# TRACE 2020 Abstract Book

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# Session I:
# Dendroclimatology
# – the tree-ring archives to study Past, Present and Future climate variability

# May-August precipitation reconstruction from pindrow fir tree-rings since early 18th century

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**Keywords**: Precipitation, Himalaya, Pindrow fir, Climate change, Kashmir valley.

Climate change Understanding of the climatic fluctuations requires longer term past climate data. There is unavailability of long instrumental climatic data in most of remote Himalayan areas. Tree rings offer a great proxy for reconstruction of regional climate data at annaul resolution. In this study, a well replicated chronology of *Abies pindrow* tree-ring width measurements near its lower elevation range was used for reconstruction of growing season May-August total precipitation since early 18th century. Trees near the lower elevation belt show significant positive response to monthly and seasonal precipitation. The response to May-August total precipitation is more than any other monthly combination and is thus used for climate reconstruction. This reconstruction added 196 years to the instrumental precipitation data of Srinagar, Jammu and Kashmir, India. The precipitation reconstruction didn't show any long-term trend however, at centennial scale, 20th century was the wettest period while as 19th century was the driest period. The reconstructed precipitation was able to capture most of the historically documented drought and flood years that occurred in Kashmir valley. Further, most of the wet and dry years captured in this reconstruction resembled earlier reconstructions from the region. This study will help in understanding the variations in precipitation at long-term scale and highlights the importance of Himalayan conifers in recording the variability in climatic factors.

Krešimir Begović, Climate-growth relationships of Norway spruce and silver fir in primary forests of the Croatian dinaric mountains

**Climate-growth relationships of Norway spruce and silver fir in primary forests of the Croatian dinaric mountains**

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**Keywords**: old-growth forest; conifers; pointer years; blue intensity; climate response

Past century has witnessed a global trend of increasing green house gas emissions, rise in temperatures, changing hydroclimatic patterns and increasing occurrence of climatic extremes. Despite their importance for environmental conservation, primary montane forests of the Dinaric Mts remain insufficiently studied. In this study, we examined the relationship between climate and growth of Norway spruce (*Picea abies* (L.) H. Karst.*)* and silver fir (*Abies alba* Mill.) in the primary forests of Smrčeve doline, located in Northern Velebit National Park, Croatia. Using dendrochronological methods, the temporal relationships between tree ring width (TRW) and blue intensity (BI) were assessed over the 1901-2014 interval, in relation to instrumental climatic data (temperature, precipitation and scPDSI). TRW and earlywood BI chronologies of both species exhibited a clear negative response to summer temperatures, while also showing a positive relationship with summer precipitation and moisture, implying that tree growth in the region is water-limited. Generally, correlation values of EWBI were stronger compared to the TRW chronologies. Although both species showed a degree of common growth response to climatic extremes, the strength of correlations with the most responsive climatic variables was temporally unstable and showed considerable variability in both tree ring parameters. The observed differential response of the two species to climate indicates that the anticipated increase in dry conditions could potentially alter the future development and composition of these primary forests, by shifting competitive pressures in favor of silver fir. Increasing drought stress around the Mediterranean could have major negative implications for these water limited primary forests.

Nickolay Tsvetanov, Exploring the spatial extent of the climate signal in a *Pinus heldreichii* Blue Intensity chronology from Southeastern Europe

**Exploring the spatial extent of the climate signal in a *Pinus heldreichii* Blue Intensity chronology from Southeastern Europe**

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**Keywords**: Climate proxy, Dendroclimatology, Bosnian pine, Bulgaria.

Tree rings from long-living tree species are one of the most valuable paleo-climate archives. Often the best correlations with the climate parameters of interest, especially summer temperature, are found for Maximum latewood density (MXD). A potential easier and more affordable surrogate for MXD is Blue intensity (BI).
We explore the spatial correlations with climate parameters of a novel BI chronology from Bosnian pine (*Pinus heldreichii* Christ) in the Pirin Mountains, Bulgaria. The tree species is among the longest-living in Europe, currently holding the record of 1230 years and has been demonstrated to be a good archive of past climate variation.
We found strong positive correlations (r>0.6) between our BI chronology and July-August temperatures (mean and maximum) over SE Europe expanding from approximately 10°E to 40°E and 35°N to 50°N. The correlations were negative with summer temperatures in the NW Europe. For summer precipitation and drought indices (PDSI and SPEI), we found significant negative correlations for the Balkan region. The correlations with the 300mb geopotential height pressure were positive for the summer for SE Europe and negative for NW Europe. The results were similar for both the Latewood BI chronologies and Delta BI chronologies. These chronologies also had strong correlations (r>0.70, reaching 0.88) with previously composed MXD series from the same locations, which were stable over the common period of the last several hundred years (1600-2009). Our results demonstrate good potential to contribute to the understanding of past climate variation in Europe by constructing long and robust BI chronologies from *Pinus heldreichii*.

