Building a unique and wide-ranging database of baseline CO2 concentrations and flux values throughout Europe

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Content of the talk

- CO_2 baseline
- Why we need a CO_2 baseline
- Examples of CO_2 baseline
- What we need to do to acquire a CO_2 baseline

CO_2 baseline

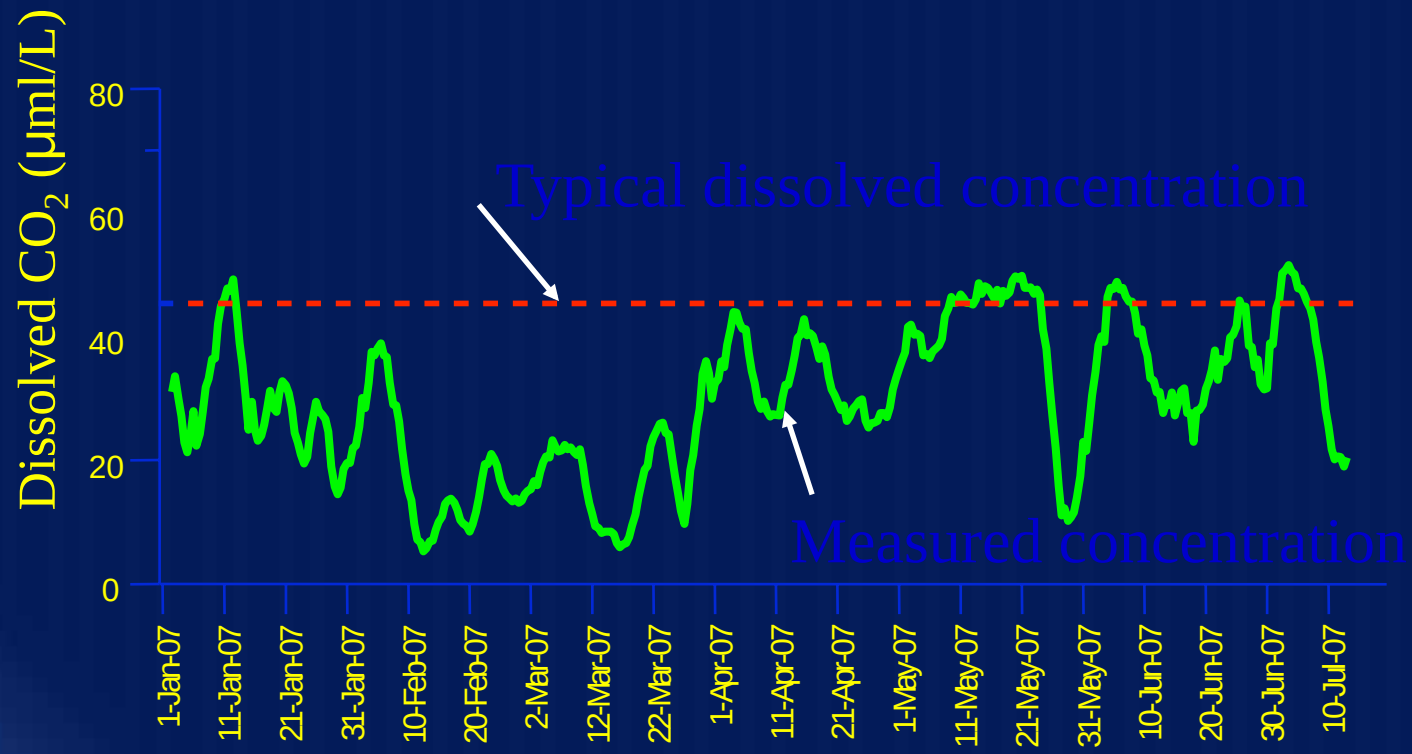
- One of the best ways to ensure public safety, to prove that stored CO_2 is not returning to the biosphere, or to quantify CO_2 migration from a deep reservoir, is by *direct* concentration and flux measurements.
- However, near surface biological production of CO_2 can mask a possible signal of migration and complicate interpretation of data. We need to know the amount of CO_2 produced by biological activity, i.e. the natural CO_2 baseline.

