Australian Government
Geoscience Australia

Quantifying surface CO_2 leaks

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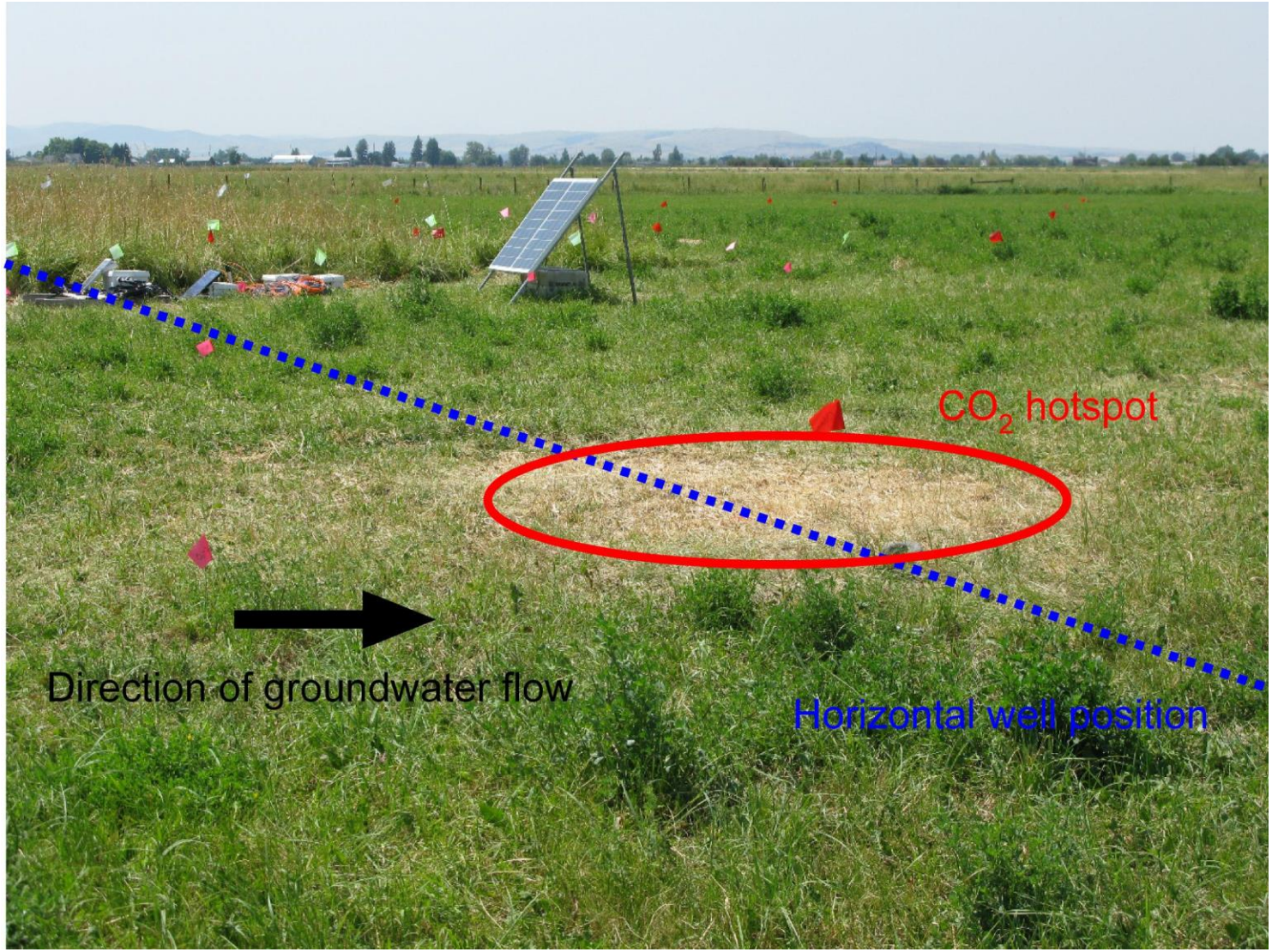
What would a leak look like?

