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Climate variability and human impacts in Central and Eastern Europe during the last two millennia

17–19 June 2015
Gdańsk

PROGRAM AND ABSTRACTS BOOK

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Climate variability and human impacts in Central and Eastern Europe during the last two millennia

PROGRAM AND ABSTRACTS BOOK

17-19 June 2015, University of Gdansk, Poland

Institute of Geography
Faculty of Oceanography and Geography
University of Gdansk

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Gdańsk 2015

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Climate variability and human impacts in Central and Eastern Europe during the last two millennia

17-19 June 2015, University of Gdańsk, Poland

Program Overview

Tuesday, 16 June 2015

15:00 – 20:00 Registration

18:00 – 20:00 Ice Breaker

Wednesday, 17 June 2015

8:00 – 8:30 Registration

8:30 – 9:00 Conference opening and introduction

9:00 – 9:30 Past Global Changes (PAGES) presentation

Session 1 (9:30 – 12:20)

Historical climatology and documentary data

Session 2 (12:20 – 18:30)

Climate reconstructions from natural archives

18:30 – City tour

Thursday, 18 June 2015

Session 2 (8:30 – 12:00)

Climate reconstructions from natural archives

Session 3 (12:00 – 12:50)

Past climate modeling and data-model comparison

Session 4 (14:20 – 17:30)

Proxy calibration, disentangling climate and human impacts

19:00 – Conference dinner

Friday, 19 June 2015

Session 4 (8:30 – 9:50)

Proxy calibration, disentangling climate and human impacts

Session 5 (9:50 – 13:10)

Past human impacts on the environment

13:10 – Conference closure

Climate variability and human impacts in Central and Eastern Europe during the last two millennia

17-19 June 2015, University of Gdańsk, Poland

Detailed Program

Keynote: 25 min. talk + 5 min. discussion
Invited talk: 15 min. talk + 5 min. discussion
Oral presentation: 15 min. talk + 5 min. discussion
Poster presentation: 2 min. talk + general discussion in the poster hall

Tuesday, 16 June 2015

Time	What	Who	Responsible
15.00-20.00	Registration open	LOC	LOC
18.00-20.00	Ice Breaker	LOC	LOC

Wednesday, 17 June 2015

8.00-8.30	Registration open	LOC	LOC
8.30-9.00	Conference opening and introduction	Wojciech Tylmann Rector UG Dean FOG Martin Grosjean	Wojciech Tylmann / Martin Grosjean
9.00-9.30	Past Global Changes (PAGES) Presentation of PAGES working groups: EuroMed2k, Landcover6k, Varves Working Group	Lucien von Gunten Ulf Büntgen Marie-Jose Gaillard Pierre Francus	Martin Grosjean
Session 1 Historical climatology and documentary data			
9.30-10.00	*Keynote:* Historical climatology in Central Europe and its scientific potential	Rudolf Brázdil	Mirosław Miętus
10.00-10.20	Historical climatology in Hungary and the Carpathian Basin since 1000 AD: present stage of research from documentary and early instrumental data (invited)	Andrea Kiss	
10.20-10.40	Climate of Poland in the last millennium (invited)	Rajmund Przybylak	
10.40-11.00	Climate variability in Poland in the period of the instrumental record (invited)	Janusz Filipiak	
11.00-11.20	Human communities as climate indicators: Water level rising in a Hungarian lowland landscape during the medieval climate change?	Zsolt Pinke	
Poster Session 1			
11.20-12.20	Meteorological information in Romanian publications and archives from the 19th century	Ioana Ipate	Martin Grosjean
	How does human perception influences the registration of hydric regime variability in historical documents?	Viorica Nagavciuc	
	Climate of Gdańsk from 1770 to 1786 based on Gottfried Reyger's meteorological observations and measurements	Rajmund Przybylak	
	Wrecks as a testimony of history and the state of the environment	Stanisław Rudowski	
	An interdisciplinary investigation of archaeological evidence for meteorological application	Elisabeth Thompson	

Time	What	Who	Responsible
11.20-12.20	Medieval climate warming reflected in the pollen and macrofossil record from urban archaeological sites in Gdańsk (N Poland)	Joanna Święta-Musznicka	Martin Grosjean
	Pollen-inferred temperature series for the northern Italian Holocene	Francesca Vallé	
	Dendroclimatic studies in the Sudetes Mountains - a key site for analysing Central European past climate variations	Magdalena Opała	
	Hydrological dynamics and fire history of the Izera Mountains during the last 800 years inferred from testate amoebae and charcoal	Katarzyna Kajukało	
	Investigation of extreme climate events using *Pinus sylvestris* tree rings from Hungary	Dávid Misi	
Session 2 Climate reconstructions from natural archives			
12.20-12.50	*Keynote:* Varved sediments and their paleoclimatic significance	Bernd Zolitschka	Achim Brauer
12.50-13.10	Varved sediments of Lake Żabińskie, northeastern Poland: a chronological frame for high-resolution paleoclimate reconstructions over the last millennium	Wojciech Tylmann	
13.10-13.30	Temperature reconstruction using chironomids (non-biting midges) preserved in the varved sediment of Lake Żabińskie, Poland (invited)	Isabelle Larocque-Tobler	
13.30-13.50	A chrysophyte-based transfer function as a tool for winter severity reconstructions in NE Poland during the past millennium (invited)	Iván Hernández-Almeida	
13.50-15.30	*Lunch*		
15.30-16.00	*Keynote:* The PAGES 2k EuroMed project – beyond tree ring-based temperature reconstructions	Ulf Büntgen	Olga Solomina
16.00-16.20	Climate reconstructions from tree-ring widths for the last 850 years in Northern Poland	Ingo Heinrich	
16.20-16.40	Climate of Poland in the last 400 years on the basis of tree rings isotope studies	Sławomira Pawełczyk	
16.40-17.00	Tree-ring based reconstruction of temperature extremes over the last five centuries in Silesia, southern Poland: a multispecies perspective	Magdalena Opała	
Poster Session 2			
17.00-18.30	Improving the study of annually laminated sediments - A new online tool	Bernd Zolitschka	Wojciech Tylmann
	Geochemical indices of environment in the varved clastic and bio- chemogenic lake sediments	Ivan Kalugin	
	Periodic characteristics of 10,000-year-long clastic-biogenic varve records from lakes Nautajärvi and Korttajärvi in continental Scandinavia during the Holocene	Antti E.K. Ojala	
	Stable isotope record of late Holocene precipitation changes from Lake Nuudsaku in southern Estonia	Nathan Stansell	
	Preboreal climate oscillations registered in multi-proxy record from Lake Suchar Wielki in the Wigry National Park, NE Poland	Magdalena Fiłoc	
	Isotopic investigations of contemporary carbonate sedimentation in lakes from N Poland	Natalia Piotrowska	
	Chrysophyte cyst-inferred variability of warm season lake water chemistry and zonal wind in northern Poland	Iván Hernández-Almeida	

Time	What	Who	Responsible
17.00-18.30	Chrysophyte cysts population dynamics in northern Poland: a two-years sediment trap experiment	Iván Hernández-Almeida	Wojciech Tylmann
	Modern limnology, sediment accumulation and varve formation processes in Lake Żabińskie, northeastern Poland: a key to understand the sediment record	Alicja Bonk	
	Sedimentological and geochemical record of meteorological variability in varves of Lake Żabińskie, northeastern Poland	Alicja Bonk	
18.30-	*City Tour*		

Thursday, 18 June 2015

Time	What	Who	Responsible
Session 2 Climate reconstructions from natural archives			
08.30-9.00	*Keynote:* Climate variability in European Russia of the past 2000 years	Olga Solomina	Lucien von Gunten
9.00-9.20	Drought severity for the last 200 years in the Voronezh region (Russia) reconstructed from pine ring width chronology	Vladimir Matskovsky	
9.20-9.40	Climate reconstructions in the Urals over the last millennium inferred from borehole temperature data	Anastasiia Gornostaeva	
9.40-10.00	Proxy data from East Central European cave sediments for the past two millennia (invited)	Zoltán Kern	
Poster Session 3			
10.00-11.00	Identifying natural and anthropogenic impacts in the southern boreal forests of Europe	Jennifer Clear	Janusz Filipiak
	Disturbance dynamics of the High Tatra Mountains, Slovakia: a multi-proxy approach combining palaeoecology and dendroecology	Jennifer Clear	
	Different successional patterns in two close located cores: comparison of mire and floating mat zone (Rzecin mire, W Poland)	Grzegorz Kowalewski	
	Reconstruction of total phosphorous in north German lowland lakes since 500 AD	Thomas Hübener	
	Human impact and past climate changes - records in lake sediments of two Pamir lakes	Piotr Szwarczewski	
	Human impact on the landscape of the Mrągowo Lake District (Masuria, NE Poland) in the Iron Age	Marta Szal	
	Impact of land-use changes in small catchments on lake sedimentation: case study of Lake Jaczno, northeastern Poland	Anna Poraj-Górska	
	Lacustrine ecosystem response to medieval hemp-retting practices – an example of three hard water lakes from SE Poland	Magdalena Suchora	
	The human activity during the first five centuries AD recorded in the laminated sediments of the Lake Czechowskie (northern Poland)	Milena Obremska	
	Anthropogenic changes of vegetation over the last millennium in NE Poland; a case study on the varved sediments from Lake Żabińskie	Agnieszka Wacnik	
	Environmental changes recorded in Lake Żabińskie (Masurian Lake District) based on the subfossil diatom flora, AD 1888-2010	Małgorzata Witak	
	Diatom biostratigraphy of the last millennium sediments of Lake Żabińskie (Masurian Lake District)	Małgorzata Witak	
Session 2 Climate reconstructions from natural archives			
11.00-11.20	Comparing varve formation and preservation during the last 2000 years in two lakes along a W-E transect in the southern Baltic lowlands	Nadine Dräger	Bernd Zolitschka
11.20-11.40	Regional and local sedimentation signatures in varved sediments of the last 150 years in three lakes in northern central Poland	Florian Ott	
11.40-12.00	Hyper-spectral imaging: A promising tool for quantitative pigment analysis of varved lake sediments	Christoph Butz	

Time	What	Who	Responsible
Session 3 Past climate modeling and data-model comparison			
12.00-12.30	*Keynote:* European Temperature of the last 2 millennia – comprehensive climate reconstructions	Jürg Luterbacher	Rajmund Przybylak
12.30-12.50	Dynamic downscaling as a way to bridge gaps between climate simulations and reconstructions (invited)	Juan José Gómez-Navarro	
12.50-14.20	*Lunch*		
Session 4 Proxy calibration, disentangling climate and human impacts			
14.20-14.50	*Keynote:* Multi-proxy, high-resolution studies of peatlands development during the last 2000 years - climatic drivers and human impact	Mariusz Lamentowicz	Ulf Büntgen
14.50-15.10	2000 years of hydroclimate variability recorded in different types of mire archives in north-eastern and north-western Poland	Małgorzata Latałowa	
15.10-15.30	Last millennium hydro-climate variability in Central Eastern Europe (Northern Carpathians, Romania): a multi-proxy approach	Angelica Feurdean	
15.30-15.50	How does fire and drought influence peatland under oceanic-continental climatic conditions? 2000 years of environmental change in Linje mire, northern Poland	Katarzyna Marcisz	
Poster Session 4			
15.50-17.30	Water level changes in the lake-mire ecosystem of humic lake Płotycze Sobiborskie reflected in Testate Amoebae and Cladocera analysis: preliminary results	Joanna Jarosz	Iván Hernández-Almeida
	Forest response to human impact in Białowieża Primeval Forest during the last two millennia	Marcelina Zimny	
	Directions of changes in the use of peatlands of the Tuchola Pinewoods from the end of the 19th to the end of the 20th century	Danuta Szumińska	
	Two millennia of forest habitats transformations as a result of land use and climatic shifts (Gdańsk Upland, N. Poland)	Anna Pędziszewska	
	Pedosedimentary record of human impact and climate changes in the Holocene - evidences from closed depressions in loess areas of Lublin Upland	Renata Kołodyńska-Gawrysiak	
	Geochemical and isotopic records of anthropogenic impact and natural environmental change in the Romanian Carpathians during the last millennia	Daniel Veres	
	Hypothesis on the relation between the late humid period of the Little Ice Age and the culmination of the Hungarian arable lands	Zsolt Pinke	
	Vegetation Change by Pollen, Macro and Microfossil Analysis in an Archaeological Site in Northwest Hungary	Rita Judit Töviskes	
	The Slavic expansions: Evidence from linguistics and paleoenvironmental archives	Michiel de Vaan	
	The correlation of soil-sediments sequences in alluvial fans and closed depressions as a sources of data about climate changes of the loess areas in the Holocene. A case study from Nałęczów Plateau (Lublin Upland, E Poland)	Renata Kołodyńska-Gawrysiak	
	Road construction impact on the landscape transformation during the last 700 years in NE Poland	Michał Słowiński	
17.30-18.30	PAGES WG Business Meetings		
19.00-	*Conference Dinner*		

Friday, 19 June 2015

Session 4 Proxy calibration, disentangling climate and human impacts			
08.30-08.50	Climate reconstructions and human impact from lakes sediments during last two millennia in the Central European Russia	Tatyana Sapelko	Pierre Francus
08.50-09.10	Climate versus human impacts on Lake Atnsjøen ecosystem (south-eastern Norway) during the last millennium	Izabela Zawiska	
09.10-09.30	Stable isotope record in annually laminated lake sediments from Lake Żabińskie (NE Poland) for the last millennium	Alicja Ustrzycka	
09.30-09.50	Spring (MAM) temperature signal in the varved sediments of Lake Żabińskie, NE Poland: calibration and reconstruction back to AD 1600	Benjamin Amann	
Session 5 Past human impacts on the environment			
09.50-10.20	*Keynote:* Pollen-based quantitative reconstructions of Holocene vegetation cover in Europe: contribution to the study of land cover – climate interactions and other examples of applications	Marie-José Gaillard-Lemdahl	Małgorzata Latałowa
10.20-10.40	Anthropogenic deforestation of northern Europe and eastern Baltic area during the last 2 millennia (invited)	Anneli Poska	
10.40-11.00	How wrong are pollen based reconstructions of landscape openness?	Martin Theuerkauf	
11.00-11.30	*Coffee break*		
11.30-11.50	Role of climatic factors and human activity in the transformation of valley floors and slopes in C-E Europe during last 2 millennia	Leszek Starkel	Martin Grosjean
11.50-12.10	Demographic changes during the first millennium AD and their impact on vegetation cover in north-western Poland	Anna Pędziszewska	
12.10-12.30	The 500 years of vegetation changes in lowland forest wetlands in relation to human impact and climate change	Andrea Gálová	
12.30-12.50	Trace elements in lake sediments as a proxy of human impacts and climate changes - limitations and possibilities of application	Piotr Szwarczewski	
12.50-13.10	Paleolimnological evidence of European spread of hypoxia in freshwaters caused by local anthropogenic pressures	Philippe Jenny	
13.10-13.30	Conference closure		Wojciech Tylmann / Martin Grosjean

Climate Variability in Central Europe of the past 2000 Years: Challenges and Perspectives

Martin Grosjean (1)*, Wojciech Tylmann (2), and Climpol Project Members

(1) Oeschger Centre for Climate Change Research, University of Bern, Switzerland
(2) Department of Geomorphology & Quaternary Geology; Institute of Geography, University of Gdańsk, Poland
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Studying regional climate variability and change is a priority area in current climate and climate impact research. This is motivated by the facts that: (i) all managed and natural ecosystems including humans are exposed to and ecosystems services depend on local and regional rather than global expressions of climate variability and change; (ii) amplitudes and rates of climate change are generally much larger at local and regional that at global scales; and (iii) at local and regional scales, unforced climate variability may mask or amplify responses of natural forcings or even be the dominant source of variability from seasonal to multidecadal time-scales. These are the reasons why a careful assessment of natural forced and unforced variability at regional scales is fundamental: natural variability will always be superposed on anthropogenic climate change and modify, mask or enhance current and future climate variability and impacts of climate change at regional scales.

