Seismic statics application plus trace interpolation

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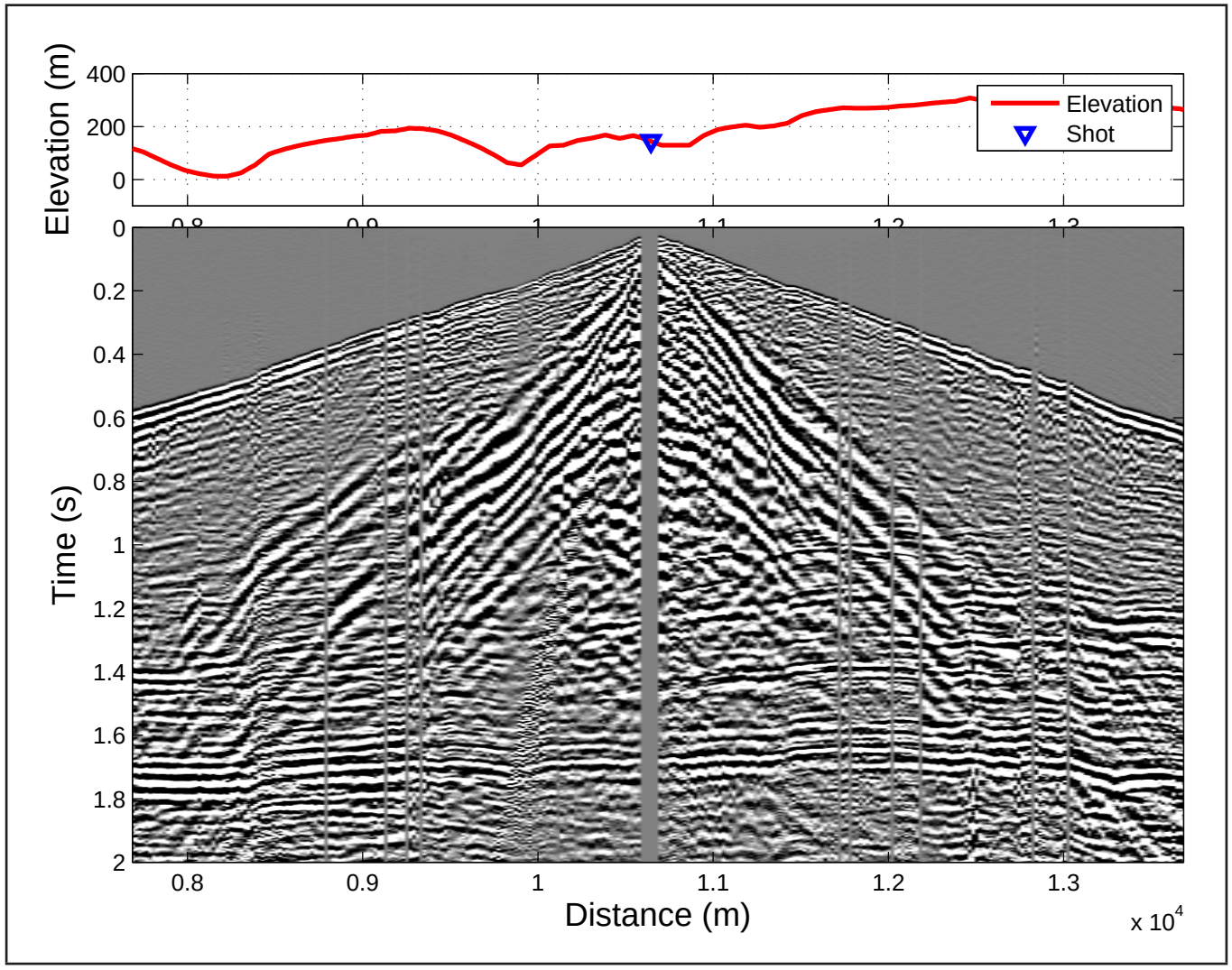
November 30, 2007

