

Passive monitoring using traffic noise recordings - case study on the Steinachtal Bridge

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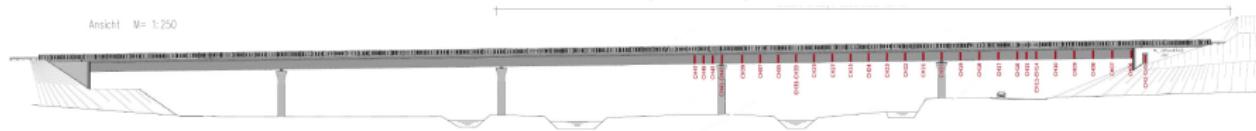
Overview

Objective

Is it possible to use ambient and/or traffic noise to monitor small-scale structures?

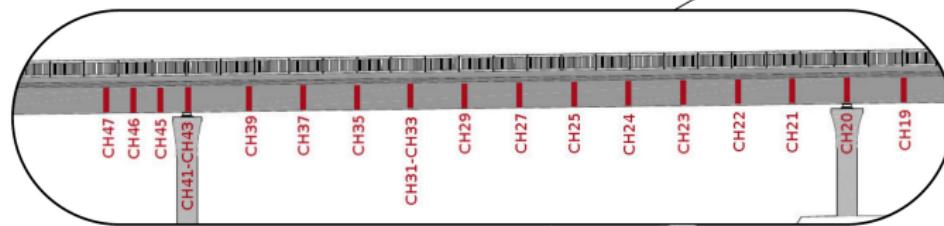
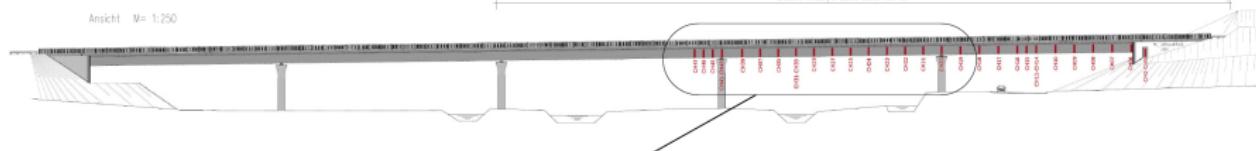
Measurement Setup I

lateral view (Geophone positions)

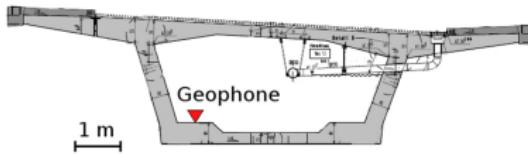


Measurement Setup I

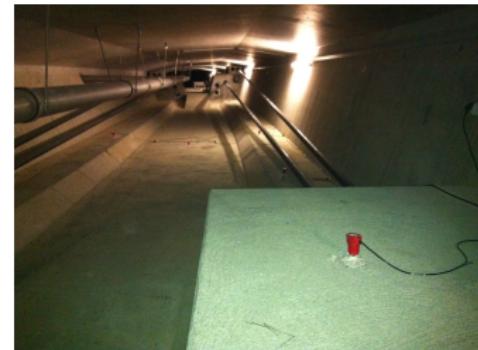
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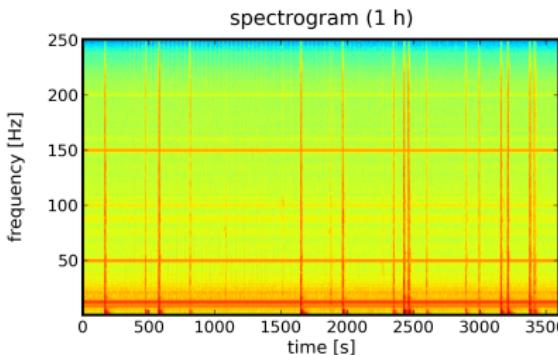
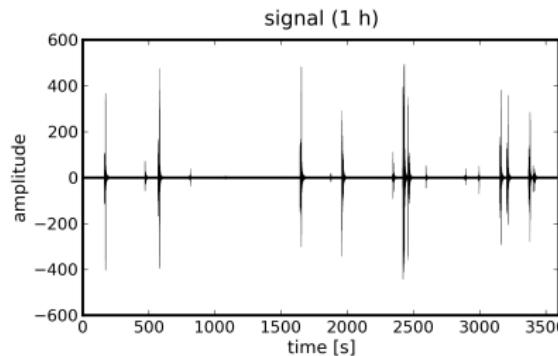
cross-section



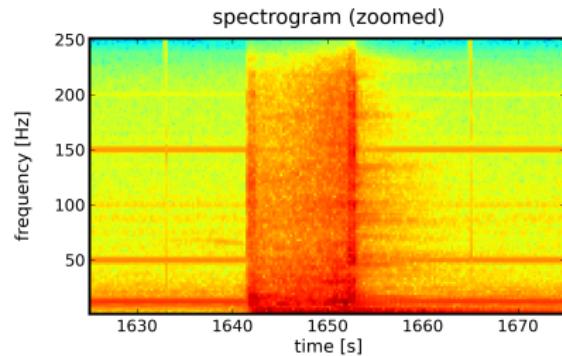
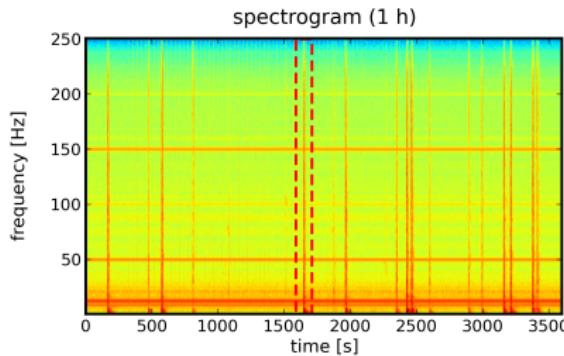
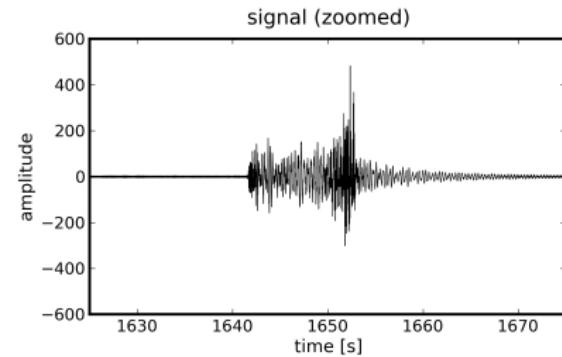
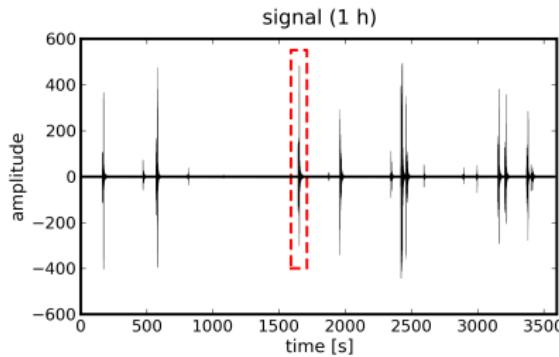
Measurement Setup II: Steinachtal Bridge