Proxy-based comprehensive regional climate reconstructions with global coverage (land and ocean) for the past 1000 – 2000 years (PAGES 2k Working Group; http://www.pages-igbp.org/workinggroups/2k-network/intro) are cornerstones and provide insight into the fundamentals of natural climate variability and the detection and attribution of anthropogenic climate change in the 20th century. Although significant progress has been made in the recent past, a number of research challenges remain:

- To assess the responses of the global climate system to perturbations, climate reconstructions with complete spatial coverage of land and ocean across all regions of the world (theoretically in 3D) are required. The spatial and temporal resolution of the reconstructions must be adequate to depict observed climate variability in space and time across a range of scales. Large data gaps still exist;
- Many ecosystems respond to multiple factors and climate variables (temperature, precipitation, effective moisture, light, wind, phenology of singularities, etc.), often in a non-linear or threshold-driven way. Many of the response functions, and thus the cornerstones for climate reconstructions are poorly constrained and the multiple influences are poorly understood. New approaches such as forward modelling of proxy-systems, neural networks etc. are worth to be explored;
- Multi-factorial response functions (mixed proxy signals) and instable proxy sensitivities (Liebig's Law of the Minimum) have also fundamental implications for data-model comparisons and data assimilation in model simulations. The model world requires data expressed in well-defined physical units for a particular calendar season. This is not always adequate for proxy-systems, and the phenological clock of many ecosystems does not necessarily follow the calendar clock;
- It is well established that expressions of climate variability and change depend very much on the season. This implies that seasonally resolved climate reconstructions (at least for the cold and the warm seasons) are required. Since most of the biological proxies are biased towards the warm growing season, data for the cold season remain a great challenge;
- Many comprehensive European climate reconstructions for the past ca. 500 years consist mostly of tree ring data and documentary data. However, many other archives would be available (peat, lake sediments, speleothems, etc.) but these are often not adequately dated and resolved, poorly or not calibrated (qualitative) and contain mixed signals from climate variability and anthropogenic activities (such as land cover changes and nutrient cycling).

Varved lake sediments can be much better explored (PAGES Varves Working Group http://www.pages-igbp.org/workinggroups/varves-wg/intro) and a new PAGES Working Group LandCover6k is under way (http://www.pages-igbp.org/workinggroups/landcover6k/) to document land use changes over the past few millennia.

From the above, the conference intends to move and stimulate paleoclimate science in the following areas:

- Filling regional data gaps in Central Europe and improving the quality of paleoclimate data (calibration, resolution, chronology, interpretation);
- Developing comprehensive multi-site multi-proxy climate reconstructions with well-understood processes (integrating observational, proxy and model data);
- Understanding and discriminating multiple influences on ecosystems (climate, human, ecosystem evolution, etc.).

We hope that every step toward more reliable paleo reconstructions will lead us to better understand human influences on ecosystems and ecosystem services. That is, down the road, what we are concerned about.

ORAL PRESENTATIONS

SESSION 1: HISTORICAL CLIMATOLOGY AND DOCUMENTARY DATA

Historical climatology in Central Europe and its scientific potential

Rudolf Brázdil (1)*

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Climate of the past millennium in Central Europe can be reconstructed based on instrumental, documentary and natural proxy data. Documentary data about weather and related phenomena represent the basic source of information for historical climatology, dealing with reconstruction of past climate and hydrometeorological events, their perception and impacts on human society. The paper presents the basic distribution of data on (i) direct descriptions of weather and proxies on the one hand and on (ii) individual and institutional data sources on the other. Several groups of documentary evidence such as narrative written records (annals, chronicles, memoirs), visual daily weather records, official and personal correspondence, special prints, financial and economic records (with particular attention to taxation data), newspapers, pictorial documentation, chronograms, epigraphic data, early instrumental observations, early scientific papers and communications are discussed in more detail and their use for creation of series of weighted monthly temperature and precipitation indices in the seven-degree scale, classifying monthly patterns from –3 (extremely cold or extremely dry months) to +3 (extremely warm or extremely wet months) is shown. Summing of indices for corresponding months gives indices for seasons (in the scale from –9 to +9) and the year (from –36 to +36). Alternatively also series of (bio)physically based documentary proxies reflecting usually any systematic economic activity (e.g. from agriculture or transport) are discussed. Advantages and uncertainties in documentary data are further mentioned. Methodology of the climate reconstruction from documentary data based on application of the standard paleoclimatological method (calibration and verification procedures) working with the overlap of documentary-based series and instrumental measurements is presented. The papers shows examples of several Central European documentary-based climate reconstructions with particular focus on Central European temperature and Czech Lands precipitation series covering the past 500 years. These series are further compared with other European reconstructions to show agreement/disagreement between different reconstructions. Documentary evidence has also great importance for the study of pre-instrumental hydrometeorological extremes as documented on examples from the analysis of droughts, floods, windstorms, tornadoes and hailstorms in the Czech Lands from the viewpoint of their occurrence, severity, seasonality, meteorological causes, perception and human impacts during the past millennium. Finally, scientific potential and perspectives of historical-climatological research and future challenges are presented.

Historical climatology in Hungary and the Carpathian Basin since 1000 AD: present stage of research from documentary and early instrumental data

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The paper has two main aims: on the one hand, an overview of published studies and investigations, discussing long-term reconstructions/data series and investigations on individual great extreme events, based on documentary evidence, is provided. On the other hand, the ongoing investigations, developing databases and their future potentials in climate reconstructions are discussed.

The presentation is divided according to main subject areas: past investigations, present state of research, datasets in development and potential future directions are discussed based on this thematic order. The main subject areas are:

- investigations on early instrumental data and systematic daily observations,
- temperature and precipitation reconstructions based on direct (and indirect) documentary evidence (temperature and precipitation index reconstructions),
- temperature reconstructions based on biophysical (phenological) evidence and physical indicators,
- weather-related hydrological extremes (e.g. floods, droughts): long-term reconstructions and individual great extremes, anomalies.

While discussing the present directions of investigations, particular subject areas for potential collaboration are also highlighted.

Due to the availability of documentary evidence, the period covered by the presentation is the last approximately 1000 years. As for the spatial coverage, the presentation aims at providing an overview of investigations carried out in the Carpathian Basin. Thus, apart from Hungary, systematic, documentary-based historical climatology investigations related to Slovakia, West-Romania, Southwest-Ukraine, North-Serbia, North-Croatia, East-Slovenia and East-Austria are also included.

Climate of Poland in the last millennium

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This paper presents the current state of knowledge on climate change in Poland over the last millennium, based on different kinds of proxy data. A summary of all available proxy data used for climate reconstructions for Poland is summarised as well. Proxy data mainly allow for reconstructions of three meteorological variables: air temperature, ground-surface temperature and precipitation. It must be underlined however, that, for example, air temperature reconstructions are possible only for different longer or shorter parts of the year, which is particularly characteristic of biological proxies (e.g. tree-rings – mean January-April temperature, chironomids – August temperature, chrysophytes cysts – cold seasons, etc.). Potentially, documentary evidence does not have such limitations. But in practice, in Poland, this is only true for climate reconstructions covering the last 500 years. The reason for this is the too-small number of historical sources in Poland prior to 1500 AD. Geothermal data allows for reconstruction of mean annual ground surface temperature generally for the last 500 years. The longest reconstructions of air temperature covering the entire or almost the entire millennium and having high time resolution are available based only on biological proxies (tree-rings, chironomids, diatoms, etc.).

At present, the best source of information about climate in Poland in the last millennium is still documentary evidence, which allows a Medieval Warm Period (MWP) to be distinguished in the study period. The MWP probably lasted from the 11th century until the 14th or early 15th century. Air temperature in the MWP was probably higher on average by about 0.5-1.0°C in comparison with contemporary conditions, and the climate was characterised by the greatest degree of oceanity throughout the entire millennium. A Little Ice Age (LIA) can be also distinguished in Poland's climate history. Data show that it clearly began around the mid-16th century and probably ended in the second half of the 19th century. In this LIA, winters were usually colder by 1.5-3.0°C in comparison with present conditions, while summers tended to be warmer by about 0.5°C. As a result, the continentality of the climate in the LIA was the greatest for the entire millennium. Mean annual air temperature was probably lower than the modern temperature by about 0.9-1.5°C. The average rise of air temperature since the mid-19th century, which is often called the Contemporary Warming Period (CWP), is equal to about 1°C and is in line with the results of reconstructions using geothermal and dendrochronological methods. The reconstruction of precipitation in Poland is much more uncertain than the reconstruction of air temperature. There was probably considerably higher average precipitation in the 12th century (and particularly in the second half of this century), in the first half of the 16th century and also in the first half of the 18th century. The second half of the 13th century and the first half of the 19th century were drier than average. In other periods, precipitations conditions were close to average, including for the entire CWP period.

Climate variability in Poland in the period of the instrumental record

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The most useful in climate reconstructions are direct measurement data, especially when they constitute the sequence lasting at least 100 years or better 200 years. Such data, carefully treated in terms of quality assurance and archiving, are of utmost importance for documenting and studying climate variability and change on decadal to centennial time scales, thereby providing basic input to relevant climate research and services.

The number of series, whose beginnings date back to the early-instrumental period from the mid-17th century to 1800, is rather limited. Due to the development of civilization, they are concentrated in a vast majority in Europe. Although the meteorological measurements begun simultaneously to those of other European countries, Poland's complicated history resulted in a loss of a majority of the archives, in many cases irretrievably. Collected and presented by Przybylak et al. (2010) list of isolated early-instrumental series of meteorological observations in Poland in the 17th and 18th centuries is impressive, however the possibility to reconstruct as well as the availability of is limited. The search for more complete data in order to reconstruct the climate variability, as well as the actions to restore the long measurement series based on the surviving and discovered collections, were taken only for a few selected locations in Poland.

The best described long-term climatological series in Poland is the one from Kraków, commenced in 1792. Its analysis resulted in the development of over two-hundred-year series of air temperature and atmospheric pressure. The most recent efforts resulted in the reconstructions of atmospheric precipitation within the last 200 years, and cloudiness and insolation from the beginning of the 20th century. As for other Polish cities, the air temperature series from respective locations were reconstructed: Warsaw and Wrocław since 1779 and 1791 respectively, Gdańsk and Hel since 1851, Puławy since 1871 and Łódź since 1903. In another studies atmospheric precipitation totals in Koszalin and Szczecin were reconstructed since 1848. The preliminary results of reconstruction of monthly values of precipitation sums of Wroclaw since 1791 were also presented. The long-term variability of air temperature and cloudiness in mount Śnieżka observatory where only limited anthropogenic influence can be observed since 1901 was also analyzed. The Polish National Meteorological Service (IMGW-PIB) is developing a project aimed at describing selected elements of Polish climate on the scale of the last century, on the basis of data received from DWD for stations presently located in Poland and formerly in Germany. The newly reconstructed climatological series of Gdańsk of a length of over 270 years is now also available, characterizing selected features of the climate, as air temperature, atmospheric pressure and precipitation of Northern Poland.

The mean annual temperatures in the period of the last 200 years show positive statistically significant linear trend. A statistically significant increase of air temperature for the period from 1836 to 1990 for the Baltic coast was also detected. For the 20th century, the spatially averaged annual temperature for Poland reveals a statistically significant increase by 0.89°C. The significant amplification can be observed after 1980. Minimum temperature shows the greater rise in comparison to maximum temperature. As a result of this asymmetry, a statistically significant decrease in the mean annual diurnal temperature range can be found. Long-term trends in precipitation and atmospheric pressure in Poland have been insignificant. In the twentieth century decreasing statistically significant trends were observed in Poland for cloudiness and sunshine duration.

Human communities as climate indicators: Water level rising in a Hungarian lowland landscape during the medieval climate change?

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The report focuses on the spatial patterns of human site selection and the correlations between the regional expansion of human communities as a response to the challenge of medieval climate and hydrological changes on the frontier of wetlands and areas suitable for settling. Based on this analysis it can be stated that differences between the elevation means of archaeological sites of the early and the late medieval periods in a 4.128 km² wetland landscape of the Great Hungarian Plain was significant ($p \leq 0.0001$; $n=549$). This means that late medieval (AD 1300-1540) settlements could have situated higher than those of the Árpád Age (AD 1000-1300) presumably. Similarly to bibliographic data of other waterfront areas, our GIS based mapping of site polygons suggests that rising water levels are likely to have influenced settlement patterns from the Medieval Warm Epoch (mid-10th – mid-13th century) to the first part of the Little Ice Age (mid-13th century - 1540). Then a zonal analysis of the study area revealed that there is a correlation between the geomorphological features and the regional and temporal variations of settlement patterns. A type of these phenomena is settlement desertion in deep floodplains. Another historically documented example of specific geomorphological settings was particularly illustrative when rising water level's practically cutting settlements off the road network. In conclusion the hydrological challenges during the medieval climate change had resulted in a significant change in the elevation means of settlements and their abandonment in the deep zones of an extensive lowland area of the Carpathian Basin.

SESSION 2: CLIMATE RECONSTRUCTIONS FROM NATURAL ARCHIVES

Varved sediments and their paleoclimatic significance

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Down-core counting of layers in annually laminated or varved sediments offers a direct and incremental dating technique for high-resolution climatic and environmental archives with at least annual and sometimes even seasonal resolution. The pioneering definition of varves by De Geer from the early 20th century had been restricted to rhythmically deposited proglacial clays. One century later, the meaning of 'varve' has been expanded to include all annually deposited laminae in terrestrial and marine settings. Under favourable basin configurations and environmental conditions, varves are formed due to seasonality of depositional processes from the water column and/or sediment transport, for example from the catchment area. Subsequent to deposition of topmost laminae, the physical preservation of the accumulating varved sequence requires the sustained absence of sediment mixing, for example via wave action and macrobenthic bioturbation. Individual (sub) laminae in varved sediments typically express contrasting colours, always differ in terms of their organic, chemical and/or mineralogical compositions, and often also differ with regard to grain-size. Various predominating climatic and depositional conditions may result in clastic, biogenic or endogenic (incl. evaporitic) varved sediments and their mixtures.

To reliably establish a varve chronology, the annual character of laminations needs to be determined and verified in a multidisciplinary fashion. Sources and influences of possible errors in varve chronology are best determined and constrained by repeated varve counts and multiple dating approaches, including radioisotopes and correlation with historically documented events. A well-established varve chronology greatly enhances the scientific value of annually laminated archives by securely anchoring the wealth of multi-proxy palaeoenvironmental information in the form of a time-series for multidisciplinary investigations.

Applications of varved records are discussed with special reference to the fields of precisely dated events like volcanic ash layers or human impact, as well as to short-term and long-term climate (temperature, precipitation, wind, hydroclimatic conditions) and environmental changes.

Such sediment records provide accurate time control for a multitude of environmentally relevant sedimentary parameters and document the frequency and rates of change of annual to millennial climatic oscillations. Monitoring approaches like sediment trapping provide detailed characterisation of modern sedimentary processes that can be applied to interpret these records and enhance the reliability of mechanistic models of varve formation. The increasing availability of modern instrumental environmental and meteorological time-series can aid in rigorous calibrations of environmental proxies in local varve settings, assessment of statistical error margins, and enhancing the validity of interpretations. Furthermore, varve records are an ideal object to carry out high-resolution and continuous non-destructive sediment logging-techniques and thus economically provide a wealth of annual to sub-annual (seasonal) information. In combination with process studies, such detailed information will be able to provide feedback and ground truthing for climate models.

Due to their exceptional high temporal resolution and in combination with their accurate „internal“ time scale in calendar years, varved sediments can be regarded as one of the most precious environmental archives. These records are necessary to extend temporally limited instrumental climate records back in time.

Varved sediments of Lake Żabińskie, northeastern Poland: a chronological frame for high-resolution paleoclimate reconstructions over the last millennium

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Varve formation in biogenic sediments is governed by complex interactions between physical, chemical and biological processes in the water column. The process-level understanding of varved sediment records is crucial for establishing accurate chronologies and reliable interpretation of proxy data. Lake Żabińskie (54°07'54."N; 21°59'01.1"E, 117 m a.s.l., 41.6 ha water surface, 44.4 m deep) in northeastern Poland provides an excellent environment for the investigation of processes that lead to the varve formation. Using results of the process study, the ultimate goal was to develop a robust chronology serving as a time-frame for further proxy-based paleoclimate reconstructions.

During a three-year long observation period we investigated limnological and hydrochemical conditions within the water column as well as recent sediment fluxes to understand the relationship between the lake water properties and the sediment formation processes. These observations indicated considerable seasonal variability in the fluxes of total organic carbon, biogenic silica and calcite. The annual sedimentation model was established based on the sediment composition variability and used for the interpretation of laminations preserved in the sediment record.

