# How does data blending influence different scales of the velocity model?

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SEP 176, pp. 32 - 47

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# Definitions

1. Blended data: overlap in shots
2. Unblended data: never been blended
3. Deblended data: once blended, now ~separated

# Some nomenclature

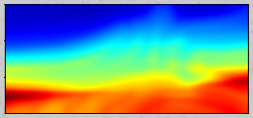
- Blending - done in the field (determined by the acquisition)
- Encoding - performed in the computer (can change from iteration to iteration)

# Recap of previous work

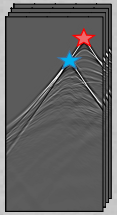
SEP meeting last year and SEG 2018:

1. Combining adaptive subtraction and waveform inversion for imaging blended data

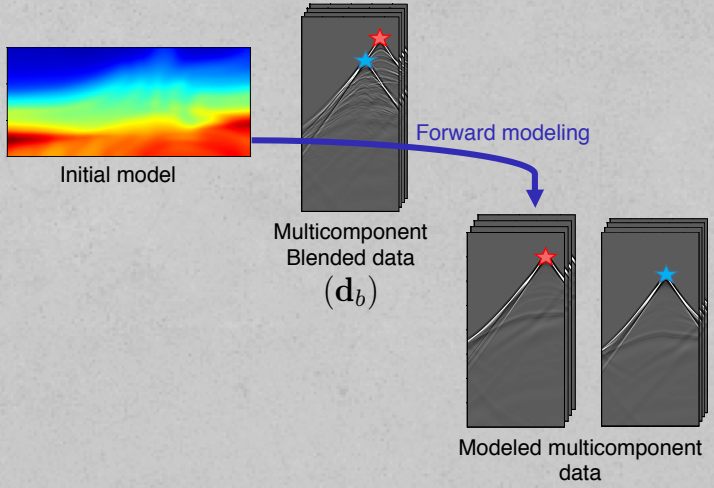
2. Multicomponent adaptive subtraction for deblending

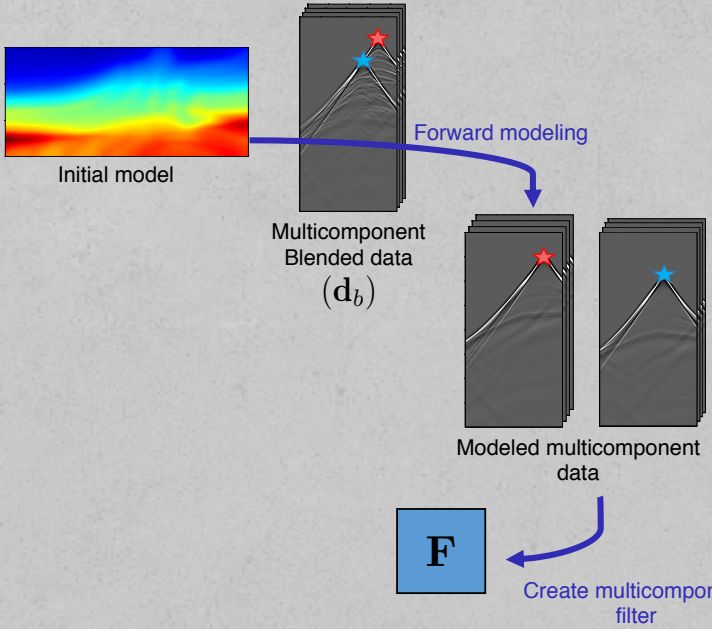


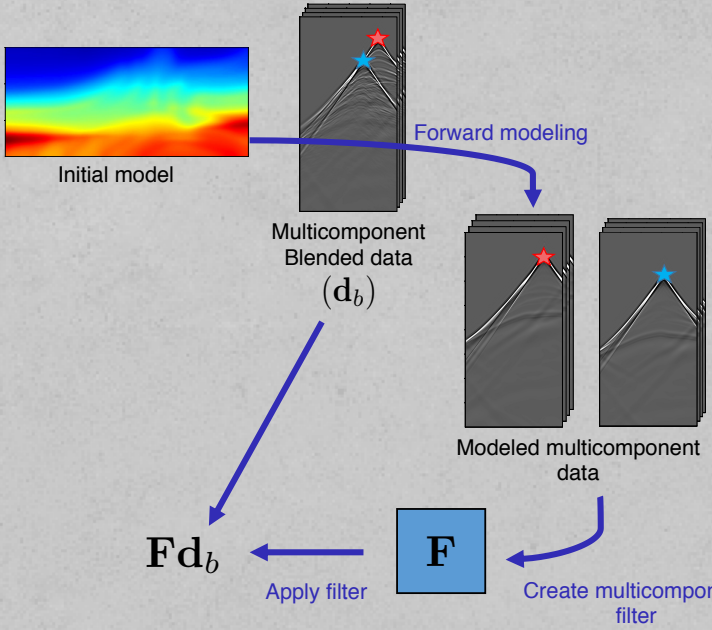
Initial model

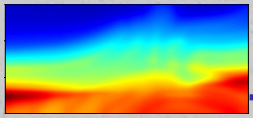


Multicomponent
Blended data
$(\mathbf{d}_b)$

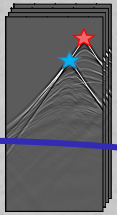

Initial model
Forward modeling
Multicomponent
Blended data
$(\mathbf{d}_b)$
Modeled multicomponent
data


Initial model
Forward modeling
Multicomponent
Blended data
$(\mathbf{d}_b)$
Modeled multicomponent
data
F
Create multicomponent
filter


Initial model
Forward modeling
Multicomponent
Blended data
$(\mathbf{d}_b)$
Modeled multicomponent
data
$\mathbf{Fd}_b$
Apply filter
$\mathbf{F}$
Create multicomponent
filter

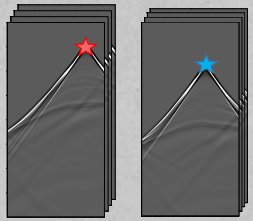


Initial model



Multicomponent
Blended data
$(\mathbf{d}_b)$

Forward modeling



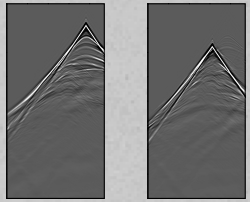
Modeled multicomponent
data

Create multicomponent
filter

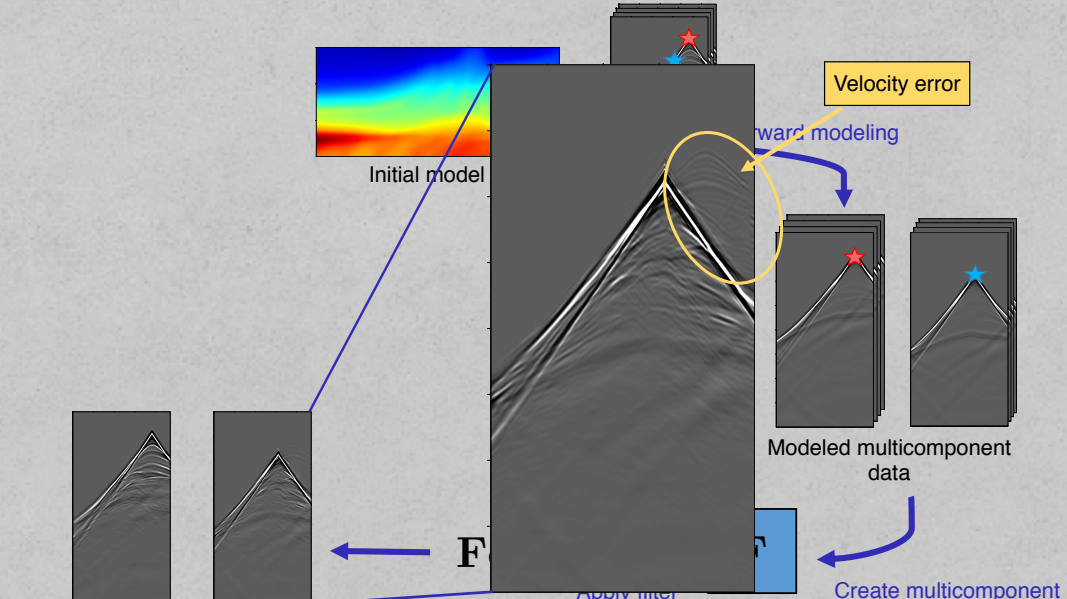
$\mathbf{F}$

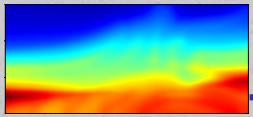
Apply filter

$\mathbf{F}\mathbf{d}_b$



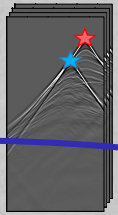
Approximately deblended pressure data


Initial model
Velocity error
ward modeling
Modeled multicomponent data
Create multicomponent filter
Approximately deblended pressure data

