Velocity evaluation using Least Squares Prestack Migration (LSPSM)

Friday's talks

12 Oct. 2012

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Outline

I. A review on Least Squares Prestack Kirchhoff Migration (LSPSM)

II. Effect of inaccurate velocity using synthetic data on LSPSM

   a) image resolution

   b) data reconstruction

   c) LCSG convergence rate

III. Real data difficulties

IV. Summary/Future work

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I. **A review on Least Squares Prestack Kirchhoff Migration (LSPSM)**

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IV. Summary/Future work

LSPSM:

- Modelling: $\boldsymbol{Gm = d}$
- Migration: $\boldsymbol{G^T d = \hat{m}}$
- Inversion: $\boldsymbol{G^{-1} d = m}$

d : Real data,

m : Reflectivity,

$\hat{m}$: Migration,

G : Kirchhoff forward operator.

G is not square and is too large.

LSPSM:

$$\boldsymbol{Gm = d}$$

$$\boldsymbol{G^T G\, m = G^T d}$$

$$\boldsymbol{m = (G^T G)^{-1} G^T d}$$

LSPSM:

$$\boldsymbol{Gm} = \boldsymbol{d}$$

$$\boldsymbol{G^T G\, m} = \boldsymbol{G^T d}$$

$$\boldsymbol{m} = (\boldsymbol{G^T G})^{-1} \boldsymbol{G^T d}$$

- Minimizing a general cost function:

$$J(\boldsymbol{m}) = \|\boldsymbol{Gm} - \boldsymbol{d}\|^2 + \mu^2\, \mathcal{R}(\boldsymbol{m})$$

$\mathcal{R}$: Regularization term,

μ : Trade-off parameter

LSPSM:

$$\boldsymbol{Gm} = \boldsymbol{d}$$

$$\boldsymbol{G^T G\, m} = \boldsymbol{G^T d}$$

$$\boldsymbol{m} = (\boldsymbol{G^T G})^{-1}\boldsymbol{G^T d}$$

- Minimizing a general cost function:

$$J(\boldsymbol{m}) = \|\boldsymbol{Gm} - \boldsymbol{d}\|^2 + \mu^2\, \mathcal{R}(\boldsymbol{m})$$

Damped: $\boldsymbol{m}_{DLS} = (\boldsymbol{G^T G} + \mu^2 \boldsymbol{I})^{-1}\boldsymbol{G^T d}$

Smooth: $\boldsymbol{m}_{SLS} = (\boldsymbol{G^T G} + \mu^2 \boldsymbol{D}_h^T \boldsymbol{D}_h)^{-1}\boldsymbol{G^T d}$

Replacing Migration with LSPSM:

- Remove migration artifacts. Attenuate acquisition footprints; Provide high resolution images*.
- Compute images that can reproduce data. Data interpolation*.
- A tool to evaluate the accuracy of the estimated velocity model.

*Nemeth et. al. (1999 ,2000) and Duquet et. al. (2000).

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Quantifying velocity accuracy:

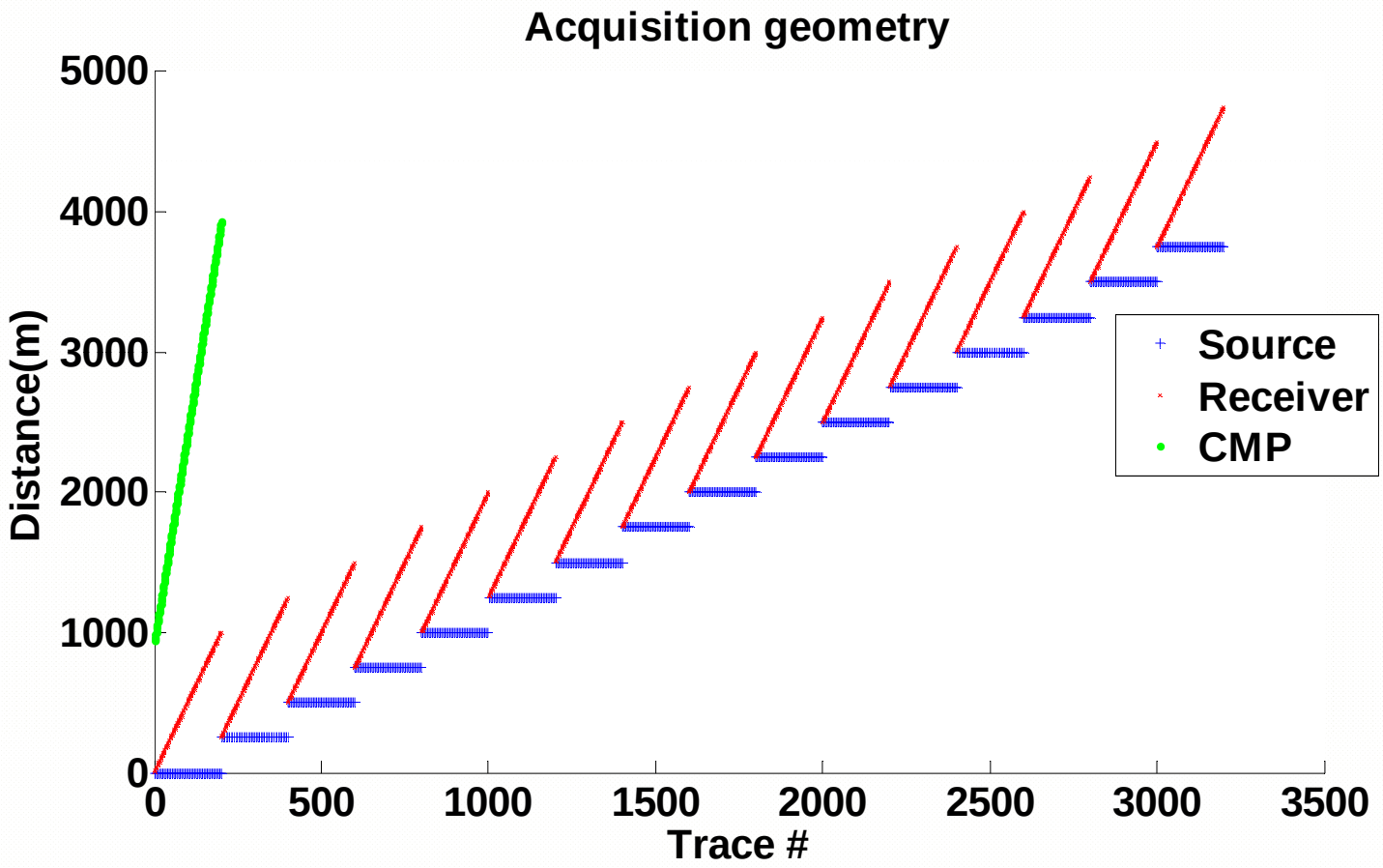
- Velocity that makes flat events on a CMP gather: NMO/Stacking velocity.
- Velocity that makes flat events on a CIG gather: Migration velocity.
- Velocity that LSPSM requires for
  - Improving image resolution,
  - in a few LSCG iterations,
  - Give good data reconstruction:

Imaging Velocity.

Synthetic data; Acquisition geometry:

