

Rapid Surface Detection of CO₂ Leaks from Geologic Sequestration Sites

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ENERGY RESOURCES ENGINEERING

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Stanford University

Objective

Develop a method to characterize and detect leakage of carbon dioxide from a geologic sequestration site, based on an autonomous, real time detection system using a mobile sensing platform

Motivation / Goals

Reduce Hazardous Conditions

Assure Regulatory Compliance

Optimize Remediation Techniques

Improve Public Perception of Carbon Dioxide

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Questions

- **Is it possible to detect a leak?**
- **Is there an optimal sampling height?**
- **Will varying wind conditions compromise detection ability?**

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Methodology – Detection Process

Step 1: Collect Data

- Picarro Gas Analyzer
- GPS
- Tri-level Wind Station
- ZERT field site

Step 2: Detect anomalous values in space

- Various methods to detect anomalous concentrations

Step 3: Spatially relate anomalous values for leak detection

- Use spatial interpolation to determine local hotspots

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Instrumentation

Picarro Gas Analyzer

- Wavelength scanned, cavity ring down spectrometer (WS-CRDS)
- Readings every 2-3 seconds

GPS Unit

- Centimeter accurate
- Readings every 1 second

Tri-level Wind Station

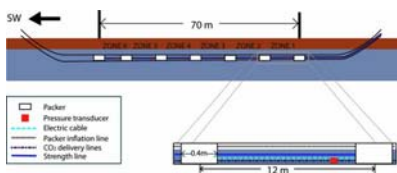
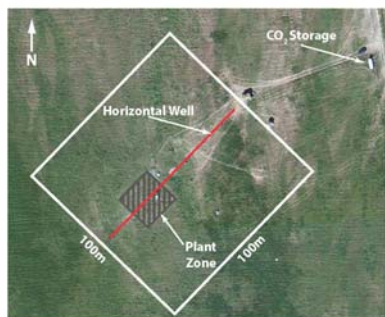
- Wind Readings at 0.3m, 0.9m, and 1.5m
- Readings every 5 seconds



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Zero Emissions Research & Technology (ZERT) Field Site

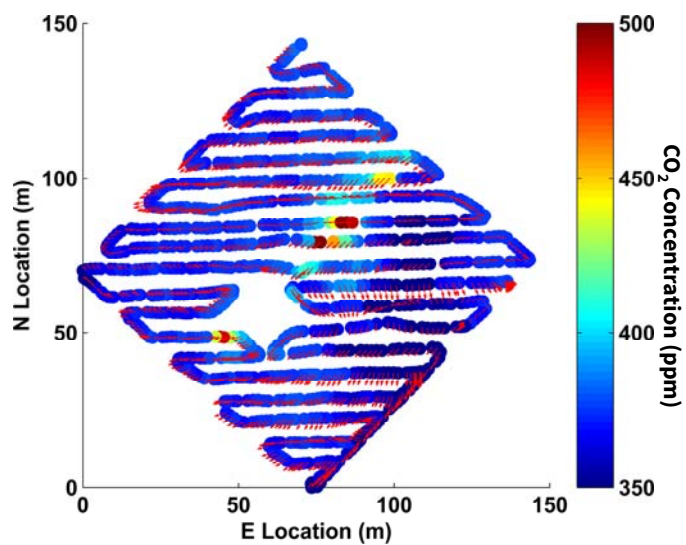


Spangler et al., 2007

- Bozeman, Montana, USA
- Developed to study near surface CO₂ transport and detection technologies
- Shallow, horizontal well
 - 100m long
 - ~ 1.8m below surface
- CO₂ leakage rate: 0.15 t/day
- Equivalent to 0.005% leak from a 1Mt per year CO₂ storage project

