Characterisation of European CO_2 storage

Baseline SiteChar Webinar

Understanding natural variability as a framework for site selection, monitoring programs and public awareness

Salvatore Lombardi
Università di Roma « La Sapienza »

Introduction

- **One of the best ways to ensure public safety, to prove that stored CO_2 is not returning to the biosphere, to trace gas migration pathways (site characterization) or to quantify leakage, is by *direct* CO2 concentration at surface and flux measurements.**
- **However, near surface biological production of CO_2 can mask a leakage signal and complicate interpretation of data**
  - **We need to understand this baseline**
  - **In the following presentation an overview of basic concepts on CO2 baseline and its meaning in Carbon Geological Storage (CGS), and deep seated gas migration, will be given**

Introduction

Stakeholders at large seldom are aware of gas migration processes, gas production in soils, gas exchange among soil and atmosphere, etc.

This is true even in countries like Italy where gas emanations are relatively common… next to our doors

Introduction

….Literally close to our doors

An example of macro leaks on shore at Ciampino town (Alban Hills - Roman Volcanic Province) Italy
Houses are only 50 m away from the fence of a gas vent with a flux of more than 7 tons of CO2 per day

Introduction

Furthermore, not many people know that CO2 in soil pore space may have two components:

- **A shallow one - Shallow natural sources are typically plant root and microbial respiration**
- **A deeper one - Deeper natural sources can result from groundwater degassing, CH_4 oxidation, and natural CO_2 reservoirs**

Introduction

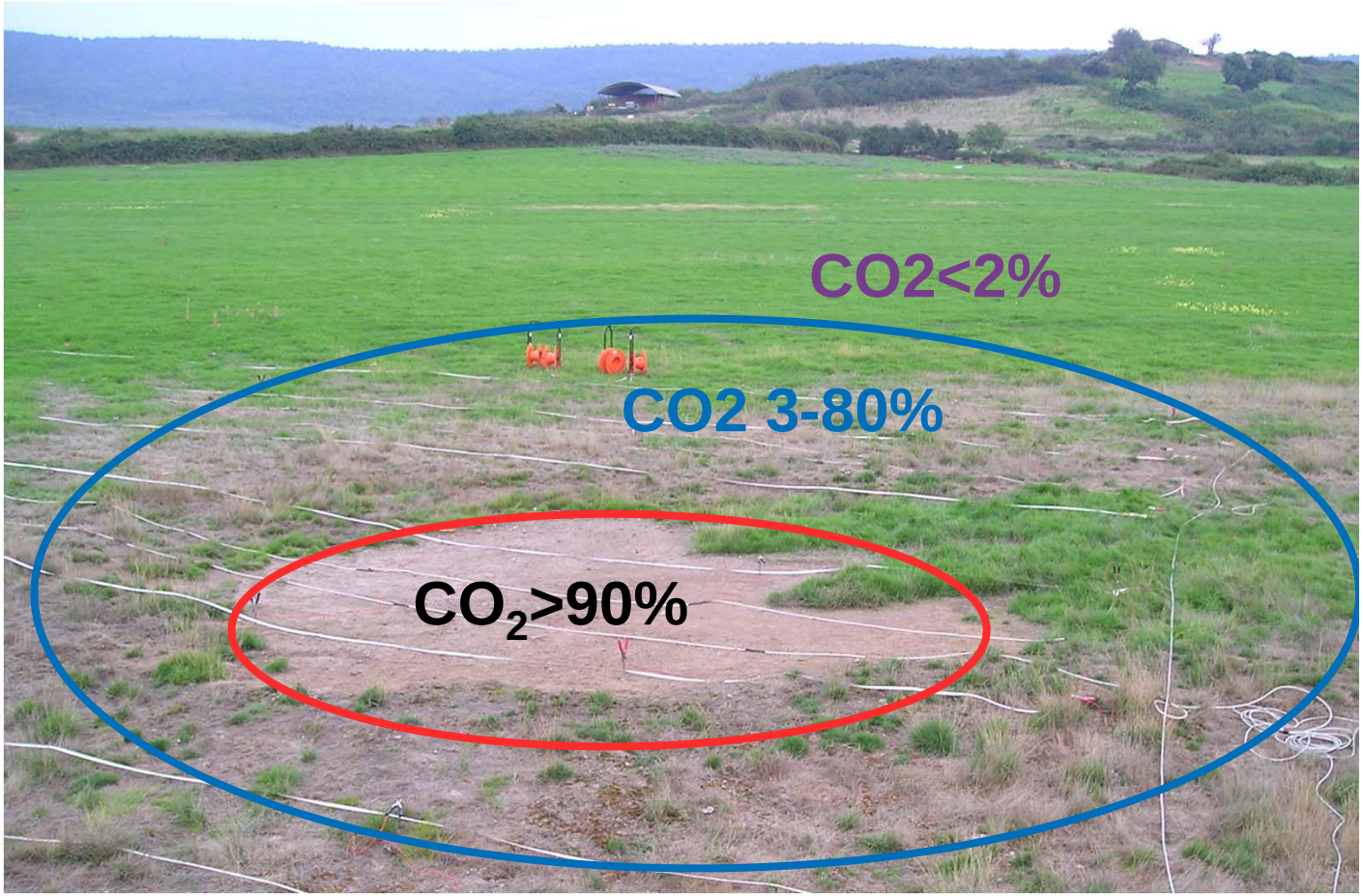
- **…. or that deep seated gas migration may give at surface macro and micro seeps**

  - **Macro seeps (see Ciampino example) are:**
    - **usually visible gas vents,**
    - **may have significant impact on the environment , even if usually at very small scale only,**
    - **mainly occur in volcanic and geothermal areas, over natural CO2 fields, along major faults**
  - **Micro seeps are:**
    - **Not visible gas emanations, detectable only by instruments**
    - **Do not have any impact on shallow environment**
    - **May be very useful: for detecting gas migration pathways; as early warning signal of gas migration from deep seated reservoirs**

