Surface gas measurements and monitoring of geological CO_2 storage sites:

Experiences at Weyburn and In Salah

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Introduction

- Near surface gas geochemical monitoring of industrial scale CO2 storage sites has been carried out in two sites with different environments, infrastructure and stages of development
- The main objects of the research are:
  - Baseline definition
  - Detection of gas migration pathways
  - Detection of possible migration around abandoned wells
  - Assessment of soil gas methods

Introduction

- **In the following discussion a comparison among the results obtained for the two sites will be presented**

- **How do local characteristics influence obtained data and study approach?**

Methodology

Both sites:

- **Soil gas sampling and analysis for CO_2, O_2, N_2, methane, ethane, ethylene, propane, He, Rn (lab and field measurements)**
- **CO_2 gas flux measurements**

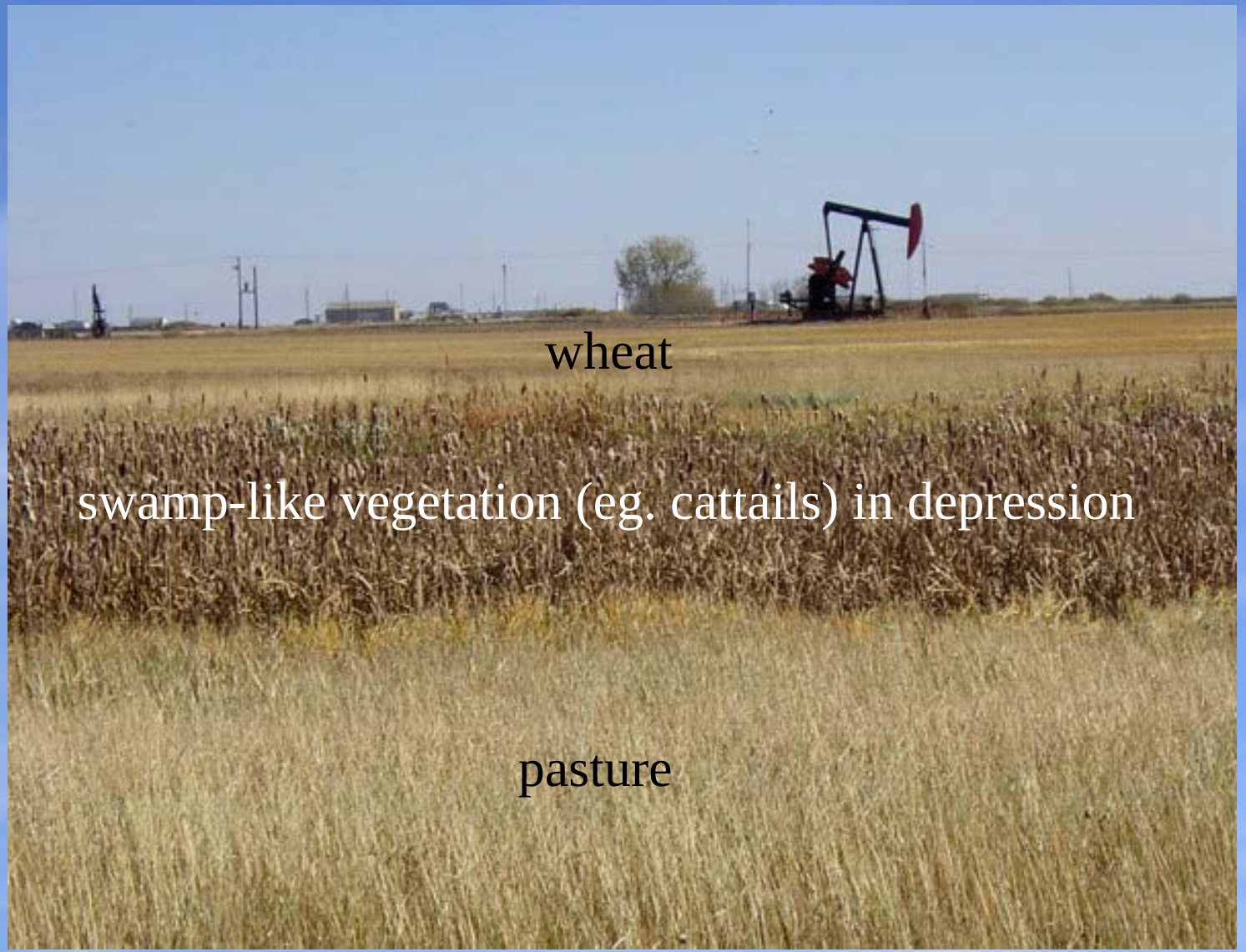
Weyburn only:

- **Continuous monitoring radon probes**
- **Gamma spectrometry**
- **Limited $\delta^{13}C$ of CO_2 measurements**

Sites – comparison

	Weyburn	*In Salah*
Type	Industrial - EOR	Industrial
Injection depth	1500	1850
reservoir	Mississipian cbte	Carboniferous ss
population	Low density, agricultural	Essentially zero
topography	flat	Plateau, wadis
Injection period	5 years	1 year
Total wells	> 600	7
climate	Semi-arid continental	desert
Surface geology	Soil, glacial till	Sand, rock
Surface/grdwater	Ephemeral swamps / perched water tables	None / very deep

