Simultaneous sources acquisition and deblending methods

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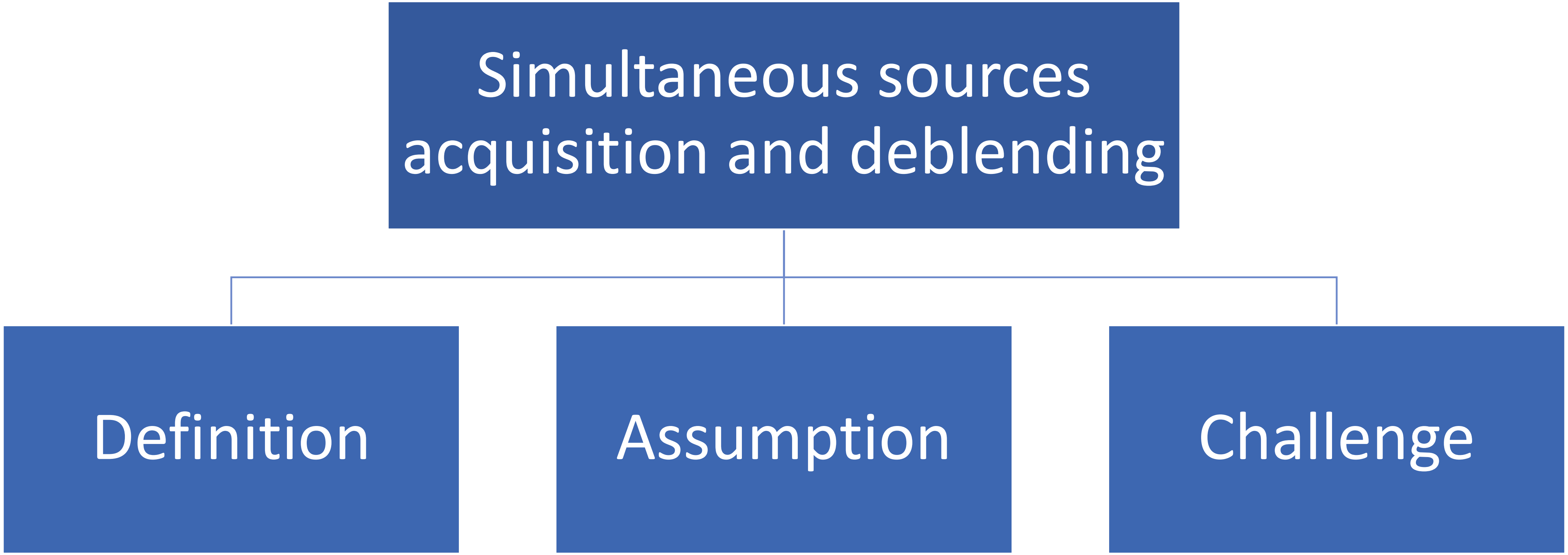
Outline

What is deblending?
- Definition
- Assumption
- Challenge

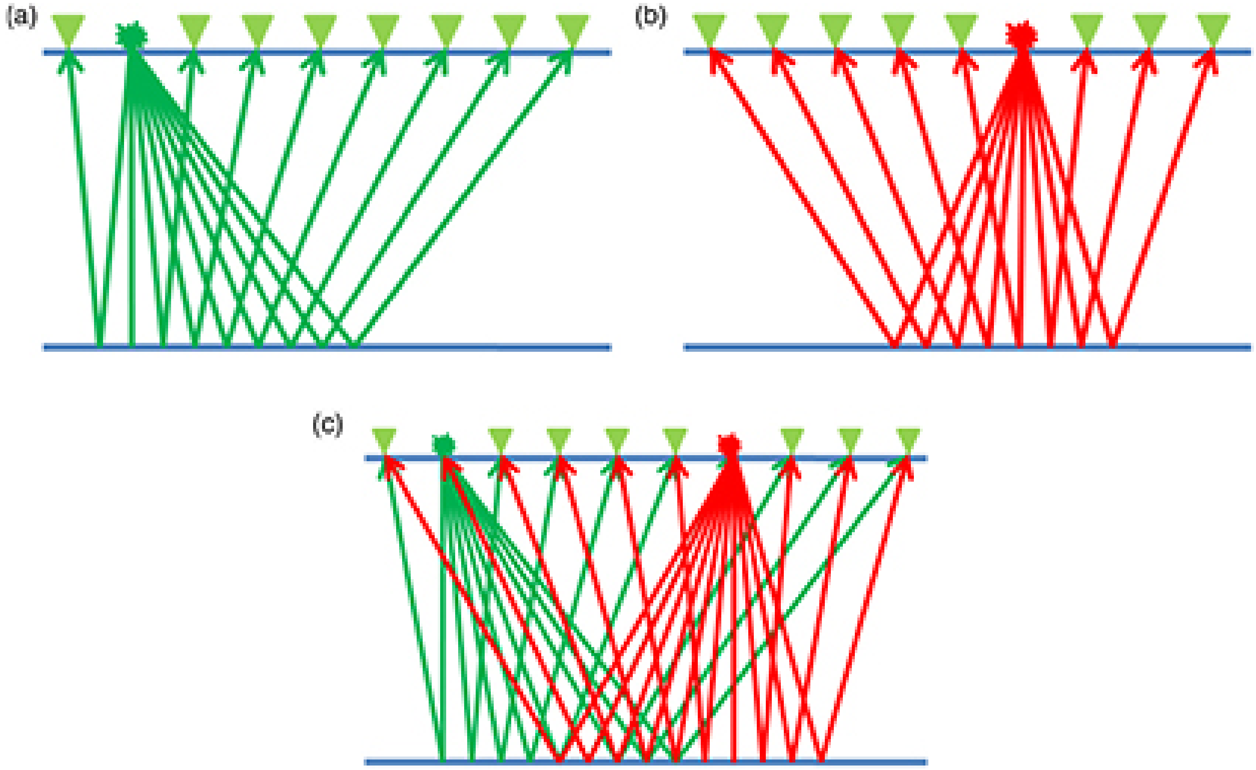
Methods
- Noise attenuation
- Multidimensional inversion
- Physical transformation

Results
- Synthetic data
- Field data

What is deblending?



Definition



(a) and (b) Illustrations of conventional acquisition. (c) Simultaneous sources acquisition

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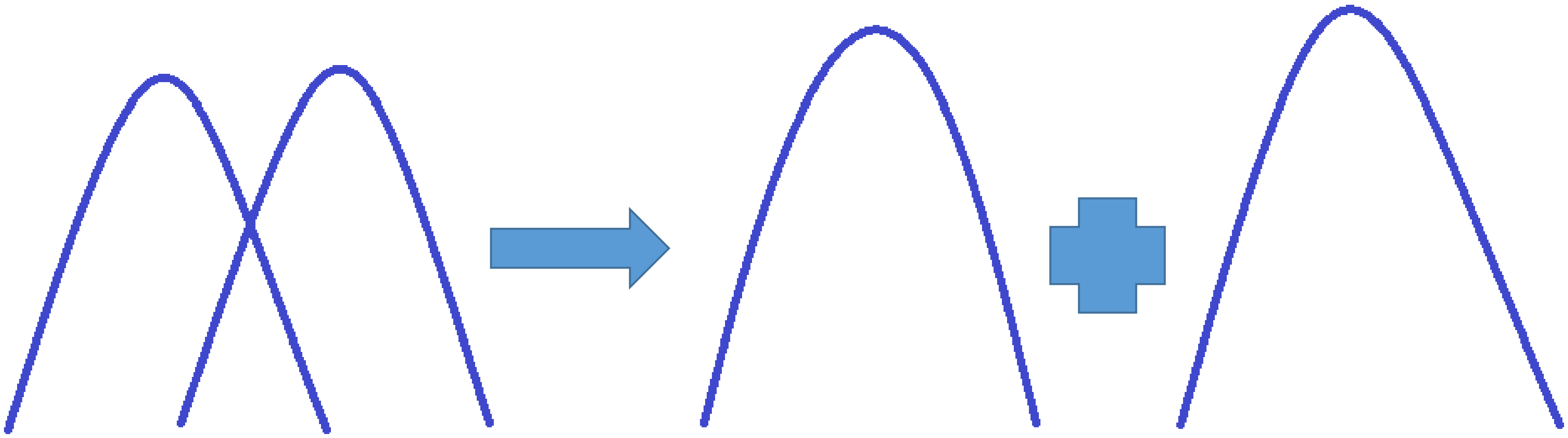
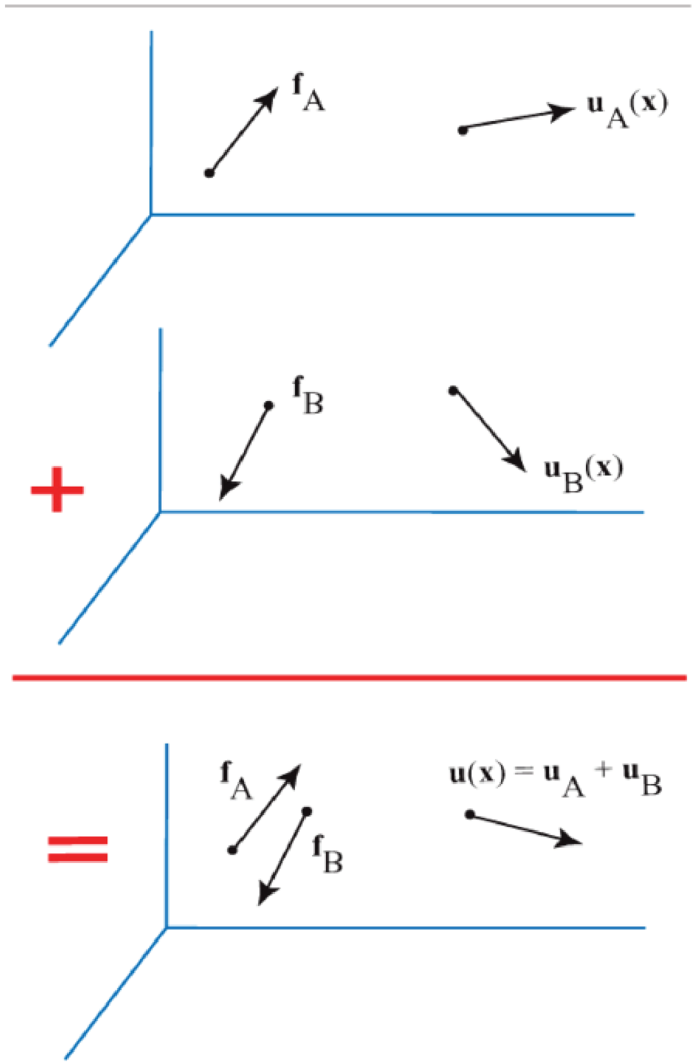
Definition



Deblending is a processing step related to simultaneous sources acquisition. It separates blended shot gathers into separated shots. Even if we can do migration with multiple source gather, the separation needs to be done before processing to get data for denoising and correction.

