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Dynamics of net CO_2 exchange in the wetland ecosystem recovering from a fire

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Wetlands, even if cover a relatively small fraction of Earth's surface, play an important role in global carbon cycle. They are the main terrestrial source of methane (CH_4), but due to anaerobic conditions they accumulate significant part of captured in photosynthesis carbon dioxide (CO_2). Due to the progressive climate change these ecosystems are exposed to different climate-inducted extreme events. One of them are fires that can significantly affect the carbon-storage potential of the wetlands.

In this study we analyze the impact of a great fire on one of the largest mid-European wetlands in Biebrza Valley (northeastern Poland) on the CO_2 net ecosystem exchange (NEE). Over 5,500 ha of landscape of the Biebrza National Park burned down during this event in April 20-25, 2020. In the north-east edge of the core of this fire, there was an eddy-covariance measurement site, where greenhouse gas fluxes (CO_2, CH_4, H_2O) had been continuously recorded since 2013. The measurement system suffered to some extent, but flux measurements were resumed after repair works in approximately 2 weeks. Almost the entire source area of eddy-covariance system was affected by the fire. Thus, post-fire measurements show the dynamics of NEE for an ecosystem recovering from a fire.

In the flux measurements period (2013-2020) the studied ecosystem was affected not only by the above fire event but also by severe droughts in 2015 and 2018-2020. In consequence in non-fire years the annual totals of CO_2 flux followed the mean ground water table level (WTL) and spanned from -990 $gCO_2 \cdot m^{-2} \cdot yr^{-1}$ (CO_2 sink) in the wettest year to +1020 $gCO_2 \cdot m^{-2} \cdot yr^{-1}$ (CO_2 source) in the driest year 2019. However, even taking into account the influence of WTL and temperature fluctuation we observed clear impact of the spring fire on CO_2 exchange. Shortly after the fire, in May, the wetland was in average a source of CO_2 (positive monthly total of NEE), which had not happened before even in the driest years. However, already in the second half of May, the absorption of CO_2 began to predominate over the emissions. From the mid-June to the end of July we observed very intensive growth of plant cover and exceptionally strong absorption of CO_2, much higher than in other years with similar thermo-hydrological conditions. Consequently, the total CO_2 flux in the post-fire period (May-December) was negative, while in remaining dry years the strong emission of CO_2 was observed for the same part of year.

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