Introduction to Monitoring velocity variations using Ambient Noise Correlation: Application to Tiltmeter data

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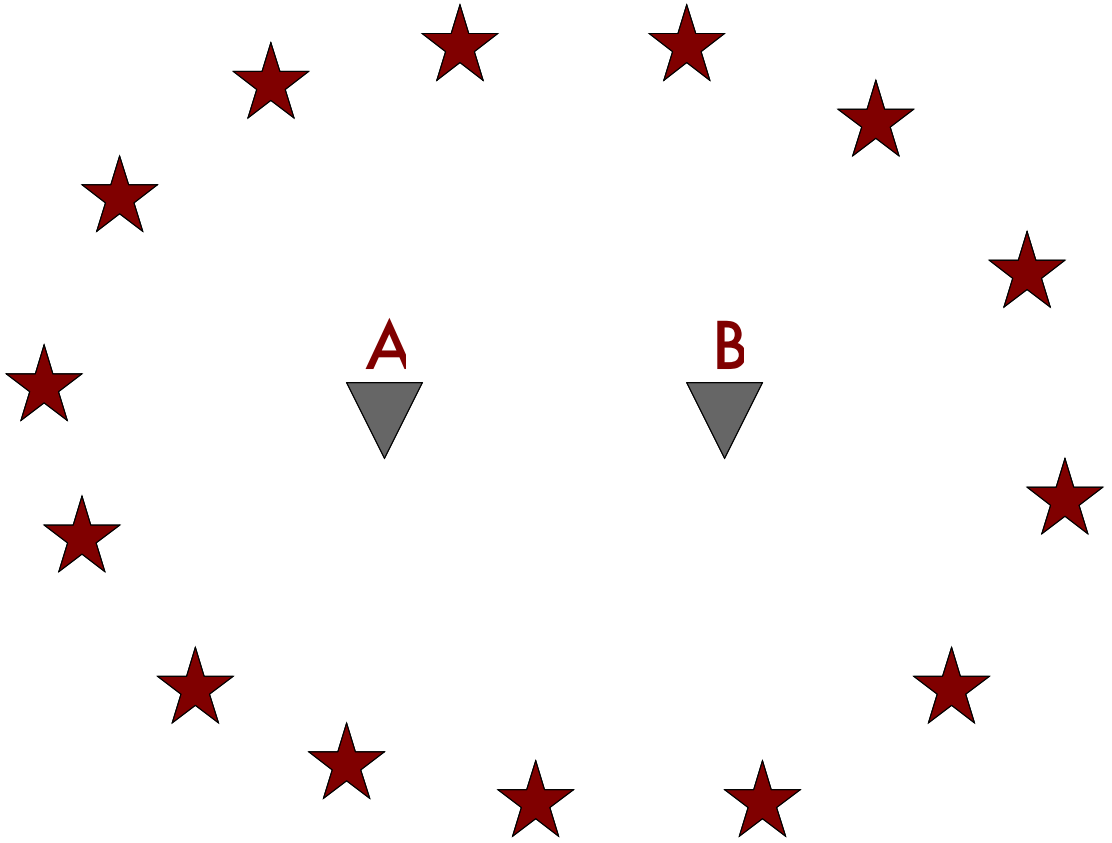
Ambient Noise Cross-correlation

In the ideal case when the noise is a random field



ie. Noise sources surrounding the receivers

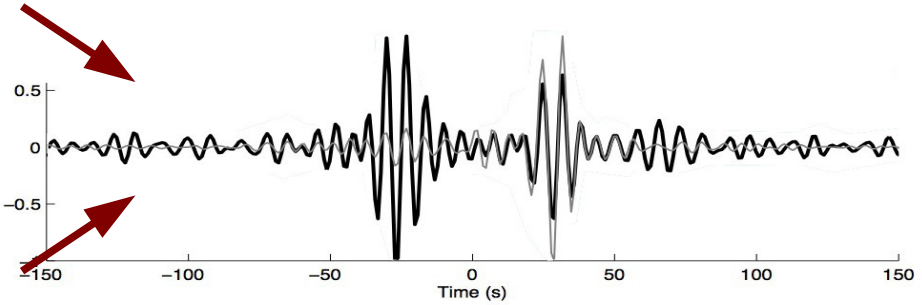
Ambient Noise Cross-correlation

In the ideal case when the noise is a random field, we expect that

A

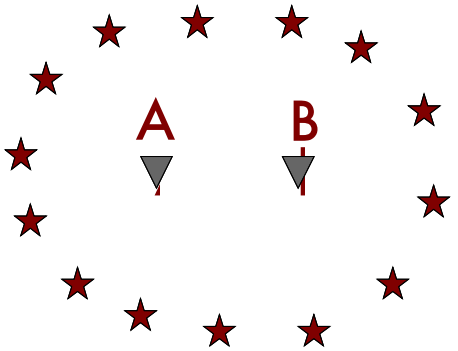
B

$C(h_A,h_B)$



$GF_{BA} + GF_{AB}$

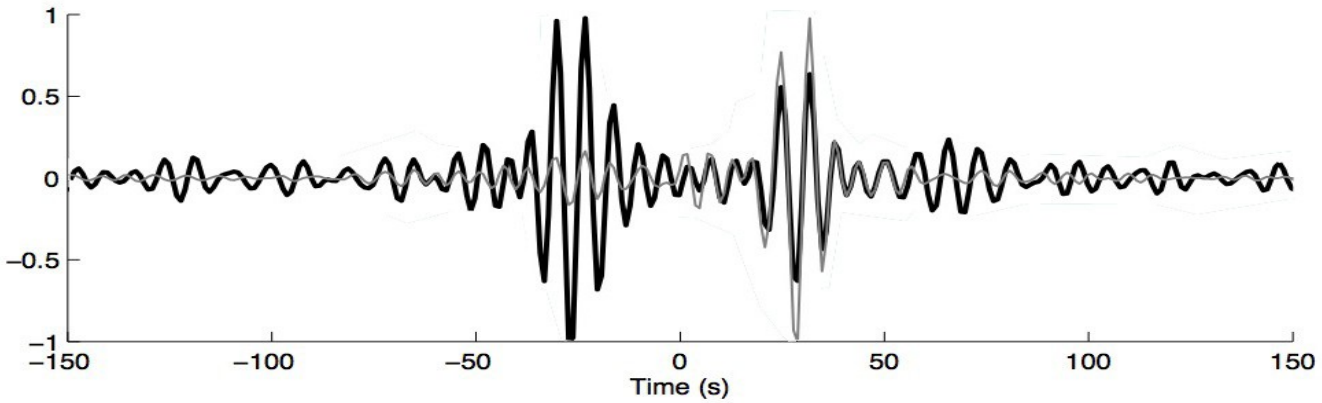
Correlation of field in A and B = Green function between A and B



Advantages:

+ Green's function *whereever*
+ Green's function *whenever*

Ambient Noise Cross-correlation



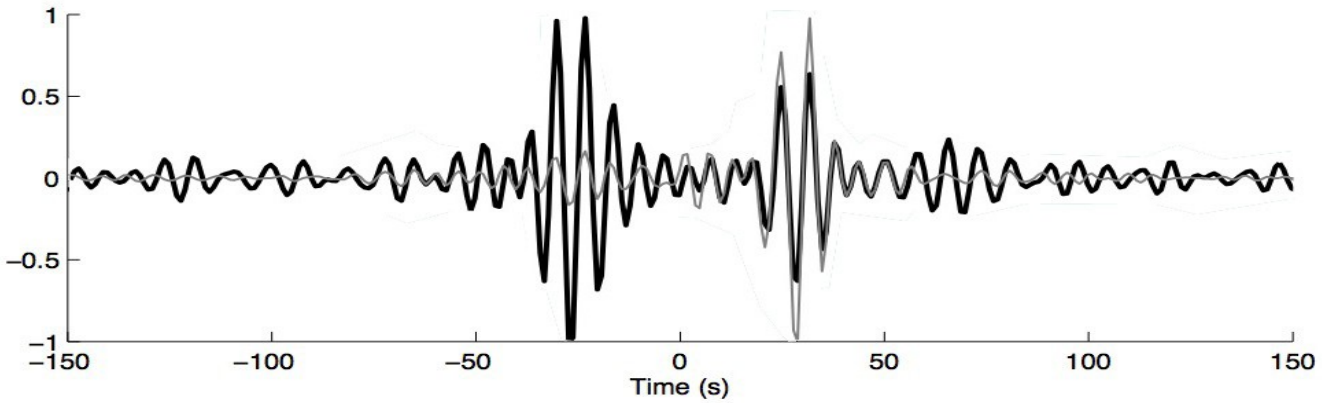
Ambient Noise Tomography

(Green's function *where*ever)

Ambient Noise Monitoring

(Green's function *when*ever)

