TRACE 2017

trees rings in archaeology, climatology and ecology

16-21 MAY 2017 Svetlogorsk Kaliningrad region, Russia

СИБИРСКИЙ ФЕДЕРАЛЬНЫЙ УНИВЕРСИТЕТ
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ASSOCIATION FOR TREE-RING RESEARCH

РНФ | Российский
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TRACE 2017: Program

Monday 15.05.2017

16:00	22:00	**Arrival of first workshop participants**

Thuesday, 16.05.2017

First workshop day

9:00	10:30	E. van dr Maaten	R Fundamentals in Dendrochronology	G. von Arx/ P. Fonti	Methods of quantitative and functional wood anatomy
10:30	11:00	Coffee break			
11:00	12:30	E. van dr Maaten	R Fundamentals in Dendrochronology	G. von Arx/ P. Fonti	Methods of quantitative and functional wood anatomy
12:30	14:00	Lunch break			
14:00	16:30	E. van dr Maaten	R Fundamentals in Dendrochronology	G. von Arx/ P. Fonti	Methods of quantitative and functional wood anatomy
16:30	17:00	Coffee break			
17:00	18:30	E. van dr Maaten	R Fundamentals in Dendrochronology	G. von Arx/ P. Fonti	Methods of quantitative and functional wood anatomy
19:00	20:30	Dinner			

Wednesday, 17.05.2017

Second workshop day

9:00	10:30	V. Shishov	Process modeling	W. Beck	Detecting Climate-Growth Relationships by Use of the Statistical Analysis Tool CLIMTREG
10:30	11:00	Coffee break			
11:00	12:30	V. Shishov	Process modeling	W. Beck	Detecting Climate-Growth Relationships by Use of the Statistical Analysis Tool CLIMTREG
12:30	14:00	Lunch break			
14:00	16:30	V. Shishov	Process modeling	W. Beck	Detecting Climate-Growth Relationships by Use of the Statistical Analysis Tool CLIMTREG
16:30	17:00	Coffee break			
17:00	18:30	V. Shishov	Process modeling	W. Beck	Detecting Climate-Growth Relationships by Use of the Statistical Analysis Tool CLIMTREG

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18:30	22:00	**Registration and welcome party**

Thursday, 18.05.2017

First conference day

8:00	8:50	**Late registration**

8:50	9:00	ATR & Host	**Welcome**

9:00	9:10	U. Sass-Klaassen	**Forests and climate change (session 1)**

9:10	9:30	G. Battipaglia	Multidisciplinary approach to assess trees response to the interaction of elevated CO2 and climate
9:30	9:50	T. Shestakova	Physiological determinants of forest growth in Europe derived from carbon and oxygen isotopes
9:50	10:10	W. Huang	Projecting tree-growth responses into future climate: a study case from a Danish-wide common garden
10:10	10:30	V. Kukarskih	Current changes of high-mountain forests in the Northern Urals: extensive analysis
10:30	11:00	Coffee break	
11:00	11:20	J. Achikolova	Radial growth variability of Gmelin larch in Siberian taiga zone
11:20	11:40	I.C. Petritan	Species-specific climate-growth relationships of Pinus sylvestris, Pinus nigra and Abies alba in central Romania
11:40	12:00	J. Schroder	Remote-sensing data are closely related to growth information in tree-ring index chronologies - a case study for Pinus sylvestris in northeast Germany
12:00	13:30	Lunch	
13:30	13:40	V. Kukarskih	**Tree-line change (session 2)**
13:40	14:00	M. Trouillier	Quantification of factors contributing to white spruce growth at a water and a temperature limited tree-line.
14:00	14:20	N. Schwab	Tree-ring studies of a central Himalayan Abies spectabilis treeline ecotone
14:20	14:40	S. Aryal	Climatic upshot on growth pattern of Pinus roxburghii in Himalaya
14:40	15:00	J. Kaspar	The relation between tree growth, temperature and wind induced biomass loss explains formation of regional treelines
15:00	15:20	M. Danek	Geographical and altitudinal variability in the tree-ring growth response to climate of European larch (Larix decidua Mill.) from the Polish Carpathian Mountains.
15:20	16:00	Coffee break	
16:00	18:30	Session chairs	**Poster session (all sessions)**
19:00	20:30	Dinner	
20:30	21:30	**ATR meeting**	

Friday, 19.05.2017

Second conference day

8:20	8:40	R. Kaczka	**Studies on climate-growth relationships (session 3)**
8:40	9:00	I. Tychkov	Large scale of tree-ring growth analysis is Siberia: process-based approach
9:00	9:20	M. Kazimirovic	First dendroclimatological insight into Black pine (Pinus nigra Arnold) climate-growth relations in Belgrade area
9:20	9:40	M. Kazimirovic	Pointer years in beech growth in the region of Žagubica, Eastern Serbia
9:40	10:00	J. Wernicke	Quantifying the influence of westerly wave trains on the moisture variability reconstructed from tree-ring stable oxygen isotopes at the southeastern Tibetan Plateau
10:00	10:30	Coffee break	
10:30	10:50	E. V. Anoop	Dendroclimatological investigations on teak (Tectona grandis L. F.) in Nilambur (North) Forest division of Kerala
10:50	11:10	N. Chizhikova	Radial growth of Scoth pine of norhtern island ecosystem
11:10	12:10	Lunch	
12:20	19:00	I. Sviderskaya	**Outdoor session to the Curonian Spit National Park**
		V.P. Dedkov	Biodiversity and ecological peculiar features of the National park "Curonian Spit"
19:30	22:00	**Conference Party**	

Saturday, 20.05.2017

Third conference day

9:00	9:10	E. van der Maaten	**Methodological issues on climate-growth relationships and long-term reconstructions (session 4)**
9:10	9:30	W. Beck	Temporal changing growth patterns in spruce forests along altidudinal gradients in the Saxonian Mountains
9:30	9:50	G. Omurova	Extreme paleoclimatic events for North-western Siberia using archaeological woodfrom the Nadymskiy Gorodok archaeological site
9:50	10:10	R. Shetti	Does gender matter? Gender specificity and its influence on site-chronologies in the common dioecious shrub Juniperus communis. L
10:10	10:30	A. Stine	Improved tree-ring climate reconstructions using Liebig's Law of the Minimum
10:30	11:00		Coffee break
11:00	11:20	A. Tainik	Constructing of super long 3290-year tree-ring chronology for the Altai-Sayan region
11:00	11:20	M. Sidorova	Constructing 514-year tree-ring chronology in forest-steppe zone of Western Siberia with the use of architectural and archaeological timber
11:20	11:40	D. Balanzategui	Wood anatomical proxies from lowland European oak and Scots pine for climate reconstructions
11:40	12:00	A. Buras	Tree-growth divergence - a global phenomenon?
12:00	13:30		Lunch
13:30	13:40	G. Battipaglia	**High-resolution information on climate-growth relationships (session 5)**
13:40	14:00	A. Arzac	Exploring and identifying climatic factors leading to IADF occurrence in Siberian Larch trees
14:00	14:20	I. Sviderskaya	Cellular structure of annual rings in Pinaceae: functional-optimization approach
14:20	14:40	P. Prislan	Adaptive strategies of Pinus halepensis and Pinus sylvestris based on (ultra)structural description of cambial rhythm
14:40	15:00	T. De Mil	X-ray CT microdensitometry for tree-ring analysis and functional traits: what can we learn from tropical trees?
15:00	15:30		Coffee break
15:30	15:50	M. Klisz	Drought, genotype or G x E, what affect intra-annual density fluctuation formation in Norway spruce?
15:50	16:10	M. Popkova	Timing of tracheid production for Pinus Sylvestris L. in South Siberia: new approach
16:10	16:20	H. Gärtner	**Hydrology related to anatomical structure and mortality (session 6)**
16:20	16:40	F. Santini	Phenotypic plasticity and intra-specific variation in water-use efficiency of Pinus sylvestris L. inferred from tree rings
16:40	17:00	J. Tumajer	Decline in groundwater level has a common response in wood anatomy, but individualistic response in tree-ring widths in Quercus robur
17:00	17:20	L. Akhmetzyanov	What do vessels hide? Potential of oak earlywood vessels for dendroprovenancing
17:20	17:40	A. Potapov	Growth response of trees to drainage and ditch network maintenance: a case study of North-East Estonia
18:00	18:20	ATR	Closing ceremony and awards
19:00	20:30		Dinner

Sunday 21.05.2017

8:00	13:00	**Departure and/or optional excursions**

List of Posters

Nr.		
	U. Sass-Klaassen	**Forests and climate change (session 1)**
1,1	R. Aus der Au	Goodbye Endless Cowboy Prairie!
1,2	A. Cedro	Natural and anthropogenic transformations of a Baltic raised bog (Bagno Kusowo, NW Poland) in the light of dendrochronological analysis of Pinus sylvestris L.
1,3	M. Bryukhanova	Modelling tree-radial growth of downy birch from permafrost zone of Siberia
1,4	A. Mironova	Dendrogeochemical features fossil larch (Pazyryk) and modern larches of Mountain Altai
1,5	M. Rousseau	The Tervuren xylarium : research material for the development of visual wood identification and for studies of tree growth and forest ecology
1,6	C. Leifsson	Tracking permafrost degradation and climate variability in Betula nana from Subarctic Sweden
1,7	D. Krause	Dating of avalanche events in the High Sudetes using dendrochronological methods

1,8	D. Fedotov	Modeling the influence of temperature and precipitation on the tree rings growth in permafrost zone of Central Siberia
	V. Kukarskih	**Tree-line change (session 2)**
2,1	V. Kukarskih	Ecological types of upper tree-lines in the Southern Ural Mountains
2,2	L. Gorlanova	Climate and the growth of coniferous trees and shrubs at the Northern Timberline in the Yamal Peninsula and Polar Urals
2,3	M. Jochner	Tree growth responses to changing temperatures: a fine-scale analysis along elevation gradients at the natural upper treeline in the Swiss Alps
	R. Kaczka	**Studies on climate-growth relationships (session 3)**
3,1	R. Cruz Garcia	Climate sensitivity of beech and oak stands in a coastal forest in northeastern Germany affected by their management regime
3,2	H. Gartner	Microscopic Preparation Techniques - Microtomes and their application
3,3	A.I. Apafaian	Radial growth behaviour of Pinus sylvestris and Pinus nigra on Romanian degraded lands
3,4	R. Malik	Growth response of Abies pindrow to changing climate along an elevation gradient in north-western Himalayas.
3,5	R. Kaczka	Deciphering the climatic signal from Norway spruce growing in the karst environment of the Velebit Mts., Croatia
3,6	N. Knysh	Impact of climatic factors on radial increment of pedunculate oak (Quercus robur L.) in Northern and Southern Belarus
3,7	M. Danek	Pointer years in larch (Larix decidua Mill.) from the Polish Carpathian Mountains
	E. van der Maaten	**Methodological issues on climate-growth relationships and long-term reconstructions (session 4)**
4,1	G. Fontana	Might Dryas octopetala be a geomorphologist's best friend?
4,2	V. Voronin	Tree-ring chronology from the Holocenedeposits of the Muya River Valley, North Baikal region, Siberia Russia
4,3	V. Kuznetsova	Possibilities and restrictions of the streamflow and PDSI reconstruction in the Volga region using dendrochronology
4,4	P. Polumieva	Dendrochronological analysis of the camp barracks built by GULAG prisoners on the White Sea coast.
4,5	S. Szymczak	Long-term oxygen isotope chronologies from a Mediterranean island
4,6	A. Piermattei	Potential and limitations of combining terrestrial and marine proxy archives from Iceland
4,7	O. Tolkach	The influence of some extreme factors of different genesis on the annual radial growth dynamics
4,8	Z. Zharnikov	Dendrochronological investigation of objects in Yeniseysk town (East Siberia)
4,9	O. Komarova	The main features of the variability of the thermal regime of temperature reconstructions by different proxy sources in Northern Hemisphere for the last two millennia.
4.10	L. Fouedjeu Foumou	A new methodology for a higher chronological resolution of charcoal manufacturing historical activities in eastern Pyrenees (Ariège, France)
4,11	A. Fertikov	Dynamics of heavy metal (Ni, Cu) and sulfur (S) content in tree-ring of larch affected by industrial pollution from the Norilsk smelters
4,12	P. Burkhalter	A Dendrogeomorphological Reconstruction of a Landslide Using Tree-ring Methods
	G. Battipaglia	**High-resolution information on climate-growth relationships (session 5)**
5,1	R. Cerrato	Pinus cembra L. maximum wood density records late summer maximum temperatures in the Ortles-Cevedale Group (Rhaetian Alps, Italy).
5,2	P. Fonti	Tracheid anatomical changes of Larix sibirica under drought stress
5,3	A. Dinella	High-resolution and multi-proxy approach to study the paleoclimate of South-Eastern Alps
5,4	D. Mashukov	Anatomical structure of the top stems of stag-headed trees of Larix gmelinii growing in permafrost soil as an evidence of water stress
5,5	V. Slobodchikova	The climatic response of anatomical characteristics of Pinus sylvestris revealed by the tracheidogram method
5,6	M. Lexa	Sign of air pollution calamity in anatomical features of spruce (Picea abies (L.) Karst) in the Klínovec area (Ore mountains)
5,7	A. Samusevich	Eearlywood and latewood anatomy parameters and their sensetiveness to air pollution and low temperature. Metodological approach to demarcation between earlywood and latewood
	H. Gärtner	**Hydrology related to anatomical structure and mortality (session 6)**
6,1	P. Prislan	Intra-annual leaf phenology, radial growth and structure of xylem and phloem in different tree parts of Quercus pubescens
6,2	J. Muller	Investigations of the dry strees effect of the water consumption and the tree growth with the use of lysimeter
6,3	I.M. Medrea	Growth patterns in relation to drought-induced mortality of main coniferous tree species in Transylvania, Romania
6,4	A. Buras	Are Scots pine forest edges particularly prone to drought-induced mortality?
6,5	A. Buras	Multivariate multi-proxy approach identifies Norway spruce growth divergence on Babia Gora Mountain, Poland

Oral presentations

Radial growth variability of gmelin larch in siberian taiga zone

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The northern territories of Siberia, Russia are one of the most suitable regions for implementing dendroclimatic and dendroecological research. Not remarkable, that in recent decades much emphasis has been given to the dendroclimatic study of the forest-tundra zone of Siberia. Whereas, northern taiga larch forests located on permafrost zone to the south still need to be studied.

In this research, climate conditions were examined to indicate their influence on radial growth of Gmelin larch trees developed on northern and southern borders of permafrost soils.

To explore the tree-rings formation of Gmelin larch trees developed on permafrost soils a practical study was performed in Evenkia, Yakutia and in the northern part of Lake Baikal territory, in the area of continuous distribution of permafrost. Five dendrochronological sites were established: site "M" (89 m a.s.l., 67° 54'43.2''N, 123° 10'14.3''3''E) and site "B" (47 m a.s.l., 65° 58'23.2''N, 123° 52'01.0 '' E) in Yakutia; PLSG – plateau at 589 m a.s.l., HLG – plateau on the left bank of the Tunguska river (both on 64° N, 103° E) in Evenkia; Hk1– Hakusy, north of Baikal territory.

A comparative analysis of TRW chronologies was performed. The longest chronologies are obtained from trees growing in the north of Yakutia, where they are affected by fungal rot in less extend due to harsh conditions. The results of dendroclimatic analysis present that climatic conditions of the previous year define tree-ring growth of larch trees on all sites. Particular, a significant increase in soil moisture was determined in Yakutia after 2000.

Noteworthy, that the climatic characteristics of TRW chronologies obtained from trees growing at a very great distanced sites have a similar trend. The study also demonstrates that it is not obligatory to take a large number of samples to implement dendroclimatic analysis.

The study was implemented within the Russian Science Foundation project №14-14-00295, 15-14-30011

What do vessels hide? Potential of oak earlywood vessels for dendroprovenancing

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Dating and provenancing of historical timber is usually achieved by applying classical dendroprovenancing based on ring-width analyses. This implies that the ring-width series of a given timber is compared to time series from a network of local and regional chronologies from the same species, serving as an indicator of the felling date and geographical origin of the tree used as timber.

The spatial precision of provenancing provided by annual variation in ring-width patterns can potentially be further enhanced by including additional information stored in the wood. For instance, strontium isotopic ratio of wood provides information about the type of the mother rock the tree was growing on, pyrolysis and FTIR data derived from the living trees gives high resolution site specific organic composition of the wood, and analyses of wood-anatomical features of trees add information about the ecology of the site.