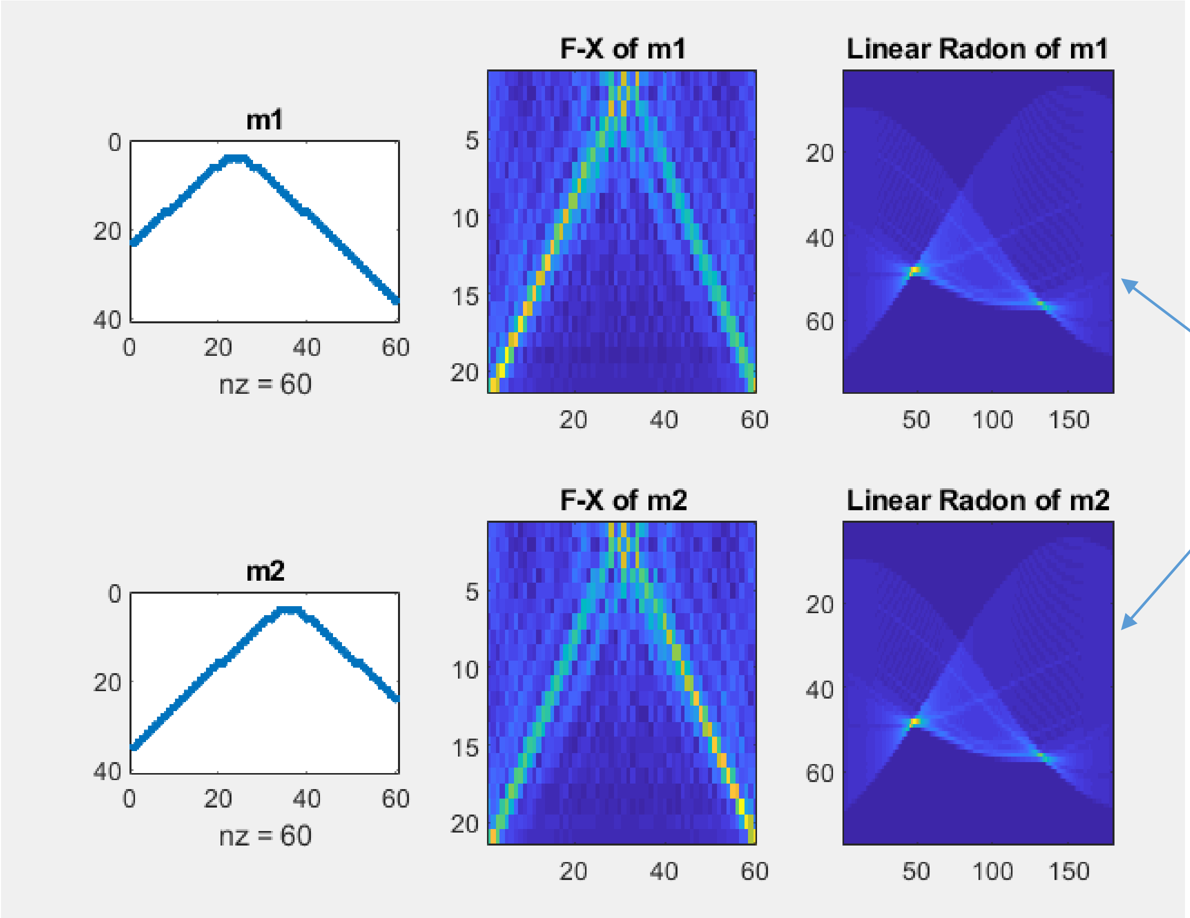
Assumption

The Earth's response can generally be approximated as linear, and any response to any complex force can be calculated as a sum of the displacements of constituent body forces.



Challenge

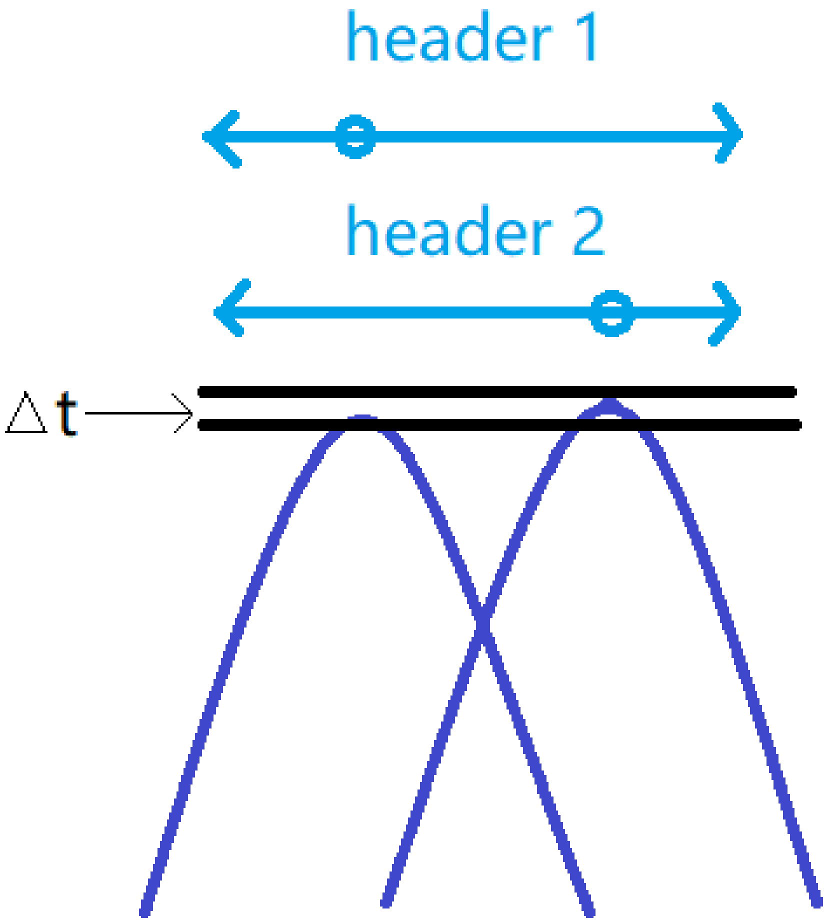
To Some extent, the blending is a kind of denoising method. We need to get the target shot gather from a “supershot” that contains multiple shot gathers. The challenging part is the properties of noise are so similar to the signal.



Polar radon transform

Challenge

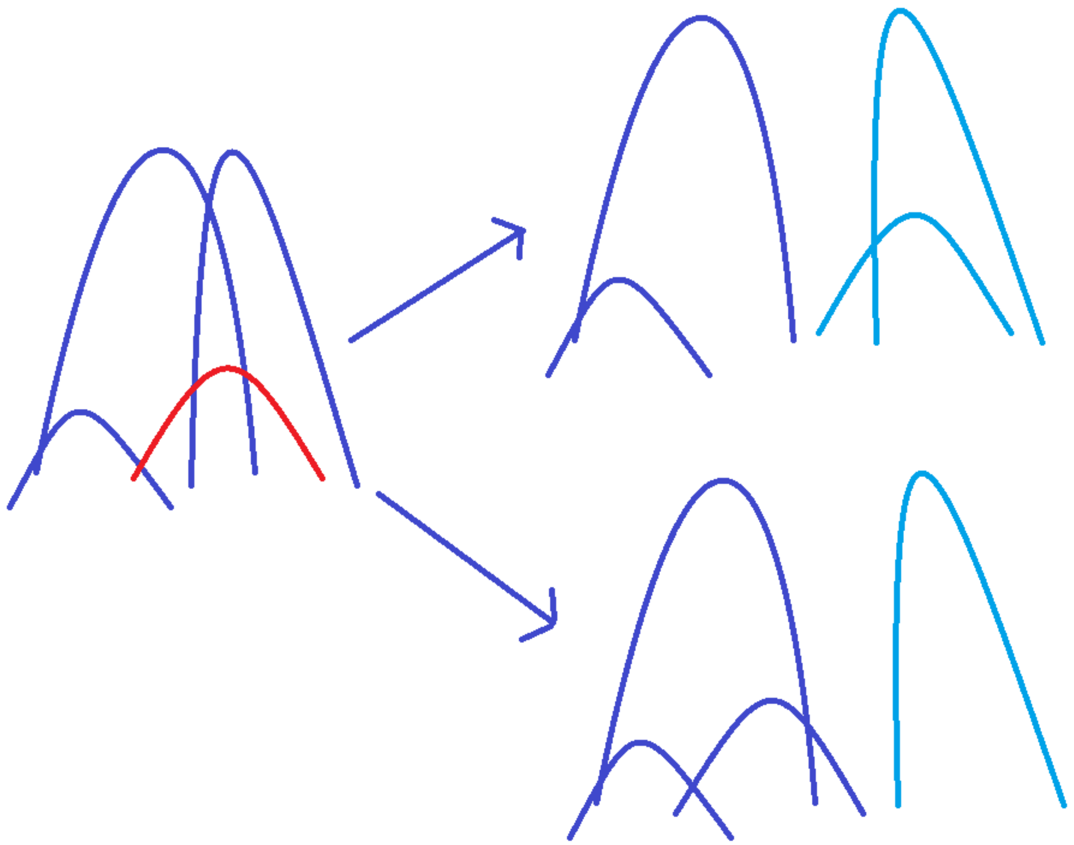
Information we get that can distinguish them are multiple sets of headers and the time delay between sources.



Challenge

Deblending in Common shot gather:

Each shot gather may have multiple events and it's hard to determine which event belongs to which shot gather.



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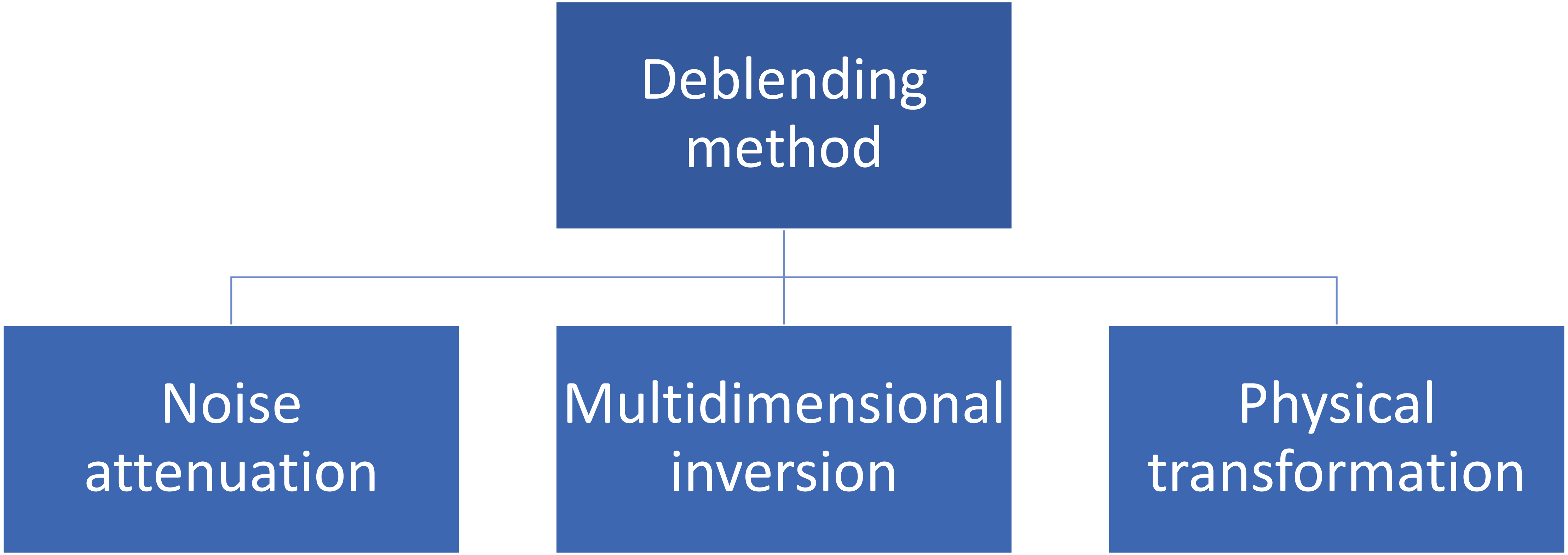
Method