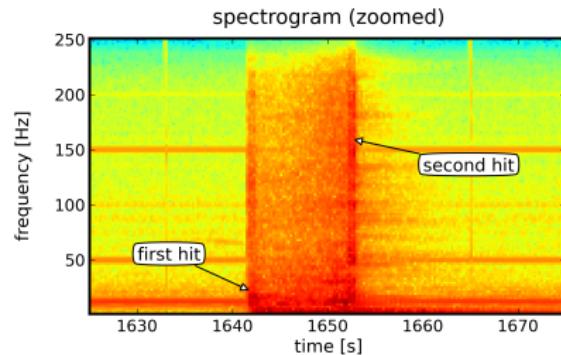
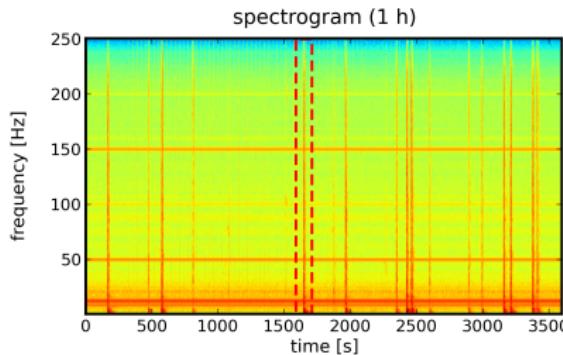
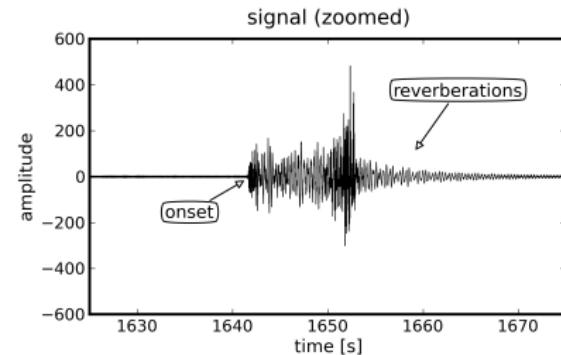
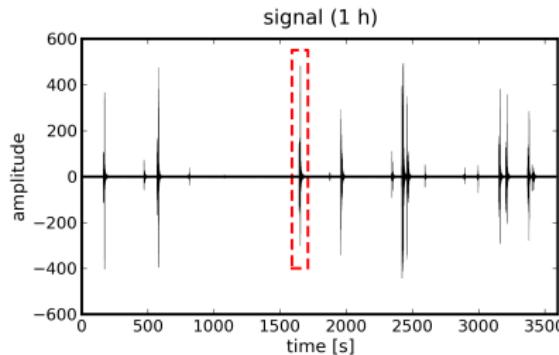
Raw Signal



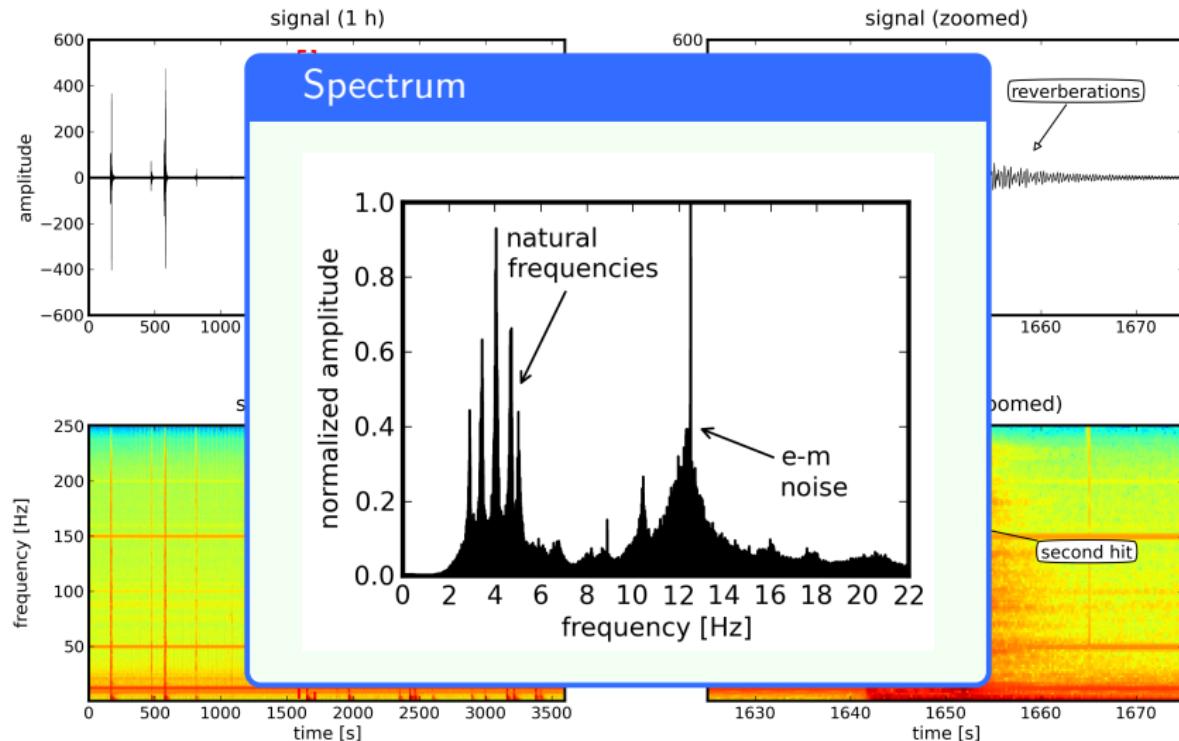
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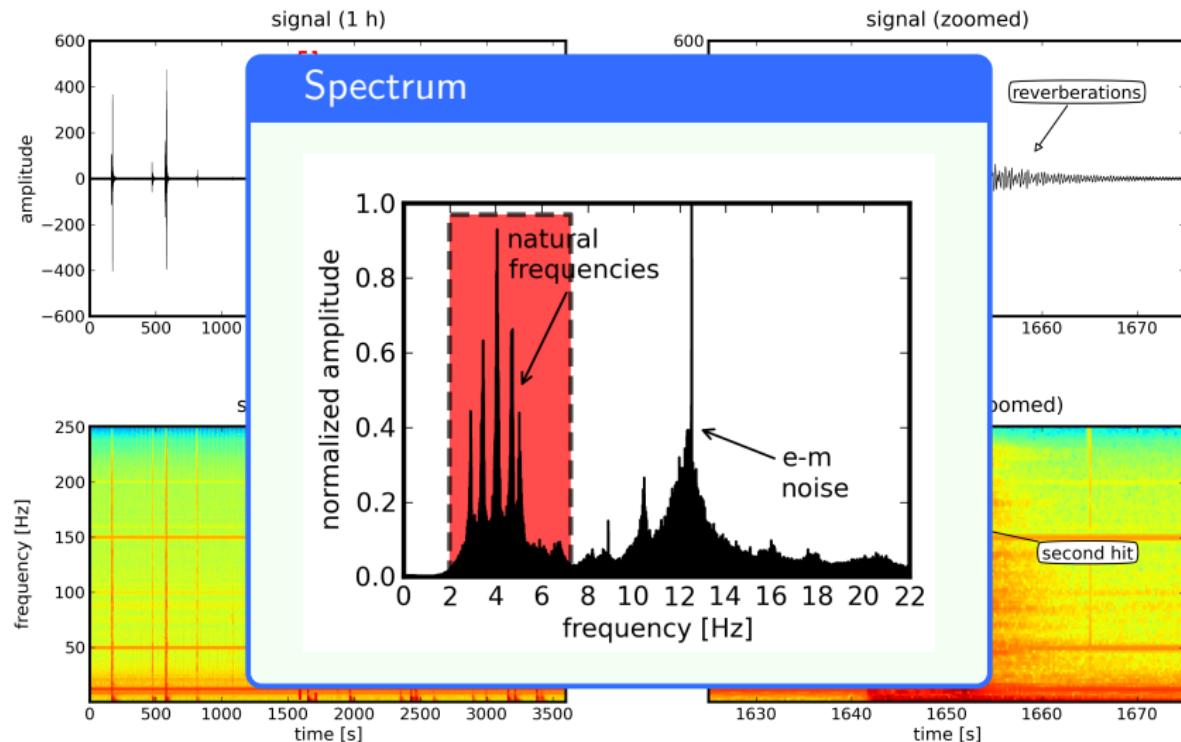
Raw Signal



