Towards continuous geophysical monitoring for CO_2 injection

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CREWES Tech talk

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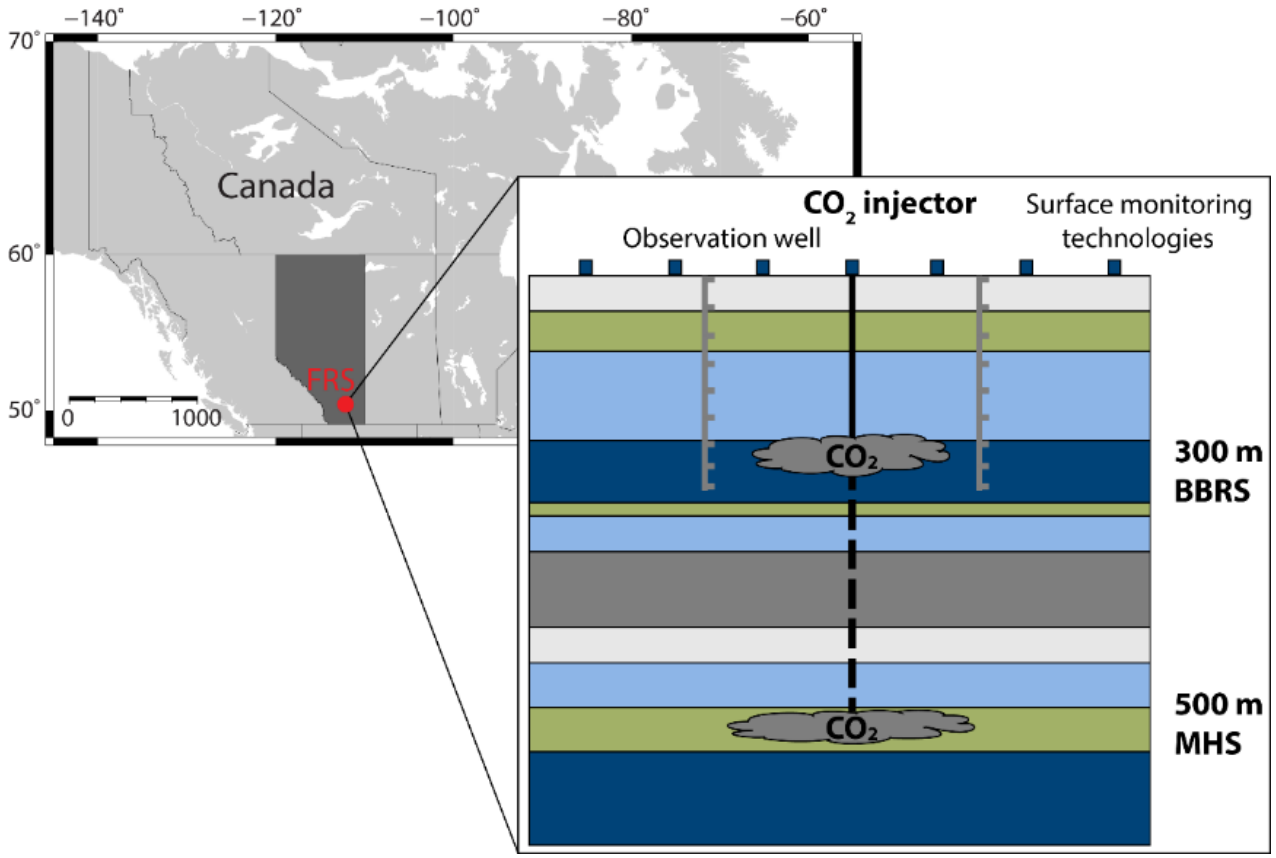
NSERC CRSNG
UNIVERSITY OF CALGARY
FACULTY OF SCIENCE
Department of Geoscience
CMC Containment & Monitoring Institute

Field Research Station

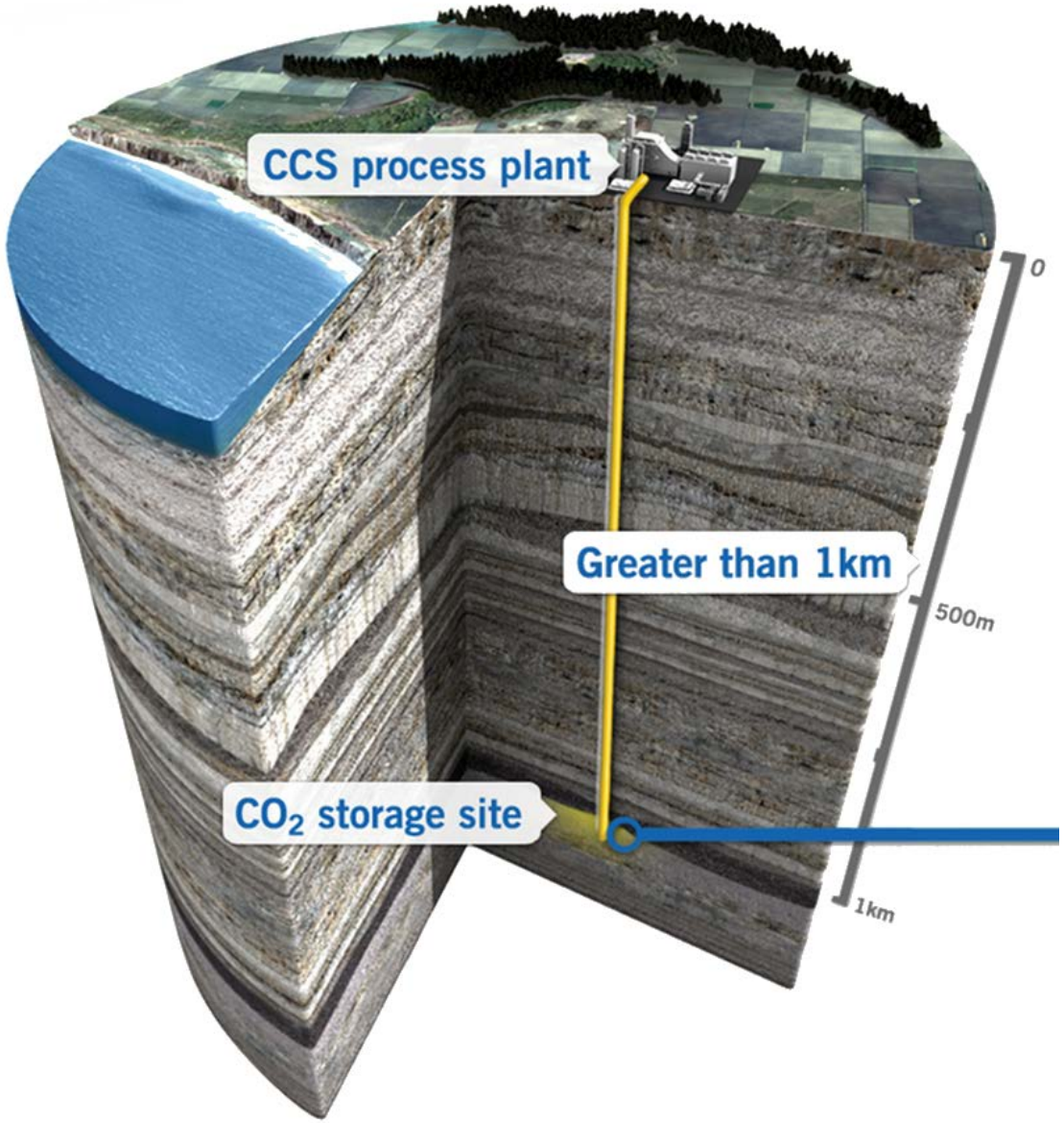
⇒ **Injection of a small amount of CO_2 (<400/tons per year) at shallow depth (300m) to simulate a leakage**



Developed by CMC Research Institutes Inc and University of Calgary

- A site for development and demonstration of MMV technologies for carbon capture and storage (CCS) as well as general containment and conformance monitoring for other applications.
- Undertake controlled CO_2 release at 300 m (Phase 1) & 500 m (Phase 2) depth; up to 400 t/yr.
- Determine CO_2 detection thresholds at shallow to intermediate depths.
- Develop and assess technologies for continuous reservoir, cap rock, overburden, and groundwater monitoring.
- University & industry field training.

Main goal – Early detection of possible leakage



Provided by the Global CCS Institute

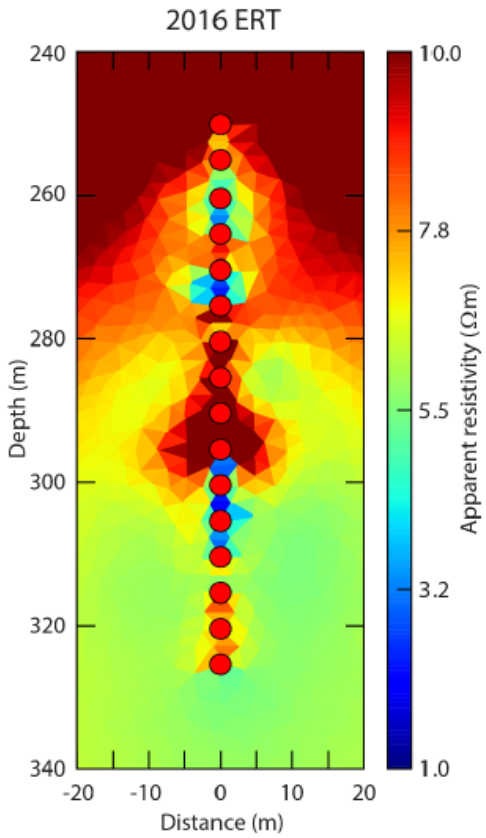
CCS is a safe technology but what if ?

How can we detect possible leakage ?

How fast ?