Deblending method
Noise attenuation
Multidimensional inversion
Physical transformation

Filtering

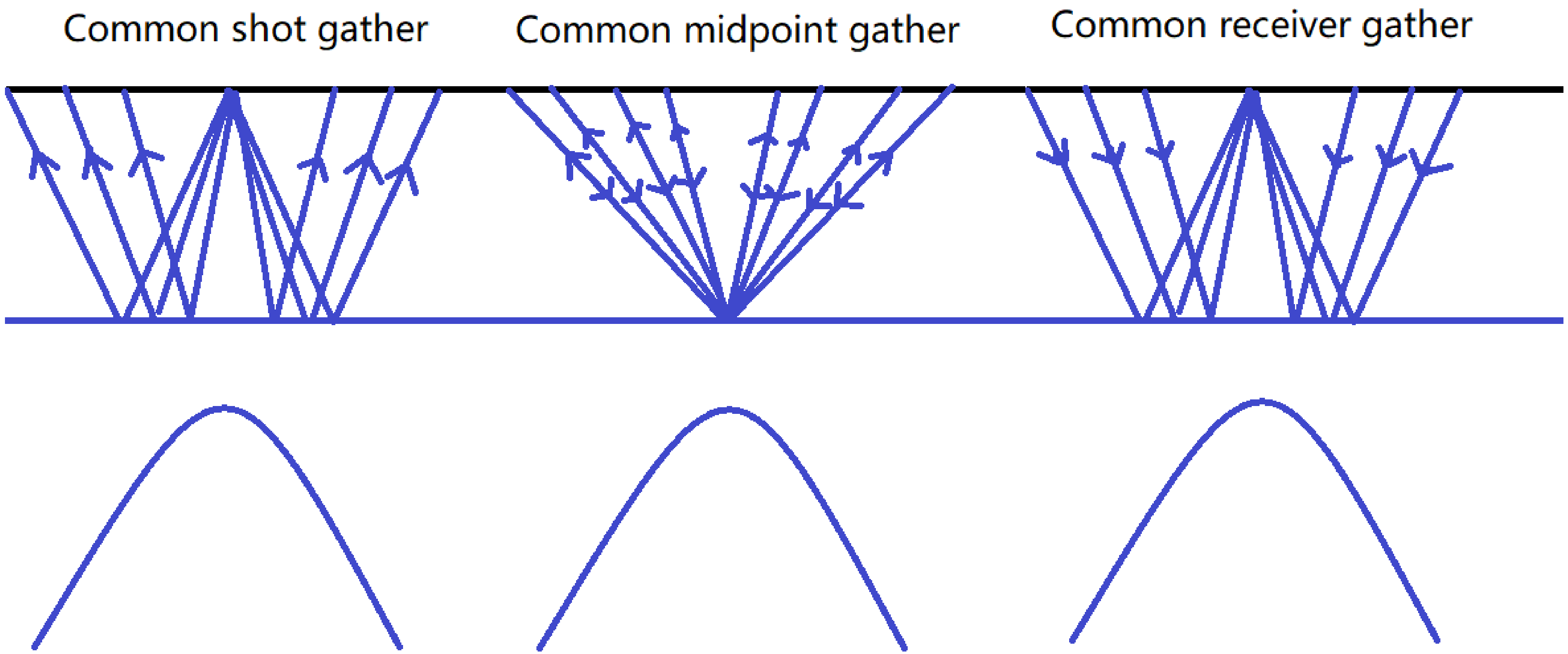
$$d^{obs} = Bm \qquad m = B^{-1} d^{obs}$$

Where d^{obs} is the blended data and m is the target shot gather,

B is the blended operator and B^{-1} is the filter operator.

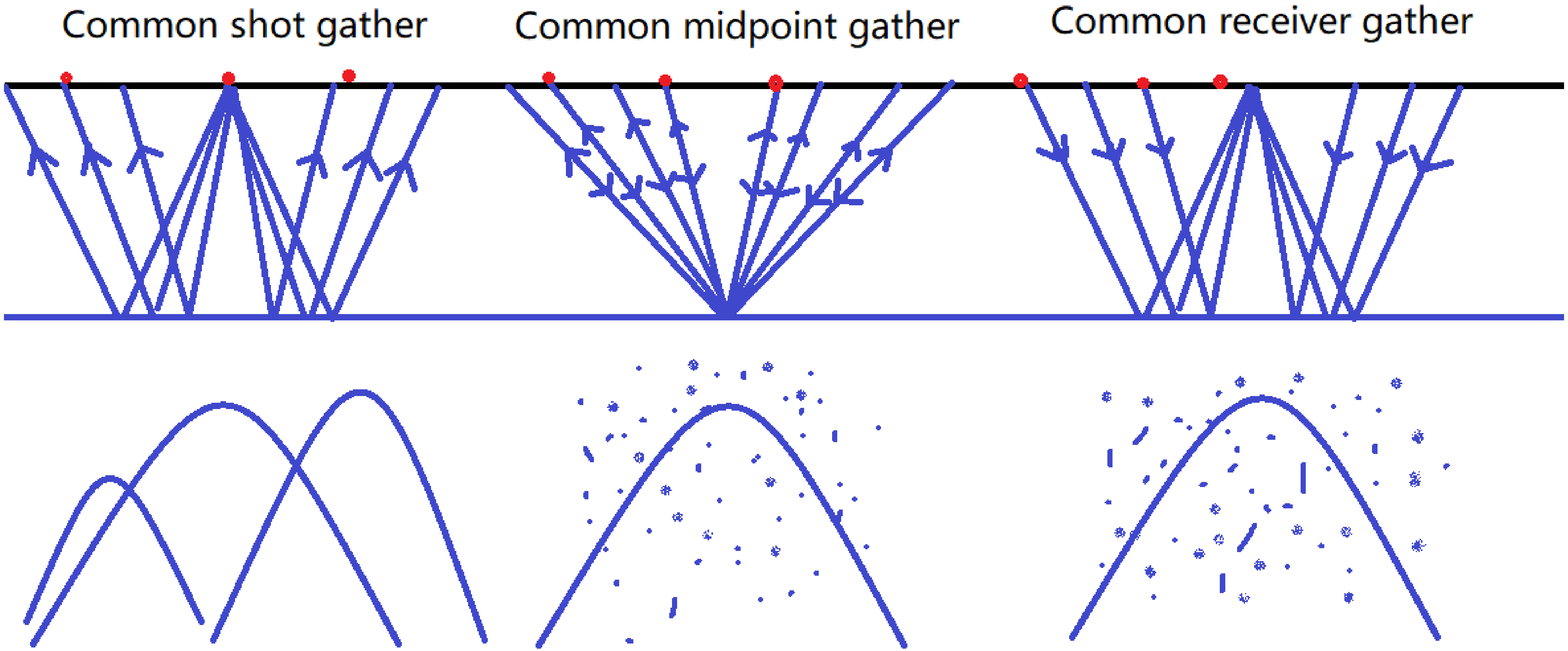
Utilizing different transform method, different target shot gathers can be seperated in different domain.

