Seismic wave Propagation and Imaging in Complex media: a European network

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Post-doctoral researcher

Host Institution: OGS, Trieste
Place of Origin: Geneva, Switzerland
Appointment Time: January 2007

Project: Green's Function Interpolation for Source Inversion.

Task Groups: TG Numerical Methods, TG Local Scale

Cooperation: University of Hamburg

GREEN FUNCTION INTERPOLATION: A USEFUL TOOL TOWARD FAST KINEMATIC SOURCE INVERSION

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Objective

- Develop and implement an interpolation method for Green functions.
  - Fast generation of a Green function database.
  - Acceleration of the kinematic source inversion.
  - “Improvement of the spatial resolution.”

Outline

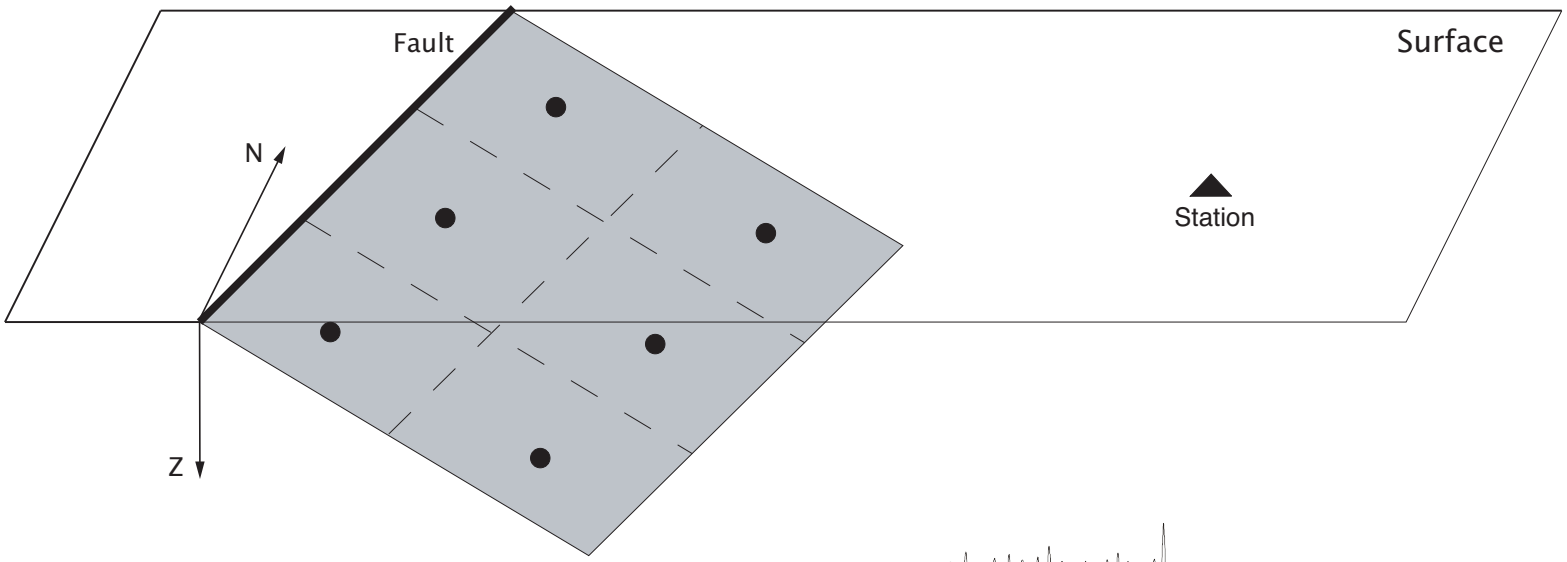
- Kinematic source inversion
- Interpolation methods and computational scheme
- Gülünay’s method
- Conclusions

Kinematic Source Inversion

$$u_k(\mathbf{x}_1, t_1) = \int_0^{t_1} \int_\Sigma \left[\frac{\delta}{\delta x_m} G_{kl}(\mathbf{x}, \mathbf{x}_1, t_1 - t) \right] C_{ijlm}(\mathbf{x})\, n_j(\mathbf{x})\, a_i(\mathbf{x}, t)\, dt\, dS$$

