ENOS Enabling Onshore Storage in Europe

INNOVATIVE TOOLS FOR RAPIDLY MAPPING / QUANTIFYING CO_2 LEAKAGE AND DETERMINING ITS ORIGIN

SE Beaubien[1], DG Jones[2], T Goldberg[3], AKAP Barkwith[2], **S Bigi[1]**, S Graziani[1], KL Kirk[2], E Mattei[4], B Mulder[3], E Pettinelli[4], L Ruggiero[1], MC Tartarello[1]

[1]Dip Scienze della Terra, Sapienza Università di Roma, Rome, Italy
[2]British Geological Survey (BGS), Keyworth, Nottingham, UK
[3]Netherlands Organisation for Applied Scientific Research (TNO), Utrecht, Holland
[4]Dip Matematica e Fisica, Roma Tre University, Rome, Italy

Study / test sites

Near-surface geology

- Latera – potassic volcanics
- San Vittorino – carbonates
- Ailano – carbonates
- Fiumicino – Tiber river sediments

Gas leakage

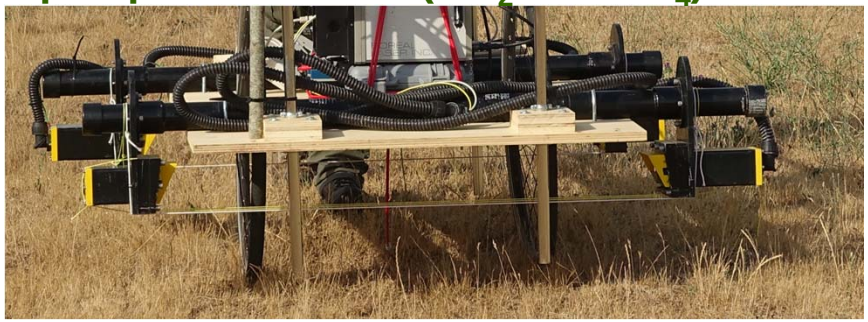
- Typically >98% CO_2, trace CH_4, H_2S, …

Leakage pathways

- Faults and fracture zones
- However, leakage over final interval is often controlled by surface sediments, because most faults are buried

Mobile system

Open path IR lasers (CO_2 and CH_4) - BGS



Mapper – UniRoma1

Sonic Anemometer - BGS

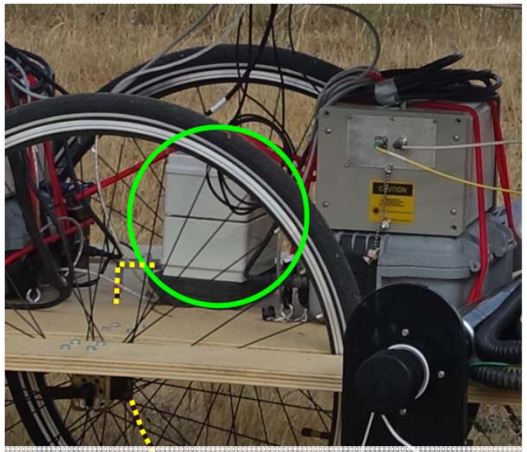
Mobile system

- Methods combine measured parameters and GPS data to map anomalies
- Measurements made every second, giving an along-trace sample spacing of about 1.5 m at normal walking speed
- Mobile results compared with CO_2 and CH_4 flux measurements made on a regular grid
- Interested in spatial resolution, method sensitivity, speed, impact of conditions