Filtering on other dimension：
For unblended shots

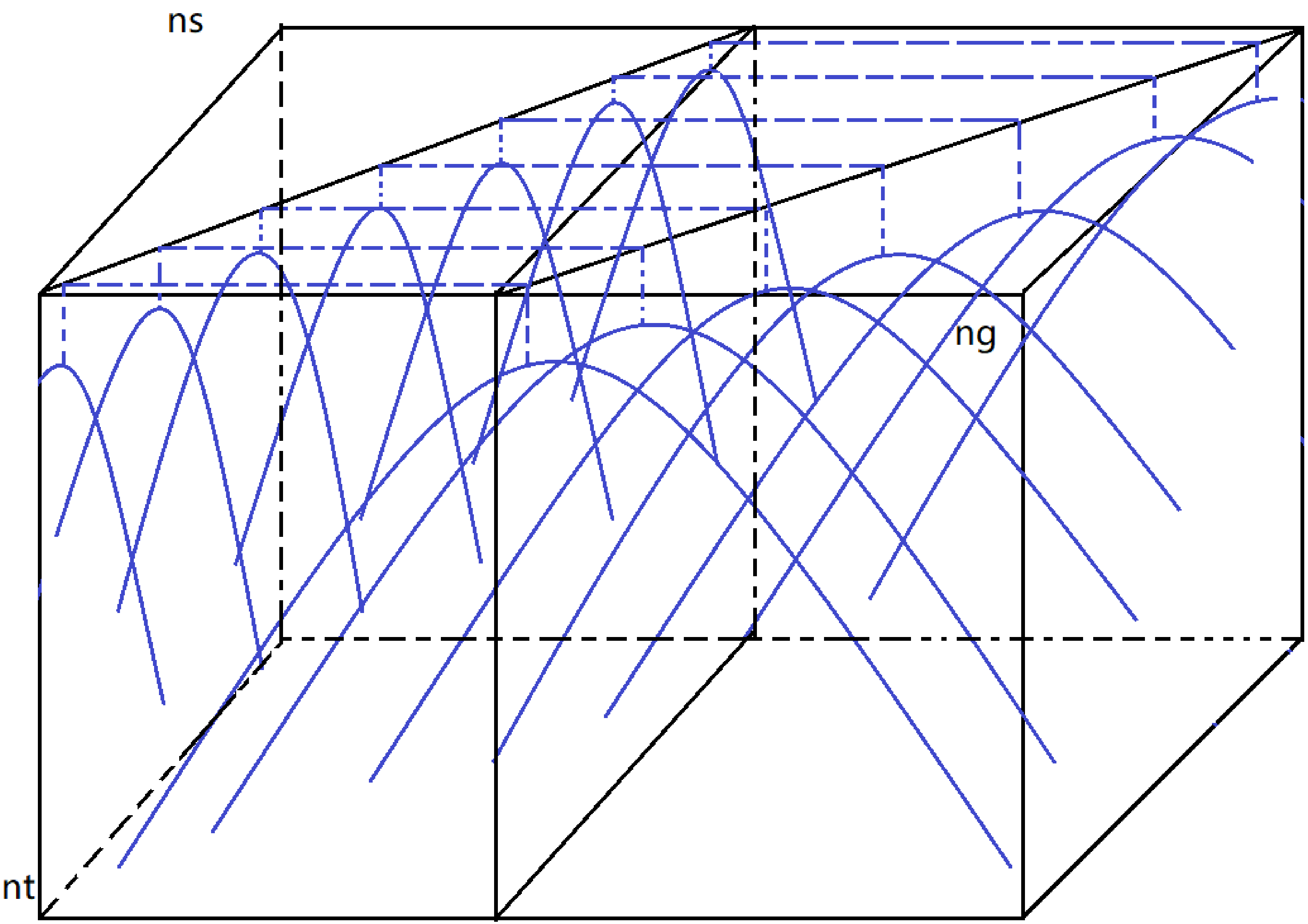


Blended shots

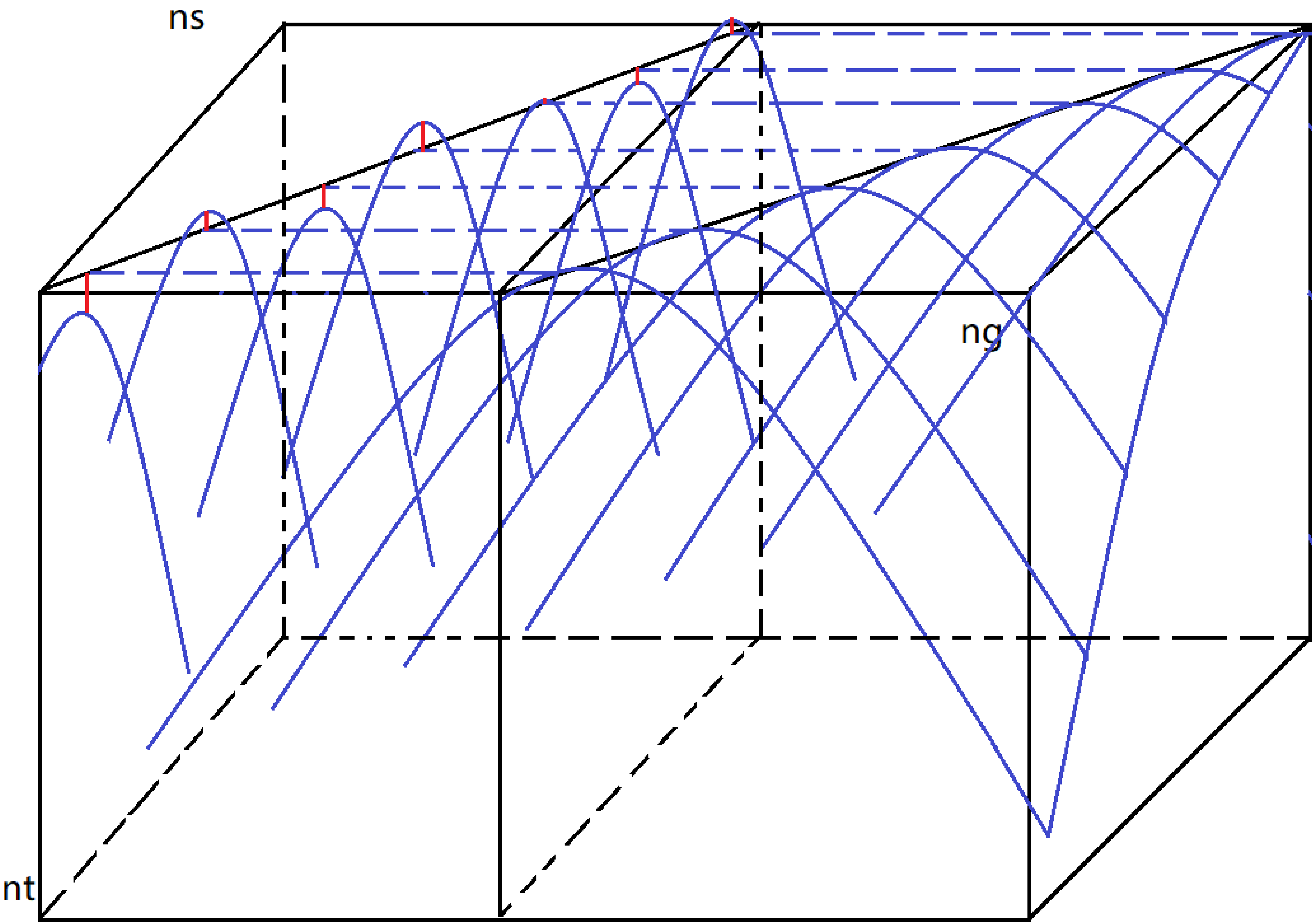
Random time delay of each event are introduced to make unwanted Interface incoherent.



Filtering

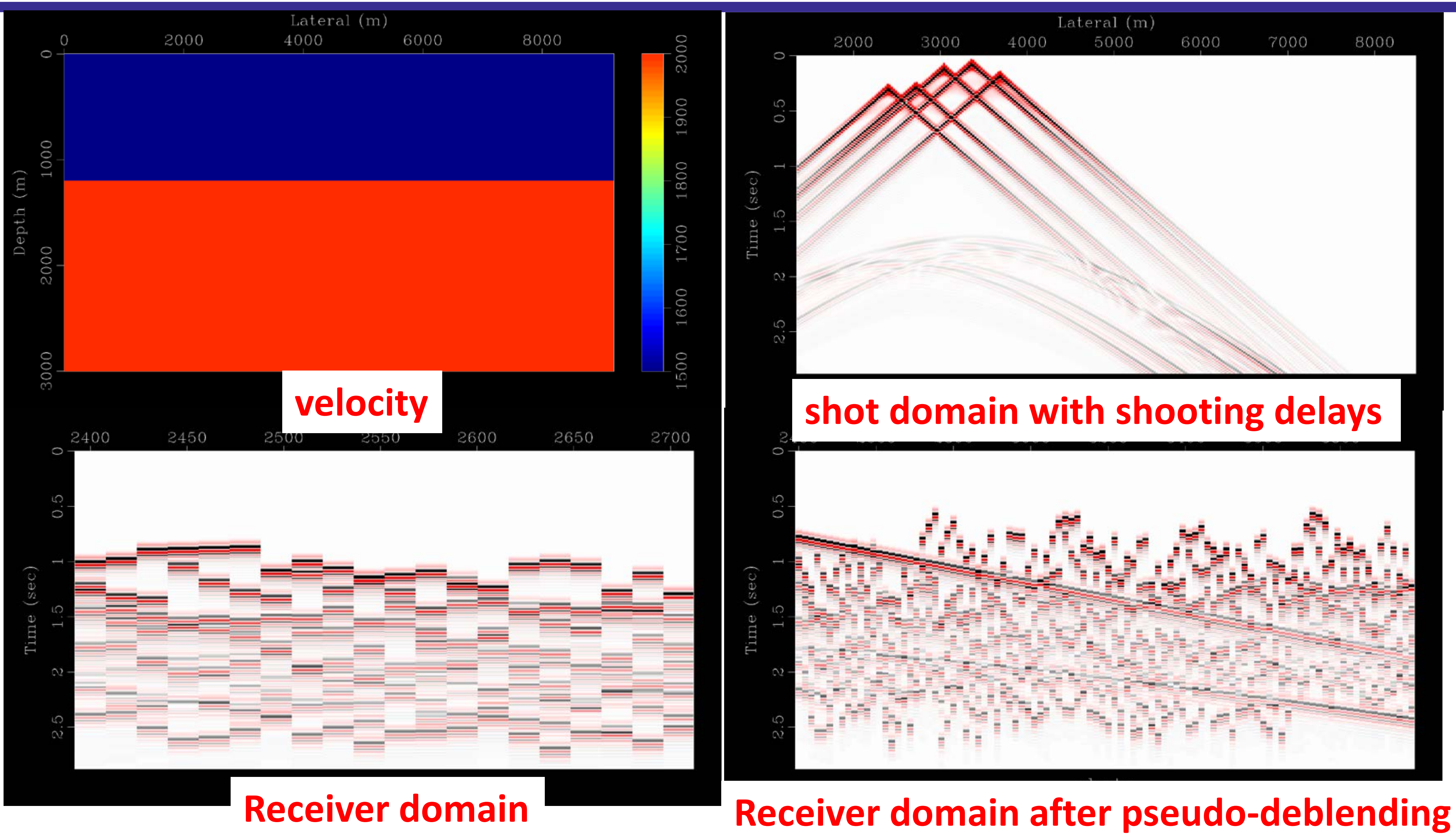


Filtering

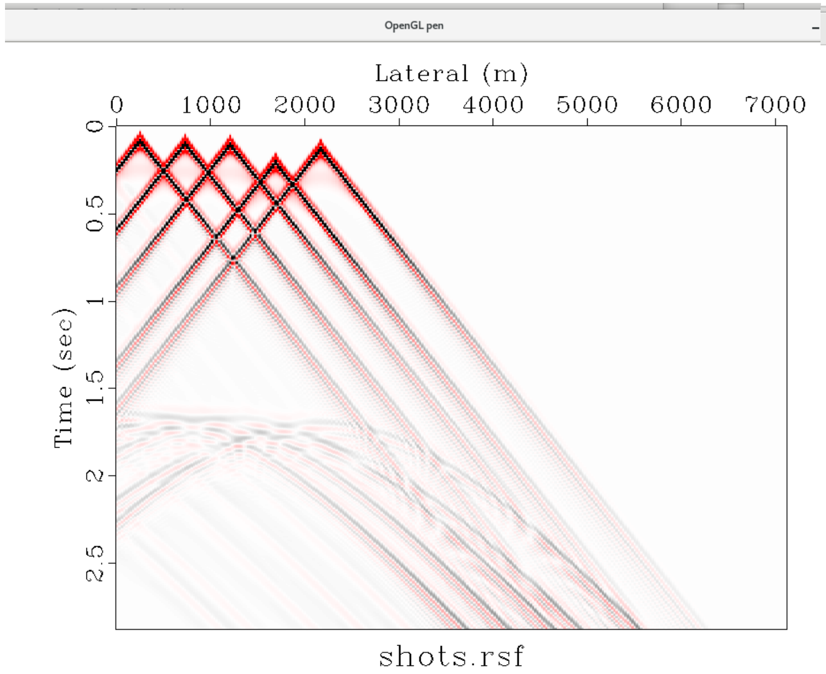


Remove time delay, unwanted shot gather become incoherent.

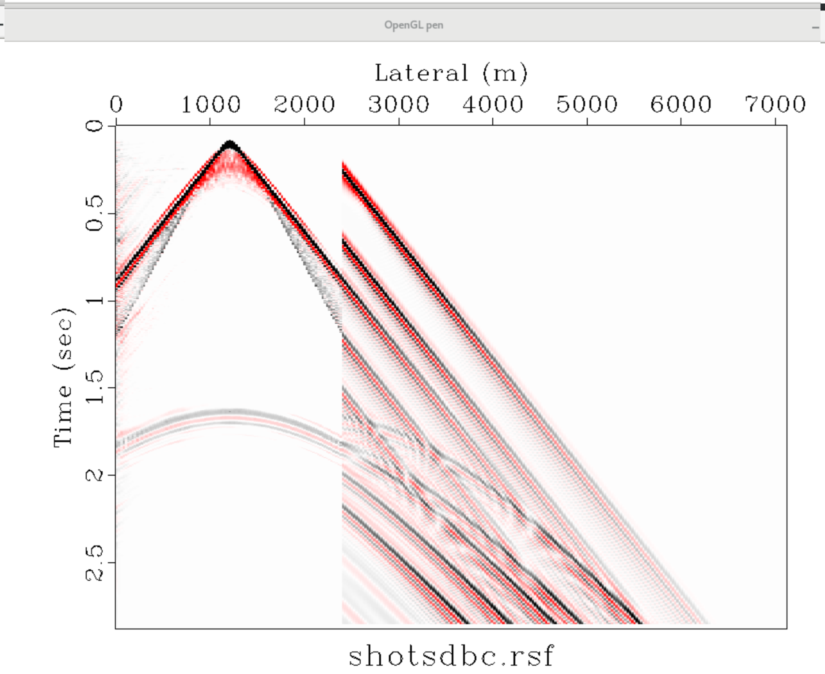
Filtering


Lateral (m)
Depth (m)
velocity
Lateral (m)
Time (sec)
shot domain with shooting delays
Time (sec)
Receiver domain
Time (sec)
Receiver domain after pseudo-deblending

