Effects of symmetric vs. asymmetric warming on soil organic matter (SOM) stabilization

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Introduction

Daily minimum temperature (T_{min}) has increased faster than daily maximum temperature (T_{max}) in many areas of the world, leading to decreases in diurnal temperature range (DTR). Projections suggest these trends are likely to continue with warming in northern latitudes and in arid regions. TERA reports on a four-year experiment using sunlit environmental chambers to compare the impacts of asymmetric warming (dawn T_{min}=ambient +5ºC, afternoon T_{max}= ambient +2ºC), to symmetric warming (constantly +3.5ºC) and ambient temperatures, on the carbon balance of a native grassland in Corvallis, Oregon. Because plants and microbes may not respond linearly to increases in temperature (i.e., Q10 responses), it is likely that biotic response to symmetric vs. asymmetric warming will lead to differences in carbon assimilation and sequestration.

Current research focuses on the effects of warming on plant physiology and gas exchange, but little current research focuses on soil dynamics or the ability of C to be sequestered as organic matter within the treated soils. My research will examine the effects of symmetric vs. asymmetric warming on soil organic matter (SOM) stabilization and/or destabilization. This research will increase understanding of the effects of global warming on carbon cycling in soils.

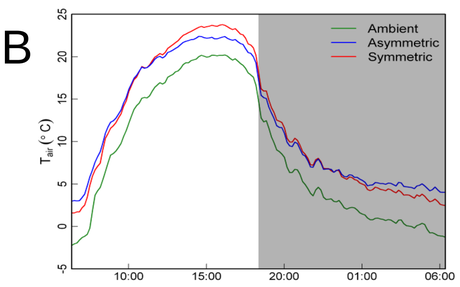
Terracosm Treatments

A

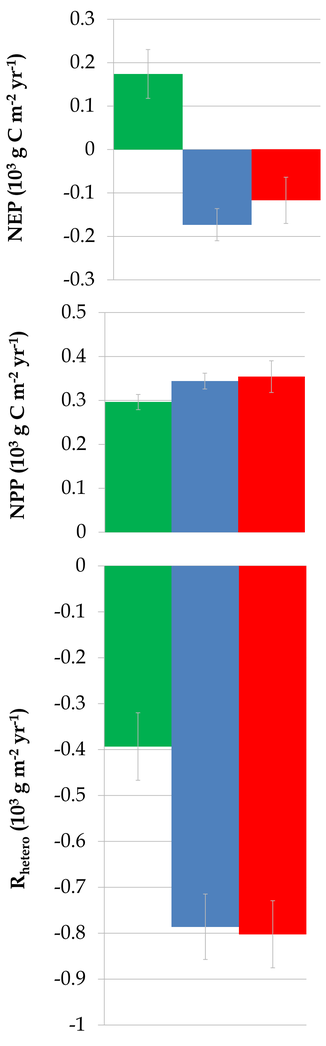
Figure A:
- TERA facility in Corvallis, operating since 2005
- 12 terracosm chambers allow monitoring of intact grassland ecosystems above- and below-ground
- Controlled for ambient humidity, CO2 concentration, air and soil temperature
- 1 m x 2 m footprint

Figure B:
- Temperature profiles for ambient, symmetric, and asymmetric treatments during the Spring.
- Symmetric treatment: +3.5°C at all times (no change in DTR)
- Asymmetric treatment: +5.0°C at dawn, changing gradually to +2.0°C at midday (decrease in DTR)

B



Known C-Balances



NEP and NPP are combined to give R_{hetero} (NEP-NPP = R_{hetero}), the amount of C respired by heterotrophs. Heterotrophic respiration is a good indicator of soil microbial respiration.

Based on the known C-balances, there is more C available to heterotrophs in the elevated chambers than in the ambient (greater NPP in elevated). There is a net loss of C to the elevated ecosystems, and a net sequestration of C in the ambient ecosystems (positive NEP for ambient, negative NEP for elevated).

