Deblending common receiver and common angle gathers

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Outline

- Ocean bottom node/OBN
- Blended acquisition and deblending
  - Denoising
  - Inversion
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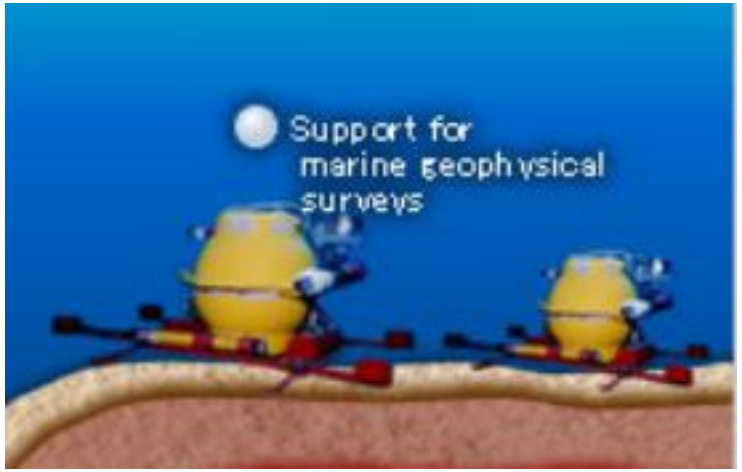
Ocean bottom node/OBN

Put nodes on the seabed:

Time consuming

Expensive

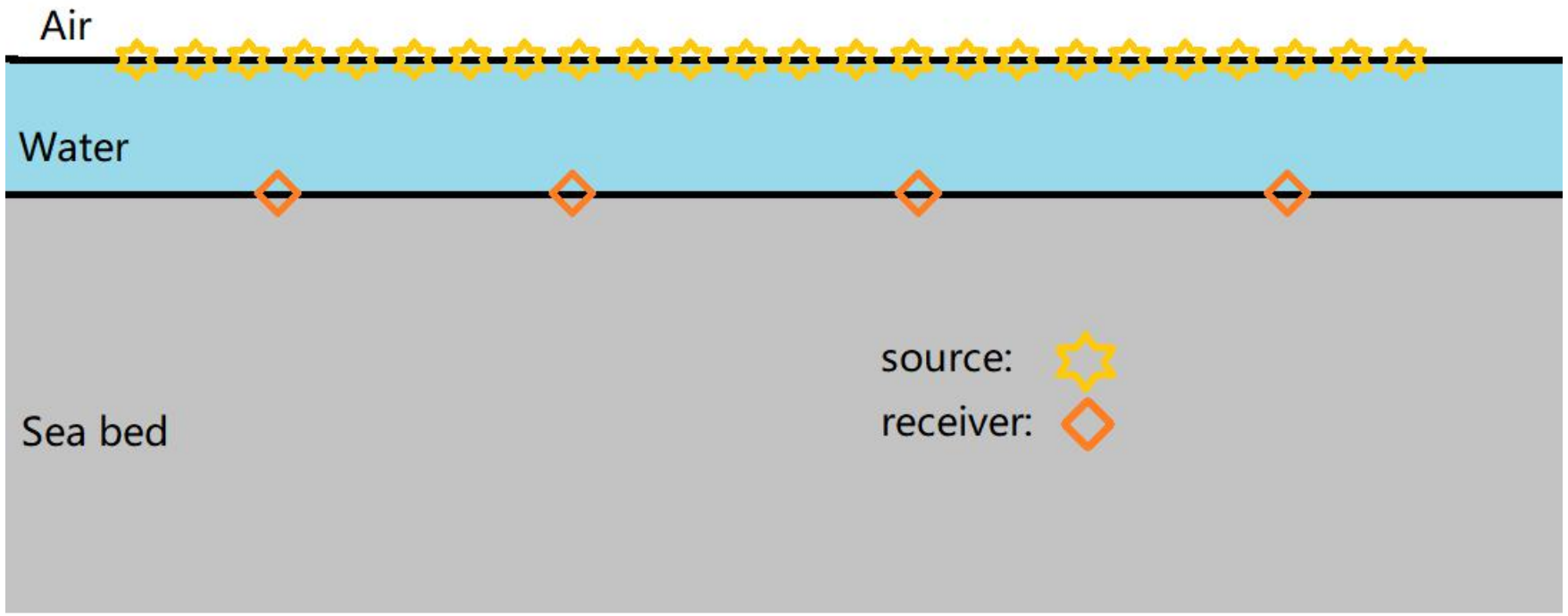


https://www.nmeweb.jp/e/duties.html

Advantage of ocean bottom node/OBN

- The signals on the seabed are quieter than those on the water surface
- OBN could cover more areas around platforms to gather data with wider azimuth and longer offsets than normal marine acquisition
- OBN could record shear wave
- OBN may attenuate multiples by separating upgoing and downing waves

Ocean bottom node



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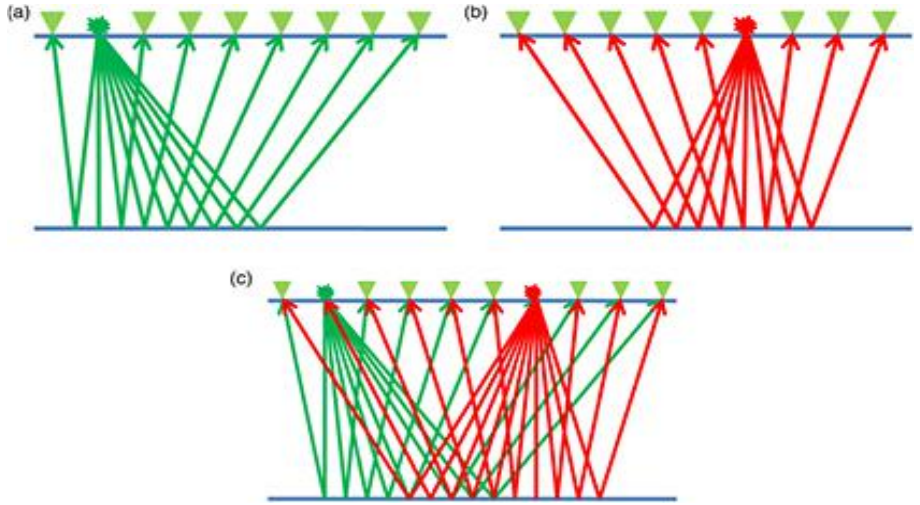
Blended acquisition

Ocean bottom node: Time consuming, expensive

Blended acquisiton can save acquisiton time



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

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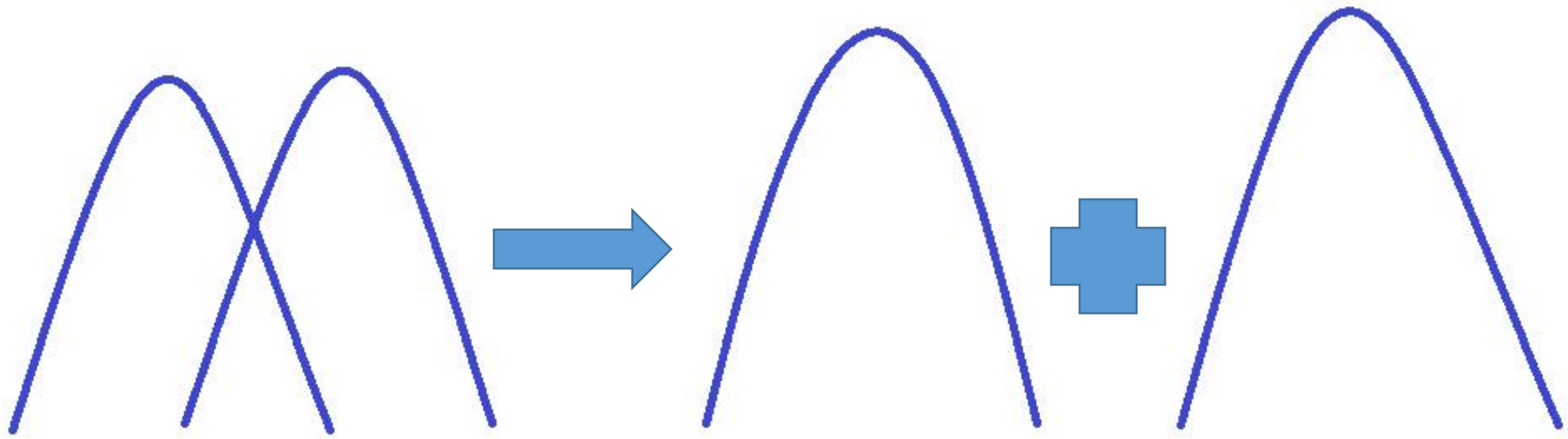
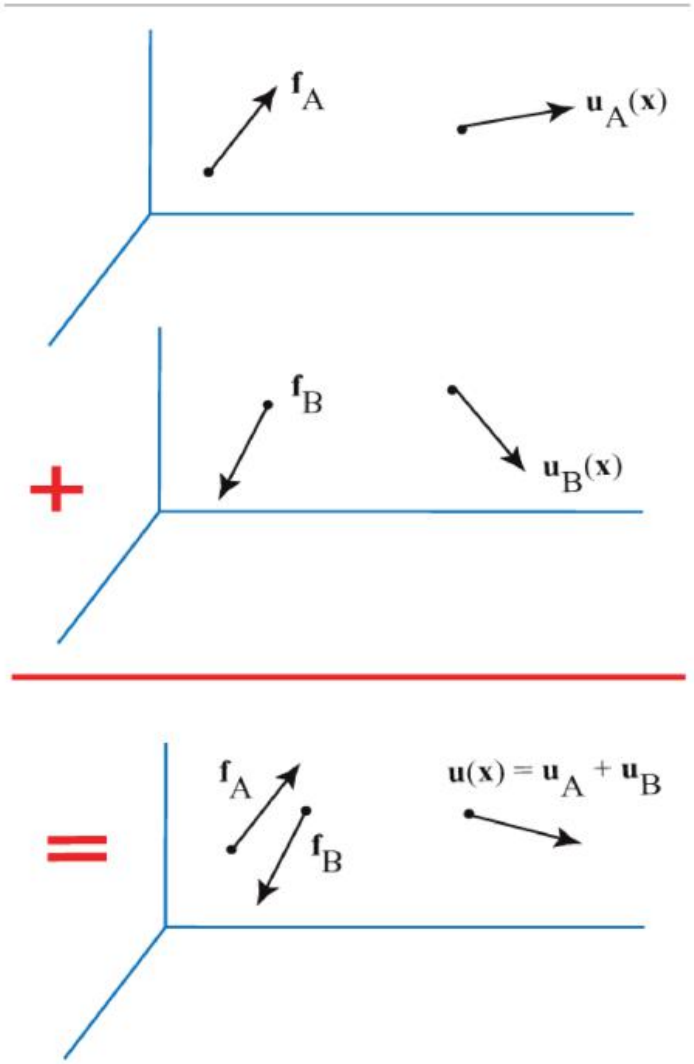
Deblending



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.

