Geophysical Research Abstracts
Vol. 18, EGU2016-3818, 2016
EGU General Assembly 2016

Can observed ecosystem responses to elevated CO_2 and N fertilisation be explained by optimal plant C allocation?

Benjamin Stocker and I. Colin Prentice
Imperial College, Department of Life Sciences, London, United Kingdom (b.stocker@imperial.ac.uk)

The degree to which nitrogen availability limits the terrestrial C sink under rising CO_2 is a key uncertainty in carbon cycle and climate change projections. Results from ecosystem manipulation studies and meta-analyses suggest that plant C allocation to roots adjusts dynamically under varying degrees of nitrogen availability and other soil fertility parameters. In addition, the ratio of biomass production to GPP appears to decline under nutrient scarcity. This reflects increasing plant C export into the soil and to symbionts (C_{ex}) with decreasing nutrient availability. C_{ex} is consumed by an array of soil organisms and may imply an improvement of nutrient availability to the plant. These concepts are left unaccounted for in Earth system models.

We present a model for the coupled cycles of C and N in grassland ecosystems to explore optimal plant C allocation under rising CO_2 and its implications for the ecosystem C balance. The model follows a balanced growth approach, accounting for the trade-offs between leaf versus root growth and C_{ex} in balancing C fixation and N uptake. We further model a plant-controlled rate of biological N fixation (BNF) by assuming that C_{ex} is consumed by N_2-fixing processes if the ratio of N_{up}:C_{ex} falls below the inverse of the C cost of N_2-fixation.

The model is applied at two temperate grassland sites (SwissFACE and BioCON), subjected to factorial treatments of elevated CO_2 (FACE) and N fertilization. Preliminary simulation results indicate initially increased N limitation, evident by increased relative allocation to roots and C_{ex}. Depending on the initial state of N availability, this implies a varying degree of aboveground growth enhancement, generally consistent with observed responses. On a longer time scale, ecosystems are progressively released from N limitation due tighter N cycling. Allowing for plant-controlled BNF implies a quicker release from N limitation and an adjustment to more open N cycling.

In both cases, optimal plant C allocation implies a sustained growth enhancement but a decreased ratio of biomass productivity to GPP. Flexible allocation, C cost of N uptake, and flexible N retention imply plant control on N availability. Thereby, plant control on BNF is essential to determine the ultimate growth enhancement under elevated CO_2 and whether this implies higher N losses and N_2O emissions.