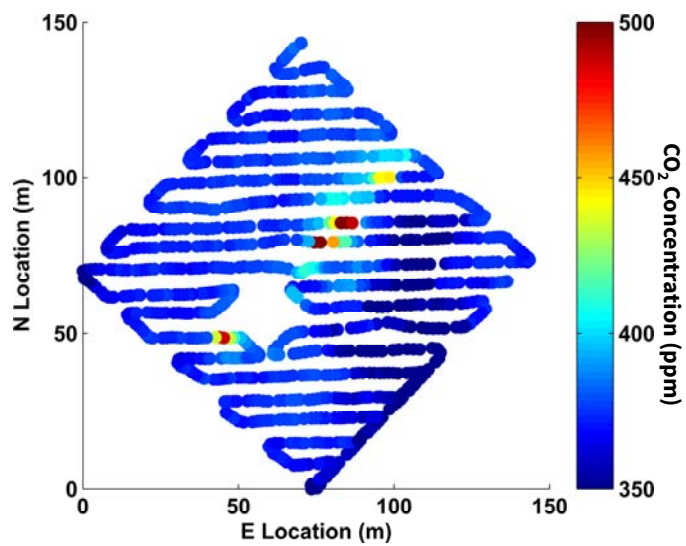
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Case Study



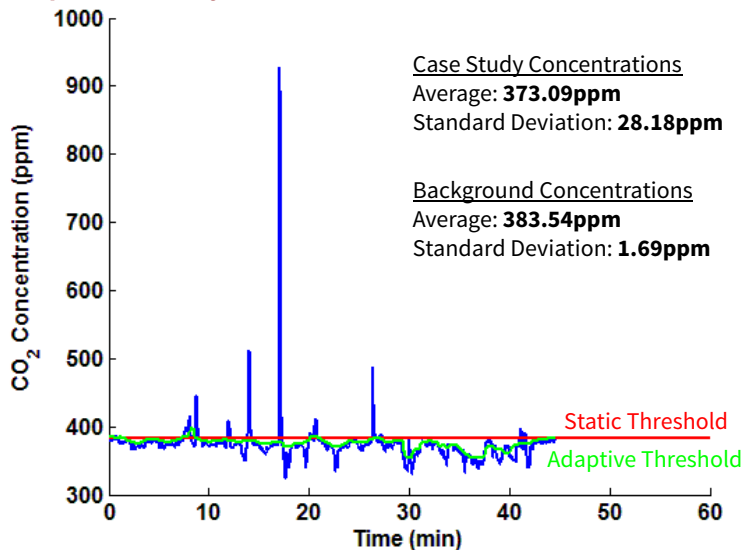
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Step 1: Data Collection



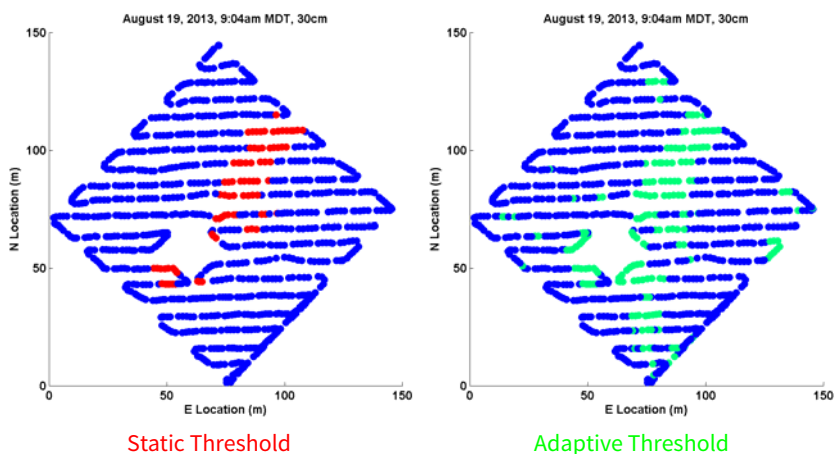
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Step 2: Anomaly Detection