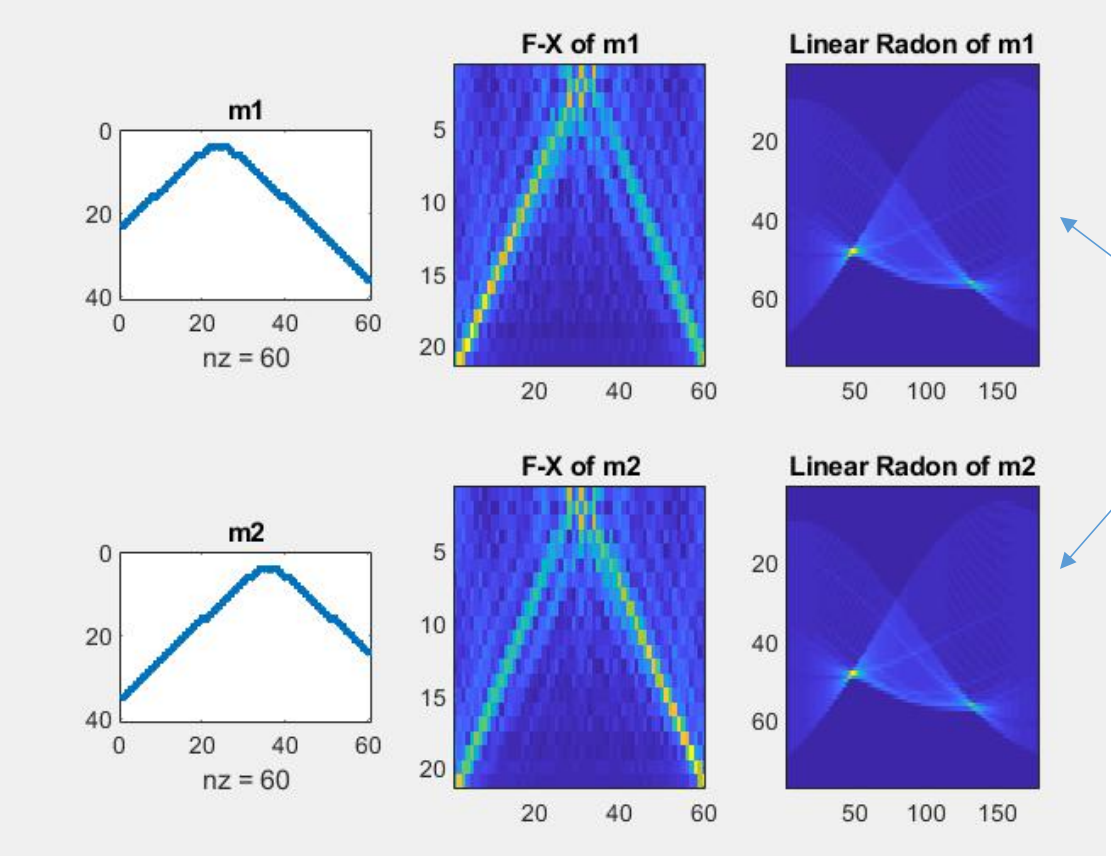
Assumption

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

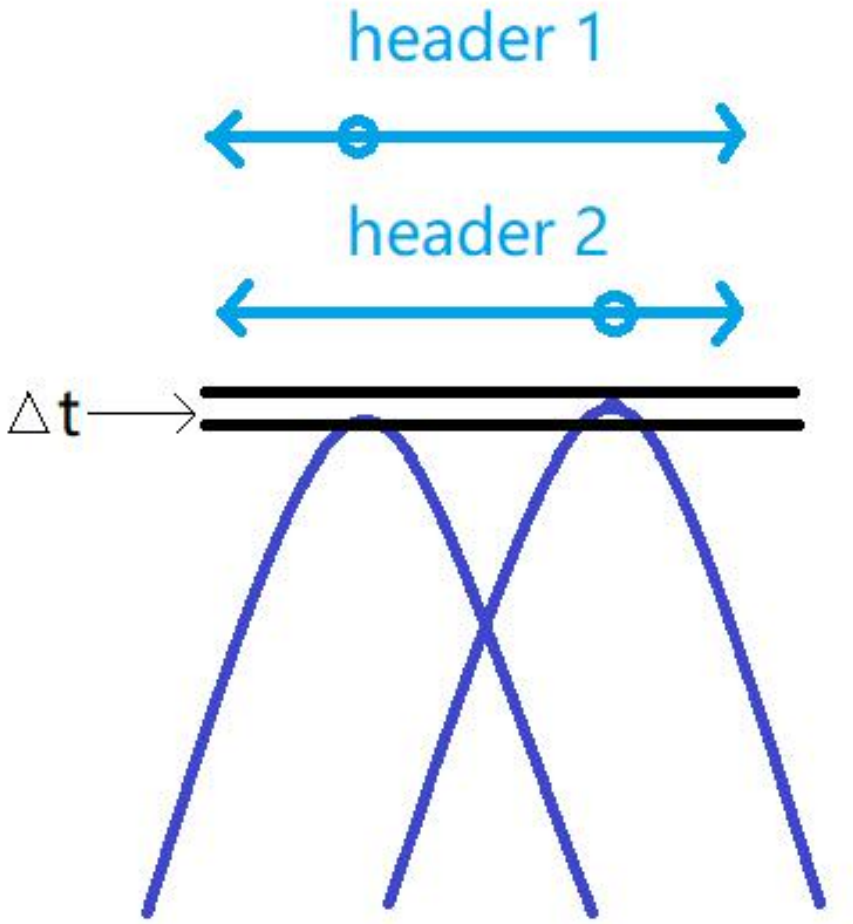
To some extent, the blending is a kind of denoising method. We need to get the target shot gather from a “supershot” that contains multiple shot gathers. The challenging part is the properties of noise are so similar to the signal.



Polar radon transform

Challenge

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



Filtering

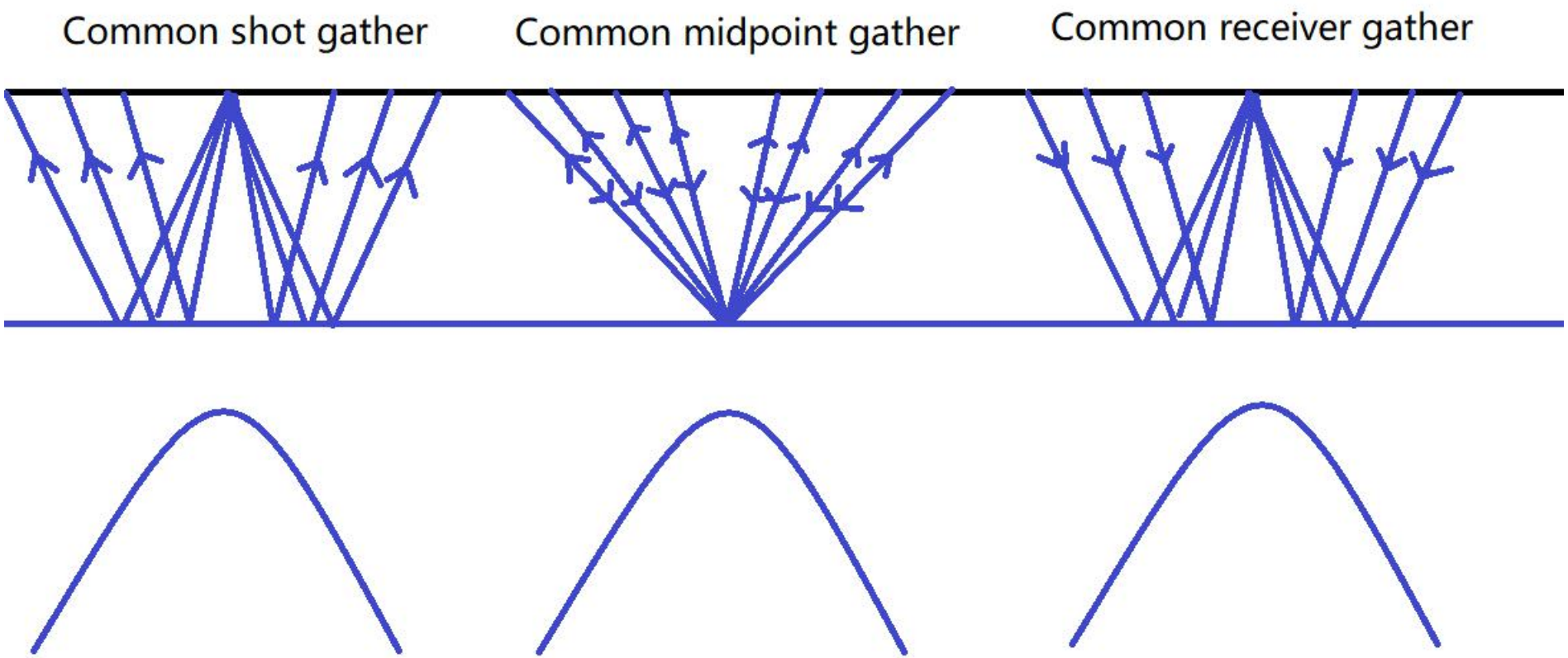
$$d^{obs} = Bm \qquad\qquad m = B^{-1} d^{obs}$$

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.

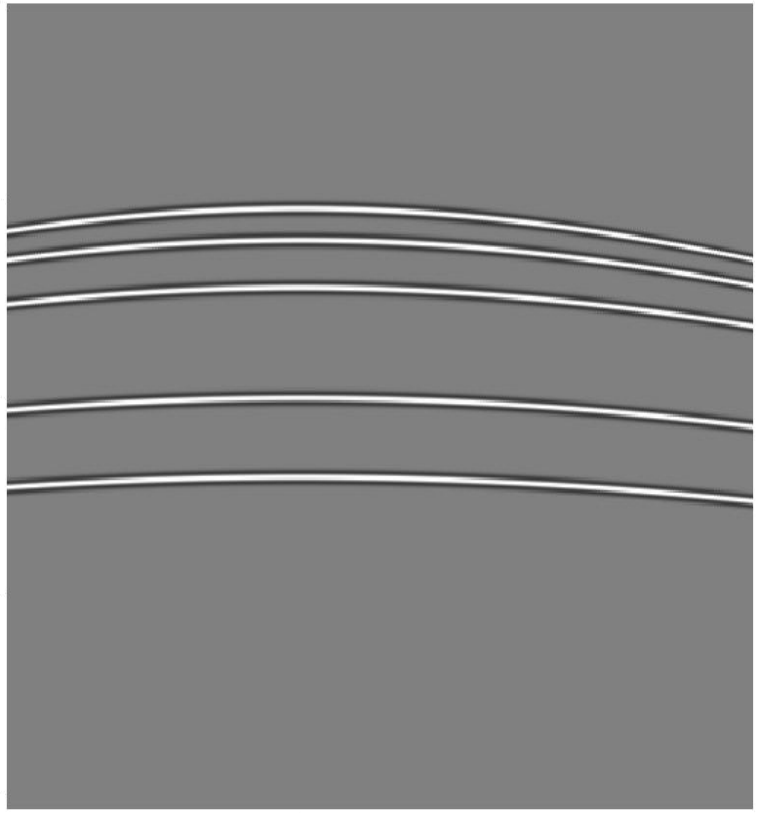
Utilizing different transform method, different target shot gathers can be seperated in different domain.

