

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

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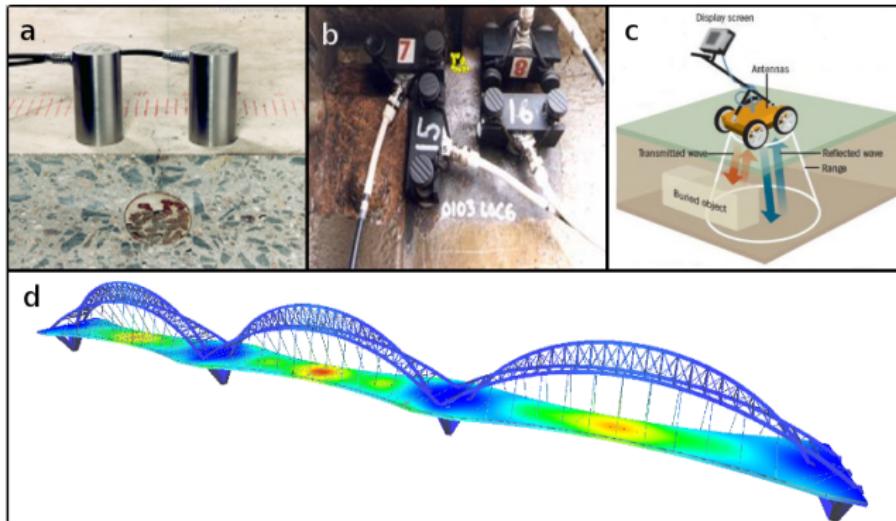
17.03.2016

Objective

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

Motivation

Issue: Combination of **precise** and **permanent** monitoring with a **simple** measurement setup and evaluation technique.



Measurement Setup I

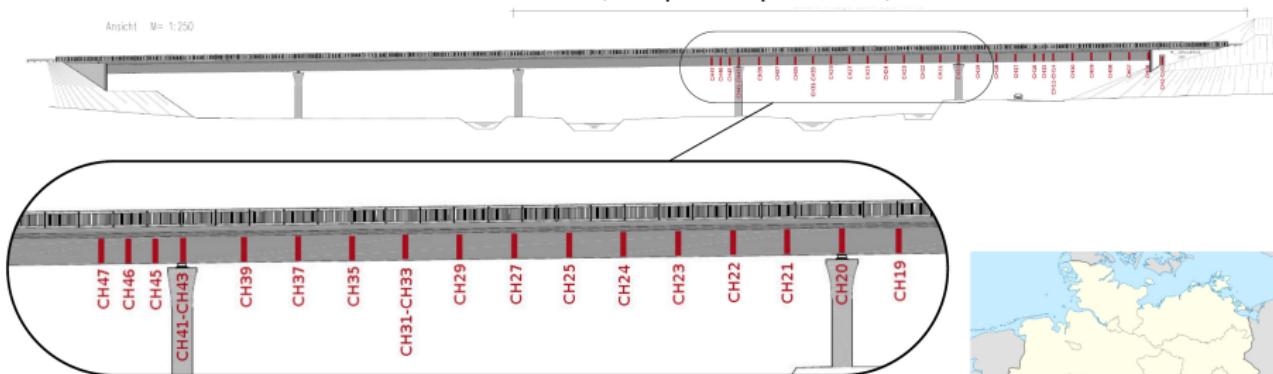
lateral view (Geophone positions)

Ansicht M= 1:250

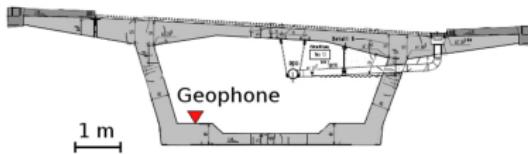


Measurement Setup I

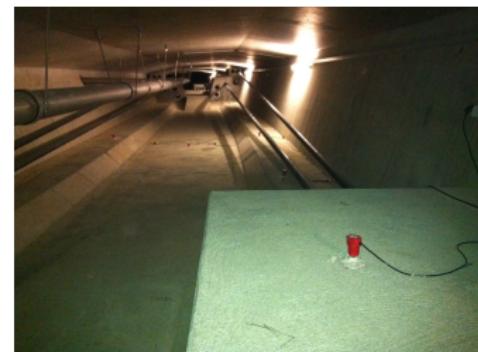
lateral view (Geophone positions)



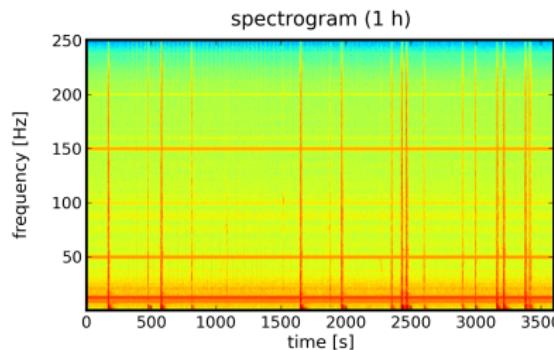
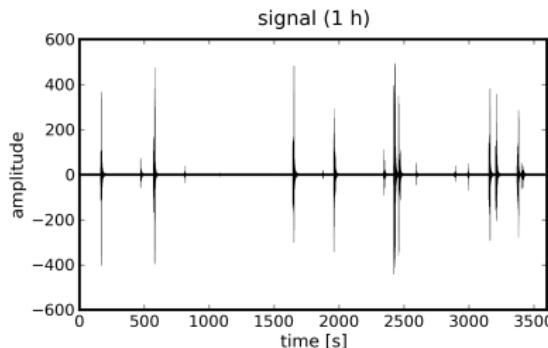
cross-section



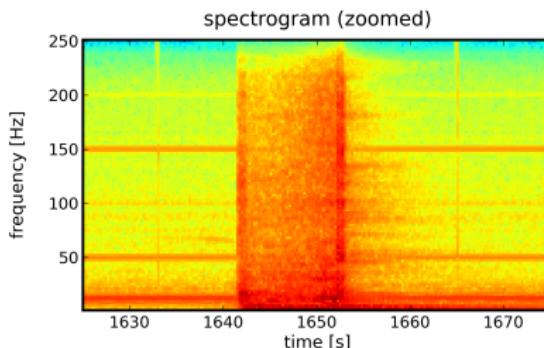
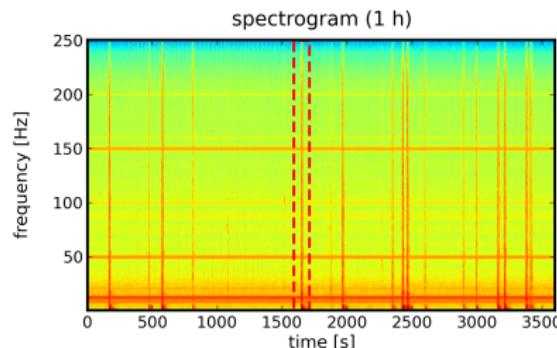
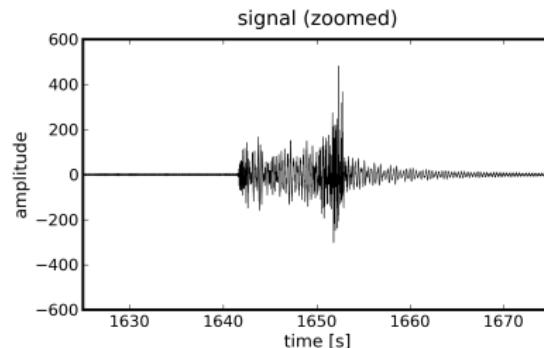
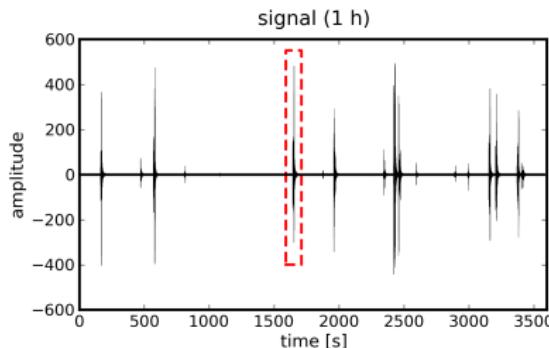
Measurement Setup II: Steinachtal Bridge