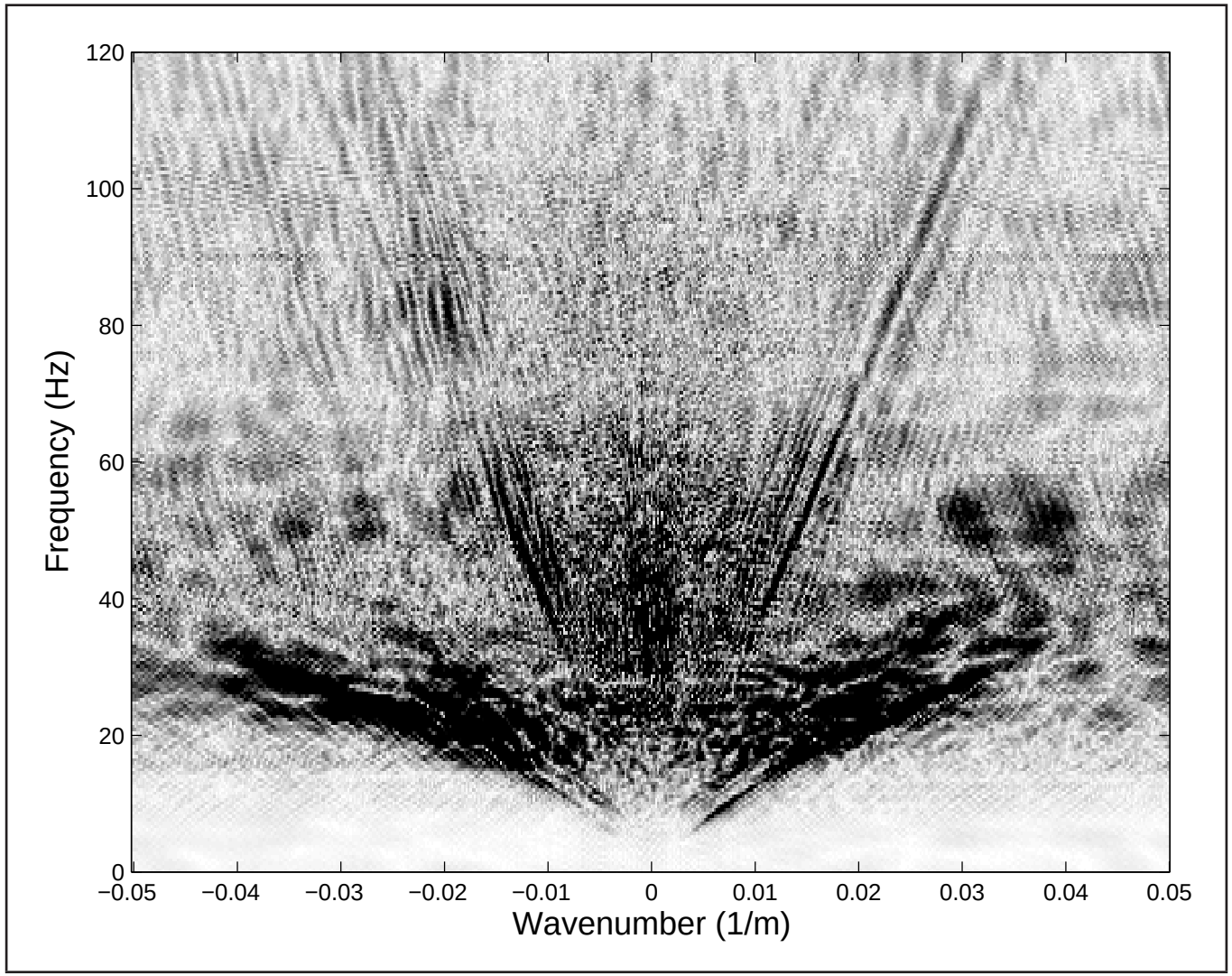
Outline

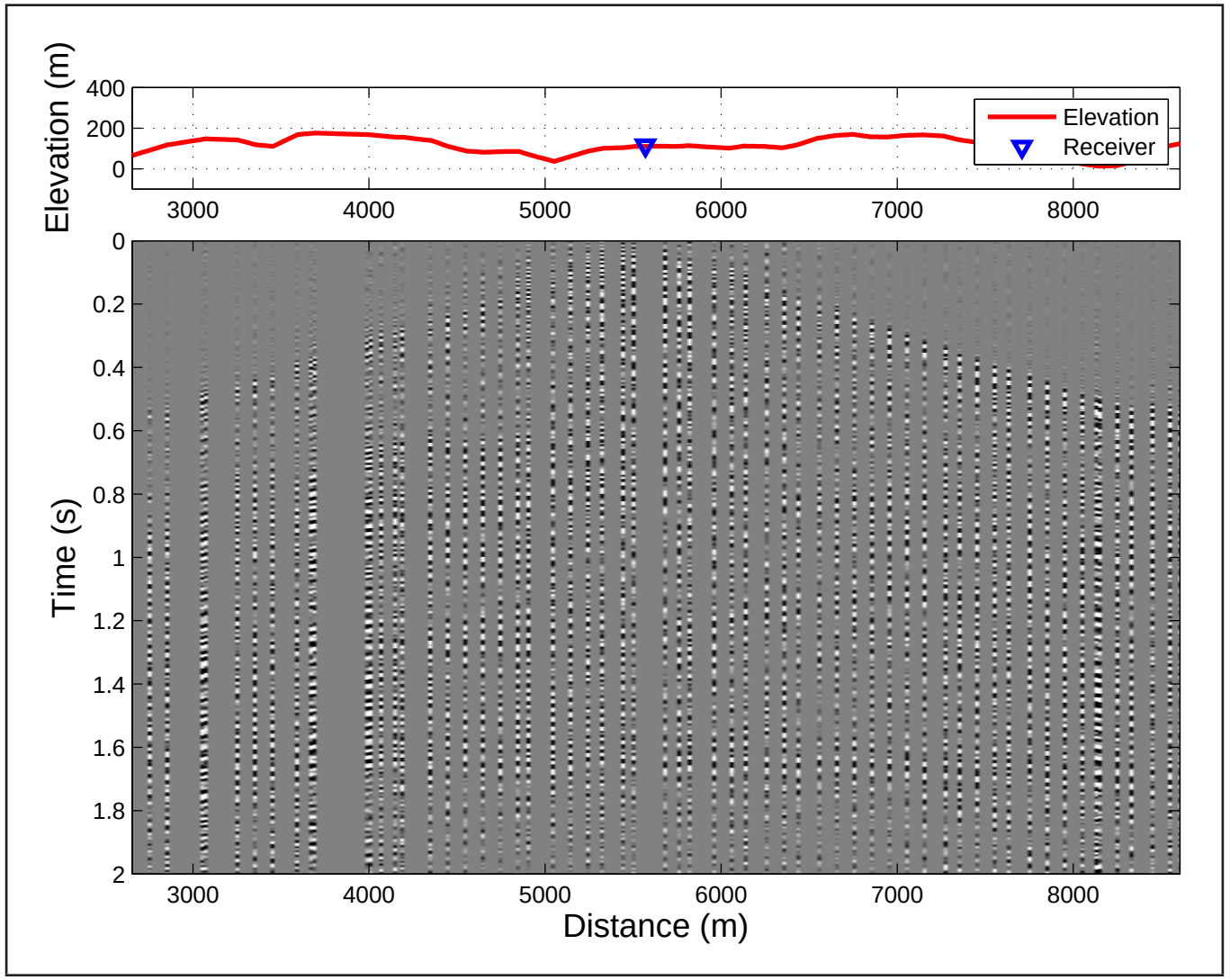
- Introduction
- Damped least squares
- Examples
- Conclusions Acknowledgements

