Interpreting Coda Wave Decorrelation from ambient seismic noise interferometry: inputs from laboratory experiments

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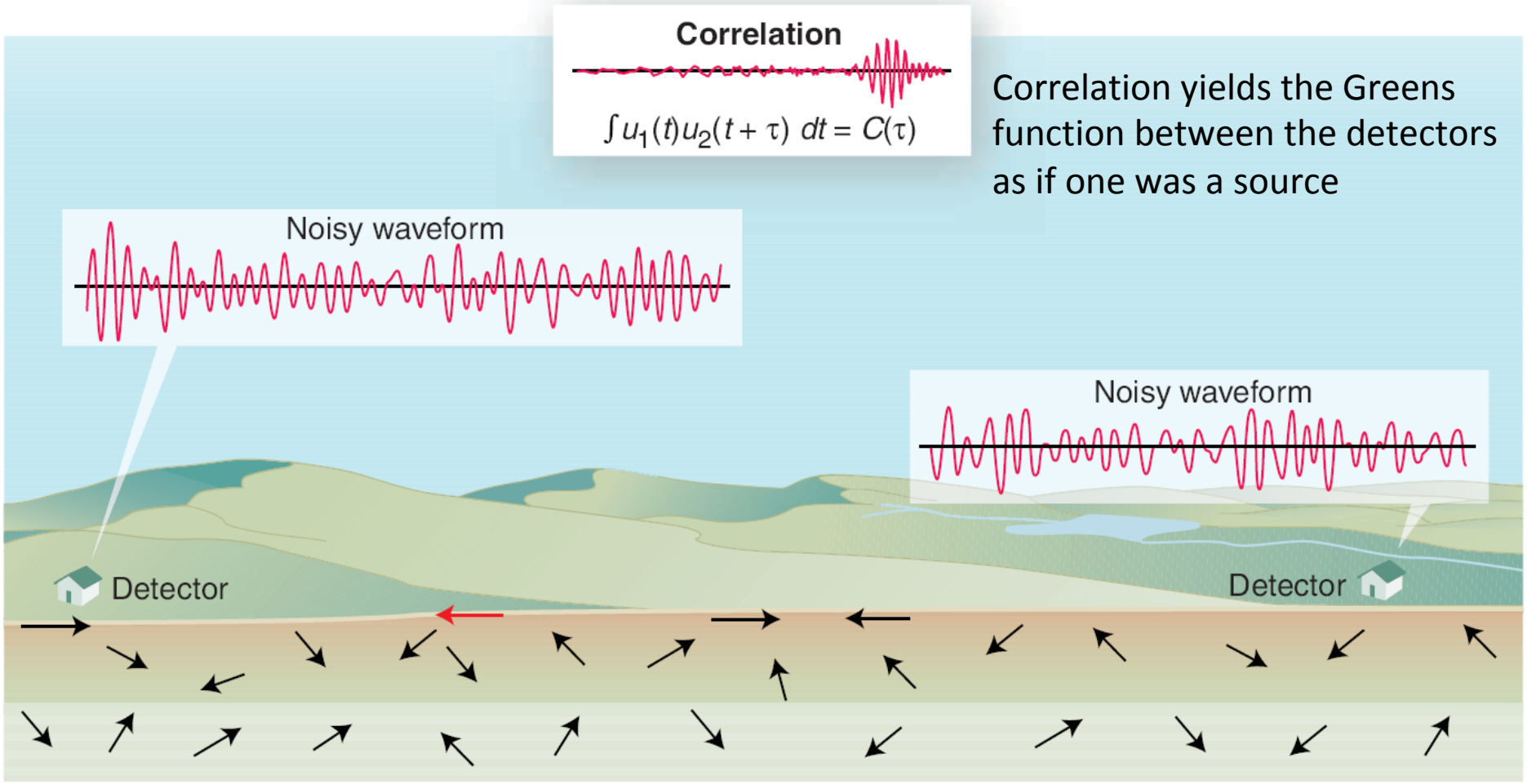
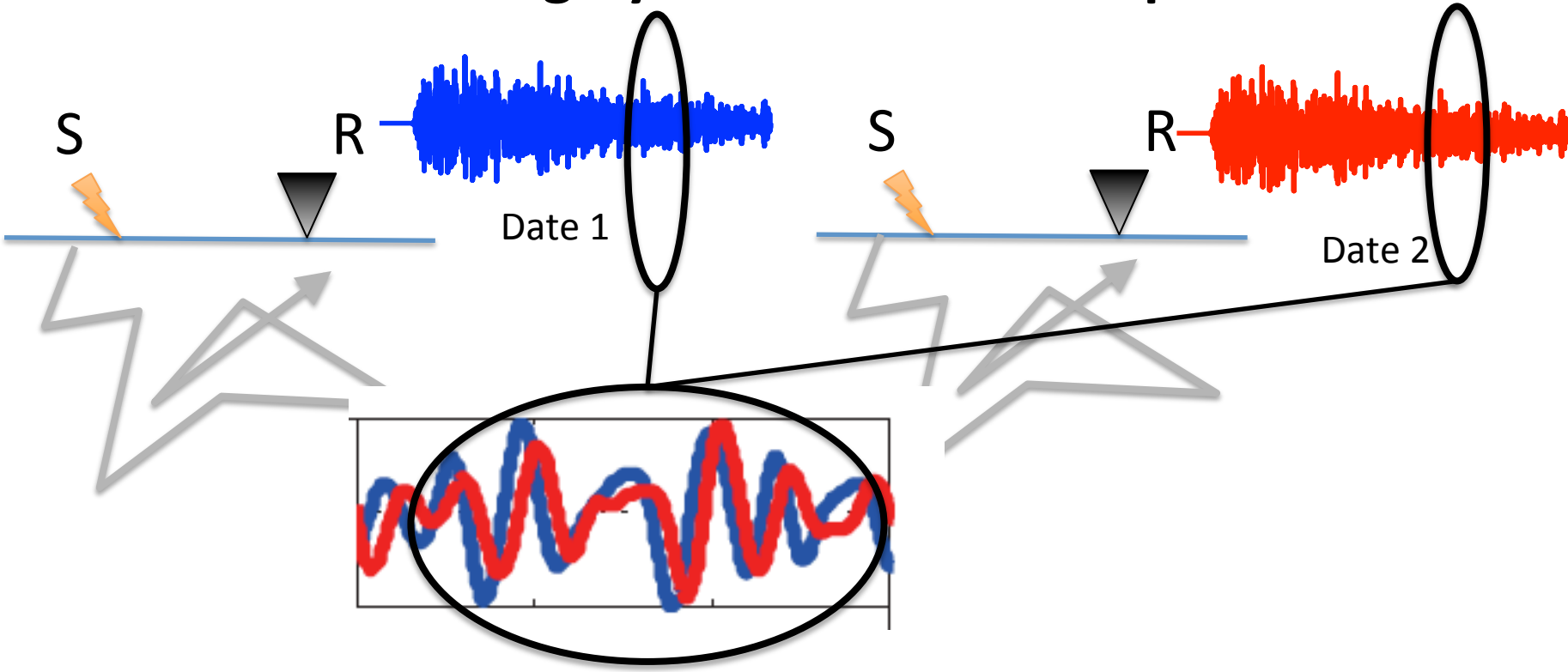
1) Ambient seismic noise is widely used to image and monitor the Earth's surface and interior



