Groundwater Quality 2019

GÉORESSOURCES & ENVIRONNEMENT

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Experimental automated measures and modelling of CO_2 flows from soils to atmosphere

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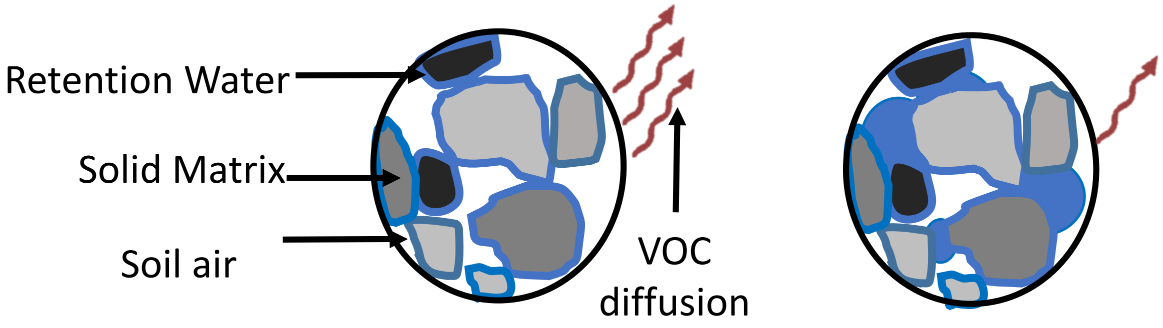
Problematic

Determining the fate and transport of vapours in the subsurface is a challenging task due to subsurface soil heterogeneity

- Temporal variability of moisture
- Spatial variability of physiochemical properties

Affect risk assessments



Influence of soil moisture on the VOC diffusion

Project Objective

Obtain reliable long term gas fluxes predictions

Strategy

Combining two approaches :

Experiment :

- Gas Flux (flux chamber)
- Soil gas concentrations
- Porosity
- Water saturation
- Residual water saturation

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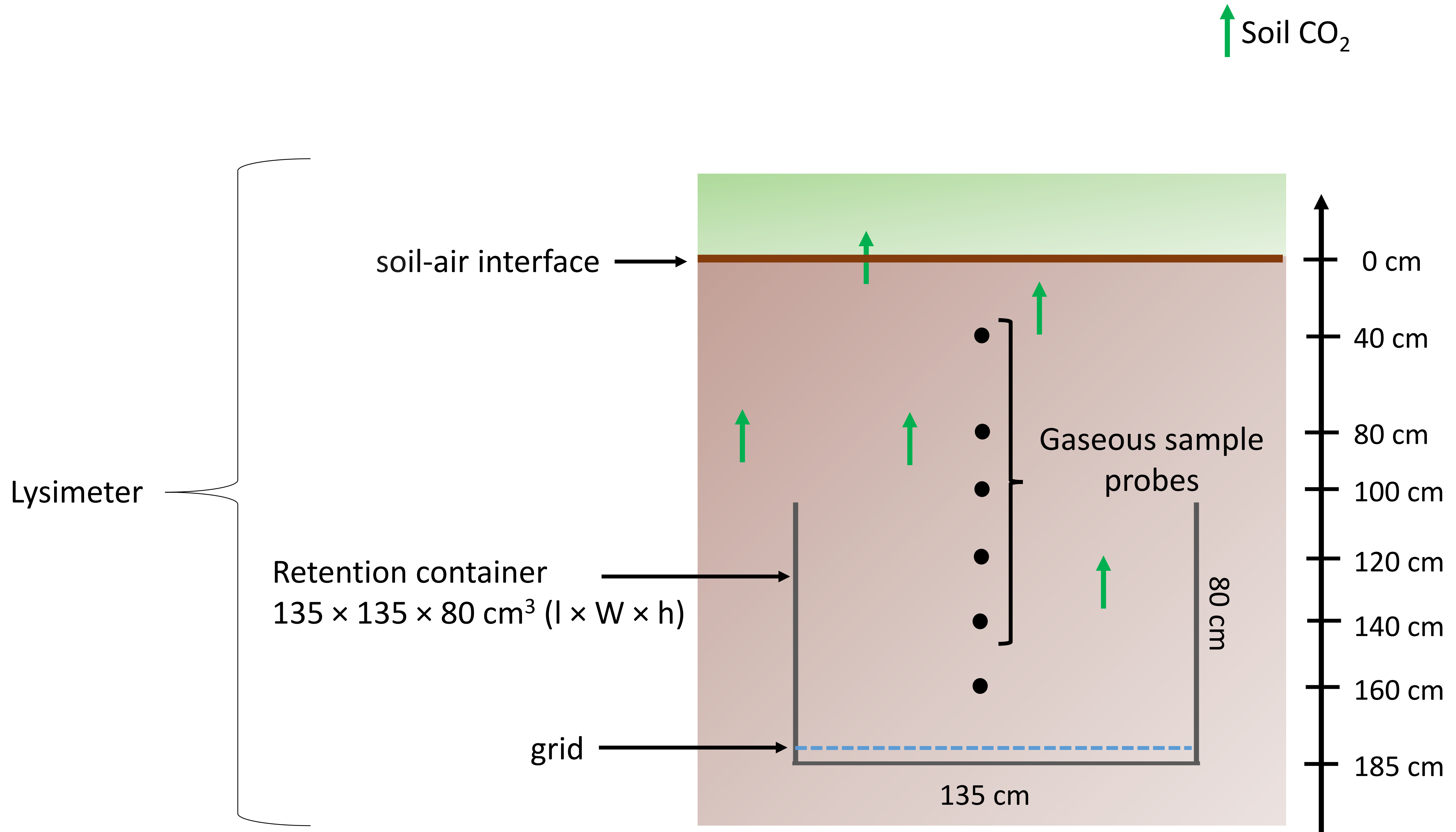
Modelling :