In the present study we analysed earlywood vessels (EV), tree-ring (TR), earlywood (EW), and latewood (LW) widths of four oak species from several sites in Northern Spain. Study sites were selected along a phytogeographic gradient – from Eurosiberian to Mediterranean regions. We analysed climate – growth relationships and identified the main growth limiting factors at each study site. We found that EV chronologies contain different climatic signals as compared to TR, EW, and LW, and moreover, they contribute to better understanding the differences among the sites. This suggests that including EV analyses into the dendroprovenancing studies will lead to enhance the precision of provenancing.

Exploring and identifying climatic factors leading to IADF occurrence in Siberian Larch trees.

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Climate variability leads to changes in cambial activity patterns at intra-annual scale that may drives abrupt intra-annual changes in wood density or intra-annual density fluctuations (IADF). Recorded in the xylem anatomy, IADF provide information of short-term variation in the pace of xylem formation. We explored how climate conditions modulate the occurrence and frequency of IADF at different time scales in the conifer Larix sibirica Ledeb. (Siberian Larch), growing under highly continental climate conditions in the forest-steppe zone in Khakasia, Southern Siberia.

We found the occurrence of two types of IADF in larch tress; IADF type E (latewood-like cells band within the earlywood) and IADF type L (earlywood-like cells band within the latewood). IADF type E were relatively more frequent (2.7%) than IADF type L (1.41%) within the analyzed period 1928-2005. The formation of both IADF types and tree-ring growth depended on climatic factors at different temporal scales. Ring width mainly responded to climate conditions prior to the onset of xylogenesis (April) and earlywood formation (May-June). In contrast, IADF responded to punctual events during earlywood and latewood formation, suggesting an early growth arrest during the spring (IADF E) and later promotion of cambial reactivation during the late summer (IADF L), reducing and extending the growing season respectively. Additionally, we found a decrease in the frequency of both IADF types in time. Thirty years moving correlations showed a decrease in the in intensity of the signal of climatic response in both types of IADF along the analyzed period.

Although IADF have been scarcely studied in Southern Siberia in comparison with Mediterranean regions, this work highlights the potential of IADF measurements in L. sibirica as a complement of ring-width chronologies in highly continental environments, helping to improve our understanding of this species cambial activity.

Dendroclimatological investigations on teak (*Tectona grandis* L. F.) in Nilambur (North) Forest division of Kerala

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A study was conducted on teak (*Tectona grandis* L. f.) grown in plantations at Nilambur (North) forest division with the objectives of analyzing tree-ring chronologies to find out their dendroclimatic potential and the tree growth-climate relationship and also to find out whether any significant relationship exists between climate and mean vessel area (MVA) of teak and its prospect for climatic reconstruction of the study area. In order to achieve the above objectives, cross sectional discs were collected from sites located in Edakkode, Kanakuthu and Conolly's plot. The average ring width and MVA of each year obtained from the different radii were used to cross date and construct the chronology using the TSAP Win software. A cubic smoothing spline was used for standardization of the tree ring data using the software ARSTAN. Bootstrap correlation and response function analyses were carried out with moving intervals to find out tree growth-climate relationship using DENDROCLIM. Statistical parameters such as Signal to Noise Ratio (SNR) and Expressed Population Signals (EPS) of all chronologies have desired levels and the sites had good dendroclimatic potential. Ring width and MVA chronologies of teak for the Nilambur region were also developed.

Rainfall in previous July, previous December and current October were correlated with ring width. Winter temperature (December-January) and southwest monsoon (June-September) were the seasonal climatic variables that mostly controlled ring width in the study sites. The monthly temperatures for January and previous June created major response in ring width. Mean vessel area responded to monthly rainfall for months previous June, previous September, previous November and current May. Seasonal climate which influenced vessel area were of southwest monsoon (June-September) temperature and rainfall and northeast monsoon (October-November) rainfall. Mean vessel area responded to monthly temperatures of previous August, current May and December. Using transfer functions climatic data for months and seasons with highest response and the period which is not available (1870-1900) from the instrumental record were reconstructed from tree ring data.

Wood anatomical proxies from lowland European oak and Scots pine for climate reconstructions

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Tree-ring based climate reconstructions from temperate lowlands are largely missing due to diffuse climate signals found in traditional tree ring-width and maximum latewood density studies. Developments in quantitative wood anatomy indicate that cell anatomical features may carry additional environmental information that could assist climate reconstruction. This motivated us to analyse wood anatomy in two tree species, the European oak (*Quercus robur* L.) and Scots pine (*Pinus silvestris* L.), as they are widely distributed across European temperate lowlands, and their common use in building materials over past centuries could possibly assist in extending the chronologies further into the past.

We combined material from living trees with historical building timber from temperate lowland forests in northern Germany and Poland covering the period AD 1300 to 2016. Approximately 46,000 earlywood oak vessels from 64 trees, and 1.2 million pine tracheid cells from 41 trees, were measured using flatbed scanner (oak vessels), confocal laser scanning microscope (pine tracheids) and image analysis tools (ROXAS).

Results indicate that both oak earlywood vessel (e.g., mean area of five largest vessels) and pine tracheid anatomical proxies (e.g., early- and latewood radial diameter) contain climate signals that are different and stronger than those of corresponding tree ring-width chronologies. Additionally, by using only raw values, or applying very little detrending to the chronologies, it may be possible to preserve lowfrequency climate signals.

Our analysis confirms that new anatomical proxies and their relation to climate provide additional climate proxy information within wood structure, however, these are yet to be fully explored. This information will be crucial in extending climate reconstruction records into largely unexplored geographic regions.

Multidisciplinary approach to assess trees response to the interaction of elevated CO_2 and climate

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Terrestrial plants play a significant role in the global carbon cycle and in the control of the carbon dioxide (CO_2) concentration in the atmosphere. The responses of plants to an increasing concentration of atmospheric CO_2 will depend on their ability to use water and nutrient resources efficiently under a changing climate. However, there is a poor understanding of the tree-level implications of the gradual CO_2 rise during the last centuries. This lacking insight limits the ability to predict responses to gradual CO_2 rise in the future

Here, I present findings of different studies where trees responses to CO_2 increase have been analyzed in species growing in Free air CO_2 enrichment (FACE) experiments and in natural conditions across Mediterranean area and tropical forests.

A multidisciplinary approach has been used, coupling dendrochronological measurements with stable isotopes (namely carbon and oxygen) analyses. Main aims were: to i) reconstruct lifetime growth patterns of trees; ii) evaluate if their growth has been stimulating by increasing CO_2 concentration and if they have been accumulating biomass over time, in the form of BAI iii) analyze the mechanisms driving the expected improvement in water use efficiency, under elevated CO_2.

Our findings provide additional support to the global observations of a slowing down of C sequestration in the trunks of forest trees in recent decades. Data indicate that the CO_2 increase alone has not been sufficient to obtain a tree growth increase. The effect of other changing environmental factors, like temperature, may have overridden the fertilization effect of CO_2.

Temporal changing growth patterns in spruce forests along altitudinal gradients in the Saxonian Mountains

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In cooperation with the public enterprise “Saxon Forest” sample plots in spruce forests along three altitudinal gradients in the Saxon Mountains were established. These altitudinal gradients are situated in the Western and Eastern Ore Mountains and in the Zittau Mountains. The sample plots comprise an elevation range from 1100m down to 150 m above sea level. In each sample plot increment cores were taken from 20 dominant trees, each tree with two cores. Tree ring width series were measured and the corresponding growth patterns were reconstructed. In all stands, at all gradients in each elevation level, similar growth disturbances occur. Heavy growth depressions were caused by sulphurous burnt gasses from brown coal as the energy base of power stations in the Bohemian basin, beginning in the 1970ies up to the middle of the 1990ies. After closing the coal mining, the investigated spruce stands recreated rapidly. Simultaneously climatic changes caused violent fluctuations of growth rates. Here, a clear differentiation between upper, middle and lower elevation sites is obvious. In the upper elevation sites warming has caused a growth benefit. The stands at the low elevation sites show increased sensitivity values compared to the high elevation sites, in the ring width series and in the index-series as well. Nevertheless, these stands show best relative resilience values after the years 2003 and 2006. Obviously, these 100 years old stands are much better adapted to a dryer and warmer climate since the beginning of their life cycle. The lowest resilience values were found in stands of middle elevation sites where hot and dry summers are exceptional and the adaption to such drought events is more difficult for old grown trees. Seemingly, old grown spruces are able to react positively to more favourable conditions, but are not able to adapt to new unfavourable conditions.

Tree-growth divergence – a global phenomenon?

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Tree-ring data are considered an essential cornerstone of paleoclimatology and a valuable tool for predicting climate change impacts on and carbon dynamics of forest ecosystems. However, a growing body of literature indicates, that the standard dendrochronological approach to evaluate tree-ring data may too rigorously neglect individualistic tree-growth: Trees of the same species sampled at one site often express different long-term growth patterns and therefore differing climate-growth relationships. This phenomenon is commonly termed growth divergence (GD) and might weaken our ability to correctly estimate past climatic extremes and variability, project future forest growth and benchmark mechanistic models. Yet, there is a complete lack of detailed information on the frequency, magnitude and severity of GD occurrence. Here, we present results from a global GD assessment covering 135 data-sets from 50 tree species distributed over 116 sites across 22 countries. We found clear signs of GD in 85 percent of all data-sets. When accounting for GD, stability of climate-growth relationships and explained variance of climate transfer functions increased remarkably. A multiple linear regression based on sample size, latitude, and climatic water balance significantly was able to explain 34 percent of global GD variations. These results advocate for an incorporation of GD assessments into dendrochronology to increase the precision of climate reconstructions as well as the prediction of forest ecosystem responses to global change.

Radial growth of Scoth pine of norhtern island ecosystem

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As shown by recent studies the northern ecosystems experience the most pronounced climate shifts caused by temperature and precipitation increase especially during the winter season. This makes the research of reaction and adaptation mechanisms featuring these habitats very appealing in the terms of the possible magnitude of changes.

The species under study is Scots Pine growing at the Sredniy island (N 66.1724 E 33.3876) of the Keretsky archipelago. A set of trees was sampled to get cores for study the annual tree-rings, and set of trees was cored regularly during the warm season to inspect seasonal growth (in 2014, 2015, 2016). Air temperature and precipitation of the warm season were registered by sensors mounted near the sampled trees. Daily air temperature and daily precipitation time series of the nearest weather station Umba are available trough the open data base of RIHMI-WDC.

Three statistical models were attempted to fit seasonal growth: logistic, Gomtertz and spline-based. The early tracheid formation can be observed by the end of May (23.05-27.05). Cell division termination can be detected in the second decade of August (11.08-16.08). The length of the radial growth season can be of 75-80 days. The culmination of growth falls on the mid of June (14.07 in 2014, 12.07 in 2015, 17.07 in 2016, as estimated by spline-based model). The sigmoid shaped dynamics of radial growth corresponds to the air temperature seasonal dynamics, but each peak of the growth is preceded by a rainfall. The total width of the formed tree-ring is sensitive to the cold spell in July.

Correlation of annual tree-ring widths with individual mean monthly temperature and summary monthly precipitation is considerably low. Estimation of complex relationship of tree-ring width with weather charactristics was attempted with use of regression trees. The most influential complex of weather fatures is precipitation of March coupled with temperature of August.

Geographical and altitudinal variability in the tree-ring growth response to climate of European larch (*Larix decidua* Mill.) from the Polish Carpathian Mountains.

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Presented study was focused on the analysis of the variability of the climatic signal in tree-ring chronologies of larch from the Polish part of the Carpathian Mountains. More than 30 sites located at low, medium and high elevations, with tree stands over 100 years old, were analysed. Constructed site chronologies (residual versions) were analysed with application of data mining methods. Cluster analysis and Principal Component Analysis was applied to distinguish the regions with similar tree-ring patterns and quantify the factors that caused observed differences. In order to explain the obtained results, the climate-growth relationship analysis was performed. The study shows that the climatic signal in larch from Polish Carpathians diversify as a result of the combination of several factors, with longitude and altitude being the strongest ones. The chronologies formed three main clusters: south-eastern; foothill zone together with mountainous western region; and distinct group of chronologies from the Tatra Mountains. The results of PCA revealed that the first three PCs have the highest contribution in variance. Varimax rotation revealed similar groups as obtained by clustering: the division to “western” and “eastern” sites, Tatra mountains and Western Bieszczady sites was observed. The climate-growth relationship analysis revealed the strong influence of the late spring climatic conditions to growth. However, the influence of the previous year, especially the end of the vegetation season, seems also to be important in some cases. The relationship between particular climatic conditions and geographical/ altitudinal site location was also analysed and discussed.

The study was supported by the National Science Centre, Poland, project no 2014/13/B/ST10/02529.

X-ray CT microdensitometry for tree ring analysis and functional traits: what can we learn from tropical trees?

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Microdensitometry is a well-established discipline for obtaining dendrochronological information from temperate and boreal trees. It is a standard method for obtaining Maximum Latewood Density, a key variable in climate reconstructions. However, often performed in addition to tree ring analysis after crossdating, its potential to delineate tree ring boundaries and to crossdate remains underused. X-ray CT microdensitometry (De Mil et al., 2016) is a fast and non-destructive tool that does not require sample treatment, allows for tree ring delineation and a recently developed pattern-matching algorithm formalizes the crossdating process. As such, tree ring width and several density-derived parameters can be extracted simultaneously, and consecutively used in routine dendrochronology software. Not only for trees in temperate and boreal regions, but for regions further towards the equator, major benefits rise: subtle cambial phenology forces the tropical dendrochronologist to look between tree ring boundaries for signals that reflect the tree's environment more accurately, beyond traditional measurements of ring width. This study further elaborates on the potential of X-ray CT microdensitometry in the light of (i) tree ring potential of lesser known tropical species, (ii) quantitative wood anatomy and (iii) database of functional traits at the Xylarium of the Royal Museum For Central Africa. Additional assessment of cambial phenology allows to convert xylem traits to the time domain, and thus, increases the environmental signal. The subtle climatic conditions, the large number of species and phenology variations result in an important research subject where the anatomical variation is well captured by using density profiles.

Modeling the influence of temperature and precipitation on the tree rings growth in permafrost zone of Central Siberia

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Tree rings are one of the most significant proxies for dating historical events and climate reconstruction. Understanding the annual rings formation is a fundamental condition for ensuring sufficient accuracy of climate reconstructions. Direct measurement of tree-ring formation is a complex and long-term procedure so, the modeling method can be a useful alternative for determining the characteristics of tree growth dynamics. The Vaganov-Shashkin process-based model allows reconstructing the seasonal growth dynamics and estimating the width of annual ring by daily data on temperature and precipitation.

Our goal was to find out the main features of seasonal growth dynamics of Gmelin Larix tree rings in permafrost conditions of Central Siberia (Evenkia, 64°18 N 100°11' W, 150 m a.s.l.).

Modeling showed a high correlation and synchronyzation with relation temperature and precipitation between real and simulated between real and simulated chronologies (R = 0.8, S = 75%). To define the limiting growth factors we analyzed groupes of **wide** and **narrow** rings separately.Comparison of the soil moisture and temperature contribution as limiting factors in wide and narrow rings showed that the soil moisture infuences on tree ring growth in a greater extent. Based on this fact we identified the soil moisture as the main limiting factor. The air temperature has an indirect effect on the rate of tree ring growth modifying the moisture content in the soil.

The research was carried out with the financial support from Ministry of Education of Russian Federation (project 784), Russian Foundation for Basic Research (project 17-44-240809), and Russian Scientific Foundation (project 15-14-30011).

Projecting tree-growth responses into future climate: a study case from a Danish-wide common garden

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Assessing growth responses to climate variations from common garden experiments is vital to identify a species portfolio matching future climate. In the study we present here we make use of a 50 years old Danish-wide common garden experiment spanning six sites with different soil types i) to analyze climate-growth responses and resilience to drought and ii) to model future growth predictions for six non-native conifers and two native broadleaved tree species.

Species-specific response-functions and Superposed Epoch Analysis of drought events are used to assess differences in sensitivity to drought.