Example of macro seep

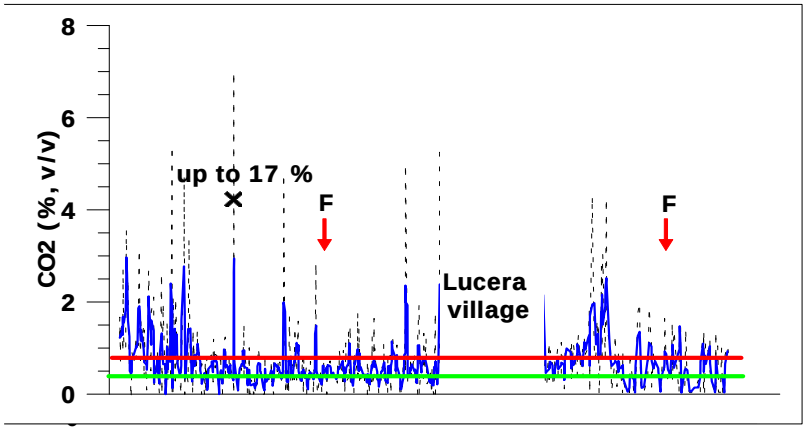
Macro seep at Latera caldera (central Italy)

Soil gas CO2 concentrations at 80 cm



Microseep: detection of migration pathways

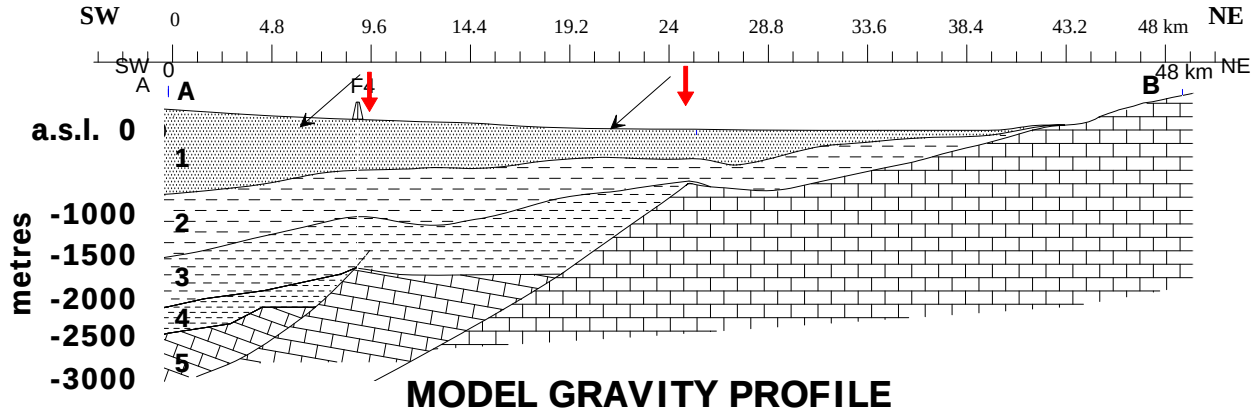
Micro seeps - Detection of hidden faults Soil gas anomalies at Candelaro Fault (Lucera Plain) Italy