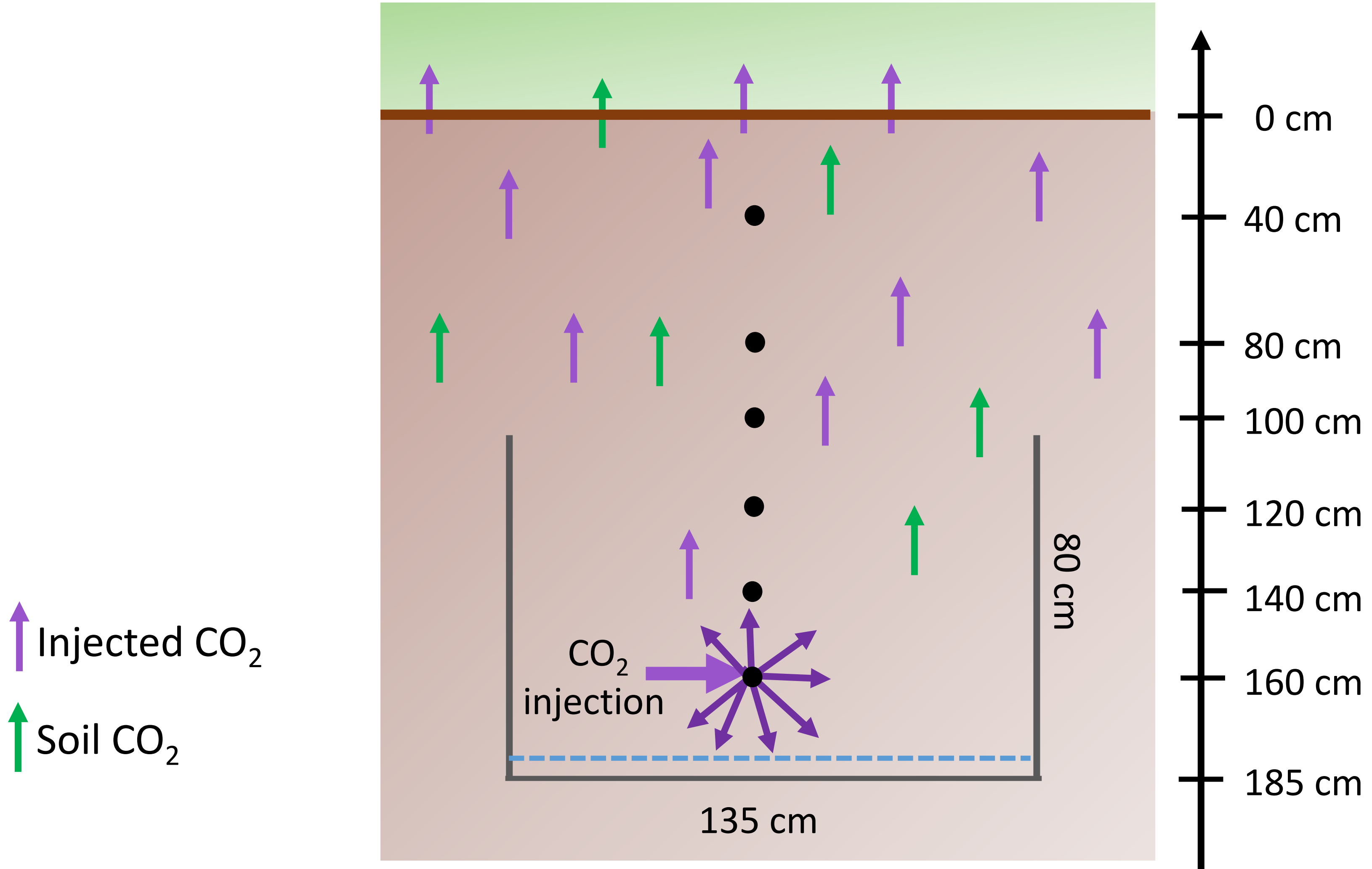
Numerical model MIN3P

Experiments in a controlled natural environment



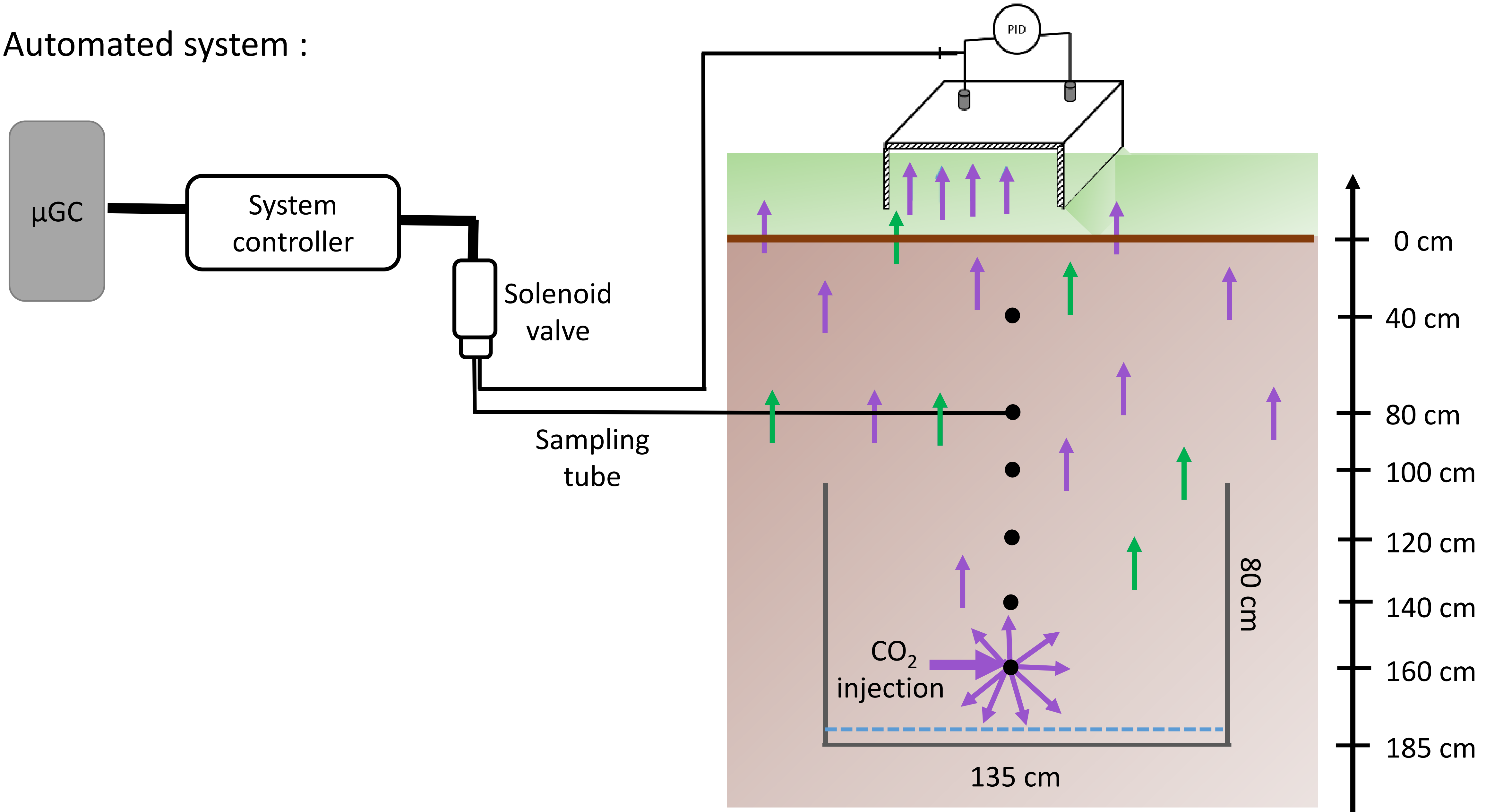
Experiments in a controlled natural environment

Step 1: CO_2 was injected and gas phase concentration were continuously monitored



