ASSOCIATION FOR TREE-RING RESEARCH

TRACE 2022

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Friedrich-Alexander-University Erlangen-Nürnberg

May 23-28, 2022

Friedrich-Alexander-Universität
Naturwissenschaftliche Fakultät

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Time Table of the Conference Days

Time	Wednesday	Time	Thursday	Time	Friday
08:00 - 08:30	*Registration*				
08:30 - 09:00	*Conference Opening*	08:30 - 08:42	D_FOHE_O1_Römer	08:30 - 09:00	Keynote presentation by Crivellaro
		08:42 - 08:54	D_FOHE_O2_Peters		
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		09:18 - 09:30	D_FOHE_O5_Jansen	09:12 - 09:24	F-CLIM-O2_Kuhl
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09:54 - 10:06	A-QWA-O3_Ziaco	09:54 - 10:06	D_FOHE_O8_Ballikaya	09:48 - 10:00	F-CLIM-O5_Rydval
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				10:24 - 11:00	*Coffee Break*
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11:26 - 11:38	A-QWA-O8_Resente	11:26 - 11:38	D_FOHE_13_Trouet	11:24 - 11:36	F-CLIM-O10_Stolz
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		12:26 - 12:45	Chair: session summary Africa Tree-Ring Society	12:30 - 13:30	*Lunch*
		12:45 - 14:30	*Lunch & Poster Session*		
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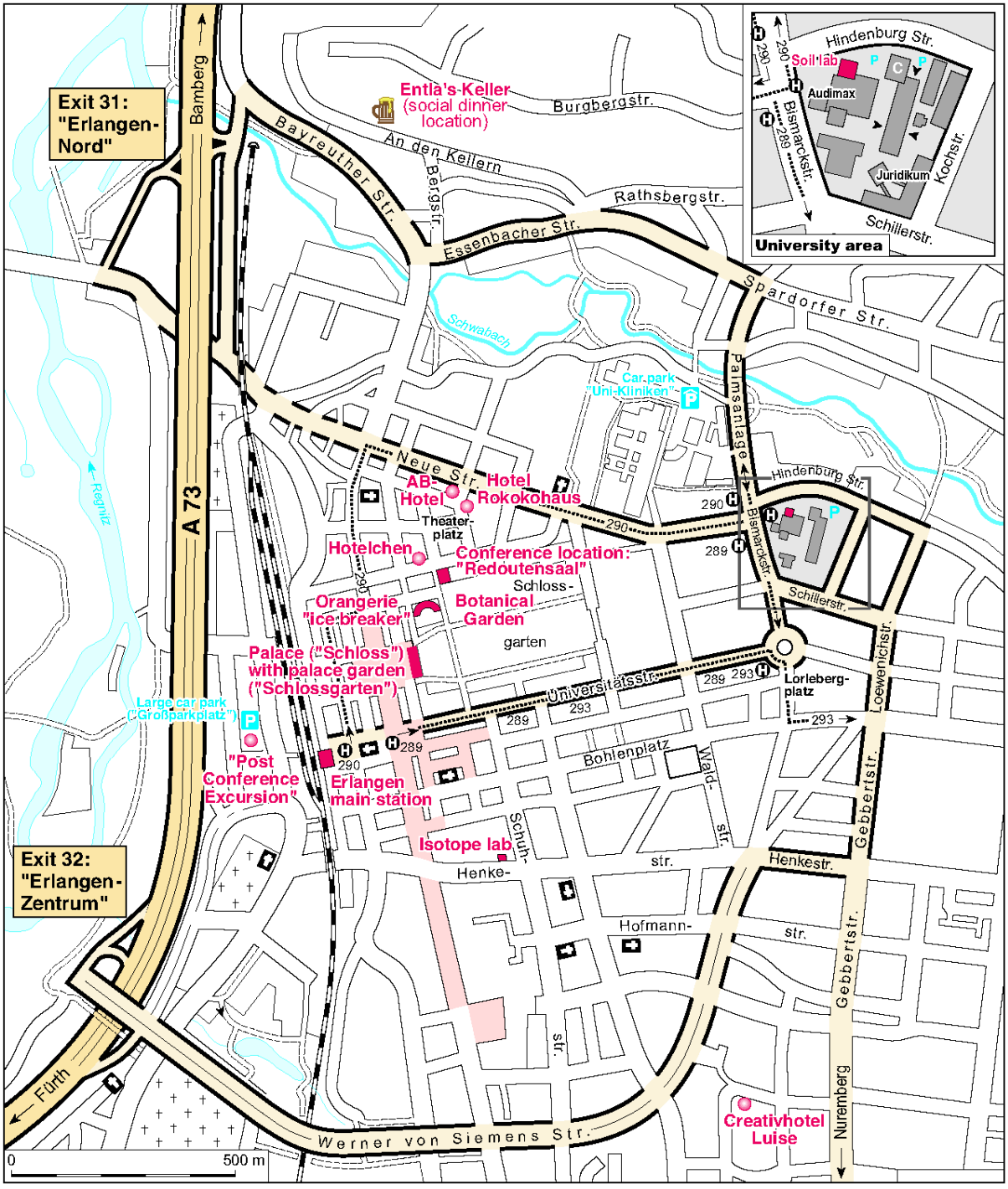
17:15 - 18:15	*ATR Business Meeting*				
		18:30 - 22:00	*Social Dinner*		

Important TRACE Locations inside Erlangen



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Session A

Quantitative wood anatomy & cambial dynamics

Presentation code: A-QWA-Keynote

What happens when dendroanatomy merges with other disciplines?

Angela Luisa Prendin[1]

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Key words: inter and intra-annual ring variation, abiotic and biotic factors, vegetation productivity, woody plants

While growing, woody plants continuously adjust their xylem structure to achieve an optimal balance of carbon costs for the competing biomechanical and hydraulic requirements under varying environmental conditions. These adjustments, remaining permanently fixed and chronologically archived in the secondary xylem, provide the 'time component' to functional responses induced by xylem plasticity. Therefore, xylem cell anatomical traits are recognized as high-resolution archives of past growth conditions and as a useful proxy to gain insight into past growth dynamics.

Dendroanatomy, the analysis of xylem-cell features along dated tree-ring series, can provide a long-term perspective on wood formation processes. The methodological advancements in the analysis of wood anatomical traits extend inferences on cambial activities from a few years up to decades. This, together with the tight and direct link between some tree-ring anatomical-based traits and plant physiological processes could be used to reconstruct individual and vegetation carbon budget dynamics.

Matching dendroanatomical information with satellite-based digital detection, it is possible to upscale high-resolution carbon budget and vegetation productivity dynamics from local to landscape and regional scales. This multiproxy approach has been successfully applied to pinpoint the drivers of narrow ring formation in a tundra shrub and to jointly quantify the direct and carry-over effects of moth defoliation with temporal and spatial outbreak dynamics. Similarly, complementing dendroanatomical with biochemical analysis, it was possible to quantify the effects of insect outbreaks on carbon investment to shed light onto plant allocation priorities under stress conditions.

We should promote networking together with the interdisciplinary application of dendroanatomy. This integration with other disciplines/methods will surely help to tackle important/urgent ecological questions.

Presentation code: A-QWA-O1

Revealing intra-annual carbon sequestration patterns through xylem anatomy and eddy covariance fluxes in eastern white pine

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Key words: dendroanatomy, cell wall area, carbon fixation, gross primary production, xylem biomass

Forests are major terrestrial carbon sinks, playing a crucial role in climate change mitigation. Nonetheless, the long-term seasonal carbon sequestration dynamics are scarcely understood. Here, we investigated the relationships between climate variability, carbon fluxes, and the xylem biomass in an 80-year-old plantation of *Pinus strobus* in Ontario, Canada. From Eddy Covariance tower, we obtained daily Gross Primary Production (GPP), precipitation, VPD and air temperature for the period 2003-2018. To estimate inter-and intra-annual xylem biomass accumulation we selected 12 trees and built wood anatomical chronologies of cell number (CN), cell wall area (CWA) and overall wall area per ring (RWA). We used moving windows correlations of daily climate data and GPP with anatomical chronologies to analyse their associations at intra-annual scale.

Temperature in early spring and precipitation in mid-spring and summer strongly positively affected GPP, while summer VPD had a negative effect. For the first time, we observed strong positive correlations between GPP in the growing season and CWA (proxy for carbon quantity in each xylem cell) both in earlywood (May 10 – Aug 1, $r = 0.652$) and latewood (Jul 3 – Sep 3, $r = 0.885$). Strong positive correlations were also found between GPP and CN and RWA ($r \geq 0.724$). Our results suggest a direct influence of CO_2 fluxes on the accumulation of carbon in woody biomass. This work will help to reduce uncertainties in woody carbon accumulation dynamics, opening new perspectives in the study of forest carbon cycle.

Presentation code: A-QWA-O2

Inter- and intra- annual variability in tree-ring growth of Norway spruce on two locations in the Czech Republic

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Key words: *Picea abies* (L.) H. Karst, tracheid anatomy, radial growth, precipitation, temperature

Xylem cells anatomy plays a crucial role in regulating hydraulic and mechanical functions of a tree, which is also influenced by local weather conditions or intrinsic factors such as age or height. This study aimed to investigate how tracheid anatomical parameters of Norway spruce trees vary at an inter- and intra- annual level and to assess correlations with weather conditions (air temperature, precipitation). Three dominant, healthy Norway spruce trees of similar age and height were selected in two forest stands located in the Czech Republic. Bílý Kříž (875-908 m a.s.l.) experiences a cool, humid climate with high annual precipitation amounts, while Rájec-Němčice (610-625 m a.s.l.) a slightly warmer one with substantially lower precipitation. For each tree, functionally important anatomical parameters of the tracheids (number of cells, lumen radial diameter, cell wall thickness, tracheid radial diameter, density, tree-ring width), obtained from three radial files at breast height diameter (1.3 m) were measured using WinDendro (Regen Instruments, Québec, Canada) for 2010-2017. Preliminary results of the study showed the cell wall thickness and density of the late-formed Norway spruce cells were found to be respectively thinner and lower in Bílý Kříž, in comparison with the drier Rájec-Němčice. The reduced availability of water in Rájec-Němčice affected mostly the shaping of cell dimensions and latewood density, depicting hydraulic adjustment of trees to site conditions. Further investigation is needed to reveal the environmental impact on the structure of the Norway spruce tracheids when severe drought events occur in the area.

Presentation code: A-QWA-O3

Assessing the relationship between xylem hydraulic architecture and growth in two subalpine conifer species from a North American sky-island

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Key words: quantitative wood anatomy; hydraulic conductivity; hydraulic safety; BAI; dendroclimate

Xylem hydraulic architecture defines the capacity of a stem to efficiently transport water. Wood cellular structure optimizes water conductivity while preventing hydraulic failure, but how this process affects stem growth in natural conditions is still not fully understood. We used quantitative wood anatomy to estimate proxies for xylem specific conductivity (*Ks*) and cell wall reinforcement (*wrein*) in two conifer species, *Pinus flexilis* (PIFL) and *Pinus longaeva* (PILO), from the Great Basin of North America (USA). Using a whole-tree sampling approach, we investigated internal variability of stem hydraulic architecture, its response to daily climate, and the relationship with basal area increment (*BAI*) in the period 1990-2013. Despite cell lumen diameter scaled along the stem following a power function in both species, the effect on *Ks* and *wrein* was different between species, pointing to higher margins of hydraulic efficiency in PILO. Both species showed a decreasing trend in *Ks*, while *wrein* significantly increased only in PILO in the 1990-2013 period, although no trends were observed in *BAI*. Climate sensitivity of *Ks* peaked over a longer period (84-102 days) compared to *wrein* (20-55 days). In both species *Ks* was the best predictor of *BAI*, showing a positive relationship with stem growth despite variability between trees, size classes, and dry *vs.* wet years. This evidence suggests that species may maximize hydraulic conductivity over safety even in water limited environments. Characterizing the mechanistic relationships between xylem anatomy, plant hydraulic functioning, and stem growth is crucial to understand species distribution under future climate change scenarios.

Presentation code: A-QWA-O4

Wood anatomy and resistance drilling density relations in Norway spruce and European beech

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Key words: wood anatomy, resistance drilling density, wood structure, wood quality

Environmental conditions affect tree ring increments, wood anatomy and, consequently, wood density, which is one of the main wood quality indicators. Although studies on inter- and intra-annual variability in tree ring features or density exist, studies demonstrating a clear link between wood structure on a cellular level and its effect on wood density on a macroscopic level are rare. To analyse these relationships we collected increment cores from 24 European beech and 17 Norway spruce trees at four sites in Slovenia. Wood density profiles were sampled by resistance drilling measurements using Resistograph. To perform analysis, resistance drilling density values, tree-ring (tree ring width, transition-TWW, and latewood width–LWW), and wood-anatomical features (vessel/tracheid area and diameter, cell density, relative conductive area, and cell wall thickness) were averaged for the first 7 cm of measurements. On the wood anatomical level, we observed significant relationships between tree-ring and wood-anatomical features in both spruce and beech. While in relations between wood anatomy and resistance drilling density we found a significant relationship only for spruce, where a significant negative correlation was found between resistance drilling density and tangential tracheid diameter, and a positive correlation between resistance drilling density and both TWW+LWW and LWW. In beech, we did not observe a significant relationship between wood anatomical structure and resistance drilling density. Our findings suggest that resistance drilling measurements can be used to evaluate differences in density within and between species. But they should be improved in resolution to be able to detect changes in wood anatomy, especially when examine samples with very narrow growth rings or species with defuse porous wood structure.

Presentation code: A-QWA-O5

Contrasting climate sensitivity of different Pinus cembra tree-ring traits in the Carpathians

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Key words: dendroanatomy, maximum density, inter-intra annual climate-structure relationship, stone pine, treeline

Climate change is observed and predicted to profoundly affect the structure and functioning of high-elevation ecosystems. Inter- and intra-annual tree-ring traits of marginal populations, especially the ones growing at the treeline, could serve as early-warning sentinels to better understand species-specific responses of long-living woody species to future climate conditions. In this study, we combined classical dendrochronology with wood density and xylem anatomical measurements to investigate the climate sensitivity of the high-elevation and scattered distributed Pinus cembra L. Specifically, we analyzed ring-width (TRW), maximum density (MXD) together with a variety of xylem anatomical traits (cell number per ring, cell density, conduit area (CA), and cell-wall thickness (CWT) time series, split into sub-ring sectors and assessed the associations with monthly and daily climate records over the last century (1901-2015) in mature trees. The results showed the strong dependency of TRW on cell number and MXD on CWT. Summer temperature resulted to promote MXD and CWT from the early- to late-wood but not TRW. On the opposite, CA resulted strongly positively associated with water availability and negatively with temperature. This study contributes to improve our general understanding of the climate-growth and -structural associations of a typical glacial relict high-elevation tree species and the results could be considered for forecasting population dynamics on projected climate changes scenarios.

Presentation code: A-QWA-O6

Spatiotemporal variability of xylem trait response to climate of a high-elevation conifer species across its geographical range

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Key words: climate sensitivity, *Pinus cembra*, quantitative wood anatomy, spatiotemporal variability, high elevation

Understanding spatiotemporal variability of tree growth response to climate is crucial to predict future scenarios of forests. This is especially urgent for relict species growing in heat-limited ecotones since they are facing faster warming than the global average. Long-term climate sensitivity of woody species has been extensively investigated through the analysis of tree-ring width and, recently, of wood-anatomical traits. Yet, no study has considered anatomical responses across the entire geographical distribution of one species. We explored climate sensitivity of xylem anatomical traits in *Pinus cembra,* a high-elevation species endemic to Alps and Carpathians, over 6 sites across its entire distributional range. Climate-growth associations for mean lumen area, cell wall thickness and cell number have been computed using daily climate records from 1920 to 2010. Series were aligned to degree-day sum thresholds, accounting for the inter-annual variability of xylogenesis dynamics. Anatomical chronologies featured common variability within the two mountain ranges but were distinct between the two areas and likely associated to regional climate. Nonetheless, climate-anatomical trait associations suggest similar species-specific mechanisms. In all sites, cell number and cell wall thickness were positively related to temperature and negatively to precipitation, while lumen area showed the opposite pattern. In the last 30 years, we observed a slight advance of the period evidencing significant responses, especially in the Alps, and a decrease in the climate sensitivity, suggesting a relaxation of the climate limiting factors. Under warmer climate, we may expect increased radial growth rates, and xylem structure less transport efficient but more resistant to cavitation.

Presentation code: A-QWA-O7

Climatic influence of wood anatomical parameters of *Tsuga dumosa* in the Nepal Himalayas.

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Keywords: cambial phenology; elevation gradient; Mediterranean climate; intra-annual density fluctuations

Himalayan Hemlock (*Tsuga dumosa*) is a tree species widely spread in the cloud forest belt of the central and eastern Himalaya and adjacent South Asian mountain regions; its durable wood is an important timber source for local populations. *T. dumosa* forms large trees which may reach ages several 100 years, hence the species has already been used in studies using tree-ring width (TRW) as a climate proxy. Due to the humid climate conditions in the cloud forest belt, TRW series of *T. dumosa* are often complacent, showing little inter-annual variability. We measured quantitative wood anatomical traits of five selected individuals, including tracheid lumen area (TLA), radial cell diameter (RCD), cell wall thickness (CWT) and modelled anatomical wood density (AWD) for the period 1940-2015 using WinCELL ™ Pro V. To increase the temporal resolution of the dendroanatomical time series, each ring was digitally divided into 10 equal sectors P1 to P10. Latewood typically covered the last two sectors P9 and P10. Chronologies of all cell parameters for sectors P1 to P8 were significantly inter-correlated. The two latewood sectors were also inter-correlated, but showed significantly different variations compared to sector P1 to P8. We identified six pointer years in the TRW series and analyzed the anatomical profiles of all cell parameters. During negative pointer years, TLA, RCD and AWD were reduced in most of the sectors. During positive pointer years, the anatomical profiles showed a higher variability and more individual patterns of wood anatomical traits. The higher temporal resolution of dendroanatomical time series can help to improve the generally weak correlation of TRW series with climate variables in cool-moist environments.

Presentation code: A-QWA-O8

The effect of flooding on height growth and wood anatomy of pedunculate oak (*Quercus robur* L.)

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Key words: Wood anatomy, Neural network, Quercus robur, Vessels, User interface

Water availability affects the height growth and the wood anatomy of trees. Around the world, precipitation and tree height are positively correlated. Taller trees typically require larger vessels or tracheids to maintain sufficient water transport. But how do trees respond to sudden changes in the water availability, for example flooding and sustained increases in the water table level?

We studied 12 oak trees (*Quercus robur* L.) sampled in the Anklamer Stadtbruch natural reserve in NE Germany. The trees that survived the flooding and following rewetting of the area, after the local dyke broke in 1995, show similar diameter but consistent differences in height. The effect of stand density on tree height in oak forests has been highly investigated already, showing that suppressed trees tend to invest resources in primary-height growth, rather than secondary-girth growth. The race for light drives these trees towards increased incidence of hydraulics constraints and mechanical damages. Therefore, we investigated wood anatomical parameters together with indicators of the trees' status (crown base height and crown diameter) to understand if and how xylem features differed between individuals and influence their adaptation potential to altered hydrological conditions.

To achieve this, we studied wood anatomical thin sections with our previously published deep learning algorithm, which automatically detects and measures oak vessels. Our study investigates the role of wood anatomical adaptation on a ~70 years span in the growth response of the oak trees to the flooding, and highlights how trees can or cannot cope with changing environments.

Presentation code: A-QWA-O9

Wood anatomical study to better understand the growth response variability of two Salix shrub species from Iceland

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Key words: Arctic, tundra shrubs, Salix arctica, Salix herbacea, wood anatomy

In recent years the application of tundra shrubs is increasing in dendrochronological studies. And to better understand the effects of current climate change on Arctic vegetation, local and regional diversity must be considered. As in the last few decades, glaciers around the Arctic have been melting at an increasingly rapid rate. Thus, new areas are becoming available and this increase in shrub cover is expected to be one of the most important consequences of climate change for Arctic terrestrial ecosystems. In this study, we aimed to understand the growth patterns of two Arctic dominant shrub species, Salix arctica and Salix herbacea from the distinct sites of Iceland. S. arctica (Arctic willow) is widespread, as one of the most important shrub species in the Arctic and S. herbacea (Dwarf willow) dominant prostrate dwarf shrub common in arctic and alpine tundra, that often grows in Iceland. The main objective of the study is to examine the anatomy of the stem and roots of these two species to better understand their radial growth and highlight the main differences between them. All analyses performed from micro-sections to their interpretation by using the microscopic and SEM images will provide a detailed insight into their anatomy. The combined wood anatomical and dendroclimatological approach will also help us to better understand recent environmental changes in the Arctic region.

Presentation code: A-QWA-O10

Temperature is not the main driver of vessel diameter tapering (when standardized by height) across climatic gradients in *Viburnum.*

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Key words: vessel widening (conduit taper), xylem, ecological wood anatomy, embolism.

It is generally assumed that tree-rings, and their vessel diameters, are wider in warmer and wetter years. To maintain constant conductance per unit leaf area as trees grow taller, stem vessels should widen from tip to base. But wider vessels are more susceptible to embolism, so taller plants are progressively becoming more vulnerable to drought or cold as they grow. The traditional theory of vessel hydraulic adaptation postulates that vessel diameter is affected by climate, with cold environments selecting for narrower vessels. Recent work suggests that plant height is an important driver, hence the relationship between vessel diameter, climate and height remains to be investigated. To explore this, we installed 16 climate stations along 5 strong elevational gradients in Mexico and measured vessel diameter of the most recent tree ring along the stems of 57 trees of 10 species of *Viburnum* (Adoxaceae). We examined the possibility that there could be adaptive variation in the Y-intercept of within-plant tip-to-base vessel widening curves, with plants in dry and cold areas having lower intercepts (narrower vessels for a given height) than in moist-warm places. We found no evidence that temperature affects vessel widening, though total plant height, leaf area, and possibly wood density appears to affect the Y-intercept of vessel widening profiles of individual stems. These findings stimulate new questions including the need to understand how vessel widening in the leaves is coordinated with that in the stem.

Presentation code: A-QWA-P1

Cambial dynamics of *Pinus sylvestris* within climatically varying growing seasons

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Key words: cambial activity, xylogenesis, growth-climate relationships, Scots pine

In the growing seasons of 2020 and 2021, growth conditions in Northern Bavaria (southeast Germany) contrasted strongly in terms of temperature and precipitation amounts. To determine the weather's impact on the short-term production rate and differentiation processes of xylem cells, tree-ring formation in these two consecutive growing seasons of five Scots pine individuals (*P. sylvestris*) was analyzed at a low-elevation site (320 m a.s.l.) growing on sandy soil. Based on the wood anatomical analysis of thin sections of bi-weekly collected micro cores, key patterns of individual tree growth such as onset, cessation, rate, and duration of xylem cell formation and differentiation were detected. The different tree responses to temperatures at the beginning of the vegetation period or precipitation amounts in spring and summer provide insights into short-term tree responses to climatic factors. In 2020, high temperatures in early spring triggered an earlier onset of cell division and a high cell production rate at the beginning of the growing season. However, dry conditions during the later growing season with a high soil water deficit in summer mitigated the production of new xylem cells as of early summer, and most of the growth ring was already completed by the end of July. In contrast, low temperatures in spring 2021 caused a late start of growth processes with low growth rates throughout the year. Yet, since no water shortage occurred during the summer of 2021, the duration of tree-ring formation lasted longer than in the previous year, leading to overall wider tree-rings. The results showed that in the Bavarian lowlands, soil water deficits in early summer cause higher growth reductions than a late onset of cambial activity due to cooler weather conditions.

