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Changes in Ecosystem Production in a High Arctic Semi Desert During the Growing Season

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Introduction

As a response to the global warming General Circulation Models (GCMs) predict that precipitation will increase at high latitudes. These conditions can increase the mineralization and potentially lead to higher soil nutrient levels. If Ecosystem Respiration (ER) is affected more than gross primary production (GEP) Net Ecosystem Production (NEP) will be negative and CO_2 will be released to the atmosphere creating a positive feed back to the global warming. If GEP is affected most strongly NEP will be positive and atmospheric CO_2 will be stored in vegetation and soil creating a negative feed back to the global warming. Water addition to a high arctic semi-desert was previously shown to increase microbial biomass and activity in the short term (Illeris et al. 2003). Here we explore the long-term effects on C balance after more than a decade of enhanced water addition.

Picture showing the research area.

Methods

CO_2 - fluxes in a high arctic semi desert at Zackenberg Research Station in Northeast Greenland were measured weekly throughout the growing season of 2009 using infrared gas analyzer (EGM-4) (Arndal et al. 2009). In order to simulate predicted future rainfall pattern and possible enhanced deposition field plots were treated with water (W), nitrogen (N) and phosphorus (P) in a fully factorial design. Water was added weekly in July and August from 1996 to 2009 corresponding to at least a doubling of the growing season precipitation. N and P were added once in 1996, 1997 and 2007.

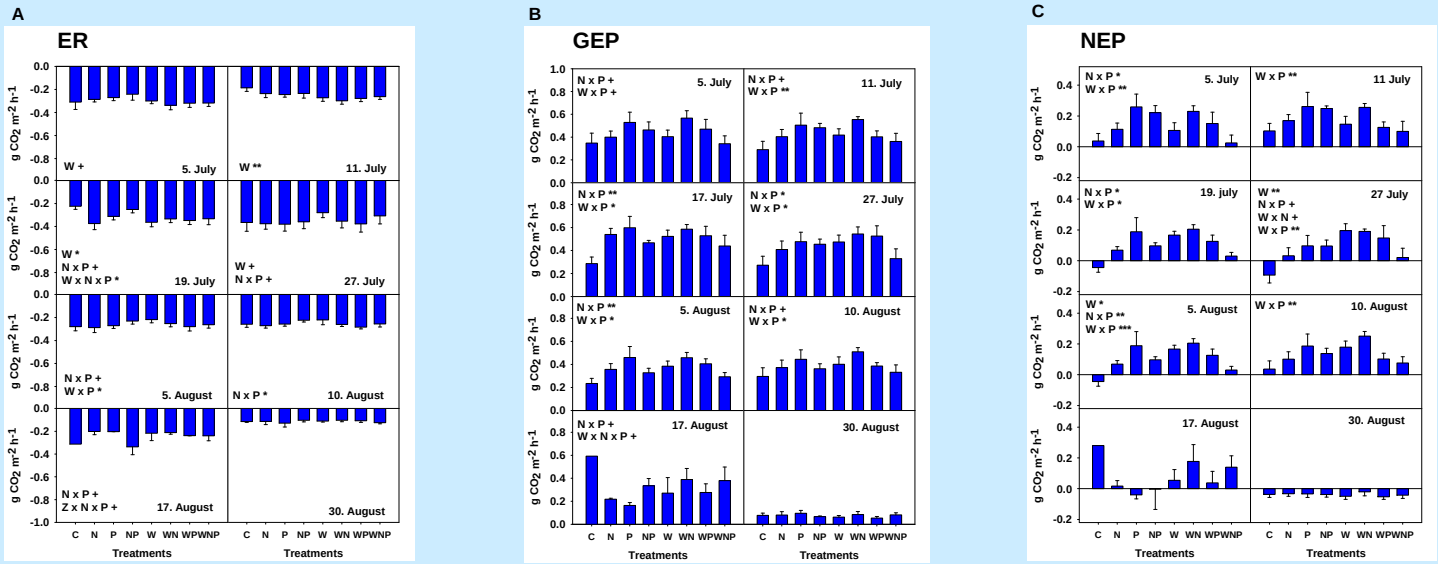

Figure 1. Weekly measurements of Ecosystem Respiration, ER (A), Gross Primary Production, GEP (B) and Net Ecosystem Production, NEP (C) in a high arctic semi desert in Northeast Greenland with applications of nitrogen (N), phosphorus (P) and water (W) in a fully factorial design. Level of significance of treatment effects and interactions using ANOVAs: + P < 0.1, * P< 0.05 , ** P < 0.01, *** P < 0.001.

Results and discussion

Results show that water addition had a positive effect on ER early in the growing season (figure 1A), however not strong enough to create a significant negative effect on NEP (figure 1C). GEP did not show any direct effect of water addition in any of the measurements indicating that respiration more than photosynthesis is limited by water. Water had a positive effect on NEP on 2 out of 8 days (figure C). Increased precipitation can therefore lead to a net uptake of CO_2 from the atmosphere into vegetation and soil, creating a negative feedback to the global warming.

Results repeatedly showed a negative interaction between water and P and between P and N for ER, GEP and NEP (figure 1A, B and C). The W x P interaction indicates that positive effects of water addition can be counteracted by P resulting in a less effective uptake of CO_2 from the atmosphere, which can weaken the negative feedback to the global warming.

Recordings of CO_2-fluxes

Location of the study area

Example of a field plot.

References

Arndal, M. F., Illeris, L., Michelsen, A., Albert, K., Tamstorf, M., Hansen, B.U. (2009). Seasonal variation in gross ecosystem production, plant biomass, carbon and nitrogen pools in five high arctic vegetation types *Arctic, Antarctic and Alpine Research* 41, 164-173. *http://dx.doi.org/10.1657/1938-4246-41.2.164*

Illeris, L., Michelsen, A., Jonasson, S. (2003). Soil plus root respiration and microbial biomass following water, nitrogen, and phosphorus application at a high arctic semi desert. *Biogeochemistry* 65, 15-29.