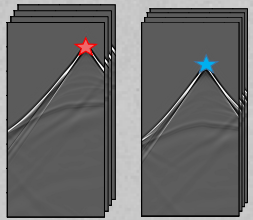


Initial model

Forward modeling



Multicomponent
Blended data
$(\mathbf{d}_b)$



Modeled multicomponent
data

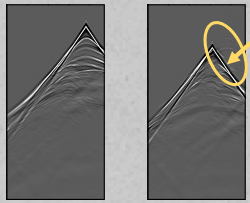
Create multicomponent
filter

$\mathbf{F}$

Apply filter

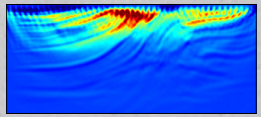
$\mathbf{F}\mathbf{d}_b$

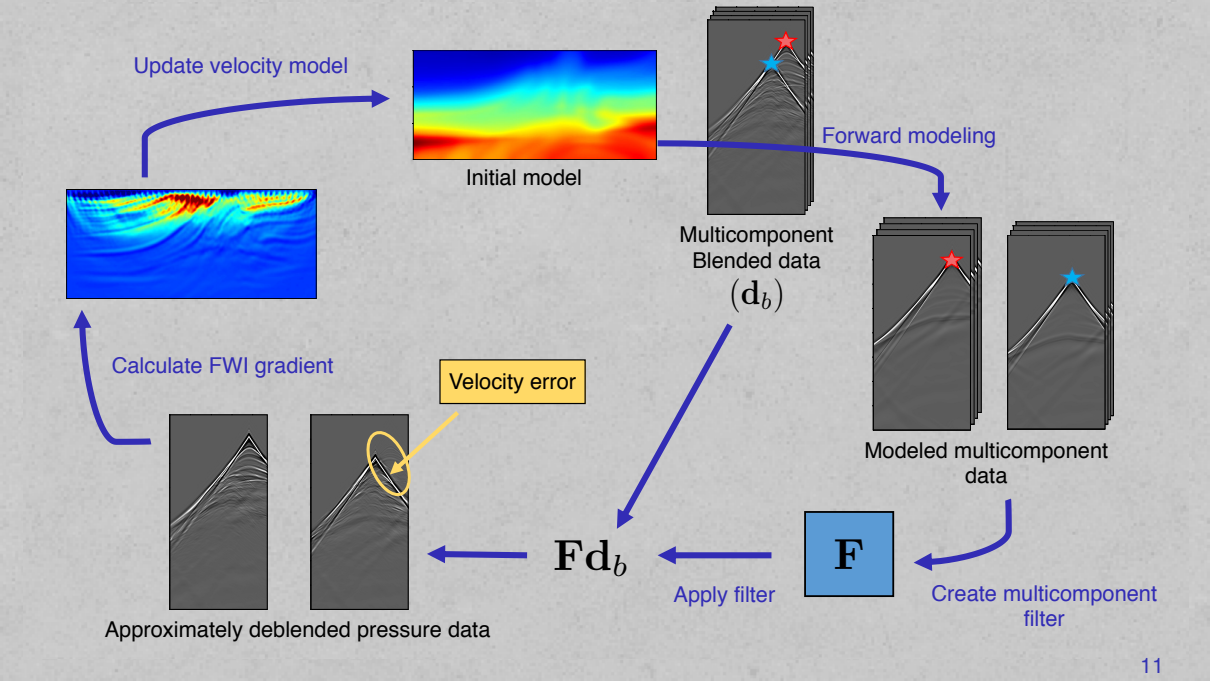
Velocity error



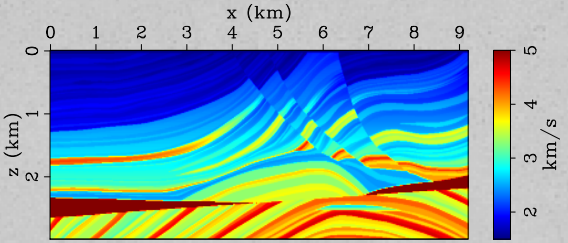
Approximately deblended pressure data

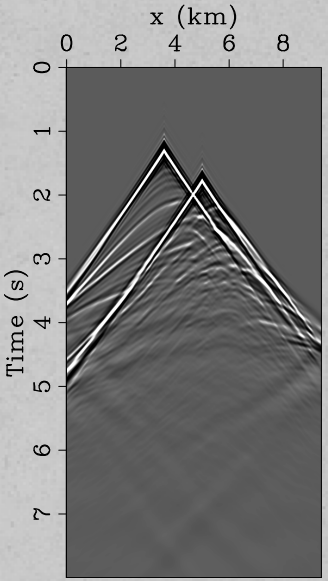
Calculate FWI gradient



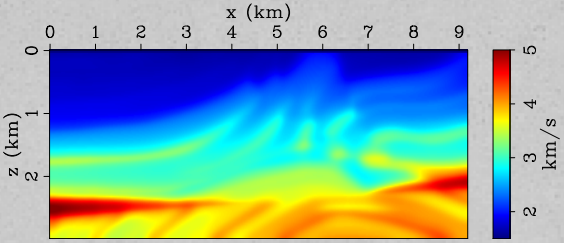

Update velocity model
Initial model
Forward modeling
Multicomponent
Blended data
$(\mathbf{d}_b)$
Modeled multicomponent
data
Create multicomponent
filter
$\mathbf{F}$
Apply filter
$\mathbf{F}\mathbf{d}_b$
Velocity error
Calculate FWI gradient
Approximately deblended pressure data

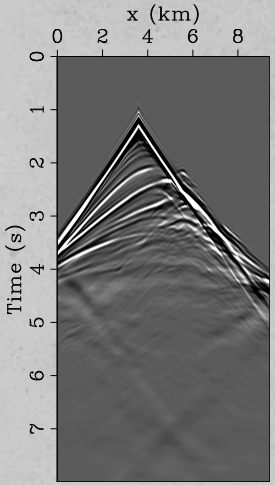
# Blended data ($\mathbf{d}^b$)

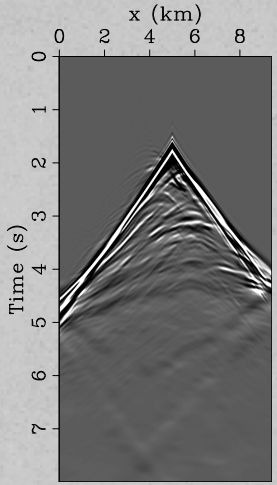


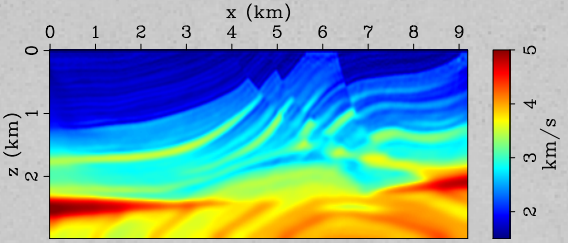
# Deblended data for inaccurate model

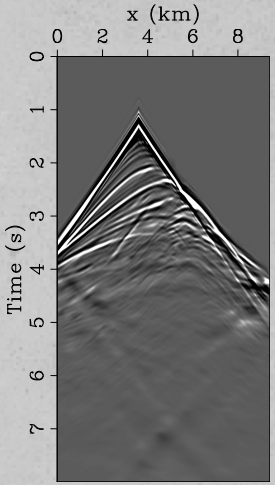


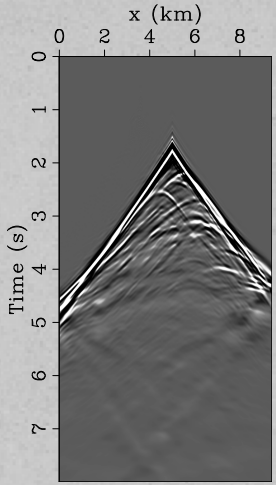



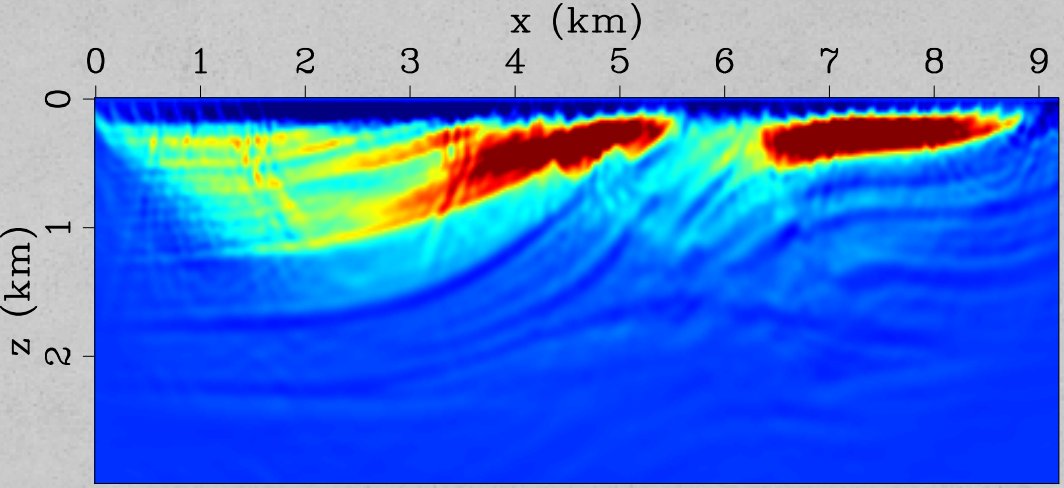
# Deblended data for more accurate model