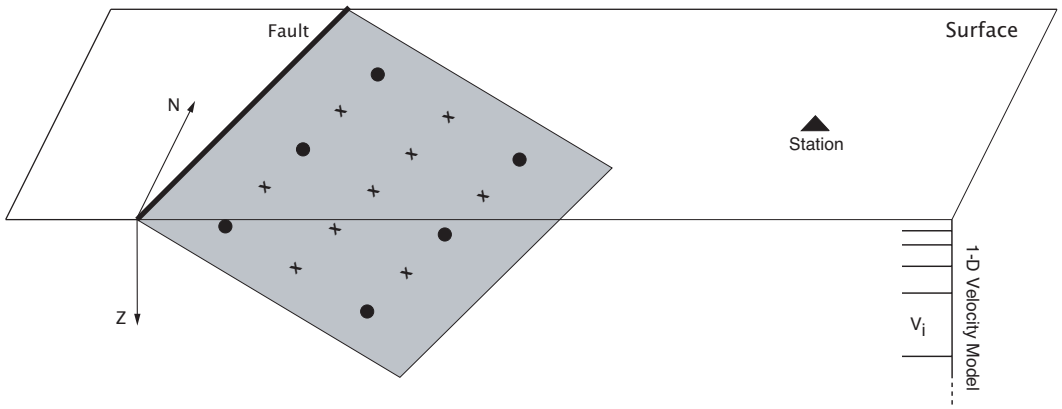
u	=	*displacement*	n	=	*normal to the surface*
G	=	*Green function*	a	=	*slip distribution*
C	=	*stiffness tensor*			

Kostrov and Das, 1988



Interpolation Context and Constraints

- Data type: regional or teleseismic
- Full waveform
  - waveform conservation
  - absolute amplitude conservation
  - coherent temporal offsets
- Velocity model: 1-D



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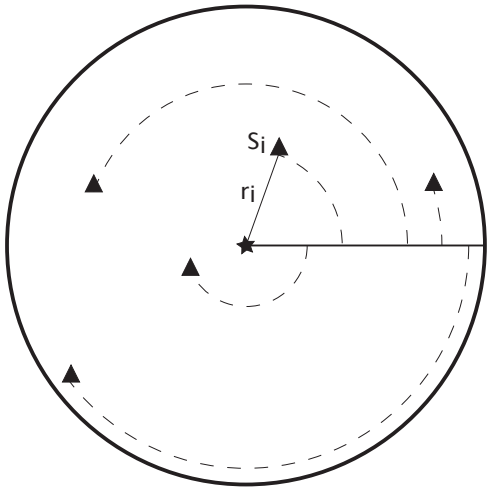

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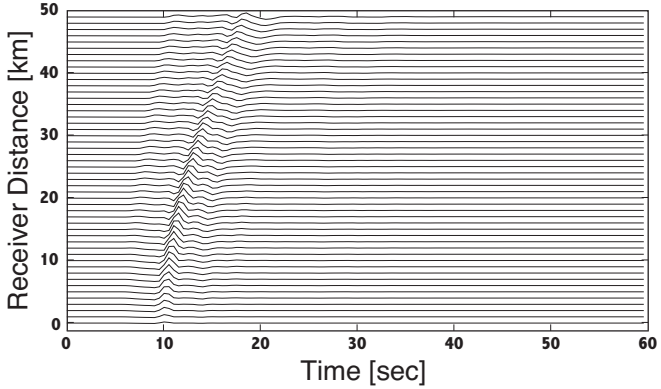

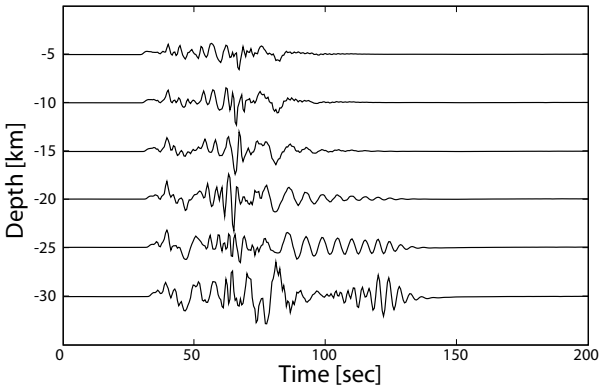

Interpolation Methods

1. Linear Interpolation
2. Radon Transform (slant stack)
   - Slant-Stack Migration (Novotný, 1987)
3. Spectral Methods
   - Spitz's method (Spitz, 1991)
   - Porsani's method (Porsani, 1999)
   - Gülünay's method (Gülünay, 2003)
4. Other
   - Wave-equation interpolation (Ronen, 1987)
   - Nonlinear interpolation (Martinson and Hopper, 1992)

