Funded by ERC grant no. 817803

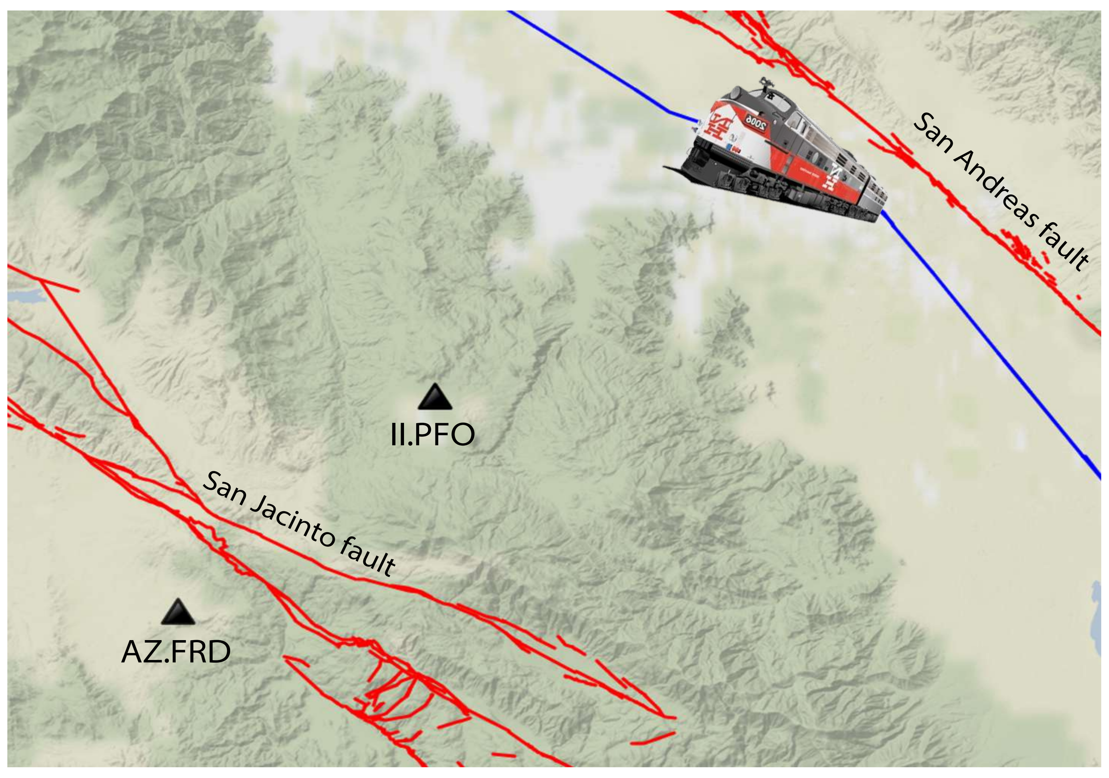
Long-range noise correlation modelling for seismic velocity monitoring
A case study at the San Jacinto fault zone

Quentin Higueret, Yixiao Sheng, Aurélien Mordret, Pierre Boué, Florent Brenguier
Université Grenoble Alpes, CNRS, ISTerre, Grenoble, France