J. Rezsöhazy, Evaluation of a dendroclimatic process-based model (MAIDEN) over the last century using the PAGES2k tree-ring width database

**Evaluation of a dendroclimatic process-based model (MAIDEN) over the last century using the PAGES2k tree-ring width database**

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**Keywords**: dendroclimatology, ecophysiological modelling, proxy system models, PAGES2k

Trees are one of the main archives to reconstruct the climate of the last millennium at high resolution. The links between tree-ring proxies and climate have usually been estimated on the basis of statistical approaches, assuming linear and stationary relationships. Both assumptions can be inadequate and this issue can be overcome by ecophysiological models such as MAIDEN (Modeling and Analysis In DENdroecology), which simulates tree-ring growth starting from temperature and precipitation daily inputs. A protocol for the application of MAIDEN to potentially any site with tree-ring width data in the extratropical region has been developed and the applicability of the model has been previously tested over the twentieth century using twenty-one Eastern Canadian taiga sites and three European sites. Following on from this recent work, MAIDEN is here applied to the PAGES2k tree-ring width database over the last century using the protocol previously developed. We show how this larger network allows refining our protocol. We highlight the potential of MAIDEN as a complex mechanistic proxy system model to analyse the links between tree growth and climatic conditions in paleoclimatic applications. Specifically, we identify the regions and sites where MAIDEN can be successfully applied, as well as estimate the uncertainty associated with the use of MAIDEN for a wide range of sites. This allows us to determine where the processes included in MAIDEN appear sufficient to reproduce the local tree growth variations and where enough data are available for its robust calibration.

# Session II:
# Dendroarchaeology
# – Tree rings and human history

## Supplying wood for timber-framed houses in Limoges (France)

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**Keywords**: dendroarchaeology, dendroprovenancing, dendrogeography, geo-history, archaeology of architecture.

Between the fifteenth and the nineteenth century, timber has played a major role for the economic and urban development of Limoges (France), as revealed by numerous still standing timber-framed houses settled in the historical districts. These well-preserved buildings are a key feature for the history of the city, and the timbers employed for their construction represent an extremely valuable source of information. Indeed, a proper and in-depth analysis of such architectural elements is likely to make a significant contribution to the understanding of the relationship between Limoges' past societies and forest landscapes. The present PhD project therefore aims at pinpointing the geographic provenance of construction timber, with a view to provide insights into the history of woodlands exploitation and past timber trade networks. For this purpose, increment cores and cross-sections will be sampled from historical oak timbers and from centennial-old oak stands distributed within the Limousin region. Given the similarity of tree-ring width (TRW) signals in closely-spaced forest stands, wood cell anatomical as well as stable isotope chronologies, more sensitive to local conditions, will be developed at each study site so as to increase the accuracy of dendroprovenancing.

# The Gribshunden Shipwreck

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**Keywords**: Dendrochronology, shipwreck, underwater archaeology

The Royal carvel ship *Gribshunden* was carrying the Danish King Hans when it sank in the Blekinge archipelago in 1495 after a fire broke out on board. When the ship sank, King Hans was on his way to the Swedish town of Kalmar in order to try to reinstate the union between Denmark, Norway and Sweden. The shipwreck was rediscovered in the early 1970s and has been investigated several times since the early 2000s. Dendrochronological analysis of nine oak samples from the ship structure revealed that the trees were felled in the winter of 1482/1483 and that the samples originated from the Meuse River valley in northern France. Apart from the ship structure, the wreck also contains a large amount of well preserved artefacts that will not only give an insight to the life on board the ship, but regional trade patterns will also be revealed. In the ongoing excavation project, the dendroarchaeological aim is to retrieve barrel staves in order to date and determine the provenance of the wood. This will help us answer questions regarding the production and lifespan of the barrels, as well as trade patterns that emerge from the barrels. The Gribshunden shipwreck, the same type of ship that brought Columbus to the Americas, is the only preserved carvel ship known to date, and research on this wreck will give us a unique insight into the Late Medieval way of life.

# Precision Dating Using Tree-ring Stable Isotopes

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**Keywords**: dendrochronology, geochronology, archaeometry, oxygen isotope, carbon isotope

The application of tree-ring stable isotopes for precision dating represents a powerful additional dating tool for the dendrochronologist. We present an overview of the development of stable isotope dendrochronology and its application to date samples previously considered undateable for reasons of series complacency, species, disturbance or number of rings. Whilst the concept of correlative dating using indicators other than ringwidth is not new, the statistical approach we have developed which assigns a probability to each date, represents a more objective approach to dating.

L. Shindo, Well-designed mountain houses feature the only dated *Pinus t. Sylvestris* timbers in the southern French Alps.