Microscopic investigations of thin sections proved the annual character of these laminations. Three varve microfacies were distinguished along the sediment profile showing a different number of calcite laminae interbedded with diatoms, organic detritus and minerogenic admixtures. The chemical composition inferred from high-resolution XRF measurements allowed for the recognition of individual seasons within one varve. The varve chronology for the last millennium (based on three independent counts) had very small uncertainty (1-2%) and was validated with independent dating methods, i.e. the ^{137}Cs activity peaks and the tephra horizon from the Askja eruption at AD 1875. The varve-based time scale was also confronted with 32 AMS ^{14}C dates of terrestrial macrofossils distributed along the sediment profile. After elimination of the ^{14}C outliers, the ^{14}C chronology established with the free-shape algorithm deviated only by 10-25 years from the varve chronology. Between AD 1250 and today, the deviation did not exceed 10 years and was insignificant taking into account uncertainties of the ^{14}C- and varve-based chronologies. Statistically significant (up to 25 yrs) deviation in the older section (AD 1000-1250) could be attributed to specific types of macrofossils as this part of the model relied on dates of plant fragments, that might have been transported to the lake with a considerable deposition lag. Overall, the whole dataset is consistent and highlights the reliability of the chronology with the accuracy of a decade.

Temperature reconstruction using chironomids (non-biting midges) preserved in the varved sediment of Lake Żabinskie, Poland

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Quantitatively reconstructing temperature using biological remains preserved in lake sediment require a set of important steps:

1. Determining that the biological organism respond primarily to temperature
2. Developing a transfer function to quantitatively reconstruct temperature
3. Validate the inferences by comparing with instrumental data
4. Reconstruct temperature over longer temporal scales

Here, the use of chironomids (non-biting midges) preserved in the varves of Lake Żabinskie (Poland) was tested. The distribution of chironomids in 50 Polish lakes has shown that temperature is an important factor affecting the midges. However, the temperature gradient (2.5°C) was not large enough to develop a local transfer function. The samples were thus merged with an existing north eastern Canadian transfer function and temperature since 1886 AD was reconstructed. A comparison with instrumental data showed that inferences obtained with the merged training sets were accurate at near-annual resolution ($r_{Pearson}$=0.74, p_{corr}<0.01) and over decadal scales ($r_{Pearson}$=0.91, p_{corr}<0.01). This transfer function was then applied to the chironomids assemblages in Lake Żabinskie to reconstruct the variations in temperature over the past millennium. Key periods of climate change were reconstructed using chironomids. This study is a yet another example that chironomids can provide accurate temperature reconstructions on short and longer temporal scales.

A chrysophyte-based transfer function as a tool for winter severity reconstructions in NE Poland during the past millennium

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Transfer Functions based on modern training sets are well established and powerful tools in quantitative paleolimnology and environmental/climate reconstructions. Lake sediments are excellent natural archives to reconstruct long-term climate and environmental fluctuations. In this sense, the project 'Climate of northern Poland during the last 1000 years: Constraining the future with the past' (CLIMPOL) aims to develop quantitative climate reconstruction in northern Poland during the last millennium using lake sediments. The Polish training set consists of Chrysophyte cyst (golden brown algae, class Chrysophyceae) sediment trap and surface sediment samples, and data for 19 environmental variables collected from 50 lakes in northern Poland. After one year of exposure, 35 sediment traps were recovered and the chrysophytes assemblages were analysed. Multivariate numerical analyses (DCA, RCA) on environmental chrysophyte data revealed that the number of days with water temperature below 4°C (DB4°C) in the epilimnion, which is related to cold-season air temperature, is the most important variable for the chrysophytes assemblages. A transfer function based on a two-component partial-least squares model (PLS-2) was developed for DB4°C (R^2_{cross} = 0.58, RMSEP= 3.41 days). The resulting transfer function was applied to an annually-varved sediment core from Lake Żabińskie for the period AD 1000-2010. Variability of reconstructed DB4°C is due to the interplay between the oscillations of the zonal flow controlled by the North Atlantic Oscillation (NAO) and the influence of continental anticyclonic systems (Siberian High). Striking correspondence between the combined volcanic and solar forcing and the DB4°C reconstruction prior to the 20th century suggests that winter climate in Poland responds mostly to natural forced variability. Very strong continued volcanic eruptions leads to particularly long winters while variability in Total Solar Irradiance plays a minor role.

The PAGES 2k EuroMed project – beyond tree ring-based temperature reconstructions

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The community-driven Past Global Changes (PAGES) 2k initiative aims to improve understanding of past climate variability during the Common Era (CE) (PAGES 2k Consortium 2014). A total of nine regional PAGES 2k working groups – one each for the Arctic, the global ocean, and every continent, e.g. Europe and the Mediterranean (EuroMed) – pursues climate reconstructions to address key questions that are most relevant and feasible at synoptic scales, and to ultimately also link the obtained variability with human history.

In this regard, PAGES EuroMed2k is now focusing during its second project phase on the compilation and evaluation of different high- to low-resolution, marine and terrestrial proxy archives from the North Atlantic/European/Mediterranean sector that cover at least several centuries but ideally even some millennia. In order to perform 'detection and attribution' studies, state-of-the-art climate model simulations supplement the profound palaeoclimatic. The consortium not only discusses potential and limitation of compiling and evaluating diverse archives but also stresses methodological constraints associated with the ultimate aim of multi-proxy field reconstructions. The group also re-draws scientific foci by strategically broadening towards lower-resolution data and geographically expanding towards Central Asia.

In may talk in Gdansk (Poland), I will i) provide an update on current activities within the EuroMed2k cluster, ii) emphasize most recent advancements in dendroclimatological research, and iii) introduce new research avenues from the Russian Altai and may even northeastern Siberia.

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Climate reconstructions from tree-ring widths for the last 850 years in Northern Poland

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Tree-ring based temperature reconstructions form the scientific backbone of the global change debate, and they are the major part of the palaeo database used for the IPCC report. However, long temperature reconstructions derived from temperate lowland trees growing well within their distributional limits in central Europe are not part of the IPCC report, which is an essential gap in the international data base. The reasons for this are threefold: diffuse climate-growth relationships, the lack of long chronologies due to absence of sufficient numbers of long-living trees and the potential loss of low-frequency signals due to the short length of the sample segments.

In order to fill this gap in the database we developed two new robust chronologies from Scots pine and European oak covering approx. the last 850 years. We combined samples from living trees and archaeological material. While the Scots pine chronology was found to be mainly related to late winter temperatures (February/March) ($r = 0.61$), the European oak chronology showed the strongest correlation with summer precipitation (May-July) ($r = 0.63$). Based on these stable correlations two robust multi-centennial reconstructions of winter temperatures and summer precipitation were produced for northern Poland. In comparison to other tree-ring based reconstructions from higher altitudes and latitudes, winter temperatures of our reconstruction, however, did not indicate any modern warming nor did our reconstructed summer precipitation suggest any modern 20th century changes. In conclusion, we were able to overcome two of the three challenges mentioned before, i.e. we developed multi-centennial chronologies and sorted out the diffuse climate-growth relationships but could not prevent the loss of the low-frequency climate signals.

Therefore, in an attempt to tackle this third problem, we measured cell structures and developed chronologies of parameters such as cell wall thickness and cell lumen area. We used our new method applying confocal laser scanning microscopy to increment core surfaces for efficient histometric analyses. We focused on samples covering the last century because meteorological data necessary for calibration studies were available for direct comparisons. It was demonstrated that the correlations with climate were strong and different from those found for tree-ring widths (e.g., N-Poland oak-vessel-lumen-area-chronology with previous September-to-December mean temperature $r = 0.61$ and N-Poland pine-tracheid-lumen-area-chronology with mean Feb-to-June temperature $r = -0.66$). By using only raw values, low-frequency signals could be sustained in the chronologies.

Climate of Poland in the last 400 years on the basis of tree rings isotope studies

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The radiocarbon (^{14}C) and the light stable isotopes (^{2}H, ^{13}C, ^{18}O) concentration in the annual tree rings (especially in pine and oak from moderate climate zone) are sensitive indicators of climate change (temperature, precipitation and insolation) and also the anthropogenic influence. The studies of climate change by stable isotope analysis were made as the investigation of alpha-cellulose extracted from the annual tree rings of pine collected from east-northern of Poland (Suwalki district) and alpha-cellulose extracted from the annual tree rings and the late wood of oak collected from the southern part of Poland (Niepolomice Forest) within ISONET Project ("400 years of Annual Reconstructions of European Climate Variability Using a High Resolution Isotopic Network"). Both regions vary in the climate condition - the influence of oceanic climate is significant in the northern region, and the continental climate in the southern region.

The measurements of ^{14}C concentration was carried out in the whole wood from 2.5-years samples of pine (1860-2003) by LSC technique and independently with annual resolution in the alpha cellulose extracted from tree rings of pine (1960-2003) by AMS technique. The stable isotope ^{13}C records over last 400 years are presented on the background of change of the climate indicators and atmospheric ^{14}C in the northern hemisphere clean air. The results clearly indicate the climate cooling during the periods of the Maunder Minimum (1645-1715) and the Dalton Minimum (1790-1820).

The coefficients of correlation between stable isotope composition and temperature, precipitation and insolation were calculated on the basis of accessible meteorological data (temperature, precipitation and insolation) for sampling sites. ^{14}C in tree rings of the last 150 years records the significant Suess effect reflected also in ^{13}C of the annual tree rings of pine collected from the east-northern and southern part of Poland. The magnitude of regional Suess effect in Poland was estimated over the last several ten years period on the basis of different statistical models.

Tree-ring based reconstruction of temperature extremes over the last five centuries in Silesia, southern Poland: a multispecies perspective

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Extreme climatic events, which have a significant impact on human activity, are particularly well known for the period of the last century, thanks to the high availability of instrumental measurements. Proxy data however provide a chance to assess variations in extremes over many centuries. An annually resolved, continuous and absolutely dated ring-width data are vitally important. The combination of different types of proxies e.g. different species or parameters, can be a powerful method to increase reconstruction quality. The Silesia region, located in the Upper Odra catchment, is one of the regions in Poland with very few historical climate studies, despite conducting meteorological observations from the early 19th century and the existence of potential sources of proxy data.

The aim of the presented study is to reconstruct the temporal changes of extreme events and deduce its course at multi-centuries time scale in Silesia region. The study was performed based on tree-ring chronologies of eight species: *Scots pine Pinus sylvestris***,** European yew *Taxus baccata,* silver fir *Abies alba,* common beech *Fagus sylvatica,* European larch *Larix decidua,* sessile oak *Quercus petraea,* pedunculate oak *Quercus robur* and northern red oak *Quercus rubra.* The dendrochronological material was collected in the nature reserves protecting the remnants of the ancient forests, which enabled to obtain the longest possible growth sequences for this area. In addition, historical wood was used for lengthening the records. Early instrumental meteorological measurements from Bytom, Raciborz, Opole and Wroclaw along with documentary evidences of extreme events in Silesia were also used for comparisons.

Of the exanimated eight species, ring width records from *Pinus sylvestris*, *Taxus baccata, Quercus petraea, Quercus robur and Abies alba* tend to show most similar responses to climate (sensitivity to winter temperature), with *Larix decidua, Fagus sylvatica* and *Quercus rubra* having a more unique response (sensitivity to May temperature, previous October temperature, spring temperature, respectively). Despite the different climatic response of each species, most pronounced extreme years occur simultaneously in many chronologies. The highest agreement of the occurrence of extreme years was observed in pine and yew data.

A calendar of anomalous warm and cold winters in Silesia since the sixteenth century was developed on the basis of tree-ring data. The eighteenth and twentieth centuries were characterized by the highest frequency of extreme years. In the analyzed five centuries the occurrence of extreme years based on dendrochronological data was consistent with documentary data (from the sixteenth to the eighteenth century), instrumental data (from the eighteenth to the twenty-first century) and also with information about volcanic eruptions.

Climate variability in European Russia of the past 2000 years

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Historical archives, tree rings, palynology, boreholes are used for the climatic reconstructions in the Russian plain, while in the surrounding mountains (Khibiny, Urals, Caucasus) the paleoclimatic reconstructions are also based on glacier fluctuations, location of the upper tree line, buried soils and Elbrus ice core. Information from historical archives covering the last 1 ka in European Russia was gathered and analyzed in numerous publications (e.g. Borisenkov, Pasetsky, 1988), however the numerical reconstructions probably have to be reconsidered using the modern technique applied in the European historical climatology (e.g. Bradzil, 2005). The phoenological series in Russia are short (up to the mid-19th century) and often inconsistent (Kuznetsova, Minin, Golubeva, 2014). The living tree-ring chronologies in the European Russia are usually also rather short (up to 200 years long) (e.g. Vaganov, Shiyatov, Mazepa, 1996) due to the very heavy anthropogenic pressure in the region. However taking into consideration the available archeological wood the possibility to extend their length up to a millennium is real. Long chronologies were constructed recently for the Vologda (1085–2009) and Solovki (1186–2008) regions (Solomina, Matskovsky, Zhukov, 2011), both are temperature sensitive. The pine and oak chronologies in the center of the Russian plain (Smolensk, Kaluga, Tula, Kostroma and Yaroslavl' regions) are currently up to 500 years long (Matskovsky, Solomina, 2015). Matskovsky (2012) identified the limit at around 54-56° where the sensitivity of the conifers change: the trees to the north are predominantly summer temperature sensitive, while those to the south correlate positively to the PDSI and soil moisture. The climatic sensitivity of trees in Caucasus even at the upper tree limit is low. The use of optical density of pine and spruce was more successful that the traditional ring width approach and allowed the high quality reconstruction of the warm period temperature for the last 300 years (Dolgova, Solomina, 2010, Dolgova, 2015). Glacier variations in Caucasus were dated with ^{14}C, tree-rings and historical data (advances at 1839-1840, 1870–90s, 1910–20s, 1960–70s. (Bushueva, Solomina, 2012), while the relatively warm periods are marked by the buried soil horizons dated by ^{14}C (170±50 (1650–1890 CE) and 380±60 (1430–1650 CE) (Solomina et al., 2013). Ice core 182 m long was retrieved from the Elbrus glacier in 2009 and is partly processed (Mikhalenko et al., 2014). The ice core covers the period of the last 300-400 years and provides numerous types of environmental information. The first high resolution multi-archive temperature reconstructions are available for the Russian Arctic (Klimenko, Matskovsky, Dahlmann, 2014) and for the center of the Russian plain (Klimenko, Sleptsov, 2003). Large climatic events such as the Roman Optimum, cooling of the Great Migration Period, the Medieval Anomaly, the Little Ice Age, and the 20th century warming are recorded in both reconstructions, though the variance is higher in the Arctic. Although some promising results were obtained recently in this region many unresolved problems still exist (improvement of the replication of the chronologies and their extension, reassessment of historical data, involvement of rich limnological archives etc.).

Drought severity for the last 200 years in the Voronezh region (Russia) reconstructed from pine ring width chronology

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For the biosphere and agriculture, droughts are among the most dangerous natural hazards connected with atmosphere circulation anomalies. Severe famines of 1920s and 1930s in the U.S.S.R. were associated with the extended spring and summer droughts. Droughts and heat-waves of 1970s and 2010 in the European part of Russia result in forest fires and increase of mortality in Russian metropoles (Lupo et al., 2012). Despite of this importance, some important issues connected with drought formation are still unresolved. For better understanding of the drought formation mechanisms and drought occurrence in European Russia long records of high-resolution drought history are necessary. Tree-ring records can be a key to resolve this issue. Different efforts to reconstruct decadal variability of precipitation and hydrological history of the region of the last eight centuries were previously made on the basis of historical data by Swets (1978), Barash (1988), Klimenko and Sleptsov (2003). McDonald et al. (2007). The signatures of severe droughts of 1938-39, 1971-72 and 2009-10 were previously found in tree-ring records of Voronezh region (Matveev et al., 2012). No tree-ring based drought reconstructions in the East-European Plain existed so far.