Presentation code: A-QWA-P2

Quantitative wood anatomy and stable isotope analyses of late 4th millennium BCE oak from the Mar'inskaya 5 burial mound, north Caucasus

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Key words: dendroarchaeology, palaeoclimate, quantitative wood anatomy, micro-CT, stable isotopes

In 2009, a large, single-standing burial mound (kurgan) was excavated north of the Caucasus mountains near the village of Mar'inskaya (Kirov rayon, Stavropol region, Russia). Initial dendrochronological dating and radiocarbon ages of structural oak beams and planks indicated felling dates of around 3200 BCE, placing the kurgan into the Bronze age Maykop culture. In 2021, our focus returned to the construction wood unearthed from the kurgan to explore whether cell morphologies (earlywood vessels) and stable isotopes (carbon and oxygen) could be used for palaeoclimate reconstruction and provide a link between late fourth millennium BCE socioenvironmental trends and climate variability. The composition of the relict wood was relatively stable, and its easily visible tree rings and brittleness made ring dissection relatively straightforward. However, this fragility also made it impossible to prepare thin sections or obtain surface scans essential for quantitative anatomical analysis. To overcome this challenge, we employed micro computerised tomography to acquire cross-sectional X-ray images and developed a novel neural network algorithm to recognise and mask obstructions inside the vessel cavity. Preliminary results from the archaeological oak material indicated that absolute values and year-to-year variability in tree-ring width and earlywood vessel size were comparable with modern oak, and moderately strong inter-series correlation suggested that an environmental forcing factor such as climate, might explain the synchronised variability observed between the samples analysed. In comparison, the results of carbon and oxygen stable isotope measurements were less promising as the recorded values mostly fell outside of the range expected for C3 plants and shared little common variability. Altogether, these observations provide strong evidence that cellulose alteration had occurred at the molecular level which might also explain the chalk-like and brittle texture of the 4500-year-old wood.

Presentation code: A-QWA-P3

Corsican Pines show high variability in cambial phenology along an elevation gradient

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Key words: Cambial phenology, Pinus nigra ssp. laricio, Pinus pinaster, Corsica, Elevation gradient

Investigating seasonal wood formation patterns is crucial to understanding the growth responses of trees to climatological factors. This study aims to quantify the variations of xylogenesis along an elevation gradient on the Mediterranean island of Corsica, where two pine species (Pinus pinaster and Pinus nigra ssp. laricio) grow in partly overlapping elevation ranges from sea level to the upper tree line. We extracted microcores from 42 trees at five sites along an East-West transect from the coasts (10m asl) to the island's central mountain ridge (1600m asl) during bi-weekly sampling campaigns between 2017 and 2019. We hypothesized that growing season length strongly links to the number of days with temperatures above 5°C and is closely associated with elevation. Our results show that days with cambial activity were twice as many at the coasts compared to the site at the tree line. During a growing season with sufficient water availability (2018), the growth durations across the transect were as expected. However, this was not the case in years with drought stress, where growth was strongly hampered, especially at the coastal sites. Additionally, we observed considerable variations between the two coasts, as the trees at the western site grew even during the "dormant" period from December to February. These findings show the high plasticity in growth behavior of one of the most widespread tree genera in Mediterranean and temperate zones.

Presentation code: A-QWA-P4

Occurrence of intra-annual density variations in two pine species along an elevation gradient on Corsica

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Keywords: cambial phenology; elevation gradient; Mediterranean climate; intra-annual density fluctuations

We studied the occurrence of intra-annual density fluctuations (IADFs) in two pine species occurring along an elevation gradient on the Mediterranean island of Corsica (France). While *Pinus pinaster* is found from sea level up to 1250 m a.s.l., *Pinus nigra* ssp. *laricio* occurs in elevations between 750-1800 m a.s.l. In mid-elevation, both pine species co-occur. We studied IADF occurrence at five low-elevation sites ranging from sea level up to 750 m a.s.l., which are represented exclusively by populations of *P. pinaster*. Three high-elevation sites covered by *P. nigra* were distributed between 1400-1600 m a.s.l. At five mid-elevation sites ranging between 790-1240 m a.s.l., both species co-occurred. We hypothesized that IADF frequency will decrease with increasing elevation because of declining temperatures and drought stress. Since IADF formation is sometimes regarded as drought adaptation, we expected that the low-elevation *P. pinaster* will show a higher IADF frequency than *P. nigra* at mixed sites.

IADFs were categorized following the terminology of Campelo et al. (2007) and their frequency (f) was stabilized considering the changing sample depth with time (Osborn et al., 1997). We counted IADF frequencies of 13.801 tree rings obtained from 190 increment cores. Total IADF frequency decreased from low to mid to high-elevation sites from 37.4% (f = 0.91) to 13.4% (f = 0.34) to 3.0% (f = 0.03), respectively. At mid-elevation sites, co-occurring *P. pinaster* IADF frequency was 24.1% (f = 0.57), in 8122 rings, which is significantly higher than in *P. nigra* (9.7% in 6044 rings; f = 0.38). At low-elevation sites, type l (78.9%) was the dominant IADF-type, whereas at mid-elevation and high-elevation sites, type l+ (47.9%) and e+ (68.1%) were the most frequent IADF types. In contrast to the higher frequency of IADFs in *P. pinaster* than in *P. nigra* at mid-elevations, the relative occurrence of the different IADF-types in both species was almost identical. These findings confirmed the initial hypothesis. We conclude that *P. pinaster* shows a higher plasticity of cambial activity than *P. nigra*, which is an adaptation to the higher hydroclimatic variability at Mediterranean low-elevation sites. On the other hand, the change in frequency of IADF-types with elevation and their identical frequency in co-occurring species within the same elevation belt points to an environmental control of cambial activity related to elevation-specific climatic patterns.

Presentation code: A-QWA-P5

Severe defoliation affects physiology, wood anatomy and post-fire growth of Pinus pinaster (Aiton) forest

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Key words: Dendro-anatomical analysis, Quantitative wood anatomy, Stable isotopes in tree rings, Post-fire recovery

Mediterranean forests are currently threatened by the effects of climate change: every year millions of forest hectares burn with severe ecological consequences. Although trees are often able to survive forest fire thanks to their adaptive traits, they may not recover previous conditions due to severe fire wounds.

In this research dendrochronology and quantitative wood anatomy studies were combined with stable isotope measurements in tree rings to assess the post-fire dynamics in a Pinus pinaster forest growing along the Italian coast of Vesuvius National Park and affected by wildfire in 2017, comparing burned plants with a severe defoliation with control plants. Dendrochronological studies showed a drastic reduction in growth of burned trees compared to control ones. Carbon and oxygen isotopes analyses demonstrated that this growth reduction was related to an impairment of photosynthetic and stomatal activity. The severe crown damage influenced the capacity of assimilation and use of carbon in the burned trees, which showed a significative decrease in cell wall thickness compared to the pre-fire period and to the control stand. On the contrary, the unburned trees showed high photosynthetic and stomatal rates even in the years following, and this was reflected not only in greater productivity but also in the xylem anatomical characteristics with an improvement in parameters linked to hydraulics proprieties such as lumen area and theoretical hydraulic conductivity.

Overall, our results suggested that relevant injuries to the photosynthetic system can affect the survive chances of the maritime pine, promoting a delayed mortality of the species.

Presentation code: A-QWA-P6

Anatomical measurements of *Juniperus excelsa* wood from Lebanon as a potential hydroclimate archive in the Middle East and North Africa (MENA) region

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Keywords: Dendroclimatology, MENA, Juniper, quantitative wood anatomy measurements.

The Middle East and North Africa (MENA) is a hotspot for climate change and potential conflict over natural resources. To protect future generations from destabilization and marginalization, governments and natural resource managers need to consider the impact of climate change on the management of natural resources and agricultural systems. A few continuous high-quality instrumental data series in MENA start in the early 1900s, but the majority cover only the latter half of the twentieth century. Proxy records such as tree-ring data allow the development of annually resolved paleoclimatic reconstructions to assess climate variability beyond the instrumental period. A variety of tree species such as juniper have been successfully used to reconstruct centuries to millennial long climate histories for different regions of the world, making it an extremely valuable natural archive of past climate variation. For MENA, the Greek juniper **(***Juniperus excelsa* M. Bieb**)** (JUEX) is a promising species to extend existing instrumental climate records due to its longevity and use in archaeological constructions. We used tree-ring width and wood anatomical measurements from a mountain site in Lebanon (2000 m asl) to investigate the dendroclimatological potential of JUEX. Using Confocal Laser Scanning Microscopy images, we measured cell lumen diameter and wall thickness for the period 1964-2020 for six individual trees. Correlation analyses were performed using chronologies developed from ten equally divided sectors across the tree ring and monthly climatic records. Lumen diameter exhibited a positive (negative) correlation with May precipitation (maximum temperature). Earlywood (Sectors 1 and 2) and latewood (Sectors 8, 9, and 10) were most sensitive to previous- and current spring-summer temperature (April to September), while the precipitation signal did not persist strongly from year to year. Lumen diameter chronologies also exhibited a significant correlation with May SPEI-1 throughout all sectors, and a strong (July - September) drought signal was found in the last three sectors. Lumen diameter size was reduced starting in the early 1990s, consistent with changing rainfall and temperature patterns in the MENA. Our preliminary findings highlight the potential of wood anatomical measurement of JUEX as a paleoclimate archive, which may also improve our understanding of how large-scale ocean-atmosphere interactions impact hydroclimate in the MENA region.

Presentation code: A-QWA-P7

Climatic influence of wood anatomical parameters of *Tsuga dumosa* in the Nepal Himalayas.

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Keywords: cambial phenology; elevation gradient; Mediterranean climate; intra-annual density fluctuations

Himalayan Hemlock (*Tsuga dumosa*) is a tree species widely spread in the cloud forest belt of the central and eastern Himalaya and adjacent South Asian mountain regions; its durable wood is an important timber source for local populations. *T. dumosa* forms large trees which may reach ages several 100 years, hence the species has already been used in studies using tree-ring width (TRW) as a climate proxy. Due to the humid climate conditions in the cloud forest belt, TRW series of *T. dumosa* are often complacent, showing little inter-annual variability. We measured quantitative wood anatomical traits of five selected individuals, including tracheid lumen area (TLA), radial cell diameter (RCD), cell wall thickness (CWT) and modelled anatomical wood density (AWD) for the period 1940-2015 using WinCELL ™ Pro V. To increase the temporal resolution of the dendroanatomical time series, each ring was digitally divided into 10 equal sectors P1 to P10. Latewood typically covered the last two sectors P9 and P10. Chronologies of all cell parameters for sectors P1 to P8 were significantly inter-correlated. The two latewood sectors were also inter-correlated, but showed significantly different variations compared to sector P1 to P8. We identified six pointer years in the TRW series and analyzed the anatomical profiles of all cell parameters. During negative pointer years, TLA, RCD and AWD were reduced in most of the sectors. During positive pointer years, the anatomical profiles showed a higher variability and more individual patterns of wood anatomical traits. The higher temporal resolution of dendroanatomical time series can help to improve the generally weak correlation of TRW series with climate variables in cool-moist environments.

Presentation code: A-QWA-P8

Do wood anatomical and hydraulic traits of Fagus orientalis Lipsky and Fagus sylvatica L. differ in their adapbtation to climatic parameters?

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Key words: Tree rings; Western Sichuan Plateau; Climate change; Divergence problem; Recent warming

Beech species are major constituents in the composition of broadleaved forests in Central Europe, the Balkan peninsula, but also in the Hyrcanian forest of north Iran. In order to cope with climate warming and the increasing risk of drought stress in Europe, Oriental beech (*Fagus orientalis* Lipsky) may be better suited than European beech (*Fagus sylvatica* L.). In a provenance trial in northern Germany established in winter 1986/87, quantitative wood anatomical and hydraulic properties of stems and branches were analysed in three individuals of four provenances at the age of 28, resulting in 24 analysed trees in total.

While we found significant differences in tree-ring width between provenances within *F. sylvatica*, differences between *F. orientalis* and mean growth rates of both species were not significant. At the stem level, detrended time series of wood anatomical traits revealed significant differences in vessel density between species. However, variability of vessel traits and calculated potential hydraulic conductivity between provenances within both species was higher than between species. We further observed an increase in average vessel diameter in both species as precipitation increased and temperature decreased in June and July. Stem wood vessel diameter variation of *F. orientalis* was more temperature–dependent than that of *F. sylvatica.* While total vessel lumen area of *F. sylvatica* was not significantly affected by any of the studied climate variables, it was positively correlated with May precipitation in *F. orientalis*. Vessel density of *F. orientalis* was unrelated to the climatic conditions, whereas vessel density of *F. sylvatica* showed a strong negative correlation with precipitation in June.

At the branch level, however, neither wood anatomical traits (vessel density, vessel lumen area or hydraulically-weighted vessel diameter) nor hydraulic efficiency (specific conductivity, K_s) or xylem safety (xylem pressure causing 50% loss of hydraulic conductivity, P_{50}) differed between species.

We conclude that the stem and branch wood vascular architecture of *F. sylvatica* and *F. orientalis* is comparable, but the xylogenesis in *F. orientalis* seems more temperature-dependent than that of *F. sylvatica*. Additional studies with longer time series and a higher number of individuals are needed to verify if *F. orientalis* might be better suited to cope with climate change although xylem safety does not differ between both species.

Presentation code: A-QWA-P9

Differences in intra-annual growth dynamics, wood formation dynamics between ring-porous wood and diffuse-porous wood species

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Key words: dendrometer, intra-annual tree growth, leaf phenology, xylogenesis and tree ring formation

Diffuse- and ring-porous species have adapted different hydraulic strategies, due to their significant differences in the size of the xylem vessels. Considering the different hydraulic adaptive strategies in diffuse- and ring-porous species, the dynamics of xylem formation of diffuse- and ring-porous species may be also different.

To test this hypothesis, we selected 10 dominant tree species in typical temperate forest, five diffuse-porous species and 5 ring-porous species respectively. We used dendrometers to measure the intra-annual stem growth dynamics of diffuse- and ring-porous species, and collected micro core samples regularly to monitor the wood formation dynamics.

Our results found that ring-porous species had lower annual growth increment and shorter growing seasons, but greater maximum growth rates. This is because the early-wood vessels with large size in ring-porous species have more efficient water transport, but are prone to lose hydraulic function as are vulnerable to freeze-thaw cycles induced embolism. Therefore, ring-porous species have greater maximum growth rates but shorter growing seasons.

Notably, we found that the ring-porous species differentiated and lignified vessels earlier than diffuse-porous species, and ring-porous wood species showed significant radial growth after the first layer of early wood vessels fully lignified, as these species rely on new formed vessels for water transport and growth. Inconsistent with ring-porous species, the process of vessels lignification happened at the same time of significant radial growth in diffuse-porous species, suggesting that their vessels can maintain hydraulic transport functions for several years.

Session B

Stable Isotopes

Presentation code: B-ISO-Keynote

Mechanistic models of stable isotopes in tree rings

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Key words: carbon isotope, hydrogen isotope, leaf water, oxygen isotope, photosynthesis

Stable isotope patterns in tree rings can be interpreted using both statistical and mechanistic models, and with approaches that use aspects of both. Statistical models are typically used to establish relationships between isotope variations and climate trends, whereas mechanistic, or process-based, models are more often applied to deduce physiological responses of trees to environmental drivers, including climate change, rising atmospheric carbon dioxide concentrations, and air pollutants, among others. In this presentation, I will discuss recent work aimed at better understanding the physiological mechanisms that lead to variation in oxygen, hydrogen, and carbon isotope ratios of tree rings. This work has been largely conducted in an ecophysiological context, but can also potentially inform interpretations of tree ring stable isotope chronologies. I will discuss how signals that originate in the isotopic composition of a tree's leaf and source water are incorporated into organic material, and where we might expect different responses to the environment for stable isotopes of oxygen compared to hydrogen. I will also discuss carbon isotope ratios of wood, and some processes that may be important determinants, but are less often considered than the primary driver, the ratio of intercellular to ambient carbon dioxide concentrations.

Presentation code: B-ISO-O1

Tree-ring stable isotopes report on German forest dieback

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Key words: carbon, oxygen, tree mortality, *Pinus sylvestris*

Central European drought spells and heatwaves are becoming more intensive and eventually lead to increased tree mortality. This fact is obvious since the consecutive drought events 2018/2019/2020, which led to extensive tree mortality. The term 'forest dieback 2.0' has already been introduced but does not describe the phenomenon precisely. Indeed, we observe extensive dieback, but also mortality among scattered individuals. This fact is recognised, but detailed observations and explanations for partial survival and dieback are still missing. Here, we use tree-rings to study the dieback process of Scots pine at the edge of its distribution range at one of the driest regions in Germany (Rhine Hesse, Mainz). We sampled trees with varying vigour (from dead to +/- vital trees) as defined by crown transparency and recorded the exact location of each tree within the sampling plot. Next to radial increment growth, we measured carbon and oxygen isotopes as indicators of tree physiological processes from 18 trees at annual resolution for the 1930 to 2019 period. Each vigour class (i.e. 1 = vigorous with <25%, 2 = moderate with 25-60% and 3 = poor vigour with >60% crown transparency) is represented with six trees without any pooled isotope measurements. This dataset and multi-methodological approach will help to understand and clarify if a tree's drought survival or dieback is determined by differing physiological strategies and/or micro-site conditions. Conceptualising the dieback initiation allows defining and predicting mortality tipping points so that in the future site-specific preventative measures can be potentially taken earlier.

Presentation code: B-ISO-O2

Volcanic water vapor outgassed during pre-eruptive ascending of magma influences tree-ring stable isotopes on Mt. Etna (Sicily, Italy)

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Key words: Volcanic eruption, tree physiology, stable isotopes, radiocarbon, Etna

Tree rings have been used to reconstruct past volcanic eruptions. However, for protecting human life, the early detection of volcanic eruptions is of major importance. Studies on Mt. Etna (Italy) demonstrated that vegetation can be affected by pre-eruptive activity. During two consecutive years before Mt. Etna's 2002/2003 flank eruption, enhanced vegetation index (NDVI) values were detected along a line which later developed into an eruptive fissure. The mechanisms by which volcanic activity leads to changes in pre-eruption tree growth processes are still not understood. We analyzed $\delta^{13}C$, $\delta^{18}O$ and ^{14}C in the rings of the survived trees growing near to the line where the pre-eruptive increase in NDVI was observed to evaluate whether the uptake of water vapor or fossil volcanic CO_2 could have contributed to the enhanced NDVI. We found a dramatic decrease in $\delta^{18}O$ in tree rings formed before 2002/2003 in trees close to the eruption fissure, suggesting uptake of volcanic water by trees during pre-eruptive magma degassing. Moist conditions caused by outgassing of ascending magma may also have led to the observed reduction in $\delta^{13}C$ following the eruption. Furthermore, only ambiguous evidence for tree uptake of degassed CO_2 was found. Our results suggest that additional soil water condensed from degassed water vapor may have promoted photosynthesis, explaining local increases in NDVI before the 2002/2003 flank eruption. Although data from other volcanoes and eruptions are needed, we suggest that NDVI may be used for the early detection of volcanic eruptions, and tree-ring $\delta^{18}O$ as indicators of past eruptions.

Presentation code: B-ISO-O3

Decrypt the fundamental processes behind the δ^2H-fractionation in plant carbohydrates

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Key words: δ^2H, isotope fractionation, photosynthesis, temperature, tree-ring cellulose

While carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) isotopes in tree-ring cellulose are widely used as climatic and physiological proxy in dendrosciences, the processes that are affecting the fractionation of non-exchangeable hydrogen (δ^2H) isotopes and shaping the tree-ring δ^2H profile are barely understood and thus not widely applied yet.

To establish a first comprehensive comparison of the photosynthetic and post-photosynthetic ^2H-fractionation of northern-hemisphere trees, we sampled leaves and twigs of 152 trees representing 73 species, 48 genus, 19 families and 12 orders containing both evergreen and deciduous angio- and gymnosperms in a common garden, as well as diurnal cycles (6 species from 6 families) of leaf sugar. We extracted leaf water and sugar, as well as twig water and the current year twig xylem cellulose for δ^2H analysis.

Our findings show a wide variation in ^2H-fractionation between species growing at a common site. The biological fractionation between leaf water and leaf sugar ranged between -169.6 and +24.2‰ and between leaf sugar and current year twig cellulose from -34.6 to +116.8‰, with gymnosperms being significantly more ^2H-depleted than angiosperms. We could show that the photosynthetic ^2H-fractionation is a dynamic process strongly affected by temperature, and that this needs to be taken into account for tree-ring cellulose δ^2H models.

We conclude that the here presented results will help to improve our understanding of the mechanisms influencing the δ^2H values of leaf sugar and tree-ring cellulose and thus enabling the scientific community to use δ^2H in tree-ring cellulose as the third isotope-proxy for dendrochronological studies.

Presentation code: B-ISO-O4

The unknown third - exploring the climatic and non-climatic signals of hydrogen isotopes in tree-ring cellulose across Europe

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Key words: deuterium, European forests, mechanistic modelling, stable isotopes, tree physiology

Hydrogen isotope ratios in tree-ring cellulose (δ^2H_c) have been far less investigated compared to carbon ($\delta^{13}C_c$) and oxygen ($\delta^{18}O_c$), and its recorded signals are still not fully understood. In this first Europe-wide assessment of the climatological and physiological information recorded by δ^2H_c we investigated 100-year tree-ring records of two genera (*Pinus* and *Quercus*) from 17 sites (36°N to 68°N). The high-frequency climate signal in the δ^2H_c chronologies was weaker than $\delta^{13}C_c$ and $\delta^{18}O_c$ signals, but similar to the tree-ring width one (TRW). δ^2H_c varied across the continent and was stronger and more consistent for *Pinus* than for *Quercus*. Years with dry summer conditions caused a significant ^{2}H-enrichment in tree-ring cellulose for both genera.

To differentiate between environmental and physiological signals in δ^2H_c, we investigated its relationships with $\delta^{18}O_c$ and TRW. δ^2H_c and TRW showed significant negative relationships, while δ^2H_c and $\delta^{18}O_c$ showed positive ones, indicating site-dependent differences. The strength of these relationships was nonlinearly related to temperature and precipitation. Mechanistic δ^2H_c models performed well for both genera at continental scale simulating average values, but they failed on capturing year-to-year δ^2H_c variations. Therefore, the information recorded by δ^2H_c is significantly different from that of $\delta^{18}O_c$, with a stronger physiological component, possibly related to the use of carbohydrate reserves for growth. Advancements in the understanding of ^{2}H-fractionations and their relationships with climate, physiology, and species-specific traits are needed to improve the modelling and interpretation accuracy of δ^2H_c. Such advancements could lead to new insights into trees' carbon-cycles, and responses to stressors.

