Spatial and temporal seasonal variation of CO_2 efflux from the soil surface in the boreal forests in Central Siberia

*Anastasia Vladimirovna Makhnykina[1], Anatoly Stanislavovich Prokushkin[2], Sergey Vladimirovich Verkhovets[1], Nataly Nikolaevna Koshurnikova[1]

1.Siberian Federal University, 2.V.N. Sukachev Institute of forest of Siberian Branch RAS

In boreal forest ecosystems, soil CO_2 flux may account for 40–80 % of the total CO_2 release in forest ecosystems [4], and it is the main pathway of transferring carbon from terrestrial ecosystems to the atmosphere. The amount of CO_2 released to the atmosphere through soil respiration is ten times greater than that resulting from the burning of fossil fuels [3]. Taking into account the considerable amounts of C stored in boreal soils [1] even small changes in soil respiration may cause great fluctuation in atmospheric CO_2 concentrations. Therefore, better understanding of soil respiration dynamics in diverse boreal forests is essential for understanding the global carbon balance [2].
The objectives of the present study are: (a) to study the dynamic changes in soil CO_2 efflux from the soil surface during frost-free season; (b) to identify the impact of meteorological variables (factors) on soil CO_2 efflux. The research was conducted in the boreal forests in Central Siberia (60°N, 90°E), Russia. Sample plots were represented by the lichen pine forest, moss pine forest, mixed forest and a plot with mineral sandy soil without a plant cover. We used the automated soil CO_2 flux system based on the infrared gas analyzer –LI-8100 (Li-cor Biogeosciences Inc., USA) for measuring the soil efflux. Soil temperature was measured next to each collar at the time of the CO2 efflux measurement with Soil Temperature Probe Type E (Omega, USA) in three depths –5, 10, 15 cm. Volumetric soil moisture was measured with Theta Probe Model ML2 (Delta T Devices Ltd., UK).
The presence and type of ground cover substantially affects the value of soil respiration fluxes. In 2015, the flow of carbon dioxide from the soil surface averaged 5.4 ±2.3 μmol CO_2 m^{-2} s^{-1}. The lowest soil respiration for forest areas was observed in the moss pine forest (1.14 μmol CO_2 m^{-2} s^{-1}). The lichen pine forest had the intermediate values (mean and SD) of soil respiration. A sandy soil plot without a plant cover demonstrated the lowest soil respiration (0.12 μmol CO_2 m^{-2} s^{-1}). The maximum soil respiration values and seasonal fluctuations were obtained in the mixed forest (29.62 μmol CO_2 m^{-2} s^{-1}).
The correlation analysis of dependence between soil temperature, soil moisture and soil CO_2 efflux showed that an increase of temperature and soil moisture at the beginning of the growing season (June) leads to inhibition of soil respiration processes. At the end of the growing season (September), we recorded a reduction in the impact of two climate factors (soil temperature and moisture) on soil respiration intensity. Nevertheless, the soil temperature appears to be the major driver controlling the soil CO_2 efflux during the frost-free season in analyzed Siberian boreal forests.
Literature:
1. Niinistö S. M., Kellomäki S., Silvola J. Seasonality in a boreal forest ecosystem affects the use of soil temperature and moisture as predictors of soil CO2 efflux. Biogeosciences, 8: 3169–3186. 2011.
2. Raich J.W., Potter C.S. Global patterns of carbon dioxide emissions from soils. Global Biogeochemical Cycles, 9: 23–36. 1995.
3. Sun L., Hu T., Kim J. H., Guo F., Song H., Lv X., Hu H. The effect of fire disturbance on short-term soil respiration in typical forest of Greater Xing'an Range, China. Journal of Forestry Research 25: 613-620. 2014.

4. Yuste J.C., Nagy M., Janssens I.A., Carrara A., Ceulemans R. Soil respiration in a mixed temperate forest and its contribution to total ecosystem respiration. Tree Physiol 25: 609–619. 2005.

Keywords: soil carbon efflux, boreal forest, Siberian forest, soil respiration, soil temperature, soil moisture