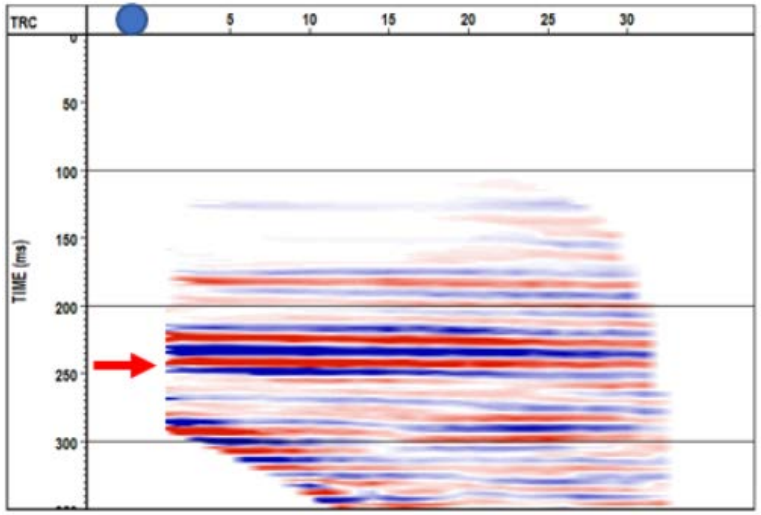
Active seismic methods – Pro and con

ERT campaigns



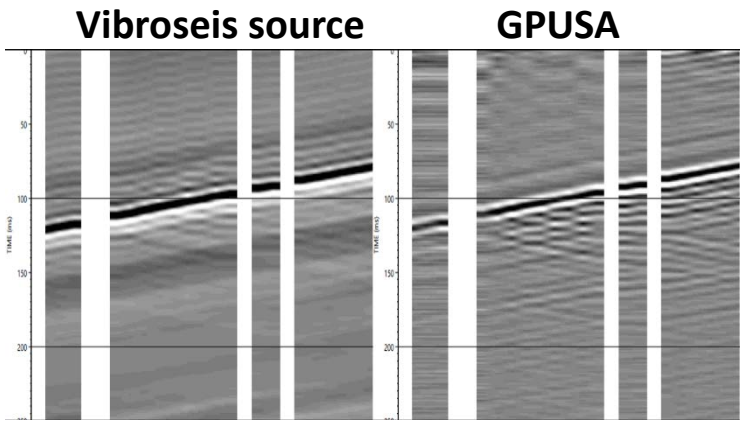
Rippe et al. 2017

VSP DAS



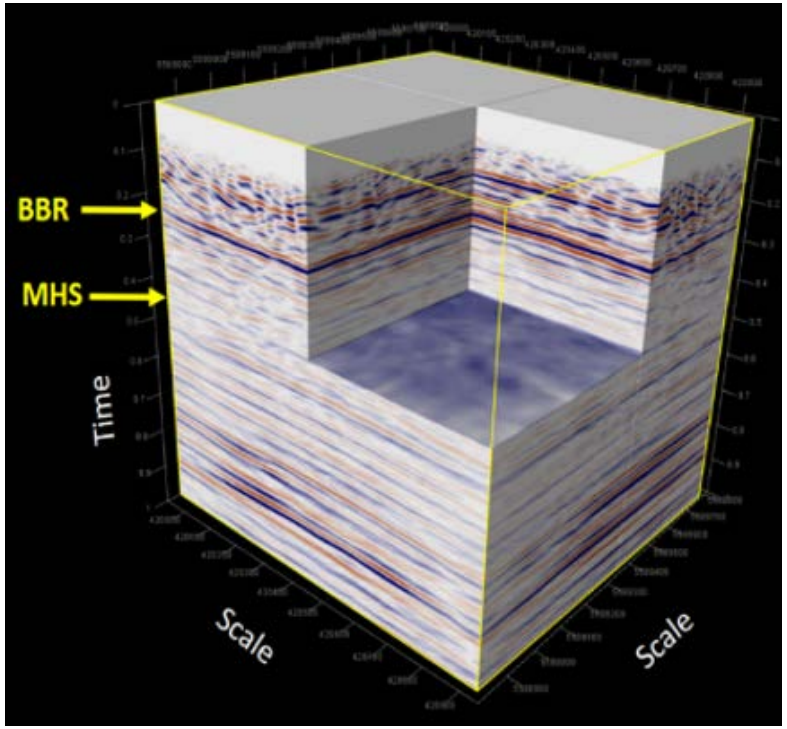
Gordon and Lawton 2018

(Semi) continuous seismic source



Spackman and Lawton 2018

Active seismic surface



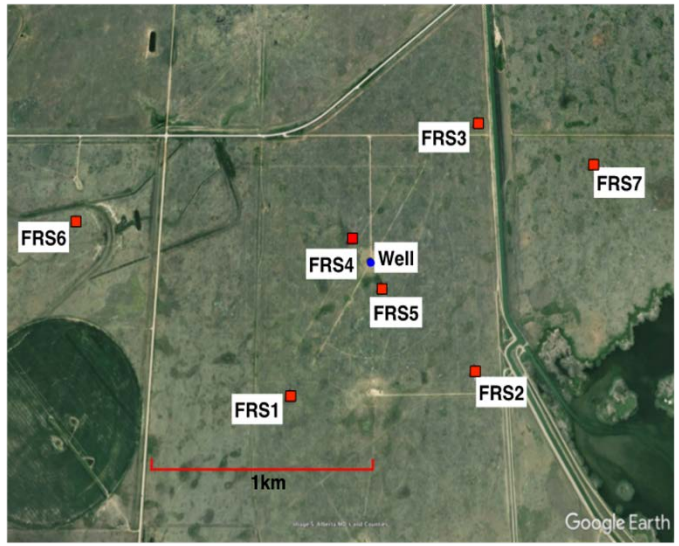
and magnetometric resistivity surveys

and cross-well seismic and electromagnetic

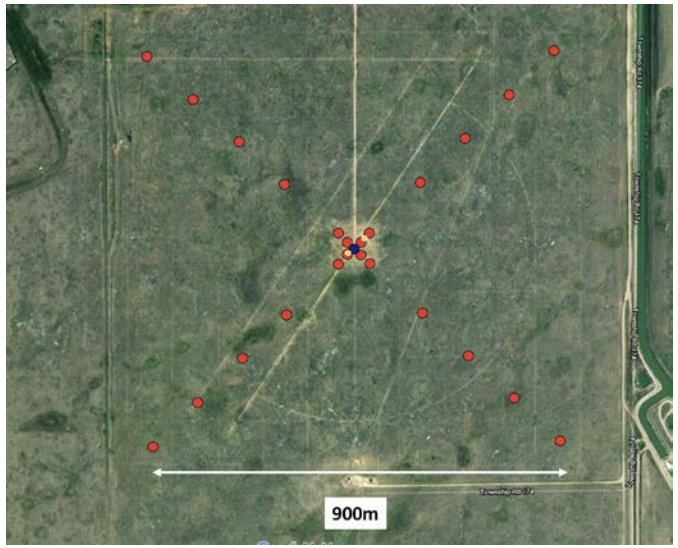
And more

Seismic continuous data

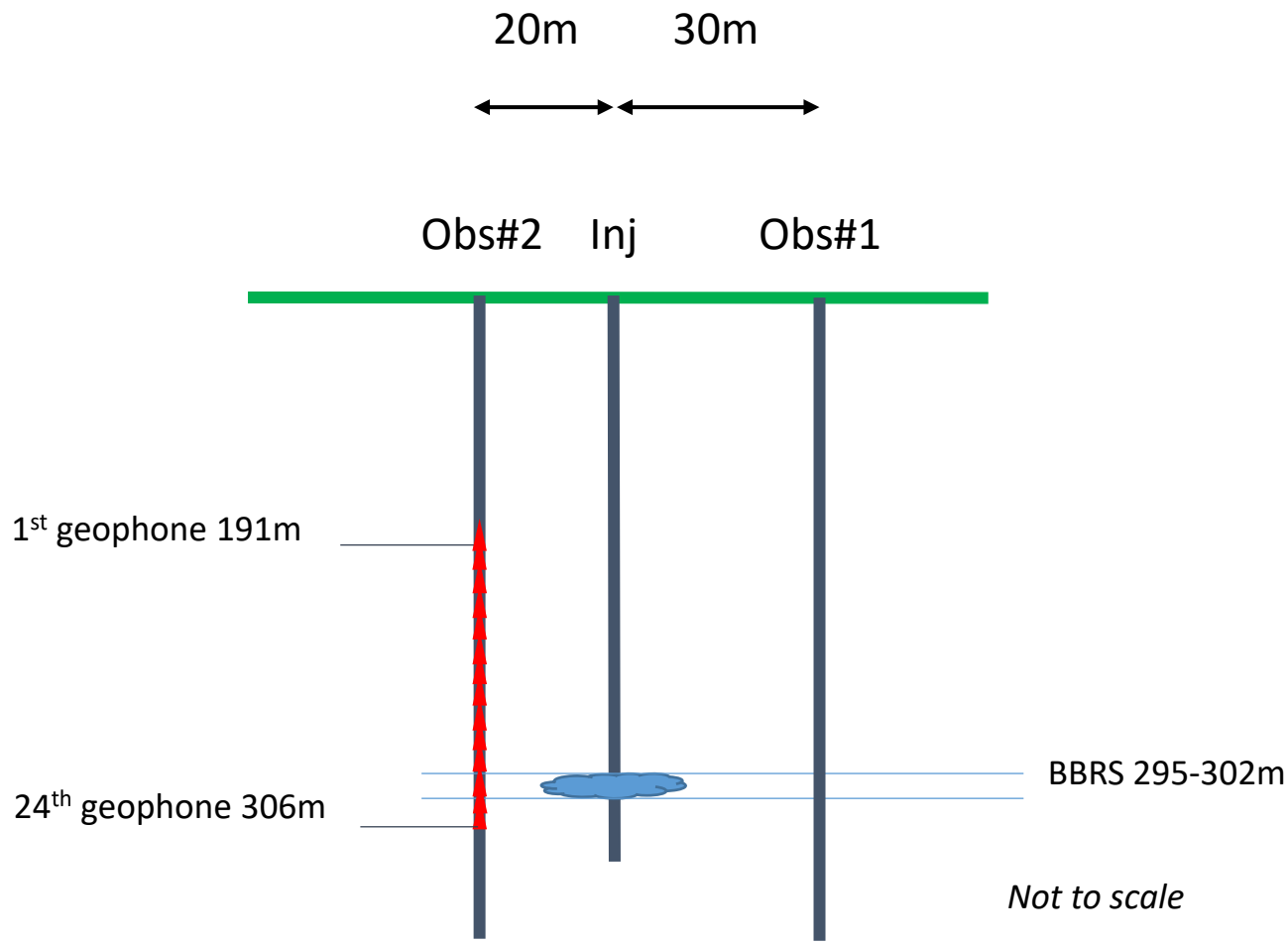
Since October 2015 - 7 broadband stations



