# Spatial variability of $CO_2$ efflux in four different ecosystems

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## Introduction

After photosynthesis, $CO_2$ efflux from soil is the second largest carbon flux in terrestrial ecosystems, and plays an important role in global carbon cycle. It is estimated that approximately 45 – 90 % of forest ecosystem respiration is from soil. Therefore, it is necessary to quantify accurately this component.

Providing manual measurements on a larger number of positions can precise estimation of $CO_2$ efflux from investigated area and together with temporal dynamics, observed in continuous measurements, can improve estimation of ecosystem carbon balance.

In this study we investigated spatial heterogeneity of soil $CO_2$ efflux in four different ecosystems, we tried to find responsible factors and to determine measurement protocol for the most precise estimation of soil $CO_2$ efflux.

## Methods

Intensive measurements of $CO_2$ efflux from soil (plus aboveground biomass in grassland) were carried out during several campaigns in 2009 - 2011. We used a portable system consisted of the infrared gas analyzer Li6200 (Li-Cor, USA) and the respiration chamber developed in the Global Change Research Centre AS CR.

The measurements were carried out on 30 to 64 positions (collars) in four ecosystems. Moreover soil temperature at the depth of 1.5 cm and soil moisture in layer 0 - 6 cm were measured next to each position.

To exclude effect of different temperature during campaigns both in the same and in individual ecosystems, measured $CO_2$ efflux was normalized for the temperature 10 °C according to the equation:

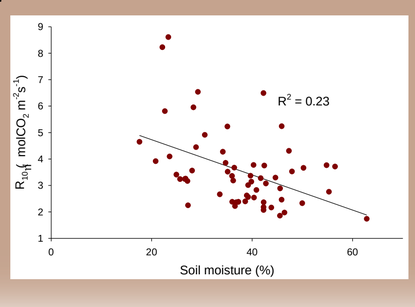
$$R_{10} = \frac{R}{Q_{10}^{\frac{T_s - 10}{10}}}$$

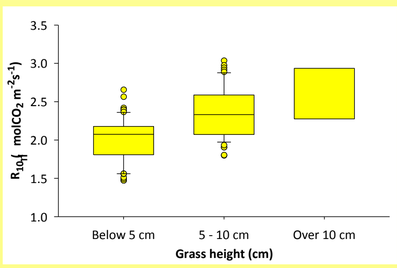
| | |
|---|---|
| $R_{10}$ | normalized soil $CO_2$ efflux |
| $R$ | measured soil $CO_2$ efflux |
| $T_s$ | soil temperature in 1.5 cm |
| $Q_{10}$ | parameter of temperature sensitivity |

## Spruce forest

Bílý Kříž in Moravian-Silesian Beskydy Mts.
877 m a.s.l., age 32 years
Haplic Podzol
Measurements
- 60 positions (10 x 6)
- 8.-9. 6. 2010 and 10.-11. 8. 2011
- mean soil moisture 32 and 38 %

Relationship of $R_{10}$ (normalized soil $CO_2$ efflux on 10 °C) and soil moisture (0-5 cm) measured on 60 position on 11. 8. 2011.

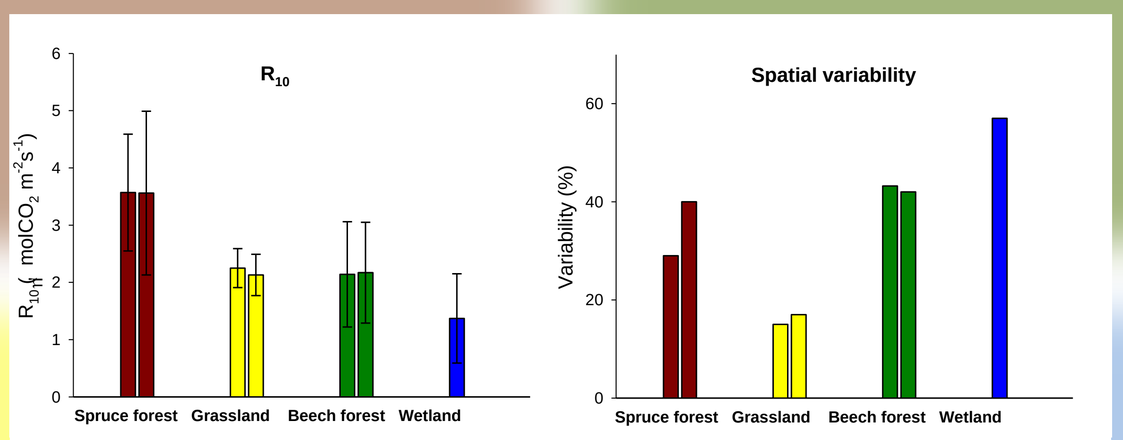



$R_{10}$ (normaliszed soil $CO_2$ efflux on 10 °C) on 60 positions with different grass height in two experimental periods in 2009.