CO_2 baseline: near surface monitoring

Geochemical Methods

- **Soil gas**
  - **Samples collected at 40-80cm depth**
  - **Rn, CO2, H2, H2S measured in field**
  - **CO2, He, hydrocarbons, O2, N2**
- **CO2 and CH4 fluxes**
  - **Accumulation chamber method**
- **Dissolved gases in water**
  - **CO2, H2, H2S**

Marine baseline



The concentration of dissolved CO_2 can be measured continually and in real time to give warning of a possible leak into the sea

Why the definition of the baseline is so important?

- Site security / operator liability
  - What if a land-owner or NGO finds soil gas concentrations of 10% CO_2 after injection has begun. Is this natural or is the site leaking?
- Monitoring
  - When monitoring is conducted, what value (soil gas, flux, eddy covariance, etc.) should be used as an "anomaly threshold" to trigger concern and more detailed study?

Why the definition of the baseline is so important?

- Carbon credit auditing
  - Assume that ***a diffuse leak is inferred*** at a storage site and a survey is made to quantify that leak
  - Assume that the total measured flux is **500 t/day CO_2 -** but this includes the natural baseline flux
  - The number of carbon credits that the operator will lose will depend on an accurate estimate of the baseline contribution to this number

Factors affecting CO_2 baseline

- Shallow natural sources are typically plant root and microbial respiration, and are influenced by:
  - Climate (temp, rainfall, atm. press., etc.)
  - Topography
  - Land use
  - Soil type