Ambient Noise Cross-correlation



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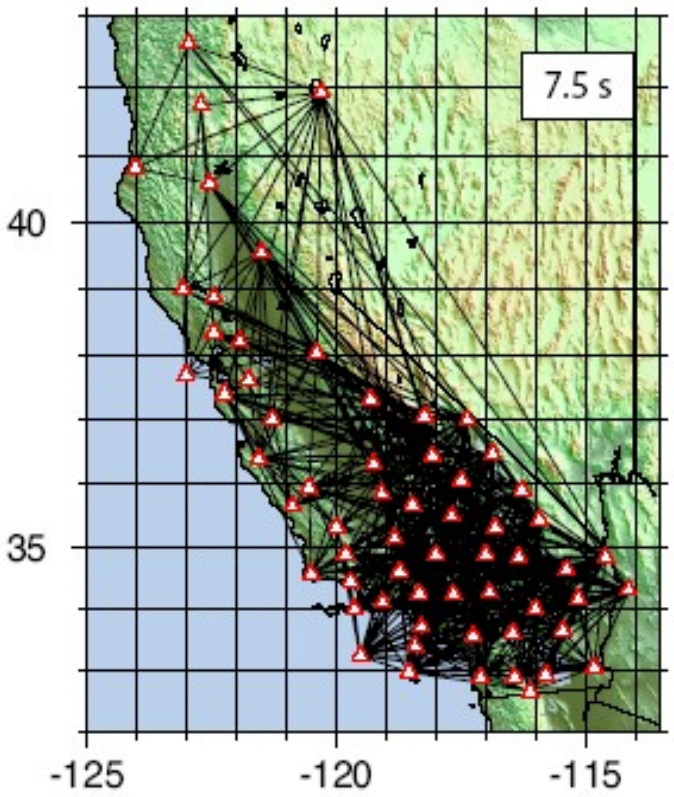
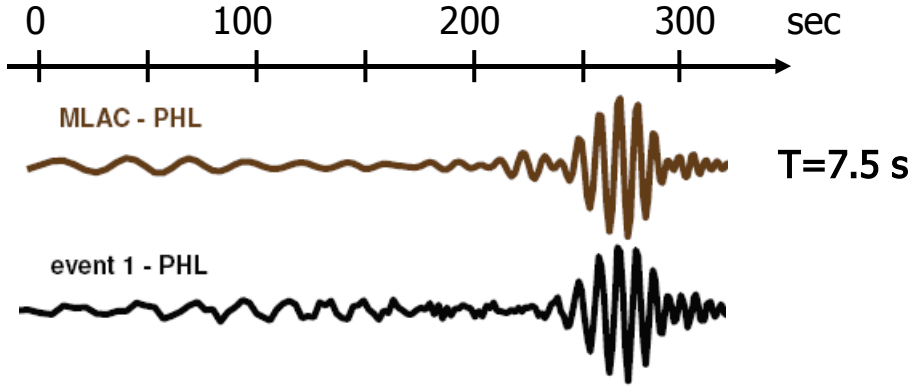
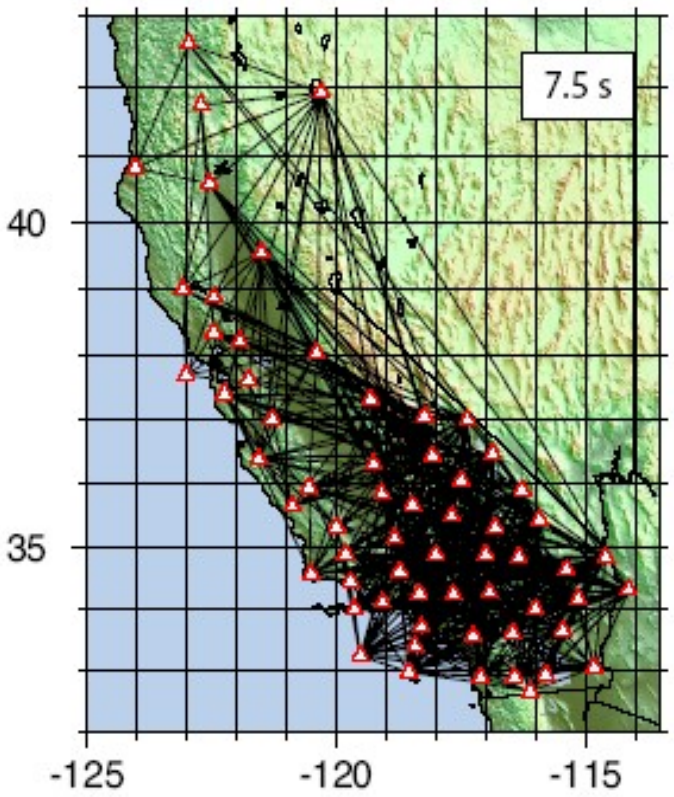
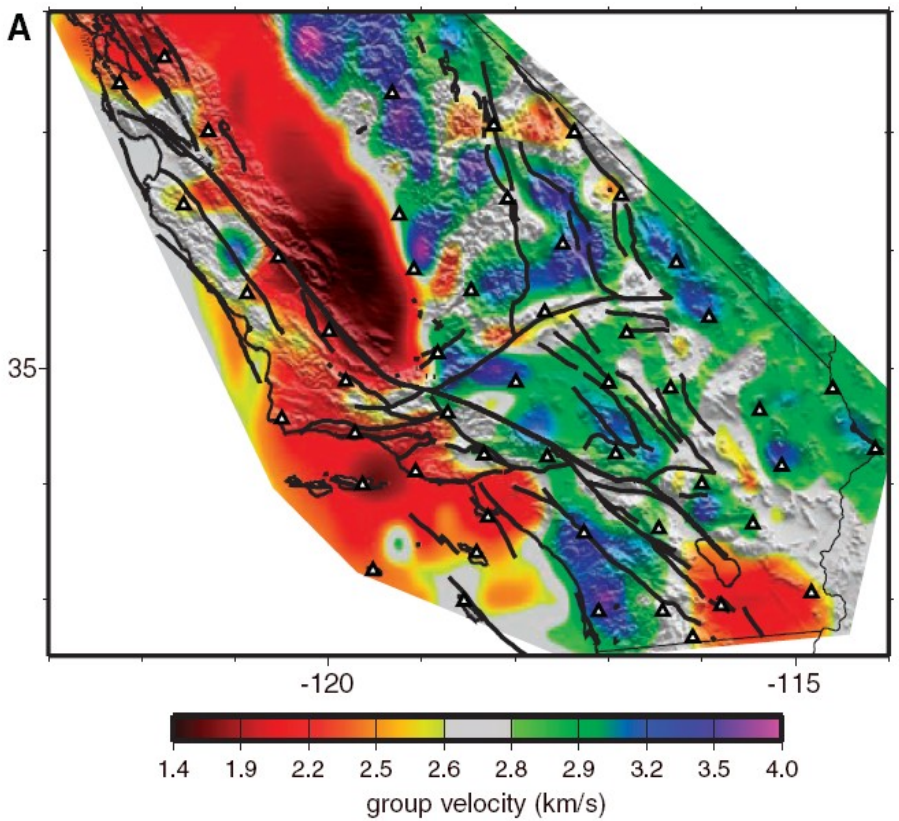




Shapiro, Campillo, Stehly and Ritzwoller, Science (2005)

Application: Ambient Noise Tomography





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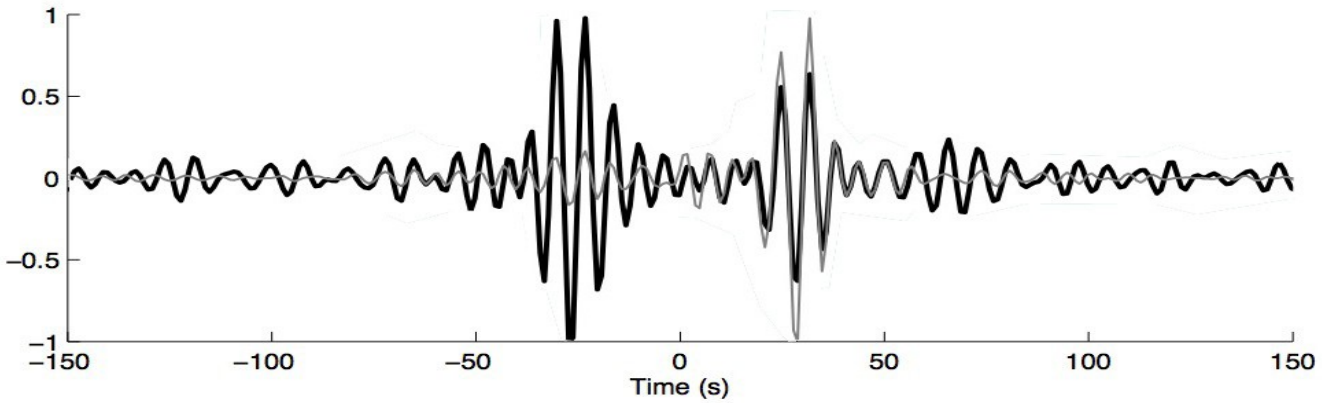

Ambient Noise Tomography

(Green's function *where*ever)