BG

Anomaly

Moving average

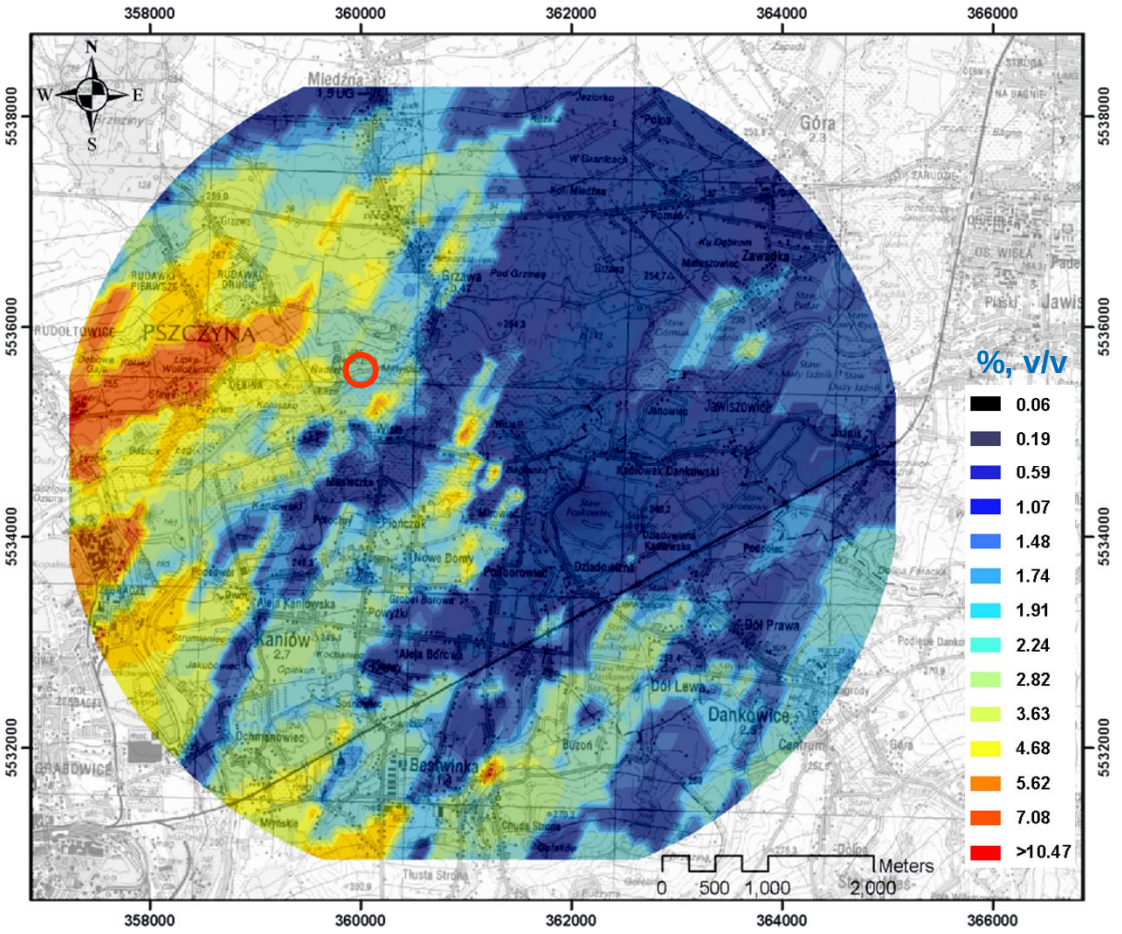


(Di Filippo et al., 1997)

Micro seep: as indicator of gas migration around an injection well

The red circle indicate the location of a CO2 injection well at Kaniow (Poland)
CO2 concentration in the surrounding area of the well is lower than the regional background
Microseeps occur locally and show a minor leak around the well (MoveCBM, EC project)

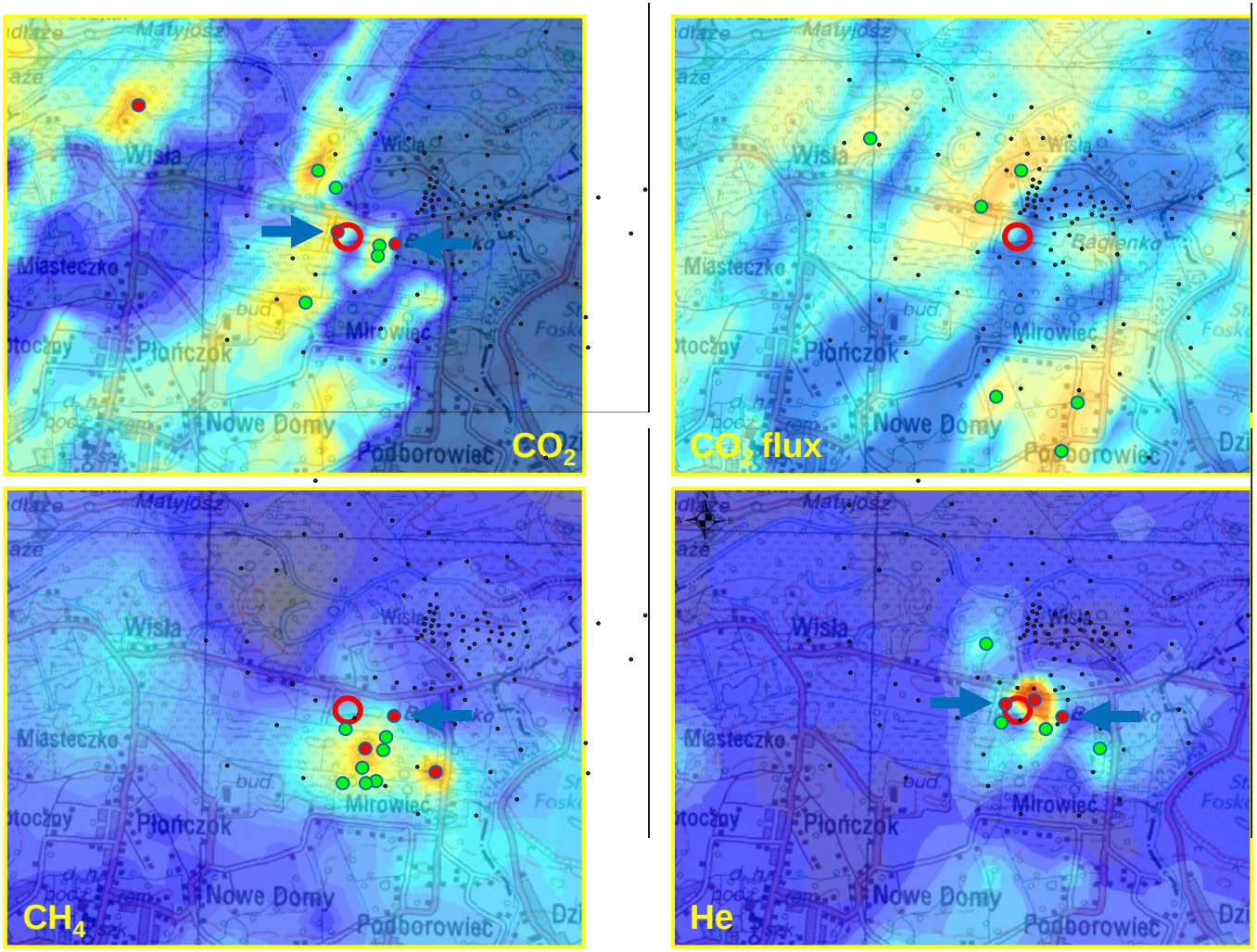
CO2 baseline at Kaniow, Poland - Contour map of CO2 concentration



Micro seep: as indicator of gas migration around an injection well at Kaniow (Poland)

Micro seeps Around the CO2 injection well at Kaniow

The detection of a complete set of gases is needed for understanding CO2 baseline



