Assessing impacts in terrestrial environments

Results from the RISCS project

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and the RISCS project team

Outline

- Overview of RISCS project
- Research on terrestrial impacts
- Experimental field sites
  - Norway
  - UK
- Natural field sites
  - Greece
  - Italy
  - France
- Progress to date – a flavour

Overview of RISCS project

- Research into Impacts and Safety in CO2 Storage
- CO2 Geological Storage will be designed to prevent leakage
- However, it is important to consider the consequences of leakage should it occur
- RISCS is concerned with the potential environmental impacts of leakage
- This is likely to be a requirement for Risk and Environmental Impact Assessments
- RISCS is assessing both terrestrial and marine impacts
- Through experiments, natural observations and modelling
- Key findings in Guide to Impacts Appraisal

Overview of RISCS project

- 4 year FP7 project, fully funded (€5.3M) started January 2010
- 24 participants (UK, Greece, Netherlands, Italy, Norway, Sweden, France, Germany) + Australia, Canada, USA
- 6 industrial participants (Enel, Statoil, Vattenfall, EoN, PPC, RWE) providing funding (c €200k each), research input and advice
- 4 non-European participants (CO_2CRC & Montana State, Regina, Stanford universities) in advisory role
- 1 NGO (ZERO)
- CO_2GeoNet (Primarily represented by NIVA, BRGM in addition to 6 participants)
- IEA-GHG – advice and help with dissemination

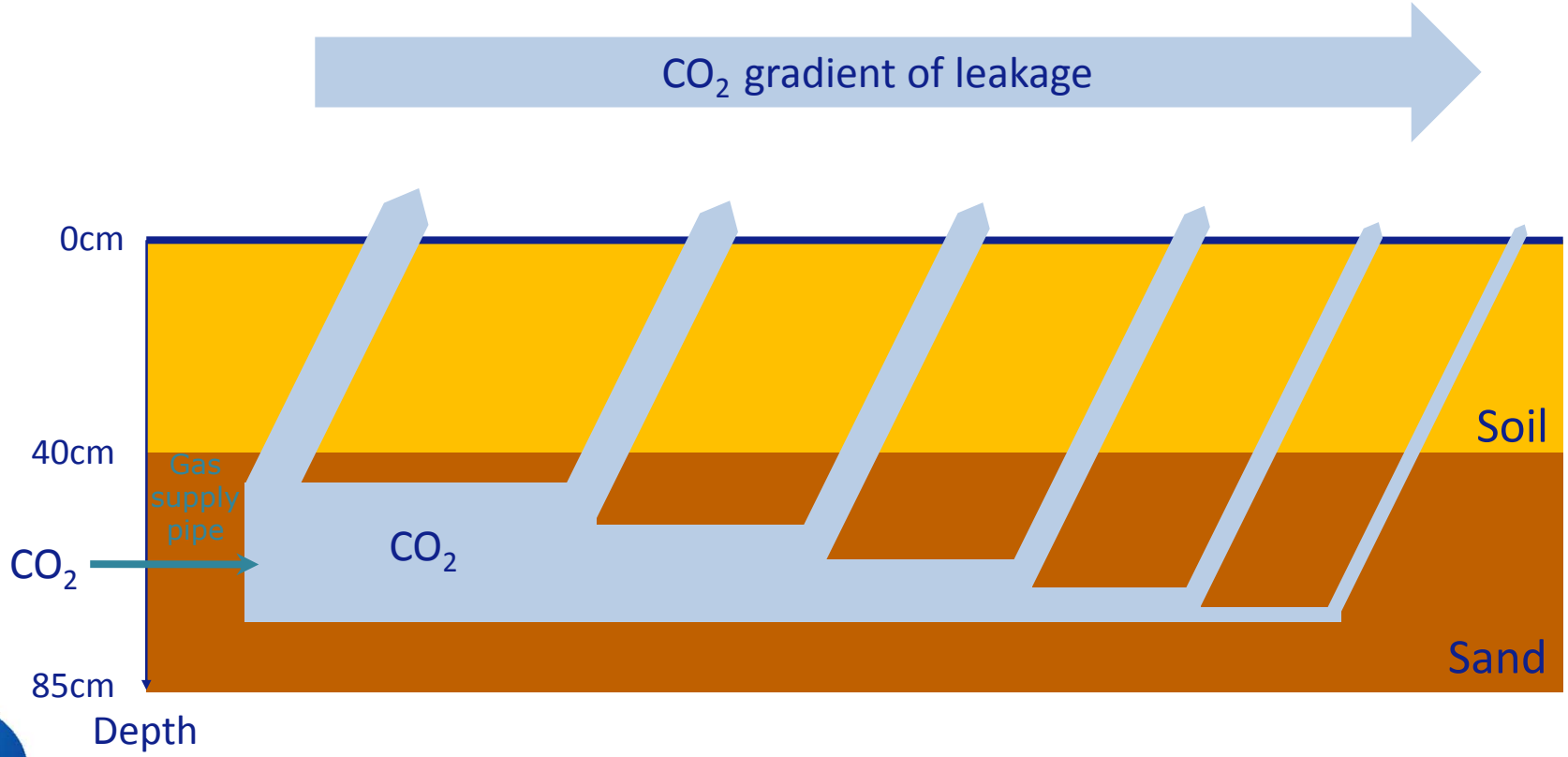
Terrestrial Impacts

- Experimental injection sites
  - Grimsrud Farm, Norway
  - ASGARD, UK
- Greenhouse experiments
  - Norway
- Natural field observations
  - Florina, Greece
  - Latera and San Vittorino, Italy
  - Montmiral, France
- Modelling of leakage scenarios using results