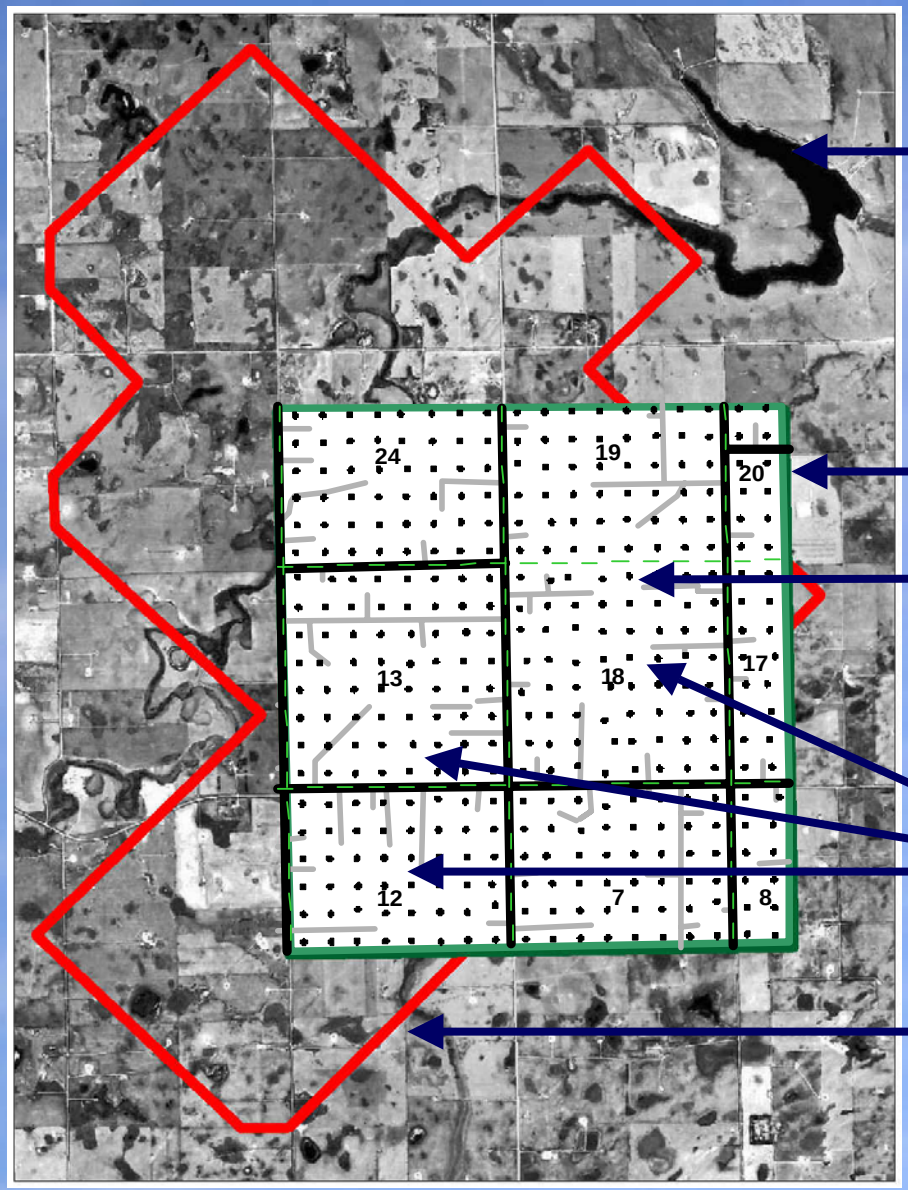
Weyburn - description



Weyburn – approach

- Sampling conducted over 5 years during 6 campaigns:
  - July 2001
  - September 2001
  - September 2002
  - October 2003
  - October 2004
  - October 2005
- Grids – regional over injection area, detailed above abandoned wells and semi-detailed at background site
- horizontal profiles and shallow vertical profiles
- Only the regional grid data, and related statistics, will be presented here, including data for the last 5 years.

Weyburn – study site



Permanent surface water

Main grid boundary

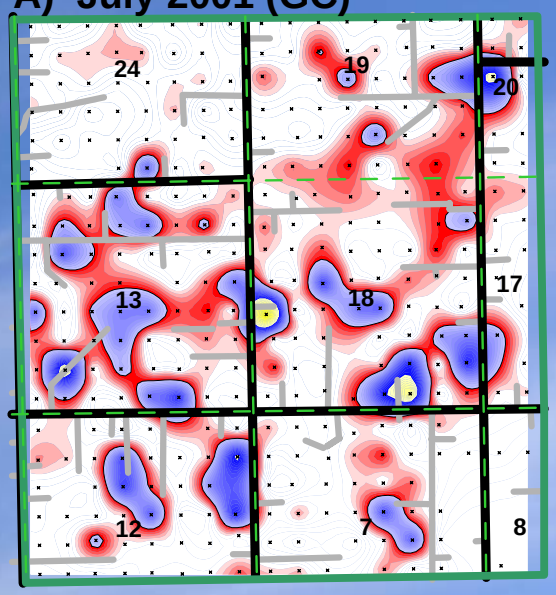
Main grid sampling point

Ephemeral surface water and depressions

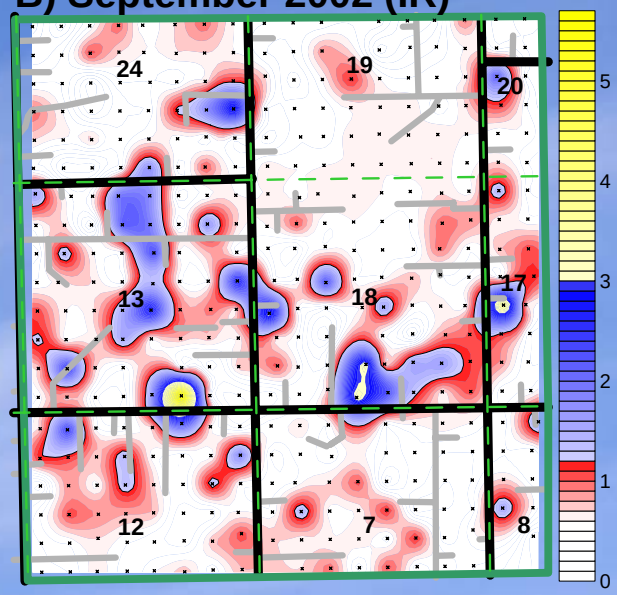
Phase A1 boundary

Weyburn – soil gas CO_2

A) July 2001 (GC)

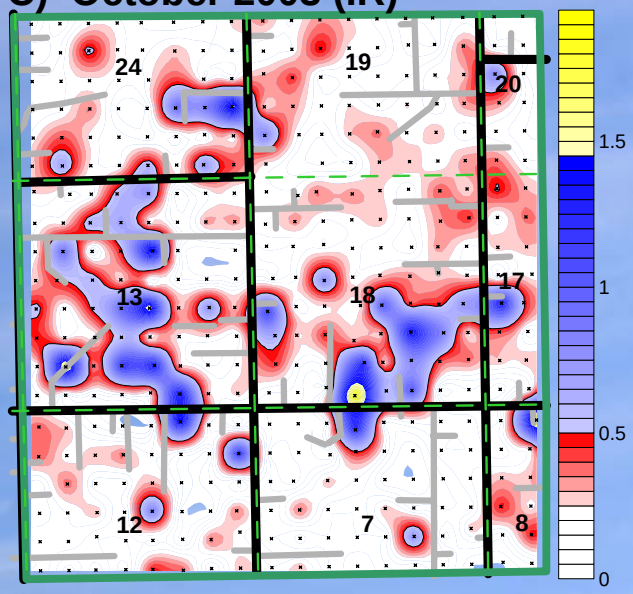


B) September 2002 (IR)

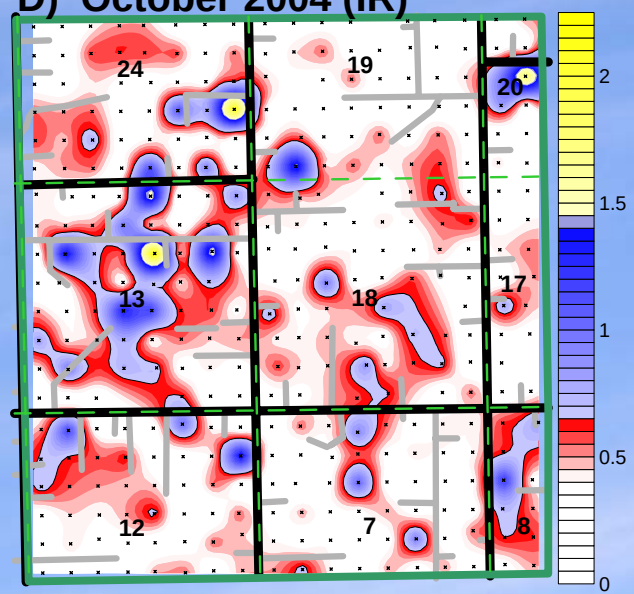


- different concentration ranges but consistent anomaly locations.
- anomalies likely linked to shallow biogenic processes, organic matter, water content etc