Ambient Noise Monitoring

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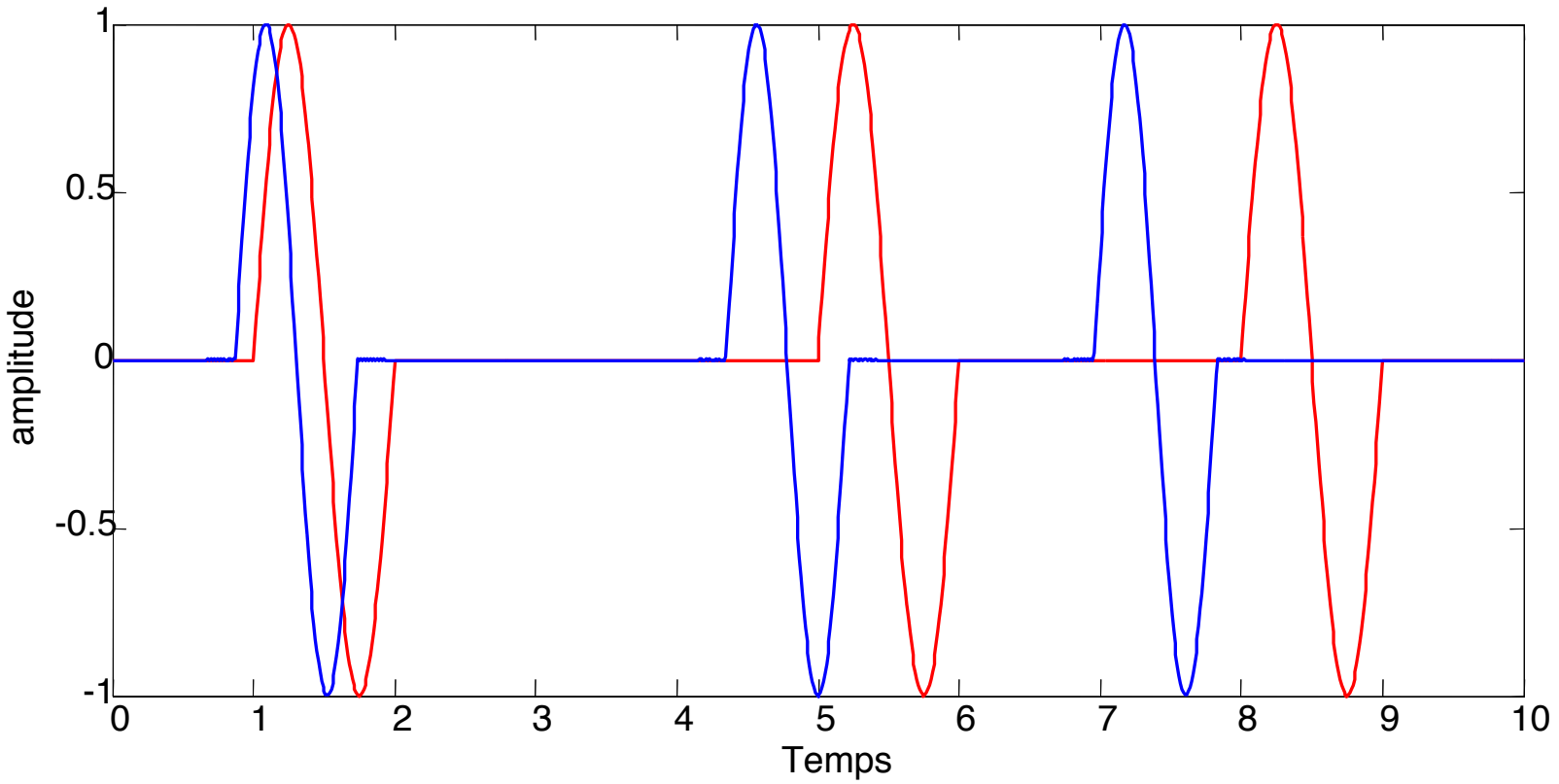
Application: Ambient Noise Monitoring

Date #1 $\longrightarrow$ $h_1(t)$

Date #2 $\longrightarrow$ $h_2(t)$

SLOW

FAST



Measuring relative velocity change: Stretching

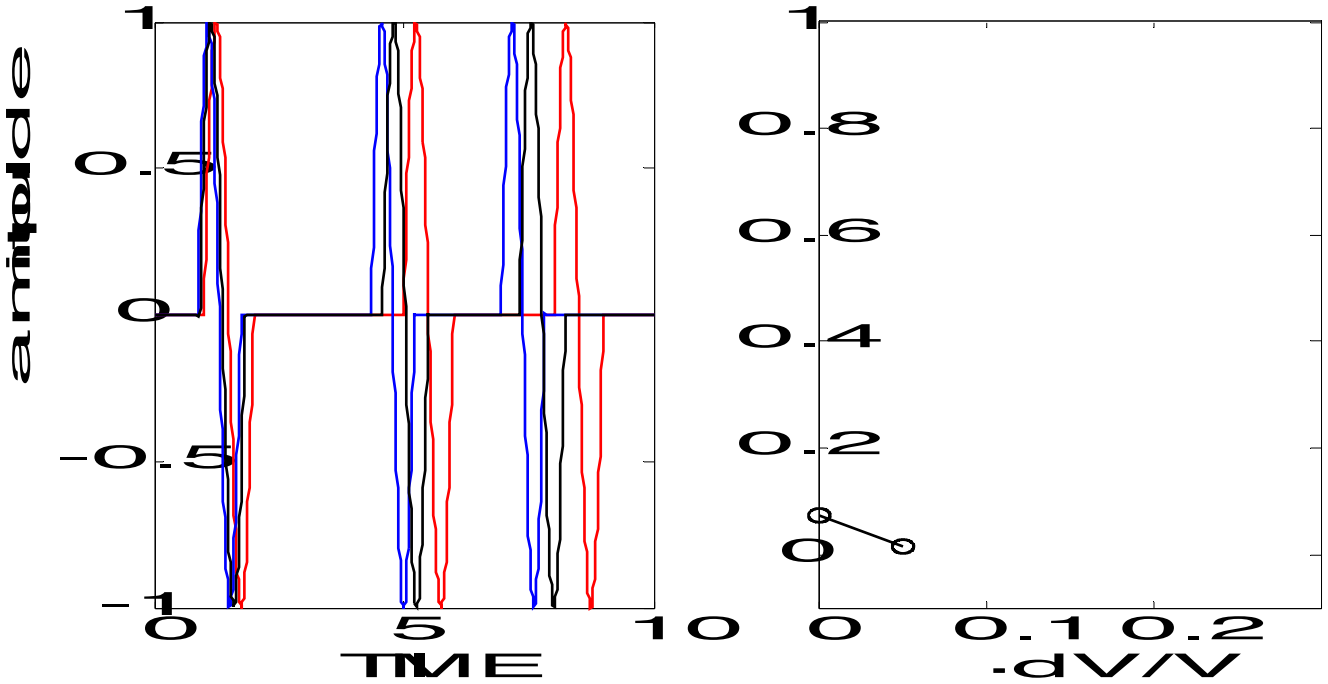
Signal date 2

Signal date 2 stretched (test)

Signal date 1

$$h_2(t) \rightarrow h_2(t[1+dV/V])$$

$$h_1(t)$$



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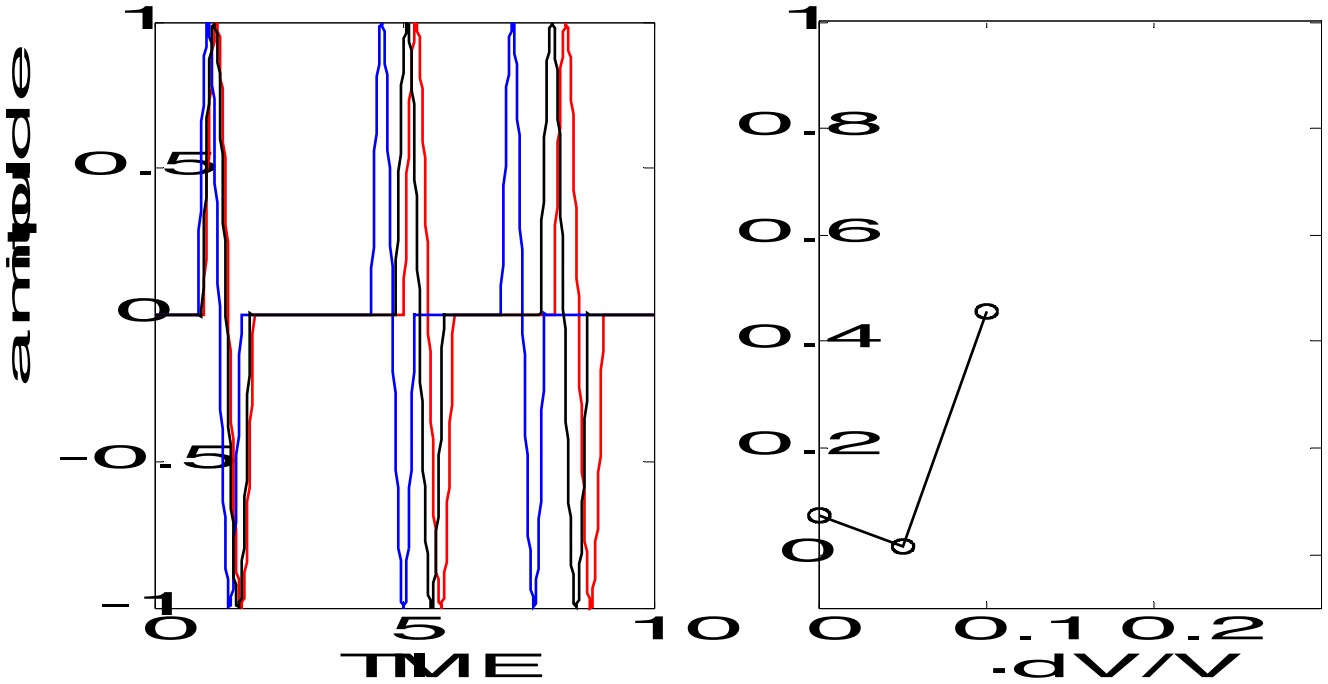

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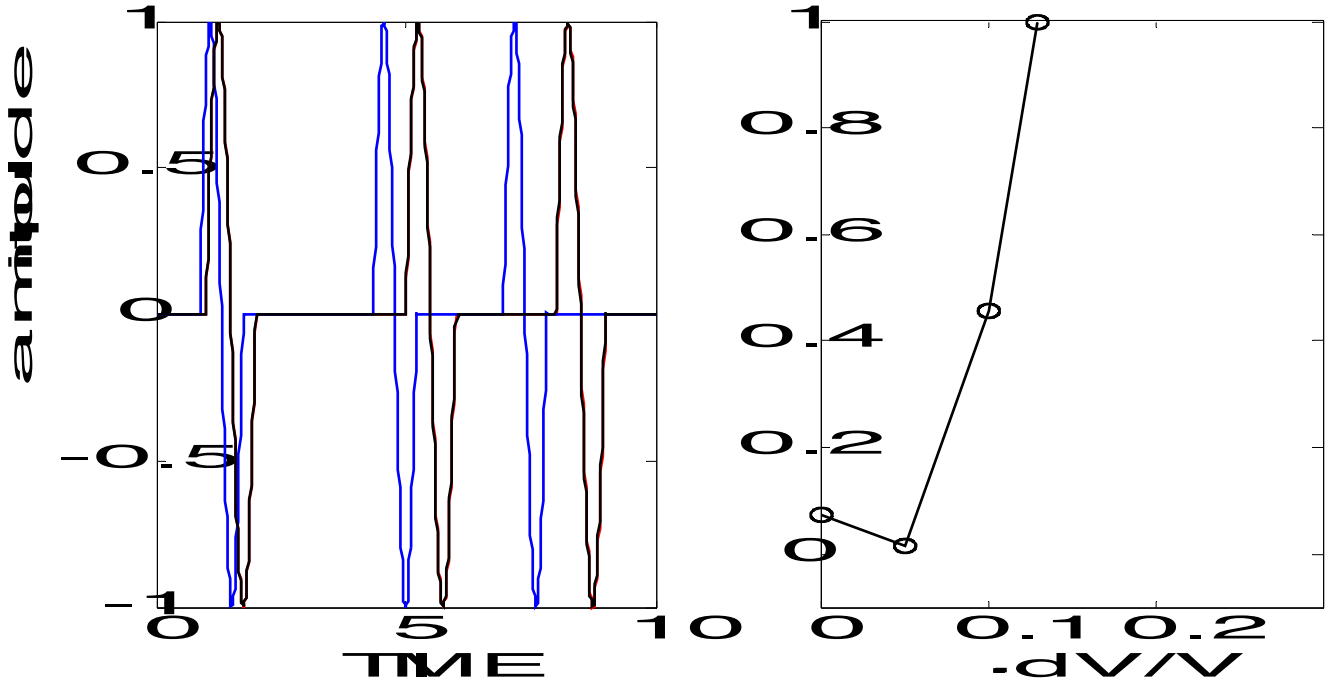