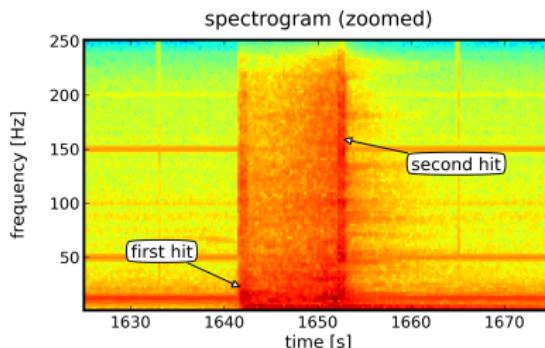
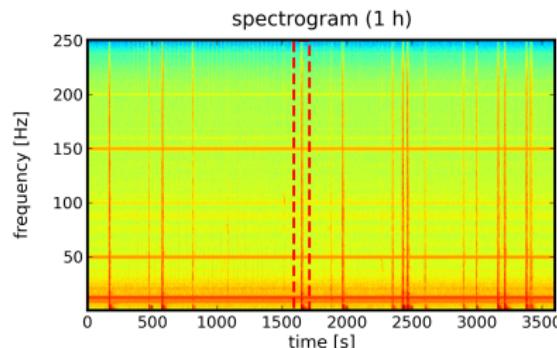
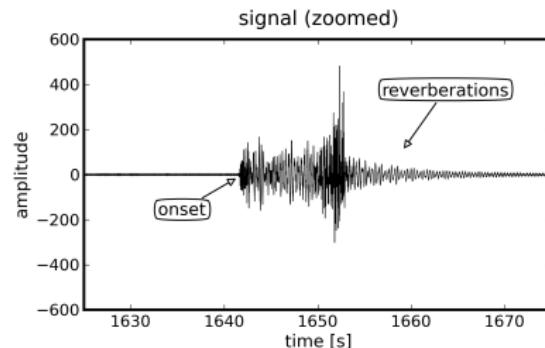
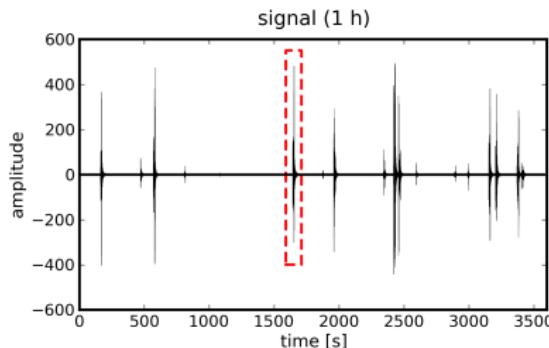
Raw Signal