Context

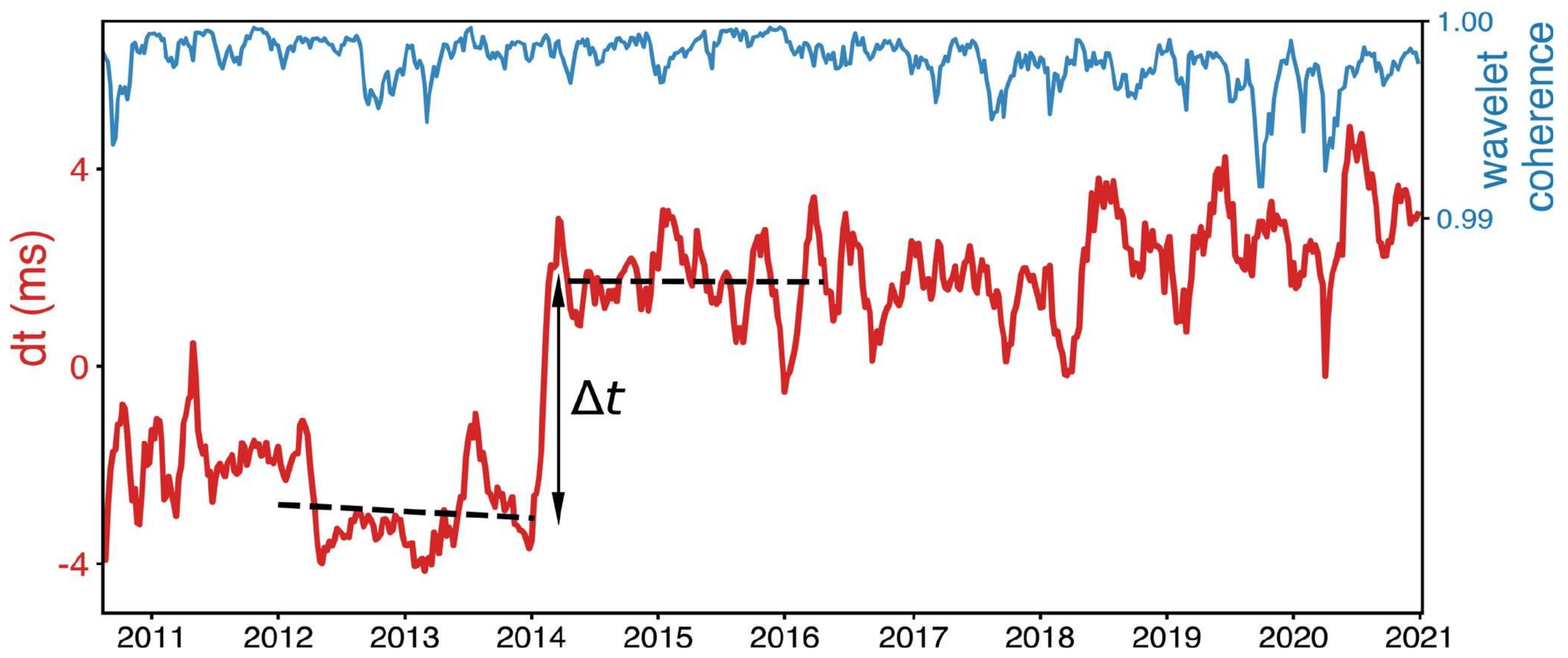
We use **seismic interferometry** to monitor **seismic velocity changes** within the San Jacinto Fault zone in California.

To infer those changes, we focus on using **repetitive anthropogenic noise sources** that mainly produces **body waves**[1] to gain more insinght into the processes around the depth of the seismogenic zone.



