Geophysical Research Abstracts
Vol. 21, EGU2019-508, 2019
EGU General Assembly 2019


# Belowground responses to aboveground changes: how variations in growing season climate influenced the biogeochemical response of two Arctic ecosystems to biotic and abiotic environmental change

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Dissolved Organic Carbon (DOC) and plant-available N in soil solution are key indicators linking microbial activity and plant nutrient uptake. In a changing Arctic, the boundary conditions for these processes may also change, which may affect greenhouse gas balances, plant community composition and the potential for transport of labile C and nutrients.

This study investigates $NO_3$-, NH4+, PO4-P and DOC content of the rhizosphere in a Low-arctic tundra heath and a fen in Western Greenland subject to changes in snow depth, summer temperature and shrub removal mimicking major abiotic and biotic environmental changes. The effects of up to four years of treatment in July-October 2013, 2014 and 2016 are reported here.

Year 2013 had average temperature and precipitation, whereas 2014 was extremely wet, and 2016 was extremely dry and warm.

The mesic tundra heath had minimum $NO_3$- content in the peak growing season, which increased during plant senescence. The $NO_3$- content was higher in the heath compared to the fen. The fen had higher peak contents of DOC and NH4+ -.

Both ecosystems were resilient to climatic changes. However, snow addition combined with summer warming and shrub removal increased winter ground temperatures and with that DOC content in 2014 in the fen and 2016 in the heath.

In the tundra heath, shrub removal and warming in combination increased the DOC and $NO_3$- content, but only significantly so in the dry 2016. That year, summer warming and shrub removal caused larger increase in ground temperature compared to the drier years.
Shrub removal kept soil moisture 5-10 % higher than at ambient conditions during the growing seasons. This effect was crucial in the dry 2016, where ambient soil moisture went below 10 vol. %, whereas it was 15-20 vol. % in plots with simulated herbivory.

In the fen, shrub removal alone and combined with warming increased DOC concentrations, but only significantly in the wet year 2014.
A PCA showed different patterns of variation in the dry, warm 2016, where PO4-P was relatively higher and total N was relatively lower. This could be due to saturated conditions, thus mobile P, and large evaporation in a warm year with N as the limiting plant nutrient.

The results suggest that the tundra heath and the fen differ in soil water chemistry composition, but also that their biogeochemical responses differ with variations in climate, and that this may be linked to their hydrological differences. In the tundra heath, low soil moisture can limit turnover rates, whereas water draining through the fen may yield high concentrations of non-limiting solutes due to evaporation in warm, dry summers, and causes it to represent DOC and nutrient availability of a larger area.

The effect of gradual climatic changes is modified by year-to-year variation in climate. We conclude that shrub removal is as or more important for microbial turnover as short term climatic changes, and that herbivory

in dry, warm years may have larger effect in mesic tundra due to the indirect retention of soil moisture caused by lower plant transpiration.