Geophysical Research Abstracts
Vol. 15, EGU2013-716, 2013
EGU General Assembly 2013

Climate sensitivity and macronutrient regulation of peat decomposition

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Organic soils act as vital global carbon stores maintained in northern latitudes by climate and nutrient limited rates of organic matter decomposition. Peatland decomposition rates are sensitive to climate change, however predicting the magnitude of the microbial respiratory response is complex due to unknown interactions between climate and substrate quality. The nutrient status of peatlands varies widely from mineral rich fens to nutrient poor ombrotrophic bogs, which have the potential to respond differently to climate driven changes in temperature and carbon (C) inputs. In this work we examine the links between peatland macronutrient C, phosphorus (P) and nitrogen (N) stoichiometry, microbial community structure and the microbial response to direct and indirect effects of climate change.

Using total soil C:N and C:P ratios to define nutrient gradients in organic soils from Svalbard and Finland we investigated the interaction between the microbial response to temperature and nutrient limitation of decomposition. In organic rich soils from Svalbard we found there was a significant relationship between increasing temperature sensitivity of respiration and decreasing total soil P concentrations. Further investigation of the potential direct link between P limitation of decomposition and increased temperature sensitivity along a minerotrophic-ombroptrophic gradient in Finland was performed using multi-factorial P limitation assays. These showed that despite varying degrees of P limitation across four peatland soils there was no relationship between P limitation and increased temperature sensitivity of soil respiration. Throughout this study we found consistently high temperature sensitivity of decomposition in organic rich soils with Q_{10} values ranging between 2 to 4.5, indicating potentially higher vulnerability of these C stores to warming than is currently predicted using a globally invariant Q10.

Following on from this we examined the interaction between peatland nutrient status and the potential for labile C substrates to stimulate (prime) decomposition of the peat organic matter. Using ^{13}C labelled glucose and hemicellulose compounds we observed significant differences in the amount and rate of microbial substrate use between peats with differing nutrient status. Nutrient addition experiments were used with labelled C substrates to investigate the role of N and P limitation in enhancing or restricting priming effects. This is one of the first studies to use ^{13}C substrates to examine potential priming effects in peat soil and it provides an insight into the importance of priming mechanisms in peat decomposition.

This work explicitly links soil microbial responses to temperature and nutrient manipulations with microbial community structure allowing us to observe how microbial communities mediate soil C losses in peat soils. Disentangling the complex interactions between soil microbial community, C and nutrient limitation of decomposition is essential for predicting the vulnerability of different peatland ecosystems to climate driven changes.