The results show that the growth of all species, except for *Quercus robur*, are significantly ($P < 0.05$) and negatively correlated with summer drought from June-August in at least one of the sites, whereby *Larix kaempferi*, *Abies grandis*, *Picea sitchensis*, and *Picea abies* are the less resilient. Negative effects of previous warm autumn or late summer were found for *P. abies*, *A. grandis*, *Abies alba* and *Pseudotsuga menziesii*. Moreover, independently of the site conditions, our model projections of growth responses under future climate prediction (RCP4.5 emission scenario) forecast that growth of *L. kaempferi*, *A. grandis*, *P. abies* and *Fagus sylvatica*. will be reduced by up to 10-16% by 2100. Minor changes in growth responses are expected for *P. sitchensis*, *A. alba* and *P. menziesii*, while *Q. robur* will increase by 12%.

This study demonstrates how such projections based on old common garden experiments could be used as inputs to support today's forest management decisions.

The relation between tree growth, temperature and wind induced biomass loss explains formation of regional treelines

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At global scale, treeline position is driven by growing season temperatures which implies that temperature at uppermost treeline positions at regional or global scales should be approximately the same, because of identically temperature-limited tree growth. However, in many regions reported treeline temperatures and growth characteristic vary considerably suggesting either additional limiting factors or different treeline response to ongoing warming. Here we present a comparison of tree growth parameters and treeline temperatures across ten mountain ranges in Central Europe north of the Alps (51-48°N, 10-20°E). We tested whether tree growth is approximately the same across all treelines and whether less limiting temperatures at warm treelines are counterbalanced by other limiting factors, or if growth varies exclusively as a consequence of temperature variability. In all treeline regions under study, approximately 3 m tall individuals of Picea abies were sampled to measure radial and height growth and to determine symptoms of biomass loss. Tree ring width, height increment below 2 m and height increment above 2 m of stem height were modelled using treeline temperature metrics, symptoms of biomass loss, reaction wood presence and site properties. We found that radial growth, height growth up to 2 m and height growth above 2 m showed high, weak, or almost no correlation with temperature metrics, respectively. Certain warm treelines with high radial growth rates were characterized by high proportions of reaction wood, frequent symptoms of biomass loss and high stem taper. However, other treelines provided limited evidence of biomass loss or presence of reaction wood, indicating that they are either a remnant of past disturbances, or their response to the recent temperature increase is delayed because of anthropogenic land use. We propose that comparing tree growth, temperature metrics and symptoms of biomass loss is particularly helpful for explaining the formation of regional treelines.

Drought, genotype or G × E, what affect intra-annual density fluctuation formation in Norway spruce?

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Norway spruce characterise bimodal distribution in Europe with northeast and south range as a result of the postglacial recolonization after the last Ice Age. The so-called ‘‘spruceless zone’’ in central Europe may be related to the forest management in 19th century. We hypothesize that ‘‘spruceless zone’’ as a place of meeting of two range centres (Boreal-Baltic and Hercynian-Carpathian) may differentiate growth reaction (intra-annual density fluctuation - IADF) of northern and southern provenances. In order to test our hypothesis we investigate nuclear microsatellite variation (SSR markers) and IADF frequency of 10 spruce populations tested on two provenance trails. To asses drought effect on IADF frequency we used standardized precipitation evapotranspiration index (SPEI) and Palmer drought severity index (PDSI) from global gridded SPEI dataset. As expected, location of provenance trails didn’t affect the genetic diversity of provenances (F_{st}: 0.013 – 0.024). Principal coordinate analysis (PCoA) based on F_{st} genetic distances for 10 populations showed the clear division onto northern and southern provenances, only population from east Poland and Tatry Mountain, had unclear positions. Provenance grouping based on the cluster analysis of IADF frequency explicitly highlighted two distinct site-belonging groups. Site-dependent provenance grouping scheme was similar for all IADF types. Drought-growth relationships of two IADFs types occurred in earlywood and transition zone showed strong, negative influence of SPEI on almost all provenances from west site (for IADFs type E) and east site (for IADFs type Eplus). In general, climatic conditions of “spruceless zone”, mainly March and April SPEI index, strongly affects growth reaction of Norway spruce manifested in E and Eplus frequency of IADFs. Our results confirm the crucial role of tree origin and genotype × environment interaction (G × E) in climate-growth reaction.

Extreme paleoclimatic events for North-Western Siberia using archaeological wood from the Nadymskiy Gorodok archeological site

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The work includes the analysis of occurrence of damage to the anatomicalstructure (frost rings, light rings and fluctuationsof the wood density) and missing tree rings in wood samples from the archaeological site Nadymskiy Gorodok, which is located in the subarctic zone of Western Siberia. The application of a comprehensive approach was based on such parameters as severity of an extreme event, synchronous formation of pathologies or missing annual rings in all studied wood species; general dates of formation of anomalies and missing rings; and years of minimum growth in chronologies allowed the identification of significant climatic events for the study area. As a result, an extreme climatic events chronology was built, which covers the period from 1170 to 1505. Comparison of the information on extreme climatic events for Nadymskiy Gorodok with similar information for other regions showed that the event of 1259 is observed in different sources and, probably, has a global nature. Another two events – 1342, 1466 years - are tracked in the north of Western Siberia and North America, therefore, have an inter-regional character. The event of 1440 is strictly a regional one and is traced only in the north of Western Siberia. These years cover the dates of documented stratospheric volcanic eruptions, bursts of acidity and aerosol development according to data from polar ice cores, as well as the historical accounts of severe cold weather, frost, crop failure, etc. These events may have had a strong impact on the socio-economic processes in a marginal agricultural zone. Two of these events are correlated with the period 1443 to 1499, when a series of military campaigns was made by the Novgorod and Moscow kings to the lower reaches of the Ob river - Ugra district.

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Species-specific climate-growth relationships of *Pinus sylvestris*, *Pinus nigra* and *Abies alba* in central Romania

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Climate change prediction indicates an increase in the frequency and intensity of drought in the Europe. Trough their long lifespan the trees are sensitive to climate change and particularly to the abrupt variations in climate conditions, which could alter their growth. In 2012 an extended tree mortality phenomena was observed in the temperate-continental climate region of Romania, near Brasov region. Especially coniferous tree species as Scot pine, Black pine and Silver fir tree species were most affected.

Using tree cores sampled in 4 stands for each species (3 affected by mortality and one without mortality) we analyzed tree-growth response of these three species to past climatic variations and driest and warmest years.

Tree-ring width was measured for about 600 trees and species-specific site chronologies were built. Response-function analysis and Superposed Epoch Analysis were applied to assess the species-specific growth sensitivity to climate and to the most five driest /warmest years.

Our results highlights a common sensitivity to precipitation of June more accentuated for pine species (available for each stand), whereas the growth of *Abies alba* was significantly influenced by the June precipitation only for the sites situated at lower altitude. Both Pinus species have a predominant summer response, especially to precipitation and less to temperature. On the contrary, *Abies alba* has a predominant temperature answer and besides summer and spring, autumn also appears in this case to play an important role.

For low precipitation (five driest years on the last 60 years), some homogeneous pattern were observed with growth being significantly reduced in the dry years and sometimes over the following few years, whereas for the high temperature no homogeneous patterns were found.

According to our findings, an increase in the frequency and the intensity of droughts could affect the three species, particularly the pine species which are very sensitive to the amount of the precipitation in the summer.

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Timing of tracheid production for *Pinus Sylvestris L.* in South Siberia: new approach

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The process of tracheid differentiation as well as an impact of external and internal factors on the tree-ring cell formation is one of the most urgent issues in modern dendrochronology. The main anatomical characteristics of tree-ring structure, e.g. number of cells, radial cell size and cell walls thickness, are closely related to the kinetic characteristics of seasonal tree-ring formation, especially with the kinetics of cell production. Due to specificity of these processes and complexity of labor-intensive experimental methods mathematical modelling can be considered as one possible approach, which requires to develop adequate mathematical methods and corresponded software components.

A number of process-based models simulate biomass production with possibility to determine the processes of cell production by cambium and differentiation cambial derivatives while the timing of seasonal activities is a fundamental and very important aspect of plant functioning. Based on the simulated integral growth rates a new block of the Vaganov-Shashkin model was proposed to estimate a cell production in tree rings and transfer it into time scale. The comparative analysis of the growth rates with one of the main tree-ring anatomical characteristics of conifers – radial cells size was carried out to provide a new procedure of timing cambium cell production during the season.

The new proposed approach is free from any complexity and limitations accompanying previous methods when the seasonal tree-growth dynamics were analyzed by direct and indirect methods.

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Growth response of trees to drainage and ditch network maintenance: a case study of North-East Estonia

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Forest growth and yield is determined by numerous various factors. In some cases, unfavourable soil aeration due to excessive moisture can limit productivity of forest stands. In order to improve site conditions, suboptimal hydrological regime can be altered by constructing networks of drainage ditches. However, without continuous water management, achieved forest growth rate can decrease due to re-paludification. To prevent this process, ditch network maintenance (DNM) operations are implemented.

The aim of this study is to assess long-term effects of drainage operations on forest growth dynamics and silvicultural response of such interventions (including DNM) in case of Estonian conditions. As a first approach data from 10 sample plots within selected ditch network in North-East Estonia were used. Scots pine sample trees (140 trees in total) were selected: tree diameter and height were measured and GPS coordinates recorded, increment cores extracted (two per tree). Climate data of the period 1946-2014 were employed. Ring-width series of single trees, unstandardized and standardized chronologies of sample plots were analyzed.

Preliminaryoc results indicate the following: 1) drainage effect of different ditches of the same plot is not homogeneous; 2) growth release depends negatively on pre-drainage tree size; 3) negative relationship between tree diameter and distance to the ditch is not necessarily the result of drainage, in some cases the same tendency existed before ditching; 4) response to DNM has a time-lag of 7-8 years; 5) climate-growth relationships can change after drainage. Further research should address factors affecting growth response to DNM (e.g. pre-treatment groundwater table level) and suggest characteristics, on which planning of DNM should rely.

Adaptive strategies of *Pinus halepensis* and *Pinus sylvestris* based on (ultra)structural description of cambial rhythm

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To understand the adaptation strategies of intra-annual radial growth in Pinus halepensis and Pinus sylvestris to local environmental conditions, seasonal rhythm of cambial activity and cell differentiation at tissue and cellular levels was examined. Two contrasting sites differing in temperature and amount of precipitation were selected for each species, one typical for their growth and the other represented border climatic conditions, where the two species coexisted. Mature P. halepensis trees were selected at Mediterranean (Spain) and sub-Mediterranean (Slovenia) sites, and P. sylvestris trees at sub-Mediterranean (Slovenia) and temperate (Slovenia) sites. We hypothesized that cambial rhythm in trees growing at the sub-Mediterranean site where the two species co-exist will be similar as at typical sites for their growth.

Repeated sampling was performed throughout the year and samples were prepared for examination with light (LM) and transmission electron microscopes (TEM).

Seasonal changes in the cytoplasm of cambial cells were examined by TEM. Number of cell layers in the cambium, as well as the number of developing xylem cells in the stage of expansion, and secondary cell-wall formation along the same radial file was assessed by LM.

Cambium in P. halepensis at the Mediterranean site was active throughout the year and was never truly dormant, whereas at the sub-Mediterranean site it appeared to be dormant during the winter months. In contrast, cambium in P. sylvestris was clearly dormant at both sub-Mediterranean and temperate sites, although the dormant period seemed to be significantly longer at the temperate site. Thus, the hypothesis was only partly confirmed. Different cambial and cell differentiation rhythms of the two species at the site where both species co-exist and typical sites for their growth indicate their high but different adaptation strategies in terms of adjustment of radial growth to environmental heterogeneity, crucial for long-term tree performance and survival.

Phenotypic plasticity and intra-specific variation in water-use efficiency of Pinus sylvestris L. inferred from tree rings

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The coupling of carbon and water cycles in terrestrial ecosystems can be studied by the analysis of water-use efficiency (WUE, ratio of productivity to water loss). However, a comprehensive investigation of the magnitude of spatial, temporal and genetic variation in WUE for tree species relevant for estimating regional carbon budgets is lacking. Pinus sylvestris is a widespread Eurosiberian conifer, but its Mediterranean populations are currently threatened by extreme drought events. In this work, we analysed carbon isotope composition of tree rings to quantify the magnitude of intra-specific variation and phenotypic plasticity in WUE for this species. The genetic variation in WUE was evaluated in a provenance trial established in the Pyrenees (Spain) comprising Spanish and German populations, whereas the extent of (spatial) phenotypic plasticity was characterised in 30 natural stands from the same area. We also evaluated plastic changes in WUE at the temporal level using two chronologies that covered the last three decades. The results showed a very low intra-specific variation in WUE for this species, which was essentially explained by differences between countries of origin. Particularly, German populations exhibited slightly larger WUE (≈10%) than their Iberian counterparts. Conversely, the spatial and temporal phenotypic plasticity in WUE was about eight- and five-fold larger than the magnitude of intra-specific variation. Spatial changes in WUE were not correlated to any climatic, edaphic and physiographic characteristic, with the exception of soil depth. Using remote sensing data we attempted at scaling up site estimates of WUE from tree to stand level. We found a positively correlation between tree-level WUE and an ecosystem-level WUE indicator that accounted for soil depth. Our findings indicate that phenotypic plasticity in WUE of P. sylvestris is much higher than intra-specific variation and is mainly driven by the capacity of the soil to retain water.

Remote-sensing data are closely related to growth information in tree-ring index chronologies – a case study for Pinus sylvestris in northeast Germany

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Valid estimations of changes in forest growth induced by climatic changes depend on the quality of the links between information on environmental factors and the applied growth models. However, many Central-European management models operate with time steps of five years on a statistical basis and lack explicit references to climate or site variables. The effects of varying environmental conditions on forest productivity can often not be simulated, let alone at annual scale.

The presentation will demonstrate an approach to overcome these methodological difficulties by exploiting open-access data on Normalized Difference Vegetation Indices (NDVI as supplied by the MODIS sensor) as indicators for annual changes in productivity. We analyzed the correlation of single and compound NDVI values with increment variation in forest stands as derived from borer core samples from representative trees in a network of Scots pine (Pinus sylvestris) stands on a geographic gradient in northeast Germany. The sample design provides data to additionally cover effects of stand age and sociological class (dominant vs. suppressed trees). To reproduce the climate-sensitive growth and increments of the trees we measured tree-ring widths and derived tree-ring index time series. These data were produced at the general level (per stand) as well as for different sub-samples.

According to our results there is a close relation between local NDVI and variation in tree-ring width indices. The derived linear models are robust, show a high degree of Gleichlaeufigkeit and correlation and can be transferred across the plots. Their integration could deliver more precise productivity estimations, especially for extreme growth conditions such as drought years. Future analyses should focus on mixed stands of different species and on the relationships between additional remote-sensing indices such as EVI and tree-ring indices.

Tree-ring studies of a central Himalayan *Abies spectabilis* treeline ecotone

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Climate warming is expected to induce treelines to advance to higher elevations. Empirical studies in diverse mountain ranges, however, give evidence of both advancing alpine treelines as well as rather insignificant responses. The large spectrum of responses is not fully understood. In the framework of investigating the sensitivity and response of a near-natural treeline ecotone in Rolwaling Himal, Nepal, to climate warming we present results of tree-ring analyses of *Abies spectabilis* (Himalayan Fir). The aim of the study was to determine the dynamics of the treeline and assess the climate influence on the growth of the trees at different elevation. 200 trees were sampled at 3 slopes representing 3 elevational zones (4100 - 4000, 4000 - 3900 and 3800 - 3700 m a.s.l.) . Tree ring width (TRW) and Blue Intensity (BI) were measured. The rate of the growth, the age structure and the forest density within the sites were analysed and compared between sites. After standardization, the chronologies were correlated with temperature and precipitation variables from local meteorological stations and grid data. We found positive correlations between fir growth and summer temperature. In general, the climate signal was stronger for BI than TRW chronologies. Final results will contribute to improved knowledge of *Abies spectabilis* climate-growth relationships and increase the concerning database from the Himalayan region. Moreover, results will be used as an indication of future growth patterns and treeline dynamics under climate change conditions.