In this study we present the new PDSI reconstruction based on tree-ring width chronologies of pine (*Pinus sylvestris*) from Voronezh region, Central Russia (51.25N, 40.25E) covering AD 1776-2000. For the climatic response identification we used correlation analyses with monthly averages of hydrometeorological series for the period 1901-2012 from the CRU TS 3.27 dataset, Palmer Drought Severity Index (PDSI) from 1870 to 2010, CPC Soil Moisture from 1948 to 2010 and some other parameters including the atmosphere circulation indices (NAO, East Atlantic (EA), East Atlantic/Western Russia (EAWR), SCAND, POLAR).

The highest correlation for the ring width is found with the PDSI (r=0.44, 1870-2000) and CPC Soil Moisture (r=0.65, 1948-2000) for the April-September growing season. Stronger correlations for the later period may be explained with increased temperatures and drier conditions in the second half of the 20th century and, on the other hand with less reliable PDSI data in the end of 19th – beginning of 20th centuries. However, strongest decreases of tree growth coincide with strongest droughts (from PDSI) all over the instrumental period. We argue that 19 – 42% of the PDSI variability in the past can be explained with our reconstruction and that the most severe droughts are recorded in it. Our reconstruction suggest occurrence of strong droughts in 1793 and 1863 that are comparable with the most severe droughts of 20th century.

The aim of this project is to further extend our tree-ring network (14 chronologies so far, 120-300 years long) to the south of European Russia and to extract information about spatial annually-resolved drought history from it. The reaction of different tree species to the heat wave and drought occurred in the central and southern parts of the Russian plain in 2010 will be considered in order to better understand predictability of droughts using the tree ring approach in this area.

Climate reconstructions in the Urals over the last millennium inferred from borehole temperature data

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The present-day distribution of rock temperatures is the important source of paleoclimatic information along with widely used proxy records. Borehole temperature data provide the reconstruction of the long-period components of temperature fluctuations which are poorly reproduced (or are not reproduced at all) by other proxies. Temperature-depth profiles measured in boreholes up to 1 km deep allow reconstructing climate changes for the last millennium.

Using geothermal data one can evaluate past ground surface temperature (GST) and surface heat flux (SHF) changes. The SHF is a thermal imbalance arising at the surface as the difference between net radiation and radiant sensible and latent heat fluxes. The SHF changes can be directly estimated from available series of GST variations. Paleoclimate information represented by the surface heat flux histories significantly differs from traditional temperature characteristics. The SHF characterizes the energy of climate changes and then it can be directly compared with energy fluxes in the atmosphere and at its upper boundary.

Here we present estimations of past GST and SHF changes reconstructed in the Urals for the last 1000 and 150 years. The GST histories were obtained by inversion of 49 temperature-depth profiles logged in the Middle and South Urals. Then the joint GST history was used to reconstruct the SHF history for the last millennium. The GST and SHF histories reveal the Little Ice Age and the Medieval Optimum, which is manifested in the SHF history less than in the GST history. The heat flux changes precede temperature changes. Reconstructed heat flux was compared with different factors of climate variability such as changes in total solar irradiance, the variation of carbon dioxide CO2 and volcanic sulfates SO4 concentrations in the atmosphere. Linear regression analysis showed that total solar irradiance is the main factor governing the millennial SHF variations. The influence of variations in carbon dioxide concentration in the atmosphere and volcanic activity is less.

The ratio of surface heat flux to solar radiation may be considered as an alternative measure of the Earth's climatic sensitivity. The ratio of two heat fluxes is a non-dimensional parameter, and additionally depends less on radiative forcing duration by contrast to traditional index of climatic sensitivity representing temperature response on radiative forcing.

The 150-years reconstruction of SHF changes was made on the basis of the Urals long-term meteorological records. The heat flux changes also precede temperature changes. The secular heat flux variation over the past 150 years occurred in opposition with the total solar irradiance oscillations, and the observed warming was mainly caused by an increase of CO_2 concentration in the atmosphere.

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Proxy data from East Central European cave sediments for the past two millennia

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Cave sediments are attractive targets for palaeoclimate studies. Usually the merit of calcareous speleothems are emphasised, however, numerous caves of the Carpathians and the Dinarides host large perennial ice deposits, which also have great potential in the palaeoclimatological and palaeoenvironmental research of our region.

Regarding the classical calcareous speleothems two features of the cave environment can be mentioned which facilitate the use of stable isotopes in palaeo-climate reconstruction. First, cave temperatures remain relatively constant throughout the year, and are similar to the mean annual air temperature of the region above the cave. Second, relative humidity in the cave atmosphere is high (RH ~95–99%), minimising evaporation that might otherwise cause kinetic isotope fractionation.

Ice caves are characterized by very distinct cave conditions. The cave temperature is well below the mean annual air temperature of the region. The subterranean temperature remains below or just slightly above the freezing point and they represent an extrazonal permafrost occurrence.

The temporal resolution achievable by individual geochemical measurements depends critically on the growth rate of the speleothem and crucial when the retrieved proxy information are to be compared to inherently annual records, such as varved sediments or tree rings.

Using conventional stalagmite sampling techniques (e.g. a dental drill with ~ 0.5mm diameter), the time interval averaged by stable isotope measurements would typically range from subannual to decadal scales challenging the comparison of the available records.

The first part of the talk will introduce those stalagmite derived records from east Central European karstic regions which cover the past two millennia. Namely, Cerenosmja (Serbia), Modrić (Croatia), Trió and Kiskőhát (Hungary) and Ascunsă (Romania). A special attention is to be paid to their temporal resolution using updated age-depth models in certain cases.

The second part of the talk will focus on ice caves. Available numerical age estimates clearly prove their multicentennial age. However, a persistent mass loss has been documented for these subterranean ice deposits throughout the past century, similarly to the much frequently cited glacier retreat. Longer cave ice core records are available from the Dobsinska Ice Cave (Slovakia) and the Focul Viu and the Scarisoara Ice Caves (Romania) will be presented.

Comparing varve formation and preservation during the last 2000 years in two lakes along a W-E transect in the southern Baltic lowlands

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Annually laminated (varved) lake sediments present unique archives for past climate and environment reconstruction beyond instrumental datasets as they allow accurate dating and multi-proxy analyses down to seasonal resolution. ICLEA (virtual institute of Integrated Climate and Landscape Evolution Analyses) focuses on understanding processes of climate and landscape evolution in the southern Baltic lowlands in NE Germany and N central Poland. Here, we compare two varved records, Lake Tiefer See (TSK; NE Germany) and Lake Czechowskie (JC; N central Poland), based on independent chronologies to decipher differences in lake responses to climate change and human impact during the last 2000 years.

TSK and JC are located in a distance of 400 km in a similar geomorphologic position within the Pomeranian terminal moraine belt of the Weichselian glaciation. We present multi-proxy data at inter-annual to sub-decadal resolution for the uppermost 380 cm (TSK) and 494 cm (JC) of the sediment profiles. Independent chronologies are based on varve counting, AMS ^{14}C dates and a tephra marker layer.

The main difference between both records is that while the JC record is almost continuously varved over the last 2000 years, about 48% of the TSK sediments are poorly or even partially non-varved. Interestingly, these phases of decreased varve preservation or even a lack of varves in the TSK record (AD 310-410, AD 710-755, AD 965-1055, AD 1200) coincide well with phases of higher diatom layer thicknesses of JC varves (AD 290-420, AD 670-730, AD 900, AD 1160). We discuss possible causes for the coincidence of different specifications of varve sediment responses to external forcing mechanisms including climate and human impact.

This study is a contribution to the Virtual Institute of Integrated Climate and Landscape Evolution Analysis –ICLEA- of the Helmholtz Association (grant number VH-VI-415) and uses infrastructure of the Terrestrial Environmental Observatory (TERENO) of the Helmholtz Association.

Regional and local sedimentation signatures in varved sediments of the last 150 years in three lakes in northern central Poland

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Beyond instrumental data and historical documents, annually laminated (varved) lake sediments are suitable high-resolution recorders of past climatic and environmental changes. Lacustrine sediments offer a unique opportunity to decipher natural variability and human impacts on environmental systems especially during the last two centuries when the latter became increasingly important. An essential factor in this respect, are processes controlled by local catchment and lake basin characteristics.

In this study we present results from three varved lakes located in a close proximity to each other in northern central Poland (Lake Czechowskie, JC; Lake Głęboczek, JG; Lake Jelonek, JEL) for the last 150 years. All lakes have been independently dated combining annual layer counting, in one case (JC) supported by ^{137}Cs dating, and a tephra marker layer (Askja AD1875 tephra) as a tie point. Our proxy data includes micro-facies (seasonal layer composition and thickness) and geochemical analyses (µXRF scanning at 200 µm step size, carbon and nitrogen analyses at 2-6 varve year resolution).

A common signature of all lake records are periods of increased varve thickness caused by particularly thick layers of pennate diatoms which occurred contemporaneously but with different durations. An interval of enhanced varve thickness occurs from AD 1860-1912 in JC, AD 1860-1900 in JG and AD 1870 to 1895 in JEL. In addition, intervals with less good varve preservation along with enhanced supply of detrital matter also occur in all lakes, but are shorter in the smaller lakes JG and JEL compared to JC (AD 1912-1952 and AD 1969-1985 in JC, AD 1960-1979 in JG and AD 1990-recent sediment surface in JEL). Here, we will discuss causes for differences and similarities in varve responses including lake-catchment size relations, local basin morphology, afforestation and agriculture, and climate (precipitation, seasonality). Finally, we will compare our results with published data from a varved lake in NE Germany (Tiefer See) located ca. 400 km to the West.

This study is a contribution to the Virtual Institute of Integrated Climate and Landscape Evolution Analysis – ICLEA– of the Helmholtz Association; grant number VH-VI-415.

Hyper-spectral imaging: A promising tool for quantitative pigment analysis of varved lake sediments

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Varved lake sediments are good archives for past environmental and climate conditions from annual to multi-millennial scales. Among other proxies, concentrations of sedimentary photopigments have been used for temperature reconstructions. However, obtaining well calibrated annually resolved records from sediments still remains challenging. Most laboratory methods used to analyse lake sediments require physical subsampling and are destructive in the process. Hence, temporal resolution and number of data are limited by the amount of material available in the core. Furthermore, for very low sediment accumulation rates annual subsampling is often very difficult or even impossible.

To address these problems we explore hyper-spectral imaging as a non-destructive method to analyse lake sediments based on their reflectance spectra in the visible and near infrared spectrum. In contrast to other scanning methods like X-ray fluorescence, VIS/NIR reflectance spectrometry distinguishes between biogeochemical substances rather than single elements. Among others Rein (2003) has shown that VIS-RS can be used to detect relative concentrations of sedimentary photopigments (e.g. chlorins, carotenoids) and clay minerals.

In this study hyper-spectral imaging is used to infer ecological proxy data from reflectance spectra of varved lake sediments. Hyper-spectral imaging permits the measurement of an entire sediment core in a single run at high spatial (30x30µm/pixel) and spectral resolutions (~2.8nm) within the visual to near infrared spectrum (400-1000nm). This allows the analysis of data time series and spatial mapping of sedimentary substances (e.g. chlorophylls/bacterio-chlorophylls and diagenetic products) at sub-varve scales.

The method is demonstrated on two varved lake sediments from northern Poland showing the distributions of relative concentrations of two types of sedimentary pigments (Chlorophyll-a + derivatives and Bacterio-pheophytin-a) within individual varve years. The relative concentrations from the spectral data set have then been calibrated with absolute concentrations derived by High-Performance-Liquid-Chromatography (HPLC). This results in very high-resolution data sets of absolute sedimentary pigment concentrations suitable for the analysis of seasonal pigment variations.

SESSION 3: PAST CLIMATE MODELING AND DATA-MODEL COMPARISON

Temperature of the past 2 millennia – results from the PAGES2k Europe/Mediterranean group

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The Past Global Changes (PAGES) project aims to improve understanding of past climate variability. Within this program, PAGES2k focuses on the past 2000 years — the Common Era (CE) — for which a variety of documentary and natural proxy records are relatively abundant.

Here we present new evidence on multisite and multiproxy temperature reconstructions from the PAGES2k Europe/Mediterranean group applying Bayesian Hierarchical modelling covering the past 2 millennia.

We discuss the new findings both in space and time and compare the gridded summer temperature product to an ensemble of millennium-length simulations from coupled general circulation models. The joint evaluation of reconstructions and AOGCM simulations allows for an assessment of the consistency between these two independent sources of information and provides a multifaceted perspective on the relative contributions of external forcing and internal dynamics to past climate variability.

Dynamic downscaling as a way to bridge gaps between climate simulations and reconstructions

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Past climate variability can be studied with two mayor approaches: climate reconstructions and simulations. They are complementary tools, that combined allow to gain insight in the evolution of climate at scales beyond the short instrumental record. However, it is important to note that they often represent different temporal and spatial scales. While proxy-based reconstructions may be representative of the seasonal evolution of local climate, current General Circulation Models provide sub-daily evolution of a climate averaged over spatial scales representative of whole countries. This scale gap is one of the most important caveats in model-reconstruction comparison exercises. An additional difficulty is the presence of internal variability in climate simulations, which precludes the perfect agreement between simulated and reconstructed climate, even if both were perfect.

Regarding the gap, downscaling techniques, developed in the context of weather forecast and fairly common in climate change studies, enable reducing the spatial scale mismatch. Dynamic downscaling in particular consists of the use of a Regional Climate Model that, driven by a General Circulation Model, simulates the climate over a limited area domain. This allows to reach resolutions of few tens of kilometres in a data set that blends the consistency of a climate driven by a set of prescribed external forcings with the explicit representation of physical processes modulating climate evolution at regional scales. Unfortunately there is no way to reduce the internal variability problem, since it is not a technical limitation but a fundamental characteristic of nature, which indeed becomes more relevant at regional scales. One way of dealing with this difficulty is through ensembles of simulations, that allow to disentangle what component of climate variability is driven by external forcings and what is attributable to unpredictable fluctuations around the equilibrium.

This contribution reviews some of the efforts carried out in the last years to reconcile high-resolution climate simulations and reconstructions. Although still seldom, nowadays there exist a number of high-resolution climate simulations for Europe over the last centuries that open a number of research opportunities and allow to answer new questions. From the assessment of the relative role of the internal variability compared to external forcing in various variables, to the evaluation of the consistency among different climate reconstructions. New approaches are currently being developed to make meaningful interpretations of agreements but especially disagreements between simulations and reconstructions.

But beyond model-reconstruction comparisons, the existence of such simulations opens new opportunities for more theoretical-focused studies that allow to increase our understanding of climate evolution in general. Prominent examples are the so-called Pseudo Proxy experiments that allow to evaluate the skill of climate reconstructions. High-resolution simulations extend the application of such techniques to phenomena not properly captured by the coarse resolution of current General Circulation Models, such as orography-induced precipitation or drought severity. Nowadays, climate simulations represent a playground whose physical consistence can be employed to carry out actual “in silico climate experiments”.

SESSION 4: PROXY CALIBRATION, DISENTANGLING CLIMATE AND HUMAN IMPACTS

Multi-proxy, high-resolution studies of peatlands development during the last 2000 years - climatic drivers and human impact

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Peatlands are exceptional wetland ecosystems. They are not only beautiful but also possess a record of the past global changes. Furthermore, they accumulated a big amount of carbon during the Holocene that is expected to affect the atmosphere through the global warming. Peatlands are important archives of the past environmental change. Especially ombrotrophic bogs are regarded as reliable source of palaeoclimatic data that are extracted with the biotic and abiotic proxies. High-resolution multi-proxy studies became a standard approach to reconstruct palaeoenvironmental changes. Nevertheless, not a lot of peatland proxies can be used for the quantitative reconstruction. Testate amoebae (TA) are often applied as a proxy of the past ground water table dynamics potentially connected with hydro-climate. In this case calibration in space approach and transfer function is used. Sometimes, TA are supported with other proxies e.g.: pollen, plant macrofossils and stable isotopes. Such data composition allows to obtain a fuller picture of the past environmental change in various spatial scales. The talk will address several issues connected with TA-based transfer function development and quantitative palaeohydrological reconstructions from peat profiles. The sites presented are located in Poland, Switzerland and Russia. Most of those archives cover the last 1000 years, however several reach also 4k. There is a common signal in studied peatlands in the last millennium, however, one should be very careful in terms of climatic interpretation. Hydrological variability can be connected with the internal feedbacks, and land-use change. It seems that data about past fire events and peatland hydrology can bring a new look at the past climate change in long time scales. Our recent research shows that pristine - stable wet bogs can be dated to ca AD 1350. This date is the beginning of the considerable hydrological disturbances connected with the Little Ice Age (LIA). In case of several Baltic bogs, the wet phase of LIA is recorded between AD 1500 and AD 1800. However, this climatic change might have been blurred by land-use change connected with deforestation. After AD 1200, increasing human impact and climatic instability was inferred, also during the LIA. The research provided information related to the time of existence, location and characteristics of the natural/pristine state of the bogs. It should be stressed that human impacted CE Europe since at least 5000 years, therefore even so early its influence should be considered in palaeoclimatic inferences. As a consequence there are variety of problems to differentiate a climatic signal from anthropogenic disturbance in the peat as well as in lake sediments. Polish and Siberian sites revealed a wet Medieval Warm Period, then Little Ice Age was hydrologically unstable. Palaeoecological studies on peatlands should possess a good ecological background to appropriately interpret past events. We made several steps towards such an interdisciplinary approach trying to compile paleoecology, monitoring and experiment in e.g. CLIMPEAT (www.climpeat.pl) and WETMAN (www.wetman.pl) projects that are expected to support our future quantitative inferences.