Since June 2019 - 24 geophones

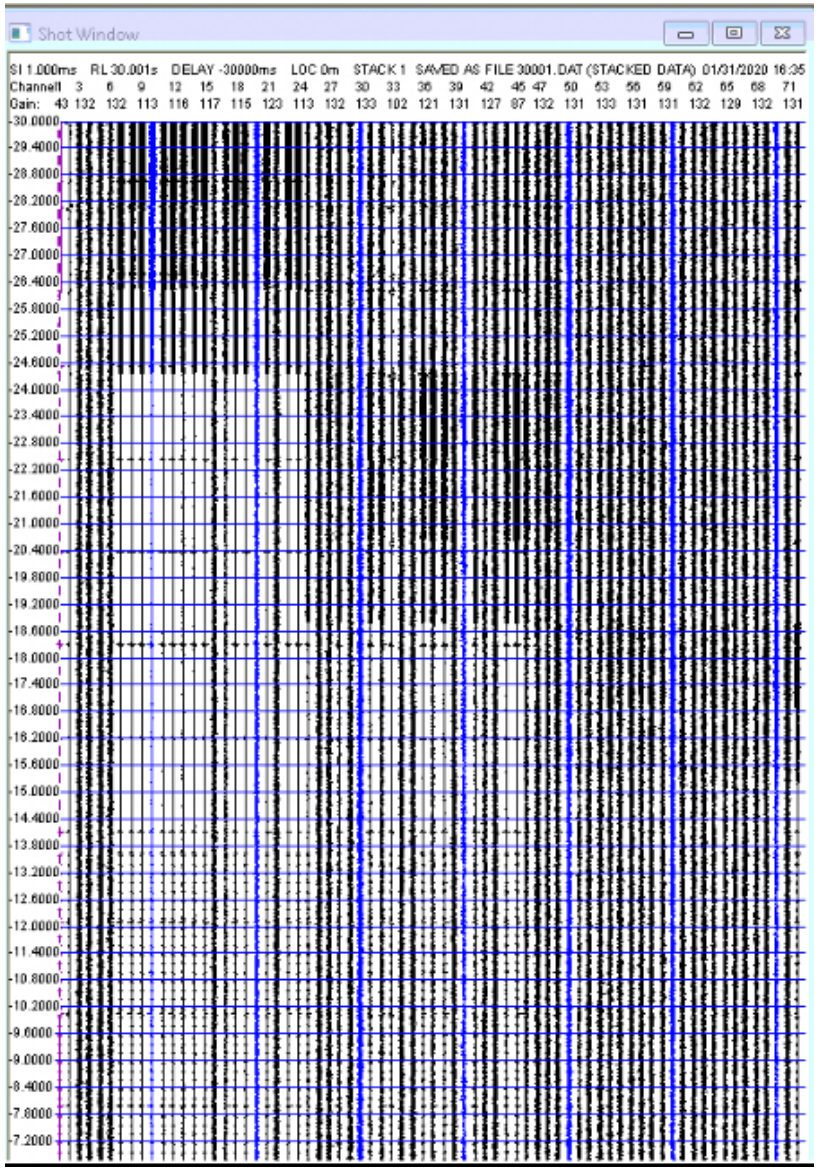


Since couple of weeks
Possibility to recorded continuously on the 24 3C downhole geophones
10 days of data

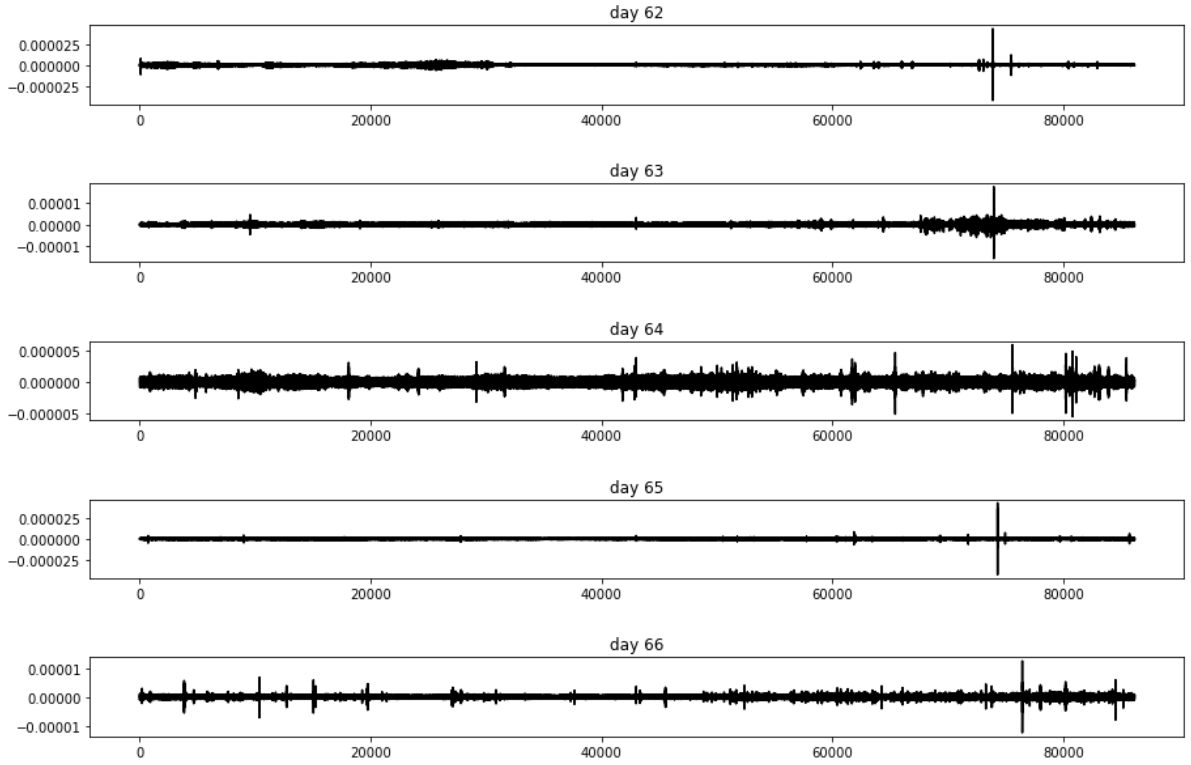


Seismic continuous data

Downhole data



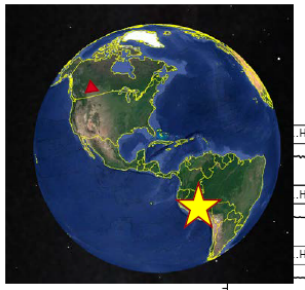
Surface data



- to study the ***possible microseismicity*** linked to CO_2 injection

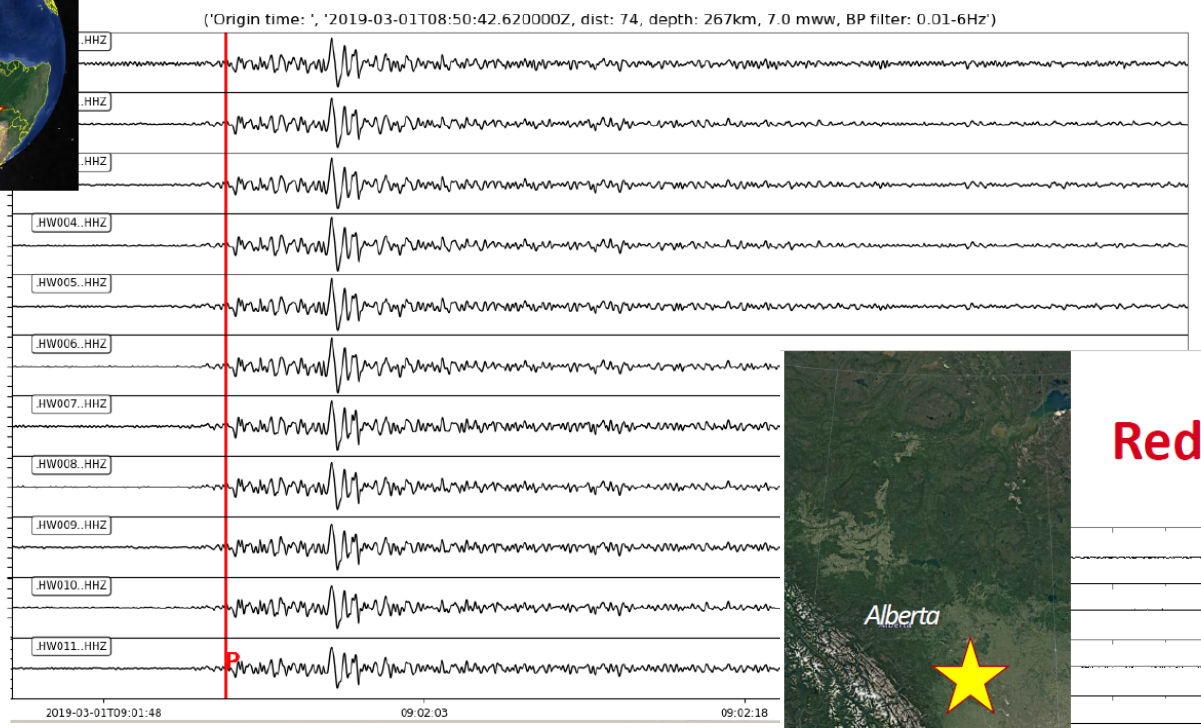
- to study the possibility of using the ***ambient noise correlation method*** as a tool for CO_2 injection monitoring