Bílý Kříž in Moravian-Silesian Beskydy Mts.
855 m a.s.l.,
Gleyic Luvisol
Measurements (of ecosystem respiration)
- 64 positions (8 x 8)
- 13.-15. 5. 2009 and 17.-19. 8. 2009 (after mowing)
- mean soil moisture 37.5 and 37.7 %

- We found no effect of moisture (in 2010) or the position distance from tree on soil $CO_2$ efflux. In 2011, **negative** dependence of $CO_2$ efflux on soil **moisture** was observed. The variability was probably caused by the high amount of gravel in the soil.
- The number of positions equal 60 is **sufficient** to define soil $CO_2$ efflux with 29 and 40 % variability.




Normalized soil $CO_2$ efflux to 10 °C ($R_{10}$) and its spatial variability (expressed as coefficient of variation) during individual campaigns in four investigated ecosystems.

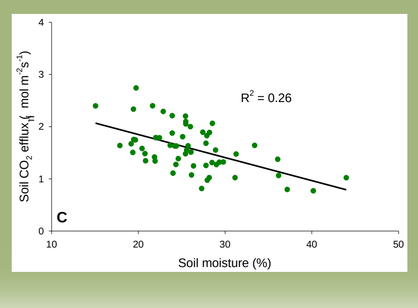
- Spatial variability of ecosystem $CO_2$ efflux was very low and it depended on the height of aboveground **biomass** during both measurements. We found also slight but significant increasing trend of $R_{10}$ with increasing soil **moisture**.
- Thanks to low variability (15 and 17 %) of $CO_2$ efflux there can be only a **small number** of measurement positions to representatively estimate ecosystem $CO_2$ efflux.

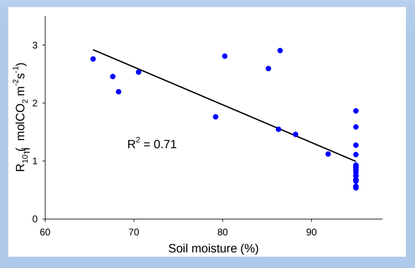
## Beech forest

- We found no effect of soil moisture (in 2010) or the position distance from tree on soil $CO_2$ efflux. In 2011, the **negative** dependence of $CO_2$ efflux on soil **moisture** was observed.
- The number of positions equal 60 is **sufficient** to define soil $CO_2$ efflux with 27 – 46 % variability.

Štítná nad Vláří in Bílé Karpaty Mts.
559 m a.s.l., age 110 years
Eutric Cambisol
Measurements
- 60 positions (10 x 6)
- 30.9.-1.10. 2009 and 18.-19.8. 2011
- mean soil moisture 22 and 32 %

Relationship of $R_{10}$ (normalized soil $CO_2$ efflux on 10 °C) and soil moisture (0-5 cm) measured on 60 position on 18. 6. 2011.




Relationship of $R_{10}$ (normalized soil $CO_2$ efflux on 10 °C) and volumetric water content (0-5 cm) measured on 30 position on 21. – 22. 9. 2010.

Třeboň in the South Bohemia
426 m a.s.l.,
sedge-grass marsh
Measurements
- 30 positions in 3 groups of 5 and one line of 15
- 21.-22. 9. 2010
- mean soil moisture 90 %

- The driving factor of the high spatial variability of soil $CO_2$ efflux (57 %) was soil **moisture** which decreased with the increased distance of the position from the lake.
- Estimation of soil $CO_2$ efflux for the whole acosystem should be done on the base of measurements in **line** with water content gradient, and providing continuous measurements of soil moisture (or water table) and temperature on different positions should help.

## Grassland

## Wetland

**Acknowledgements:** This work was supported by projects CzechGlobe (CZ.1.05/1.1.00/02.0073) and CZ.1.07/2.4.00/31.0056