Filtering on other dimension : For unblended shots

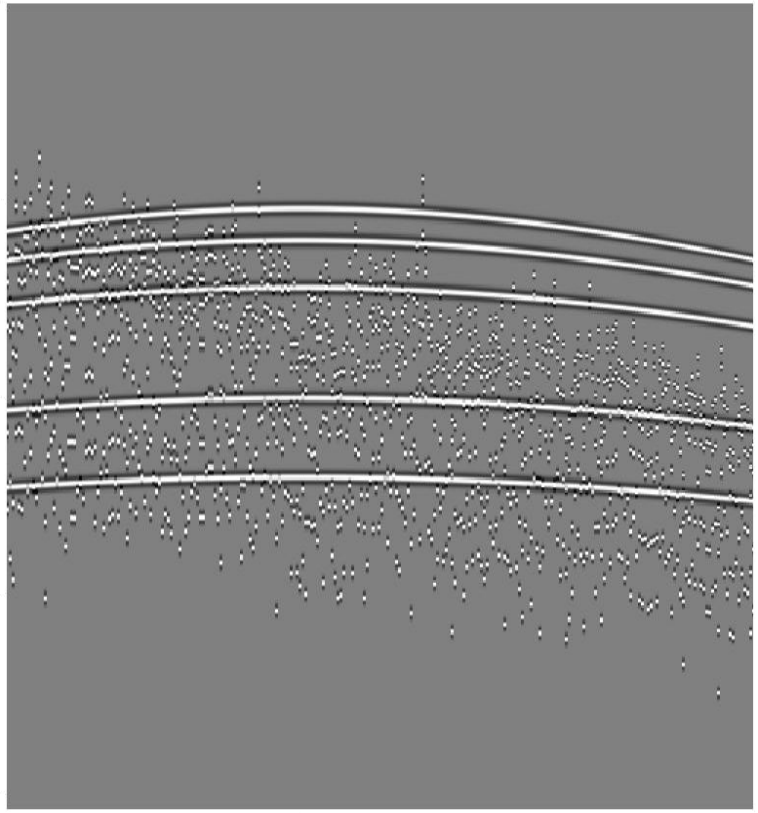


Blended shots in common shot and midpoint domain

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



Unblended

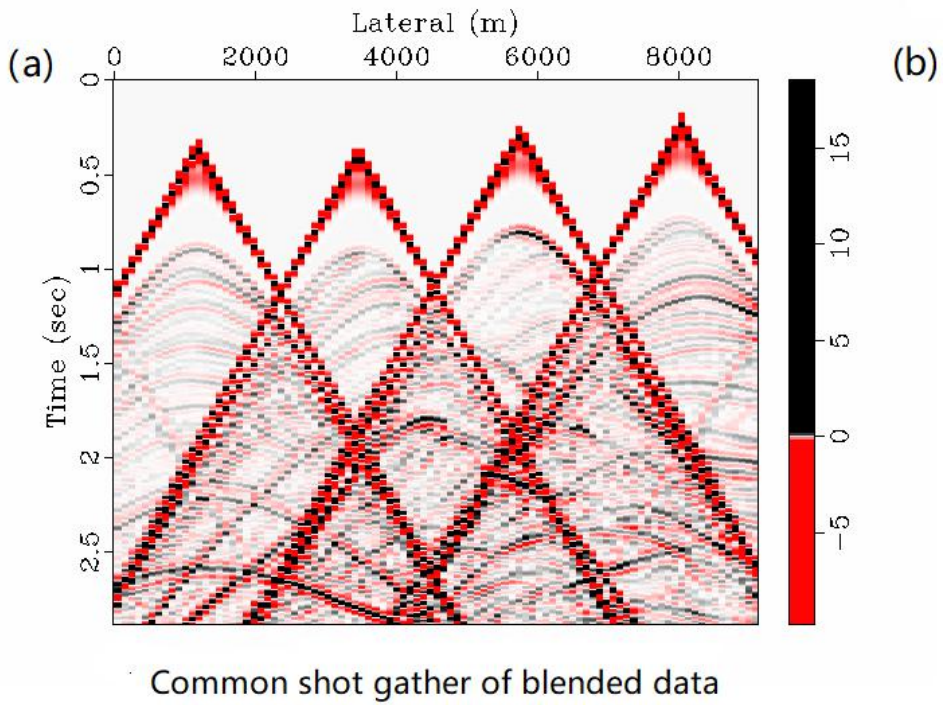


blended

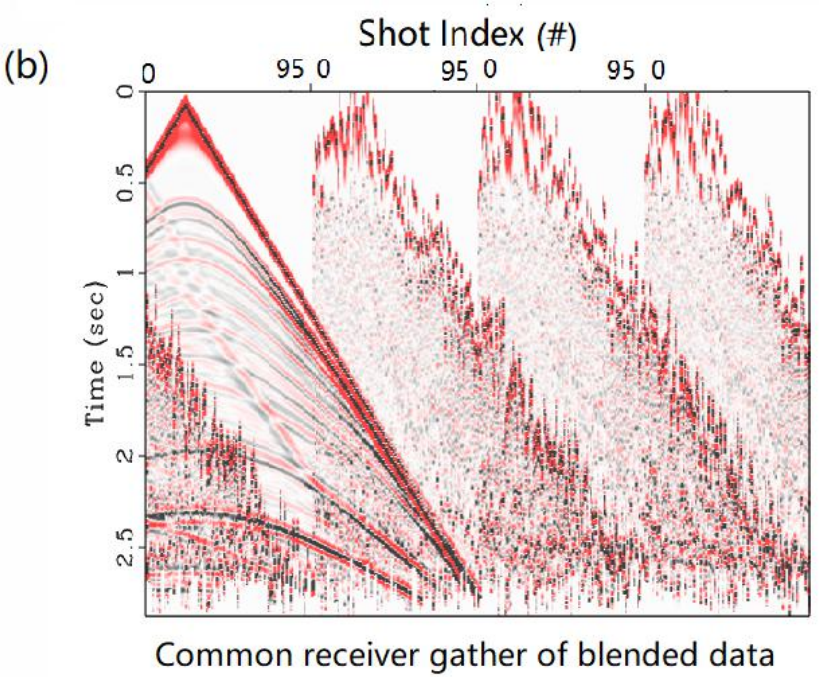
(Yangkang Chen, 2013)

Blended shots in common shot and receiver domain

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

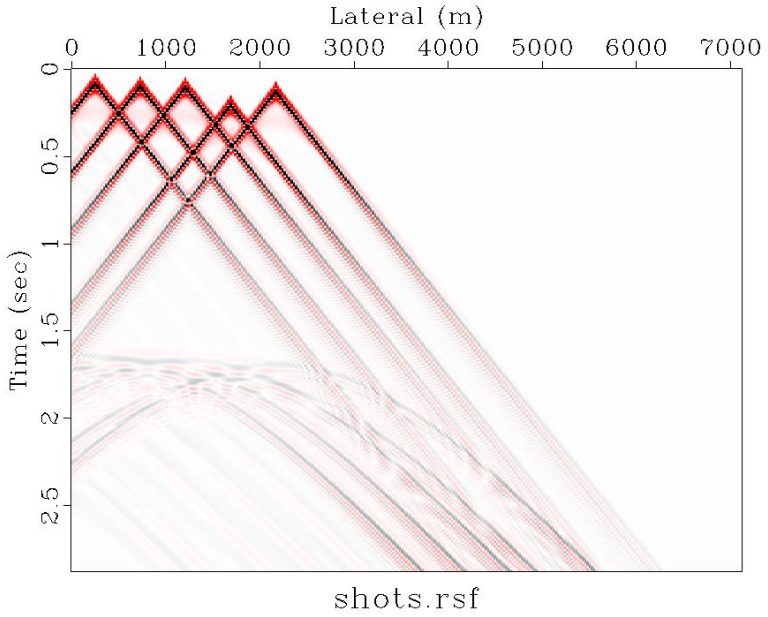


Common shot gather of blended data

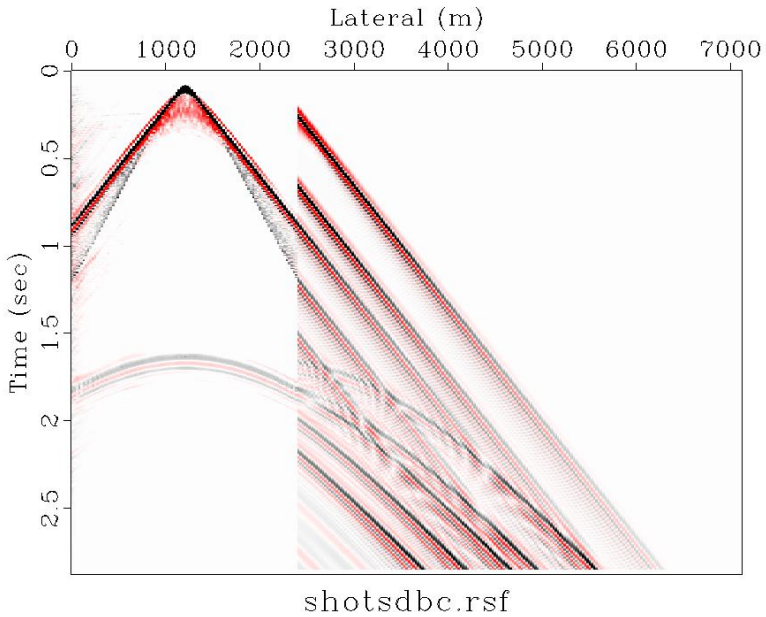


Common receiver gather of blended data

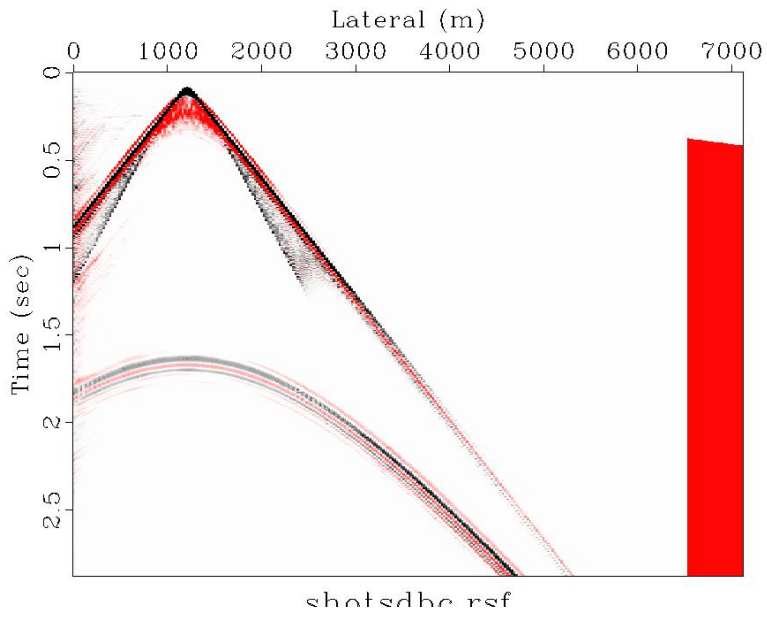
Deblending by filtering in receiver gathers



original blended



One third of receiver gathers filtered



All receiver gathers filtered

Increasing number of receiver gathers being filtered

D Trad, 2019

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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.

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.

Inversion

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

For example it’s a Fourier method.

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

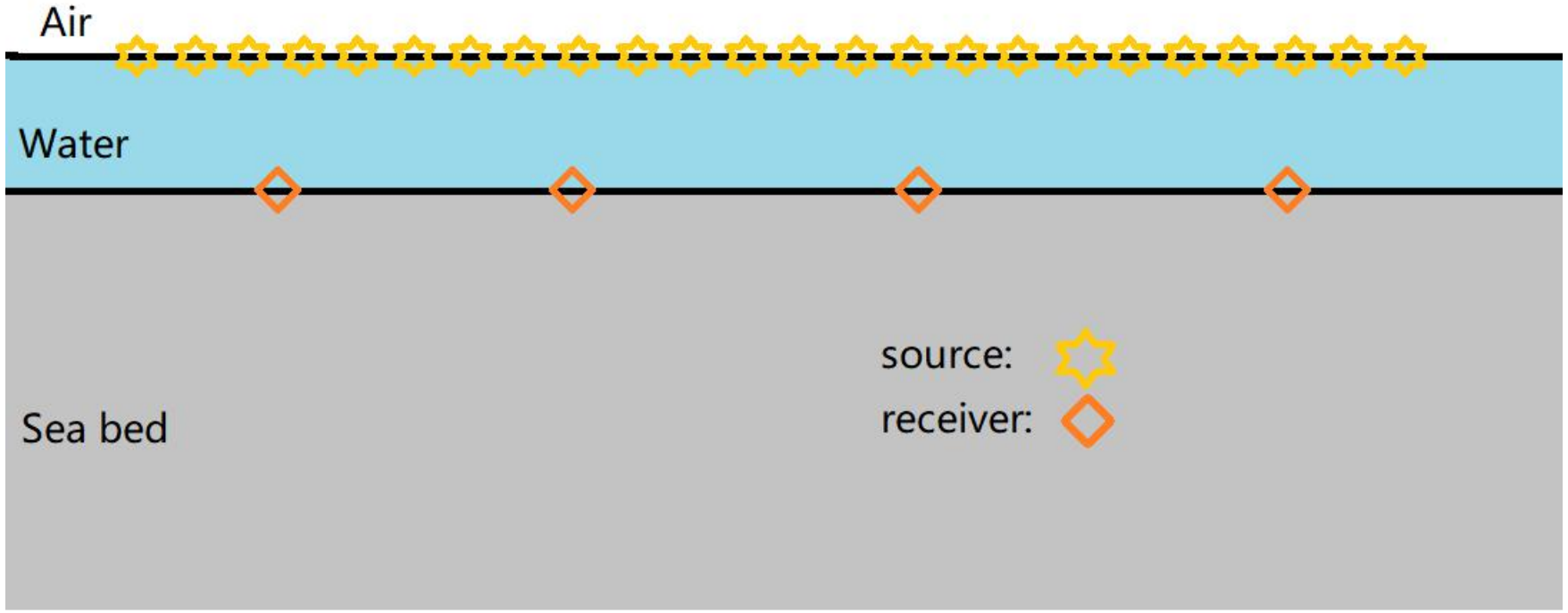
Where Ft is time domain FT, Fx is spatial FT, P is a separation operator that focusing on the transformed domain. P reflects the difference of independent shot gathers.

