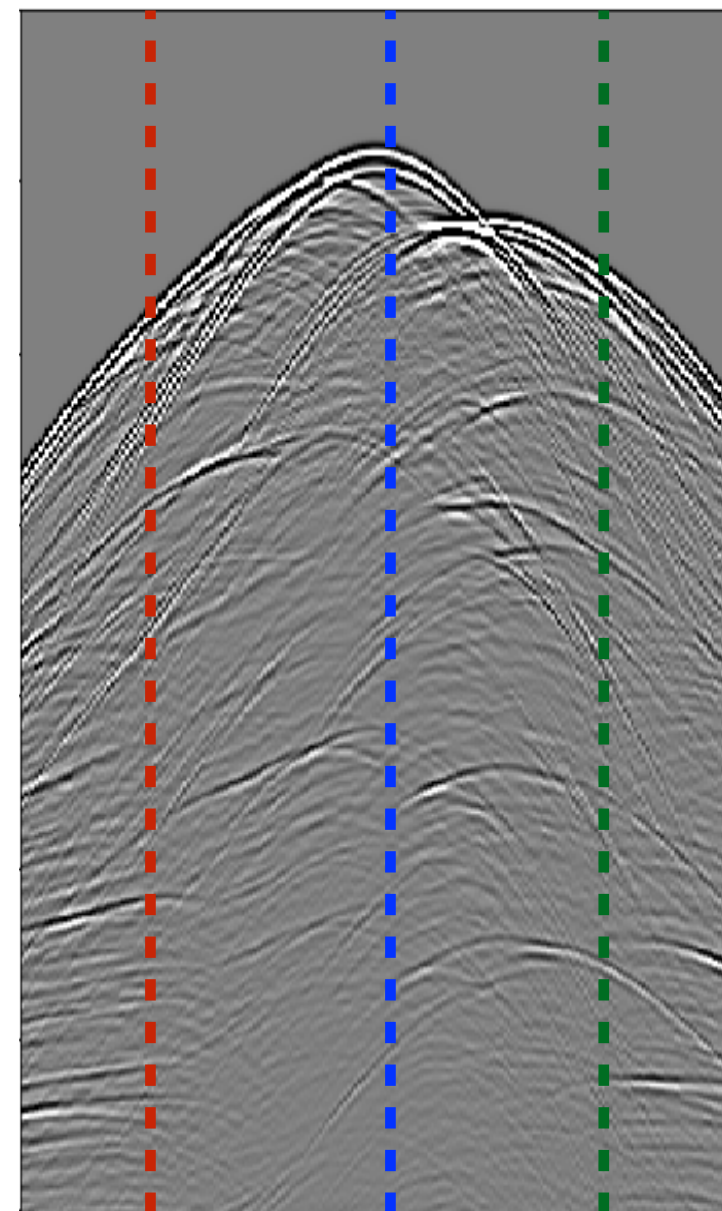


Scattering-based Marchenko

