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Can we use of non-annual wood anatomical traits in dendroclimatology? The study of rays in Norway spruce from two contrasting climatic environments.

Ryszard J. Kaczka (1,2), Barbara Spyt (2), and Lenka Plavcova (1)

(1) Institute of Biology, University of Hradec Kralove, Hradec Kralove, Czech Republic (ryszardjkaczka@gmail.com), (2) Faculty of Earth Science, University of Silesia, Sosnowiec, Poland

The wood anatomical features (quantitative and qualitative) are frequently used to define the environmental influences on tree growth and plant adaptation to e.g. climate change. The ray parenchyma is rarely investigated and employed for such analyses, and the potential of its anatomical traits is little known.

We tested if there are anatomical differences in rays of Norway spruce grown in two contrasting environments (namely, temperature-driven timberline spruce forest and drought-sensitive lowland monoculture). We also analysed what climate signal the ray-based chronologies register in comparison with more standard proxies.

Cores from 30 trees per site were sampled and a common 50-year-long period (1959 - 2009) was selected for further analyses. The cores were polished and photographed under the stereoscope at high magnification allowing to perform ring-width and anatomical measurements at the same wood surface. Three sets of data were collected: a) ray parenchyma measurements including: i) the total number of rays per annual ring, ii) the number of rays continuing from the prior ring, iii) the number of newly formed rays in each annual ring; b) the width of tree ring including annual, early- and latewood width, c) wood density measured as the blue intensity of early, latewood, and delta blue. Consequently, 9 chronologies of ray, ring width and blue intensity parameters per site were developed. The inter-parameters and inter-site analyses were performed. The dendroclimatic analyses of all the chronologies were performed using instrumental and gridded data.

The spruce trees growing in extreme, cold environment of altitudinal treeline were characterised by generally narrower rings and lower density compared to the trees from the lowland site. However, the most significant difference between locations was related to the length of rays. The rays were significantly longer in trees at the timberline site compared to the lowland site. These differences are likely related to the different strategies for the allocation and storage of non-structural carbohydrates between the timberline and lowland trees. The differences are also reflected in correlations with climate drivers. Overall, our data demonstrate that the use of finer-scale anatomical parameters in addition to the more traditional dendrochronological measures can provide novel insights in tree growth-climate relationship and its adaptation to the environment.