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How will climate warming impact winter CO_2 emissions from northern peatlands?

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Canada's peatlands hold more than half of the organic carbon stocks stored in all Canadian soils. Over 90% of these peatlands are in the boreal and subarctic regions that are undergoing accelerated climate warming. Climate models project that the rate of warming will continue through the 21st century, with the greatest warming occurring during the non-growing season (NGS). Given that NGS carbon dioxide (CO_2) emissions are mainly driven by microbial respiration, warming, even at sub-zero temperatures, is expected to increase the CO_2 emissions during the NGS. Therefore, understanding the factors that regulate CO_2 emissions during the NGS is critical for predicting the fate of the climate-sensitive peat organic carbon stocks. In this presentation, we examine the role of environmental variables in NGS CO_2 emissions at a Canadian peatland research site to infer how these emissions may evolve under climate warming scenarios. We developed a support-vector regression machine-learning model whose results imply that soil moisture, soil temperature, snow cover, and photosynthesis are key predictor variables explaining the variability of net ecosystem CO_2 fluxes during the NGS. The model was applied to a 13-year (1998-2010) continuous record of eddy covariance flux measurements at the Mer Bleue Bog (located near Ottawa, Canada). The CO_2 fluxes were most sensitive to the net radiation above the canopy, wind speed, soil temperature, and soil moisture. Next, we used regional climate projections for the site to forecast future changes in the 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. Time permitting, we will also discuss results from a laboratory incubation CO_2 experiment with soils from Canadian boreal and temperate peatlands under variable moisture and temperature conditions. The incubation temperature ranged from

−10 to +35°C and included freeze–thaw events. The results showed that CO_2 production rates increased more sharply with temperature for the boreal peatland soils than the temperate ones. This indicates that boreal peatlands may increase future NGS CO_2 losses to a larger degree than temperate peatlands. Our results thus further highlight the potential for a strong positive climate feedback loop from accelerated peatland CO_2 emissions. They also point to the need for more realistic representations of northern soil processes in earth system models.