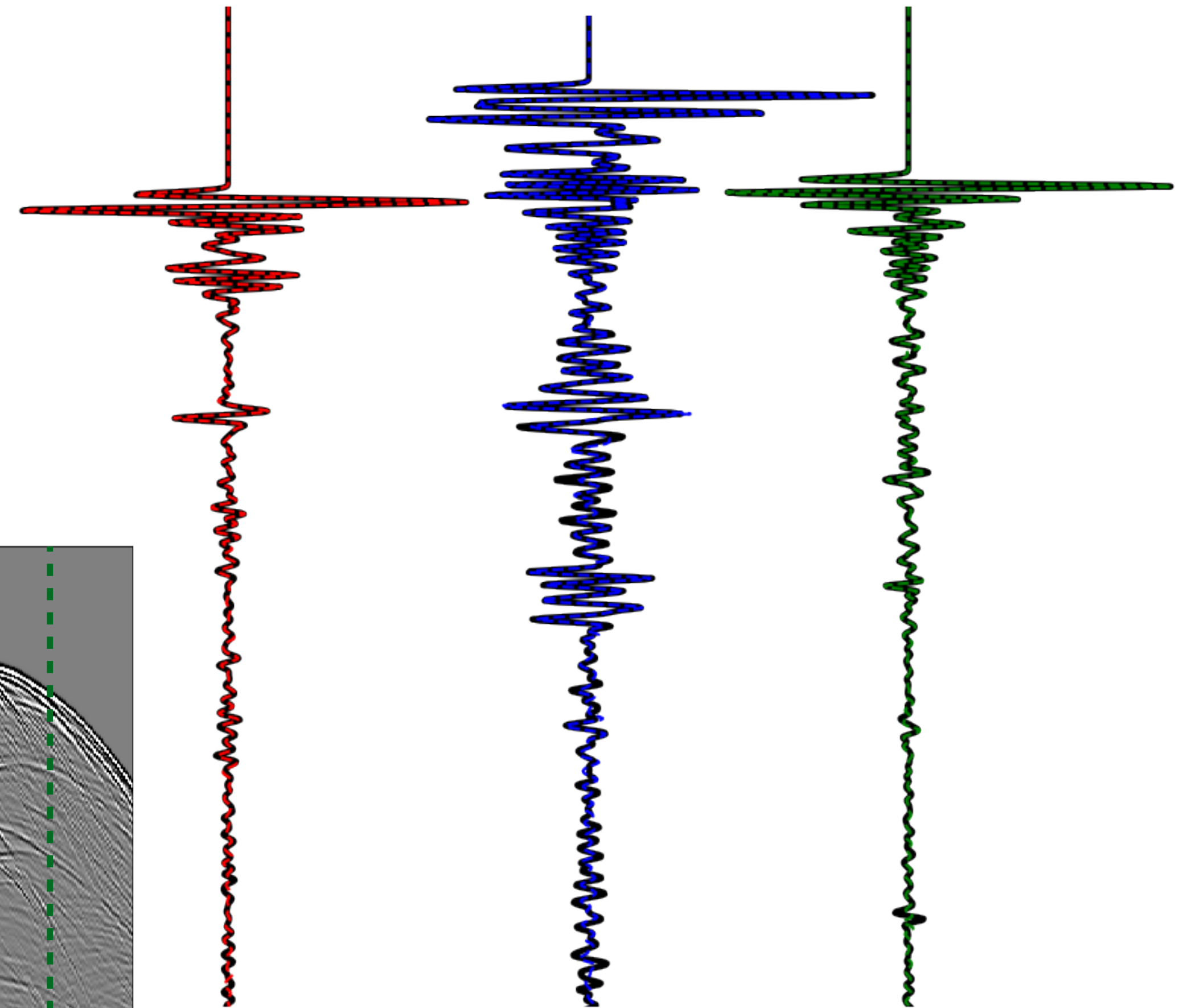
7



Time (s)



Position (m)

