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Effects of Winter Pulsed Warming and Snowmelt on Soil Nitrogen Cycling in an Agroecosystem: A Lysimeter Study

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In cold regions, climate change is expected to result in warmer winter temperatures and increased temperature variability. Coupled with changing precipitation regimes, these changes can decrease soil insulation by reducing snow cover, exposing soils to colder temperatures and more frequent and extensive soil freezing and thawing. Freeze-thaw events can exert an important control over winter soil processes and the cycling of nitrogen (N), with consequences for soil health and nearby water quality. These impacts are especially important for agricultural soils and practices in cold regions. We conducted a lysimeter experiment to assess the effects of winter pulsed warming and snowmelt on N cycling in agricultural soils. We monitored the subsurface soil temperature, moisture, and pore water geochemistry together with air temperature, precipitation, and greenhouse gas fluxes in 18 agricultural field-controlled lysimeter systems (surface area of 1 m^2 and depth of 1.5 m) at the University of Guelph's Elora Research Station over one winter (December 2020 to April 2021). The lysimeters featured two soil types (loamy sand and silt loam) and two corn-soybean based crop rotations. The study presented here is for 4 lysimeters managed under a corn-soybean-winter wheat rotation with cover crops. Additionally, ceramic infrared heaters located above some of the plots (n=6) were turned on after each snowfall event to keep the soil surface snow-free for the entire winter. Pore water samples collected from different depths in the lysimeters were analyzed for dissolved organic and inorganic carbon (DOC, DIC), total dissolved nitrogen (TDN), nitrate (NO_3^-), nitrite (NO_2^-), chloride (Cl^-), sulfate (SO_4^{2-}), phosphate (PO_4^{3-}), and ammonium (NH_4^+). Nitrous oxide (N_2O) fluxes were measured using automated soil gas chambers installed on each lysimeter. The results from the snow-free lysimeters were compared to those of lysimeters without heaters. As expected, the removal of the insulating snow cover was found to cause more intense soil freeze-thaw events which, in turn, altered the pore water N distributions and leaching to the groundwater, as well as the soil N_2O gas emissions. Overall, our study illustrates the important role of winter snow cover dynamics in modulating the coupled responses of soil moisture, temperature, and N cycling.