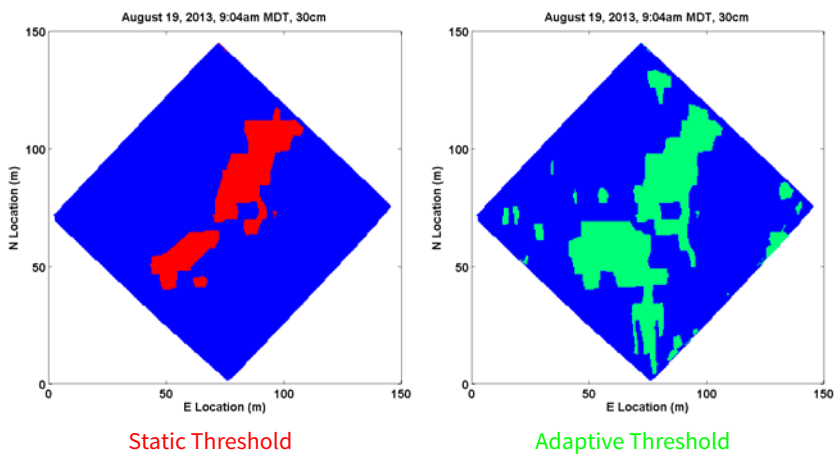
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Step 2: Anomaly Detection



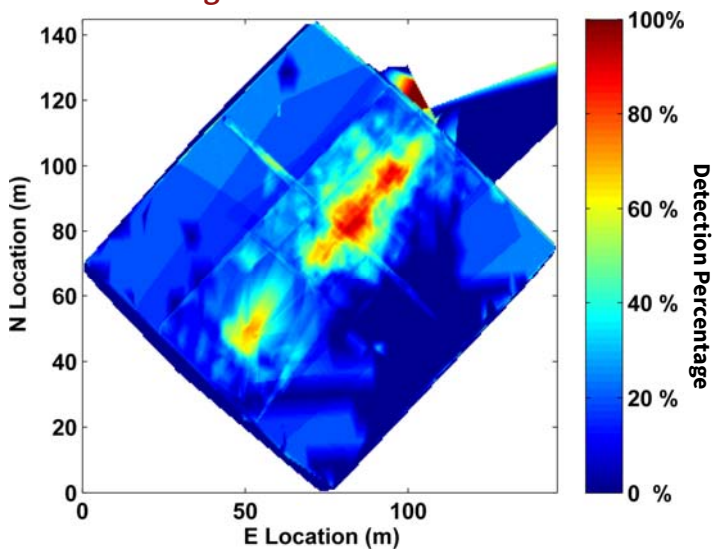
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Step 3: Determine Anomaly Location