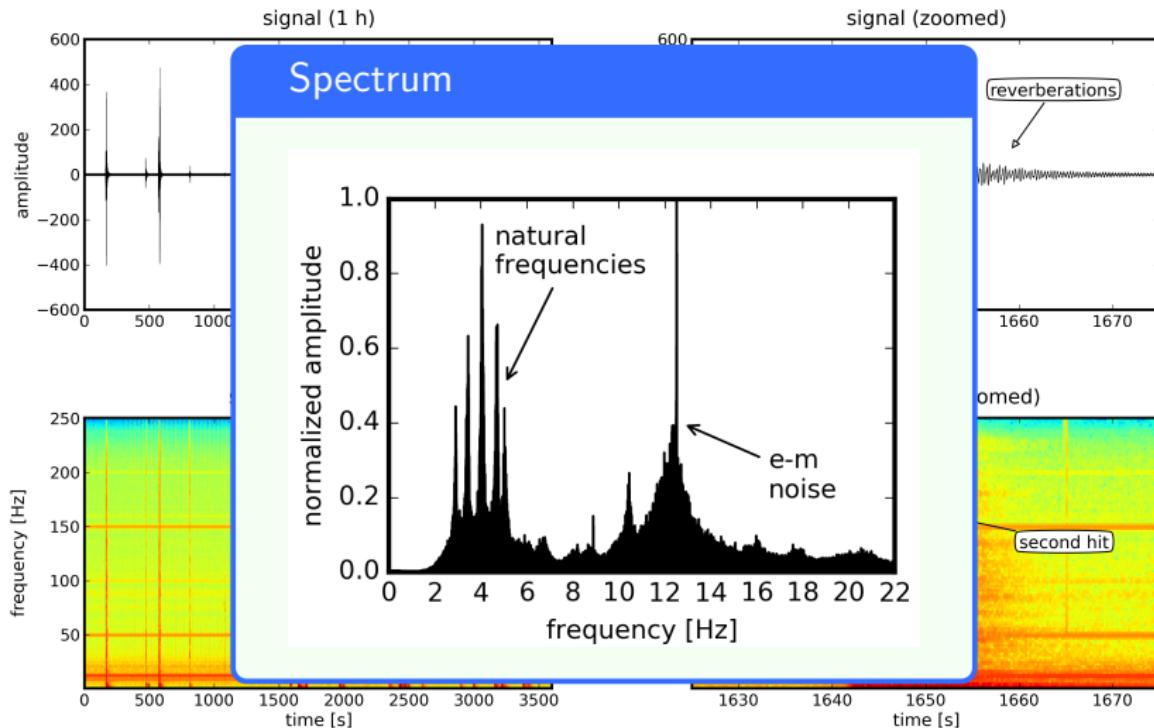
Raw Signal



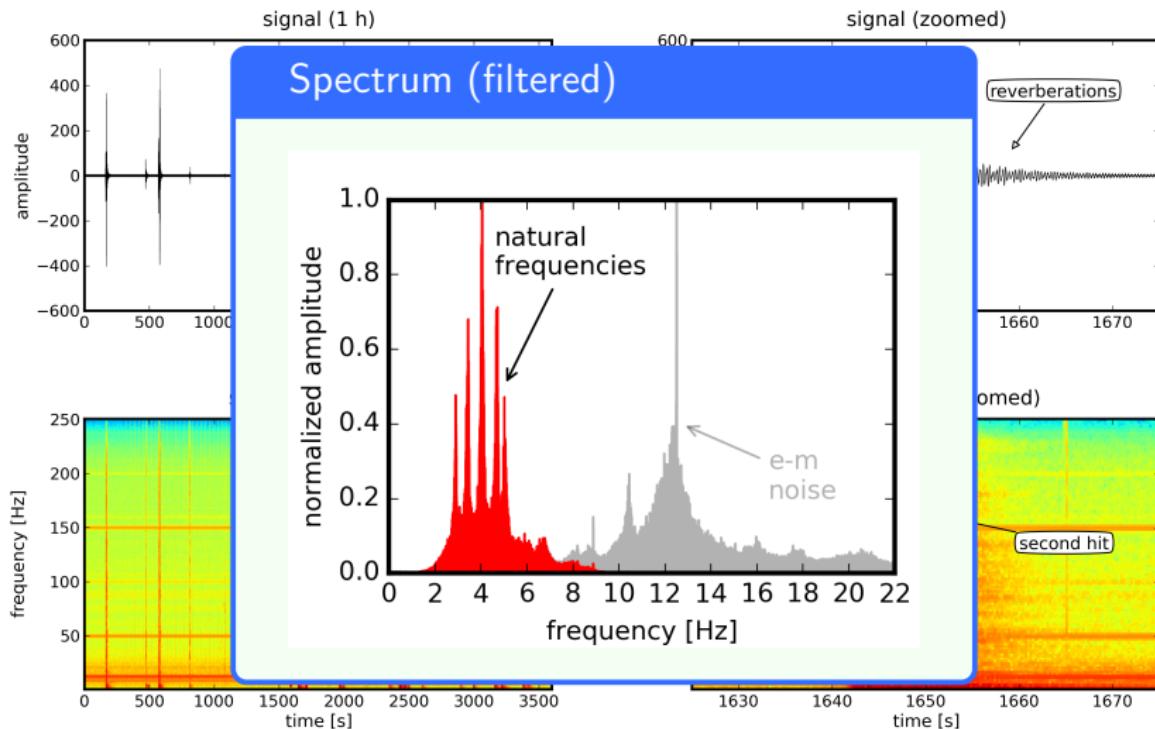
Raw Signal



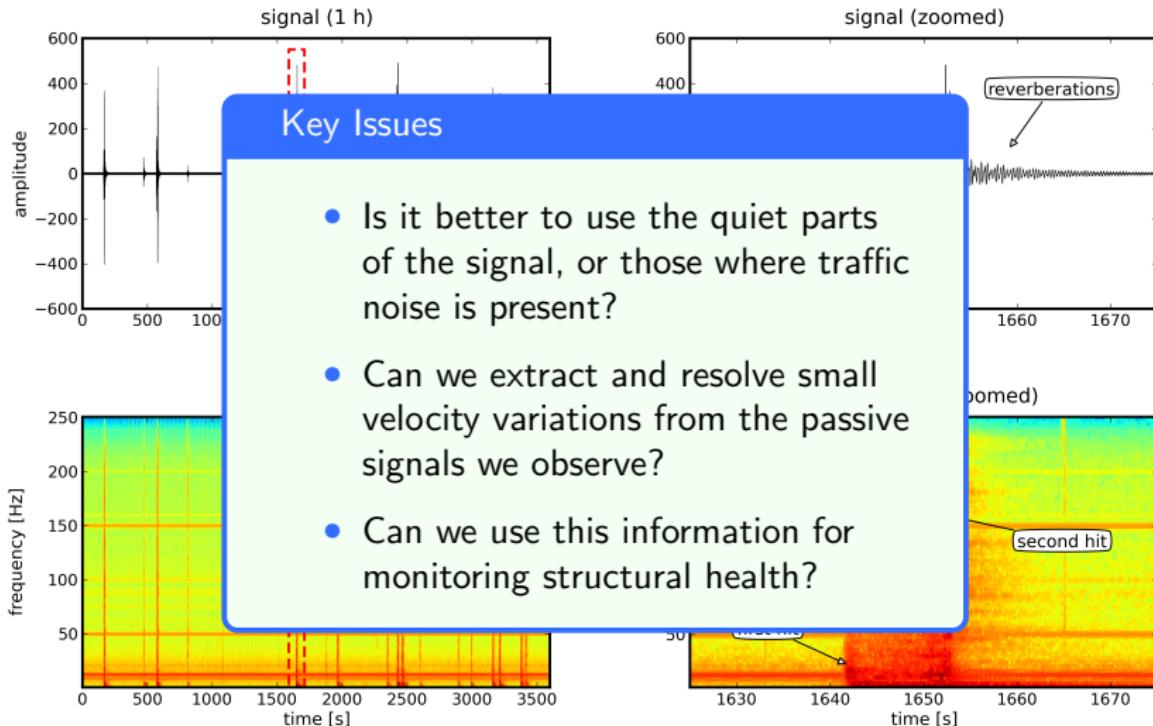
Raw Signal



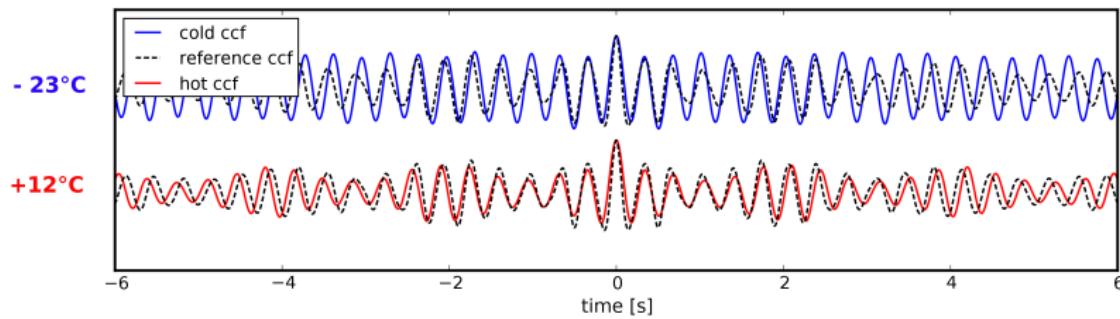
Raw Signal



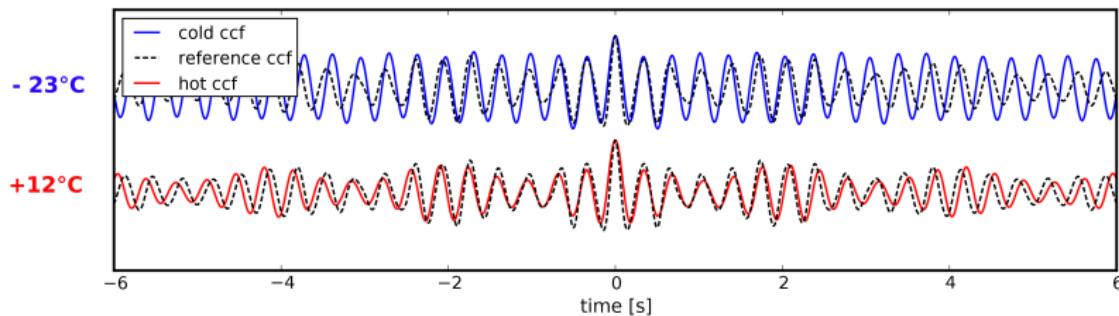
Raw Signal



CWI & Cross-correlations



CWI & Cross-correlations

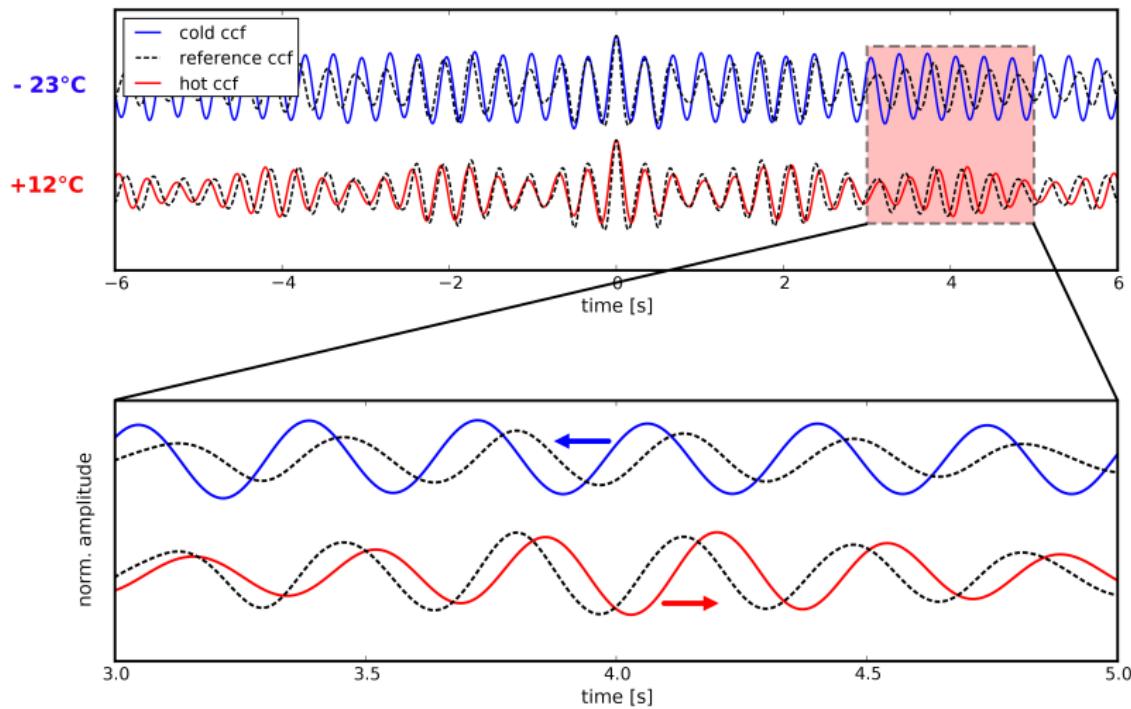


Hourly cross-correlations
for receiver pairs

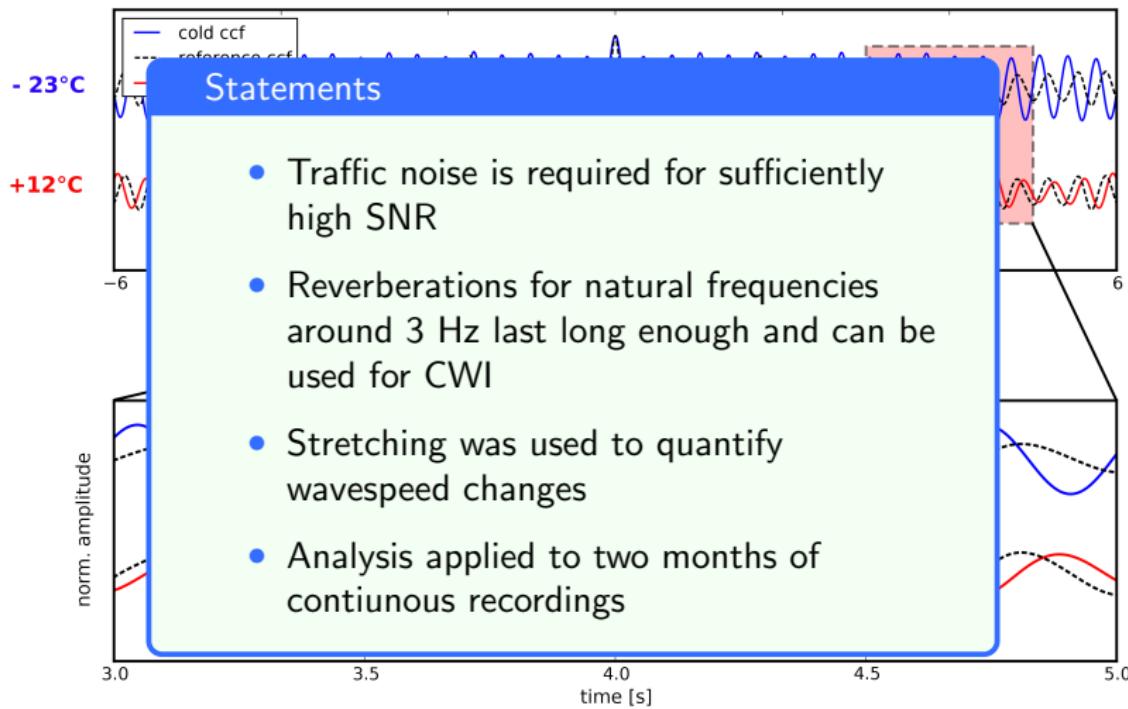


Unilateral sources
and reverberations
⇓