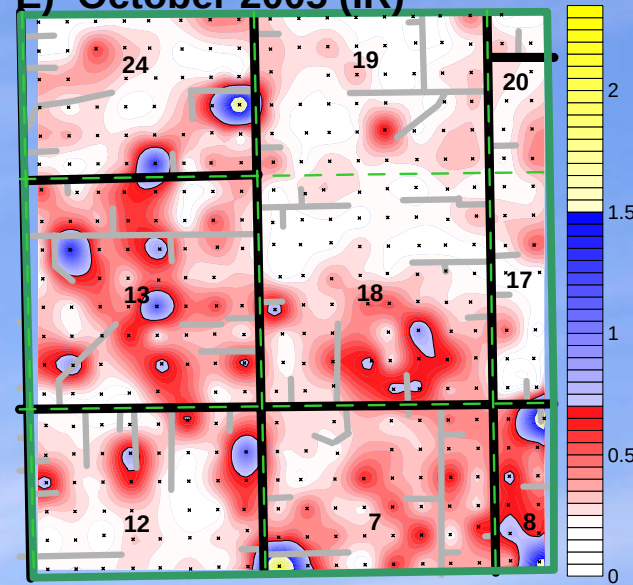
C) October 2003 (IR)



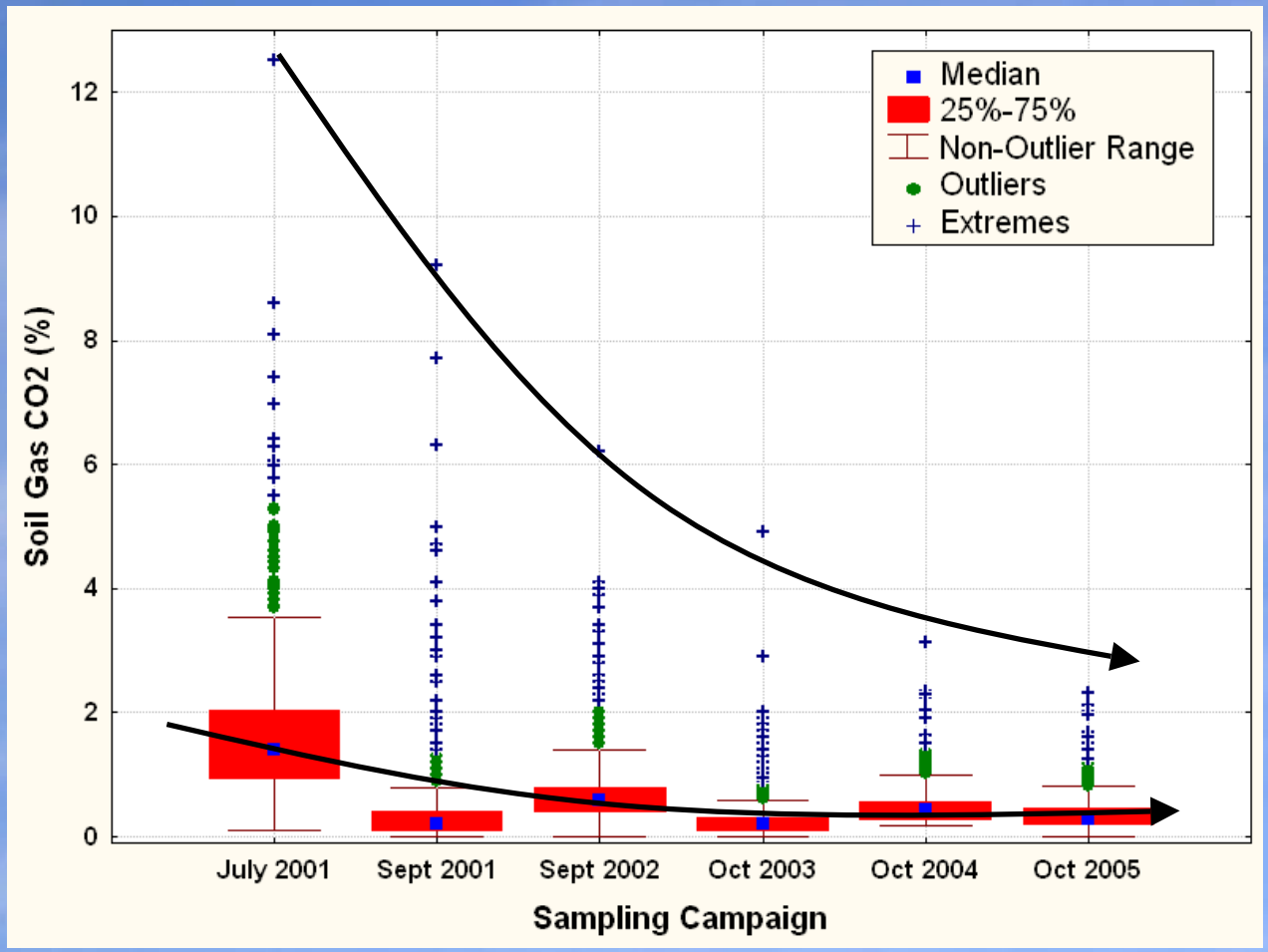
D) October 2004 (IR)



E) October 2005 (IR)