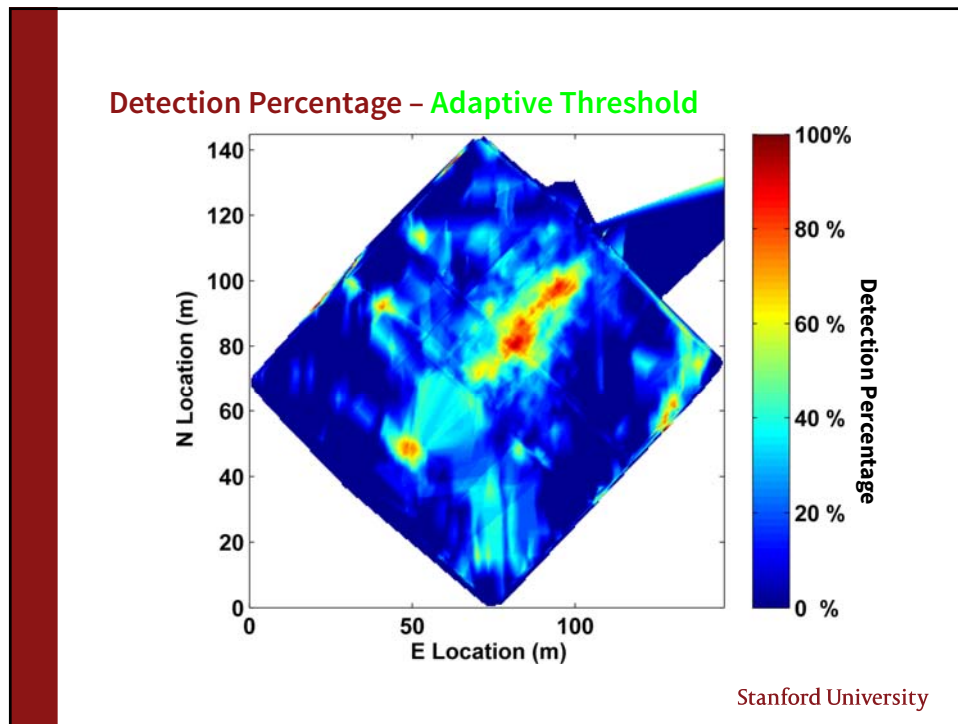


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Detection Percentage - Static Threshold



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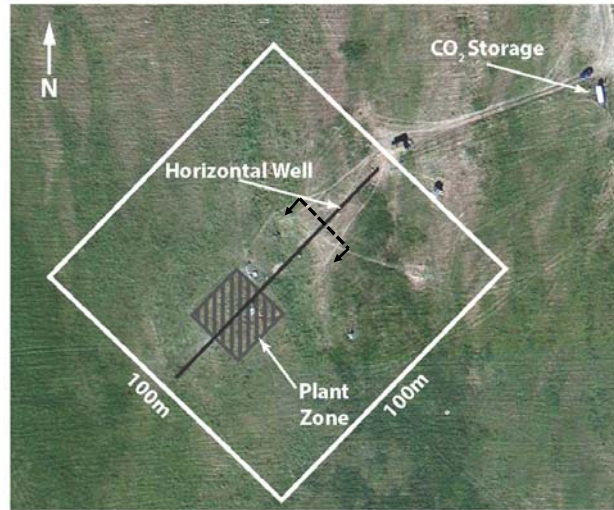


Questions

- **Is it possible to detect a leak?**
 - Yes! A relatively small leak can be detected using this method
 - Using absolute concentrations has proven to be a robust method
- **Is there an optimal sampling height?**
- **Will varying wind conditions compromise detection ability?**

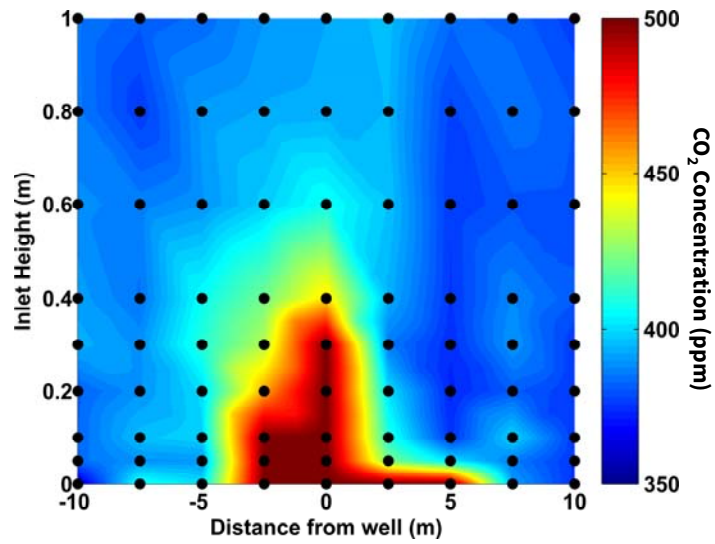
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Profile of CO₂ plume across source