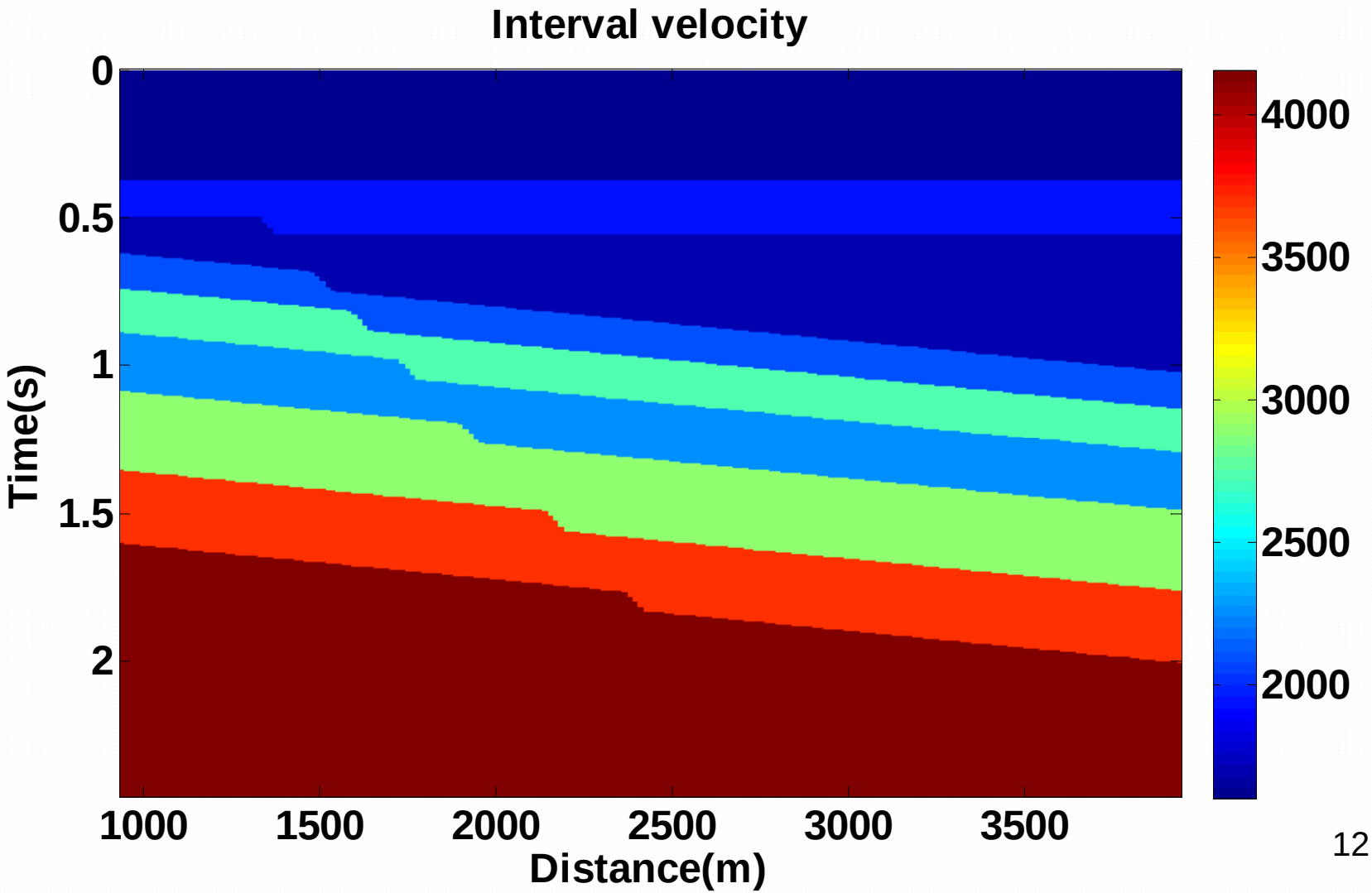
– 16 sources, 250m interval

– 200 receivers, 5m interval



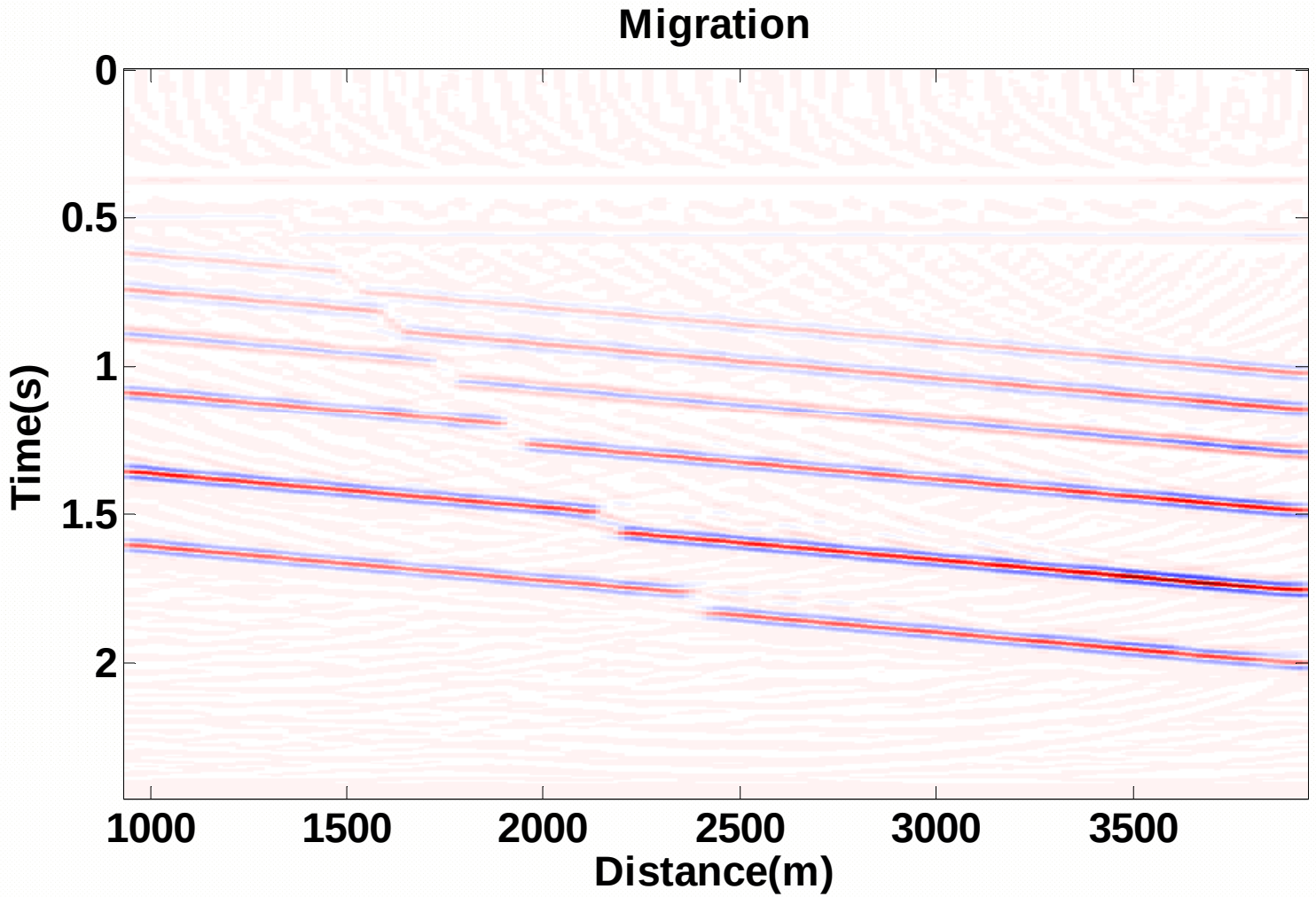
Synthetic data; Velocity model:

– Velocity 1600-4160 m/s



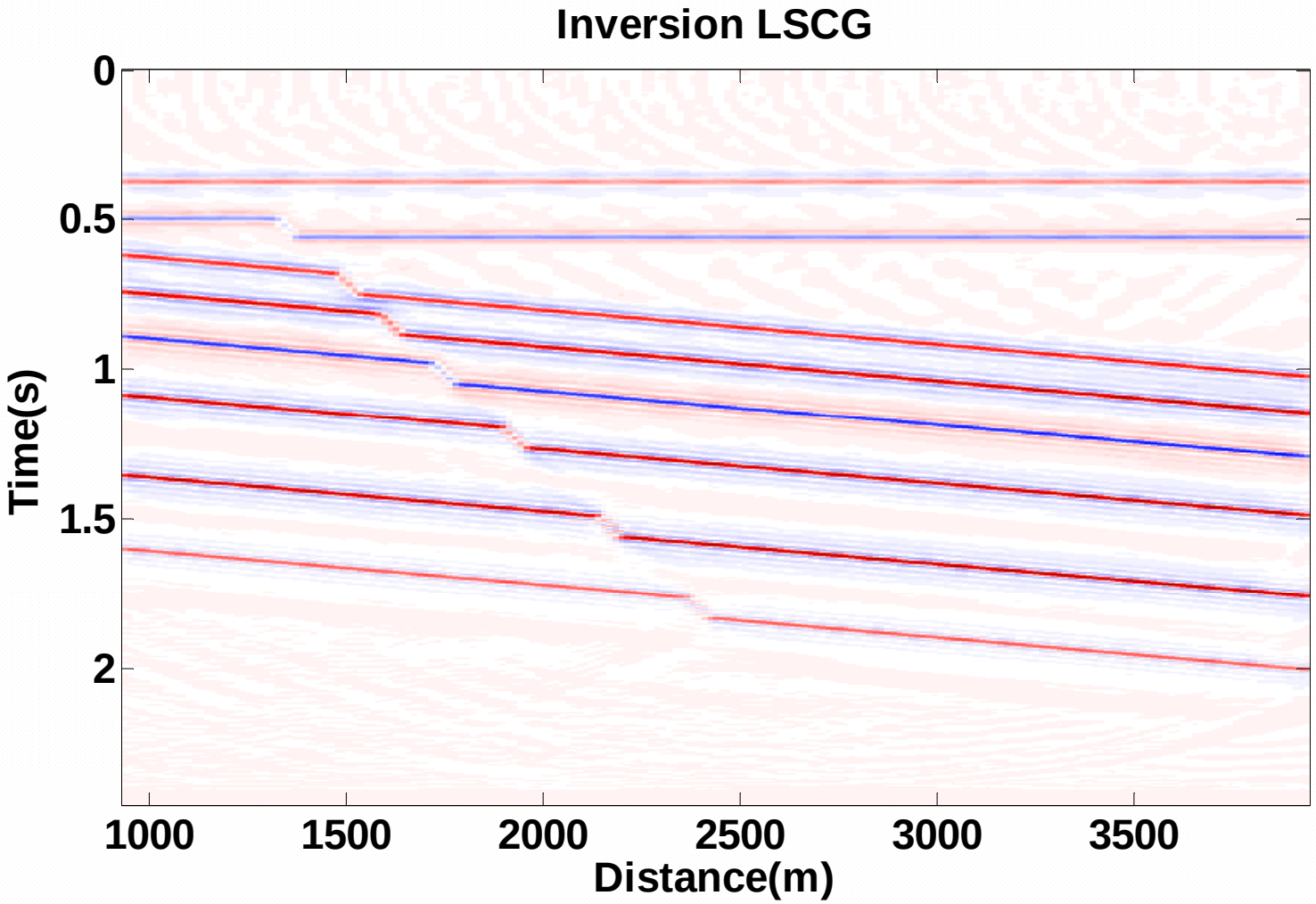
Synthetic data; Migration:

- Exact velocity



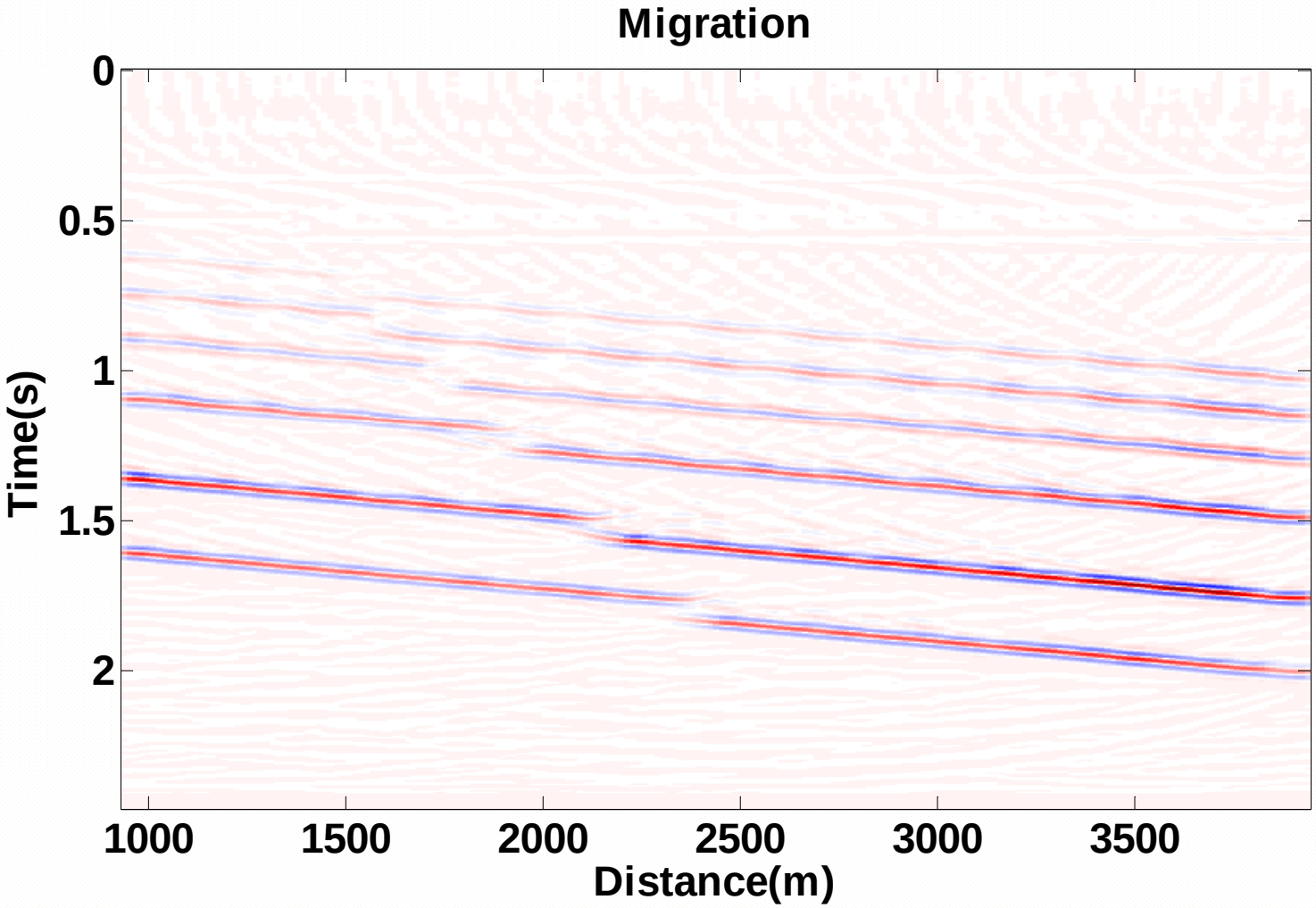
Synthetic data; LSPSM:

- Exact velocity



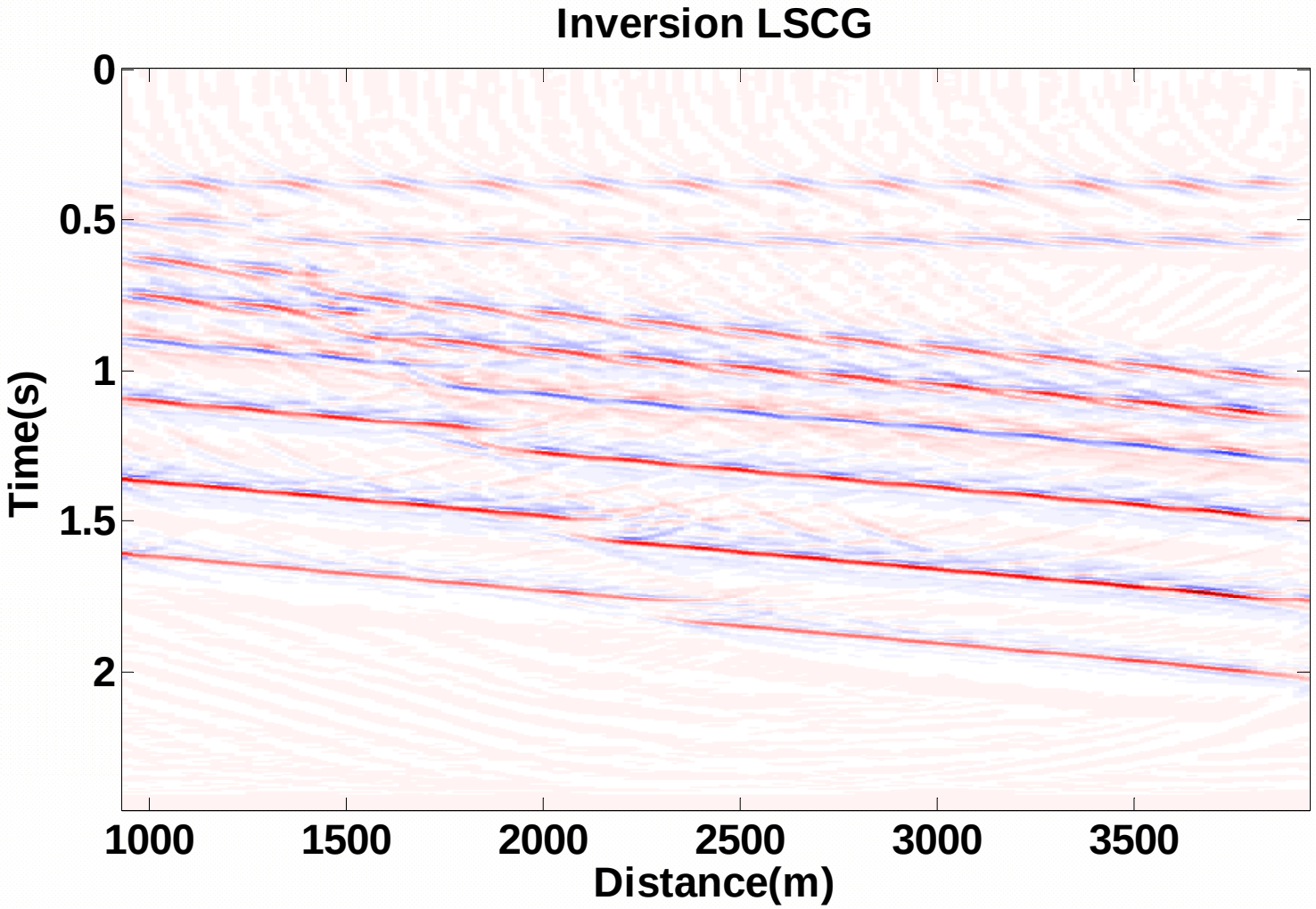
Synthetic data; Migration:

- 5% higher velocity

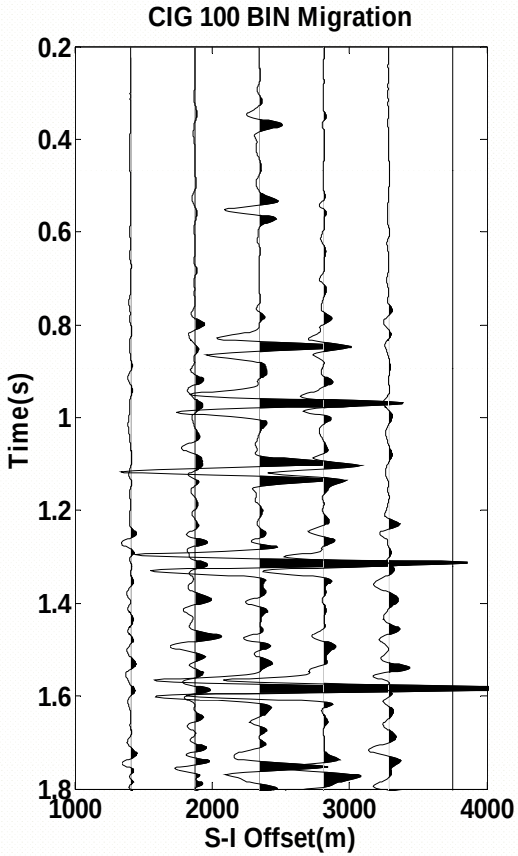


Synthetic data; LSPSM:

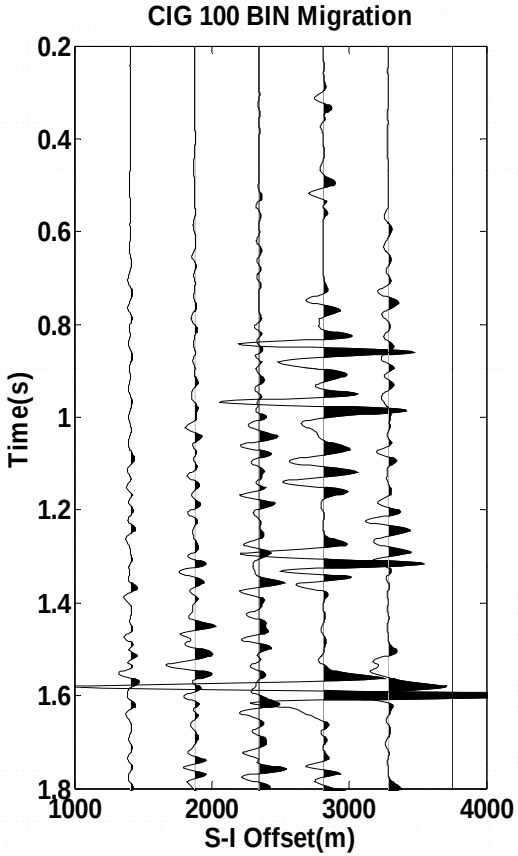
- 5% higher velocity



Synthetic data; Migration shot domain CIG:

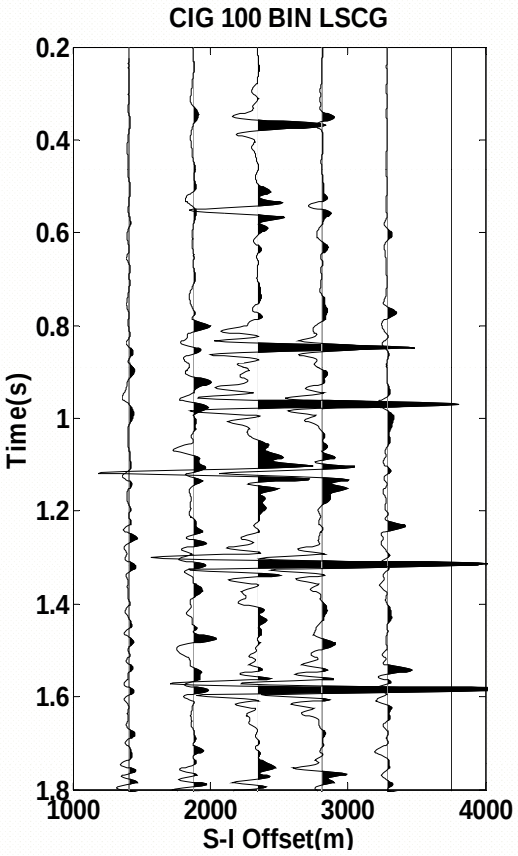


Exact velocity

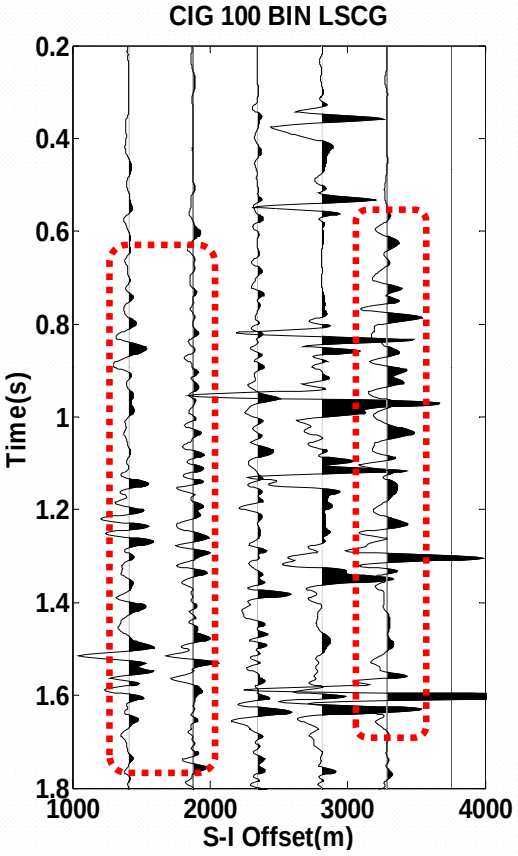


5% higher velocity

Synthetic data; LSPSM shot domain CIG:



Exact velocity



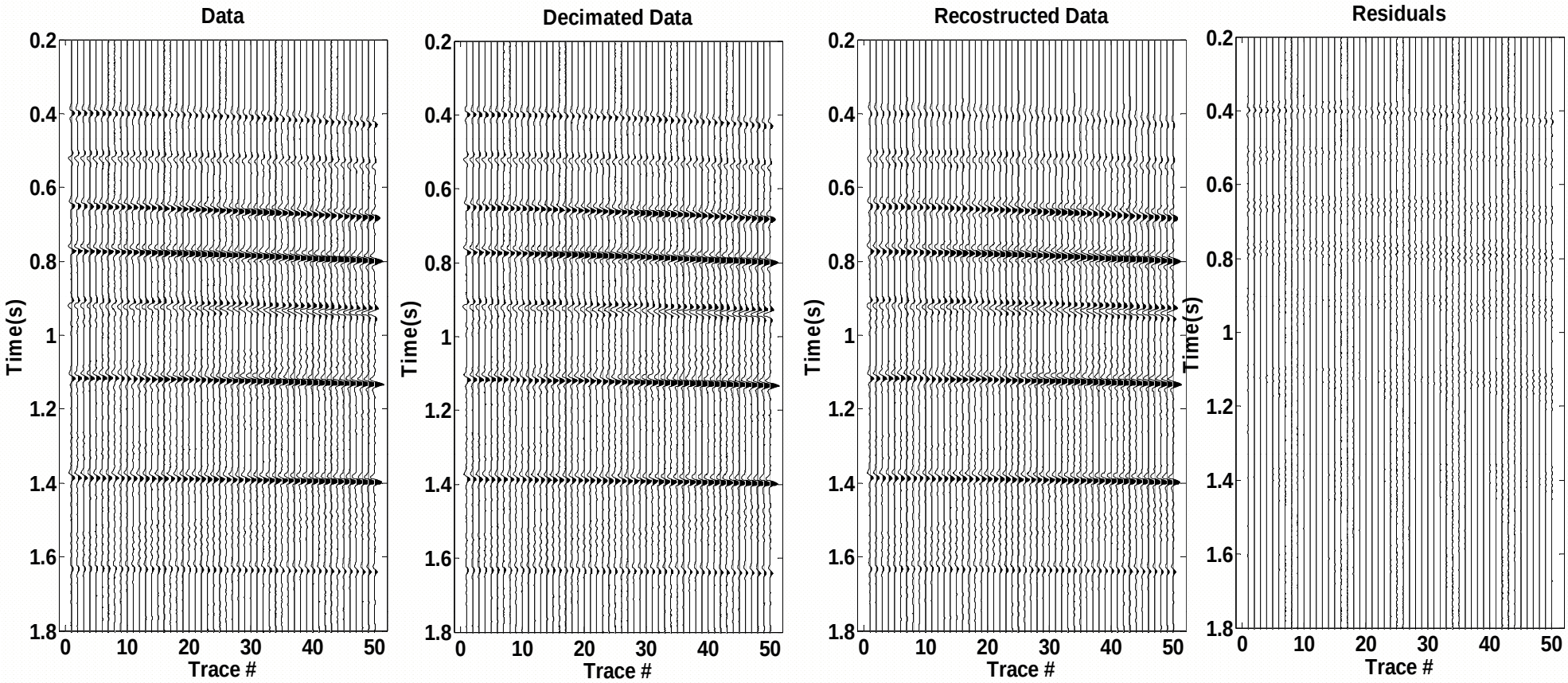
5% higher velocity

Velocity evaluation:

- Inaccurate velocity introduces artifacts into the LSPSM more than migration image.

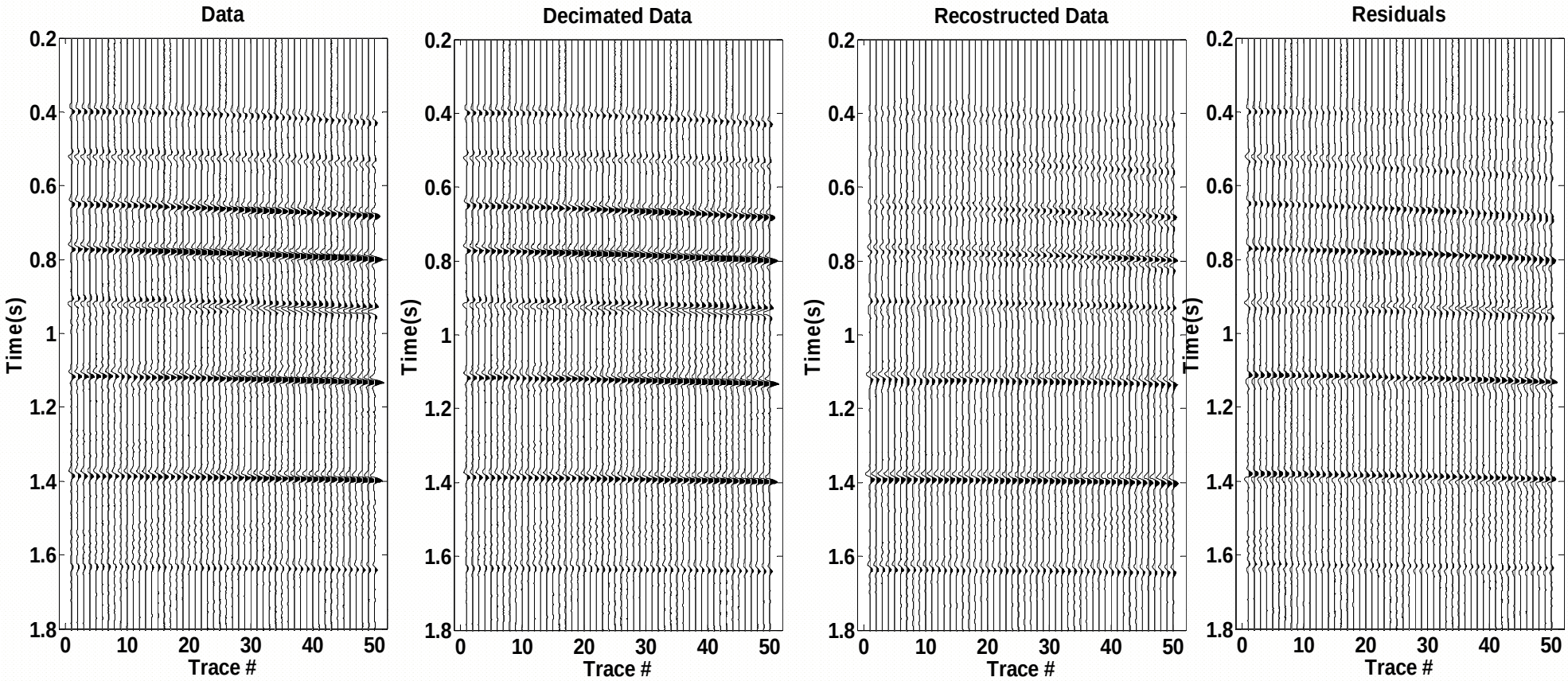
Synthetic data; Data Reconstruction:

- Exact velocity

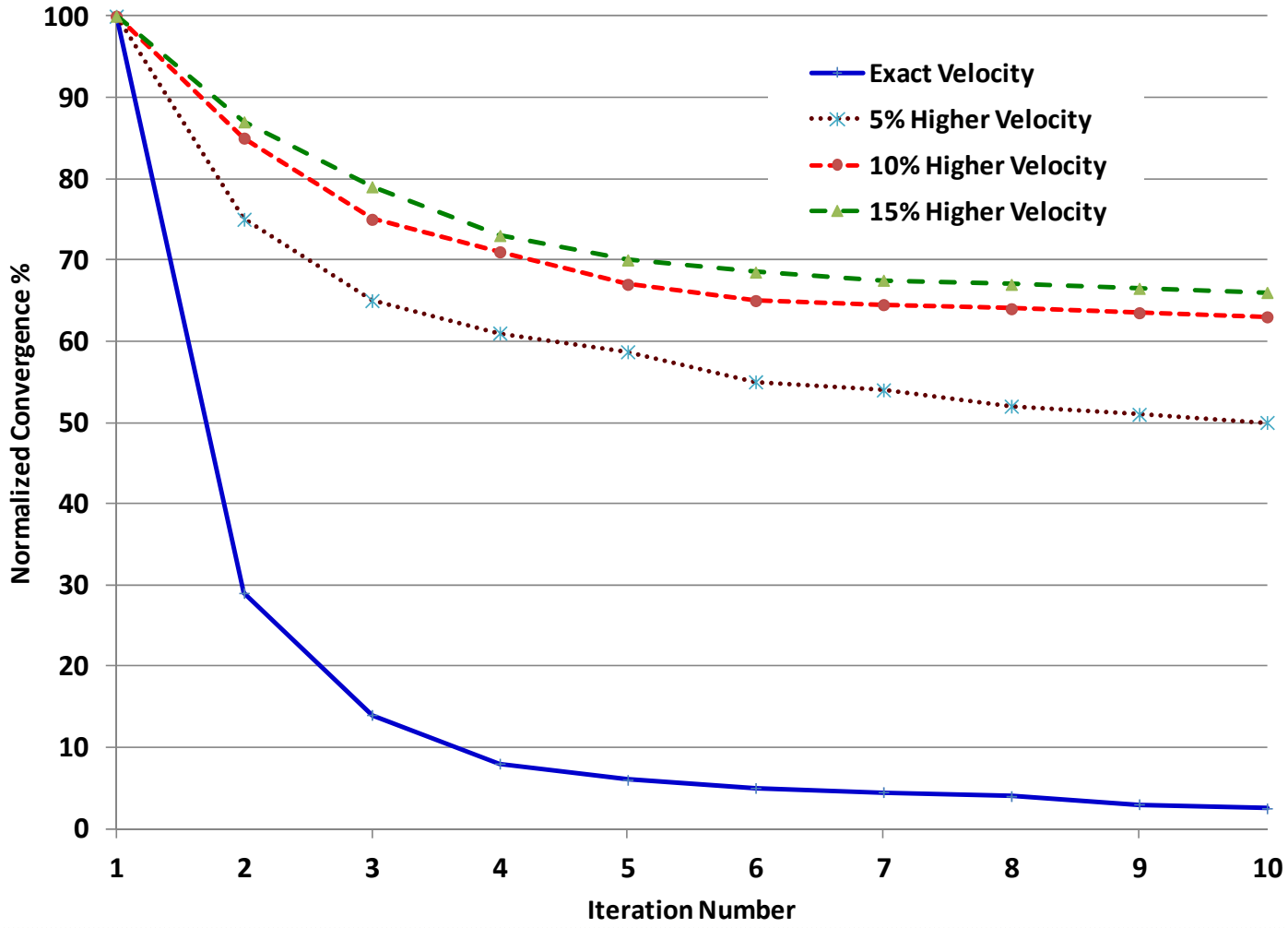


Synthetic data; Data Reconstruction:

- 5% higher velocity



Synthetic data; LSCG Convergence:



Velocity evaluation

- LSPSM is more sensitive to the accuracy of the velocity model.
- One can define an imaging velocity is accurate enough when:
  - Provide higher image resolution,
  - in less iterations,
  - Provide acceptable data reconstruction.

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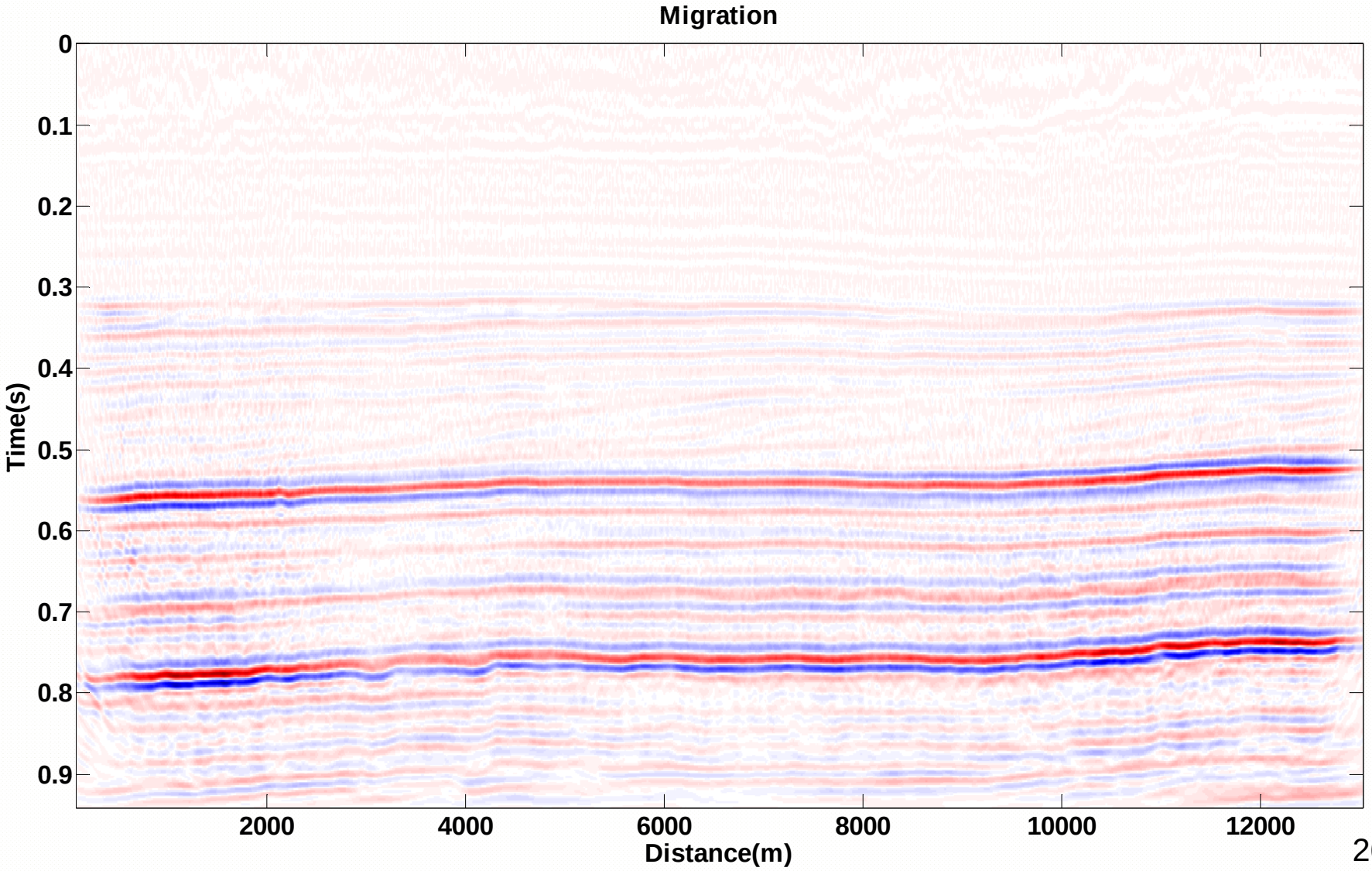
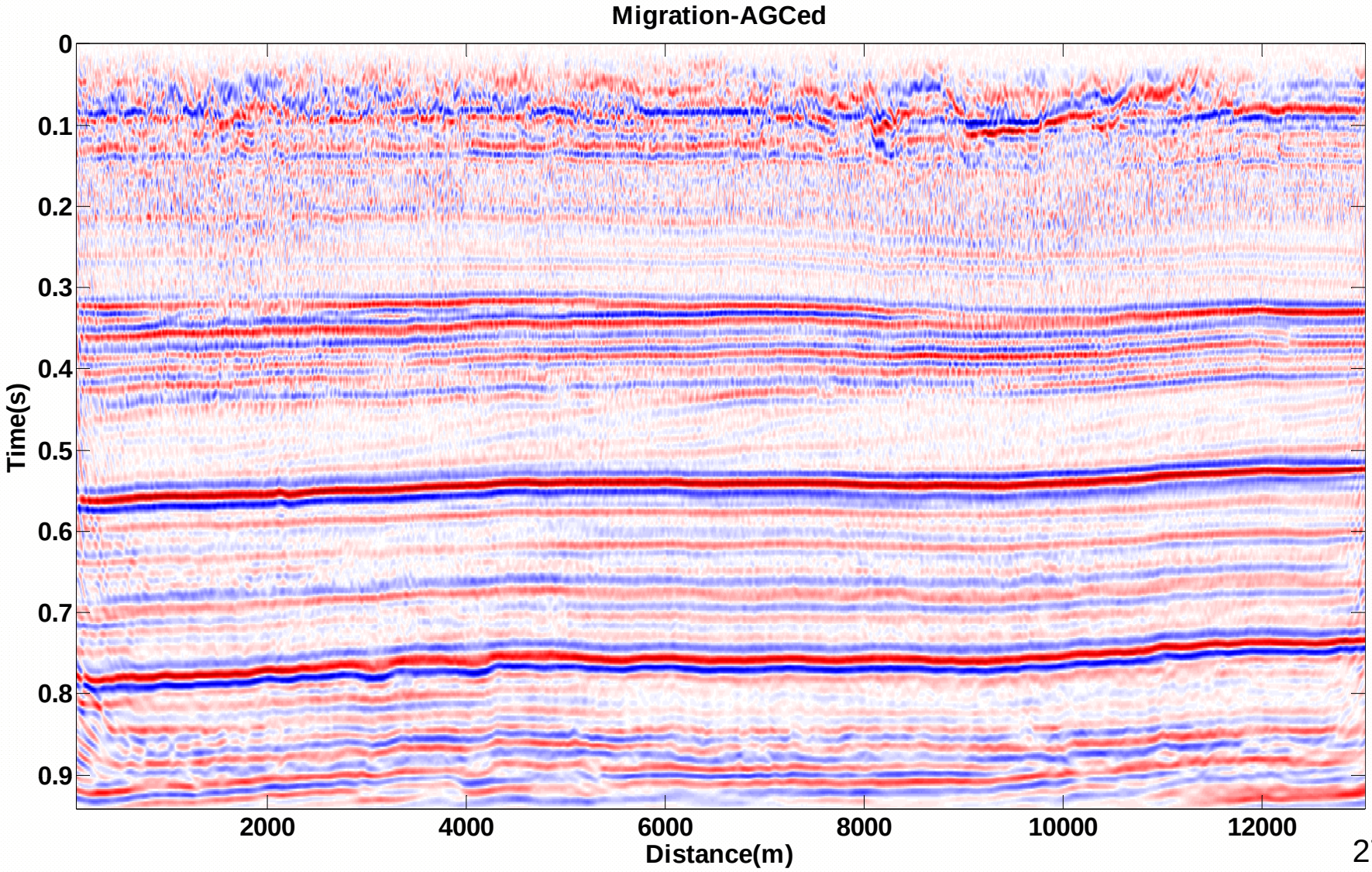
Velocity evaluation:

- Real data NE-BC
- 65000 trace, 10 m interval
- 220 source
- 50% of regularly selected data

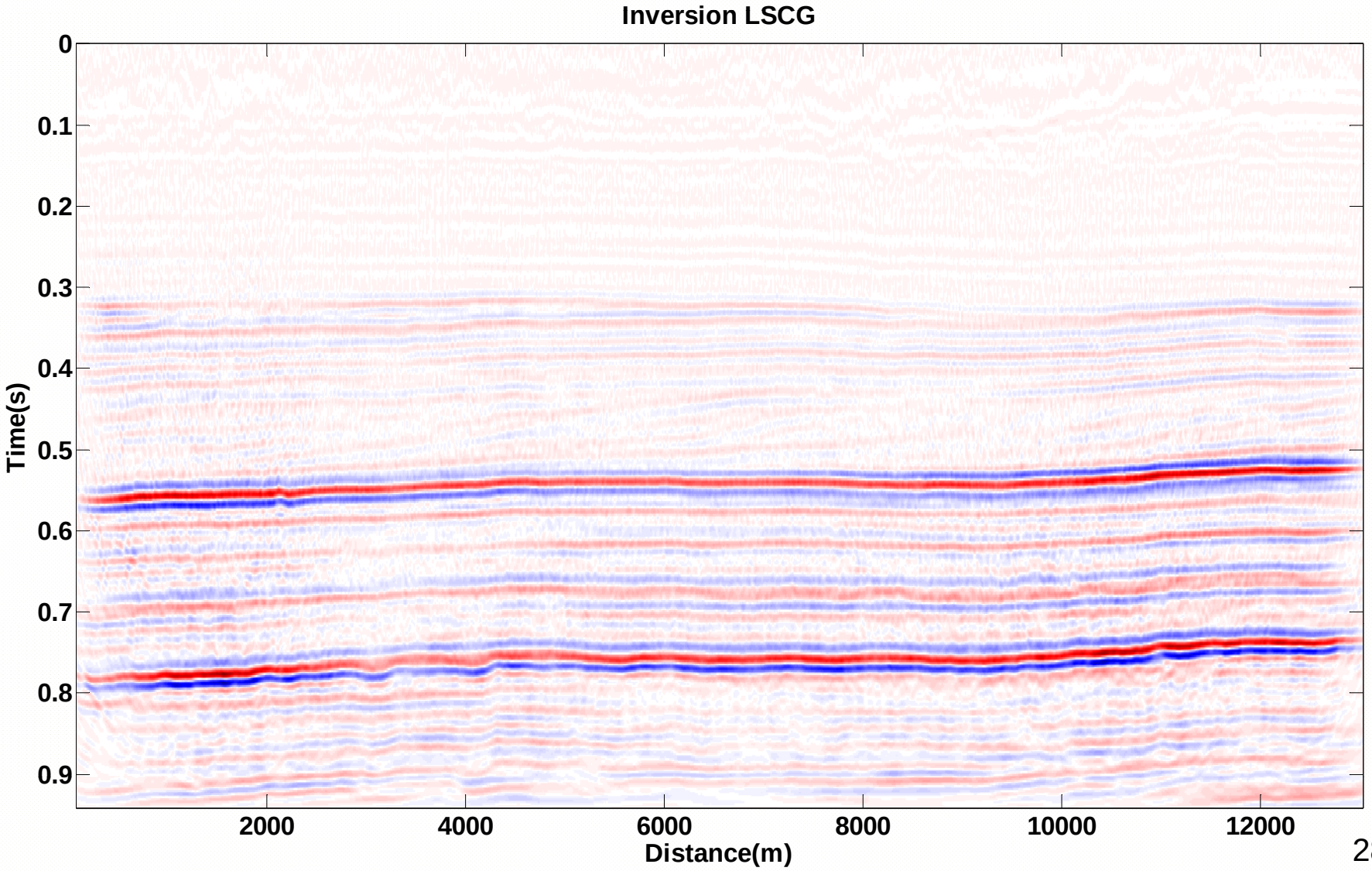
Real data; Migration:



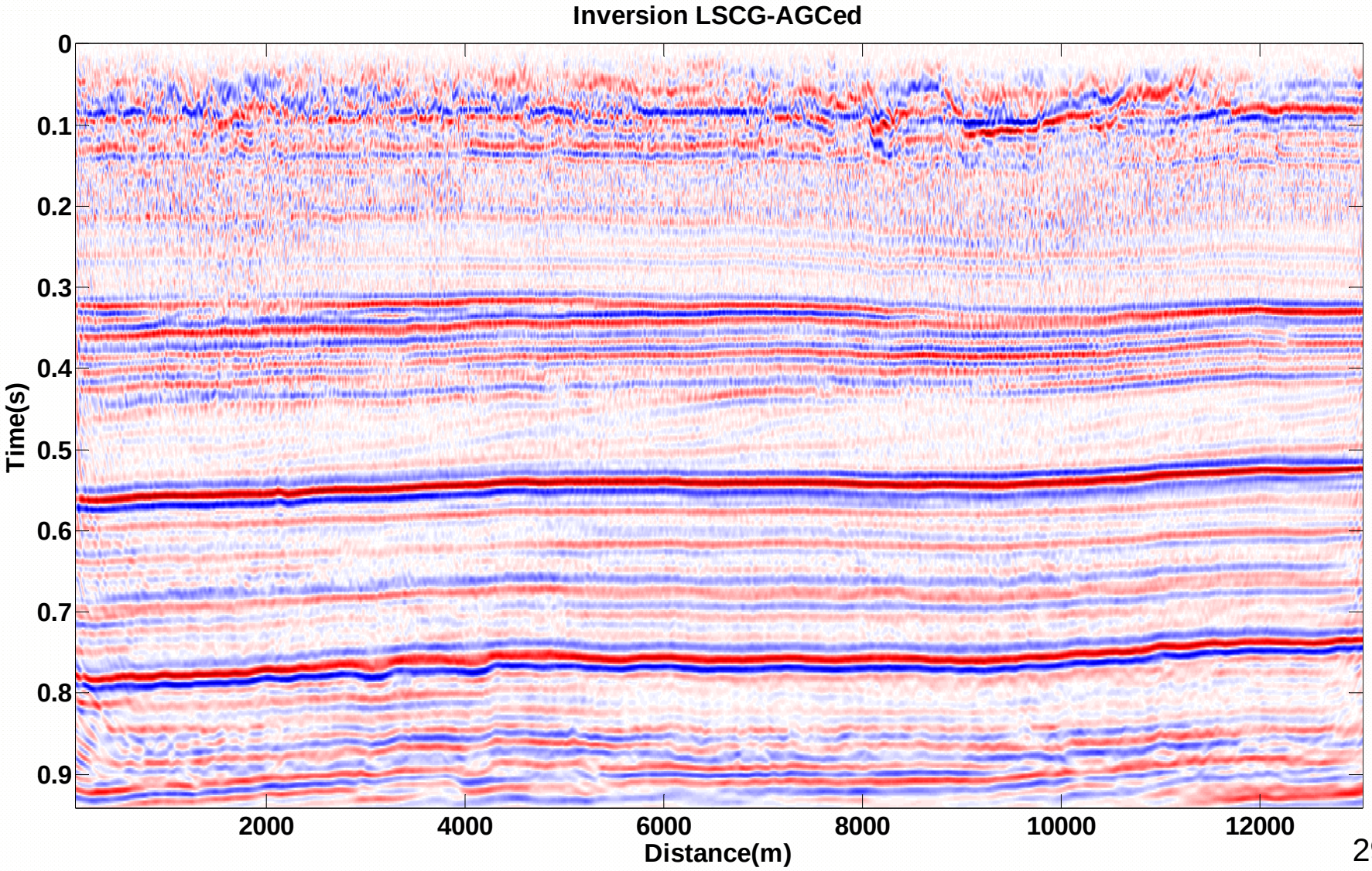
Real data; Migration (AGC):



