

# Atmospheric and Environmental Physics $\Delta\text{O}_2/\Delta\text{CO}_2$ Research Update

Atmospheric Potential Oxygen Workshop

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Physics & Astronomy  
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The University of Calgary

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Biological Sciences, UofC

Monzu Alam (PhD awarded Jan. 2018)

Models & measurements for reaction, diffusion and mass  
flow of CO<sub>2</sub> and O<sub>2</sub> in near-surface soils

Nasrin Pak (MSc awarded Dec. 2012)

Atmospheric CO<sub>2</sub> Leak Detection  
from carbon capture and storage sites

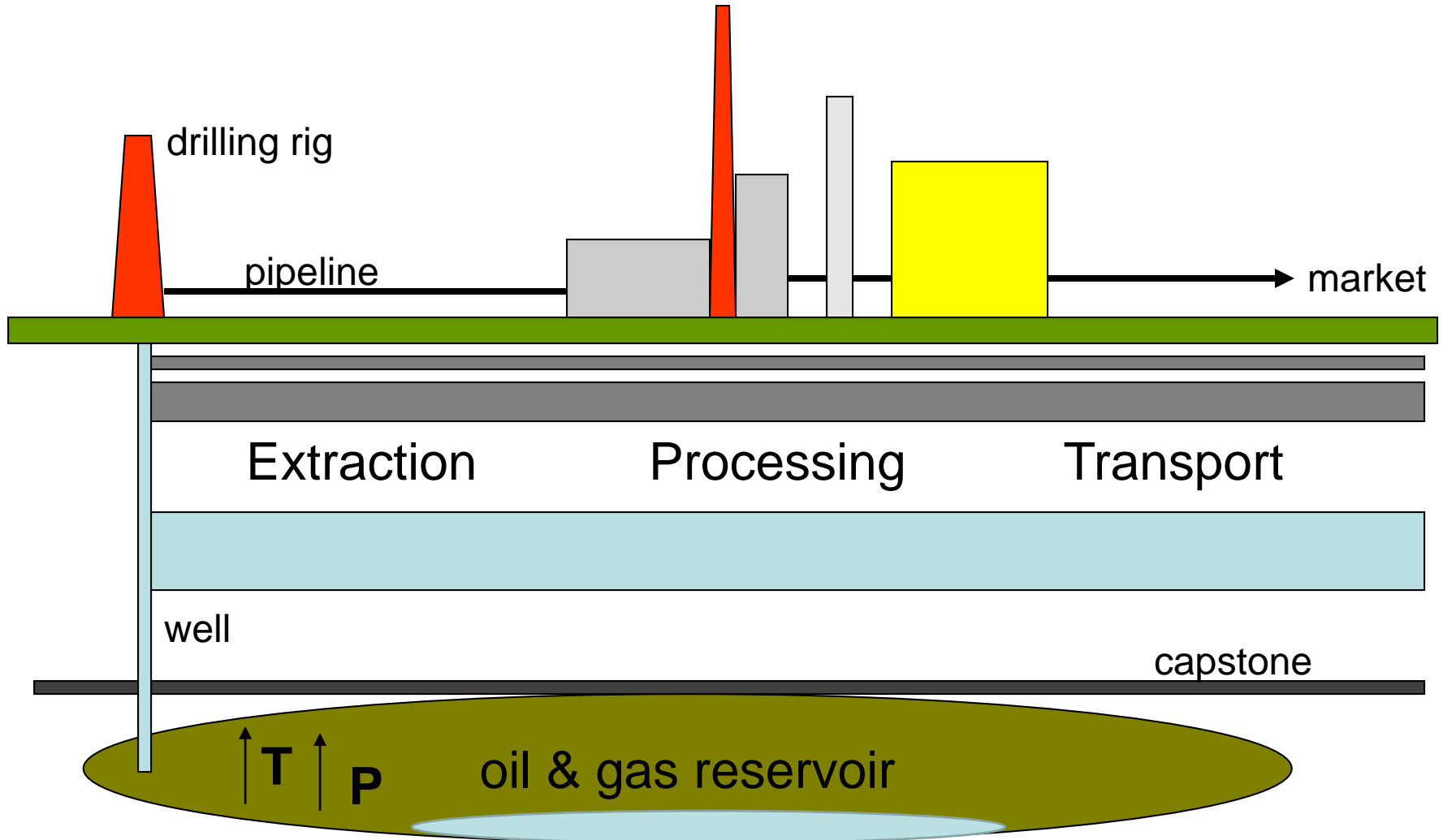


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# Rationale

GHG accounting

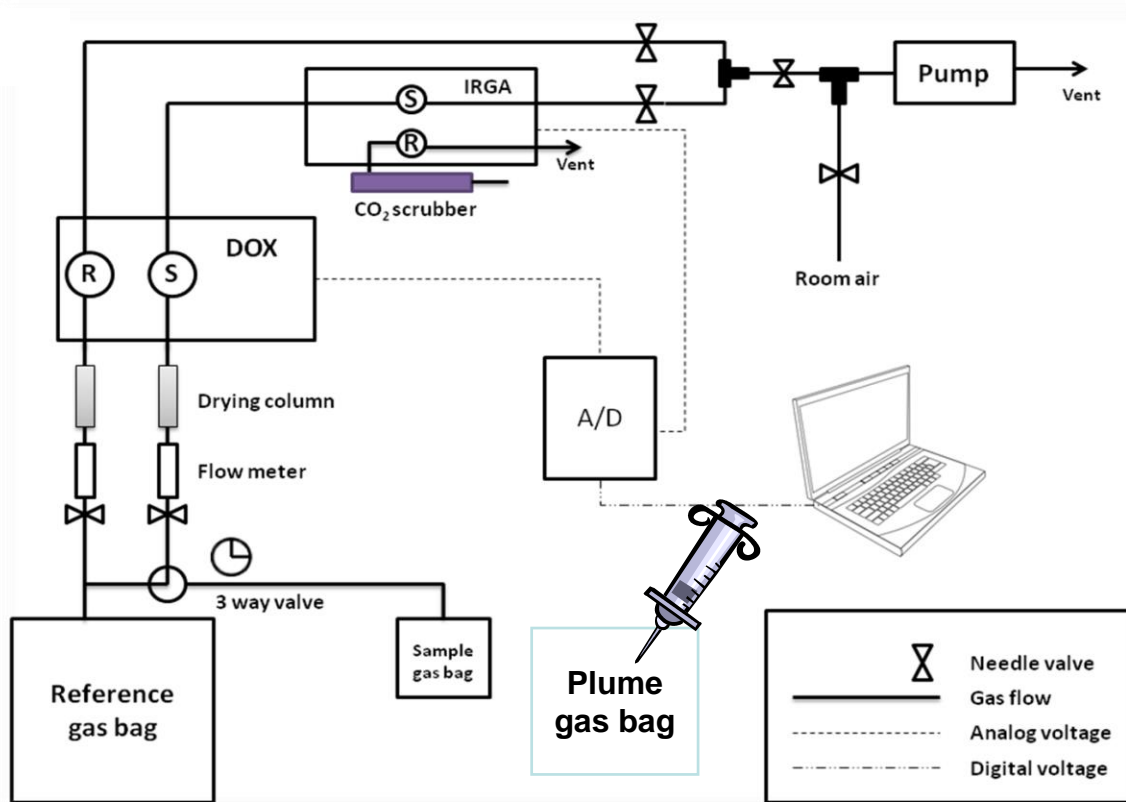
CO<sub>2</sub> leak detection (e.g. from Carbon Capture and Storage)