Events detection



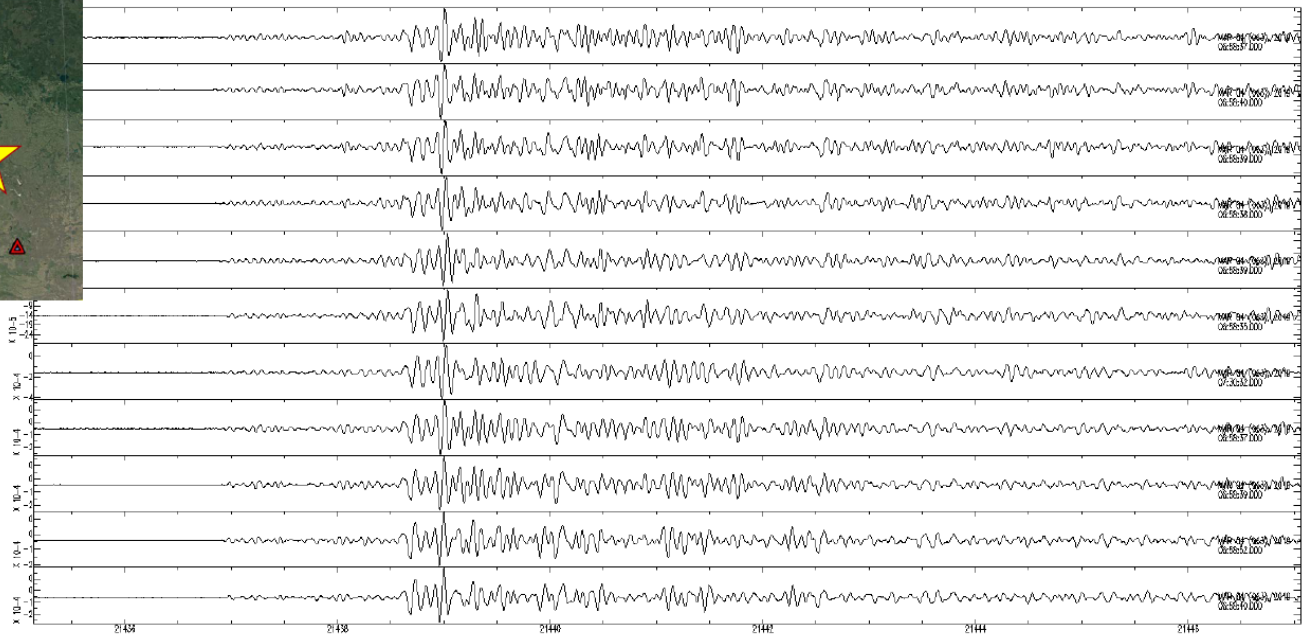
GoogleEarth

South America Earthquake; March 1, 2019



Red Deer AB, Earthquake; March 4, 2019

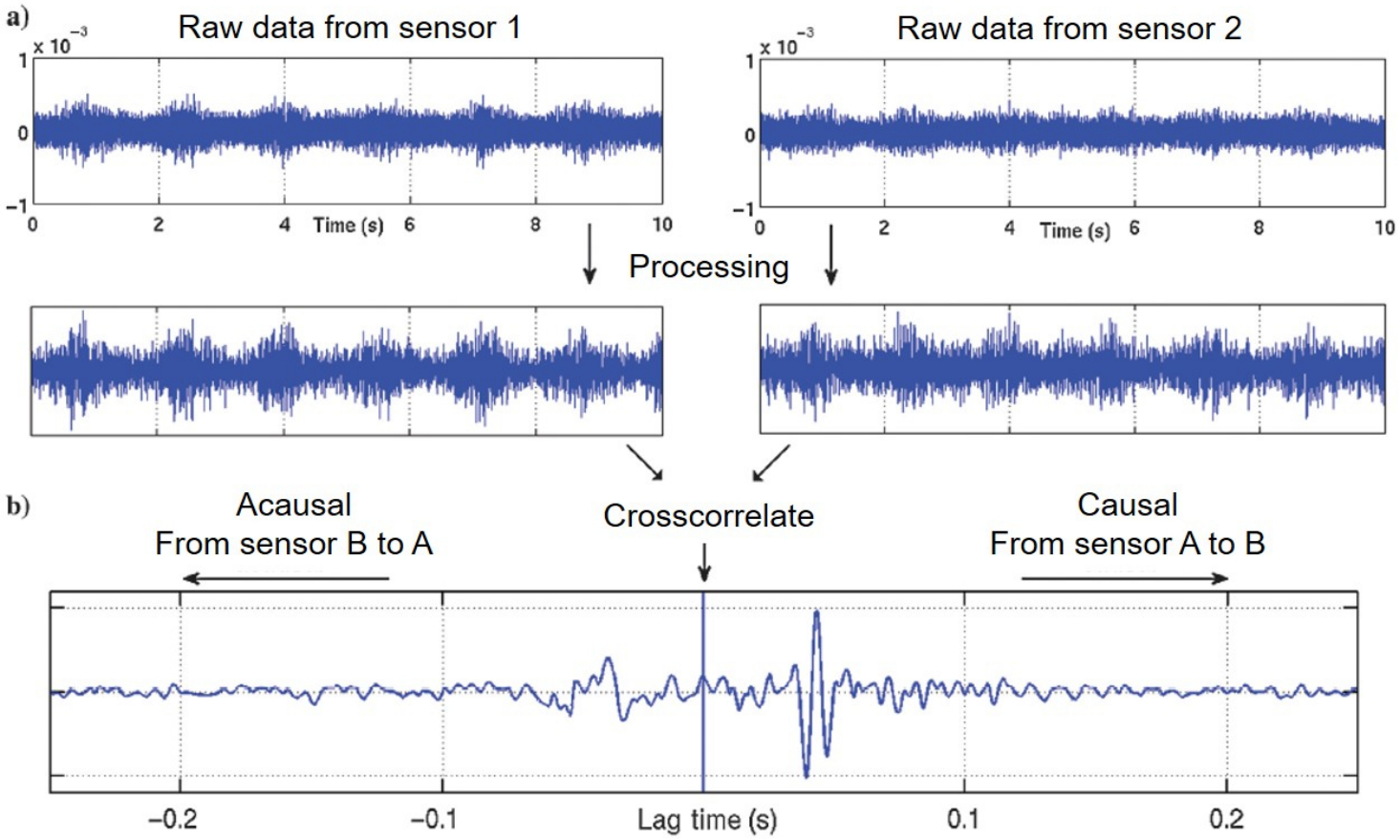
GoogleEarth



From H. Gilbert and G. Savard

Ambient noise correlation method

Principle *:* reconstruct the Green's function by correlating the continuous ambient noise recorded between two captors.



For tomography

Surface waves

⇒ dispersion curves

⇒ inversion

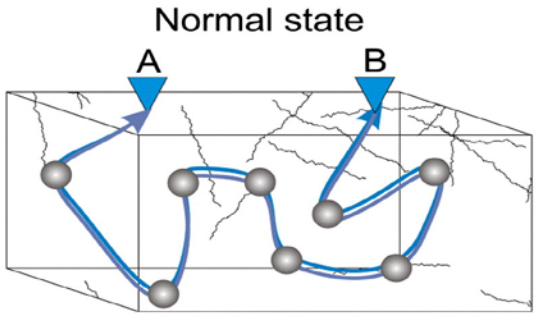
⇒ elastic models

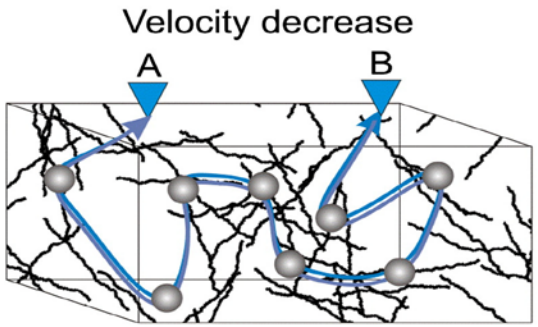
For monitoring

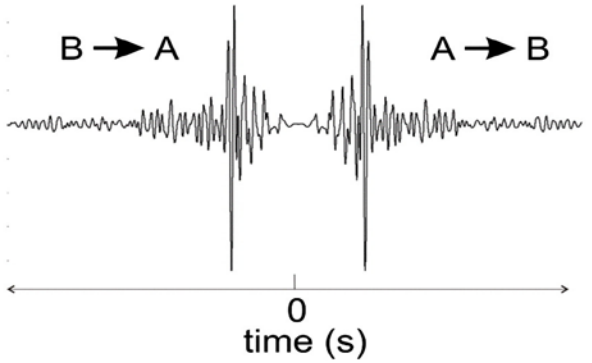
If the medium changes, the result of the Green's function will change

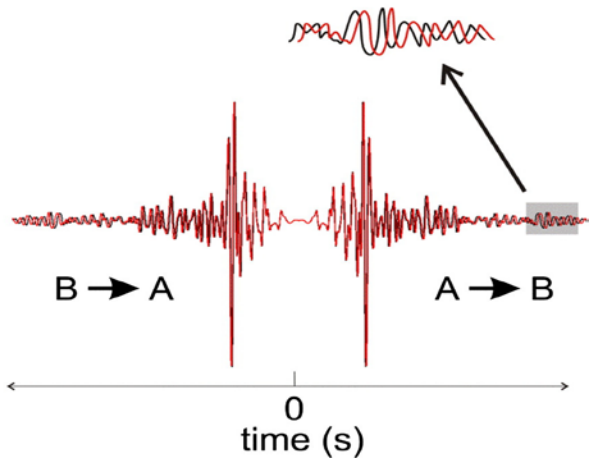
Monitoring with ambient noise correlation

If the medium changes, the result of the Green's function will change







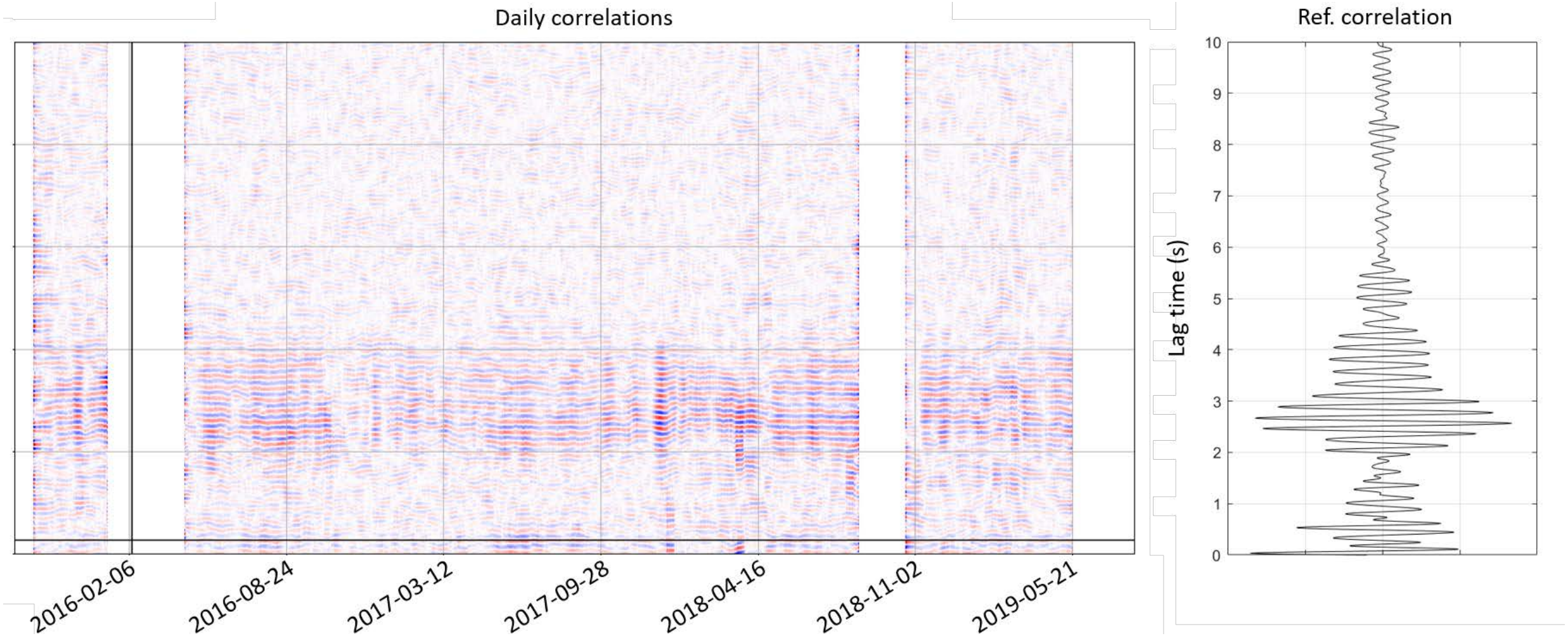


MWCS method (or doublet method, *Poupinet et al., 1984, Clarke et al. 2011*)