**Well-designed mountain houses feature the only dated *Pinus t. Sylvestris* timbers in the southern French Alps.**

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**Keywords**: dendroarchaeology, Alps, farms, *Larix decidua*, *Pinus sylvestris*

In the southern French Alps, Cervières valley (near Briançon city) has traditional houses in which wood plays an important role. Some of them are still inhabited. How old are these houses? How were they built to adapt to the particular environment of this mountain region? What were the lifestyles of the inhabitants, inseparable from this architecture? History, archaeology and dendrochronology provide answers.
Six houses (1620-2061 m a.s.l.) have been sampled. Twenty-eight timbers were made of *Pinus t. sylvestris* and 18 of *Larix decidua*. While this region is known for its *Larix* trees, the predominance of *Pinus* in these buildings is certainly linked to its availability in the surrounding forests. The oldest timbers (16th c.) come from the houses at the highest altitudes, either because they are older or because they have been less restored. One house, which has not been significantly restored since the 18th century, has been studied in depth. It has 8 levels including 5 levels of wood barn. The barn is mainly composed of *Pinus* with a chronology covering the period 1530-1731. These *Pinus* have been dated on a *Larix* mean chronology and are the only archaeological *Pinus* dated in the southern French Alps.
Cervières is mentioned from the 12th c. in the texts but the oldest timbers only date from the 16th c. At that time, and more particularly in the 17th-18th c., several barns were built to store large quantities of provisions. This reflects the prosperity of the inhabitants, undoubtedly linked to favourable environmental conditions.

Tito Arosio, On the different behavior of the stable isotopes ratios in the deciduous larch with respect to the evergreen conifers ▶️

**On the different behavior of the stable isotopes ratios in the deciduous larch with respect to the evergreen conifers**

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**Keywords**: stable-isotopes, deuterium, not climatic trend, larch

The analysis of stable isotopes in tree-ring cellulose is an important tool for paleo-climatic investigations of past millennia, but its interpretation is complicated by different species behaviors and by non-climatic signals. With the aim to detect species-specific and non-climatic signals for future improved climatic reconstructions we measured and analysed $\delta_{13}C$, $\delta_{18}O$ and $\delta D$ isotopes in the tree-ring cellulose of wood samples collected at high altitude in Alps covering the whole Holocene period. We found that deciduous larch and members of its family were highly depleted in $\delta D$ with respect cembran pine and other evergreen conifers, while the $\delta_{18}O$ and $\delta_{13}C$ values were not statistically different between the two species. Next, we analysed the same database of 201 trees for age trends of the stable isotopes. We aligned the trees on the cambial age and the isotopes values were normalized to minimize geographical effects. Mean values showed that after 100 years of age the values of the three isotopes remained constant, while they varied in the juvenile period. The juvenile trend of $\delta_{18}O$ was complex and similar in the two species, that of $\delta_{13}C$ and of $\delta D$ varied in cembran pine but was unchanged in larch. In conclusion our data show that $\delta D$ offers a unique signature for larch that can be useful for studies of subfossil wood. Furthermore the juvenile patterns of $\delta_{13}C$ and $\delta D$, but not that of the of $\delta_{18}O$, differ in larch and cembran pine. Moreover, both species do not show age-effects after 100 years.

# Session III:
# Methodological challenges in analyzing tree-ring data

J. Jevšenak, Daily climate data reveal stronger climate-growth relationships - especially for precipitation and SPEI data ▶️

**Daily climate data reveal stronger climate-growth relationships - especially for precipitation and SPEI data**

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**Keywords**: tree-ring network; daily climate data; climate-growth relationships; dendroTools; dendroclimatology;

Although climate data on daily resolution are often available, tree-ring proxies are usually compared to gridded or observed station climate data with monthly resolution to analyse climate-growth relationships. To highlight the advantages of using data on daily scales, an extended European tree-ring network was compiled from various sources of tree-ring data and analysed with the E-OBS daily gridded data on a 0.1-degree regular grid. A total of 1860 tree-ring chronologies were used to compare correlation coefficients calculated with aggregated day-wise and month-wise mean temperature, sums of precipitation and standardised precipitation-evapotranspiration index (SPEI). Absolute correlations calculated with day-wise aggregated climate data were on average higher by 0.060 (temperature data), 0.076 (precipitation data) and 0.075 (SPEI data). The benefit of using a daily rather than monthly approach is therefore greater for precipitation and SPEI data, which is related to the autocorrelation usually present in temperature series. Bootstrapped correlations are computationally expensive and were calculated only a 70 % of subset of the data. The results are consistent for calculations with and without bootstrapping. Based on the share of overlapped confidence intervals for bootstrapped correlations, statistically significant differences between the daily and monthly approach were found in approximately 1 % of examples. A comparison of time windows used for calculations of correlations revealed slightly later onset, earlier ending day of the year and shorter time intervals for the daily approach. Again, in comparison to temperature data, differences between daily and monthly time windows were greater for precipitation and SPEI data.