Positive

- easy and fast
- requires two waveforms
- coherent temporal offsets

Negative

- amplitudes are not preserved
- waveforms are not necessarily conserved

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Positive

- irregular sampling allowed

Negative

- numerically costly

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Positive

- fast

Negative

- operates on a seismic section
- regular spatial sampling

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Positive

- fast and accurate

Negative

- 2 systems of linear equations

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Positive

- fast
- 1 system of linear equations

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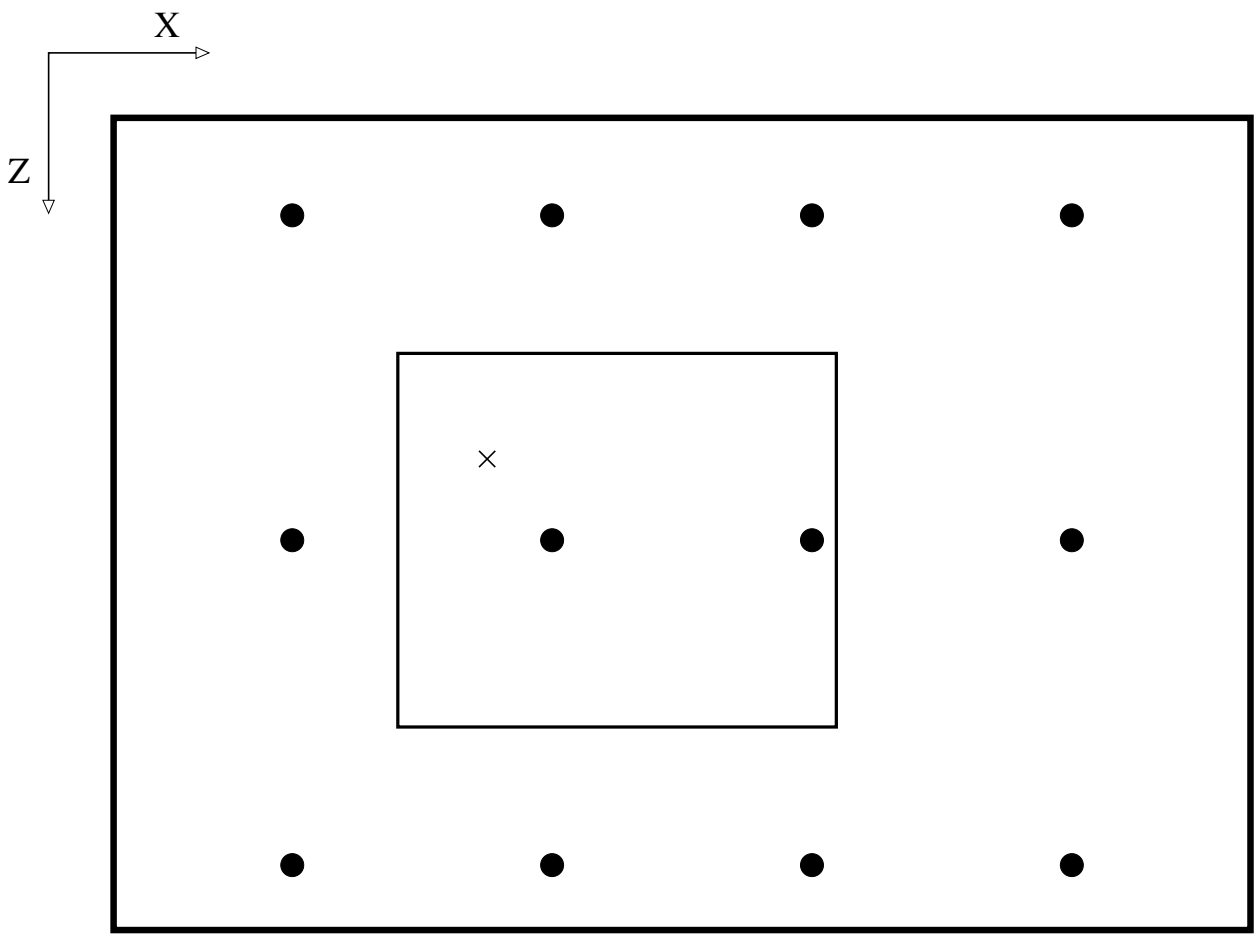
Positive