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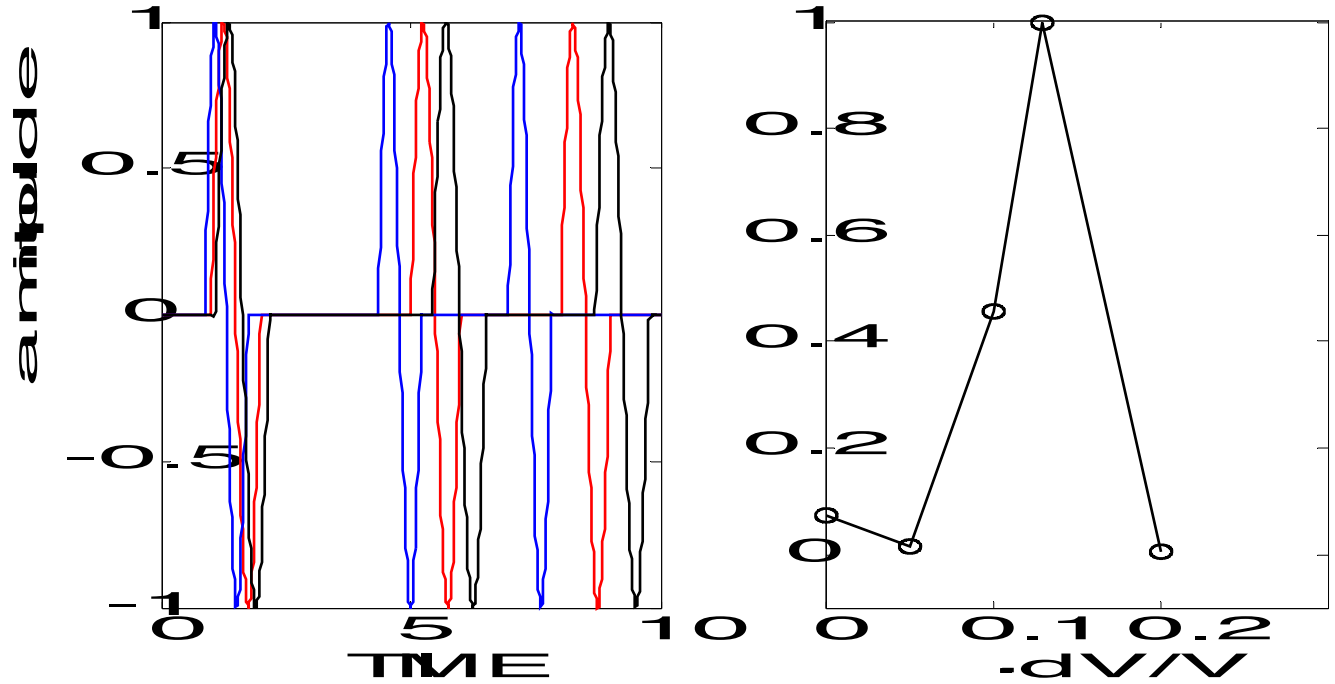

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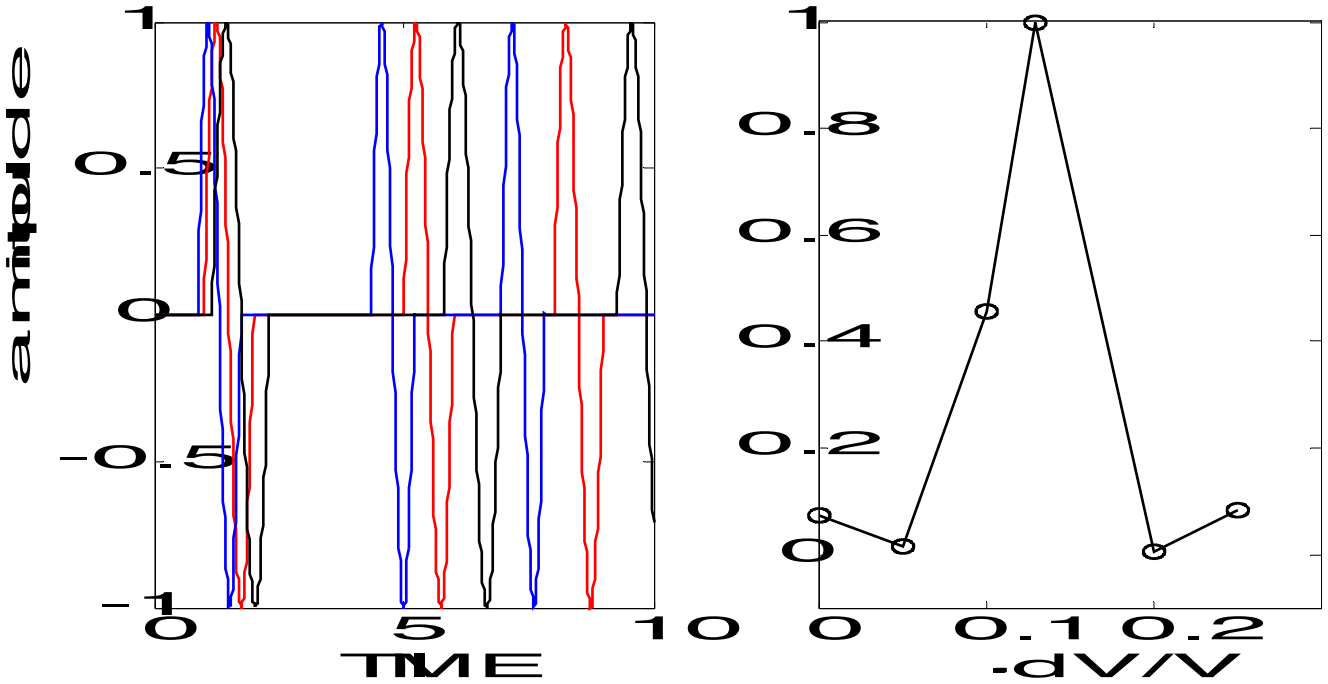

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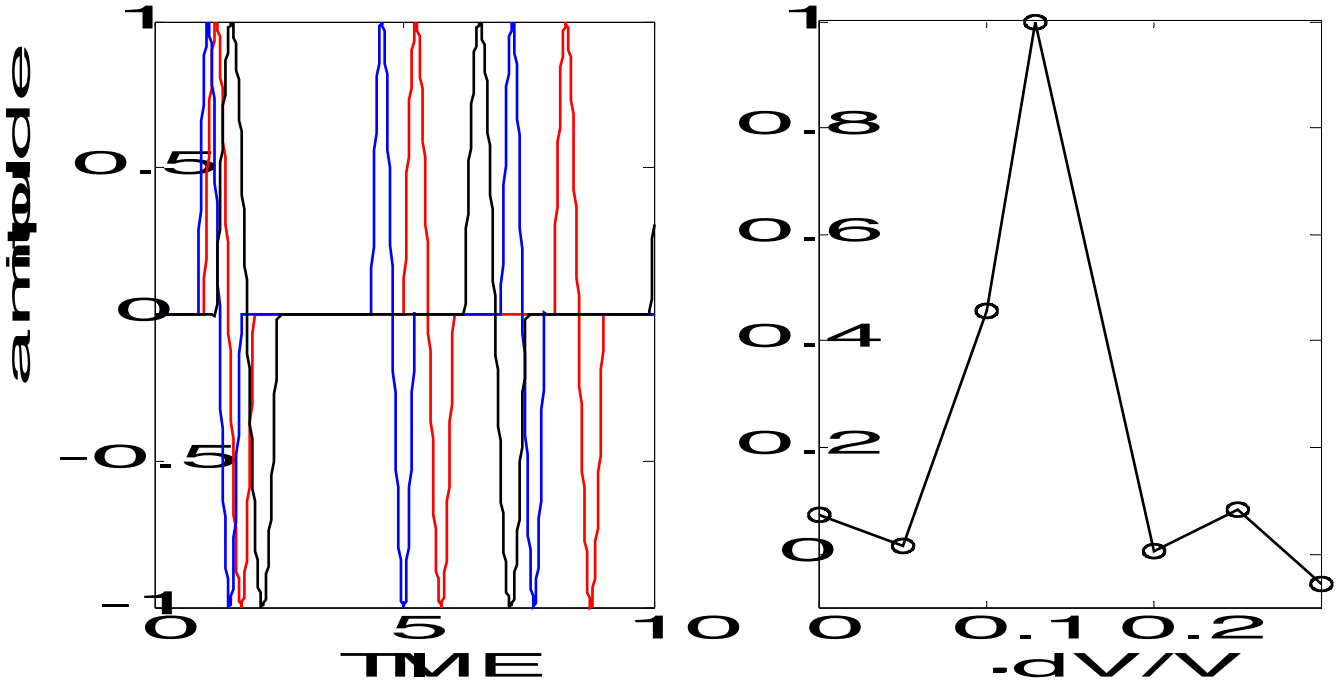