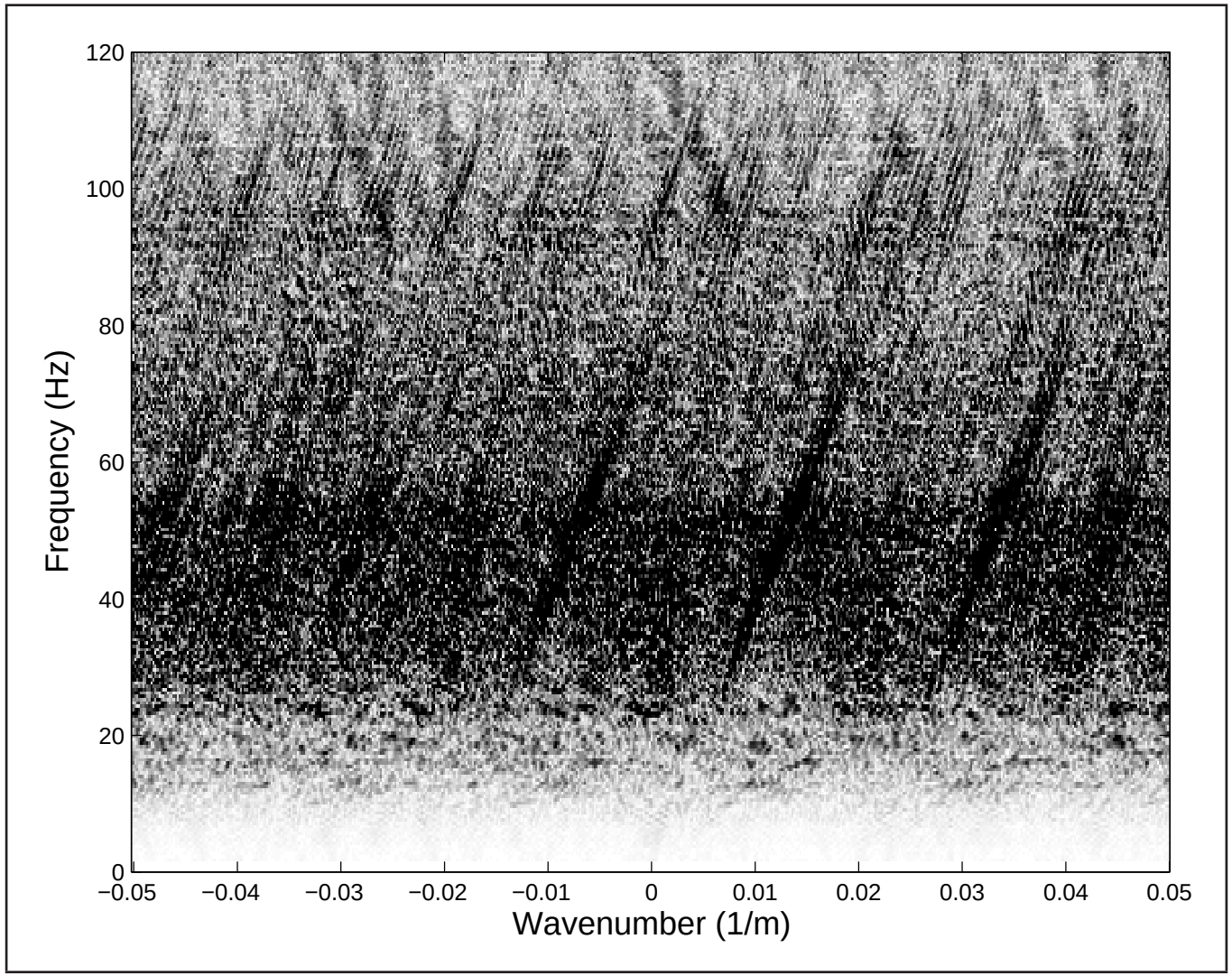
Introduction

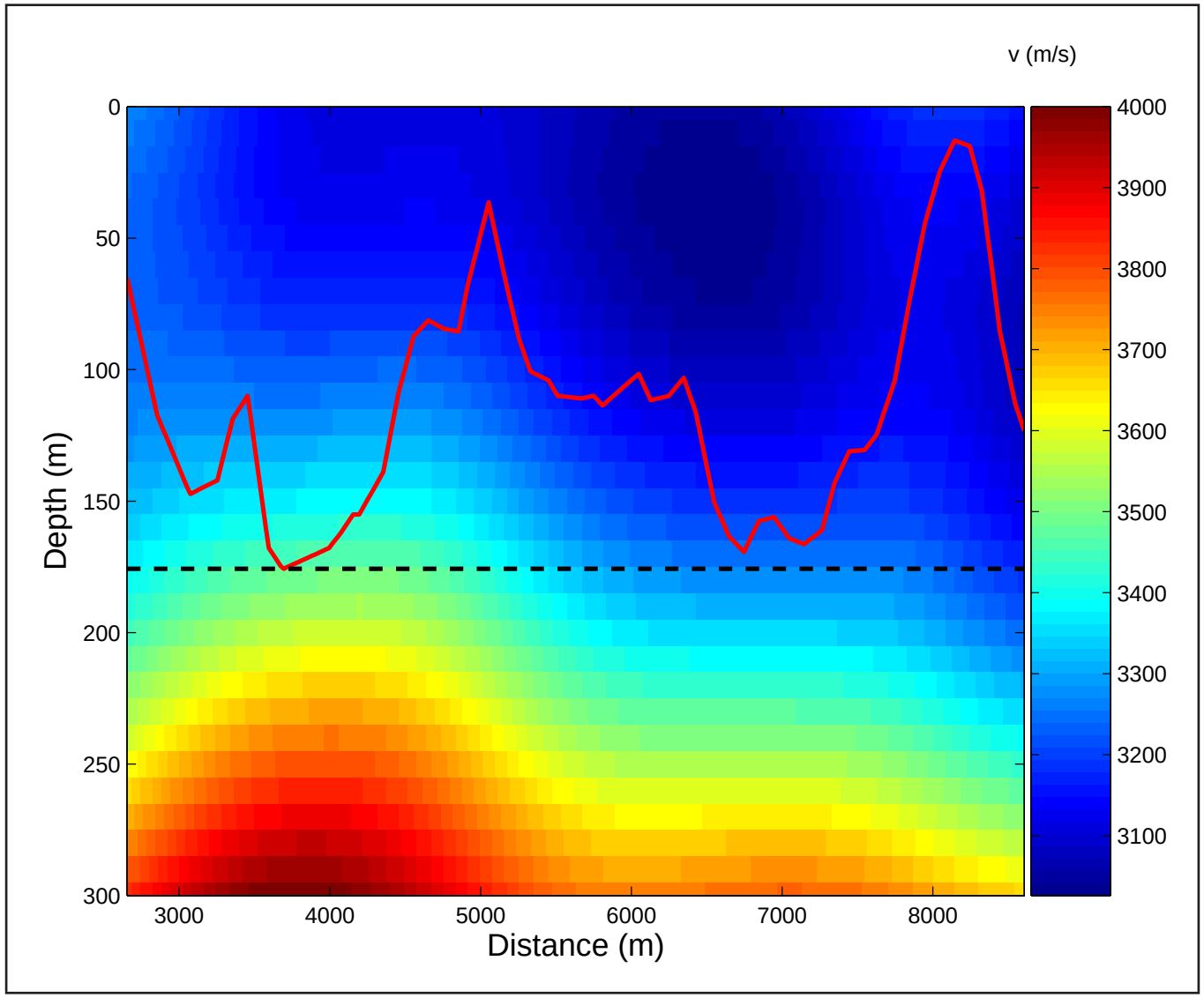
- Heterogeneity and topography cause "statics" and missing traces
- Depth migrate through nearsurface based on headwaves - don't invoke an imaging condition
- Then, reflection analysis is improved - fix reflections with headwaves