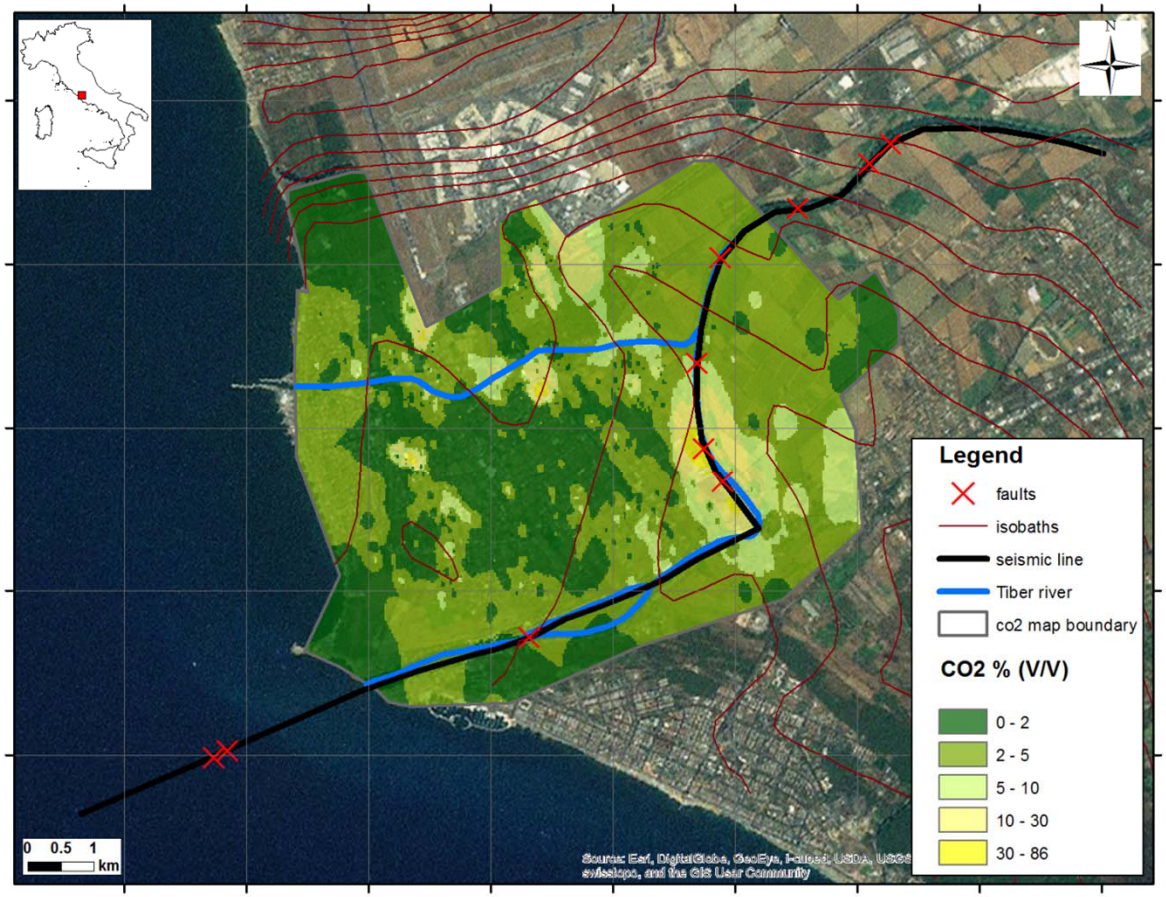
Basic deep seated gases migration concept

- **How macro and micro seeps form and “work”**
  - **Mostly for advection through more permeable pathways (faults, fractures)**
  - **A continuous flow of gas exist between seeps at surface and deep reservoirs; as such**
    - **Micro seeps may be used as early warning of CO2 migration**

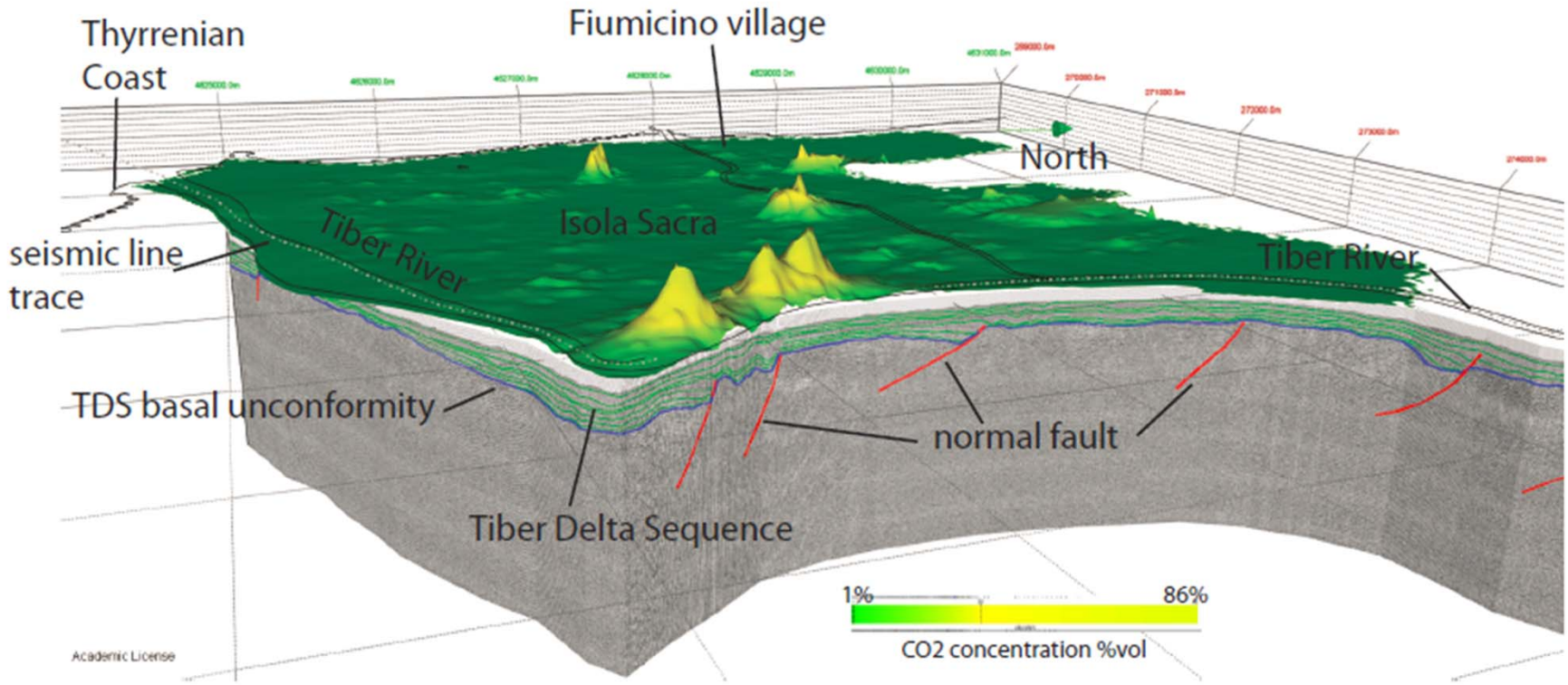
Basic deep seated gases migration concept