Open path IR lasers (CO_2 and CH_4) - BGS

- Deployed 20-30cm above ground
- Fast response with no memory effect

Mapper – UniRoma1

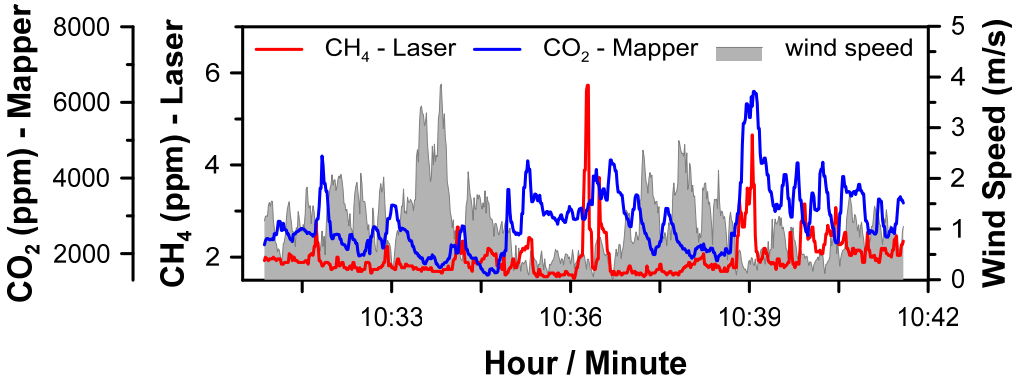


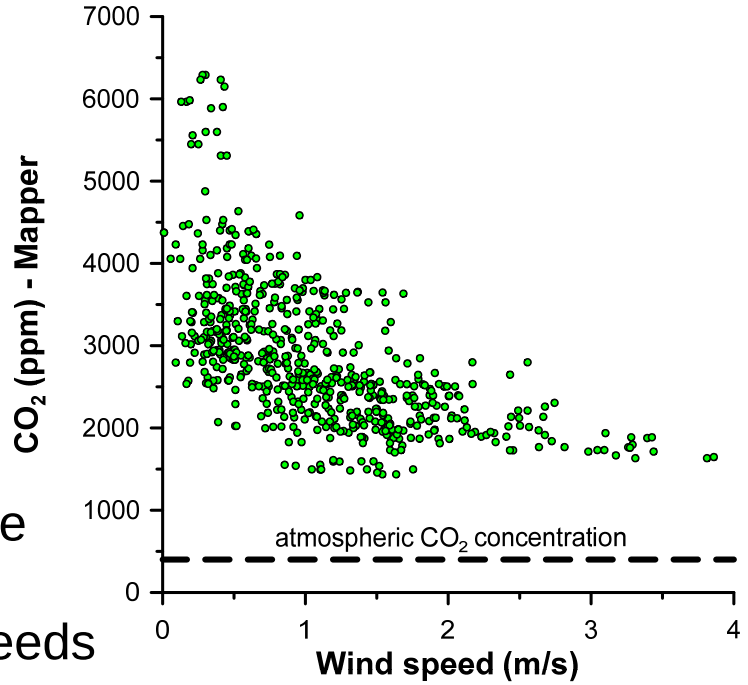
- pumps air from ground surface into NDIR sensor
- Close to ground there is potential accumulation

Sonic Anemometer - BGS

- Measures 3D wind properties

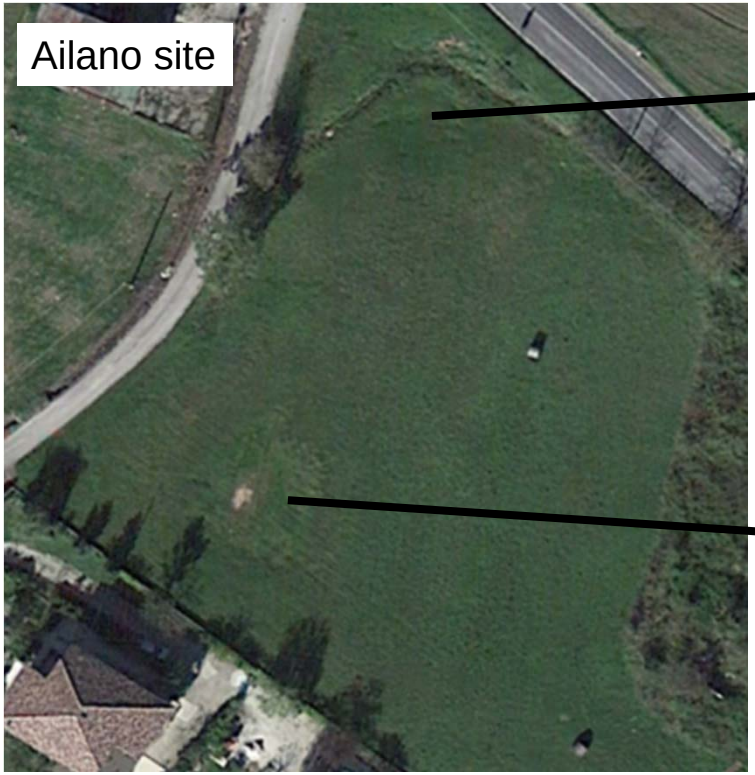
Static measurements on a gas vent – wind effect