Elevation (m)
400
200
0
Elevation
Shot
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Time (s)
0.8
0.9
1
1.1
1.2
1.3
Distance (m)
x 10^4


120
100
80
60
40
20
0
Frequency (Hz)
−0.05
−0.04
−0.03
−0.02
−0.01
0
0.01
0.02
0.03
0.04
0.05
Wavenumber (1/m)


Elevation (m)
400
200
0
3000
4000
5000
6000
7000
8000
Elevation
Receiver
Time (s)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Distance (m)


120
100
80
60
40
20
0
Frequency (Hz)
−0.05
−0.04
−0.03
−0.02
−0.01
0
0.01
0.02
0.03
0.04
0.05
Wavenumber (1/m)


v (m/s)
4000
3900
3800
3700
3600
3500
3400
3300
3200
3100
0
50
100
150
200
250
300
Depth (m)
3000
4000
5000
6000
7000
8000
Distance (m)

Damped least squares

- Statics and interpolation by damped least-squares

$$\psi_{z+\Delta z} = \left[U^A_{-\Delta z}\, W_e\, U_{-\Delta z} + \varepsilon^2 W_m\right]^{-1} U^A_{-\Delta z}\, W_e\, \psi_z$$

- Very expensive - $\propto$ Pflops for one 1000×1000 trace gather

$$\left[U^A_{-\Delta z}\, W_e\, U_{-\Delta z} \psi_z\left(x'\right)\right](x) =$$
$$\frac{1}{(2\pi)^4} \int \psi_z\left(x'\right) e^{-i\left[k_x, y-x'\right]} e^{-i\left[k'_x, x-y\right]}$$
$$\alpha\left(y, k'_x\right)_{\Delta z}\, \tilde{\alpha}\left(y, k_x\right)_{-\Delta z}\, dk_x\, dy\, dk'_x\, dx'$$