Physiological determinants of forest growth in Europe. Derived from carbon and oxygen isotopes

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Deciphering large-scale spatiotemporal patterns of tree performance is essential to forecast global responses of forest ecosystems to environmental changes and their function as carbon sinks. Long-term information can be gained through the analysis of stable isotopes in tree rings as surrogates of plant carbon and water economies. We characterized the physiological determinants (inferred through carbon isotope discrimination, $\Delta^{13}C$, and oxygen isotope composition, $\delta^{18}O$) of tree productivity across Europe in the twentieth century using a network of 23 conifer and broad-leaved stands. We hypothesized that the temporal coherence in ring-width patterns among stands (i.e. synchronous growth) increases northwards across the continent as low temperatures override precipitation as main limiting factor for productivity. We found spatial autocorrelation within the network for ring-width, $\Delta^{13}C$ and $\delta^{18}O$ spreading over sites up to 1,000 km apart. However, growth synchrony was not uniform at continental scale, but increased northwards along a latitudinal gradient (r = 0.77; P < 0.01) concurrent with spatially decreasing temperature and evapotranspiration. Latitudinally-structured relationships between ring-width and $\Delta^{13}C$ (decreasing northwards; r = –0.90; P < 0.001) and $\delta^{18}O$ (increasing northwards; r = 0.62; P < 0.05) pointed to drought impairing carbon uptake via stomatal regulation of water loss as the main mechanism underlying temporal coherence of forest growth below 50°N. Growth synchrony was higher across Europe during the second half of the twentieth century, with the exception of Fennoscandia. This result, together with a stronger relationship between ring-width and $\Delta^{13}C$ in this period, suggested increasing drought effects homogenizing growth patterns across southern and central Europe. We conclude that potential forest shifts from temperature- to moisture-sensitive growth can be tracked continent-wide by detailed analyses of latitudinal changes in tree dependence on gas exchange processes.

Does gender matter? Gender specificity and its influence on site-chronologies in the common dioecious shrub *Juniperus communis*. L

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In recent years the number of shrub based dendrochronological studies have increased strongly as shrubs grow in areas with sparse or limited tree growth and are reliable proxies for ecological reconstructions. While many shrubs are monoecious, some are dioecious and prior tree based studies have shown differing growth patterns between the sexes of dioecious species. This is often related to higher resource investment into female reproductive organs and therefore less resource availability for radial or apical growth in female plants. Is this true is shrubs also? To investigate if gender specific differences potentially affect ring-width data, a common parameter in dendro-studies, we chose Juniperus communis. L a widely distributed and well investigated dioecious shrub species in the northern hemisphere. Our samples were collected from seven sites around the circumpolar Arctic – From the Ural Mountains via Scandinavia to Greenland.

We used several tests: 1) Cluster analysis of all raw and mean detrended ring-width series from individual shrubs at each site failed to find gender biased clusters. 2) We created gender specific ring-width and BAI (basal area increment) chronologies for each site and computed a moving window correlation. Our analysis showed instabilities in time suggesting that there might be differing gender specific responses over specific periods. 3) We then performed a climate correlation analysis (with temperature and precipitation data) with gender-specific ring-width chronologies and found insignificant gender bias. 4) We analysed gender-specific cumulative growth curves by aligning ring-width and BAI data by cambial age, but found no significant differences.

Our analysis suggest that, at least for Juniperus communis.L, there seem to be no significant differences in growth between the sexes based on ring-width and BAI data. Inclusion of different sexes might therefore not significantly affect a common site-chronology.

Constructing 514-year tree-ring chronology in forest-steppe zone of Western Siberia with the use of architectural and archaeological timber

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In past West Siberian forest-steppe area in the Middle Irtish was intensively and long influenced by a human. The largest part has been plowed and applied as farming. Furthermore, often fires, boggy grounds and other factors prevent trees achieving middle age. In this case based on living trees long tree-ring chronology (TRW) has not built yet. However, there are a lot of wooden buildings and archaeological sites with good quality timber preserved in this area. Connecting chronologies based on living trees samples, architectural and archaeological timber samples solve the problem. For this reason, in 2014-2015 we sampled a 71 cores collection of living trees from five sampling areas. Therefore, we constructed 215-year chronology of *Pinus sylvestris* L. To extend it, we collected 171 samples from 13 wooden architectural monuments in Tara city and in open-air museum "Starina Sibirskaya" in the Middle Irtish in 2014-2016. Also, we used archaeological timber collection of 117 cross-sections which archaeologists sampled (Tataurov, Chernaya, 2016). Thus, we built 453-year "floating" chronology using only on architectural and archaeological timber samples. Cross-dating of both chronologies allows to date unique examples of Russian wooden buildings from the one of the first Siberian city Tara and archaeological fortifications remains of XVII century. As a result, we constructed the first regional 514-year tree-ring chronology "Tara" (1502-2015) for the forest-steppe zone in Western Siberia.

This work was supported by the Russian Humanitarian Science Foundation (15-31-01005).

First dendroclimatological insight into black pine (*Pinus nigra* arnold) climate-growth relations in belgrade area

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The radial growth of artificially established black pine (*Pinus nigra* Arnold**)** in the area of Belgrade and its dependence on climate was studied using dendroclimatological methods. The site is classified as *Quercetum-frainetto cerris* Rudski. The climate in Belgrade is a moderate continental one, with an average daytime temperature of 12.3°C and average yearly precipitation of 692.4 mm (1959-2014).

Two versions of chronology (standard and residual) were established from 24 black pine trees (48 radial increment series). The following common characteristics of the chronologies were calculated: mean sensitivity (MS), Expressed population signal (EPS), Signal-to-noise ratio (SNR) and first principal component (PC1). The response of black pine radial growth to climate was evaluated through (1) correlation and (2) response function analysis. In that context, correlation analysis were performed between the radial growth indices and the seasonalized precipitation and temperature data in the period from 1959 and 2014 using Pearson's correlation coefficients. Furthermore, climate signals from black pine radial increment indices were also studied by means of response functions. The applied response function analysis includes 24 precipitation and temperature variables from October prior to September of the current year.

The obtained results of the correlation between black pine radial increment indices and monthly temperature and precipitation data pointed out that there was a strong tendency towards positive response to summer precipitation and a weak negative response to spring and summer temperature. This dendroclimatological study of black pine was performed for the first time in Serbia. It is necessary to perform future studies of black pine radial growth-climate relations in order to expand the data base and to obtain new valuable knowledge of importance for sustainable management black pine forest.

Pointer years in beech growth in the region of Žagubica, Eastern Serbia

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Pointer years in beech growth in the region of Žagubica were determined by applying several methodological procedures, according to the approaches introduced by Shweingruber (1990) and Cropper (1972). The primary sample was taken from five beech stands and it was purified in order to maximize homogeneity of the growth response.

For the longest common period a total of 27 pointer years were recognized by the applied procedures. Only one positive (1992) and six negative (1947, 1962, 1978, 1988, 1994, 2001) years were identified by more than one procedure. Additionally, considering that seven out of eight procedures showed 1988 as negative, it could be designated as a year with especially unfavourable growth conditions.

Subsequently, the dependence between their occurrence and the climate was studied using correlation analysis. The results of pointer years' analysis have highlighted the effect of precipitation. The largest number of identified pointer years corresponded to wet June of the current year.

The determined pointer years, especially the ones detected by several procedures, are in accordance with those observed in the previous studies in nearby areas. This fact could serve as a foundation for establishing the network of pointer years on a broader scale. Taking into account that significant climatic impact has been detected, further dendroclimatological researches (response function method, calculation of multiple regression stepwise analysis, a separate analysis of early and latewood response to precipitation and temperature etc.) should be performed.

Cellular structure of conifer tree-rings – functional-optimization approach

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The most persistent structural feature of *Pinaceae* annual rings is the combination of season trends in variations of tracheid diameter and wall thickness along the radial direction, that is the existence of early - and latewood layers within the ring. But there are other minor variations in morphometric cellular structure: they are deviations from the season trends. Our aim was to determine what combination in changes of radial dimeter and wall thickness could provide the most optimal combination of water conductance ability, mechanical strength at the least metabolic cost.

To evaluate the water transport ability we have applied the hydraulic math model taking into consideration lumen and pit conductance. The mechanical strength was estimated as the portion of the wall volume in the tracheid volume, and the metabolic cost – as the amount of substance in the wall. The differences in the ring cellular structure was modeled as the differences in the ring tracheidogram.

The modeling has shown that the well-known combination of season trends in tracheid diameter and wall thickness variations provides the greatest contribution to the formation of the ring with the optimal combination of functional parameters. The alterations in the season trends can substantially change functional characteristics of the rings. For example, if the ring consists of the early and latewood tracheids differing by their wall thickness but their radial diameters are the same, then their integral water conductance ability is by a quarter less than of the actual ring. If the ring has no structure at all and all the tracheids are of the same radial size and wall thickness then it can conduct water by 40% less than the actual ring. The deviations of tracheid diameters or wall thickness from the season trends can only modify the integral functional characteristics of annual rings.

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Constructing of super long 3290-year tree-ring chronology for the Altai-Sayan region

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The Altai-Sayan Mountains is one of the largest mountain systems of central Asia connecting the current-day territories of Russia, China, Mongolia and Kazakhstan. This region plays an important role in the formation of climatic processes that typically prevail over large parts of central and northern Asia. The combination of mainly undisturbed high-elevation conifer forests and the abundance of well-preserved dry-dead wood make this region particularly interesting from a dendroclimatological point of view. Currently, alpine tree-ring chronologies covered the territory of the Altai-Sayan region are not homogeneous and very varied. In 2013 – 2016 we sampled the collection from living trees and remains of trunks of Larix sibirica from the upper treeline (2250 m) to expand the existing network TRW and improve the quality of TRW.

Currently it allowed building of super long 3290-year tree-ring chronology, which will allow to reconstruction the changes the early summer temperature, the dynamics of the upper treeline for the last three thousand years and to date the high-altitude archeological monuments for the Altai-Sayan region.

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Quantification of factors contributing to white spruce growth at a water and a temperature limited tree-line

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Climate in Alaska is changing at rates above average, exposing white spruce, one of the major tree species in the North American boreal forest, to new environmental conditions. Potentially, both temperature and water availability can limit white spruce growth. Thus, we selected two sites of the species range margins, where we assumed temperature (Brooks Range) and water-limited growth (south-exposed bluff near Fairbanks).

At both sites, we established permanent plots (~1ha) and took tree-ring samples from all white spruce trees within these plots. We also obtained individual tree meta-data like tree height, social status, vitality class and measured coordinates with a DGPS. Principal component analysis and individual-tree climate correlations were used to assess individual differences in climate sensitivity. Linear mixed-effect models were then used to select significant parameters and to quantify how much variance in ring width could be explained by climate and meta-data.

Autocorrelation with previous year ring width, a proxy for the trees reserves, contributed most to current year ring width. Second highest effect on ring width was the year. This effect is composed of abiotic and biotic components, that are not included in other variables and that act on the whole population in the same way. Third were the specified climate variables: negative effects of drought for the water limited site and positive effects of potential evapotranspiration and temperature for the Brooks Range. Vitality class, social status and crowding index only had minor effects on ring width.

These results help to understand which factors limit the growth of white spruce individuals at different sites. Even though the high autocorrelation of tree-ring width is well known, its quantification relative to other factors increases our understanding of white spruce growth. By analysing the interplay of the different variables, especially harmful and beneficial situations for white spruce individuals can be explored.

Decline in groundwater level has a common response in wood anatomy, but individualistic response in tree-ring widths in *Quercus robur*

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Drought events and the overuse of groundwater for water supply might cause significant decline of groundwater level in naturally poorly drained forest stands. However, the documented growth reactions of trees to decline of groundwater level vary a lot and range from positive because of increased soil aeration to strongly negative because of drought stress. We analyzed changes in tree-ring width and earlywood average vessel lumen area of Quercus robur from four sites above artesian aquifer, whose groundwater level abruptly declined in 1990s about 5 m due to water pumping. Since we expected different responses of individual trees due to local microtopography and fine root distribution, the both site-level and tree-level analyses of growth responses were performed. Tree-level analysis was based on clustering of individual trees with similar long-term trend into "responder" groups using Principal Component Analysis. Our results showed that there was not a uniform site-level response of tree-growth to groundwater level pumping. Individual trees were separated into groups of drought limited and water abundance limited individuals. The response of trees to groundwater pumping was contrasting between clusters - drought sensitive trees responded negatively and growth of trees limited by water abundance remained stable or slightly increased. Inter-series correlation as well as negative correlations with soil moisture index (scPDSI) of drought limited trees significantly increased in the period of deepest groundwater level. Contrarily to tree ring widths, earlywood vessel lumen area series contained common temperature signal, with no imprint of groundwater level alteration. Our results indicate that poorly drained forest ecosystems are characterized by significantly individualistic response of radial growth to groundwater level alteration. These individualistic responses could be, however, shadowed in stand-level average tree-ring width chronologies.

Large-scale tree-ring growth analysis in Siberia: process-based approach

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In tree-ring climate relationship analysis one of principal problems, and at same time, one of main factors of successful study is to apply adequate methods and tools of data analysis. And one of such tools, what proofed it usefulness and productivity it is process-based modeling.

But usually use of models is reduced to mechanical functions either for confirmation of work hypotheses or quantitative assessment of physiological tree growth process, unlike statistical methods of analysis. Process-based models can be used purposefully for analyzing the behavior of biological systems under different climatic conditions that they can investigate. Imitation modeling is not a theory, but a methodology for solving problems. Thus process-based modeling is useful methodology for research.

In the study, we analyze relationships between climate and tree-ring growth on a global scale by use of the process-based Vaganov-Shashkin forward model of tree-ring width formation. VS-Oscilloscope (a software of the visual parameterization for the Vaganov-Shashkin model) requires as inputs only study site latitude, daily mean temperature, and daily accumulated precipitation.

The study goal is to analyze a complex process of the seasonal kynetics in tree-ring formation in details, by simulation cambial activity of conifer species based on climate variability.

To archive the goal we analyze a simulate cambial activity on dendrochronological data of circular boreal transect in Siberia (from Yenisei-river to Lena-river). The approach used allows to reveal a qualitative and quantitative assessment of the model parameters, to highlight the principal climatic factors and to determine the dynamics of their influence on the wide-spread territory.

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Quantifying the influence of westerly wave trains on the moisture variability reconstructed from tree-ring stable oxygen isotopes at the southeastern Tibetan Plateau

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An increasing number of publications discuss the role of westerlies for the current and past moisture variability in many parts of the northern hemisphere. It is proven that the westerlies distinctly modulate the hydroclimate of Europe and Western Asia and the southeastern Tibetan Plateau (TP) as well. In this context, westerly wave trains are supposed to occasionally emphasize (impede) the meridional moisture transport during the Asian Summer Monsoon (Wernicke et al. 2017). These findings are based on significant spatial correlations among centers of wave-train action along the north-hemispheric great cycle route. Even though spatial correlations corroborate the influence of westerlies in the Asian summer monsoon region, underlying mechanisms and their fingerprints in tree-ring stable oxygen isotope time series are undescribed yet.

This presentation examine the impact of westerly wave trains on the youngest part of an annual moisture sensitive stable oxygen isotope chronology from the southeastern TP derived from long-living spruce trees (Picea balfouriana). For this purpose, the meridional wind component derived from ERA20C-reanalysis data will be examined with regard to westerly wave-train activity. Furthermore, we compute the spectral coherency between the wave-train activity and our δ18O- chronology. On the longer term, the findings might corroborate the idea that a frequency increase in westerly wave-train activity during the Little Ice Age and the Current Warm Period introduced a wetter (drier) climate at the southeastern TP.

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Poster session

Goodbye Endless Cowboy Prairie!

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Several studies have shown that a wide range of tree species have invaded grasslands in different regions of the world. The invasion of Juniperus virginiana and Pinus ponderosa in the semiarid Sandhills of Nebraska is one example for this ongoing process. By the means of dendrochronology we investigated their growth and their reaction to drought at different stand densities, in the Sandhills and at two stands outside the Sandhills in North-Eastern Nebraska, at approximately 300km to the east, to understand their capacity to adapt. In addition we analysed the water use efficiency (WUE) of P. ponderosa. Our results show that tree-ring widths are highly correlated with precipitation in the Sandhills whereas outside the Sandhills the correlation was lower. The WUE was higher in the Sandhills which indicates a good adaptation of the trees to the limiting environment in the Sandhills. The climate seems not to limit growth heavily due to the ability of the species to adapt.

Modeling tree-radial growth of downy birch from permafrost zone of Siberia

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The projected climate changes suggest significant impacts on high-latitude forest ecosystems. Particularly, climate warming in boreal regions will increase frequency and severity of fires causing changes of forest dynamics. Stands age will decrease and tree species composition will shift from gymnosperm to angiosperm. However, due to their shorter lifespan, angiosperm tree species were rarely investigated. Because of their specific sensitive phenological and physiological traits these species have a huge potential to provide important insights into ecophysiological and dendroclimatological responses to global warming.