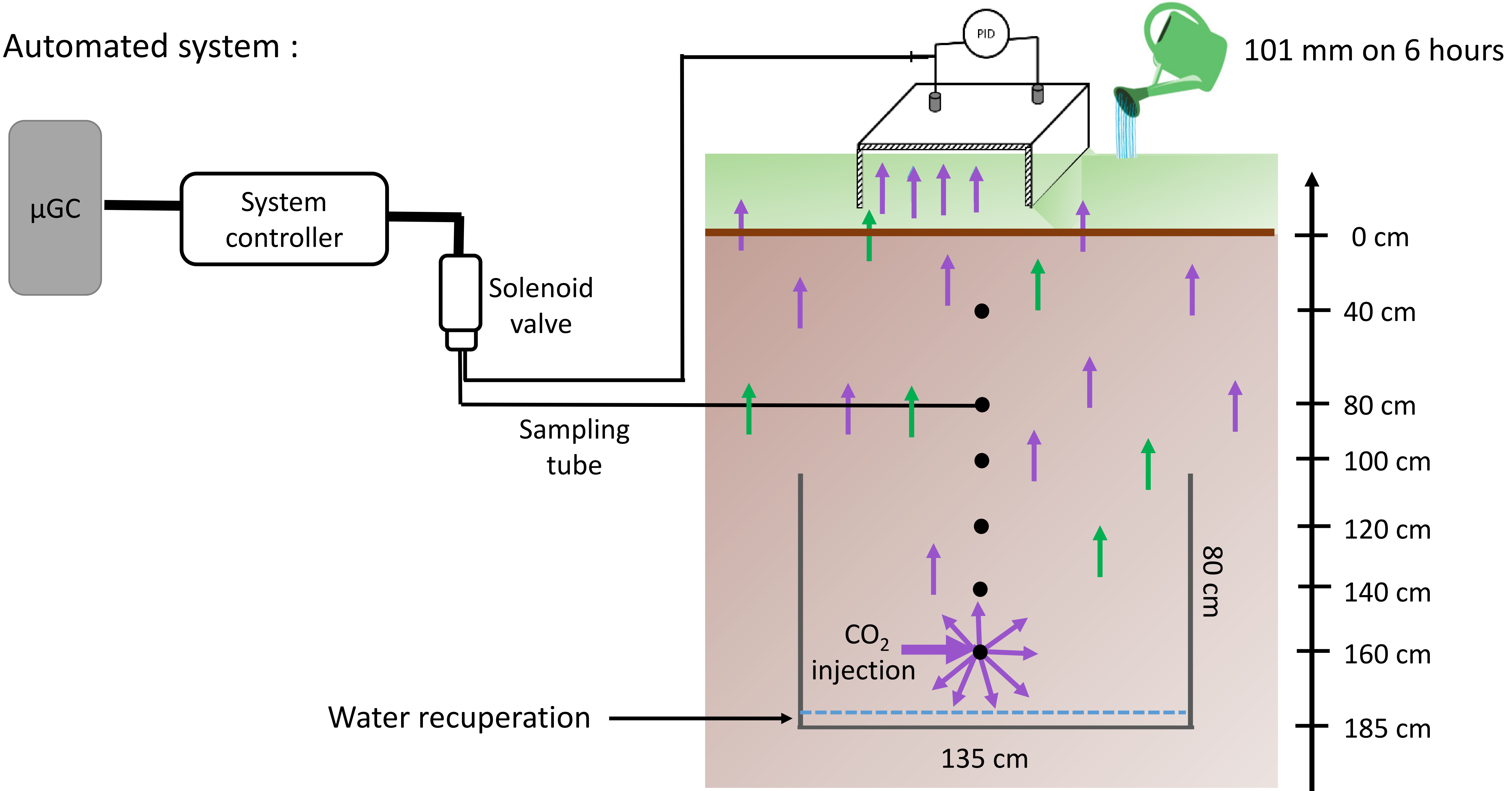
<u>Step 1:</u> CO_2 was injected and gas phase concentration were continuously monitored

Automated system :

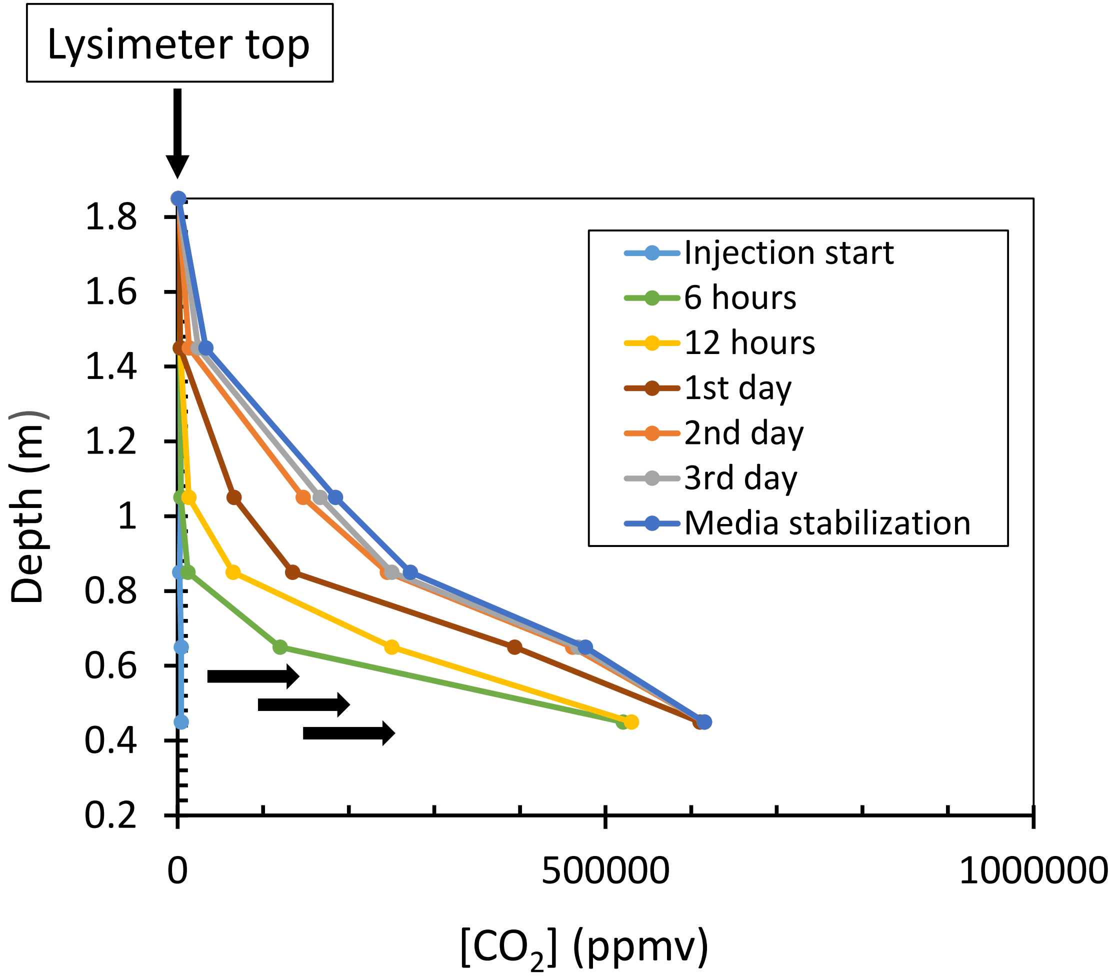


Step 2: A rainfall event was simulated and CO_2 continuous monitoring during a simulated rainfall event