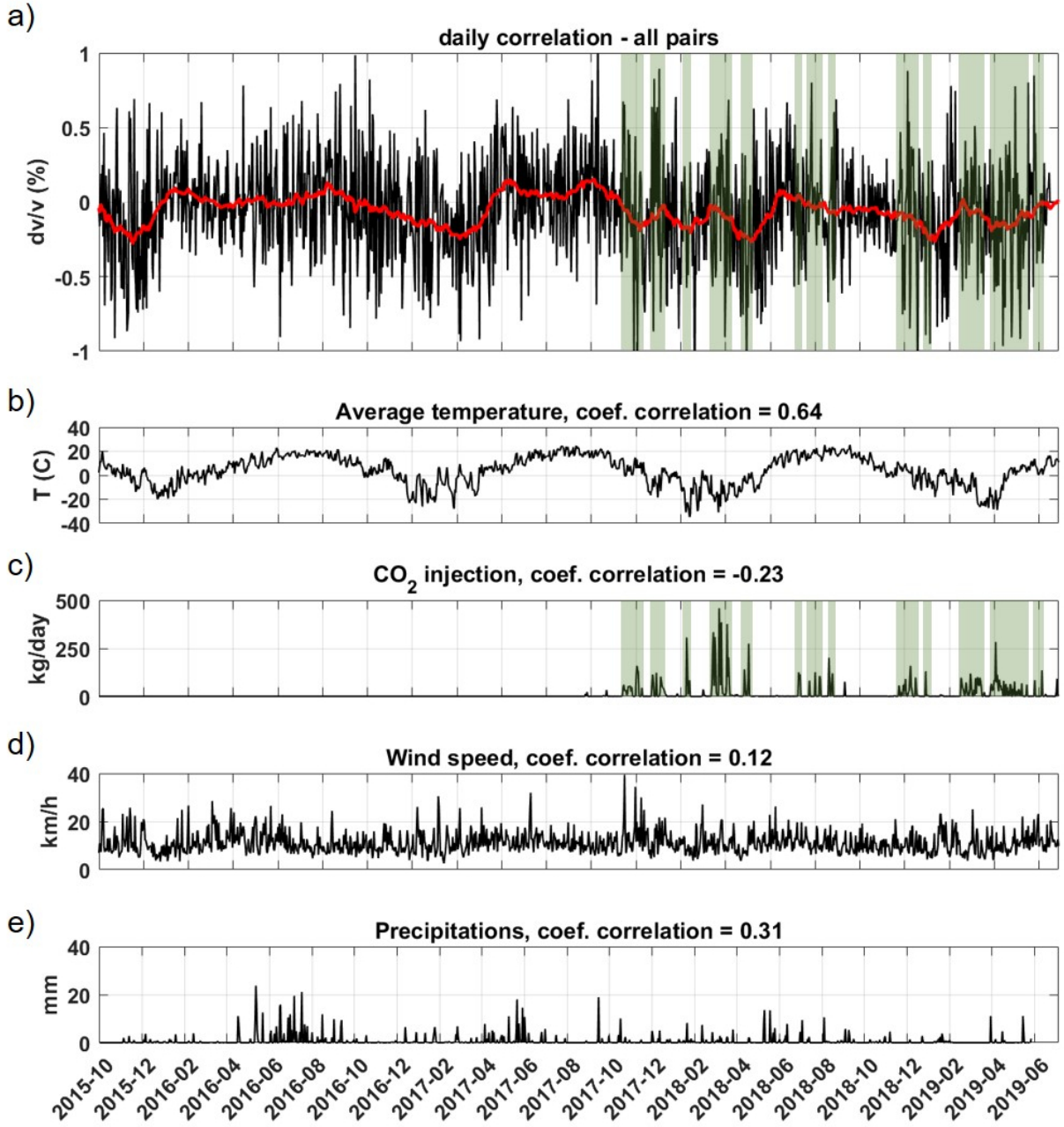
Time shift between reference correlation and current correlation

$$\delta v/v = -\delta t/t$$

Velocity variations



Velocity variations

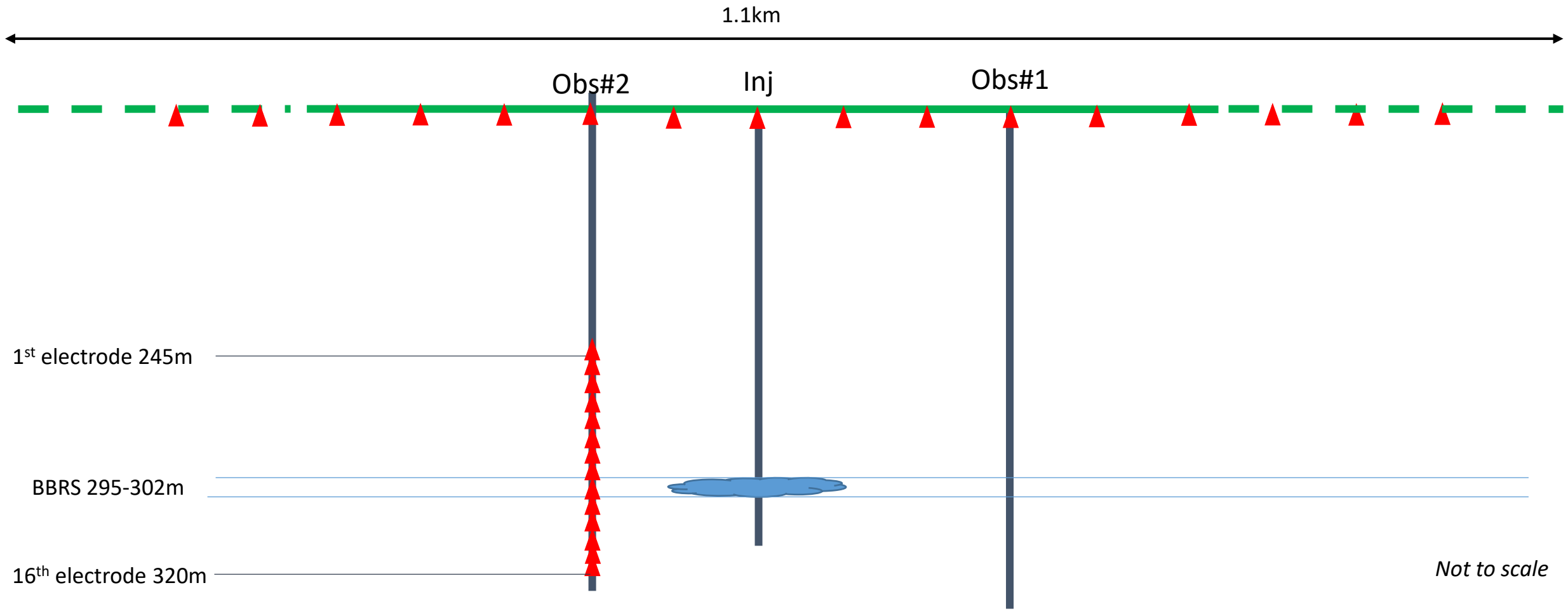


- Moving-Window Cross Spectrum Analysis, [0.1-1]Hz frequency range, from 0.5 to 5s
- good correlation between the smoothed dv/v curve and the average temperature
- CO_2 injection periods seem to correspond to periods of velocity variation decreasing

