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Drought responses of a normally well-watered boreal forest ecosystem

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In the boreal zone water is seldom a limiting factor for plant activity. Springtime snowmelt reloads soil water reservoirs and during the short summer the amount of precipitation is usually enough to keep the ecosystem moist. In Finland, for example, the three summer months (June, July and August) account for more than 30% of the annual precipitation (700 mm/year).

We have carried out ecosystem-scale atmosphere-biosphere exchange measurements at the SMEAR II station in Hyytiälä, Southern Finland since 1996. The station is surrounded by a homogenous Scots pine (Pinus sylvestris L.) stand, which was sown after prescribed burning in 1962. The measurement set up includes an eddy-covariance system for measuring CO2, water vapor and sensible heat fluxes, soil water content measurements by the TDR-system, theta probes and equi-tensiometers, radiation measurements above and inside the canopy as well as automated chamber measurements for soil respiration and shoot-scale photosynthesis. We also measure sap flow in the trees using the Granier method and water tension inside the xylem using stem diameter variation measurements. This set-up allows also estimation of the variation in the stem hydraulic conductivity as well as stem water storage capacity.

During the 11 years of measurements there has been three summers when soil water content has limited activity of the ecosystem: 1999, 2002 and 2006. In this study we compared the ecosystem responses of the dry summers to the long term averages of our site and evaluated the conditions when ecosystems-scale effects on the carbon fluxes start occur. We also studied the effects of drought on different components of ecosystem respiration and the water transport and storage capacity of the pine trees. Interestingly, drought did not reduce stem or shoot respiration significantly but the first rainfall event after the drought increased soil respiration more than photosynthesis turning the ecosystem from a sink to a source of carbon.