CO2 baseline at Fiumicino area (Rome)

Both shallow and deep CO2 component are present in this baseline



Basic deep seated gases migration concept



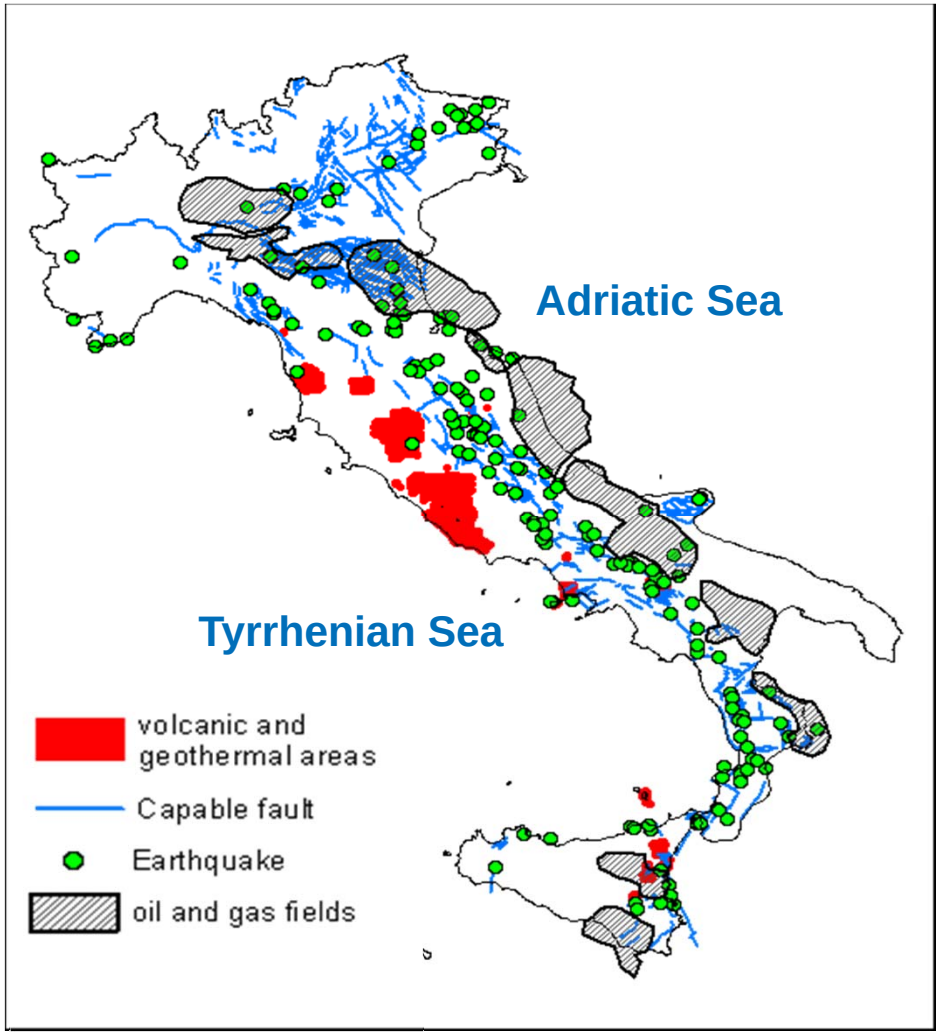
3D representation of the main geological, structural and geochemical feature at Fiumicino area (Rome)

Is it feasible to create CO2 baseline at local at regional scale?

- At local scale – examples have been already presented
- At regional scale - in the following slides an example at regional scale will be given

CO2 Baseline at regional scale (central Italy)