- fast

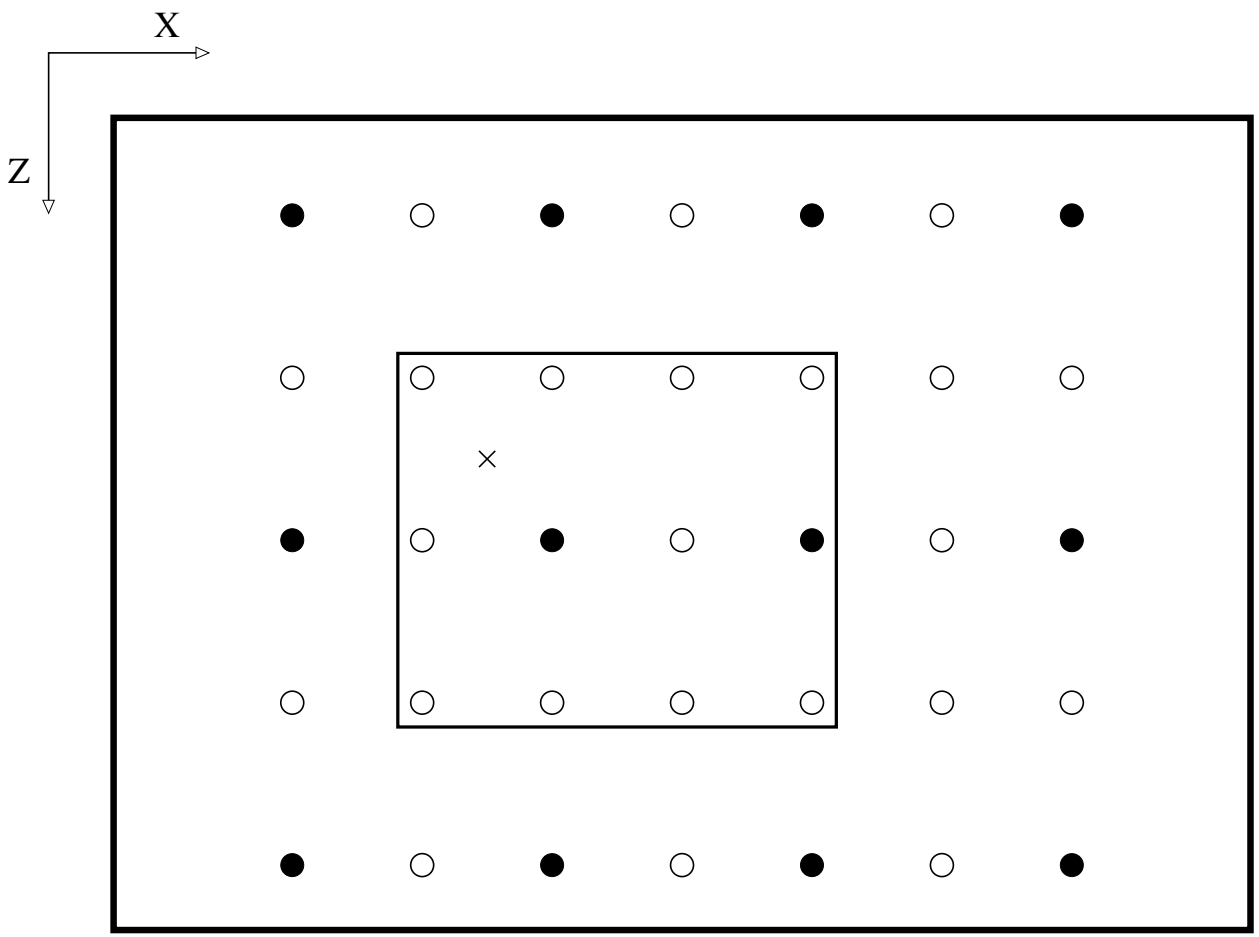
Negative

- generates noise

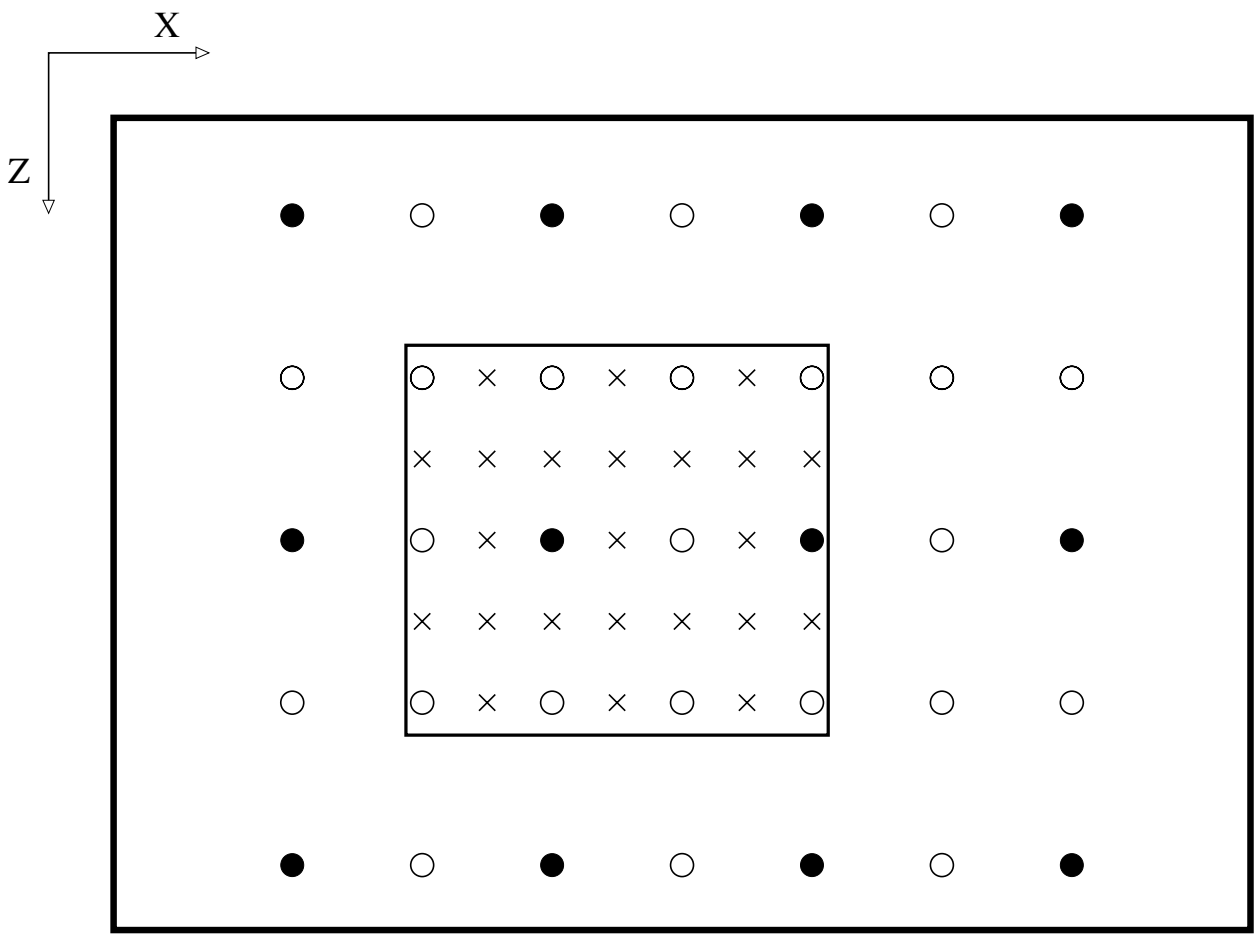
Hierarchical Computation Scheme



Hierarchical Computation Scheme



Hierarchical Computation Scheme

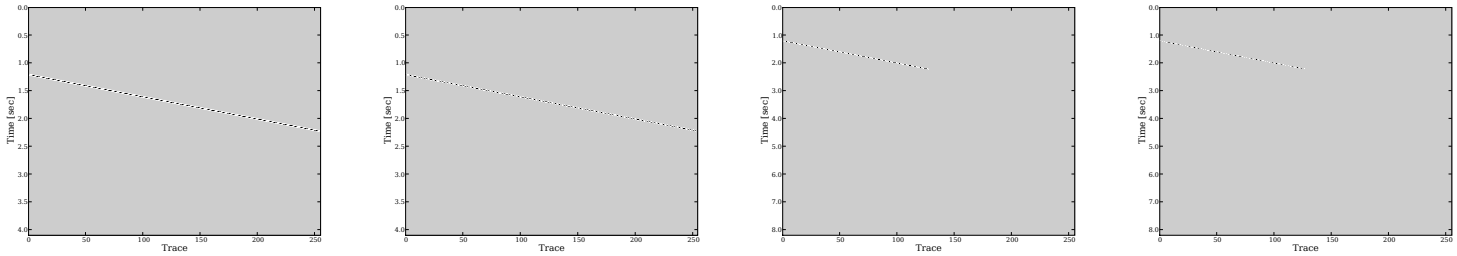


Gülünay's Interpolation