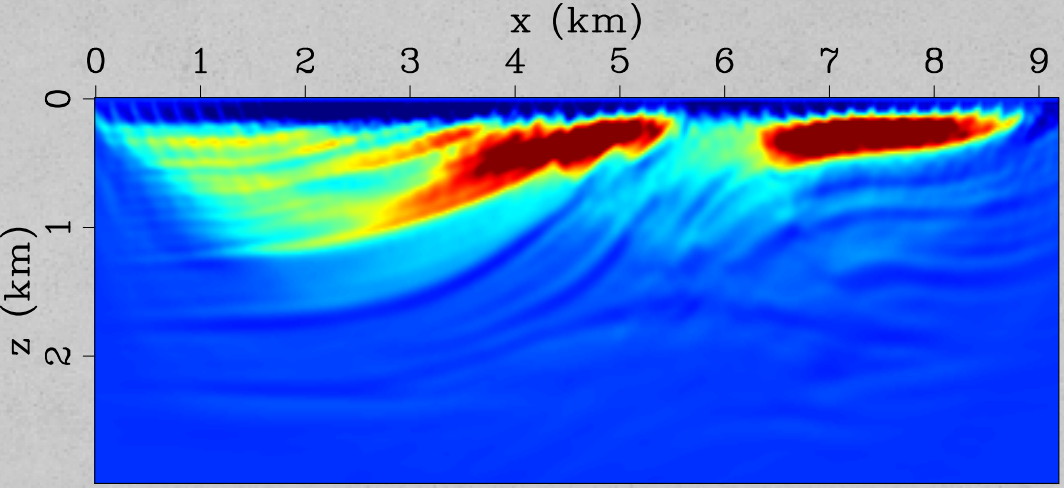



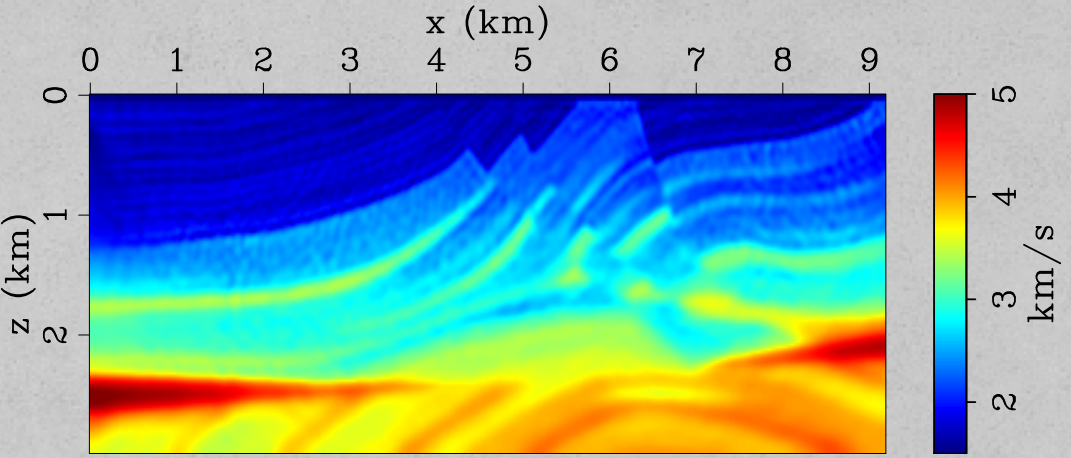
# Gradient of “raw” blended data



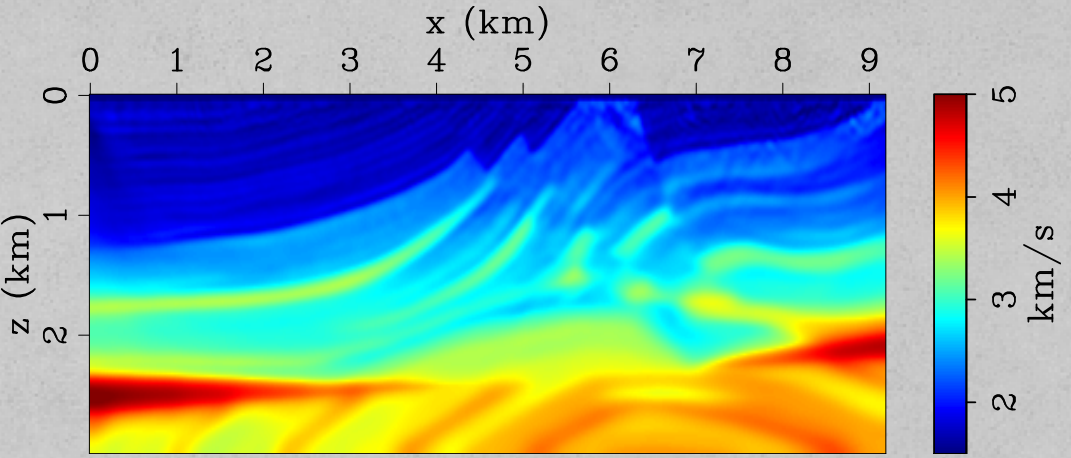
# Gradient of preconditioned ata



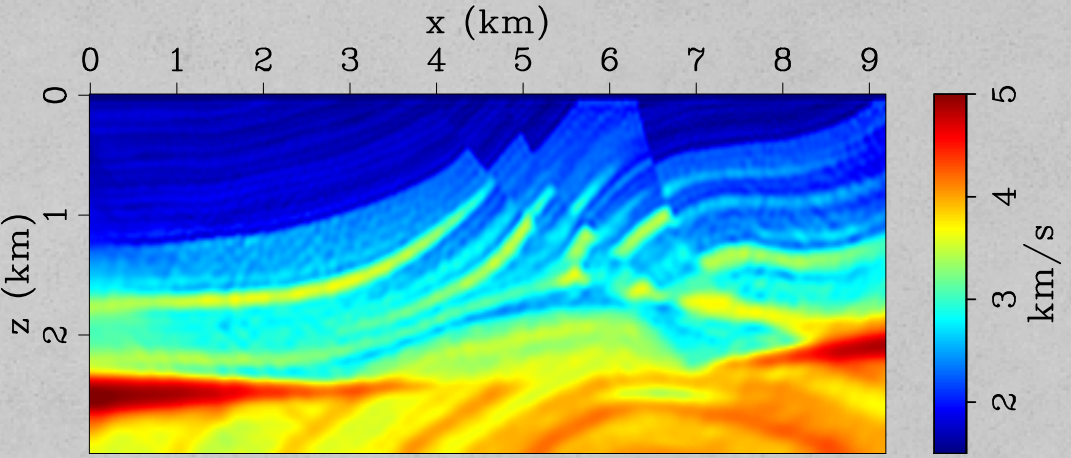
# FWI of blended data (20 iterations)



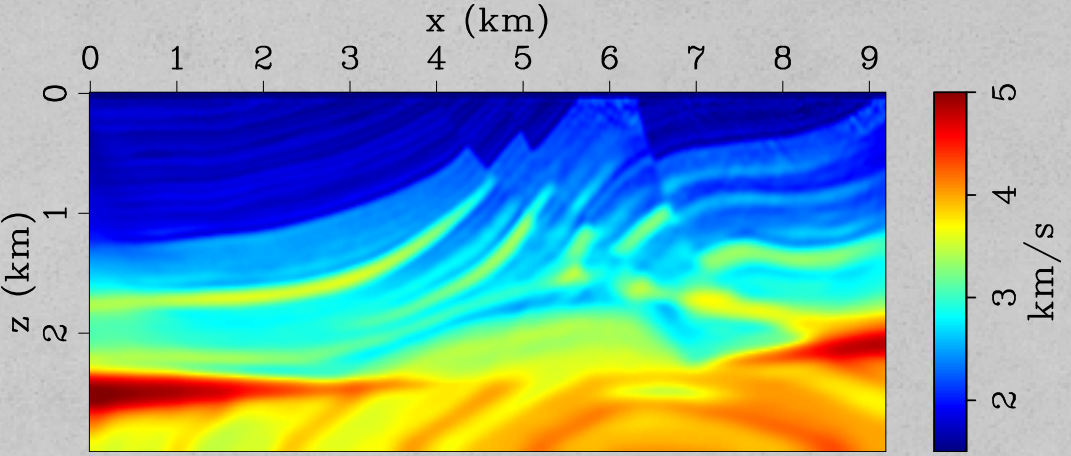
# FWI of preconditioned data (20 iterations)