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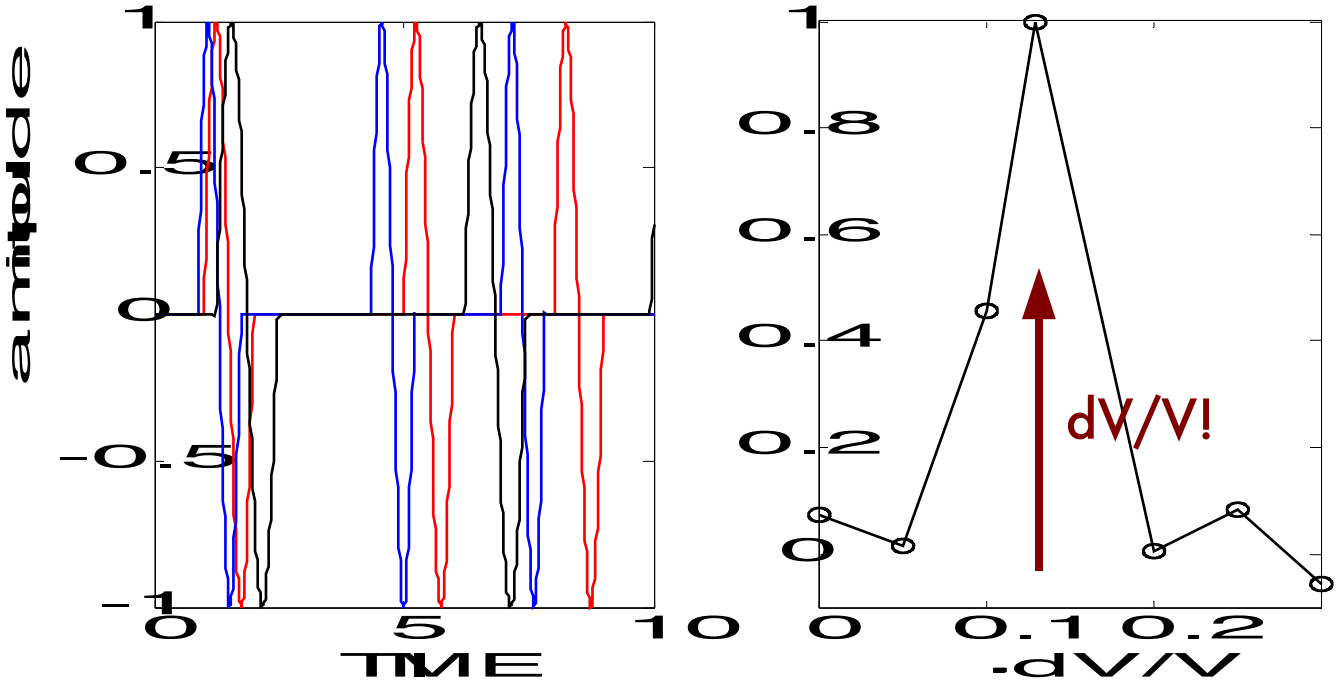
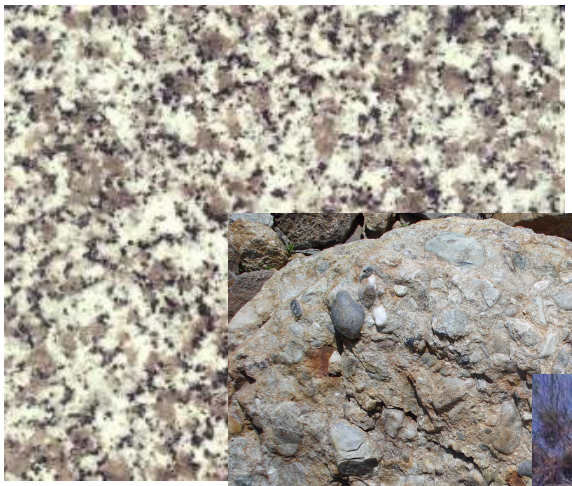


Monitoring: Importance of Scattering



mm

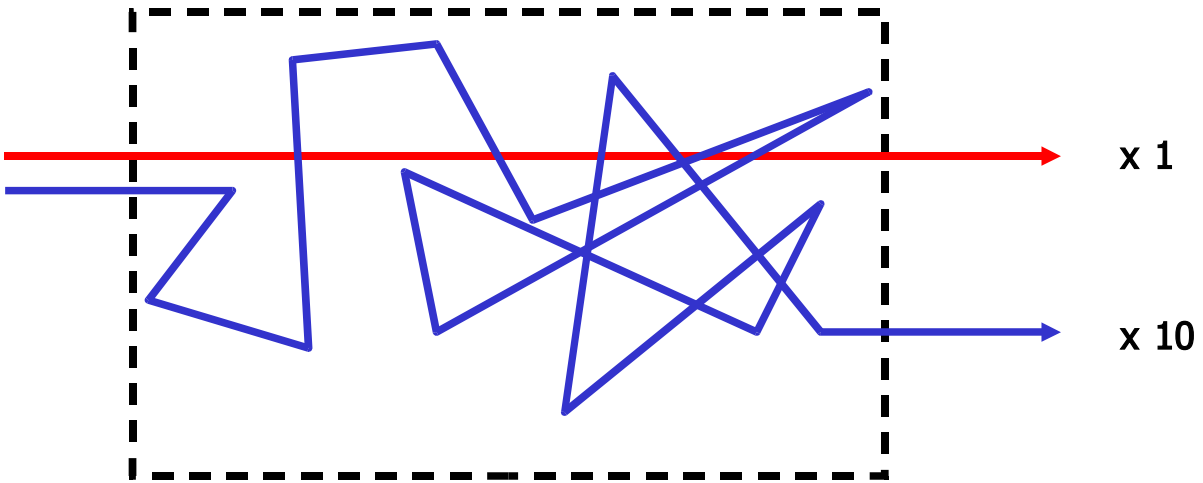
cm

m

km

The Earth is heterogeneous!

Monitoring: Importance of Scattering

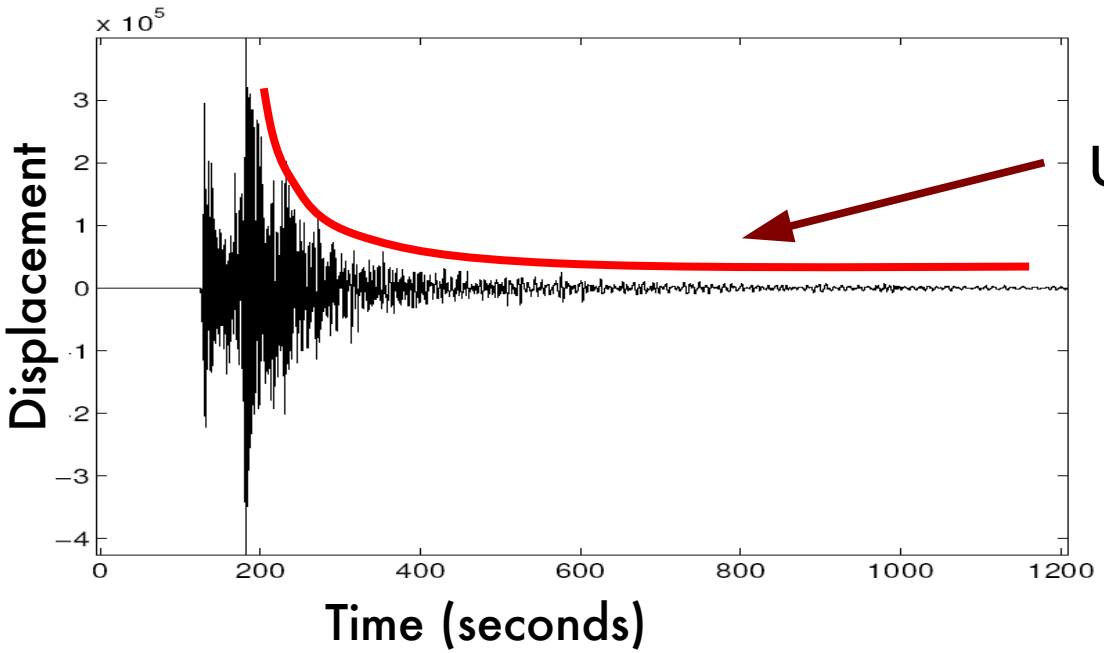


Scattered waves:

Longer time in the medium

More sensitive to weak changes

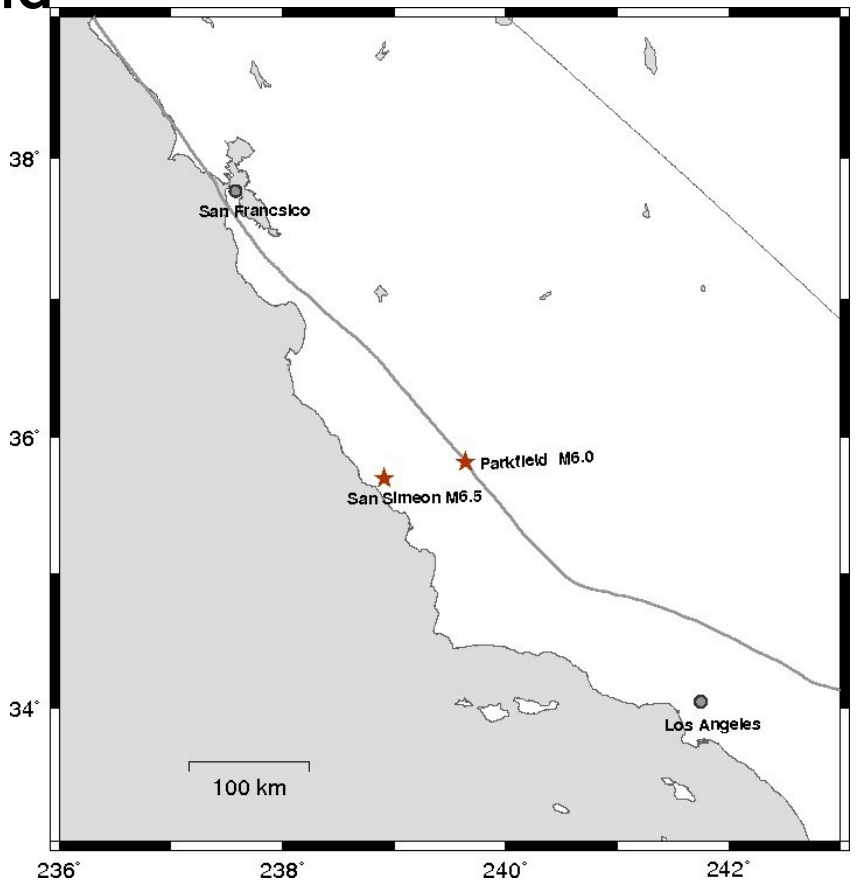
Monitoring: Importance of Scattering



Use the Coda!