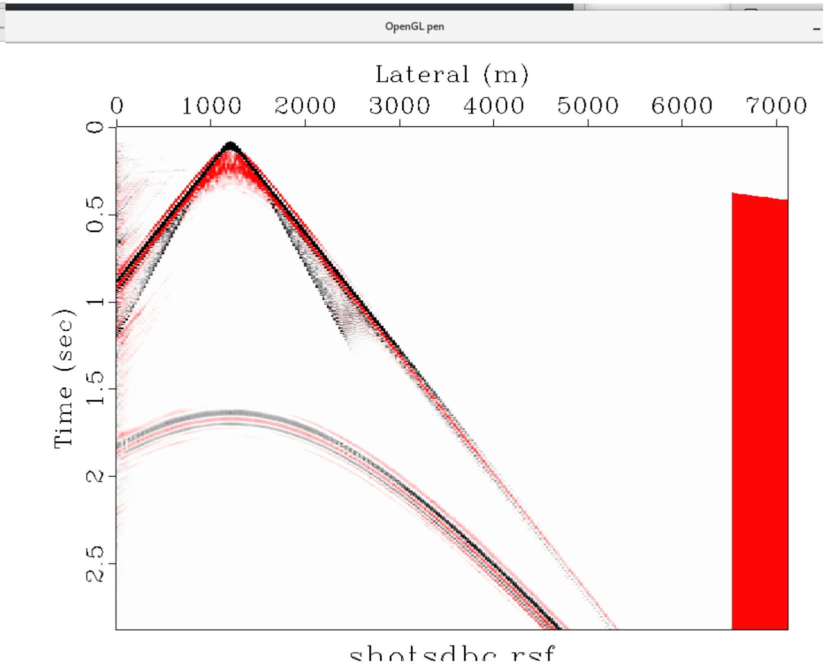
Deblending by filtering in receiver gathers