# FWI of blended data (40 iterations)



# FWI of preconditioned data (40 iterations)

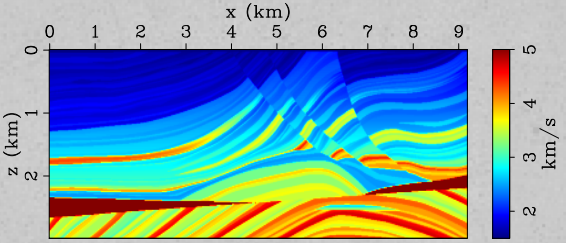


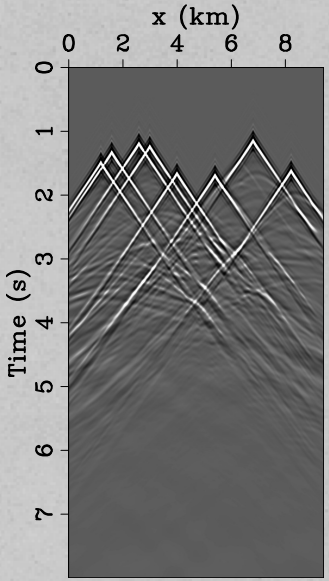
# Summary of previous work

1. Artifacts mitigated at early iterations

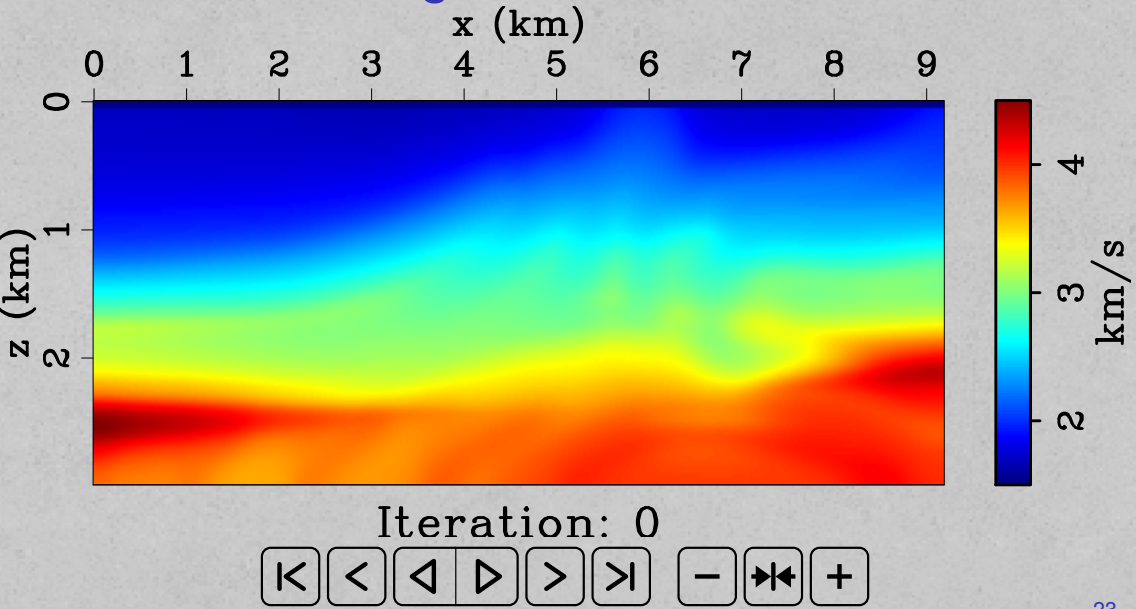
2. Recover accurate deblended data via iterative deblending

# FWI of eight blended sources

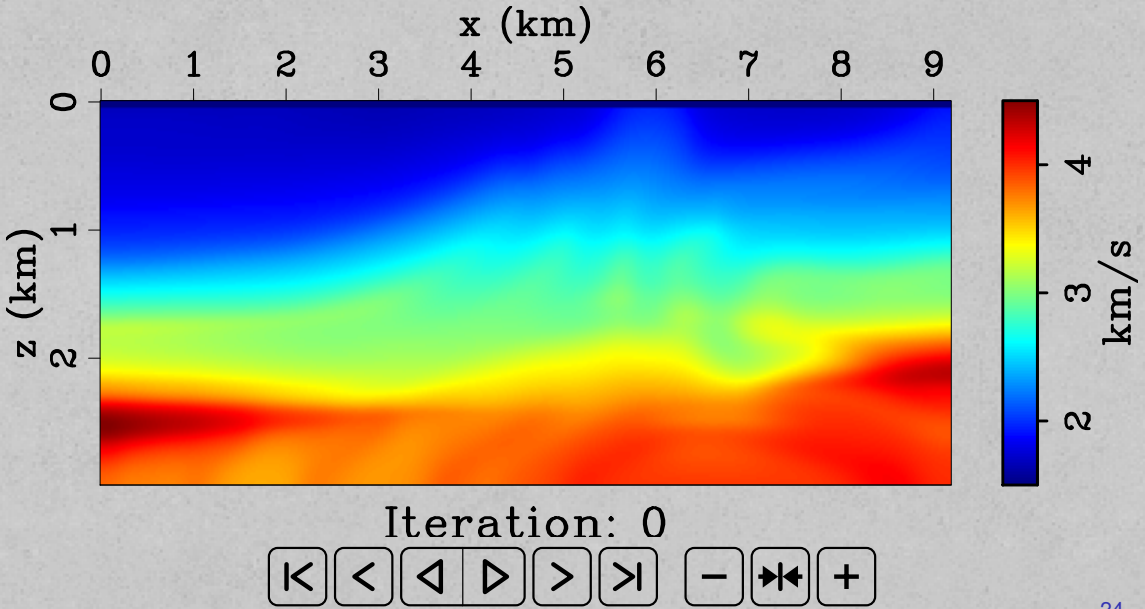


# FWI of eight blended sources



# FWI of 16 blended sources



# Overarching questions

1. Why can’t we just iterate?

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2. What scales of the velocity model are most influenced by data blending?

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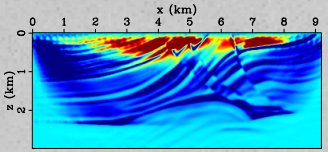
1. Why can't we just iterate?

2. What scales of the velocity model are most influenced by data blending?
   - Back-scattered component
   - Tomographic component

# Different scales of the WI gradient

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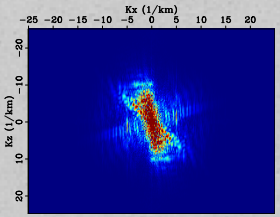

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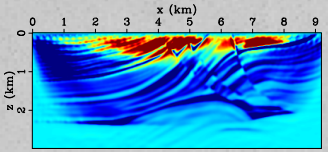


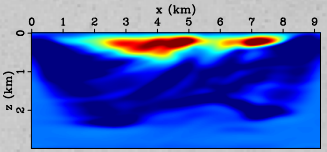


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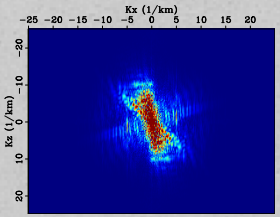


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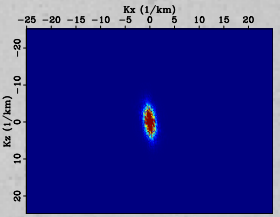

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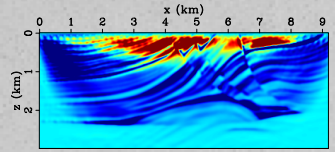


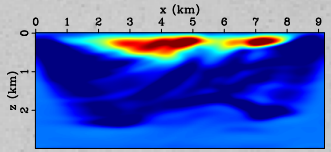


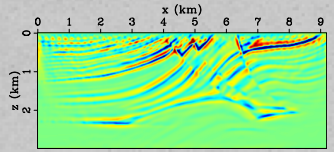


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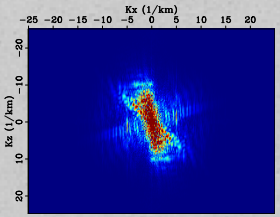


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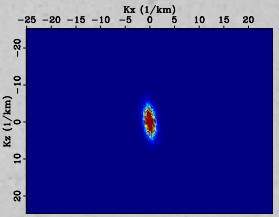
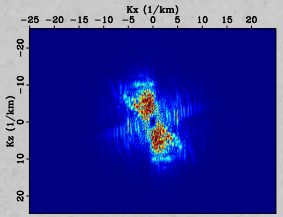
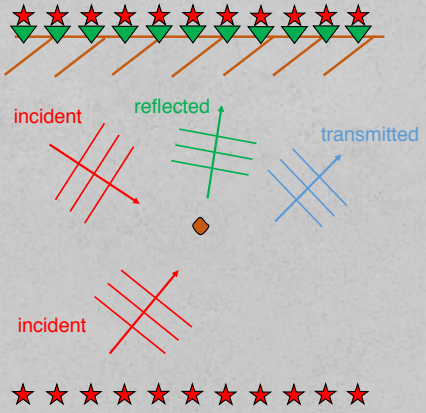