Presentation code: B-ISO-O5

Progress in laser-ablation isotope-ratio analysis of tree rings

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Key words: laser, stable isotopes, carbon, climate, physiology

Stable isotope ratio analysis of tree rings has been widely and successfully applied in recent decades for climate and environmental reconstructions. These studies were mostly conducted at an annual resolution, considering one analysis per tree ring, sometimes focusing on late-wood. However, the wood cells and corresponding organic matter continuously laid down during the growing season hold even more information that can be retrieved with high-resolution intra-annual isotope studies. Such studies are still relatively rare, but would have a unique potential for reconstructing seasonal climate variations or short-term scale changes in physiological plant properties, like water-use efficiency. The reason for this research gap may be mostly technical, as on the one hand sub-annual, manual splitting of rings is very tedious and time consuming, while on the other hand automated laser-ablation for high-resolution analysis is not yet well established and available. Here, we give an update on the current status of laser-ablation research for analysis of carbon isotope ratios of wood, describe a recent commercially available laser-ablation system and its operation, and discuss practical issues related to sample preparation. We show the application of the technique in a Scots pine forest in Switzerland where adult trees were labelled with $^{13}CO_2$ and this signal traced in the tree-rings of the year of labelling as well as the following year. With this work, we hope to stimulate future progress in the promising field of high-resolution environmental reconstruction using laser ablation.

Presentation code: B-ISO-O6

Accurate intra-seasonal reconstruction of intrinsic water use efficiency from high-resolution tree ring $\delta^{13}C$ data via laser-ablation IRMS analysis

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Key words: eddy covariance, leaf gas exchange, compound-specific isotope analysis, post-photosynthetic isotopic fractionation, *Pinus sylvestris* L.

In the current study, we study the reliability and accuracy of tree ring $\delta^{13}C$ in intra-seasonal reconstruction of intrinsic water use efficiency (iWUE), a key index linking terrestrial carbon and water exchanges. For this purpose, we reconstructed the intra-seasonal iWUE from laser-ablation $\delta^{13}C$ analysis of tree rings ($iWUE_{iso}$), and compared it with iWUE estimated from leaf gas exchange ($iWUE_{gas}$) and eddy covariance data ($iWUE_{EC}$) for two *Pinus sylvestris* L. dominated boreal forests during 2002 to 2019. With careful timing of $iWUE_{iso}$ via xylogenesis observation and wood growth modelling, $iWUE_{iso}$, $iWUE_{gas}$ and $iWUE_{EC}$ aligned well in their intra-seasonal patterns but differed in absolute values. By examining $\delta^{13}C$ offsets between leaf sugars, phloem sugars and tree rings over the growing seasons 2018 and 2019, via compound-specific and bulk isotope analysis, we found that post-photosynthetic $\delta^{13}C$ alteration led to an over-estimation in $iWUE_{iso}$ by 7% and 30% for resin-extracted wood and wood cellulose, respectively. The neglection of mesophyll conductance in $iWUE_{iso}$ modeling, on the other hand, resulted in an over-estimation of 7%. Inter-annual trends of $iWUE_{gas}$, $iWUE_{iso}$ and $iWUE_{EC}$ were different, due to distinct environmental drivers on iWUE at leaf-, tree- and ecosystem- levels, and due to potential biases in each iWUE estimation method. Our results demonstrate the accuracy of using tree ring $\delta^{13}C$ to estimate iWUE at intra-seasonal scale, beyond its conventional application on annual resolution. The finding is especially significant for studies, which seek to detect intra-seasonal tree physiological dynamics in terms of iWUE but have no access to instrumental data.

Presentation code: B-ISO-P1

Wood anatomy and stable carbon isotope assessments support higher drought vulnerability of forest-edge Scots pine trees

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Key words: Climate change; Forest edge, microclimate, hydraulic traits

Compared to forest interior trees, forest edge trees are more exposed to higher temperature and lower humidity, which amplify vapor pressure deficit and evapotranspiration. These more extreme conditions are expected to exacerbate the exposure to drought decline, as already observed for forest edge Scots pine trees (Buras et al. 2018).

Yet, open questions remain with respect to possible physiological explanations for the higher drought susceptibility of edge trees. To address these questions, we compared wood anatomy and tree ring stable ^{13}C isotopes from trees that survived and succumbed the 2015 extreme drought representing 1) alive- interior, 2) alive-edge, and 3) dead-edge groups.

We observed systematically higher $\delta^{13}C$ at the forest edge, possibly indicating higher drought stress but possibly also higher rates of photosynthesis compared to the forest interior. However, the observed systematically lower cell-wall thickness and wood density at the edge may indicate lower availability of photo-assimilates for cell-wall formation, potentially supporting the hypothesis of higher drought-stress at the edge. Finally, earlywood hydraulic diameter was generally higher at the edge with dying trees diverging from surviving trees after the extreme 2003 drought, potentially indicating hydraulic adjustments to compensate for drought-induced embolisms.

Buras, A., Schunk, C., Zeiträg, C., Herrmann, C., Kaiser, L., Lemme, H., Straub, C., Taeger, S., Gößwein, S., Klemmt, H.-J., Menzel, A., 2018. Are Scots pine forest edges particularly prone to drought-induced mortality? Environ. Res. Lett. 13, 025001. https://doi.org/10.1088/1748-9326/aaa0b4

Presentation code: B-ISO-P2

Tree-ring $\delta^{18}O$ and $\delta^{2}H$ provide evidence of climate driven changes in water inputs from glacier streams in the Turtmänna river basin, Switzerland

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Key words: Tree-rings, Stable Isotopes, Turtmänna basin

The earlywood and latewood chronologies of the stable oxygen ($\delta^{18}O$) and hydrogen ($\delta^{2}H$) isotopes derived from tree-rings show a distinctive pattern of intra-annual variations in isotopic compositions in the Turtmänna river basin located in south-western Switzerland. This basin has a high altitudinal range from 4,150 m to 678 m above sea level, with extensive glacier cover above 2,500 m above sea level. An upstream hydropower dam (2,200 m a.s.l) takes off almost all glacial melt, but this is then compensated for by water supply from rainfall and snow melt from un-exploited basins downstream. Without the impact of hydropower we would expect a downstream gradient in the depletion of stable isotopes, which should be reflected in the stable isotope signature of trees. To assess whether or not these trends are seen in the stable isotope records of trees in this catchment, we double-cored a European Larch (*Larix Decidua*) tree proximal to the river and distal to the river, at a site close to the hydropower dam (site-1), intermediate (site 2) and distal (site-3), as well as a reference tree. The standard chronology after crossdating dated back to 1851 (*i.e.* 170-years record) shows decreasing growth over the last two decades. Growth was correlated positively with precipitation ($r = 0.50$), and negatively with temperature ($r = 0.30$) during the growing season. Results suggest a progressive temporal increase in $\delta^{18}O_{TR}$ in both earlywood and latewood reflecting a switch to rainfall supply from snow-melt, and to snow-melt from glacier-melt.

Presentation code: B-ISO-P3

Interannual variations of $\delta^{18}O$ *Nothofagus betuloides* in Fuego-Patagonia and its relationship with regional/hemispheric climatic variability

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Key words: Antarctic Oscillation (AAO), Amundsen Sea Low (ASL), stable oxygen isotope (δ18OTRC), *Nothofagus betuloides*, and Fuego-Patagonia.

The recent climatic trends of Fuego-Patagonia at Southernmost South America (SSA) are related to the interannual variability and long-term trend of the Antarctic Oscillation (AAO). Additionally, the AAO interacts closely with the Amundsen Sea Low (ASL), inducing regional changes in temperature, precipitation, wind speed, and sea ice formation around Antarctica. However, this region's scarce and short instrumental climate records affect the understanding of the interplay between AAO and ASL and its effects on the SSA climate. To counteract this short-term climatic record, the stable oxygen isotope time series ($\delta^{18}O$) for *Nothofagus* forests has performed well in reproducing past climatic variations. Our work aims to study the interannual variability of the $\delta^{18}O$ series from the *N. betuloides* tree rings in Fuego-Patagonia for the last 60 years and correlate these series with the regional climatic variability. The *N. betuloides* forests on Isla Navarino were sampled in the austral summer of 2020. The dendroisotopic technique was used to obtain interannual values of $\delta^{18}O$ based on ten individual cores. The resulting $\delta^{18}O$-chronology was correlated with local climatic variables of Puerto Williams and regional and hemispheric indices such as ASL and AAO, respectively. The tree-ring δ18O of *N. betuloides* show a good correlation with the precipitations of November-January (r=-0.66), the maximum temperature of October-December (r= 0.62), and November-February wind speed (r=0.69). Furthermore, tree-ring $\delta^{18}O$ of *N. betuloides* reveal strong relationships with ASL (r=-0.80) and AAO (r=0.77) for October-January, explaining 64% and 59% of the total variance of these variables, respectively, evidencing that the δ18O of *N. betuloides* forests has an enormous potential to study the local, regional and hemispheric climate.

Presentation code: B-ISO-P4

Dendroecological analyses of conifer species along an elevation gradient in the central Himalaya

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Key words: Nepal Himalaya; elevation gradient, stable oxygen isotopes, resilience climate response

The extreme and complex topography of the Himalayas leads to substantial spatial variations in climatic variables such as radiation, air temperature, and precipitation, resulting in high spatial variability of local climatic conditions. Being under the South Asian Summer Monsoon (SASM) influence, Nepal receives most of its annual rainfall during the summer monsoon (June-September) season. In recent years, the weakening of the SASM has resulted in an increased frequency of drought events, posing adverse effects on the human population and forest ecosystems. In this study, we examined the response of different conifer species to the moisture conditions along an elevation gradient using tree-ring width (TRW) and stable oxygen isotopes in tree-ring cellulose ($\delta^{18}O_{TRC}$). We found a declining trend of mean $\delta^{18}O_{TRC}$ with increasing elevation. While TRW showed a species-specific relationship with climate throughout the elevation gradient, inter-annual variations of $\delta^{18}O_{TRC}$ were significantly correlated to summer monsoon climate at all sites and for all studied species. However, the correlation was more robust at the higher elevation. Besides, the average resilience and resistance of the species calculated using TRW during drought events followed a declining trend with increasing altitude. The results show that the regional monsoon climate controls the $\delta^{18}O_{TRC}$ of Himalayan conifer trees in a very homogenous way across species and elevation belts, although the local atmospheric and site conditions may alter the strength of the regional climate effect.

Presentation code: B-ISO-P5

Effect of competition reduction on the iWUE in beech

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Forests play a significant role in climate change mitigation through the capture of CO2 from the atmosphere and the fixation of C in biomass. Tree competition is strictly related to forest vertical and horizontal structure. Many forest processes (e.g. water balance, nutrient cycling, carbon partitioning, light absorption) are influenced by stand structure, and consequently by tree competition. In mature stands, characterized by closed canopies, silvicultural interventions modify the forest structure and reduce competition. The canopy develops to maximize carbon fixation. Thinning, after a drastic decline of stand leaf area index, deeply modifies the ratio between shade and light leaves. Tree rings and their isotopic signatures are powerful tools to investigate the responses of trees to different forest management under the forcing effect of climate changes. The shift of Δ13C of the annual growth rings produced during each growing season is related to changes in intrinsic water-use efficiency (iWUE) calculated as the ratio between photosynthesis and stomatal conductance. This physiological parameter was recognized as indicator of tree vitality, hence to its capability to adapt to climate change. In this context, among the activities of the project LIFE CLIMARK, we conducted a study with the aim to evaluate the effect of silvicultural treatments on physiological response of beech trees. The specific objective was to evaluate the effect of the competition reduction on intrinsic water use efficiency (iWUE) and to assess the relationship between iWUE and productivity. Hence, in a pure beech forest, we collected wood cores inside permanent plots, where all the trees were georeferenced, for isotopic analysis of α-cellulose of tree rings.

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Studying the present to understand the past: Oak tree ring series from the Lake Constance region

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Key words: Quercus; wood sourcing; forest exploitation; settlement history;

Reference tree-ring studies of actual stands play a key role in the interpretation of dendroarchaeological data in terms of sourcing, forest exploitation, woodland management with regard to settlement activities and developments. Starting with B. Becker at the University in Hohenheim at the end of the 80ies, this cooperation between dendroecology and dendroarchaeology has a long tradition in SW-Germany. Within this scope, we present here oak tree ring series of selected stands at and around Lake Constance with a particular attention paid to a potential differentiation of *Quercus robur* vs. *Q. petraea* according to site conditions. With a well defined direct hinterland surrounded by steep slopes from 400 to 600m asl, the "Sipplinger Dreieck" at the Obersee serves as an especially suited application field in terms of site catchment. This potential area of agricultural activity and sourcing for timber is less than 3 km² in size. In the bay, the underwater remains of prehistoric settlements attest repeated human occupation waves within a time span of 2000 years. The modern reference presented here allows a closer illustration of former interpretations related to cyclic exploitation of oak timber sources, operating first with *Quercus* on lower slopes – most probably *Quercus robur* – and ending on the higher ones — *Quercus petraea*.

Presentation code: C-ARCH-O2

How a few boards in the mud became an early medieval mill

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Key words: Dendroarchaeology, Dendrochronology, Large timber collection, Early medieval mill

In September 2021, historic timbers were uncovered at a construction site in Aichach, Bavaria. The site could be identified as an early medieval mill based on a broken paddle fragment. 525 wood finds have been examined so far in the dendroarchaeological laboratory of the BLfD, which corresponds to about two thirds of the archaeological samples.

In addition to small finds such as paddles, vessels and tools, numerous construction timbers were found, many still in situ. For the first time, an intact mill pond, including dam, filter system and mill channel, could be excavated. In this case the wood species composition is exciting, since a large part of the construction timbers consisted of alder and beech. Only heavily used structures like the sluice gate or the substructures of the mill building were made of oak. The investigations have not yet been completed. First measurements date to the 8th and 9th centuries AD. A heavy flood event ended milling at this site.

A comprehensive archaeological evaluation is planned, including age structures and wood species composition. In addition, the possibility arises to expand the Bavarian regional chronologies in the Early Middle Ages. The excellent state of preservation of the material allows not only age dating and wood type analysis but also technomorphological investigations. However, the sheer mass of the timbers would offer many more starting points for statistical analyses on early medieval forest structures, wood species selection or climate reconstruction.

Presentation code: C-ARCH-O3

Botanical collections from historical expeditions as a new source of dendrochronological data about climatic conditions in the Arctic since 16th century

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Key words: Arctic, herbarium, juniperus, salix, cross-dating

Studies about Arctic environment changes are limited to the length of single instrumental data, which exceptionally reach beyond 20th century. Additionally using Arctic dendrochronology as a tool for climate reconstruction is limited by the age of tundra wooden plants which rarely exceeds ~100 yrs. To overcome this main limitation, an innovative approach linking contemporary growing tundra species with growth-ring chronologies from specimens collected from historical botanical collections will be used. Our data from northern Scandinavia, Spitsbergen and Greenland, include the largest collections of Arctic plants gathered from the world most important Herbaria collections.

"Historical" dwarf-shrub specimens had been collected in the field during polar expeditions since the beginning of the 18th century. The combination of this unique research material and the use of cross-dating method will enable the development of composite dwarf-shrub chronologies reaching back since the beginning of the Little Ice Age. Preliminary results allowed for construction of dendrochronological scales for *Juniperus communis* from southern Greenland covering the period 1536-1880 A.D., and for *Salix glauca* and *S. arctica* from Disko area for the years 1850-1950.

Further research allow us to address many important gaps in the knowledge on the connections between accurate, but short meteorological series and long but less precise, uncalibrated Holocene proxy data. The climate reconstruction of the Arctic, obtained on the basis of composite dwarf shrub records, using innovative methodological approach, will be unique and first of its kind.

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Presentation code: C-ARCH-O4

Novel techniques for dendro-historical studies reveal timber-supply practices in the South of Spain in post medieval times

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Key words: Southern Spain, dendro-history, cultural heritage, multidisciplinary provenancing, ITRAX

Andalusia, the southernmost region in Spain, hosts a great amount of built heritage, with several of them being included in UNESCO's World Heritage List. This heritage provides perfect material for dendroarchaeological studies in the region. However, the complex historical background and the intense reuse of timber coupled with the lack of chronologies has hitherto hampered the correct interpretation of the history of some buildings. Here, we used a battery of novel techniques, namely blue intensity, wood chemistry and isotopes, to understand the supply areas for formerly undated timbers from selected historic buildings. Dendrochronological study of roof beams from the Jaen Cathedral (built in 16th -18th centuries) revealed that timber from the Cazorla mountains was used in their construction. While timbers of the main construction phases were dated, supposedly reused samples (originating possibly from lower elevations) remain undated, and their provenance unidentified.

A more drastic example is the investigation of timbers at the Colegial del Salvador church in Seville, built between 1679 and 1712. This tree-ring width based research failed to provide exact date and provenance of the timbers, as 70 out of 73 remained undated, suggesting use of different sources of timber from different periods.
Other examples in the region include timbers of the Hospital Real in Granada, built between 1511-1525, where pilot dendrochronological attempts have also shown complexity in precise dating and provenancing. Our results confirm that use of wood chemistry and blue intensity methods can overcome the problem of lack of long tree-ring width chronologies from different elevations

Presentation code: C-ARCH-P1

Jeddah – A historical port city between Mecca and imported timber

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Key words: dendrochronology, historical timber, dating

Jeddah, the main port city and gateway for millions of Muslims on their routes to Mecca in Saudi-Arabia, has a long historical and cultural history. The old historical city centre consists of hundreds of houses (often in poor conditions) mainly built from timber. Several of the houses were sampled and analysed dendrochronologically. It turns out that the houses were built from various imported timber species. In an otherwise very dry country without any trees or datable tree, the wood from Jeddah offers good opportunities for dendrochronological dating and indicates a worldwide timber trade for different kinds of tree species. In addition, comprehensive historical mapping of the old city centre was conducted, which helped to illustrate the architecture and different uses of the houses. Dendrochronological dating of the timber facilitated a construction timeline. Further dendrochronological research aims to fill some historical gaps in the construction timeline of one of the most important cities as a gateway to the Muslim sanctuary Mecca.

Presentation code: C-ARCH-P2

New tree-ring data on driftwood and construction timber from the Isfjord area, Svalbard

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Key words: tree-rings, dendrochronology, Svalbard

The Svalbard Archipelago is well studied by means of dendrochronology, but the tree-ring network across Barentsburg is missing. The goal of the study is to build and to date floating tree-ring chronologies consisting of driftwood and architecture wood along Grenfjord and Isfjord, including Barentsburg and Coles Bay villages.

We analyzed 193 samples (conifers), mainly driftwood (156), wood from pipeline (17) and berths in Barentsburg (10) and Coles Bay (20). Two floating chronologies S03A (198 years, samples from the pipeline in Barentsburg) and S07A (219 years, driftwood from the Cape Finneset) were built and absolutely dated using the chronology from the Solovetsky Archipelago ("Solovki", 1185-2017). The possibility to build a floating chronology indicates a significant similarity of tree growth under common climatic conditions. The preliminary results of dating the S03A chronology show that the wood for its construction was most likely imported in the middle of the 20th century (dates by 1945, t-test=6.6) from the basin of the Northern Dvina River.

Dating results of S07A show that samples with reliable correlation coefficients date relative to each other (r=0.52-0.63) and can be composed into the floating chronology. It dates using Solovki back to 1572 with t-test=4.6, but the dating needs to be clarified due to its low degree of reliability.

The obtained results are important from a methodological point of view - the driftwood from Svalbard often does not allow to build floating chronologies and hardly dates due to the difference in the initial habitats (the entire Arctic from Mackenzie to Pechora).

Presentation code: C-ARCH-P3

Hydrogen isotope ratio is a tool for identifying Larix wood in archaeological samples

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Key words: Wood, Larix, Picea, Hydrogen isotope, Tree Species

Identifying wood species in archaeological specimens is important for evaluating timber structures and the conservation of historic buildings. This is commonly done by microscopic wood anatomy; however, this is often problematic when the wood samples are poorly conserved and deteriorated. A particular challenge is the distinction of Picea from Larix, species often used for timber wood that have similar microscopic anatomical features. Recently an analysis of the cellulose hydrogen stable isotopes from conifers grown at high and low altitudes showed that Larix wood is characterized by a uniquely highly depletion of deuterium values compared to the rest of the conifers, including Picea. We aimed to verify if this property can be utilized to solve the Larix-Picea problem for archaeological samples, which are generally small and in deteriorated conservation states. Thus we obtained 36 archaeological specimens, most of which with ambiguous identification as larch or spruce. The samples highly deteriorated, and the cellulose could be extracted only from 20 of them. By applying a cutoff value of dD -80 ‰, we identified all the Larix samples, including one that was previously attributed as not Larix. Only one sample with a value just above the cutoff remained uncertain. In conclusion, the evaluation of cellulose deuterium content is a valuable tool for robust and unambiguous identification of Larix timber wood in poorly conserved archaeological samples.

The default font to be used is Times New Roman, 12-point size. The abstract must be no longer than 250 words and should indicate the aims of the investigation, the main results and the conclusions. Figures, diagrams, tables, graphs and/or photos, as well as references are not allowed.

Session D

Forest Health

Presentation code: D-FOHE-O1

Multi-species tree growth response to climate change in southwestern Germany

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Keywords: tree-ring width network, climate sensitivity, forest dynamics, recent warming, Central Europe

Central Europe has been affected by unprecedented summer droughts in the 21st century, resulting in large-scale forest decline that has impacted many native tree species. Growth analyses of multiple tree species from mid to low elevation in Europe remain sparse, despite decades of dendroclimatological studies, and limit our understanding of how forests will evolve under changing climate conditions. Here, we introduce a new multi-species tree-ring width network of 65 individual sites (>2500 trees) from southwestern Germany and assess the climate sensitivity of major European species (*Abies*, *Picea*, *Pinus*, *Pseudotsuga*, and *Quercus* genera). Early spring temperature and mid-summer drought conditions were identified as regional climatic drivers of forest growth. The dense network also provides new insights into local- and species-specific climate-growth relationships and outlines a warming-induced shift in climate sensitivity towards greater water dependence at the end of the 20th century. Our findings highlight the usefulness of multi-species approaches in evaluating future changes to Central European forests and management strategies.

Presentation code: D-FOHE-O2

The silent suffering of trees during the 2018 heatwave

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Key words: European forests, 2018 heatwave, Dendrometers, Tree water deficit, Radial growth

Heatwaves exert disproportionately strong and sometimes irreversible impacts on forest ecosystems. These impacts remain poorly understood at the tree-species level and across large spatial scales. Large-scale analyses of hourly dendrometer records are ideal to yield crucial insight into drought impacts on tree growth and desiccation along environmental gradients. However, the lack of harmonized datasets has precluded composite analysis of regional-scale dendrometer data to date.