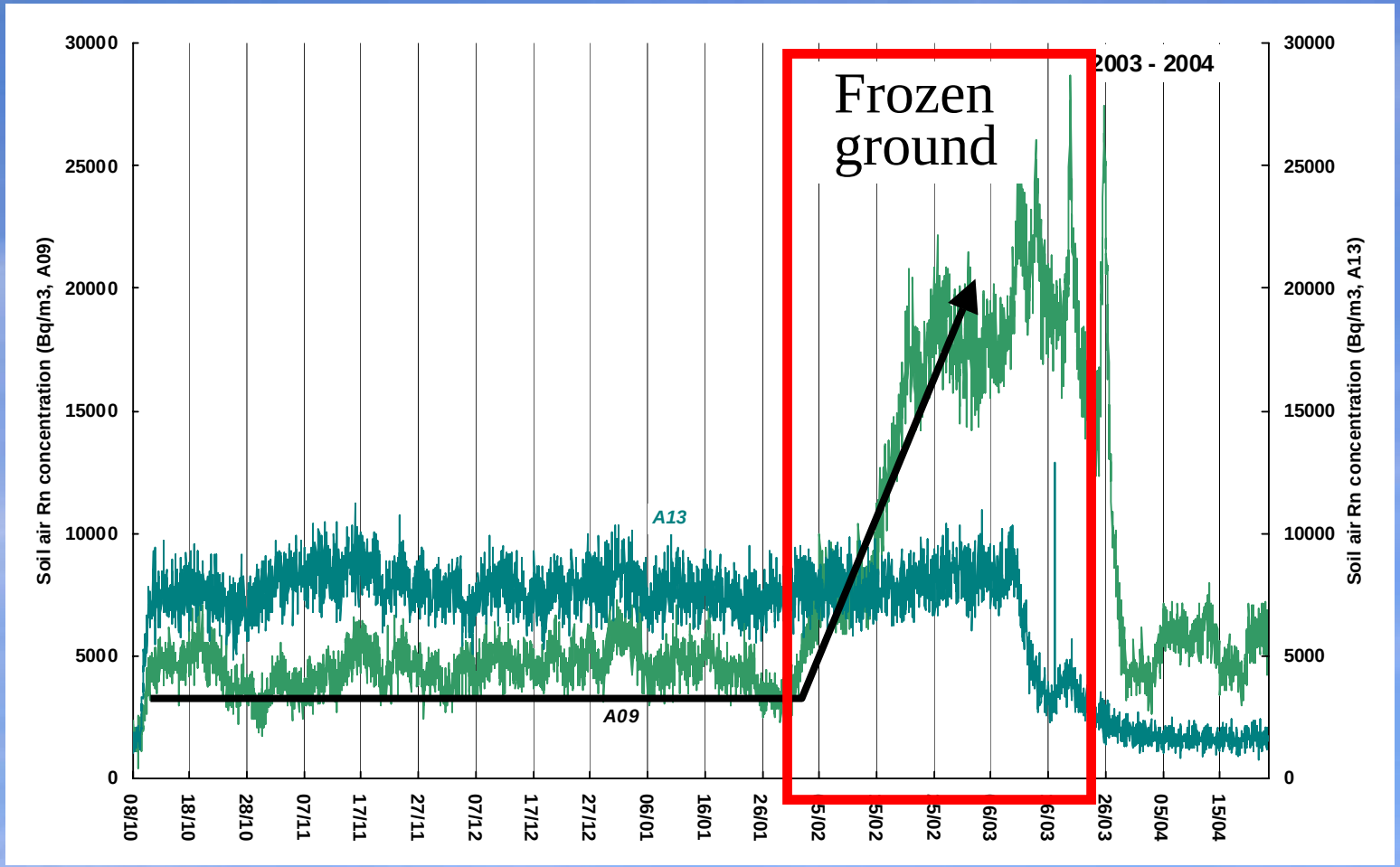
Weyburn – soil gas CO_2



Extremes approach constant value

Median approaches constant value

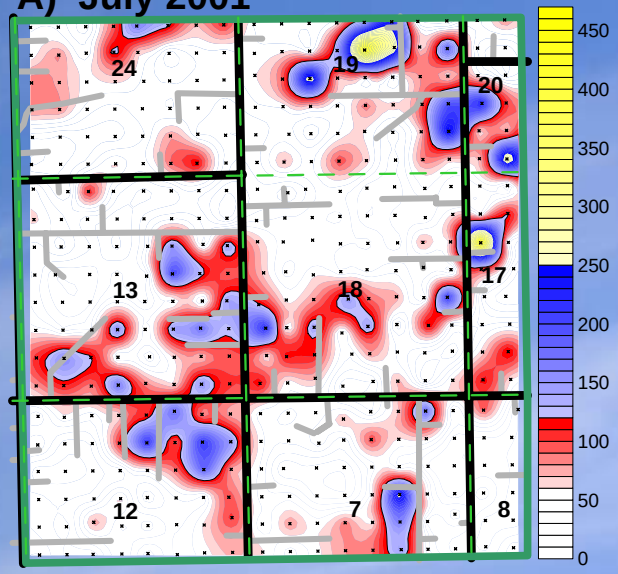
Weyburn – continuous Rn monitor



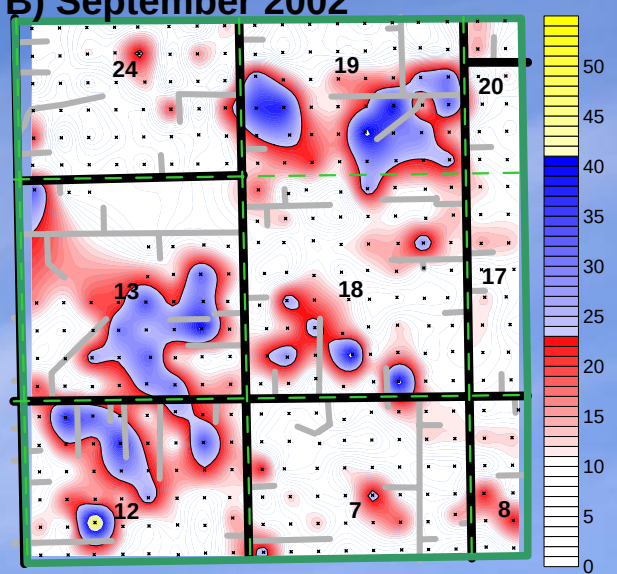
- The soil surface can freeze, preventing the escape of soil gases to the atmosphere and thus accumulation
- Here soil frozen for 5 weeks results in the progressive built up of Rn inside the continuous radon monitor in mid to late winter

Weyburn – CO_2 flux

A) July 2001

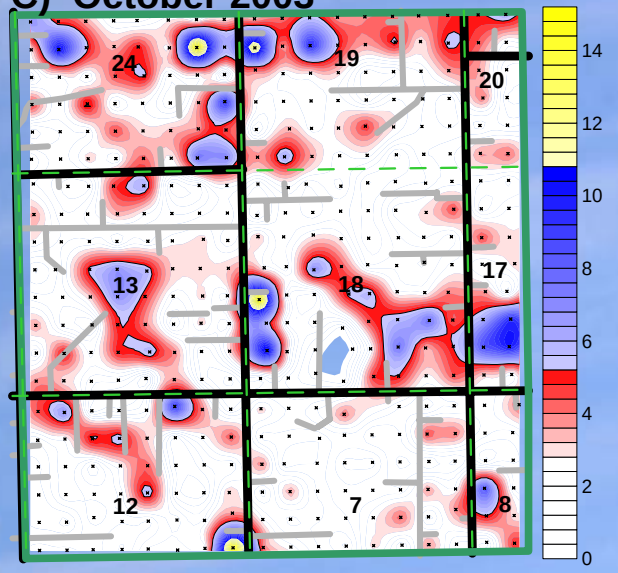


B) September 2002

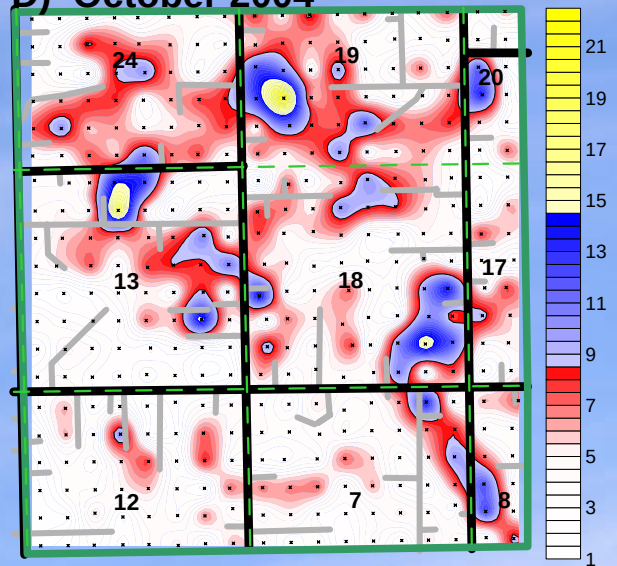


- July and September distributions similar
- All 3 October surveys similar
- Maybe due to similar moisture regime