Statistically, there is no difference in R_{hetero} between elevated treatments with known C-balances. Heterotrophic respiration in the elevated treatments exceeds the respiration in the ambient treatment.

Ambient in **GREEN**
Asymmetric in **BLUE**
Symmetric in **RED**

*NPP is calculated by the sum of above- and below-ground primary production. Measured root biomass and a literature value of 44% C by mass were used to calculate bNPP (Warembourg, F.R., Estelrich, H.D., 2001. Plant Phenology and soil fertility effects on below-ground carbon allocation for an annual and a perennial grass species. Soil Biology and Biogiochemistry 33, 1299).

Research Questions

The negative NEP found in the warmed treatments (NPP<R_{hetero}) means there is a net loss of fixed C in these chambers. The warmed treatments have higher NPP, so the net loss in C is comes from much higher rates of soil respiration, specifically from microbes. This C loss could be due to the destabilization of either recently fixed and relatively labile C or else older and more recalcitrant pools. We expect warming to increase microbial activity, which might lead to preferential loss of C from the most labile pools. However, priming (from increased root exudation or leaf litter inputs) of old C by labile new C inputs might preferentially destabilize older, recalcitrant C. Similarly, older, more recalcitrant C should be more affected (have a higher Q_{10}) than more labile soil C, and thus would be preferentially destabilized.

Question #1: In the warmed treatments, does loss in soil C correspond to loss in labile or recalcitrant soil C?

Q_{10} response is the factor by which respiration increases for every 10° increase in temperature. If Q_{10}>1, the relationship between temperature and respiration is exponential; if Q_{10}~1 it is nearly linear. For Q_{10}>1, treatments with the highest maximum daily temperature (the symmetric treatment) will correspond to the highest microbial activity and greater respiratory soil C loss. If Q_{10}~1, then mean daily temperature will determine destabilization in the soil C pools (symmetric and asymmetric treatments will be the same). Analysis of plant C balances from TERA show that Q_{10}~1, but this does not necessarily mean that Q_{10} is small for soil respiration.

Question #2: How does Q_{10} influence destabilization of the labile and/or recalcitrant pool? Is the Q_{10}-soil respiration relationship linear or exponential?

Experiment

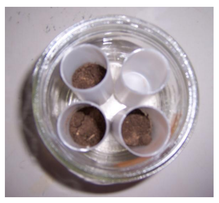
The experiment consists of the year-long incubation of soil cores from each terracosm chamber. The soil cores were taken from the top horizon of soil, 0-10 cm, in May and June, 2010. Density fractionation of a subsample from each chamber will occur at the beginning and end of the experiment to determine change in SOM fractions.

Density Fractionation

Density fractionation separates SOM into a light and a heavy fraction, and each fraction is analyzed for total- and polysaccharide- C. The method for density fractionation uses a high density liquid, sodium polytungstate (SPT), to separate SOM fractions based on particle densities. When soil is added to SPT in a vessel, the light fraction floats and can be collected from the top, while heavy fraction SOM collects as sediment at the bottom of the vessel.

Heavy fraction SOM is generally accepted as containing the more stabile, recalcitrant C pools, while the light fraction is much more labile. Density fractionation and subsequent C analysis before incubations will produce data on fixed C pools, and fractionation after incubation will give a measurement of C liability.

Incubations



Soil cores (0-10cm) from each terracosm chamber will be incubated at room temperature, ~25 C, for one year. There are four chambers per treatment, and one sample per chamber. 20 g of soil per sample will be split between three 20mL scintillation vials and placed in a half-pint Mason jar. Another scintillation vial in the jar will hold water. Prior to incubation, soil moisture measurements will be taken, and quartz sand will be mixed into each sample in a 50/50 ratio by weight.

Periodically, the jars will be sealed off for 12 to 24 hrs and gas chromatography will be used to measure the rate of respiration in each sample. Between samplings, jars will be covered with air-permeable cellophane. Sampling frequency will decrease over time, as respiration rates decrease exponentially.

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