Development and Validation of a Measurement System for Characterizing Subsurface CO_2 Concentration Profiles in Soil

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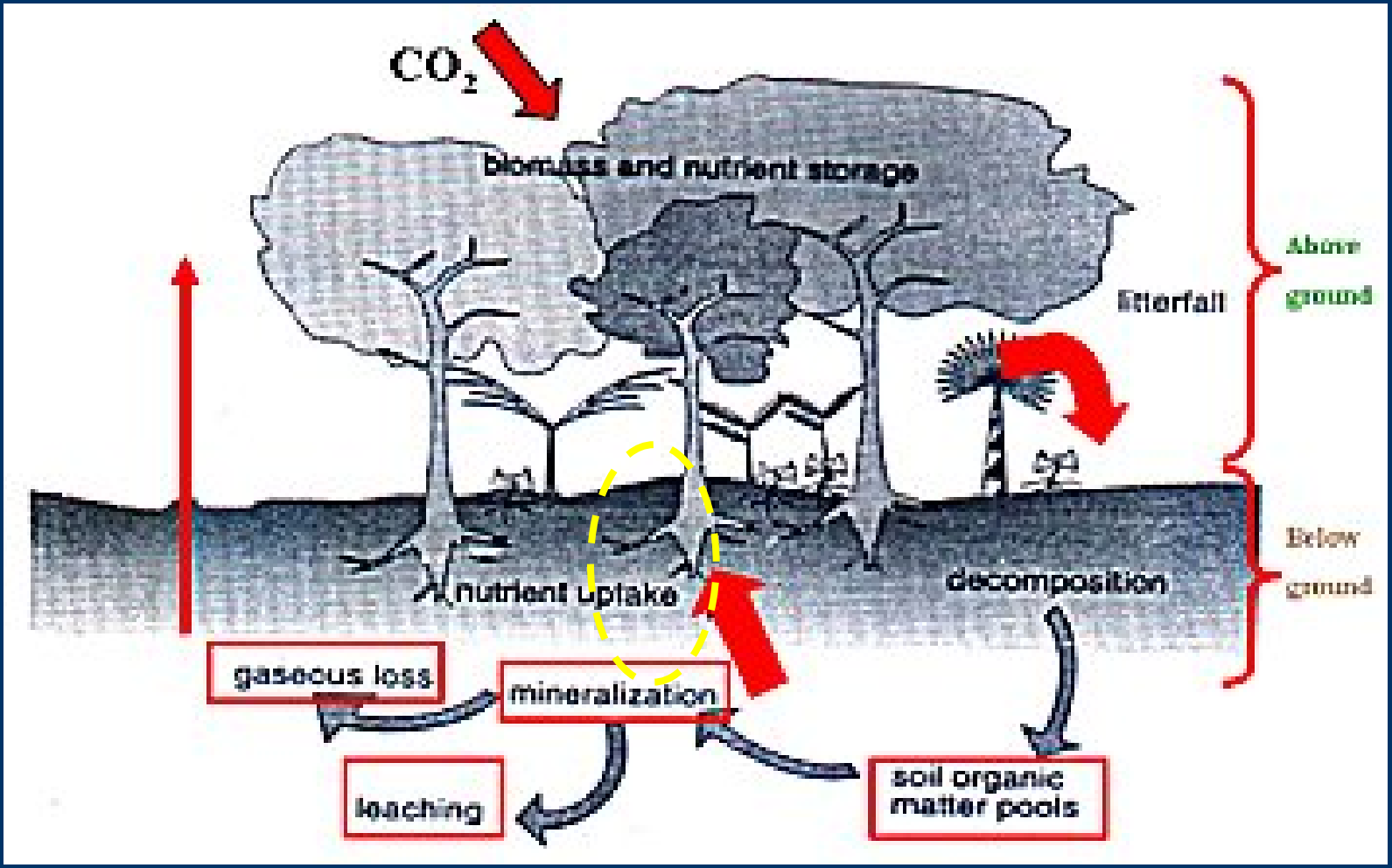
Introduction



