

Poster #1-32**Coupled Long-Term Experiment and Model Investigation of the Differential Response of Plants and Soil Microbes in a Changing Permafrost Tundra Ecosystem**

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New estimates place 1460-1600 billion tons of soil carbon in the northern circumpolar permafrost zone, more than twice as much carbon than in the atmosphere. Understanding the magnitude, rate, and form of greenhouse gas release to the atmosphere is crucial for predicting the strength and timing of this carbon cycle feedback to a warming climate. Here we report results from an ecosystem warming manipulation where we increased air and soil temperature, and degraded the surface permafrost. We used snow fences coupled with spring snow removal to increase deep soil temperatures and thaw depth (soil warming) and open top chambers to increase growing season air temperatures (air warming). The soil warming treatment has successfully warmed soils by 2-3°C in winter, has increased growing-season depth of ground thaw by up to 50%, and has degraded an increasing amount of surface permafrost each year of the project. We have subsequently manipulated the surface water table that together with warming influences air and deep soil temperatures, permafrost, and soil moisture conditions that are primary drivers of tundra ecosystem carbon balance across the Arctic landscape. Here we report measurements of long-term carbon dioxide and methane exchange as a metric of changes in ecosystem carbon storage. Overall, soil warming had a much stronger effect than air warming, and the dynamics changed non-linearly over the course of the long-term experiment. Soil warming that degraded permafrost stimulated both gross primary productivity (GPP) and ecosystem respiration (ER) such that the system was initially a net sink of C in the growing season. In the second phase (6-10 years), ground subsidence as a result of thaw continued to increase soil moisture and saturate the soil. While permafrost thaw continued to progress, both GPP and ER became suppressed and resulted initially in neutral growing season C exchange, and eventually net C release (source). Soil warming has also altered the form of C release, as measurements have now documented a 3-20x increase in CH₄ emissions depending on how wet the soil became after permafrost degradation. The negative responses of plants and soils to continued permafrost thaw were not simulated by the CLM model, which projected increased GPP and ER with increased thaw. This suggests improved model structure that includes the physical subsidence of ground, which causes surface soils to become wetter, may be needed in order to capture the non-linear dynamics revealed by this unique long-term experiment.