The Ginninderra greenhouse gas controlled release facility

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CO2CRC

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GA-CO2CRC controlled release facility

- Collaboration between Geoscience Australia and the CO2CRC
- Hosted at CSIRO Ginninderra Experiment Station
- 800 hectares of cropping/grazing land
- 10km from centre of Canberra
- All year access
GA-CO2CRC Greenhouse gas controlled release facility, Ginninderra, ACT
Horizontal well and packers

- Based on ZERT facility
- 125mm φ HDPE pipe x 120m long
- Slotted every 0.5m over 100m, installed 2m deep
- Six release chambers
- Sandy loams and clays with occasional coarse gravel
**CO₂ supply**

- 2.5t liquid CO₂ tank
- Maximum CO₂ capacity is 600 kg/d
- First sub-surface release 144 kg/d & second 178 kg/d
- $\delta^{13}C$ of CO₂ ~ -18‰
  (source is primarily from an ethanol plant)
Techniques deployed during 2012

- Soil gas
- Soil flux
- Soil analysis
- Atmospheric tomography
- Eddy covariance
- Kr tracer studies (soil gas and atmospheric analysis)
- Electromagnetic surveys (EM31 and EM38)
- Ground penetrating radar
- Airborne hyperspectral
- In-field phenotyping (hyperspectral, thermal, 3D imaging)
- Microbial soil genomics
Can we quantify leakage?
Quantification - Soil flux

- Soil flux breakthrough was within 1 day
- Measured less than release rate for 6 weeks.
- Where is the CO$_2$ going?
Soil gas vs soil flux

- Considerable lag between surface expression of soil flux and sub-surface soil gas (1m deep)
- Detected Kr tracer in 1m deep well, 30m from horizontal well
- Surface CO$_2$ expression much less than sub-surface footprint (not “V” shaped)
Quantification using eddy covariance

• Detection works (given approx. location!)
• Quantification is problematic
  – Violates key assumptions, especially ones related to homogeneity
• CO$_2$ leaks are patchy
Surface biological CO$_2$ exchange

$F_c = CO_2$ flux
Technique needs more work for CO₂ leakage
Atmospheric tomography (Bayesian inversion)

Continuous measurements of atmospheric temperature, and wind speed and direction in all three dimensions allowed characterization of plume dispersion.

Both CO₂ and N₂O were released simultaneously from a small area source to simulate a leak.

Atmospheric sampling at 8 points surrounding the release using University of Wollongong FTIR Trace Gas Analyser and 8 separate Vaisala CO₂ sensors
Simultaneous localisation and quantification

CO$_2$ emission rate determined within 3%
Localisation determined within 1m
Wireless atmospheric CO$_2$ sensor array - Ginninderra
Scaling up: Atmospheric CO\textsubscript{2} sensor array (CO2CRC Otway Stage 2B)

- 9 - 15 t/d controlled CO\textsubscript{2} releases
- 8 Vaisala Carbocap sensors 150 - 470m from release point
- Big problems with accuracy and precision
- Data processing nasty
- Needs in-field referencing to higher precision instrument
- Localisation ok, accurate quantification appears tricky
Challenge: locating a surface leak

- Quantification ok, but finding leaks in the first place is tricky
- Model simulations suggest a diffuse leak (100mx100m) 1km from single atmospheric station needs to be ~50t/d before statistically detectable
- Point source ~ 20t/d at 1km

Latera Caldera, Italy (~10 t/d)
2\textsuperscript{nd} release at Ginninderra (Oct - Dec 2012)

Focus on finding leaks using surface techniques (178 kg/d)

- Airborne hyperspectral
- Ground penetrating radar
- In-field phenotyping
- Electromagnetic surveys
- Walking around!
Flying around?

- UAV rotorcraft equipped with CO$_2$ sensor

Photo courtesy of Uwe Zimmer and Florian Poppa, ANU
Summary

• CO₂ surface expression less than sub-surface footprint (no “V”)
• Quantification techniques still require work
• Finding small surface leaks over large areas remains the greatest challenge
• Cross calibration of techniques important
Researchers

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