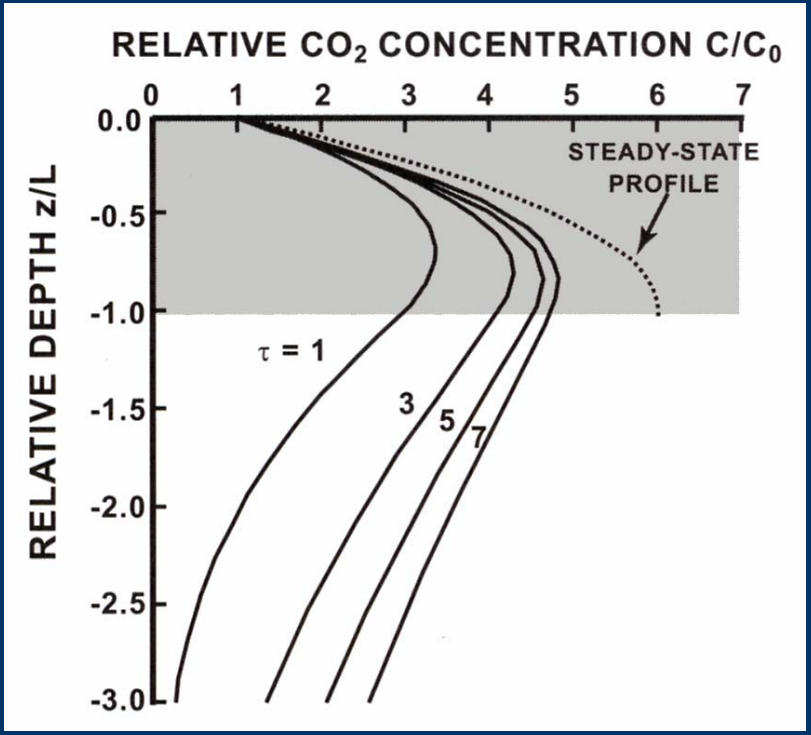
FAO

Introduction (contd.)

- CO_2 – Greenhouse Gas
- Soil Carbon Sequestration
  - Biomass production removes CO_2
  - 10 % of anthropogenic emissions
- Soil contains approximately 2.6×10^{29} prokaryotic cells

Motivation

- Gradient-based measurement requires linear gradient in subsurface concentration.
- It is unclear where the peak concentration occurs.
- This is likely affected by soil, environmental and plant factors.



Objectives

- To identify the optimal depth for maximum CO_2 concentrations under different cropping systems in a calcareous Mollisol.
- To compare the flux measurements with that collected by a Li-8100 CO_2 measurement system.

