

Estimation of soil respiration: Techniques for measurement of soil gas

Mark Blonquist

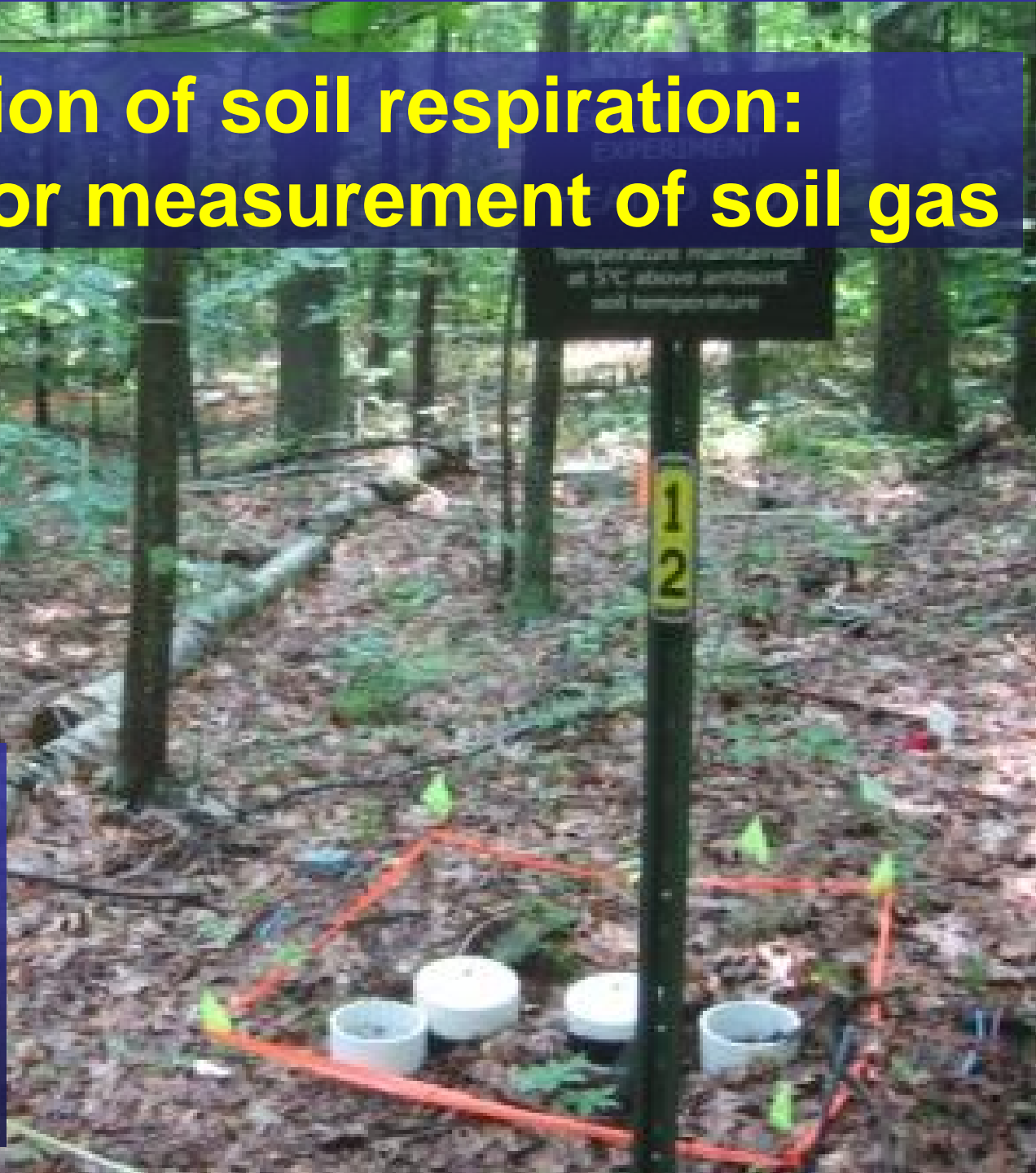
Apogee Instruments

Bruce Bugbee

Utah State University

Scott Jones

Utah State University



Two methods for soil respiration measurement

Soil surface flux (chambers):

- widely used
- commercially available (\$15,000-60,000)
- must account for altered boundary layer
- doesn't need diffusion coefficient



Photo from LI-COR Biosciences

Gradient flux (buried sensors):

- not commercially available (\$3,000-\$15,000)
- provides subsurface data
- requires diffusion coefficient
- challenging to measure subsurface gas concentration

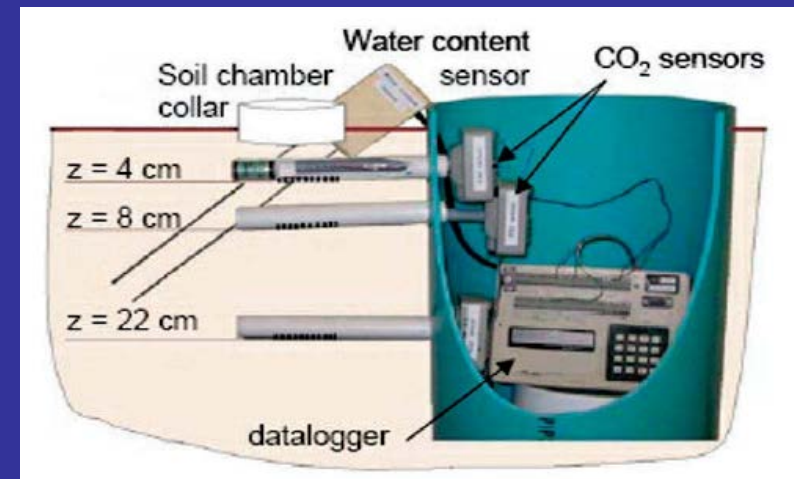
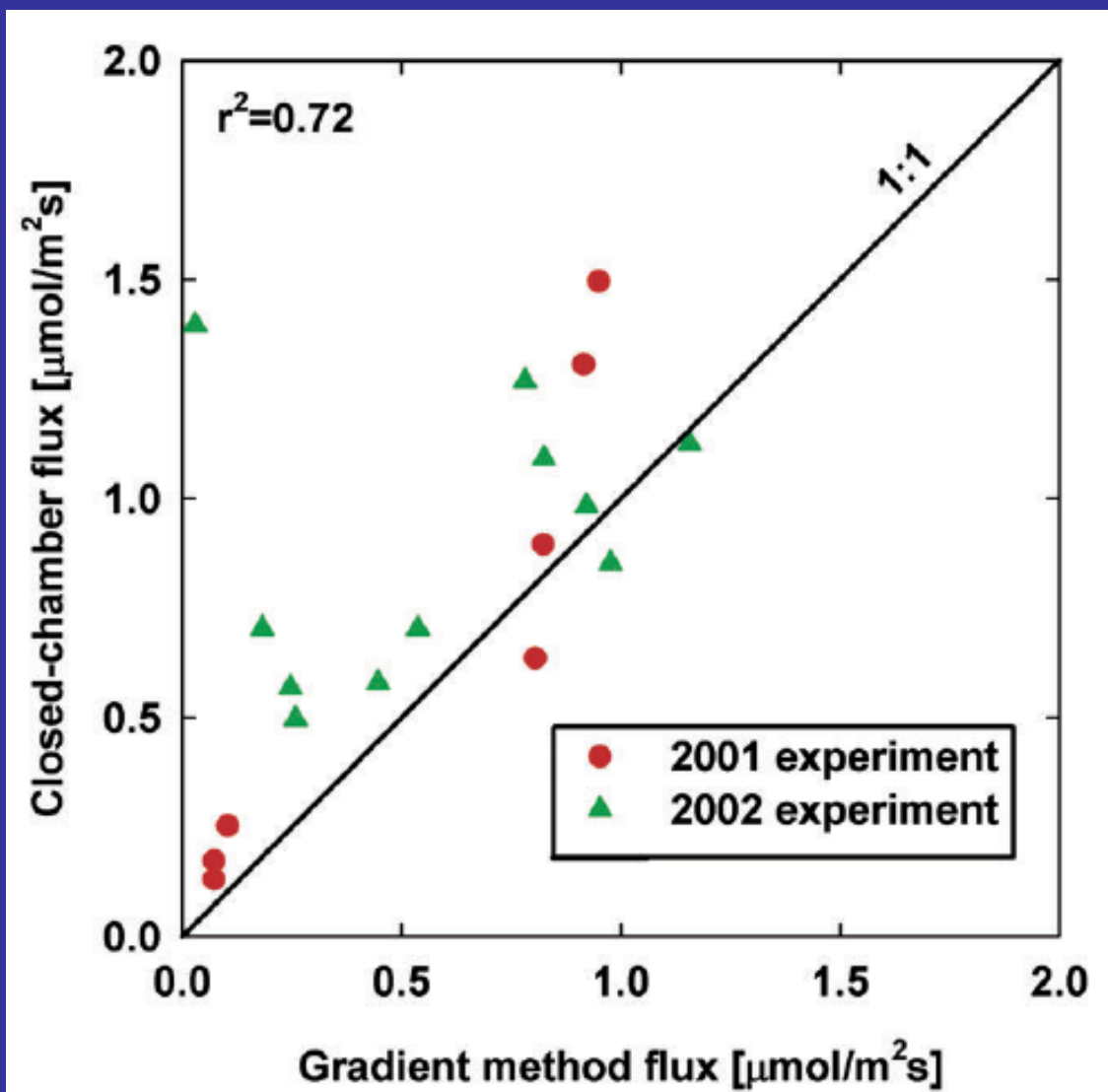