**Proposing a novel approach for the identification of pointer years**

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**Keywords**: extreme events, climate change, methodology, Cropper values, relative growth change

Studying the response of trees to extreme events is gaining increasing attention, particularly in the context of climate change research. In this context, the identification of pointer years from tree-ring data is crucial to distinguish 'normal' growth fluctuations from extraordinary growth reactions.

Yet, tree-ring science lacks a uniform and systematic approach to identify pointer years as pointed out by Jetschke et al. (2019). Commonly used methods suffer from relatively subjectively chosen window sizes over which the required parameters are computed, as well as arbitrary thresholds beyond which a particular year is considered a pointer year. Given the variety of existing methods and applications thereof, the classification of pointer years is yet rather case- and investigator-specific. However, to allow for direct comparison among studies and lower the potential for subjective biases a systematic and objective method is required.

Under this framework, we present a novel approach for identifying pointer years. The approach is based on standardized, inter-annual growth changes which are derived from the whole population sample. Thereby, the new method allows for an objective estimation of the probability that a given growth change would occur by applying internationally accepted significance levels (e.g. $p < 0.05$). Thus, pointer years are defined objectively without the need to specify window sizes or any other thresholds beyond the significance level. For validation, we applied the novel approach to 1000 pseudo-populations with known pointer years. The validation revealed a perfect detection rate and a superior performance in comparison to four other commonly used pointer year detection means.

Jetschke, G., van der Maaten, E., van der Maaten-Theunissen, M., 2019. Towards the extremes: A critical analysis of pointer year detection methods. Dendrochronologia 53, 55–62. https://doi.org/10.1016/j.dendro.2018.11.004

# Session IV:
# Forests ecology
# – tree-ring perspectives on global change impacts

Benjamin Meyer, Higher susceptibility of beech to drought in comparison to oak: A multi-method dendroecological analysis 

**Higher susceptibility of beech to drought in comparison to oak: A multi-method dendroecological analysis**

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**Keywords**: drought, resilience, climate change, European beech

The expected increase in drought severity and frequency as a result of anthropogenic climate change, leads to concerns about the potential of native tree species to cope with these changes. To determine the susceptibility of *Fagus sylvatica* (beech) and *Quercus spec.* (oak) – the two dominant deciduous tree species in Central Europe – to drought, we quantified the climate sensitivity and drought-response of radial growth for both species, using an array of dendroecological methods. Underlying tree-ring data were collected from a site east of Coburg, Bavaria, which had shown pronounced stress-symptoms (early leaf coloration) during the record drought of 2018. Using a combination of climate-growth relationships, tree resilience indices and multivariate statistics (PCGA), we were able to show a clear difference in drought susceptibility between beech and oak. Beech displayed a higher sensitivity to mean monthly temperature and the drought index SPEI integrated over three months and showed lower resistance and resilience to drought events than oak. In particular, beech was unable to fully recover from the 2003 drought, after which it expressed a stark growth decline, i.e. drought legacies, which was not observed for oak. Our study assigns beech a higher risk than oak to suffer from anticipated climate change.

C. Leifsson, Drought-legacies alter the way climate affects tree growth – a global analysis ▶️

**Drought-legacies alter the way climate affects tree growth – a global analysis**

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**Keywords**: climate-growth relationship, recovery effects, ITRDB, linear mixed models

Understanding how extreme drought events affect tree-growth is gaining more and more attention in tree-ring research. The main motivation is the rising threat to forest integrity worldwide through the increasing frequency and severity of extreme droughts under climate change. Yet, little is known about how the connection between climate and growth may change in the years following extreme droughts, i.e. during the so-called legacy period. Studying such possible alterations of climate-growth relationships may improve our understanding of forests' drought response and thereby improve projections of tree-growth under climate change.

Using 3063 data-sets from the International Tree-Ring Data Bank (ITRDB) we assess whether and, if so, how climate-growth relationships change in the legacy period as quantified using the standardized precipitation evapotranspiration index (SPEI). We then use Linear Mixed Models to test for significant differences in the drought sensitivity during legacy vs. non-legacy periods, aiming at attributing these differences to climatological and biological factors.

Preliminary results show temporary deviations in climate-growth relationships for legacy periods. However, contrasting patterns among sites and species reveal a challenging ecological complexity of legacy-effects on forests' drought response. While some site-species combinations become more sensitive to climatic factors, others become desensitized or even experience reversed relationships. Under this framework, further research is needed to connect the heterogeneous picture of drought impacts with the diversity of hydraulic strategies and site conditions to enhance our process understanding and consequently improve predictions of tree-growth under climate change.