Application: Parkfield, California

- 13 stations, 78 station pairs (Z)
- Continuous data: 2003-2007
- Processing:
  - [0.1 0.9] Hz
  - spectral whitening
  - one bit normalization
  - Reference GF: stack of 4 years
  - 30 day stacks



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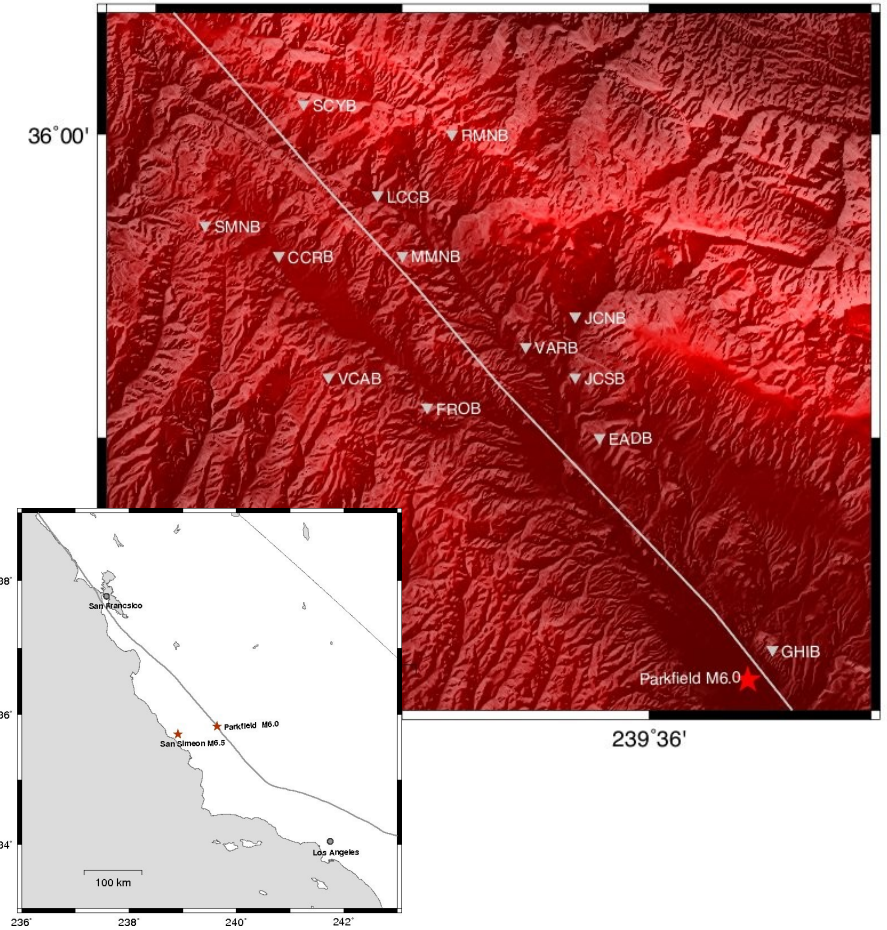
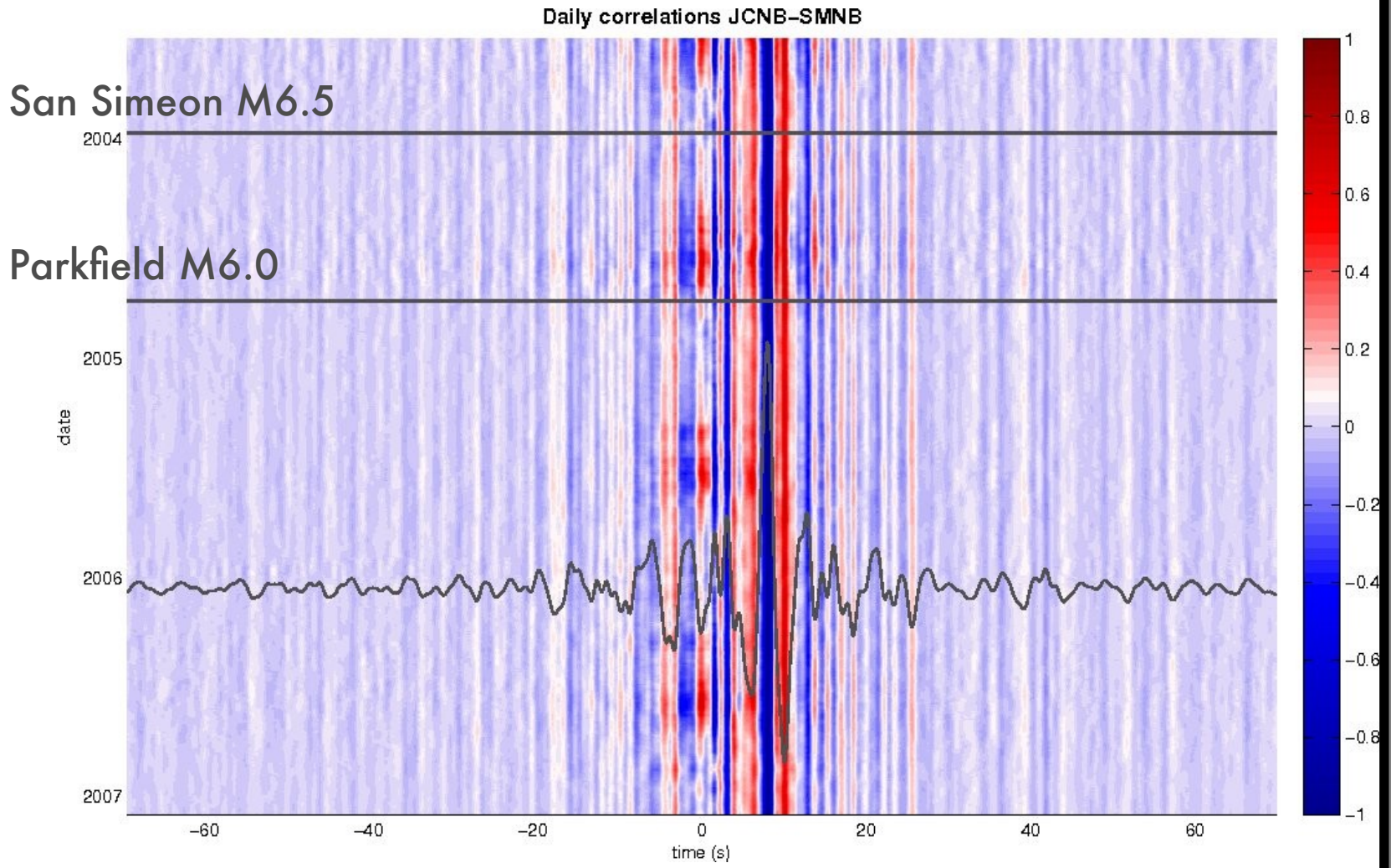
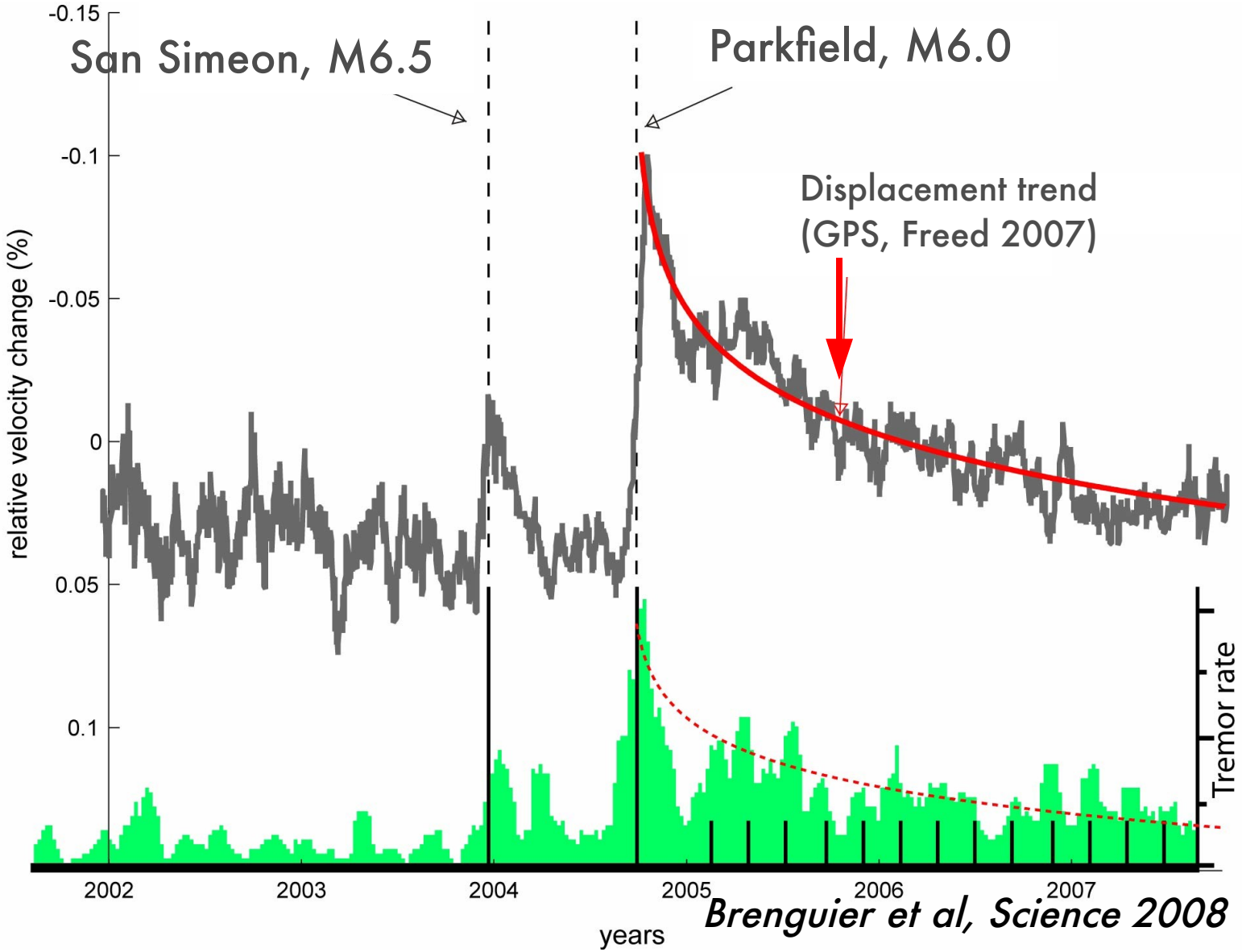