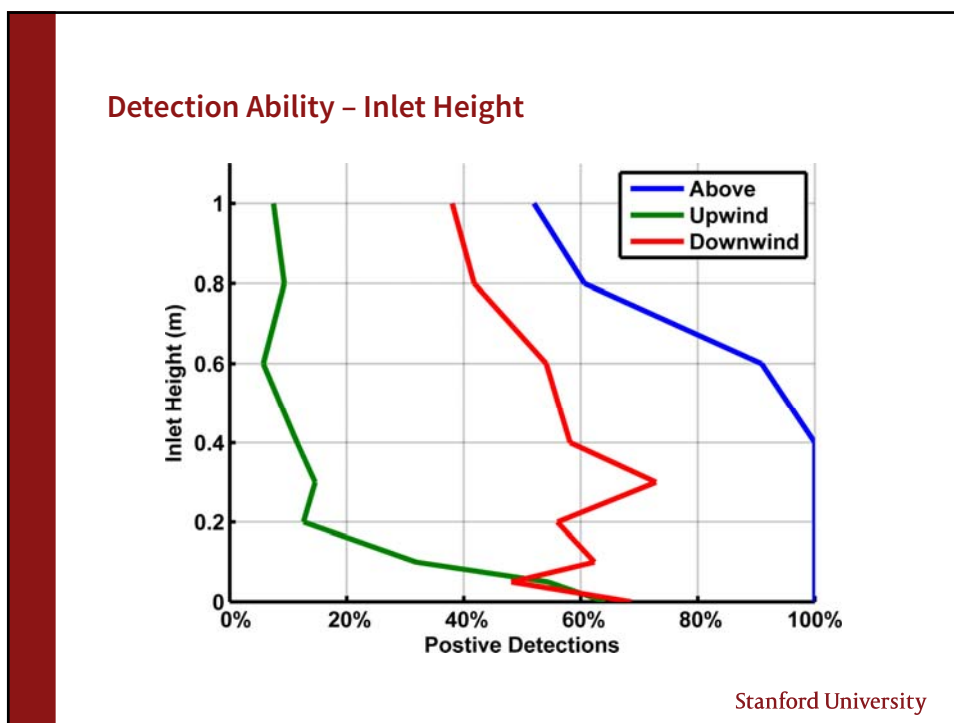
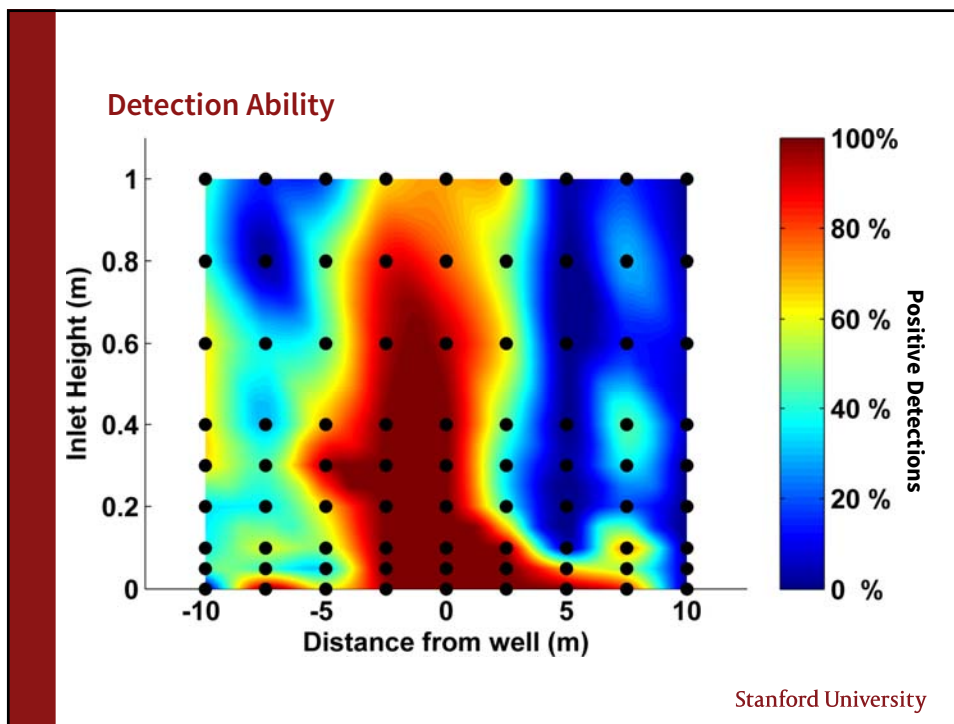