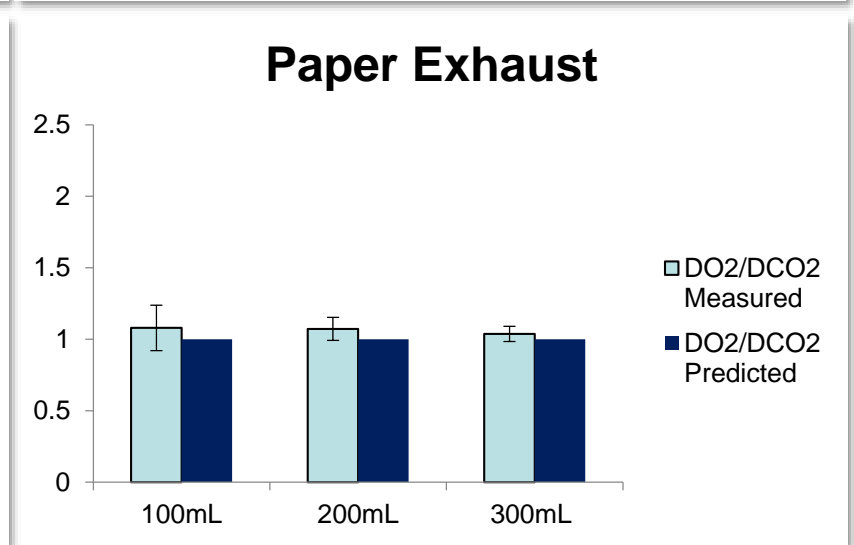
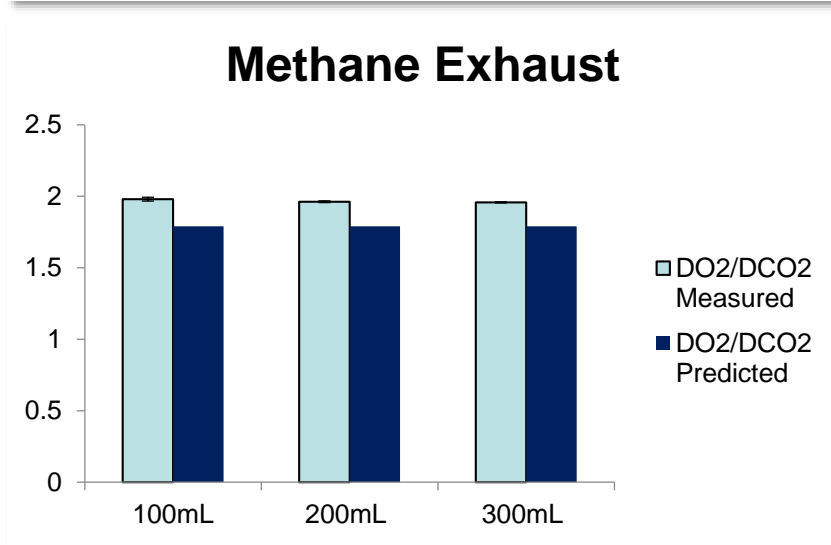
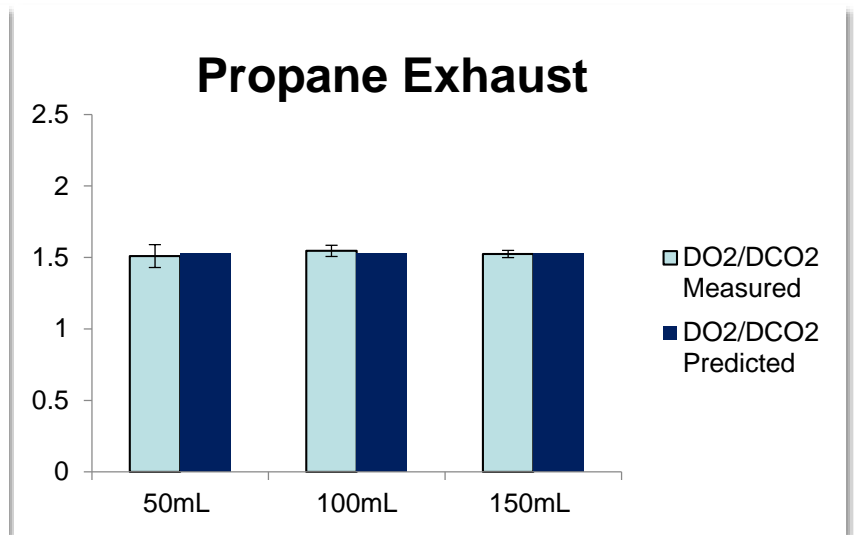
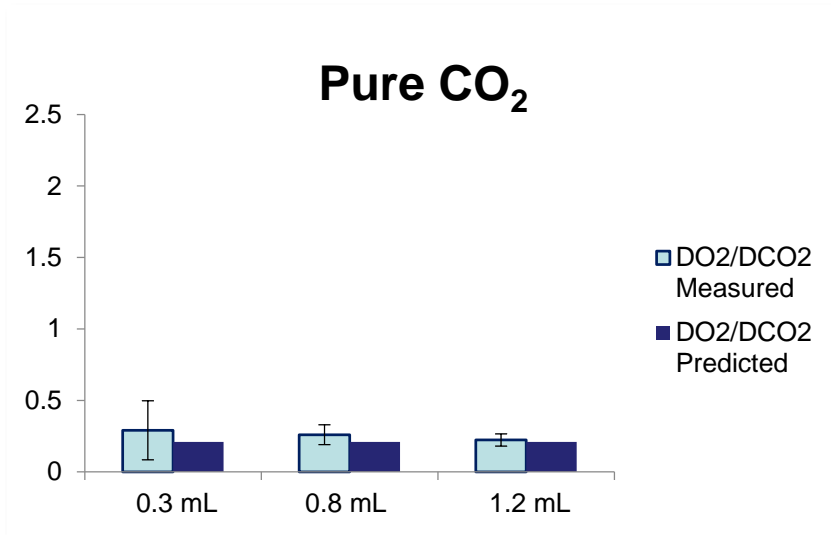
# Instruments