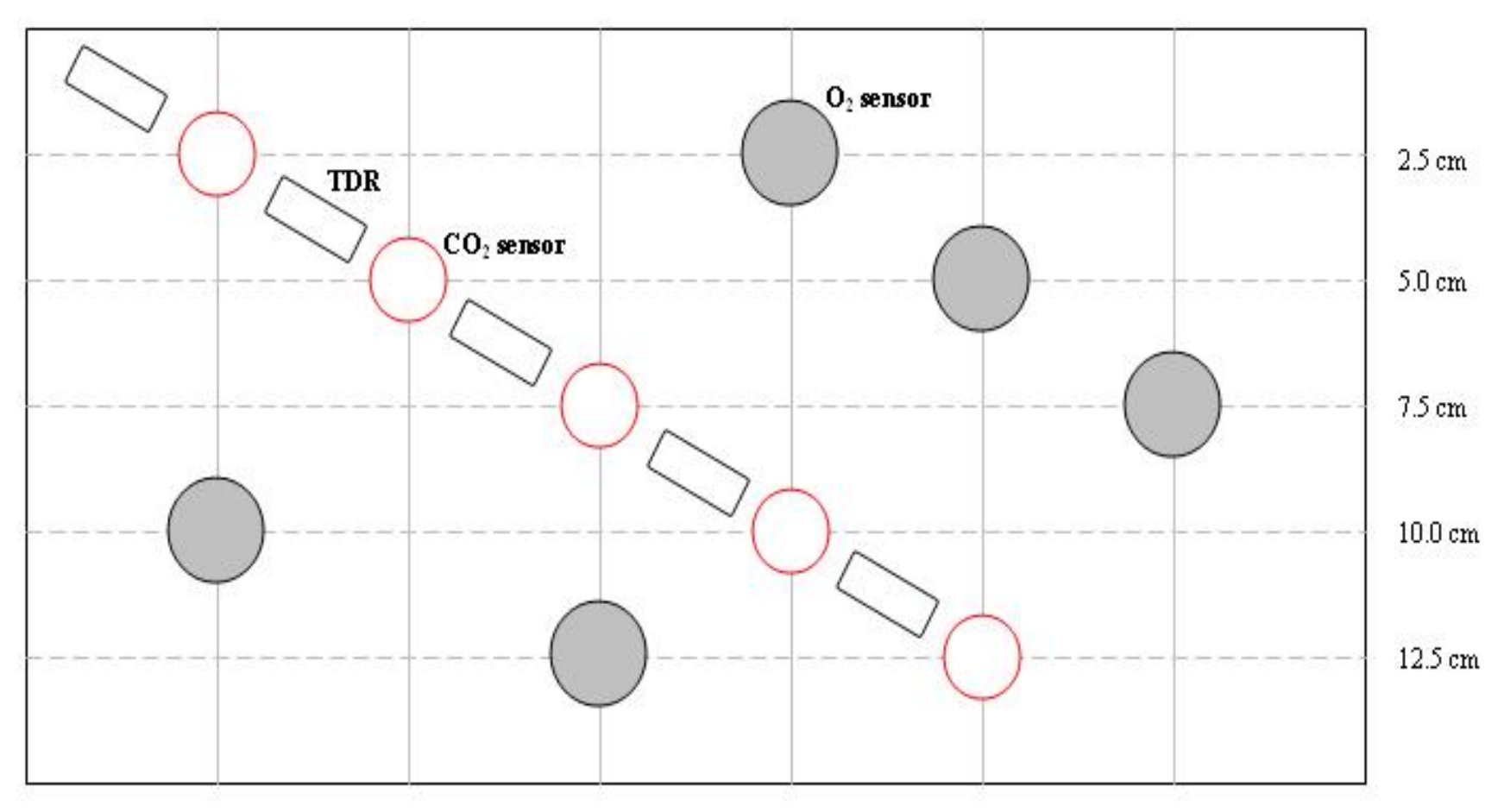
Study Site

Utah State University Research Farm

Gradient Method

Sensor Locations

Soil Surface



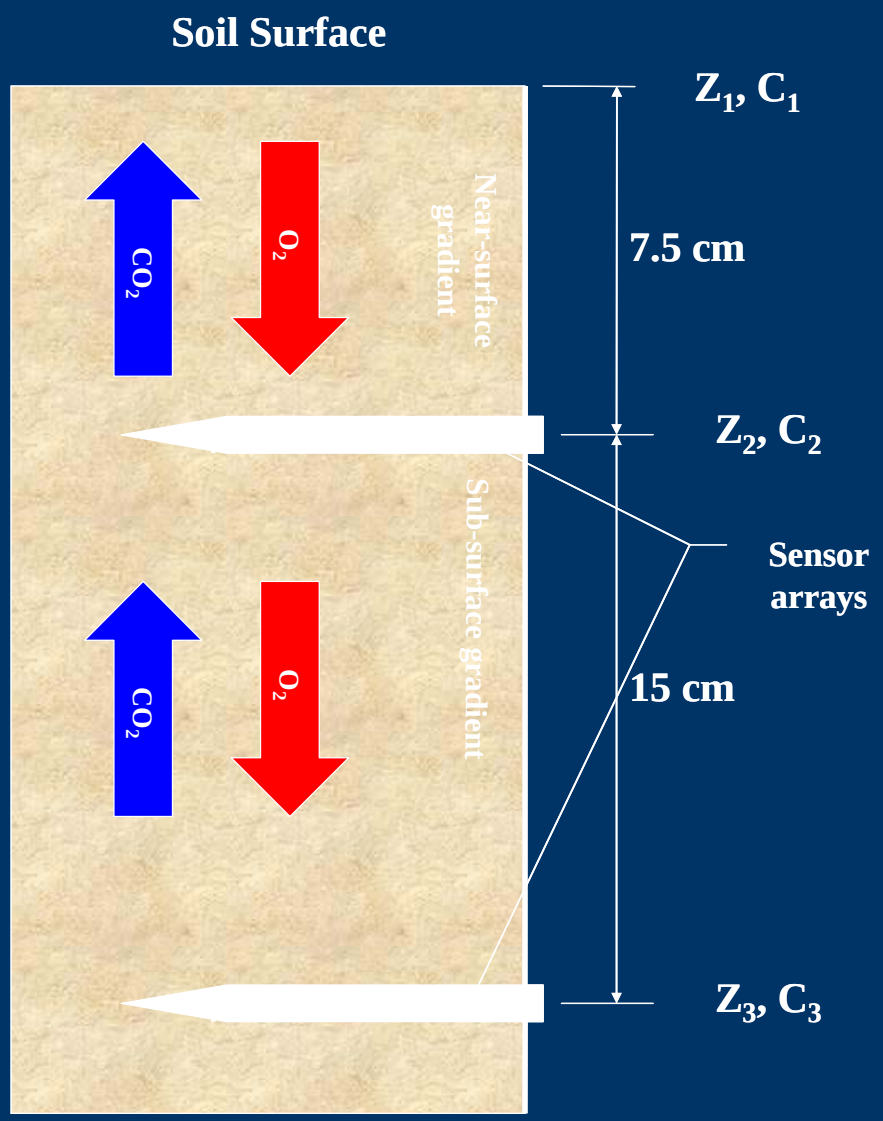
Flux Determination

Flux determination