Correlation yields the Greens function between the detectors as if one was a source

Weaver & Lobkis (2002); Campillo & Paul (2003)

2) Diffuse waves are highly sensitive to small perturbations



Relative Velocity Change are observed with **Coda Wave Interferometry**
[Poupinet et al.(1984) ; Snieder et al, Science (2002)]

Structural changes are observed with **Coda Wave Decorrelation**
[Cowan (2002); Larose et al. (2010)]

QUESTION 1 : what is the effet of water infiltration or fluid injection in granular or porous materials ?

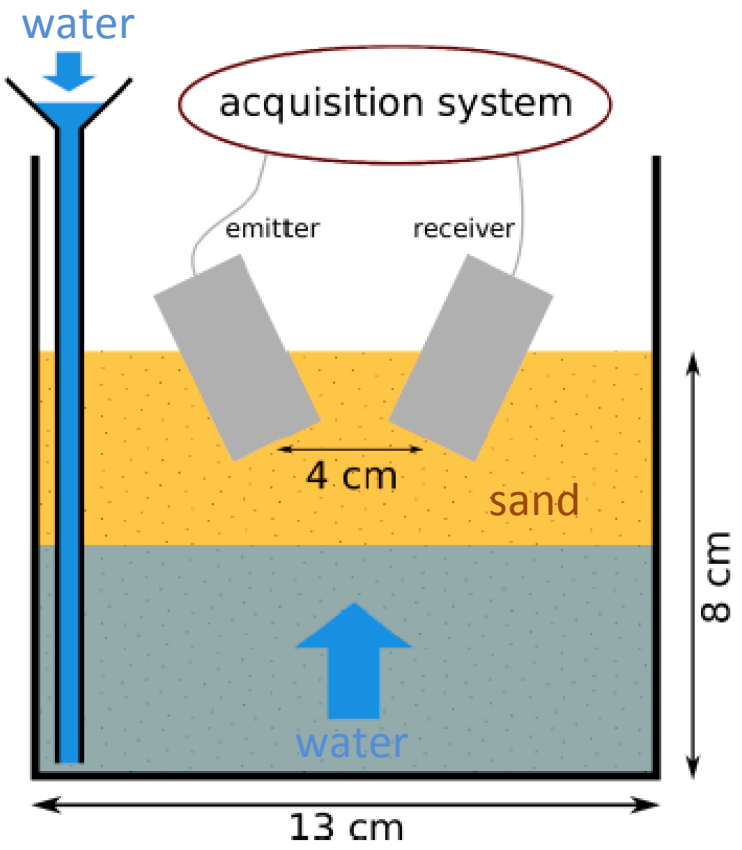
We expect :

- a decrease of apparent velocity in the coda
- a decorrelation of the waveforms

QUESTION 2 : which effect is dominating ?

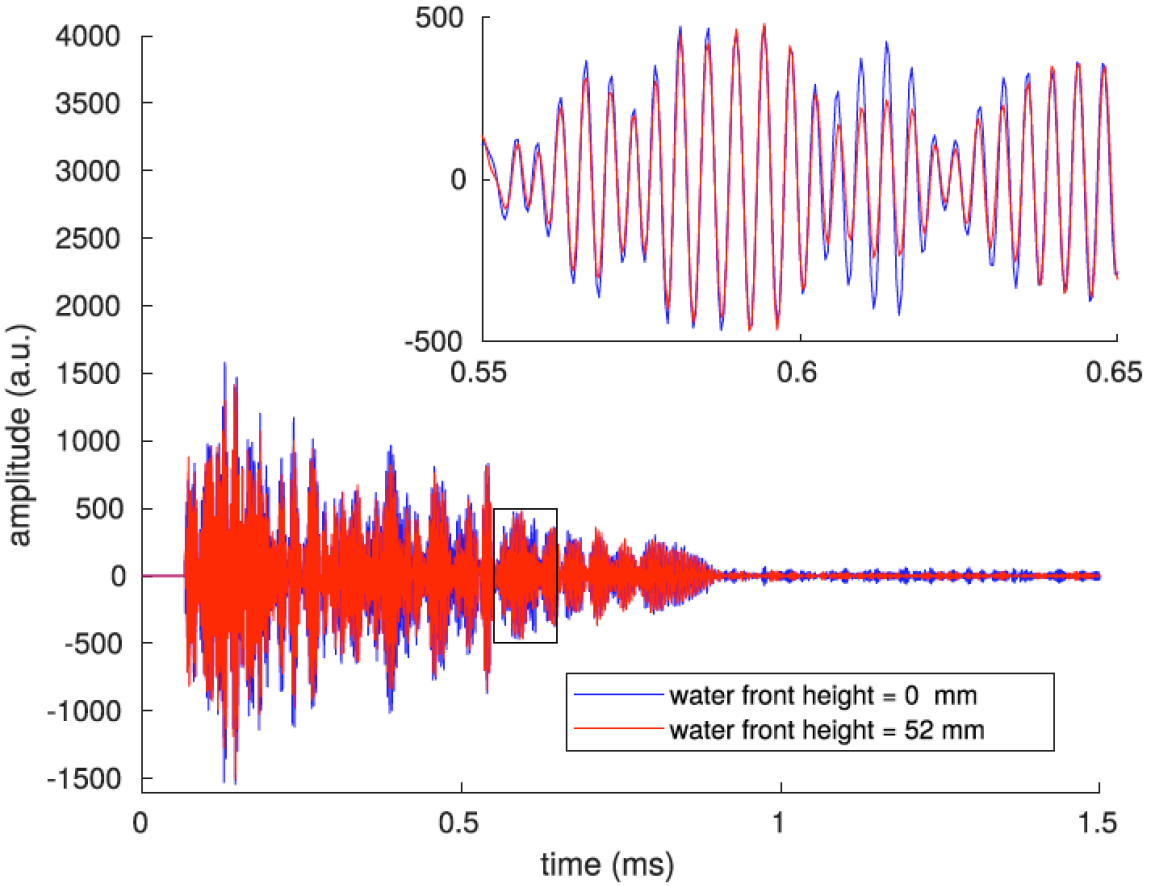
Laboratory test: Water injection in sand (active experiment)