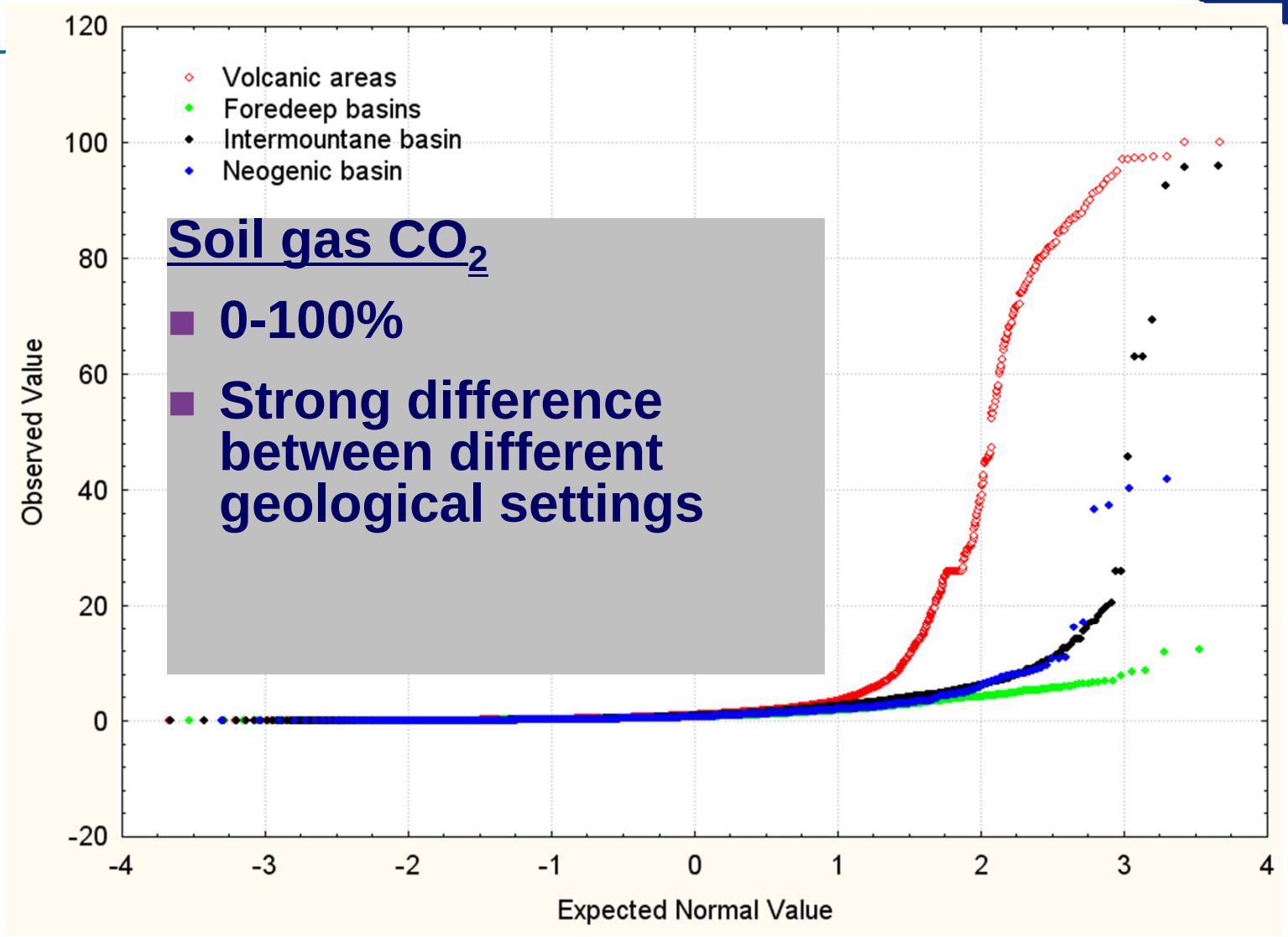
- **Soil gas samples collected throughout central-southern Italy during the last 25 years for various projects related to:**
  - **Tectonic / structural / fault / volcano research**
  - **Geothermal / oil-gas / mineral exploration**
  - **Environment / nuclear waste – CO2 disposal**
- **Database has >35,000 samples for helium and > 15,000 for CO_2 and CH_4**



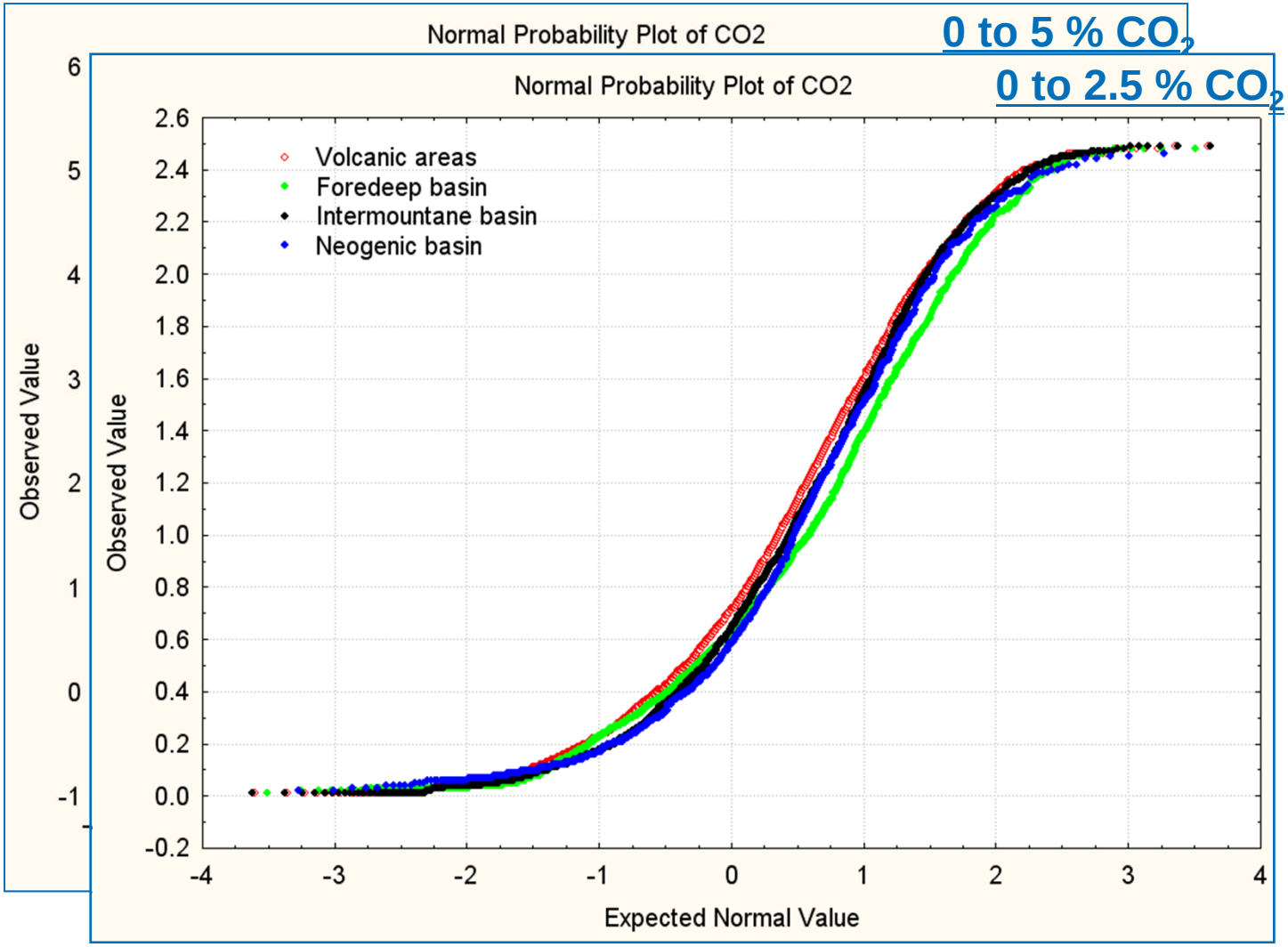
CO2 Baseline at regional scale (central Italy)