Photo from Turcu et al. (2003)

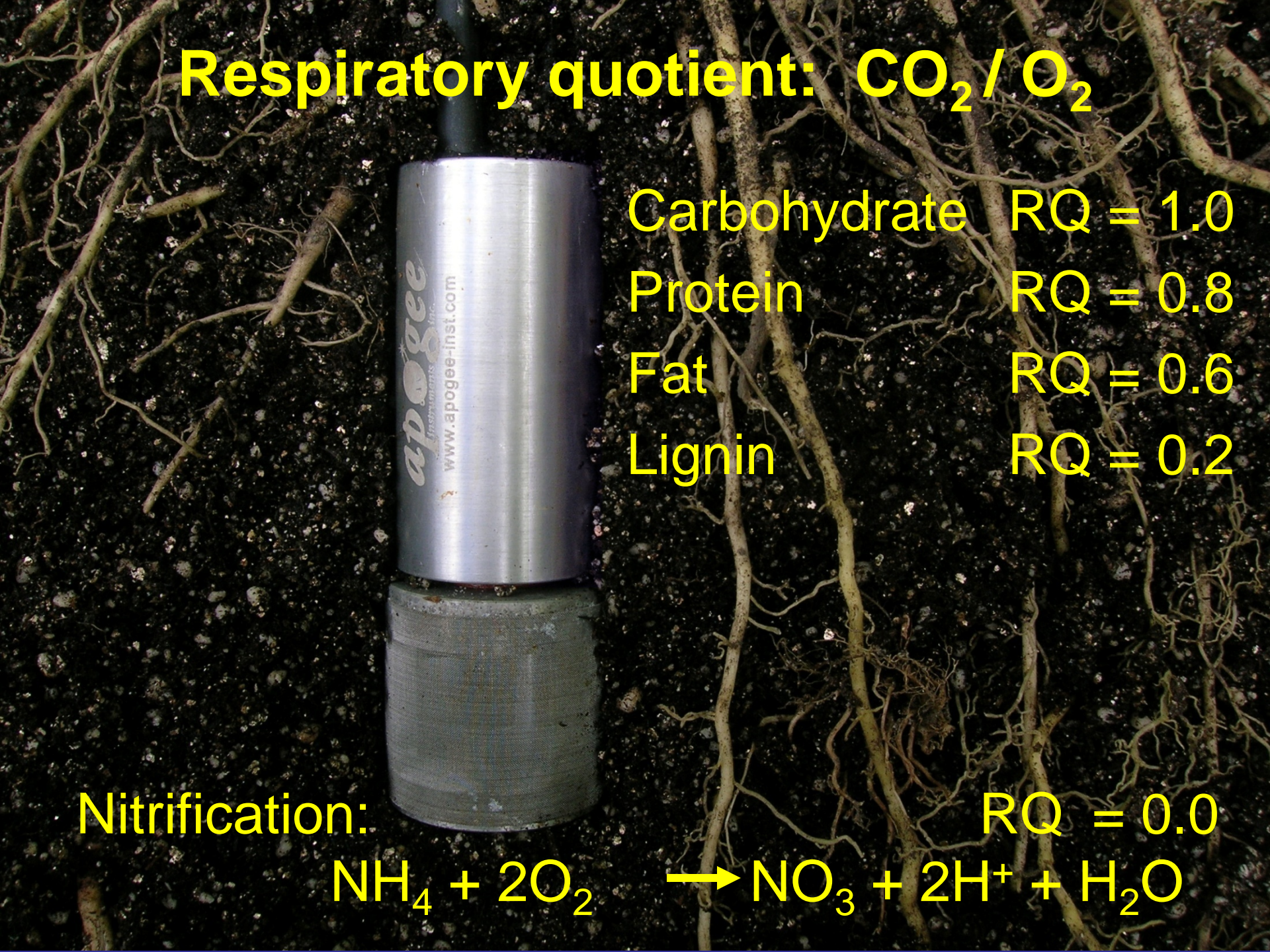


Continuous Soil Carbon Dioxide and Oxygen Measurements and Estimation of Gradient-Based Gaseous Flux

Vasile E. Turcu, Scott B. Jones, and Dani Or*

Respiratory quotient: CO_2 / O_2

Carbohydrate	RQ = 1.0
Protein	RQ = 0.8
Fat	RQ = 0.6
Lignin	RQ = 0.2



Two ways to express gas concentration

Absolute Units

- partial pressure
[kPa]
- moles of gas per unit volume
[mol m⁻³]
- mass of gas per unit volume
[g m⁻³]