no perfect
Green's functions

CWI & Cross-correlations

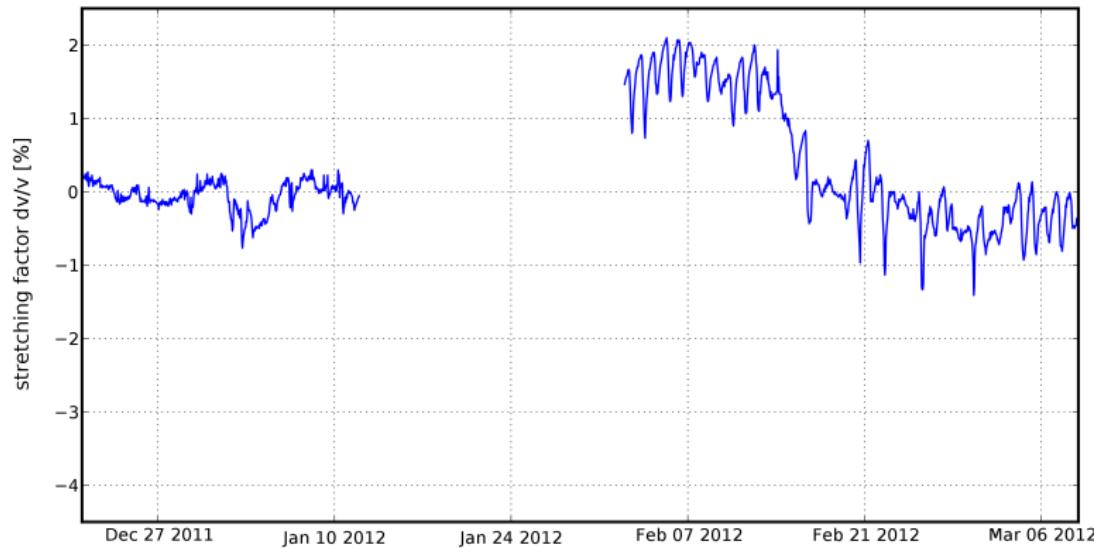


CWI & Cross-correlations



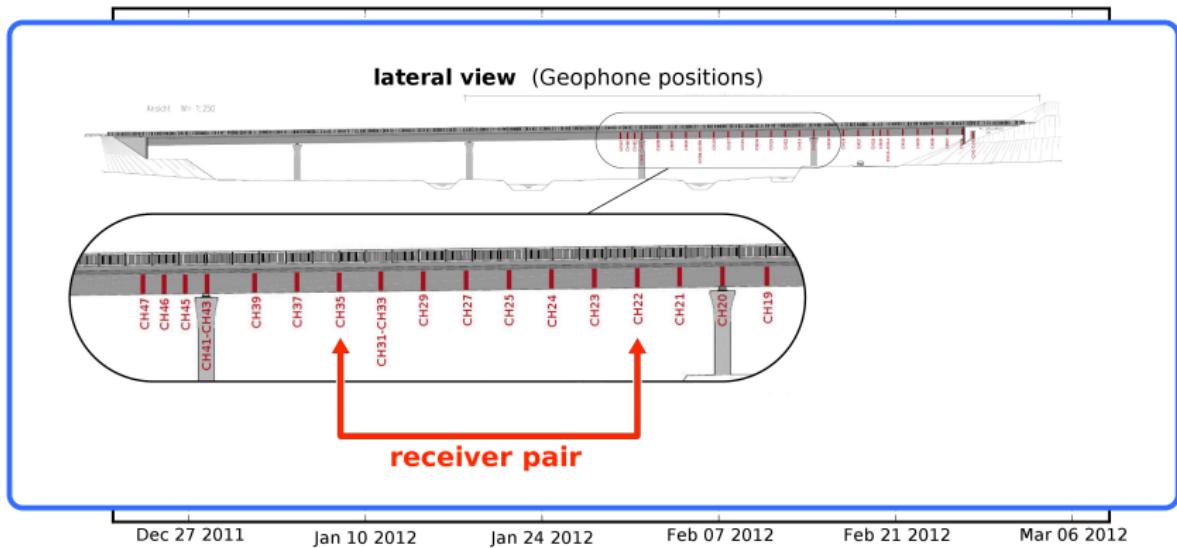
Observed Results

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



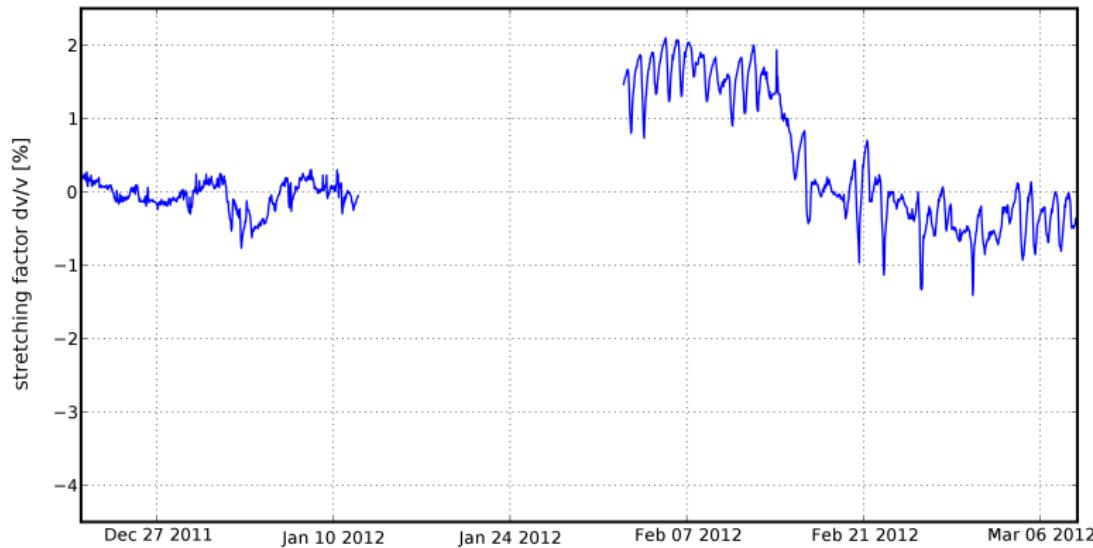
Observed Results

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



Observed Results

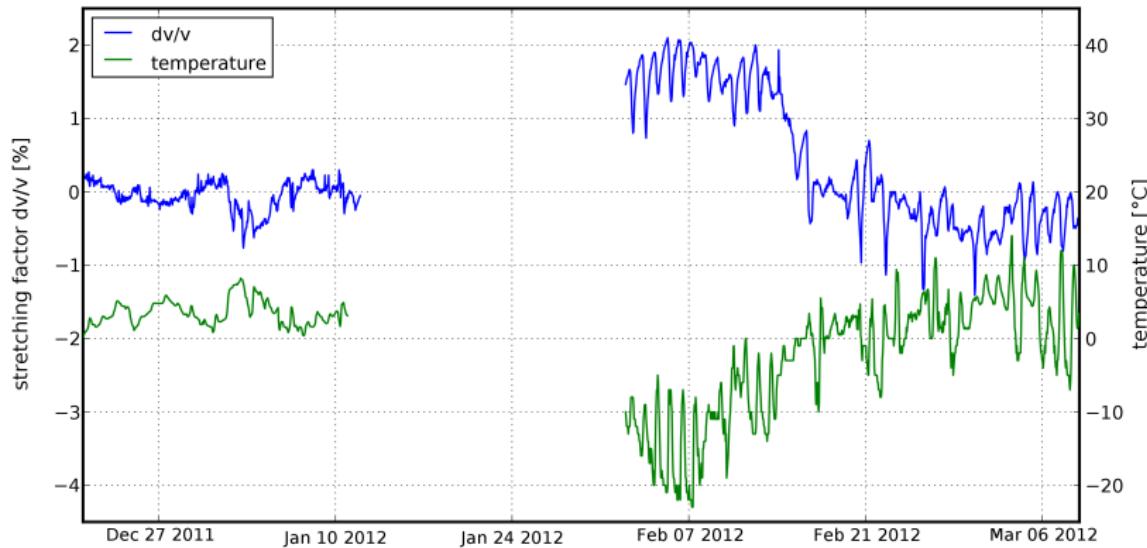
Velocity variation $\frac{\Delta v}{v}$



Observed Results