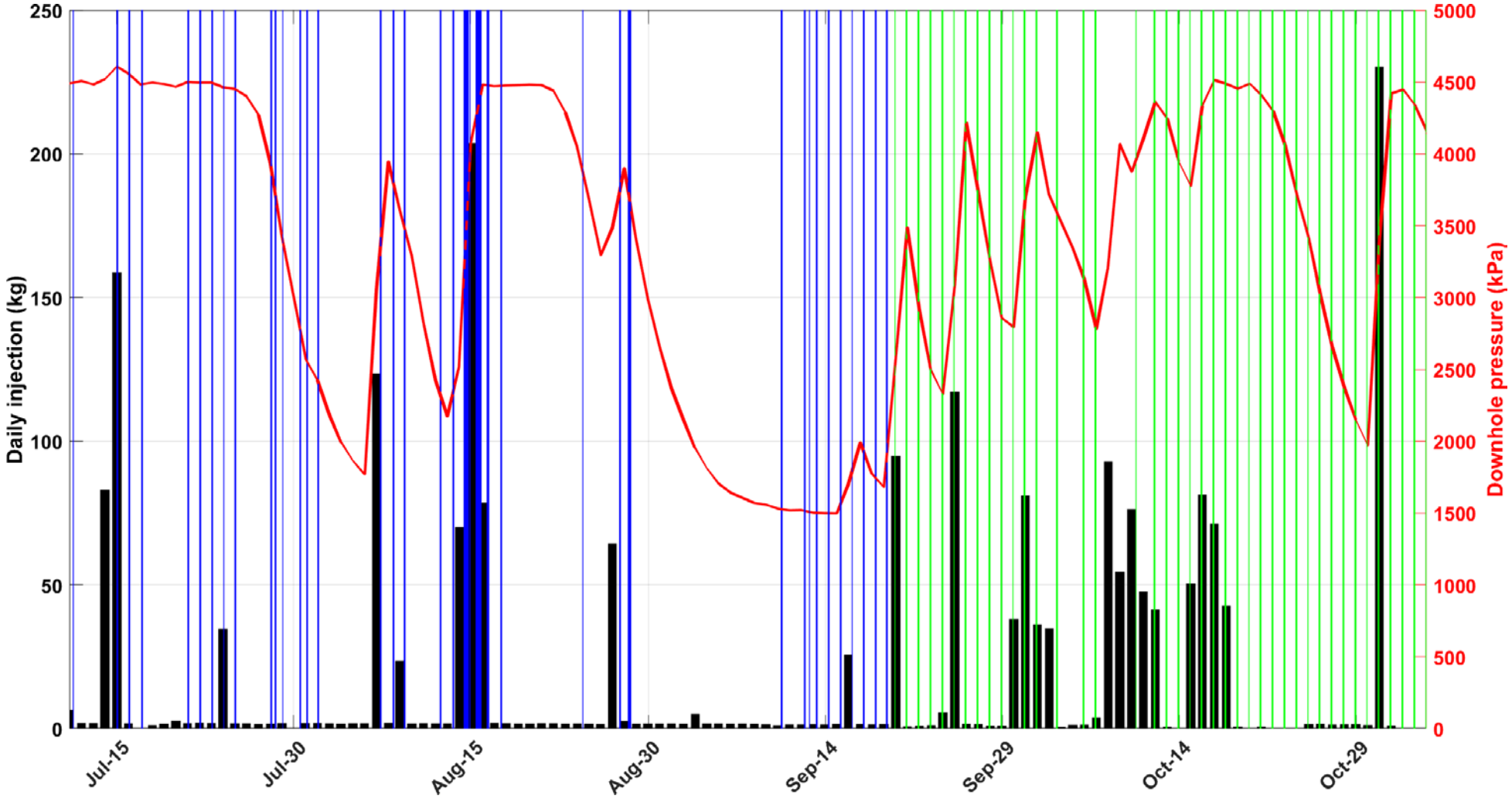
ERT at the FRS

Permanently installed electrodes :

- 16 in obs#2, between 245 and 320 m depth, 5m spacing
- 112 along the trench, 1.1km, 10m spacing



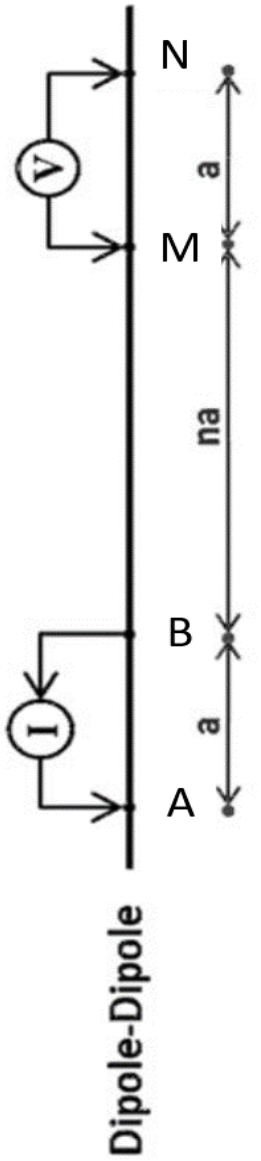
ERT semi continuous dataset

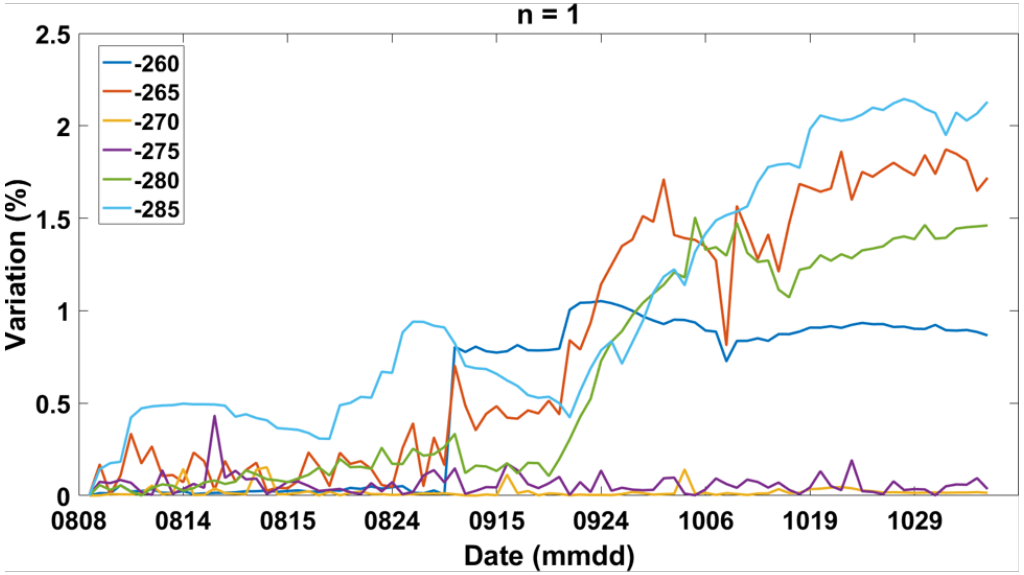


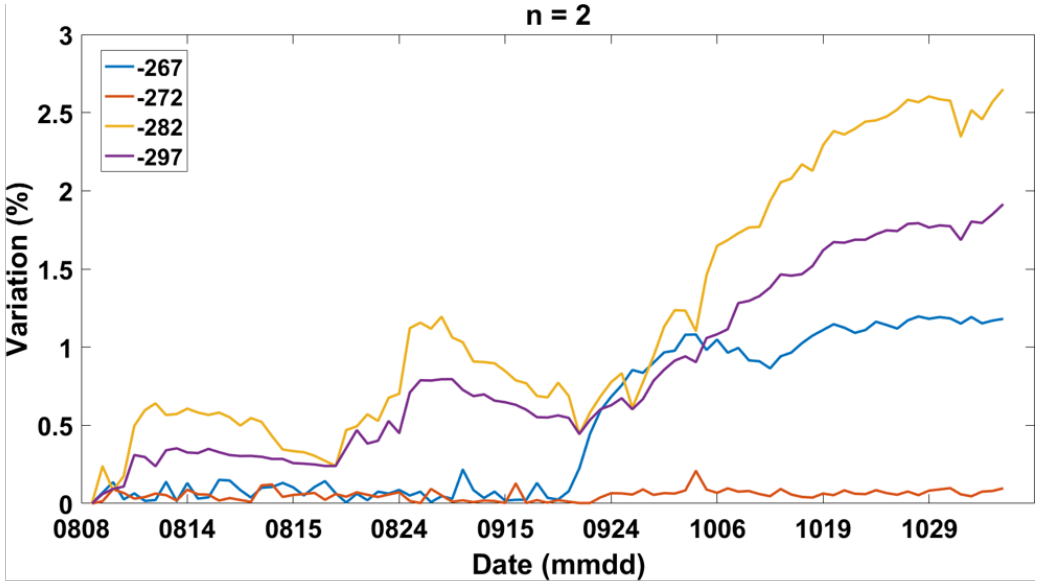
Blue : only borehole measurements

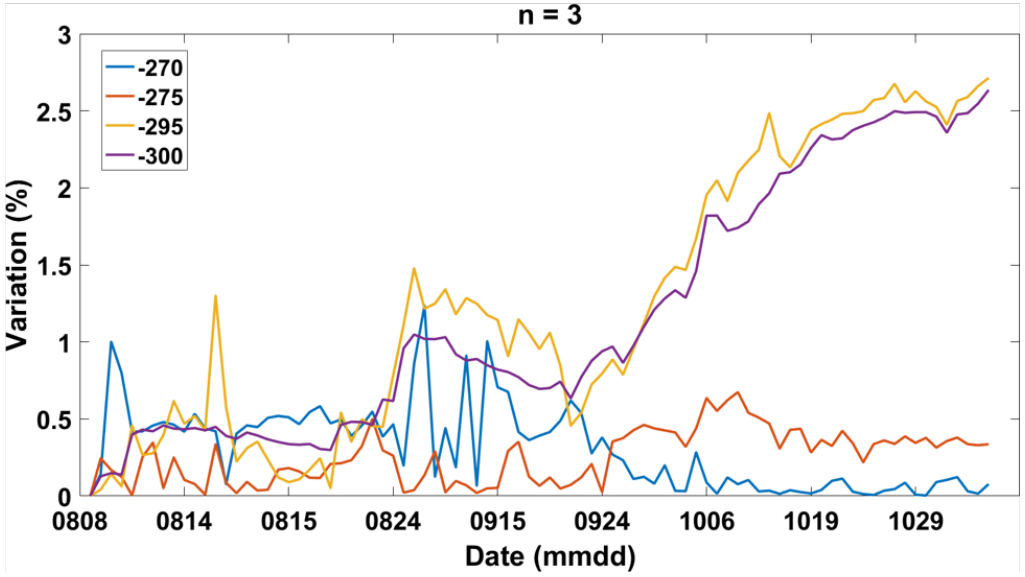
Green : borehole and surface to borehole measurements