Grimsrud Farm, Experimental site

To test effects of CO2 leakage on crops at high latitudes using a CO2 gradient

Injection system

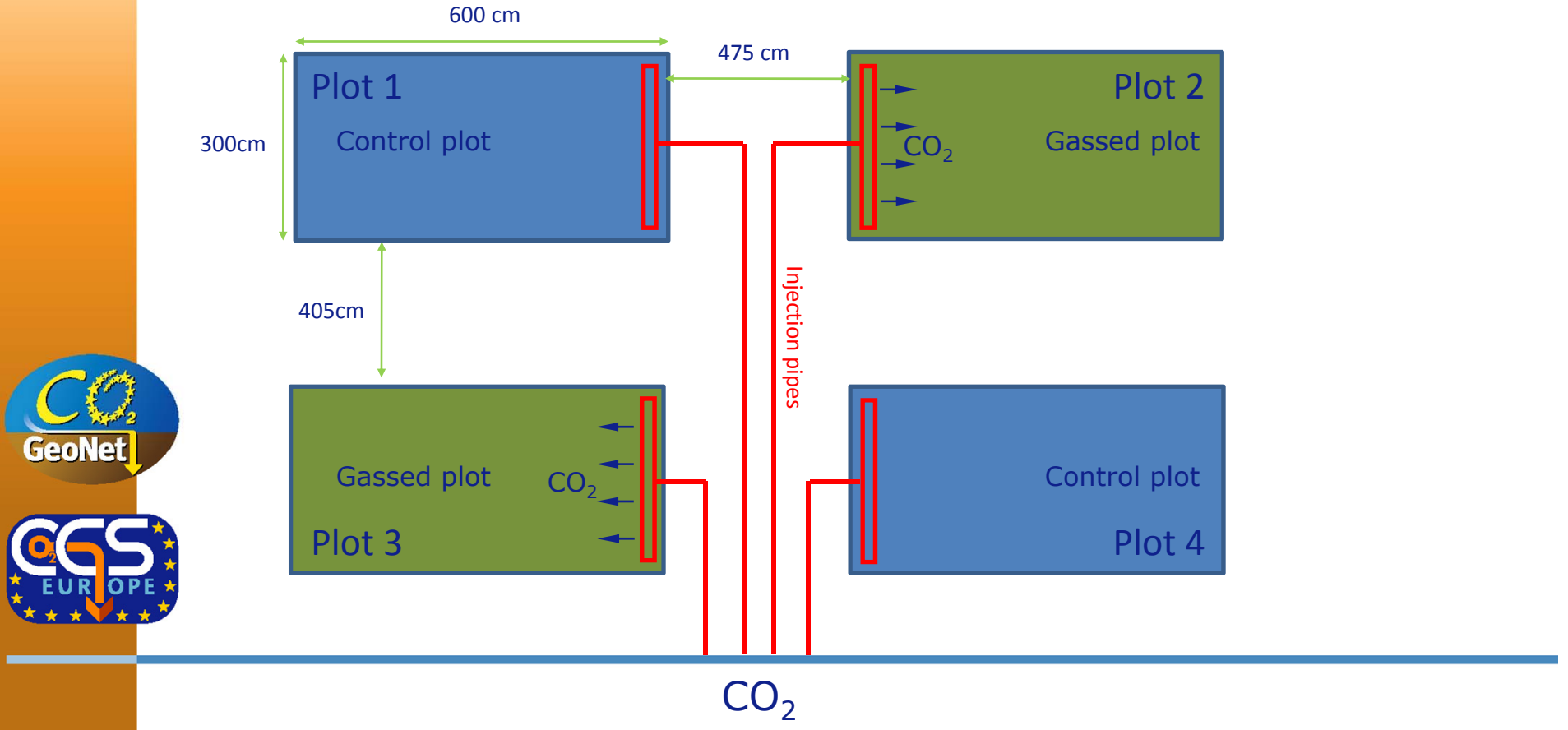


Generates a CO_2 gradient by injecting CO_2 at depth in a permeable Sand layer buried under a less permeable layer (clayey soil).

Experimental plot preparation

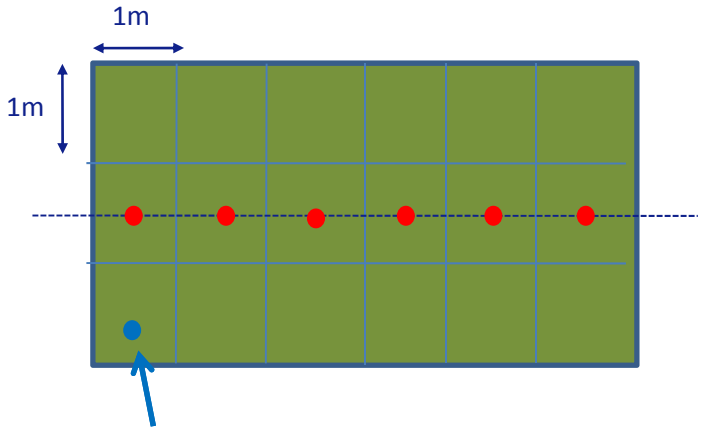
Four experimental plots (6m x 3m) were created in August 2010 in a clayey glacial moraine soil

Two will be gassed to simulate leakage and two used as controls

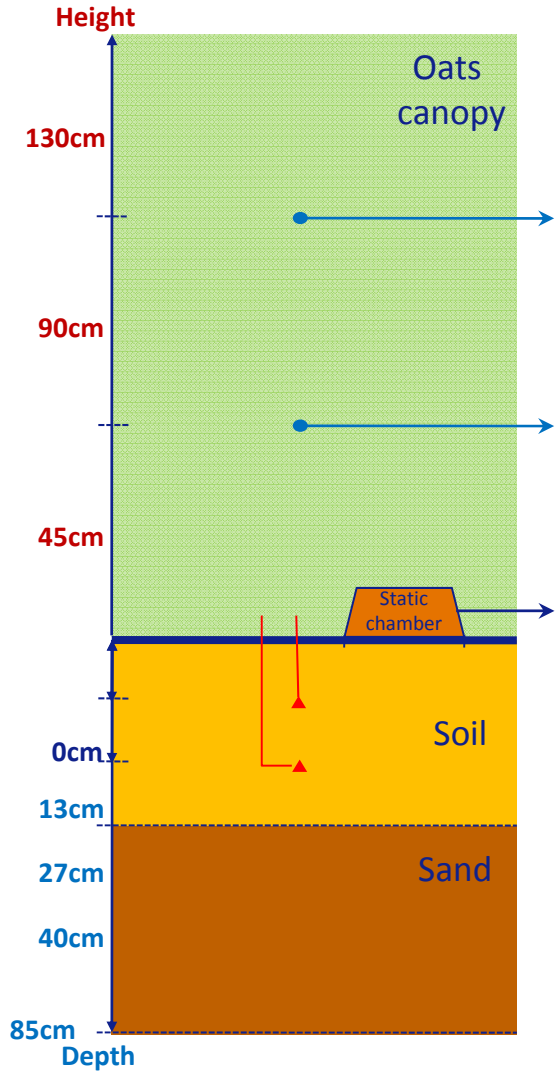


CO_2 and flux measurements

Flux measurements and gas sampling points



Also soil temperature and humidity (2 depths)