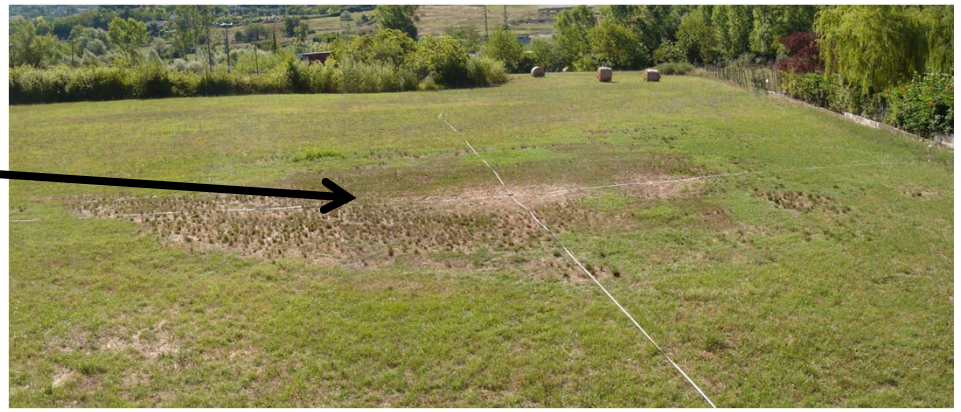




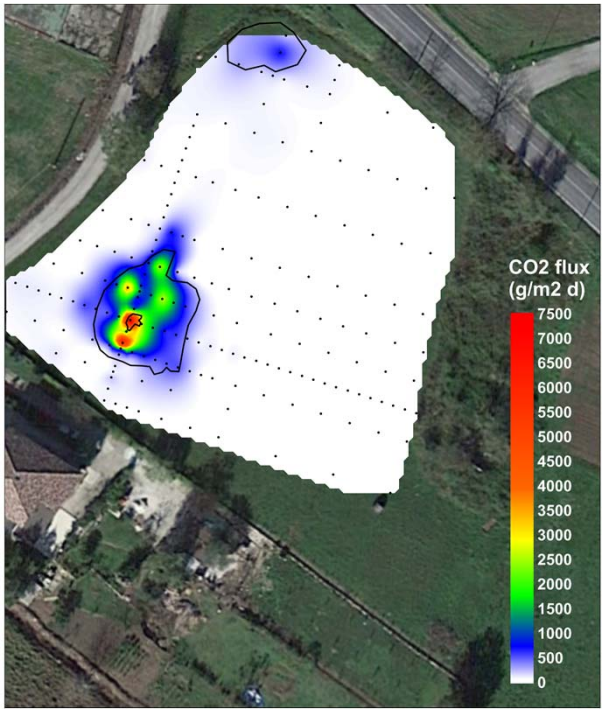
- Placed sytem on gas vent for ~10 minutes to determine temporal variability
- Good correlation between CO_2 at ground surface and trace CH_4 at 20 cm height
- Much higher Mapper values during low wind speeds
- But even at 4 m/s, Mapper CO_2 is still >1500 ppm