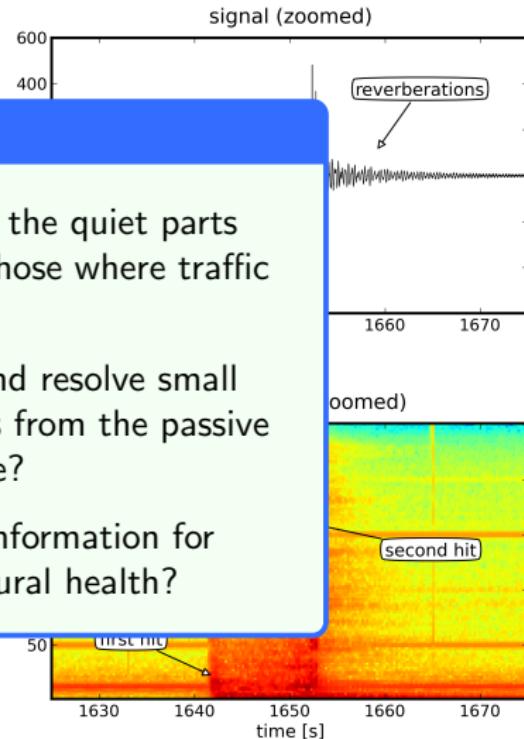
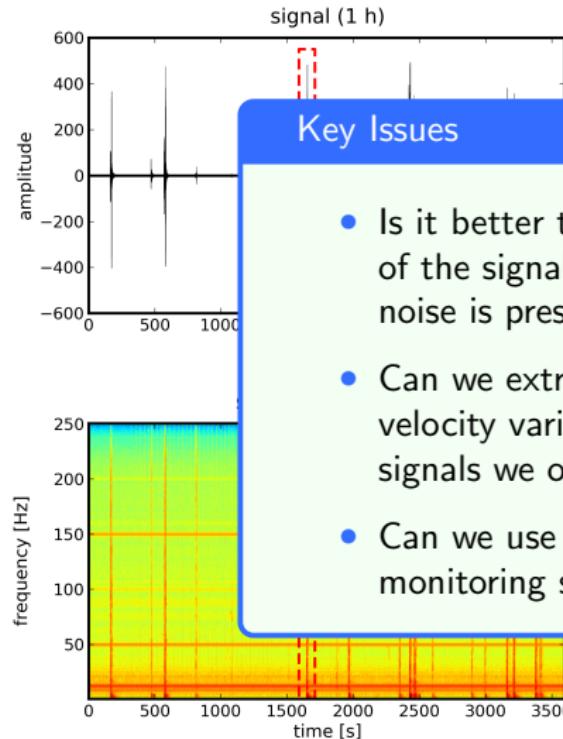
Raw Signal