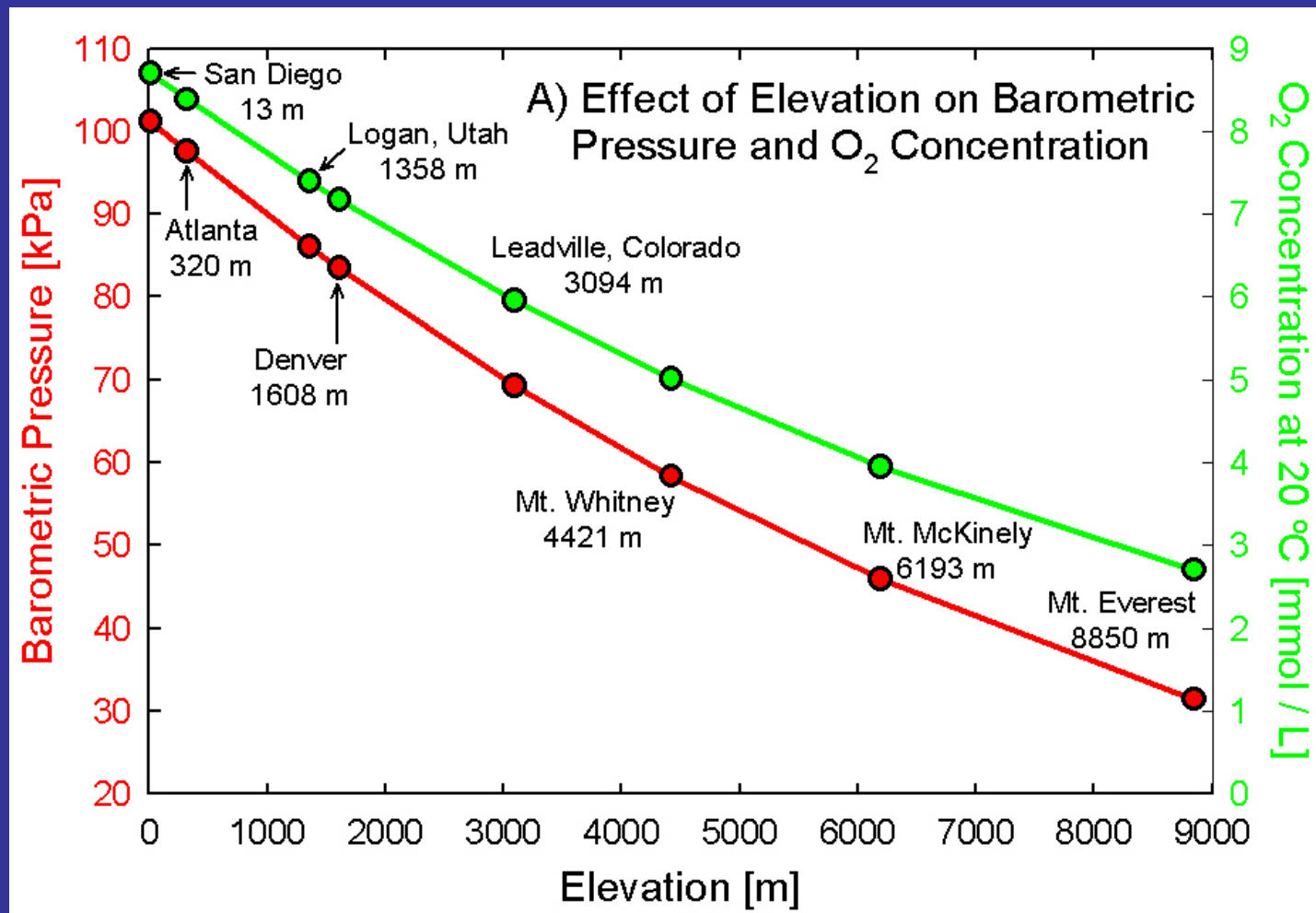
Relative Units

- percent gas in air
[%]
- mole fraction
[kPa kPa⁻¹ air]
- parts per million
[ppm]

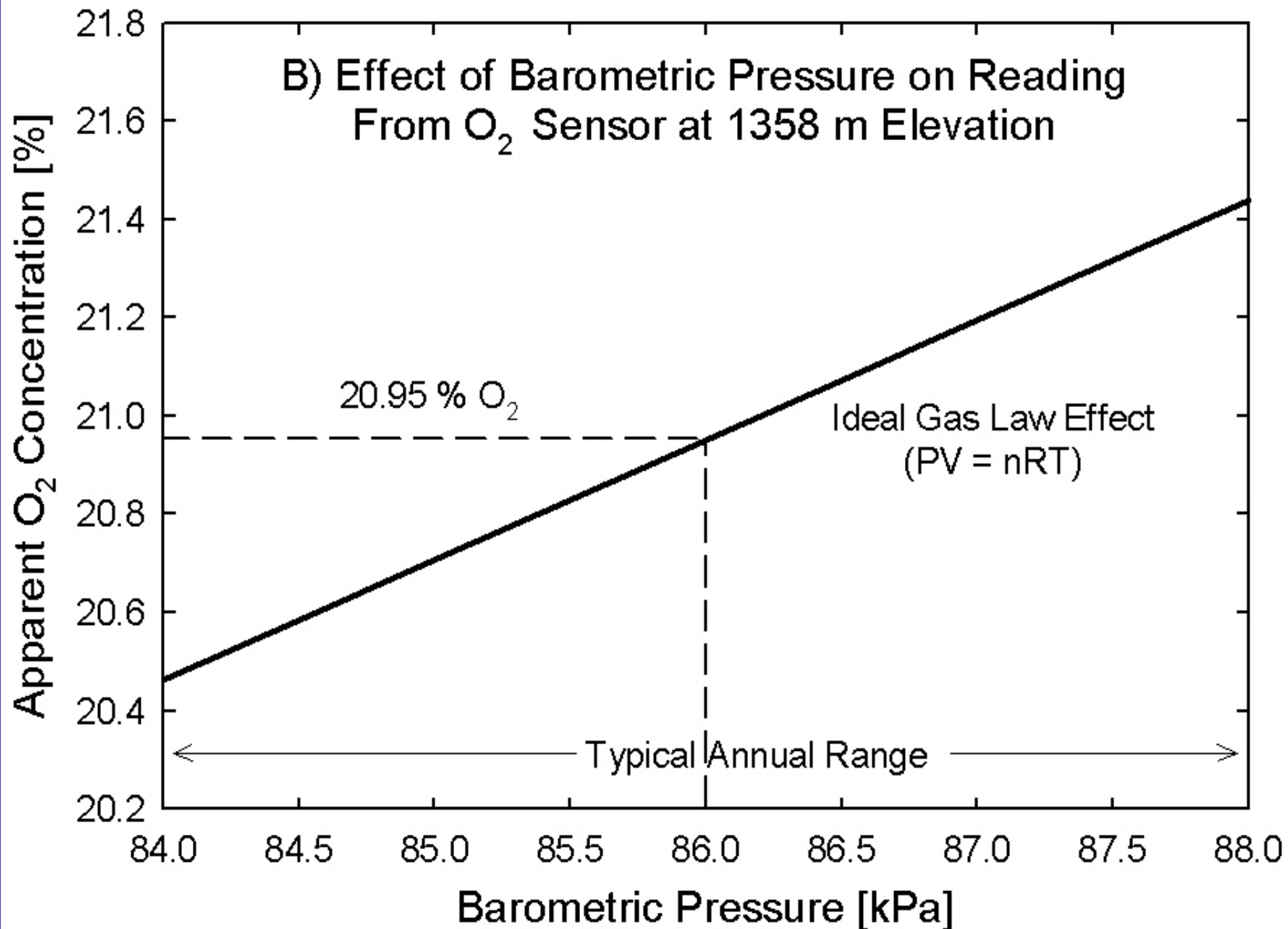
Gas sensors respond to absolute concentration, but are generally calibrated to read relative units