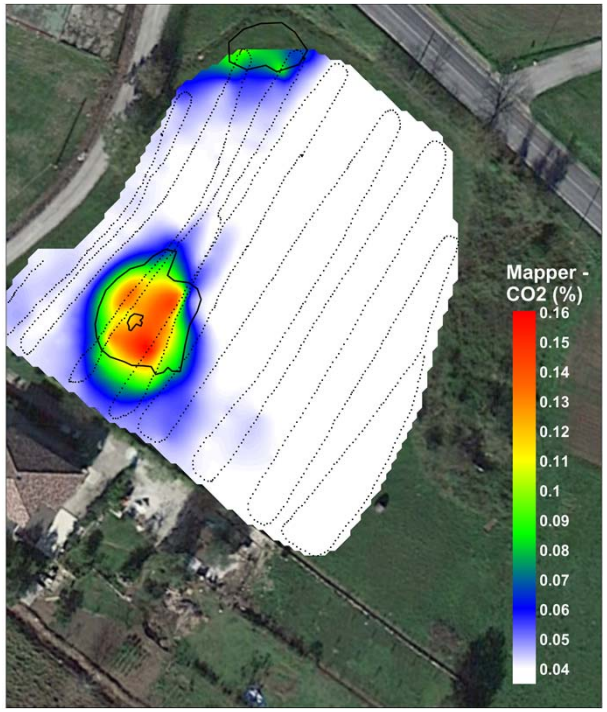
Mobile - leakage detection

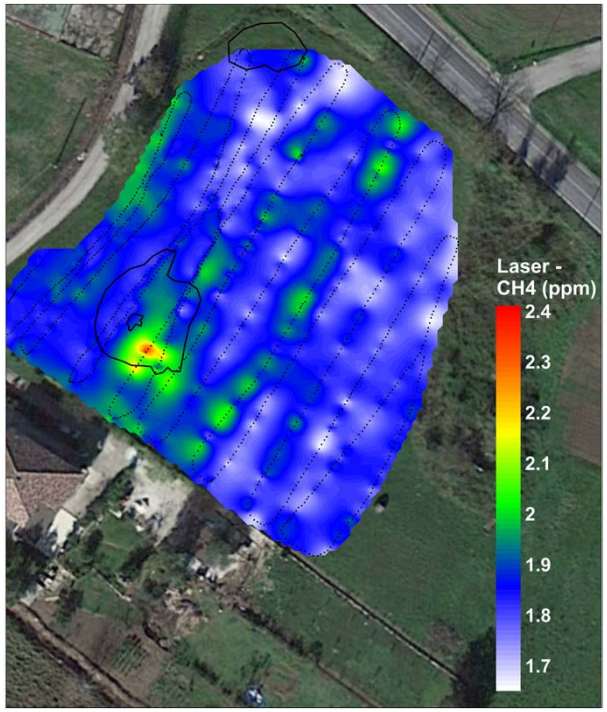




Mobile - leakage detection



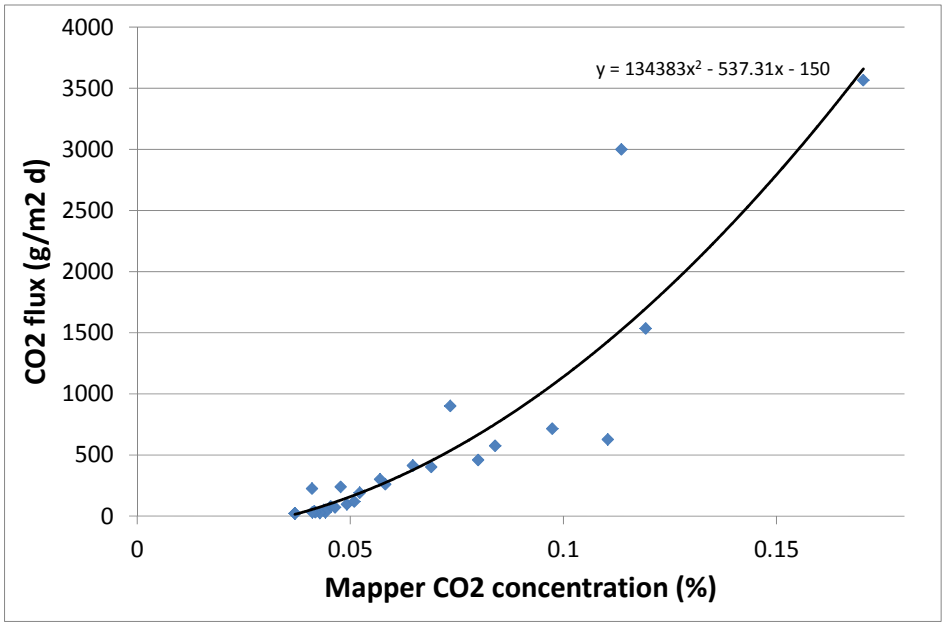




- Excellent correlation between the two techniques;
- 190 flux measurements took ~10 person hours, mobile system only took 30 minutes