Parkfield, California

4 years of correlations for station pair JCNB-SMNB



Results Parkfield, 30 day stack:



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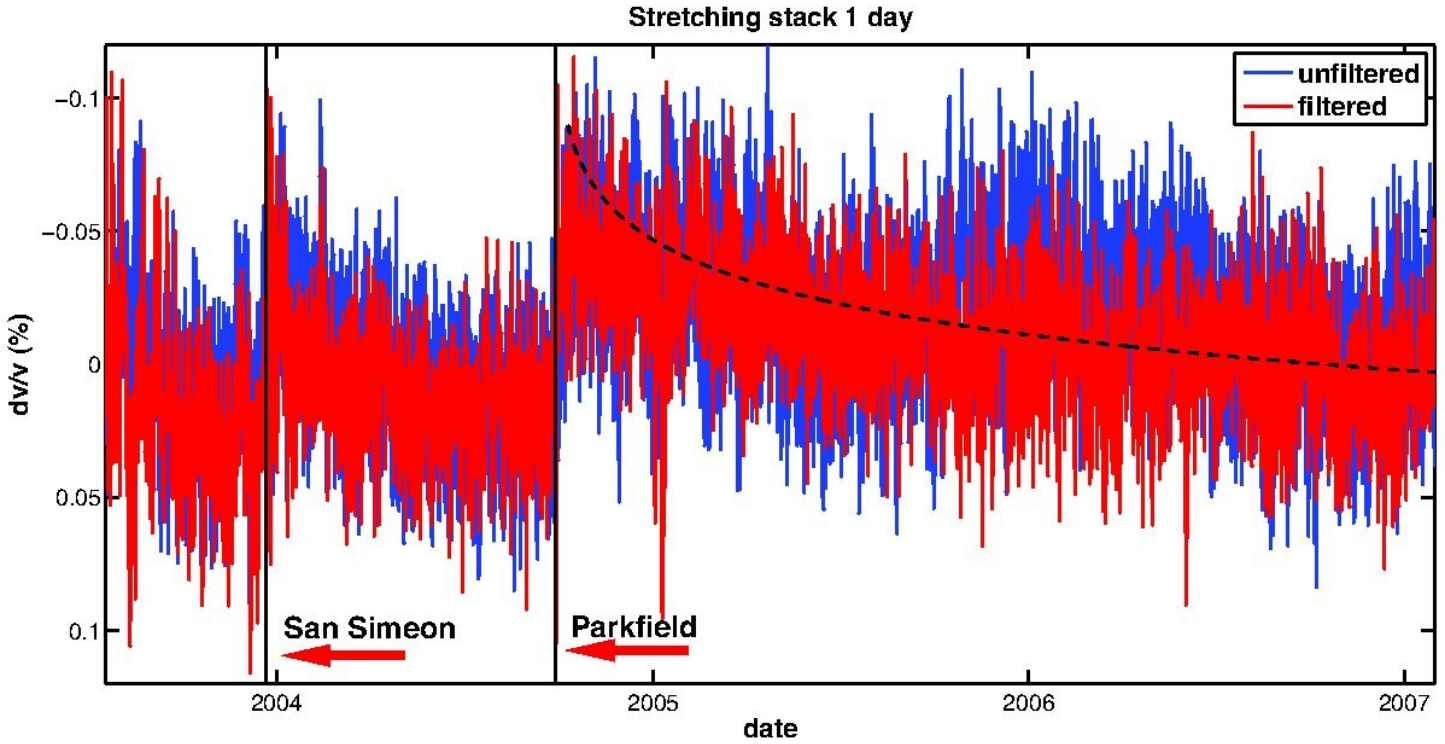
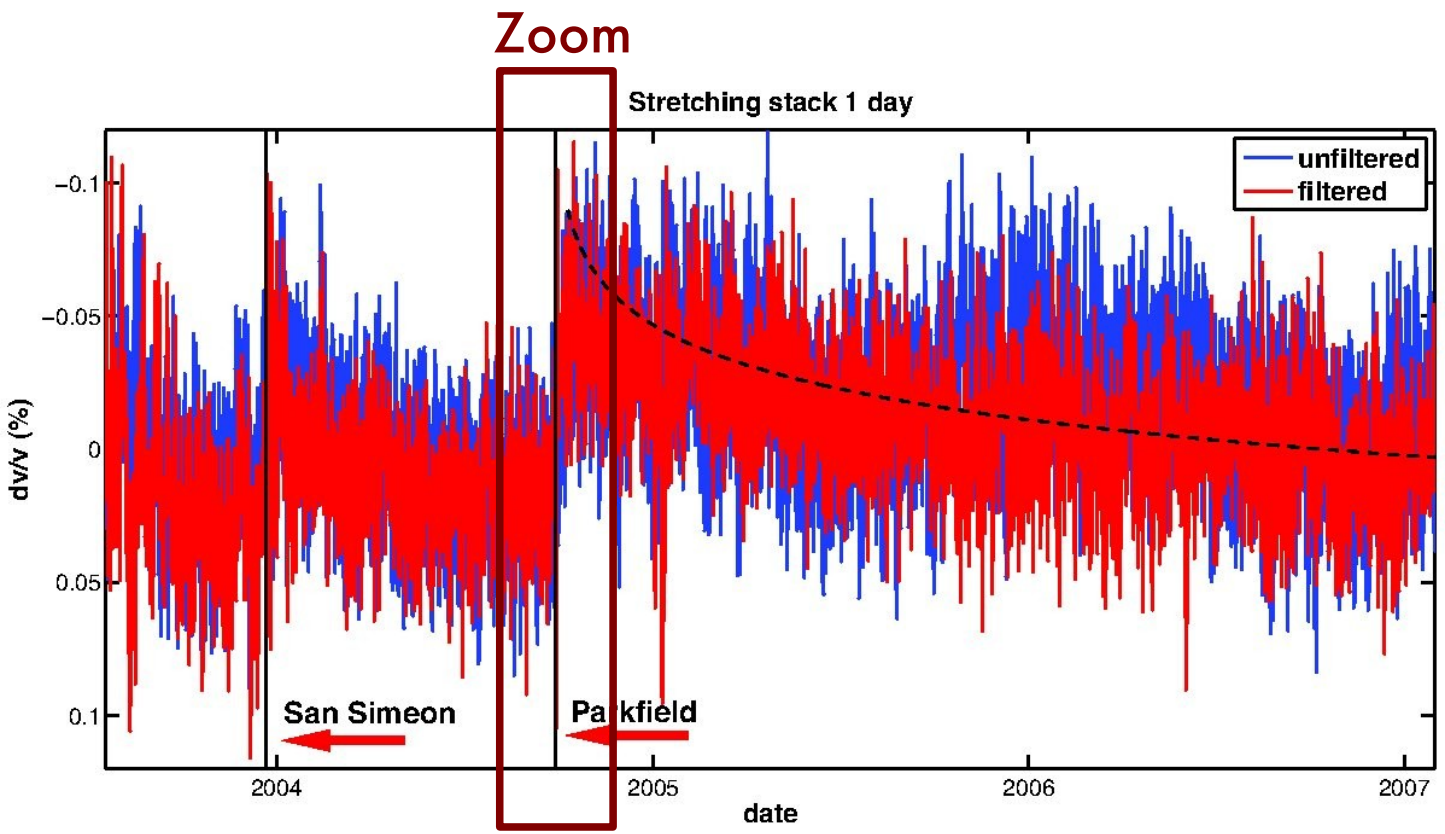