Factors affecting gas concentration in soil

- Barometric Pressure

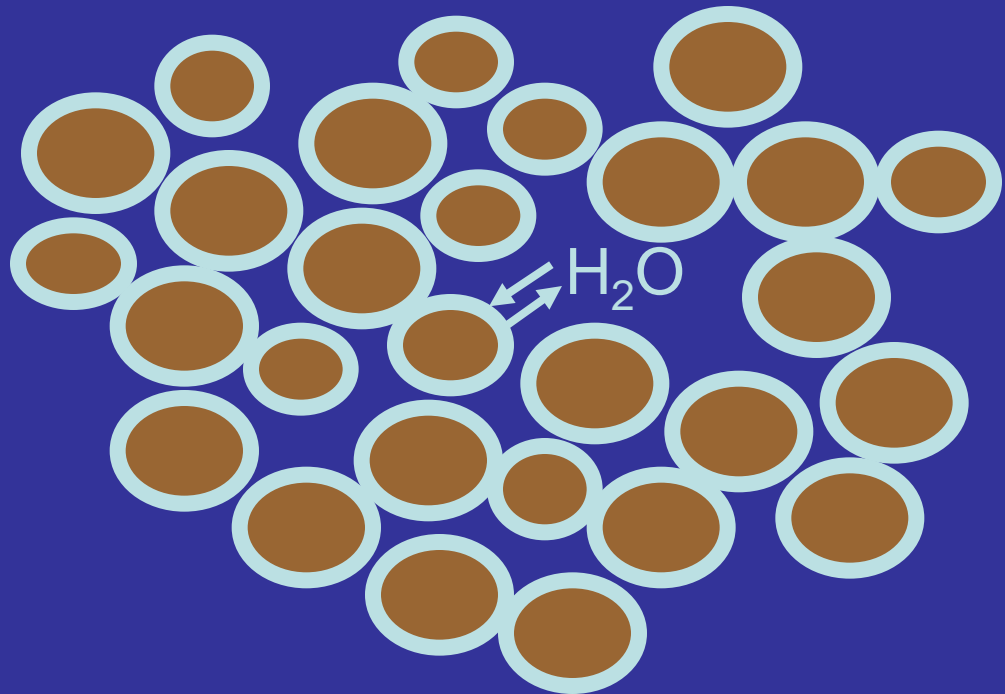


B) Effect of Barometric Pressure on Reading From O₂ Sensor at 1358 m Elevation



Factors affecting gas concentration in soil

- Barometric pressure
- Humidity
(function of temperature)



Effect of Temperature and Humidity on O₂ Concentration in Air

Relative O₂ Concentration [%]

