

Seasonal climatic constraints of soil-gas baseline monitoring at the Zar-3 pilot CO₂ storage site, Czechia

P. Jirman¹ – J. Franců¹ – V. Hladík^{1†} – P. Pařízek¹

¹ Czech Geological Survey, Czech Republic

Introduction

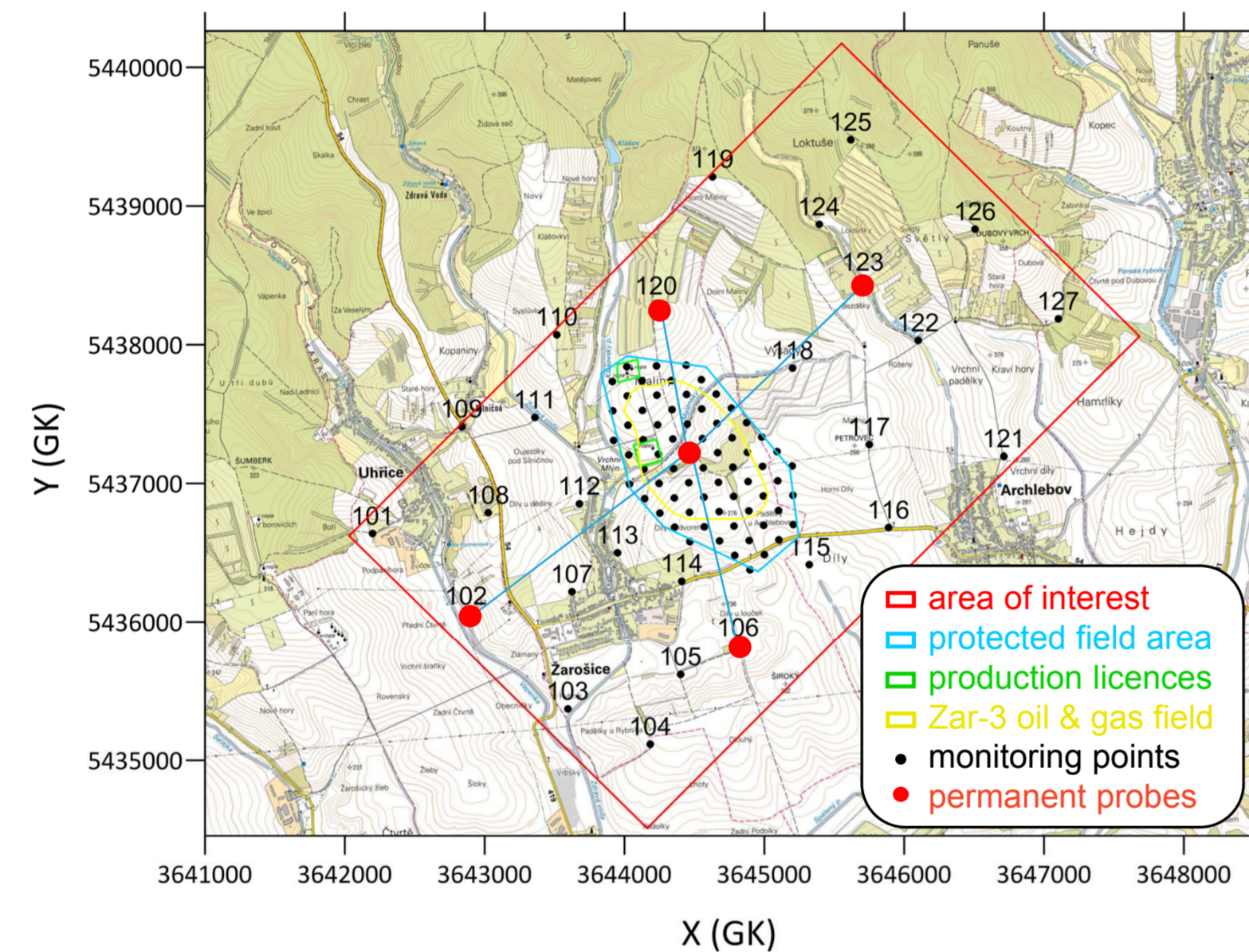
CO₂-SPICER (CO₂ Storage Pilot In a CarbonatE Reservoir) aims at preparation of a CO₂ storage pilot in the Zar-3 oil & gas field, SE Czechia. The Zar-3 field was discovered in 2001 and is now in the final production phase. The reservoir structure is an erosional relic of fractured Jurassic dolomites on the SE margin of the Bohemian Massif. The primary caprock of the storage complex is built by Upper Jurassic and Eocene strata overlain by secondary caprock of the Carpathian Flysch fold-and-thrust belt.