For the sake of simplicity : we use one active source and one receiver (no ambient noise correlation at first). This is a standard Coda Wave Deccorelation experiment.

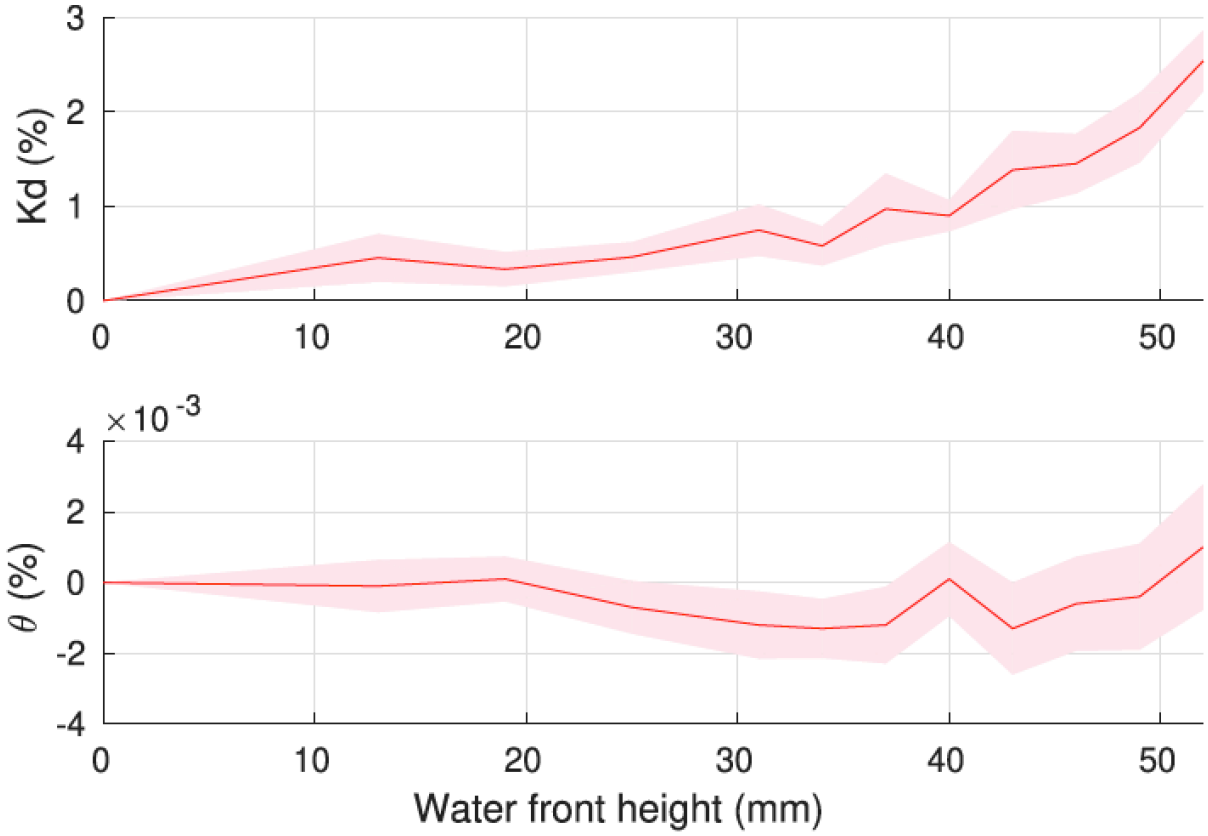


Laboratory test: Water injection in sand (active experiment)

Example of changes in the late coda, including decorrelation (change of waveform) and relative velocity change (phase shift).