- No reported CO_2 leaks from CO_2 storage sites
- Investigating possible leakage scenarios using:
  - natural CO_2 leaks
  - simulated leaks from controlled release facilities

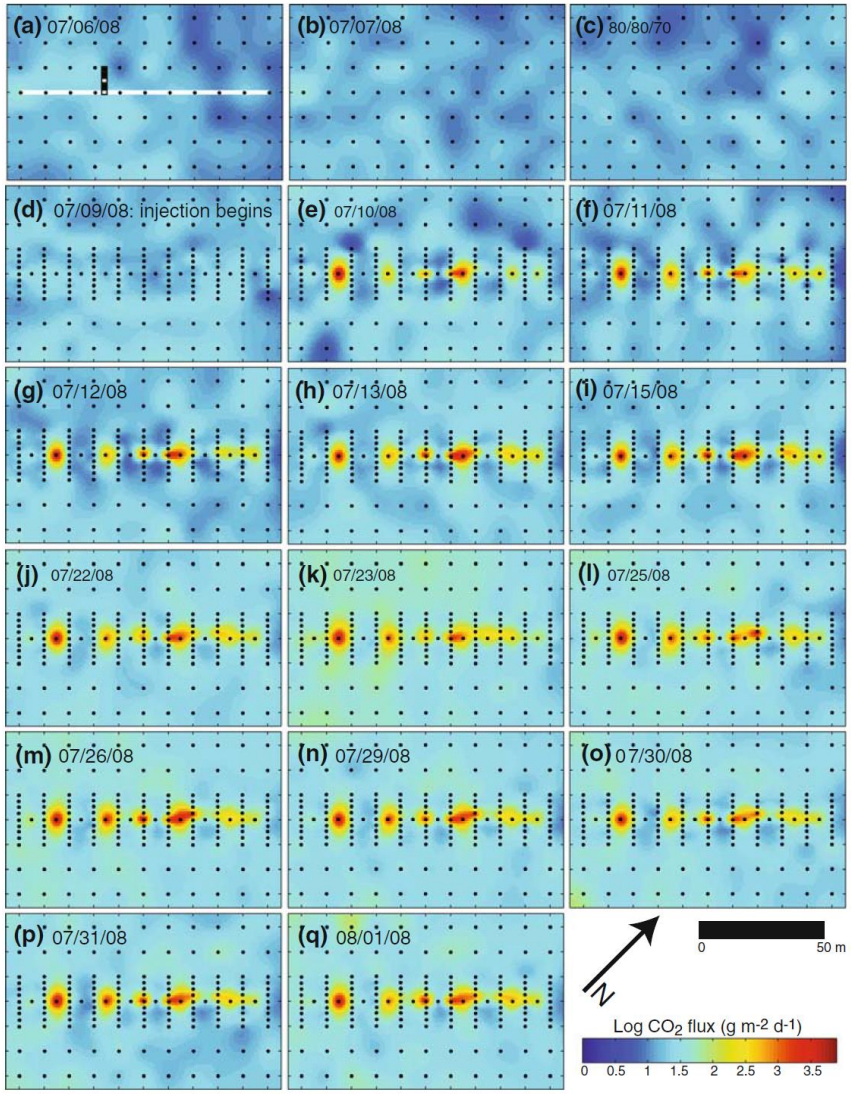
ZERT controlled release facility, Montana USA