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

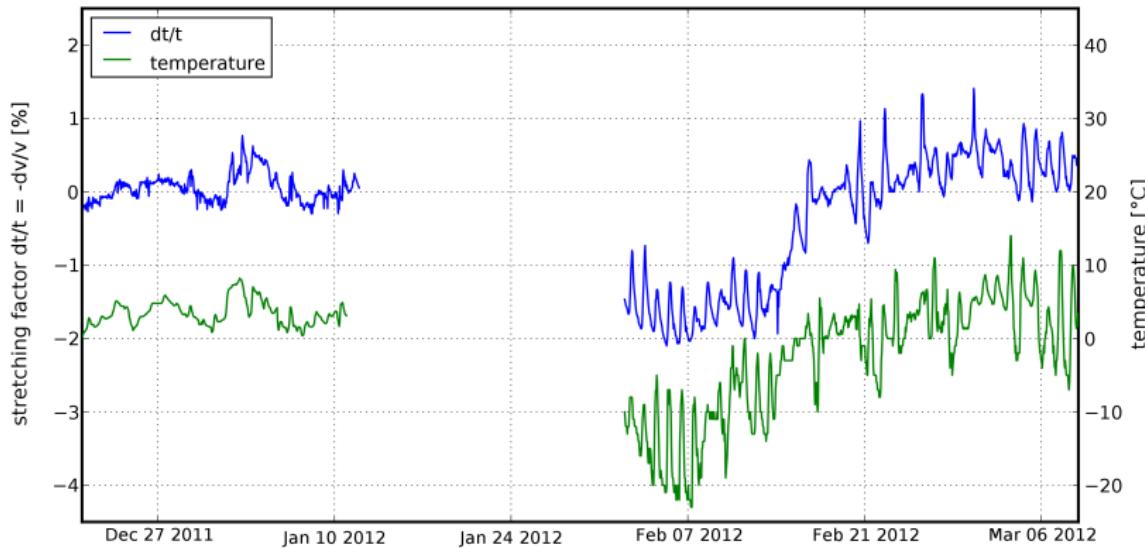
Temperature



Observed Results

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

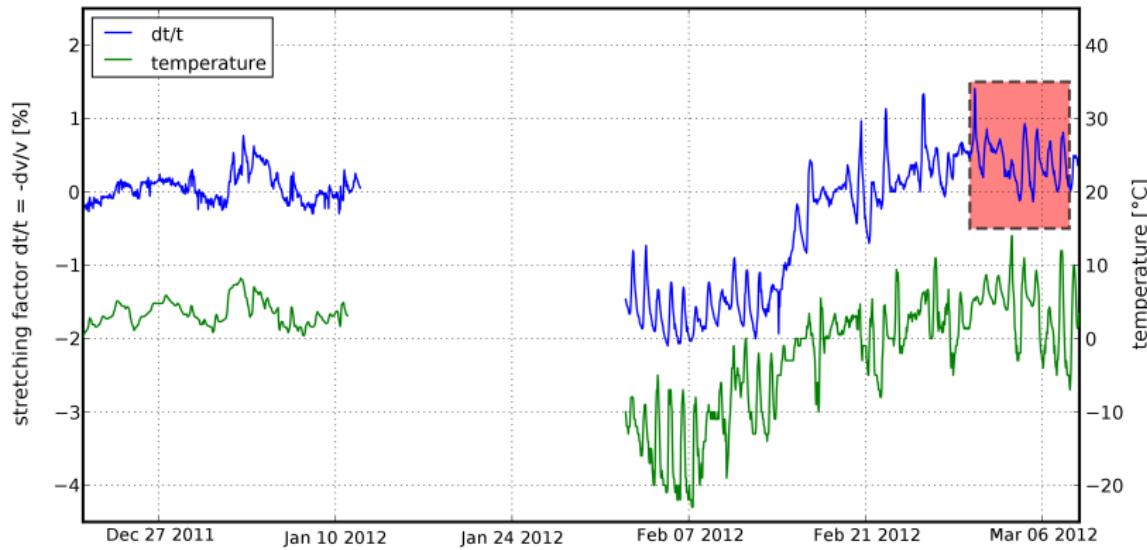
Temperature



Observed Results

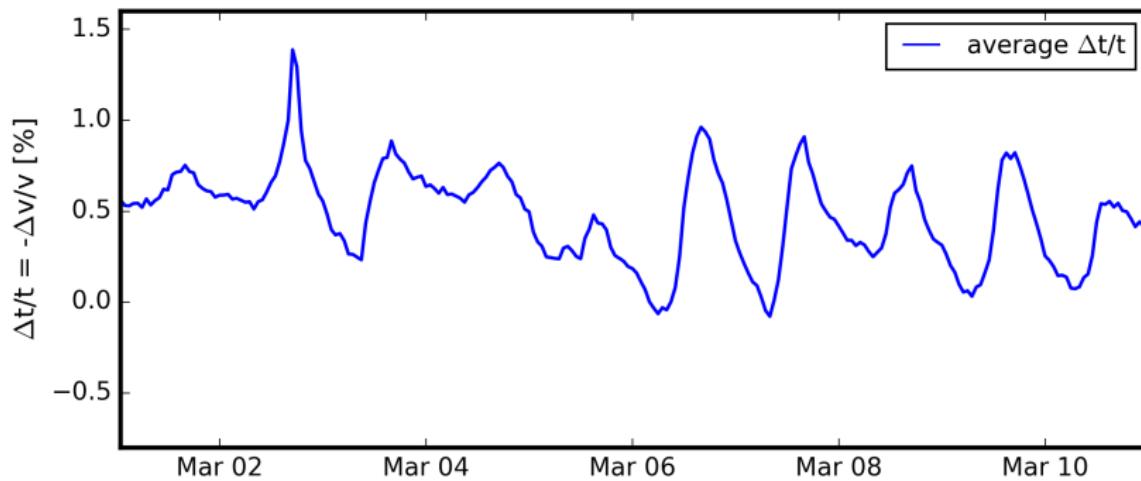
Velocity variation $\frac{\Delta t}{t}$

Temperature



March 2012

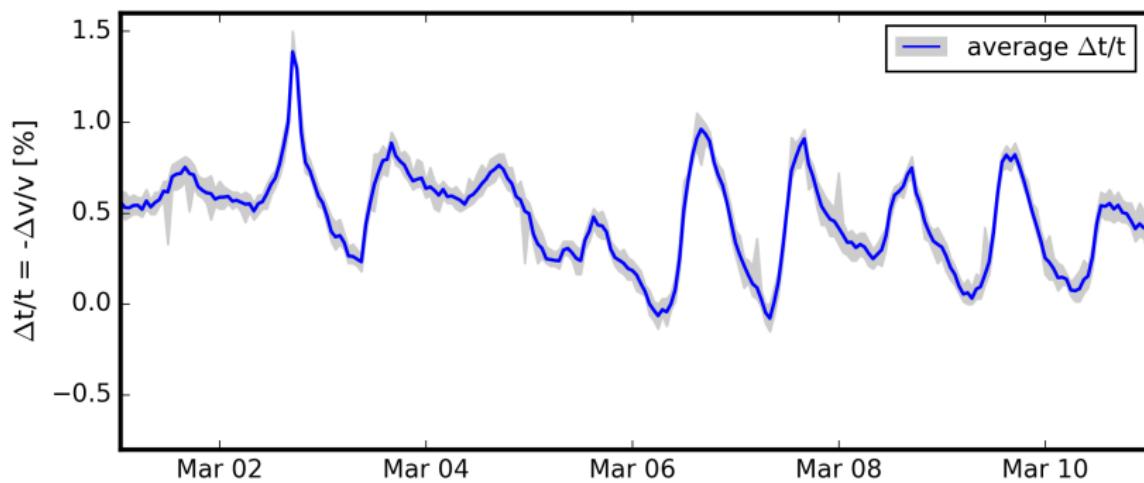
Velocity variation $\frac{\Delta t}{t}$



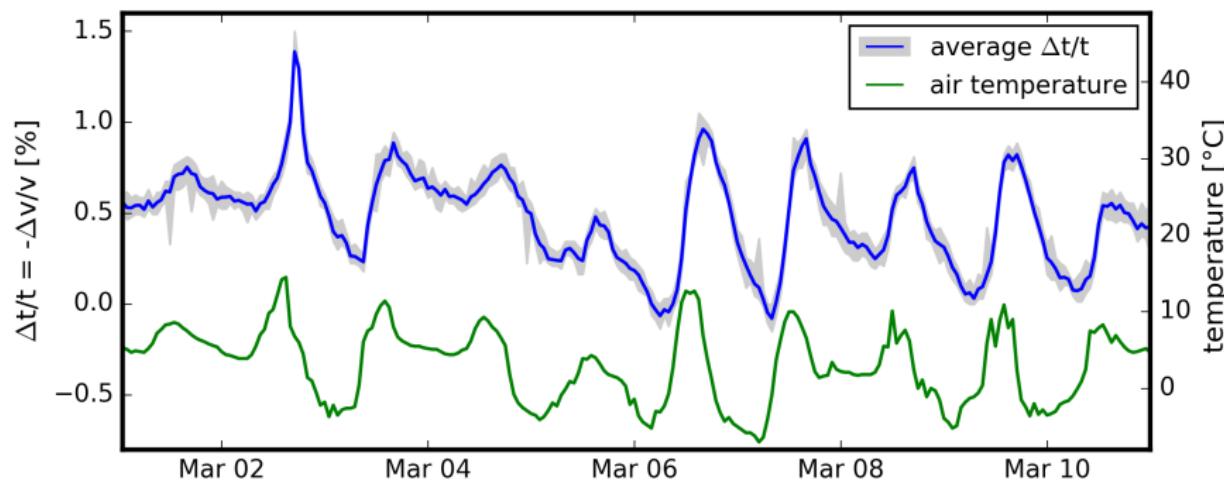
March 2012