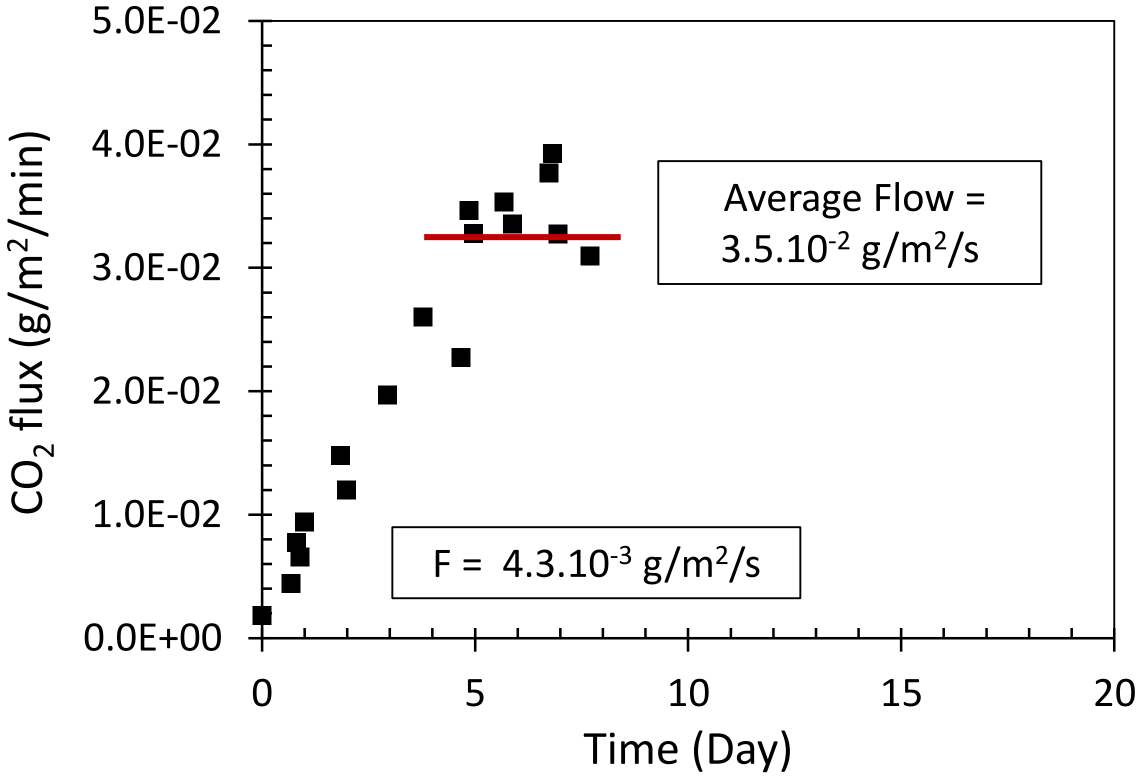
Automated system :



Experiments results during CO_2 injection:

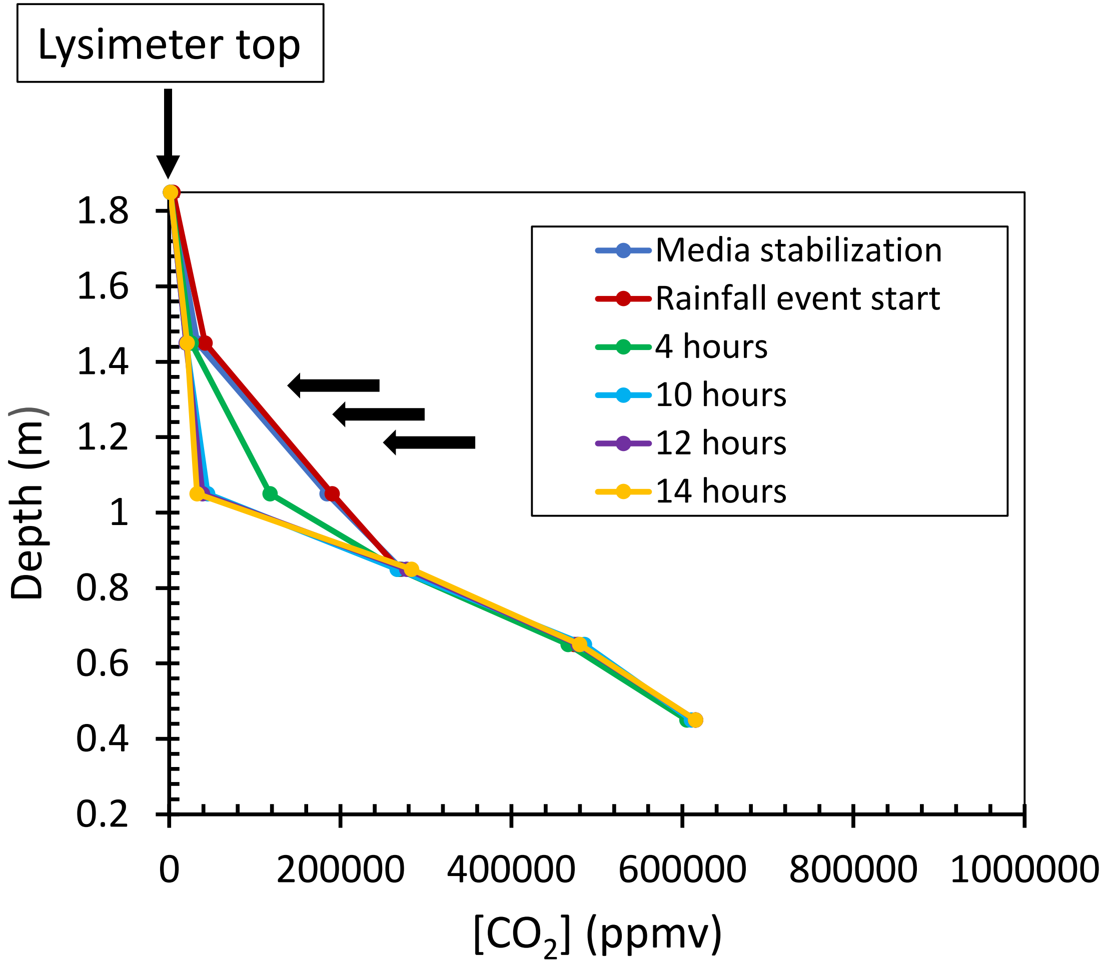


Evolution of CO_2 concentrations at different depth until stabilization

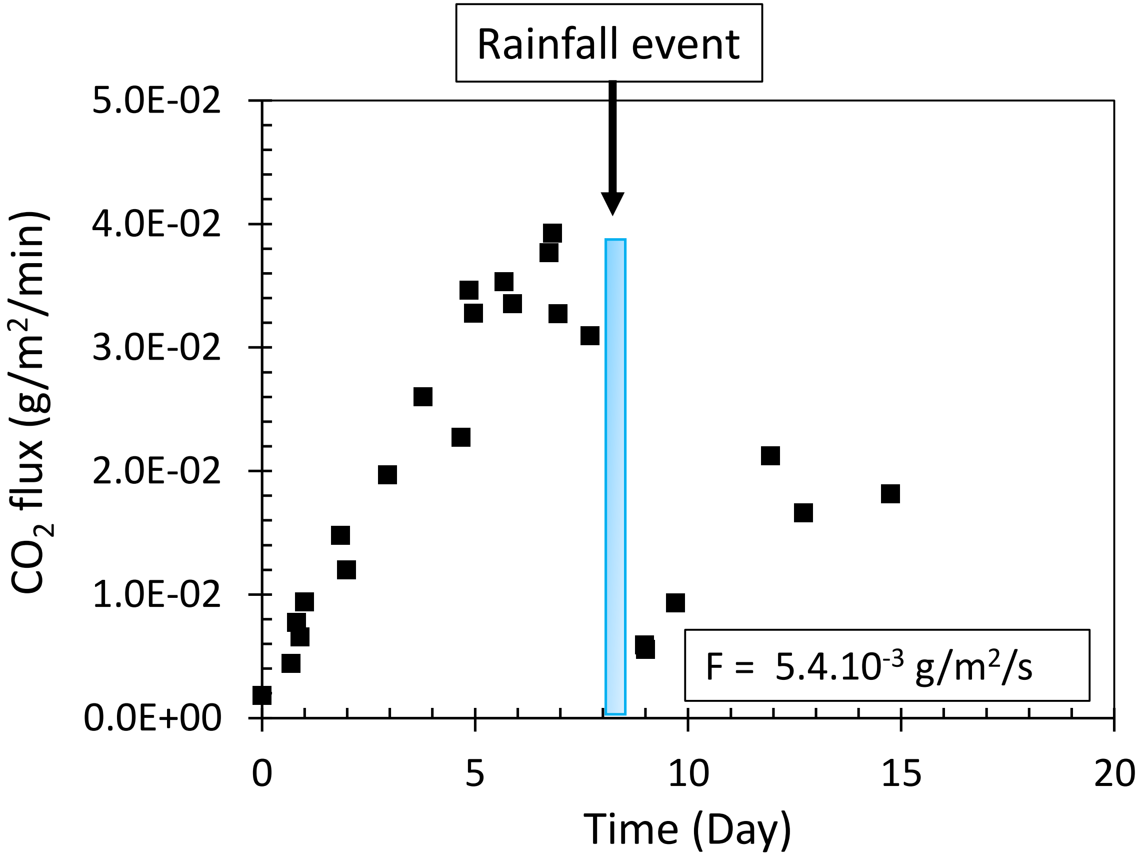


Evolution of CO_2 fluxes until stabilization

Experiments results during simulated rainfall event:

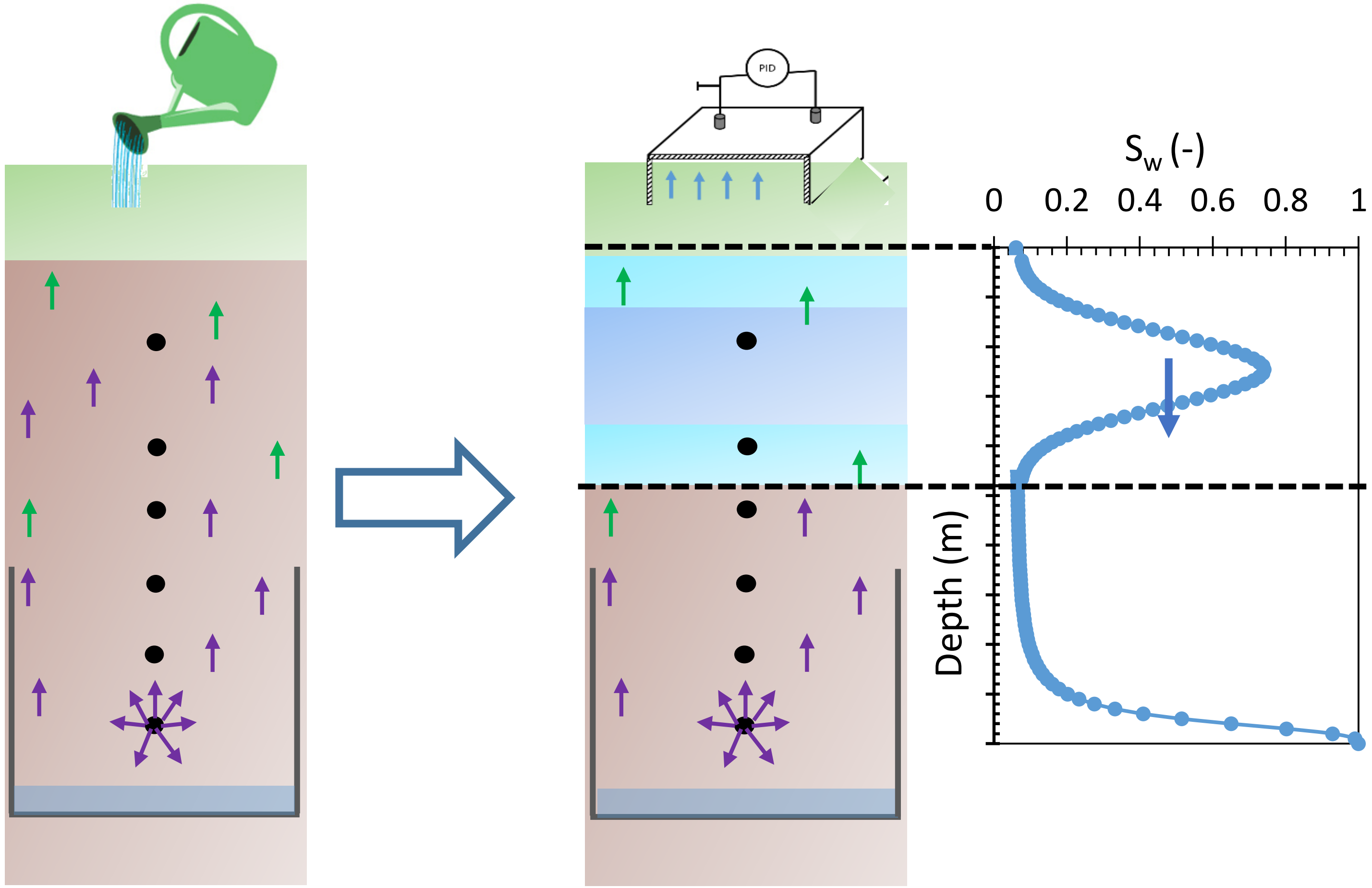


Decrease of CO_2 concentrations during the rainfall event



Decrease of CO_2 fluxex

Experiments results during simulated rainfall event:



$$F = De \times \frac{dC}{L}$$

De : effective diffusion coefficient (m^2/s),
L : thickness (m), C : CO_2 concentration (g/m^3)

Millington and Quirck relationship (1961) :

$$D_e = \frac{\theta_g^{10/3} \times D^g + \theta_w^{10/3} \times D^W \times H}{\theta^2}$$