CO_2 release from a 70m long line source, 2-3m underground

ZERT – 0.1 t/d simulated CO_2 leak



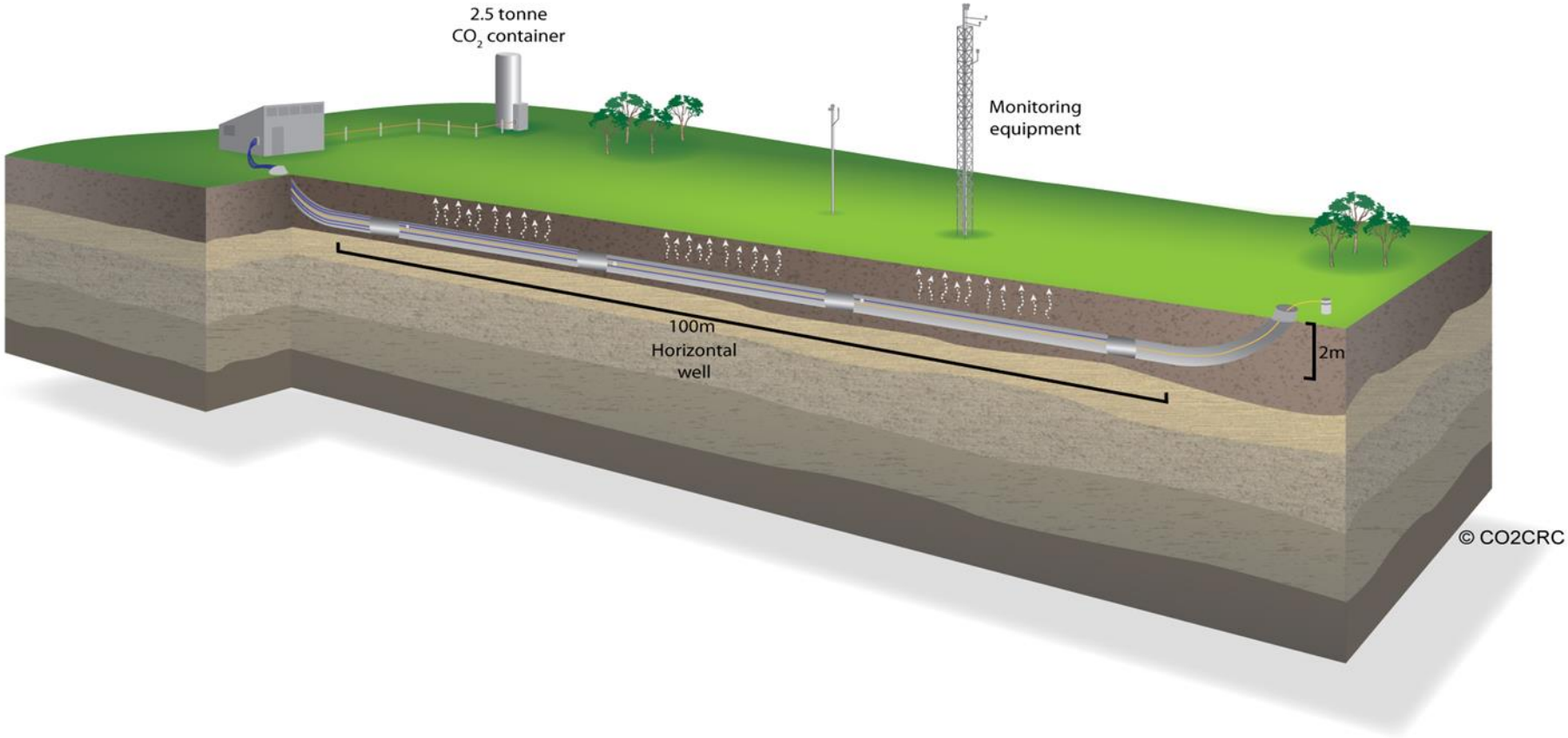
ZERT surface hot spots



Lewicki et al., 2010

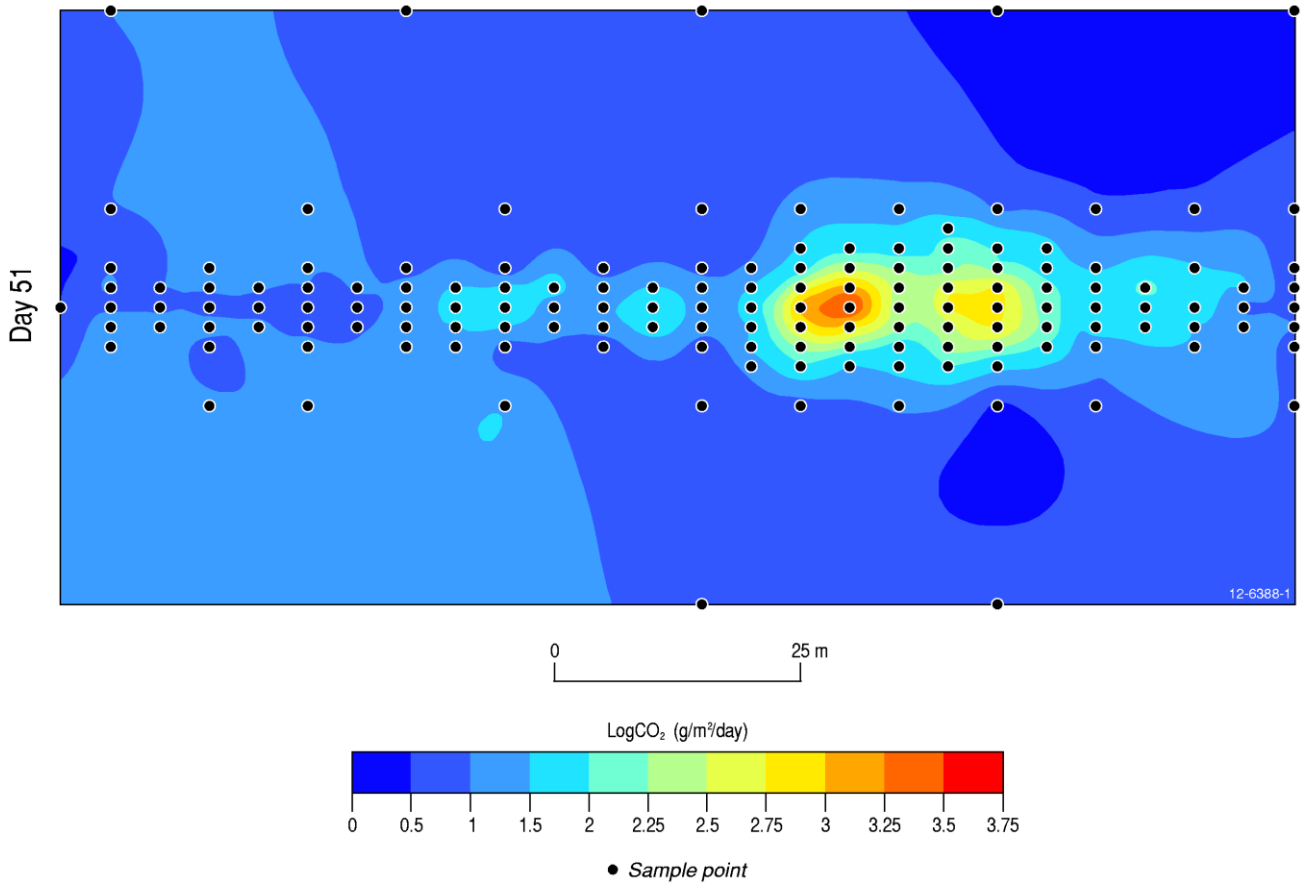
Ginninderra controlled release facility, Canberra

CO_2 release from a 100m long line source, 2m underground



Ginninderra - 0.1 t/d simulated CO_2 leak

Ginninderra CO_2 hot spots



Natural CO_2 leaks at Latera Caldera, Italy

~10 t/d natural CO_2 leak

Natural CO_2 leaks at Latera Caldera, Italy

- ~10 t/d natural CO_2 leak
- Views of CO_2 bubbling up through stream

Natural CO_2 leaks at Latera Caldera, Italy

0.2 t/d natural CO_2 leak

Leaks are ‘patchy’

- Patchiness is a common theme from controlled release experiments (ZERT, Ginninderra, CO2 Lab (Norway)) and natural CO_2 seeps
- CO_2 finds highest permeability pathways to the surface
- High fluxes over a small area, not low fluxes over large areas
- Patches of dead vegetation a good indicator
- What appears homogenous is not when it comes to leakage

How do we quantify a leak?