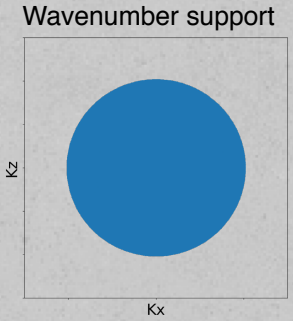



# Single point scatterer

# Complete illumination

# Theoretical wavenumber support ($k$-space)



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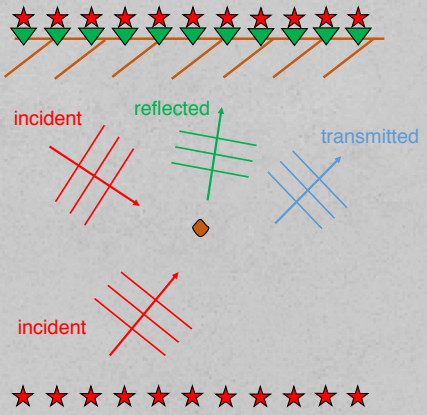
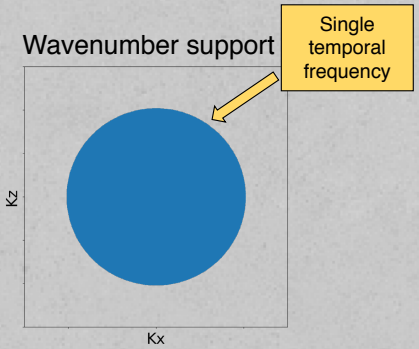
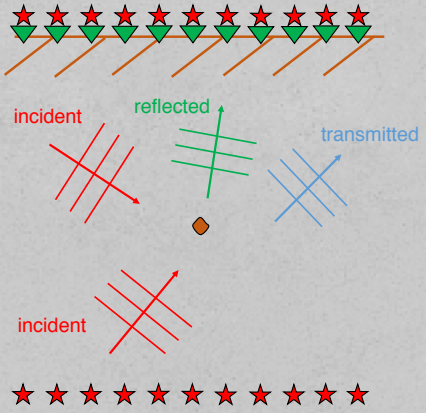
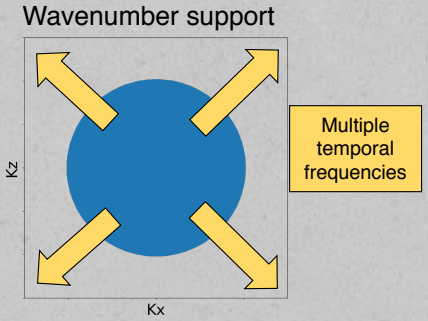


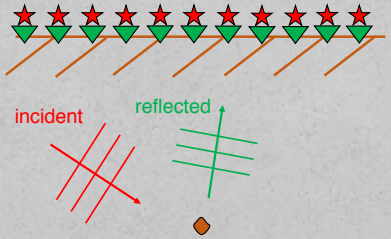



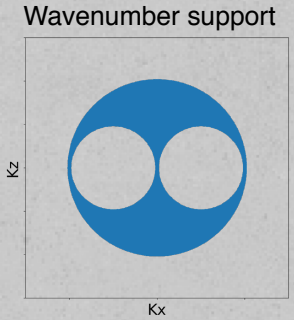
# Theoretical wavenumber support ($k$-space)



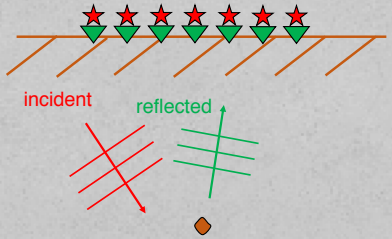



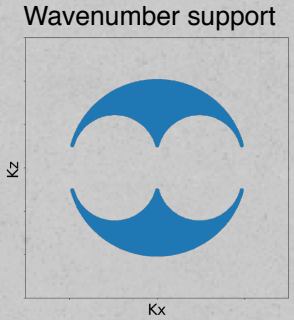
# Surface acquisition (backscattered)



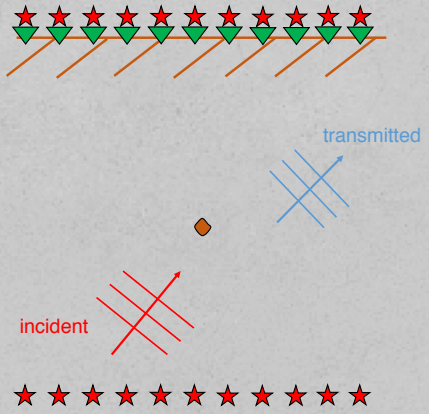



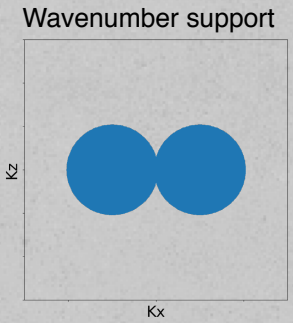
# Surface acquisition (limited but long offset)



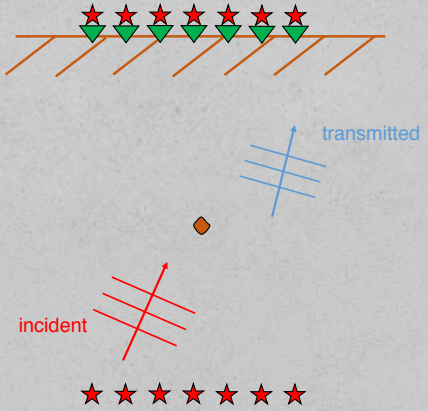



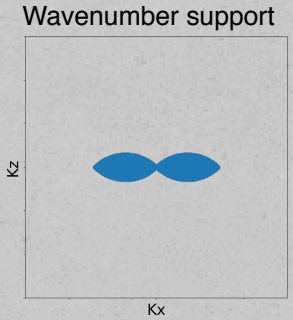
# Transmission data (tomographic)