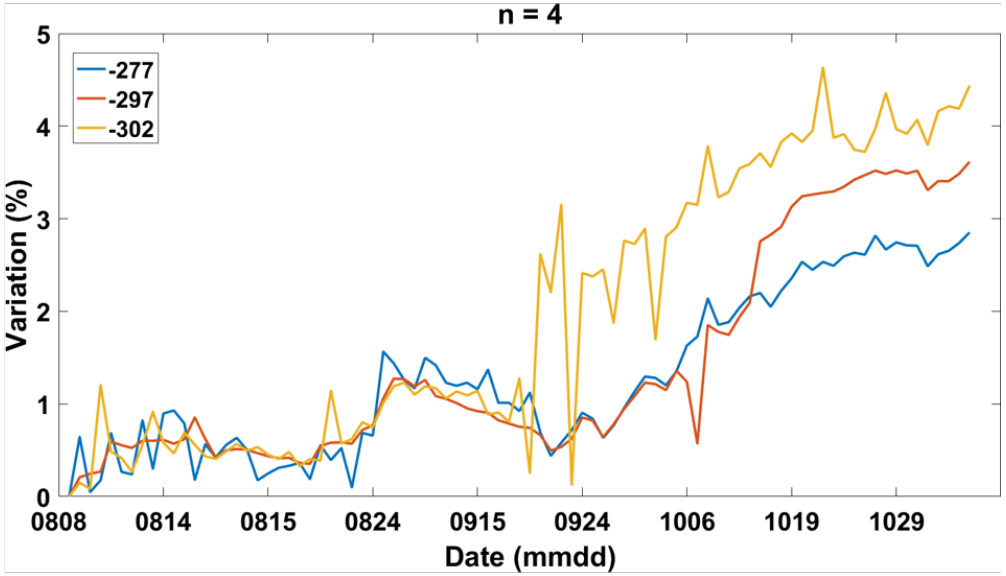
(Very) preliminary results











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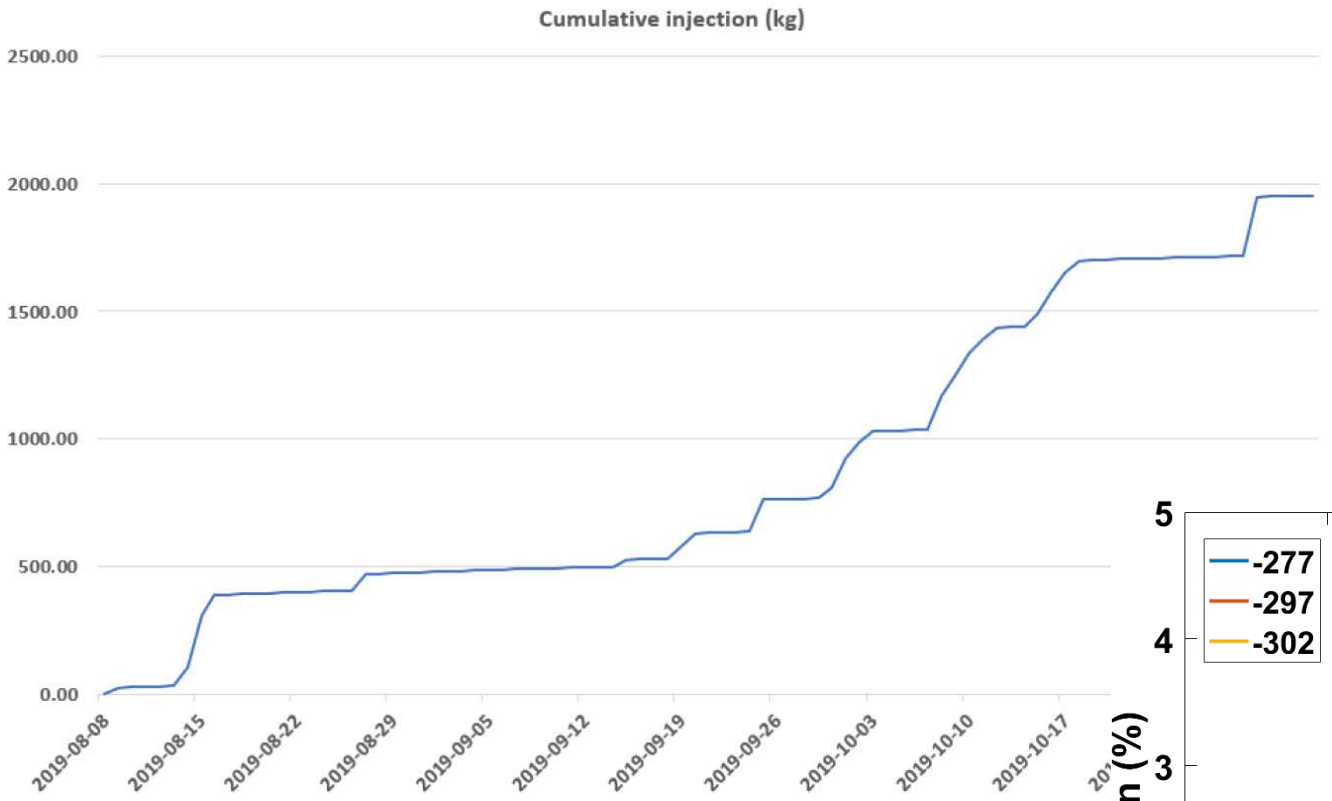
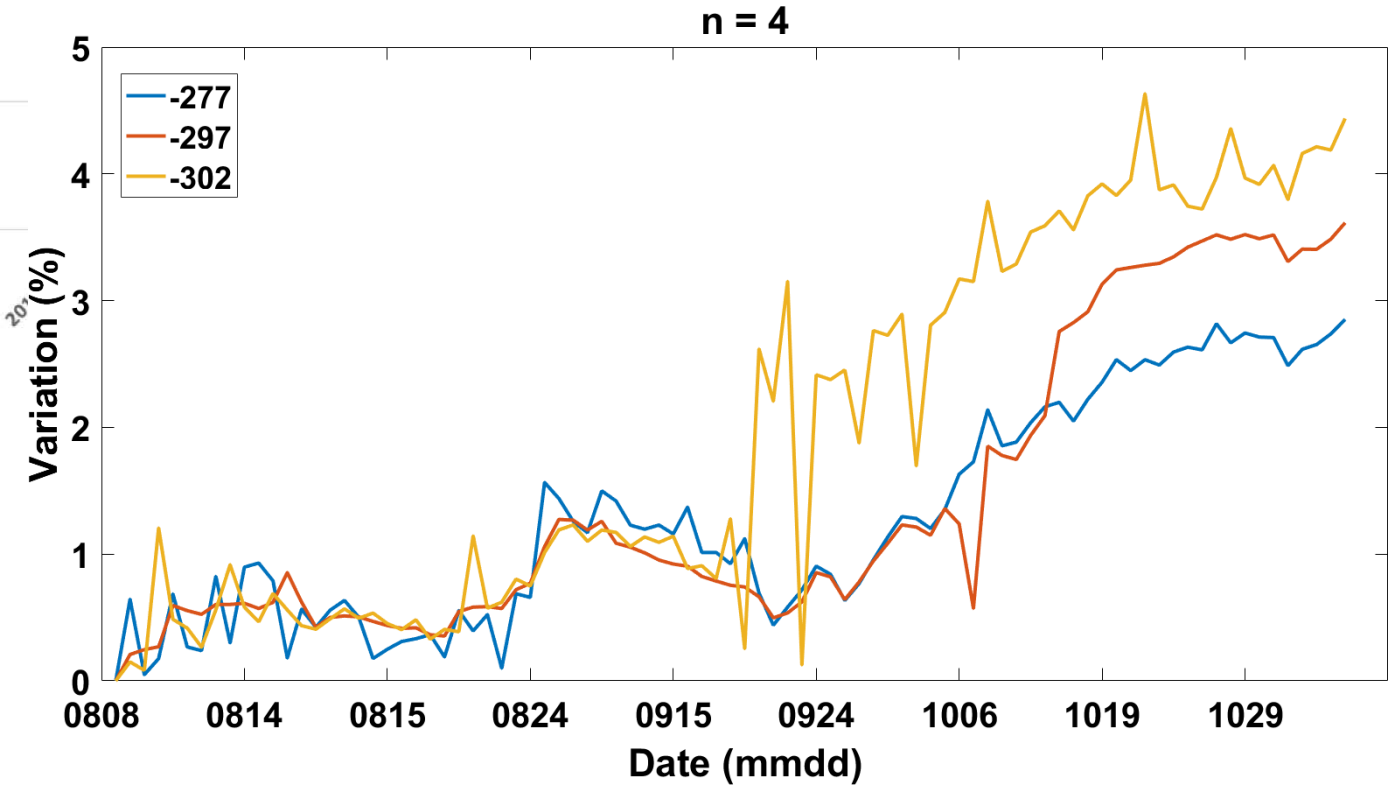
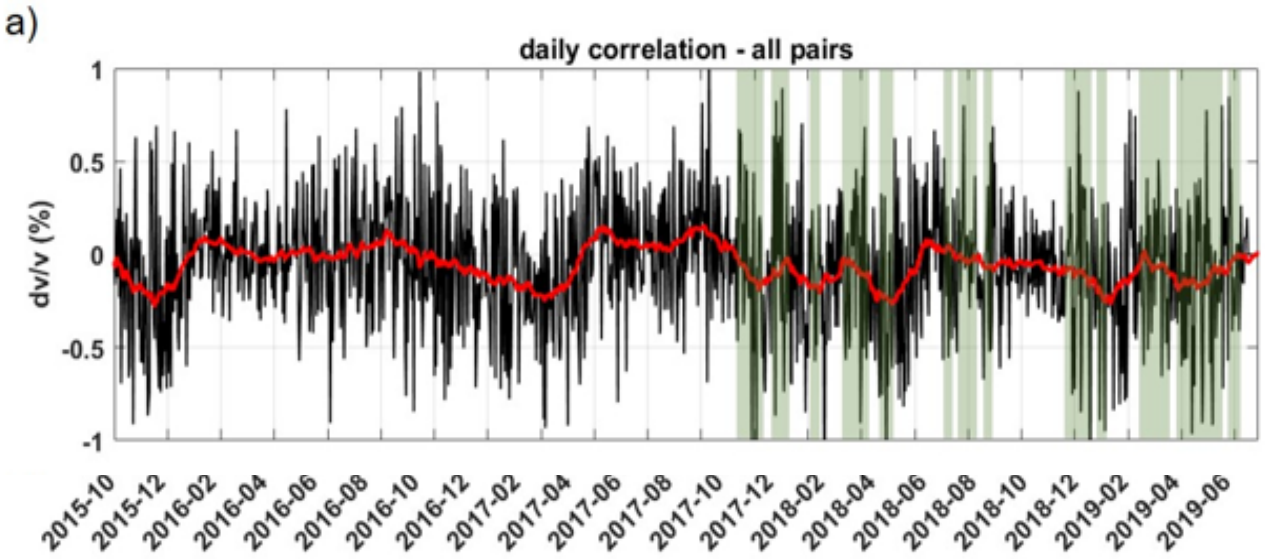




Conclusions and future work

Continuous monitoring with ambient noise correlation

Clear effect of ambient temperature, possible effect of CO_2 injection.

