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Canopy gradients in shoot exchange of carbon dioxide and water vapour in a mature Norway spruce forest

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Terrestrial ecosystems can act both as sinks and sources in the global carbon cycle. Forests are an important part of this system and a better understanding of their functioning is essential for predicting the future climate and evaluating mitigation strategies.

Much progress has been made in understanding the main processes controlling plant-atmosphere gas exchange: photosynthesis, respiration and stomatal conductance and their environmental responses. These responses also form the basis of mechanistic plant-atmosphere modelling. However, most previous studies that describe the spatial and temporal variability in leaf scale gas exchange have either been based on laboratory experiments or on field campaigns with measurements at a limited number of environmental conditions. The results may therefore be ecologically unrealistic and have a limited ability to represent the true interactions between the gas fluxes and their biological and meteorological regulators on a long-term basis.

This study was conducted at the Skogaryd research site, a 60 year old Norway spruce dominated mixed stand growing on drained peat soil in south-western Sweden. The carbon dioxide and water vapour exchanges between one year old Norway spruce shoots and the atmosphere were monitored between 2007 and 2009 using continuously measuring automated chambers. The measurements were made under the naturally occurring meteorological conditions once every half-hour at five heights in the crowns of three adjacent trees.

The measurements of photosynthesis, respiration and stomatal conductance all show clear vertical gradients in the canopy. These gradients and their temporal variation are correlated with both meteorological and biological factors. Photosynthesis is mainly controlled by light availability and the amount of nitrogen per unit needle area. The light climate is determined by canopy position and the nitrogen content by needle morphology and incident radiation. Shoot respiration also correlates well with the above mentioned variables as well as with temperature. The temperature response of respiration, Q10, varies with both season and the vertical position of the shoot. Stomatal conductance at different canopy positions varies with incident radiation, vapour pressure deficit and temperature. The presence of these vertical gradients and their temporal variability further emphasize the difficulty and the importance of accurately representing the canopy gas exchange in global climate models.

Results will be presented regarding the photosynthetic capacities, the respiration rates and the stomatal conductance of shoots in relation to canopy position, needle structural and chemical properties, radiation climate and temperature.