Large-N semi-permanent seismic arrays : Technical choices and strategy for the FaultScan experiment

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FaultScan Project

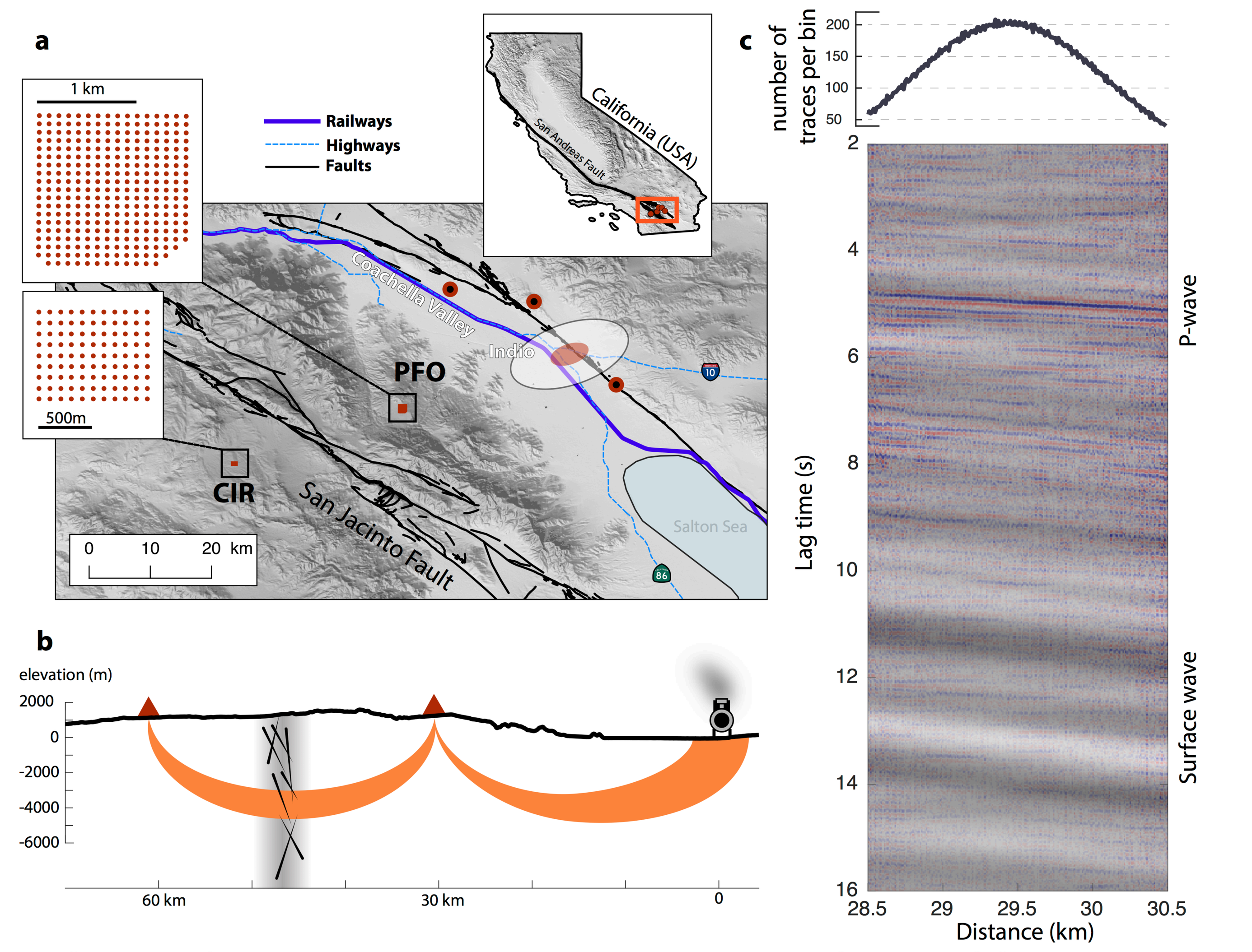
The FaultScan project aims to develop a new type of telescope oriented towards the interior of the Earth to detect the faint movements that are the precursors to major earthquakes.

The original idea of the project is to show that seismic noise generated by vehicle traffic and especially by heavy freight trains, can be turned into a powerful repetitive seismic source to continuously probe the Earth's crust, especially in seismic fault zones, at a few kilometers depth.

The project will start with an experiment on the San Jacinto fault in California. Several dense arrays composed of hundreds of seismological stations are going to be deployed closed to the fault.

The second objective of the project is to find which kind of instruments would be the best to operate large-N semi-permanent seismic arrays of **400 stations during at least 3 years**.

Moreover, these dense arrays will produce a large volume of data, about 30 TB / year. The data processing is going to be a real challenge.



