Strategies for Characterizing Shallow Soil Gas Flux and Chemistry, Blan Farm, Hancock County, Ky.

Investigators:

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Monitoring, Mitigation, and Verification (MMV)

- MMV—portfolio of geophysical, geochemical, geological, and engineering techniques used to accurately document the fate of CO$_2$ injected into subsurface reservoirs.
- DOE’s perspective—successful sequestration means that 99% of injected CO$_2$ remains in the reservoir for geologically significant time periods.
- “For surface and near-surface soil gas measurements to be effective as an MMV tool, need to understand natural carbon cycle and its variability.” (GEO-SEQ, 2004)
Soil Gas Chemistry Objectives

- Develop pre-injection database characterizing atmospheric, biologic, and geologic (microseepage) contributions to soil gas flux and chemistry

- **Use database to resolve anomalies, if any, during injection and post-injection phases**

- Evaluate influence of basin specific factors on soil gas flux and chemistry, e.g. shallow coals and reclaimed mine lands

- *The challenge: resolve microseepage signal << biologic and atmospheric signal*
Blan Farm Geologic Setting

1000 ft
Shallow (< 1 m) Measurements
Shallow Soil Gas Chemistry

- Measured bulk (CO₂, CH₄, C₂H₆, C₃H₈) and carbon isotopic composition (δ¹³C-CO₂)
- Duplicate measurements per location at 30, 60, 100 cm
- Bulk and isotopic atmospheric composition also measured
- Characterize season variation and anthropomorphic influences
Shallow Soil Gas Chemistry

Collecting soil gases in Robinson Forest, fall 2005
Soil Gas Flux

- Measure fluxes using closed chamber method
- $\text{CO}_2$ flux measured directly w/ Licor LI-8100 equipped w/ infrared gas analyzer
- $\text{CH}_4$ flux determined indirectly by measuring change in chamber composition w/ time
- Triplicate flux measurements per location to capture variability
Soil Gas Flux

- Flux Chamber
- Temperature Probe
- Optical bench w/ Infrared analyzer
Average W06, S06 Soil Gas CO₂

Avg. Atmospheric CO₂ = 425±28 ppmv

- Winter—48,593 ppmv
- Summer—163,424 ppmv

Reclaimed mine land
Average W06, S06 Soil Gas CH$_4$

Avg. Atmospheric CH$_4$ = 1.94±0.03 ppmv

Summer—25 ppmv

Winter—7.6 ppmv

Reclaimed mine land
CO$_2$ and CH$_4$ Fluxes

- Positive CO$_2$ fluxes measured at all locations
  - Summer (avg. = 15.7±6.2 grams/m$^2$/day, n=84) > winter (avg. = 4.6±0.8 grams/m$^2$/day, n=83)
- For CH$_4$, most chamber locations (65%, n=106) showed no consistent decrease or increase w/ time
  - 28% (n=46) showed negative CH$_4$ flux (avg. = 1.69±1.5 grams/m$^2$/day)
  - 7% (n=11) showed positive CH$_4$ flux (avg. = 1.31±1.4 grams/m$^2$/day)
Soil Gas Anomalies and Microseepage

- Positive CH$_4$ fluxes in oxidized soils
- Soil gas CH$_4$ concentrations consistently > atmospheric in oxidized soils
- Enriched $\delta^{13}$C-CO$_2$ values relative to atmosphere-soil organic matter mixing line
- Presence of light hydrocarbons (e.g. C$_2$H$_6$, C$_3$H$_8$)
Reclaimed Mine Lands and MMV

-30.00 -25.00 -20.00 -15.00 -10.00 -5.00 0.00

Avg. 100 cm Bulk TOC

Avg. Atmosphere

Eastern Ky conventional reservoir gas

Reclaimed mine land

CO₂ Concentration (ppmv)

δ¹³C-CO₂ (‰, PDB)