Stretching, 1 day average

Parkfield, California



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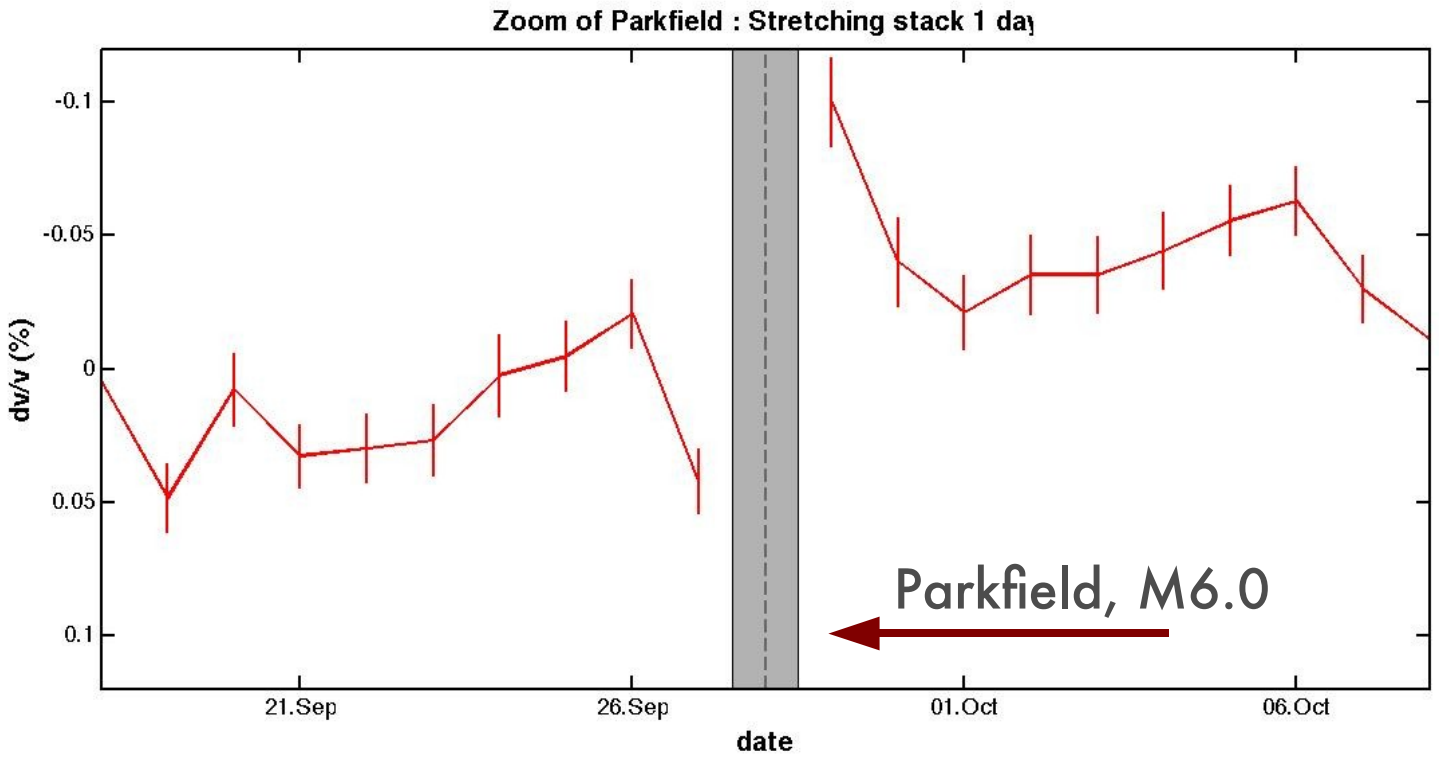
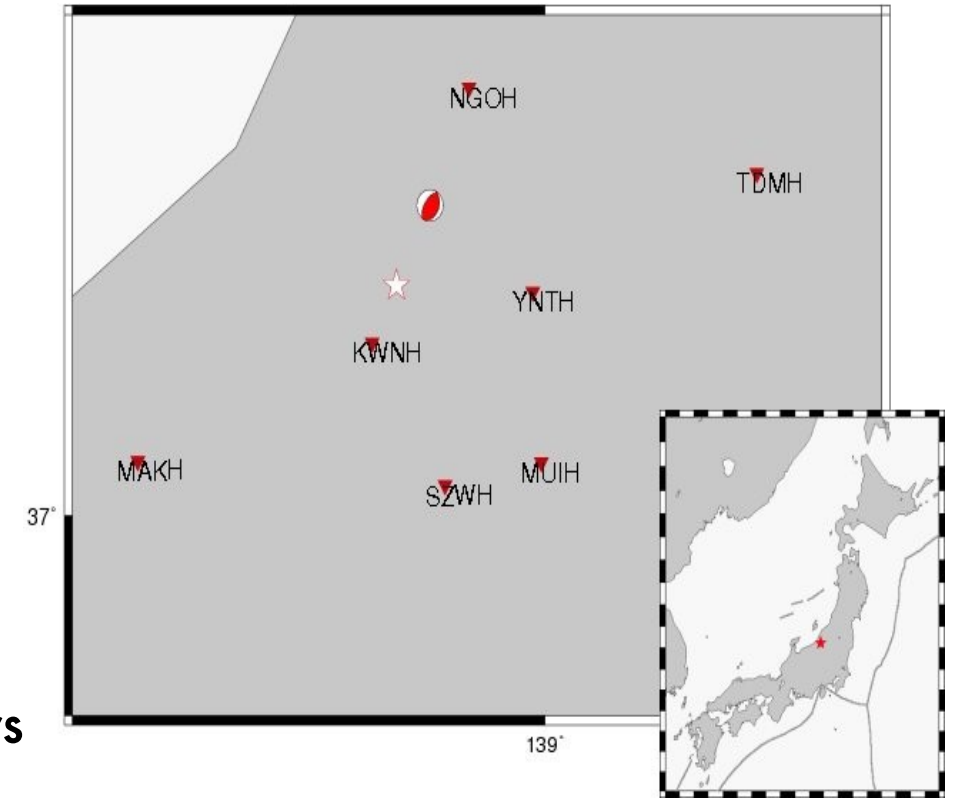


Stretching, 1 day average

Tiltmeters: Chuetsu, Japan

- HiNet borehole Tiltmeters
- 13 station pairs
- Continuous data: 2004-2005
- Processing:
  - [0.1 0.3] Hz
  - spectral whitening
  - one bit normalization
  - Reference GF: stack of 2 years
  - 30 day stacks



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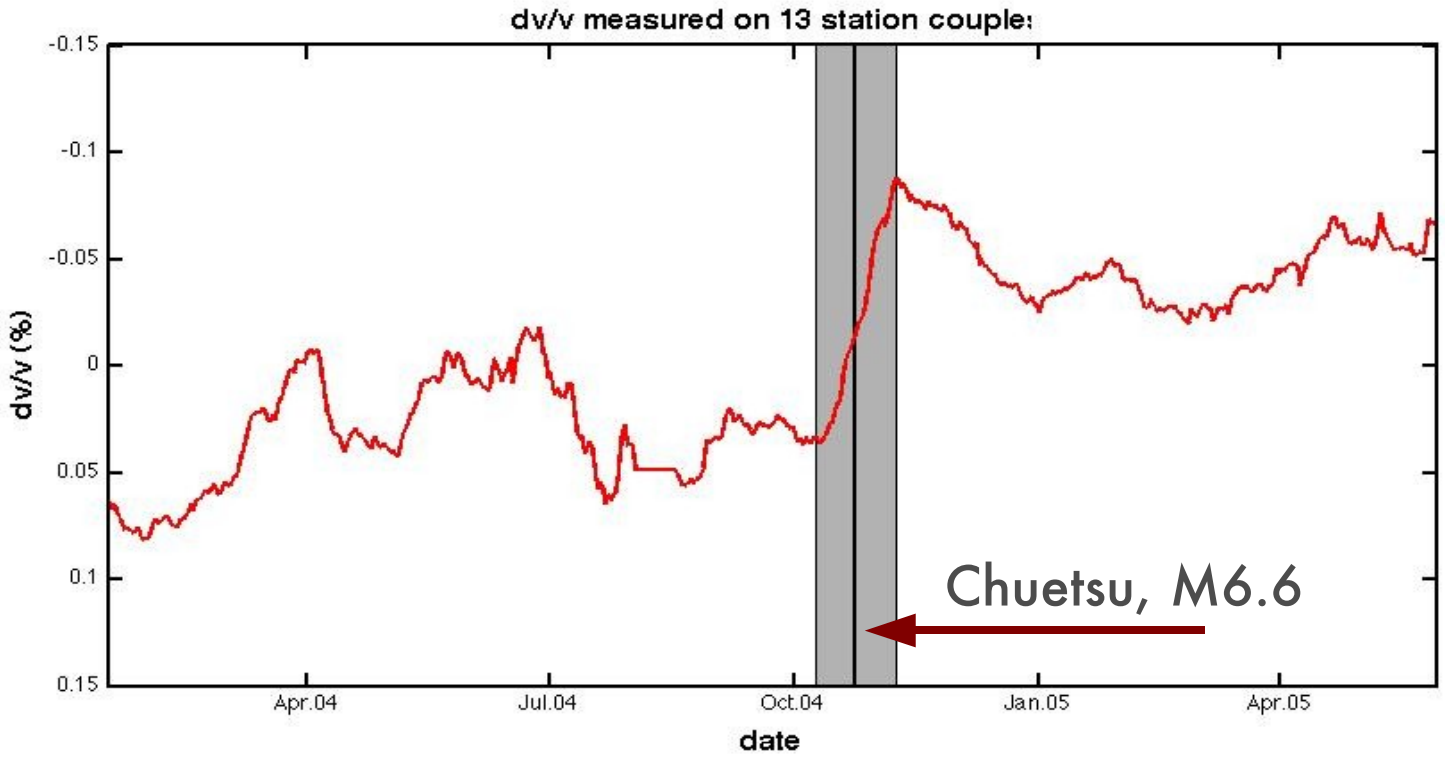

Stretching, 30 day average

Velocity changes: Interpretation?

Postseismic stress relaxation
Superficial Damage
Fluid Migration
…

Summary:

Reconstruct Green's Functions by correlating seismic noise

Use for:

- High resolution Tomograpy
- Velocity change Monitoring

Monitoring: use the scattered waves of reconstructed GF's coda

In Parkfield and Chuetsu:

- 0.1% relative velocity change
- case of Parkfield: change is coseismic!

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Thank You!