A. Müller, A new approach to derive forest response to future climate conditions on the local scale by combining dendroecology and climate modelling

**A new approach to derive forest response to future climate conditions on the local scale by combining dendroecology and climate modelling**

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**Keywords**: forests; growth-climate response; tree-ring analysis; Bavaria

Climate change scenarios expect higher temperatures and increased summer drought stress for southern Germany. However, it is not clear all regions across a topographically complex areas are equally affected. To investigate the response of important tree species to climatic conditions and extreme events on a local scale, we established a network of eleven study sites across the Free State of Bavaria in southeast Germany. The study sites are aligned along topographic and elevation gradients, which modify the local weather conditions depending on the dominant wind direction. Therefore, we focus on the effects of certain weather types on the growth and ecophysiology of the monitored forests. We will develop chronologies of tree-ring width and stable carbon and oxygen isotopes for the dominant deciduous and coniferous tree species at each site. By calculating correlations between tree-ring widths parameters and climate variables, we will determine the growth-climate response of trees under defined weather types and calibrate growth rates for the 20$^{th}$ century. A Joint Event Coincidence analysis will help to identify intersections of climate events and growth variations. Cambial growth dynamics is monitored with high-resolution dendrometers and calibrated against local meteorological records to derive site specific cambial growth models. By combining the dendroclimatological results with climate modelling scenarios on expected future frequencies of critical weather types on the local scale, we will derive individual growth models for each site and estimate risk potentials under extreme weather conditions. The poster illustrates the project design concept and illustrates first results from individual study sites.

**How fast do pine trees respond to precipitation events and dry periods?**

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**Key words**: dendrometer, Pinus nigra, Pinus pinaster, drought response, soil water reservoir

Water availability is the limiting environmental factor for plant growth and productivity, especially in arid or semi-arid environments. The identification of water sources and the tree's reaction to short-term changes in environmental conditions is therefore of great importance to evaluate the vulnerability of forest ecosystems to current climate change. In this study, we use dendrometer measurements to analyze the response of pine trees (*Pinus nigra* and *Pinus pinaster*) to precipitation events and dry periods in a Mediterranean ecosystem on the island of Corsica (France). The five study sites with six or 12 trees per site were aligned along an elevation gradient ranging from sea level to 1600 m asl in order to determine the responses under various climate conditions.
We observed a fast response to precipitation events at all five study sites because most of the radial stem increment change visible in the dendrometer data occurred in the first six hours after the starting point of the event. Lower elevation sites reacted faster and more intense to small precipitation events than higher elevation sites. The highest stem increment increase did not occur in seasons with highest precipitation amounts. The stem increment change to dry periods was more variable between the sites because two sites showed an increase in stem circumference despite of no precipitation. Hence, trees at these sites must have access to deeper soil water sources that can be exploited under dry conditions. Trees growing at such sites are therefore less vulnerable to drought periods.

M. Trouillier, What is a growth trend? – The complexity of an apparently simple concept

**What is a growth trend? – The complexity of an apparently simple concept**

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**Keywords**: growth trends, low frequency signal, detrending

Trees and forests are of interest to many disciplines and various tree and forest parameters can be studied to quantify growth trends and changes in response to the environment: Dendrochronologists study temporal changes in radial tree growth by analysing tree-ring width time-series, forest economists assess the changing woody biomass production by assessing tree's height-age relationships and biogeochemists use eddy-covariance towers, which measure forest's gas exchange, to assess how much carbon a forest sequesters. But is there a fixed relationship between e.g. average tree-ring width and forest's biomass production? Which type of growth trends includes which responses of trees and forests to environmental change?

Generally, environmental change does not just affect a single variable like tree-ring width. Instead, trees and forest stands respond to environmental change with changing tree density (trees per area), altered growth allocation (height vs. radial growth vs. root) or adjusted wood density. Typically, these effects are only studied separately and interactions between radial growth, growth allocation and tree density are not considered in growth trend analyses. Furthermore, the time scales at which these variables can change differ significantly, ranging from annual (ring width) up to centuries (tree density).

We argue that the quantification of growth trends must consider this ecological complexity. We propose that growth-trend estimates should aim to quantify the growth of the potential natural forest (PNF). The PNF is that forest that would develop under the respective environmental conditions, which includes all relevant tree and forest parameters, as well as temporally lagged responses.

A. Arzac, Water availability controls secondary growth and phenology of Pinus sylvestris along an aridity gradient in southern Siberia

**Water availability controls secondary growth and phenology of Pinus sylvestris along an aridity gradient in southern Siberia**

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**Keywords**: Drought, MODIS, phenology, SPEI, VS-model.