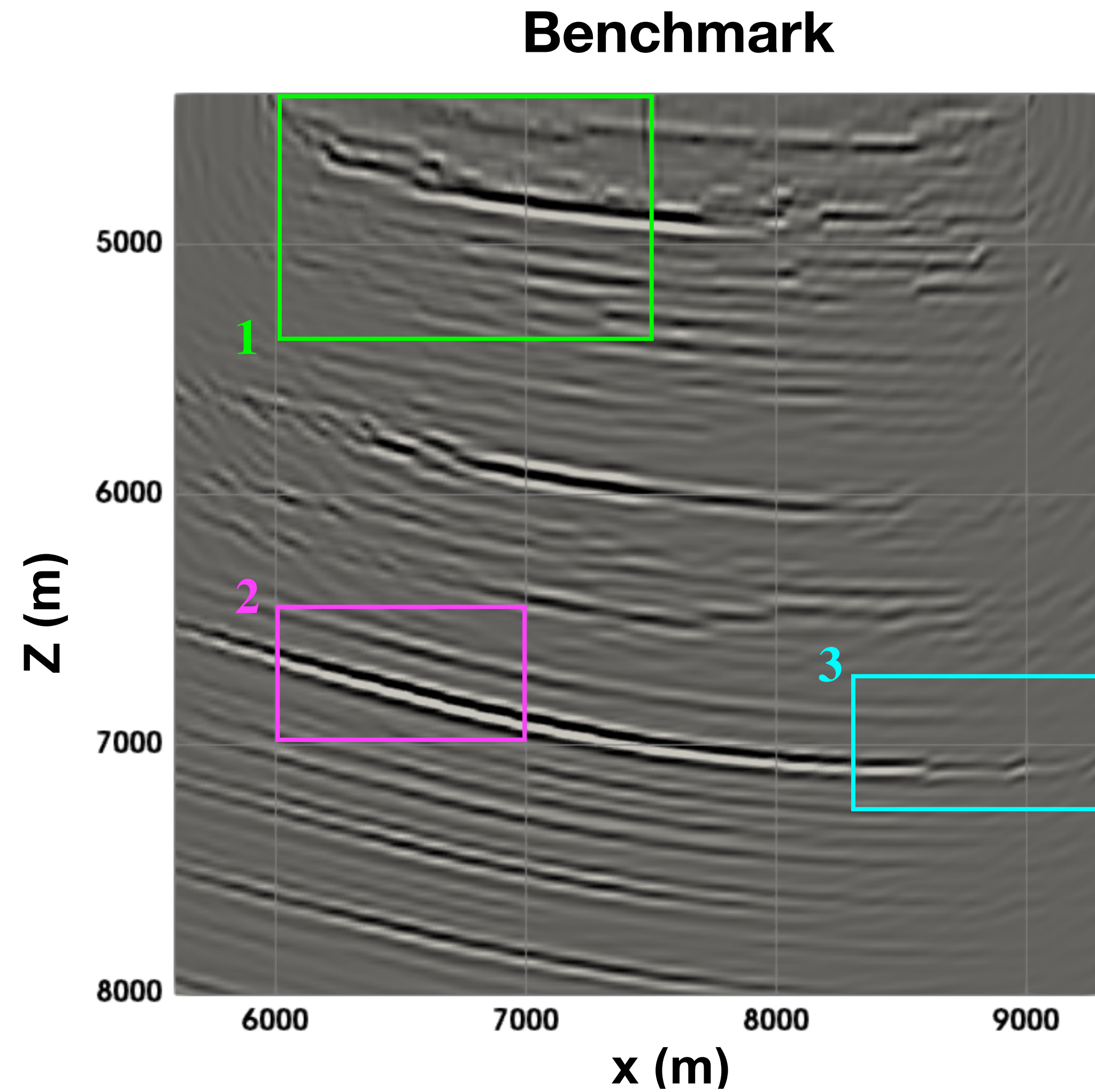