2000 years of hydroclimate variability recorded in different types of mire archives in north-eastern and north-western Poland

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Mires are important archives of information on past hydroclimatic conditions, however, as they differ in respect to the main source of the feeding water, the surface wetness, which is the subject of palaeoecological reconstructions, may be driven by various factors in different mire types. The aim of our lecture is to compare the palaeohydrological information concerning the last 2000 years, based on palaeoecological analyses of various mire-types in north-eastern and north-western Poland.

Sub-fossil remains of organisms living in bogs and mires are valuable source of information about past hydrological conditions during formation of the deposit. We used pollen analysis including broad range of non-pollen palynomorphs (NPPs), plant macrofossils and changes in peat humification, as palaeoecological proxies to reconstruct changes in hydrology of eight mires situated within the area of Białowieża National Park in NE Poland and four mires in the Kashubian Lake District (NW Poland). In the case of this study a range of NPP taxa appear to reflect changes in the mire habitats with the great sensitivity. It concerns several taxa of algae (e.g. *Botryococcus*) and cyanobacteria (e.g. *Anabaena*, *Aphanizomenon*), large number of fungi (e.g. *Entophlyctis lobata*, HdV-96, *Tilletia sphagni*), rhizopods (e.g. *Centropyxis discoides*, *Arcella*) and others.

All the mires, at their minerotrophic and ombrotrophic phases, suffered from temporal water deficits which resulted in hiatuses within the sediments. Even so, the high resolution palaeoecological analyses enabled us to reconstruct not only the individual characters of changes in particular study objects, but also to indicate several wet and dry shifts on these mires surfaces which correlate among the sites. These apparently concurrent events are discussed in terms of climatic fluctuations as a potential factor responsible for the wet and dry periods in the mires history. The most prolonged dry phase concerns the Early Middle Ages.

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Last millennium hydro-climate variability in Central Eastern Europe (Northern Carpathians, Romania): a multi-proxy approach

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Proxy-based reconstructions of climate variability over the last millennium provide important insights for understanding current climate change within a longer-term context. Past hydrological changes are particularly difficult to reconstruct, yet rainfall patterns and variability are among the most critical environmental variables. Ombrotrophic bogs, entirely depended on water from precipitation and sensitive to changes in the balance between precipitation and evapotranspiration, are highly suitable for such hydro-climate reconstructions. We present a multi-proxy analysis (testate amoebae, plant macrofossils, stable carbon isotopes in Sphagnum, pollen, spores and macroscopic charcoal) from an undisturbed ombrotrophic peat profile from the Rodna Mountains (northern Romania) to establish a quantitative record of hydro-climatic changes in this region. We identify five main stages: wet surface mire conditions between 800 and 1150 AD, and 1800 and 1950 AD; and drying of the mire surface between 1300 and 1450, 1550 and 1750, and 1950 and 2012 AD. Our multi-proxy reconstructions suggest that conditions during the Medieval Climate Anomaly Period (MCA; 900-1150 AD) were considerably wetter than today, whilst during most of the Little Ice Age (LIA; 1500-1850 AD), they were dry. Mire surface conditions in the Rodna Mountains have dried markedly over the last 40 years as a result of global warming approaching the driest conditions seen over the last 1000 years. There is a marked difference between current hydro-climatic conditions (dry mire) and those of the MCA (wet mire). This implies that for the study region, the MCA cannot provide analogous climatic conditions to the contemporary situation. The dry conditions during the last millennium did not only lower the water table in the mire, but also increased local fire activity. Our reconstructions are in partial agreement with water table estimates elsewhere in central and Eastern Europe and augment the regional perspective, but generally contrast with those from NW Europe, especially during LIA. It is also apparent that the reconstructed patterns of moisture conditions show a much more complex regional pattern than that for palaeo-temperature. We suggest that these distinctive regional differences result from fluctuations in large-scale atmospheric circulation, which determine the relative influences of continental and oceanic air masses. Comparing different proxies also facilitates a better understanding of the detail of the climate variability recorded (temperature, P-E) as well as the driving forces (climate, human).

How does fire and drought influence peatland under oceanic-continental climatic conditions? 2000 years of environmental change in Linje mire, northern Poland

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Sphagnum peatlands in CE Europe are influenced by ongoing climate change and human activity. A marked increase of anthropogenic influence on peatlands has been noticed in the last two millennia. As an effect, peat desiccation and increased sensitivity to fire were observed. However, still little is known about the effect of drought and fire on peatlands located under oceanic-continental conditions. Current studies reveal that the combination of low precipitation and high temperatures is expected to increase fire frequency in the near future and, consequently, cause substantial hydrological changes in *Sphagnum* peatlands functioning. The aim of this study was to reconstruct the last 2000 years of hydrological and fire history at Linje mire in northern Poland. We wanted to explore (1) drought and fire influence on peatlands in transitional climate, (2) main drivers of fire activity, and (3) climatic vs. anthropogenic forcing on peatlands. Two-meter core was extracted from a peatland and sub-sampled with high resolution for the multi-proxy analyses. A novel approach for Polish peatlands was used: joint testate amoebae-based water table depth and charcoal-inferred fire activity reconstructions. Moreover, we used pollen analysis to reconstruct vegetation change and human impact on the environment. Our results show four hydrological stages of peatland development: moderately wet (from ~35 BC to 800 AD), wet (from ~800 to 1390 AD), dry (from ~1390 to 1700 AD) and a phase with water table fluctuations (from ~1700 AD to present). The results show that increased fire activity was of human origin and was one of the main factors that influenced peatland hydrology in the last 700 years. This was manifested by a hydrological instability that appeared at the onset of the Little Ice Age. However, the mire response through hydrological changes towards drier conditions was delayed in relation to the surrounding vegetation changes. A shift in testate amoebae communities was observed - a wet community (dominance of *Archerella flavum*, *Hyalosphenia papilio* and *Amphitrema wrightianum*) shifted to a dry community (dominance of *Cryptodifflugia oviformis* and *Euglypha rotunda*). The lowest water tables are correlated with increased fire activity and highest ash content.

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Climate reconstructions and human impact from lakes sediments during last two millennia in Central European Russia

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For climate reconstruction and human impact during last two millennia we analyzed the Glubokoye Lake sediments in the Central European Russia (Moscow region). Glubokoye Lake is one of the best investigated lakes in Russia in the aspect of long-term (over 100 years) biomonitoring. The lake area is 0.59m^2. The maximum depth is 32 m. For the first time we received the results of multiproxy paleolimnological investigations of lake sediments. Our multiproxy study of climatic and anthropogenic changes from Lake Glubokoye includes pollen, chironomids, diatom, geochemistry and lithostratigraphy. Reconstructed July temperature over the last 1170 years ranges between 14.8 to 16.4 ± 1.2°C. The ratio of climate change and human impacts is reflected in changes in vegetation, chironomids, diatoms, LOI, phosphorus and metals.

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Climate versus human impacts on Lake Atnsjøen ecosystem (south-eastern Norway) during the last millennium

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The main aim of our study was to trace long-term natural and human-induced ecological changes in the Lake Atnsjøen ecosystem.

Lake Atnsjøen is located in a mountain area (Rondane) at 701 m a.s.l., in the south eastern part of Norway. Due to the remote location and because a large part of its catchment is located in the Rondane National Park (and hence protected by law), we expected that human impact on the lake has been relative week. The climate of the area has continental features, annual precipitation varies between 400-600mm. Lake Atnsjøen is surrounded by a lichen rich pine and birch forests. Above the tree line dominating vegetation type is alpine tundra. Lake Atnsjøen has steep slopes and flat bottom, with a maximum depth of 80.2m. Macrophytes, dominated by *Isoëtes lacustris*, are limited to a narrow zone close to the shore.

A sediment core from 20m depth taken in the South-Eastern part of the lake was used in order to study the history of Lake Atnsjøen. We applied the multi-proxy approach and made several paleolimnological analysis of the sediments; pollen, cladocerans, chironomids, diatoms, macrofossil, chemical and sedimentological properties. The chronology of the core was established by ^{210}Pb and ^{14}C dating.

The Chironomid-based reconstruction of the mean July temperatures show distinct cooling that started around 1390 AD and ended approximately at 1850 AD. This is within the range of generally accepted frame of the LIA (Little Ice Age). The reconstruction shows slight warming around 1450 AD which may suggest that LIA in Lake Atnsjøen region consisted of two cold. The pollen analysis revealed that there has been continuous human activities within the catchment due to agriculture through the last 1000 years. The effect of human activity was less pronounced during the LIA and in the 14th century. The latter was likely caused by the “black death”, the pandemic plague which decimated the population in whole Europe, including Norway.

The Cladocera analysis showed that the lake ecosystem changes were mainly driven by climate. In LIA the rate of Cladocera remains per 1cm2 was lowest during last 1000yrs and the Bosminid sex ratio highest, indicating unfavourable edaphic conditions for pelagic species. The Cladocera diversity measured by Shannon index was also lowest between 1590-1800 AD. The dry density of the sediment showed fluctuation in the last 1000yrs but the most prominent increase was recorded between 1620-1770 AD.

The analysis of cladocerans showed that the lake ecosystem changes were driven mainly by climate. The cladocerans' remains per cm^2 had a minimum while the Bosminid sex ratio had a maximum during the LIA, indicating hard conditions for pelagic species. The diversity of cladocerans (Shannon index) also had a minimum between 1590-1800 AD.

The pollen and macrofossil analysis showed that dominant water plant in Lake Atnsjøen during last millennium was *Isoëtes lacustris*, a species characteristic for oligotrophic lakes. Its abundance decreased between 1590-1880 AD which coincide with LIA and may indicate that the littoral zone was affected by climate cooling.

The LIA ended in the Lake Atnsjøen region around 1810 AD and was followed by a rapid increase in temperature that continued until the present, however with a slower pace. This resulted in a slight increase of lake productivity represented by higher TOC concentrations and an increase in cladoceran diversity. Higher productivity was also due to increased number of farms established in the catchment from the 1750ies, specially from late 19^{th} century to early 20^{th} century. Furthermore, the introduction of chemical fertilisers in the area between World War I and World War II have likely also contributed to higher productivity.

The multi-proxy studies allowed us to conduct a complex reconstruction of the climate changes and their influence on Lake Atnsjøen ecosystem evolution during the last 1000 yrs. The climate was the main driver of changes and LIA cooling strongly impacted environment in the Rondane National Park Region.

The multi-proxy studies allowed us to conduct a complex reconstruction on how ecosystem of Lake Atnsjøen was altered during the last 1000yrs. The climate has been the main driver of changes in the studied region which was strongly affected by cooling during LIA and climate warming that started in 19^{th} century. In resent time agricultural activities has led to an increase in lake productivity.

Stable isotope record in annually laminated lake sediments from Lake Żabińskie (NE Poland) for the last millennium.

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Stable isotope record of carbon (^{13}C) and oxygen (^{18}O) has been analysed from an annually laminated sediment from Lake Żabinskie (Mazurian Lakeland, NE Poland) with high resolution (1-3 yrs).

The sediment layers which were formed in each year during the last millennium contain information about environmental changes in the past. The calcite layers are formed in lake sediment in warm months of the year, therefore the reconstruction of summer climate variables in the past is potentially possible. The investigation of correlation between isotope dataset and instrumental climate data for years 1897-2008 AD confirmed that theory. The record of temperature, precipitation and SPEI (Standardised Precipitation Evaporation Index) coefficient, which is a combination of both temperature and precipitation, was tested. The strongest linear correlations were found for most samples for June, July, August (JJA) months but in some cases the correlation coefficient was stronger when also May was taken into account. For the whole 120-yrs series the correlation between $\delta^{18}O$ and average JJA temperature is 0.007, average JJA precipitation is 0.16 and average JJA SPEI is 0.20, however only correlation between $\delta^{18}O$ and JJA SPEI is significant. Analyzing the results from 1897 to 2008 we can distinguish period 1948-2008 with relevantly stronger correlations: R(SPEI) = 0.37. This period is connected with cessation of human activity close to Lake Żabinskie.

Reconstruction of climate variables for the last millennium was made using transfer function obtained for calibration period (1897-2008). Reconstructions showed that known climate extremes like Medieval Warm Period, Little Ice Age with Sporer (1420-1570), Maunder (1645-1715) and Dalton (1790-1820) Minimum was recorded in sediment from Lake Żabinskie.

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Spring (MAM) temperature signal in the varved sediments of Lake Żabińskie, NE Poland: calibration and reconstruction back to AD 1600

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High resolution, well-calibrated records of lake sediments are fundamental for the assessment of climatic and environmental changes. Varved lake sediments are particularly valuable archives in this context. However, due to the multitude of responses within lake ecosystems, the key issue is to understand how climate variability interacts with other environmental pressures such as eutrophication. This is a pre-requisite for a climate reconstruction beyond the instrumental period.

Here we present a multi-proxy record of sedimentary pigments, geochemical and spectroscopic data from Lake Żabińskie (Masurian Lake District, north-eastern Poland) with the aims to: (i) detect and differentiate climate-driven changes from other environmental controls, and (ii) test whether the climate signal can be extended back to the last 1000 years. Lake Żabińskie exhibits highly organic biogeochemical varves of simple inorganic composition (predominantly summer-precipitated endogenous calcite). The hundred most recent years of sedimentation were studied from a short gravity core, while deeper sections were analyzed from a piston core. Pigments were extracted from the short sediment core at 1-cm resolution and measured using High Performance Liquid Chromatography (HPLC). We also measured pigments with scanning Visible Reflectance Spectroscopy (VIS-RS; 380-730 nm) to assess whether the down-core resolution can be increased.

In a first part, we use Principal Component Analysis (PCA) and cluster analysis to demonstrate that the recent eutrophication of the lake can be discriminated from climate-driven change during the instrumental period AD 1907-2008. The eutrophication signal is evidenced by a recent change in the algal community from green algae (rich in chlorophyll a) to more competitive blue-green algae (rich in ß-carotene), which leads to an environment with light-limiting conditions for chlorophyte growth. Further, we show that concentrations of chlorins (diagenetic products of chlorophyll a) are not affected by this eutrophication signal, and can be calibrated with mean spring (MAM) temperature ($r = 0.63$, $p < 0.05$, $n = 105$, 5-yr filtered). Consistently, monthly limnological measurements (2011-2013) reveal the highest chlorophyll a concentrations in spring.

In a second part, we extend the calibration model between chlorins and spring temperature back in time. This quantitative millennial-long spring temperature record compares well with pre-instrumental data from Warsaw and Vilnius back to AD 1779 ($r = 0.38$, $p < 0.05$, $n = 206$, 5-yr filtered). In addition, our MAM record shows similarities with tree-ring based JFMA temperature reconstruction from northern Poland back to AD 1600. Particularly, both records show a decrease in spring temperature with the progression of the Little Ice Age, with a minimum recorded at the end of the 18th century. However, prior to AD 1600, the sedimentation processes in Lake Żabińskie change radically, which cannot be further attributed to climate variability. This is reflected by lower rates of erosion, mass accumulation and fluxes of sedimentary organic matter.

