Fact Sheet

EFFECTS OF DIURNAL TEMPERATURE CYCLES ON CARBON DIOXIDE EVOLUTION FROM SOIL

PROBLEM

Global warming predictions benefit from reliable estimates of carbon dioxide (CO_2) production. Atmospheric CO_2 is influenced by CO_2 exchanges with soil, which are dependent on microbial activity. Microbial activity, in turn, depends on soil conditions, including temperature, carbon bioavailability, nutrient status, moisture, aeration, and pH. Near the surface, soil temperatures can fluctuate significantly in 24 hours, yet the influence of diurnal soil temperature fluctuations on microbially mediated CO_2 evolution is not well characterized. Similarly, the validity of using the mean daily temperature to estimate CO_2 evolution during periods of significant diurnal temperature fluctuations is uncertain.

SOLUTION

We characterized diurnal fluctuations in soil temperatures in a sub-Arctic region, and then evaluated the impact of similar diurnal soil temperature fluctuations on CO_2 evolution.

In a field study at Fairbanks, Alaska, we measured hourly soil temperatures for three years at four different depths. We then configured a laboratory respirometer to mimic these cycles. Using a Fairbanks soil, we monitored CO_2 evolution from soil as we cycled soil temperatures 10°C above and 10°C below a mean value of 25, 15, or 5°C, and also as we held temperatures constant at the mean daily soil temperatures of the cyclic treatments. Using this scheme, we were able to measure cumulative CO_2 evolution at constant, cyclic unfrozen, and cyclic freeze–thaw temperatures.

RESULTS

Field soil temperature standard deviations for diurnal cycles were greater than 6°C at the surface and greater than 4°C at 20 centimeters. Under the laboratory conditions, diurnal cycles in which the soil remained above freezing had no significant effect on cumulative microbial respiration as measured by CO_2 evolution. In these cases, using the mean daily soil temperature to predict microbial activity may be appropriate.

When the diurnal minimum dropped below freezing, cyclic temperatures increased cumulative microbial respiration, as measured by CO_2 evolution, compared to holding the temperature constant at the diurnal mean. This result is counter-intuitive. In this simulation case, CO_2 evolution predictions based on daily mean temperatures would be underestimated.

We are extending this research to evaluate other soil types, available carbon sources and levels, soil water contents, and different temperature regimes.

POINT OF CONTACT

Dr. C. M. Reynolds
603-646-4394
Fax: 603-646-4561
E-mail: reynolds@crrel.usace.army.mil

August 1999

US Army Corps of Engineers®
Cold Regions Research & Engineering Laboratory

CRREL, 72 Lyme Road, Hanover, NH 03755-1290
http://www.crrel.usace.army.mil