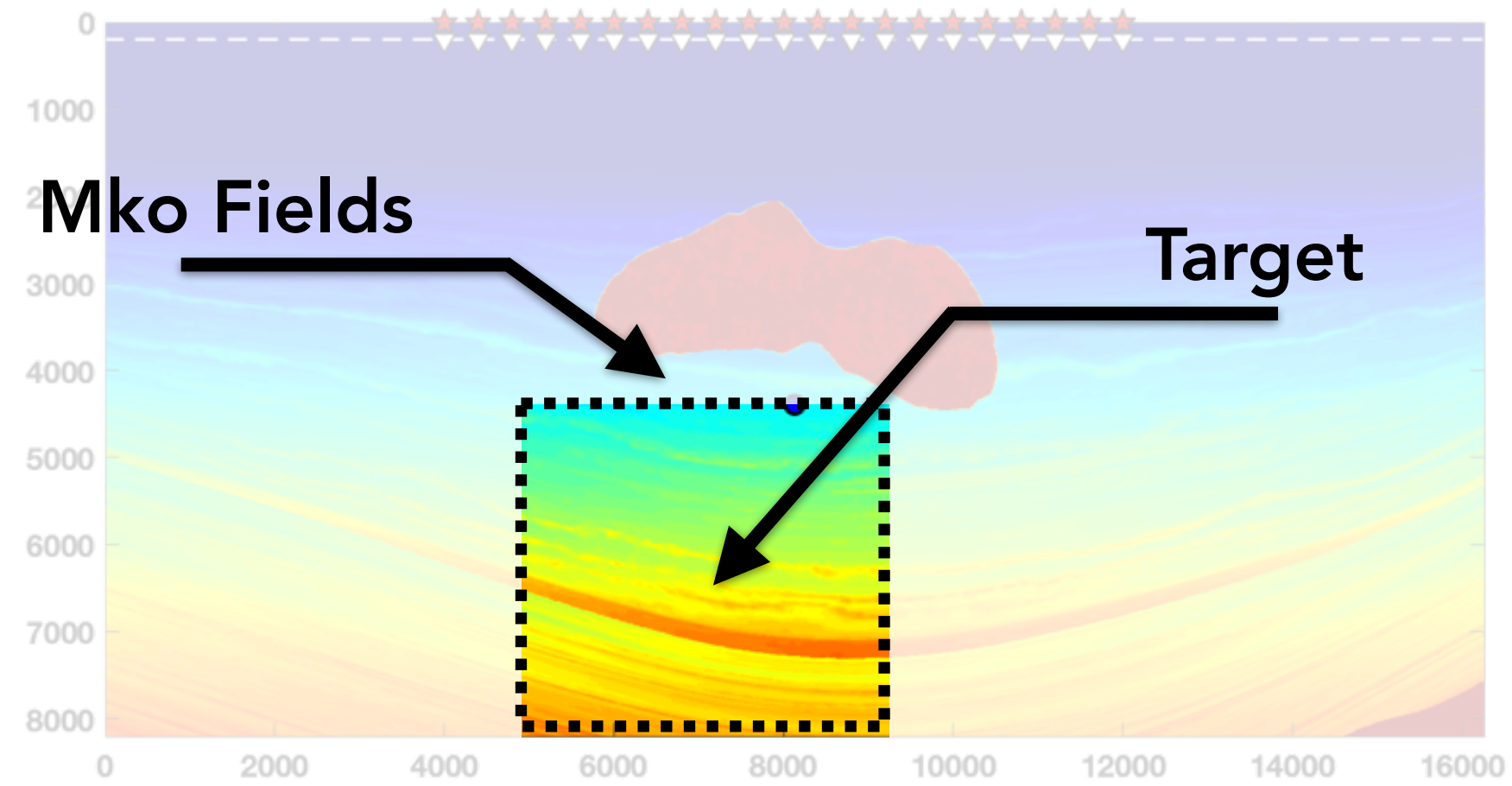


