Geophysical Research Abstracts
Vol. 17, EGU2015-807-1, 2015
EGU General Assembly 2015

Integrating inter- and intra-annual tree-ring width, carbon isotopes and anatomy: responses to climate variability in a temperate oak forest

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While many forests are experiencing strong tree declines due to climate change in temperate ecosystems, others nearby to those declining show no apparent signs of decline. This could be due to particular microsite conditions or, for instance, to a higher plasticity of given traits that allow a better performance under stressful conditions. We studied oak functional mechanisms (Quercus petraea) leading to the apparently healthy status of the forest and their relation to the observed climatic variability. This study was conducted in the Barbeau Forest (northern France), where cores from mature trees were collected. Three types of functional traits (secondary growth, physiological variables - δ13C and derived Δ13C and iWUE- and several anatomical ones -e.g. vessel area, density-) were recorded for each ring for the 1991-2011 period, distinguishing EW from LW in all measured traits. Among the three types of functional traits, those related to growth experienced the highest variability both between years and between individuals, followed by anatomical and physiological ones. Secondary growth maintained a constant trend during the study period. Instead, ring, EW and LW δ13C slightly declined from 1991 to 2011. Additional intra-ring δ13C analyses allowed for a more detailed understanding of the seasonal dynamics within each year. In particular, the year 2007 (an especially favorable climatic year during the growing season) showed the lowest δ13C values during the EW-LW transition for the whole study period. Inter-annual anatomical traits varied in their responses, but in general, no temporal trends were found. The results from structural equation modeling (SEM) showed direct relationships of seasonal climate and growth, as well as indirect relationships mediated by anatomical and physiological traits. We further discuss the implications of these results on future forest responses to ongoing climate changes.