Atmospheric gas sample
for CO_2 content and $\delta^{13}C$

Soil-atmosphere CO_2 flux
and $\delta^{13}C$ (24h)

Soil gas samples

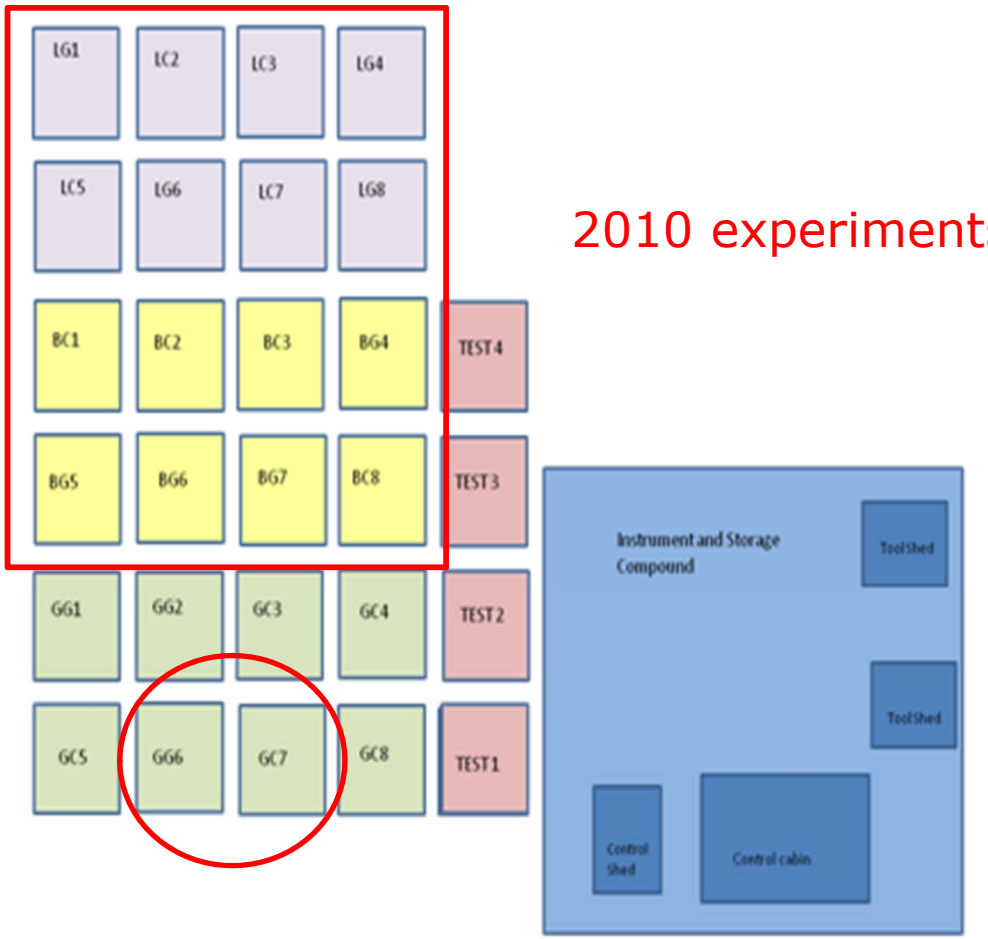
Detail of a sampling point

Progress and plans

- Plots set up and tested in 2010
- Results showed a CO2 gradient, but only over a 3 m distance
- Plots were sown with oats in May 2011
- Two plots will be gassed at 1 l.min-1 with natural gas (δ13C = -46‰)
- CO2 measurements (fluxes, concentration and δ13C) will last the whole growing season
- Plant yields, height, biomass, leaf nutrient and δ13C
- Experiment will be supplemented by greenhouse exposure experiments
- Data will be used for an eco-physiological model

ASGARD experimental site

Existing plots



2010 experiments

New RISCS plots

16/05/2011

ASGARD: 2010 Spring Crop Experiments

Crops

- Oilseed rape (*Brassica nupus*)
- Barley (*Hordeum vulgare*)

CO_2 supply

- CO_2 delivered from 6th June 2010
- Injection at a depth of 60 cm
- Supply rate 1 litre min^{-1}

Visible changes

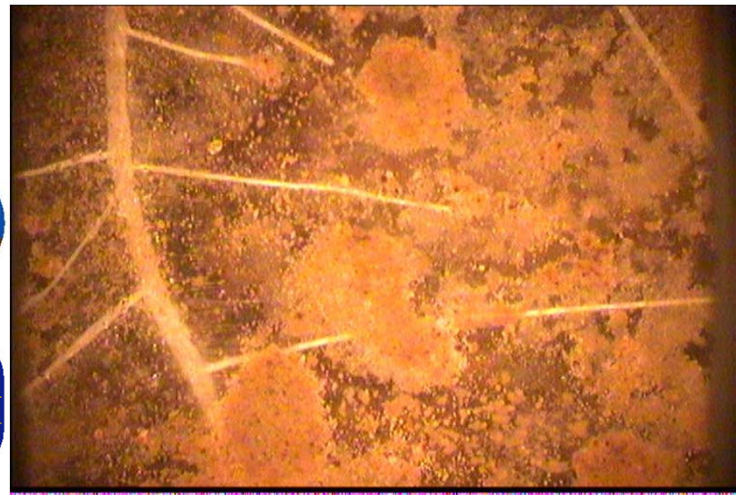
- Occurred within 7 days
- Oilseed rape leaves turned purple
- Barley leaves turned yellow

ASGARD: 2010 Root Measurements

Root photographs

Images in oilseed rape plots before gassing and then every 2 weeks until harvest

Images every cm to a depth of 1m



Photograph of oilseed rape roots taken at 45cm depth from the South tube in Plot 1 on 13th July 2010.

ASGARD: 2010 Root Measurements

Root photographs of oilseed rape

Control roots

Number of primary and secondary roots increase with time and depth.

