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The switching of a mid-European temperate mire from carbon sink to source in extreme climate conditions

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Reversing the natural feedbacks that limit the rise in temperature is one of the major threats of climate change. One such mechanism is the exchange of carbon gases between the ecosystem and the atmosphere in wetlands. Wetlands cover only about 3% of the Earth's surface, but in natural conditions act as a CO_2 sink and store a significant amount of carbon in the soil. The organic carbon accumulated in the Northern peatland is estimated as one-third of the world's pool of organic carbon, equivalent to more than half the amount of carbon in the atmosphere. Climate extremes such as droughts and hot spell, can reduce or even invers this role. The water table drawdown and higher temperatures lead to enhanced peat oxidation and releasing a large portion of peat carbon as CO_2. It can switch a peatland from sink to source of carbon. However, some studies suggest that other mechanisms may compensate or even turn away this effect in real peatland ecosystems. Consequently, it is vitally important to empirically verify whether the paradigm of peatland transition from carbon sink to source in hot and dry conditions is valid for natural ecosystems. Despite the growing number of observations, it is hard to find datasets clearly showing such effect in the sense that they were collected in an undisturbed environment, represent for the whole ecosystem scale, and span full annual totals.

In this study we provide a strong empirical confirmation of switching of the mid-European temperate mire from carbon sink to source under extremely dry and hot climate conditions. The analysis is based on eight-year eddy-covariance measurements at site (53°35'30.8'' N, 22°53'32.4'' E, 109 m a.s.l.) located in a one of the largest coherent lowland wetlands in Central Europe – the Biebrza National Park (north-eastern Poland). In the analyzed measurement period (2013-2020) the studied ecosystem was affected by severe droughts in 2015 and 2018-2020. In wet years the peatland was a significant sink of CO_2 (down to −990 $gCO_2 \cdot m^{-2} \cdot yr^{-1}$) whereas in dry years we observed a substantial release of CO_2(up to +1020 $gCO_2 \cdot m^{-2} \cdot yr^{-1}$). At the same time, a CH_4 emission dropped from 29 $gCH_4 \cdot m^{-2} \cdot yr^{-1}$ in the wettest year to about 1−4 $gCH_4 \cdot m^{-2} \cdot yr^{-1}$ in dry years, which does not compensate for the amount of carbon released in the form of CO_2(even taking into account higher global warming potential of CH_4). At the same time, relatively small differences in the water vapor flux (evapotranspiration) between wet and dry years were observed. It demonstrates that the scenario of positive feedback between wetland carbon release and climate change could be realistic and supports the need of natural wetland preservation or

rewetting.

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