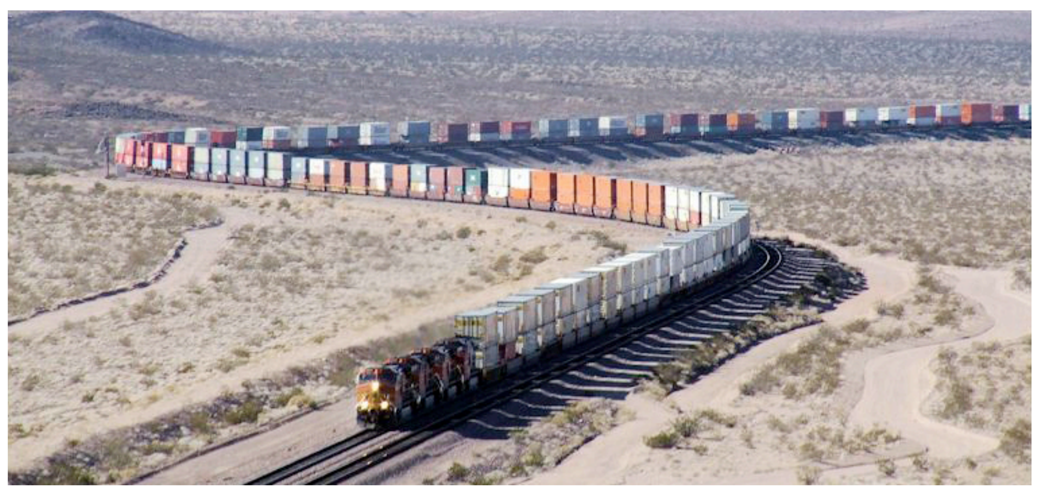
Results of an exploratory seismic experiment in Southern California in 2017 (Brenguier F. et al, (2019).Train traffic as a powerful noise source for monitoring active Faults with seismic interferometry,10.1029/2019GL083438)

(a) Location of the two dense seismic arrays in red.
PFO = Piñon Flat Observatory; CIR =Cahuilla Indian Reservation
The blue line shows the location of the freight train railways and highways.

(b) Sketch illustrating the body wave generated by trains and used by seismic interferometry to reconstruct a body wave traveling between the two arrays (in red) across the San Jacinto Fault.

(c) Causal and anti-causal stacked noise correlations between the two arrays using distance-averaged bins. Each bin is 10 m long.
The top figure shows the number of stacked correlations per bin.
The high-frequency content (1–10 Hz) is in color and the low-frequency content (0.2–1 Hz) in gray.

San Andreas Fault, California, USA



Giant freight train in South California generates seismic waves equivalent to earthquake of magnitude 2

Technical solution n°1: Swapping nodal system

Geospace system, GSB3 node (USA)

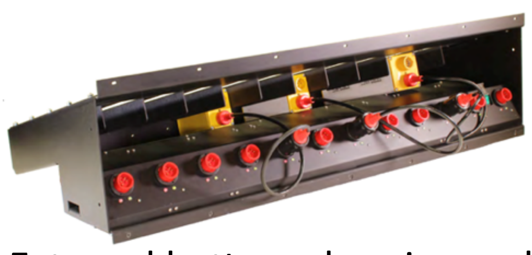
-> Internal and External Li-ion battery
-> 120 days autonomy
-> External 3C 5Hz geophone
-> Power consumption 85 mW
-> 64GB internal SD card
-> Station QC with smartphone/laptop

Every 4 months
External batteries + digitizers swap

100 stations visited at each field service

DTCC system, China
Derived SmartSolo node
Prototype under development

-> External Li-Ion Battery
-> 100 days autonomy
-> External 3C 5Hz geophone
-> Power consumption 135 mW
-> 64GB internal SD card
-> Station QC with smartphone



External battery charging rack
~6hours for a 80 days autonomy external battery

Data retrieval system
In the lab, requires 230V
Transfer rate = 100 min/slot
for 4 months @ 250 Hz

Technical solution n°2: Autonomous low power stations

Prototype under development – GFZ/DIGOS (Germany)

3-channels autonomous seismological station
-> based on proven DATA-CUBE recorder technology
-> 3C 5Hz deported geophone
-> Power consumption 219mW
-> supplied with a 20W solar panel
-> Internal lead gel battery (7Ah, 15 days autonomy)
-> Directly recharged through the solar panel
-> 32GB internal SD card

Autonomy = based on the SD card capacity (9 months @ 100Hz)

Rugged tablet for data collection

Every 4 months, data collect on the field
3GB / month / station @ 100Hz
Data transfer rate = 3GB / 5 min
5 teams on the field

27 hrs /team (~4 days)
For 400 stations

Technical solution n°3: mixed nodal system

A combination between:

Autonomous nodes supplied with solar panel and internal battery

AND

Nodes supplied with a combination of external and internal battery

Example of autonomous Nodes, Geospace (USA)

Swapping digitizers is still required for data retrieval

BUT

Higher Autonomy of autonomous nodes
=
SD memory card capacity (9 months @ 250Hz)

Tender under process

Arrays deployment = June 2020
End of experiment = June 2023