Inversion: reverse time migration

Reverse time migration in common shot and recevier domain

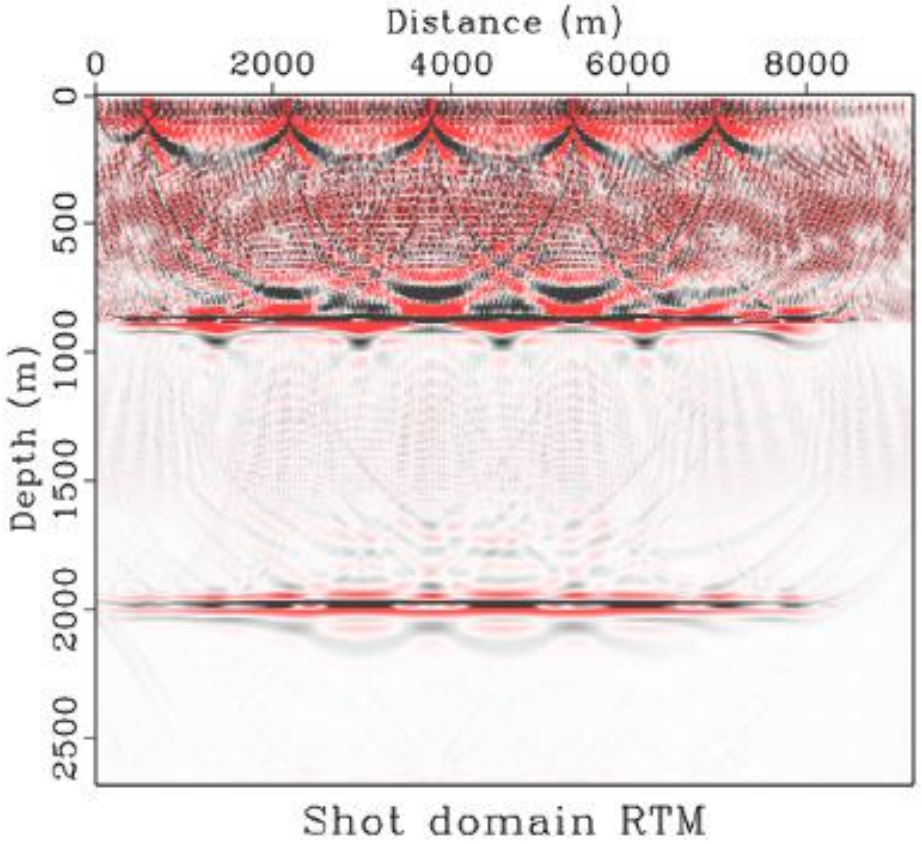
Inversion in common receiver gather

Unblended data for RTM in common shot domain and commmon receiver domain

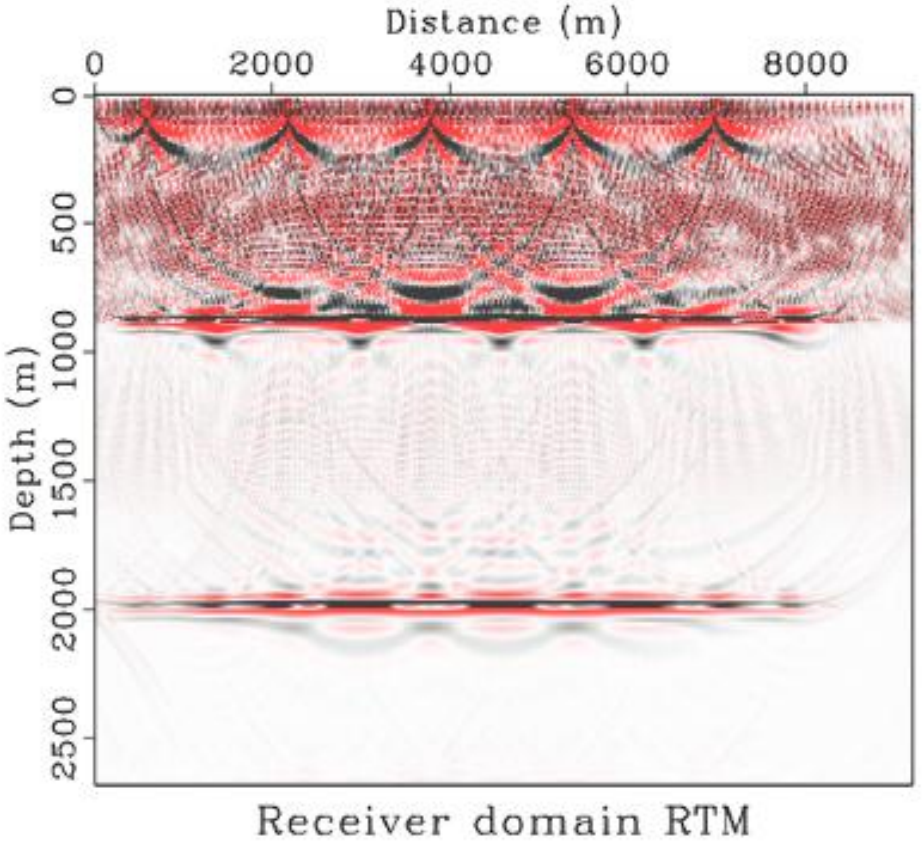


Inversion in common receiver gather

Unblended data for RTM in common shot domain and commmon receiver domain



Shot domain RTM



Receiver domain RTM

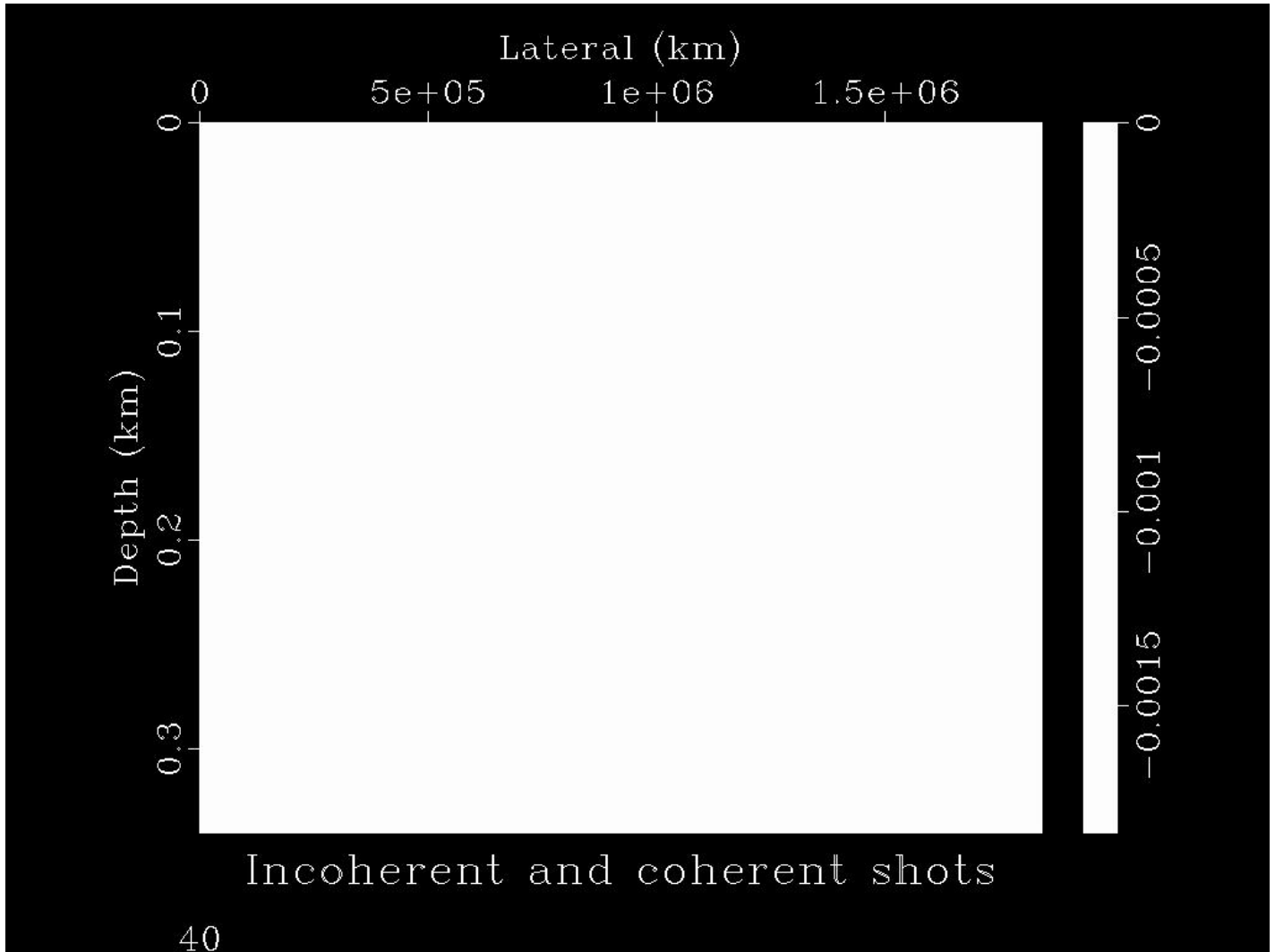
Inversion: reverse time migration

Blended reverse time migration in common shot and recevier domain

Blending acquisition

Blended RTM in shot domain.

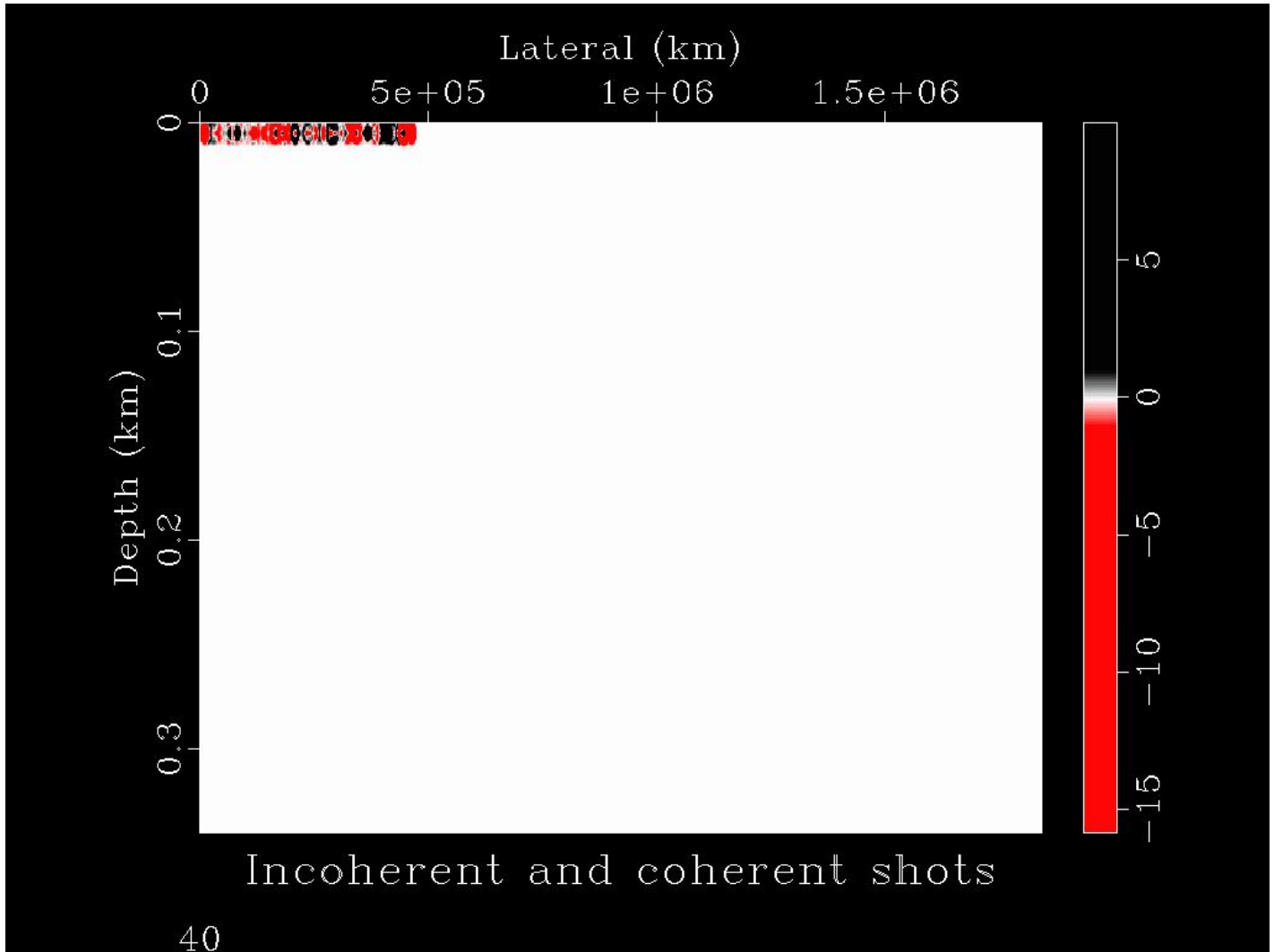
1.inject sources in forward wavefield



Blending acquisition

Blended RTM in shot domain.