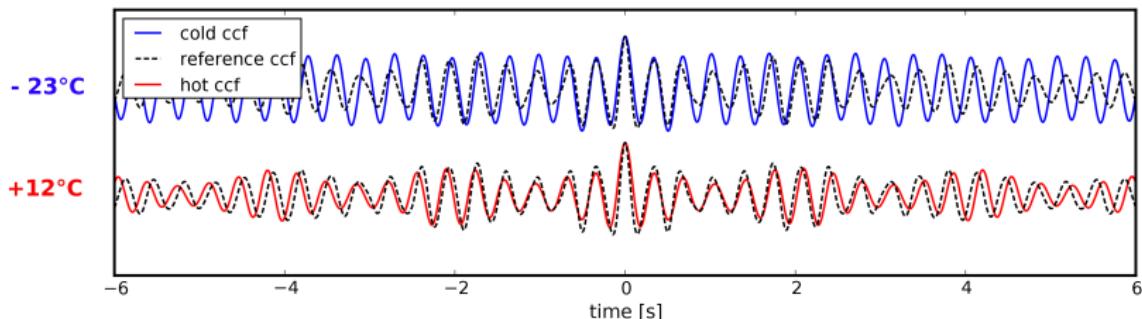
Raw Signal



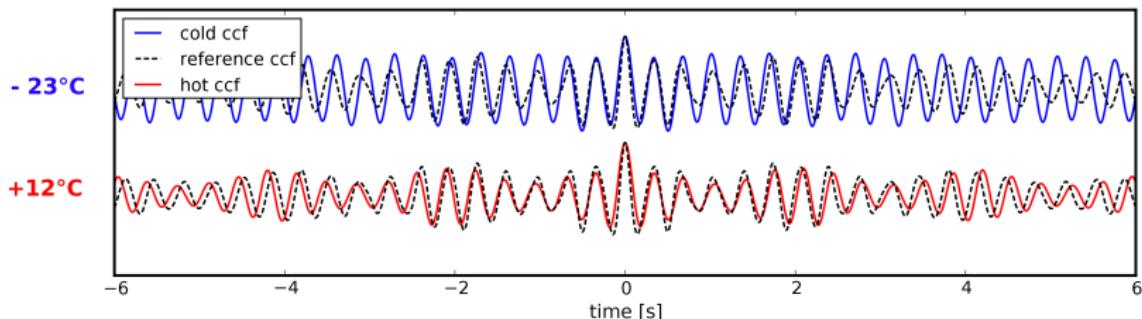
Raw Signal



CWI & Cross-correlations



CWI & Cross-correlations



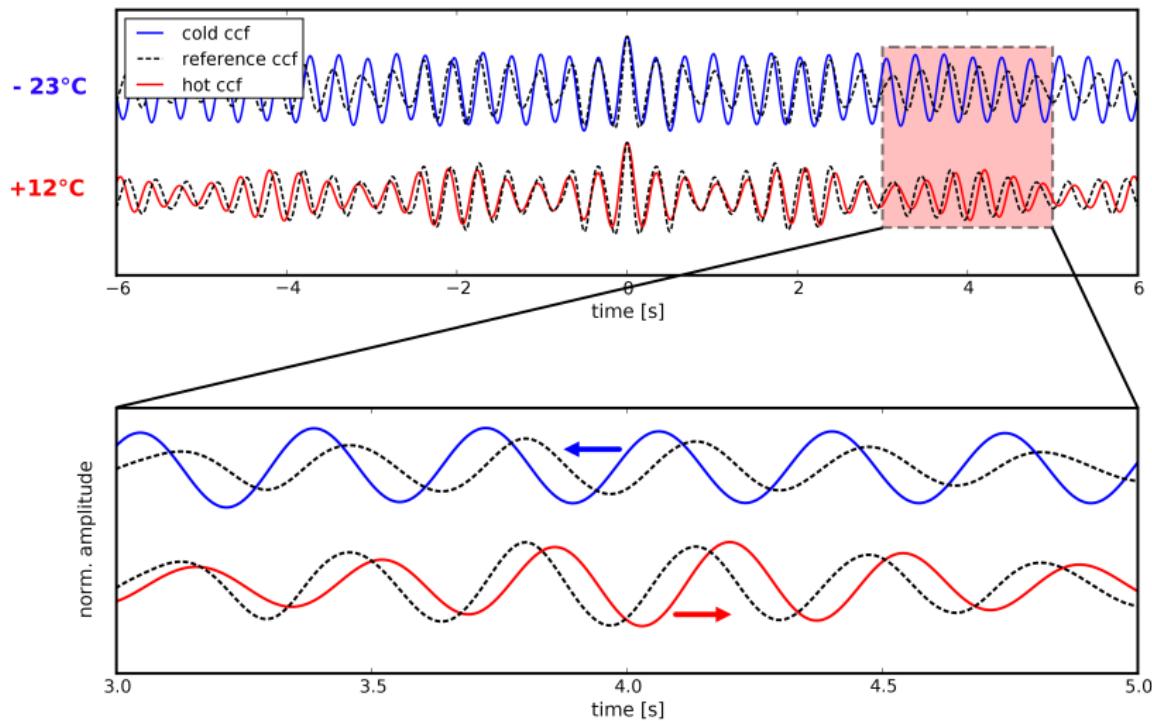
Hourly cross-correlations
for receiver pairs



