How will decreasing winter snow cover affect nitrogen cycling in agricultural soils: Results from a lysimeter study

Danielle Green, University of Waterloo; Fereidoun Rezanezhad, University of Waterloo; Sean Jordan, University of Guelph; Claudia Wagner-Riddle, University of Guelph; Hugh A.L. Henry, University of Western Ontario; Stephanie Slowinski, University of Waterloo; Philippe Van Cappellen, University of Waterloo

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, nitrous oxide (N2O) emissions, and nearby water quality. These impacts are especially important for agricultural soils and practices in cold-temperate regions, such as in southern Ontario. We conducted a lysimeter experiment to assess the effects of winter pulsed warming, soil texture, and snow cover on N cycling in agricultural soils. We monitored the subsurface soil temperature, moisture, and porewater geochemistry together with air temperature, precipitation, and N2O fluxes in four agricultural field-controlled lysimeter systems (surface area of 1 m2 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) which were managed under a corn-soybean-winter wheat rotation with cover crops. Additionally, ceramic infrared heaters located above two of the lysimeters were turned on after each snowfall event to melt the snow and then turned off to mimic snow-free winter conditions with increased soil freezing. Porewater samples collected from different depths in the lysimeters were analyzed for total dissolved nitrogen (TDN), nitrate (NO3-), nitrite (NO2-), and ammonium (NH4+). N2O fluxes were measured using automated soil gas chambers installed on each lysimeter. The results from the snow removed lysimeters were compared to those of lysimeters without heaters (i.e., with snow). As expected, the removal of the insulating snow cover resulted in more intense soil freeze-thaw events, which in turn enhanced dissolved N export from the lysimeters via two potential routes: leaching to groundwater and N2O emissions. Both loss routes have important implications for water quality and greenhouse gas budgets; N loss to groundwater can negatively impact downstream streams and lakes that receive groundwater discharge, while N loss as N2O increases radiative climate forcing. Overall, our study illustrates the important role of winter snow cover dynamics and soil freezing in modulating the coupled responses of soil moisture, temperature, and N loss from soils by enhanced NO3− leaching to groundwater and N2O emissions.