South tube (Low surface gas/high deep gas areas)

↓ Roots with depth and time

↓ No of secondary roots

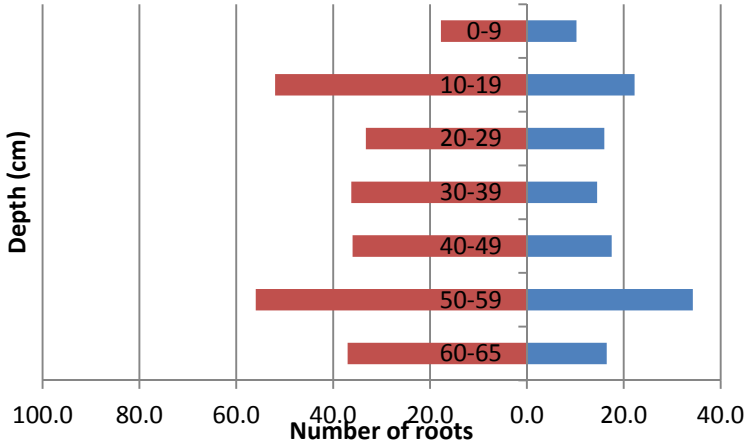
East tube (High gas areas)

↑ Roots at 10-30 cm depth

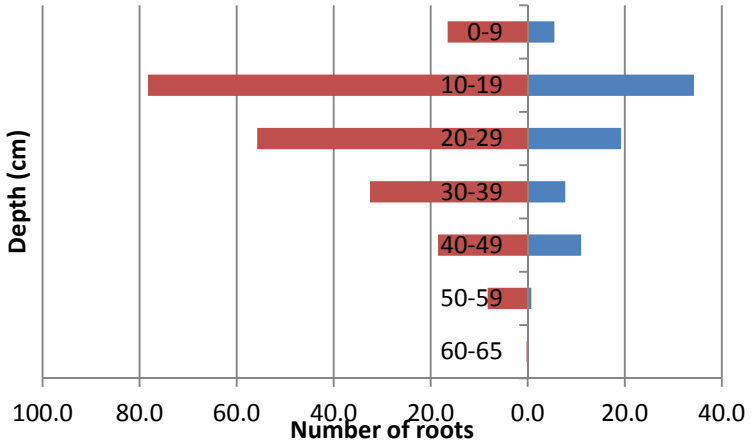
↓ Roots at 30-60 cm depth

↓ No. of secondary roots

Control



CO_2 gassed (East tube)



Number of primary roots (red) and secondary roots (blue) after 41 days gassing

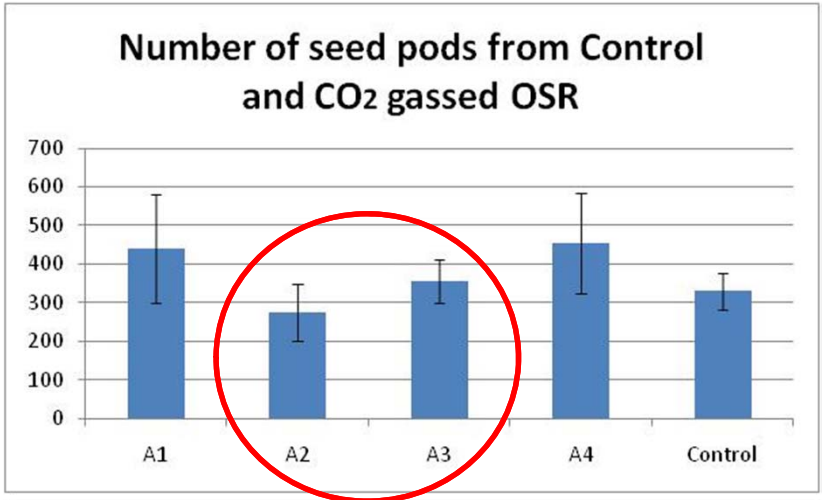
ASGARD:2010 Spring Crop Experiments: Biomass