RH

0%

20%

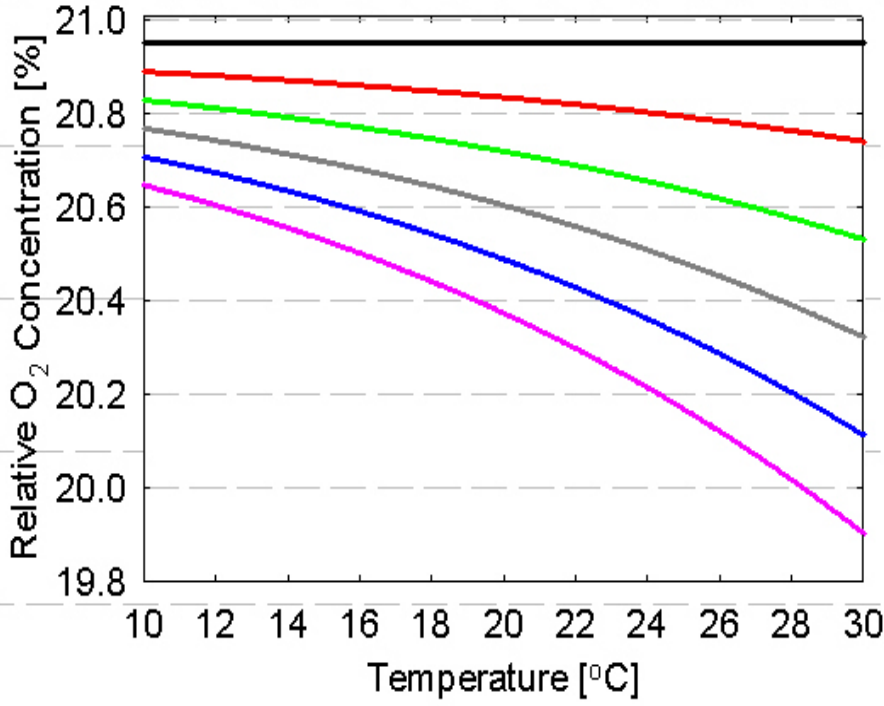
40%

60%

80%

100%

21.0
20.5
20.0
19.5
19.0
18.5
18.0
17.5



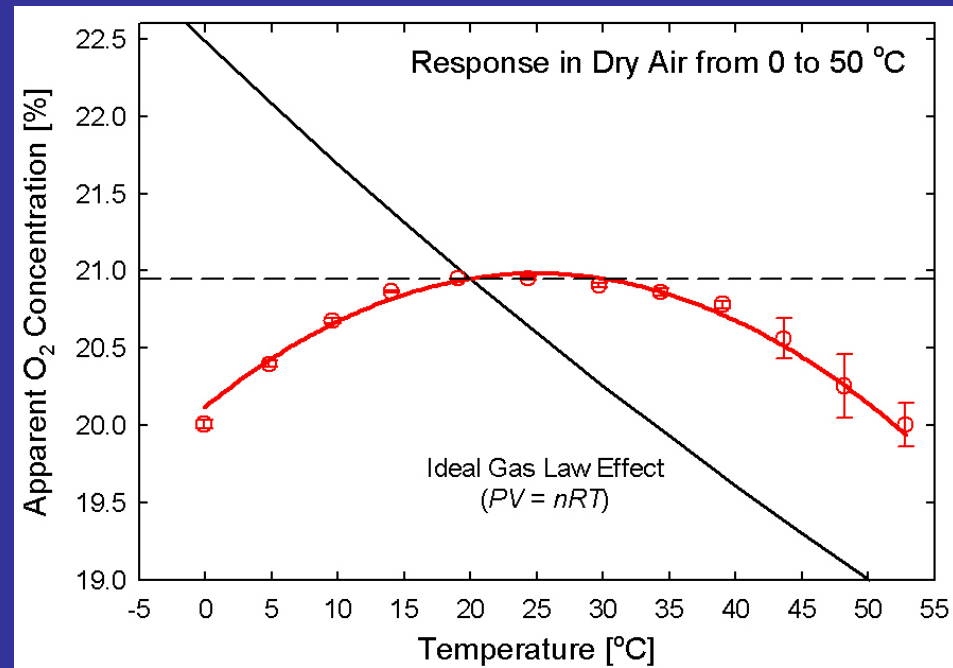
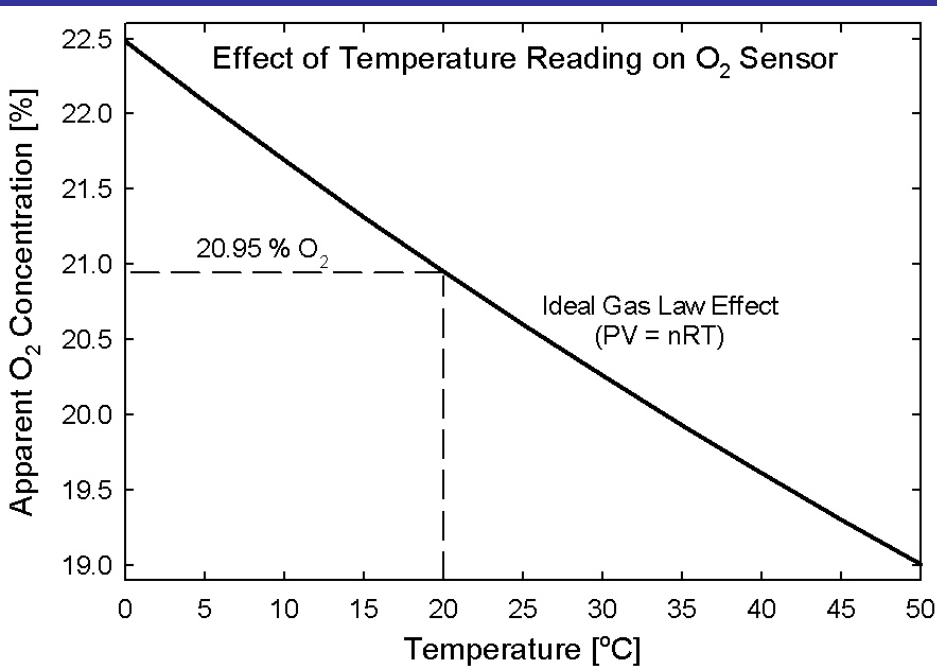
Temperature [°C]



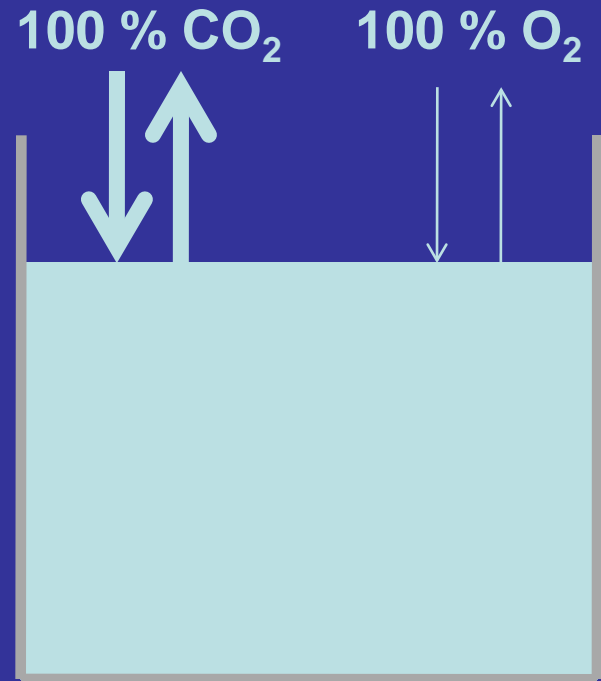
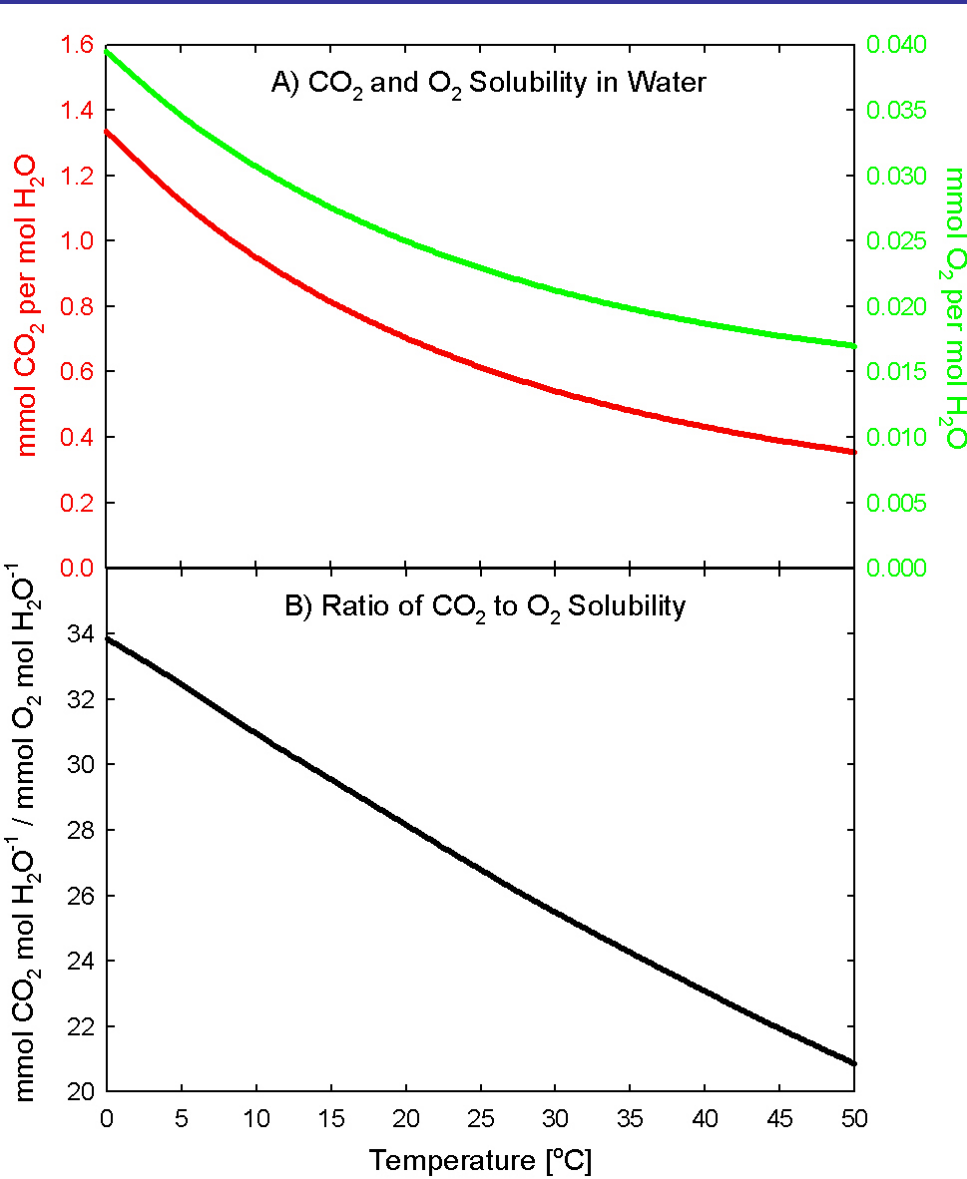
45 50