$$J_g = D_s(\theta)\frac{C_2 - C_1}{z_2 - z_1}$$

Diffusion Coefficient

$$D_s = D_a \frac{(\phi - \theta)^{2.5}}{\phi}$$

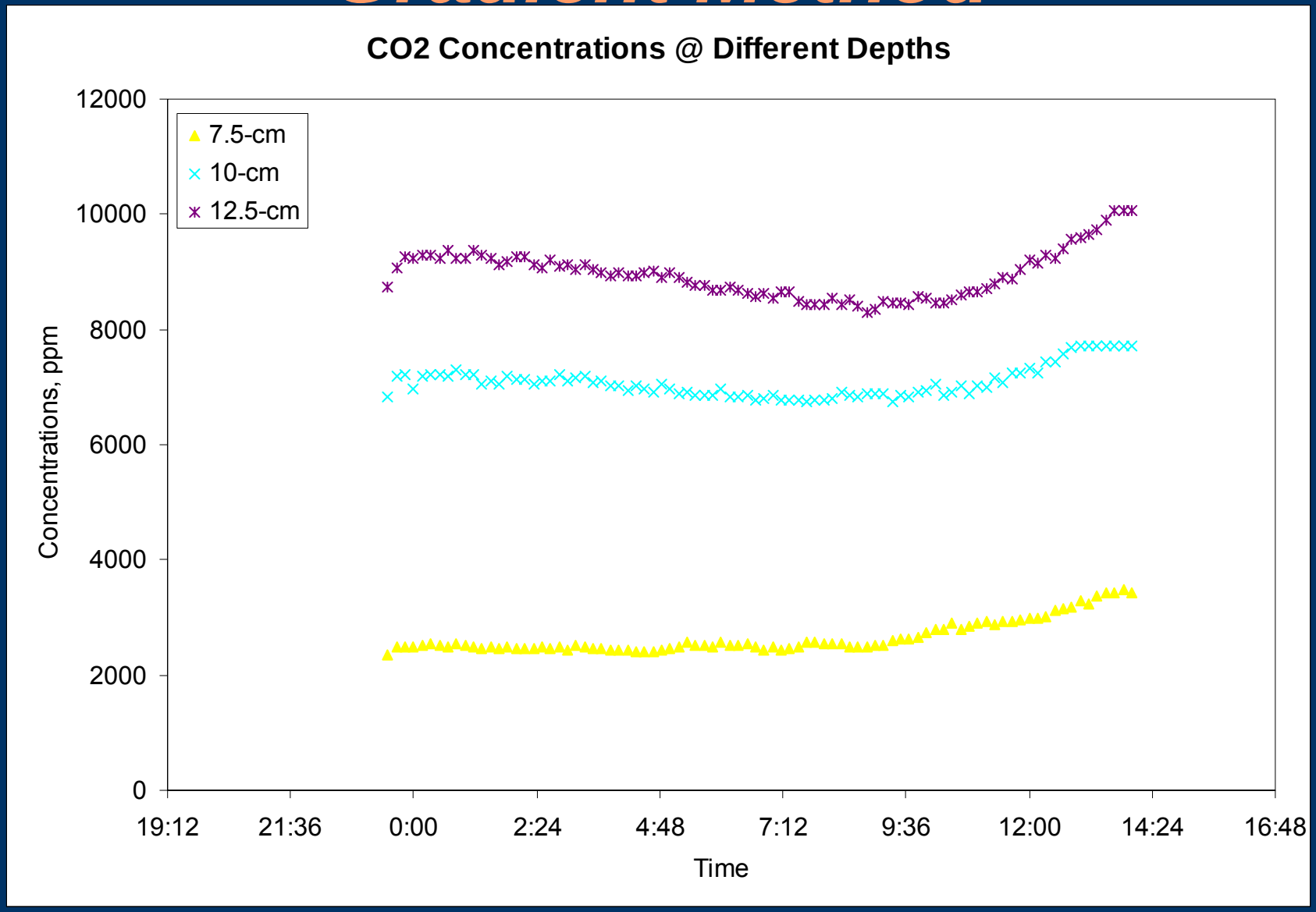


Gradient Method

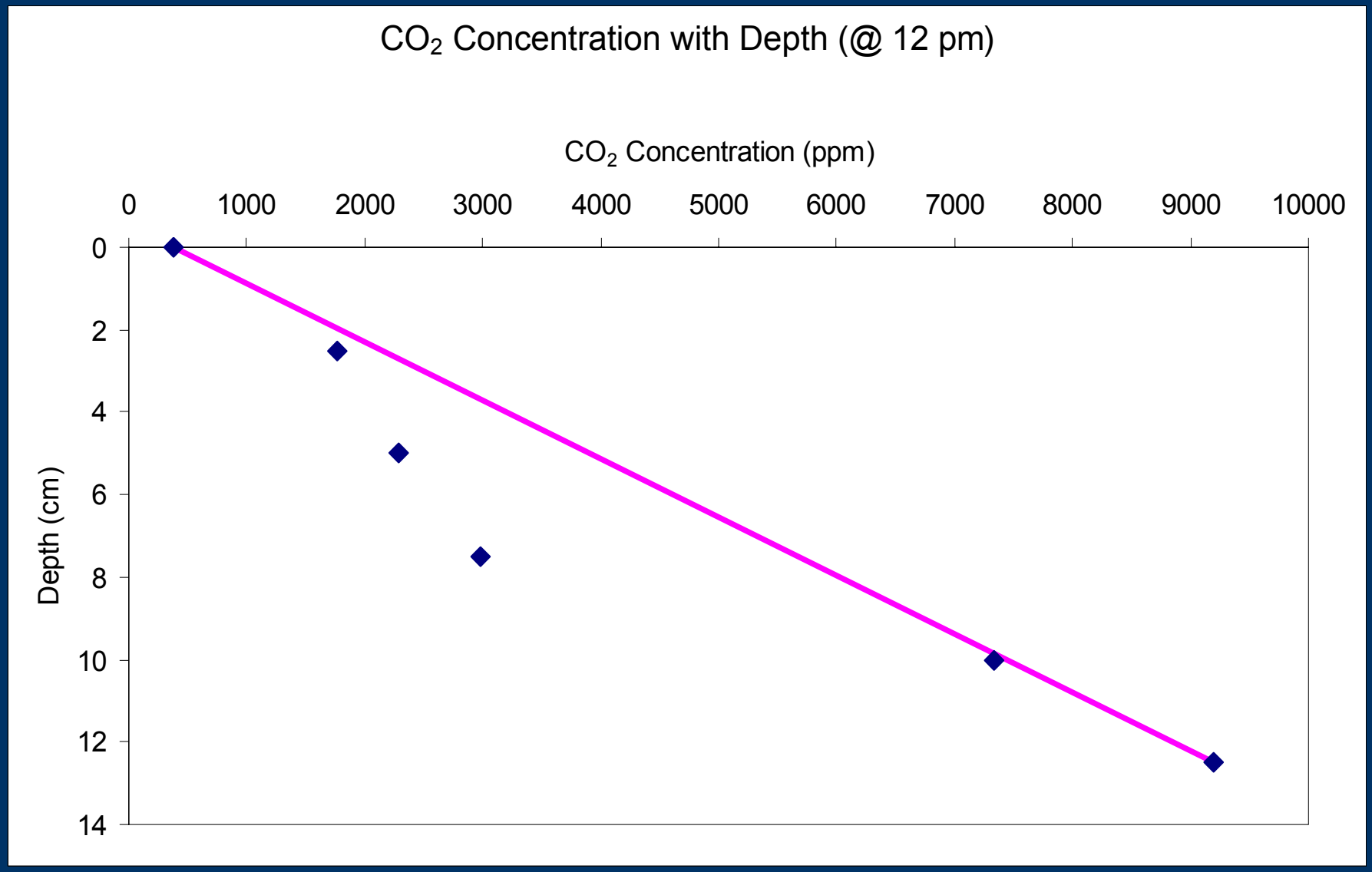
Advantages

- Continuous measurement of the soil CO2 concentration
- No disturbance to the soil surface or vegetation beyond installation
- No perturbation of the surface boundary conditions during measurement