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Profile of CO₂ plume across source



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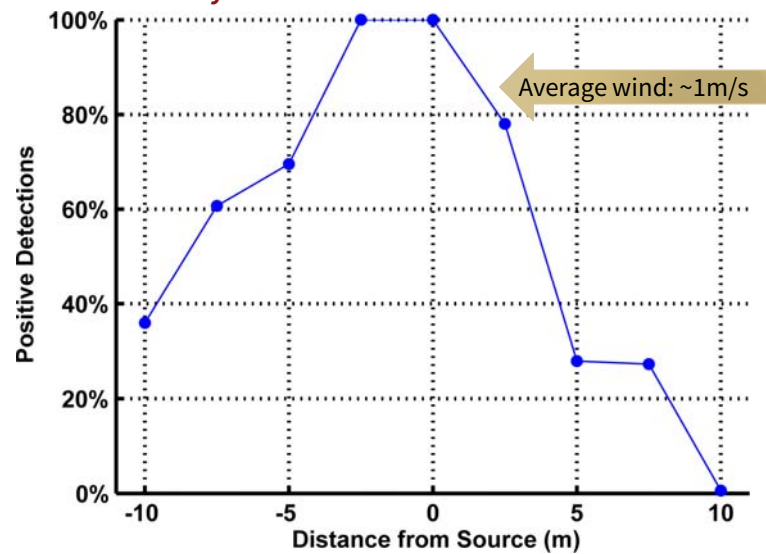


Questions

- **Is it possible to detect a leak?**
 - Yes! A relatively small leak can be detected using this method
 - Using absolute concentrations has proven to be a robust method
- **Is there an optimal sampling height?**
 - As low to the ground as practical
- **Will varying wind conditions compromise detection ability?**

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Detection Ability – Distance from source



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Questions

- **Is it possible to detect a leak?**
 - Yes! A relatively small leak can be detected using this method
 - Using absolute concentrations has proven to be a robust method
- **Is there an optimal sampling height?**
 - As low to the ground as practical
- **Will varying wind conditions compromise detection ability?**
 - Not if sampling is low to the ground and within ~2.5m of leak
 - Wind can actually assist in detection if sampling downwind from source

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Further Research

- **Test various anomaly detection methods (Step 2)**
- **Wind can help detect upwind leaks**
 - Qualitatively observed
- **Relate flux to concentration data**
 - Order of magnitude estimate
 - Large variance in concentration data above a given point
- **Apply to other scenarios**
 - Test under different scenarios
 - Tracking coal seam fires

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- David Borns Ph.D., Sandia National Laboratories

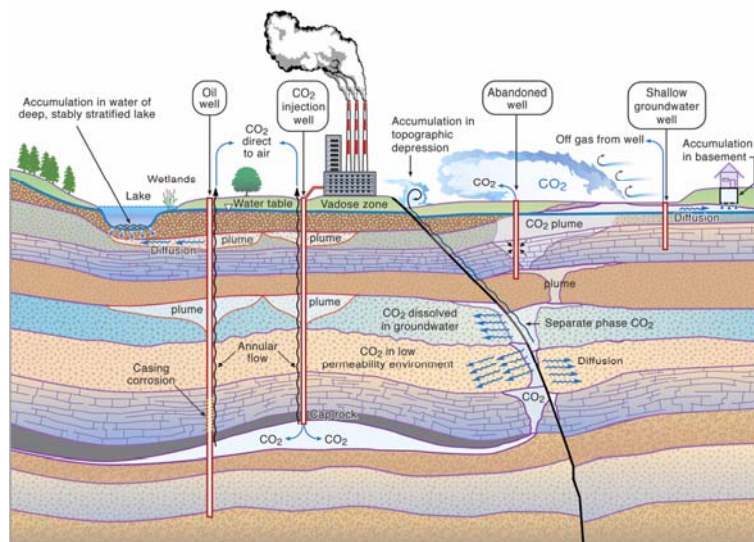
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Questions?