Factors affecting gas concentration in soil

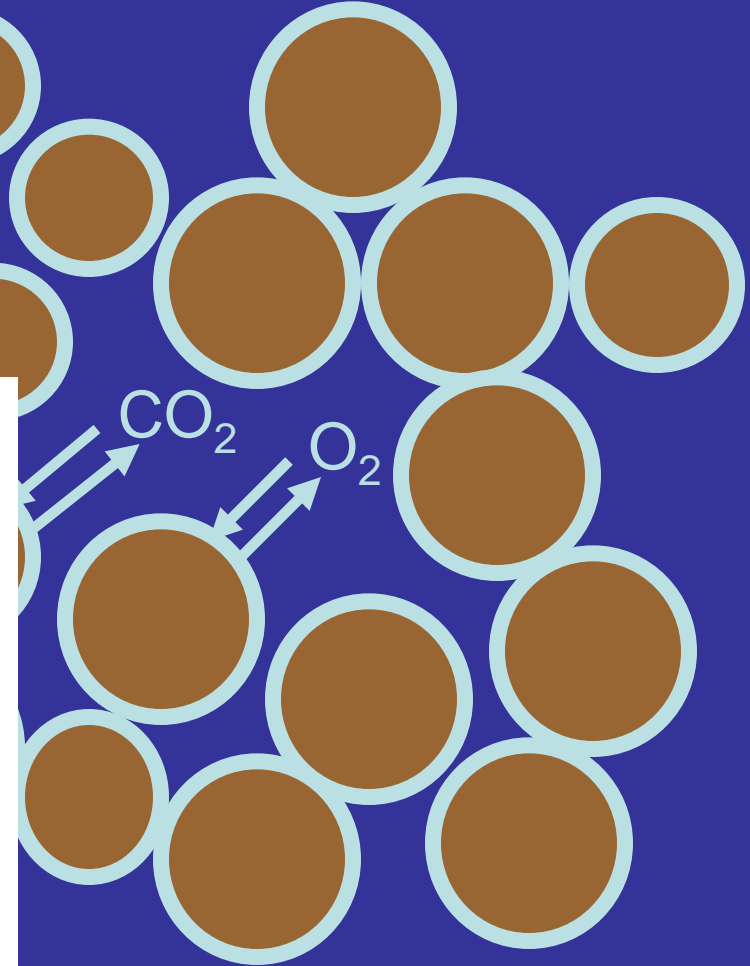
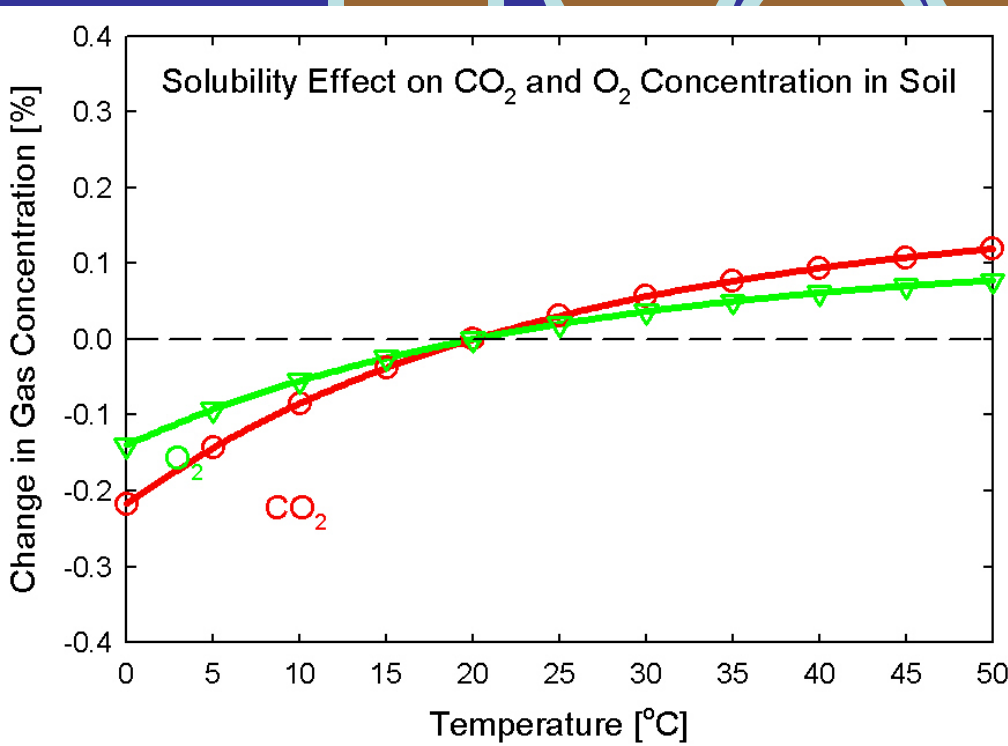
- Pressure
- Humidity
- Temperature
 - effect on molar density and sensor electronics
 - gas / liquid partitioning

