Do variations of the ambient noise wavefield reflect on measured seismic velocity changes?

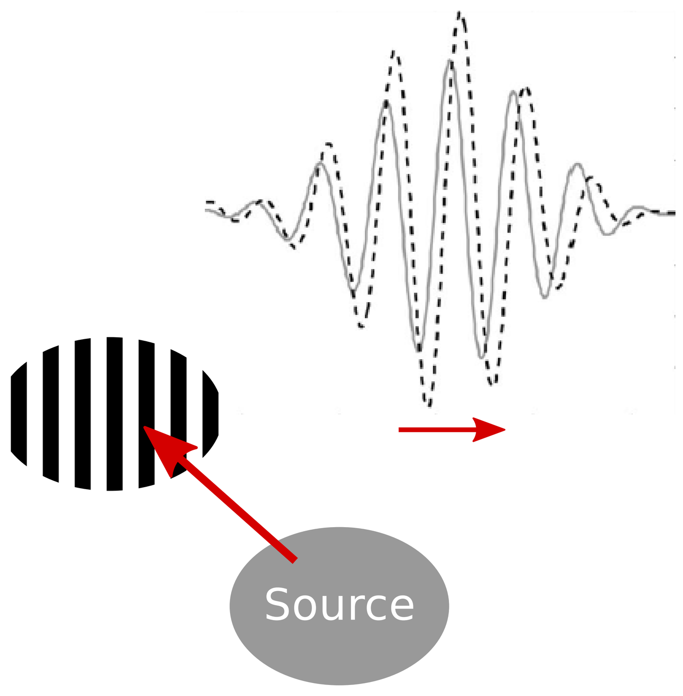
Céline Hadziioannou[1], E. Larose[2], P.Roux[2], M. Campillo[2], J. Wassermann[1], H. Igel[1]

[1] Ludwig-Maximilians-University München, Germany [2] ISTerre Grenoble, France

contact: hadzii@geophysik.uni-muenchen.de

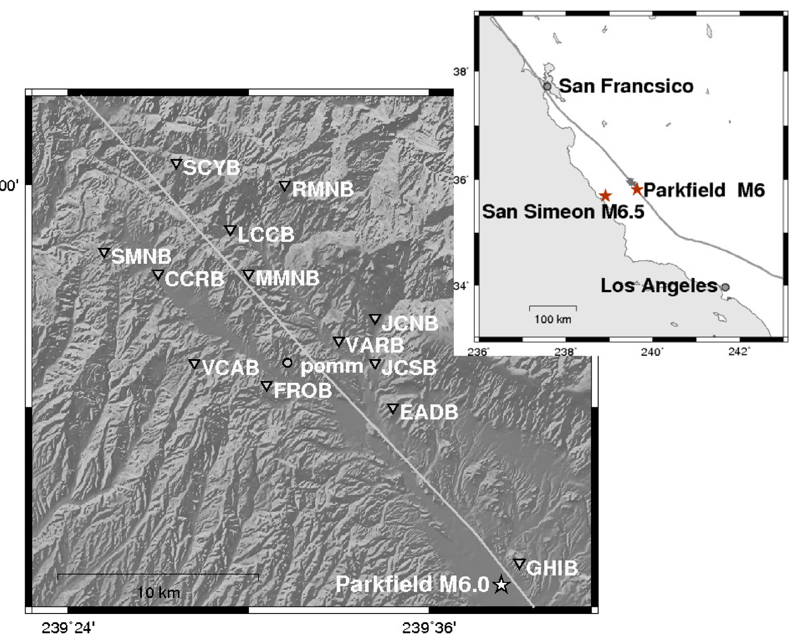
1 Anisotropic noise and correlations

- Noise correlation function resembles Green's function when noise distribution isotropic
- Change in noise source distribution timeshifts direct wave traveltime [Froment et al., 2010]
- In monitoring: measure small timeshifts in the coda of the correlation
- What happens to velocity change measurements when noise sources change?



2 Parkfield, California

- 4 years continuous data, 13 stations
- 2 events: San Simeon 2003 (M_w=6.5) & Parkfield 2004 (M_w=6.0)
- reference trace: 4 year average noise correlation
- temporal velocity changes measured on 5 day stacks
- Secondary microseismis: 0.1 - 0.2 Hz
- See also: [Hadziioannou et al., 2011]



3 Noise source influence on velocity change measurement

(a) **Primary noise source orientation**

Smooth seasonal variations
Don't reflect on dv/v measurements directly

(b) **Changes of the total noise wavefield**

Coherence of beamformer output
Stable with sudden changes (*e.g.* storms)