Location and layout of the study site

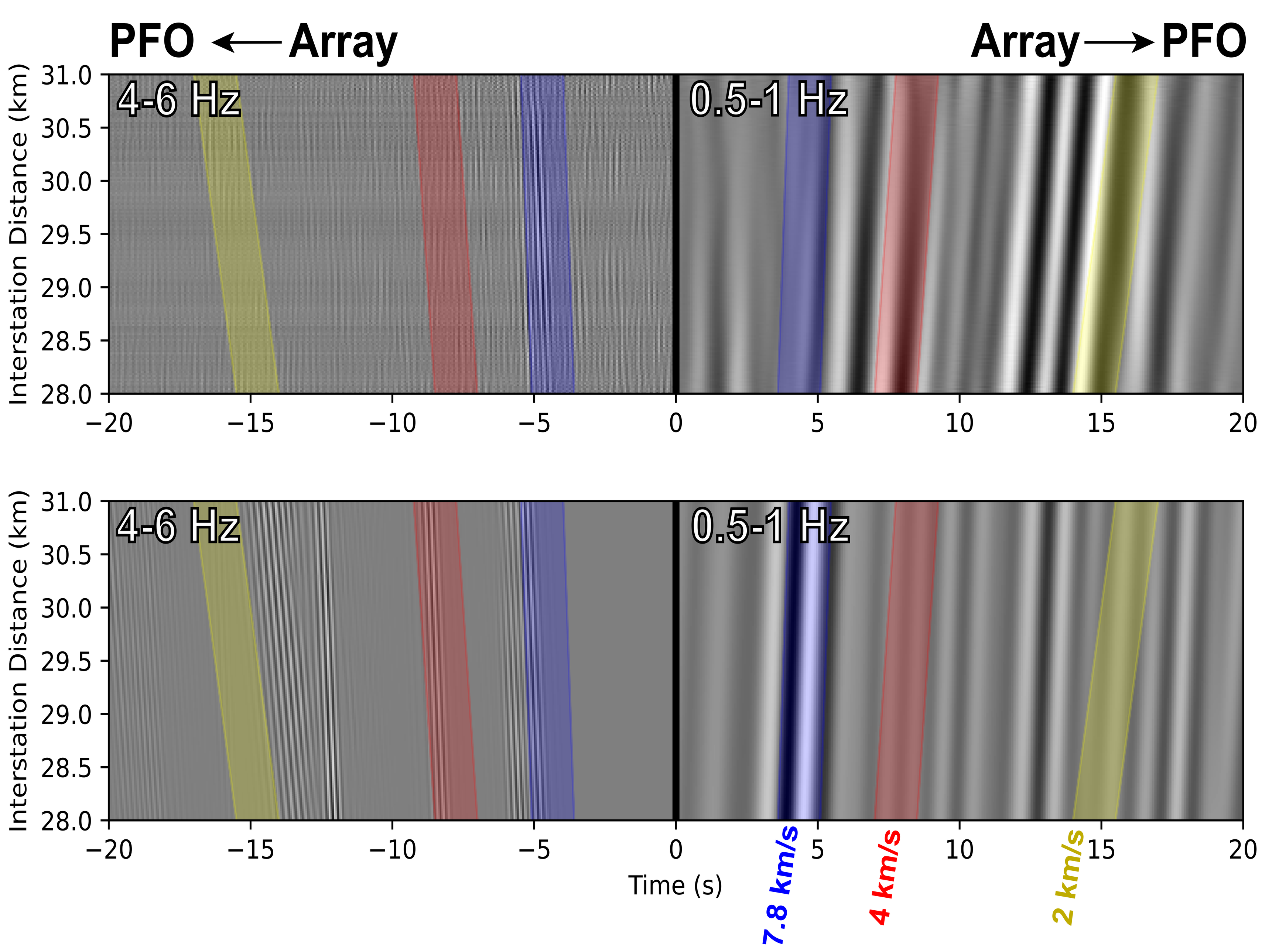
Performing 10 years of **seismic velocity monitoring**[2], Sheng et al. observed a 2-month-long velocity perturbation in 2014.



Sheng et al. (2022)

In order to **investigate** and **quantify** the **different scenarios** that can lead to the observed **travel time change** in 2014, we use **numerical modeling** of train signal **correlations**[3].

Using this approach, we can assess the **reliability** and **depth sensitivity** of our **monitoring observations**.

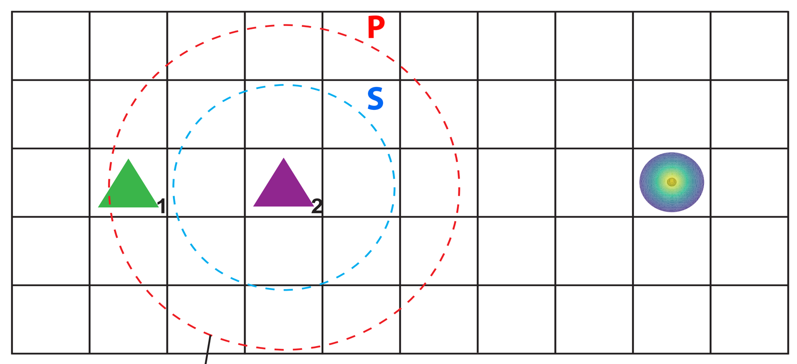


Correlogram comparison between observed (top) and synthetic cross-correlation (bottom) revealing body wave arrivals