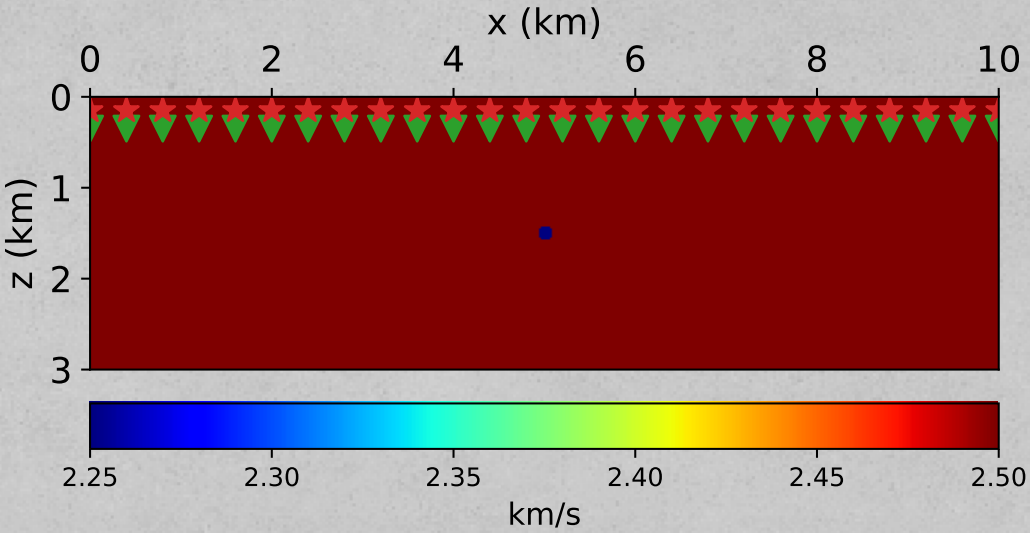



# Transmission data (limited offset)

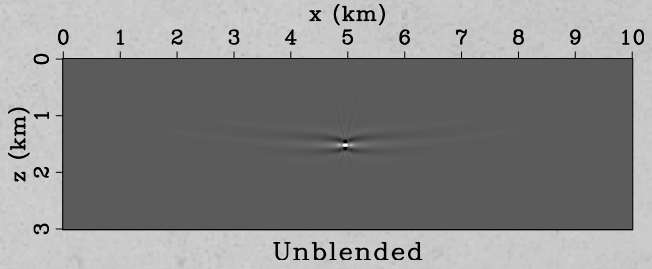


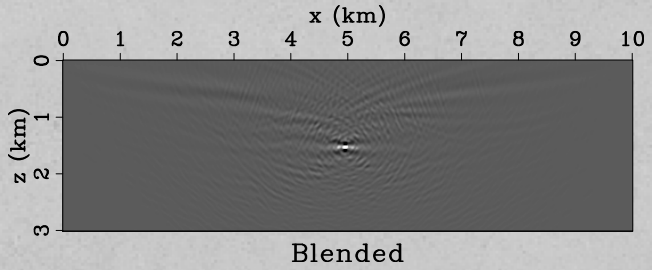



# Reflection (backscattered) example

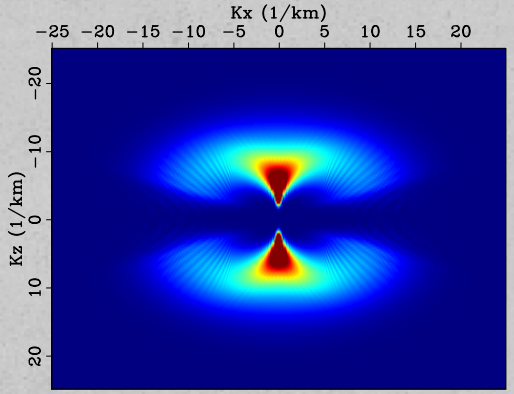


# Image of backscattered data

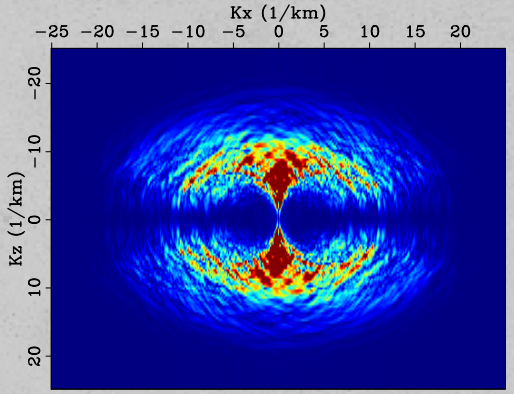


# Wavenumber support

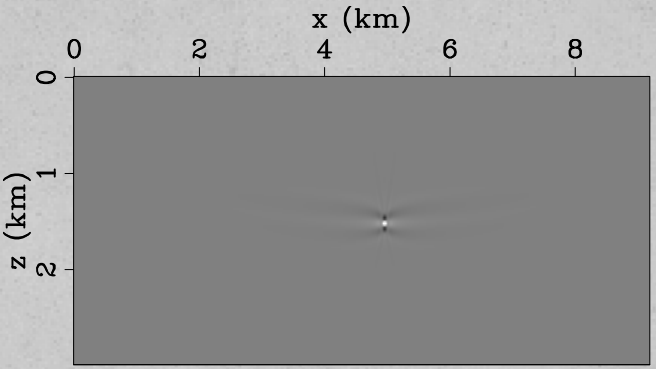


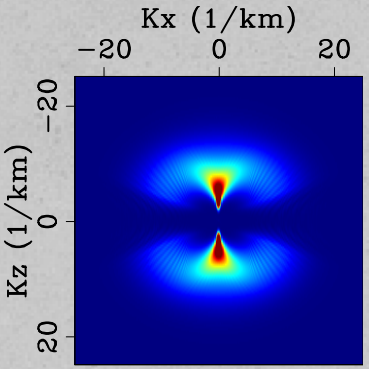

Unblended




Blended

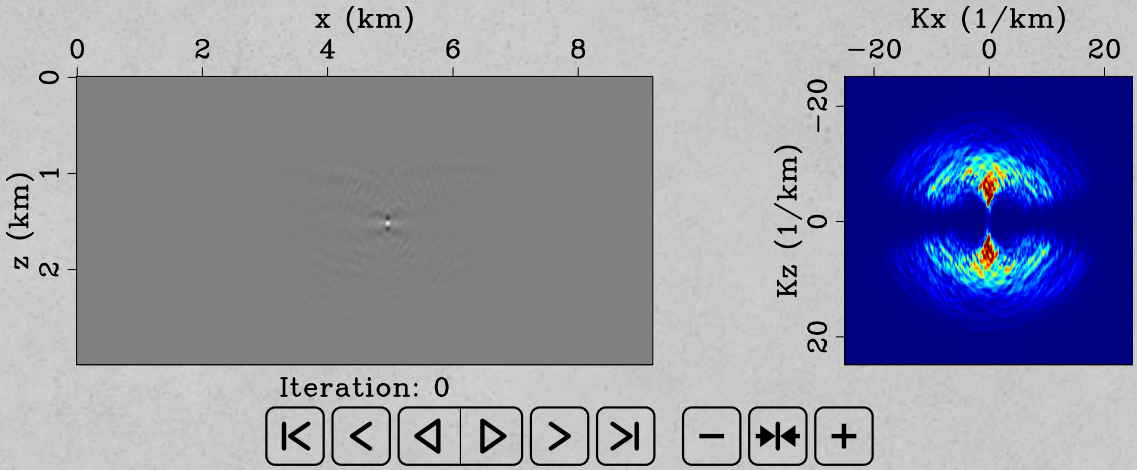
# Linearized inversion of unblended data



