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Uniform climate sensitivity in tree-ring stable isotopes across species and sites in a mid-latitude temperate forest

Claudia Hartl-Meier (1,2), Christian Zang (3), Ulf Büntgen (4,5), Jan Esper (1), Andreas Rothe (6), Axel Göttlein (2), Thomas Dirnböck (7), and Kerstin Treydte (4)

(1) Department of Geography, Johannes Gutenberg University Mainz, Johann-Joachim-Becher-Weg 21, 55128 Mainz, Germany (treydte@wsl.ch), (2) Forest Nutrition and Water Resources, Technische Universität Mu¨nchen, Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising, Germany, (3) Ecoclimatology, Technische Universität Mu¨nchen, Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising, Germany, (4) Swiss Federal Research Institute WSL, Zuercherstrasse 111, 8903 Birmensdorf, Switzerland, (5) Oeschger Centre for Climate Change Research, University of Bern, 3012 Bern, Switzerland, (6) Faculty of Forestry, University of Applied Sciences Weihenstephan-Triesdorf, Hans-Carl-von-Carlowitz-Platz 3, 85354 Freising, Germany, (7) Department for Ecosystem Research and Monitoring, Environment Agency Austria, Spittelauer Lände 5, 1090 Vienna, Austria

Tree-ring stable isotopes, providing insight into drought-induced eco-physiological mechanisms, are frequently used to reconstruct past changes in growing season temperature and precipitation. Their climatic response is, however, still not fully understood, particularly for data originating from non-extreme, mid-latitude environments with differing ecological conditions.

Here, we assess the response of δ13C, δ18O and tree-ring width (TRW) from a temperate mountain forest in the Austrian pre-Alps to climate and specific drought events. Variations in stem growth and isotopic composition of Norway spruce, common beech and European larch from dry, medium and moist sites are compared with records of sunshine, temperature, moisture, precipitation and cloud cover. Results indicate uniform year-to-year variations in δ13C and δ18O across sites and species, but distinct differences in TRW according to habitat and species. While the climate sensitivity of TRW is overall weak, the δ13C and δ18O chronologies contain significant signals with a maximum sensitivity to cloud cover changes (r = -0.72 for δ18O). The coherent inter-annual isotopic variations are accompanied by substantial differences in the isotopic signatures with offsets up to $\sim 3‰$ for δ13C, indicating species-specific physiological strategies and varying water-use efficiencies. During severe summer drought, beech and larch benefit from access to deeper and moist soils, allowing them to keep their stomata open. This strategy is accompanied by an increased water loss through transpiration, but simultaneously enables enhanced photosynthesis. Our findings indicate the potential of tree-ring stable isotopes from temperate forests to reconstruct changes in cloud cover, and to improve knowledge on basic physiological mechanisms of tree species growing in different habitats to cope with soil moisture deficits.