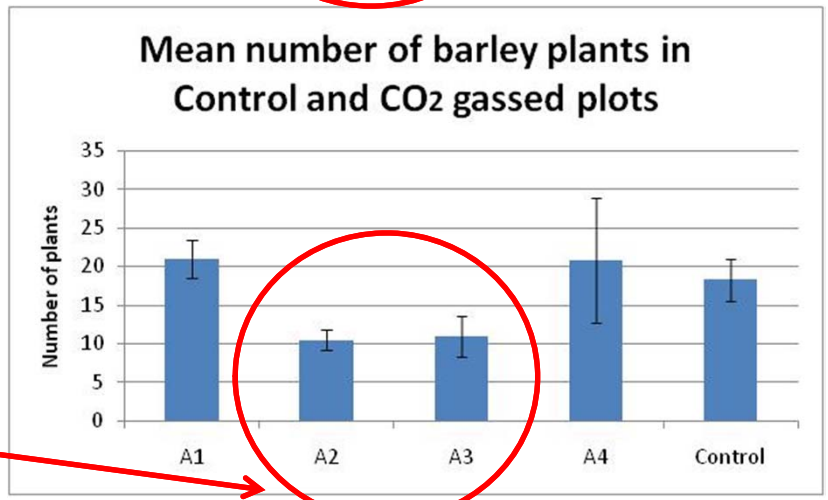
Barley

- ↓ number of plants and tillers
- ↓ weight of stem and ears
- ↓ no. of grain

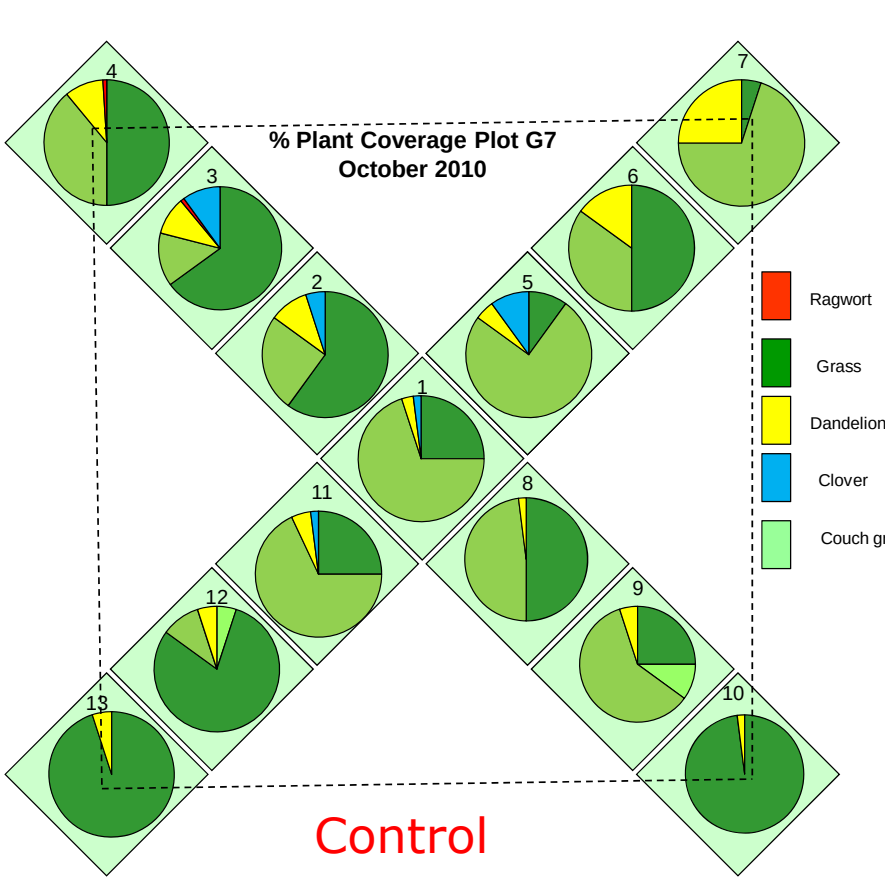
Oilseed rape

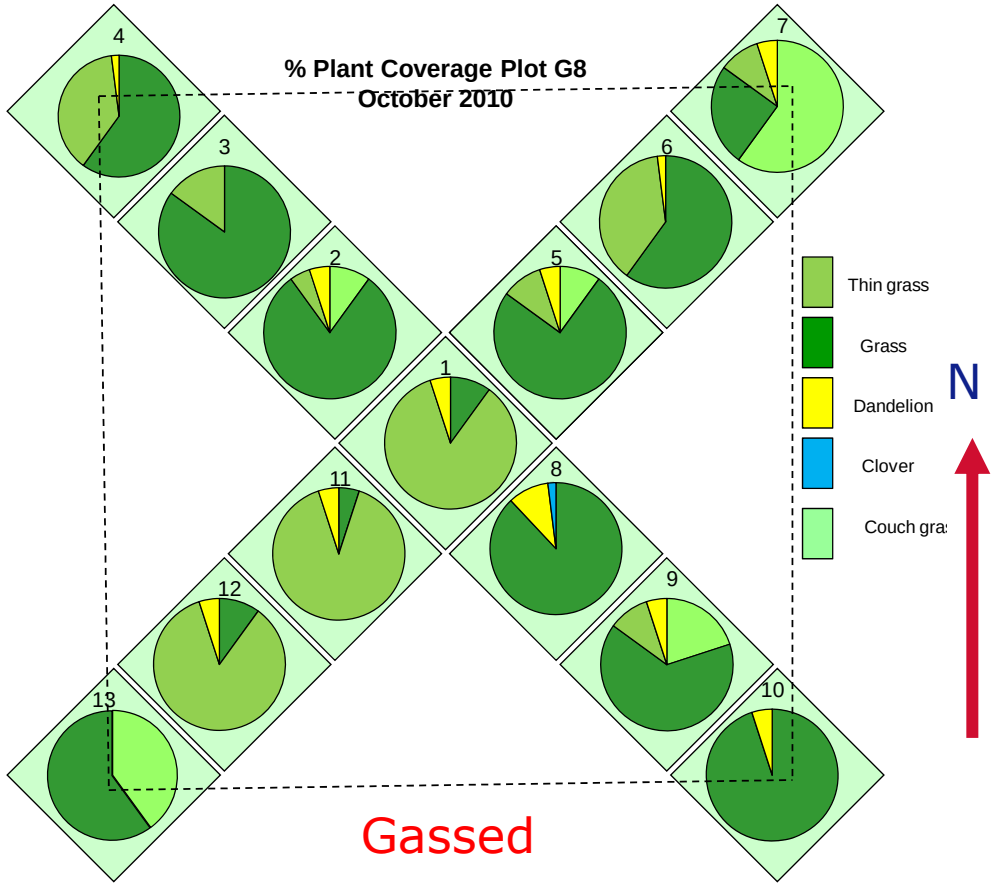
- ↓ length of stem
- ↓ no. of seed pods



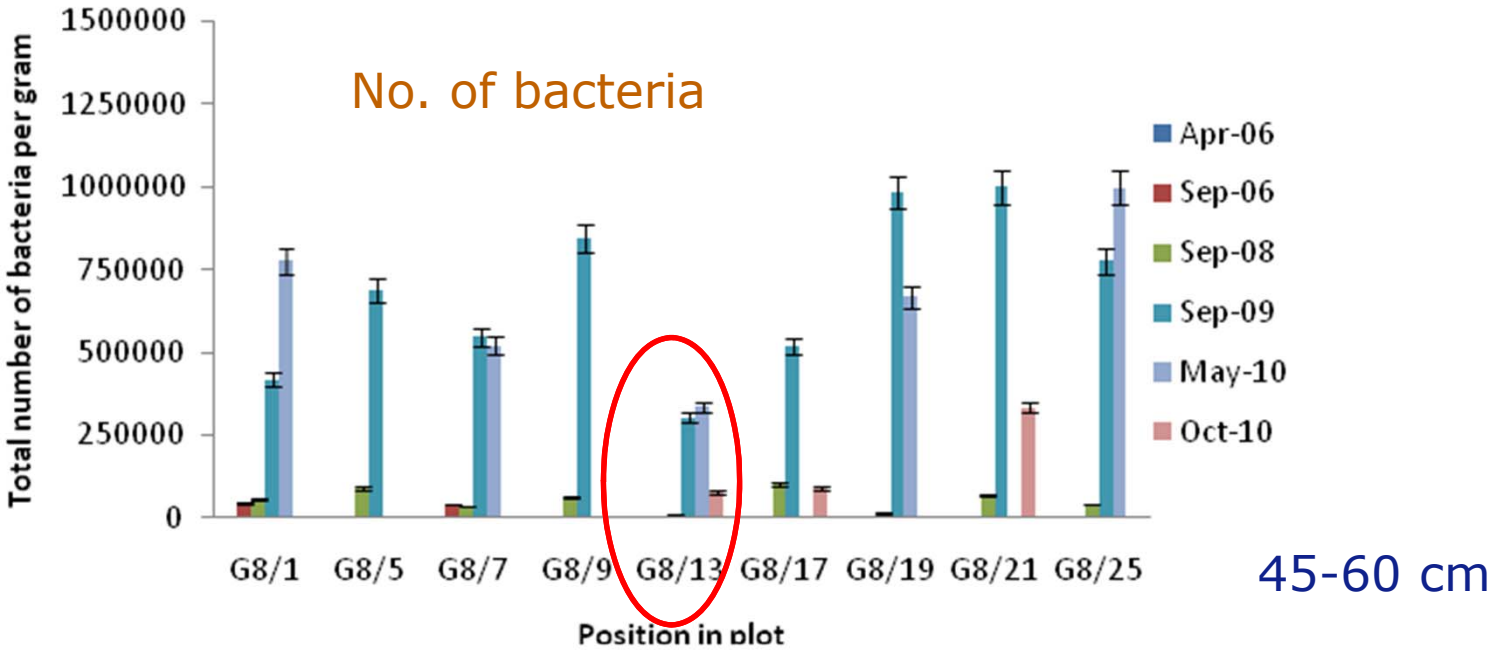