Water availability is one of the most limiting factors of growth in southern Siberia, and the current above-average warming might increase the frequency and severity of drought periods, affecting forest phenology with significant consequences on water, climate and carbon dynamics. In this study, we combined dendrochronological methods, tree growth modeling (VS-model) and remote sensing (MODIS) to explore Pinus sylvestris L growth and phenology along a latitudinal gradient of increasing drought in southern Siberia. Analyses were performed for the period 1960−2017, and results indicated that P. sylvestris growth is sensitive to drought, although the timing and intensity of the climate variables shifted along the gradient with earlier and higher climatic control in the southern site. Interestingly, the intensity of the climatic control decreased in recent decades, suggesting more favorable conditions for growth. VS-model phenology simulations were verified by MODIS estimation for a 14-years period (2001−2014), without significant differences for the beginning of the growing season, validating the simulation of longer phenological series by the VS-model. In this sense, results suggested an advance of the starting of growing season along the whole gradient, being faster (at a rate of 5.6 days/decade) in the southern site during the recent time. In addition, the earlier start of the growing season was closely related to spring temperature (April and May). These results suggest that P. sylvestris is adjusting its secondary growth and phenology as a response to changing climate conditions by shifting the timing of the starting of the growing season to a favorable climate window.

K. Janecka, Climate overrides microsite effect in Scots pine around the south Baltic Sea 

**Climate overrides microsite effect in Scots pine around the south Baltic Sea**

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**Keywords**: tree-ring width, latewood blue intensity, temperature, drought, stationarity of climate signal

Limited research has been directed into understanding the microsite effects on climate sensitivity of Scots pine (*Pinus sylvestris* L.) tree-ring width (TRW) and latewood blue intensity (LBI) on coastal dunes. In this study, we examine spatial-temporal variability of Scots pine growth and climate sensitivity at nine coastal dune sites around the south Baltic Sea. Using TRW and LBI, we analyse dune ridge and bottom microsites to: (i) investigate growth variability across our network, (ii) identify dominant climate-growth responses, and (iii) test their stationarity over time.

We applied hierarchical clustering (HC), linear mixed models (LMM), and classical climate-growth analysis. The HC for both tree-ring proxies clustered microsites into north and south sub-regions indicating broadly coherent regional patterns in tree growth. The LMM results indicate that microsite type has only a minor effect on absolute growth, which means that at the same age, dune ridge and bottom trees have similar stem diameters. Furthermore, the LMM also found no differences in climate sensitivity between both microsites. Climate-growth analysis revealed a dominant, broad-scale influence of winter-spring temperature and local-scale effects of winter-spring drought on TRW and LBI. Temporal stability analysis showed climate-growth responses are not stable over the studied period.

In summary, our results indicate that microsite conditions play a minor role in the growth and climate sensitivity of Scots pine from the south Baltic Sea dunes. Climate appears to be the stronger driver of growth variability, however, climate-growth responses are not stationary over time.

Juliane Stolz, From wet to dry: Shifts in climate sensitivity of pine and beech along a precipitation gradient in northeastern Germany ▶

**From wet to dry: Shifts in climate sensitivity of pine and beech along a precipitation gradient in northeastern Germany**

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**Keywords**: climate change, drought stress, dendroecology.

Global change and concomitant extreme events will impact forest ecosystems on a large scale. Range shifts and forest diebacks have already been observed. To react adequately to these changing conditions, we have to assess the extent of global change and its respective consequences using big datasets on a large scale. For the study region of Mecklenburg-Pomerania, northeastern Germany, climate change predictions foresee increases in mean annual temperature and changes in precipitation regimes, resulting in more abundant and severe summer droughts. To assess the impacts of drought stress, we employed a network of 56 permanent plots spread along a precipitation gradient which were monitored for soil-, vegetation- and canopy characteristics since 1986. For this study, tree-ring data for Scots pine and European beech was collected to extend the existing database.
We analyzed climate-growth relationships and observed that drought sensitivity increased over the last decades irrespective of species, with beech generally showing stronger responses to drought. Further, beech was found to be more drought sensitive at drier sites, whereas no such trend was observed for pine over the precipitation gradient. For pine, winter temperature was identified as main driver of tree growth. Its importance increased over time, possibly driven by winter photosynthesis during warmer late winter/early spring conditions. An analysis of growth responses in extreme years substantiates the higher drought sensitivity of beech, posing questions on the future role of this species in the region.

A. Bräuning, A new approach to derive forest response to future climate conditions on the local scale by combining dendroecology and climate modelling

**A new approach to derive forest response to future climate conditions on the local scale by combining dendroecology and climate modelling**

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**Keywords**: climate change response, dendroecology, online platform, citizen science, environmental education

The recent droughts accompanied by elevated tree mortality and forest decline created increasing public awareness of the devastating impacts of climate change on European forest ecosystems. On the other hand, precise knowledge on how trees respond to drought stress, and on how climate change is affecting forest ecosystems is often lacking. We therefore developed a new online teaching tool that is based on a network of internet-connected trees over the German state of Bavaria (BayTreeNet; https://baytreenet.de/) and is embedded in the existing European TreeWatch.net (https://treewatch.net/). The 'talking trees' are equipped with dendrometers and sap flow sensors which are displayed online together with climate data. The ten trees are distributed over the state of Bavaria in a way that they reflect different local climates related to the complex topography of the province. In contrast to existing platforms, our approach includes embedded explanatory comments on tree responses by trained students. Each talking tree is ministered and commented by a partner school in the neighborhood. In addition, the network approach is able to create awareness that different climate patterns influence different areas in different ways by modifying the regional rainfall distribution. By combining tree responses to local weather conditions with a network of contrasting climatic conditions, a deeper understanding of the impact of climate change on regional forest ecosystems shall be achieved. The learning results of the students are evaluated by an educational project, which will lead to the development of a new education unit in natural science education.