When Θ_w increases

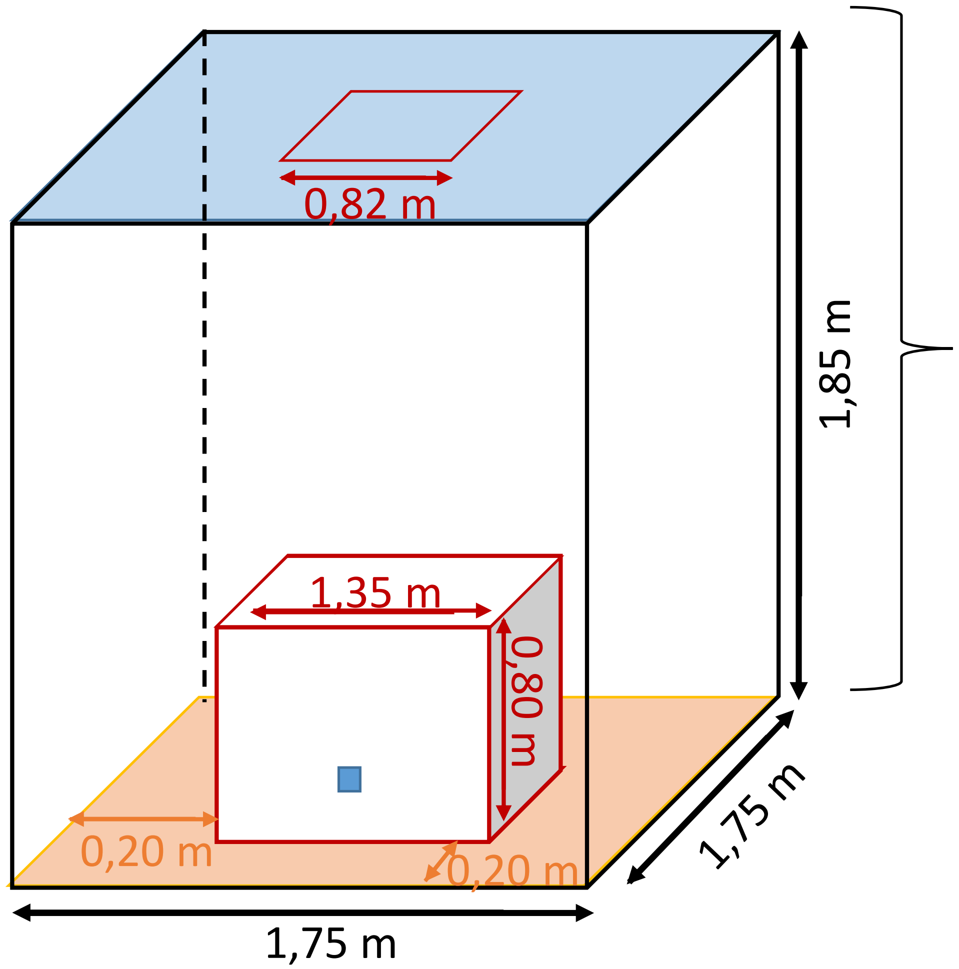
D_e ↘

\+

Dissolution of gaseous CO_2 in the aqueous phase (H)

Surface fluxes decrease

MIN3P setup

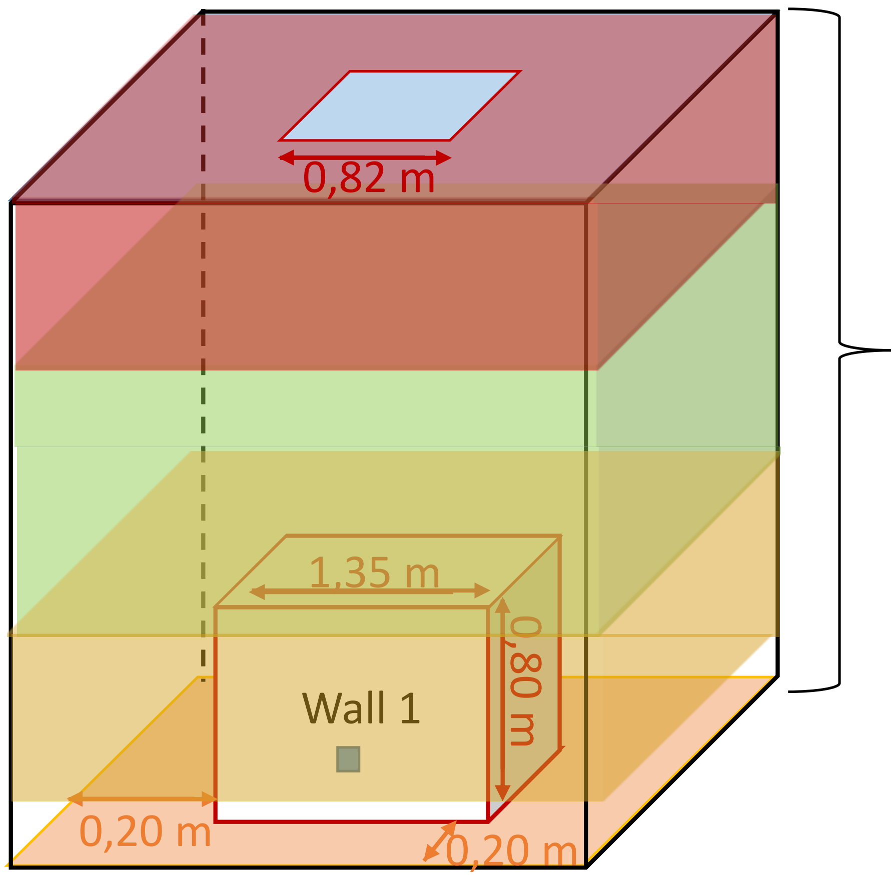


Media properties:

- Porosity: 0.3
- Water residual saturations: 0.05
- Van Genuchten parameters:
  $\alpha = 15.25\ m^{-1}$
  $n = 1.85$
- Free-water diffusion coefficient : $1.32 \times 10^{-5}\ m^2/s$
- Free-gas diffusion coefficient : $1.84 \times 10^{-9}\ m^2/s$