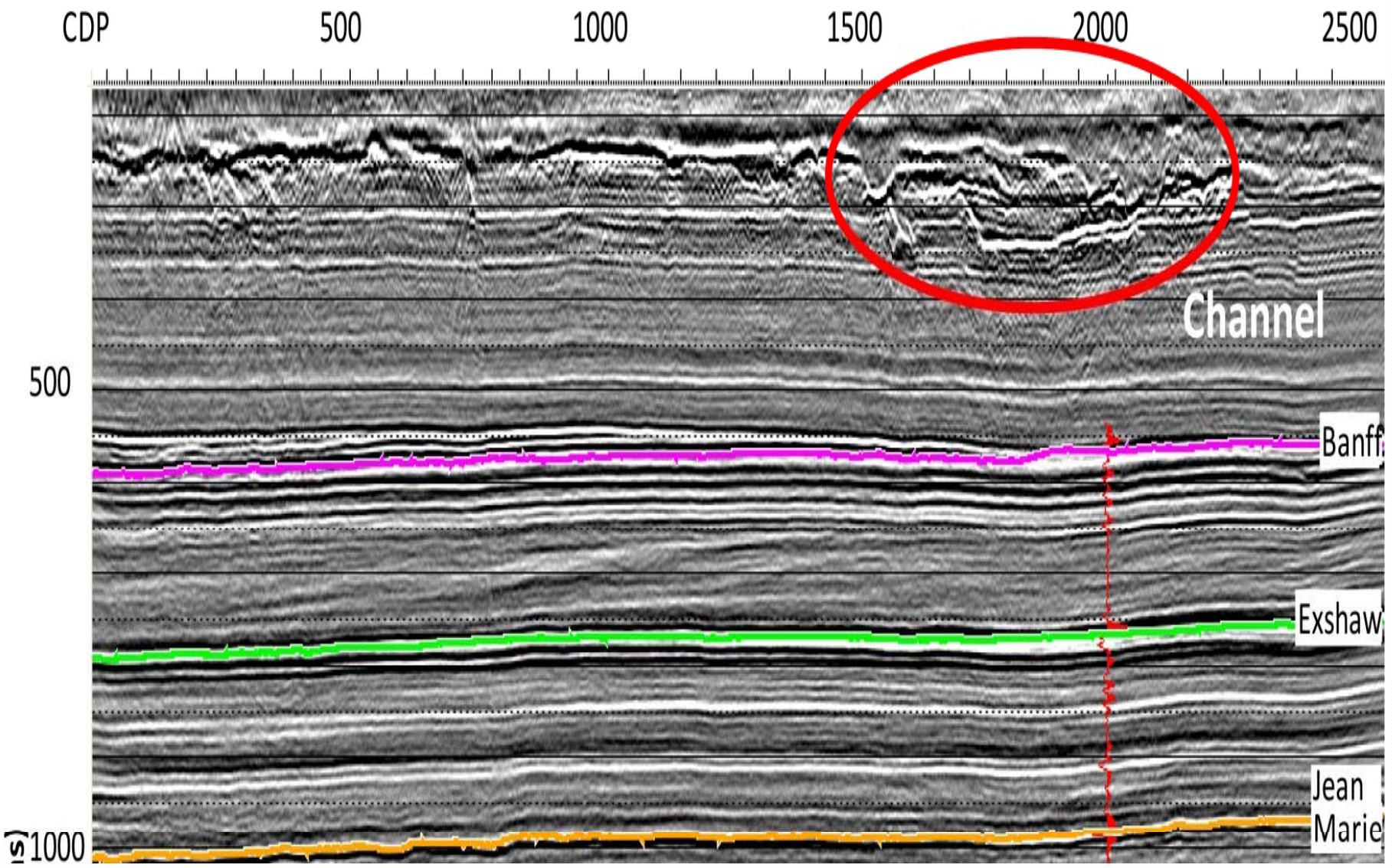
Real data; LSPSM:



Real data; LSPSM (AGC):



Real data; Result from processing company:



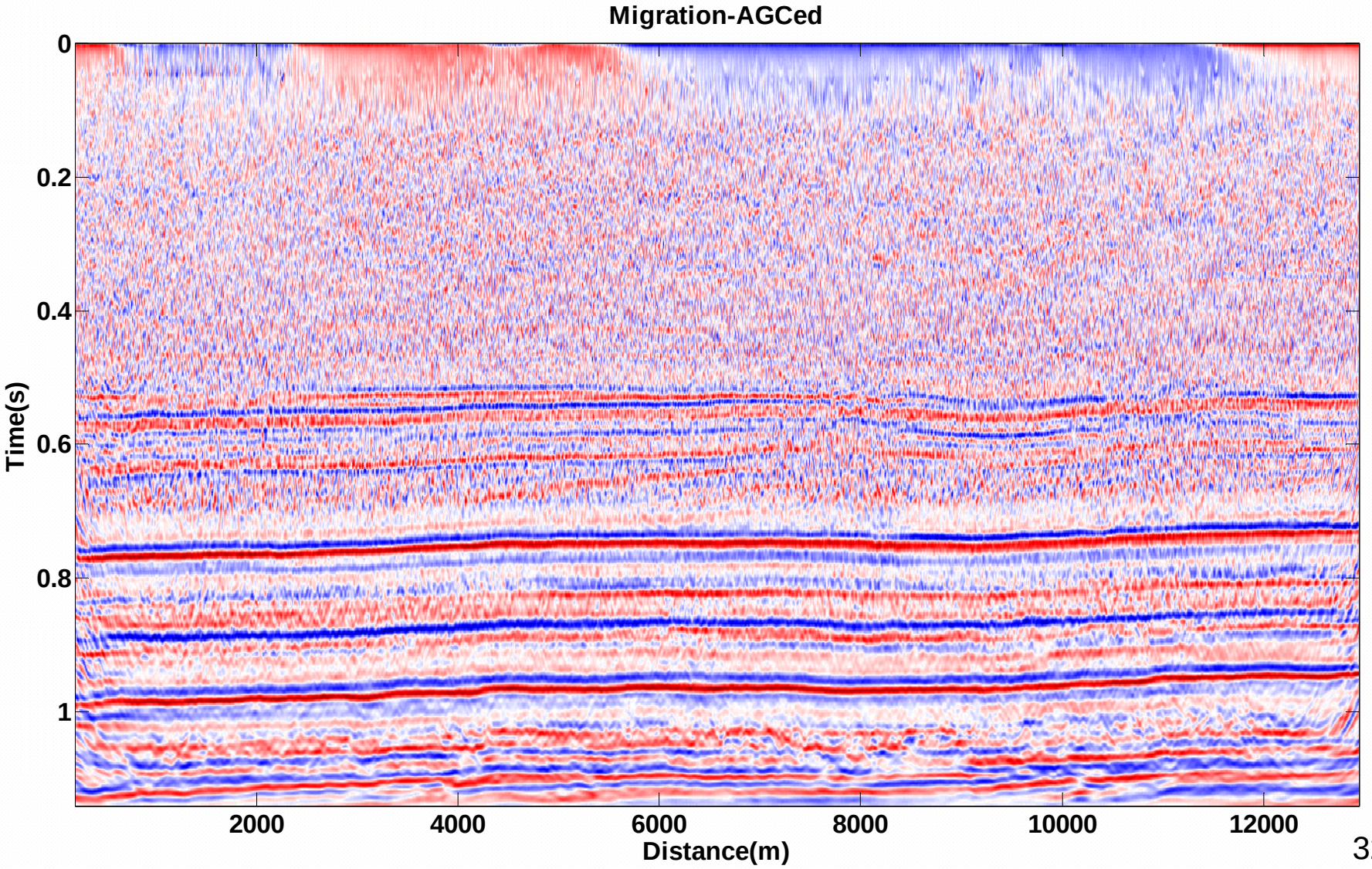
Velocity evaluation:

- Velocity semblances show interbed multiples.
- Parabolic Radon Transform for de-multiplication.

- Real data after de-multiplication:

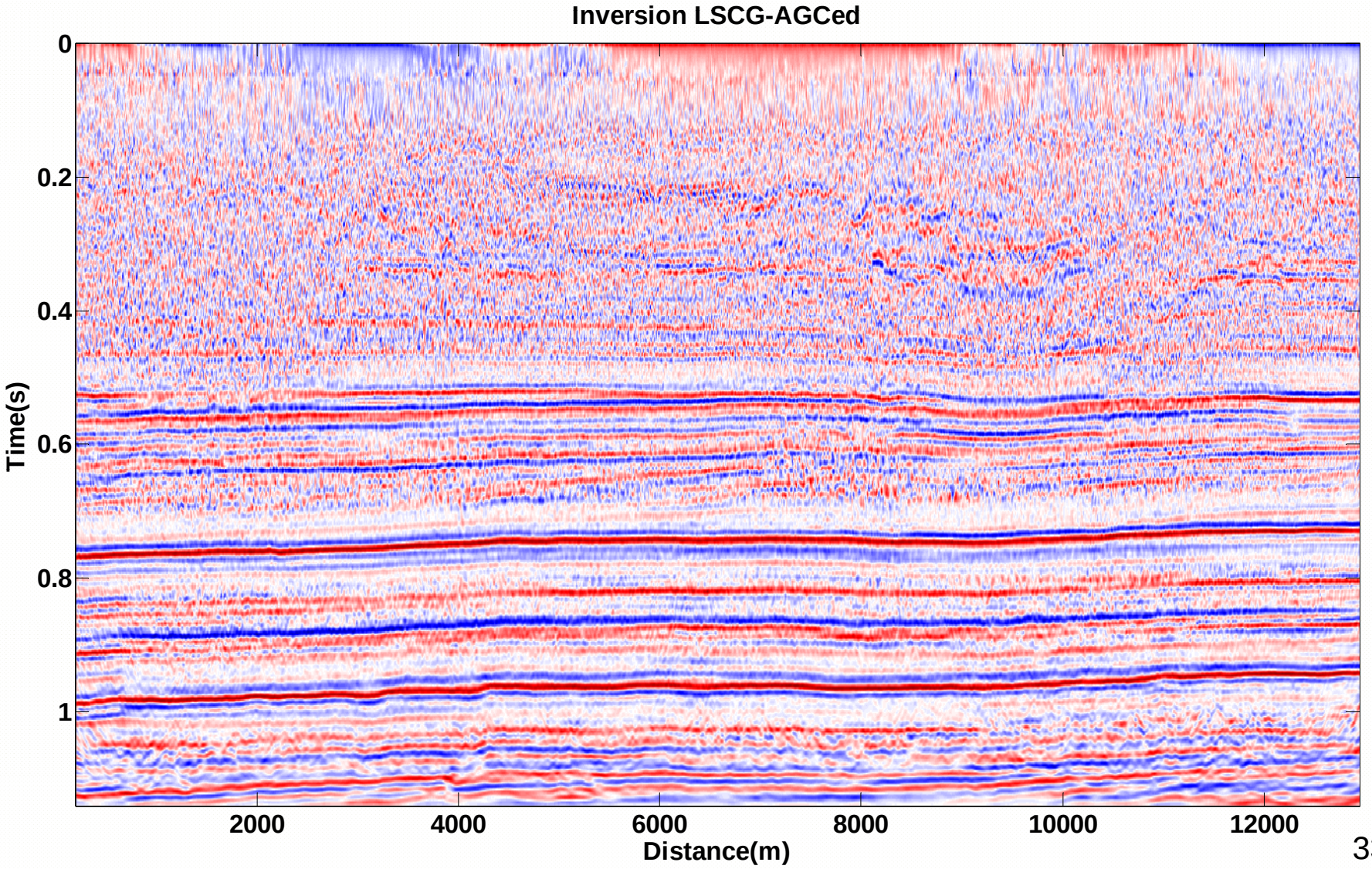
Demultipled real data; Migration (AGC):