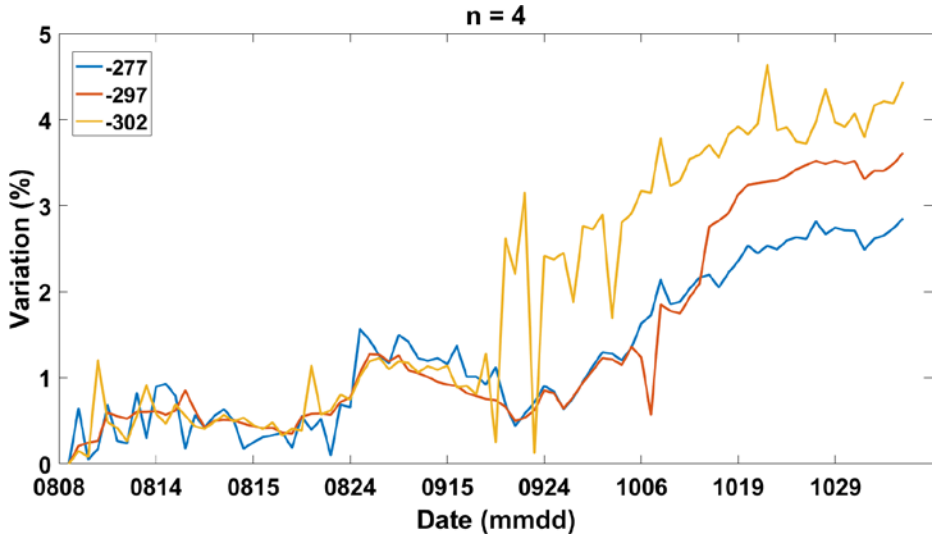


Future work includes:

- Better understand the effect of each variable on the velocity variation
- Add the 24 geophones which are recording since June 2019
- Events detection

Semi-continuous monitoring with ERT

Seems to detect the CO_2 injection.



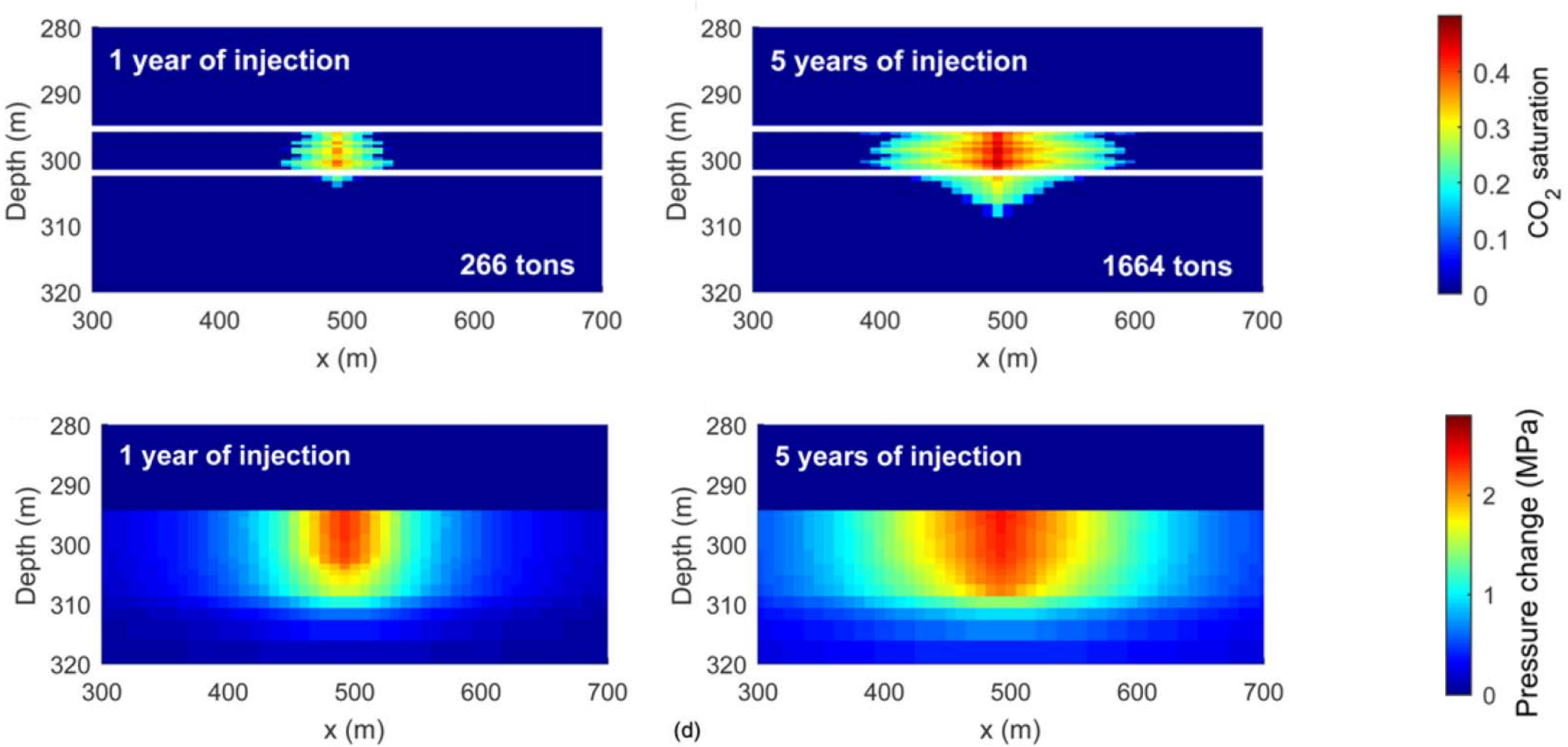
Future work includes:

- Developing a semi-continuous routine to apply to the raw data to be able to quickly detect any CO2 saturation changes;
- Inverting the dataset to get an electrical resistivity tomography of the subsurface.

Second goal – Monitoring of the plume

Geophysics data => CO_2 saturation and pressure

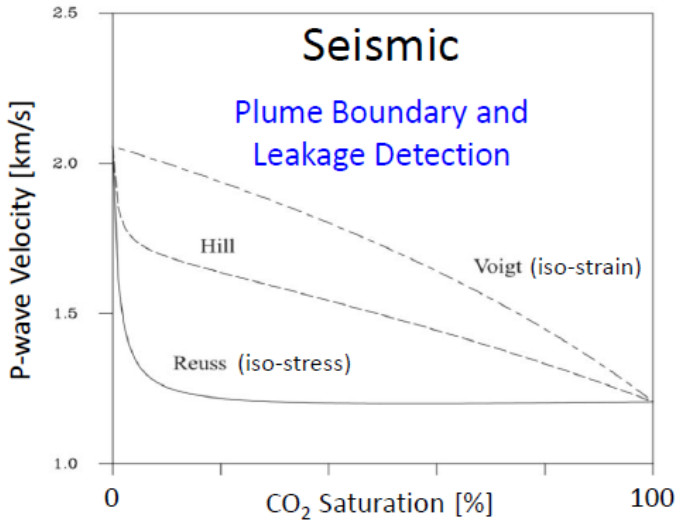
What is working at the CaMI Field Research Station can work for any reservoir type

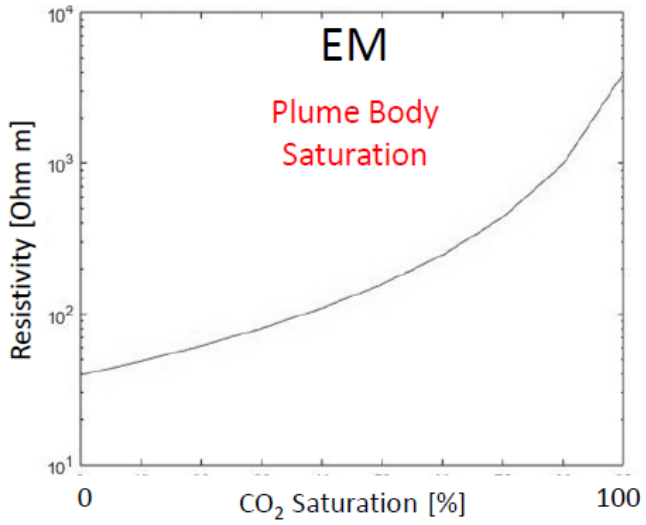


Conclusions and future work

Integration of the different geophysical data

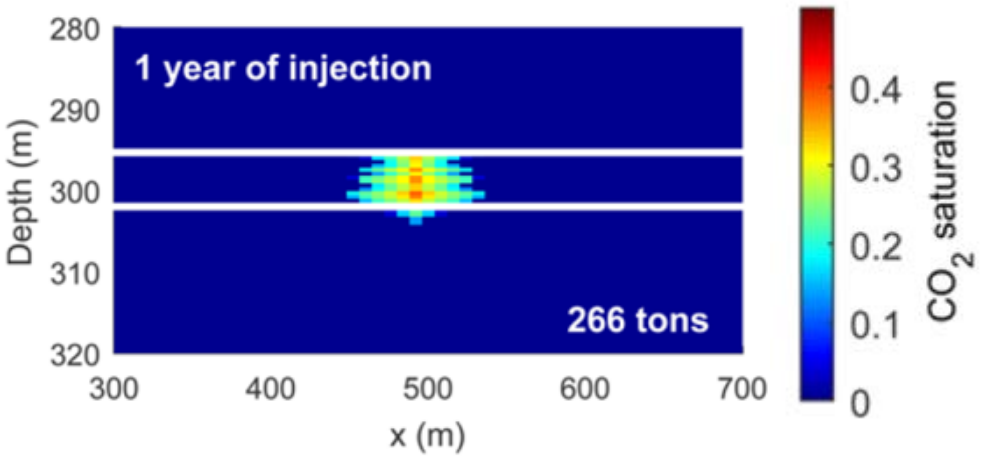
Vasco et al., 2014

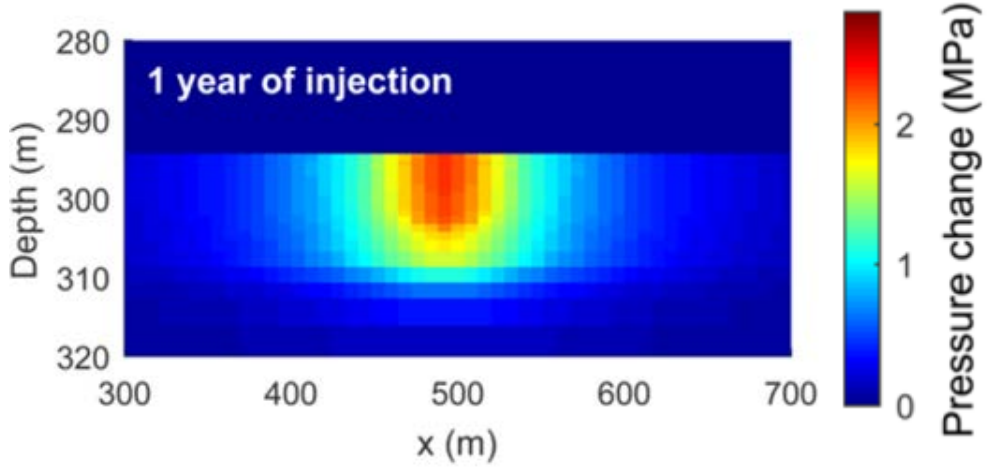




Boerner et al., 2015

Joint inversion to get CO2 saturation and pressure response of the reservoir





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