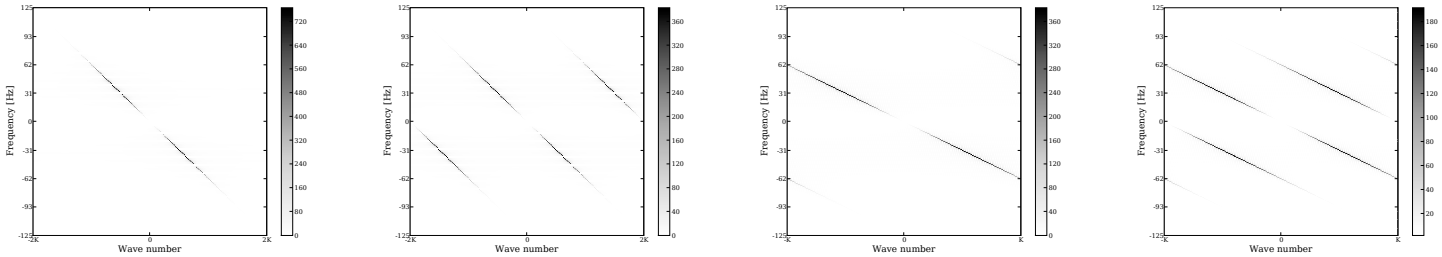
A synthetic example

256x1024 256x1024 256x2048 256x2048

T-X



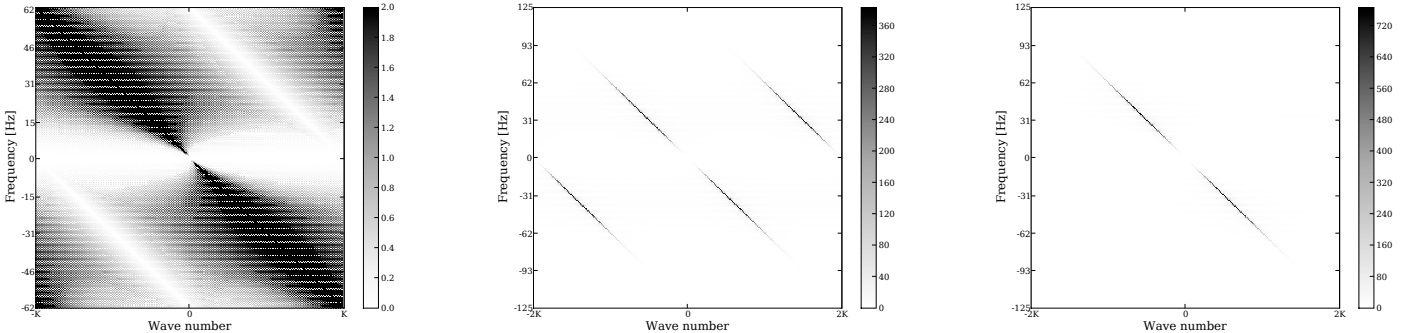
F-K

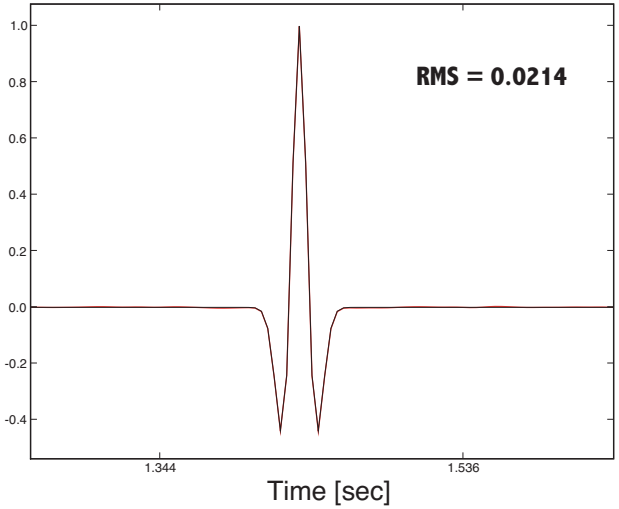


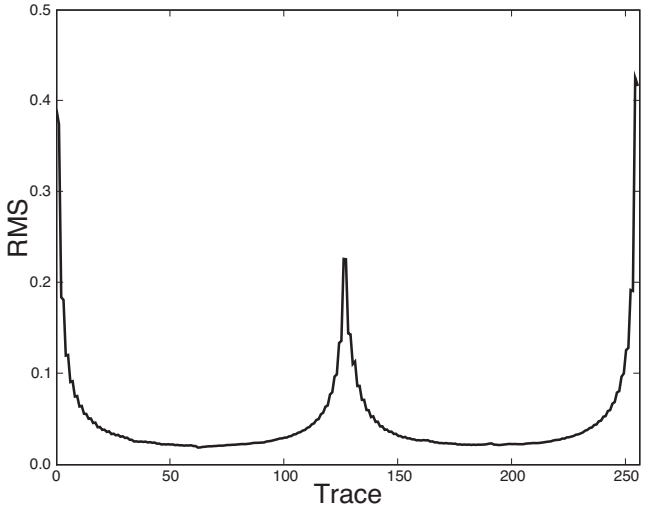
Gülünay's Interpolation

A synthetic example

F-K