Methods

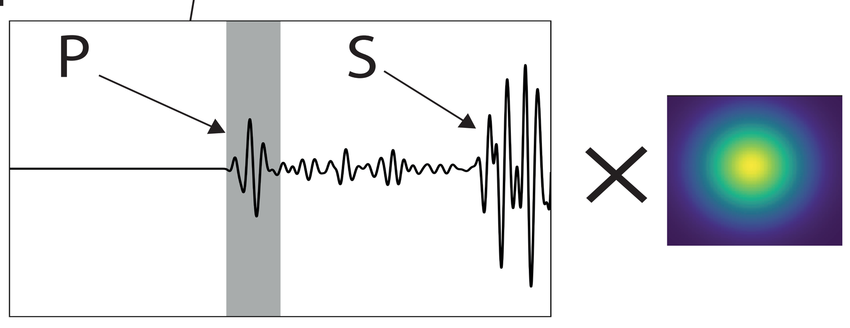
Assuming spatially **uncorrelated noise sources** the **correlation function** between two receivers is given by $C_{ij}(x_1, x_2) = \int G_{i,n}(x_1,\xi)G^*_{j,m}(x_2,\xi)S_{nm}(\xi)d\xi$

1.



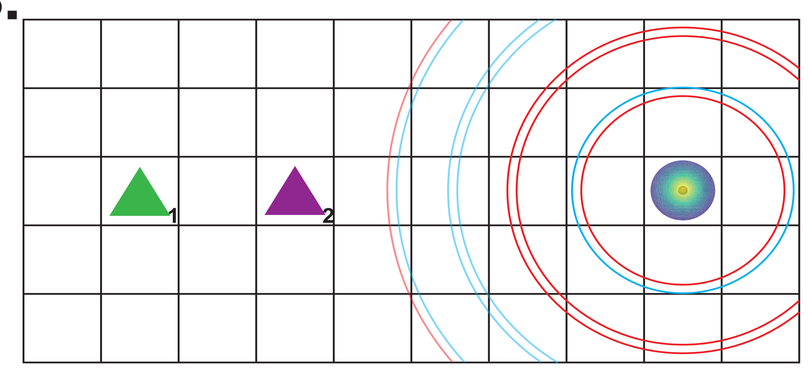
Using a **spectral element method solver** we compute first the green function $G_{j,m}(\xi, x_2)$

2.



Assuming only **body waves generation** from the source, we window around the first **P wave arrival**, time-reverse it and combine it with the noise spectral density

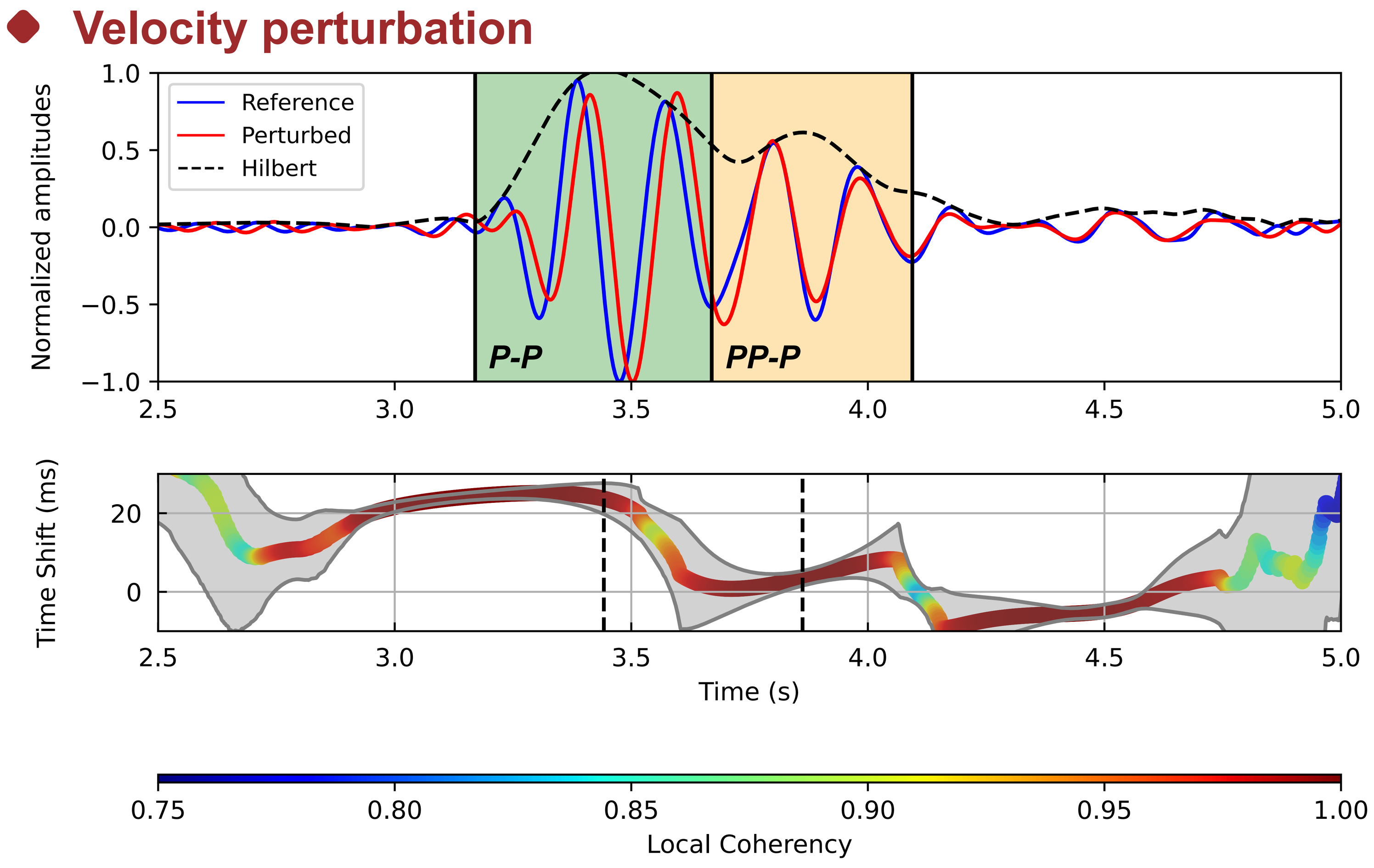
3.



