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Legacy of constant and diurnally oscillating temperatures on soil respiration and microbial community structure.

Adetunji Alex Adekanmbi, Yiran Zou, Xin Shu, Liz Shaw, and Tom Sizmur
University of Reading, England, School of Archaeology Geography and Environmental Science, Geography and Environmental Science, Reading, , United Kingdom of Great Britain and Northern Ireland
(a.a.adekanmbi@pgr.reading.ac.uk)

Increasing temperatures due to the greenhouse effect are known to increase soil respiration, releasing more CO_2 into the atmosphere and resulting in a positive feedback in our climate system. Diurnal oscillations in air temperatures influence soil temperatures and thus may affect soil microbial activities and organic carbon vulnerability. Laboratory incubation studies evaluating the temperature sensitivity of soil respiration frequently use measurements of respiration taken at a constant incubation temperature in soil that has also been pre-incubated at a constant temperature. However, such constant temperature incubations do not represent the field situation, where soils undergo diurnal oscillations in temperate under the influence of changing air temperature. We investigated the effects of constant and diurnally oscillating temperatures on soil respiration, organic matter and soil microbial community composition. A Grassland soil from the UK was either incubated at a constant temperature of 5, 10 or 15 °C , or diurnally oscillated between 5 and 15 °C (increasing or decreasing at 2.5 °C for 3 hour intervals within each 24 hours). Soil CO_2 flux was measured by temporarily moving incubated soils from each of the abovementioned treatments to 5, 10 or 15 °C, such that soils incubated at each temperature had CO_2 flux measured at every temperature. Our approach used incubation and measurement temperatures as factors to explore the influence of incubation temperature on the respiration at the measured temperature and to determine temperature sensitivity of CO_2 flux for each incubation treatment. We hypothesised that a higher measurement temperature would result in greater CO_2 flux and that, irrespective of measurement temperature, CO_2 emitted from the 5 to 15 °C oscillating incubation would be similar to that from the 10 °C incubation. The results showed that both incubation and measurement temperatures influence soil respiration differently. Soil respiration measured at 15 °C was greater than that of 5 and 10 °C, irrespective of the incubation temperature. Incubating soil at a temperature oscillating between 5 and 15 oC resulted in greater CO_2 flux than constant incubations at 10 °C or 5 °C, but was statistically similar to 15 °C. This may be because extracellular depolymerisation is the rate limiting step in soil respiration and the time spent at 15 °C in the oscillating treatment was sufficient to depolymerise enough polysaccharides to maximise intracellular respiration. The greater CO_2 release in soils incubated at 15 °C or oscillating between 5 and 15 °C coincided with depletion of the soil organic carbon and a shift in the phospholipid fatty acid profile of the soil microbial community, consistent with thermal adaptation to higher temperatures. Dissolved organic carbon and C/N ratio significantly decreased in soils incubated at 15 ºC or oscillating between 5 and 15 ºC with attendant increase in the ratios of Gram negative to positive bacteria and cis/trans ratio, and decreased Fungi/Bacteria ratio. Our results suggest that daily maximum temperatures are more important than daily minimum or average temperatures when considering the response of soils to warming.