Laboratory test: Water injection in sand (active experiment)



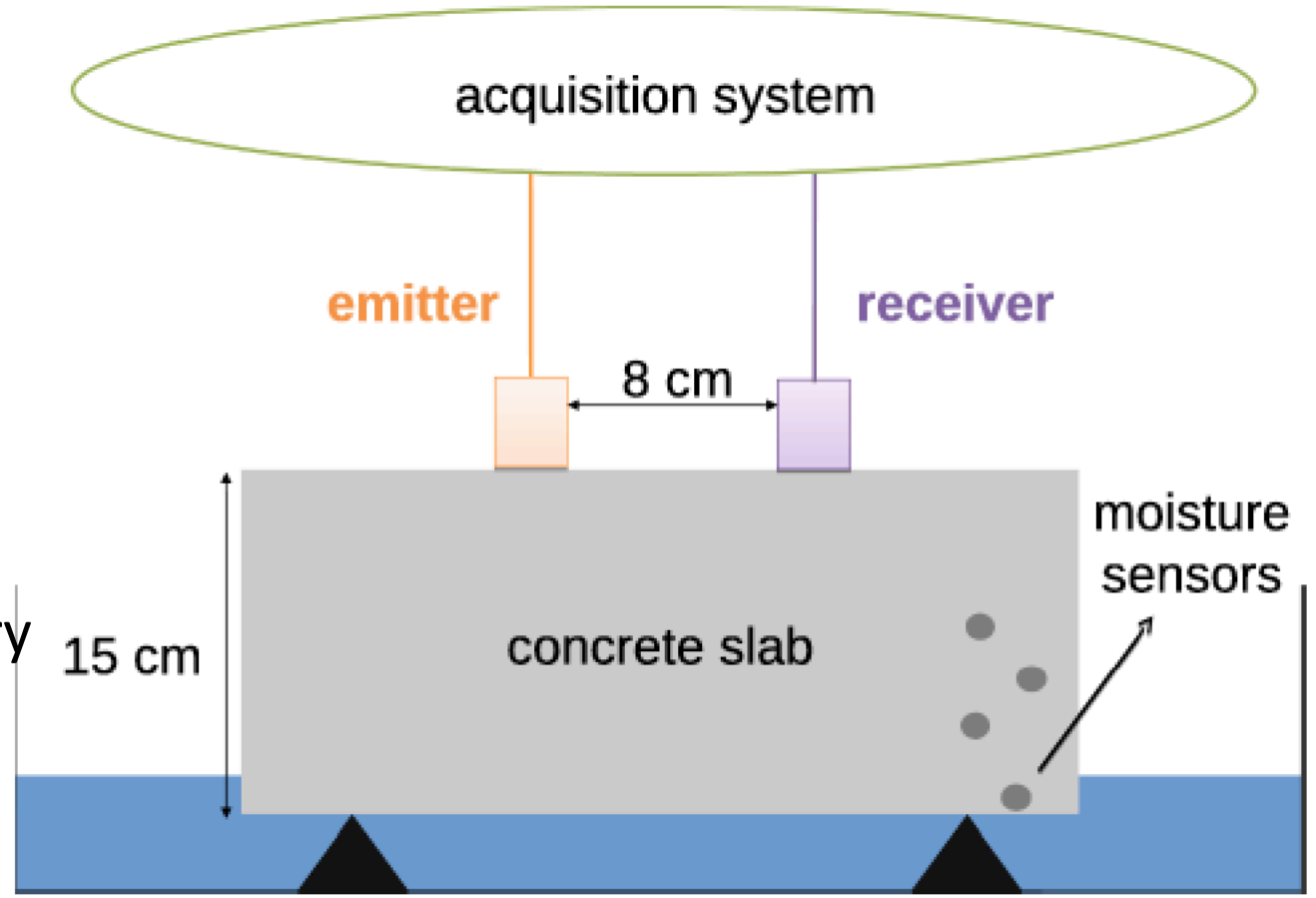
Coda Wave Decorrelation

Coda Wave Interferometry

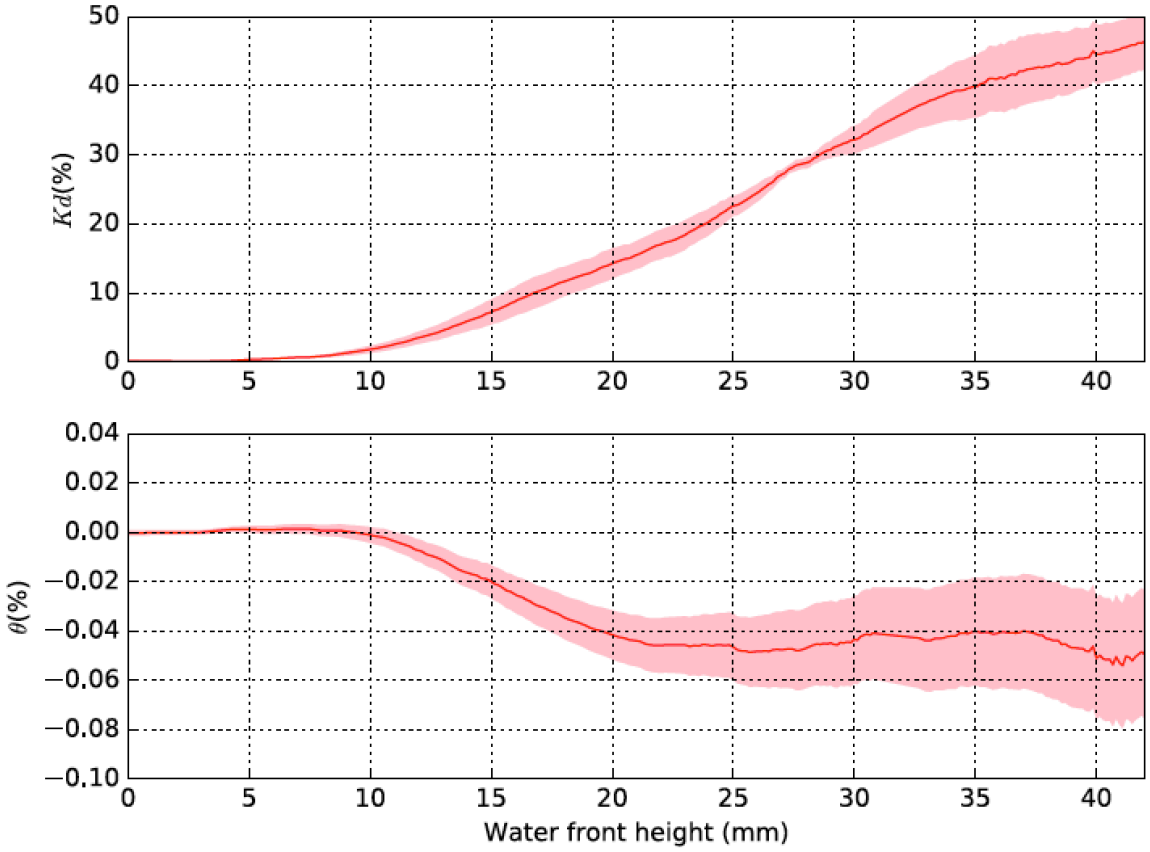
- CCL : Coda Wave Decorrelation is more sensitive to water injection in porous sand than Coda Wave Interferometry

Application 1: moisture migration in concrete

- Moisture modifies concrete strength and aging.
- Ultrasound and electromagnetism are complementary technis