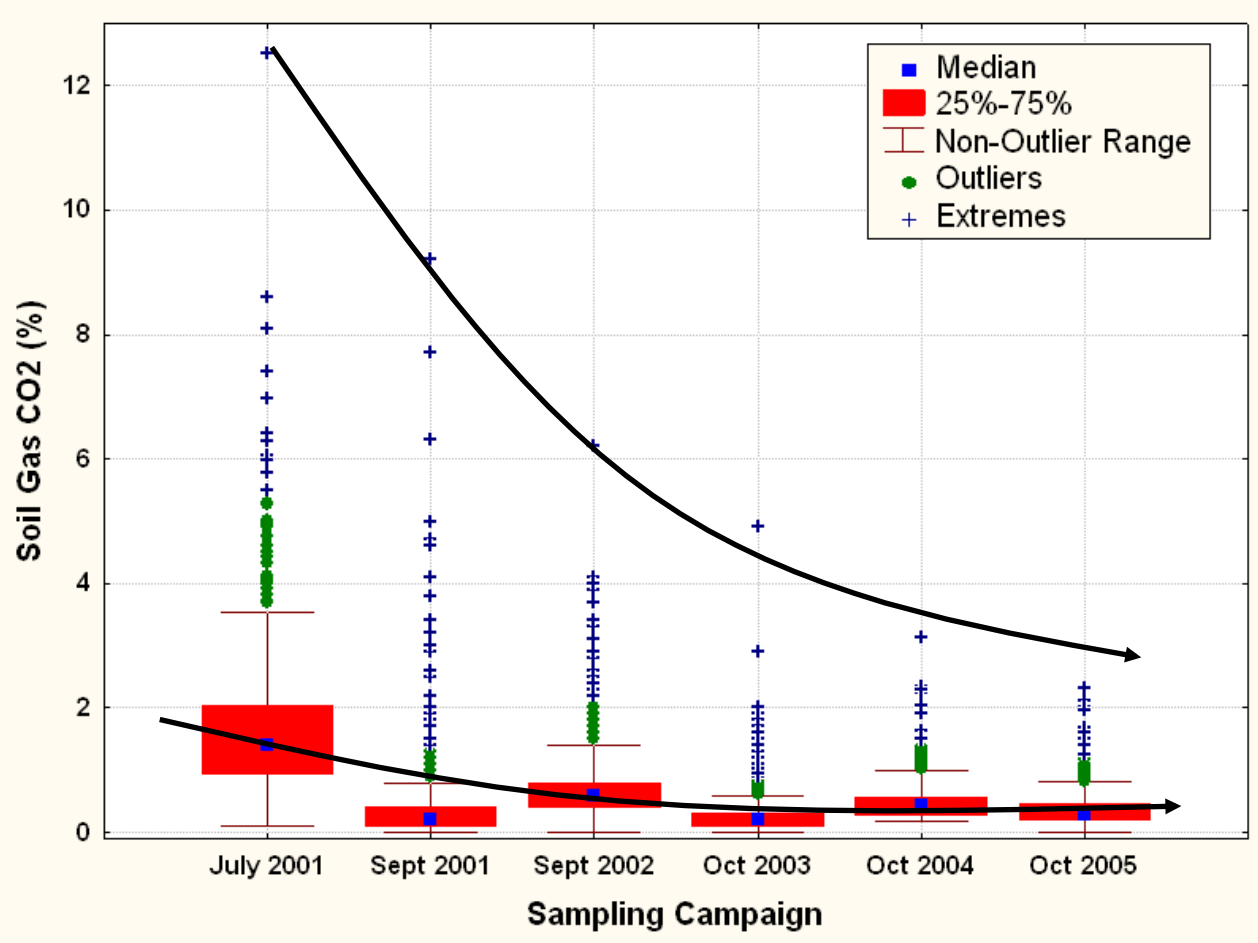
Factors affecting CO_2 baseline

- The influence of these parameters will depend on scale and location, for example:
  - Cooler wetter climate in northern Europe versus warmer dryer one in southern Europe
  - Shallow soil / geology dominated by peats and organic rich soils versus thin mineral soils on bedrock
  - Forested areas versus agricultural areas where fertilizers and pesticides are applied

The Weyburn example

- A 360 point grid (200m spacing) and two detailed profiles (25m spacing, c. 1km long) were established over the original CO_2 injection area
- These points were sampled during 6 sampling campaigns, conducted during two seasons (summer and fall) over 5 years.
  - July 2001; Sept. 2001; Sept. 2002; Oct. 2003; Oct. 2004; Oct. 2005.