Poor fit

MIN3P setup

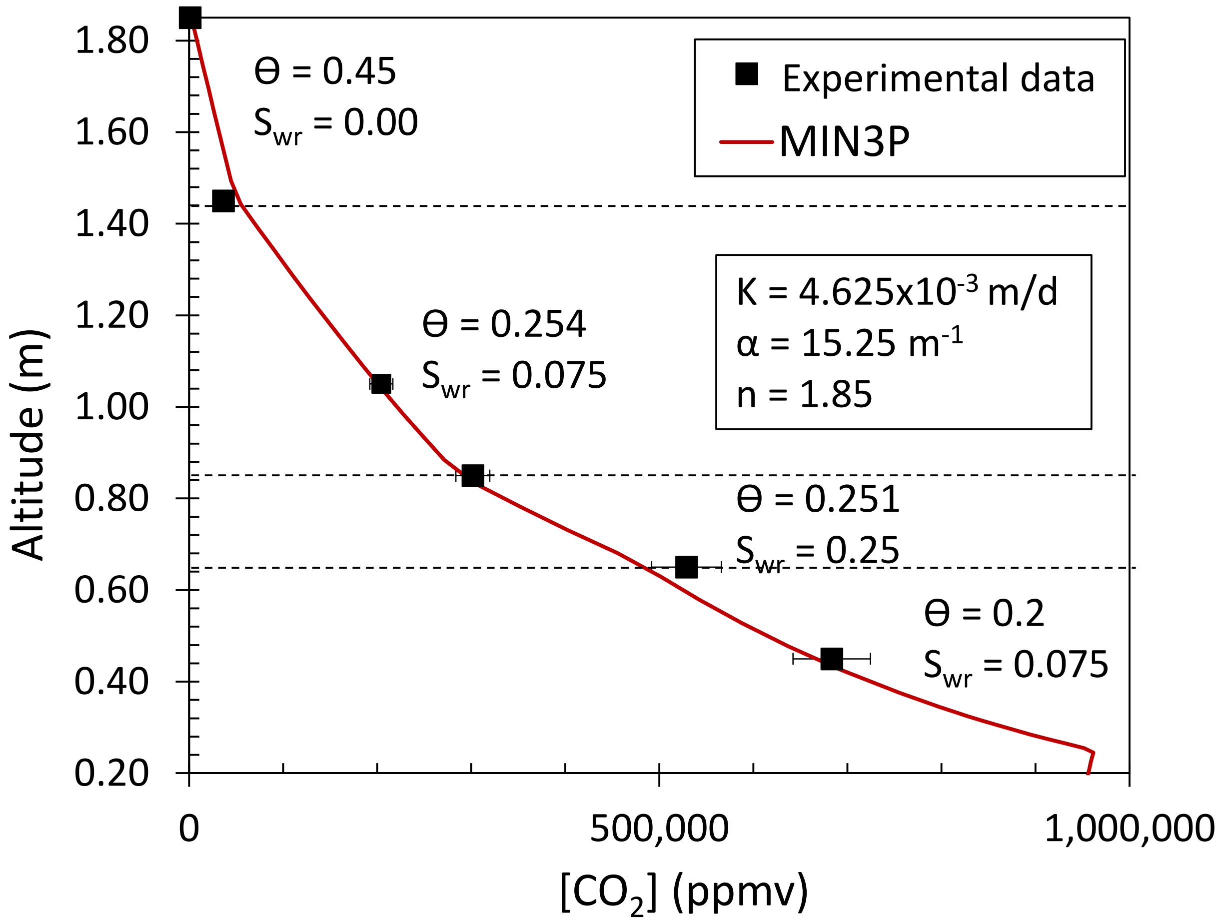


Media properties :

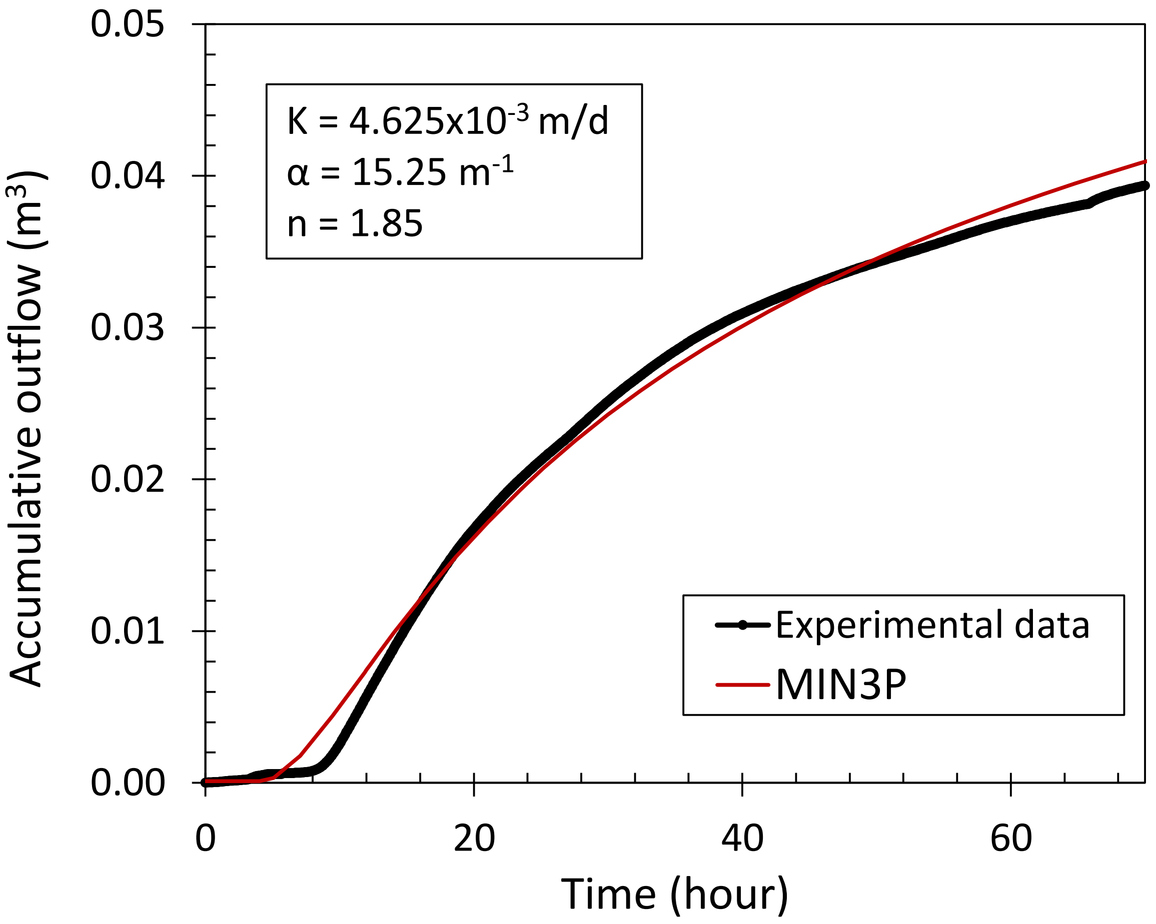
- ≠ porosities
- ≠ Residual water saturations…

MIN3P setup – Model calibration

Modelling of CO_2 concentrations stabilized profile :