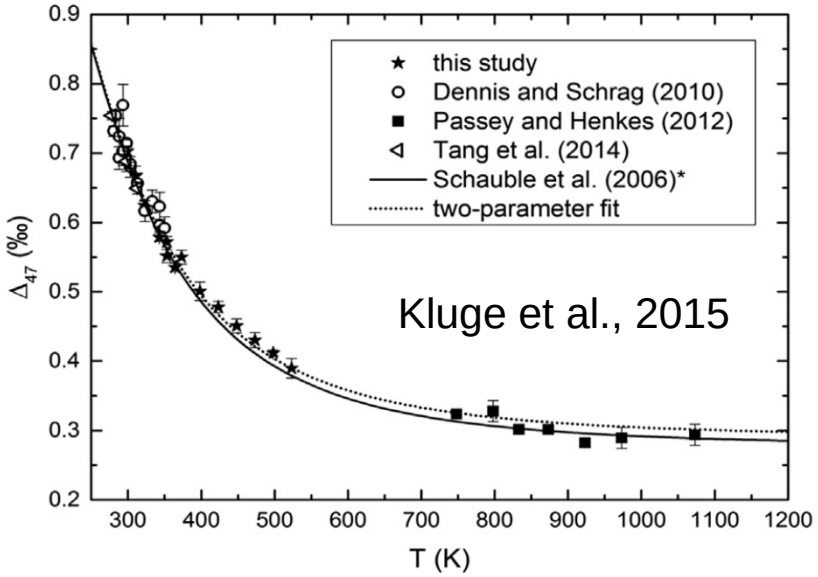
Mapper – leakage quantification

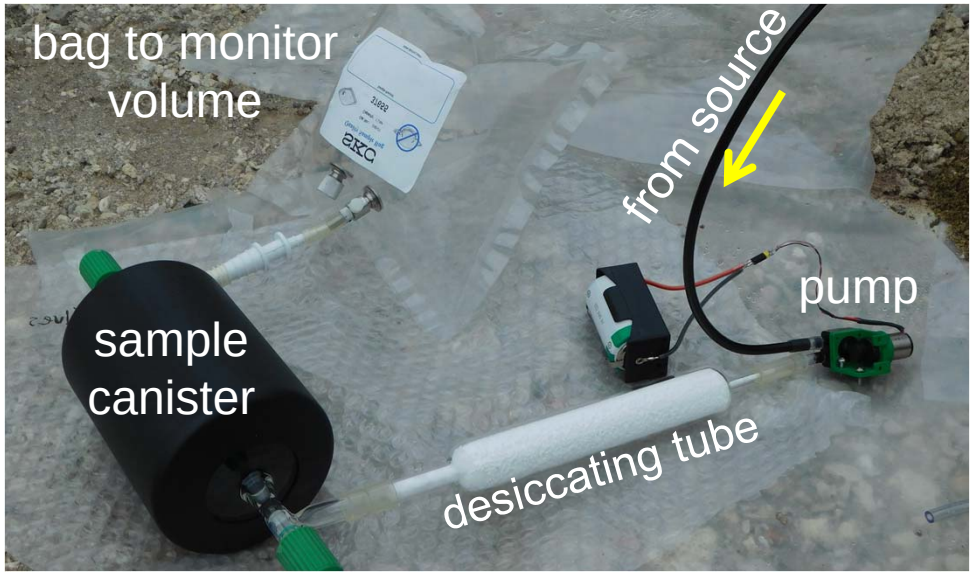
Use Mapper results as a flux proxy, because faster and higher spatial resolution



- An empirical relationship between boundary layer concentrations and point flux values is defined based on limited points representing the total range
- “convert” all Mapper data to flux, and use this to estimate total flux
- At the same time the complete, point flux dataset is also used to estimate total flux
- Initial results yielded a Mapper estimate that was about 60% of the point flux
- development may yield more precise estimate because less interpolation error compared to point measurements