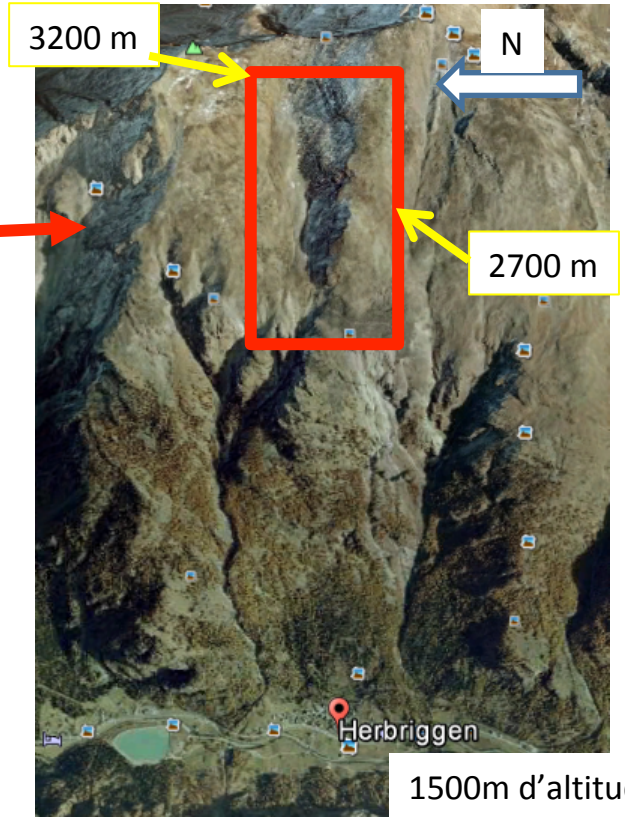


Application 1: moisture migration in concrete

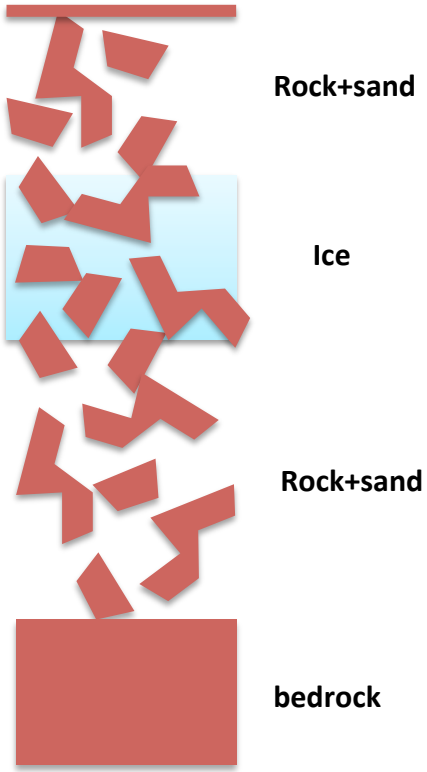


CCL : Coda Wave Decorrelation is more sensitive to moisture migration in concrete than Coda Wave Interferometry

Application 2: the Rock Glacier « Gugla » Wallis (CH)



1500m d'altitude



- The unstable slope threatens the Herbriggen village 1000m above
- Rockslides occur during the melting season
- Water is interpreted as the key factor

Together with :