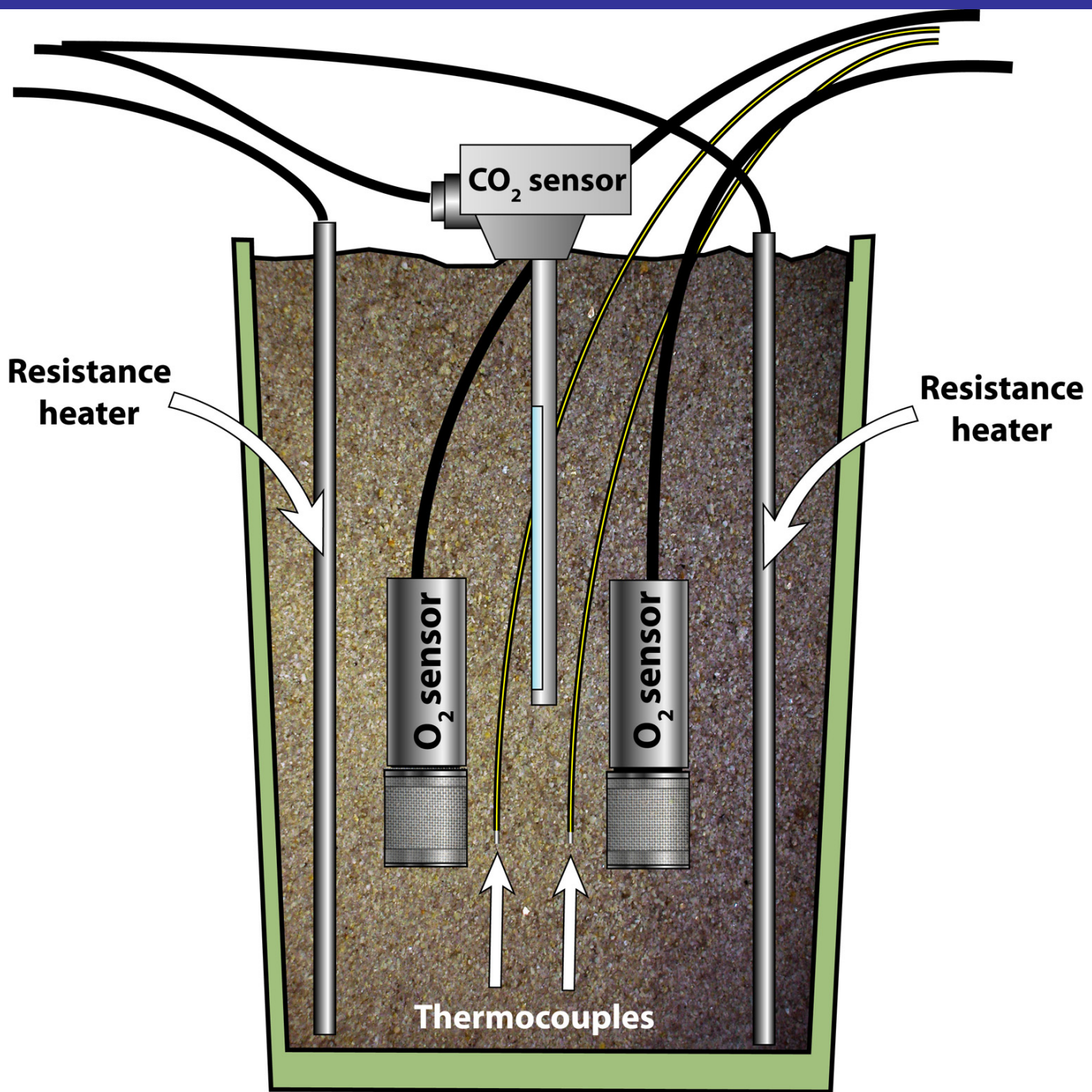


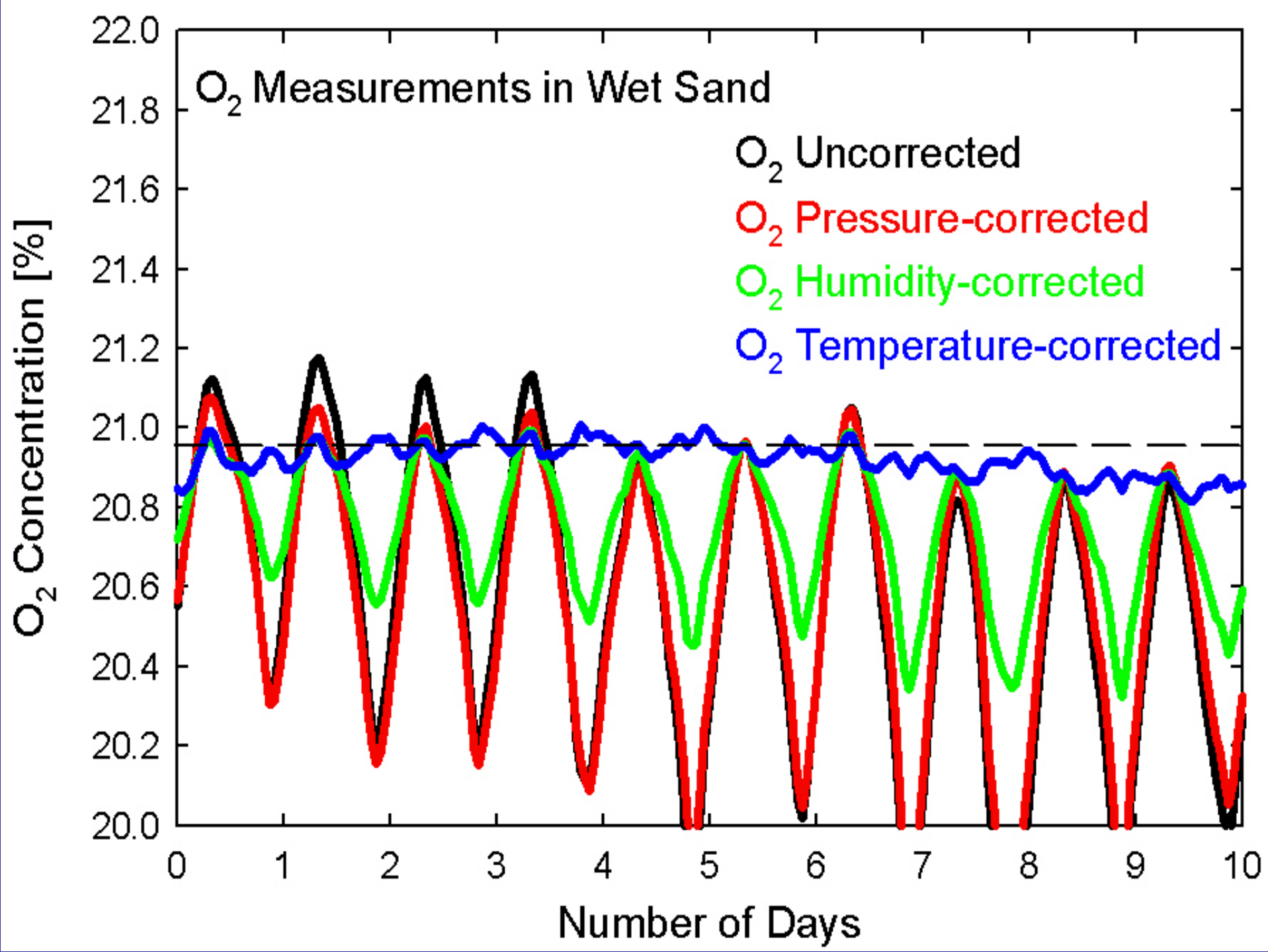
Pure CO₂ is 30 times more soluble in water than Pure O₂