The best way to understand tree growth and tree responses to environmental changes is modeling, which allows by using already available experiment/field data and based on the biological principles of growth interpret the climate-growth relationships. In our study we applied the process-based Vaganov-Shashkin (VS) model of tree-ring growth via a new parametrization approach VS-Oscilloscope for the first time to an angiosperm tree species (*Betula pubescens* Ehrh.) from cryolithozone to understand tree-radial growth dynamic. The parameterization of the VS-model provided highly significant positive correlations ($p < 0.05$) between simulated growth curve and initial tree-ring chronology for the period 1951-2011, and displayed the average duration of the growing season and intra-seasonal key limiting factors for xylem formation. Modeled result can be valid at the regional scale for remote birch stands, while justification of the local soil-related input data for the model provided precise individual tree-growth dynamic for each stand and substantiated responses to driving factors.

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Multivariate multi-proxy approach identifies Norway spruce growth divergence on Babia Gora Mountain, Poland

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Tree-growth divergence (GD) – i.e. differing growth reactions of individual trees to external forces within a population – has frequently been reported for various Spruce species (*Picea* ssp.) in North America[1,2]. Since the most dominant European Spruce (i.e. Norway spruce, *Picea abies*) is frequently considered for dendroclimatological and dendroecological investigations, the question arises to what extent it may be affected by GD and – if so – how this may affect corresponding research.

Here, we present results from a regional Norway spruce network from Babia Gora Mt., in the Western Carpathians, Poland. We altogether analyzed 213 Norway spruce individuals separated among 10 sites representing different environmental conditions related to altitude, slope aspect, and forest history. Each individual was sampled for time-series of tree-ring width (RCS-detrended) as well as blue intensity (BI). Both proxies were analyzed for GD using the Principal Component Gradient Analysis (PCGA)[3]. Subsequently, we performed classical climate-growth correlation analyses either on the basis of site-chronologies or on the basis of PCGA responder chronologies.

Our results clearly revealed the occurrence of GD for Norway spruce on Babia Gora Mt. The timing of divergence occurred in the 1960ies and 1970ies – possibly indicating a combined effect of air pollution from coal power plants and cold/dry summers as the main cause of GD in the region. Detailed analyses highlighted that within-site differentiation of growth patterns overrode between site differentiation thus indicating that micro-site heterogeneity was more important compared to differences in elevation and aspect. PCGA allowed for simplifying the network consisting of ten sites to five (RCS) and four (BI) representative PCGA-chronologies, respectively. Climate correlation analyses revealed stronger correlations with seasonal temperatures for specific PCGA-chronologies in comparison to site-chronologies, and allowed for increasing the explained variance of respective transfer functions by 15 % (RCS) and 42 % (BI), respectively. Consequently, dendrochronological studies based on Norway spruce should consider the possible occurrence of GD.

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Are Scots pine forest edges particularly prone to drought-induced mortality?

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In 2016, Scots pine (*Pinus sylvestris* L.) forests experienced a pronounced dieback in several regions across Germany. Being an economically important tree species, identification of the reasons for this dieback is desirable. The dieback is likely to be associated with a record drought event which occurred in 2015. However, visual observations indicate that forest edges were particularly affected. This observation is supported by a study from Sweden which showed that Scots pine trees growing at a north-facing forest edge expressed a higher water use if compared to trees from the interior[1]. We therefore hypothesize that Scots pine trees are more prone to drought-stress induced dieback when growing at the forest edge.

To test this hypothesis, we investigated the growth performance of Scots pine across five affected stands in Franconia, southern Germany. By means of dendroclimatology and UAV-borne remote sensing, Scots pine growth performance and vitality was compared among the stands.

Our results revealed differing Scots pine growth reactions between the forest interior and forest edge as indicated by I) a significantly decreasing normalized differenced vegetation index (NDVI) towards forest edges, II) a clear separation of tree-growth between forest edges and interior using multivariate techniques, and III) partly differing sensitivity of edge and interior trees to the water availability index SPEI[3].

In conclusion, our results highlight Scots pine to be more prone to drought-stress when growing at the forest edge. This finding has important implications for forest management activities in the context of climate change adaptation, since foresters may need to revise concepts of Scots pine management at forest edges and in forest islands under an increasingly warmer and drier climate.

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A Dendrogeomorphological Reconstruction of a Landslide Using Tree-ring Methods

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Dendrogeomorphological methods are regularly used to date and reconstruct spatial and temporal landslide activities achieving the highest accuracy in mass-movement dating. The aim of the thesis presented here is to i) map the extend of the landslide "Bruust-Haltiwald" in Lucerne, Switzerland and ii) to date past and current landslide activities using tree-ring analyses. In contrast to common dendrogeomorphic analyses, we do not focus on conifers only. At this special site, we focus on beech (*Fagus sylvatica* L.) and fir (*Abies alba* Mill.). Consequently, we analyze the occurrence of eccentric growth in both species as a base for a more detailed analysis of tension wood as well as compression wood to accurately date past movements of the landslide body. For a detailed analyses of tension wood, micro sections were prepared for all beech cores showing eccentricities, because this tension wood is not visible macroscopically.

A total of 122 increment cores were taken and analyzed from beech and fir. For each tree, two opposite cores were extracted, prepared with a core-microtome and analyzed to measure ring width and identify eccentricities. 11 trees per species were cored upslope and downslope on the landslide. As reference, 20 trees per species were cored away from the landslide body to record common growth conditions of the area. All reference trees were definitely not influenced by the landslide.

First results show that the analyses of micro sections in addition to a pure eccentricity determination strengthens the results and allows for a more detailed reconstruction of events.

Natural and anthropogenic transformations of a Baltic raised bog (Bagno Kusowo, NW Poland) in the light of dendrochronological analysis of *Pinus sylvestris* L.

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This study was conducted in a drained, exploited, and afforested Baltic bog Bagno Kusowo, located in NW Poland. The study aimed (i) to assess the effects of climatic factors on tree-ring width of *Pinus sylvestris*; (ii) to investigate the effect of anthropogenic changes in the hydrological system on trees; and (iii) to reconstruct the changes in site conditions in the study area and in its immediate vicinity in the last 150 years. Wood samples for dendrochronological analyses were collected from 45 trees. Next, using classic dating methods and standard procedures, chronologies were constructed, as a basis for further analyses: signature years, correlation and response function, as well as percentage growth change. The results of dendroclimatological analyses show weak increment-climate relationships and the analysis of weather conditions in the identified signature years did not detect any unambiguous relations with tree-ring width. However, results of the analyses indicate that the dominant factors affecting tree growth dynamics in the bog are changes in the hydrological system. Moreover, our results show many phases of human impact on environmental changes. Dendrochronological methods, combined with an analysis of old maps and other historical records, allowed us to reconstruct transformations of the ecosystem with a high resolution.

Pinus cembra L. maximum wood density records late summer maximum temperatures in the Ortles-Cevedale Group (Rhaetian Alps, Italy).

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Increasing temperatures over the last decades are well established. To place the ongoing climate change in a long-term context, climate information extending beyond the industrial era is needed. Many regional climate reconstructions have facilitated our understanding of past climate dynamics. Furthermore, local reconstructions are essential to enhance regional climate models by improving the spatiotemporal data coverage back in time. The Alpine region is a key area in terms of impacts of climate change, which is especially evident in the reduction of glacier extents. The use of maximum latewood density (MXD) chronologies can provide a better temperature information than the tree-ring width, nevertheless MXD series in this area are still characterized by a considerable lack. To investigate the potential of deriving high-quality temperature information from the Rhaetian Alps, 12 Pinus cembra L. trees, sampled at around 2000 m a.s.l., were used to construct a MXD chronology. The chronology spanned from 1780 to 2015 and its potential as a temperature proxy was assessed. The correlation between the standard (residual) chronology and CRU-TS 3.24 temperature data, shows that the MXD was significantly correlated with May and July-September (May and August-September) mean maximum temperatures during the last century. Thus, contrary to MXD data from higher latitudes, MXD in this study does not contain information of an extended growing season (April-September). Still, our results underline the potential of Pinus cembra to reconstruct mean maximum temperature variations, especially during the latter part of the growing season, providing additional information on months not inferred by other species. Future studies on MXD of this species will further increase the temporal and spatial data availability allowing detailed climate reconstructions.

Stable isotopes in Siberian tree-rings

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As well known, trees growing in northern tree line in the permafrost zones are very sensitive to climate changes due to limiting of temperature regimes. The tree ring width and tree ring density therefore provide temperature information but relatively little is known about precipitation changes. However, under low amounts of precipitations and relatively warm and dry conditions trees respond to limited water resources by reducing stomatal conductance, resulting in a diminished intercellular CO_2 concentration. The $\delta^{18}O$ in tree rings are mainly influenced by the isotope signal in precipitation, which represents the source water for trees. Enrichment in $\delta^{18}O$ occurs in the needles during transpiration, which may be enhanced under drought conditions. A mixed signal of source and needles water enrichment is finally stored in tree-ring cellulose.

The stable carbon and oxygen isotope chronologies obtained from the Siberian north show significant relationships not only with temperature (like tree ring parameters) but also with precipitation (unlike tree ring parameters). Most of the Siberian sites covered by permafrost play a key role in stabilizing of the climatic system. The $\delta^{18}O$ signal could be weak in the year to year variability due to the complex soil hydrology caused an increased water availability from thawing by permafrost and a mixture of winter precipitation, and summer rainfall. However, it is possible to expect strong long-term signals connected with annual precipitation and atmospheric circulation patterns.

The application of the stable isotope analysis in combination with dendrochronology is steadily increasing because stable isotopes provide complementary information about climatic variabilities, particular paleoecohydrological changes.

In fact, the quantitative information about climatic changes in the past could be obtained with a using multi-disciplinary approach by analyzing multi-proxy data.

Pointer years in larch (*Larix decidua* Mill.) from the Polish Carpathian Mountains

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The results presented here are a part of the broader dendroclimatological study of larch from the Polish Carpathian Mountains. Pointer years analysis was performed in the site network consists of more than 30 sites. Tree-ring sequences of larches from various elevations, with various slope aspects, more than 100 years old, were analysed. Pointer years were determined using low-pass filtering based on running means and standard deviations of ring-width measurements – method originated from Cropper (1979). The standardization was done in five year moving window. Years with values above 0.75 of Z-score standard deviations (defined as “moderate pointer years”) and above 1 (“strong”) were taken into consideration. Among the detected years, 3 positive (1961, 1966, 1986) and one negative (1980) points out as “strong pointer years” in more than half of the analysed sites. The results of pointer years were analysed taking into account the groups distinguished by cluster analysis done for the site chronologies. The differences in the occurrence of particular pointer years and its strength within and between particular clusters were discussed. To find the possible explanation of the observed pointer years

the results of the climate-growth relationship analysis, climate data for the region and other available data were used and analysed.

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Current changes of high-mountain forests in the Northern Urals: extensive analysis

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Here we show the significant changes in the composition, morphological and age structure of forest stands in the treeline ecotone of Molebny Kamen ridge (Nothern Urals, Russia), which occurred in the second half of the XX century. Recorded dynamic of climatic conditions led to the treeline shift, change of the dominant species (from white birch to Siberian stone pine) and increase of radial growth of trees.

Dendroanalysis show high synchronicity and significant correlation between 4 generalized tree-ring chronologies , that also indicate a decisive role of climatic factors in the growth dynamics of the studied area. The analysis of climatic response found that radial growth of all studied species is determined by the spring and early-summer conditions.

High-resolution and multi-proxy approach to study the paleoclimate of South-Eastern Alps

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Paleoclimate reconstructions are expected to be more detailed, higher is the resolution of the data from the natural archives. In this framework, ombrotrophic peat bogs are an excellent archive of multi-source data, which we can study and compare, providing important elements for past climate reconstruction. The Alps represent an optimal area to study past climate trends because they were subjected to strong climatic changes over time. Because of this peculiarity, several studies have been carried out in the Alps, providing paleoclimate reconstructions dating back to very ancient times. Nevertheless, we still observe a gap of knowledge about the Holocene climate trend in the South-Eastern Alps. This area is characterized by the presence of numerous mountain peatlands, which have been studied in terms of vegetation composition, but a complete investigation of these natural archives to derive past climate information is still partially missing. The aim of this study is to reconstruct the Holocene climate in the South-Eastern Alps by using a high-resolution and multi-proxy approach. We will analyze a high-altitude peat, collecting a set of information along the peat stratigraphy so to include: radiocarbon dating, testate amoebae distribution, plant macrofossils and dendrochronological and stable isotope analysis of subfossil trees. This approach should allow us to obtain a strong climatic signal in order to reconstruct the past climate trend in the South-Eastern Alps. Furthermore, the climatic signal associated to the last decades will be analyzed to assess the impact of atmospheric CO_2 increasing and global warming on these ecosystems in order to adopt sustainable management and conservation strategies.

Dynamics of heavy metal (Ni, Cu) and sulfur (S) content in tree-ring of larch affected by industrial pollution from the Norilsk smelters

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Anthropogenic factor associated with the resource-extractive industries, is continuously increasing its pressure on northern ecosystems. Where, vegetation is limited not only by the temperature regime but also by the deficiency of macro and microelements Tree-rings was shown to be a valuable proxy of atmospheric pollution and dendrochemistry is a promising method to trace environmental changes. Here we present the results of elemental analysis of wood and soil from the ecosystems affected by the pollutants emitted by the smelters of Norilsk Industrial Region.

Heavy metal (Ni, Cu) and sulfur (S) concentration in wood of larch with annual resolution was studied. The element content was defined with the use of X-ray fluorescence scanner Itrax Multiscanner for both dead due to pollution and still living trees at sites located at various distances from the sources of pollution, for a complex geo-ecological assessment of the studied sites.

Elemental content of the wood samples was combined with the data on elemental content of soils. For soils received total content (Ni, Cu, S), concentration water-soluble form and movable form in ammonium acetate buffer-extractor these elements.

It is shown that the contamination of the explored areas is due to the air transport of anthropogenic emissions of smelters, which is reflected in the accumulation of heavy metals and sulfur in the organic-soil horizons. And subsequent transport under physiological nutrition and accumulation in different parts of the tree. The maximum content in the studied elements in larch wood samples was found in the areas which are located on the way of gas and dust emissions in accordance with the wind rose. Also was found, that the hydrogeological regime of the area, affects the content of heavy metals in soils.

Preliminary results demonstrate a high potential of multi-elemental analysis of tree-rings in detection of the features of changes in wood chemistry at one of the most polluted region of the world.

Might *Dryas octopetala* be a geomorphologist's best friend?

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Debris flows are natural hazards endangering human life and infrastructure in alpine areas. It is therefore important to gain a detailed understanding of these events by reconstructing the frequency of past debris flows. The aim of the study presented is to analyze to what extent the pioneer dwarf shrub mountain avens (Dryas octopetala L.) can be used to reconstruct debris-flow events in the alpine site Marlt-Graben.

The Marlt-Graben is situated at the foot of the Ortler mountain peak, north of the village Sulden in South Tyrol (Italy). The site is highly affected by debris-flows and avalanche events. Consequently the mountain slope shows a series of very distinct debris-flow channels composed of mostly calcareous moraine material, which are partly covered by vegetation like mountain pine (Pinus mugo) and mountain avens. This dwarf shrub species is restricted to calcareous substrates and is widely spread in respective high mountains and arctic regions. Within three debris flow channels with differing vegetation cover densities 150 mountain avens plants were sampled and their distance to the channelbed was measured. One thin sections per plant was cut from the main stem using a GSL1-microtome. The samples were bleached, stained, embedded in Canada balsam and each section was photographed under the microscope. Thereafter ring-width measured was performed using WinDendro. In a further step the cross-dating of the samples of each levee of one channel was attempted using TsapWin.

First results show a relation between the mean age of the plants on the levees and the respective density of the vegetation cover. Unfortunately no common growth pattern on the levees could be observed relating the distance of the plant to the channelbed and the plant age. While determining a minimal plant age was possible, the cross-dating was difficult. The plants did not show a common growth signal. However groups of plants with similar growth pattern were found. Nevertheless, precise cross-dating was not possible based on single sections per plant.

These results indicate that while Dryas octopetala can be used to define a minimum number of years since the last erosive event happened, a precise dating of events within the channels based on cross-dating of these shrubs is hardly possible.

Tracheid anatomical changes of *Larix sibirica* under drought stress

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Tracheid anatomical analyses can help understanding xylem structural responses to climate. In this work we aimed at identifying which cell anatomical metric (such as cell lumen size and cell wall thickness) can provide indications of tree responses to a changing climate under water-limited conditions.