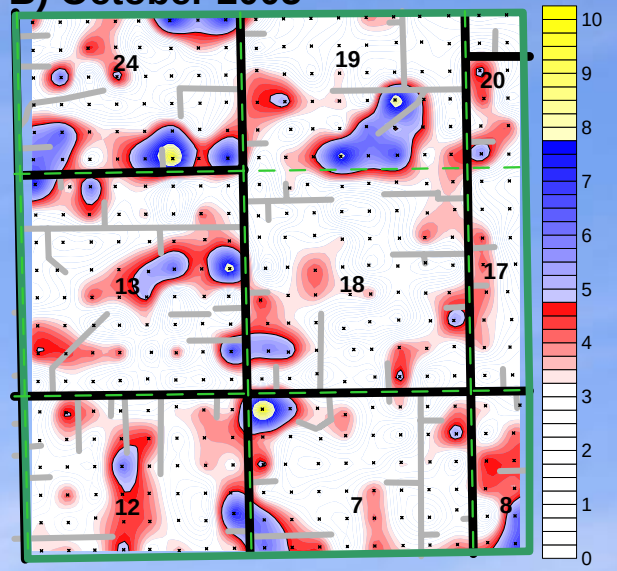
C) October 2003



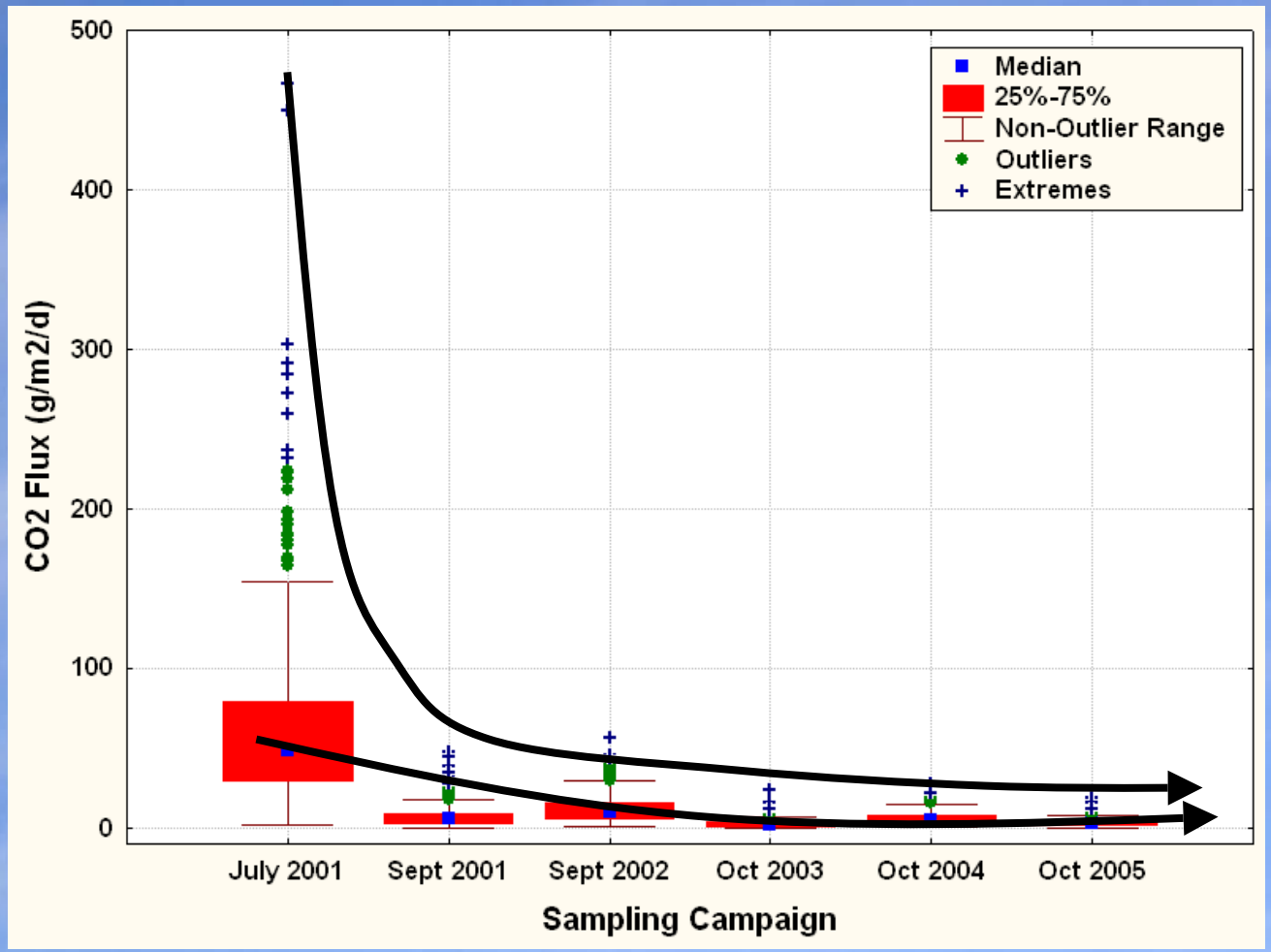
D) October 2004



B) October 2005

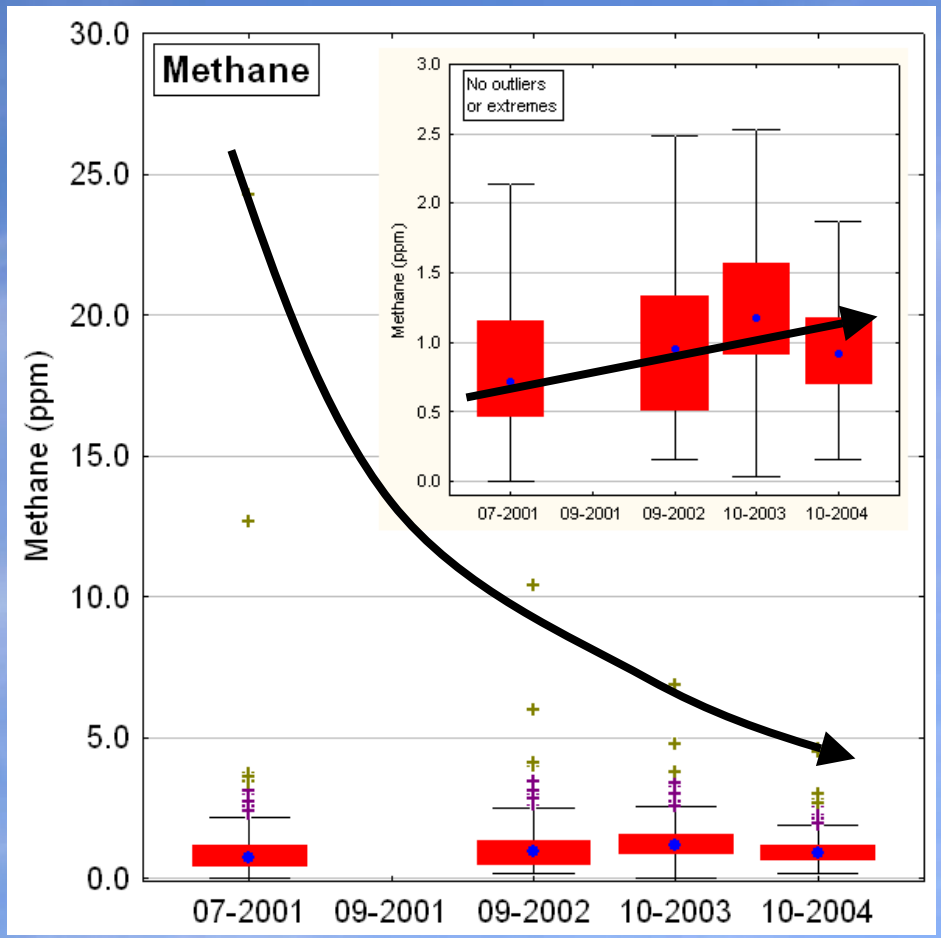


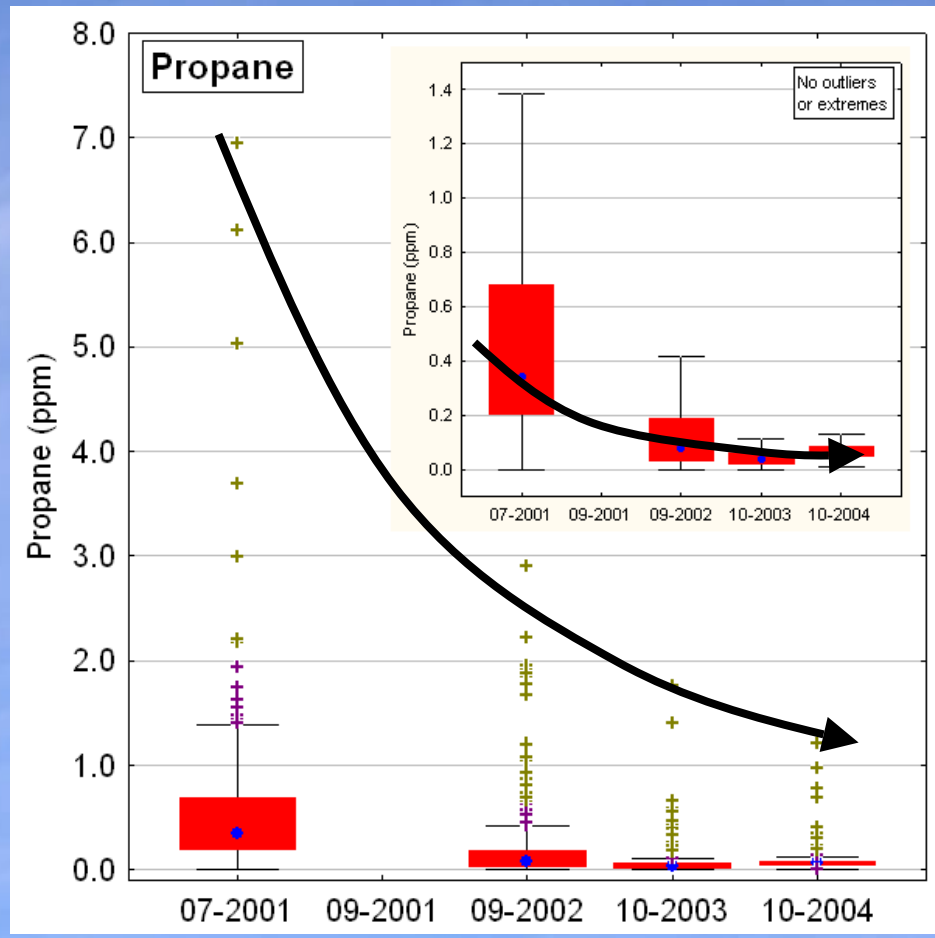
Weyburn – CO_2 flux



Extremes and median almost constant during all fall campaigns

Weyburn – hydrocarbon gases

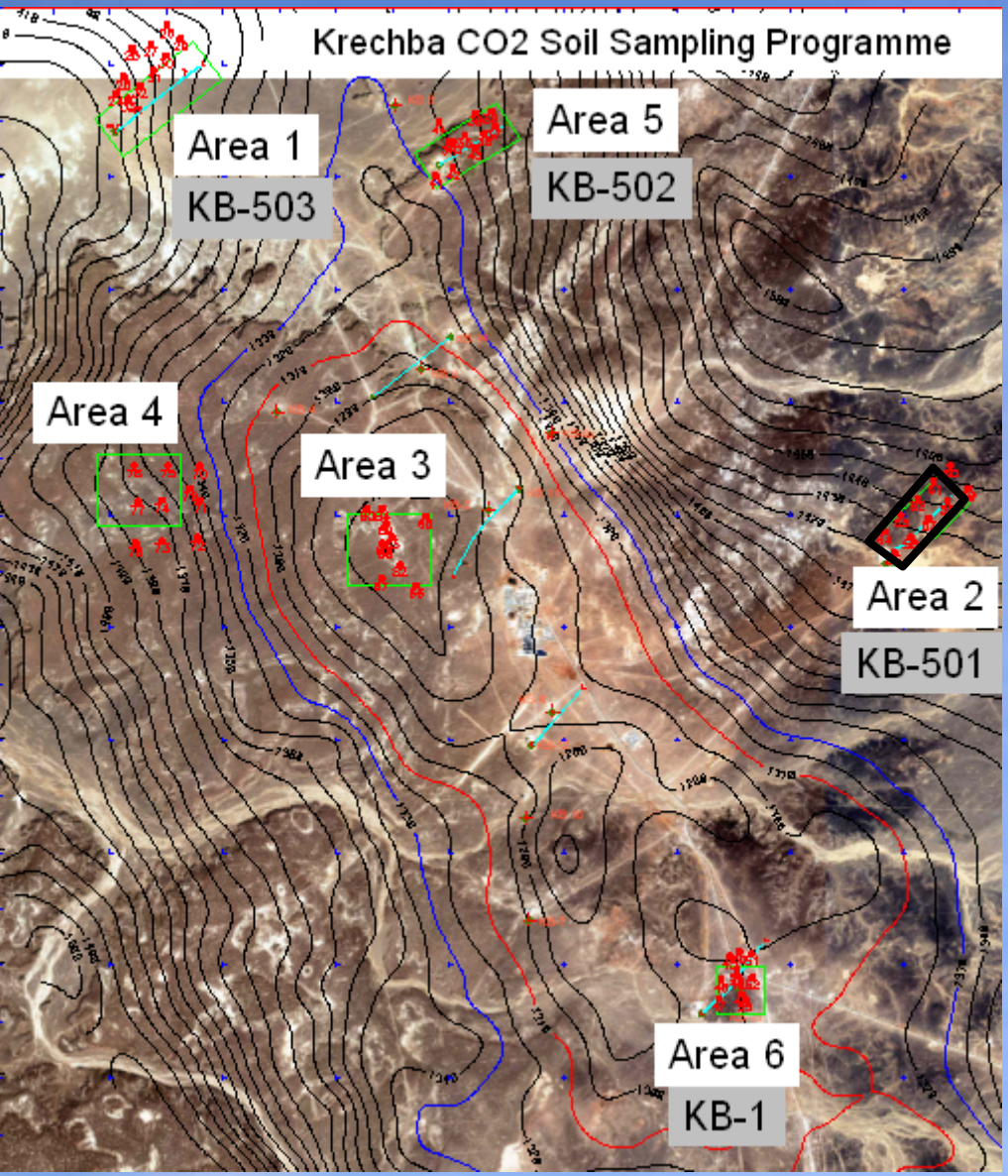




- Methane (and ethane) decrease in outliers but slight increase in median due possibly to dryer ground and diffusion from atmosphere
- Propane shows decrease in outliers/extremes, and also decrease in median similar to CO2 and CO2 flux

In Salah

In Salah – Feasibility Study



Sampling areas:

- 3 around CO2 injection wells (KB501-503)
- 1 around original discovery well (KB-1)
- 1 at top of reservoir structure
- 1 in background area