CO_2 Concentrations -Gradient Method-



CO_2 Concentrations -Gradient Method-

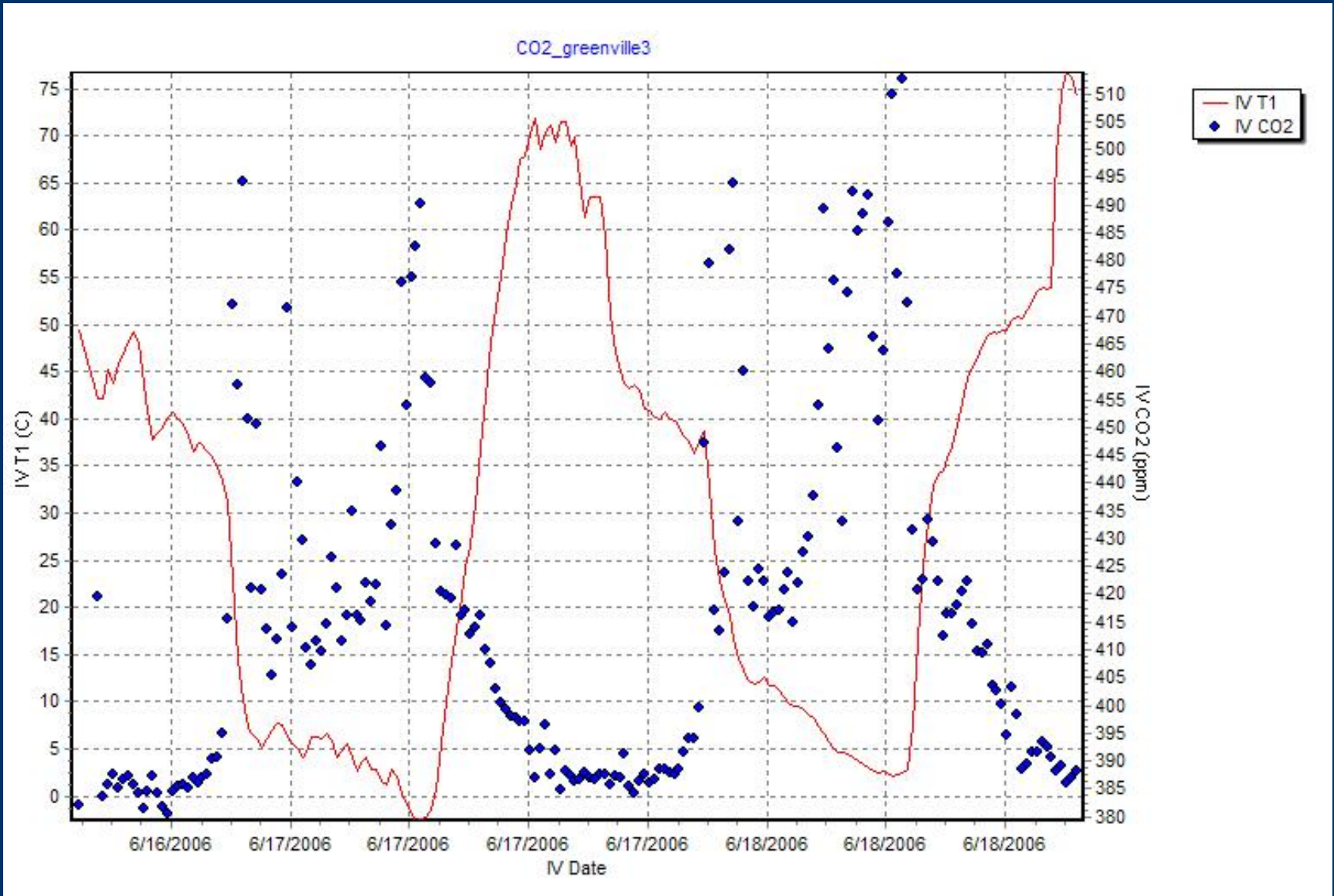


Closed Chamber System

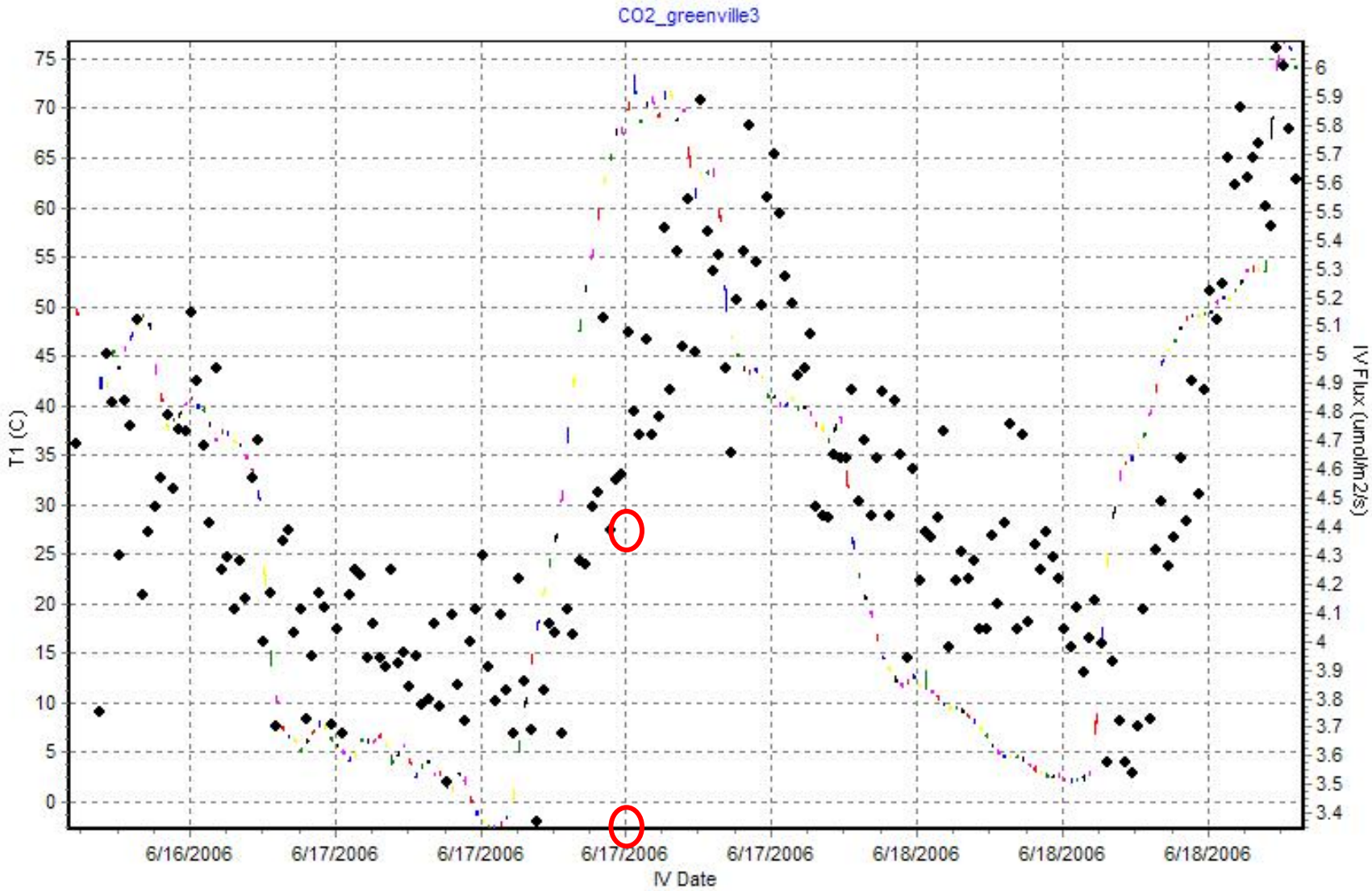
- Changes in gas concentration within an enclosure on the soil surface
- Li-6200 / Li-6400 / Li-8100 (LiCor Inc., Lincoln, NE)
- Static / Dynamic Systems

Closed Chamber System

Chamber Concentration



Chamber Flux



Summary

- The gradient-based approach for soil CO_2 flux determination requires a linear concentration gradient in the near surface for accurate estimates.
- Limitations to this approach include inappropriate sensor placement, variations in surface CO_2 concentration and inaccuracies in diffusion coefficient determination.
- Future work will consider different crop rooting systems to determine the relationship between rooting depth and peak CO_2 concentration.