Here, we investigate the effects of the record-breaking 2018 European heatwave on tree growth and tree water status using a unique collection of high-temporal resolution dendrometer data collected from 53 sites in Europe. A total of 21 broadleaf and conifer species were monitored during three consecutive years (2016-2018), with *Fagus sylvatica*, *Quercus* spp. (*Q. petraea* and *Q. robur*), *Picea abies* and *Pinus sylvestris* being best represented. From the individual dendrometer time series, we derived tree-specific daily cumulative growth and daily extremes of water deficit in the stem.

Relative to the two preceding years, annual stem growth was not consistently reduced by the 2018 heatwave, but tree stems experienced twice the temporary shrinkage due to depletion of internal water reserves. Conifer species were less capable of rehydrating overnight than broadleaves across gradients of soil and atmospheric drought, suggesting less resilience toward transient stress. In particular, *P. abies* and *P. sylvestris* experienced extensive stem dehydration. Our high-resolution dendrometer network was suitable to disentangle the effects of a severe heatwave on tree growth and desiccation at large-spatial scales in situ, and provided insights on which tree species may be more vulnerable to climate extremes.

Presentation code: D-FOHE-O3

Beech crown dieback cannot be predicted by resilience indices but long-term growth divergences

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Key words: Competition, drought resilience, early-warning signals, Fagus sylvatica, tree vitality

European beech (*Fagus sylvatica* L.) has strongly suffered from the exceptional 2018 drought and subsequent dry years that hit Central Europe. While many trees showed severe signs of dieback and even died, other co-occurring trees showed no sign of dieback or only minor damage. The reasons why some beech trees were more severely impacted than others are still poorly understood. Our goal was to investigate the predisposing drivers of beech dieback following severe drought events. We analyzed the differences in the long-term growth trends, neighborhood composition, early-warning signals, and growth responses to past severe droughts of co-occurring vital and severely declining beech trees at six sites in Switzerland.

Overall, trees that showed severe crown dieback were characterized by lower growth rates in the past than their vital counterparts. We also found diverging growth trends between both vitality classes over time. Compared to vital trees, declining trees exhibited a substantial growth decline starting around the year 2000. Further, we could not detect any difference in the effect of competition and neighborhood species composition on increment growth. The analysis of early-warning signals suggests that declining trees were generally less resilient towards external influences such as climatic variabilities. Interestingly, vital trees also showed higher recovery after more severe summer drought years.

Our results indicate that in comparison to vital trees, declining beech trees showed predisposing signs to crown dieback by having lower growth rates, prolonged growth declines over time as well as higher intra-annual growth variance and autocorrelation.

Presentation code: D-FOHE-O4

Drought resilience and stability of coexisting planted silver fir, Norway spruce and Douglas fir trees in the face of climate change

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Key words: climate change, tree rings, conifers, native, non-native

Forests worldwide are undergoing worrisome drought-associated tree mortality events. As climate change is expected to increase droughts' frequency and severity, concerns have been raised whether forest ecosystems might become increasingly susceptible to drought-induced collapse. There is thus a whole debate on what should be done in order to have climate change adapted forests. Planting fast-growing and drought-resistant tree species has been suggested as a solution. However, their drought resistance is commonly assessed in their natural habitats thus neglecting that their response to drought may vary considerably when planted outside their natural distribution range. In situ quantifications of how coexisting native and non-native planted conifers respond to drought are scarce but highly valuable. Here, we study mixed plantations of silver fir (native to Romania), Norway spruce (native to cool-mountainous European regions) and Douglas fir (non-native to Europe), located in the SW of Romania. Our purpose is to deepen into the drought resilience and ecological value of these three native and non-native conifers and see if indeed planting non-native tree species outside their natural distribution range, especially Douglas fir, is the right answer to have climate change adapted forests. For this, we are using tree rings along with competition and diversity indices, which will help us understand the resilience and stability on the long-run of these conifers to challenging climate change conditions. Specifically, growth patterns and tree-growth responses to drought are being compared, allowing us to better understand how coexisting silver fir, Norway spruce and Douglas fir trees will face climate change.

Presentation code: D-FOHE-O5

Tree ring records reveal fast recovery of stems after insect defoliation events in boreal forests

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Key words: mountain birch, dendrochronology, remote sensing, insect defoliation outbreaks, disturbance

Climate change affects tree growth in boreal forests through altered growing conditions and changes in disturbance regimes. Especially at the boreal-tundra ecotone, forests are expected to expand northwards under warmer conditions, while at the same time, disturbances may intensify and hamper forest expansion. We integrated tree-ring research, remote sensing, and field surveys to assess tree recovery of mountain birch boreal forests following insect defoliation events in northern Norway. We assessed annual growth from tree-ring records of 38 surviving birch stems (*Betula pubescens* var. *pumila).* All trees were single-stemmed individuals which experienced decadal defoliation by geometrid moths. These disturbance events were clearly visible in the tree-ring record and coincide with remote sensing indicators of massive forest defoliation events. We further found that during non-disturbance years, climatic conditions largely explained variation in stem growth. Following defoliation events, most surviving stems started to form wider rings again within a few years. This suggests that surviving stems may quickly recover from perturbation. While this may indicate a high resilience of surviving stems to regular insect defoliation, our results cannot be generalised to overall forest resilience. Our results suggest, however, that survivors of defoliation may recover fast enough to act as recruitment source for wider forest recovery.

Presentation code: D-FOHE-O6

Mixture effects on the drought sensitivity and radial growth of silver fir, larch and Douglas fir in Switzerland

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Key words: mixture effect, conifer, drought, neighbourhood, competition

Extreme droughts are expected to become more frequent in the context of climate change and these climatic events are a limiting factor for tree growth in many forest ecosystems. The use of native and non-native species in mixture is seen as a potential strategy to minimise the risks but still little is known about the mixture effects on drought response in terms of radial growth. Silver fir, larch and Douglas fir are of interest to forestry for their timber quality. These species are also seen as more resilient to drought than for example spruce. For our study, 400 trees with contrasting mixture have been cored in eight forests covering a wide range of bioclimatic conditions in Switzerland. Tree rings, together with the data on neighbouring trees collected in the field, helped in answering the question: How does the local neighbourhood of a tree influence its individual response to extreme droughts in terms of radial growth? We expected trees growing in mixed conditions to better resist to extreme drought events, compared to trees surrounded by individuals of closely related functional traits. Preliminary results show that this difference is not so clear. In some cases, especially for larch, it seems that the mixture effect positively influences the drought resistance. Larch, being a deciduous conifer, may benefit from growing in the surrounding of evergreen trees, with different functional traits and requirements.

Presentation code: D-FOHE-O7

Drivers of wind mortality in Central European primeval mountain forest as revealed by tree rings

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Key words: Disturbance history; *Fagus sylvatica*; *Picea abies*; Growth release; Wind mortality

The driving forces of tree mortality following wind disturbances of mountain mixed European temperate forests belongs among issues not comprehensively resolved. Hence, we aimed to elucidate the key factors of tree resistance to historical severe disturbance events in the Boubínský Primeval forest, one of the oldest forest reserves in the Czech Republic. By using spatially explicit tree census, dendrochronological and soil data, we study spatial and temporal patterns of past disturbances and mathematically compared selected characteristics of neighbouring trees that were killed by a severe storm in 2017 and those that remained undisturbed. The tendency of trees toward fall was primarily driven edaphically, limiting severe events non-randomly to previously disturbed sites. While disturbed trees usually recruited in gaps and experienced only one severe release event, surviving trees characteristically regenerated under the canopy and were repeatedly released. Despite the fact that disturbed trees tended to reach both lower ages and dimensions than survivors, they experienced significantly higher growth rates. Our study indicates that slow growth with several suppression periods emerged as the most effective tree strategy for withstanding severe windstorms, dying of senescence in overaged life stage. We conclude that the presence of such ancient, high-density wood trees contributes significantly to the resistance of an entire stand to severe storms.

Presentation code: D-FOHE-O8

How trees can contribute to remove airborne particles and accumulate them in the tree rings

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Key words: air pollution, ultrafine particles, tree rings, nanoplastics, foliar uptake

Dendrochemistry has proven to successfully provide a temporal record of trace metal deposition from a variety of pollution sources. Trace element uptake by trees was mainly thought to occur by soil-root transfer but recently some studies demonstrated that direct transfer of particulate matter from the atmosphere to the shoots is possible. However, the physiological mechanisms involved in the uptake and transport processes of these ultrafine particles is largely unknown. Their presence in the tree rings is still unexplored.

We have conducted several experiments to understand the foliar and root uptake of particles with size smaller than 100 nm in forest tree species. C^{14}-labelled nanoplastics were hydroponically applied to the root system of birch, oak and spruce. A similar experiment was performed with gold nanoparticles on beech and pine, with the addition of foliar application of nanoparticles on the leaves. The results of these experiments show that trees take up and transport (via xylem or phloem pathways) nanoplastics and engineered nanoparticles into the stem. These ultrafine particles are able to enter either the leaves, mainly through the stomata, or the roots through the root tips or microscopic cracks and eventually accumulate in the stem.

The presence of nanoparticles in tree rings can be potentially explored by the use of dendrochemistry, that can assess their spatial and temporal distribution in areas close to pollution sources.

Presentation code: D-FOHE-O9

Impact of pollution on multiple tree ring parameters of Norway spruce in Central Europe

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Key words: Blue intensity, Quantitative wood anatomy, Sulphur deposition, Climatic signal, Czech Republic

Central European forests experienced high rates of pollution in the second half of the 20th century associated with the establishment of heavy industry and coal-fired power plants, especially along the borders of the Czech Republic, Germany, and Poland. Consequently, growth declines were detected in heavily polluted forests. However, knowledge about the recovery of these forest systems and extent to which pollution has influenced the climate-growth relationship in various tree-ring parameters remains sparse. Therefore, we aimed to investigate the impact of pollution on chronologies generated from several tree-ring parameters, incl. ring-width (RW), blue intensity (BI), and quantitative wood anatomy (QWA), to understand how tree productivity and climatic signals were affected. Norway spruce samples were collected from five high-elevation temperature-limited locations along the Czech and Slovakia-Poland border, representing pollution-affected landscapes. RW and BI were measured on all samples and QWA data were produced from a subset of samples and their responses to climate variables were assessed. Distinct pollution-related RW suppression trends were detected in the latter part of the 20th century and isolated using the curve intervention detection method. This corrected pollution signals in RW series and modified the temperature response in pollution-affected periods but did not eliminate the effect entirely. Climatic response of BI and QWA parameters outperformed RW, and the pollution impact was more limited. This study provides valuable insight towards improving the utility of pollution-affected tree-ring chronologies used in dendroclimatic research, which will ultimately contribute to substantially improving the calibration of climate reconstructions from regions affected by atmospheric pollution

Presentation code: D-FOHE-O10

Long-lasting drought legacies in Atlas cedar forests and declining growth resilience in the last half millennium

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Key words: Dendroecology, VS-Lite, *Cedrus atlantica*, droughts, ecological memory

Recurrent droughts may drive delayed growth recovery in vulnerable forests. Unpreceded droughts and forest dieback in drought-prone Mediterranean ecosystems might be related by analyzing the long-lasting drought legacies through lagged effects that hinder tree recovery and suppress growth resilience capacity. Nevertheless, large uncertain remains regarding the mechanistic basis of legacy effects on vulnerability threshold triggering die-off at different spatial and temporal scales. We investigated 40 Atlas cedar forest sites with recent die-off cases, encompassing wide ecological and climatic gradients in north Morocco. Growth during severe droughts was examined during the past five centuries and compared with simulated recovery in forward growth models for the unpreceded last century drought extremes. Legacy effects of drought were calculated as the differences between detrended-only tree-ring series (i.e. after removing long-term growth trends) and pre-whitened tree-ring series for the period 1500-2012. Length and degree of tree-growth recovery time was defined when extreme low tree-ring indices returned to one. Superposed Epoch Analysis was used to estimate whether legacy effects differed from random. We found widespread drought legacy effects, while their magnitude increased markedly in dry Middle and High Atlas sites, and in response to late-season droughts (July–October). Long-term growth decline and limited recovery could be extended to 5 to 10 years after severe droughts. Legacy effects were most prevalent in dry (High and Middle Atlas, respectively) than in wet sites (Rif). These results point out to identify vulnerable areas based on growth responses to long-term multi-year climate extremes.

Presentation code: D-FOHE-O11

Why greenness increases and tree growth decreases in temperate forests of northern China?

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Key words: *Pinus tabuliformis*; tree-ring; Normalized Difference Vegetation Index (NDVI); northern China; wood anatomy

Forest greenness (NDVI) in northern China has been increasing since the 1980s; meanwhile, tree radial growth showed apparent decreasing trends. To interpret why such patterns occurred, we put forward two hypotheses: 1) High greenness in early spring limited tree growth by accelerating evaporation (ET) and reducing soil moisture content (SWC); 2) More photosynthetic products from the higher greenness were flown into underground (fine roots and soil). To test these hypotheses, we selected the tree-ring width and wood anatomical traits from 23 pure temperate *Pinus tabuliformis* forests distributed along a moisture transect in this study area. Continuous increasing NDVI and decreasing tree radial growth during 1980-2018 were confirmed in most sampling sites in this study. NDVI in early spring (March and April) positively correlated with evaporation in the early growing season (April and May) in the whole study. However, NDVI in early spring correlated with SWC negatively in wet sites and positively in dry and medium sites. Lower tree-ring width and cell wall thickness were detected in drier sites where the soil organic matter and fine roots biomass were higher. We can conclude that the factors that caused the inconsistent trends in NDVI and tree radial growth differ in dry and wet sites. Carryover effects of high greenness in early spring on tree growth were proved in wet sites. Changes in carbon allocation strategy: more biomass allocated into underground were confirmed in dry sites.

Presentation code: D-FOHE-O12

Fire-Climate-Human dynamics over the last 2000 years in the mesic *Araucaria-Nothofagus* forests

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Key words: *Araucaria-Nothofagus* forests, fire regime, western Andes, tree rings, sedimentary records

Few paleoenvironmental studies have been undertaken in the *Araucaria-Nothofagus* forests of northern Patagonia, yet these forests are considered highly vulnerable to ongoing threats from climate change and anthropogenic activities. To better understand their history: dendrochronological, pollen, charcoal, and chironomid records, spanning the last 1800 years, were analyzed from Tolhuaca National Park, Chilean western Andes (38.2°S; 71.8°W) and Nahuelbuta National Park in the Coastal Cordillera (37,8°S; 73°W). Charcoal-inferred fire episodes were compared with local tree-ring based chronologies from the last 430 years to better interpret the fire history reconstruction. The results indicate that periods with high fire activity were associated with decreased *Araucaria* abundance, as this conifer cannot survive a high severity fire regime for extended periods (between 200 and 1500 CE, with peaks around 200-400 CE and 1100-1500 CE). Pollen and chironomid assemblages suggest a shift from warm and dry to cold and wet conditions at 1500 CE. After 1750 CE, the appearance of exotic pollen taxa (e.g., *Plantago* and *Rumex*) and evidence of poor water quality reflect land-use changes (agriculture, logging, and pastoralism). We relate long-term changes in the vegetation and fire regime to increased climate variability (modulated by SAM and ENSO) over the last 1800 years and to human presence after 1850 CE. The most severe fire events in the *Nothofagus* and *Araucaria* forests occurred when suitable fire-prone conditions were superimposed with high human densities. Acknowledge Fondecyt 1201528 Project.

Presentation code: D-FOHE-O13

800 years of summer European-North Atlantic jet stream variability and its impact on climate extremes and human systems

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Key words: dendroclimatology, jet stream, climate extremes, human-environment interactions

The primary dynamical driver of summer climate extremes in Europe is the latitudinal position of the jet stream over the Europe-North Atlantic (EU) region. To study long-term variability in the EU jet stream latitude (JSL), as well as its potential impact on past climate extremes and human systems, we have reconstructed EU JSL variability over the past 800+ years (1200-2005 CE). To accomplish this, we have combined five European tree-ring chronologies to reconstruct the July-August JSL for the EU domain (EU JSL). Our reconstruction explains 40% of summer EU JSL variability over the instrumental period with strong skill.

We find that opposite EU JSL phases have consistently resulted in contrasting summer climate extremes between northwestern and southeastern Europe over the past 800 years. These summer climate extremes include heatwaves, droughts, floods, and wildfires that have been captured in a network of historical documentary data that further document the societal impacts of EU JSL-related climate extremes on both sides of the dipole.

Our summer EU JSL reconstruction shows a century-long northern phase from ca. 1355-1450 CE, corresponding to anomalously wet and cool summers over the British Isles and dry and hot conditions over the Balkans. This northern phase is comparable to the recent (1970-present) EU JSL configuration. We also found a southern phase, with opposite summer climate dipole conditions, from ca. 1810-1860 CE. Our results suggest that the EU JSL has been a long-term driver of the European summer climate dipole, as well as of associated climate extremes and societal impacts.

Presentation code: D-FOHE-P1

Lower drought resistance of Douglas fir compared to Norway spruce at extremely dry site in Central Europe

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Key words: Douglas fir, Norway spruce, drought sensitivity

The ongoing climate change has strong impact on forest ecosystems. Rational use of introduced species could be one of the ways in terms of forest management adaptation to climate change. In Czech Republic, one of most important introduced tree species is Douglas fir (*Pseudotsuga menziesii*, PSME), which is considered as potential substitution of Norway spruce (*Picea abies*, PIAB), which faced extensive dieback during last decade, especially in lower and middle elevations. We aimed to compare climate-growth relationships between PIAB and PSME at site representing extremely dry and nutrient-poor conditions within Czech Republic. We constructed basal area increment and indexed site standard tree ring chronologies both for PSME and PIAB. Then we compared: 1) trends in basal area increment chronologies, 2) climatic signals (precipitation and SPEI), and 3) indices of tree resilience (resistance, recovery, resilience) between PIAB and PSME. All analysis were computed in R (packages dplR, treeclim, pointRes). Our results showed better basal area growth of PIAB compared to PCAB during last four decades. We also found stronger early spring and summer precipitation and SPEI signals for PSME compared to PIAB. Both species showed similar values of resistance during drought years, but PIAB showed significantly higher recovery within post-drought periods. In our study site, the impact of drought is more intensive for PSME than on PIAB. Therefore, our results indicate that the generally accepted fact of higher drought resistance PSME may not always be valid.

Presentation code: D-FOHE-P2

The comparison of growth performances between generative and old-growth coppiced trees

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Key words: coppiced trees, generative trees, climate signal, resilience indices, Sessile oak

European forests have a long history of traditional coppice management. Coppicing was gradually abandoned in Central Europe by the early and mid-20th century. The returning to this traditional way of forest management is now intensively discussed in Central Europe due to conservation of biodiversity, biomass production and adaptation of forestry to ongoing climate change. The aims of this study were to detect: 1) differences in growth rate depending on cambial age between generative (GE) and coppiced (CO) *Quercus petraea* trees; 2) differences between climate signal and indices of tree resilience between GE and CO trees. First we explored the average growth rate depending on cambial age for each category (GE, CO) and each investigated sites. Then we calculated bootstrapped correlations between indexed tree-ring widths and monthly climatic data (precipitation total, SPEI) within site-level and compared these between GE and CO trees. Moreover, we calculated indices of tree resilience and compared these between GE and CO trees. Our results showed better juvenile growth of CO compare to GE trees at most sites suggesting better competitiveness caused by developed parent root system of CO trees. Trees showed very similar climate signal pattern with no systematic differences between GE and CO at all sites. Both GE and CO indexed chronologies were positively correlated with March–May as well as Jun-August precipitation and SPEI. Similarly we didn't find any differences in indices of tree resilience (resistance, recovery, resilience) suggesting no differences in drought limitation between GE and CO trees.

Presentation code: D-FOHE-P3

Impact of within-site heterogeneity on drought-induced mortality and decline in European beech

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Key words: drought, tree mortality, European beech, tree-ring width, stable carbon isotopes

The severe drought conditions of 2018/2019 in Central Europe resulted in considerable vitality loss, crown dieback and mortality in the ecologically and economically important European beech (*Fagus sylvatica* L.). Yet, a high level of within-site heterogeneity in impact was observed, with strongly affected trees neighbouring seemingly unaffected ones. Such uneven responses are likely caused by differences of various abiotic and biotic factors over small scales. As a consequence, we propose an integrated approach to disentangle the drivers of drought-induced mortality in European beech, which incorporates climatic variables, fine-scale soil properties, and structural factors.

To that end, a network of 25 beech stands across Northern Bavaria has been established (Beech Drought Network, BDN). At each site, we sampled trees following a specific design to obtain a treatment (drought-affected trees) and a control (unaffected trees) group. In addition to the assessment of growth-related vitality using tree-ring width, we will use stable carbon isotope ratios at annual scale as a physiological proxy for drought stress. Using remote-sensing and soil analysis we will quantify the small-scale heterogeneity in abiotic factors and their connection to soil water availability within the stand, as well as intra-specific competition as a critical biotic factor. Lastly, embedding the BDN into the European Beech Tree Network (EBTRN) will allow us to establish the biogeographic context for drought-related patterns of growth decline and recovery across the distributional range of European beech. These data shall further our understanding of the effect of micro-habitat on beech vulnerability to extreme drought.

Presentation code: D-FOHE-P4

The Swiss stone pine (Pinus cembra L.) in the extreme environment of cliff forest indicates growth reactions for changing climate and disturbance history

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Key words: disturbances, cliff forest, climate change, Pinus cembra, tree rings

The changing environment raises questions of forest dynamics and species distributions. The high-elevation cliff forests are a valuable type of ecosystem, where trees are exposed to multiple site-specific environmental factors. The aim of the study was to determine how temperature and precipitation as well as disturbance regime influence the radial growth of mountain tree species – Swiss stone pine interannual and intra-annual scales. The 449-year long chronology was constructed based on 104 tree ring series from stone pine growing in the cliffs of the Western Carpathians. The quality of tree-ring measurements was verified with COFECHA, the climatic analyses were done using DendroClim2002 and the disturbance regime was detected with TRADER. We showed that a pattern of climate/growth relationship of stone pine has been changing over the last century. In the last decades, the negative influence of summer precipitation on tree growth has abated which is contrary to observation from some parts of the Alps. The temperature of the previous autumn, winter, and early spring, which had a significant influence on stone pine growth in the past, is not an important factor now. However, the growth of trees in cliffs was strongly related to summer temperature over the whole century. Numerous releases in tree rings show a small-scale disturbance pattern, which is responsible for gradual mortality of trees in cliffs. The knowledge of the dynamics of cliff forests with dominant stone pine seems to be very important in the understanding of the functioning of these unique and valuable mountain ecosystems.

Presentation code: D-FOHE-P5

Site matters: Differences in tree-species adaptability as a function of climate and soil

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Key words: adaptability; forest site conditions; dendroecology; Douglas fir; American red oak

Multifunctional forest ecosystems should integrate a high diversity of native species reflecting current site conditions complemented by introduced species that increase their adaptability to drastic environmental changes. The optimal planting material for the "assisted migration" of non-native trees has to be carefully selected from suitable stands. A high degree of resilience against climate change is a central criterion for assessing this suitability.