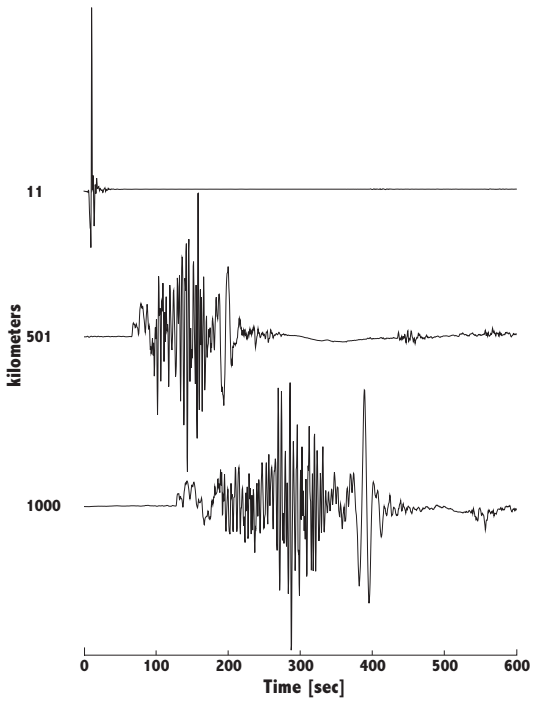


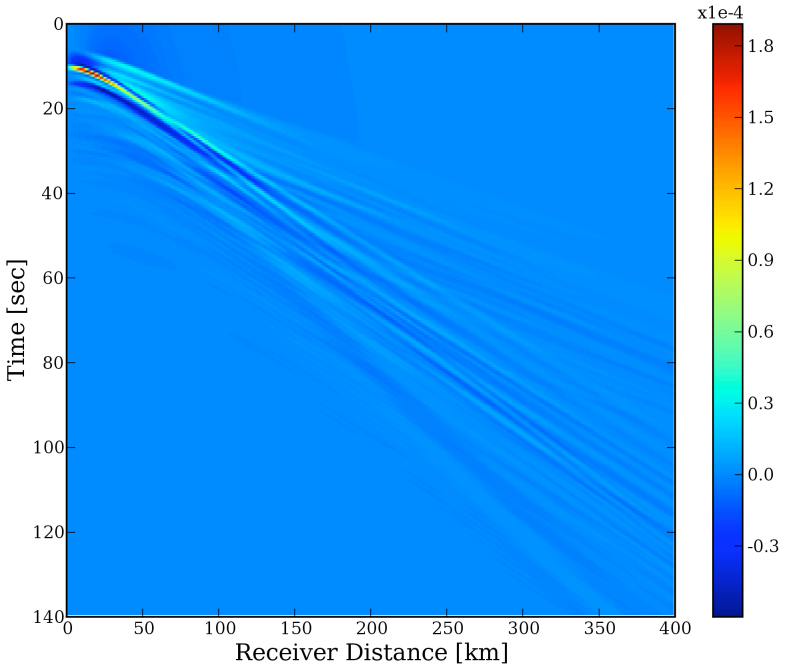




Data

Green functions for the Marmara Sea region



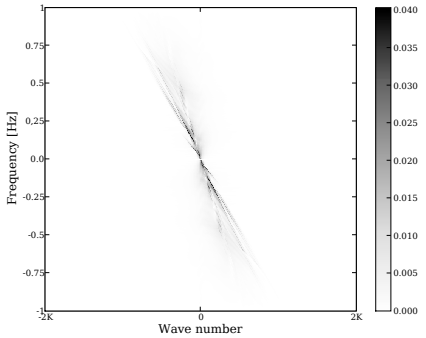


- $M_0 = 1\ Nm$
- $STF = 1.5\ sec$
- $t = 600\ sec$
- $dt = 0.5\ sec$
- $r = 1 - 1000\ km$
- $z = 5 - 35\ km$

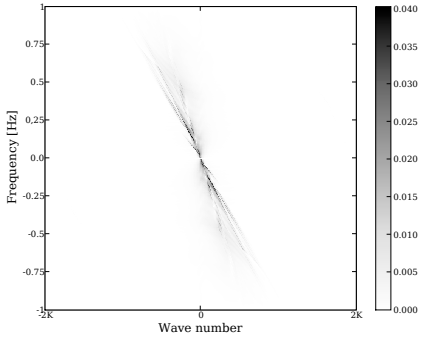
