Geophysical Research Abstracts
Vol. 16, EGU2014-10652, 2014
EGU General Assembly 2014

Key mechanisms of metabolic changes in mountain pine and larch under drought in the Swiss National Park

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Forests are of great ecological, economic and social importance worldwide. In many regions they have been recently affected by water deficits during summer droughts due to increasing temperatures and shortage of precipitation (Allen et al. 2010). Climate models predict that drought frequency will continue to increase during the 21st century and beyond (CH 2011).

Since the foundation of the Swiss National Park (SNP) in 1914 these forests have not been managed any more, which allows to study natural processes in these forest ecosystems. Since the 1990s, annual and spring temperatures increased in the SNP up to 0.5 ºC and 1.02 ºC, respectively, and average summer temperature increased up to 0.6 ºC. Annual precipitation decreased by 81 mm compared to the mean values (927 mm) from 1917 to 1989. Therefore, detailed studies of drought effects on the physiological functioning of trees over the last decades are needed.

Recently, mortality processes of mountain pines were observed in the Swiss National Park (Bigler, Rigling 2013). It is of great interest to investigate and compare the physiological responses of mountain pine and larch to drought and to understand the mechanisms behind the mortality processes. The goal of our study is to investigate the key mechanisms of tree physiological responses to drought in the SNP using state-of-the-art methods of classical dendrochronology, tree physiology, stable isotope, and compound-specific isotope analyses.

Long-term responses of mountain pine and larch trees from north- and south-facing sites to drought will be inferred from tree-ring width data. Based on climatic data a drought index will be calculated and reconstructed back in time. New chronologies for stable carbon and oxygen isotope ratios derived from both pine and larch tree-ring cellulose will provide retrospective insight into the long-term whole-plant physiological control of gas exchange derived from estimates of stomatal conductance, photosynthetic rate and intrinsic water use efficiency. Carbon isotopes ratios of specific sugar compounds such as sucrose, raffinose, fructose, ribose and pinitol in needle and wood samples will help to evaluate the impact of drought on the carbohydrate balance and carbon allocation. Analyzing the oxygen isotopic compositions of soil water, sap water (water in branches) and precipitation we will determine the role of the different water sources for tree growth under drought conditions.

The proposed work will provide a unique opportunity to assess the survival potential of mountain pine and larch trees exposed to drought that will help to estimate risks of modern climatic changes and forest damage.

This project was supported by Marie Heim-Vögtlin Programme PMPDP2_145507/1 granted to Olga Churakova (Sidorova).

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