High CO2

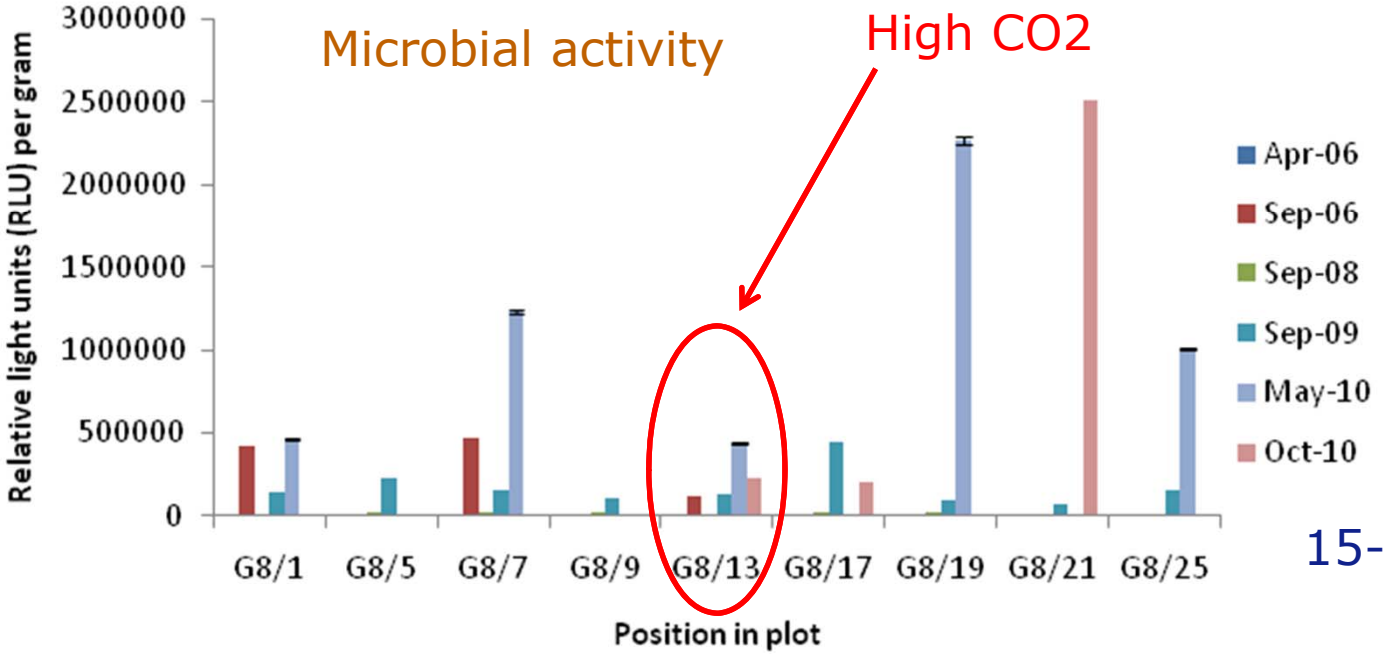




- Appears that monocots are inherently more tolerant of high CO_2 concentrations in non adapted site
- Other factors need to be considered – plants age, N concentration
- Similar observations at Latera site, Italy