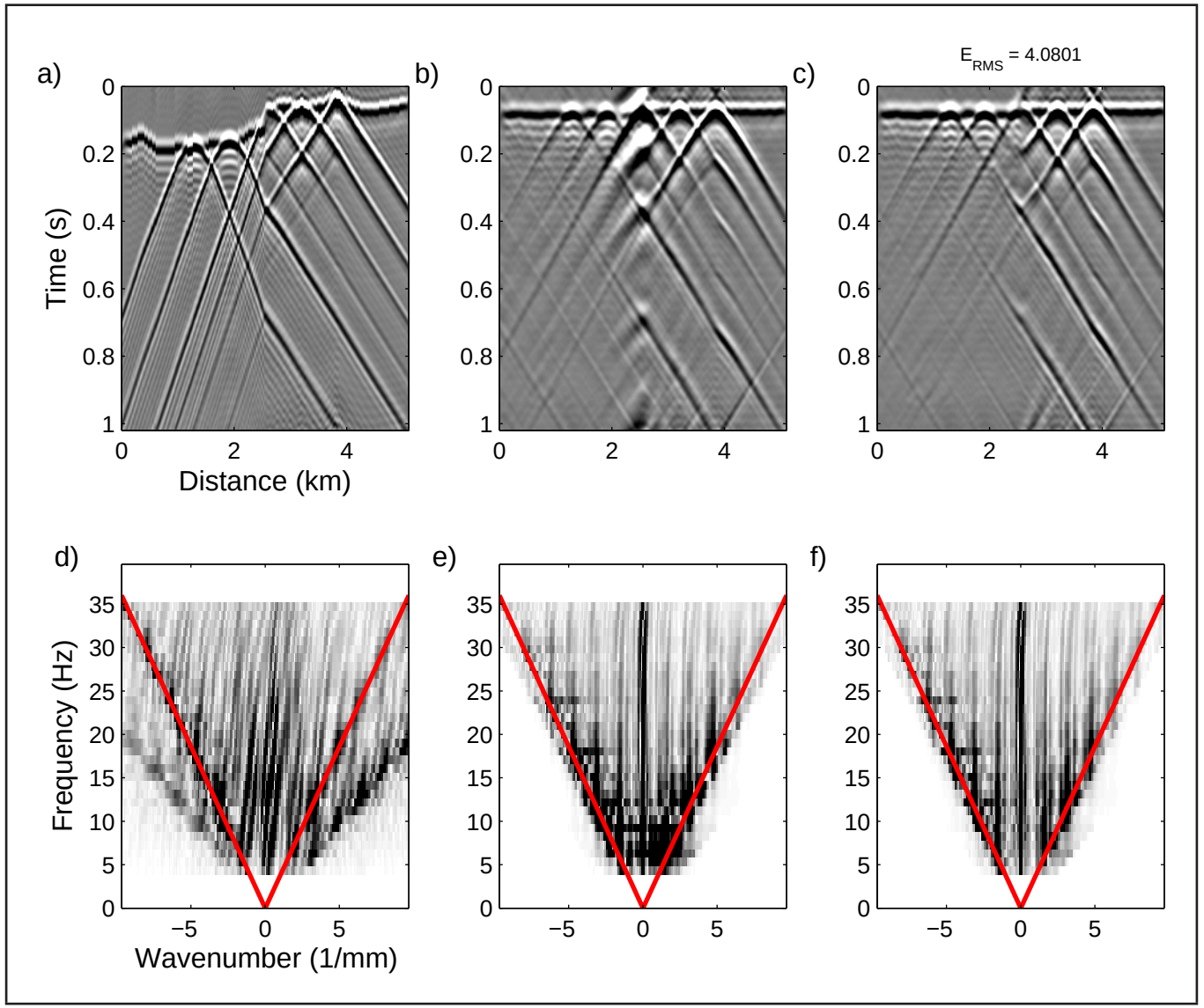
- Expand around one of the wavenumbers

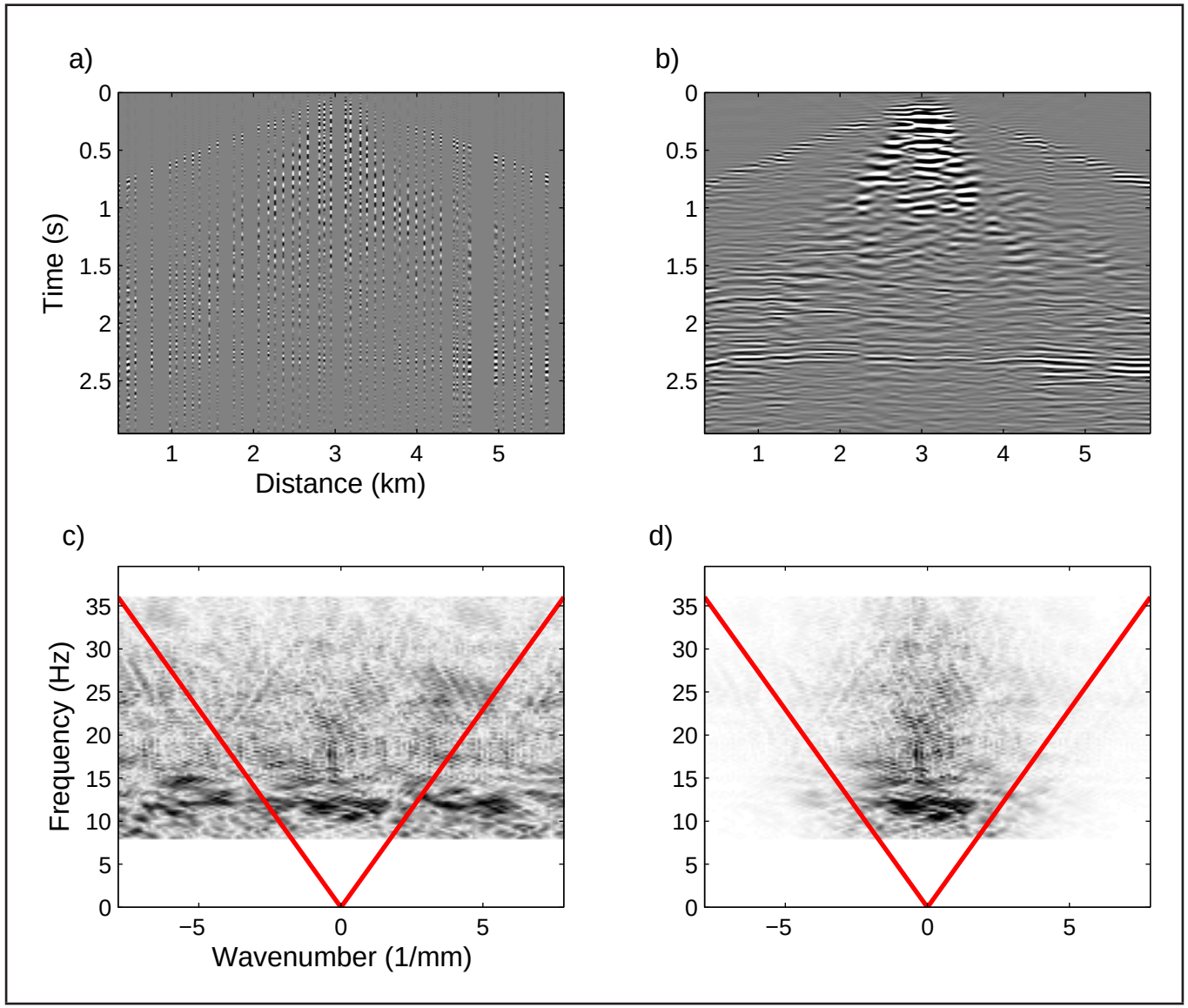
$$\left[U^{A}_{-\Delta z}\, W_e\, U_{\Delta z}\, \psi\left(x'\right)\right]\left(x\right) =$$