E. D'Andrea, Frost and drought: effects of extreme weather events on stem carbon dynamics in a Mediterranean beech forest

**Frost and drought: effects of extreme weather events on stem carbon dynamics in a Mediterranean beech forest**

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**Keywords**: Extreme weather events, *Fagus sylvatica* L. (beech), resilience, stem carbon efflux, wood formation.

The effects of short-term extreme events on tree functioning and physiology are still rather elusive. European beech is one of the most sensitive species to late frost and water shortage. We investigated the intra-annual C dynamics in stems under such conditions.

Wood formation and stem $CO_2$ efflux were monitored in a Mediterranean beech forest for three years (2015–2017), including a late frost (2016) and a summer drought (2017).

The late frost reduced radial growth and, consequently, the amount of carbon fixed in the stem biomass by 80%. Stem carbon efflux in 2016 was reduced by 25%, which can be attributed to the reduction of effluxes due to growth respiration. Counter to our expectations, we found no effects of the 2017 summer drought on radial growth and stem carbon efflux.

The studied extreme weather events had various effects on tree growth. Even though late spring frost had a devastating impact on beech radial growth in the current year, trees fully recovered in the following growing season, indicating high resilience of beech to this stressful event.

# Session V:
# Inside wood –
# wood anatomical features as indicators of environmental and climate changes

M. Häusser, Cambial phenology of two pine species on Corsica show highly differing seasonality along elevation gradients

N. M. Häusser[1*], S. Szymczak[1], F. Huneau[2,3], E. Garel[2,3], S. Santoni[2,3], A. Bräuning[1]

**Cambial phenology of two pine species on Corsica show highly differing seasonality along elevation gradients**

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**Keywords**: Cambial phenology, Pinus nigra ssp. laricio, Pinus pinaster, Corsica, Elevation gradient

Investigating seasonal wood formation patterns is crucial to understand the growth responses of trees to environmental 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 hypothesized that growing season length shows a strong link to the number of days with temperatures above 5°C and is closely associated with elevation. We extracted microcores with a trephor borer from 42 trees at five sites along an East-West transect from the coasts (10m asl) to the central mountain ridge (1600m asl) of the island. During biweekly sampling campaigns, we collected altogether 800 samples during the vegetation period of 2018. After thin sectioning, the numbers of cells in the enlarging, cell wall-thickening, and mature states were counted in each thin section. Finally, cambial growth models for all sites were prepared by means of Gompertz functions.
Xylogenesis lasted 100 days (Jun-Sep) at the highest elevation, whereas in the central forest belt between 790m to 1000m asl, tree-ring formation was showing portions of enlarging cells for 150 to 165 days (May-Oct). As hypothesized, the coastal sites displayed the longest growing seasons of 200 to 300 days (Feb-Nov). We found a significant difference between west-facing and east-facing sites, the former showing a shorter duration of xylogenetic phases than the latter.

D. Castagneri, Long-term impacts of *Zeiraphera diniana* outbreaks on larch xylem structure and biomass accumulation

**Long-term impacts of *Zeiraphera diniana* outbreaks on larch xylem structure and biomass accumulation**

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**Keywords**: defoliation, insect outbreak, *Larix decidua*, xylem functional traits, quantitative wood anatomy

Xylem anatomical traits determine stem hydraulic and mechanical functions, and therefore influence performance of tree individuals, populations, and species. However, biotic disturbances such as defoliator insect outbreaks can strongly affect xylem formation, structure and functionality.

In this study, we aimed to assess immediate and legacy effect of larch budmoth (*Zeiraphera diniana* Guenée) outbreaks on the xylem anatomical structure of European larch (*Larix decidua* Mill.). Analyses were performed in the Lötschental valley (Swiss Alps) within (1900 m a.s.l.) and above (2200 m) the optimum altitudinal range of larch budmoth. We investigated eight outbreaks occurring during the 20th century.

Cell lumen size was slightly reduced in the first 2-3 years of outbreaks, especially in the early part of the ring. The more carbon-demanding cell wall was thinned over the entire ring, but more strongly in the last part. Tracheid number was more and longer affected than cell morphology. These variations resulted in significant reduction of tree-ring biomass and theoretical hydraulic conductivity for up to six years.