original blended



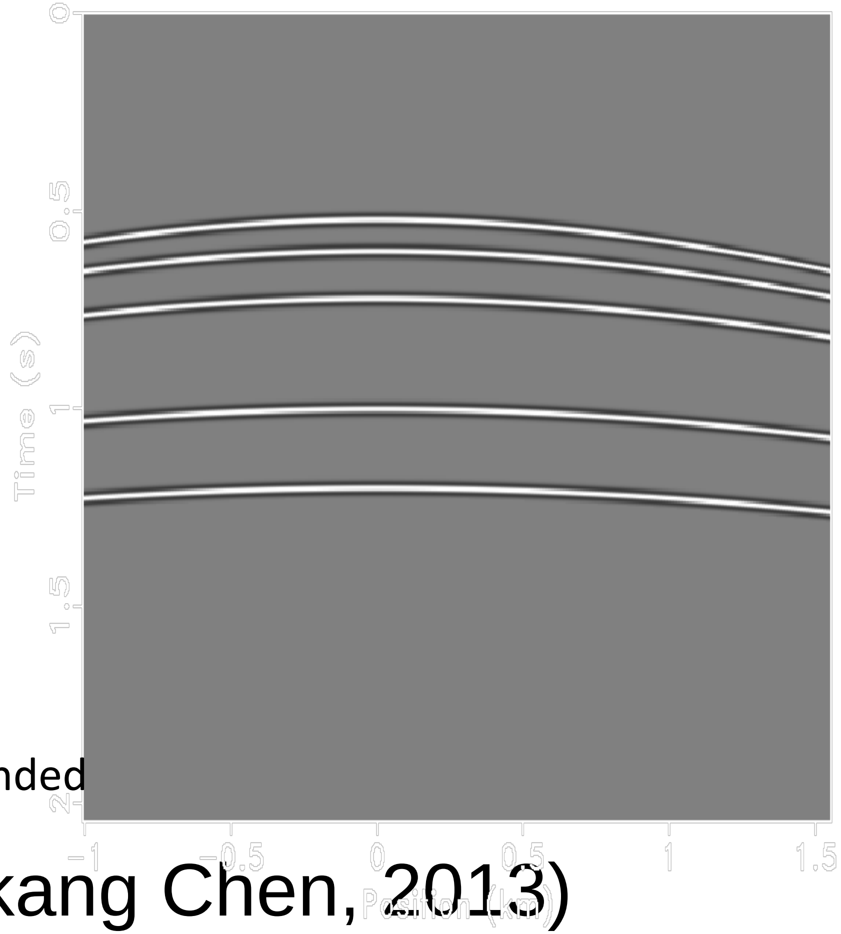
One third of receiver gathers filtered



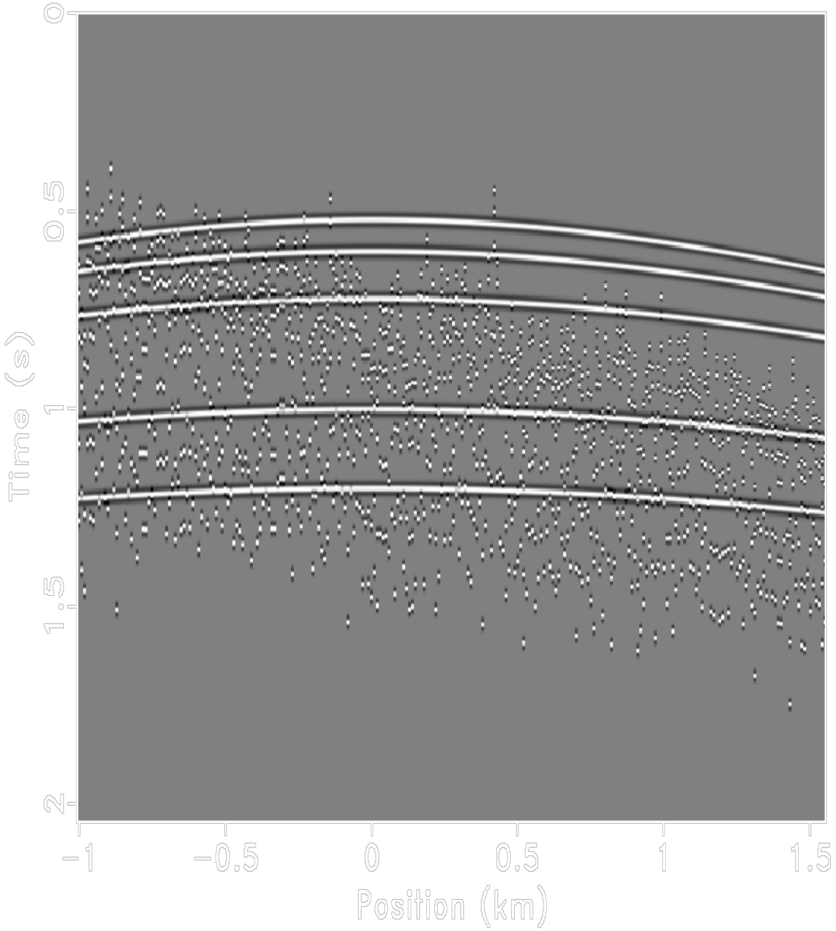
All receiver gathers filtered

Increasing number of receiver gathers being filtered

CMP gather



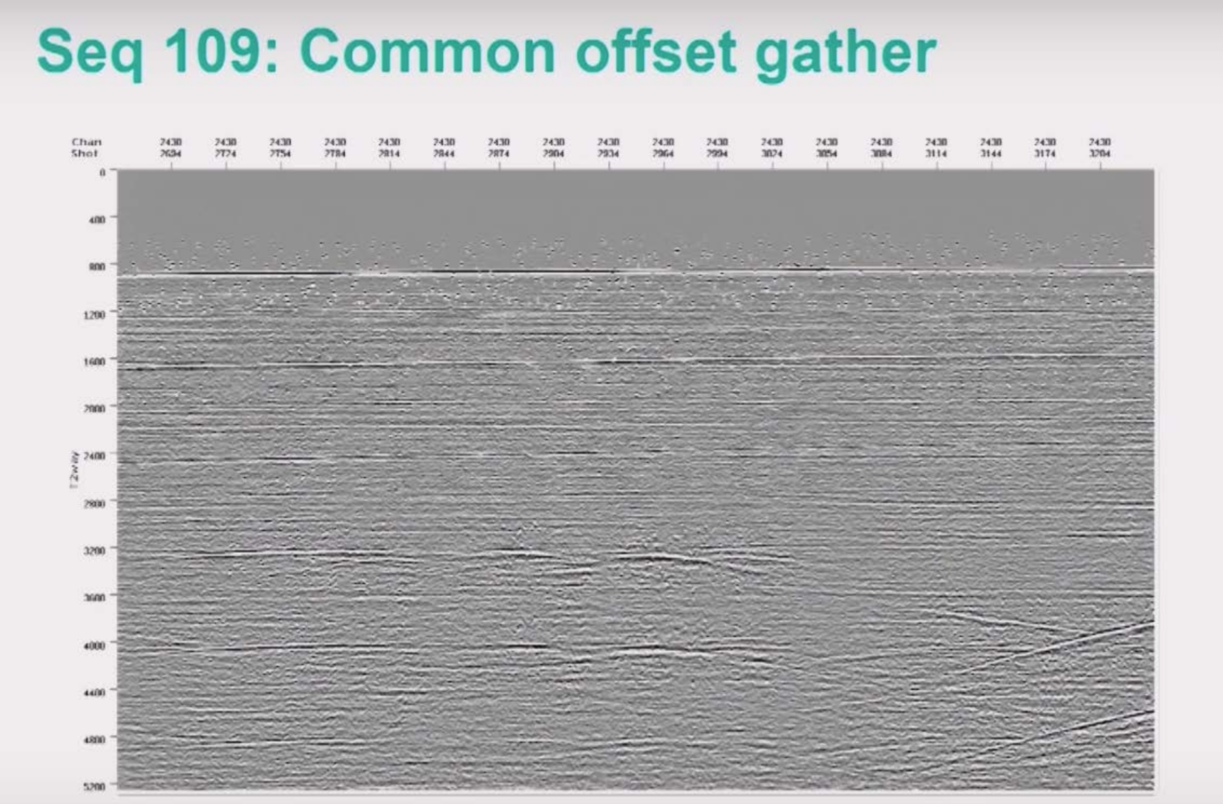
Unblended



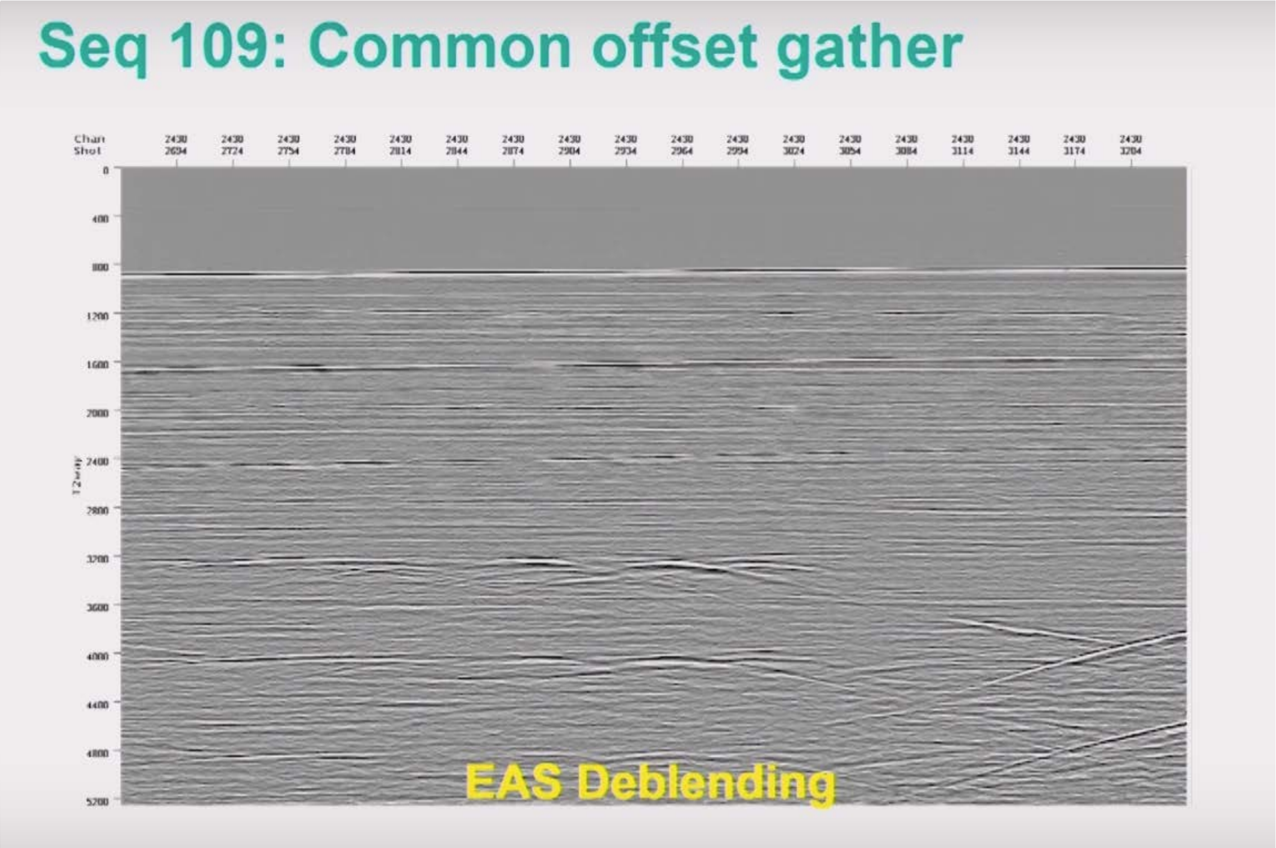
blended

(Yangkang Chen, 2013)

Common Offset gather



blended



(Jan Langhammer,2016)

Multidimensional inversion

$$d^{obs} = \sum_{i}^{n} B_i L_i m_i$$

Where d^{obs} is the blended data, m is the model, n is the number of sources in blended data, B_i is the #i blending operator corresponding to the # of sources. L_i is a forward operator that transforms model into target domain.

Multidimensional inversion

$$J = ||d - \sum_{i}^{n} B_i L_i m|| + ||m||$$

As is usual for constrained inversion, we first define an objective function. The model is founded by minimizing the cost function.

Multidimensional inversion

The key part in deblending method is the definition of L.

For example it's a Fourier method.

$$L = F_t^{-1} F_x^{-1} P F_x F_t$$

Where Ft is time domain FT, Fx is spatial FT, P is a separation operator that focusing on the transformed domain. P reflects the difference of independent shot gathers.

Multidimensional inversion

The key part in deblending method is the definition of L.

For example It's a Radon method.

data = L matrix · model

$$\begin{bmatrix} d(\omega,h_{min}) \\ d(\omega,h_i) \\ d(\omega,h_{max}) \end{bmatrix} = \begin{bmatrix} exp(-i\omega h_i q_j) \end{bmatrix} \begin{bmatrix} m(\omega,q_{min}) \\ m(\omega,q_j) \\ m(\omega q_{max}) \end{bmatrix}$$

Physical transformation

$$d^{obs} = \sum_{i}^{n} B_i L_i m_i$$

The key part in deblending method is the definition of L.

When m is reflectivity model, L is forward modeling and L^{-1} is migration, this is mig and demig method.

For a multiple source system, we need to be careful about the crosstalk between two shots

$$d^{obs} = B_1 d_1 + B_2 d_2$$

The reverse can be described as

$$d_1 = B_1^{-1} d - B_1^{-1} B_2 d_2$$

$$d_2 = B_1^{-1} d - B_2^{-1} B_1 d_1$$

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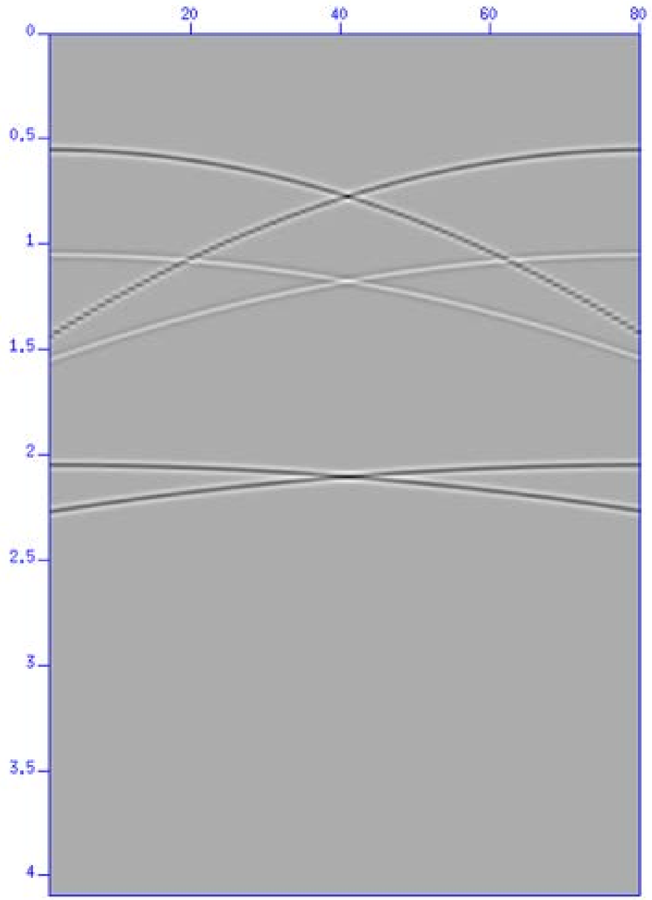
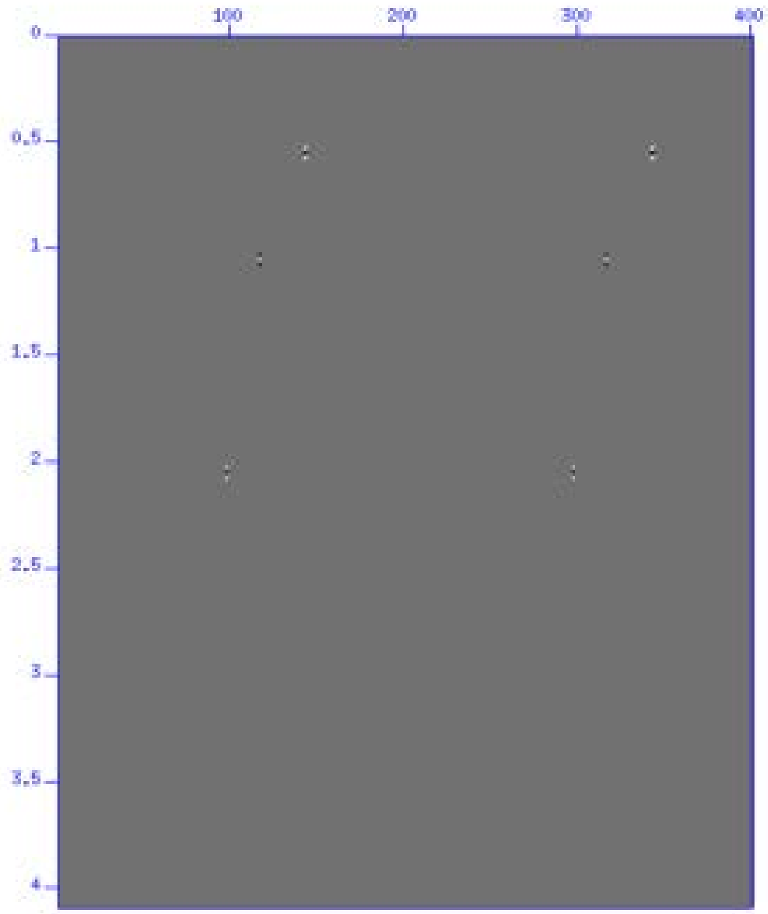
Synthetic data for hybrid radon method