- Primary technique is soil flux measurements
- Atmospheric measurements
  - Eddy covariance
  - Single sensor
  - Sensor array
  - Integrated line measurements

Soil flux

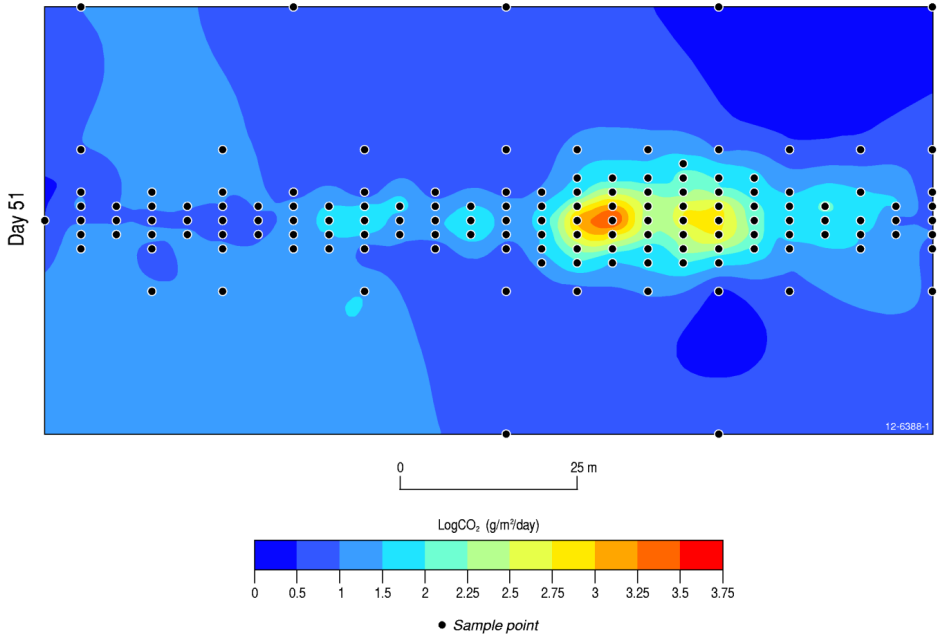
- Quick and easy but laborious
- ~150 measurements per day
- Accuracy is ~ 15%
- Two different approaches:

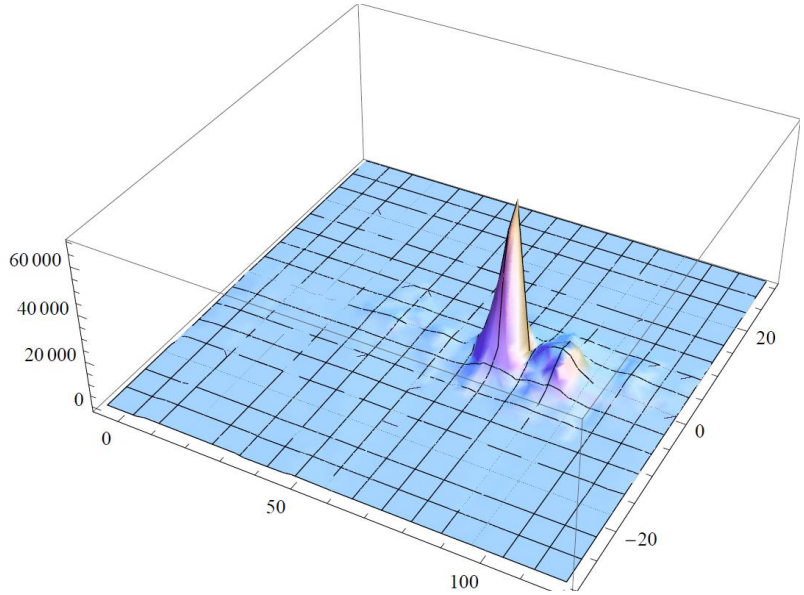
semi-permanent collars

Westsystems, 2012

portable chamber

Soil flux – integrate flux measurements for total emission





g/m²/d

0.1 t/d leak

Atmospheric techniques – Eddy Covariance

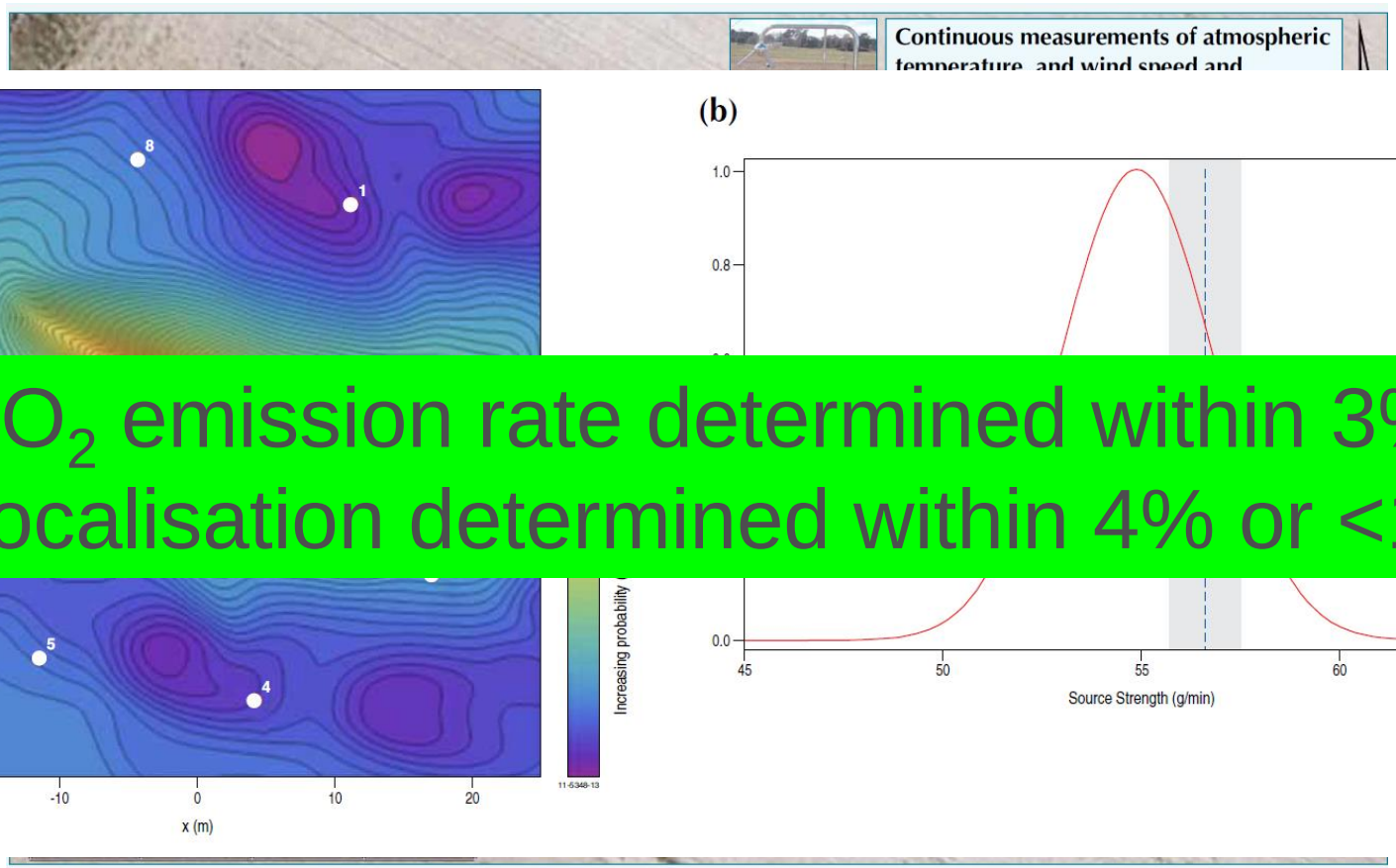
- Measures the vertical flux over relatively small areas (e.g. ~100 x 100m)
- Quantifying leaks requires lot of data processing
- Footprint not well defined
- Application to small leaks could violate EC assumptions