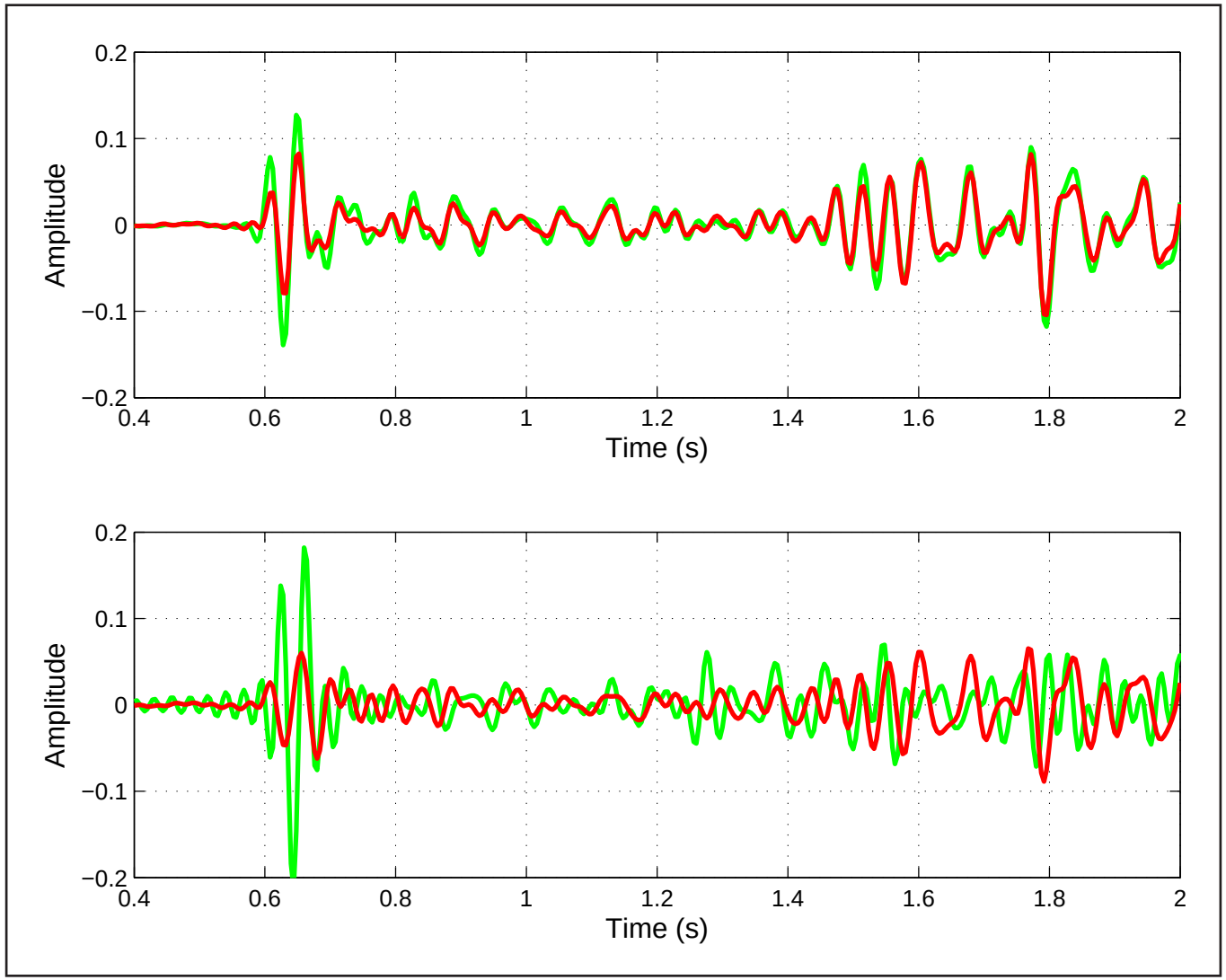
$$\sum_{j=0}^{\infty} \frac{i^j}{j!} \frac{1}{\left(2\pi\right)^2} \int \psi\left(x'\right) e^{-ik_x\left[x-x'\right]} \left[\partial_x^j\, h_j\left(x,k_x\right)_{\Delta z}\right]\, dk_x\, dx'$$