Differential Oxygen Analyzer (DOX)

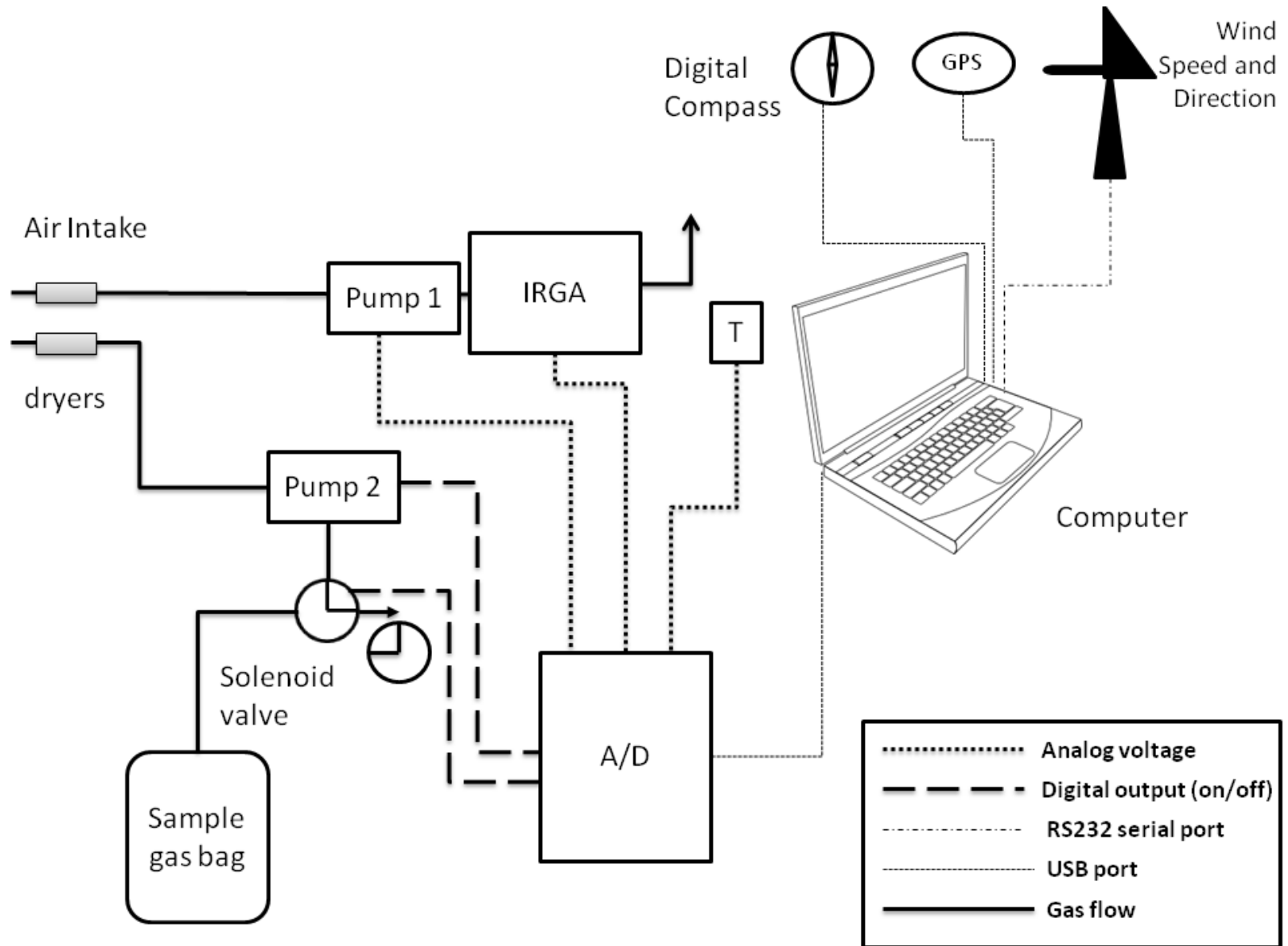
Infra Red Gas Analyzer (IRGA)