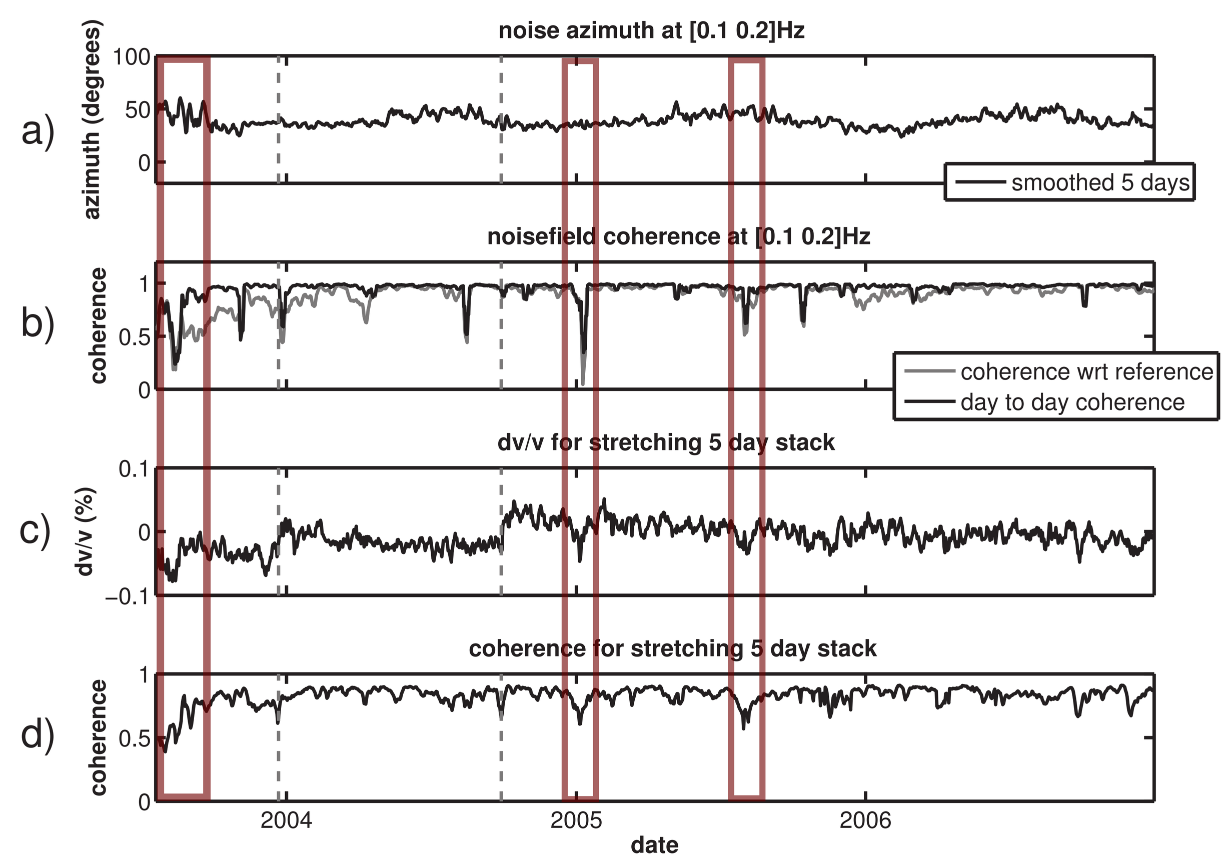
(c) **Relative wave speed change**

Relative seismic velocity change from ambient noise correlations
Waveform decoherence leads to increased fluctuations

(d) **Waveform coherence**

Noise correlation coherence with respect to reference
Waveforms decorrelate when sources change suddenly

4 Beamforming vs. relative velocity change



5 Beamforming without an array

Co-located measurements of

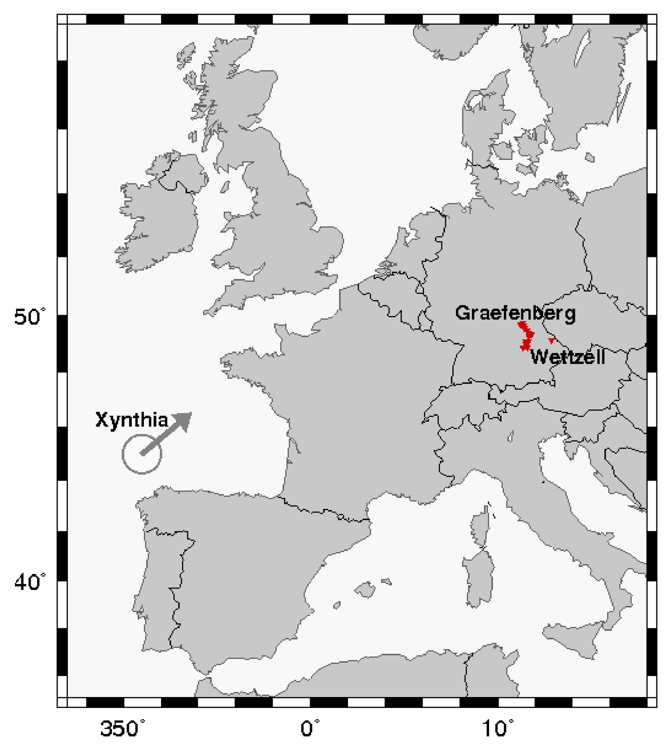
- vertical rotation rate (ω_z)
- translational acceleration (a_T)

relate as:

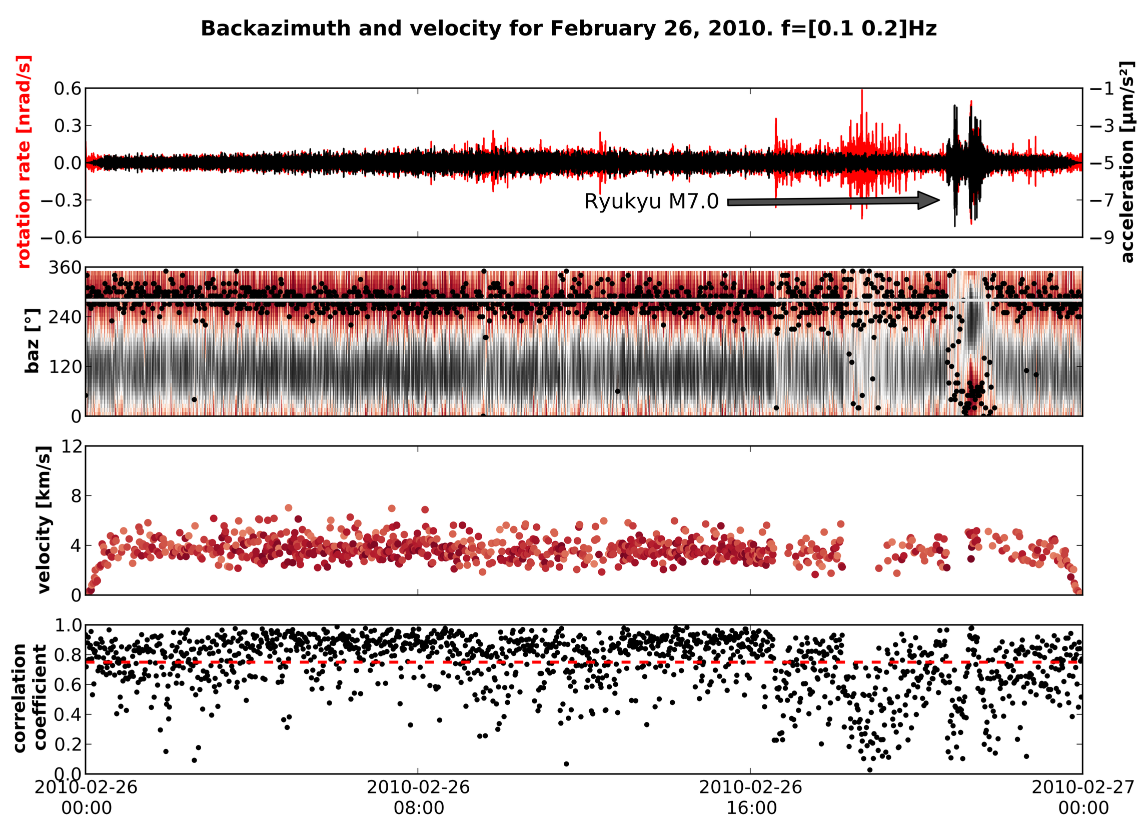
$$\frac{a_T}{\dot{\omega}_z} = \frac{-k^2c^2A\sin(kx-kct)}{\frac{1}{2}k^2cA\sin(kx-kct)} = -2c \quad (1)$$

From this relation and the similarity of the waveforms we can determine apparent phase velocity (c) and backazimuth of SH-type waves.

Rotational motions are measured at the Wettzell Ringlaser, translational motions at the broadband station WET, during the Xynthia storm.



6 Source direction from co-located ω_z and a_T



(a) Rotation rate (red), transverse acceleration (black). Event (M_W7.0 Ryukyu) with backazimuth = 45°. (b) Backazimuth, colorscale is the cross-correlation coefficient (red: positive high; black: negative high). (c) Phase velocity obtained from amplitude ratio ($\frac{a_T}{\dot{\omega}_z}$). (d) Maximum correlation coefficient. f = [0.1 0.2]Hz

7 Conclusions

- ⋆ Smooth changes in source orientation no effect on dv/v measurement
- ⋆ Sudden changes in noise wavefield result in noisier dv/v measurement
- ⋆ Knowledge of behavior of noise distribution important for the interpretation of dv/v observations
- ∘ 'Beamforming' on ambient noise possible with only co-located measurements of rotational and translational motion
- ∘ Azimuth found is consistent with $f-k$ analysis for Rayleigh waves

8 References

Froment, B., Campillo, M., Roux, P., Gouedard, P., Verdel, A., and Weaver, R. (2010). Estimation of the effect of nonisotropically distributed energy on the apparent arrival time in correlations. *Geophysics*, 75(5):SA85.

Hadziioannou, C., Larose, E., Baig, A., Roux, P., and Campillo, M. (2011). Improving temporal resolution in ambient noise monitoring of seismic wave speed. *Journal of Geophysical Research*, 116(B7):B07304.

www.geophysik.uni-muenchen.de/∼hadzii