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Leaf physiological responses of mature Norway Spruce trees exposed to elevated carbon dioxide and temperature

Shubhangi Lamba (1), Johan Uddling (1), Mats Räntfors (1), Marianne Hall (2), and Göran Wallin (1)
(1) Department of Biological and Environmental Sciences, University of Gothenburg, Gothenburg, Sweden, (2) Centre for Environmental and Climate Research (CEC), Lund University, Lund, Sweden

Leaf photosynthesis, respiration and stomatal conductance exert strong control over the exchange of carbon, water and energy between the terrestrial biosphere and the atmosphere. As such, leaf physiological responses to rising atmospheric CO_2 concentration ([CO_2]) and temperature have important implications for the global carbon cycle and rate of ongoing global warming, as well as for local and regional hydrology and evaporative cooling. It is therefore critical to improve the understanding of plant physiological responses to elevated [CO_2] and temperature, in particular for boreal and tropical ecosystems. In order to do so, we examined physiological responses of mature boreal Norway spruce trees (ca 40-years old) exposed to elevated [CO_2] and temperature inside whole-tree chambers at Flakaliden research site, Northern Sweden. The trees were exposed to a factorial combination of two levels of [CO_2] (ambient and doubled) and temperature (ambient and +2.8 degree C in summer and +5.6 degree C in winter). Three replicates in each of the four treatments were used. It was found that photosynthesis was increased considerably in elevated [CO_2], but was not affected by the warming treatment. The maximum rate of photosynthetic carboxylation was reduced in the combined elevated [CO_2] and elevated temperature treatment, but not in single factor treatments. Elevated [CO_2] also strongly increased the base rate of respiration and to a lesser extent reduced the temperature sensitivity (Q10 value) of respiration; responses which may be important for the carbon balance of these trees which have a large proportion of shaded foliage. Stomatal conductance at a given VPD was reduced by elevated temperature treatment, to a degree that mostly offset the higher vapour pressure deficit in warmed air with respect to transpiration. Elevated [CO_2] did not affect stomatal conductance, and thus increased the ratio of leaf internal to external [CO_2]. These results indicate that the large elevated [CO_2]-induced increase in CO_2 uptake is partly counteracted by substantial increases in autotrophic respiration in boreal spruce. Furthermore, stomatal results suggest conservative leaf-level water use of spruce under rising [CO_2] and temperature.