Objectives

- Baseline monitoring showing the pre-storage pattern of CO₂ content in soil gas
- Identify soil-gas anomalies
- Compare temporal variations of soil-gas composition in selected seasons of the year
- Define climatic and soil controls on changes in measured parameters
- Integrate soil gas method in consize Storage site monitoring plan
- To oversee that the future storage goes well and the seal is efficient

Soil-gas monitoring grid

- 95 points for periodical monitoring
- 5 permanent probes for continuous monitoring



Soil-gas monitoring grid above the Zar-3 oil & gas field.

Methods

Periodical monitoring:

- Yearly in winter, spring and late summer
- Ecoprobe-5™ evaluates CO₂, CH₄, O₂ and total petroleum (CH₄ to C₄H₁₀) content
- Measured in 80 cm deep holes drilled at each monitoring point prior to the measurement

Continuous monitoring:

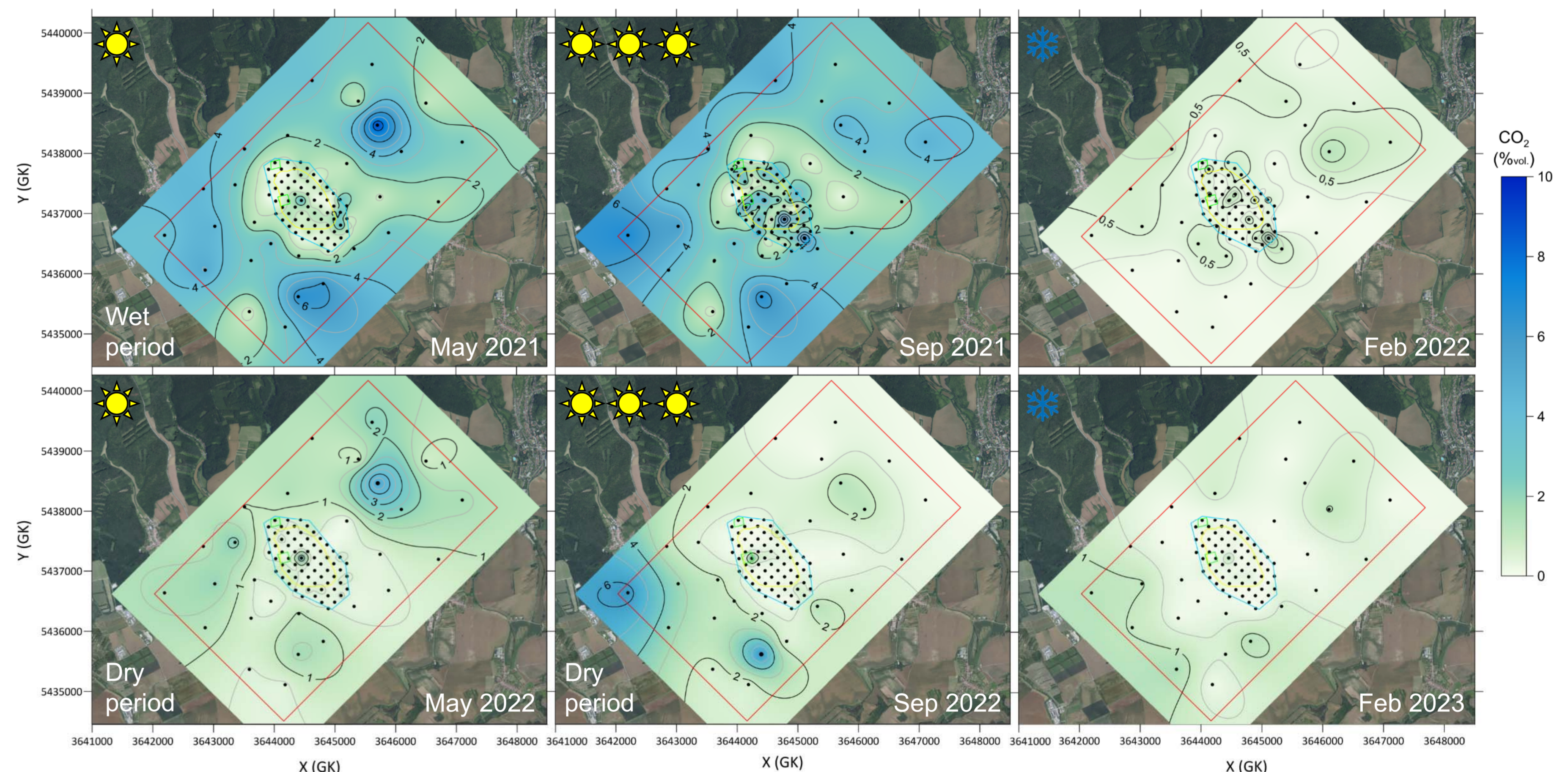
- Since June 2021 till present
- 5 permanent probes for CO₂ monitoring
- Buried 80 cm below the ground surface