Our study seeks for parameters to be used as reliable indicators for outstanding resilience in parent populations of future forest trees. For the investigations we chose two species with high ecological and economic potential for Central-European forests, *Pseudotsuga menziesii* and *Quercus rubra*. Borer core samples from stands under different site conditions in East Germany were analysed for selected dendroecological parameters such as (i) "autonomous" values including auto-correlation, Gini coefficients, and pointer years, and (ii) climate-growth relations in annual and monthly resolution. Additionally, we checked the time series of tree-ring width and TR indices for their reactions to extreme climatic conditions based on the established components of resilience.

The main results show site-specific, stand-related differences in the analysed parameters. A cautious summary can be understood to show a larger degree of overall resilience in populations that grow under less favourable site conditions. We conclude that adaptive effects to more extreme periods may already be seen in those trees that have experienced a higher level of climatic "uncertainty" during their lifetime. Thus, dendroecological explorations may well support comprehensive efforts for an optimal choice of breeding material for future forests.

Presentation code: D-FOHE-P6

Introducing the European Forest Condition Monitor: an open-access information- and data-platform for forest ecologists

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Key words: Remote sensing; MODIS; drought; late frost; ice storms

Understanding trees' reaction to extreme environmental conditions is a central aspect of dendroecological research. In this context, tree-ring measurements as well as monitoring of ecophysiological parameters can provide retrospective or concurrent data, respectively, allowing for the quantification of trees' response to various climatic stressors. Despite near-real time, high-resolution gridded climate datasets, quantifying the actual stress perceived by trees at a given place and time is often hampered by site-specific parameters (e.g., soil texture, stand density, micro-climate) modifying the actual stress load. Consequently, site-selection within a forest-stress context often has to face uncertainties regarding the actual impact of presumably extreme conditions on tree performance.

To overcome this potential limitation, the European Forest Condition Monitor (EFCM; Buras et al., 2021) quantifies canopy condition on the basis of canopy greenness in near real-time at a spatial resolution of 250 m x 250 m and in relation to all observations since 2001. The EFCM platform (http://interaktiv.waldzustandsmonitor.de/) allows for visualizing relative canopy greenness for countries in the EU for any specific date in a two-week interval since January 1st 2001 and download of corresponding data. Thereby, the EFCM informs forest ecologists about actual forest stress over the past two decades which may guide study-site selection within a dendroecological context. Our poster briefly describes the underlying methodology and exemplifies how extreme drought, late frost, and ice storms but also advanced or delayed spring phenology are reflected in canopy greenness to guide the interpretation of available EFCM products.

Presentation code: D-FOHE-P7

No evidence of CO_2 fertilization effect during unfavorable summers at forest vulnerability hotspots

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Key words: Mediterranean Basin, tree growth, intrinsic water use efficiency, broadleaf, conifer

It remains unclear whether the positive effect of increased atmospheric CO_2 concentration on forest growth (i.e., 'CO_2 fertilization effect') can counteract the negative effects of increased temperature. Studies addressing this question have generally been inconclusive due to the myriad of factors influencing tree growth and intrinsic water use efficiency (iWUE). The proximity of forests to the limits of the species' physiological tolerance to climate further complicates understanding of the processes due to enhanced legacy effects and stronger expression of physiological trade-offs. Here, we use a large network of tree-ring growth and stable carbon isotopic measurements to determine whether the CO_2 fertilization effect can outweigh the climate-induced growth reduction in Mediterranean coniferous and broadleaf forests at the limits of their distribution during summer of extremely high vapour pressure deficit (VPD). Our results show that the growth reduction induced by high summer VPD is not associated with an increase in iWUE. Furthermore, reductions in tree growth during years with unfavourable summer climate are generally not offset by increased tree growth during summer with favourable conditions. During the driest summers (i.e., high VPD) of the last decades, tree radial growth decreased on average by 15% in deciduous broadleaf tree species, but by 3% in coniferous species, despite similar increases in iWUE (approximately 6% in both groups). The variability between sites within a single tree species is extraordinarily high, reflecting the differential impact of summer heatwaves in the Mediterranean Basin and the strong influence of site-specific conditions on tree growth.

Presentation code: D-FOHE-P8

Influence of air pollution on the relationship between climate and radial tree growth

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Key words: tree rings, climatology, air pollution

The annual tree growth varies from one vegetation season to another, due to the variation of environmental factors from one year to another. Air pollution can change the normal behavior of tree growth both in terms of growth dynamics and response to environmental changes. This study presents results of industrial pollution influence on the relationship between tree growth and climatic factors. Two species of trees were studied, norway spruce (*Picea abies* L.) and silver fir (*Abies alba* L.), from the Tarnița region (Suceava), from northern Romania, which was intensely polluted by mining, extraction and processing of non-ferrous metals. The sampling design was done systematically in order to capture different degrees of pollution (intensely polluted, moderately polluted and unpolluted). The analysis of the radial growth dynamics shows that during the period with higher mining intensity (1978-1990), the trees in the intensive polluted area has significantly lower growths compared to the other areas. Regarding the effect of pollution on the climate-growth relationship, the response of trees depending on each species and the degree of intensity of air pollution.

Presentation code: D-FOHE-P9

Growth resilience of five conifer species to climatic extremes along an elevation gradient

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Key words: climate change, mountain forest, tree ring width, resistance, recovery

Climatic extreme events such as drought periods or storm events have a stronger impact on forests than continuous changes in climate conditions. Therefore, we analysed the reaction of tree growth to exceptionally warm, cold, and dry years within the LTSER platform Matsch|Mazia in the Italian Alps. We measured tree ring width of five different conifer species (*Larix decidua*, *Picea abies*, *Pinus cembra*, *Pinus nigra*, *Pinus sylvestris*) at multiple elevations, and determined pointer years showing very narrow or wide rings. Using data from a nearby climate station, we checked which of those exceptional growth years corresponded to climatic extremes. For those events we calculated resilience, resistance, and recovery of tree growth. First results indicate that negative pointer years occurred more often at lower than at high elevation and in *Larix* and *Picea* than in the *Pinus* species. We expect a similar pattern for resilience components with stronger resistance, recovery, and resilience to drought-related negative growth years at higher elevation and for *Pinus* species. Overall, our study should provide further insides into climate change effects on mountain forests.

Presentation code: D-FOHE-P10

Strong negative impacts of mega droughts on oak forest health in the Zagros Mountains, Iran

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Key words: Quantitative wood anatomy, Earlywood width, Latewood width, Oak decline, Persian oak

Abrupt climate change has strongly affected oak woodlands in the Zagros Mts., Iran. In this study, we aim to evaluate the impacts of extreme droughts on forest health. We analysed tree-ring width (TRW), earlywood width (EWW), latewood width (LWW) and wood-anatomical parameters in earlywood and latewood of *Quercus brantii* Lindl in the southern Zagros Mts., where *Q. brantii* reaches its southern bioclimatic limit. Evaluation of climate growth relationships revealed positive correlations between winter precipitation and ring-width parameters (EWW, LWW, and EWW) and earlywood and latewood vessel size parameters. In contrast EW and LW vessel size parameters were negatively correlated with mean monthly temperatures, in January to March and July to August. Ring-width and vessel size parameters of *Q. brantii* showed declining trends during the recent recorded severe droughts. In 2008, when a mega drought event occurred, which was accompanied by an increase in seasonal temperatures, an oak decline phenomena and insect outbreak expanded epidemically in the Zagros oak woodlands. The negative trends of ring-width and vessel size parameters of *Q. brantii* from 2002 to 2008 revealed that this native oak species tried to adapt to increasing drought frequencies by reducing EW and LW vessel size and its growth rate. However, simultaneous occurrence of a mega drought and high temperatures in 2008 imposed additional water stress, and ecological implications, i.e. insect outbreak and fungal pathogen attacks resulted in large-scale oak dieback in the Zagros Mts.

ASSOCIATION FOR TREE-RING RESEARCH

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Session E

Tropical Dendroecology

Presentation code: E-TROP-O1

Understanding climate responses of tropical tree growth using a mechanistic growth model

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Key words: maximum five: Process based model, climate sensitivity, tropical tree growth

Tropical tree growth is influenced by multiple climatic conditions, but how these drivers constrain variation in **tree growth** is poorly understood. **Process based models** can help to identify these **co-limiting drivers** and the **pathways** by which they force tree growth. Here we use a simulation model to study how temporal and spatial variation in climatic conditions drive stem growth.

IBTREE is a process based individual tree growth model that **simulates** the production of **leaves**, **fine roots**, **reserves** and **sapwood.** It was especially developed to predict sapwood growth (tree rings) and thus allow model-data integration. The model takes air temperature, precipitation, light and CO_2 as input and simulates **source limited** growth that is determined by the balance between photosynthesis and respiration. We applied IBTREE to ***Toona ciliata*** (Meliaceae), a semi-ring porous, light sensitive canopy tree distributed from **Nepal to Australia**. We compared simulated stem growth fluctuations with observed tree-ring width series for six climatically distinct locations where *Toona ciliata* occurs naturally.

We show that the IBTREE model is able to predict a large part of the variation in sapwood growth on a continental scale over long time periods. **Negative temperature** responses and **positive precipitation** responses were found both in simulations and tree-ring data. The model unravels the mechanisms behind these climate responses: **temperature** drives tree growth through its effects on photosynthesis and respiration; while **precipitation** works through water limitation on photosynthesis. We conclude that climate is an important driver of tree growth across a large share of the distribution of *Toona ciliata*.

Presentation code: E-TROP-O2

Vessel Characterization and Ring-width feature of a Multipurpose Agroforestry species (*Garcinia kola.* (Heckel)) along two vegetation zone, Nigeria

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Key words: Tropical dendrochronology, Ring width, Vessel anatomical, *G. kola*

The main drivers of physiological response to environmental conditions of trees are mainly vessel anatomical features and ring width. This is possible because, during the environmental stress condition, trees species record the environmental changes through their physiological adjustment. This approach is relatively new and could be challenging in tropical evergreen agroforestry species dues nature of seasonal differences, growth patterns, and the human pressure on the species for the sustenance of livelihood. Standard chronologies of ring-width and vessel variables were developed along two vegetation zones in Nigeria from 1980 to 2018. A dendroclimatic analysis was conducted and revealed that all chronologies shared a common environmental signal, principal component analysis conducted established the relationship among the variables. The vessel number (VN) is negatively correlated with the mean annual temperature, the mean vessel area (MVA) is positively correlated with the mean temperature. The ring width (RW) in the rain forest and derived savanna is positively correlated with both mean temperature and precipitation during the rainy season. The mean vessel area and VD are strongly positively correlated with Mean temperature and precipitation in the derived savanna zone during the pick of the rainy season (June to August). The vessels are more abundant from samples from rainforest area than those from the derived savanna area, unlike the RW that indicated similar pattern. The results revealed that the wood anatomical were comparatively more sensitive to climatic variables than RW. Hence, they could be good indicators for evaluating ecophysiological responses to environmental changes in tropical agroforestry species.

Presentation code: E-TROP-O3

Novel applications of wood chemistry for provenancing tropical timbers: can we finally log those logs?

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Key words: maximum five (Times New Roman - 11 points – Regular) Origin identification, multi-element analysis, stable isotope, tropical wood

Dendroprovenancing is a well-developed research field, fuelled by the increasing amount of chronologies worldwide. When trees make no distinct rings however, such as in large parts of the tropics, other methods are needed to trace wood origin. As many tropical regions deal with high occurence of illegal logging, an independent method to verify timber origin is needed to curb illegal timber trade. Therefore, our aim is to investigate the tracing potential of two chemical methods: multi-element analysis (ICP-MS; 60+ elements) and stable isotopes (IR-MS; C, O, H, S). To this end, we established an extensive geolocated reference dataset as part of the TIMTRACE project. It includes samples of two major timber species, Azobe (*Lophira alata,* Ochnaceae) and Tali (*Erythrophleum sp.,* Fabaceae), from over 20 sites across Cameroon, Gabon and Congo.

Our multi-element analysis provided a tracing resolution down to 100 kms. The method has a high potential in areas where soil clay and organic matter content vary at small spatial scales. Stable isotope analysis – on the other hand – may help verifying provenance at larger spatial scales (> 500 km). Whereas the water isotopes (O, H) in wood were strongly determined by rainwater stable isotope ratios and rainfall climatic variables, the effects on C in wood were more species specific. Which method, or combination of methods, is most suitable depends on the provenancing question at hand. Our results about the underlying mechanisms help to guide their application and are the first to reveal the potential of multi-element analysis for timber provenancing.

Presentation code: E-TROP-P1

Impacts of climate and dry-season on ring width and density of *Cedrela fissilis* Vell. in Brazilian Amazon

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Key words: dendroecology, climate change, drought, VS-lite, secas, tropical forests

During the last two decades the tropical Amazon forests have been impacted by frequent and severe droughts. Little is known about the impacts of these extreme events on wood traits. We quantified long- and short-term impacts on growth and wood density response and resilience strategies under extreme droughts, analyzing the wood trait trends and correlations with climate variables (temperature, precipitation, and the SPEI drought index). We simulated tree-ring formation and its responses to soil moisture using the process-based VS-Lite growth model. Our results show how climate anomalies and dry spells increased since 1990s in the southern Amazon region and have affected the growth and wood density of *C. fisillis.* Ring width, latewood width and minimum wood density showed the highest sensitivity to drought. *C. fissilis* showed wider and dense rings during wetter years, and narrower and less dense during drier years, which suggest that the species experiences functional plasticity in its wood to adapt to dry conditions. Changes in the season timing of water limitations during the dry season shift growth thresholds and long-term resilience towards growth decrease and wood density increase, increasing the vulnerability of *C. fissilis* to projected climate warming scenarios. The short-term resilience is evidenced more in wood density than in the ring width, indicating the species´ ability to adapt to short-drought periods. However, the inherited effect of consecutive droughts can create a negative impact on the trade-off between growth and plasticity of wood density on a long-term scale. This study is a first attempt to illuminate aspects of the characteristics of the annual growth rings of *C. fissilis* trees in relation to climate sensitivity and resilience to drought, based on long-term data from the moist tropical forest with annual dry season of the Amazon.

Presentation code: E-TROP-P2

Growth rings pattern and their relationship between microdensity and wood anatomy in *Caryocar Glabrum (Aubl.) Pers.*

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Key words: *Caryocar Glabrum*, microdensity, dendrochronology, wood anatomy, precipitation.

The Amazonian has forests with extensive vegetation, however, this resource has been affected by the extraction only for commercial purpose. Because of that there is a wide range of forest species that have not yet been studied.

The main purpose was to determine the relationship between microdensity and growth ring pattern with precipitation and temperature. For this study, we recollected 5 trees by the destructive method from the Matereni community, obtaining 2 transversal sections for each tree, 10 samples in total. To identify the ring limit, the samples were polished with sandpaper from 60 to 800 grain.

Microscopic wood structure was analysed with histological sections using a microtome and the microdensity profiles were constructed using X-Ray techniques. Also, meteorological variables such as precipitation and temperature, were obtained from Senamhi, the meteorological agency of Peru.

The results presented that precipitation showed a strong correlation from November to December of the previous year, on the other hand, the temperature correlation was positive and significative from April to August. This dendroecological study recognize the potential of *Caryocar Glabrum* to future studies because of ring delimitation and the wood properties, furthermore, improves the knowledge about tropical Amazonian species.

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Presentation code: E-TROP-P3

Geomorphological analysis help to explain stable isotope patterns in tropical mountain rainforest trees

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Keywords: stable carbon isotopes; stable oxygen isotopes, tropical trees, geomorphological analysis

Time series of stable isotope ratios often show higher inter-tree correlations than tree-ring width. We studied stable carbon and stable oxygen isotopes of 14 *Cedrela montana* (Meliaceae) individuals in a tropical mountain rainforest in southern Ecuador. The study area is located in 2000 m a.sl. and is characterized by a deeply dissected steep terrain and a humid climate with ca. 2,200 mm mean annual rainfall. Though the overall inter-series correlation (Rbar) was moderately high (Rbar = 0.47 for $\delta^{18}O$, Rbar = 0.48 for $\delta^{13}C$), isotope patterns of some individuals matched less well than others. For example, Rbar of the four "best" and "worst" fitting trees varied between 0.69 and 0.30 for $\delta^{18}O$, and between 0.83 and 0.41 for $\delta^{13}C$, respectively. To find the causes for such divergent behavior between tree individuals, we conducted a spatial analysis of geomorphological features of the study are using ARC GIS and an underlying digital elevation model. Multiple regression analysis using various morphometric variables indicated a significant influence of slope angle on stable isotope values. In our study area, slope angle is a variable correlated with soil depth and probably also to moisture and nutrient supply. The inclusion of further variables shall us help to predict which trees, according to their position within the landscape, have a high probability to show more individual stable isotope patterns, and which trees probably better represent a common climatic signal. This may save a lot of analytical laboratory efforts and improve the common chronology signal for dendroclimatological studies.

Presentation code: E-TROP-P4

Dendrochronological potential and growth-ring anatomy of West African angiosperm trees

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Key words: Angiosperm trees, dendrochronology, ring-boundary anatomy, semi-arid areas, West Africa

The semi-arid savannas of West Africa are undergoing severe human pressures and climate change, leading to deforestation and rapid disappearance of native species being main providers of ecosystem services. In such context, understanding tree ecological responses to environmental conditions is mandatory for sustaining savanna conservation. The study aims to characterize ring-forming species in savanna ecosystems and assess their potential for dendrochronological studies. Wood samples were collected from dead trees at different sites across the Sudano-sahelian and the Sudanian climatic zones of Burkina Faso. Overall, thirty-five (35) woody species belonging to twenty-four (24) genera and nine (10) families were sampled. Standard dendrochronological techniques were applied to wood samples. To describe growth-ring anatomy, we performed macroscopic and microscopic observations of stem discs and micro-sections, respectively. Most of the studied species (98%) showed growth ring boundaries mainly demarcated by marginal parenchyma bands (65.71%), and often in association with thick-walled latewood fibres (31.43%), narrow vessels elements (31.43%) and radially flattened latewood fibres (14.28%). The ring boundaries distinctiveness varied from distinct (68.57%) to fairly distinct (28.57%). All the studied angiosperms (100%) had diffuse porous wood structure, with solitary (57.14%) or grouping vessels (28.57%). The growth ring anatomical features and the ring distinctiveness differ between families and species. Fabaceae species had growth rings delimited by thin bands of terminal parenchyma bands, while thick bands demarcated growth rings of Anacardiaceae species. Cross-dating was successful within discs and within species, and between some species and families. This study revealed high dendrochronological potential of West African angiosperms.

Presentation code: E-TROP-P5

Does climatic zones affect vessels distribution and wood density of *Strychnos spinosa* in Benin (West Africa)

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Key words: *Strychnos spinosa*, Vessel characteristics, wood density, Climatic zone, Benin.

Several studies established that the environment plays an important role in the structure and function of plant species. In this study we assessed how far climatic zones influence vessels and wood density of the diffuse porous angiosperm spiny monkey orange (*Strychnos spinosa* Lam.) from Benin, in tropical West Africa. Stem disks samples were collected from different climatic zones in National parks and gazetted forest ecosystems and and processed for wood anatomy measurements. In one hand, thin sections were taken from cut pieces with sledge microtone and the protocol described by Gärtner et al. (2015) was used for their staining. On the other hand, the saturated cut pieces were dried in oven for 72h at 105°C and the wood specific density was determined according to Nogueira et al. (2005). From the current study, even though there was no significat difference, wood density varied from biogeographical zone and wood's sampling sites. In the Sudanian zone it is ranged from 0.53 to 0.58 g.cm^{-3} with an overall mean value of 0.55±0.05 g.cm^{-3}. It varies from 0.52 to 0.58 g.cm^{-3} with a mean value of 0.54±0.16 g.cm^{-3} in the Sudano-Guinean zone. The species was characterized by vessels largely grouped tangentially or radially with some solitary. The vessel-related anatomical traits varied with high amplitude (coefficient of variation CV > 25%) between different sites located in different climate zones. The variability of the traits is higher within one climatic zone than between climatic zones, and even more pronounced within trees. Consequently, the climatic zones have less influence on the studied features than local site conditions.

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Presentation code: F-CLIM-O1

A Prehistoric tale of woe, as told by the silent sounds of relic trees.

The potential use of Taxus baccata to reconstruct environmental changes of South-Eastern England in the Middle Holocene

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Key words: palaeoreconstruction, chronology, *Taxus baccata*, Holocene, England

Broadly, my PhD research reconstructs environmental and climate conditions in the past at high resolution using plant rings. While last centuries are spanned with data from living trees, far past can be reconstructed with using sub-fossil wood. This material is rarely found because it requires both high decay resistance of species and specific conditions preserving wood.
South-Eastern England is one of unique areas containing sub-fossil trees that are currently excavated from soil. Although plenty of yew trees are exhumed, there is no record of native yew tree growing in the region nowadays. This suggests that the conditions of coastal regions in Middle Holocene differed significantly from what we observe today.

In my PhD, I aim to build a *Taxus baccata* chronology that will explain environmental changes in Middle Holocene, according to climate response in relic yew tree rings, and investigate what caused Taxus baccata to seemingly, suddenly decline at 4000 years BP.

More than 200 yew trees have been collected in the field and a chronology of 700-years has been built spanning the period 4800-4100 BP with using more than 30 yew trees.
This chronology has become both the first sub-fossil *Taxus* chronology and the longest for *Taxus baccata*. The work has confirmed the extreme challenge of using Taxus in tree ring research due to its irregular growth pattern and investigated different ways of minimizing environmental noise in ring width. The results have showed the existence of mature woodlands with 200-300 years old yew trees in Middle Holocene in SE England and their potential to reconstruct climate changes.

Presentation code: F-CLIM-O2

Machine Learning paves the way for a robust millennium-length Alpine temperature reconstruction

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Key words: dendroprovenancing, elevational offsets, temperature sensitivity, European larch

Tree-ring series from high elevations have been used to reconstruct temperature variability over the past millennium for Central Europe. In the European Alps, historical wood from buildings is commonly used to extend tree-ring series from living trees and to build millennium-length chronologies. However, the unknown provenance of construction wood can limit its use for climate reconstructions. To address this issue, we sampled 187 living larch trees along two elevational transects (1400-2300 m asl) and 308 historical larch series from buildings in the Simplon and Matter Valley in Switzerland to build a millennium-length larch chronology of maximum latewood density. We used Machine Learning methods to provenance the historical series to specific elevations with similar growth behaviour. This approach enabled us to mitigate effects of elevational offsets among historical tree-ring series, to enhance the climate sensitivity of the resulting chronology, and to develop a robust temperature reconstruction back to 802 CE. We conducted additional analyses to estimate the effects of larch budmoth mass outbreaks on chronology variance.