Injecting the output of the last step as the source time function, we retrieve the **full correlation wavefield**

Results

Velocity perturbation



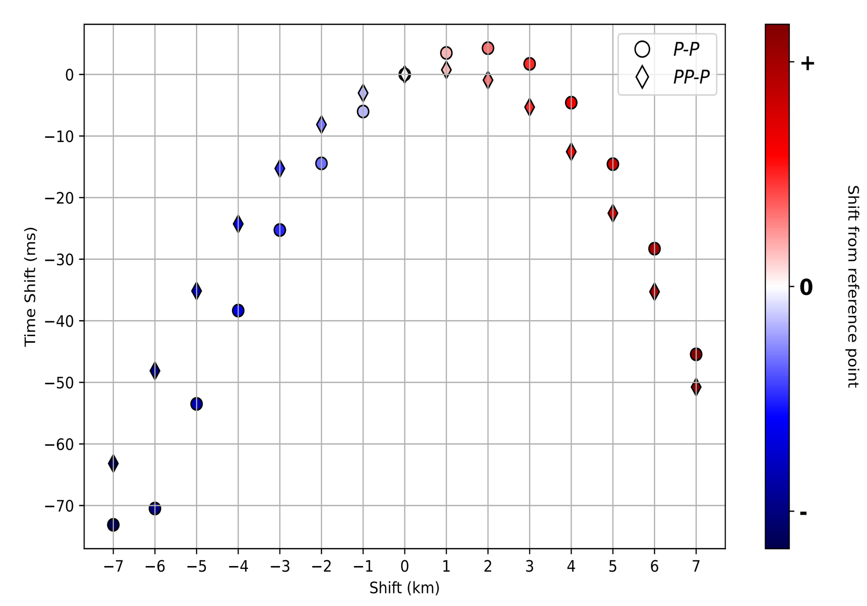
Decreasing the velocity by 1% in the 2-5 km depth range strengthen the time shift considering the **P-P interactions**. Since the **PP-P interactions** are mostly sensitive to change at the surface, our monitoring is even more sensitive to the fault.

It corresponds to a pourcentage amount of **velocity reduction** of about $\left|\frac{\delta t^{P-P}}{t^{P-P}}\right| \approx 0.7\%$

Noise source position uncertainty

The **uncertainty** on the position of the train induces a considerable **time shift**.

It is therefore important to constrain the time window used to produce the **cross-correlations**.



[1]Brenguier et al., Geophysical Research Letters 2019, 46, 16.
[2]Sheng et al., Geophysical Research Letters 2022, 49, 19.
[3]Sager et al., Geophysical Journal International 2022, 228, 3.

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quentin.higueret@univ-grenoble-alpes.fr