Gülünay's Interpolation

Marmara Sea database: GF component 1, source depth: 30 km

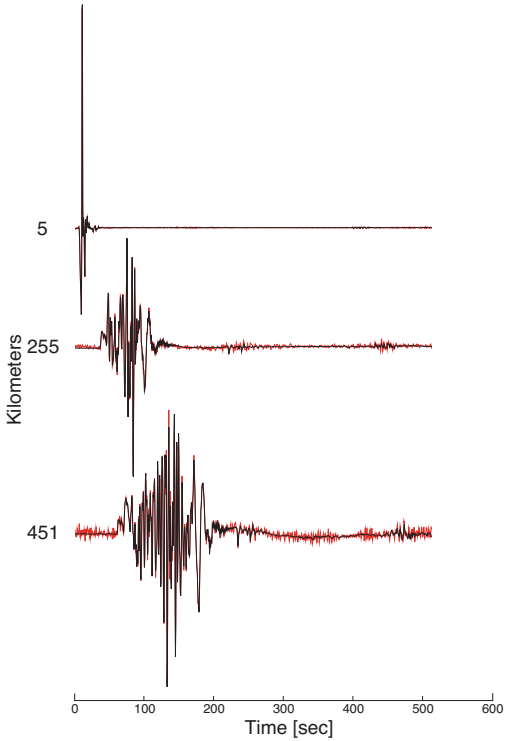
Original section: F-K



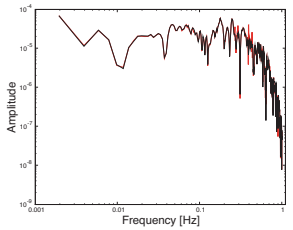
Interpolated section: F-K

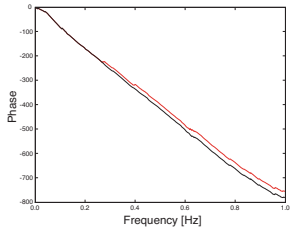


Trace Comparison

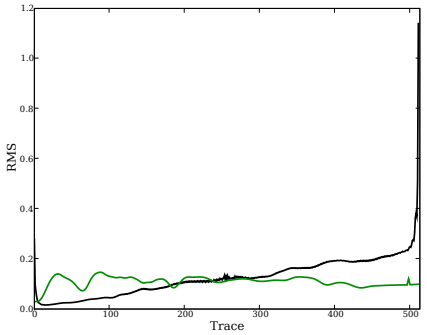


Amplitude and Phase Spectra





RMS



Conclusions

- Gülünay's interpolation succeeds.
- Diminishes by at least 50% the number of Green functions to calculate.

Further Work

- Test how sparse can the original data be.
- Implement a method for the 2-D case.