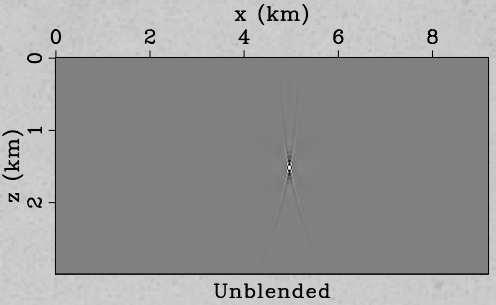



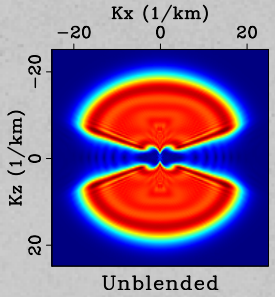

Iteration: 0

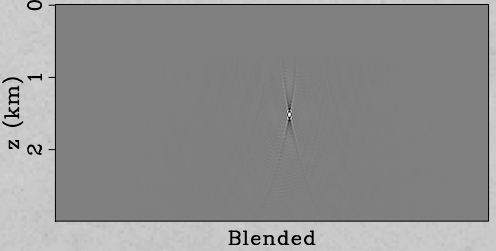
# LWI of blended data

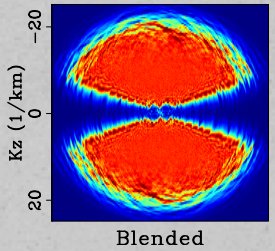


# LWI comparison

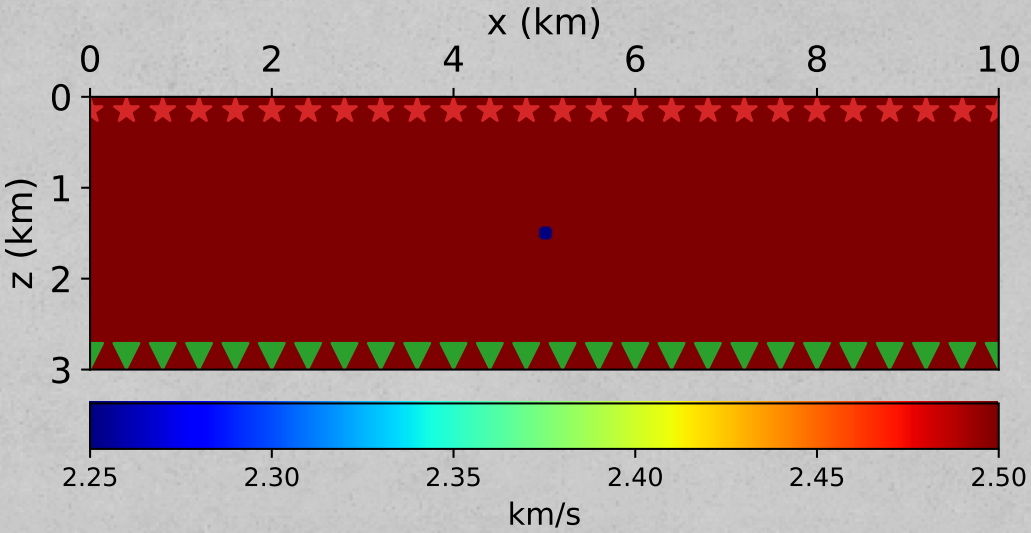


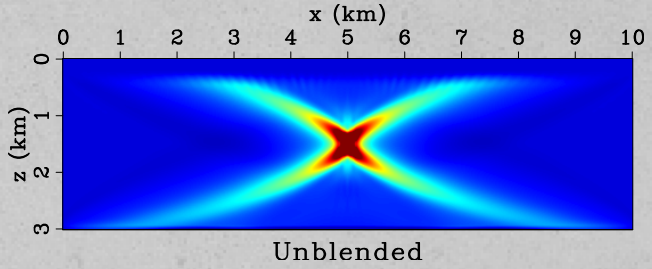



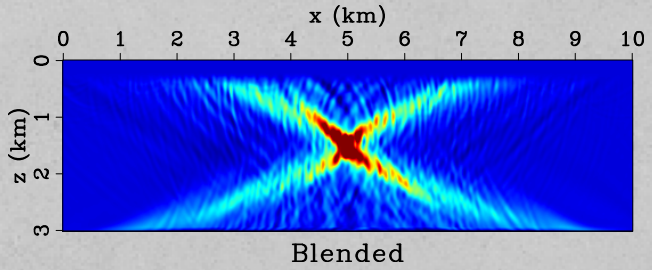



# Transmission (tomographic) example

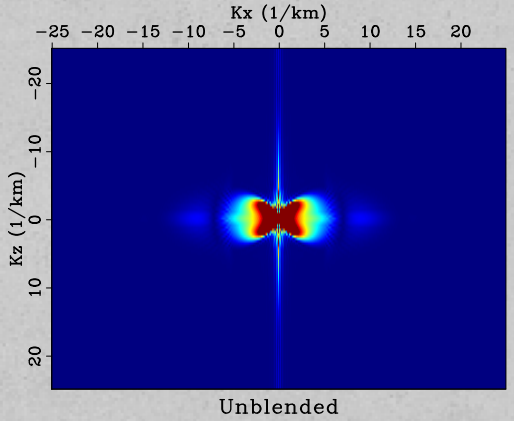


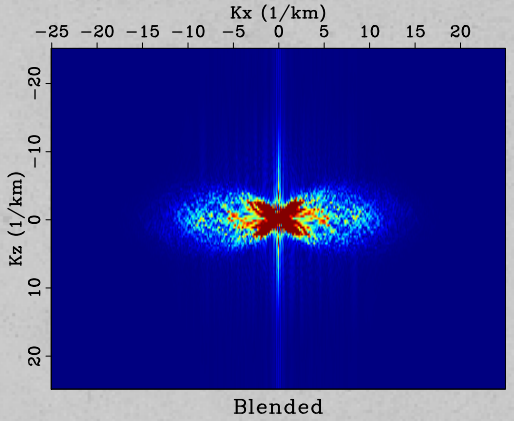
# Image of transmission data



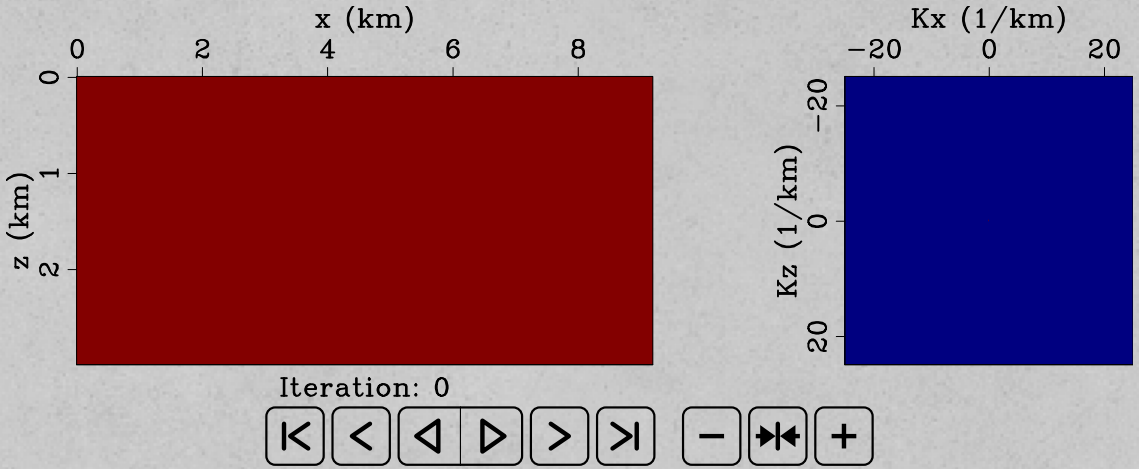



# Wavenumber support

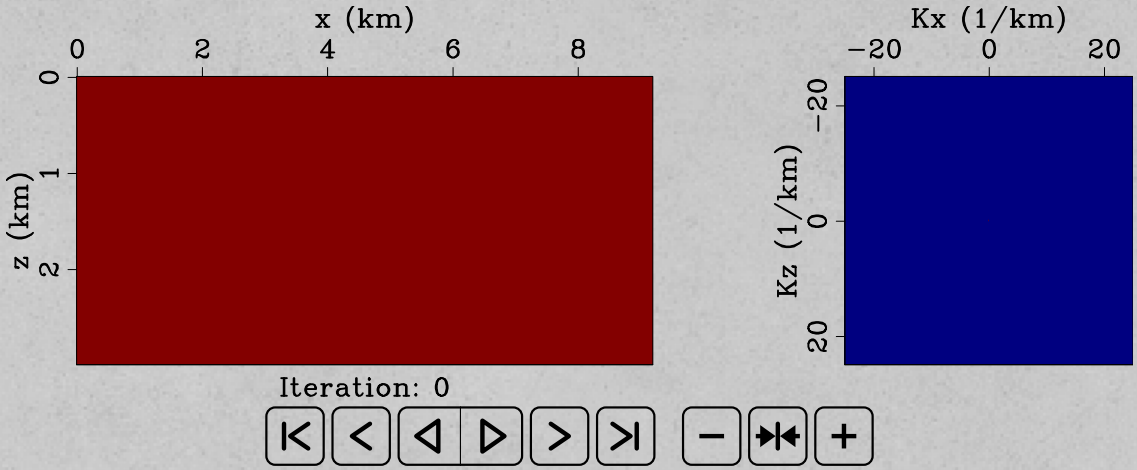


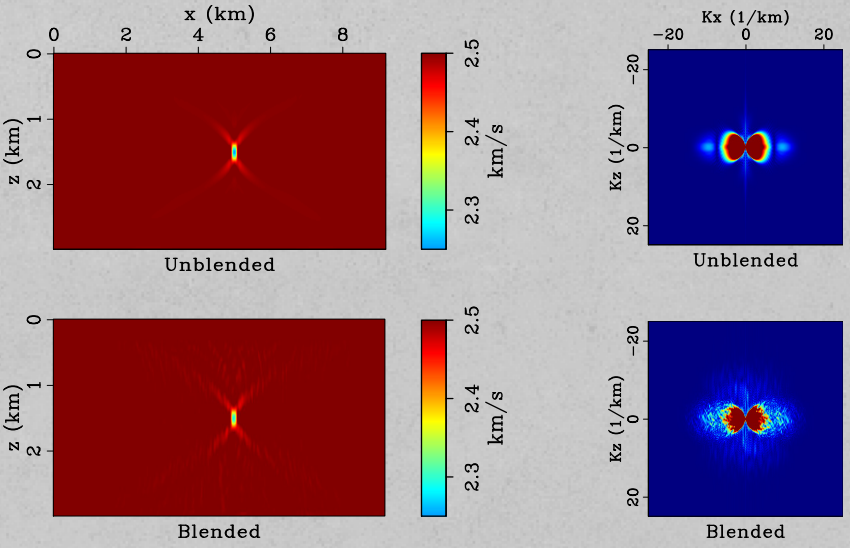
# FWI of unblended data



# FWI of blended data



# FWI comparison



# Summary/Comments

1. High wavenumbers are most affected
   - Backscattered component
   - Transmission component

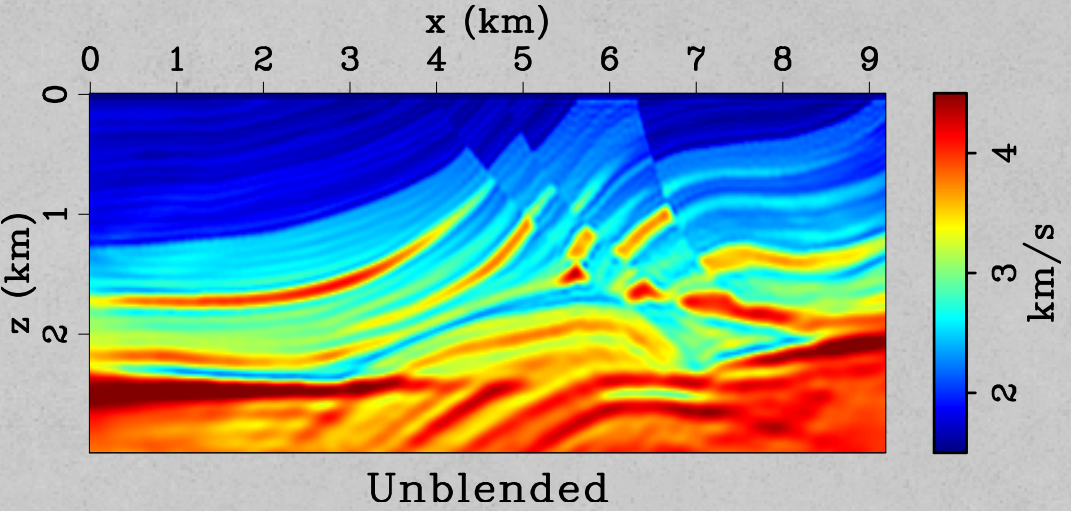
2. Inversion is effective in mitigating many artifacts