SESSION 5: PAST HUMAN IMPACTS ON THE ENVIRONMENT

Pollen-based quantitative reconstructions of Holocene vegetation cover in Europe: contribution to the study of land cover – climate interactions and other examples of applications

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Pollen-based reconstructions of past vegetation cover is achieved using various kinds of methods of which reconstruction of the distribution of past biomes using the biomization technique has been the most common during the past 10 to 20 years. Reconstruction of the Leaf Index Area (LIA) using pollen-LIA transfer functions has been/is also used in e.g. northern America and northern China. The more recent methodological approach developed by Sugita (2007a and b), the Landscape Reconstruction Algorithm (LRA), applies simple but robust models of the pollen-vegetation relationship including models of dispersal and deposition of small particles in the air. This approach makes it possible to estimate the past cover of plant taxa (in % cover of a quantified area) using fossil pollen records. The LRA includes two models, the REVEALS model to estimate regional vegetation cover at a spatial scale of ca. 100 km x 100 km, and the LOVE model to estimate local vegetation cover at a spatial scale of a few km around the study sites. The LOVE model can be applied given there are REVEALS estimates of regional vegetation cover for the study area. The LRA has now been tested/validated in several regions of Europe and northern America, and used in a growing number of palaeoecological studies. REVEALS estimates of regional vegetation cover for a large part of Europe and five time windows of the Holocene (Trondman et al., 2014) were used to compare pollen-based reconstructions of deforestation with the scenarios of past anthropogenic land-cover change (ALCC) from e.g. Kaplan et al. (2009) (KK scenarios). Spatially continuous datasets of the cover of evergreen trees, summer-green trees and open land for several time windows of the Holocene were produced by spatial statistical modelling using the pollen-based REVEALS estimates and, as covariates, spatially continuous estimates of past land cover obtained by combining simulated potential vegetation (from the dynamic vegetation model LPJ-GUESS) with the ALCC KK scenarios. These continuous datasets were developed to study land cover-climate interactions using a regional climate model. So far, model simulations of the regional climate in Europe at 6k and 0.2 k years BP using the ALCC KK scenarios as descriptions of the anthropogenic deforestation at those times showed that anthropogenic land-cover change at 0.2k (compared to 6k) had a significant effect on climate (both temperatures and precipitations) through biogeophysical processes (Strandberg et al., 2014). Future, similar studies will use land-cover descriptions based on the REVEALS estimates. Other examples of the contribution of pollen-based reconstructions of past vegetation cover (at both regional and local spatial scales) are related to questions on e.g. human resources in the past, erosion through deforestation and relationships with water quality, and biodiversity.

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Anthropogenic deforestation of northern Europe and eastern Baltic area during last millennium

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The role of terrestrial ecosystems as climate agents through geochemical and geophysical effects in the global climate system is well acknowledged. The land cover induced forcings can through feedback mechanisms be expected to exaggerate or dampen the effects of climate changes induced by other agents (e.g. changes in atmospheric chemistry or solar insolation). The significance of anthropogenic land cover change (ALCC) as a non-neglectable climate forcing factor at a regional scale was recognized rather recently. Today several model based global ALCC human deforestation estimates are available, however, these exhibit large spatial, temporal and quantitative differences (Gaillard et al 2010).

The recently developed Landscape Reconstruction Algorithm (LRA) models (Sugita 2007a, b) provide proxy-based quantitative estimates of past land cover at regional and local spatial scales. We have employed the LRA to reconstruct the development of the land cover in northern Europe for three time slices (1250-1600, 1600-1850 and 1850 – 2000 CE). Detailed transient regional and local scale reconstructions were composed for the Eastern Baltic area for the last millennium. The eastern Baltic is placed on the border of a boreal and a nemoral forest zone and close to northern limits of crop farming range. Therefore the area is expected to exhibit high sensitivity to climate change and considerable fluctuations in the extent of anthropogenic deforestation.

The overall vegetation development in north-western Europe shows a persisting anthropogenic deforestation with considerable exploitation of the areas available for agrarian activities already before last millennium (Trondman et al 2014). The regional and local reconstructions of the Eastern Baltic reveal the dominance of woodlands in many of the investigated areas up to the beginning of the last millennium. The reconstructed forest composition exhibits an overall increase of early successional broad-leaved species and an increase in boreal coniferous species in northern Europe at the expense of nemoral broad-leaved ones throughout the last millennium. An increase in the agrarian activities led to a large scale deforestation during the first three centuries of the last millennium. From the 14th to the 18th century, the woodland cover decreased drastically both at regional and local scales, causing an open agrarian landscape dominated by croplands and grasslands to emerge. During the last century, the woodland cover has increased again. The methodology used for the reconstructions was successfully validated at a local scale in southern Estonia by comparing the reconstructions with historical maps and other such documents (Poska et al 2014).

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How wrong are pollen based reconstructions of landscape openness?

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In naturally forested areas such as Central Europe, forest openness is a prominent proxy for human activity and influence on the landscape. Reconstructing openness from the pollen record is problematic, however. Most open taxa produce little pollen and are thus underrepresented or virtually absent in the pollen record. Reconstructing openness therefore requires methods to correct underrepresentation of open taxa. Appropriate methods have become available over the past decade and are increasingly applied. The most critical step in these methods is calibrating the pollen-vegetation relationship, i.e. calculating how much pollen single species produce. Calibration requires extensive surface pollen data sets and detailed vegetation data from the pollen source area of each sample site. To apply suitable distance-weighting on vegetation data, calibration furthermore requires a profound understanding of pollen dispersal.

Calibration is mostly conducted in the modern world, but changes in land management have changed pollen productivity of open taxa. Grasses, for example, produce less pollen if, as today, grasslands are mown more frequently. Increased fertilization on the other hand may have increased biomass- and pollen productivity of other open taxa. The demise of wild herbs in modern industrial land management has sharply decreased overall pollen production of open vegetation. Using the modern situation as a reference thus introduces yet unknown errors in the reconstruction of past openness.

To quantify the magnitude of these errors, we compare pollen based estimates of past openness with historic data. We use high resolution pollen data from annually laminated Lake Tiefer See. Reconstructions are based on pollen percentage data as well as on pollen accumulation data.

This study is a contribution to the Virtual Institute of Integrated Climate and Landscape Evolution Analysis –ICLEA- of the Helmholtz Association (grant number VH-VI-415) and uses infrastructure of the Terrestrial Environmental Observatory (TERENO) of the Helmholtz Association.

Role of climatic factors and human activity in the transformation of valley floors and slopes in C-E Europe during last 2 millennia

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Two main factors, climatic fluctuations and human degradation of natural resources are reflected in hydrological regime and in transformations of slopes and valley floors. Especially distinct roles play the intensity and frequency of extreme meteorological events.

During last two millennia, clearly registered cooler and more humid phases alternated with warmer and relatively drier ones. It does not indicate that during warmer phase the heavy downpours are absent (Starkel 2005). At the transition from time B. C. to first century A.D. the cooler phase is coming to the end reflected in the last distinct rise of lake level in northern Poland, formation of several, deep landslides in flysch Carpathians and debris flows in the Tatra Mts. and advances of Alpine glaciers of Geschöner phase. The 2-4 century A. D. it was much warmer and drier. It coincided with expansion of agriculture not only on territory of Imperium Romanum but also beyond it. This is reflected in cutting of trees, active soil erosion and formation of thick member of overbank alluvial loams. Extensive deforestation caused the rise of groundwater level and formation of shallow lakes in the former dead ice depressions in Northern Poland. Next cooling in 5-6 c. A. D. was the time of Dark Ages and collapse of agriculture. But great number of black subfossil trunks and avulsions of river channels indicates frequent great floods probably also from snowmelt phases. It was supplemented by many landslides and debris flows us well as distinct advances of glaciers in the Alps. Gradual rise of population and intensification of agriculture starting from 8-9th century facilitated by warming caused great activation of soil erosion, supported by heavy rains in second half of 11th century. Colonization of hilly areas after decades of wars and catastrophes was next cause of intensive flooding and soil erosion. Starting from early 16th century till mid- 19th century several cooling's were effected in great advances of alpine glaciers of the Little Ice Age. This period is well documental by historical records and measurements of temperature and precipitations since mid- 19th century follow gradual warming accompanied in last decades by clusterings of heavy rains reflected in extreme floods and activisation of landslides.

The analysis of parallel, records on climatic phenomena and human activity made possible to distinguish three types of phases with increased transformations of slopes and valley floors, depending either on leading role of natural climatic or on anthropogenic factors (Starkel 1992).

1. Phase controlled by more humid climate.
2. Controlled by human activity (deforestation, cultivation).
3. Concordance of climatic and anthropogenic factors.

Demographic changes during the first millennium AD and their impact on vegetation cover in north-western Poland

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In north-western Poland, the first millennium AD was a period of prominent demographic, cultural and economic changes which had an important impact on natural environment. In this area, the environmental effects of these processes were regionally differentiated not only because of variation in timing and scale of anthropogenic pressure, but also due to variation in some natural factors.

The aim of our lecture is to present a first attempt to

i. reconstruct changes in settlement dynamics pattern in both time and space through the northern part of Pomerania, between Vistula and Odra River, based on pollen data supplemented by other sedimentary proxies;
ii. assess the scale of changes in a forest cover in the period of interest;
iii. detect if potential small-scale agricultural activity could persist in a period of general economic decline (Migration Period);
iv. reconstruct pattern of migration and establishment of beech (*Fagus sylvatica*) in the area under concern and the role of natural factors and human activity in this process.

New high resolution palaeoecological data and some older records from the area are used for the purpose of this study. They indicate that in the Roman Iron Age the scale of human impact on the forest cover in the mouth of the Odra River was much lower than in the eastern part of the area, what resulted in the earlier onset of the reforestation having its optimum during the Migration Period. In the eastern part of the area the waves of intensive deforestations strongly affected forest habitats and delayed the subsequent woodland succession. The pollen data suggest that in some areas small-scale agriculture was probably continued through the most of the Migration Period. The new deforestation phase connected with the early medieval occupation started distinctly earlier in the western Pomerania. The clearly diachronic expansion of beech over the area was a result of complex factors with human activity among them.

Our data provide new, more precise insight to the earlier knowledge on the timing and scale of human impact during the first millennium AD and on the interactions between natural and anthropogenic factors driving forest succession in the region.

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The 500 years of vegetation changes in lowland forest wetlands in relation to human impact and climate change

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Lowland wetlands belong to ecosystems which have been the most influenced by human activities, and the majority of them have been destroyed and turned into cultural land. In general, the most important factors in the succession of wetlands are trophy and water regime. Both can be considerably modified by human activities, either intentionally or indirectly. The last few hundreds of years have been characterized by a great intensity of anthropogenic impact, which has often changed the vegetation to a greater extent than the previous thousands of years. To understand the development at this time scale, it is useful to combine the knowledge of ecology, palaeoecology and history. The approach of historical ecology, which combines the methods of natural sciences with those of humanities, has proved useful in explaining past processes which have led to the present situation.

In our research, we have studied the development of several lowland wetlands located in the forest of Hodonínská Dúbrava. Dúbrava is a large ancient temperate oakwood situated in the northwestern part of the Pannonian Basin (SE Czech Republic). Previous palaeoecological research based on pollen analysis has shown that oak started to dominate in the 14th century probably as a result of new forest management regulations. However, the impact of woodland management on local wetland vegetation has never been studied in detail.

We evaluated the ecological requirements of recorded wetland species to reconstruct past changes in water level and trophy. We compared these results with historical data about human activities in Dúbrava since the Middle Ages. In addition, we mapped the abandoned drainage channels dug within the Wood in the past. This multi-proxy data enabled us to reconstruct the past development of wetlands and to discuss the driving forces of past vegetation changes.

The macrofossil data show that the most important changes in local development took place in the last two centuries. These changes have similar tendencies and timing in all the three profiles. The most important changes at the end of 19th century and in the middle of 20th century can be connected to the creation and subsequent abandonment of the drainage channels. The last few decades of the 20th century have brought a visible increase in nutrients and an important and gradual lowering of the water table. We discuss possible anthropogenic and climatic driving forces of these changes. It seems that the changes in the local development of the wetlands were not always straightforward and not all of the changes can be easily explained.

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Trace elements in lake sediments as a proxy of human impacts and climate changes - limitations and possibilities of application

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Heavy metals accumulated in the bottom lake sediments are important indirect indicators (proxies) of past human economic activity in areas adjacent to the lakes (and in the case of lakes fed by the rivers in the drainage areas adjacent to them). They can also be used as the proxy of regional climate/vegetation changes.

The authors analyzed bottom lake sediments of few lakes located in NE and central Poland (both the lakes that do not exist at present and those that are still filed with the water and are quite deep). In the sediments taken using the different types of augers, both from the ice cover or from the boats, there have been analyzed such textural features as organic matter content, carbonates content, grain size and trace elements contents (of selected metals e.g. Cd, Cu, Pb, Zn, Ti, Ni, Co, Cr and Fe, Mn using the AAS or ICP MS methods). There have been also checked the trace elements content on the separated single grains, during the SEM analyzes, with the XRF method. The obtained results were then correlated to the available palaeobotanical data.

The human impact in bottom sediments is recorded by increase of trace elements content and in increase of terrestrial material transported to the lake from deforested, cultivated areas in the vicinity of the lakes. There have been observed in the vertical profiles the peaks of increase of trace elements that were well correlated with the archeological data (available from the Archaeological Picture of Poland). The intensity of geochemical signal and impact of the human activity to the bottom sediments depended on the land use of the shore of the lake – especially the deforestation, development of the agriculture, ancient metallurgy and industry with the simultaneous destruction of the rushes belt favored the bigger supply, wider range and stronger contamination of the bottom sediments.

Paleolimnological evidence of European spread of hypoxia in freshwaters caused by local anthropogenic pressures

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The development of seasonal or persistent hypoxia in many aquatic environments severely stresses ecosystems, causing a decline of fisheries, a loss of biodiversity, and an alteration of food webs, including mass mortality of fauna. In lakes, long-term instrumental monitoring surveys remain limited, preventing a regional reconstruction of hypoxia's dynamic and pinpointing long-term causes of these changes in Europe. Nevertheless, hypoxic conditions are recorded in lakes when varve sediments start to be preserved once thresholds in oxygen-depleted conditions are crossed. Here, we compiled i) the records of 959 dated lake records across Europe and ii) the time when varves started to be preserved in varved lakes as an indication of the regional evolution of hypoxia over the last 2,000 years. Then, we compared these data with anthropogenic and environmental variables compiled for each of these 959 watersheds. Our results show that 108 sites were naturally hypoxic during the last 2,000 years but that afterward continental hypoxia started spreading in Europe around AD 1900, mainly because of local growth in population density, human footprint and land uses, leading to eutrophication. No significant correlation was found with changes in precipitation or temperature. Furthermore, no sign of general return to past well-oxygenated conditions are observed despite implementation of local restoration programs and implementation of policies limiting nutrients yields since several decades in Europe. This highlights the low resilience of lacustrine systems in the context of the added likely stress due to global warming and population increase.

POSTER PRESENTATIONS

POSTER SESSION 1

Meteorological information in Romanian publications and archives from the 19th century

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In Romania, the systematic collection of meteorological data started in the second half of the 19th century, but the number of stations was very limited and they were sparsely distributed over the territory. As a consequence, the meteorological archives include only a few complete data set making difficult to characterize the climate of the period. Proxy evidences exploited so far are very scarce and they refer mainly to dendrochronology and stratigraphy. Major historical and social events occurred in the 1800s and abundant written information may be found in documents and journals, providing a potential source of meteorological information about Romania's territory unexploited in a systematic manner yet. This study is the result of a thorough and comprehensive screening of the meteorological references published in the central newspapers of the epoch, and extensive inspections of the national archives. Meteorological calamities like drought (e.g. 1816-1817; 1845-1847), extreme temperature, heavy rains or strong wind events (e.g. 1802) are frequently reported in the daily journals and magazines, while valuable information about the climate may be found in several travel books and monographs. We aggregated the findings in an open access database containing geo- and time-referenced data about the characteristics of the mentioned phenomena and their consequences. Whenever it was possible, the information was compared with instrumental data from weather stations or from other sources in order to validate its accuracy and credibility. In the end, we may conclude that we can present significant preliminary results of this endeavour, as a basis for refining and reconstructing the 19th century climate over the Romania's territory.

How does human perception influences the registration of hydric regime variability in historical documents?