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

Deviation
(32 receiver pairs)



March 2012

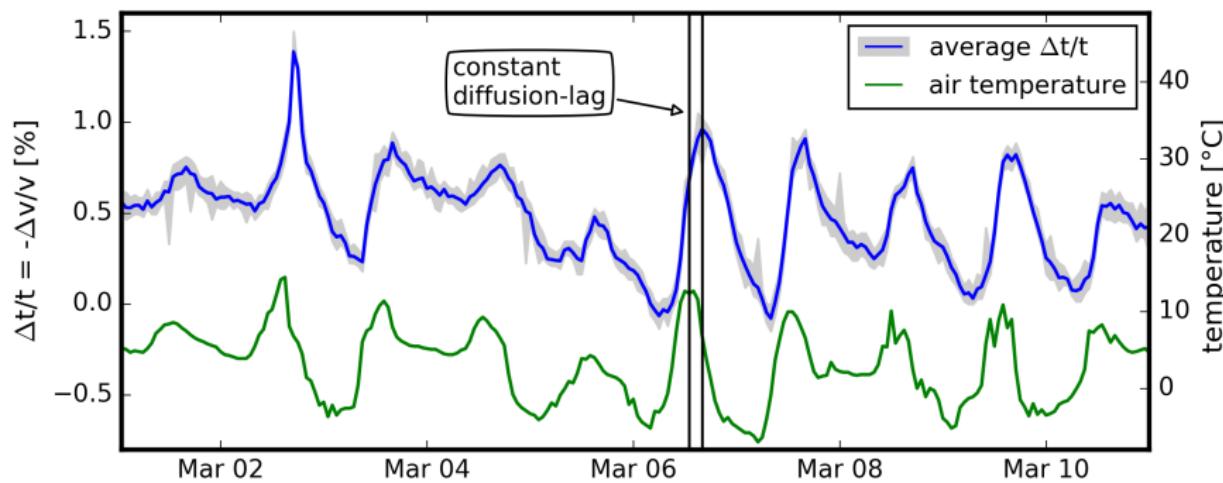
Velocity variation $\frac{\Delta t}{t}$ Deviation
(32 receiver pairs)**Temperature**

March 2012

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

Deviation
(32 receiver pairs)

Temperature



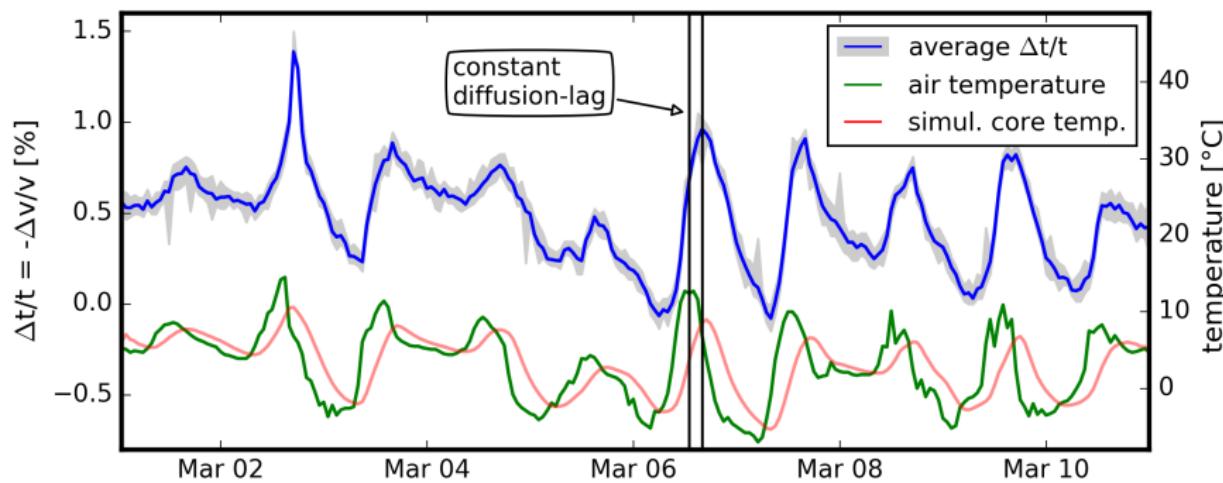
March 2012

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

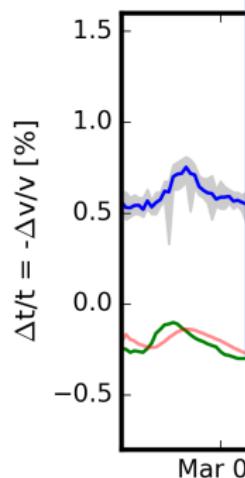
Deviation
(32 receiver pairs)