The Weyburn example

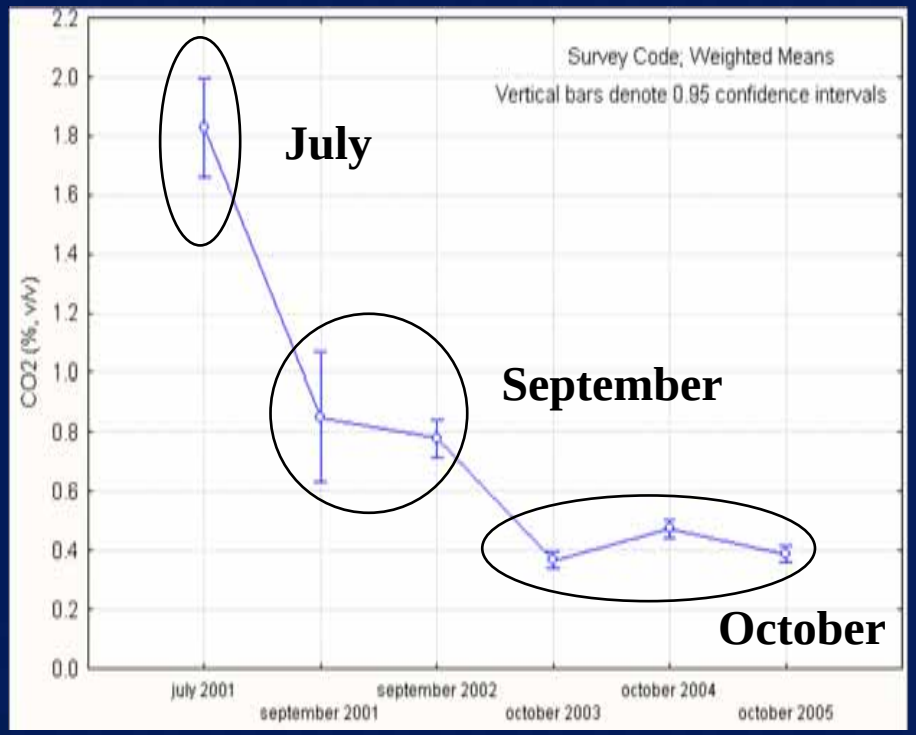


Overall the values decrease with sampling later in the season

- Extremes approach constant value
- Median approaches constant value

Shows potential for wide range of <u>natural</u> CO_2 concentrations

The Weyburn example



Variance analysis

- **The decrease of *weighted mean* values is clearly linked to sampling period**
- **The summer periods (July-September) show the highest data *variability*, while the CO_2 values of the autumn periods (October) are very stable.**

The URS Italian database

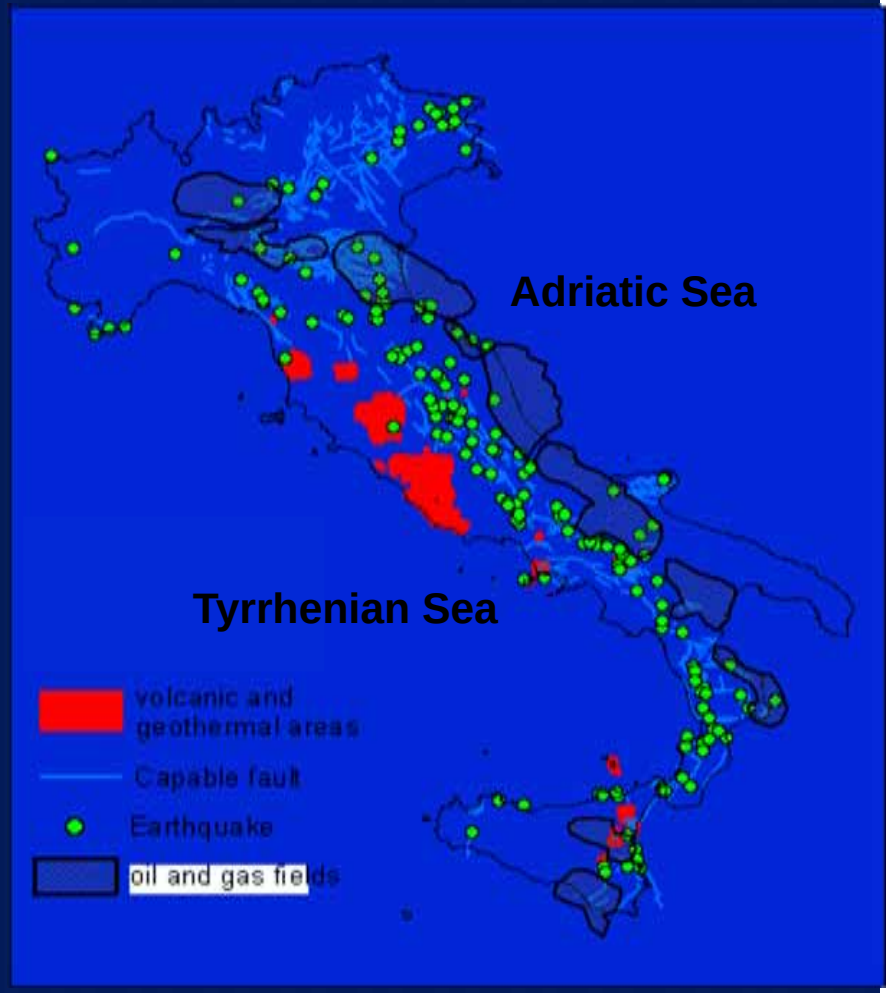
- Soil gas samples collected throughout central-southern Italy during the last 25 years for various projects related to:
  - Tectonic / structural / fault / volcano research
  - Geothermal / oil-gas / mineral exploration
  - Environment / nuclear waste – CO_2 disposal

The URS Italian database

Why Italy?