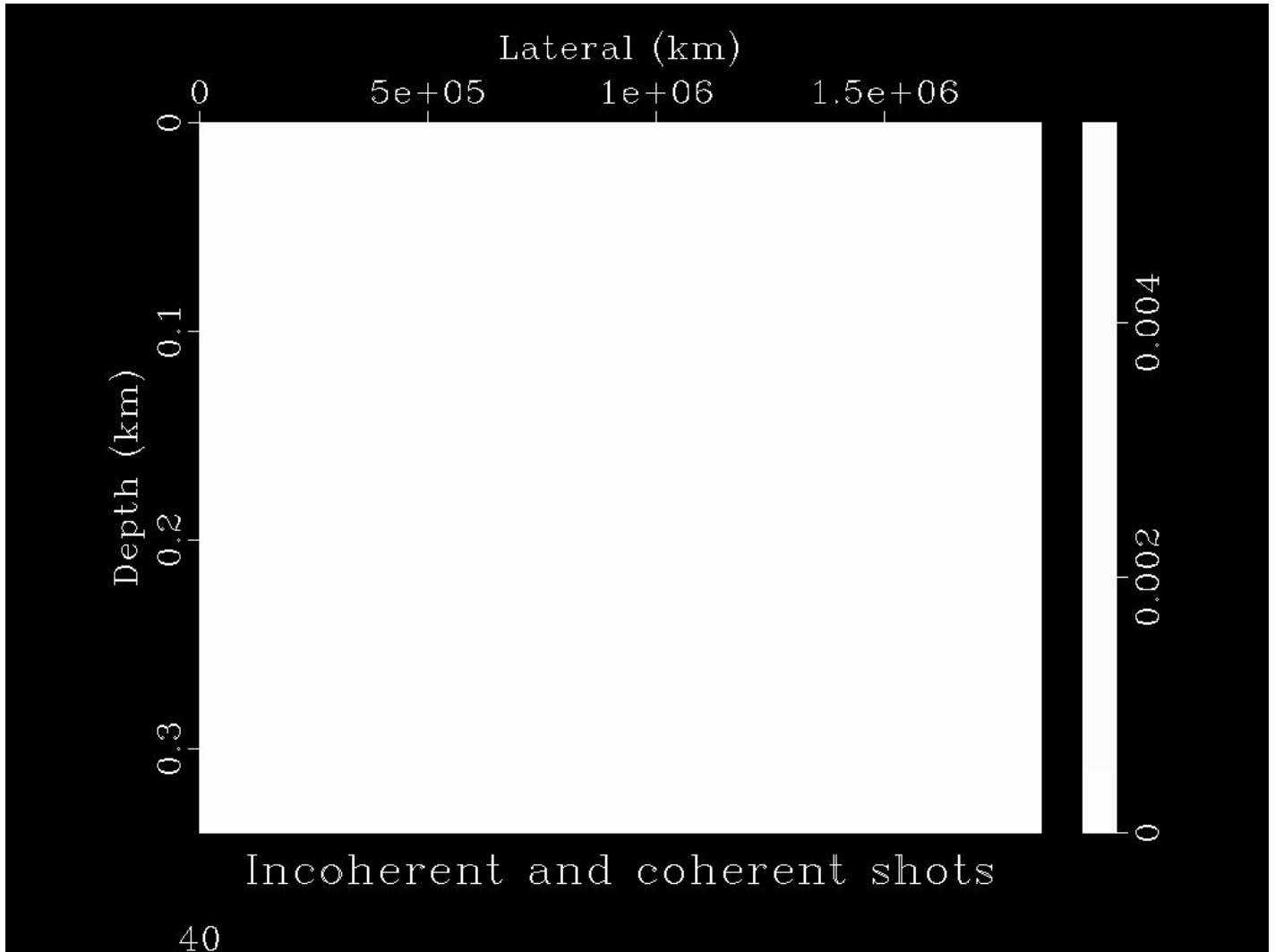
2.inject data in backward wavefield



Blending acquisition

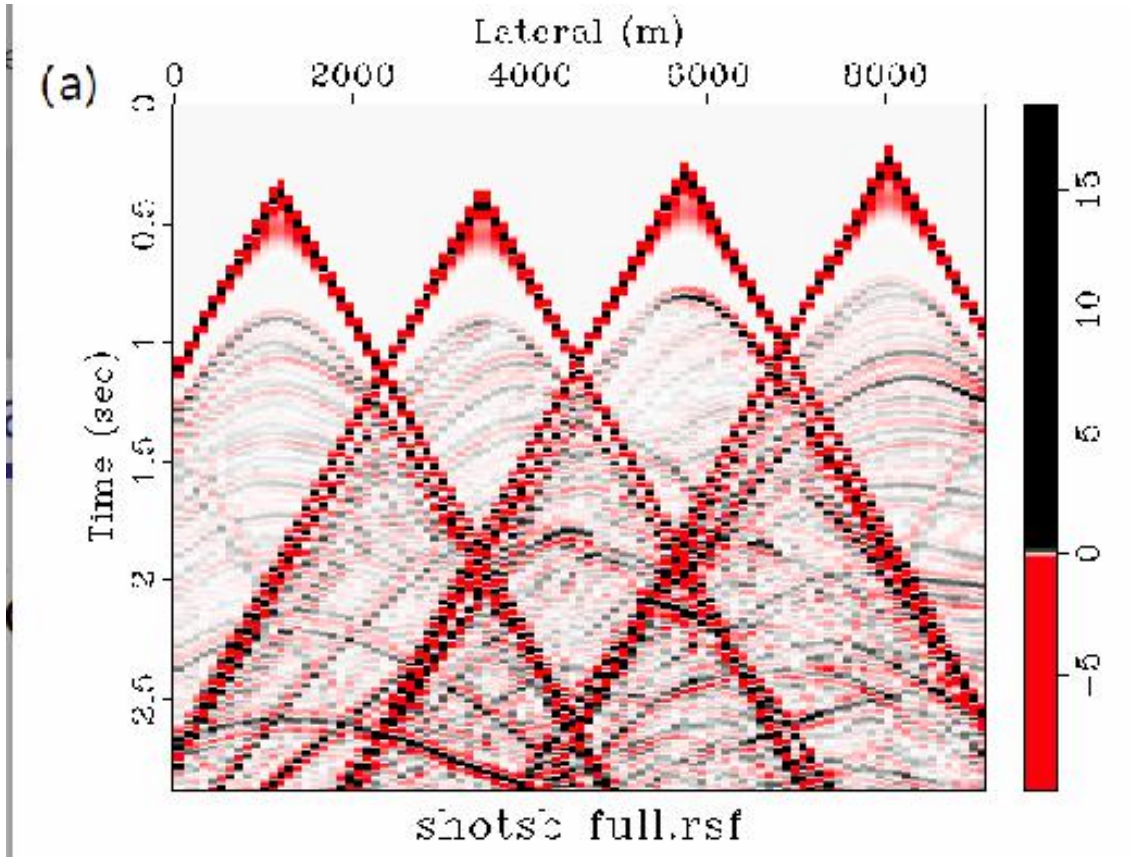
Blended RTM in shot domain.

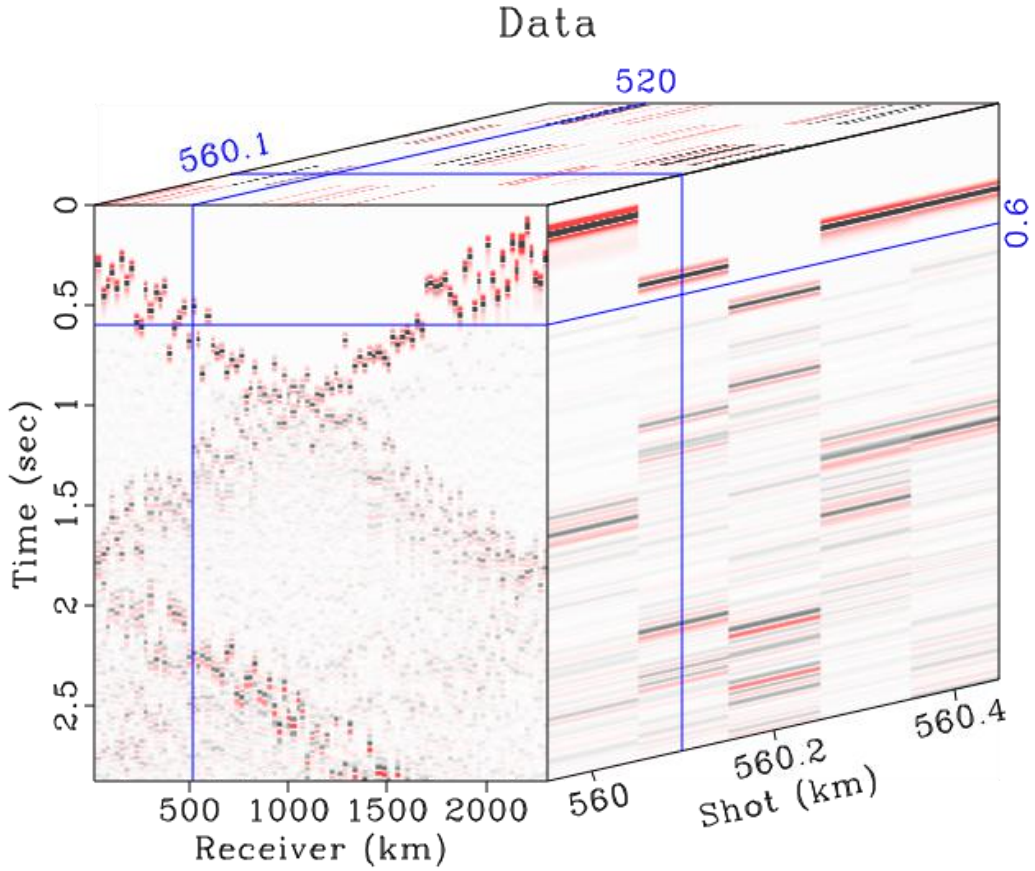
3.Cross-correlation of the two wavefields



What is deblending?

Each single shot in every “Supershot” has its own delay time.



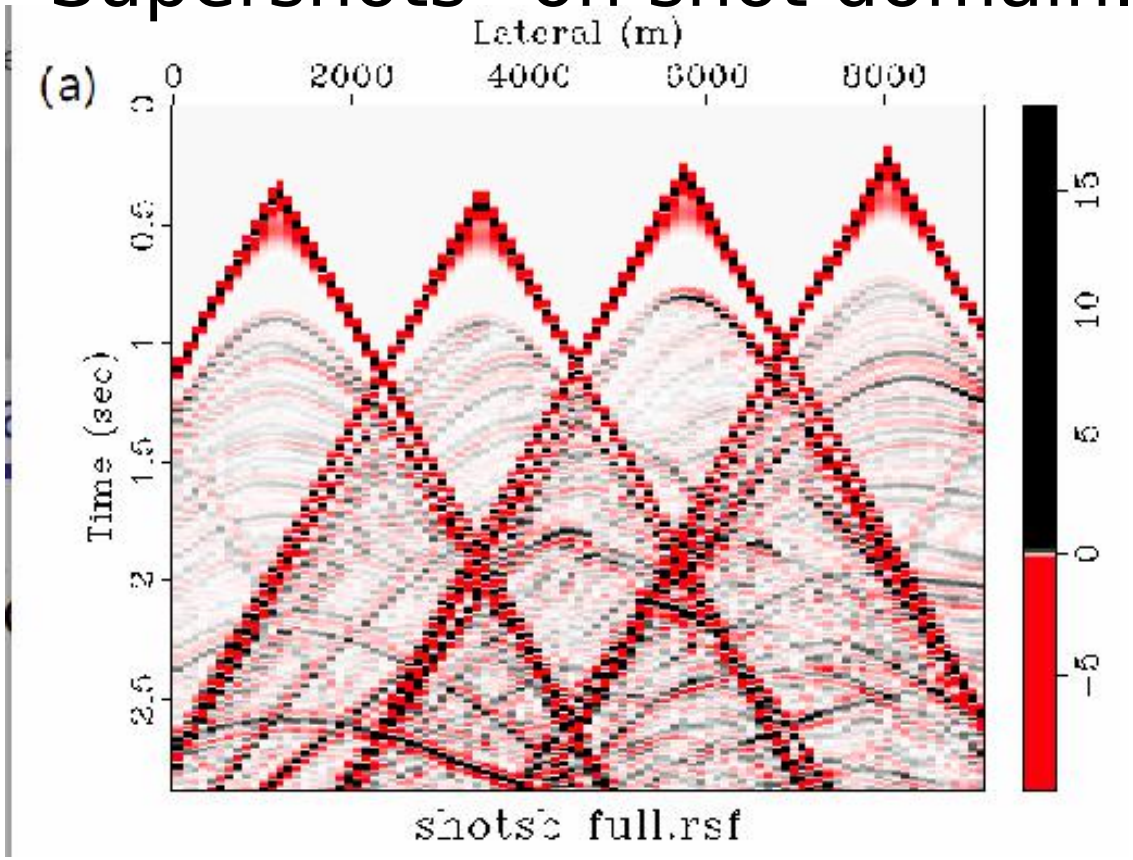


What is deblending?

Blended RTM in shot domain.

Pseudo-deblending

Shift target shot’s delay time as zero for each shot inside “Supershots” on shot domain.