Atmospheric techniques - single sensor

- Quantifying leaks requires lot of data processing
- Need meteorological data
- Need to be downwind of leak
- Couple with modelling software:
  - Backward Lagrangian Stochastic “bLS” model for short distances (e.g. Windtrax)
  - atmospheric transport models for greater distances (e.g. TAPM)
- Total flux quantification can be moderately accurate (e.g. typically 10-50%)

Atmospheric techniques – sensor array

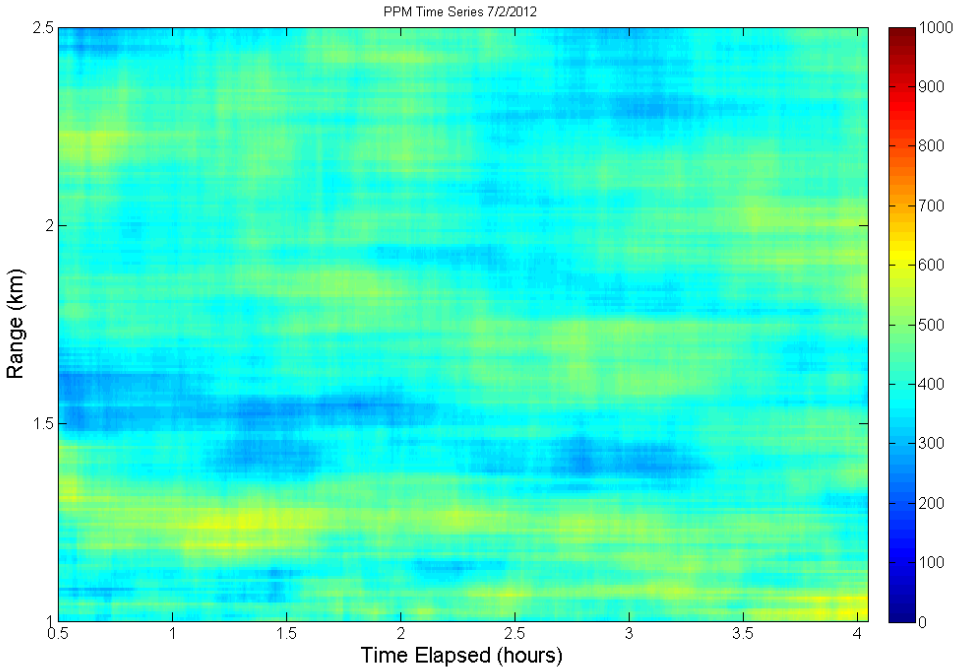
- Atmospheric tomography – very accurate
- Requires lots of measurements and large amounts of data processing



CO_2 emission rate determined within 3%
Localisation determined within 4% or <1m

Atmospheric – integrated line measurements

- Line measurements (e.g. DIAL or TDL) could resolve emissions quicker and accurately when coupled to inverse models
- Tuneable Diode Laser (TDL) systems presently too insensitive for small CO_2 leaks



CO_2 DIAL system (Figures courtesy of Kevin Repasky, Montana State University)

Conclusions

- CO_2 leaks likely to be small and patchy
- Soil flux measurements easiest method for quantifying leaks
- Atmospheric tomography is very accurate but difficult and slow
- Integrated line measurements coupled to inverse modelling show promise for rapid quantification (e.g. within a day)
- But … need to find the leak in the first place
  - ➢ soil flux and atmospheric techniques are primarily for quantification, not detection

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Questions?