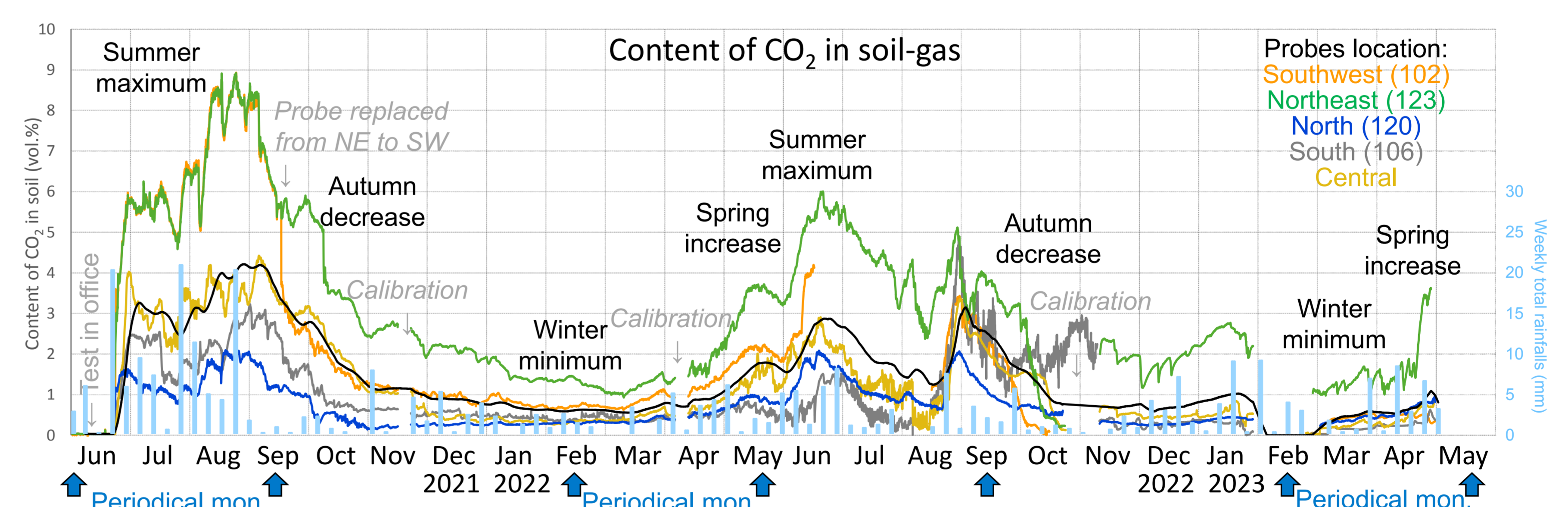
Periodical soil-gas monitoring using the Ecoprobe-5 (left) versus IGS permanent probe used for the continuous monitoring (right).

Results and discussion

- The CO₂ content in soil-gas shows periodic variations, depending on the season of the year. The trends of spring increase, summer maximum, autumn decrease and winter minimum are clearly visible. The maximum CO₂ content in soil-gas was up to 9 %_{vol} in 2021, but only up to 6 %_{vol} in 2022 due to lower total rainfall in 2022 and decreased vegetation and microbiological activity.
- All the permanent probes have been placed in grasslands to exclude the potential effects of the land-use. The differences among the trends measured by individual permanent probes are primarily caused by different soil properties, e.g. Permeability, wetness, water table level and vegetation in situ.
- Atmospheric pressure drops are more important than its absolute value.



Periodical monitoring: Contour maps of the average CO₂ content (%_{vol}) in soil-gas. The highest content was measured during the summer-autumn seasons due to the vegetation growth and biological activity. The CO₂ content in soil-gas strongly relates to the total rainfalls (see below).



Continuous monitoring: Time-plot of CO₂ content variations in soil-gas measured by five permanent probes (labelled in colours). The maximum content was measured in summer seasons (similarly to the periodical monitoring). The black trend line represents "weekly moving average" of all probes.

Conclusions

- Climatic controls, mainly seasonal temperature variations and total rainfalls, play a key role in the content of CO₂ in soil-gas due to their effects on vegetation and biological activity
- The effect of atmospheric pressure on CO₂ content in soil-gas was found to be matter of hours or days
- The CO₂ baseline carried out over multiple seasons makes it possible to quantify the natural variability and to establish the threshold values that could indicate the potential leakage

Acknowledgements

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