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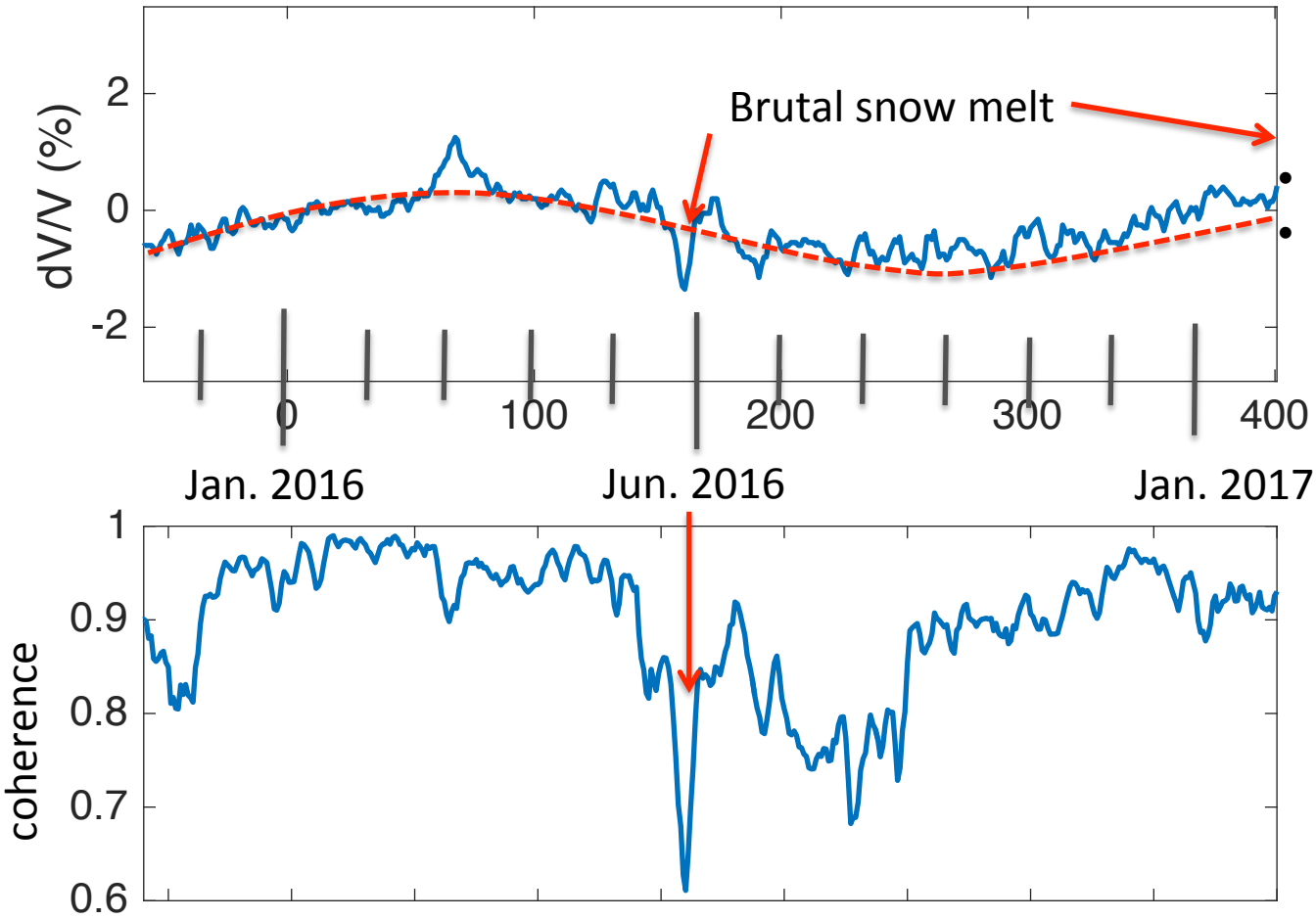
KANTON WALLIS

Application 2: the Rock Glacier « Gugla »



- Water saturation
- Risk of slope destabilisation

See also :
Guillemot et al, GJI (2020)

Together with :

CANTON DU VALAIS
KANTON WALLIS

CCL : Coda Wave Decorrelation is more sensitive to water infiltration than Coda Wave Interferometry

Thank you for your attention !
And please, read our paper :

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Tracking fluids in multiple scattering and highly porous materials: Toward applications in non-destructive testing and seismic monitoring

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ABSTRACT

Seismic and ultrasonic waves are sometimes used to track fluid injections, propagation, infiltrations in complex material, including geological and civil engineered ones. In most cases, one use the acoustic velocity changes as a proxy for water content evolution. Here we propose to test an alternative seismic or acoustic observable: the waveform decorrelation.

We use a sample of compacted millimetric sand as a model medium of highly porous multiple scattering materials. We fill iteratively the sample with water, and track changes in ultrasonic waveforms acquired for each water level. We take advantage of the high sensitivity of diffuse coda waves (late arrivals) to track small water elevation in the material. We demonstrate that in the mesoscopic regime where the wavelength, the grain size and the porosity are in the same order of magnitude, Coda Wave Decorrelation (waveform change) is more sensitive to fluid injection than Coda Wave Interferometry (apparent velocity change). This observation is crucial