Baseline Atmospheric Monitoring: Arcturus – a joint project of CSIRO and Geoscience Australia

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Why baseline atmospheric monitoring?

- **Risk of leakage**
  - High leakage rate:
    - Risks to health for the public & ecosystems
    - Local issue
  - Low leakage rate:
    - Impact on climate
    - Carbon management & accounting
    - Global issue

- **Baseline monitoring** – understanding the pre-existing variability of CO₂ (and associated tracers) – is integral to running a robust monitoring strategy that could credibly aim to detect a climatically compromising leak
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Terrestrial ecosystem
Our approach

• Ask what is a rational target for leakage detection

Global average leakage less than 0.1% of that stored p.a. required for long term mitigation

0.1% p.a. of industrial scale storage (~10^6 t) = 1,000 t CO₂ p.a.

Design a strategy that aims to meet this target


30% energy penalty

500 ppm stabilisation assumed
Concentration perturbations from our target leak rate

1000 t CO$_2$ p.a = 32 g.s$^{-1}$

Leaked from a single point (0,0,0)

Plots are horizontal contour plots (at 10m height) of the concentration enhancement induced by the leak under a range of atmospheric conditions (very little, through to considerable mixing)
Reliable flux recovery requires ≥1% enrichment

A controlled release study (Loh et al 2009) determined that enhancements of the order of 1% above background concentrations are required for reliable flux quantification.
Detection limits

Fraction of the target leak rate required to generate 1% enhancement in the background concentration

From Loh et al (2009)
Target leak rate for CH$_4$ = 72 t CH$_4$ p.a. (based on fraction of CH$_4$ in the reservoir at Otway)
Quantifying a ‘manufactured leak’ at Otway

Opportunistic controlled release

Geochemical sampling

Venting from the observational well head for 75 minutes

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Emission rates:
82 t CO$_2$ p.a. (< 10% target detectable leak)
67 t CH$_4$ p.a. (~ target detectable leak)

From Etheridge et al (2010)
Quantifying a ‘manufactured leak’ at Otway

Supported by forward modelling
Mean CH$_4$ enrichment at sampling location
40-45 ppb (one hour)
CSIRO GHG \textit{in situ} measurement sites
Arcturus

- Rural area – managed crops (sorghum, chickpeas) and grazing
- Geologically – sits in the Bowen Basin
- Container on easement of road
  - cropping to the east
  - grassland to the west
- Lat: 23° 51’ 31.4” S
- Long: 148° 28’ 28.6” E
- Mast intake heights: 10 m and 5 m above ground
- Met data: wind speed & direction at 10 m

- >40 km from towns, 500 km from coast
- Many mining activities in the area
- Beef feedlot in area
- (8 km from CO₂ geological injection project)

- CO₂/CH₄/H₂O and \(^{13}/^{12}\)CO₂ CRDS instruments operational in situ
- Flask samples ~ monthly for other trace gas species
- EC tower (CO₂, CH₄ and H₂O) recently installed
Issues at Arcturus

• Moderately remote
  • 50 km from Emerald (nearest airport)
  • 30 km dirt road
  • 4WD

• Mains power unreliable
  • Dual conversion UPSs recently installed, 4 hours runtime for each instrument

• Water
  • heavy rain makes roads impassable

• Communications
  • Can be patchy
Operating coal mines in the Bowen Basin
Understanding the $\text{CH}_4$ variability

- Estimates of emissions from coal mines in the region were used in CSIRO’s TAPM (The Air Pollution Model), to generate a time series of $\text{CH}_4$ concentrations at Arcturus expected to be contributed from the coal mine emissions.

- Predicted excursions of 20 -100 ppb are frequently coincident with measured enhancements of similar magnitude, structure and duration.

- Mismatches due to:
  - Time varying emissions from mines
  - Additional regional and local sources of $\text{CH}_4$ (e.g. cattle and soil emissions)
Future work – incorporating flux measurements

Flux measurements will help to resolve the contribution of local CO$_2$ and CH$_4$ sources.

We will develop our understanding of the CO$_2$ climatology through further modelling.

The largest contribution to CO$_2$ variability is likely to be agricultural crops and natural vegetation.
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