Baseline over a wide range of geological scenarios has been performed:

- **Volcanic areas**
- **Tectonic areas**
- **Adriatic through**



The URS Italian database

Database has >35,000 samples for helium and about 15,000 for CO_2 and CH_4

Total area covered by CO_2 soil gas surveys

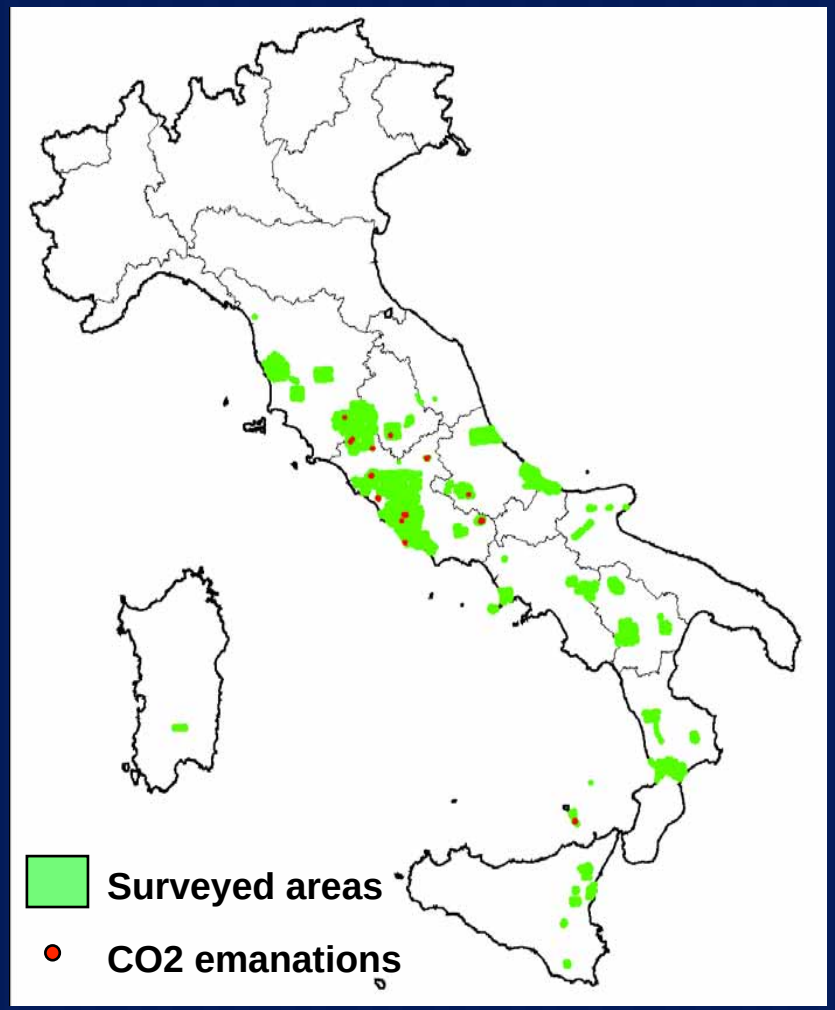
→ 5800 km^2

Areas with CO_2 in soil air above 20% (v/v)

→ 6km^2 (0,10%)

Areas with CO_2 in soil air above 60 % (v/v)