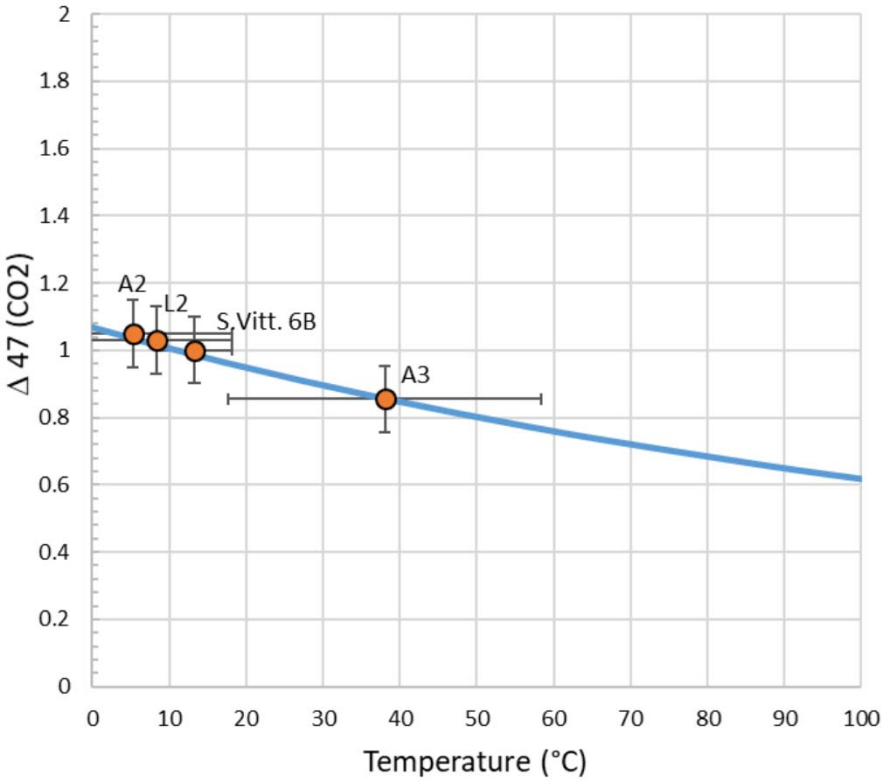
Origin determination – Isotopologues





- formation temperature of CO_2 determines the abundance of CO_2 isotopologue (mass 47), with temperature being controlled by the local geothermal gradient.
- samples collected at all four sites, with the hope that results would differentiate different formation depths.

Origin determination – Isotopologues



- although many samples were analysed, extraction line problems meant that only four yielded acceptable results
- three fall within the T range of average groundwater (13 to 15°C) while one is slightly higher (38°C), instead of expected values >150°C
- resetting of the Δ47 signal is likely due to re-equilibration of CO_2 with groundwater along its flow path
- results are not promising for the use of this method for CCS monitoring

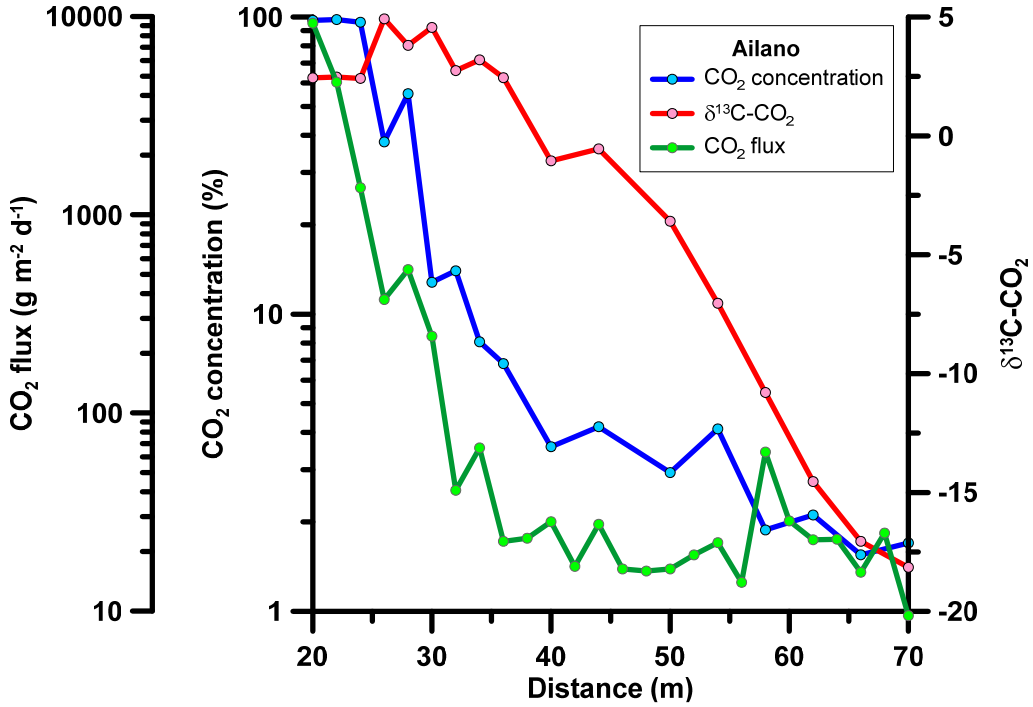
Origin determination – Stable carbon isotopes