3. **4D**: Deblending can sometimes do more harm than good (Krupovnickas et al., 2014)

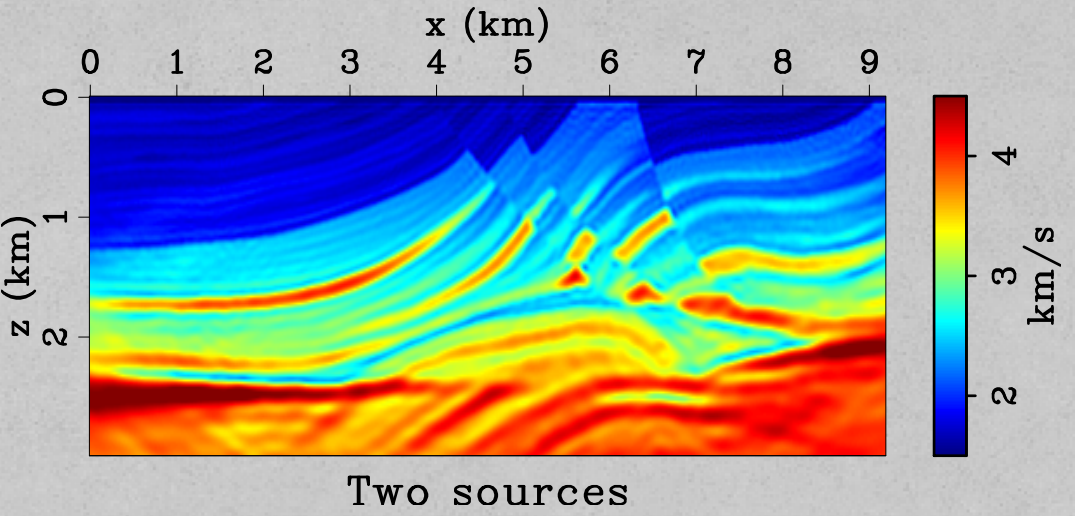
# Is waveform inversion good enough for 4D?

**Q**: Can we use waveform inversion of blended data for 4D analysis? (Ayeni et al., 2009)

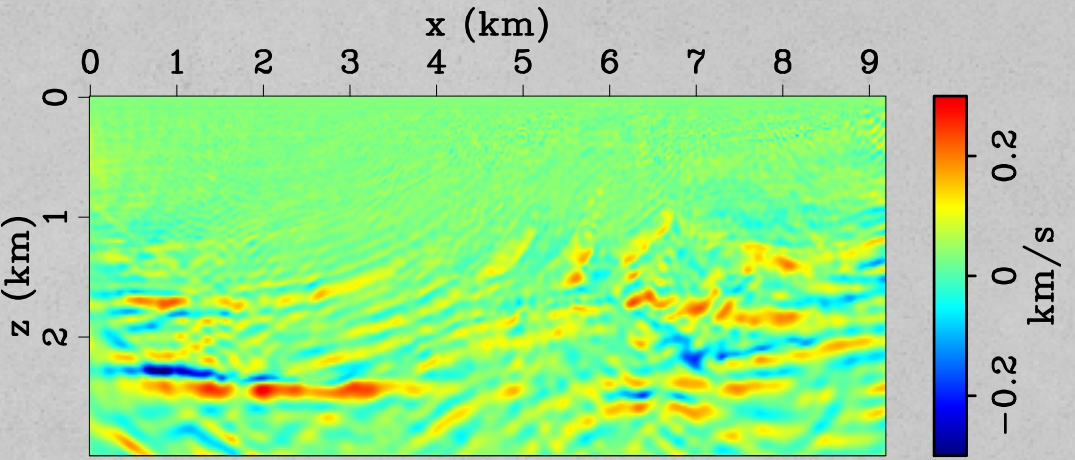
# Conventional FWI



# Blended FWI: two sources

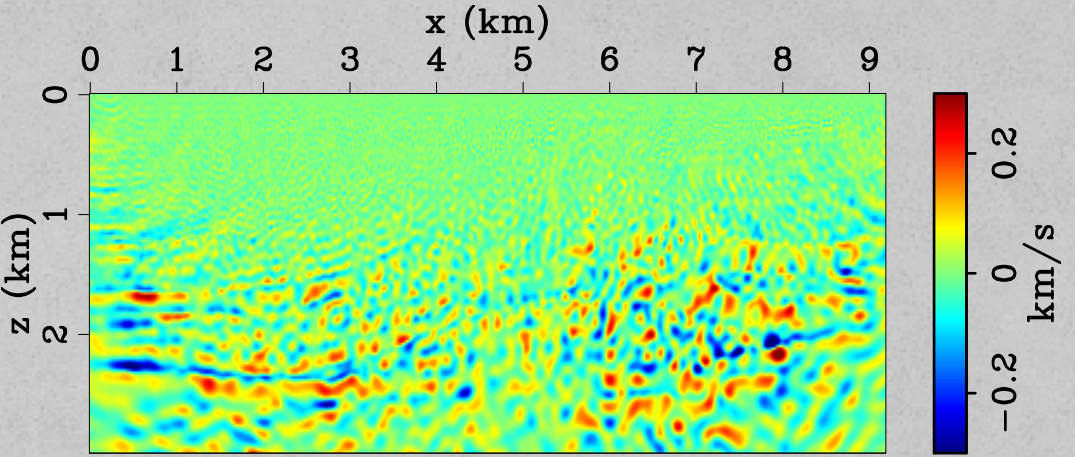


# Two sources: difference




Difference: two sources

# Eight sources: difference

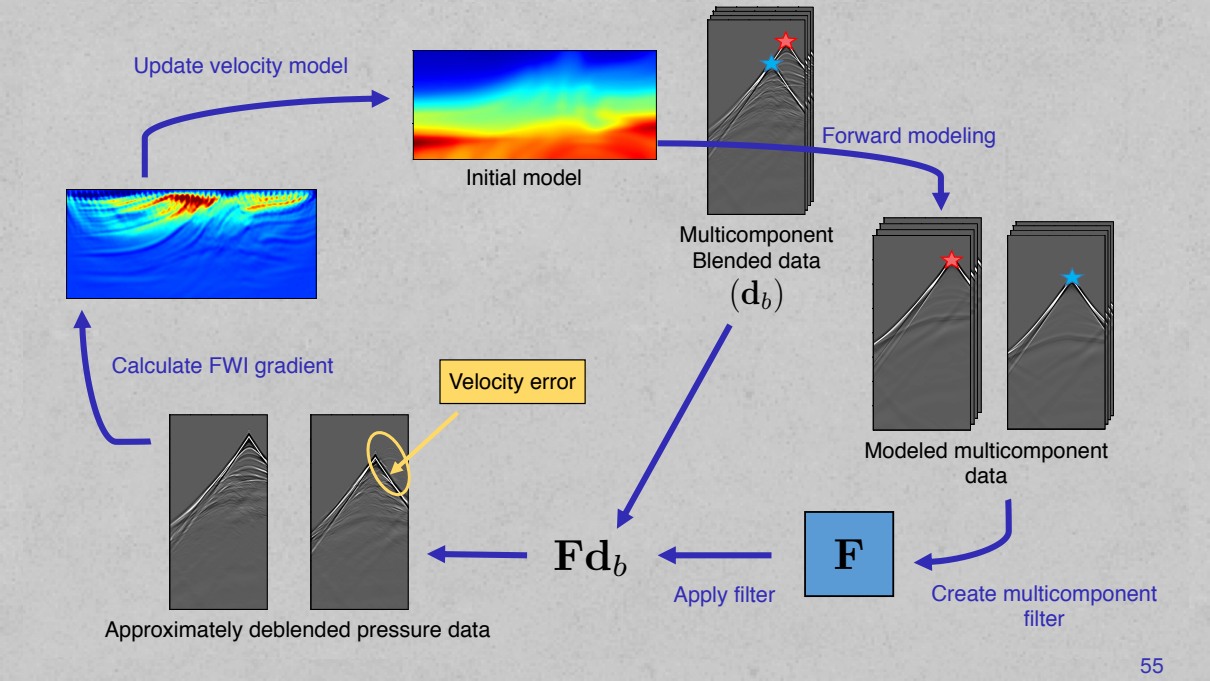



Difference: eight sources

# Is waveform inversion good enough for 4D?

**Q**: Can we use waveform inversion of blended data for 4D analysis? (Ayeni et al., 2009)

**A**: Perhaps for two sources


Update velocity model
Initial model
Forward modeling
Multicomponent
Blended data
$(\mathbf{d}_b)$
Modeled multicomponent
data
Create multicomponent
filter
$\mathbf{F}$
Apply filter
$\mathbf{F}\mathbf{d}_b$
Velocity error
Calculate FWI gradient
Approximately deblended pressure data

# Questions?