Presentation code: F-CLIM-O3

The „pre-industrial" temperature baseline from a tree-ring perspective

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Key words: northern hemisphere; temperature reconstruction; early instrumental; coverage bias; 1.5°C

Since the Paris Agreement, climate policy focuses on the 1.5 and 2°C targets. However, the agreement lacks a formal definition of the "pre-industrial" temperature baseline that these targets refer to. If global warming is discussed w.r.t. the 1850-1900 mean as in the 5th Assessment Report by the IPCC, uncertainty in the observed temperature is significant. Here, we analyse gridded datasets of instrumental observations together with large-scale climate reconstructions from tree-rings to evaluate the robustness of the baseline temperature. For an extended summer season in the Northern Hemisphere extratropics, the 1851-1900 instrumental temperature means are on average 0.22°C warmer than the tree-ring based temperature reconstructions. Cooler reconstructed temperatures frequently occur in regions that are undersampled by the instrumental datasets. Infilling techniques, used to increase the spatial coverage of gridded instrumental fields, produces data that correlate weakly with local reconstructed temperatures in the second half of the 19th century. The offset between observed and reconstructed baseline temperatures declines, if the infilled data are removed from the instrumental grid and moving correlations between these masked hemispheric averages are more stable. Correlations with minimum temperature, calculated to identify a potential solar exposure bias in early instrumental temperature records, appear likewise robust. Our findings indicate that the coverage bias is more important than the exposure bias when estimating global temperatures based on gridded observations. Proxy-based temperature reconstructions suggest an overestimation of instrumental temperatures during the 1851-1900. An adjustment of this baseline bias would further reduce the probability of reaching global warming targets.

Presentation code: F-CLIM-O4

Recent increase in European summer VPD is unprecedented over the past 400 years

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Key words: oxygen isotopes, climate reconstruction, atmospheric moisture, network

Vapour pressure deficit, VPD, is a key component of global hydroclimate and directly affects terrestrial evapotranspiration, ecosystem functioning and vegetation productivity. Periods of high VPD are seen as a primary driver of drought-associated tree growth reduction and tree mortality in many forest ecosystems, particularly in conjunction with limited soil moisture. Long-term changes in VPD and its spatio-temporal variability are, however, still uncertain, particularly in the context of the pre-industrial past, but are essential for reducing uncertainties in Earth System models. Here we utilize a unique European network of oxygen isotope records for development of the first 400-year-long, robust reconstructions of summer VPD variability across the European continent. These records indicate strong spatiotemporal coherence and physiological sensitivity to summer VPD variability particularly in regions with non-limiting soil moisture conditions such as Western and Eastern Central Europe, Southern Fennoscandia and the mountainous regions of the Alps & Pyrenees. Our reconstructions suggest that the widely reported recent increase in VPD is unprecedented over the past 400 years. Increased tree-ring $\delta^{18}O$ sensitivity to summer VPD in the recent decades suggests an intensification of the atmospheric moisture demand and amplified evapotranspiration. Our reconstructions place the actual European summer VPD dynamics into a preindustrial context and provide the basis to implement long-term VPD variability and the plant physiological response to it into the next generation of Earth System models.

Presentation code: F-CLIM-O5

400-year multi-parameter reconstruction of Carpathian temperatures from tree rings

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Key words: paleoclimatological reconstruction; multi-parameter analysis; high-resolution imaging; non-climatic biases; Carpathians

Although numerous proxy-based climate reconstructions have been developed and despite the prevalence of relatively long instrumental records throughout Europe, reliable information about past climate is still lacking in some regions, particularly eastern parts of the continent. This issue is linked to limitations in data quality and large uncertainties in existing records. The REPLICATE project aims to fill this spatial paleoclimatic and data quality gap by utilizing a multi-parameter approach to reconstruct climate using Norway spruce (*Picea abies*) tree-ring samples. We have developed a set of temperature-sensitive chronologies from across the Carpathian Mountains to advance our understanding of recent climatic variability in this region. From these chronologies, annually resolved, robust, high-quality summer temperature reconstructions covering the past 300-400 years are being developed for four locations across the Carpathians. To optimize the climate signal, we used a combination of multiple parameters, including tree-ring width (RW) chronologies corrected for disturbance; blue intensity from scanned images (BI); color bias-free surface intensity (SI) from microscope-based high-resolution images; and traditional and surface-based quantitative wood anatomy (QWA/sQWA). This approach strengthens the climate signal considerably, and initial results indicate that these Carpathian temperature reconstructions will yield records with reduced uncertainty that explain between 50% and 60% of the regional temperature variability. These new records will, in turn, provide improved spatial information on the transition from the LIA to the modern warm period, which is important for tuning and downscaling climate models by providing constraints on climate model performance and improving predictions of future climate scenarios.

Presentation code: F-CLIM-O6

Freshet- and drought-season runoff reconstructions for the Fraser Basin Headwaters, British Columbia, Canada

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Key words: Dendrohydrology, Streamflow, Flood, Drought

Pluvial and drought conditions have recently worsened in the Fraser River Basin (FRB), British Columbia, causing significant impacts to western Canadian economy, ecosystems, and societal wellbeing, as well as the costliest natural disaster in the province's history in 2021. These extreme events present a major management challenge since the FRB is susceptible to unregulated spring flood and summer drought events, even in the same year. Meanwhile observational streamflow datasets are both short and potentially forced by anthropogenic warming, providing an incomplete record of long-term natural hydrological variability. Here, we present the first multi-century, seasonally-resolved paired freshet and drought reconstructions for the Fraser Basin Headwaters (FBH), the primary driver of overall FRB discharge. By independently reconstructing spring freshet- and summer drought-season runoff, we overcome methodological limitations that precluded prior attempts to reconstruct total water-year runoff in this basin. The reconstructions more than double the length of existing hydrologic datasets, and are used to analyze the magnitudes, durations, and statistical probabilities of anomalously high and low runoff of the past 140 years. We find that high freshet-season flows have intensified, enhancing the risk of flooding in the event of coeval extreme precipitation and that the frequency and temporal clustering of both high freshet and low drought-season runoff has intensified in recent decades. Our new datasets suggest existing hydrologic data underestimate past and future extreme events, and signal managers and stakeholders should take more conservative approaches in adapting to future FRB conditions under climate change.

Presentation code: F-CLIM-O7

Coupling between summer North Atlantic jet variability and European forest productivity and growth

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Key words: European beech, North Atlantic jet stream, tree growth, gross primary production, extreme weather events

European forests stock 30% of the total carbon stored in the biomass of temperate forests globally. As essential components of the biosphere, these forests are highly influenced by land–atmosphere interactions and climate extremes that may alter carbon uptake and storage. Dynamically driven extreme weather events have large ecological, social and economic consequences including large tree-growth reductions and forest mortality. These events are likely to become globally more frequent and intense under increased anthropogenic forcing and associated changes in coupled atmosphere-ocean circulation. The jet stream latitude (JSL) over the North Atlantic-European domain provides a synthetic and robust physical framework that integrates climate variability not accounted for by atmospheric circulation patterns. Problematically, we lack a quantitative perspective on the dynamic drivers of summer climate extremes, and particularly JSL variability, in relation to forest productivity. The assessment of the physical coupling between summer North Atlantic-European JSL variability and anomalies in temperate European beech (Fagus sylvatica L.) forest radial growth and productivity over Europe reveals not uniform impact across Europe. Surface climate impacts of north-south summer JSL displacements create a northwestern-southeastern dipole in forest productivity and radial-growth anomalies. Summer JSL variability over the eastern part of the North Atlantic-European domain (5-40E) exerts the strongest impact on European beech forests, inducing anomalies in carbon uptake and radial growth of up to 30% and 50%. The net effects of JSL movements on terrestrial carbon fluxes will depend on forest density, carbon stocks, and productivity imbalances across biogeographic regions.

Presentation code: F-CLIM-O8

Drought legacy effects in radial tree growth are meaningful but rarely significant under heightened statistical scrutiny

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Key words: auto-correlation, lag effect, superposed epoch analysis, time-series simulation, biological memory

Drought legacy effects (DLE) in radial tree growth (RTG) have been extensively studied over the last decade and are believed to critically influence carbon sequestration in woody biomass. However, the statistical significance of DLE depends on our definition of expected vs. unexpected growth variability, a definition that has not received sufficient scrutiny.

Here, we revisit popular DLE analyses using the ITRDB and employ a synthetic data simulation to disentangle four key factors influencing the magnitude of DLE. We show that DLE are mainly influenced by the auto-correlation of RTG, depend on climate-growth cross-correlation, are directly proportional to the inherent variability of RTG, and scale with the chosen extreme event threshold. Using this simulation, we can reproduce the magnitude of observed pattern, meaning DLE are nothing else than biological memory.

We further find that the interpretation of DLE following isolated drought events at individual sites is challenged by high stochasticity, and show that stronger DLE for conifers are a result of higher auto-correlation compared to deciduous broadleaves.

We present two pathways to improve the future assessment and interpretation of DLE: First, we provide a simulation algorithm to *a posteriori* account for auto-correlated residuals of the initial regression model between growth and climate, thereby retrospectively adjusting expectations for "normal" growth variability. The second pathway is to *a priori* include lagged climate parameters in the regression model. Doing so strongly reduces the magnitude of observed DLE and thus challenges us to consider the full spectrum of expected variability when evaluating drought-induced growth deviations.

Presentation code: F-CLIM-O9

Deciphering the climate drivers of bimodal growth in conifers using the VS-mode

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Key words: bimodal growth, continentality, seasonal precipitation, shrub, tree, Vaganov-Shashkin model

It has become extremely important to assess cambium dynamics and radial growth plasticity in response to climate change. However, long records of xylogenesis are scarce, thus limiting our ability to analyse climate-growth couplings. Alternatively, process-based growth models such as the Vaganov–Shashkin model (VS-model) can be used to simulate intra-annual growth dynamics of tree and shrub species, mainly conifers. Such models could allow disentangling the climate drivers of major growth patterns. One of these patterns is the bimodal growth, already described in Mediterranean, drought-prone regions, and characterized by growth peaks in spring and autumn when climate conditions are warm and wet. We used the VS-model to decipher the main climate drivers of bimodality considering eight conifers (four pines and four junipers, both trees and shrubs) inhabiting ten sites with contrasting climate conditions across Spain. For each species, we selected two sites with different continentality (and Mediterranean influence) since we expected to find bimodal growth in less continental sites were precipitation peaks in spring and autumn. The VS-model simulations were successfully calibrated and verified by comparing them with measured tree-ring data. Bimodal growth patterns were found in less continental sites (Mediterranean) showing low spring/autumn precipitation ratios. Such patterns were corroborated by xylogenesis and / or dendrometer records available in some of the study sites. In most sites, growth was enhanced by wet-cool prior winter and spring conditions, but in the most bimodal sites autumn precipitation also enhanced growth. We discuss differences between species and sites to develop a model of bimodality, a major feature of radial-growth plasticity in water limited environments.

Presentation code: F-CLIM-O10

Through eagle eyes - Assessing the potential of satellite-derived LAI to observe climatic effects on tree-ring width and masting events

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Key words: tree-ring growth, masting, LAI, climate correlations, remote sensing

Masting, a recurrent and complex phenomenon in European beech, is mainly driven by warm/dry summers in the mast year (t_0) and the year before (t_{-1}), and cold/damp summers two years before masting (t_{-2}).

The relationship between tree-ring width (TRW) and masting is well studied on a local intra-population level, but larger inter-population studies are scarce because of time-consuming and laborious acquisition of masting data. This paper investigates the potential to identify and assess masting via remotely sensed leaf area index (LAI), which could lead to improved large-scale masting analyses.

We employed a regional monitoring network consisting of 19 beech stands along a precipitation gradient in north-eastern Germany providing time series of TRW (1961 – 2017) and categorical masting data (1992 – 2020). Combined with remotely-sensed LAI from the MODIS satellite sensor (2000 – 2020), we assessed the relationship between all three parameters by correlation analysis and further identified common climatic drivers. Spatial masting patterns along the gradient were analyzed using precipitation data, as well as field-measured and remotely-sensed soil moisture.

TRW and masting showed strong correlations with summer conditions. While TRW is mainly receptive to climate conditions in t_0, masting shows distinct patterns throughout t_{-2} to t_0. LAI was not correlated with either parameter and showed no distinct climate signal. The absence of a common climate signal between LAI and TRW/masting indicates a low potential to identify and assess masting using satellite-derived LAI at a coarse resolution. Nonetheless, in light of steadily improving technology we are convinced that remote sensing approaches may be able to provide substantial benefits with growing importance for future research.

Presentation code: F-CLIM-O11

Influence of post-drought climate sensitivity deviations on secondary growth in European beech

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Key words: legacy effects; drought recovery; climate-growth relationship; dendroecology

Extreme drought events will have an increasing influence on forests in the course of climate change. It is thus pivotal to understand their direct impacts and subsequent recovery patterns, so-called growth legacies, which are often reported as changes in secondary growth. Yet, secondary growth alone cannot fully explain internal physiological responses to droughts.

Climate-growth relationships are naturally non-stationary on longer time scales due to temporally variable growing conditions. On shorter time scales, extreme drought events represent considerable perturbations that likewise alter the climate sensitivity of growth, corresponding to physiological impacts caused by drought. Decoupled growth-climate relationships would be expected in the case of a damaged hydraulic system or reallocation of carbon to rebuild foliage. Conversely, tightened coupling would be expected in the case of stricter growing conditions as per the law of the minimum or carbon reallocation towards increased xylogenesis. Therefore, post-drought changes in the climate sensitivity of growth serves as a potential avenue of detecting physiological drought impacts.

Here, we aim to find intraspecific changes in post-drought climate-growth relations for the ecologically and economically important European beech (Fagus sylvatica L.). Using the European Beech Tree-Ring Network (EBTRN), which covers the entire distributional range of the species, we compute post-drought changes in climate-growth relationships in addition to direct growth legacies and attribute them to abiotic and biotic factors.

Preliminary results indicate a complex connection between growth recovery rates and diverging post-drought climate sensitives which feature a more nuanced response pattern compared to growth impacts.

Presentation code: F-CLIM-O12

To the point: drought-induced extraordinary growth differs between conifers and broadleaves

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Key words: Pointer years; Climate change; ITRDB; Drought-legacies

Studying the impact of drought on tree-growth is a central aspect of dendroecological climate-change research. This is because current extreme droughts are likely to represent anticipated normal conditions at the end of the 21st century, depending on climate-change severity. Consequently, assessments of historic drought-impacts on tree growth may improve projections of a specific species' potential to survive at a given place under climate change.

In tree-ring research, a commonly applied approach to identify extraordinary growth is the pointer-year analysis. By intersecting pointer years with extreme drought events, drought-resilience components can be identified and compared among sites and/or species to quantify immediate (resistance) and medium-term (recovery) drought impacts.

Using a recently developed and subsequently refined approach for pointer-year detection and definition of post-drought recovery periods, we here analyse the ITRDB for resistance and recovery patterns on global scale with particular emphasis on the comparison between conifers and broadleaved tree-species. Preliminary results indicate a significantly weaker resistance of conifers, while their recovery appeared to be higher compared to broadleaves. Interestingly, we did not find systematic differences in the duration of the recovery period between clades: for both gymnosperms and angiosperms the duration seemed to be mostly related to climatic conditions during the recovery period. Concluding, our study provides additional insights on the drought-response of trees at global scale.

Presentation code: F-CLIM-O13

Rates of soil erosion in high-latitude regions tracked by cell-size changes of Arctic dwarf shrubs

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Key words: Arctic, dwarf shrubs, dendrochronology, soil erosion

Arctic and sub-Arctic terrestrial environments with bare surfaces, large amounts of loose sediment, and low and sparse vegetation are especially sensitive to soil disturbances. The surface morphology shows evidences of intense soil erosion including very common erosion escarpments, spots and troughs. The aim of the study was to determine soil erosion rate on the basis of wood anatomy features of Arctic dwarf shrubs. The research were carried out in NE Iceland and south Spitsbergen affected by severe erosion. The main research question we examined were: (1) Can data from dwarf shrubs be used to reconstruct the history of soil degradation, and if yes, (2) Can such data be used to estimate the rate of erosion and degradation of soils? Ours is the first study to utilize dendrochronological techniques in exposed roots of dwarf willow (*Salix herbacea* L.) and net-leaved willow (*Salix reticulata* L.). We detected the erosion signal in the roots by analyzing changes in cell-size and width of growth rings. When dwarf shrub roots are exposed, cell sizes are reduced by >50%, with maximum changes in individual plants exceeding 150 - 200%. Based on this relationship, were able to estimate erosion rates since the 1970s for Iceland and since 1950s for Spitsbergen. We found rapid increases in erosion rates after mid-1990s, reaching rates of 5.4 cm yr−1. These increased aeolian erosion rates may be linked to climate change, as this period coincides with increased numbers of hot and warm, as well as dusty days.

Presentation code: F-CLIM-P1

Millennium length tree-ring anatomy from the iconic Yamal chronology

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Key words: Dendroanatomy, Siberia, Temperature reconstructions

Tree-rings form the backbone in many Northern Hemisphere temperature reconstruction of the past millennium. A select few sites are nearly always included due to their length, skill and strategic location. The Yamal chronology from northern Russia is one of the most prominent examples, currently extending almost 9000 years back in time. Ring widths from this site have been repeatedly measured over decades and featured in numerous reconstructions and methods development articles. The most widespread tree species in the collections of subfossil wood samples is Siberian larch (*Larix sibirica* Ledeb.). Now the time has come to analyze a subset of these trees for quantitative wood anatomy to explore if it is possible to add a new set of skillful predictors and further strengthen temperature reconstructions from this region. Here we present the process of developing a >1000 years long dataset of tree-ring anatomy using methods largely developed or refined over the last decade at WSL Switzerland. The dataset will include >10 million analyzed cells feeding information to dozens of annualized parameters. The hope is that we will uncover temperature signals which at least in part are separated in seasonality from the one of ring width, and that statistical properties such as autocorrelation describing the biological memory of the formed wood tissue will behave similarly to instrumental observation, and in extension give a more precise representation of volcanic cooling events.

Presentation code: F-CLIM-P2

A reconstruction of June–July temperature since AD 1383 for Western Sichuan Plateau, China,using tree-ring width

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Key words: Tree rings; Western Sichuan Plateau; Climate change; Divergence problem; Recent warming

Global warming has a significant impact on the ecosystem of the high-altitude areas of the Tibetan Plateau, such as land degradation and the rapid retreat of glaciers. It is important to understand the effects of global warming occurring over hundreds or thousands of years. However, the long-term reconstruction of temperature is still lacking for the region of Western Sichuan Plateau (WSP). In this study, we reconstructed summer (June–July) temperatures back to 1383 for the WSP region based on a significant positive correlation between the standard chronology and summer temperature. The reconstruction passed statistical tests and explained 55.4% of the climatic variance in the period for which data are available (1962 to 2005). There have been five periods with warm summers and five with cold summers during the past 623 years. Warm periods occurred in 1383–1445, 1525–1590, 1700–1724, 1825–1870, and 1930–1960, while relatively cold periods occurred in 1446–1524, 1591–1675, 1725–1824, 1900–1929, and 1961–1990. A comparison with observed data and regional temperature reconstruction series shows that the reconstruction has a high degree of consistency and is indicative and reliability. The spatial correlation was analyzed with Climatic Research Unit gridded data to detect the spatial representativeness of the reconstruction, confirming that the reconstruction has a strong regional temperature signal for the WSP. Furthermore, ensemble empirical mode decomposition indicates quasi-oscillations of 2.8–3.3 years, 6.4–8.3 years, 11.1–14.2 years, 25–38.4 years, 89 years, and 138 years in the reconstructed temperature time series during the past 623 years. El Niño Southern Oscillation cycles, solar activity, and Atlantic multi-decadal oscillation can potentially be the primary forcing factors. Meanwhile, the coordinated action of temperature-induced drought stress with a late growing season related to delayed snowmelt can potentially be attributed to the divergence problem (observed around 2005).Please indicate clearly in your submission the session and type of presentation.

Presentation code: F-CLIM-P3

An MXD perspective on climate responses of eruptions in 1808/1809 (unidentified volcano) and 1815 (Tambora)

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Key words: Volcanic eruptions, MXD chronologies, ITRDB

There were two significant volcanic eruptions at the beginning of the 19th century: that of Tambora in 1815 is well documented but the other, in 1808 or 1809, is known only from ice core records. Occurring so close in time, the overall climatic response to these events may have been amplified. Here we report a study of maximum latewood density (MXD) chronologies spanning 1795-1830 CE available from the International Tree-Ring Data Bank aimed at characterising spatiotemporal patterns of summer cooling across this period. While we identify a clear and widespread climate impact after Tambora's eruption at nearly 200 North Hemisphere sites, the response to the unidentified eruption appears weaker and more spatially heterogeneous. Further investigation of wood anatomical features such as frost rings, light rings and blue rings is planned to shed further light on the climatic response to the 1808/09 eruption and its role in contributing to climate forcing throughout the 1810s.

Presentation code: F-CLIM-P4

Differences in growth-climate relationships among Scots pines growing on various dune generations on the Southern Baltic coast

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Keywords: dunes, podzols, Scots pine, *Pinus sylvestris* L., tree-ring width, dendroclimatology, Baltic See, Poland

This study aims at analyzing growth rate and growth-climate relationship in Scots pine (*Pinus sylvestris* L.) growing on coastal dunes of different ages on the Southern Baltic coast. Podzols have deloped on these dunes. Depending on dune age, however, podzols are characterized by a different degree of development and richness, which represents the main factor differentiating the studied habitats: the oldest brown dunes (BD), younger yellow dunes (YD), and the youngest white dunes (WD). Samples were taken from 68 trees using Pressler drills. Using classic cross-dating methods, local chronologies were compiled that served as the basis for further analyses. Basic analyses of soil properties were also performed. Trees growing on brown dunes display the widest tree-rings and the highest rate of cumulative radial growth. Both rates are the lowest for trees growing on white dunes (WD). The dominant meteorological factor shaping tree-ring widths is late winter/early spring air temperature (February/March). However, in poorer habitats with inferior soil air-water conditions, rainfall sums and rainfall distribution through the year become progressively more significant factors. On white dunes (WD), the strongest growth-climate correlations are obtained for summer precipitation. These results identify habitat richness as the main factor shaping growth dynamics in Scots pines growing on dunes. Due to the protective function of the studied tree stands (coast protection), and in light of the rising sea levels and increasing storm intensities, further studies are required, aiming at understanding all interrelationships occurring in these valuable ecosystems.

Presentation code: F-CLIM-P5

Exploring the complexity of climate/growth responses of Norway Spruce in the Tatra mountains, Slovakia

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Key words: climate/growth response, *Picea abies*, treeline,

The effect of climate on tree growth can be modulated by different parameters, for example tree size, competitive status, stand structure and elevation. Taking these parameters into account when studying climate/growth responses is important in order to gain a more differentiated picture of tree and forest growth dynamics in times of climate change. In 2021 we established south facing one-hectare plots in closed canopy forest and at corresponding tree line in the Tatra mountains, Slovakia, focussing our work on *Picea abies.* We cored all trees ≥ 10 cm DBH in a forest subplot (N=103) and all trees at treeline (N=58). The large sampling size is aimed to give a realistic representation of the stand dynamics and to find potential differentiating growth responses. Treeline and forest plots were not separated by a steep altitude gradient (only 25m difference in elevation), nonetheless significant differences in stand structure exist. Trees are smaller and younger at tree line compared to forest with the oldest individuals overall occurring in the forest – concurrent with a potential treeline shift upslope. However, preliminary principal component gradient analysis revealed no clear grouping of growth patterns between treeline and forest, which potentially indicates a gradual forcing of one environmental or ecological parameter across both plots. While the majority of raw ring width series show generally similar patterns, an increase in ring width from around 1950 or 1980 is apparent in many, but not all trees at both plots. Potential growth divergence, as well as potential underlying mechanisms are currently investigated.