— True

— Estimated

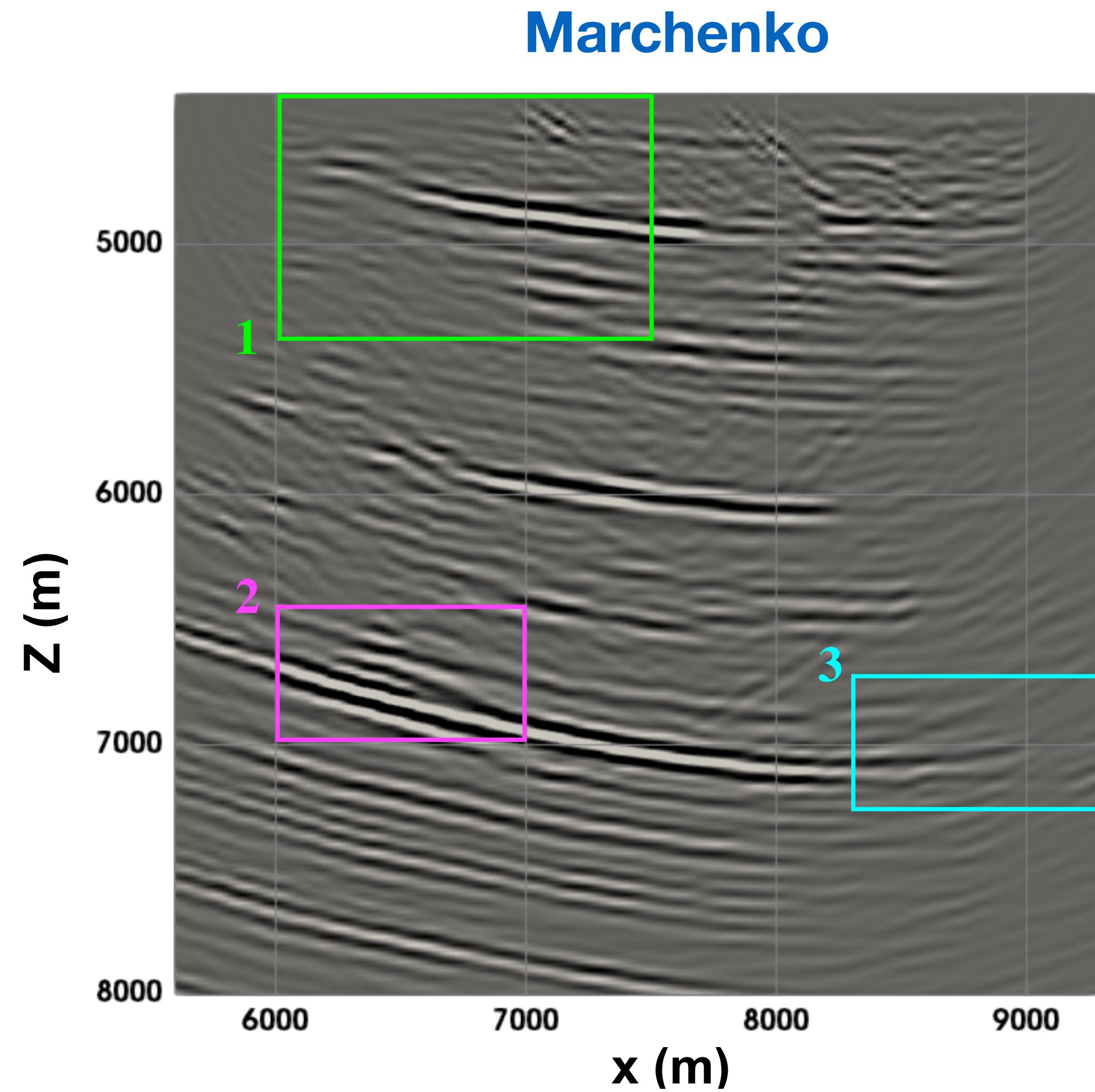