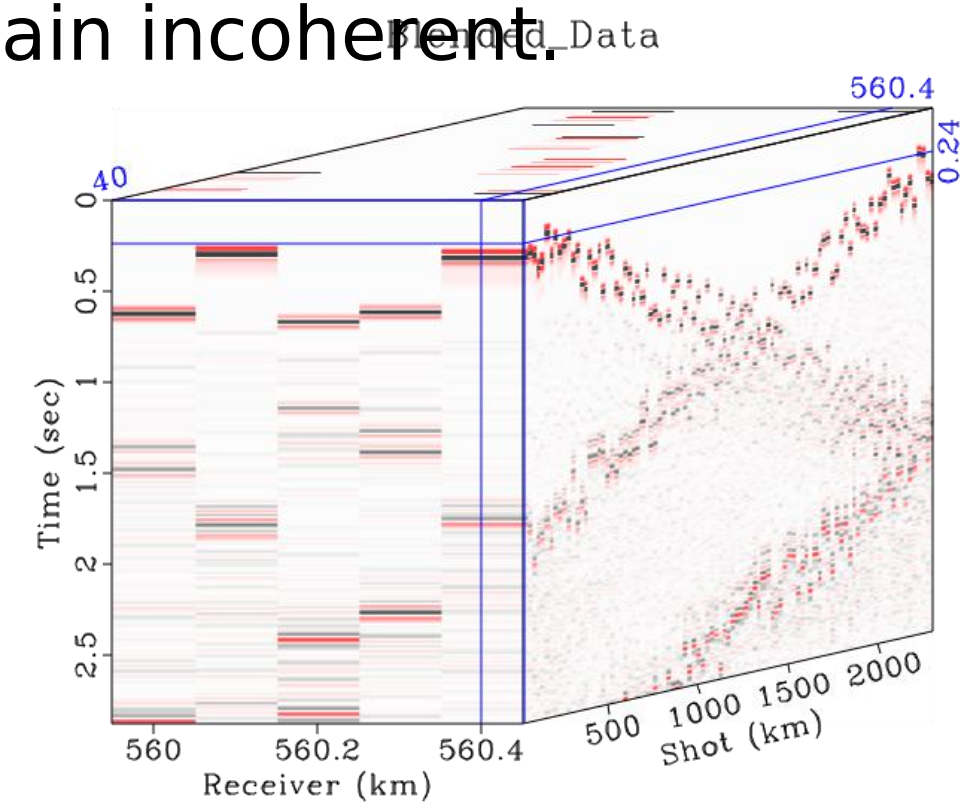


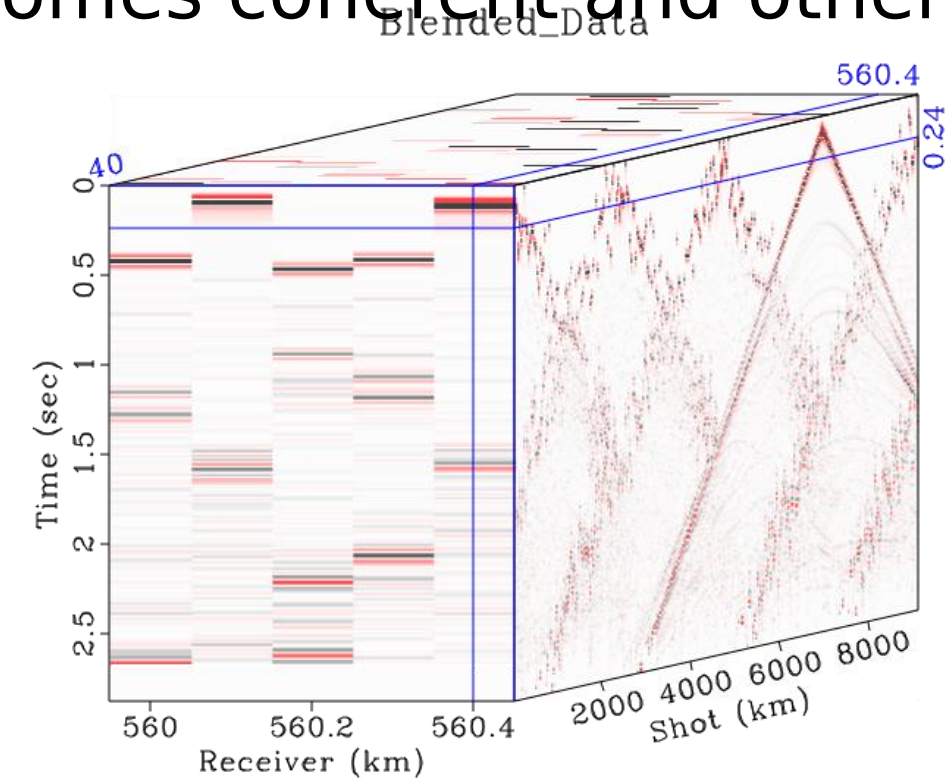
Blending acquisition

Pseudo deblending extents the data size *nblended* times,

where *nblended* is the number of simultaneous shots in each supershot.

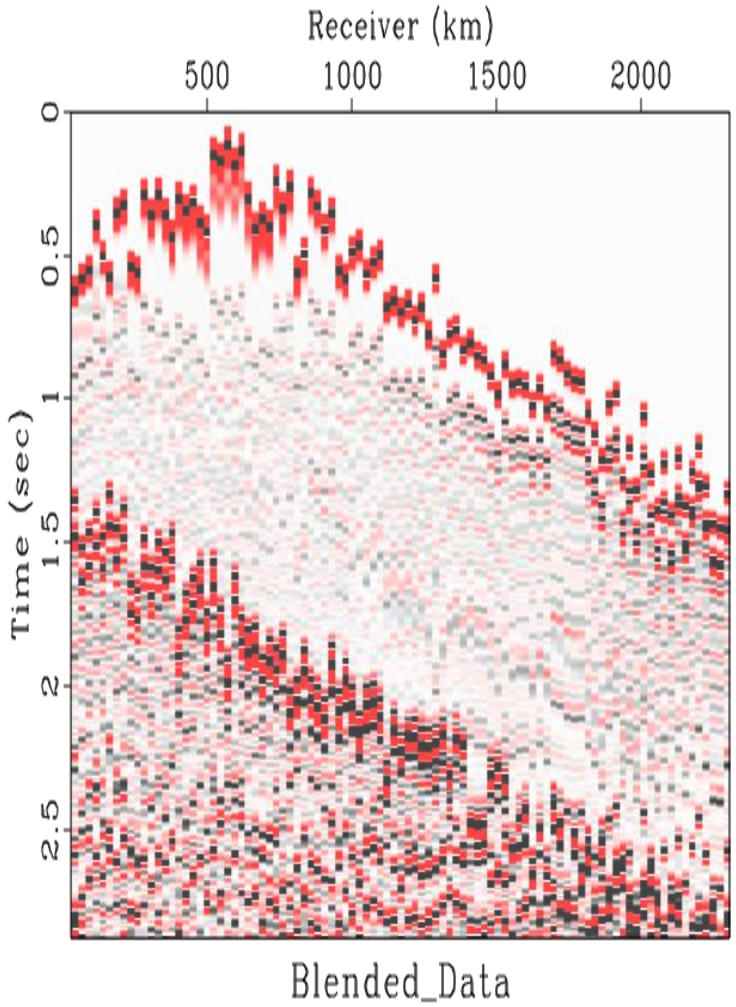
After shifting, the target shot becomes coherent and other shots remain incoherent.

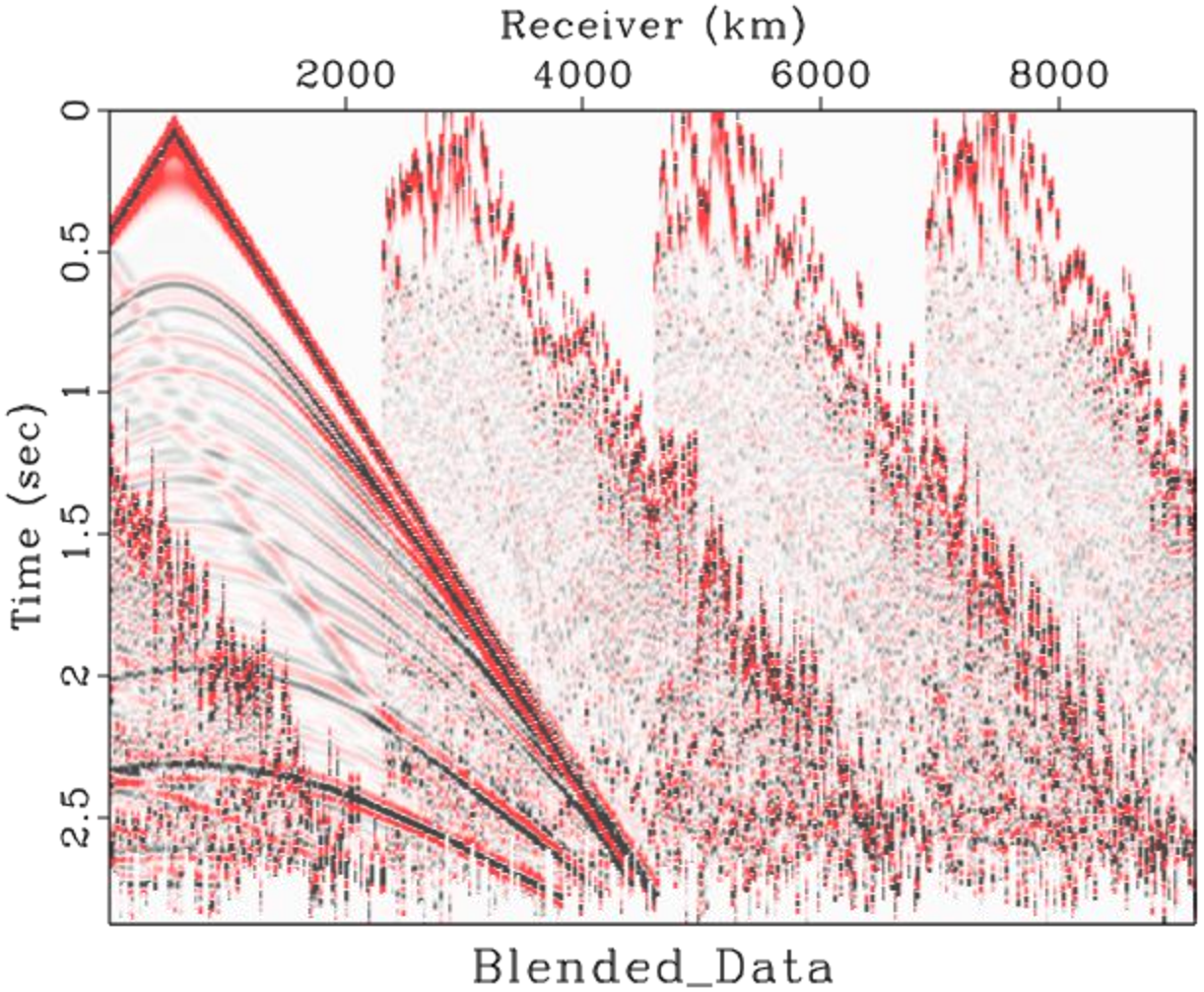




Blending acquisition

Extending and shifting/dithering:



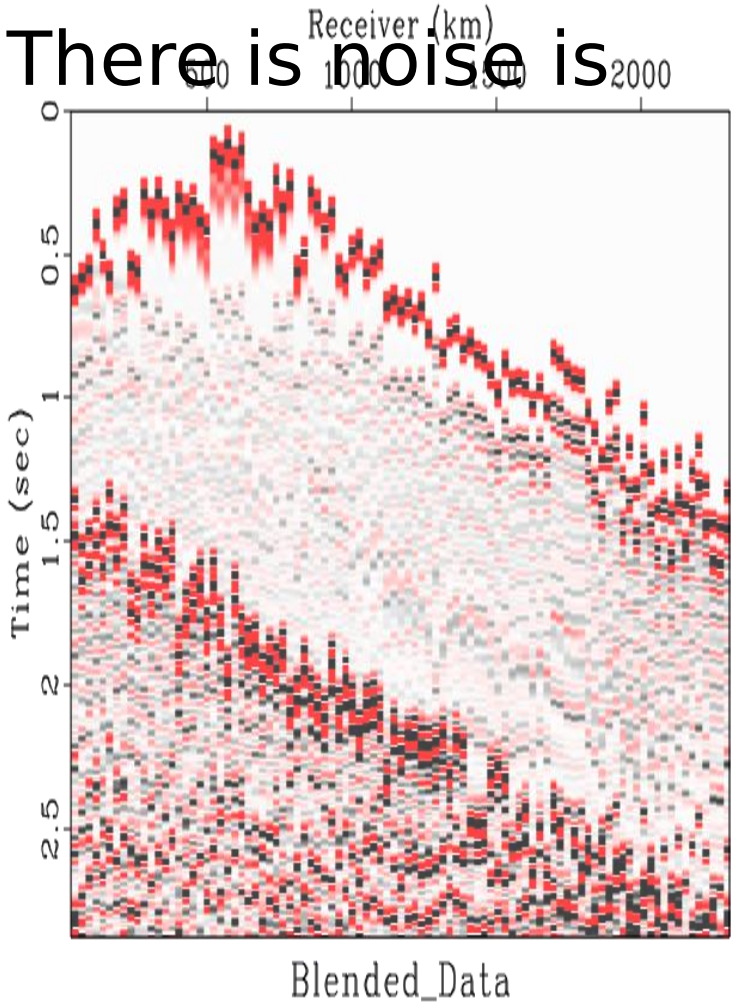


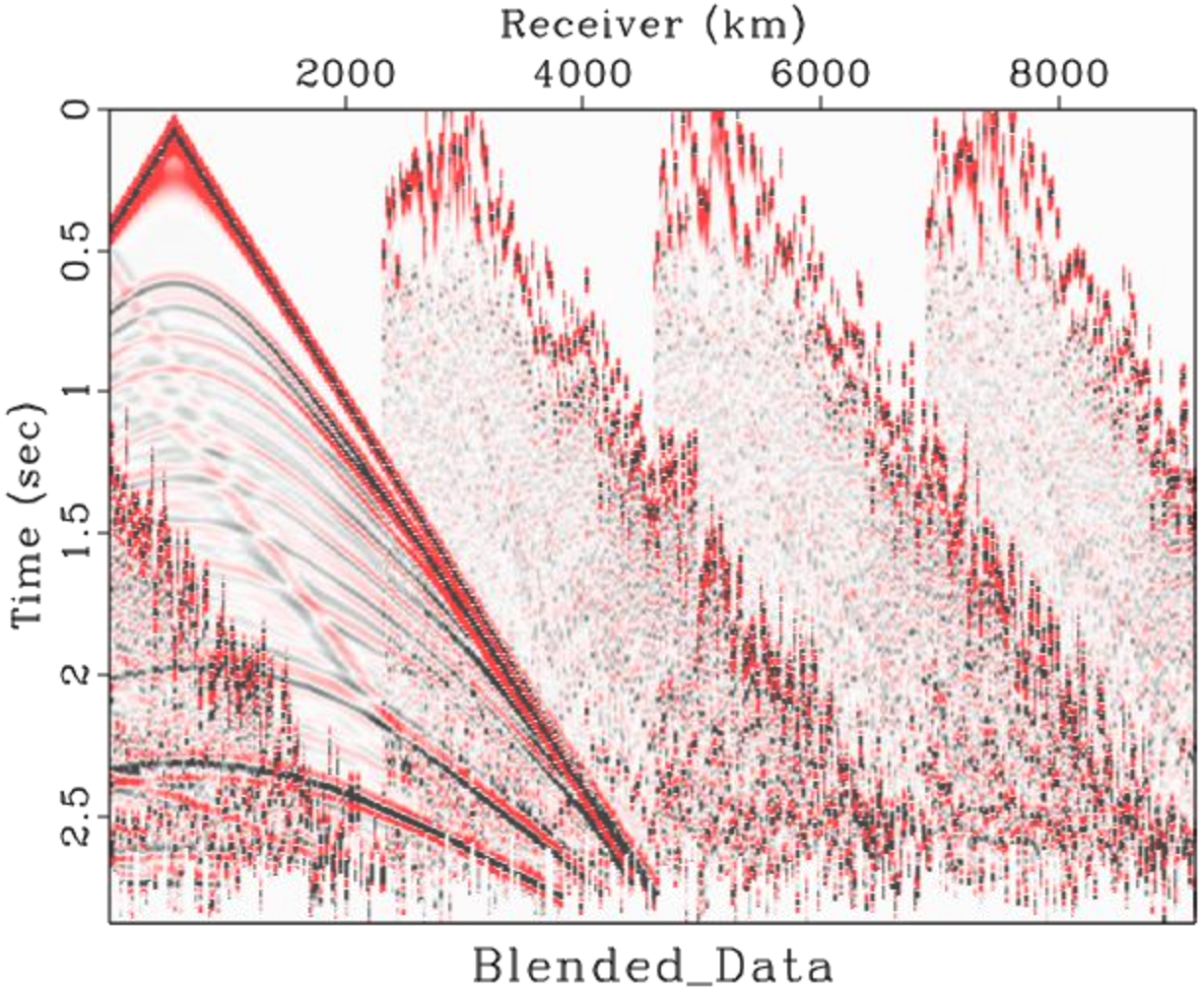
Blending acquisition

Extending and shifting/dithering:

Target shot is coherent and unwanted shots are incoherent

There is noise is





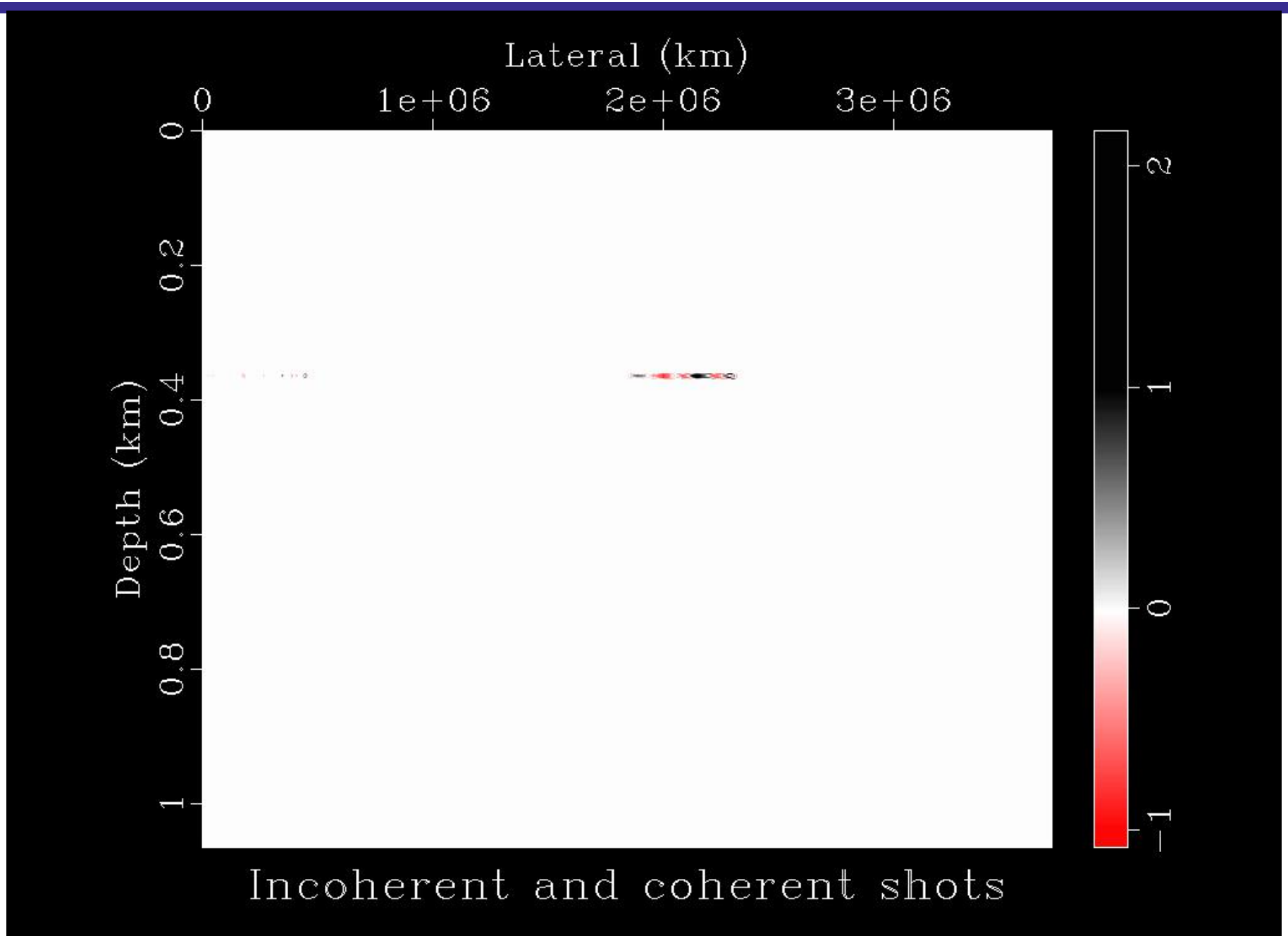
Coherence effects on RTM imaging condition

In blended receiver domain RTM, target shot is coherent and unwanted shots are incoherent.

RTM imaging condition amplifies coherent shots while cancels incoherent shots

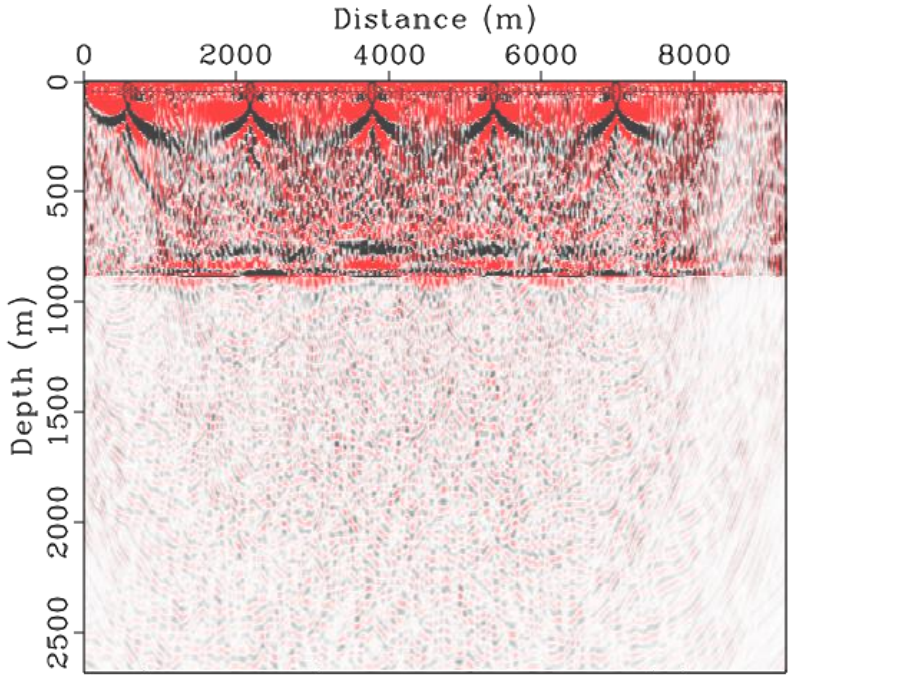
Therefore blended RTM could remove the noise of blending.

Coherency effects in RTM

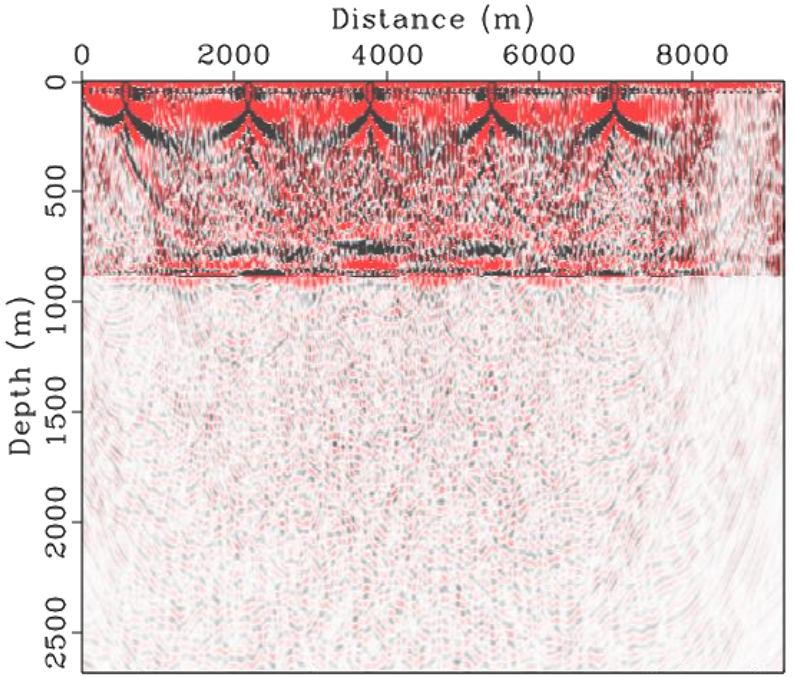


RTM results in common shot and receiver domain

Two layered model



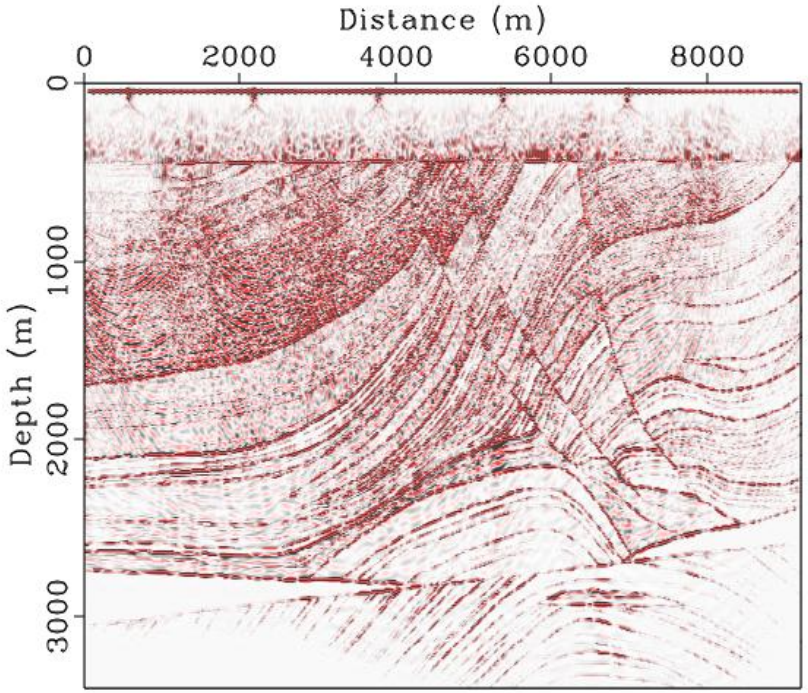
Blended shot domain RTM for two layer model