We measured tracheid anatomical features along the 1986 to 2015 tree-rings from 8 mature *Larix sibirica* growing in the dry forest steppe in Khakassia (Russia). Tracheid measurements were performed on annual ring cross-section using ROXAS and were grouped per sectors according to their position in the ring. Superposed epoch analysis was used to assess the trees' resilience to drought through xylem adaptation.

Results indicate that xylem formation is affected by drought. In particular previous summer and early season mostly decreases the lumen of earlywood tracheid. Summer precipitation mostly affects the wall thickness of latewood cells. The impact of drought last for only 1 year and causes an increase in construction costs per unit of potential water transport.

This detailed analysis of intra-ring xylem anatomical responses highlighted that climate can affect both earlywood water transport and latewood density. Our analyses emphasizes that these ecosystem can rapidly recover from drought events and show strong resilience to sporadic extreme events.

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A new methodology for a higher chronological resolution of charcoal manufacturing historical activities in eastern Pyrenees (Ariège, France)

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In the 80-90s several geohistorical and palaeoecological studies carried out on the northern Pyrenees slope were decisive to reconstruct long-term human-forest-climate interactions especially the impact of ore processing and charcoal manufacturing activities on forest cover changes. The anthracological study of numerical charcoal kilns have led to reconstruct forest evolutions since the beginning of the Modern era to the 19th century. Most of radiocarbon dates from charcoal kiln remains are situated on the modern radiocarbon plateau. This is a major problem especially to identify groups of synchronous charcoal kilns located in the same area. Since 2013, new researches funded by the Observatory Human-Environment Haut-Vicdessos (LABEX DRIIHM) and focused on ancient forests with numerous charcoal kiln remains allowing a renewal of methodological approaches. . One of the current main focus is to obtain a higher chronological resolution of charcoal manufactury activities in developing dendrochronological analysis of larger charcoals from both main species charred by charcoal makers: *Fagus sylvatica* L. and *Abies alba* Mill. This exploring study carried out in the Bernadouze forest (Haut-Vicdessos, Ariège) is based on the construction of a local and original reference chronologies for *Fagus sylvatica in Eastern Pyrenees from* living trees. In a second time, individual tree-ring width series from charcoals will be crossdated to obtain floating chronologies of charcoal manufacturing activity and to identify synchronous charcoal kiln groups. In a last phase, we will attempt the crossdating of reference chronologies from both living trees and charcoals using also chronological benchmarks from several radiocarbon analyses. This poster will present more accurately this suitable methodological approach to reconstruct forest history in past mining European areas with a higher chronological resolution. Expected results from this new approach will permit to enhance knowledge about forest management evolution from the end of the medieval period to the 19th century

Climate sensitivity of beech and oak stands in a coastal forest in northeastern Germany affected by their management regime

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Understanding how climate change is affecting forest growth is a central concern to be addressed given the potential of forests for carbon sequestration (Pachauri et al., 2014). Adapting forest management strategies to changing environmental conditions is only possible if we disentangle the effects of climate and management on forest growth. In this study, we apply this question for typical central European lowland forests. We used a retrospective dendrochronological analysis for similarly age-structured Fagus sylvatica L. and Quercus robur L. stands each under two different management schemes (managed vs unmanaged). Climatic parameters included in the analysis were temperature, precipitation, and a drought index (SPEI). Although temperate forest trees growth is controlled by a number of factors, minor differences in climate sensitivity could be found between differently managed sites, as well as between species. In general, trees in managed stands show a larger climatic sensitivity than trees in unmanaged stands. These results are probably related to the higher structural homogeneity in managed sites resulting in less inter- and intra-species competition, which enhance the importance of climatic drivers on radial growth (van der Maaten, 2013). Knowing about the main climatic growth drivers affecting these two species, which are representative for climax ecosystems in central European forests, can help adapt sustainable forestry guidelines in this region and increase their carbon sink potential.

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Microscopic Preparation Techniques - Microtomes and their application

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In the past, studies on new analytical techniques in wood anatomy, dendrochronology and plant physiology mostly focus on microscopy, image analysis or modelling procedures of cellular plant development. The development of technical devices required to produce high quality micro sections, which still are the base for analytical techniques, was more or less ignored.

Until recently, environmental studies based on micro sections were rare. This was mainly because there were no suitable microtomes and accessories available. Commercial microtomes are principally constructed for embedded tissues in medical domains. Purely mechanic devices were not stable enough and for this more or less suited for cutting rather soft material only. In contrast to fast and widespread computer based image analysis developments, mechanical based techniques for preparing different sized specimens of variable density have been largely neglected. In many laboratories, independent of their financial and personal capacities, suitable microtomes were hardly existing.

In contrast to this, there was an increasing demand to combine wood anatomical and dendrochronological methods for a more detailed understanding on how environmental conditions influence the growth of woody plants. Especially the intense inclusion of wood anatomy in tree-ring sciences required the development of new techniques enabling to analyse wood anatomical parameters over long time periods e.g., on centennial or even millennial time scales.

The development of new microtomes to produce micro sections up to a length of 40cm presented here was a step towards the integration of wood anatomy in time series analysis. Despite the pure development of cutting devices, we also developed efficient techniques to stabilize cells while cutting by avoiding the time consuming procedure of embedding the material.

Climate and the growth of coniferous trees and shrubs at the Northern Timberline in the Yamal Peninsula and Polar Urals

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Dendroclimatic studies in subarctic regions revealed important space and time dependencies of radial growth of tree species as well as of climatic conditions. Climate reconstruction from tree rings of shrubs could provide more details on inter-seasonal/intra-seasonal variability of summer temperature in the cold regions. The long living Siberian juniper is one of the most promising species for dendroclimatic studies in Siberia, Ural Mountains and northern Russia in Europe. Siberian juniper ring-width indices contain temperature information on summer months (June–July), and spring month (May). If juniper ring width–mean May temperature relationship turns out to be reproducible and reliable, this open the possibility to reconstruct new climatic data. Such a reconstruction has been produced on the base of estimation of parameters of multiple linear regression equation. The resulting reconstruction matches better with the actual temperature curve than those based on single species

The analysis of anomalous structures in tree rings provides a promising method for reconstructing frosts and multiday abrupt temperature declines during the growing season in times before the advent of instrumental meteorological observations. This is of particular importance in the subarctic regions of Siberia and the Urals where, in contrast to the situation in Europe, there are virtually no records of anomalous climatic events in preinstrumental times. Frost and light rings of living and dead individuals of Siberian juniper and Siberian larch growing at the upper (Polar Ural Mountains) and polar (Yamal Peninsula) tree lines in northwest Siberia have been studied to reconstruct summer frosts and abrupt temperature declines during the second half of the growing season over the past 1250 years. Comparison of our data with data from other regions of the world shows that there is agreement in the timing of extreme temperature events between several regions

Intra-annual leaf phenology, radial growth and structure of xylem and phloem in different tree parts of *Quercus pubescens*

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Knowledge of the intra-annual timings of leaf development and radial growth (including the phloem part) in different tree parts is generally missing. To understand the time-course of leaf development and radial growth patterns in different tree parts better, we studied leaf phenology and intra-annual xylem and phloem formation and structure in the stem and at two locations in branches of sub-Mediterranean Q. pubescens.

Onset and end of cambial cell production were synchronized at the two locations in branches but differed at the stem base. The period of cell production was thus a month longer in the stem, resulting in 82.8 and 45.1 % wider xylem and phloem increments, respectively. In addition, the xylem ring was wider than the phloem ring in all three parts, being 80.1 % and 55.8 % in stem and branches, respectively, of the annual radial increment. Earlywood occupied 52.9 % (stem) and 74.9 % (branches) of the xylem ring, and early phloem 53.7 % (stem) and 43.3 % (branches) of the phloem ring. Most of the annual radial increment in stem and branches was formed prior to full leaf development. Latewood and late phloem were formed in the period of full leaf unfolding.

Our study confirmed that the temporal sequence of leaf development and radial growth is not contemporary in Q. pubescens. Different intra-annual patterns of xylem and phloem formation in different tree parts result in different architecture, which is in line with different roles of stem and branches in terms of tree functioning. To link the structure and function of vascular tissues, data from different tree parts are crucial because discussion on translocation pathways and water transport in a tree is based on these findings. The observations further suggest that anatomical data from stem/ branches cannot be extrapolated and interpreted to the whole tree level.

Ecological types of upper tree-lines in the Southern Ural Mountains

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The upper tree-lines are the most important biogeographic boundary of tree distribution in mountains. Groups of tree-line types are different: (1) Biological (species), characterized by different mesoclimatic conditions and, as a consequence, different tree species composition. (2) Ecological, based on various environmental factors and topographic complexity of mountain relief, characterizing by a uniform species composition and located at different altitudes above sea level within a separate ridge. (3) Anthropogenic, formed in response to a variety of human activities and located below the natural upper tree-line (Gorchakovsky, Shiyatov, 1985). In recent years the main attention of researchers is focused on the study of the spatiotemporal dynamics of ecological tree-lines. The purpose of this work is to identify the main ecological types of the upper tree-lines in the Southern Urals using annual tree-ring growth on each of them. Three main ridges of Southern Urals were investigated: Dalniy Taganay, Nurgush and Zigalga, main coniferous species growing here is Siberian Spruce (*Picea obovata* Ledeb.) There are edaphic, thermal, wind and snow upper tree-lines in the Southern Urals. Edaphic tree-line (debrysflow, kurumnik, stone river tree-line) is connected mostly with unfavorable ground conditions (no any soil above tree border). Climatic (temperature) tree-line is one of the highest situated tree-lines and tree distribution is limited by temperature. Most of modern investigations of upper tree-line dynamic are concentrated on this type. Wind tree-line is border, which is limited by strong wind. Tree-line is located lower as climatic tree-line and connects normally with high heterogeneity of mountain ridges. Snow tree-line forms near glaciers and snowfields. Due to slow snow melts, the growth period is very short. Differences in tree-ring width dynamics are revealed.

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Testing the reaction of five tree species to industrial air pollution

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Tree growth in industrialized regions is impacted by various kinds of air-pollutants resulting in a reduction of tree-growth, a temporary stop of cambial activity or even dieback of trees (Innes and Cook 1989). Upper Silesia is the most industrialized region in Poland. Its development in the 19th and 20th century was based on heavy industry: coal mining, metallurgy, and later energy production. During the intensive production period in the second half of the 20th century, a severe and long lasting growth decline of Pinus sylvestris was observed (Danek 2007, Malik et al. 2012). Political and economic changes in the 1990s caused a dramatic decrease in heavy industry production and coincided with changes in emission policy. Both resulted in a drastic reduction of emissions and a consequent improvement of regional environmental conditions.

The aim of our study was 1) to identify the pollution imprint on growth (TRW), and 2) to compare the character and rate of recovery after 1990 of five major tree species growing in a mixed forest. We sampled three coniferous (*Picea abies* L. Karst, *Abies alba* Mill, *Pinus sylvestris* L.) and two deciduous tree species (*Quercus robur* L., *Fagus sylvatica* L.) for a dendrochronological analysis (50 trees per species).

Coniferous species seemed more affected than deciduous species, which hardly show any influence of pollution. Conifers had distinct growth depression in the years of intensive pollution (1970s and 1980s) and showed a considerable recovery in the decades after. Within conifers, silver fir seems most impacted, compared with Scots pine and spruce.

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Tree growth responses to changing temperatures: a fine-scale analysis along elevation gradients at the natural upper treeline in the Swiss Alps

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Tree population dynamics and particularly growth rates of trees are decisively affected by ambient temperatures. Hence, climate warming is expected to have severe impacts on the growth and species ranges of trees, especially where temperature acts as a limiting factor. While the relationship between temperatures and tree growth has been analyzed for a long time, the relative importance of air versus soil ambient temperatures as well as the functional form of growth and those temperatures, when approaching the limits of tree growth, remains to be explained.

We therefore compiled temporally and spatially highly resolved air and soil temperature parameters along nine elevation gradients in the Swiss Alps, reflecting fine-scale differences in growth conditions along these transects. These temperatures were then paired with tree-ring data from more than 200 trees of four major treeline species along the same transects.

Using Spearman's rank-correlations, we found the contributions of different temperature parameters to variability of basal area increment to vary across species and sites. The highest correlations of both air and soil temperatures with basal area increment were achieved using combined degree-day sums of the current and previous growing season. The importance of soil temperature for growth appeared to be site-specific. Approaching treeline, the basal area increment of all species was highly dependent on degree-day sums. Assuming a linear relationship between basal area increment and degree-day sums, the residuals largely increased towards higher degree-day sums. This indicates a gradual decrease rather than threshold behavior of the temperature limitation and increasingly important factors other than temperature influencing tree growth when moving down from the treeline. Long-term trends of tree growth confirmed this pattern by featuring clear and strong increases in ring-width for all species at the highest elevations during the last century and increasingly undetermined trends when approaching the lower end of the transects.

Deciphering the climatic signal from Norway spruce growing in the karst environment of the Velebit Mts., Croatia

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Dinaric Karst regions constitute particularly complex habitat for forest which results from water availability, soils characteristics as well as microclimate. Therefore, describing the growth-climate relationship based on the size of annual tree rings composes a challenge.

The aim of our study was to decipher the climatic signal in ring width and density related proxies of Norway spruce in the Velebit Mts., Croatia, representing classical mountain karst environment in Dinaric region.

We collected core samples from more than 150 trees among 14 sites located in the timberline ecotone (cca 1500 m a.s.l). Two kinds of sites can be distinguished – the limestone slope and the karstic sink. Six different parameters were measured on wood samples, three related to width of tree ring: whole annual ring, early- and latewood widths and three related to Blue Intensity (BI) as a surrogate proxy of wood density: early- and latewood BI as well as delta BI. The instrumental and gridded (0.5^{o} and 0.25^{o}) climate data was used to compute the growth-climate relationship.

None of the ring-width parameters revealed any statistically significant correlations with climate variables whereas the BI proxies correlated better with climatic series. The latewood BI revealed positive correlation with summer temperature (June-August 0.33). However, the strongest signal was obtained using delta BI (parameter derived from both early-and latewood BI). The delta BI correlated with temperature obtained from the local meteostation and showed positive influence of whole growing season (May-September r=0.49) and summer – early autumn (June-September r=0.51) temperatures.

Impact of climatic factors on radial increment of pedunculate oak (*Quercus robur* L.) in Northern and Southern Belarus

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Pedunculate oak are one of the most valuable tree species that naturally grow in forests of Belarus. Oak's state and growth are largely depends on the influence of climatic and anthropogenic factors.
The objects of our research were mature oak stands in Northern (BL08o, DSN01o, VRH02o) and Southern Belarus in National Park «Belovezhskaya Pushcha» (NPBP64o, NPBP71o, NPBP72o) in different forest types. Totally 106 wood samples were taken. The tree-ring chronology for each sites include from 10 to 22 trees. The average tree age is 150 years, but some trees has an age about 300 years old.
For chronologies in the northern Belarus, significant negative correlation coefficient was noted between the annual increment and the temperature of August of the previous year in DSN01o chronology (-0.33). For the same chronology positive correlation coefficient was between the annual increment and precipitation in August of previous year (0.25) and precipitation in January (0.23) of this year. Also, negative significant correlation coefficient between radial increment and temperatures in August of the previous year is observed in chronologies BL08o (-0.26). The high temperatures in August of previous year contribute of drought in the end of vegetation and trees cannot start to growth actively in the next year. For VRH02o chronology significant positive correlation coefficients were noted between radial increment and temperatures of all winter months.
For chronologies in the southern Belarus, there is a positive relation between the radial growth and precipitation of summer months in the chronology NPBP64o. This confirms that great amount of precipitation and high temperatures contribute to the active growth of oak trees in the study area. For chronology NPBP71o positive correlation was observed between the radial increment and temperature of October of the previous year (0.27). The NPBP72o tree-ring chronology is characterized by positive significant correlation coefficients between radial increment and temperatures of December of previous year (0.30) and March (0.23). Significant positive correlation coefficients are observed between the radial increment and the precipitation in July (0.30) and August (0.44).
The response function explains 30.2% of the variation of tree-ring width in the chronology of BL08o, 37.7% – DSN01o, 39.2% – NPBP64o, 18.9% – NPBP71o, 40.7% – NPBP72o, 53.5% – NVG01o and 43.2% – VRH02o.
The main differences in the response of increment to climate for Southern Belarus are positive influence of precipitation in summer months and negative influence of air temperature in August of the previous year. At the same time, temperatures of winter months and temperatures of the vegetation period positively influence on increment in Northern Belarus. Despite the fact that climatic factors play the main role in fluctuation of oak radial grows we discovered impact of other factors – cuttings, drainage, pests, which can radically change the tree grows.

