Geophysical Research Abstracts
Vol. 12, EGU2010-1856-1, 2010
EGU General Assembly 2010

Water Consumption, Soil Temperature and Soil Respiration in Model Ecosystems of Young Oak Stands Treated by Air-warming and Drought

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IPCC scenarios predict a global mean annual temperature increase during the 21st century of 2 – 6 °C, as well as changes in precipitation patterns. The multidisciplinary project "Querco" addresses the question how increased air temperature and extended drought periods will influence stands of young oaks.
For this purpose, mixed stands of young Q. robur, Q. pubescens and Q. petrea (4-year-old trees from seeds of four different provenances each) were composed in the WSL open-top model-ecosystem chambers on either acid or calcareous forest soils and grown under four different climate treatments (control, air-warming, drought, air-warming & drought) from 2007 to 2009. Drought treated chambers only received about one third of water during the growing seasons from May to October as compared to the control. Further, we established longer drought periods without any irrigation. The air-warming treatment was established by keeping the side walls of the open-top chambers more closed than in the controls.
Unsurprisingly, evapotranspiration from dry soils was much lower than from irrigated soils. There was significantly more evapotranspiration from the acidic than from the calcareous soil. These findings are in line with increased leaf transpiration rates and a tendency towards higher leaf biomass in oaks growing on acid as compared to calcareous soil. The higher evapotranspiration from acid soils also was in line with the fact that soil water potentials decreased more in acidic than in calcareous soils, an effect that became particularly significant during periods of high consumptive water demand by the trees. While soil water potentials were strongly decreased by the drought treatments down to 1 m depth, the air-warming treatment had almost no effect on soil water potential.
Treatments, air-warming and drought, significantly increased soil temperature. In drought treated soils, this effect was related to the lower water content as compared to the control soils. As intended, air-warming led to higher air temperatures at day time. But also the drought treatment increased air temperature due to reduced air chilling by evapotranspiration. Thus the highest temperatures were observed in the combined air-warming and drought treatment.
Soil respiration was much lower under drought conditions than in control plots. No differences in soil respiration remained 10 days after rewetting of the soils, indicating that regeneration of biological soil activity was complete within short time. Air-warming had only little effect on soil respiration.
We conclude that increased temperatures and extended drought periods, two important trends associated with global climate change, will have strong effects on forest ecosystems. Reduced soil water availability during drought periods will be a particular severe challenge for trees in temperate forests. In comparison to many other forest tree species in temperate humid regions, oaks have the advantage to sustain longer periods without rain and therefore may be well prepared to deal with future climate conditions. In a next step, we will use our results to model and simulate the potential future water regime of oak forests under various site conditions in different IPCC scenarios.