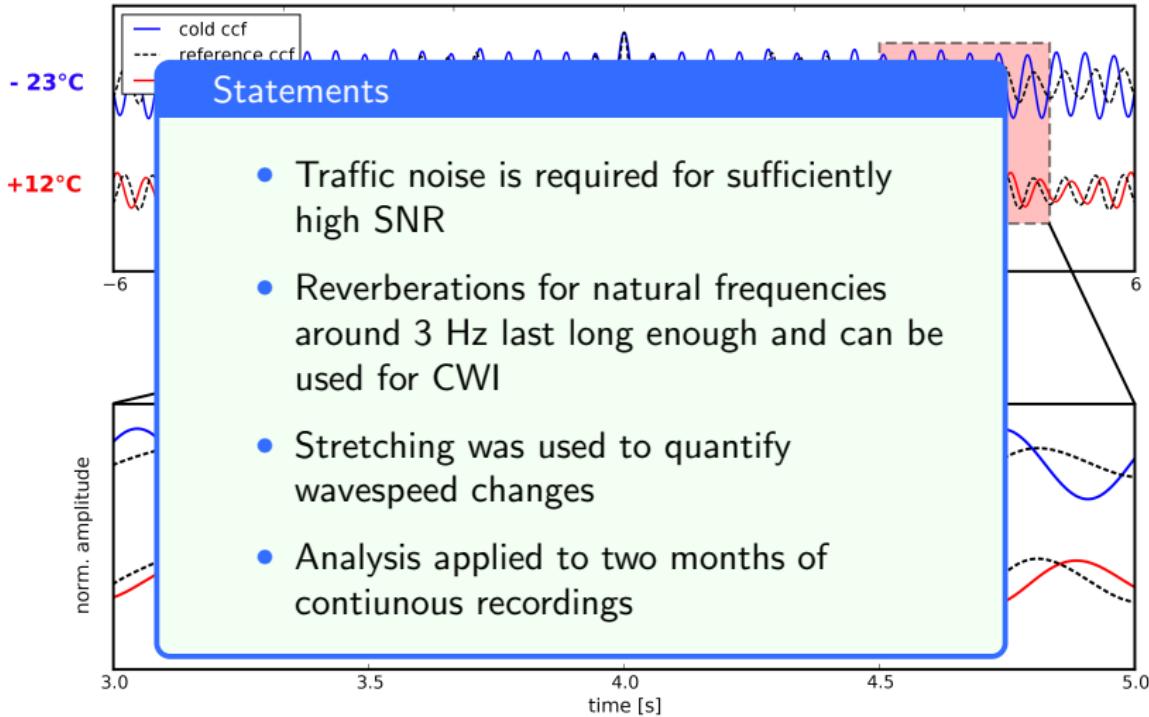
Unilateral sources
and reverberations
↓

No Green's func-
tion retrieval

CWI & Cross-correlations

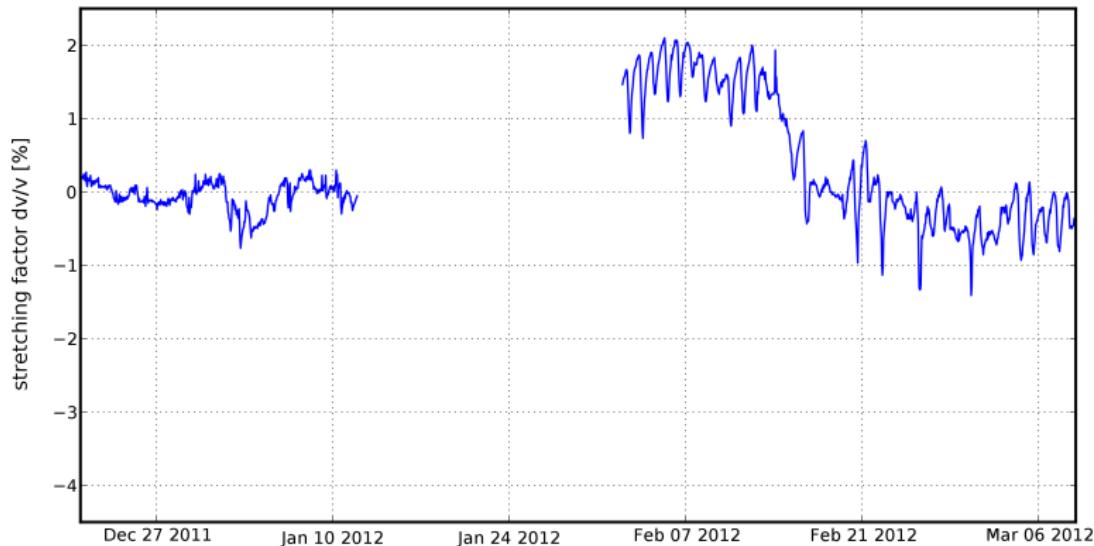


CWI & Cross-correlations



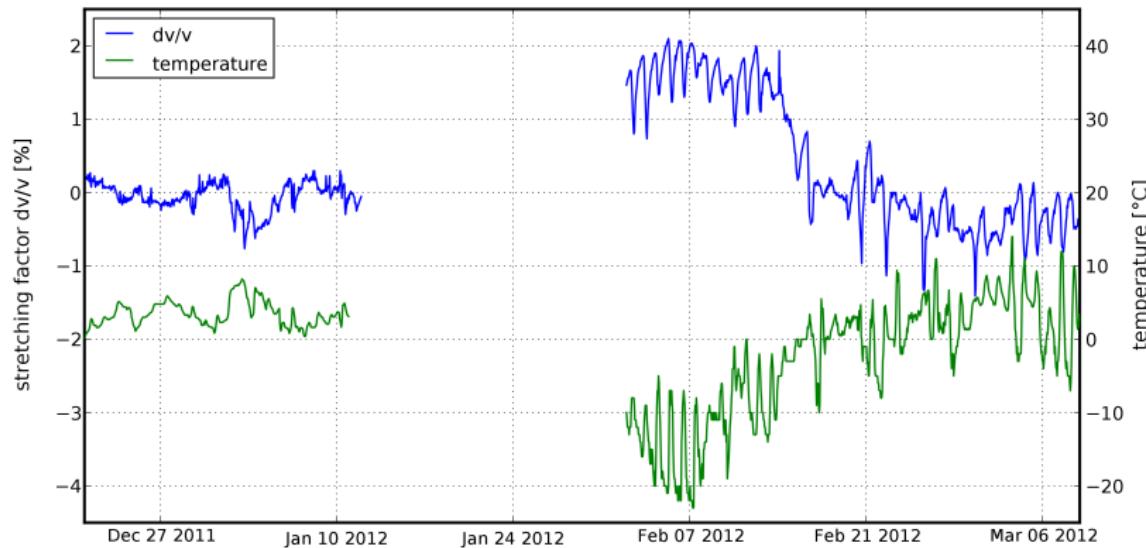
Observed Results

Velocity variation $\frac{\Delta v}{v}$



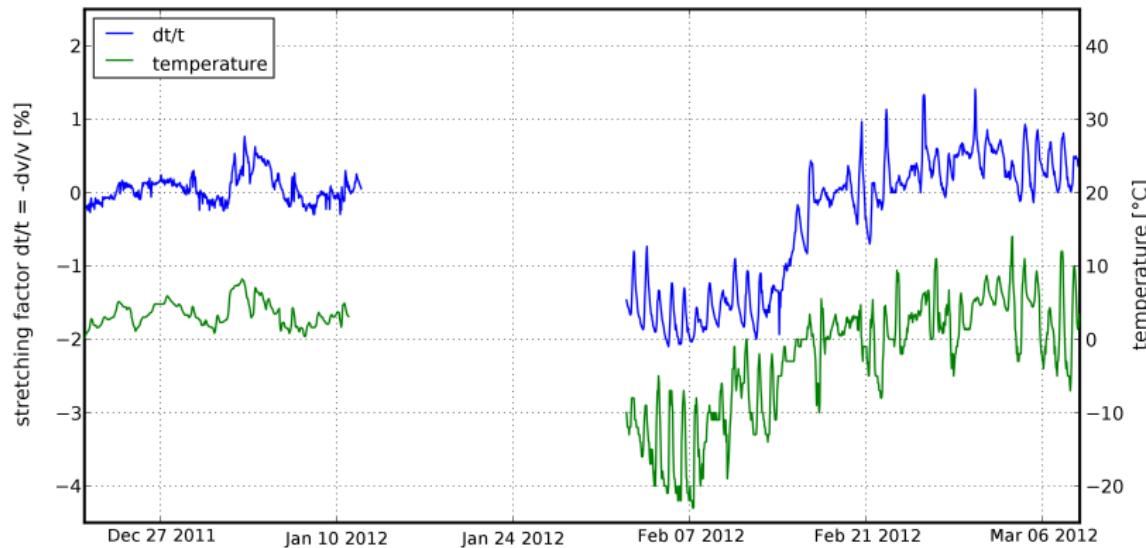
Observed Results

Velocity variation $\frac{\Delta v}{v}$ + Temperature