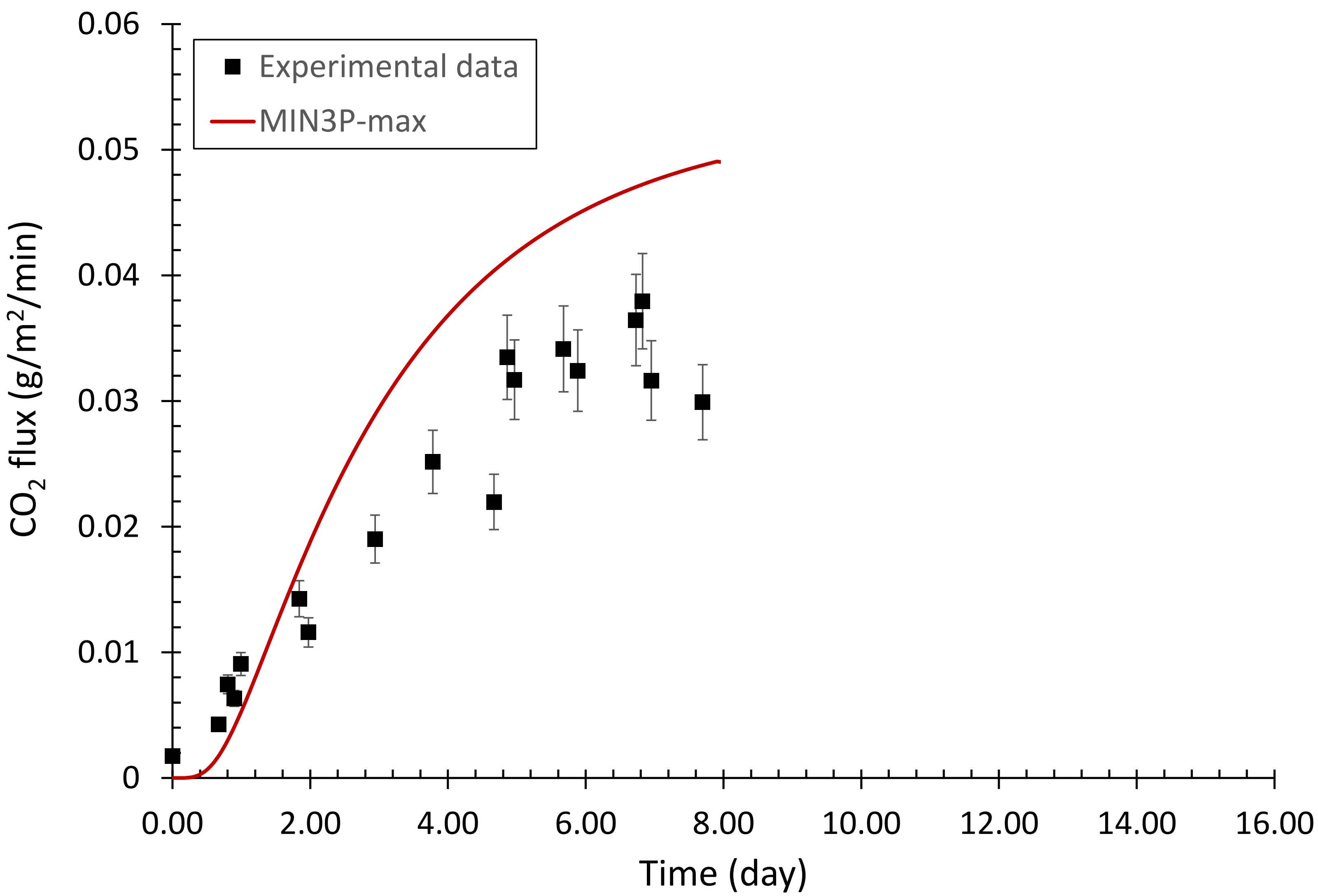
Modelling of rainfall event :



Good agreement

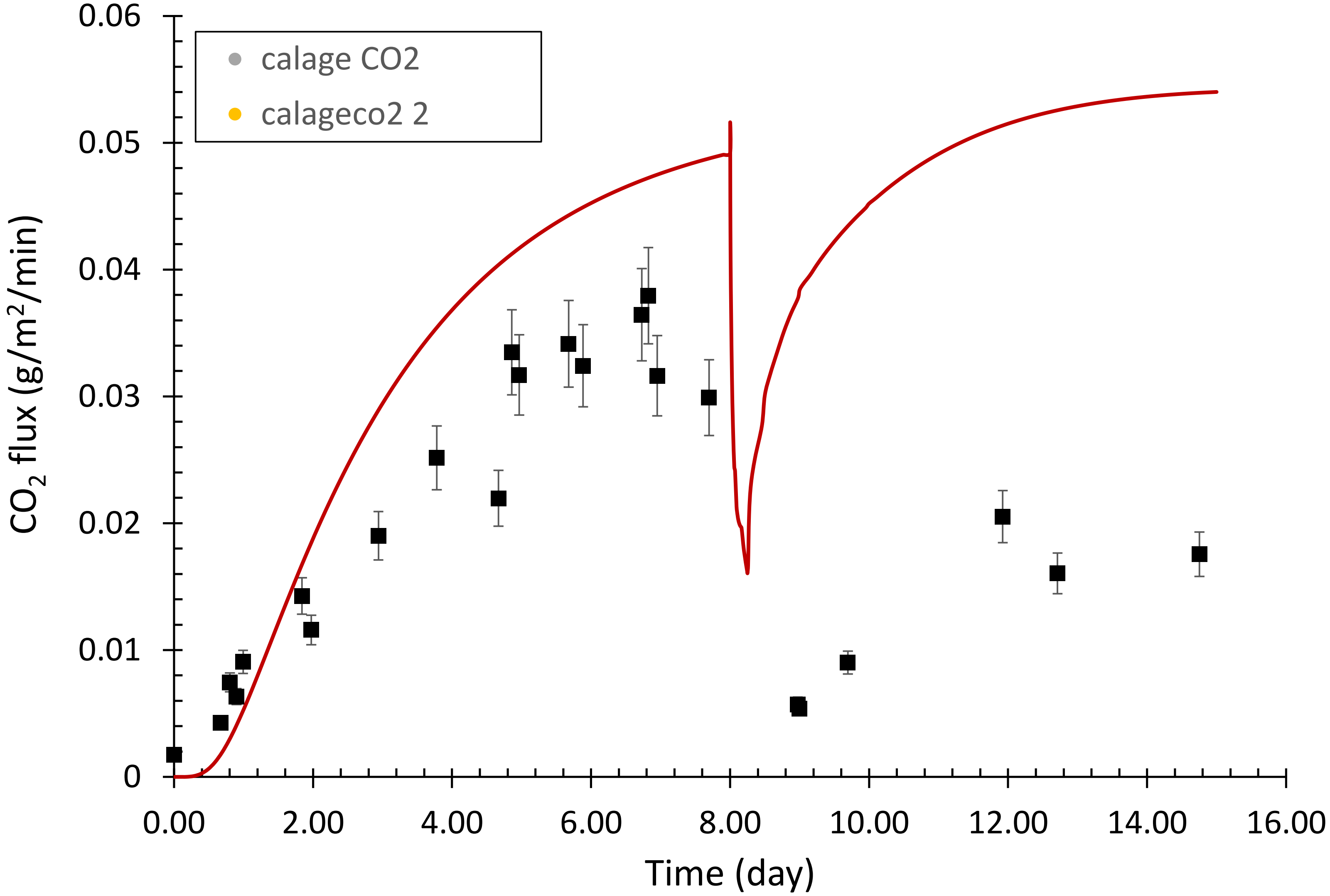
MIN3P Results

First simulation about predicting CO_2 flux :



MIN3P Results

First simulation about predicting CO_2 flux :



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Conclusions and perspectives

- Experimental and modelling flux results showed the importance of interaction between the water and gas phase

- For modelling, good agreement were obtained between experimental and simulated CO_2 profile as well as the rainfall event

In order to obtained reliable long term gas flux, further studies need to be carried out to:

- Improve the MIN3P model to improve the flux values accuracy

- Test this method on real industrial contaminated sites

Thank you for your attention