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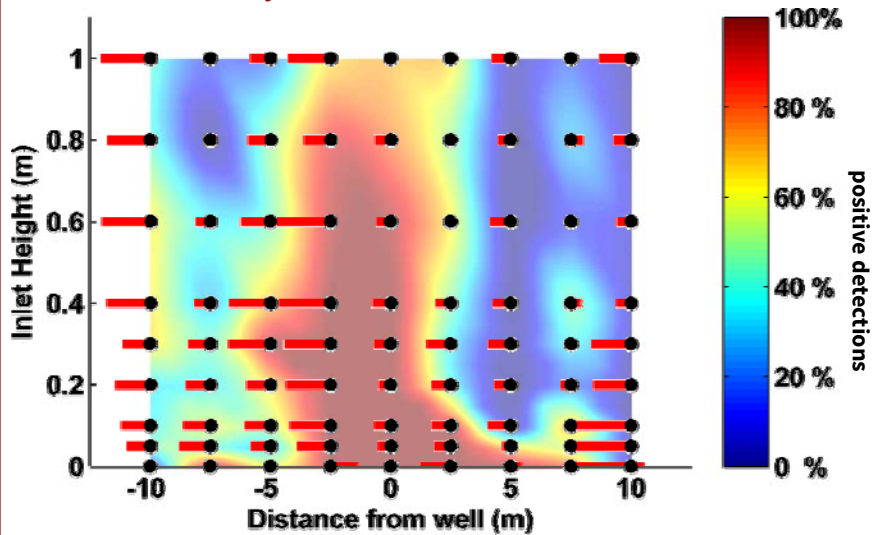
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Possible CO₂ Leakage Pathways



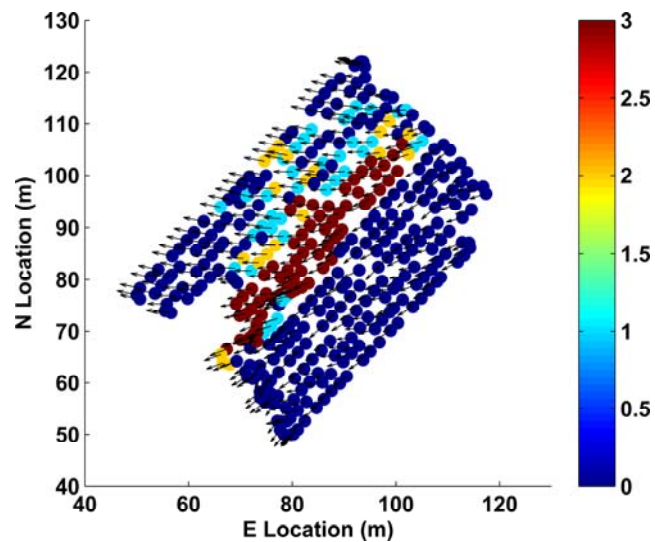
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Detection Ability



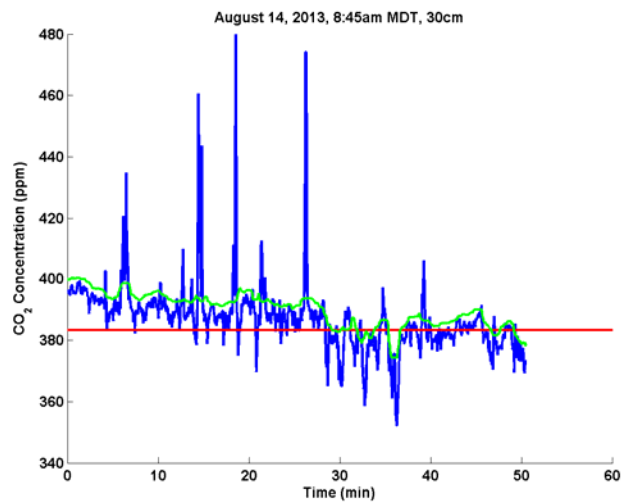
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Detection Ability Downwind



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Problem with Static Threshold



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