# $\Delta O_2/\Delta CO_2$ Variations in Air



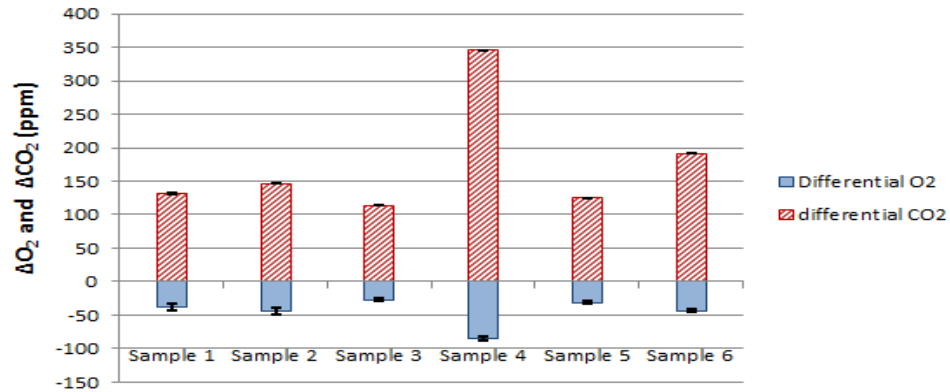
# Portable Detection/Collection System (no DOX)



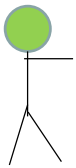
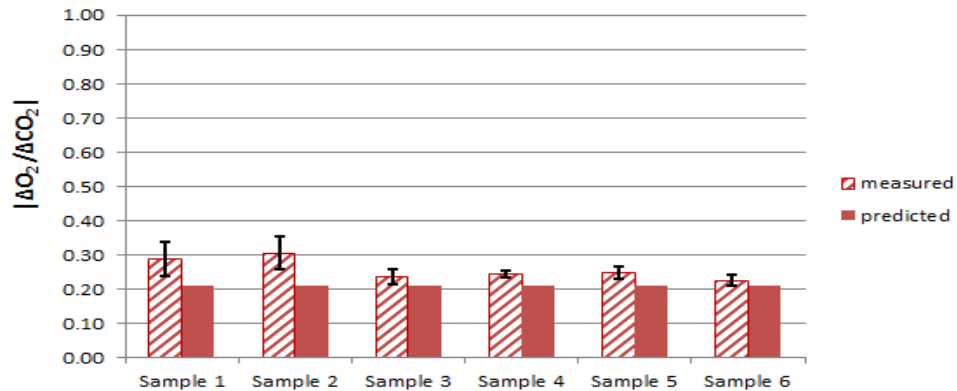
# Field Test

 Dry Ice

### Plume samples collected at the field



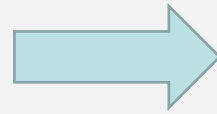
### Gas Concentration Ratio (GCR)



# $\Delta O_2/\Delta CO_2$ Variations in Soil: Models

## **Model I: Coupled $O_2$ & $CO_2$ reactions in soil**

- diffusion
- mass flow (MF)
- concentration gradients
- soil moisture & pH



Gas phase reactions dominate across moisture, pH gradients

## **Model II: same as Model I (minus moisture)**

- Respiratory Quotients
- CCS  $CO_2$  leak conditions



- $0.7 < RQ < 1.2$ , MF accounted for -0.2 to +1.1 % of  $CO_2$  flux to soil surface
- $CO_2$  leak rates 1 & 5 x biological flux, MF contribution increased to 3% and 13 %.



# $\Delta\text{O}_2/\Delta\text{CO}_2$ Variations in Soil: Measurements

Difference between bulk air and soil surface

$$\text{GCR} = \Delta\text{CO}_2/\Delta\text{O}_2$$

Observed gradients & GCR fit model predictions  
for simulated CCS leaks 2-3 times normal  
Biological flux rate ( $\sim 2 \mu\text{moleCO}_2/\text{m}^2/\text{s}$ )

# Conclusion

A portable  $\Delta\text{CO}_2/\Delta\text{O}_2$  system for low level  $\text{CO}_2$  detection is feasible using the IRGA/DOX system

Acknowledgements: Thanks to Dr. Ofelia Rempillo whose expertise was instrumental in creating the portable  $\text{CO}_2$  detection system. Funding was provided by the University of Calgary & Natural Resources Canada