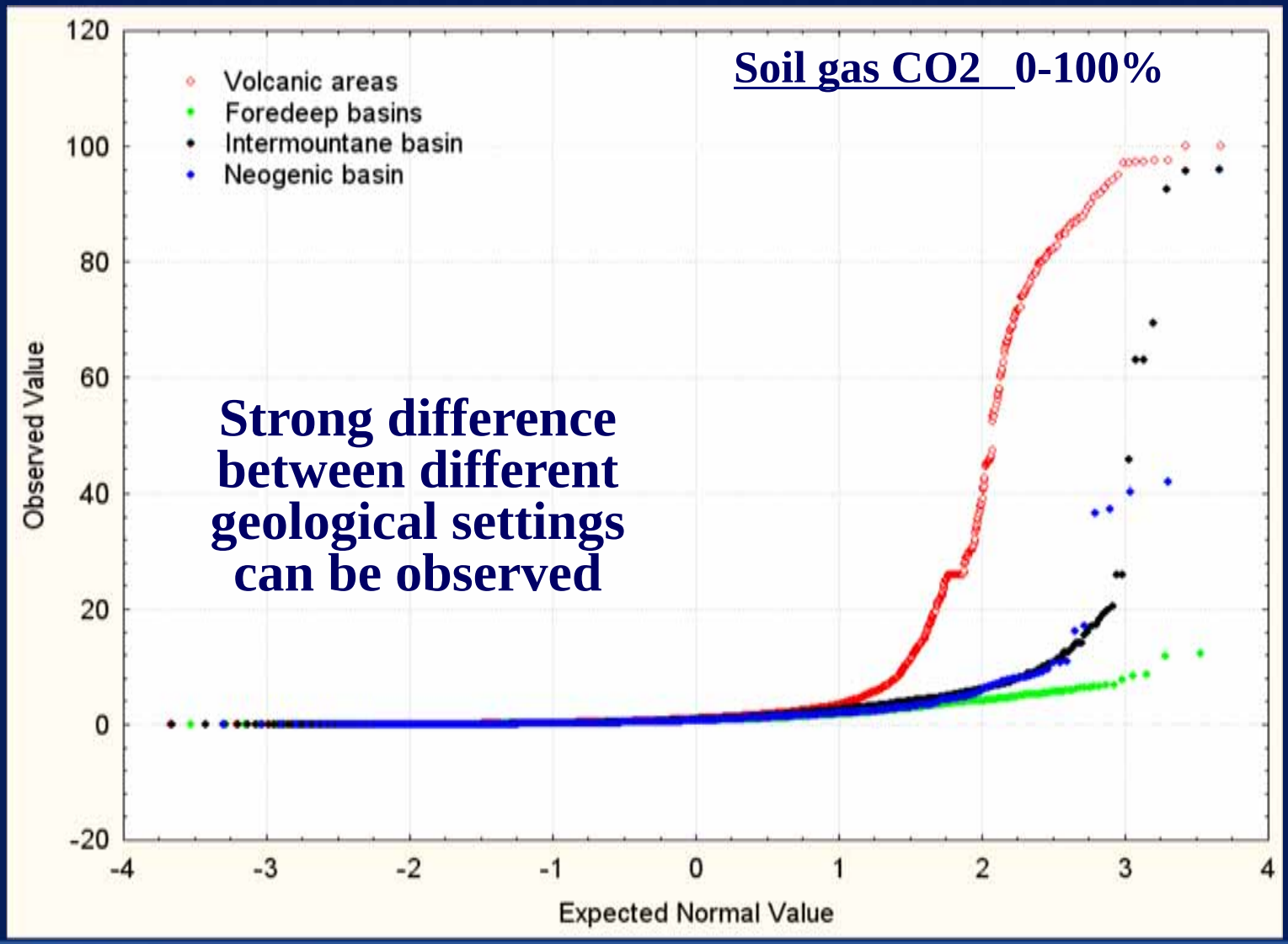
→ 1km^2 (0,02%)