45-60 cm



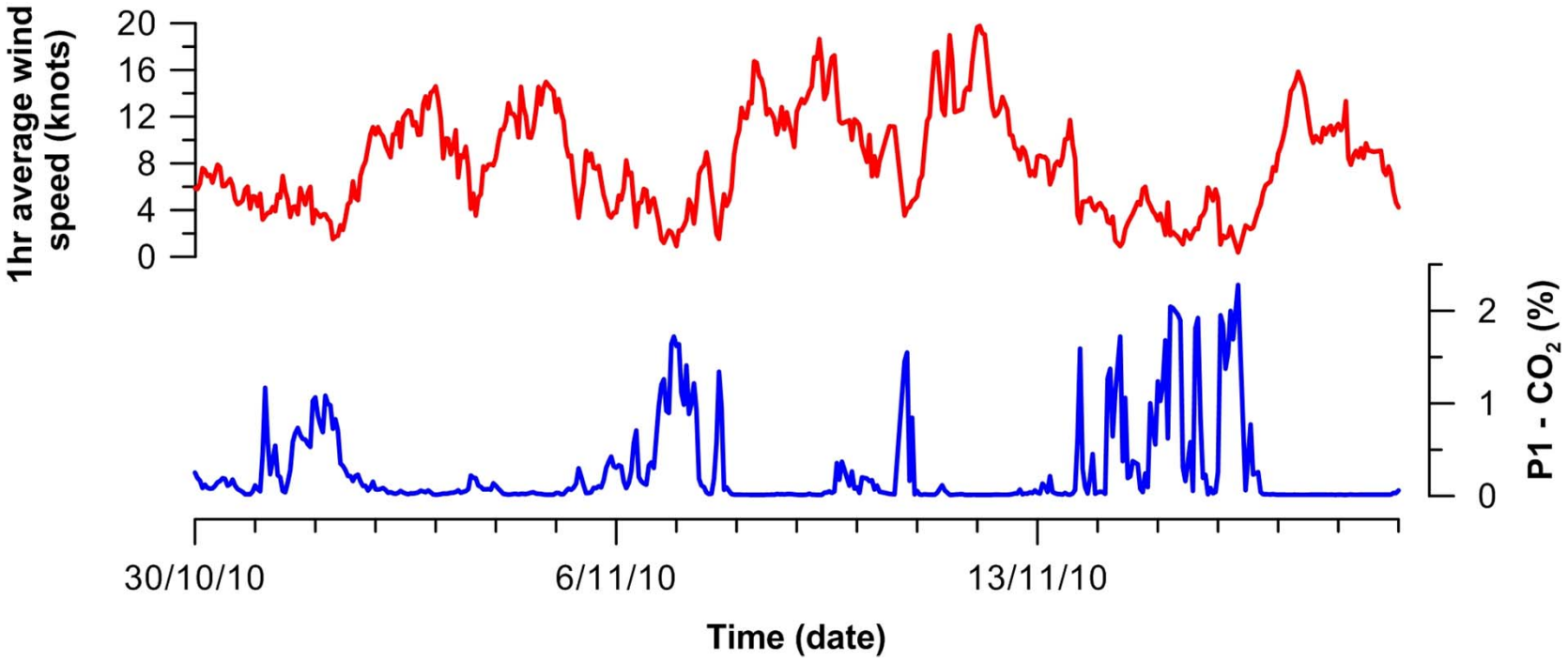
15-30 cm

Soil gas monitoring station

- 3 probes – 2 in soil, one on ground surface
- Monitor CO_2 and CH_4 concentration, T, P every 30 minutes
- Data transfer in real time, access via the internet

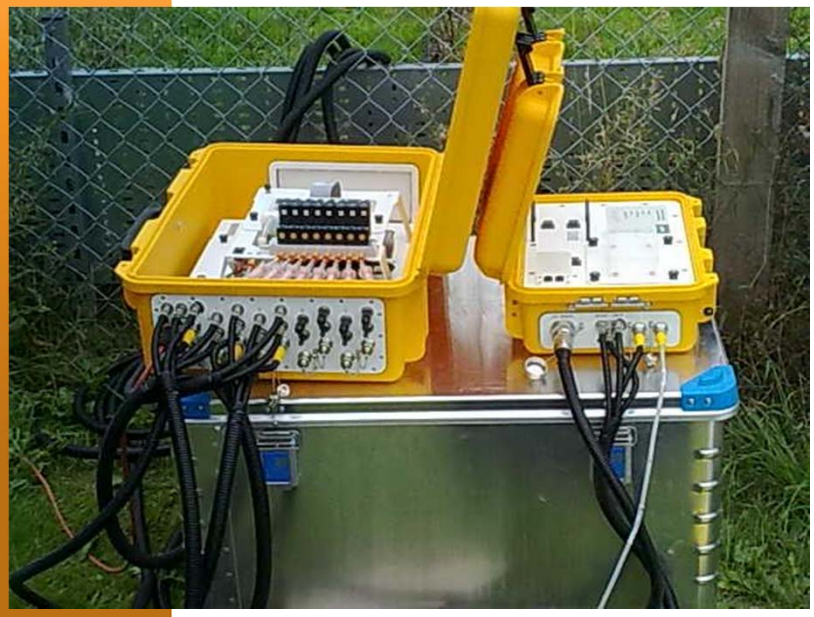
Soil gas monitoring station

- One probe placed on ground above injection plot
  - Strong inverse correlation between CO_2 and wind speed