Hybird
Radon
Transform



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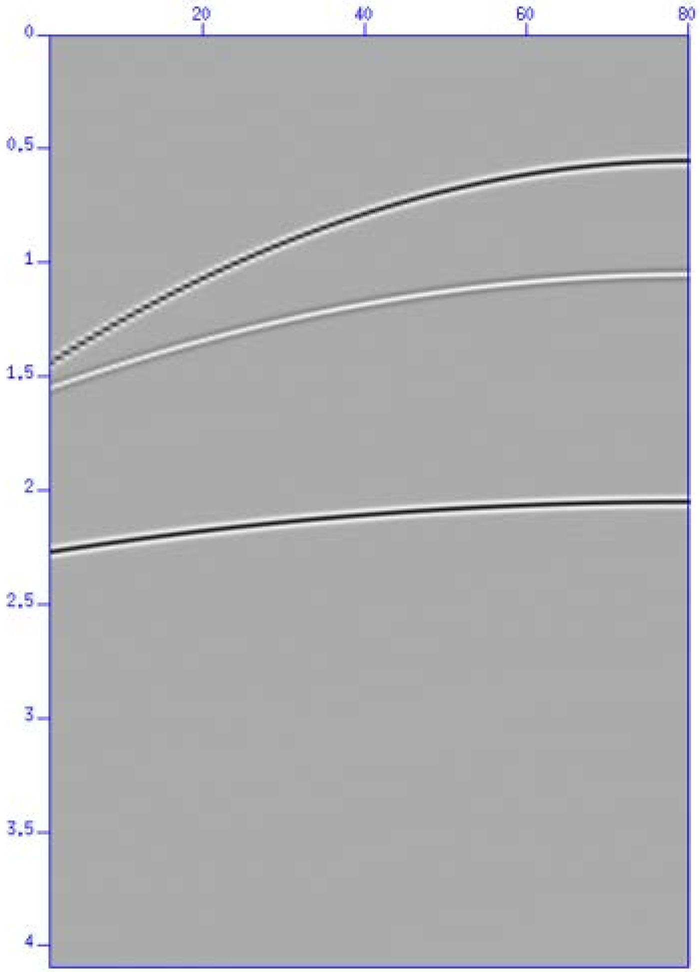
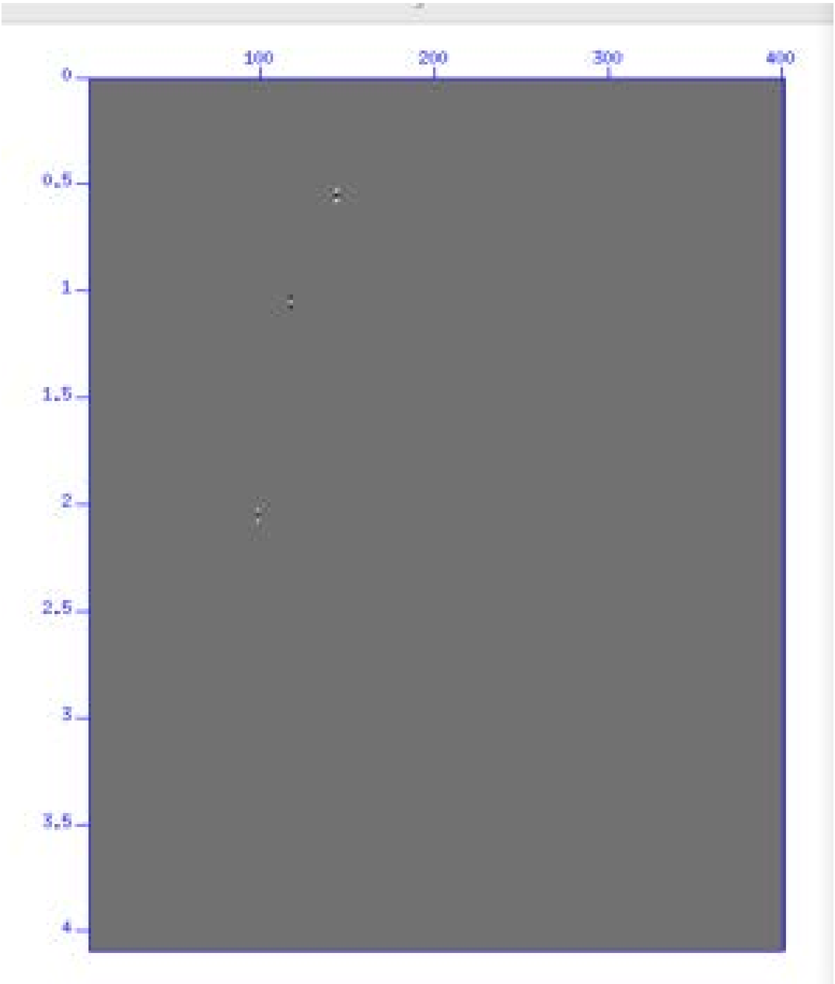


Mute on Radon domain



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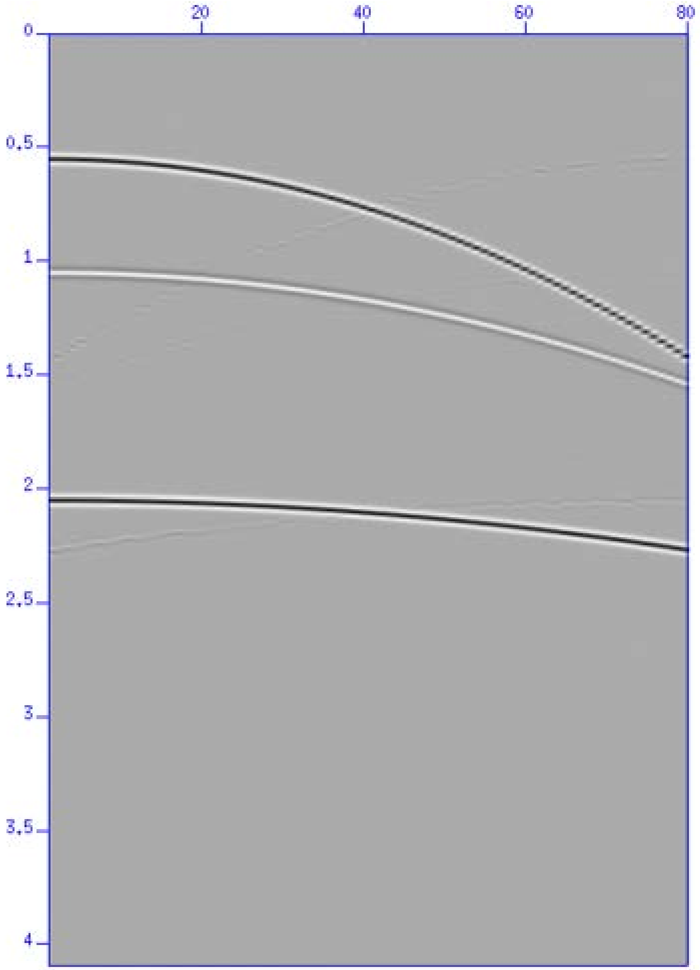
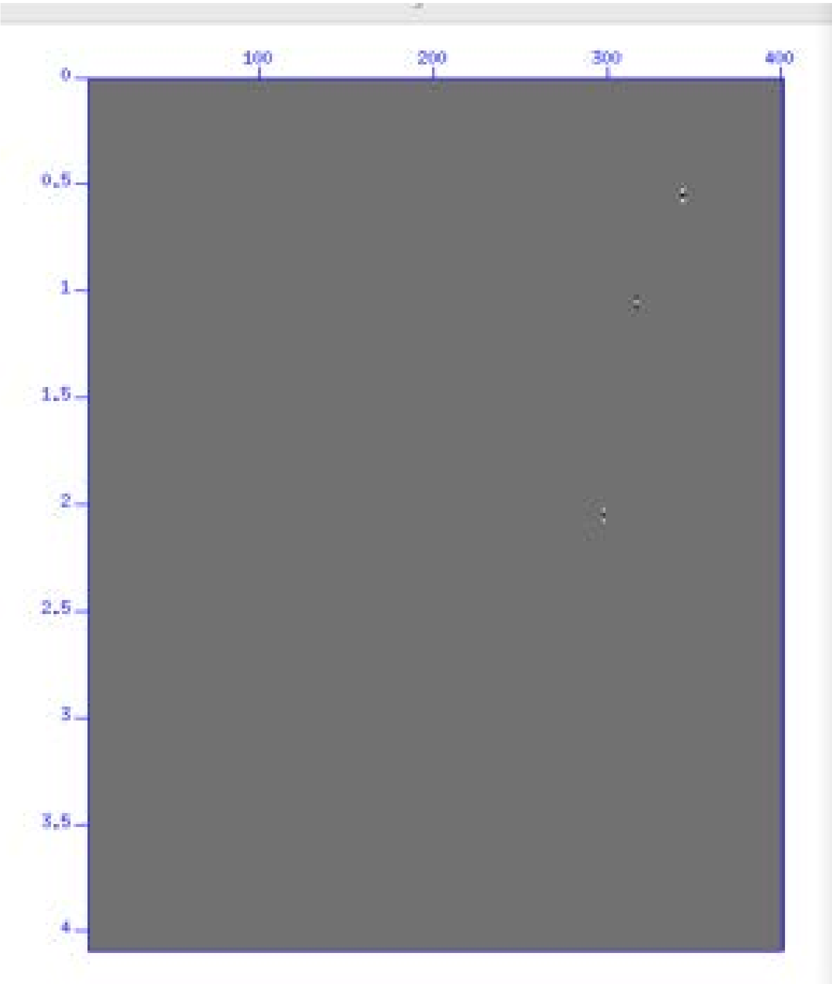
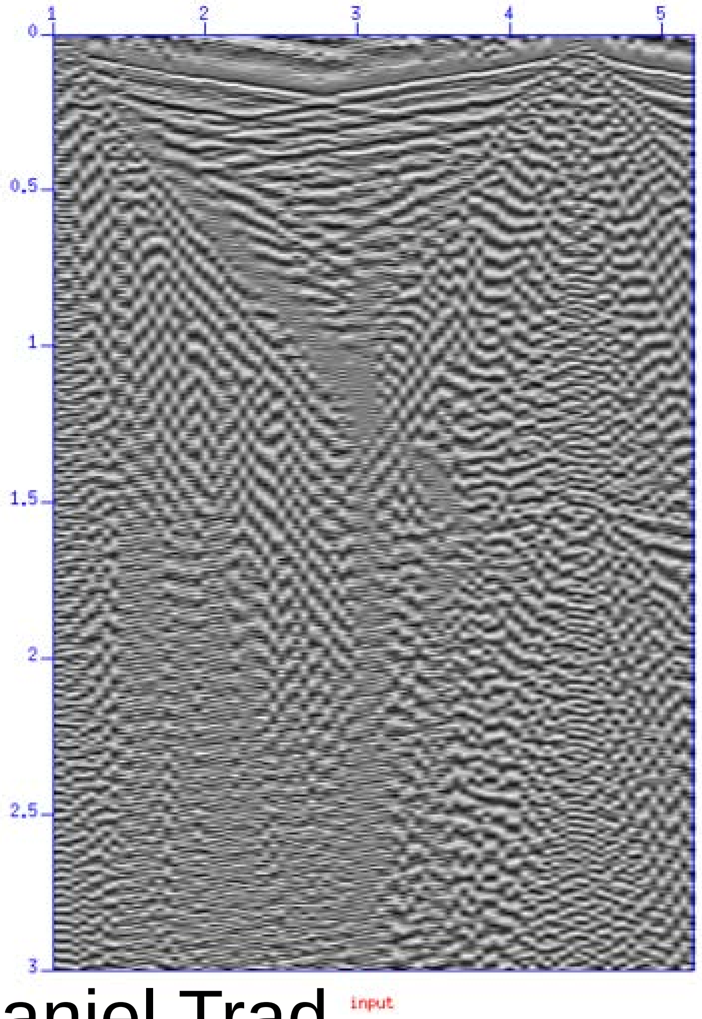