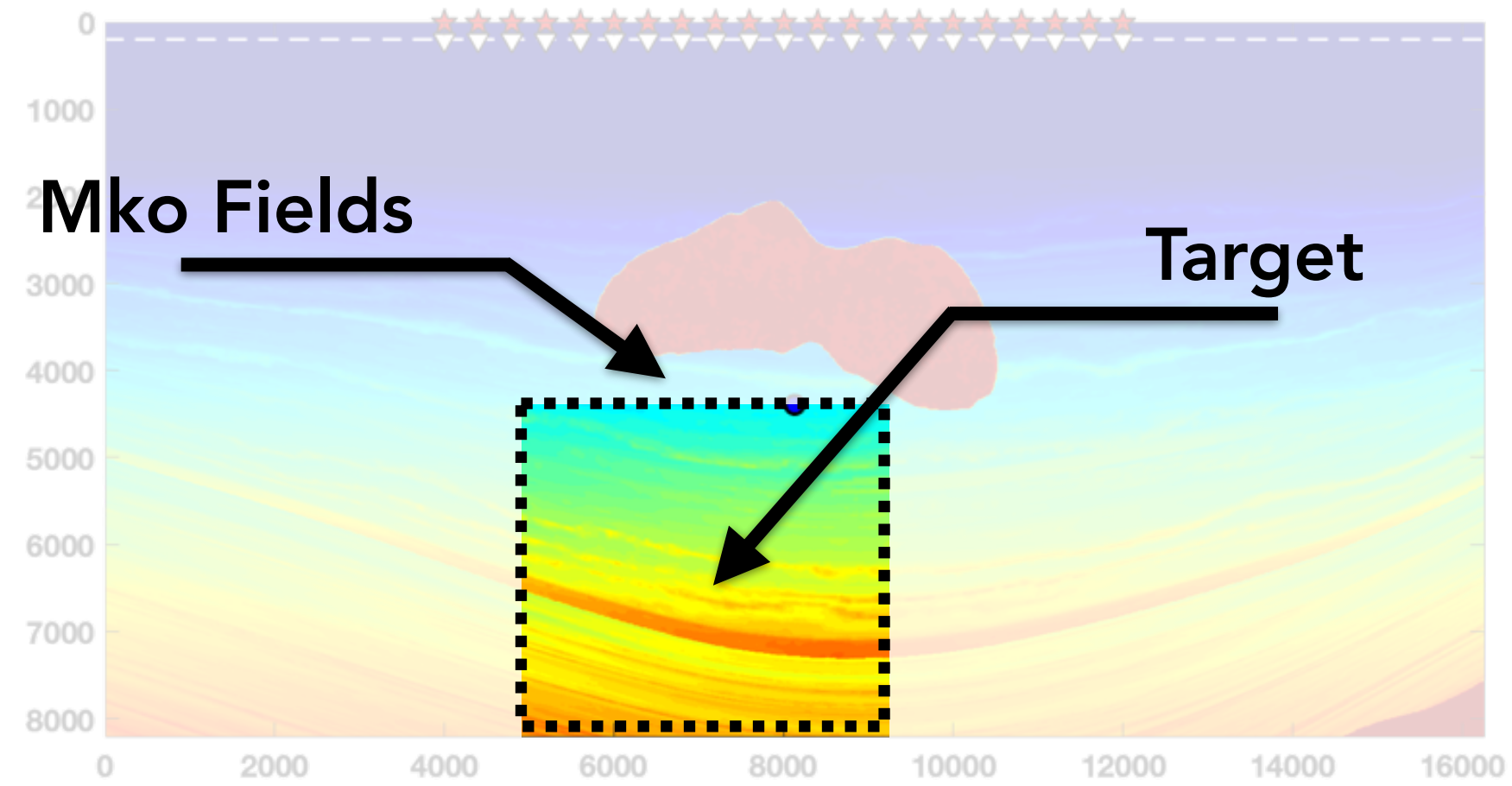
Target oriented imaging