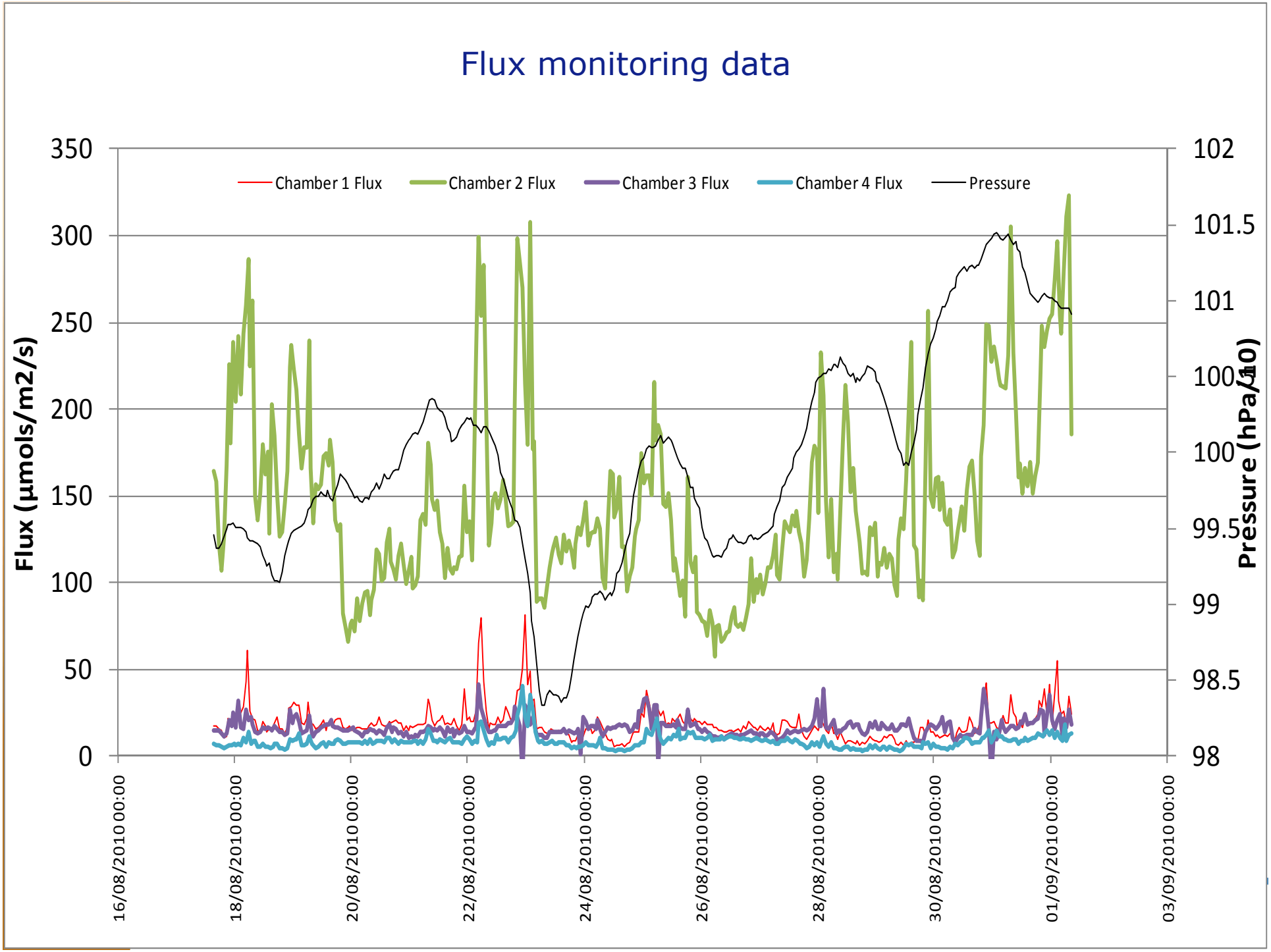


Flux monitoring station

- 1 measurement/Ch/h
- Now every 30 mins



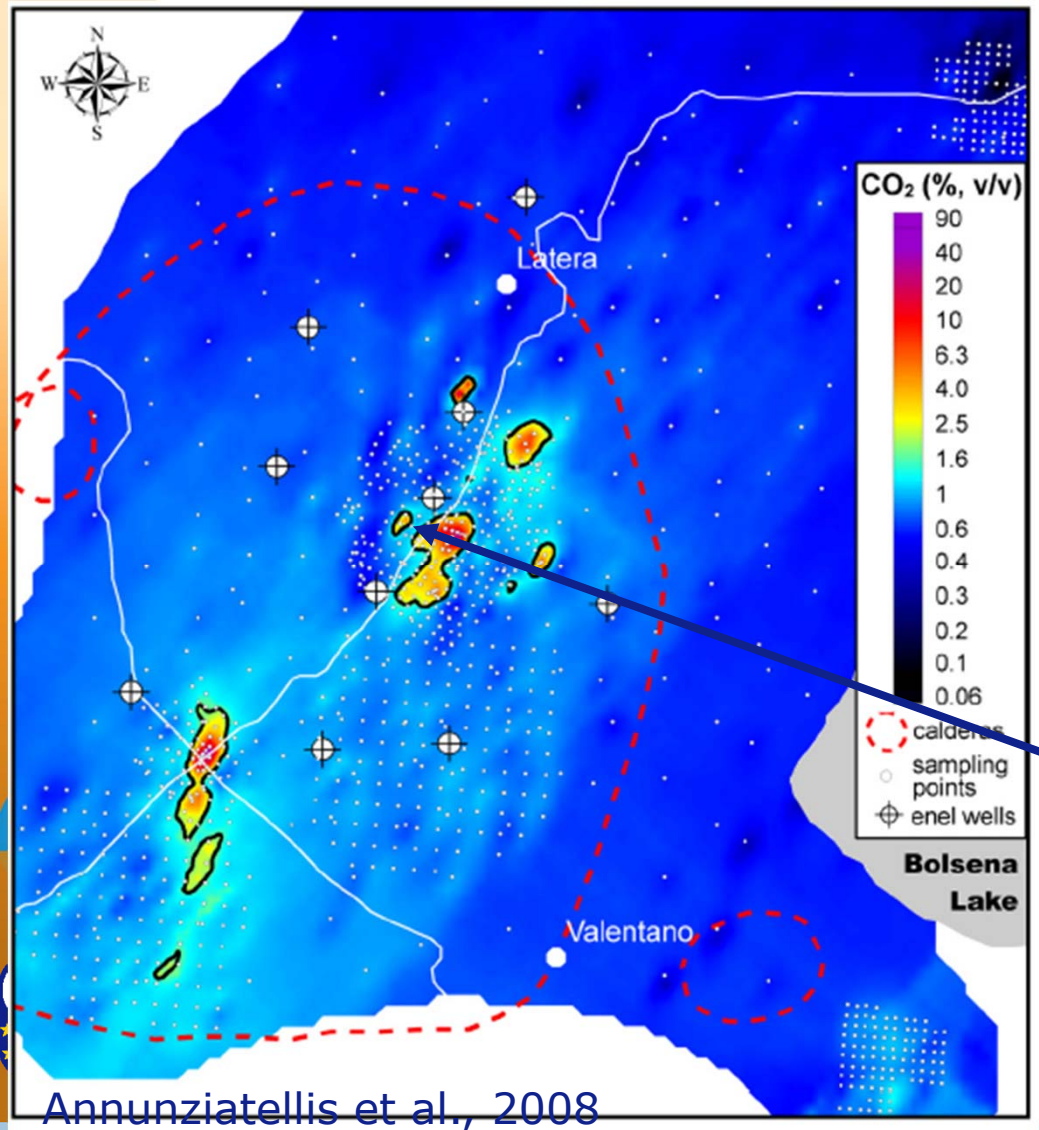
- Measure in sequence
- Remote control/data


Flux monitoring data
Chamber 1 Flux
Chamber 2 Flux
Chamber 3 Flux
Chamber 4 Flux
Pressure
Flux (µmols/m2/s)
Pressure (hPa/10)
350
300
250
200
150
100
50
0
102
101.5
101
100.5
100
99.5
99
98.5
98
16/08/2010 00:00
18/08/2010 00:00
20/08/2010 00:00
22/08/2010 00:00
24/08/2010 00:00
26/08/2010 00:00
28/08/2010 00:00
30/08/2010 00:00
01/09/2010 00:00
03/09/2010 00:00

Naturally leaking sites in southern Europe

- Wide variety of flux rates
- Range of time scales
  - Recent e.g. Florina well site
  - Long term (e.g. Latera, San Vittorino, Montmiral)
- Different compositions
- Impacts on:
  - Groundwater quality
  - Use of CO2-impacted water for irrigation (e.g. corn, wheat)
  - Impact of gas on vegetation
- Review of existing data, collection and analysis of groundwater samples, Florina

Latera [CO2]



Annunziatellis et al., 2008

- Extensive soil gas sampling through-out the Latara caldera has defined areas of CO2 leaks
- Proposed study site