The main features of the variability of the thermal regime of temperature reconstructions by different proxy sources in Northern Hemisphere for the last two millennia

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A short series of instrumental data of the climate makes it necessary to consider indirect sources in the study of the variability of the temperature regime. The purpose of our study is to identify the main temperature anomalies in the Northern Hemisphere over the past 2000 years.

We have studied paleoclimatic climate reconstructions in the Northern Hemisphere. The main objective of this study is to build a generalized climate reconstruction over the past two thousand years based on all available climate reconstructions based on various proxy sources. Only the reconstructions published in scientific journals were used. The data presented in the publications were digitized by scanning and conversion in their program into a digital form and normalized.

Thus, 102 paleoclimatological reconstructions with a by year resolution were processed. Then they were divided into several groups by the type of proxy sources. As a result, the main features of the variability of the thermal regime in the Northern Hemisphere were determined, the most common regularities (anomalies) were found in temperature reconstructions based on proxy sources. We determined the similarities and differences between reconstructions and determined the influence on the result of the selected indirect source.

We conclude on the frequency with which large climatic events occur in the reconstructions, such as the Little Ice Age, the Medieval Warm Period, and others. For the generalized of the graph over the entire period for various indirect sources over the past 2000 years, the alternation of high-frequency oscillations is characteristic, along with noticeably prominent long periods of warming and cooling. All the reconstruction of various indirect sources show a noticeable warming since the 19th century, which is characterized by the beginning of industrialization. According to all sources, the current warming is unprecedented in the last 2000 years.

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Dating of avalanche events in the High Sudetes using dendrochronological methods

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Snow avalanches occur not only in alpine areas but also in mid-mountains such as the High Sudetes (Czech Republic / Poland). They represent important feature with implications in ecology, forestry, geomorphology and natural risk prevention. The information about avalanche activity (i. e. magnitude and frequency) is necessary to understand the above mentioned consequences. The presented poster deals with dating of avalanche events using dendrochronological methods in 12 avalanche paths located in both western (i.e. the Krkonoše Mts.) and eastern (i.e. the Hrubý Jeseník Mts. And the Králický Sněžník Mts.) parts of the High Sudetes Mts. Total of 501 trees (*Picea abies* (L.) Karst.) located within the avalanche paths and on their borders were sampled and analysed by standard field and laboratory methods. Following markers of disturbances were taken into account: dead wood, scars, traumatic resin ducts, abrupt growth changes, eccentricity and reaction wood. In the western part the results of dendrochronological approach were validated by the avalanche catalogue gathering information about observed avalanche events since the second half of the 20th century. Moreover, meteorological data and evidence about avalanche events in different paths were used for the validation in the Eastern High Sudetes because of absence of avalanche catalogue in this area. The occurrence and frequency of avalanches in the Eastern High Sudetes is lower than in the western part of the High Sudetes and and there is high variability in avalanche frequency among avalanche paths. The results show good ability of dendrochronological methods to reconstruct strong avalanche events because 55 % of such observed events were correctly dated. This indicates suitability of dendrochronological approach for use in areas for which information about avalanche activity is lacking.

Possibilities and restrictions of the streamflow and PDSI reconstruction in the Volga region using dendrochronology

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There are no instrumental observations of hydrometeorological parameters longer than 120 years in the Volga Region and in Russia as well. The length of hydrological records such as river streamflow is even shorter and goes up to 50-60 years. However, dendrochronological method gives the possibility to extend the actual instrumental data in case of strong, stable and significant correlations between tree ring data and reconstructed parameter. During the study, we have built 9 pine (*Pinus sylvestris* L.) tree ring chronologies and one regional chronology MasterTY. Then, based on tree ring data and linear regression model we tried reconstructing streamflow of Ilet river (1827-2013) and Palmer Drought Severity Index (1825-2013) for the region. The study shows a big potential for such reconstructions in the Volga region. The models explain 27 to 34 % of the PDSI and streamflow variability. The reconstructed datasets reflect the main extremes in the actual data.

The study was supported by RFFI project № 16-35-00408.

Tracking permafrost degradation and climate variability in *Betula nana* from Subarctic Sweden

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Permafrost around the globe is decreasing in spatial extent and thickness. While the complete disintegration of permafrost is a significant change, many biogeochemical processes that follow and contribute to changing the environment are dependent on the extent of the active layer. One such is the spread of shrubs which has come to dominate many of these areas. This leads to them potentially being a significant force on how the environment develops. To find a way to estimate the spatiotemporal patterns of permafrost degradation in Subarctic Sweden, we assess the potential of using annual shrub growth rings as indicators of permafrost change. A total of 90 specimens of the shrub *Betula nana* were collected at three different locations based on a temporal gradient of permafrost degradation. The shrubs were serially sectioned to facilitate crossdating, then microsectioned and stained to make visual RW measuring possible. The goals are (1) to find a signal in the growths that correspond with the times of permafrost degradation for each respective site, and (2) to assess their usability for dendroclimatology. Preliminary results show (1) most shrubs covering the relevant time period with some being a up to few decades older than the period when the permafrost is thought to have disappeared, and (2) despite growing in an extreme environment they show a similar inter-annual environmental dependence.

Sign of air pollution calamity in anatomical features of spruce (*Picea abies* (L.) Karst) in the Klínovec area (Ore mountains)

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Fossil fuel emissions caused one of the globally highest pollutant deposition. Upper parts of the Ore mountains have been stressed mainly by the sulphur dioxide for a long period of time especially in 70s and 80s of 20th century. That's why is the region of northern Bohemia and neighbouring parts of Saxony and Poland often called "black triangle". Klínovec area is thanks to combination of altitude, low temperatures occurrence and presence of pollution fundamentally model locality.

Data produced using quantitative wood anatomy method can serve us as sensitive indicator of environmental changes. Research deals with how enormous pollution loads together with frost can affect microscopic structure of old spruce stand wood. Values of anatomical features for period before, during and after highest pollution loads as number of tracheids, lumen area, cell wall thickness and tree ring width from three localities nearby Klínovec hilltop at altitude around 1 000 m.a.s.l. and from one locality at the hilltop (1 244 m.a.s.l) have been measured for individual years and compared. Number of cells together with tree ring width seems to be the most responsive feature. Increasing of feature values after stress period is apparent.

Tree-ring measurements across European forest sites reveal effects of global-change drivers on tree growth dynamics

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The last decades are characterized by an upsurge in the number of studies on global environmental change impacts on forests. In temperate forests, the most important global changes include land-use change (e.g. changes in forest management), climate change, and increased atmospheric deposition. Since the existing research has strongly focused on the effects of single factors on tree growth dynamics, studies investigating the combined (and potentially interacting) effects of these changes are lacking. Multi-factor studies are urgently needed since interactions among drivers might cause responses to differ from those in single-factor studies. In this study, we will evaluate the interactive effects of past forest management, climatic changes, and increased deposition, on growth and competition dynamics of European tree layers. In a pan-European network of 192 plots, spread over 19 study sites, we cored a total of 370 dominant individuals of *Quercus robur/petraea*, *Fagus sylvatica,* and *Fraxinus excelsior*, the three most common broadleaved species in temperate European forests. Our sites covered a large gradient in climatic conditions and atmospheric deposition rates, while the different plots of each study site, encompassing similar site characteristics, covered distinct classes of past forest management. We demonstrate how this sampling design allows disentangling the effects of the three global-change drivers on tree growth responses such as growth release characteristics, tree growth rates, and intraspecific competition rates. Our results should provide a more mechanistic understanding of how the three drivers of change interactively affect tree growth dynamics, so that forest managers and policy makers might make more informed decisions on sustainable resource extraction in European forests.

Growth response of *Abies pindrow* to changing climate along an elevation gradient in north-western Himalayas

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The climate of the Himalayan mountain range changes drastically with increasing elevation, the growth is expected to react differently to this changing climate. The relationship between the regional climate and growth is not well understood in case of Himalayan conifers.

Tree ring cores of *Abies pindrow* were studied along an elevation gradient in the north-western Himalayas. Ring-width chronologies were developed from three elevations: Low (2350-2450 m a.s.l.), Mid (2650-2750 m a.s.l.) and High (2950-3150 m a.s.l.). 452 cores from 244 trees were used in this study. The mean ring-width decreases significantly with increasing elevation from 2.40 mm at Low to 1.42 mm at High elevation. Also, Mean Sensitivity decreased with elevation from 0.24 at Low to 0.18 at High elevation. To understand the response of tree growth to environmental factors along elevation gradient, correlation and response function analysis was used to study the relationships between tree ring-width and mean monthly temperature and total monthly precipitation from 1901-2013. Low elevation trees correlated negatively with growing season May and July temperatures and positively with May, July and August precipitation. Similarly, Mid elevation trees responded negatively to growing season May, June and July temperatures and positively with May precipitation. High elevation trees responded negatively to growing season temperature especially May and July; and responded positively to May, July and August precipitation. These results show the changing response of tree growth to regional climatic conditions with changing altitude. Further analysis of these tree cores will help us to better understand the relationship between climate and growth in *Abies pindrow* along the elevation gradient in forests of north-western Himalayas.

Anatomical structure of the top stems of stag-headed trees of *Larix gmelinii* growing in permafrost soil as an evidence of water stress

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In last decades, against warming of the climate and the extreme weather events increasing high percentage of dead and stag-headed trees in northern forests has been registered. The researchers suggest that the reason for the desiccation is in drought, which can lead to tree water deficiency.

The aim of this research was to obtain some arguments in favor to the assumption that water stress should be the reason of top shrinkage in larch trees growing in permafrost conditions.

Even-aged larch forest growing in the north facing slope (Central Siberia, 64°19´ N, 100°13´ E) was under investigation. Thirteen healthy and twelve stag-headed trees were chosen. From each tree sampled disks at several stem heights (close to root collar, at 1/4, 1/2, 3/4 of stem height and at 20-30 cm beneath apex) were cut.

Stag-headed and healthy trees differed by xylotomy characteristics. The former had narrower tree rings, thicker cell walls and larger lumens; crude distortion of radial rows of tracheids and absence of latewood were also observed within the last several tree rings.

From the results of the analysis of the “sliding time-window correlations”, it can be stated that comparatively low precipitation and high air temperature (which leads to high transpiration) from the beginning of June to the middle of July might provoke water stress in trees.

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Growth patterns in relation to drought-induced mortality of main coniferous tree species in Transylvania, Romania

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Tree mortality associated with drought and high temperature events has become a widespread phenomenon during the last decades, affecting forested biomes all over the world. This phenomenon is not only restricted to dry sites, severe and recurrent droughts have been identified as a key in the recently accelerated rates of tree decline and mortality also in temperate forest from Europe. In the past years (particularly 2012), extended tree mortality was observed in the temperate-continental climate region of Romania, where mainly Scot pine, Black pine and Silver fir tree species are affected.

Using a paired sampling design we compared the growth patterns of the living and dead trees considering the driest years among the last 60 years with the aim to investigate if the drought was an inciting mortality factor.

For each tree species 3 stands affected by mortality was chosen in the Transylvanian side of the Southern Romanian Carpathians and 30 pairs of standing recently dead and living trees was sampled per stand. From each tree, two wood cores were extracted and measured accordingly to the dendrochronological methods. A mean time series of tree ring widths was obtained for each species and stand and converted to basal area increment, index which was used to compare living and dead growth patterns. The three species differed in their growth reaction patterns to the recurrent drought years occurred in the last 60 years. The greatest reduction of growth rate prior to death compared to the living growth was recorded for silver fir species, the slightest reduction for black pine, while Scots pine occurred an intermediate position. Different patterns could be explained by the different altitude of each stand, pine species were planted at low altitude (500-600m) outside their natural range, compared to silver fir that grown at higher altitude (1000-1300m) in optimum natural habitat.

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Investigation of the dry stress effect on the water consumption and the tree growth with the use of lysimeter

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Broad areas of the northeast German lowlands are characterised by low precipitation, distinct periods of summer drought and sandy soils with low water retention capacity. In this region, forest hydrology research looks into the influence of differently structured forest on the landscape water balance. The use of different types of lysimeters in this region has a tradition of more than 100 years.

The Eberswalde lysimeters are excellently suitable for the complex investigations because of her size (100m² of surface and 5m of depth). The investigations are completed by the use of especially developed weighable lysimeters and an open field laboratory. Lysimeters are indispensable in investigations of water consumption of small forest trees of different origin in the face of increasingly limiting water resources arising from climate change.

A main topic of the research is to investigate the water consumption and the growth of small trees at decreasing water resources. The ability of trees to adapt to climate change is still unexplained in the main. The investigation of their yield capacity under the conditions of drought and heat is a declared research objective. Main emphasis of the research consists in the investigation of cause and effect relationships under the conditions of different levels of drought on water consumption, radial growth and fine root dynamics of the trees. Young trees are more sensitive to dryness because their roots cannot reach the water content in deeper soil layers.

The relationships between increasing soil water drying and evapotranspiration of young beeches and oaks are represented. The decrease of evapotranspiration is followed by the reduction of radial growth. The results are important to the sustainable forestry in “Future Forests”.

Potential and limitations of combining terrestrial and marine proxy archives from Iceland

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Seasonally constrained and annually formed growth patterns of some organisms can provide information on environmental conditions prior to the instrumental era. Nowadays, annually resolved proxy data are mainly obtained from the terrestrial biosphere, because similar data from marine environments are less explored. Iceland is a perfect location where both tree-ring (dendro) and bivalve shell growth increment (sclero) chronologies can be developed from adjacent terrestrial and marine sites. Here we introduce the first network of Icelandic birch (*Betula pubescens* Ehrh.) and rowan (*Sorbus acuparia*) ring width chronologies, as well as ocean quahog (*Arctica islandica* L.) sclerochronologies.

We have studied common signal i) within the different terrestrial records, ii) between terrestrial and marine records, and iii) between both these proxy archives and instrumental climatic records to identify the environmental variables most closely associated with growth in each of the records. The tree-ring chronologies were not only significantly positively correlated to each other, but also correlated to June-August temperature. In contrast, shell increment time-series (sclerochronologies) did not cross-correlate well with each other which is likely due to habitat differences. Furthermore, some of the observed disagreement between the dendrochronologies and sclerochronologies possibly originates from unequal sample sizes, different seasonal timing and rate of the growth as well as different sensitivities to climate variables. However, our data shows that the interrelationships among so diverse species and ecosystems might indeed be beneficial to reconstruct a more complete picture of terrestrial and marine ecosystem functioning and productiveness on a yearly base.

Dendrochronological analysis of the camp barracks built by GULAG prisoners on the White Sea coast

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One of the darkest periods of the Russian history is the establishment of special purpose camps for political prisoners – the Gulag. The first camp was functioning as a great social experiment that combined two main purposes - a severe punishment and getting free labor force.

However, field research of the sites of the former Soviet camps is not still the most popular method of getting relevant data, though this method proves to be very important – especially in the case of total loss or lack of archival sources. Many places are still not registered, not described, not included in the history of the Gulag system. This is one of the many gaps which need urgent attention. Field studies are particularly relevant now, when plenty of still existing remains of camp settlements are threatened with extinction due to natural reasons or because of vandalism.