Our analysis indicates that, under carbon source limitations due to defoliation, the wood formation processes are affected in the order cell division > wall thickening > cell enlargement. Consequences on both xylem hydraulic properties and tree-ring biomass should be considered when assessing long-term defoliator effects on xylem functioning, forest dynamics, and terrestrial carbon cycle.

T. Pampuch, Wood anatomical adjustments of *Picea glauca* to drought and temperature limitations at treeline

**Wood anatomical adjustments of *Picea glauca* to drought and temperature limitations at treeline**

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**Keywords**: boreal forest, local adjustment, treeline, wood anatomy, white spruce

Trees need to adjust to abrupt changes in environmental conditions at the boreal treeline ecotones. Site-specific differences in growth and performance of individual trees in the boreal zone are well documented, but research focusing on xylem anatomy is scarce. In this study, we explored the xylem anatomy of white spruce (*Picea glauca* [Moench] Voss) from three different treeline sites in Alaska, a latitudinal treeline, an elevational treeline, and a drought-limited treeline. At each site, we sampled six trees with similar height and measured tree-ring width and xylem anatomical traits. We fitted a linear mixed effect model to test whether site had a significant influence on each measured trait. Preliminary results suggest that lumen area is smaller and late wood density is higher at the drought-limited site than at the latitudinal and elevational treeline sites. This would indicate that trees from the drought-limited treeline have locally adjusted to the scarce water availability by changing the cell structure. This anatomical adjustment could be the result of either a plastic response to local conditions, a local adaptation or a combination of both (i.e., a genetically driven change in the plasticity). Using neutral genetic markers, we could show differences between populations, but we were not able to determine if local adaptation or isolation by distance drives the differentiation. Further studies at an anatomical level in combination with genetic markers possibly under selection (e.g. SNPs) are needed to achieve a more comprehensive understanding of these intraspecific responses to different environmental conditions.

J. Vieira, Tree growth under climate change: evidence from xylogenesis timings and kinetics

**Tree growth under climate change: evidence from xylogenesis timings and kinetics**

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**Keywords**: Cambial activity, irrigation, manipulation experiment, tracheidograms, water exclusion, wood formation

Tree growth is one of the most studied aspects of tree biology, particularly secondary growth. In the Mediterranean region, secondary growth is mainly driven by water availability. Climatic projections for the Mediterranean region predict more frequent and intense droughts and extended rain-free periods. To investigate tree growth within the predicted climatic conditions, a water manipulation experiment was conducted in 2017 in a maritime pine stand (*Pinus pinaster* Aiton) on the Perímetro Florestal Dunas de Cantanhede (40°21′26″N, 8°49′14″W). Fifteen trees of similar social status, age, height and diameter at breast height were divided into three groups: control, rain exclusion, and irrigation. Rain exclusion was accomplished by installing a continuous plastic sheet on the forest floor from March to September; whereas irrigated trees were watered twice a week in September. Cambial activity and xylem formation were monitored every 10 days from February 2017 to March 2018 to assess tree growth dynamics. The number of cells in the cambium and in the consecutive phases of xylem differentiation were fitted with generalized additive mixed models (GAMMs), which were later used to infer timings and kkinetics of xylogenesis. Cell production peaked around March (vernal equinox) in all treatments. Trees under rain exclusion decreased cell production rates, xylogenesis duration and latewood cell-wall thickness. September irrigation did not produce noticeable differences in xylogenesis compared to trees in the control treatment. The synchronization of maximum cell production around the spring equinox could allow Mediterranean trees to mitigate the impact of summer drought.

**Effects of contrasting moss species on shrub growth and xylem anatomy under different precipitation regimes at the subarctic tundra**

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**Keywords**:

In the tundra, bryophytes may be the dominant growth form covering the soil surface of shrub communities. They can modulate soil conditions through their capacity to retain moisture and nutrients and their chemical characteristics. The study of the interaction between shrubs and bryophytes is essential to understand the functioning of these shrub communities, which are expanding due to global change. In this study, we collected *Betula nana* and *Empetrum hermaphroditum* ramets growing on moss carpets dominated by the species *Hylocomium splendens*, *Pleurozium schreberi* or *Sphagnum* spp., which differ in their growth habit and the density of their carpets. We sampled three ramets per site and moss species in eight locations at the subarctic alpine tundra near Abisko, Sweden. Half of the sites correspond to low precipitation areas (571-755 mm) and the other half to high precipitation (811-1155 mm). We prepared microscopic sections of the shrubs stem base and measured growth rings and xylem anatomical parameters (vessel lumen area, vessel density and grouping, and theoretical hydraulic conductivity) to investigate structural and functional adjustments to the different moss species and precipitation regimes. We also measured leaf C and N concentration and isotope composition ($\delta^{13}C$, $\delta^{15}N$), as well as soil pH and water and nutrient content (nitrate, ammonium, phosphate, dissolved organic C and dissolved organic N). We discuss the importance of moss species combined with the precipitation regime for the performance of tundra shrubs in the context of a changing climate.