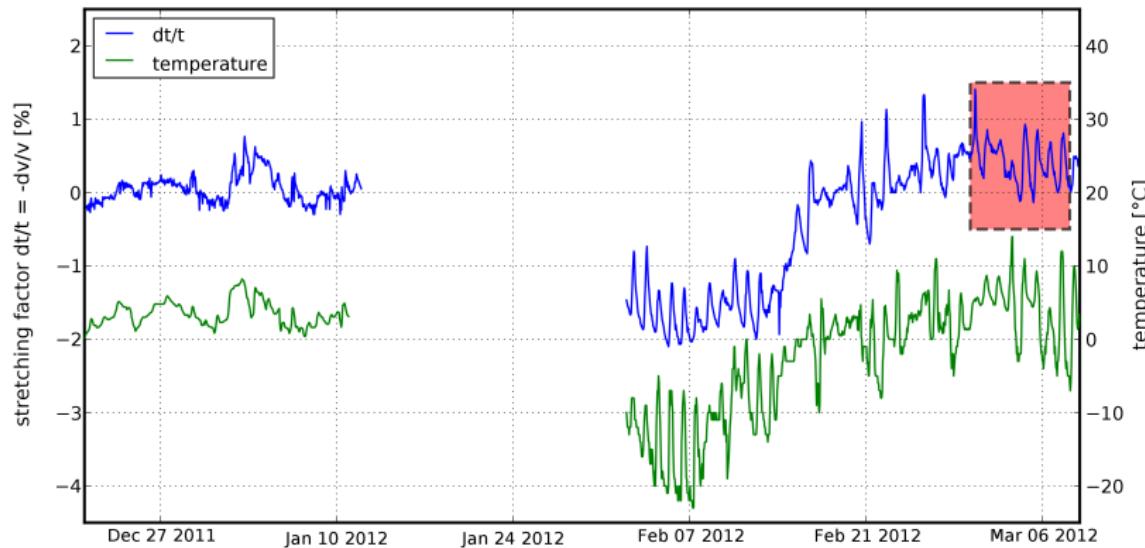
Observed Results

Velocity variation $\frac{\Delta t}{t}$ + Temperature



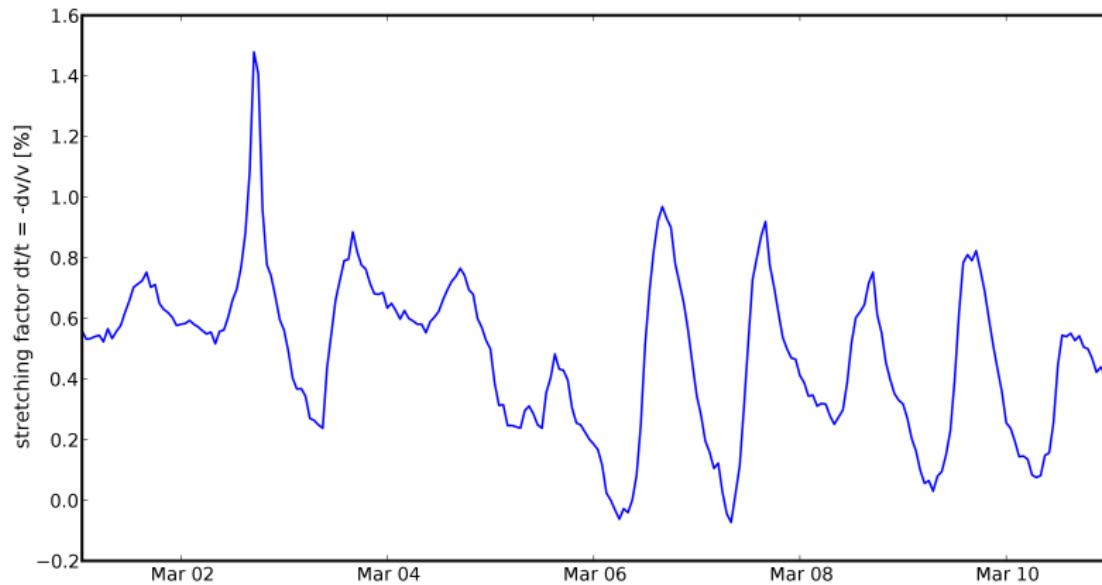
Observed Results

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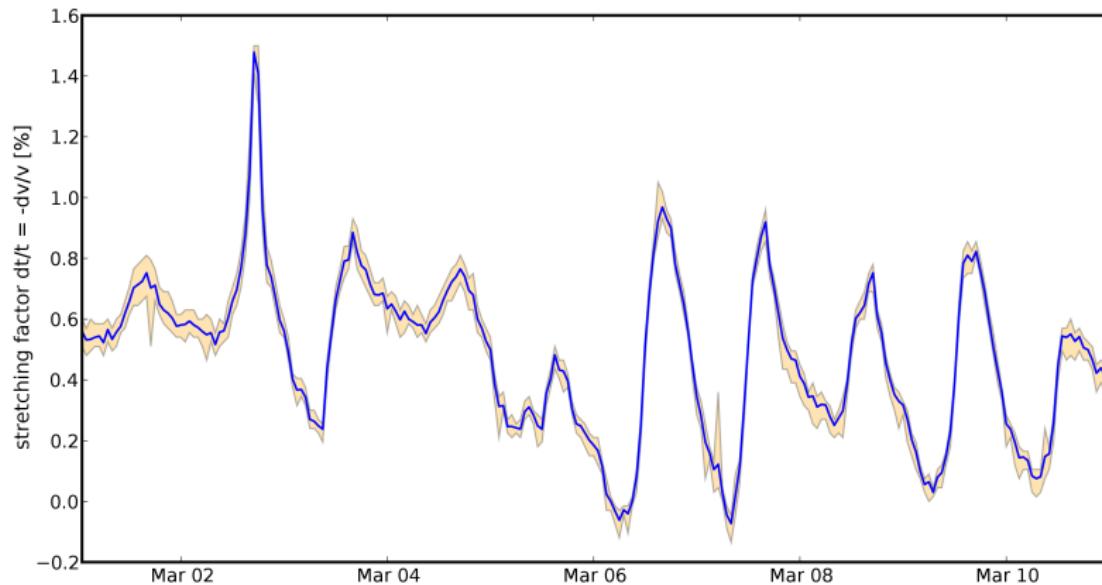
March 2012

Velocity variation $\frac{\Delta t}{t}$



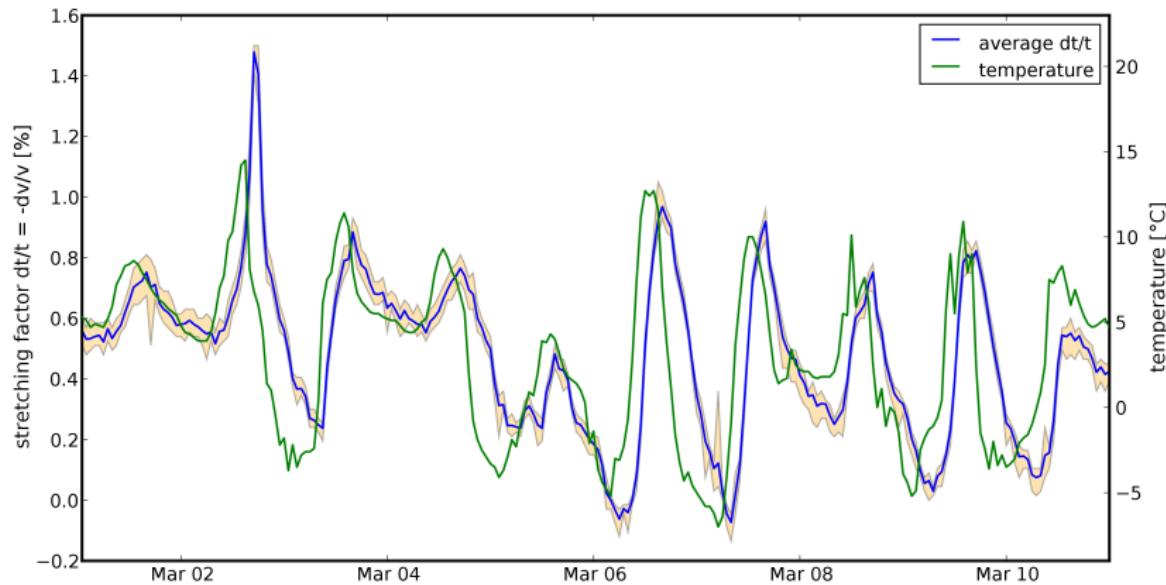
March 2012

Velocity variation $\frac{\Delta t}{t}$ + Deviation (8 receiver pairs)