Solubility is roughly equal when CO₂ concentration is 0.6 %







CO₂ Measurements in Wet Sand

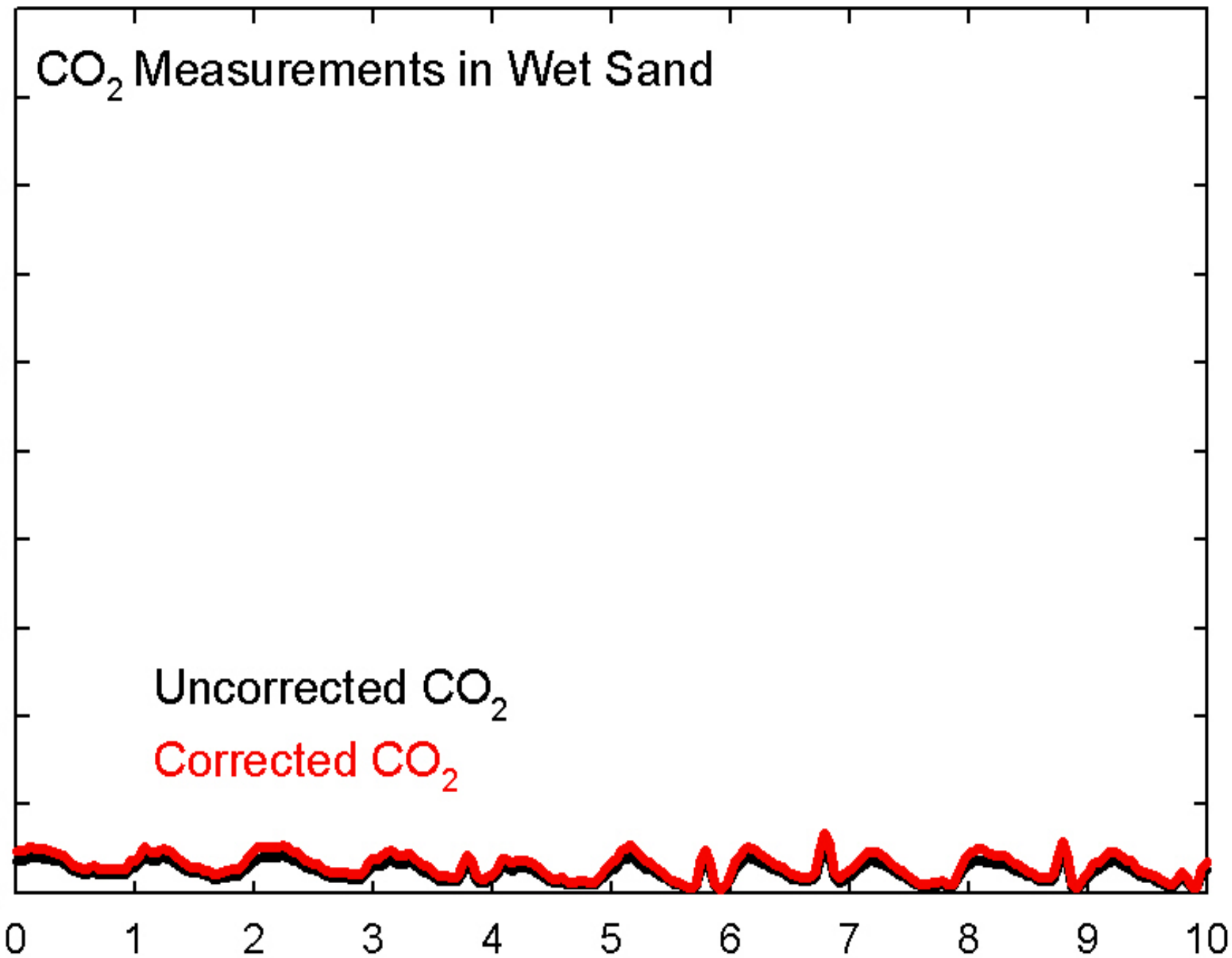
CO₂ Concentration [%]

1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0

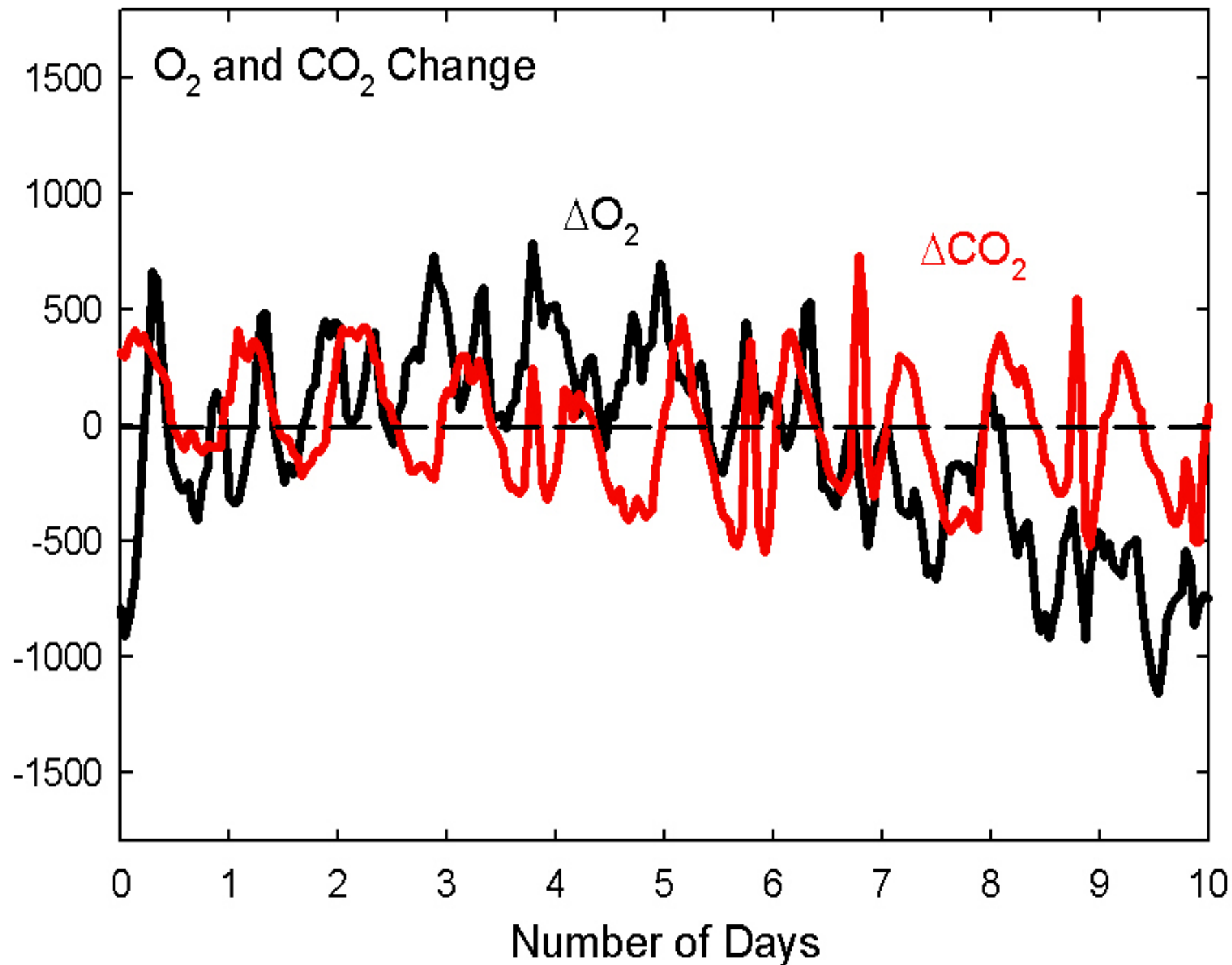
Uncorrected CO₂
Corrected CO₂

0 1 2 3 4 5 6 7 8 9 10

Number of Days



Change in Gas Concentration [ppm]



Conclusions

- Gradient flux approach warrants further consideration; in situ gas measurements need appropriate correction to account for physically-based fluxes
- O₂ measurements provide a useful supplement to CO₂ measurements