- Only 5% of data



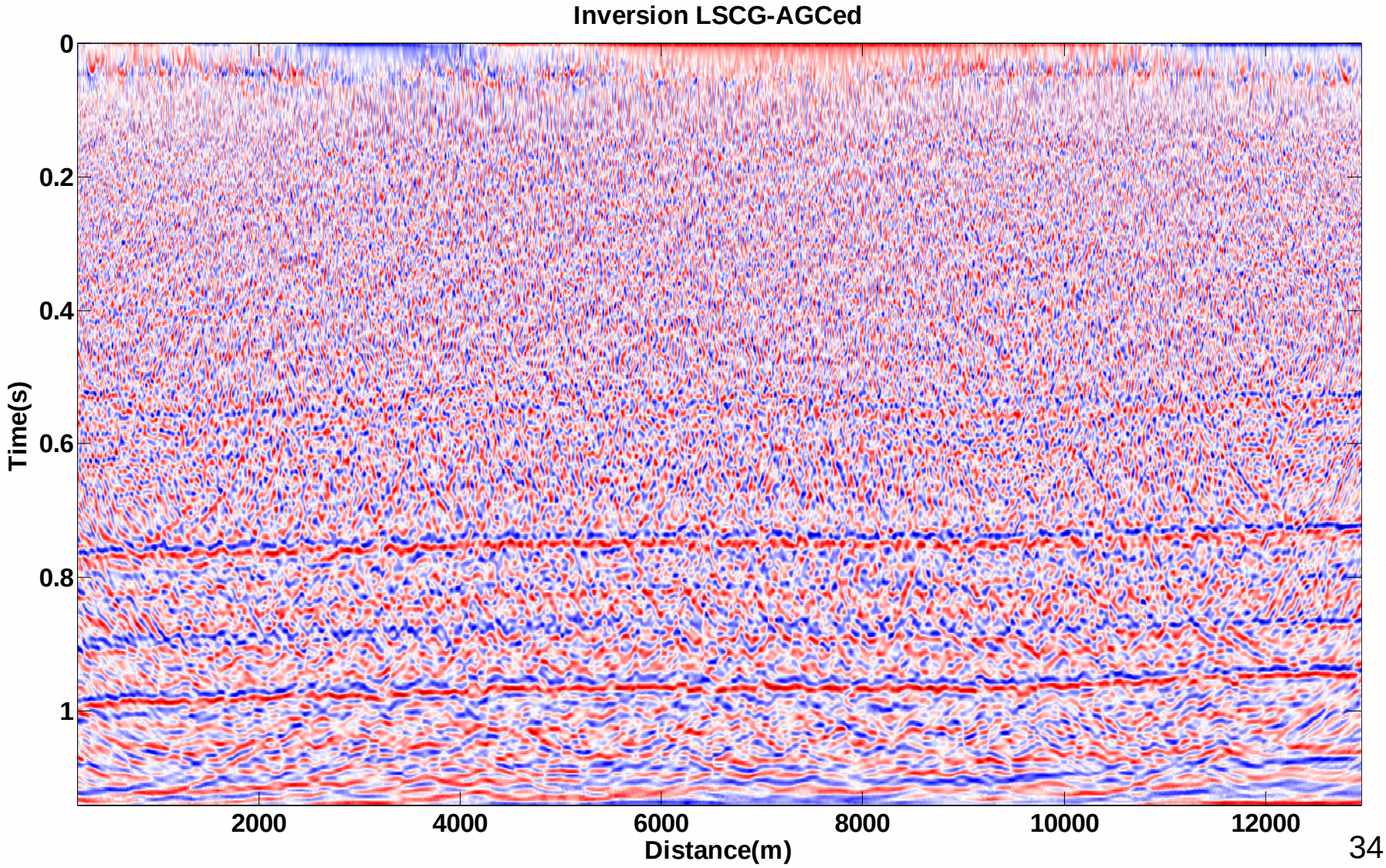
Demultipled real data; LSPSM (AGC):

- Only 5% of data

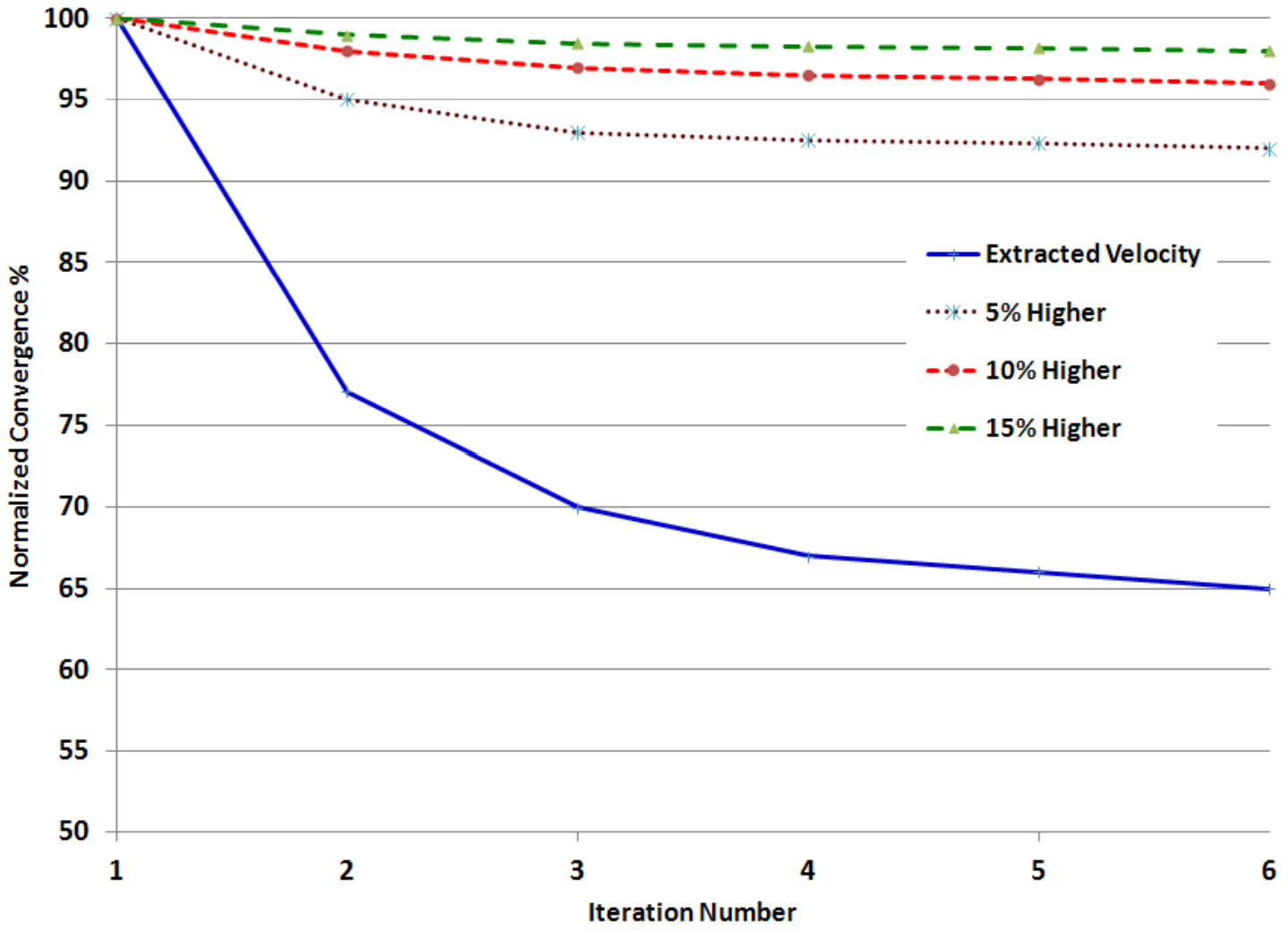


Demultipled real data; LSPSM (AGC):

- only 5% of data & 5% higher velocity



Demultipled real data; LSCG Convergence:



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Summary:

- Kirchhoff LSPSM provide high resolution image and attenuate migration artifacts.
- It requires a good knowledge of velocity.
- Velocity is accurate when LSPSM:
  - Provide higher image resolution,
  - in less iterations,
  - Provide a good data reconstruction.

Summary:

- LSPSM may be used for evaluation of estimated velocity.
- Cost can be reduced if highly decimated data (5%) used.
- Data should be multiple-free.

Future work (before Sponsors' meeting)**:**

- Changing multiple attenuation method, parameters, or software.
- Adding regularization term.

  – Suggestions
  – Recommendations
  – Questions