8



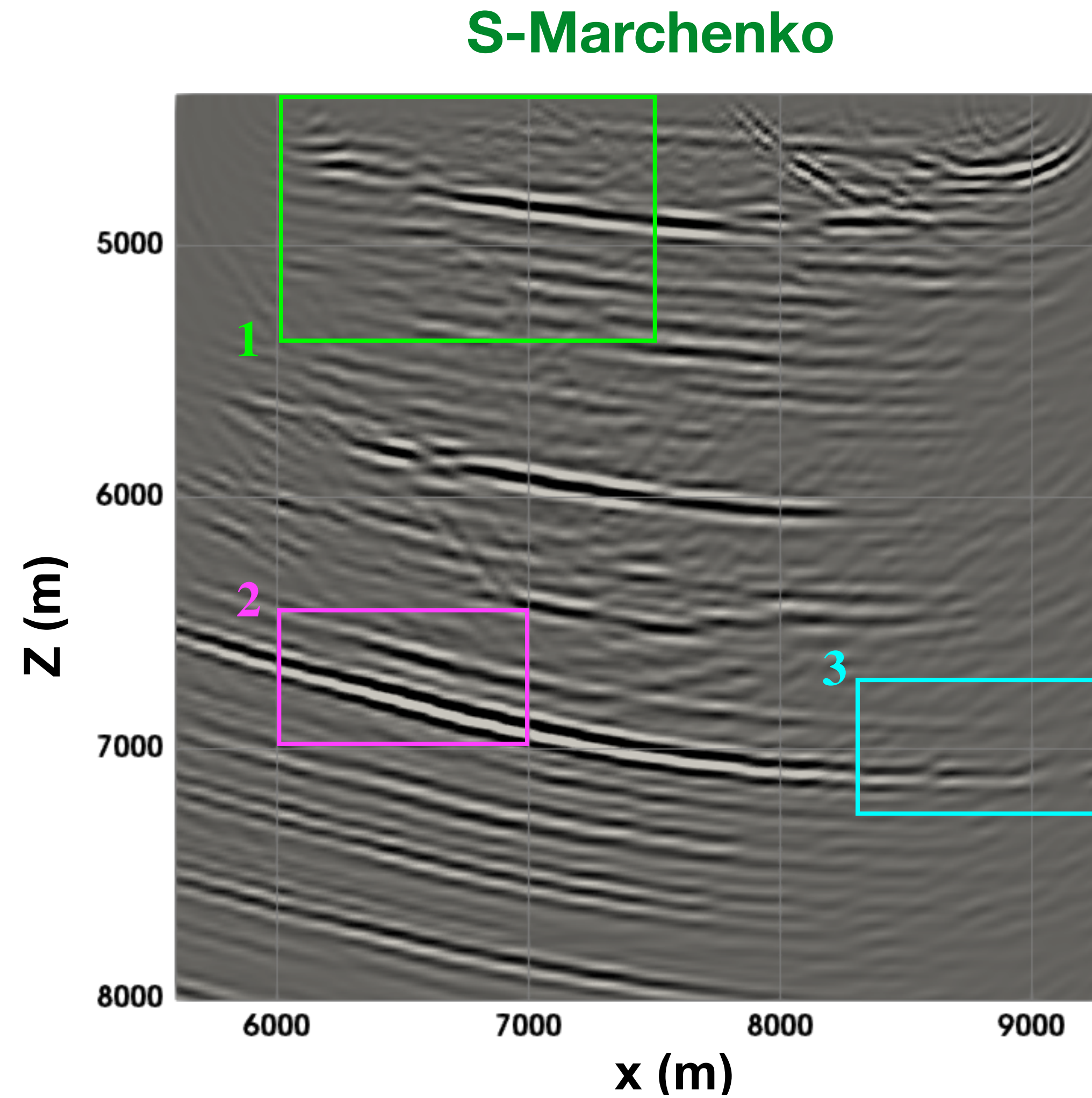
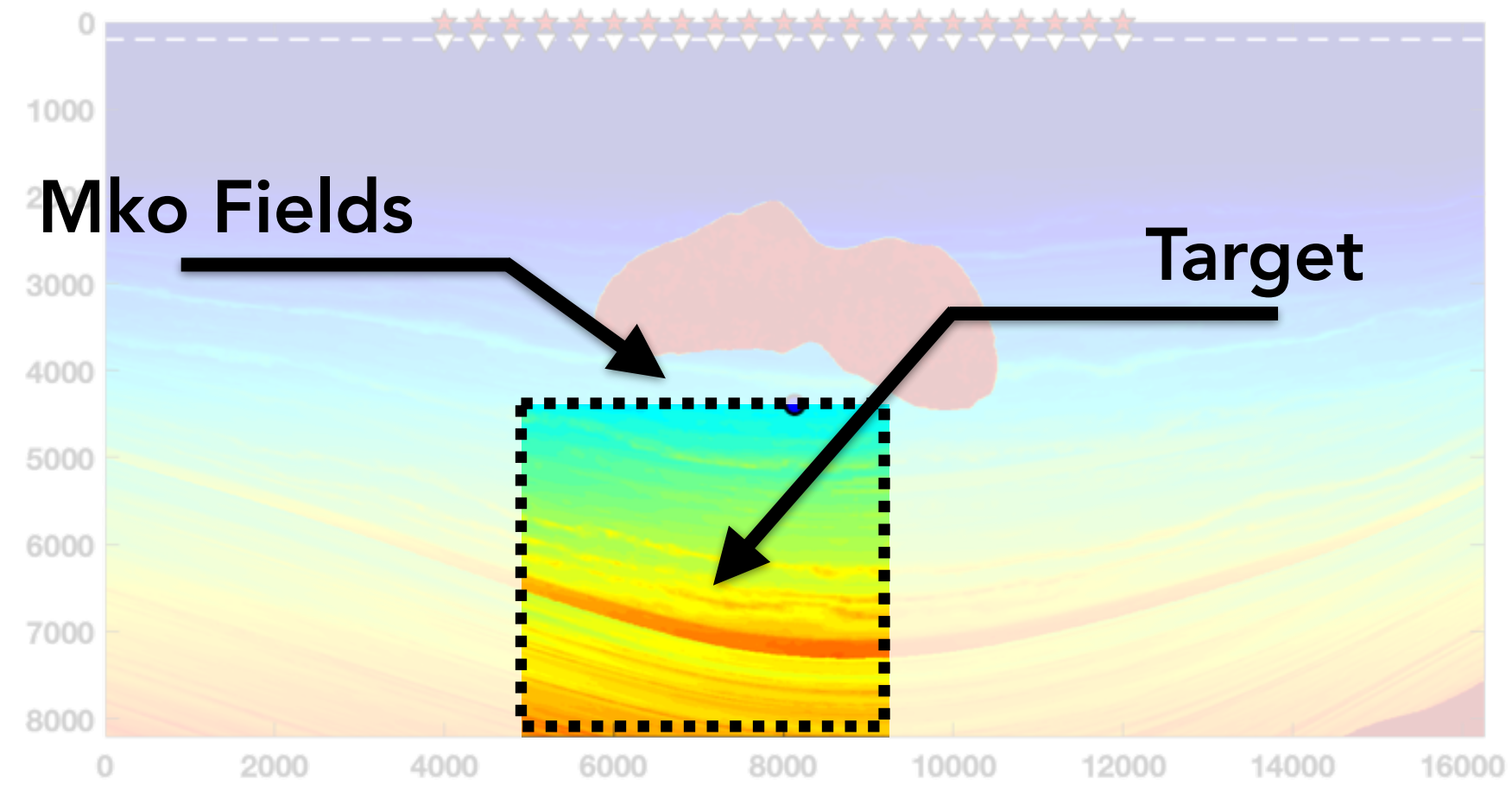
Target oriented imaging

8



Target oriented imaging

8



Marchenko

- Broggini F Et al, 2012, Focusing the wavefield inside an unknown 1D medium: Beyond seismic interferometry, GEOPHYSICS
- Wapenaar, K. Et al, 2014, Marchenko imaging, GEOPHYSICS

Rayleigh Marchenko

- Ravasi M, 2017, Rayleigh-Marchenko redatuming for target-oriented, true-amplitude imaging, GEOPHYSICS
- Slob E, and Wapenaar K, 2017, Theory for Marchenko imaging of marine seismic data with free surface multiple elimination, EAGE Technical Program Expanded Abstracts

Scattering Marchenko

- Vargas D., and Vasconcelos I., 2020, Rayleigh-Marchenko Redatuming Using Scattered Fields in Highly Complex Media, EAGE Technical Program Expanded Abstracts
- Vargas, D. et al, 2021, Scattering-based focusing for imaging in highly-complex media from band-limited, multi-component data: GEOPHYSICS