Temperature

Simulated core temperature



March 2012

Velocity variation $\frac{\Delta t}{t}$ Deviation
(32 receiver pairs)**Temperature****Simulated core temperature****Overall Results**

$$\frac{\Delta v}{v}$$

-1.5% to +2.1%

temperatures

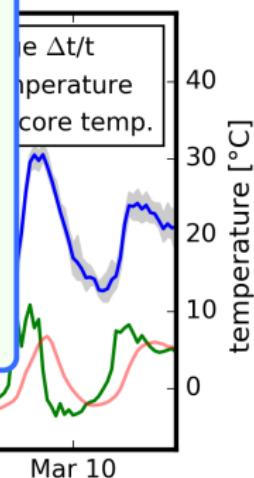
+14°C to -23°C

average rate

0.064 %/°C

diffusion lag

≈ 3 hours



Reliability Tests

Thermal expansion

Expansion/Contraction of the bridge

Instrument stability

Temperature dependence of geophones

Msmt range

-1.5 to +2.3 %

Reliability Tests

Thermal expansion

Expansion/Contraction of the bridge

⇒ Effect in the order of $6\text{-}14 \cdot 10^{-4} \frac{\%}{^\circ C}$ for
steel-reinforced concrete



Msmt range

-1.5 to +2.3 %

Instrument stability

Temperature dependence of geophones

Reliability Tests

Thermal expansion

Expansion/Contraction of the bridge

⇒ Effect in the order of $6\text{-}14 \cdot 10^{-4} \frac{\%}{^\circ C}$ for steel-reinforced concrete

Msmt range

-1.5 to +2.3 %

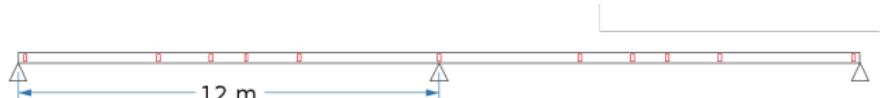
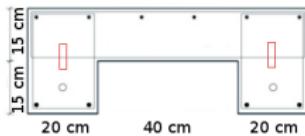
Instrument stability

Temperature dependence of geophones

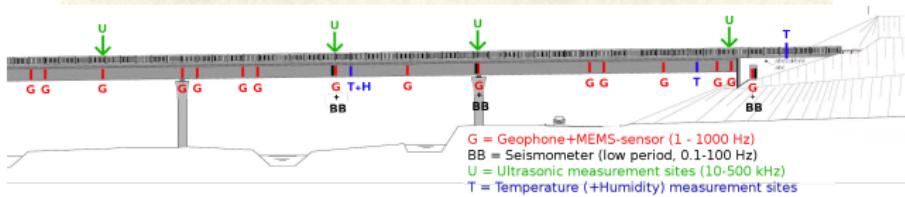
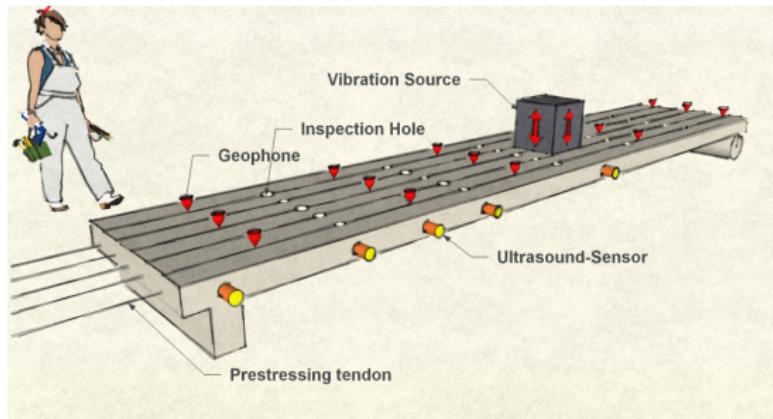
⇒ Apparent delay of max. **0.52 %** for extreme shifts in corner frequency.

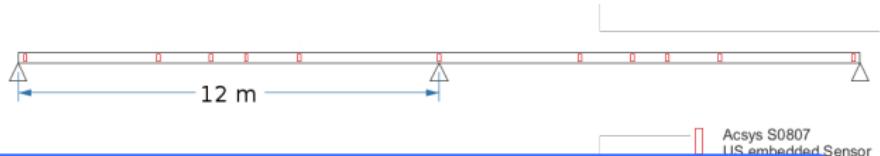
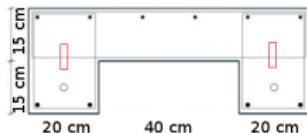
Conclusions

- 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



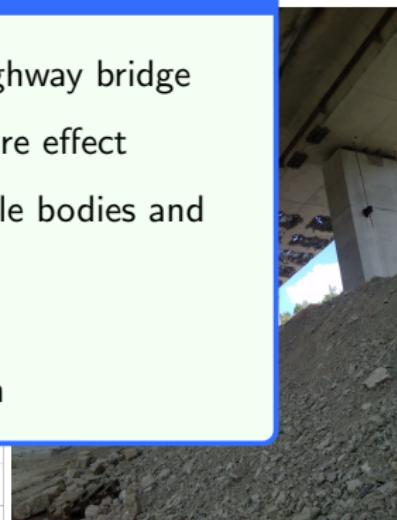
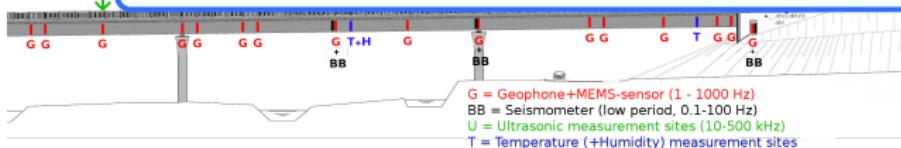
Acsys S0807
US embedded Sensor

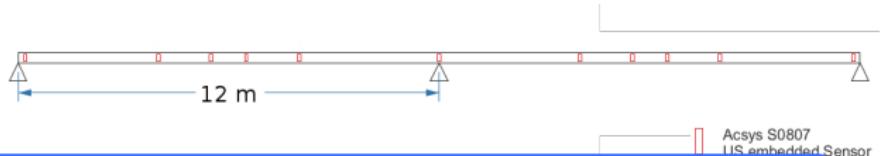
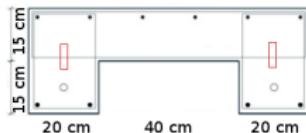




Perspective - aspired project

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



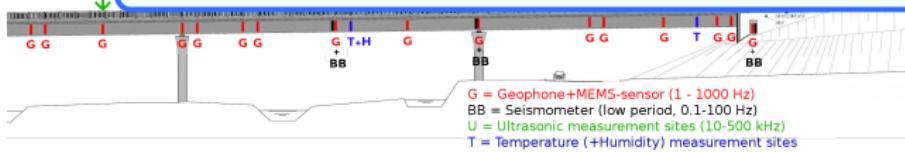


Perspective - aspired project



Aim

Detect corrosion-induced **decrease in prestressing** and associated **concrete crack evolution**