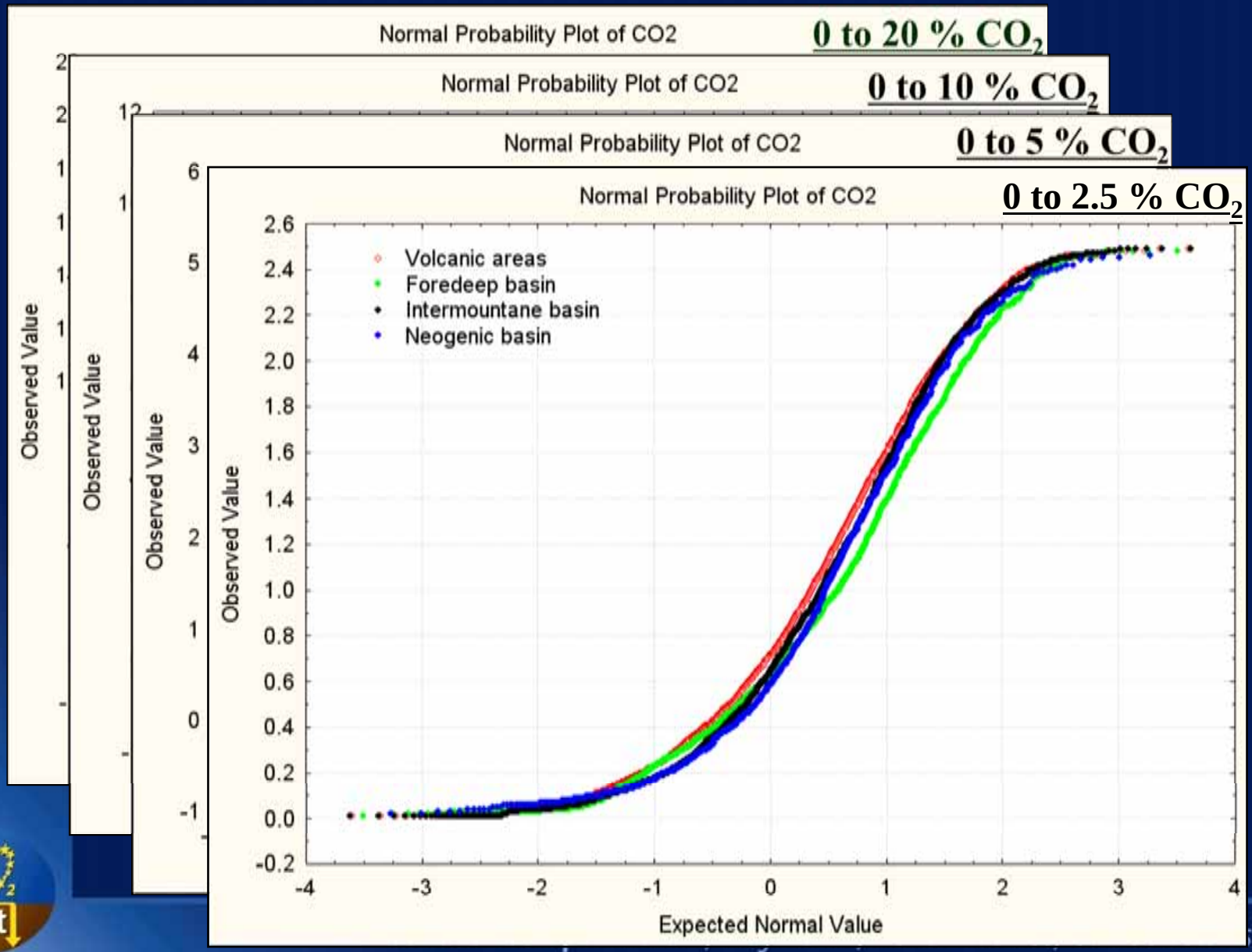
The URS Italian database

- The following slides show a series of normal probability plots (NPP) for CO_2 data divided for the type of geological setting:
  - volcanic areas and fore deep, intramontane, and neogenic basins.
- NPPs made by filtering the database at different thresholds
  - 0-100%; 0-20%; 0-10%; 0-5%; 0-2.5%

The URS Italian database



The URS Italian database



Preliminary conclusions

- **Baseline, near-surface gas geochemistry data is needed:**
  - **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 CCS purposes**

Building an European CO_2 baseline

- What is needed
  - Framework. A database is needed which describes the combined spatial and temporal conditions at a regional level.
  - 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

Building an European CO_2 baseline

- What types of measurements needed?
  - 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

Building an European CO_2 baseline

- 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

Thank you for the attention

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