This paper presents the results of an expedition to the White Sea coast, Cape Kindo, Kandalaksha Bay. There were several destroyed wooden buildings discovered. Based on the few written records and plans available, it is a remote part of the central Solovetsky camp, the first testing ground for the new Soviet repressive system. In 2014 and 2015, two expeditions were organized in the area of their location. To accurately determine the period to which a particular building belongs, the selection of wood samples was made from the surviving walls for dendrochronological dating. Most samples were taken from the side of the logs where the outer growth rings are preserved. These external growth rings are most important for dating, because the outer ring indicates the date when the tree was cut. The dating of the samples was carried out by the method of cross-dating with the master chronology of the Scotch pine from Solovetsky region. The length of the chronology from the camps is 350 years (1929-1580). Chronology exhibited high inter-series correlations ($R=0,44$, $p < 0.01$), which indicates the high reliability of dating

Dendrogeochemical features fossil larch (Pazyryk) and modern larches of Mountain Altai

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Relevance of the work due to the need to study the environment of the Altai, subject to long-term transfer of pollutants from the neighboring territory of East Kazakhstan. The main objective of this study was to conduct a comparative analysis of dendrogeochemical features of the fossil and modern Larix Siberika from Pazyryk in the southeast of the Altai Mountains and the modern larch, growing in the area of cross-border transfer of chemical elements from the territory of the Republic of Kazakhstan. *The methods used in the study.* Sampling; natural drying, separation of samples into time slots, grinding cores, ashing at 450o Spila with the definition of the ash content in accordance with GOST 26929-94; quantitative instrumental neutron activation analysis method (determination of the content of 28 chemical elements) for all samples, and quantitative method for the analysis of mass spectrometry with inductively coupled plasma (determination of the content of a chemical element 61) for larch samples from Pazyryk; processing and analysis of empirical data by statistical methods. *The results.* Obtained by chemical elemental composition of the annual rings of fossil and modern larches of Pazyryk. Dendrogeochemical comparative analysis shows the predominance of the chemical element composition of a fossil larch elements: Li, Al, P, K, Ti, V, Co, Cu, As, Se, etc. And in the fossil larch: Be, B, Na, Mg, Ca, Cr, Mn, Fe, Ni, Zn, Br, Sr, and others. In the chemical elemental composition of annual rings reflected climatic, orographic and geochemical environmental factors, as well as the selection and conditions of storage of samples themselves annual rings of larches.

The Tervuren xylarium: research material for the development of visual wood identification and for studies of tree growth and forest ecology

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The xylarium of the Royal Museum for Central Africa is one of the most important wood collections in the world. Nowadays, it consists in more than 70000 specimens from 13000 different species, mainly originating from tropical regions. Initially established for the study of commercial species, it has progressively shown several other interests.

The main applications of the xylarium have evolved towards wood identification, tree growth study and forest ecology, leading to a diversification of the types of samples that are harvested: discs, cores, “barreaux” or “bouchons” (cambial zone samples). In parallel, the existing xylarium online database is being modified to provide more information on specimens in terms of dimension, form, density, chemical profiles, etc. It will also include time series of measurements, such as growth-ring widths and other quantitative features on a pith to bark transect. In parallel, a visual wood identification tool for non-specialists is being designed and will soon be available.

To conclude, the xylarium is in constant evolution and can be used in varied purposes. It is crucial that such collections are maintained and developed to meet the needs to better understand the ecology of tropical forests.

Earlywood and latewood anatomy parameters and their sensitiveness to air pollution and low temperature. methodological approach to demarcation between earlywood and latewood

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The aim of this work is to evaluate the influence of EW/LW differentiation method on the results of quantitative wood anatomy analysis on the example of Norway spruce from the Ore Mountains. The research is carried out in the Czech part of the Ore Mountains where 9 permanent plots along the main ridge were established. Sites are located along the gradient of forest damage (heavily, medium and slightly damaged sites) after 1995/1996. The age of spruce stands is 40 – 60 years. The demarcation between earlywood and latewood is estimated on base of Mork's index calculation and the results of X-ray densitometry. Altogether 374 tree rings are analysed by both methods. On base of our results we will be able to define the optimal border value for X-ray densitometry demarcation between EW and LW for Norway spruce. It will also give us the possibility to compare the influence of methodological approach on quantitative wood anatomy. As the result we will be able to estimate the influence of low temperatures and air pollution on lumen area, cell-wall thickness and cell number in the tree-rings of *Picea abies* and we will define which part of the tree ring, EW or LW, is more sensitive to the given abiotic stressors.

Radial growth behaviour of Pinus sylvestris and Pinus nigra on Romanian degraded lands

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The aim of this study is to reconstruct, using dendroecological tools, the radial growth and its structure in plantations of black pine and Scots pine on moderately degraded land due to farming and grazing. This undertaking is critical for Romania, where more than a third of the surface has less productive soils, at the same time being exposed to climatic risk phenomena and, thus, generating high economic losses. A total of 330 trees of different ages and social position, from 11 stands of different densities, were cored for retrospective tree-ring analysis. The amount of tree radial growth, averaging 1.5 mm×year^{-1}, with slight differences between the two species of pine, distinguishes the trees'social status. The two pine species denote distinctive growth dynamic, characterized by an accentuated juvenile growth spurt and bigger range in the growth of the Scots pine. The growth decline is predominantly a maturation effect which begins when the tree is around 40 years old and seems to be irreversible. After this age, weak or moderated interventions are not enough to revive its growth. In a single plot there is anthropogenic deposition on tree growth in the short term and only with the rainfall supply. The contribution of climate (temperature together with rainfall) to the last radial increments in decline is between 3-57 %, depending on plots. On degraded lands, the pine mixtures are steadier than monocultures and will be managed, through heavy thinning, towards local hardwood ecosystems after a rotation of 30-40 years.

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The climatic response of anatomical characteristics of *Pinus sylvestris* revealed by the tracheidogram method

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The variability of cell sizes within annual rings is influenced by external conditions, but in addition it is also related to the magnitude of an absolute production of cells per growing season, i.e. with an average number of cells in the radial file of tree-ring. Thus, a mixed signal consisting of climate and cell production is observed in the annual variability of the values of cellular structure parameters. One of the goals of this research was to clean the signal from the cell production effect, to leave only the climate signal.

In this study we used tracheidogram method which reflects variability of consecutive growth of anatomical parameters during the vegetation period. Key anatomical characteristics, such as maximum radial size of tracheid and cell wall thickness, the size of tracheids of the ring transition zone and corresponding to the maximum cell wall thickness, were revealed on thracheidogram. To analyze them in response to clear climate influence was the main objective of this investigation. For this we explored five trees of *Pinus sylvestris*, taken from Khakasia region in Russia for the period 1964-2009 years. It was find out that maximum cell wall thickness and size of tracheids corresponding to the maximum cell wall thickness in tree-ring had the strongest correlation with the cell production. This dependence was removed by extracting the index values of anatomical characteristics. Then the correlations of indexed parameters with mean values of air temperatures and sum of precipitation were calculated.

The periods of the greatest climatic response of anatomical characteristics were identified, which consistented with their gradual growth during the vegetation season. The time and periods of growth and development of anatomical characteristics relative to each other were analyzed.

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Improved tree ring climate reconstructions using Liebig's Law of the Minimum

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A basic principle of ecology, known as Liebig's Law of the Minimum, is that plant growth reflects the strongest limiting environmental factor. This principle implies that a limiting environmental factor can be inferred from historical growth patterns, and in dendrochronology such reconstruction is generally achieved by averaging collections of standardized tree-ring records. Averaging is optimal if growth records are composed of a signal of interest plus unrelated noise, but if variable growth across trees reflects the operation of the Law of the Minimum, averaging is no longer optimal because certain variations reflect a local, more-limiting factor. Here we use a large collection of Arctic tree-ring density records to show that growth patterns reflect operation of Liebig's Law. Recognition that the Law of the Minimum operates at the level of individual trees can be leveraged to improve the skill of dendroclimatological reconstructions. Reconstruction of Arctic-wide temperature using a reconstruction method that takes advantage of the law of the minimum increases the squared cross-correlation with instrumental records from 0.14 to 0.42. The greatest increases in reconstructive skill occur at the lowest frequencies and result in recovery of recent trends in Arctic warming, eliminating the so-called "divergence problem" in tree-ring density reconstructions of arctic temperature. More comprehensive models of tree-growth may offer still greater improvement in reconstructive skill.

Long-term oxygen isotope chronologies from a Mediterranean island

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Oxygen isotope ratios in tree rings have been established as an important archive for palaeoclimatic research questions. Additionally, they can help to better understand tree physiological processes because they are influenced, beside the isotopic signature of source water, by fractionation processes in leaf water during transpiration, biochemical fractionation during biosynthesis and 18O/16O exchange reaction between xylem water and phloem concentrate. Here we present four annually resolved long-term oxygen isotope chronologies from different upper tree line locations on Corsica. The chronologies are characterized by a high variability between different locations. Trees from the southern sites show lower mean δ18O values which is attributed to precipitation originating from subtropical air masses. Correlations of the δ18O values with climate parameters are very weak; however, significant correlations with winter precipitation may indicate a dependency on the isotopic signature of winter precipitation. This hypothesis is further substantiated by strong correlations of tree-ring δ18O with δ18O values of precipitation and stream water.

For a thorough interpretation of the oxygen isotope chronologies, the new established project CorsicArchive (Altitudinal Gradients and Forest Response: Climate, Hydrology and Isotope Variability of a Mediterranean Ecosystem) foresees to measure oxygen isotope ratios in tree rings, needle water, xylem water, soil water and precipitation in intra-annual intervals on the island of Corsica. The superordinate aim of the project is to better understand the processes responsible for spatial and temporal oxygen isotope variability in tree rings and in the hydrological cycle on Corsica. The project contributes to a better understanding and quantification of palaeoclimate in the western Mediterranean and enables assessment of past and future hydroclimate variability and of changes of forest ecosystem productivity along an elevation gradient on a Mediterranean island.

The influence of some extreme factors of different genesis on the annual radial growth dynamics

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The influence of technogenic contamination of different impacts and zoogenic defoliation on radial increment dynamics of trees from the pine and the birch stands was analyzed. The area of research of anthropogenic impacts is located in the Southern taiga subzone; the areas of zoogenic defoliation are in the subzones of the pine-birch precursor forest-steppe and Northern forest-steppe. Method of the sorting out of high-frequency component of the dynamics of radial growth of pine trees (Pinus sylvestris L.) and of birch (Betula pubescens Ehrh) was used as the response of organisms to non-standard external factors in forest stands affected by the anthropogenic impact and zoogenic defoliation. The goal of this work was to establish a relationship of extreme factors of various origins and dynamics of the annual radial increment and to reveal the value of the high frequency oscillations. The influence of a zoogenic defoliation were studied in birch stands withering after defoliation and tolerant, and resistant to it trees. It was found that on the same test plots the more value of high frequency oscillations observed in tolerant and resistant to defoliation of birch trees, and the less in trees withering after defoliation. The highest indicator of the high frequency oscillation part of increment was in the trees from the resistant to defoliation stands – 0.39 fluctuations. Two-time defoliation is characteristic of the forest stand where the trees are characterized by a small value of high frequency oscillations of radial growth. Considering the high frequency characteristics of the radial growth of trees after a zoogenic defoliation as markers of resistance to exogenous factors, it is possible to evaluate the compensatory potential of trees growing in the zone of contamination. The values of the high frequency component of the tolerant birch trees are the same order with the high-frequency characteristics of the pine trees in the impact zone of contamination and of some trees from the buffer zone. High frequency characteristics of the annual radial growth of trees that are resistant to extreme factors of different genesis are close to the values of high-frequency fluctuations of the weather conditions in the periods in question. The value of high frequency components does not differ between pine – birch species.

Population dynamics of the shrub Sea-buckthorn as an indicator of the impact of gas extraction and future climate change

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Gas extraction has since 1986 caused land subsidence on the eastern part of the Dutch Wadden Island of Ameland, an area with biodiverse coastal vegetation. This subsidence simulates future climate change by increasing the relative sea water and groundwater levels.

Aerial photography and dendrochronology were applied to study the effect of the changed hydrology as well as dune aging on the vegetation structure of our modelling species, Sea-buckthorn (*Hippophae rhamnoides* L).

Aerial photographs indicate an increase of the Sea-buckthorn population in the young dunes since 1959 and a decrease at low elevation since the start of gas extraction. Less establishment of Sea-buckthorn in low elevations with increased seawater flooding was also shown using tree-ring research. Moreover, flooding, but also ground water levels were found to limit growth in low areas, especially after gas extraction started.

An important biotic factor limiting growth of Sea-buckthorn is outbreaks of the brown-tail moth (*Euproctis chrysorrhoea* L.), which occurred across all strata and largely affected plant growth in extensive clusters.

Based on these results we conclude that shrub mortality at low elevation will increase, mainly related to inundation especially in older dune areas. In contrast, shrub growth at higher elevations is likely to be stimulated by increased moisture availability due to increased groundwater levels. Especially in calcium-rich dune areas this could lead to expansion by Sea-buckthorn, which could form a threat to the protected 'Grey dune' habitat type.

This study illustrates the processes behind changes in complex coastal dune vegetations as a consequence of soil subsidence. The fact that the same triggering factors and mechanisms are operational in case of sea-level rise points to the broad relevance and potential of our integrated approach of using a combination of aerial photography and dendrochronology for assessing consequences of future climate change on coastal ecosystems.

Drought-induced birch mortality in Hustai National Park, Mongolia

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Trees in the forest-steppe ecotones face drought stress due to more extreme seasonal fluctuations in precipitation and temperature, which reduce their growth and competitive ability. In addition, browsing pressure can hinder tree regeneration. To disentangle the impact of these climatic and browsing factors on the mortality of birch trees in Hustai National Park, Mongolia, we applied dendrochronology to determine growth-limiting factors and assessed tree mortality and browsing pressure on young and adult birch in two forest areas. We found that birch growth in both populations is positively driven by winter precipitation and negatively affected by summer temperature. This suggests that soil moisture at the beginning of the growing season is crucial for birch growth. It was predicted that mortality differed among the two forest areas with a lower frequency of the smaller DBH classes in areas where deer density is high. Tree mortality differed significantly among the populations and was higher in larger than smaller trees, but no significant relation was found between mortality and deer density. These results suggest that under expected climate change with declining precipitation rates, the birch forest of Hustai National Park is converting into a steppe ecosystem, like described for other forest ecosystems in this ecotone.

Tree-ring chronology from the Holocene deposits of the Muya river valley, North Baikal, Siberia, Russia

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We found mass graves of sub-fossil wood in the alluvial deposits of the river Muya in the North Baikal area, which are possible to use for construct a continuous chronology of almost the entire period of the Holocene. In total, more than 250 disks of trees were selected. The majority of samples of wood contained about 150 rings, the maximum number of the rings found in one sample were equal to 546 years. In researched area we created absolutely dated tree- ring chronology of living larch trees for the temporary period of 1669AD – 2012 AD. During cross dating with tree- ring chronology of sub-fossil wood its temporary extent increased to 1580 AD – 2012 AD and was created to generalize Std-chronology. A 645-year long radiocarbon dated chronology (581AD – 1310 AD) consisting of 20 samples was developed. This chronology has a temporary distance from generalized STD-chronology only in 268 years. This also applies to five radiocarbon dated chronologies 7927-7160 BC, 5937-5738 BC, 4687-4466 BC, 3955–2898 BC and 1426–740 BC built on base of about 25, 9, 12, 45 and 20 larch trees, respectively. It revealed a clear correlation dynamics of the larch tree-rings from the study area with the amount of precipitation in May and June (R = 0,42). For dendroclimatic analysis we determined that the parameters of the model, its verification and performed calibration reconstruction of the amount of precipitation in May and June. The correlation between the reconstructed and measured data, smoothed by the 3-year moving filter is R = 0,72 (R2 = 0,25; F 1,42 = 14).

Dendrochronological investigation of objects in Yeniseysk town (East Siberia)

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Ancient Siberian city Yeniseysk is a city-museum of Russian traditional philistine architecture, located in the Middle Yenisey river. Large collection of wooden architecture objects (over 100 buildings) preserved there, which differ from their purposes and building traditions. However, the main issues about their calendar dating have not been solved yet. Based on the architectural-planning analysis and historical, ethnographical sources, all Yeniseysk building's dates were approximately determined. To fill the gap, we made a comprehensive analysis included historical, architectural and dendrochronological methods. For this purposes, we laid 8 sampling area and analyzed over 1,000 samples from 68 historical objects.

As the result, we constructed a regional 470-year chronology of Pinus sylvestris L and a regional 450-year chronology of *Larix sibirica* Lebeb. in the Yeniseysk area. It allowed dating 51 wooden historical buildings. The earliest four wooden houses located in Perensona and Tamarova str. were dated as the first quarter of the XIX century. Fifteen objects dated from the period the late 60s - 70s of the XIX century were probably built after the fire destroyed a large area of Yeniseysk in 1869. Fourteen buildings in the historic center were constructed in the 70-80s of the XIX century. Seventeen monuments were erected in the late XIX - early XX centuries.

To sum it up, we have done the first large dendrochronological research of historical city in Eastern Siberia. Our results confirmed that Yeniseysk is a unique Siberian city preserved examples of traditional philistine architecture. It allowed to determine the stages of Yeniseysk development in the period of economic rising and demonstrate the continuity and character of city culture. In future, our study will allow us to proceed to the next stage as the dating of archaeological timber, which was obtained during excavations of historical center Yeniseysk building in XVII-XVIII centuries.

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