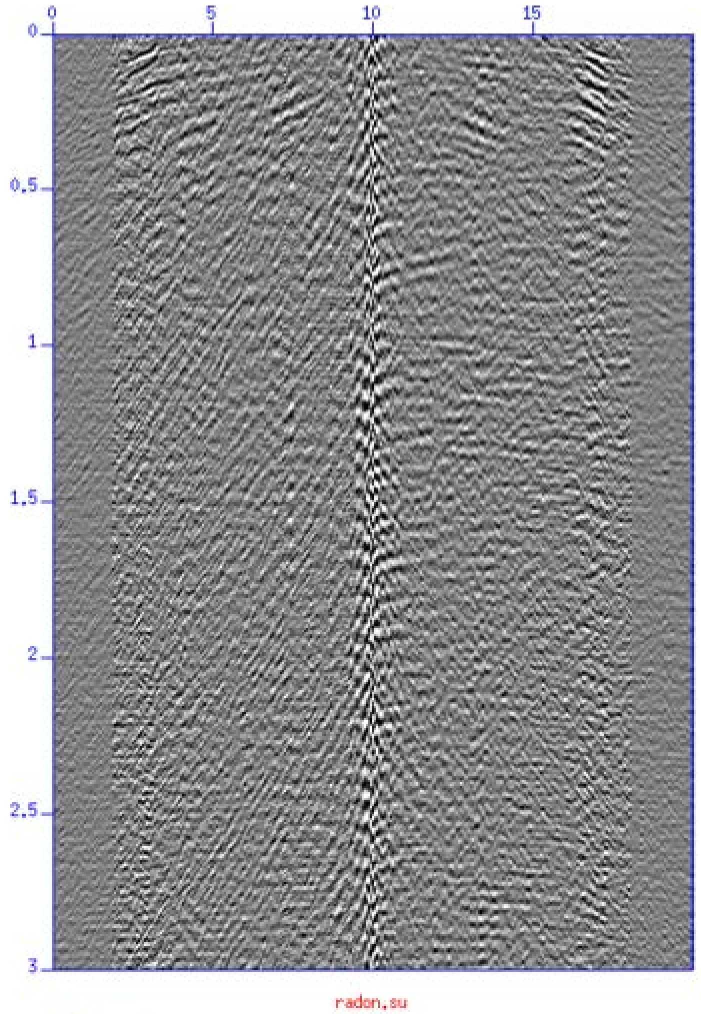
Mute on Radon domain



Field data for hybrid radon method



Hybrid
Radon
Transform



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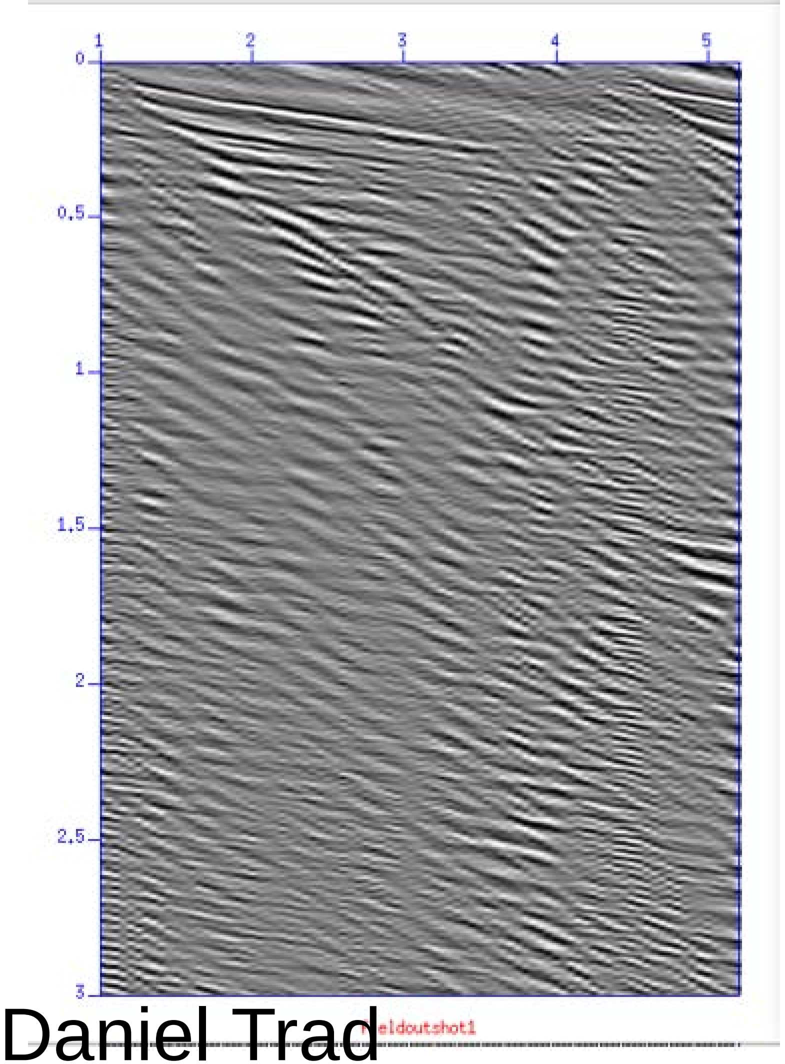
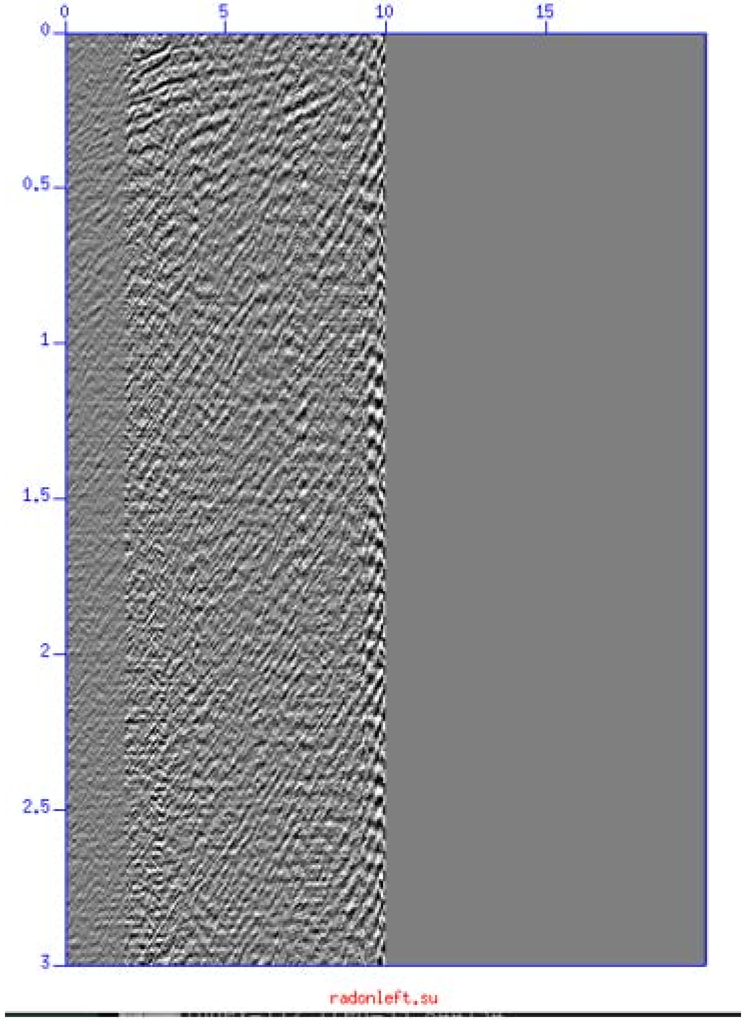
Field data for hybrid radon method



Mute on Radon domain



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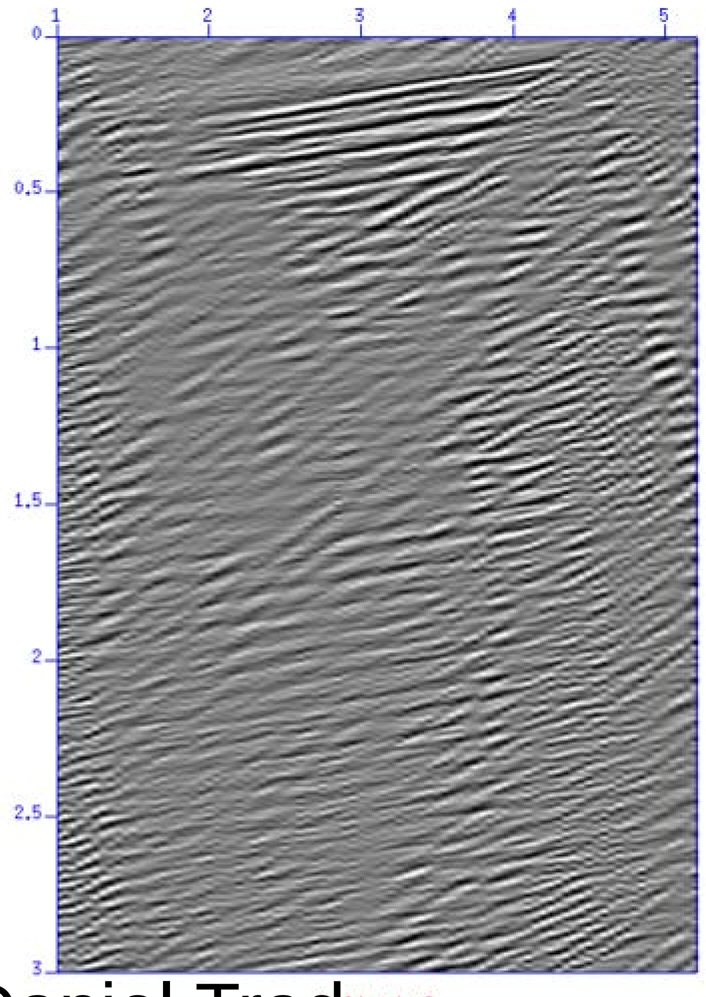
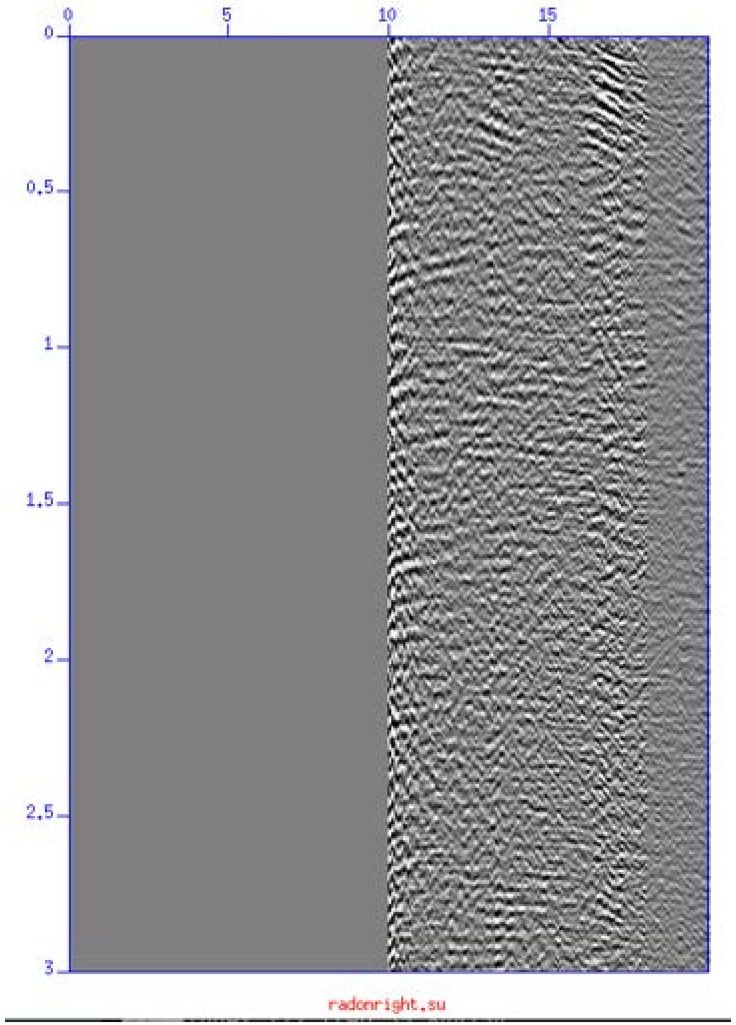
Field data for hybrid radon method



Mute on Radon domain



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Acknowledgement

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References

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Trad, Daniel, et al. "Fast and Robust Deblending Using Apex Shifted Radon Transform." *2012 SEG Annual Meeting*. Society of Exploration Geophysicists, 2012.

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Liu, Bin, and Mauricio D. Sacchi. "Minimum weighted norm interpolation of seismic records." *Geophysics* 69.6 (2004): 1560-1568.

EAGE E-Lecture: Triple-Source Simultaneous Shooting by Jan Langhammer:https://www.youtube.com/watch?v=NmSQv3iGyf4

Questions?