Presentation code: F-CLIM-P6

Stands wetness defines radial growth sensitivity to surrounded environmental drivers, a proxy for pedunculate oak (*Quercus robur* L.) across Southeastern Europe

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Key words: Generalized Additive Mixed Model, Environmental modelling, Drought

Surrounding climate, environmental, and stand factors define radial growth dynamics. In pedunculate oak (*Quercus robur* L.) forests across Southeastern (SE) Europe, drought and wetness conditions are generally considered among the main environmental drivers.. On the other hand, all surrounding factors either boost and/or neutralize each other's effects, and define different oak's radial growth responses. Our study focused on 22 oak stands across SE Europe characterized by different wetness conditions, which were classified into three groups (WGs)—dry (<650 *mm*), moderate (650−750 *mm*), and wet (>750 *mm*). A Generalized Additive Mixed Model (GAMM) was applied to calibrate 38 environmental and climate factors (temperature, precipitation, soil moisture, river water level, and drought indices) that are expected to exert influence on radial growth. The GAMM outputs showed different oak responses to the 38 examined variables due to the variations in stand wetness conditions. Likewise, more than half of these variables exhibited nonlinear trends, which are better suited for nonlinear modelling (such as GAMM modelling) in tree-ring studies. In general, oaks from the dry WG are more sensitive to drought compared to those in the moderate WG. Our findings further indicate that all analyzed pedunculate oak stands are highly sensitive to the surrounding factors and can be used in environmental modeling and reconstruction based on radial growth and other tree-ring properties.

Presentation code: F-CLIM-P7

The effect of altitude on the Norway spruce climate response in an area with frequent climate inversions from Eastern Carpathians

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Key words: *Picea abies*, tree ring width, basal area increment, blue intensity, dendroclimatology

The climate response of trees differs due to altitude or climate particularities (e.g. thermal inversions). The study area, the Gheorgheni region, Romania (Eastern Carpathians), has a mountain climate with frequent thermal inversion in winter. The climate-growth relationship was analysed for two tree ring datasets (low elevation – below 1000 m a.s.l. and high elevation – above 1500 m a.s.l.). Daily temperatures were provided by two local weather stations (Joseni – 750 m a.s.l. and Bucin – 1282 m a.s.l.). For each series, bootstrap Pearson correlation between cumulative daily temperature data and 3 proxies (tree ring width - TRW, basal area increment – BAI and blue intensity - BI) was computed. The results show that altitude changed the climate response pattern in the case of blue intensity, and remain similar for TRW and BAI. At high elevation, a positive and significant correlation between BI and current summer temperature was observed. Meanwhile, for lower elevation, only the August temperatures were positively correlated with the BI. The BAI chronology from the lower elevation showed different time windows with significant correlation depending on information recorded in the two weather stations. The correlation pattern between TRW and temperature is similar, regardless of elevation or weather station. Results emphasize that Norway spruce growth climate response pattern can change with altitude, depending on tree ring parameters. The Norway spruce climate response patterns (TRW and BAI) in a region with frequent winter thermal inversions differs from positive summer temperature correlation which are specific for mountain areas.

Presentation code: F-CLIM-P8

Shifting tree growth sensitivity following extreme drought events

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Key words: drought, climate sensitivity, Scots pine, extreme climate events, legacy effects, climate-growth relationships, WPS.

Central European forest stands show pronounced growth depressions and higher mortality rates in response to extreme droughts. However, drought does not uniformly affect stands, as some trees show more severe symptoms and vulnerability compared to neighbouring individuals. Here, we present an assessment of the short-to-long-term impact of the 1976 drought on *Pinus sylvestris* forests in southwest Germany. We investigate the changing within-population synchrony in response to the event in both space and time, considering the series intercorrelation and components of tree resilience analysis, and study varying recovery capacities of trees and sites. The results indicated that within-population synchrony of pine populations was stand-specific and varied through time. Decreases in within-population synchrony suggest contrasting growth trajectories after the drought event in neighbouring trees, dividing tress within a stand into recovered and harmed trees. Components of tree resilience before and after the event were significantly different between groups. Our results indicate a decline of the sensitivity of tree growth to climate variability in the harmed trees compared to the trees that recovered from the 1976 drought extreme. As a result, the proportion of harmed trees control the stand-wide growth-climate relationships that are typically used in tree-ring based climate reconstructions. Quantifying the processes that mediate the uncertainty of tree drought responses to climate will be important for modelling forest performance in a warmer and dryer future.

Presentation code: F-CLIM-P9

Climate signals in tree-ring width, density and $\delta^{18}O$ from junipers in Pamir-Alay (Tajikistan)

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Key words: Central Asia, juniperus, oxygen, density, drought

We developed a 1108 years chronology of tree-ring widths, based on Himalayan pencil juniper (*Juniperus semiglobosa* Regel) trees, for the Pamir-Alay Mountains, Central Asia. Dendroclimatological analysis demonstrates that precipitation has significant effects on tree growth in the semiarid mountainous area of northwestern Tajikistan located on the edge of the great mid-latitude Karakum and Kyzylkum deserts. We also explore the effect of slope exposure and elevation on the climate signals. The highest level of linear correlation (r =0.67) is observed between tree growth and seasonalised winter (previous December–February) precipitation. These results enable to reconstruct the region's drought history over the period AD 908–2015.

For more detailed paleoclimatic reconstructions, additional proxy data were developed: oxygen isotope ratio of tree-ring cellulose ($\delta^{18}O$) (time span 1436 – 2014) and maximum latewood density (MXD) (time span 1329 – 2015). For $\delta^{18}O$, we found negative relationships with winter precipitation. MXD is positively related to June temperatures, and negatively to mean winter temperatures.

Our study indicates that trees growing under significant environmental stress record strong signal, but by combining proxies, the strength of climate correlations can be increased and the range of extractable parameters extended. The multiproxy approach provides an additional climatic information from long tree-ring chronologies.

Presentation code: F-CLIM-P10

Growth behavior assessment of subalpine fir in relation to climate and glacial variability from Kashmir, northwest Himalaya

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Key words: *Abies spectabilis*, Tree-ring width, Westerlies, glacier mass balance, volcanic activity

To understand the impact of climate and changes in the Alpine environment on the growth behavior of Himalayan fir (*Abies spectabilis*), we developed a 392 years (1625-2017 CE) tree-ring width chronology (TWC) of *Abies spectabilis* growing between 3200 to 3500 masl in the Westerlies-dominated Kashmir region of NW-India. The Himalayan fir TWC reveal correlations significant negative with mean temperature (r= 0.53) of the summer months (May-July), and significant positive with precipitation (r= 0.60) of winter and spring months (January-April). Westerly driven winter precipitation plays an important role for tree growth in the following growing season by providing soil moisture resources. Significant positive correlations (r= 0.53) with relative humidity during the early summer season April-July also highlight the impact of drought conditions on Himalayan fir. We additionally investigated the relationship between TWC and averaged glacier mass balance (GMB) data of Nehnar, Shishram, and Kolahoi glaciers in Kashmir for years 1975-1985 CE and found negative relationship (r= -0.61, p<0.10). Cold katabatic winds from the glacierized areas significantly regulate the growth of trees at tree-line, thus providing sensitive tree-ring sequences recording changes in GMB. Moreover, there is a prominent decline in the growth trend for the years 1816-1822 CE. These low growth years correspond to multi-year abrupt summer cooling following the 1815 CE Tambora volcanic eruption. Our TWC therefore is suitable for recording seasonal climate variability and valuable to investigate the effects of GMB and volcanic events on forest growth at high-elevation sites in the Western Himalaya.

Presentation code: F-CLIM-P11

High elevation conifers in Southwest China (Yunnan Province) showed differential growth patterns and climate response in recent years

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Key words: northern Yunnan, tree-ring width, $\delta^{18}O_{TRC}$, *Abies*, *Larix*

Recent climate warming has strongly influenced the high-elevation forests on the Tibetan plateau (TP). We envisaged this study to quantify the impact of regional and global climate change on two conifer species at the south-eastern margin of the TP in Bai-Ma Snow Mountains, Yunnan province. We analysed radial growth and stable oxygen isotope ratios in tree-ring cellulose ($\delta^{18}O_{TRC}$) of *Abies georgei* and *Larix potaninii* trees collected from two study sites along an elevation gradient between 3850m and 4130 m a.s.l. The tree-ring width (TRW) series of *Larix* species were longer than those of *Abies* in both study sites. The resulting TRW chronologies at low-and high-elevation sites spanned 171 and 194 years for *Abies* and 221, and 339 years for *Larix*, respectively. The long-term growth rates of *Larix* showed an increasing trend, whereas *Abies* followed a decreasing trend, specifically after 2000 AD, pointing to species-specific response patterns to the recent warming. The growth of *Larix* was primarily controlled by minimum temperatures during the summer season, while that of *Abies* responded mainly to summer precipitation. Such contrasting responses of different tree species can be crucial for reconstructing the climate variability within a complex mountain topography for different seasonal windows. Structural equation modelling (SEM) revealed that among all climate modes, the Atlantic Multidecadal Oscillation (AMO) strongly influenced the growth of species both directly and through temperature variation. The still ongoing $\delta^{18}O_{TRC}$ analysis will help to identify the impact of different moisture sources on the ecology of the studied tree species.

Presentation code: F-CLIM-P12

Hydrological models and their application to dendroclimatology – Examples from the United States

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Key words: streamflow, reconstructions, hydrological models, PRMS

Tree-ring records have been used extensively to reconstruct past streamflow variability. Annually resolved estimates for several centuries prior to observations, and in some cases millennia, have been produced from dendroclimatic proxies. However, despite an often strong hydroclimatic signal embedded in the rings, some factors limit the skill of such reconstructions, including human interference with the hydrological cycle. We examine the relationship between local output from a Precipitation-Runoff Modeling System and tree-ring chronologies from six U.S. regions of varying climate and ecology. Strong positive correlations between tree growth and capillary zone moisture variability are recorded. When compared to correlations with precipitation, the tree ring-capillary zone relationship is overall stronger with a more coherent seasonal focus within the respective regions. The capillary zone moisture also appears to capture spatial variability at a finer resolution than gridded soil moisture products. The difference between hydrological zones could isolate uncertainties during model calibration but also help identify localities from which new proxies containing independent and unexplained variance may be collected. Although the results are not equal across regions, we suggest that there are several potential advantages to be gained from using hydrological model parameters as the target in dendroclimatic reconstruction exercises.

Session G

Applied Dendrosciences

Presentation code: G-APP-Keynote

Professors' teaching is not students' learning (as much as ring counting is not dendrochronology)

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Whilst teaching dendrochronology and related subjects, we most likely focus on the content we want to deliver and we do it at our best. Still, we rarely provide engaging lectures that attract students and maximise their learning. Therefore I am introducing a practical method to structure an effective lesson. It is not only about showing enthusiasm and passion but also about focusing on students' needs and creating a strong problem/solution dynamic narrative.

Presentation code: G-APP-O1

Up & Down Matter: A case study of stem and coarse root parenchyma in a Mediterranean beech forest

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Key words: Climate change, Resilience, Tree ring, Xylem Parenchyma

Beech trees ability to mobilize carbon reserve, to survive strong source–sink imbalances, is a key trait for the species resilience under global change, especially in vulnerable areas as the Mediterranean basin. The parenchyma cells are involved in transporting, loading, storing and de-loading of non-structural carbohydrates. Tree stem and coarse roots contains most of the total NSC pools. The amount of parenchyma within a tree ring may be a good estimator of its potential carbohydrate storage capacity.

In this context, we collected cores from codominant trees (mean age of 110 years) in a Mediterranean beech forest. Samples were extracted at the end of November 2017, when the xylem maturation phase were already ended. Cross-sections from tree rings of stem and root were analysed by transmitted light microscopy and image analysis. We measured the density of ray and axial parenchyma (RAP) in stem and coarse root ring in the last 30 and 15 years, respectively. Our objectives were to: I. evaluate the inter-annual relationships between stem and root RAP; II. assess the climatic factors affecting the variability of parenchyma density.

Our results demonstrated that the stem and root axial parenchyma density are highly related. However, roots have shown a higher value than stem, due to the different physiological role of the two organs. Moreover, we only found a significant negative effect of previous August SPEI on the density of stem axial parenchyma, which correspond to the period when trees are allocating carbon resource to reserves.

Presentation code: G-APP-O2

Canopy accession characteristics and drivers across primary forests of the Carpathian mountains

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Key words: beech; canopy recruitment; closed-canopy forest; disturbance; spruce

Canopy disturbances in closed-canopy forests affect patterns of tree layer regeneration through increasing light levels in the previous subcanopy layers. Pronounced growth spurts may be detected after suppressed trees are released from shading (growth releases; GR) or after gap formation improves light conditions for trees in establishing young cohorts (open canopy recruitment events; OCR). GRs and OCRs are a crucial phase for a successful canopy regeneration, in turn affecting structural development and carbon cycling in a forest. Our knowledge into how individuals of different tree species react to increased light levels after disturbance in different life stages is limited. Furthermore, disturbance regimes are likely to interact with climatic drivers of tree growth rates during canopy accession. We utilized tree-ring samples of more than 5300 *Fagus sylvatica* and *Picea abies* trees from across the Carpathian primary forests to study the variability and drivers of average radial growth and duration of canopy accession events. The growth during GRs was positively correlated with reconstructed disturbance severity and summer temperature, while spring precipitation was positively correlated with beech growth only. The growth rates during GRs increased consistently in the past century. The impact of selected variables on spruce OCR growth was similar to the impact on GR growth. Beech OCR growth and duration of all the GR and OCR events, however, only showed weak or non-significant relations with selected variables. Disturbance rates and temperature positively affect canopy accession rates, yet the trend might shift with further intensification of disturbance regimes and warming climate.

Presentation code: G-APP-O3

Disturbance dynamics and carbon storage in old-growth forests

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Key words: carbon dynamics, turnover rates, dendroecology, net primary productivity

Forest disturbances and tree growth are major drivers of dynamics and long-term carbon storage in forests. Combining forest inventory data and tree-ring analysis allows for a retrospective estimate of aboveground forest biomass (AGB) and disturbance dynamics at decadal to centennial scales, both being directly related to net primary productivity (NPP). We used this combined approach to estimate precisely-dated ages of aboveground carbon and carbon turnover times in temperate old-growth forests in Western Europe and Eastern North America, where trees exceed 400 years of age. In some forests, the combination of no logging and natural disturbance regimes dominated by small, frequent disturbances over centuries resulted in high forest stability, long carbon turnover times, and high mean carbon ages1(00 and 170 years). In contrast, more recently disturbed forests or forests with more intense disturbances appear to have reduced ages of mean carbon and turnover rates (<125 years). In general, annual forest aboveground productivity (i.e. faster growth rates) was inversely correlated with long-term carbon storage potential. The large amounts of biomass stored at long time scales in uncut old-growth forests highlight the importance of forest management, ecosystem stability, and natural disturbance as a part of the global carbon cycle. This approach would be useful to elucidate long-term carbon storage of forests at broader spatial scales.

Presentation code: G-APP-O4

Hillslope Processes Affect Vessel Lumen Area and Tree Dimensions

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Key words: stem eccentricity, height limitation, hillslope processes, tree stability, biogenic creep

The height growth of the trees depends on sufficient mechanical support given by the stem and an effective hydraulic system. On unstable slopes, tree growth is affected by soil pressure from above and potential soil erosion from below the position of tree. The necessary stabilization is then provided by the production of mechanically stronger wood of reduced hydraulic conductivity. Unfortunately, the interaction between tree growth (both radial and axial) and stabilization in the soil is still insufficiently understood. Therefore, in this study, we aimed to quantify the impact of hillslope dynamics on the degree of tree growth and hydraulic limitation, and the potential effect on tree height growth and growth plasticity. To evaluate this effect, we took four cores from 80 individuals of Quercus robur and Fraxinus excelsior and measured tree-ring widths (TRWs) and vessel lumen areas (VLAs). The tree heights were evaluated using a terrestrial laser scanner, and local soil depth was measured by a soil auger. Our data showed a significant limitation of the tree hydraulic system related with the formation of eccentric tree-rings. The stem eccentricity decreased with increasing stem diameter, but at the same time, the negative effect of stem eccentricity on conduit size increased with the increasing stem diameter. Even though this anatomical adaptation associated with the effect of stem eccentricity differed between the tree species (mainly in the different degree of limitations in conduit size), the trees showed an increase in the proportion of hydraulically inactive wood elements and a lowered effectiveness of their hydraulic system. In addition, we observed a larger negative effect of stem eccentricity on VLA in Quercus. We conclude that the stabilization of a tree in unstable soil is accompanied by an inability to create sufficiently effective hydraulic system, resulting in severe height-growth limitation. This affects the accumulation of aboveground biomass and carbon sequestration.

Presentation code: G-APP-O5

Tree-ring analyses of Fagus sylvatica at different sites in Slovenia showing different climatic suitability

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Key words: European beech (*Fagus sylvatica*), species distribution, climatic suitability, gridded climatic data SLOCLIM, tree-rings

We present tree-ring analyses of European beech (*Fagus sylvatica* L.) from sites with different climatic suitability for beech growth in Slovenia, where beech is the most abundant forest species growing on a variety of sites differently affected by climate change. A collection of tree-ring data from 29 sites with latitudes 45.55-46.45°, longitudes 13.73-15.54°, and elevations 355-1,300 m a.s.l. was used for the analyses. The basic characteristics of the local chronologies (raw, standard, and residual), the climatic influence on the tree-ring variations, and their temporal stability were analysed. Special attention was paid to the characterization of beech trees growing on marginal sites in southwestern Slovenia with dry, hot summers at the transition from temperate to Mediterranean climatic regimes.

Using a silvicultural database of beech occurrence (percentage of growing stock) of the Slovenia Forest Service in more than 300,000 forest stands, corresponding local climate data from the SLOCLIM high-resolution climate dataset, and modelling with general linear models, helped to produce maps of different climatic suitability for beech.

The results show that beech generally occurs at lower amounts than its potential. Dendroecological analysis along geographic gradients, evaluated with particular attention to limiting factors (e.g., summer temperatures and precipitation) and temporal variations in climatic effects, helped us define marginal areas where beech survival is increasingly threatened. Our results confirm substantial variability in tree-ring chronologies under different climatic conditions. We showed in which way high temperatures combined with summer drought limit beech growth in SW Slovenia at the transition from temperate to Mediterranean climatic regimes.

Presentation code: G-APP-O6

Drought sensitivity of forest genetic resources of silver fir (*A. alba*), European beech (*F. sylvatica*), and Norway spruce (*P. abies*) across Germany

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Keywords: drought sensitivity; seed stands; temperate forests; adaptation; micro-site conditions

Against the backdrop of climate change, heatwaves and drought spells are projected to become more frequent, prolonged, and severe in the future. These unprecedented changes threaten forest ecosystems worldwide and have to be addressed by research and forest management alike. In provenance research, the focus has traditionally been on identifying reliable genetic resources related to growth, quality, vitality, and resilience against pathogenes, since recommendations for forest practice were primarily aimed at yield maximisation. Accordingly, previous studies concentrated on specific phenotypes associated with high growth rates rather than climate sensitivity or adaptation to local site conditions. However, crucial genetic adaptation and selection processes occur along the ecological gradient from wet-cold to warm-dry sites. Thus, traditional provenance experiments may be less suitable for investigating the drought tolerance of provenances, demanding further research in forest stands usually harvested for seed production.

The objective of this study is to investigate the drought sensitivity of native forest genetic resources of silver fir (*A. alba*), European beech (*F. sylvatica*), and Norway spruce (*P. abies*) along an ecological gradient across Germany. We focus on quantifying growth responses towards drought depending on (1) (micro-) site conditions, (2) previous drought events, and (3) relative drought intensity.

In this interdisciplinary project, we combine landscape genetics, soil science, and dendroecological resilience research. In our talk, we will present and discuss first results.

Presentation code: G-APP-O7

Climate change and the Norway Spruce treeline in the central Scandes: Treeline evolution and a Blue Intensity temperature reconstruction

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Key words: Climate, Treeline, Spruce, Blue intensity

Climate is changing globally, and the effects are more notable in sensitive environments such as mountain regions. In these regions vegetation is mainly limited by temperature, so by using tree-ring data from temperature sensitive trees it is possible to assess the impact of warming on tree growth, but also to estimate past temperatures.

This study presents a dendroclimatological study of Norway Spruce (*Picea Abies* L), growing at the treeline in the central Scandinavian Mountains. The aims of the study were to 1) examine how spruce growth at the treeline has been affected by recent climatic warming, and 2) to reconstruct past summer temperatures with Blue Intensity (BI) measurements. Samples were collected on different slopes in Vålådalen, Sweden in 5 m elevational belts from the treeline and down the mountainsides. Here we wanted to answer if there were differences in growth evolution derived from ring widths and BI-measurements between different elevations and slope directions.

Our results show that the spruce treeline is now advancing faster than previously, especially on south-eastern facing slopes. BI-measurements showed the highest (significant), correlations with July temperatures, and the correlation were a bit lower on the south-eastern facing slopes.
Tree-ring widths showed the highest (significant), correlation with June temperatures, being similar at all slopes. Further results and conclusions will be given at the presentation.

Presentation code: G-APP-O8

Influences of tree growth conditions on wood properties

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Key words: tree growing, dendroclimatology, technical wood properties

Due to the influence of climate change, the growth conditions of trees in Germany and Europe will change. This change also influences the technological properties of wood. As a result, downstream industries (woodworking and processing companies) will face challenges. In order to ensure the most efficient use of the resource wood, technically supported derivations and predictions are necessary. We therefore want to investigate the relationships between environmental factors and density distribution for important commercial tree species in Germany. From this, a model will be developed to derive future tree growth and the resulting wood properties.

A key parameter for the material usage of wood is the density and density distribution over the cross-section. Density affects the mechanical properties of wood and is a critical factor in its usability. The density of native woods varies due to growing conditions and climate. So far, the density of the wood can usually only be determined after felling. It would be advantageous to predict the density in order to better assess the usability of stands. This would also allow to predict the quality of future stands under consideration of climate change.

Experimental work on existing wood species is carried out to investigate the relationship between growth conditions and wood properties. Using specifically collected log slices, growth (especially wood density) is investigated in relation to environmental factors and subsequently modelled. In parallel, the technical wood properties are investigated in relation to the material density. Subsequently, both areas will be merged.

Presentation code: G-APP-O9

Icelandic long-lived woody species highlight contrasting interactions with Northern Hemisphere Arctic amplification

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Key words: dendroecology, tree-ring, climate-growth association, Arctic Amplification, climate change

Current climate change is inducing heterogeneous warming trends worldwide, with faster rates at higher latitudes in the Northern Hemisphere (phenomenon known as Arctic amplification). Here, applying a dendroecological approach, we investigated growth trends and climate sensitivity of various species (common juniper, birch, rowan, spruce and lodgepole pine) to better understand the effects of Arctic amplification in long-lived species with contrasting growth habits (shrub vs tree and deciduous vs evergreen).