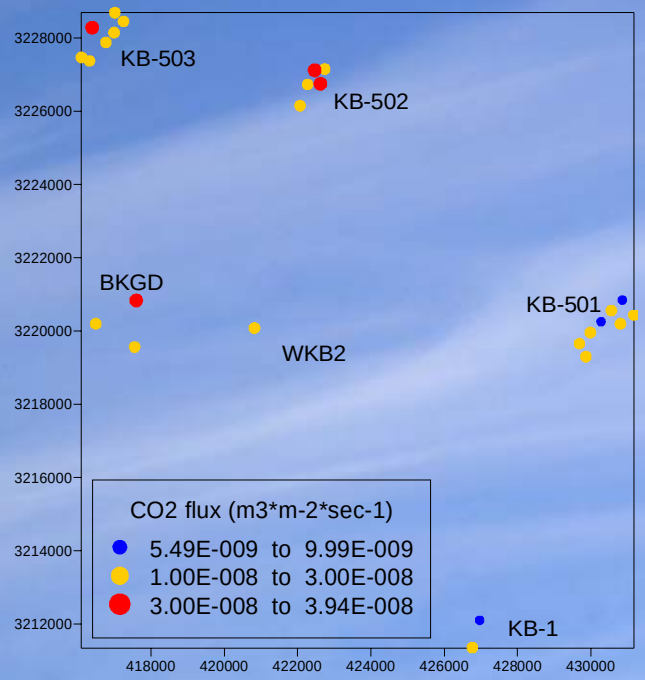
Contours

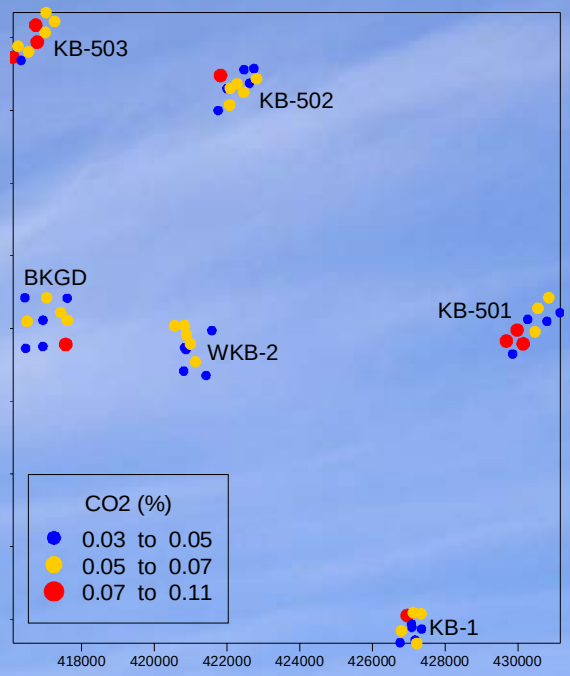
Red delimits gas in reservoir

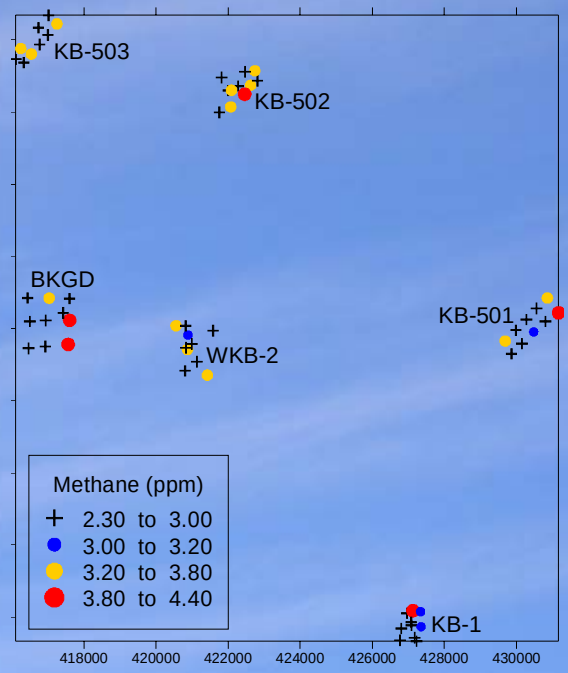
Blue delimits water in reservoir

CO2 is injected below the gas-water contact

In Salah



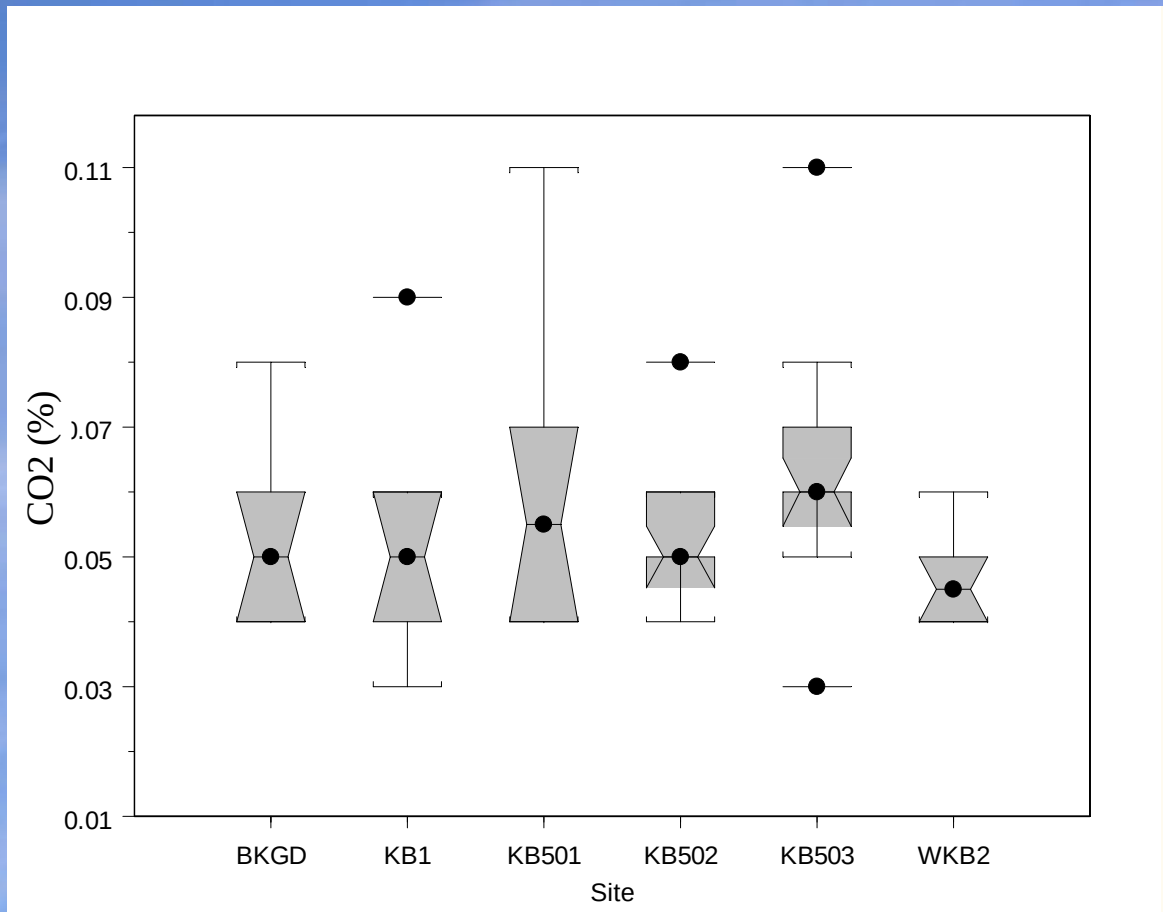




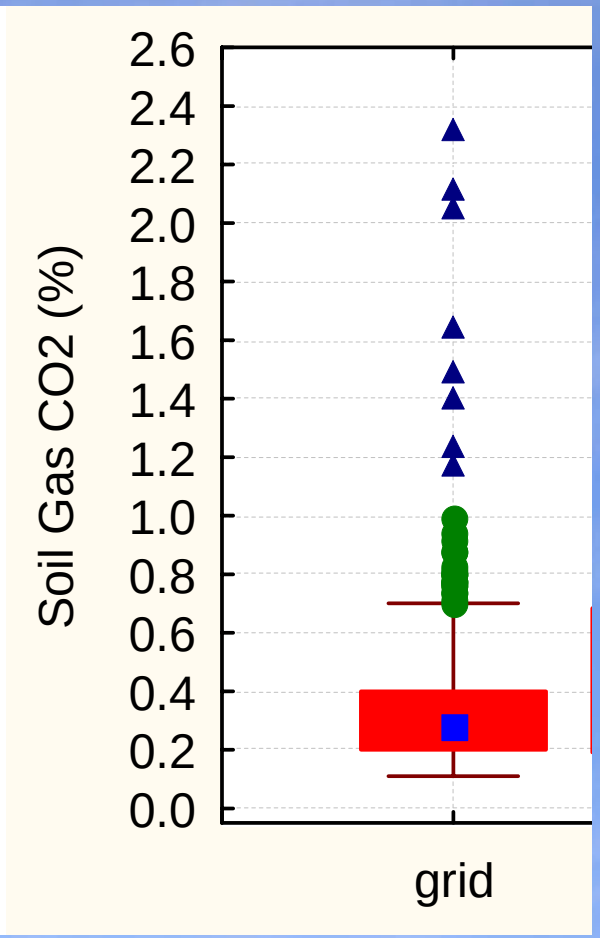
- in general all 5 sites show similar ranges of concentrations
- CO2 and CO2 flux values are extremely low
- methane values are slightly higher than normal for soil gas

CO2 statistical comparison

In Salah



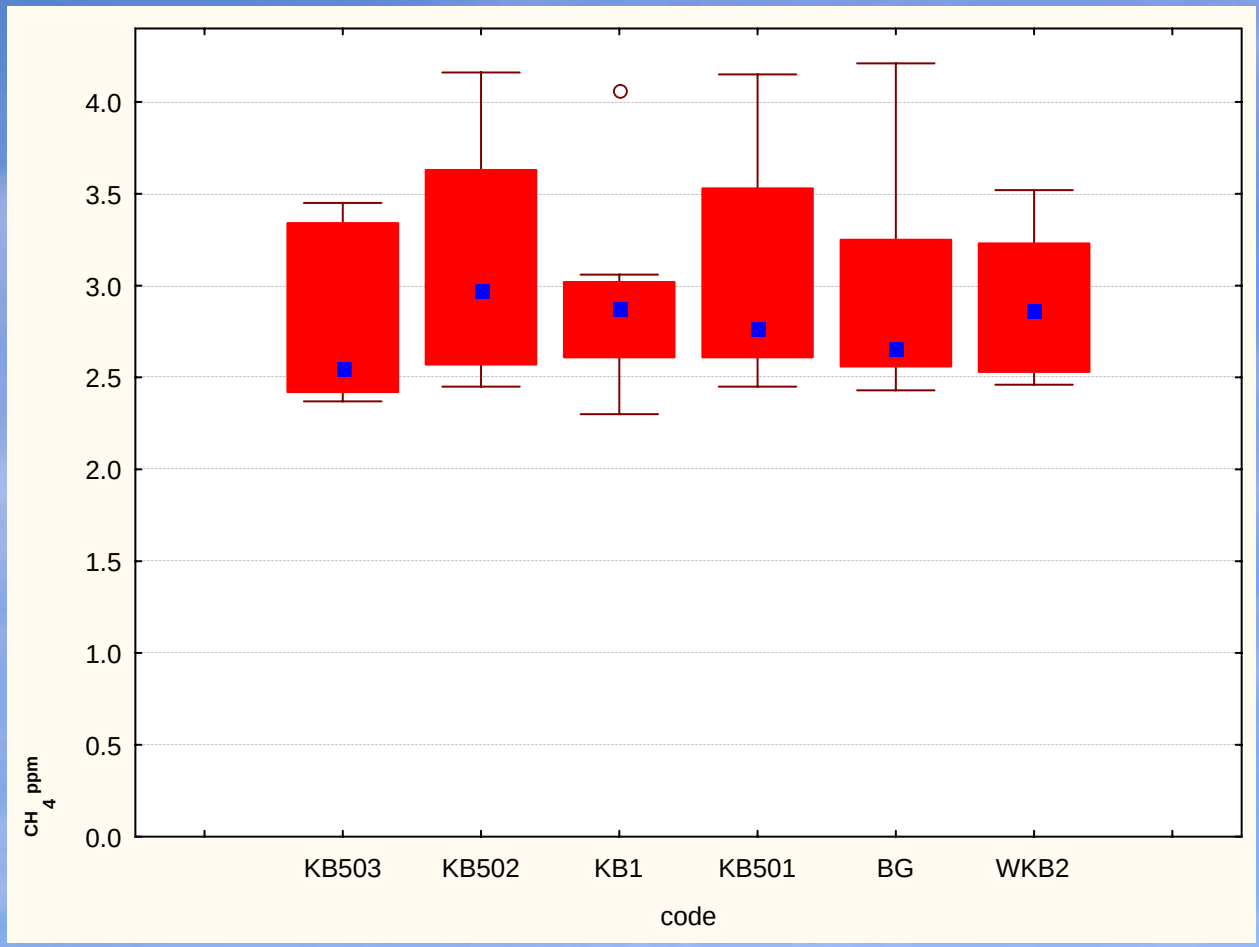
Weyburn



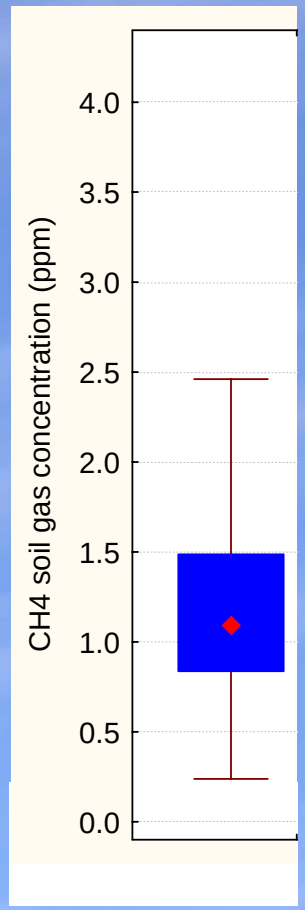
- note that there is a 1 order of magnitude difference in values between the two sites. CO2 flux shows similar picture

CH4 statistical comparison

In Salah



Weyburn



- CH4 values are consistently higher at In Salah, at all 6 study areas, including the background site. No methanotrophy.

Conclusions

- The different shallow geological setting and climate may influences the distribution of soil gases in terms of migration and consumption / production reactions.

- At Weyburn late fall sampling is recommended to minimise the signal of biogenic CO2 while at the same time avoiding the problem of frozen soil allowing gas accumulation.

- In contrast the desert conditions at In Salah mean that there is very little biogenic signal, and thus there is the potential to more easily detect a small leakage from depth and sampling period is less critical

- However the dry, highly permeable and almost sterile sandy soil at the desert at the In Salah site results in the rapid downward migration of atmospheric gas. Thus future sampling will be much deeper.

Recommendations

- Baseline sampling should be conducted during different seasons to define the range of natural soil gas variations
- Sampling strategy is likely to be a compromise between having a high enough sample density to locate what may eventually be a small leak and the need to cover large areas..
- As such preliminary studies should be conducted, including geology, structural and remote sensing, in order to focus on potential migration pathways such as faults and wells.
- In addition to the standard soil gas approach, more detailed work at these limited number of sites could include deep vertical profiles and isotopes to help separate deep and shallow processes.