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The climatic changes have influenced human activities since the oldest times, which has an important role on the way of life. In the absence of meteorological data, population has drafted a way of perception on climate changes in terms of their influence on the main activities which they performed, namely agriculture. The aim of this study is the reconstruction of the hydrologic changes over the past 1000 years in Romania, based on historical documents. Overall, we have found a higher frequency of extreme events during the Little Ice Age (LIA), in comparation with Medieval Warm Period (MWP), due to expansion of the agricultural space and increased vulnerability. However, two factors possibly alter the validity of this reconstruction: 1) decrease in number and quality of data-points further back in time and 2) seasonal differences in the perception of extreme events by agricultural populations. When dealing with this later point, our analysis show that: (i) in spring, people reported more dry years, as these were possibly hampering the development of new crops, while wet years were not influencing in a special way the agriculture; (ii) in summer, the agricultural crops are more sensitive both to the drought and flooding, for this reason people have reported both the rainy and dry seasons; (iii) in autumn, rainy periods were especially reported, as they prevented harvesting, while dry periods, favorable for this, were possibly overlooked.

Our results suggest that the use of historical documents as sources of palaeoclimatic data must take into account the perception people have on the same event, depending on when it occurs in an agriculture-dominated society.

Climate of Gdańsk from 1770 to 1786 based on Gottfried Reyger's meteorological observations and measurements

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Gottfried Reyger (1704-1788) came from a merchant family living in Gdańsk. His research interests after graduation focused on natural science, geography and astronomy. He is best known as the author of *Tentamen floras Gedanensis* (1764-1766). He was a member of *Naturforschende Gesellschaft in Danzig*, Gdańsk's first scientific society focusing on natural sciences, established in 1742. In addition to these interests, he also conducted systematic daily weather observations in Gdańsk in the period from December 1721 to the end of 1786, the results of which were presented at two publications "*Die Beschaffenheit der Witterung in Danzig as Jahr 1722 bis 1769 beobachtet nach und ihren Veränderungen Ursachen erwogen*" (1770) and "*Die Beschaffenheit der Witterung in Danzig. Zweyter Theil vom Jahr 1770 bis 1786, nebst Zustätzen zur Danziger Flora*" (1788). Reyger's descriptions are fairly accurate, as the author devoted much attention to the properties of thermal and pluvial characteristics of each month, weeks and sometimes even individual days.

Results of reconstructions of air temperature and precipitation in Gdańsk for period 1722-1769 based on Reyger's observations were presented during the IGU Conference in Cracow in 2014 and were recently published in *Przegląd Naukowy Inżynieria i Kształtowanie Środowiska*, Vol. 23 (4), Nr 66, pp. 360-375. In the present paper we focus on the period 1770-1786 for which Reyger (in the second mentioned publication) described weather for each month using also instrumental observations of air temperature and precipitation which probably he did twice or three times a day (in the morning, noon and in the evening times). Quality and detail of weather descriptions in the latter period is markedly better than for the former one.

Reconstruction of the variability of temperature and precipitation for all months, seasons and years of the period 1770-1786 was done. For this purpose the method of 3-point monthly thermal and pluvial precipitation data indexing (below normal (-1), normal (0) and above normal (1)), carried out in relation to the contemporary conditions independently by three researchers (two climatologists and one historian) has been used. However, an evaluation of meteorological conditions in seasons and years was made on a 7-point scale according to the proposal of Pfister et al. (1994).

Wrecks as a testimony of history and the state of the environment

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Shipwrecks settled at the bottom of the seas provide historical evidence, which determine the level of technical culture reflecting the times in which the ships were built. Their meaning is known and has been appreciated for years (see the work of the Maritime Museum). Until recently, the lack of appropriate research methods and techniques made it impossible to obtain a detailed, comprehensive picture of the surveyed seabed surface, including the area in close vicinity of the wrecks. Currently practiced methods of research, based on the use of modern surveying devices ensure the obtainment of complete information on the entire surface of the survey area. The methods ensure accurate recognition through the supply of data, which are characterized by great precision and density per each unit of the surveyed surface. This also applies to data describing the wrecks and their surroundings.

Wrecks and their impact on the environment which is visible during surveys, indicate the course of the dynamic and biological processes. Analysis of obtained information allows for a relative reference of changes over time. Thus, we obtain new knowledge about the occurring processes, such as the type and rate of deposition, redeposition and erosion.

The presented images of selected fragments of the seabed surrounding the wrecks of the southern Baltic area are taken from research conducted under the long-term program called „Monitoring of seabed contamination in areas of wreck settlement" as well as have been obtained during the performance of other work.

Our goal is to present current possibilities of wreck research (also at the bottom of lakes and rivers) as a new source of data about the environment, its history, current state and change trends.

An interdisciplinary investigation of archaeological evidence for meteorological application

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This paper examines the identification and isolation of seasonal meteorological signatures within archaeological information. Stable isotopic analysis of horsehair is used to determine fluctuations in temperature and precipitation. Isotopic analysis of carbon and nitrogen values within horsehair provides location change and dietary information that is temporally resolved over the lifetime of the horse. Additionally, changes within the oxygen isotope measurements of the horsehair over time can offer insight into seasonal fluctuations in atmospheric conditions. In this study, current meteorological records are cross-examined against modern horsehair data in order to provide ground-truthing for further investigation of seasonal signals within historical horsehair. This provides a useful starting point for further comparative analyses against tree-ring data, which show similar fluctuations in isotopic values in correspondence with meteorological measurements.

This data will contribute to a greater understanding and utilisation of interdisciplinary archaeological data for seasonal climate analysis. It provides opportunities for considering the separation of climate noise from archaeological information, so as to determine other influences in the past. Subsequently, it may also provide information on the origin of the precipitation in specific regions and thus insight into the growing capacity of certain habitats during specific periods.

Medieval climate warming reflected in the pollen and macrofossil record from urban archaeological sites in Gdańsk (N Poland)

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High frequency and abundances of the sub-fossil remains of some aquatic and terrestrial plant taxa having relatively high thermal requirements, are used as a proxy for characterization of climate conditions in medieval Gdańsk.

Large numbers of sub-fossil remains of *Salvinia natans* and *Stratiotes aloides* have been found in the sediments from several urban archaeological sites located in different parts of Gdańsk. *S. natans* is represented in the fossil material by megaspores and microspores with fragments of microsporangia. *S. aloides* occurs as macroremains: leaf-spines and fruits (usually very rare in the sediments).

S. natans is characterized by large, natural distribution mainly in a sub-tropical and warm sub-oceanic temperate climate. In recent times, it continues to be spread by humans to many regions of the world. Gdańsk lies at the northern limit of the European distribution range of this species and its vigorous expansion in this area is observed only very recently. *Stratiotes* is widespread throughout Europe and in the north-western Asia; in Poland it does not display any specific geographic pattern, however, it does not produce fruits and propagates on vegetative way only. Today, both taxa grow in shallow, eutrophic waters in oxbow-lakes with a thick layer of organic substrate in the bottom sediments. Moreover, *Salvinia* occurs in ditches and channels, and in shallow, slowly flowing rivers.

According to the palaeocological data, *Salvinia* was present in oxbows and slowly moving waters together with *S. aloides*, already in the period preceding human settlement in the area of Gdańsk, i.e. in the 5th and 6th centuries, and then its main population expansion took place in the 7th–8th century. In the 9th–10th century it started to decline, but irregular occurrences continued up to at least the 16th century. Fruit production by *S. aloides* is confirmed for the 6th, 8th, 9th and 13th century, but large numbers of it leaf-spines are still observed in the sediments up to the 15th century.

Based on the recent observations, we may suggest rather mild winters in this area during the early medieval period, as frost is among the most important factors limiting survival of the Salvinia megaspores. Relatively warm springs with water temperatures around 12 °C were needed for megaspore germination, and a long growing season could have a significant impact on the high reproduction rate of *Salvinia*. The climate warming could be also among the important factors forcing the expansion of Stratiotes triggered by generative reproduction.

Moreover, the archaeobotanical data confirm, that around 11th to 13th century, in the ruderal plant communities developing on nutrient rich habitats, several relatively thermophilous species (*Chenopodium hybridum*, *Conium maculatum*, *Urtica urens*, *Origanum vulgare*, *Descurainia sophia*) occurred abundantly. Some of these species are archaeophytes of the Mediterranean and Irano-Turanian origin.

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Pollen-inferred temperature series for the northern Italian Holocene

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Plant assemblages and pollen production are sensitive to temperatures, rainfall and other factors. They can be used to infer climate parameters and provide inputs into climate modelling. This is especially true in high mountain ranges, where vegetation is organized along wide altitudinal gradients triggered by temperature changes. Our study aims at: 1) exploring the potential of pollen data for quantitative paleoclimate estimates focusing on an area (the southern side of the Italian Alps), where this reconstructions are still scanty; 2) testing the reliability of pollen-inferred T series for the Late Holocene, a period when both climate and human activities interfere with vegetation; 3) answering the question "are pollen data reliable to reconstruct both long-term climate trends and oscillations at a secular scale"?

We present pollen-inferred quantitative temperature reconstructions for the coldest (T_{jan}) and warmest (T_{jul}) months obtained from lacustrine to palustrine stratigraphic successions in northern Italy covering the last 3 ky. Reconstructed T series will be presented both as absolute values and as anomalies (difference between reconstructed and modern instrumental values). The procedure was first tested on a shorter time window (200 years) where instrumental records are available and provide a tool for model validation. The modern training set used to be compared with fossil pollen spectra from the last millennia is the large dataset of modern pollen and climate data archived in the EMPD-European Modern Pollen Database (Davis et al. 2013), composed by nearly 4800 modern pollen samples covering a wide variety of ecoregions, from lowland coastal areas to high-altitude mountain sites, throughout Eurasia and northern Africa. Regression and calibration methods (LWWA, LWW-PLS) and the MAT (Modern Analogue Technique) approach were used to reconstruct temperatures. Our pollen-inferred temperature reconstructions for the last 3 kyr well correlate with established climate proxy records (oxygen isotope records from ice cores, records of Alpine Glaciers fluctuations, stalagmites). Our tests suggest the potential of pollen data as proxies for quantitative climate reconstructions, but also highlight the need to integrate the large EMPD database with local modern training sets to calibrate the relationships between pollen rain - modern vegetation - climate parameters.

This research is promoted by the CNR-DTA NextData Project, aiming to build an Italian database collecting data from continental and marine archives to investigate the climate variability of the last millennia.

Dendroclimatic studies in the Sudetes Mountains - a key site for analysing Central European past climate variations

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The Sudetes Mountains are the highest mountains in the north-eastern border part of the Bohemian Massif which belongs to Hercynian European Highlands. They are a significant orographic barrier for moist polar maritime air masses coming from the Atlantic Ocean. This area can be considered as a key site for analysing Central European past climate variations. In spite of relatively low altitudes, the highest parts are characterized by typical mountain climate, with mean annual temperature 0.7°C and precipitation 934 mm (at Śnieżka Mt, 1602 m a.s.l). In the Sudetes Mountains a clear pattern of the vertical climatic zones, followed by the zonal pattern of the plant cover is visible. Norway spruce (*Picea abies*) forms the upper timberline on the elevation 1250–1350 m a.s.l. Due to a few hundred years of human activity in that area the potential plant cover was transformed into spruce monocultures, mainly in the lower subalpine forest zone. Only at upper subalpine zone much of the primeval forest communities survived. Intense industrial activity in the area of western foothills caused an exceptional atmospheric pollution via precipitation and fog, which can be observed as massive spruce forest dieback, documented by numerous regional studies.

Understanding past climate variations is crucial for the assessment of recent warming, which is especially visible in the mountain areas. However, studies conducted in the Sudetes primary concern tree rings as indicators of atmospheric pollutant deposition. Only few temperature reconstructions exist for the Czech Sudetes Mountains. Therefore, the aim of our study is to: (1) characterize the dendroclimatic response of spruce in terms of different topographic conditions and existing ecological stress, (2) investigate the potential for tree-ring based climate reconstruction of the northern part of the Sudetes Mountains.

The field research was carried out within the major mountain ranges (on the elevation 890-1230 m a.s.l.): Bystrzyckie Mountains, Izera Mountains, Orlické Mountains, Golden Mountains, Giant Mountains and Śnieżnik Mountains. In 2012-2014, 22 sites of Norway spruce located at different altitudes and expositions were sampled. In addition, historic timbers from highest located villages and hamlets were also investigated, in order to lengthen the dendrochronological records. Meteorological data from Śnieżka Mt (1951-2010) was used in the dendroclimatic analysis.

Analysis of about 450 ring width series reveals the high inter-correlation (range from 0.55 to 0.80). The strength of tree-ring/climate relationships proved to be significantly dependent on site exposition. The lowest correlation was obtained for the sites with effective fog deposition - western and northwestern slopes (windward to prevailing airflow). In general, the positive influence of May, June and July temperature on tree growth is evident (the correlation value range from 0.45 to 0.65). In addition, at some sites the amount of snowfall significantly influences the spruce radial increment, as well. Preliminary results indicate that recently sampled tree-ring material for the Polish part of the Sudetes enable for spring/summer temperature reconstruction over the last two hundred years. However, our results demonstrate that dendroclimatic reconstruction of this exceptionally polluted area need appropriate site selection in order to avoid bias in the record.

Hydrological dynamics and fire history of the Izera Mountains during the last 800 years inferred from testate amoebae and charcoal

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Although the mountain peatlands of Western Sudety are considered as specific and unique, still the palaeoecological inferences from this region are very rare. Hence little is known about their development history. Our study raises the complex questions about the anthropogenic impact on wetland ecosystems and shifts in its natural development. The aims are to: i) reconstruct past hydrology of peatland, ii) reconstruct fire dynamics on the peatland and its surroundings, iii) infer palaeohydrological and trophic fluctuations connected with land-use changes and fire activity. We hypothesize that land-use change (e.g. deforestation and forest fires) affected peatland ecosystems that were also strongly influenced by the recent extreme atmospheric pollution. The study combines the potential of testate amoebae and charcoal analysis in the high-resolution multi-proxy palaeoecological reconstruction of the history of the bog in the Izera River valley in the central part of the Izera Mountains. Investigated peat core covers the last 800 years – period of the increasing anthropogenic impact. Five hydrological stages of peatland development were recognized as a result, showing a transition from moderately wet, acidic conditions towards the dryer, more neutral phase and then return to wet, acidic stage. Within them several trophic and hydrological fluctuations, most possibly connected with human activity were identified. Moreover the increase of the fire activity was observed together with the beginning of the human presence in this area during the development of the nearby settlement. Inappropriate forest management (deforestations, introduction of non-native species, pest plagues) and atmospheric pollution combined with severe environmental conditions contributed to the destabilization of peatland ecosystems and caused a shift in the structure of the testate amoeba communities. Analysis of other proxies will give an opportunity to explain past peatland dynamics in more detail and it will reveal the threats for biodiversity refuge sites such as the Izery Mountains, to plan the best strategy for nature conservation.

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Investigation of extreme climate events using Pinus sylvestris tree rings from Hungary

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Since the Carpathian Basin is seriously concerned in the negative impacts of global warming it is particularly important to investigate how trees respond to the changing climatic conditions, which factors are the most favourable for their growth and how these factors will alter in the future. In the present study our aim was to identify the fingerprints of negative extreme climate events using Scots Pine tree rings from different parts of Hungary. Investigating various study sites we could analyse the effects of local conditions and climatic influences on the tree rings.

During the work we focused on the last 120 years because according to the global trends the number and frequency of negative extremes have increased dramatically in the last century. With the examination of typical anatomical features referred to dry conditions such as intra-annual density fluctuation (IADF) and exceptionally narrow rings (NR) we identified the most unfavourable circumstances to tree ring growth.

To evaluate the climate-growth relationship we calculated bootstrapped correlation between tree ring width indices and monthly temperature and precipitation data as well as we used different aridity indices to test whether temperature and precipitation responses are merged in an improved drought response. To analyse IADFs and narrow rings over the time we calculated the stabilized frequency which take account of the changing sample depth.

According to our results, summer precipitation is the most important factor in tree ring growth on our study sites but summer temperature has a significant secondary role which substantially strengthen during the years with negative extreme values. The occurrence of IADF and exceptionally narrow rings can identify the drought periods well. In our results the stabilized frequency of IADF and NR show significant positive connection with May, June and August temperature just as with the values of aridity indices calculated to the summer period. Parallel to this the correlation between precipitation and intra-annual density fluctuation and exceptionally narrow rings is significantly negative during the vegetation period. All these results mean that IADF and NR formation is highly connected to extreme events in summer, hence drought periods are squarely demonstrable and can be reconstructed with the different attributes of tree rings in our study sites.

