Poster #9-20

Whole Ecosystem Warming Stimulates Greenhouse Gas Production and the Mobilization of Ancient Peat Carbon in Northern Peatlands

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The goals of this research are to investigate the metabolic pathways of soil organic matter decomposition, controls of greenhouse (GHG) production, and the response of the microbial C cycle to environmental change (warming, CO_2 enrichment). Multiple field campaigns were conducted to capture the response of whole-ecosystem warming (WEW) at the Marcell Experimental Forest (MEF), Minnesota, where the Oak Ridge National Lab (ORNL) has established the Spruce and Peatland Response Under Changing Environments (SPRUCE) experiment. Greenhouse gases (CO_2, CH_4), the environmental metabolome, and microbial communities were characterized using advanced analytical chemistry and environmental genomics technniques. Four years after initiation of deep peat heating, multiple lines of evidence indicate that WEW stimulates organic matter decomposition and leads to substantial alteration in the belowground carbon cycle. While we observe increases in both CO_2 and CH_4 production, CH_4 shows a greater response to temperature as evidenced by declining CO_2:CH_4 ratios in the shallow subsurface (<30cm). To further inform this shift towards increasing methanogenesis, we examined changes in microbial genomic traits, metabolites, and proteins involved in organic matter degradation. Concomitant with increases in CH_4 production, we observe increases in the relative abundance of hydrogenotrophic methanogens along with microbial enzymes diagnostic of methanogenesis. Sugars and fermentation products were positively correlated with increasing temperature in heated treatments relative to controls. Thus, it appears that warmer temperatures stimulate photosynthetic production, thereby releasing labile C (e.g. sugars) from plants which, in turn, stimulates fermentation increasing the availability of substrates that ultimately lead to increasing surficial methane production with warming. Results from microbial community analysis also show an increase in the relative abundance methanotrophic bacteria and an overall decline in microbial diversity with WEW. While the response of the shallow subsurface peat to warming appears to be strongly affected by fresh plant inputs, in deeper peat (>30 cm), we observe radiocarbon (^{14}C) evidence for the release of old catotelm carbon in response to warming. Four years from the onset of deep peat heating, the respiration product, dissolved inorganic carbon (DIC), is ^{14}C-depleted in the +9°C treatment plot in comparison to similar depths in the control plots up to 2m deep in the peat. These results suggest that ancient catotelm C is mobilized and respired in the heated treatments. Further analyses will reveal whether this mobilization of ancient C is solely the result of warming or may be stimulated by downward advection of increasing labile C inputs from the surface (i.e. priming).