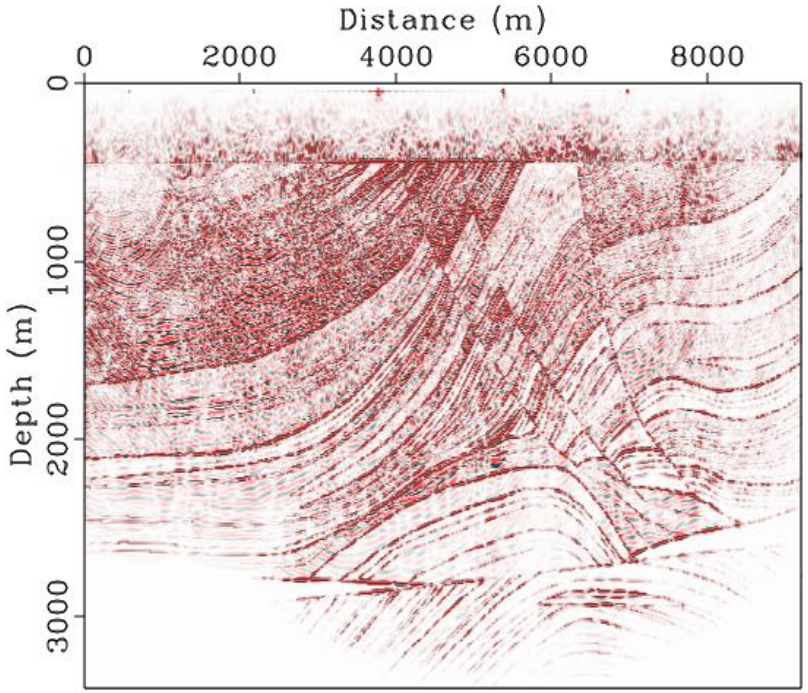
Blended receiver domain RTM for two layer model

RTM results in common shot and receiver domain

Marmousi model



BLended shot domain RTM for marmousi model



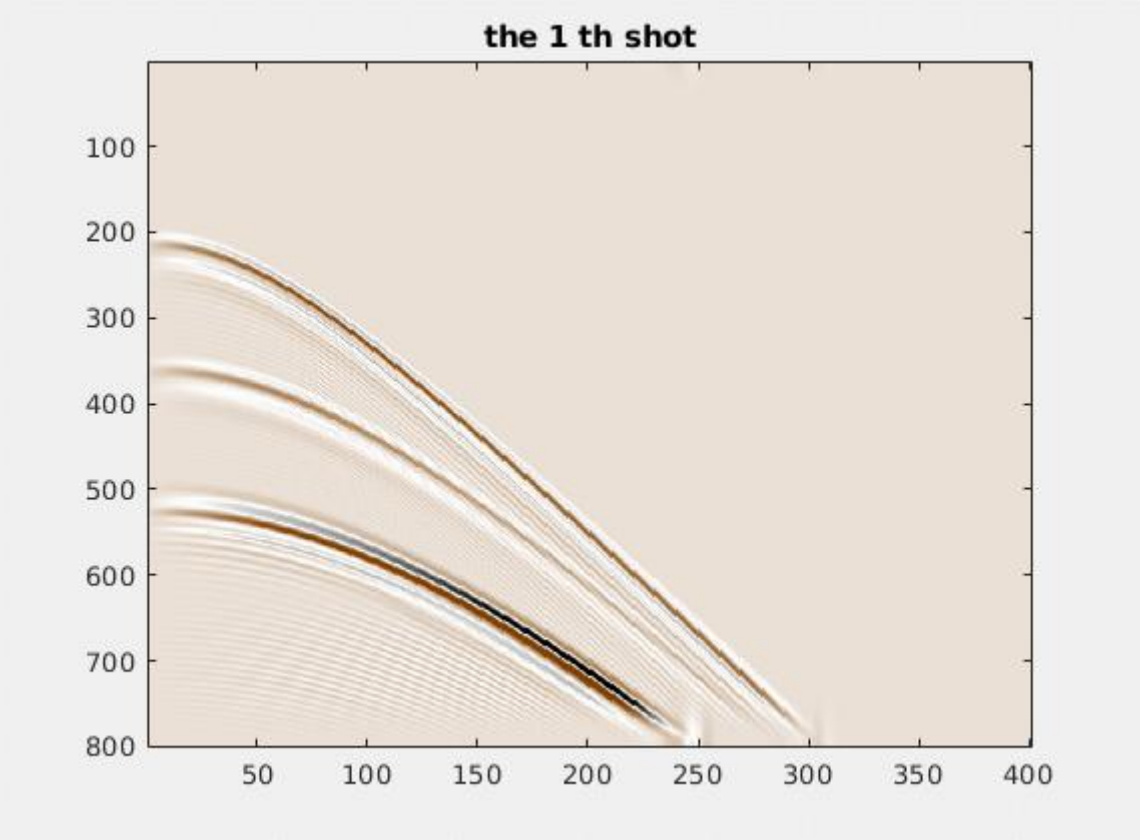
Blended receiver domain RTM for marmousi model

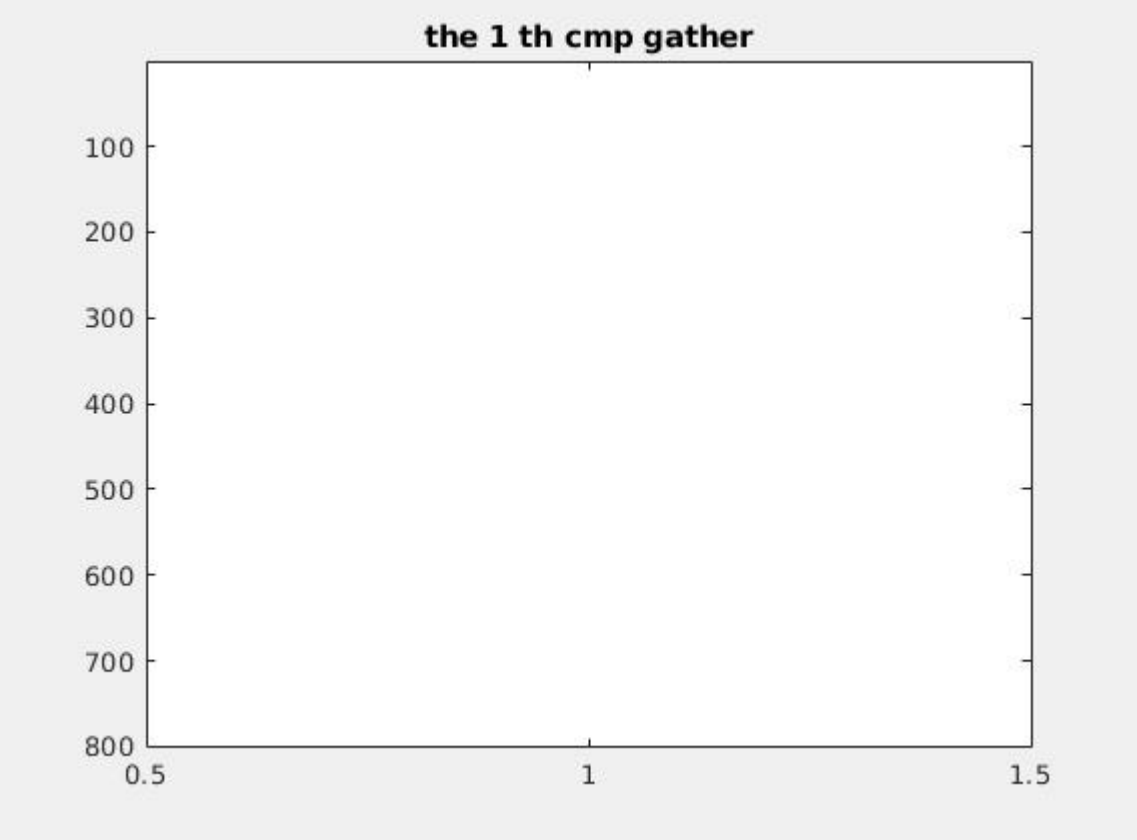
Inversion: reverse time migration

Reverse time migration in midpoint domain

Offset original means the distance between a shot and a receiver at the surface. <-data-space parameter

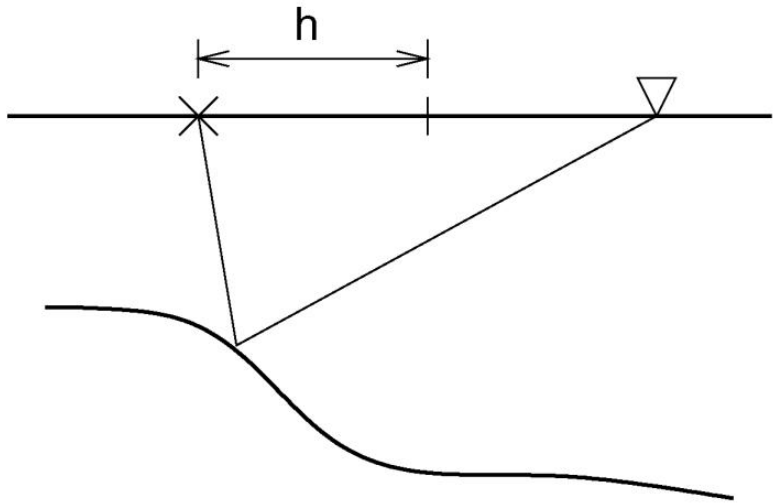
CSG and CMP


the 1 th shot
100
200
300
400
500
600
700
800
50
100
150
200
250
300
350
400

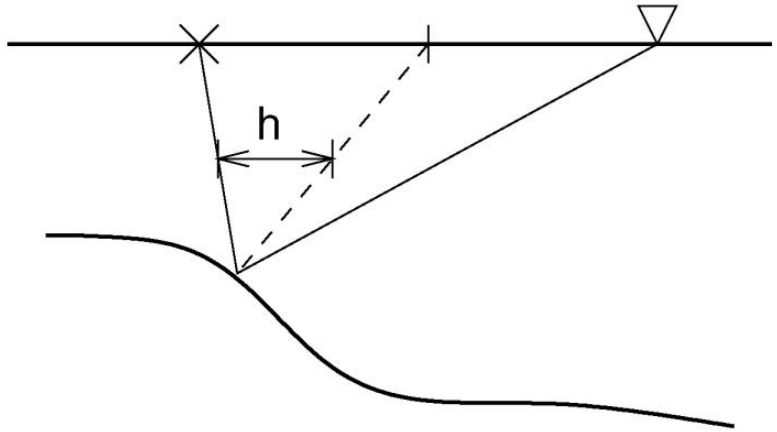

the 1 th cmp gather
100
200
300
400
500
600
700
800
0.5
1
1.5

Deblending in offset domain common image gather

But in downward propagation wavefield, the offset between the two wavefields decreases as the depth increases for each reflection point.



(a) Before migration



(b) During migration

Deblending in offset domain common image gather/ODCIG

So in ODCIG, the subsurface offset shall be included.

For each depth in one midpoint, there shall be a series of offsets.

The offset range increases as depth increase.

Deblending in angle domain common image gather

Deblendin

Conclusion

Receiver domain RTM saves computation for OBN.

Blended acquision saves acquisition time and cost.

RTM attenuates incoherent shots

Dithering in blelnded receiver domain RTM is effctive in deblending

Future work

Apply LS in Blended RTM in receiver domain

Connection between dithering and datum

Deblending RTM in Common Receiver Gather utilizing dithering

->Deblending RTM in Common Offset Gather

->Deblending RTM in Common Angle Gather

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=NmSQv