- **The following slides show a series of normal probability plots (NPPs) for CO_2 data divided on the basis of the type of geological setting:**
  - **Volcanic areas**
  - **Foredeep basins**
  - **Intramontane basins**
  - **Neogenic basins**
- **NPPs made by filtering the database at different thresholds**
  - **0-100%; 0-5%; 0-2.5%**

The URS Italian databCO2 Baseline at regional scale (central Italy)



CO2 Baseline at regional scale (central Italy)



The Vasto example

- **The Vasto area is an actively exploited gas reservoir system on the east coast of Italy**
  - **Helium soil gas surveys were conducted at this site after several years of exploitation, and then again many years later**
  - **Results show how baseline values change with human intervention, and illustrate the importance of baseline surveys for monitoring purposes**

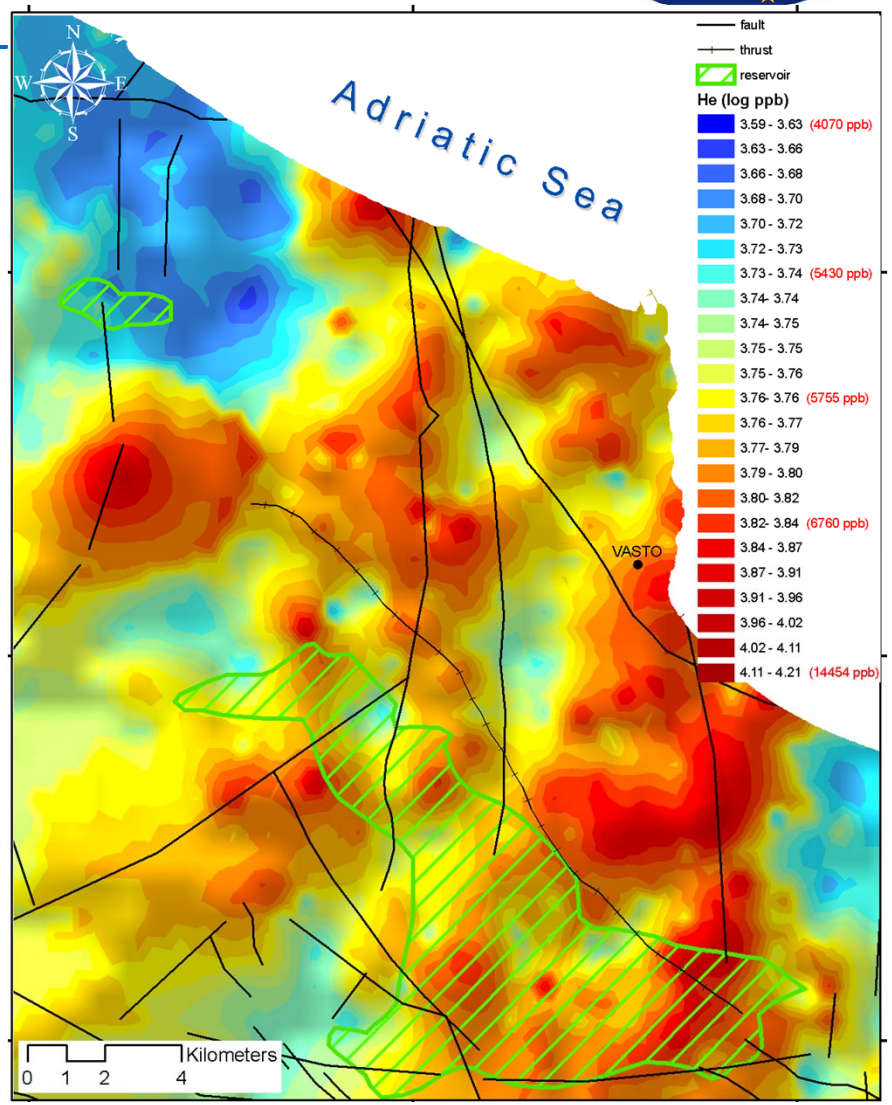
Basic deep seated gases migration concept

VASTO BASIN	N	Mean	Median	Min	Max	Std.Dev.
He_ppm	1503	5.72	5.43	3.29	**16.25**	0.98
Rn_Bq_L	488	11.74	5.18	0.37	219.78	22.00
CO2 %	**669**	1.11	**0.51**	0.02	**12.29**	1.50