We collected samples in 13 sites across Iceland for a total of 171 junipers and 320 trees (78 conifers and 242 broadleaves). We analysed ring-width time series focusing on temporal and spatial associations with land and oceanic climate parameters over the last century.

The oldest individuals were among junipers, with a maximum age of 163 years. Coniferous trees, coming from plantations, resulted the youngest (53 to 62 years). Shrub and tree growth revealed divergent growth trends, with juniper showing the highest growth rate in response to current warming while trees, especially broadleaves, showed a steadier growth rate or even a growth decline. Tree growth was positively correlated to warm summer temperatures, with a key role of minimum temperature for broadleaves. Shrub growth (juniper) seemed highly influenced by the Sea Surface Temperature.

This work provides insight into climate change impacts in a peculiar island at high latitudes where woody plants are still a marginal component of the vegetation. It also contributes to reduce uncertainties about how long-living species will perform under rapidly changing conditions in this unique tundra environment.

Presentation code: G-APP-O10

Automation of tree-ring detection and measurements using deep learning

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Key words: Tree-ring detection, Automation, Convolutional Neural Networks, Phenotyping

We present a neural network-based algorithm for automated detection and measurement of tree-ring boundaries from coniferous species. We iteratively trained our Mask R-CNN extensively on over 8,000 manually annotated rings. The CNN performed well, recognizing over 99% of ring boundaries (precision) and a recall value of 95% when tested on real world imaged Norway Spruce cores. Additionally, we have implemented automatic measurements based on minimum distance between rings. With minimal editing for missed ring detections, these measurements were a 99% match with human measurements of the same samples. Our CNN is readily deployable through a Docker container and requires only basic command line skills. Application outputs include editable annotations which facilitate the efficient generation of ring-width measurements from tree-ring samples.

Presentation code: G-APP-P1

Soil carbon storage in near-natural beech forests – soil moisture regime and deadwood as the main controls in a changing climate (BENEATH)

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Key words: soil water availability, deadwood, tree growth, sap flow, dendromass

Near-natural forests should have a positive effect on total carbon (C) storage in comparison to managed forests. Currently, dramatic changes in the soil moisture regime are ongoing. This includes extended and severe droughts and extreme rain events with unknown impacts on the C storage capacity. Hence, it is largely unknown how increasing amounts of deadwood (i.e. coarse woody debris) due to a reduced management will affect long-term C storage in soils as a function of the soil moisture regime. Interactions between available soil water, deadwood, living trees with their rooting systems, and soil C storage are poorly understood under the rapidly changing environmental conditions with increasing frequency of droughts and heavy rainfall events. Therefore, we will determine the influence of spatio-temporal patterns of soil moisture on above- and belowground C storage in the "Kossa Beech Forest" in the Dübener Heide (NW Saxony). Natural gradients in the soil water regime will be used to assess the impacts of climate change induced shifts of the moisture regime on C storage in beech forests as the base to deduce scenarios for future development of C storage in these forests. The focus of this interdisciplinary research approach is to quantify the effects of an altered soil moisture availability on beech growth, deadwood accumulation, and long-term soil C storage. Therefore, our recently started project will combine long-term integrated monitoring of important soil and stand parameters with field experiments, state-of-the-art analytical methods in the laboratory and modeling approaches.

Presentation code: G-APP-P2

Elevational differences in the timing and intensity of larch budmoth outbreaks in two valleys of the European Alps

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Key words: dendroecology, cyclicity, insect outbreaks, larch budmoth, European Alps

Cyclic outbreaks of the larch budmoth (*Zeiraphera griseana*, hereafter referred to as LBM) have affected the growth of their larch host trees (*Larix decidua*) in the European Alps. These regular defoliation events have weakened since the 1980s, likely in response to climate change, but recured in 2018. Here, we investigate the LBM activity along two elevational gradients in the Swiss Alps using tree-ring width (TRW) and maximum latewood density (MXD) measurements from 15 sites between 1,400 and 2,300 m a.s.l. While the effect of the LBM events overall disrupted the tree-ring climate signal, correlations with instrumental JJA temperature recordings remain significant ($p \leq 0.001$) for TRW (0.38 at 2,000 m and 0.64 at 2,300 m a.s.l.) and MXD (0.54 at 2,000 m and 0.74 at 2,300 m a.s.l) with the latter recovering quicker from the negative effects of LBM defoliation. Redfit and wavelet spectra as well as superposed epoch analysis of site chronologies reveal a maximum impact of LBM outbreaks at elevations around 1,900 and 2,000 m a.s.l. from where the signal gradually diminishes towards the upper and lower ends of the LBM distribution range. The timing of the growth response to LBM events varies between the two valleys but also between different elevations within the same valley.

Presentation code: G-APP-P3

The effect of solar irradiance on radial stem increment in short time scale

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Key words: dendrometer, solar irradiance, sink limitation

Tree growth is often associated with minimum temperatures or suitable moisture conditions. However, solar irradiance is a key component of photosynthesis, creating the assimilates for production of the new wood tissue. Since increase solar irradiance, may substantially increase radial growth, a gap in sink limitation hypothesis is supposed. If however, tree growth is sink limited, the effect of solar irradiance should have only a limited effect on tree radial growth. To test our hypothesis, we installed 110 automatic dendrometers at three tree-species (*Abies alba*, *Fagus sylvatica* and *Picea abies*), growing in two old growth forest reserves in Central Europe (Boubín and Žofín old growth forest), under almost ideal climate conditions. Meteorological data were measured using in situ meteorological station (in Žofín old growth forest) and extracted from the EOBS database (in Boubín old growth forest). Daily means of stem size were derived from dendrometer data, and consequently zero-growth approach was used to to determine the growth of monitored trees on a daily scale. Stem increments were modelled using linear mixed effect models. Our data showed non-linear response of solar irradiance to stem increment. The non-linearity was caused mainly by increasing VPD due increased solar irradiance. This result proved turgor as a limiting factor of cambial kinetics, and proved the studied trees to be sink limited, With the exception of smaller trees, shaded by canopy trees or with insufficiently developed tree crown. Simultaneously, our results revealed moisture as a dominant limiting factor of tree growth at both sites. Substantial between-species differences revealed the highest tolerance of *Fagus sylvatica* to solar irradiance, proving its environmental plasticity and ability to be competitively the strongest tree species under most of the climate change scenarios.

Presentation code: G-APP-P4

TreeDataClim – dendroclimatic database regionally focused on Czechia

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Key words: temperate forests; dendroclimatology; growth trend; growth reduction

Tree-ring series represent valuable information on growth trends and climate-growth responses of woody species. Big collections of tree-ring series are especially important as they allow generalization of results across extensive regions which can be then used in forest management practices and policy measures. Although intensive sampling of tree-ring cores started already in the 1960s in former Czechoslovakia, access to already collected tree-ring data at different institutes is difficult. The majority of contemporary analyses still relies on newly collected data and neglects data acquired in past. To partly overcome this problem we developed a dendroclimatic database regionally focused on Czechia. The database contains raw tree-ring data, stand and tree-level variables, site characteristics, and climatic data. Data has been often collected in the 20th century from stands that no longer exist because of various disturbances. So far, more than 1100 sites and 20 000 trees have been included. Site data can be visualized using the associated web-GIS tool. We present a basic overview of growth-climate responses for main tree species (*Picea abies, Pinus sylvestris, Quercus* sp., *Fagus sylvatica, Abies alba*) and first analyses of the spatial extent of extreme growth reductions following extreme climatic events.

Presentation code: G-APP-P5

Silver fir - still a drought-resistant tree species in Central European conditions?

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Key words: Abies alba; Norway spruce; European larch; dendroclimatology; growth

The extensive decline of main coniferous species Norway spruce and Scots pine has been observed in recent years in many Central European countries. The primary cause is recurrent droughts with subsequent activation of harmful biotic agents. Silver fir is still considered a drought-resistant tree species. However, it has not yet been sufficiently studied how the fir cope with the recent dry period, which is extreme in duration and intensity. The aim of our work was to analyse spatio-temporal variation in the climate-growth response of fir in areas with recent vast spruce decline. In 2019-2021, altogether 22 fir populations in different regions of the Czech Republic were sampled, covering an altitude gradient of 410-775 m a.s.l. The growth performance of fir was compared to Norway spruce and/or European larch growing in the same site conditions. In fir, the missing rings mostly occurred in the period 1966-1985, when air pollution peaked, but in recent years no missing rings have been identified. In spruce and larch, the missing rings were less common than in fir and occurred mainly in the last dry years after 2015. Dendroclimatological evaluation showed a significantly lower sensitivity of fir and larch to summer drought compared to spruce. The significant negative response of fir to the high summer temperatures and the lack of precipitation was recorded at sites up to 450 m a.s.l.; the growth response of larch was insignificant at all sites. In contrast, spruce shows high sensitivity to summer drought across the entire altitude gradient studied.

Presentation code: G-APP-P6

Long-term management effects on tree growth dynamic of *Pinus pinea* L. in southwestern Europe

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Key words: Silviculture, Mediterranean forests, dendroecology, droughts, resilience

The role of Mediterranean conifer forests in the global carbon cycle and the increase in forest risks has led to the implementation of adaptive management practices to stimulate long-term growth and carbon storage and reduce the occurrence and severity of forest fires. Here we combined dendrochronology and forest inventories in contrasting stages of forest dynamic of Umbrella pine (*Pinus pinea* L.) planted at southwestern Spain. To determine the relationships between the time of management on stand structure, age-growth dynamics and their effects on long-term growth trends and resilience to droughts, we selected different stand conditions: Managed mature forests (> 140 years), unmanaged and managed middle-age stands from seed origin (~70 years), unmanaged and managed young-planted stands (~35 yrs) across the study area in Doñana Natural Park. We reconstructed past growth dynamics at each stand condition. Thinning treatments had a positive effect on primary and secondary growth, producing an increase of aboveground live biomass and carbon stock and reducing fuel continuity. Our findings suggest that management at early stages reduced growth sensitivity to summer temperatures and spring-summer droughts. Under extreme drought, managed stands showed better resistance capacity. We conclude that high thinning intensity at early stages is a useful silviculture intervention on Umbrella pine forests that enhances their growth and resilience making them better adapted to aridification trends, reducing fire risk and increasing carbon storage.

Presentation code: G-APP-P7

A novel approach to predict inter- and intra-annual growth of tree using dendrometer data

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Key words: Dendrometer, growth prediction, machine learning algorithm, clustering,

Dendrometers allow an investigation of the intra-annual growth variation of trees in high temporal resolution. Many studies have already shown the usefulness of applying dendrometer measurements in dendroecological research. In this study, we present a novel approach to analyse the data generated by dendrometers and to use them to predict future growth in inter-and intra-annual resolution. This approach uses machine learning (ML) algorithms to classify the daily radial or circumference changes in several clusters, each representing a growth pattern. Then, a supervised ML technique relates the pre-assigned clusters with patterns of daily climate. The occurrence of each cluster for a specific period can then be correlated with the total radial/circumference change. This relationship can then be used to model the radial/circumference change under future climate scenarios. Such approaches offer a wide field of applications and are important not only to assess the growth performance of particular species under different climate scenarios, but also to study changes in trees' physiological behaviour (e.g., changes of growing season length, formation of false rings, etc.).

Presentation code: G-APP-P8

Let trees talk: an interdisciplinary approach to teach the effects of climate change on forest ecosystems

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Growth of temperate forests under climate change varies across landscape gradients, among tree species and among different components of tree biomass. Major above-ground forest biomass compartments are represented by tree stems and foliage. Inter-annual climatically-driven variability of major above-ground forest biomass compartments - tree stems and foliage - controls forest carbon sequestration. However, the understanding of differences between climatic response of stem and foliage at landscape level is limited. In this study, we examined the relationship between stem and leaf biomass and their climatic responses of *Pinus sylvestris* (PISY) and *Picea abies* (PCAB) in topographically complex terrain. We used tree-ring chronologies and time series of the normalized difference vegetation index (NDVI) derived from high-resolution Landsat scenes as proxies for stem and leaf biomass, respectively. Our results show that the responses of tree-rings to climate differ significantly from those found in NDVI and that stronger climatic signal is retained in tree rings. While at moisture-limited PISY stands, the stem biomass (tree rings) is strongly topographically driven, leaf biomass represented by NDVI is relatively insensitive to topographic variability. In landscapes close to the climatic optimum of PCAB, relationship between stem and leaf biomass is weak and their relationships to climate are frequently even reverse. Differing climatic signals of NDVI and tree rings suggest that the response of canopy and stem growth to ongoing climate change might be decoupled. This reveals complexity in future carbon sequestration dynamics of forest ecosystems and the need for assessment of climatic responses of individual tree compartments.

Presentation code: G-APP-P9

TREOS (Tree Ring-Earth Observation by Satellites) – a network initiative to link ring-width measurements with satellite-borne earth observations

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Key words: Vegetation indices; Machine learning; Multi-spectral remote sensing; Tree-rings

In recent decades, satellite imagery has developed rapidly and now provides open-access to time series with high temporal and spatial resolution. Earth observations by satellites (EOS) can be linked with radial tree growth if on-the-ground calibration is performed, which could then support upscaling of tree growth from individual trees to site and landscape levels. Statistical relationships between EOS and tree rings are commonly studied in alpine and boreal forests where single growth factors often determine growth. However, at mesic sites in temperate climates, tree growth is limited by multiple factors, and the relationship between EOS and tree growth is still challenging. We hypothesize that at mesic sites, additional site descriptors such as elevation, slope, and forest characteristics play an important role in explaining tree growth. Furthermore, application of machine learning algorithms and using higher resolution satellite data could increase the predictive accuracy of already established models. However, to train according algorithms, regional to continental tree-ring networks covering most recent years are needed to allow for a sufficiently high sample-size throughout the monitoring period of the most important satellite missions (e.g. Sentinel 2 since 2015). We therefore invite researchers to join our TREOS initiative by sampling and/or providing recently sampled tree-ring data from below 1000 m elevation. Based on the network we aim to improve our understanding of the robustness and uncertainty of the link between EOS and key ecological processes in forest stands and establish corresponding transfer functions.

Presentation code: G-APP-P10

Dendroecological and remote sensing time-series reveal dynamics in willow biomass across ice-free Greenland

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Key words: annual rings, Arctic shrubs, climate sensitivity, *Salix* spp., vegetation productivity

An increase in the terrestrial carbon (C) sink in the Arctic due to enhanced plant growth caused by recent climate change is a potentially important feedback mechanism on the global C cycle. To better understand ongoing and future changes in above ground C, we measured 240 growth ring time-series and basal diameters during harvest of two closely related willow species (*Salix arctica* Pall. and *Salix glauca* L.) at 20 sites across ice-free Greenland. We combined these shrub data with regional remote sensing observations. Together, the sites cover the climatic sub-zones of the Arctic, from the low Arctic to the extreme northernmost High Arctic. Across Greenland, temperature significantly predicted shrub growth at eight sites. Biomass data from two sites enabled us to establish an allometric relationship between willow basal diameter and individual above ground biomass (AGB) with good predictive power. Cumulative site-level shrub biomass was approximated using Landsat Normalized Difference Vegetation Index (NDVI), allowing us to estimate changes in shrub biomass over the past four decades. While we observed increases in estimated shrub biomass during recent decades at some sites, others showed no systematic change despite similar rates of warming. Our results demonstrate that warming led to different magnitudes of growth and biomass change depending on local and regional environmental variation that is not related to differences in air temperature per se.

Presentation code: G-APP-P11

Exploring the phenotypic plasticity and genetic adaptation of drought responses in European beech provenances

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Key words: climate change, *Fagus sylvatica*, provenance trials, wood anatomy, reaction norms

In the context of climate change, drought events are increasing in both frequency and intensity, shaping tree species performance and distribution. In Central Europe, European beech (*Fagus sylvatica* L.), a widely distributed species with a high economic and ecological value, is expected to show decreases in productivity as well as higher mortality in response to changing climatic conditions. However, knowledge gaps still exist on the adaptative potential of this species. Therefore, this study, which is part of the BucheTIG-project, aims to investigate the drought tolerance of beech provenances growing under different environmental settings. Specifically, individuals from 31 provenances growing at three sites along a north-south gradient in Germany will be compared in terms of ring width, wood anatomical features, and leaf traits, allowing for a complete understanding of genotypic influence and phenotypic plastic responses to drought. Defining reaction norms, i.e. the pattern of phenotypic expression for a given genotype across environmental gradients, may improve species-specific future predictions and management decisions related to assisted migration.

Presentation code: G-APP-P12

Moving Trees

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Key words: Dendrogeomorphology; wood anatomy; compression wood; acceleration / inclinometer data; dendrometers

This study aims at testing a new experimental design to assess a conifers' capacity to cope with processes bringing them out of balance. Although growth reactions of trees to mechanical stress are known, similar reactions can be caused by a variety of processes, as the formation of reaction wood caused by avalanches or landslides. Consequently, we are still not able to associate a growth disturbance to a specific process without knowing the precise position of the tree while growing. Furthermore, the precision of reconstructions based on eccentricity measurements only, without anatomical support, are still discussed. These obstacles are the main reason why the potential temporal accuracy of dendrogeomorphological reconstructions cannot be combined with dendroclimatic data to allow for a high-resolution description of Holocene environmental changes and related processes. Dendrogeomorphological data based on wood anatomical analyses could provide new insights to existing and upcoming networks of millennia-long chronologies currently focusing on climate reconstructions if anatomical specifications of growth reactions to specific mechanical stresses would be better understood. We intend to overcome these obstacles by continuously measuring the (increasing) inclination of trees as well as their growth reaction counteracting the inclination in the source area of the rockfall zone linked to the landslide of Brienz / Albula (Grisons, Switzerland). Details of the study design and most recent results about dendrogeomorphic reconstructions of the study area are presented on the poster.

Presentation code: G-APP-P13

Stem sprouts of Norway spruce as indicators of the modern mass movements activity in the temperate climate zone; A case study of Giant Mountains (SW Poland)

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Key words: Giant Mountains, dendrogeomorphology, wood anatomy, debris flows,

Debris flows and debris-entrainment snow avalanches are common processes occurring at the forest-alpine ecotone boundary in the Giant Mountains (SW Poland). We used combined dendrochronological methods to spatiotemporal reconstruct of these landforming processes activity in the eastern part of the mountains called "Lomniczka" glacial cirque. It is the deepest glacial cirque basin in this area located on the north-western slope of Śnieżka Mt. (1603 m.a.s.l.). The bottom of the cirque is 1100-1150 m.a.s.l. and its slopes are characterized by numerous debris flow tracks.

The reconstruction was carried out by means of growth reaction characteristics of Norway spruce trees. 20 increment cores from 19 trees were collected and analysed following standard dendrochronological techniques. Additionally, 27 disks samples from branches horizons (up to 2 meters above actual ground level) from all examined trees were collected and prepared to extend the analyses and check their usefulness in dating modern geomorphic processes.

Results shows anatomical changes in wood of branches as a response to contact to the new level of ground, created by debris flows. We found evidence in growth-ring widths and wood anatomy of multi-stage debris flows which confirms usefulness of branches as an additional source of information about mass movements activity. Based on these data, we recommend to use a combination of methods and compare data from the branches to the data from the stems. This will more accurately and more reliably assess the dynamic and activity of landforming processes.

Presentation code: G-APP-P14

International education and research during the pandemic: 31st European Dendroecological Fieldweek 2021 in Val Mustair, Switzerland

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Key words: Dendroarchaeology, Dendroclimatology, Wood Anatomy, Blue Intensity, Dendroecology

The European Dendroecological Fieldweek (EDF) provides an intensive learning experience in tree-ring research for anyone approaching or working in dendrochronology. Here we present an overview of scientific activities of the 31st EDF, held in Val Müstair, Switzerland, in summer 2021. Despite the COVID-19 pandemic, the EDF gathered 20 participants and 10 instructors (7 dendrochronologists and 3 local experts) from 10 European countries and provided valuable outcomes for the local stakeholders such as Biosfera, the forest service and the private-public of Val Müstair.

During the eight days of the EDF, six groups developed different tree-ring projects, carefully designed with respect to the loal environmental setting. The dendroarchaeology group dated two buildings, an abandonned stable and a house in Val Müstair, providing private owners with accurate construction dates. The dendroclimatology group explored the potential of a relict Scots pine forest growing at ~2000 m asl for climate reconstruction, and created a chronology from 1648 to 2020 CE. The wood anatomy group found that the larger vessel sizes and and higher radial growth rates of two alpine shrub species at moist compared to dry sites, while tree ages were similar at both sites. The Blue Intensity group identified a robust climate signal in the BI chronology of high-elevation Norway spruce trees, which was significantly stronger than in the tree-ring width chronology. One dendroecology group found that growth of local larch trees recorded outbreaks of the grey larch budmoth between 1880 and 1980, a stop of outbreaks after and its return in 2018. A second dendroecology group investigated larch trees along an abandoned irrigation channel and could not detect a significant effect of the irrigation stop on growth.

The EDFs continuously provide an essential service to the dendrochronological community, and this even during challenging times. The 31st EDF was again an educational, scientific and multi-cultural experience in a unique environmental setting. It resulted in highly interesting and valuable scientific outreach and opened up new avenues for future tree-ring research in Val Mustair.

Presentation code: G-APP-P15

Let trees talk: an interdisciplinary approach to teach the effects of climate change on forest ecosystems

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Keywords: talking trees; dendroecology; educational research; climate modelling; weather types

Transmitting trees' responses to changing weather conditions as registered with dendrometers, sap flow measurement systems and other devices via the internet in real time has become an increasingly used practise to sensitize the public and to create awareness of climate change effects in forest ecosystems. While some of these attempts do not provide easily understandable information about the trees' responses to changing weather conditions and are therefore "expert systems" requiring deeper knowledge, we established a network of eleven "talking trees" in the free state of Bavaria, southeast Germany, that addresses high school students as target audience and involves them in a monitoring project on tree health.

In an interdisciplinary approach combining dendroecological measurements with climate modelling and educational research, the project BayTreeNet (https://baytreenet.de) aims to develop a teaching module to improve the understanding and interest of students about regional climate change. Trained school classes comment the real-time tree reactions and on-site weather data, and translate the current tree responses into simple text messages via "Twitter". All weather data, tree data, and explanatory text messages are displayed on the project website. By comparing the different activities of trees within the network, the local tree responses to current weather conditions can be related to specific weather types. E.g., while trees in basins in the rain shadow of mountain ranges suffer from dry conditions during north-westerly winds, trees growing at high-elevation sites receive ample amounts of rainfall. Such patterns depend on the dominant wind direction and change under the prevalence of other weather types. This approach creates a deeper understanding of the impact of weather patterns on spatially explicit ecosystem responses on changing climate conditions. The progress in the understanding of climatic impacts on forest ecosystems and the motivation of the students to learn about regional climate change effects, as well as their readiness to change their own behaviour are evaluated using self-developed questionnaires.