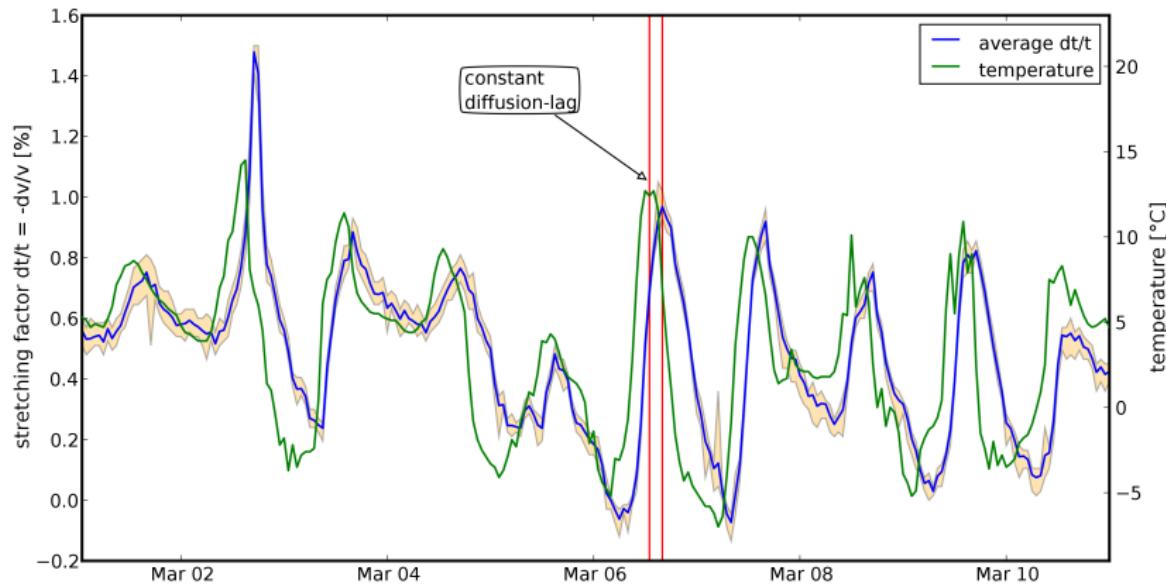
March 2012

Velocity variation $\frac{\Delta t}{t}$ + Deviation (8 receiver pairs) + **Temperature**



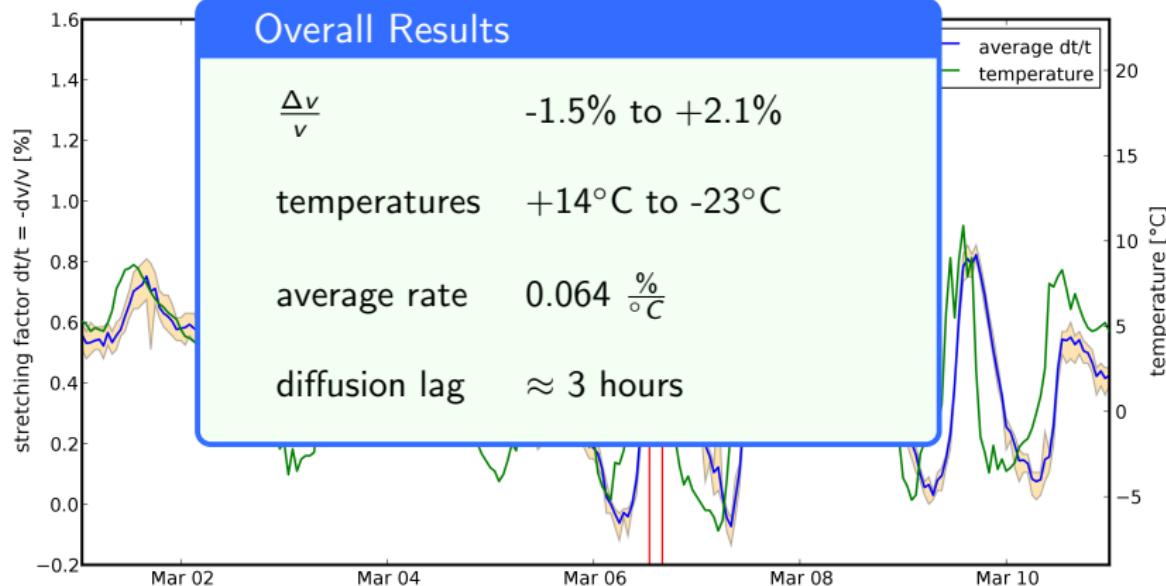
March 2012

Velocity variation $\frac{\Delta t}{t}$ + Deviation (8 receiver pairs) + **Temperature**



March 2012

Velocity variation $\frac{\Delta t}{t}$ + Deviation (8 receiver pairs) + **Temperature**



Reliability Tests I

Thermal expansion

- Varying inter-receiver distances cause traveltime variations
- $\frac{\Delta t}{t} = -\frac{\Delta v}{v}$
⇒ Effect in the order of $6-14 \cdot 10^{-4} \frac{\%}{^\circ C}$
for steel-reinforced concrete (cf. *Keller, T. and C. Menn (1992)*)

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reference range:
-1.5 to +2.3 %



Reliability Tests II

Mathematical test of instrument stability

- Calculate temperature dependence of geophones
- Deconvolve impulse response and convolve with slightly different response ($\Delta f_c = 0.2$ Hz)
⇒ Correlation of original and simulated signal yielded an apparent delay of **4.8 · 10⁻² %.**

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Conclusions

- Resolution of velocity variations is possible via cross-correlations from ambient traffic noise on a bridge
- Captured small velocity variations caused by temperature fluctuations:
relative velocity $\frac{\Delta v}{v}$: -1.5% to +2.1%
temperature range: +14°C to -23°C
- Strong correlation between temperature and $\frac{\Delta v}{v}$ series
- Advantages: high temporal resolution, high accuracy, low logistical effort