Stable isotope analyses of CO_2 in the soil (60 cm deep) used to separate:

- biogenic CO_2, which typically has $\delta^{13}C$-CO_2 of -15 to -25‰
- geogenic CO_2, which in Italy typically has values around -1 to +2‰

Compared with CO_2 concentration in the same samples and CO_2 flux on surface

Origin determination – Stable carbon isotopes



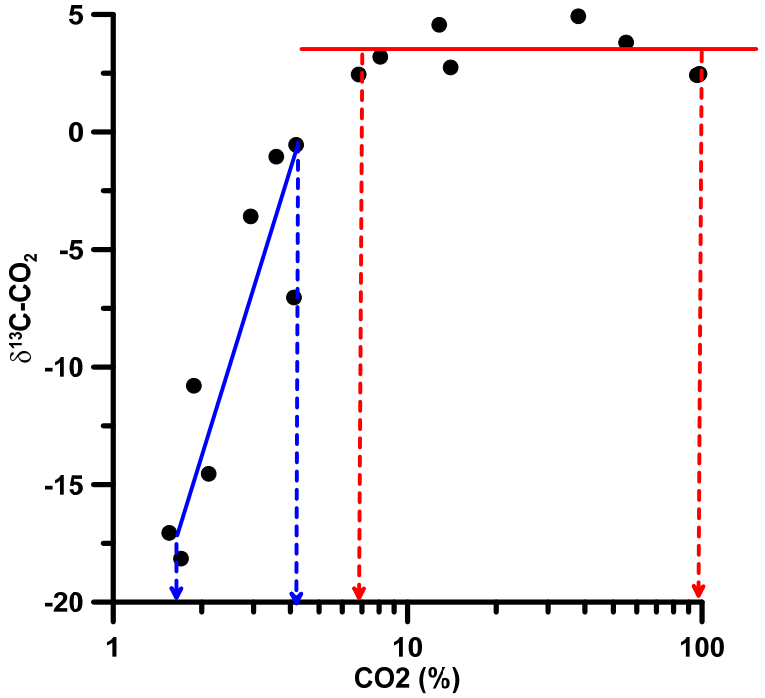
Ailano

- 50 m long profile moving away from the core of a strong gas vent (about 9,000 g m^{-2} d^{-1})
- Samples collected every 2 m (note log scale for CO_2 conc. and flux
- Results show spot and not diffuse leakage
- Flux goes to baseline in first 15 m, but isotope and CO_2 concentration values approach biogenic levels after about 50 m

Origin determination – Stable carbon isotopes

Ailano

- Direct comparison between CO_2 concentration and $\delta^{13}C$-CO_2
- Above about 7% CO_2 the isotopic values are relatively constant and representative of geogenic end member
- Below 4% CO_2 there is mixing between the geogenic and biogenic end members
- Difficult to determine if lowest value (1.6%, -18‰) represents pure biogenic end member



For information please contact enos@brgm.fr
or visit www.enos-project.eu

Thank you !

ENOS

Enabling Onshore CO_2 Storage

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 653718