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Peatlands and Climate Warming: Winter Carbon Cycling

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Northern peatlands hold large stores of carbon which are susceptible to loss under future climate warming. Most climate projections predict that the rate of warming will continue through the 21st century, with the greatest warming occurring during the winter. Given that microbial respiration is a major driver of carbon dioxide (CO_2) production in soils, warming, even at sub-zero temperatures, is expected to increase northern peatlands CO_2 emissions during the non-growing season (NGS; winter plus portions of the shoulder seasons). Therefore, understanding the factors that regulate CO_2 emissions during the NGS is critical for predicting the fate of the vulnerable peat carbon stocks. In this presentation, we examine the governing environmental variables of NGS CO_2 emissions in a northern peatland to infer how these emissions may respond to future climate warming. We developed a machine-learning model whose results imply that changes in soil moisture, soil temperature, snow cover, and photosynthesis are the primary drivers of net CO_2 fluxes during the NGS. The model was applied to a 13-year (1998-2010) continuous record of eddy covariance flux measurements at Mer Bleue Bog (located near Ottawa, Canada). Next, we used regional climate projections to forecast future changes in peatland net ecosystem exchange of CO_2 during the NGS. Under the highest radiative forcing scenario, the NGS Mer Bleue peatland CO_2 emission rates could experience a 103% increase by 2100. Our results thus highlight the potential for a strong positive climate feedback loop from accelerated peatland carbon loss. We further highlight the importance of a consistent identification of the NGS by comparing alternative definitions based on local climatic parameters (air temperature, soil temperature, and snow cover). While each alternative definition yields a positive correlation between the cumulative NGS net ecosystem CO_2 exchange and the duration of the NGS, the greatest proportion of variability is explained when using the snow cover to delineate the start and end of the NGS, followed by air temperature and soil temperature.