Geophysical Research Abstracts
Vol. 12, EGU2010-11894-1, 2010
EGU General Assembly 2010

13C-derived water use efficiency in Mediterranean pines across a precipitation gradient are related to differential moisture-dependant Ci-regulation responses.

Kadmiel Maseyk (1), Debbie Hemming (2), Alon Angert (3), Steven Leavitt (4), and Dan Yakir (5)

(1) Universite Pierre et Marie Curie, UMR Bioemco, Thiverval-Grignon, France (kadmiel.maseyk@grignon.inra.fr), (2) Met Office Hadley Centre, Exeter, United Kingdom, (3) Institute of Earth Sciences, Hebrew University, Jerusalem, Israel, (4) Laboratory of Tree-Ring Research, University of Arizona, Tucson, AZ, USA, (5) Department of Environmental Sciences and Energy Research, Weizmann Institute of Science, Rehovot, Israel

Persistent predictions of warming and drying in the entire Mediterranean and other regions motivate investigation of terrestrial ecosystem responses to such change. We have used 30 year (1974-2003) records of tree-ring derived growth measures (basal area increment, BAI) and cellulose 13C isotopic composition from three sites across a geographical rainfall gradient to explore the temporal behaviour and physiological responses to variations in climatic (rainfall, temperature) and atmospheric ([CO2], Ca) drivers in Pinus halepensis trees. Potential juvenile effects on the cellulose 13C record were negligible in the two even-aged low density stands and excluded from the mixed-aged natural stand. Agreement between estimates of intrinsic water use efficiency (Wi) from cellulose 13C values and leaf-scale gas exchange measurements, consistency across the sites in the Wi response to soil water content and an observed insensitivity to known thinning events at the dry site give us confidence that leaf-level physiological responses, and not age and density effects, dominate the 13C isotopic record in these trees.

Site-level differences and inter-annual variations in the earlywood (EW, associated with the wet and productive period) 13C-derived estimates of Wi were related to annual precipitation in a common, site-independent manner, with reduced sensitivity to annual rainfall above ∼600mm. Rainfall was also the predominant driver in inter-annual variations in BAI. While there were no trends in rainfall amount over this period, there were clear trends of increasing Wi in both the EW and latewood (LW) that ranged between ca. 5 and 20% increase over the study period. These trends were better correlated with the increase in Ca than a temperature increase (∼0.04°C y-1)that was also observed across the sites.

The different sensitivities of Wi to Ca (dWi/dCa of 0.1 to 0.5 umol mol-1 ppm-1) represented shifting Ci-regulation (Ci, leaf internal CO2 concentration) responses associated with the hydrological conditions and operational limits of Ci or Ci/Ca set-points. A constant Ci/Ca was observed under the most favourable conditions (mesic site EW), indicating active regulation to maintain Ci/Ca at an apparent optimum (0.62 $\pm$ 0.01) with increasing Ca. Consequently, Wi increased appreciably over time (dWi/dCa = 0.26). With increasing moisture deficits, i.e. at the drier sites in the wet season and the drier LW period at the wet site, average Ci (and Ci/Ca) was lower, and attributed to lower average stomatal conductance. However, with the increasing aridity there was an increasingly passive response in Ci regulation with increasing Ca (dCi/dCa = 0.7 at the intermediate site and 1.0 at the dry site), resulting in an increase in Ci/Ca towards the apparent optimum and mild increases in Wi. Consequently, while average Wi increased, sensitivity of Wi to Ca decreased with aridity. At the arid extreme of the analysis (latewood in the dry site), a different strategy was observed. Here Ci was lowest (190 ppm), but was also maintained relatively constant over the period, resulting in the sharpest increase in Wi observed with the increase in Ca. This low Ci possibly represents a lower functional Ci limit for this species, and the change in strategy (from passive Ci regulation and increasing Ci/Ca to active Ci control and decreasing Ci/Ca) served to maximise the increase in Wi under the driest conditions, within the constraint of this minimum Ci. Overall, the results contribute to our understanding of the range of adjustments forest ecosystems may make to the dry conditions anticipated in the future.