Perspective

Aspired Project

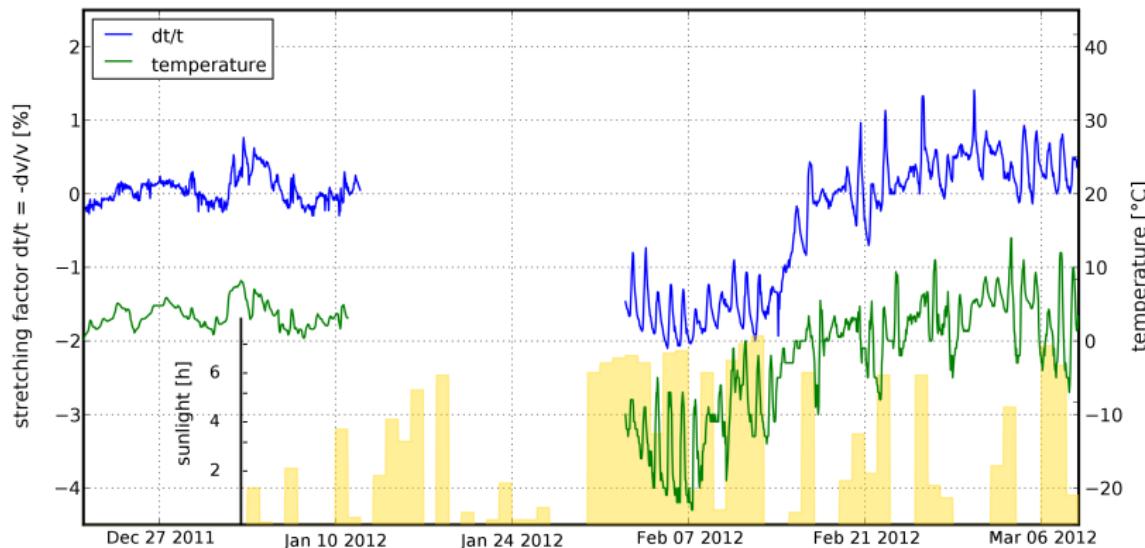
- Long-term (> 1 year) monitoring of a highway bridge
 - ⇒ improve characterization of temperature effect
- Damage-scenario tests on sample bodies and expired structures
- Numerical simulations
 - ⇒ confirm reliability of damage detection

Questions

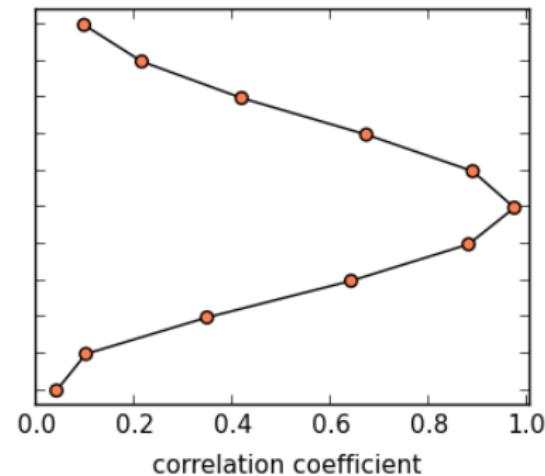
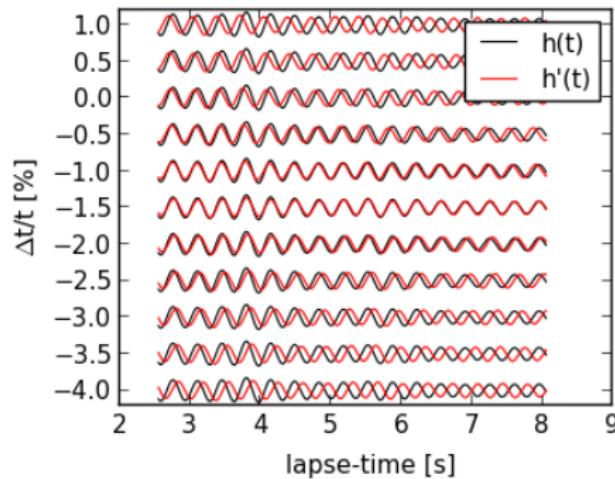
Thank you!



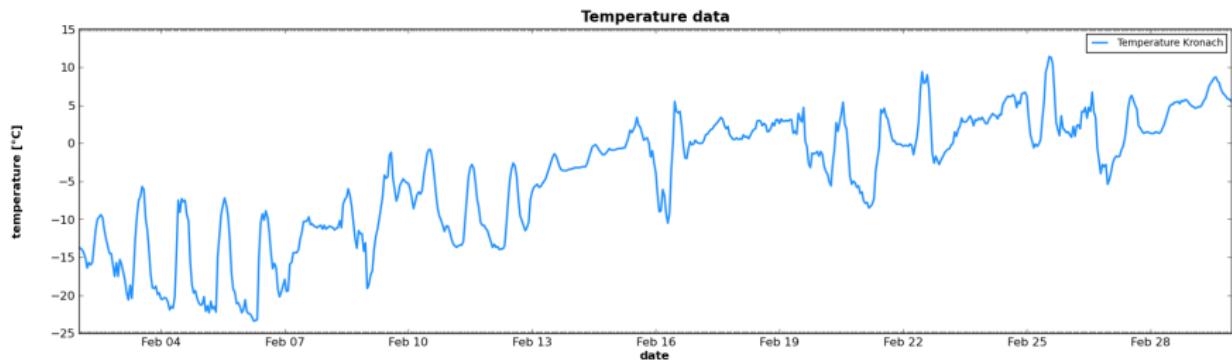
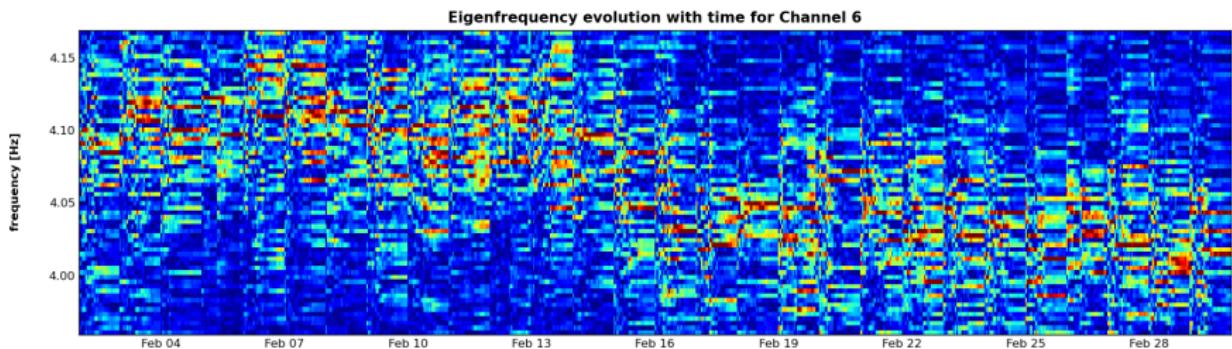
Daily Sunlight



Stretching Method



Eigenfrequency Evolution



Instrument Stability Test

Frequency Response of GS-11D 4.5Hz 380 Ω vertical component Geophone