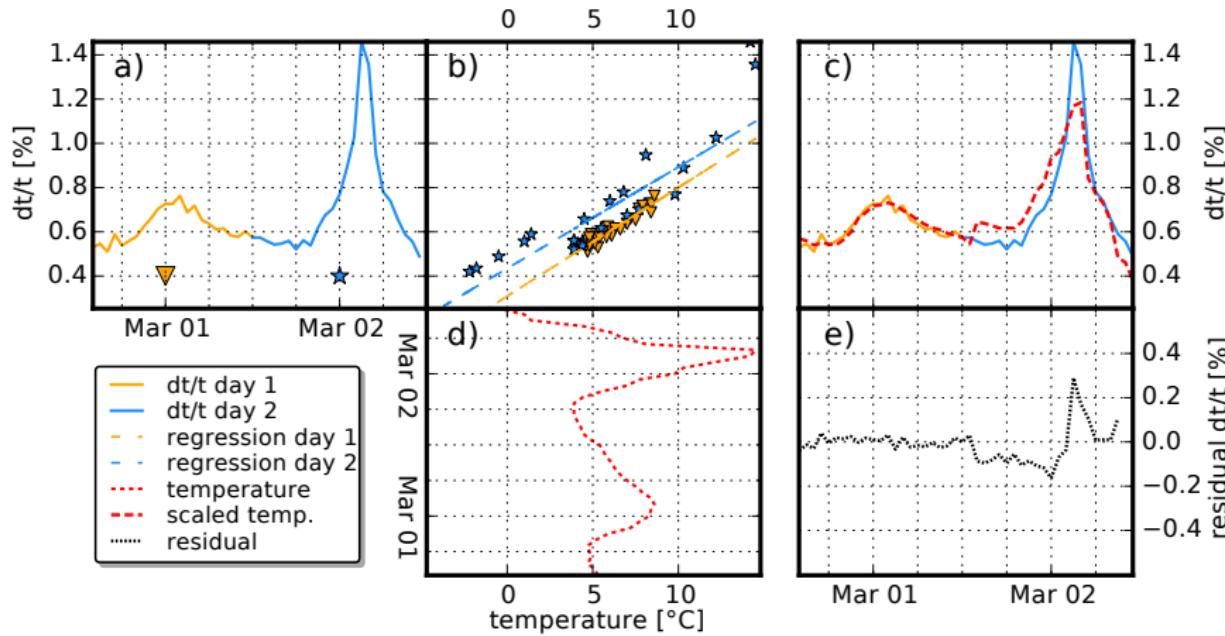


Questions

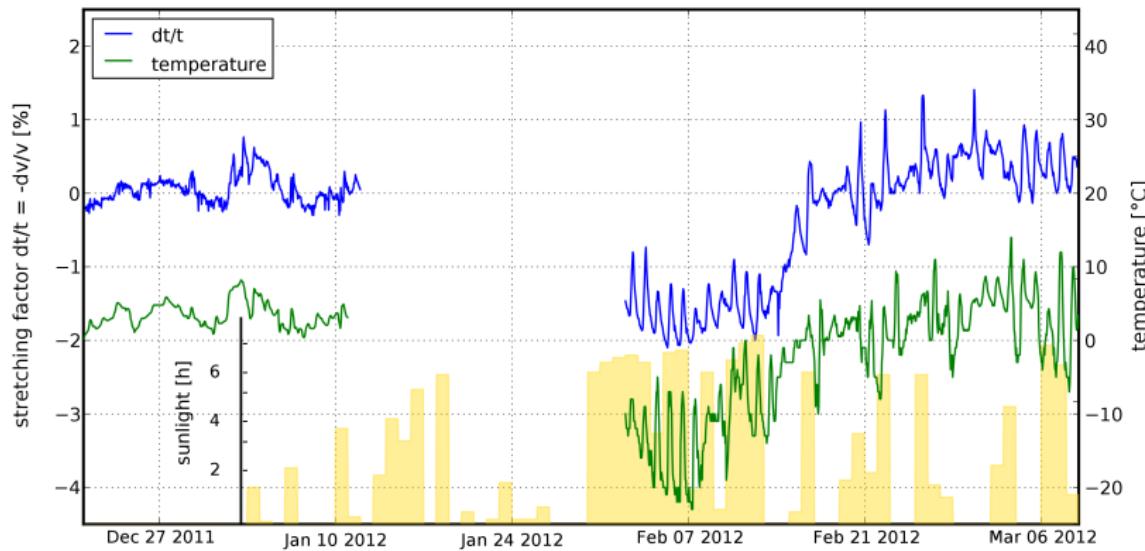
Thank you!



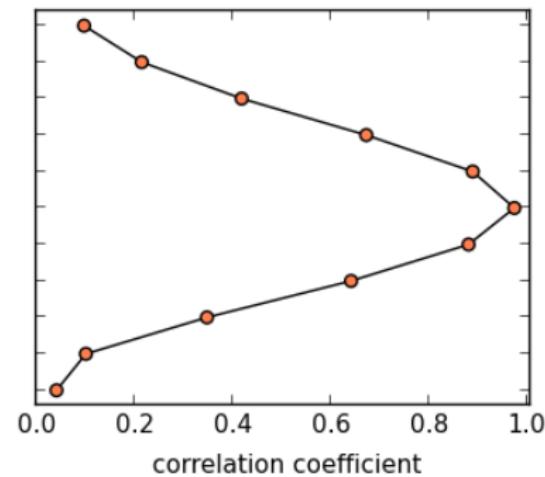
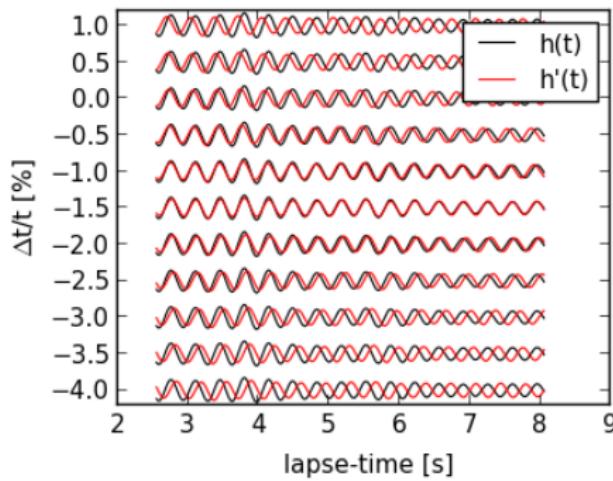
Temperature reduction



Daily Sunlight

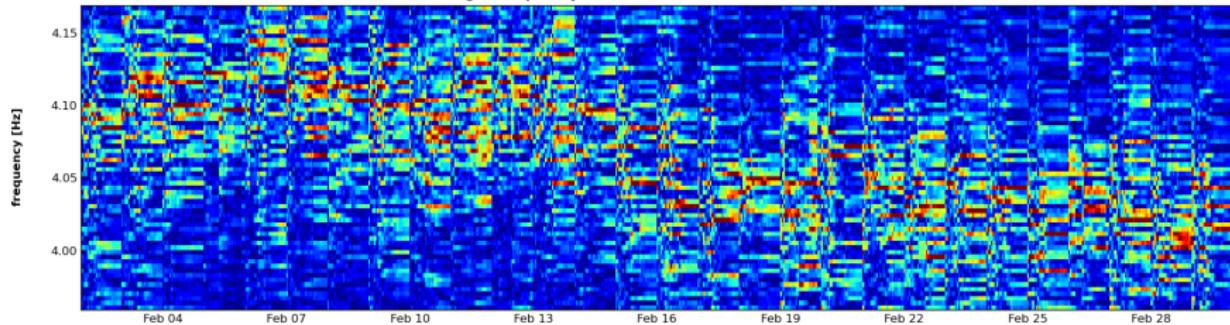


Stretching Method

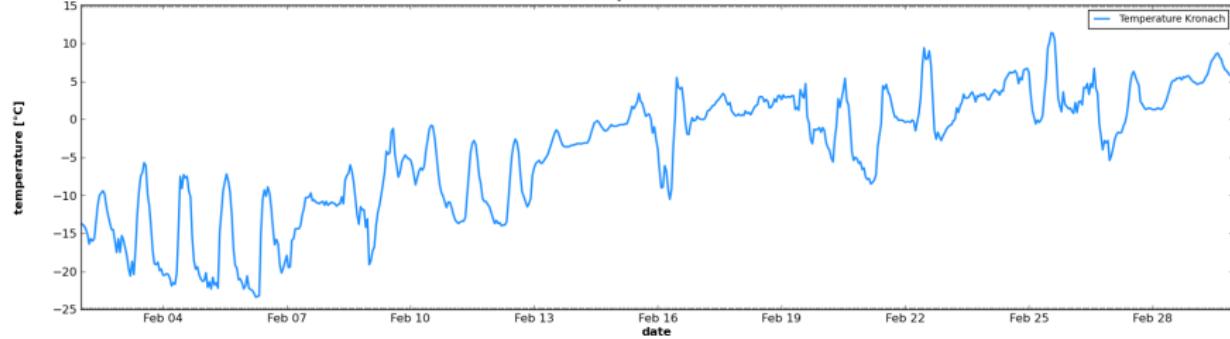


Eigenfrequency Evolution

Eigenfrequency evolution with time for Channel 6



Temperature data



Instrument Stability Test

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