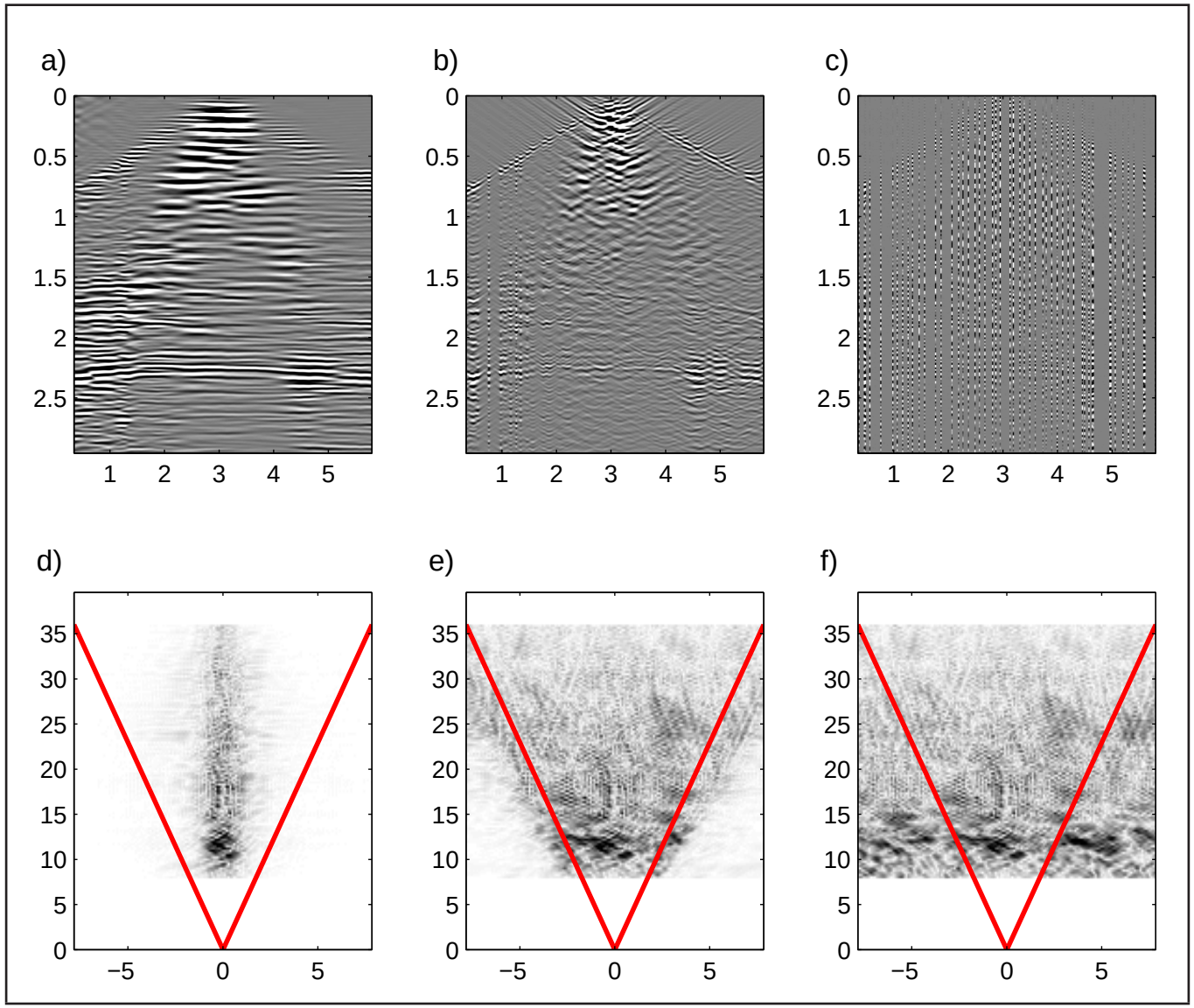
where

$$h_j\left(x,k_x\right)_{\Delta z} = \left[\partial_{k_x}^j \alpha\left(x,k_x\right)_{\Delta z}\right] \tilde{\alpha}\left(x,k_x\right)_{-\Delta z}$$


a)
b)
c)
E_{RMS} = 4.0801
Time (s)
Distance (km)
d)
e)
f)
Frequency (Hz)
Wavenumber (1/mm)


a)
b)
c)
d)
Time (s)
Distance (km)
Frequency (Hz)
Wavenumber (1/mm)
0
0.5
1
1.5
2
2.5
1
2
3
4
5
35
30
25
20
15
10
5
−5
0
5


0.2
0.1
0
−0.1
−0.2
Amplitude
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Time (s)
0.2
0.1
0
−0.1
−0.2
Amplitude
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Time (s)


a)
b)
c)
d)
e)
f)
0
0.5
1
1.5
2
2.5
1
2
3
4
5
35
30
25
20
15
10
5
0
−5
0
5

Conclusions

- Data regularization/datum, imaging, and model building improved
- Can be run as interpolate only or as statics only
- A further approximation is required for 3D
- Conjugate gradient solution will be faster

Acknowledgements

- CREWES sponsors, faculty and staff
- UC Faculty of science