ITALY	N	Mean	Median	Min	Max	Std.Dev.
He_ppm	41039	**5.48**	5.31	1.20	315.2	3.04
Rn_Bq_L	17132	135.80	18.50	0.10	75800.0	1642.67
CO2 %	**20435**	2.30	**0.92**	0.00	**100.0**	7.22

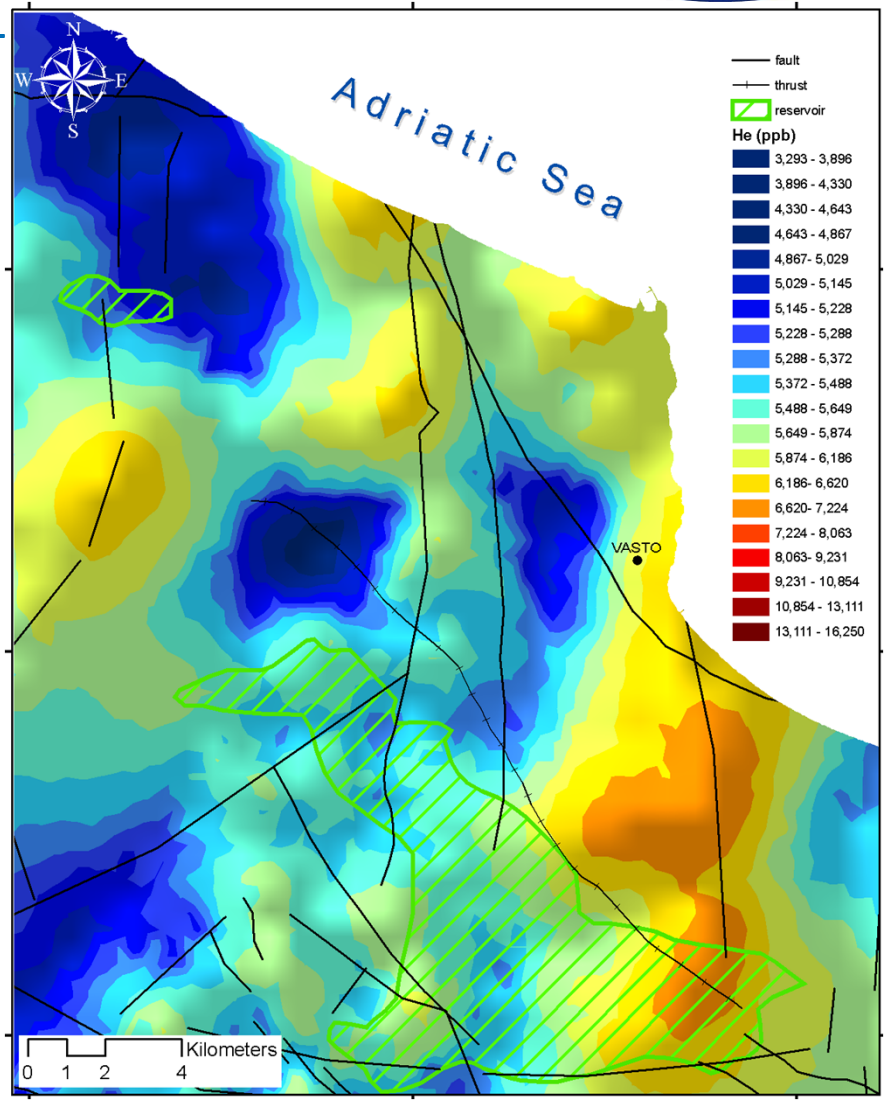
The Vasto example

- **Survey 1987-1988**
  - **Contour of soil gas helium results**
  - **Regional sampling**
  - **Large anomalies in correspondence with regional faults**



The Vasto example

- **Survey 2004-2005**
  - **Second survey conducted in same area, after reservoir depressurization**
  - **Some anomalies are located in the same areas**
  - **However there is an overall decrease in concentrations**



Final remarks

- **What is needed**
  - ***Framework*. A database is needed which describes the combined spatial and temporal conditions at a regional level. Presently it is difficult to put a local survey in context because of limited regional data**
  - ***Protocols*. Particularly needed for sampling density and survey design, to ensure a statistically and spatially representative sampling of the study area**
  - ***Model input*. Basic chemical parameters for migration and impact models**

Final remarks

- **What types of measurements needed?**
- **At regional scale:**
  - **Soil gas surveys of CO_2, and possibly of other tracers like helium and CH_4**
  - **CO_2 flux measurements**
- **At local scale**
  - **Soil gas surveys of CO_2, and possibly of other tracers like helium and CH_4**
  - **CO_2 flux measurements**
  - **Continuous monitoring of soil gas and/or flux**
  - **Spatial and temporal monitoring of dissolved CO_2 (and other gases) in groundwater**

Final remarks

- **Possible approach**
  - **Regional surveys, based on distribution of samples in different settings (land use, geology, topography)**
  - **Repeat regional surveys during different seasons to address climatic effect (water content, temp., etc.)**
  - **Detailed surveys on “baseline anomalous” areas to test methods that distinquish deep from shallow anomalies (vertical profiles, isotopes, tracers, etc.)**
  - **Detailed studies on “high risk” areas (faults, wells) to develop approaches to focus work / decrease costs**

Conclusions

- **Baseline, near-surface gas geochemistry data is needed for site selection:**
  - **To determine possible hidden faults (i.e. gas migration pathways), to interpret monitoring results, for carbon credit auditing, for site security, public outreach, and owner liability reasons**
- **Regional and local surveys needed to interpret local context and quantify importance of geology, weather, land use on gas distribution and values**
- **Case studies show the potential of multiple surveys and large databases for CGS purposes**