POSTER SESSION 2

Improving the study of annually laminated sediments – A new online tool

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Annually laminated (varved) sediments are natural archives of paleoenvironmental conditions that offer accurate "internal" time control in calendar years, exceptional high temporal resolution and the possibility to calculate flux rates. The "Varve Image Portal" (http://www.pages-igbp.org/workinggroups/varves-wg/varves-image-library) displays images of various varve types. It exemplifies the compositional and structural diversity of varved sedimentary sequences and summarizes the existing knowledge about varves with representative images.

Although the scientific community has come to appreciate the paleoenvironmental value provided by marine and lacustrine varves, a widespread lack of awareness remains about the need to carefully document and verify their annual character before exploiting lamina counts for geochronological purposes and paleoenvironmental interpretations. A misconception between varved versus finely laminated sediments might partially originate from the history of the expression "varve", introduced by De Geer in 1912 to describe minerogenic proglacial lake sediments of Sweden. Later on, this term was extended to organic-rich lacustrine as well as to marine sediments with preserved successions of seasonal sub-laminations. The large diversity of sediments featuring a "varved" character sometimes led to the illusion that most, if not all finely laminated sediments are varved, which is not always the case.

It is the specific aim of the "Varve Image Portal" to provide exemplary visual information about annually laminated sediments to assist, train and guide researchers in their judgement about the relative timing of (sub)laminae and constraining the geochronological potential of laminated sedimentary sequences. The "Varve Image Portal" intends to disseminate existing image information and to facilitate efforts of students and scientists to get acquainted with this challenging topic. Each image of this data base is accompanied by metadata which include information about the image and its study site as well as references with DOI links of related publications.

Geochemical indices of environment in the varved clastic and bio- chemogenic lake sediments

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As it well known, recent quantitative estimations of high-resolution environmental variability are based on geochemical records in lake sediments. Necessary requests for study origin of rhythmic paleoclimatic signal in bottom sediments are following: 1) accurate sampling/coring and preparing of solid preparates 2) high resolution submillimeter analytics, 3) absolute dating and 4) calibration of geochemical time series by instrumental data.

The basic request to sediment records is primary succession of deposition without next disturbances of matter. Naturally, annually laminated sediments (varves) are the best objects for paleoclimatic study, because they allow to investigate seasonal variability for understanding long-term environmental pattern. Also, varved sediments seem to be applied as the model for identification of element-indicators for non-laminated sediments.

The XRF scanner on Synchrotron Radiation provides big geochemical dataset for next mathematic treatment, including time series construction. XRF scanning realizes rapid and non-destructive determinations more than 30 trace elements in a range of concentration from 1 up to 10000 ppm in annual layers. That makes sedimentary cores comparable with tree-rings. Geochemical and physicochemical investigation of lake sediments provides basic information to identify geochemical signals with paleoclimate.

In general, sediment consists of mineral component, organics and carbonates. The proportions between these components are affected by environmental parameters, because measured element content or their combinations show correlation with meteodata on instrumental time interval. That allows applying geochemical variability to reconstruct the environmental parameters in the form of time series.

The proportions between main components are controlled by temperature, atmospheric precipitation, water salinity and other external forcings. So, layered structure of lake bottom sediments and detectable elements content variability both represent a continuous record of environmental history.

Element composition and its climatic response. Bottom sediments represent conditions of physical weathering, temperate bioproductivity and aridity, which concerns to mountain lakes within extra tropical zone.

Mineral matter responses to runoff. Mineral clastic part is correlated with x-ray density. It includes “clastic” rock-forming - Si, Al, Ti, Fe, Mg, Ca, K and trace elements such as Sr, Rb, Y, Zr, REE etc. Organic component of sediment more reflects temperature by means of productivity in the catchment and waterbody. Organophillic elements are Br, I, U and others soluble elements correlated with organic Carbon or LOI<500°C. Bio-chemogenic component is more characteristic for saline lakes, where Ca-, Mg- and Sr- carbonates precipitated in dependence of temperature, aridity and water salinity.

Separate geochemical indices are directly used for paleo- environmental evaluation. For example, elements with changing valency may be a special indicators of outer conditions. Fe is strictly connected with sulfur in sulphide under anoxic conditions. And also Fe forms siderite in carbonate ion saturated, but calcium poor, water in the sedimentation system. Mn-enriched layers, crusts and nodules mark usually a long – term pauses of sedimentation in oxic systems. Mo/Mn ratio is good correlated with anoxic atmosphere. And so on.

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Periodic characteristics of 10,000-year-long clastic-biogenic varve records from lakes Nautajärvi and Korttajärvi in continental Scandinavia during the Holocene

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Annually laminated (i.e. varved) sediments provide intriguing proxies to understand and quantify the influence of external forcing on lacustrine sedimentation because they record the prominent features of changes with seasonal resolution. Their advantage is that they provide time series with a regular sampling period, where each data point independently represents the deposition of a single year or a specific season, thus allowing periodicity analysis without any smoothing or interpolation of data with an age-model. Here, we studied 10,000-year-long sediment records with clastic-biogenic varves from Lakes Nautajärvi and Korttajärvi, Finland. We targeted on periodic features of clastic laminae thickness variations that we know is indicative for hydroclimate, i.e. snow storage in winter and the discharge intensity during the following snow melt, which causes the suspended minerogenic sediment load to be transported and accumulated on the bottom of these lakes.

However, as lacustrine varved sediments are known to contain site-specific inhomogeneities due to factors such as basin evolution, anthropogenic land-use superimposed on natural variability of sedimentation, and typical ±1 to 2% errors in varved chronologies, their high-resolution (annual) site-to-site correlation is often not straightforward, not even between closely situated lakes that accumulate similar types of varves, as proven with studies in northern Sweden and SW Finland. Nevertheless, the comparison of clastic-biogenic varved sequences on longer timescales is important when natural variance and periodic features in hydroclimate change are assessed. Here we deciphered periodic features of lakes Nautajärvi and Korttajärvi varved datasets and highlighted the observed features and anomalies with regard to cold and snowy winters in continental Scandinavia. The purpose of the present study was to determine dominant periodic characteristics of mineral matter sedimentation in these lakes and to examine which periodicities are shared between both sites, and finally to discuss possible reasons for the observed periodicities.

We used two independent methods, the Posterior SSA method, which couples the SSA with Bayesian posterior modeling of the signal, and the spectral analysis with REDFIT program, to extract periodic features from these time series and assess their statistical reliability. Periodicity analyses revealed that seasonal sediment fluxes of catchment erosion correspond to environmental changes with significant periodicities of 1500−1800, 1000, 600−800, nearly 300, nearly 200, 150−170, nearly 90 and 47 years, showing variable coherency with different climate forcing factors and other palaeoproxy records in the Northern Hemisphere. Our results indicate that the Holocene winter climate in continental Scandinavia was forced by a combination of several factors, at least by the North Atlantic ocean−atmosphere circulation-patterns and solar variability, with varying influences through time.

Stable isotope record of late Holocene precipitation changes from Lake Nuudsaku in southern Estonia

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Radiocarbon dated, finely laminated lake sediments record Holocene precipitation changes from southern Estonia. Modern water isotope data suggest that Lake Nuudsaku is a mostly open system that is primarily fed by winter precipitation and groundwater, and summer precipitation plays only a secondary role in the overall hydrologic balance. Initial results indicate that changes in insolation likely drove the overall Holocene pattern with relatively wet conditions during the early Holocene, followed by arid conditions during the middle Holocene and a return to wetter conditions during the late Holocene. However, there is pronounced millennial and centennial-scale variability that cannot be explained by insolation forcing alone. Notably, there is a trend toward wetter conditions from ~4.0 to 2.0 ka, followed by a trend toward drier conditions during the last 2 millennia. This late Holocene pattern diverges from the pattern observed in records from north-central Estonia that suggest an overall trend of wetter conditions for the last ~4 ka. These initial results thus indicate that the Lake Nuudsaku sediments have the potential to yield a unique near-annual to decade-scale record of past precipitation changes from the southern Baltic region.

Preboreal climate oscillations registered in multi-proxy record from Lake Suchar Wielki in the Wigry National Park, NE Poland

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For several years in the Department of Botany of the University of Białystok are carry out interdisciplinary palaeoecological research of several dystrophic lakes in the Wigry National Park. The main goal of the research is to determine how global changes of climate that occurred during the Late Glacial and Holocene (especially cold climate fluctuations that take place every approx. 1.500 years (around 11.100, 10.300, 9.400, 8.200, 5.900, 4.200, 2.800 and 1.400 cal. years BP) influenced on post-glacial succession of vegetation in the Suwałki region.

The multi-proxy data (pollen, diatom and Cladocera analyses, ^{14}C dating) from sediments of Lake Suchar Wielki (Wigry National Park) covering the period ca. 11.600-9.850 cal. BP have allowed on reconstruction of the Preboreal abrupt environmental changes in north-eastern Poland. Reconstructed development of terrestrial and aquatic environments suggests fourth negative climate oscillations during the Preboreal period. The first three occurred in the older part of the Preboreal and they were dated on ca. 11.300-11.150, 11.100-11.000 and 10.900-10.800 cal. BP. The scale and nature of these coolings as well as their consequences for vegetation development were different. However, all changes in the percentage share and concentration related to pine and birch, which at that time formed forests. Similarly, in the case of the last cooling in the second half of the Preboreal ca. 10.300-10.200 cal. BP, which it was preceded by a gradual decline in the concentration of pine and birch pollen.

Isotopic investigations of contemporary carbonate sedimentation in lakes from N Poland.

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The study area of NE Poland is a region of most pronounced seasonal climatic contrasts and best preserved varved sediments in lakes. Within the project “Climate of northern Poland during the last 1000 years: Constraining the future with the past (CLIMPOL)” the isotopic investigations have been performed aiming at the creation of transfer functions for the reconstruction of temperature in the past.

The presented study will be focused on the results of isotopic measurements (δ^2H, $\delta^{13}C$ and $\delta^{18}O$) for samples of water and contemporary carbonates collected from the lakes along the West-East transect in northern Poland, which have been chosen to form the CLIMPOL training set for calibration space-for-time. The measurements have been performed with use of continuous-flow IRMS Isoprime coupled with automated carbonate/water preparation device Multiflow.

The measurements of $\delta^{18}O$ for lake water (47 samples) demonstrate variability of values from -7.7 to -1.9‰ (VSMOW) and show a general W to E gradient. The δ^2H measurements have been performed and the results vary from -71 to -19‰ (VSMOW). The plot of δ^2H versus $\delta^{18}O$ reveals linear correlation with the equation: $\delta^2H = 6.42(\pm0.45)*\delta^{18}O - 11.9(\pm2.3)$ ($R^2 = 0.81$).

The $\delta^{18}O$ and $\delta^{13}C$ of carbonates from sediment traps have been determined for 35 samples, and the results range from -13.1 to -6.1‰ ($\delta^{18}O$, VPDB) and from -10.6 to +0.15‰ ($\delta^{13}C$, VPDB).

The obtained results have been used to calculate temperatures from $\delta^{18}O$ according to so-called “temperature equation” (Kim and O’Neil, 1997), which produced exotic results of 35°C on the average. These results demonstrate that during the $CaCO_3$ precipitation the isotopic equilibrium is not present. On the other hand, the correlation between $\delta^{18}O$ in water and $\delta^{18}O$ in carbonates ($R^2 = 0.76$) suggests that carbonates record the isotope composition of water in which they are formed.

It seems that temperature signal can be recovered from the isotope dataset, as the values of $\delta^{18}O$ in sediment trap carbonate and summer temperature (June, July, August) are correlated ($R^2 = 0.38$). This simple linear equation was tested as a transfer function to reconstruct the temperature for CLIMPOL master site record from Lake Żabinskie. The comparison of calculated temperatures and instrumental record for the last 120 years shows that generally the average temperature can be reconstructed, but the inter-annual variability is poorly reflected in the reconstructions.

The presented study is a part of the project “Climate of northern Poland during the last 1000 years: Constraining the future with the past (CLIMPOL)”, funded within Polish-Swiss Research Programme.

Chrysophyte cyst-inferred variability of warm season lake water chemistry and zonal wind in northern Poland

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Chrysophyte cyst assemblages from sediment trap and surface sediment samples of 50 lakes in northern Poland were related to environmental variables using multivariate numerical analyses (DCA, CCA). Water electric conductivity, total nitrogen, total phosphorous, turbidity, and cation and anion compositions (Ca^{2+}, HCO_3^-) accounted for significant and independent variations in the chrysophyte cyst assemblages. A quantitative transfer function was then developed to estimate Ca^{2+} (log_{10} transformed) from modern chrysophyte cyst assemblages using weighted-averaging regression (WA) with classical deshrinking (R2boot=0.68, RMSEP=0.143). The first 112 varves (AD 1898-2010) of Lake Żabińskie (Masurian Lake District, NE Poland) were analysed for chrysophytes, and the transfer function was applied to quantitatively reconstruct epilimnetic Ca^{2+}. Cyst-inferred lake water Ca^{2+} concentrations were significantly correlated with zonal wind speed ($m \bullet s^{-1}$) (R=0.50; $p_{adj}<0.001$; AD 1898-2010; 3-yr filtered). We suggest that these changes in calcite precipitation in Lake Żabińskie depend on the lake mixing regime, driven mainly by westerly winds. Observational data from this lake show that the Ca^{2+} variability in the epilimnion depends on the efficiency of Ca^{2+} scavenging by $CaCO_3$ precipitation in early summer which, in turn, is a function of water column stratification, temperature and the wind regime from late spring to early fall.

Chryosphyte cysts population dynamics in northern Poland: a two-years sediment trap experiment

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Here, we present the study of the chrysopyhte assemblages from sediment traps deployed during two consecutive years in 15 lakes from Northern Poland (October 2011-November 2013). Chrysophyte cysts assemblages are known to be sensitive to winter climate (temperature, length of the winter) and/or to water chemistry (electric conductivity, Ca^{2+}, etc.). During the experiment, one year experienced a short and mild winter, the other year a very cold and long winter. Field surveys were carried out to recover the sediment trap material every fall, along with the measurement of several environmental variables (water chemistry, turbidity, water temperature). Multi-year sediment trap studies are necessary to record seasonal and year-to-year changes in phytoplankton production, including cyst producing. The objective of this pilot study is to quantify the environmental and climatic variables that describe chrysophyte population dynamics that in turn will shed more light on the ecological preferences of this group of algae and improve its application in paleo-studies.

Modern limnology, sediment accumulation and varve formation processes in Lake Żabińskie, northeastern Poland: a key to understand the sediment record

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Reconstructions of paleoclimatic and paleoenvironmental data from sediment records require a thorough knowledge of the physical, chemical and biological factors that influence sediment formation process and signal preservation in lake sediments. Lake Żabińskie is an eutrophic lake located in Masurian Lake District (northeastern Poland) and presents features typical for kettle-hole lakes, i.e. a small surface area (41.6 ha) and considerable depth (44.4 m). During monthly field campaigns a board range of physical and chemical parameters of the lake water column as well as sediment fluxes were measured in this lake to understand the relationship between the lake water properties and the sediment formation processes.

Here we demonstrate that different mixing patterns may occur in Lake Żabińskie, depending on the meteorological conditions during winter/spring and fall/winter time periods. The hypolimnion was characterized by higher conductivity and anoxic conditions with only short periods of available oxygen, which created conditions ideal for the formation and preservation of biogenic varves in Lake Żabińskie. The material collected from the sediment trap showed changes in sediment fluxes with characteristic spring maxima and, optionally, a second late fall maxima. Considerable variability was also observed for the fluxes of total organic carbon, biogenic silica and calcite. Microscopic analysis of thin sections revealed distinct calcite laminae deposited during growing season and interbedded with large amount of diatoms and organic-rich laminae with minerogenic contributions. The seasonal variability was also reflected in the chemical composition inferred from high-resolution XRF measurements. A characteristic annual succession of elemental composition followed a distinct pattern: spring was marked with a silica peak followed by a major calcium peak; during summer and fall minor calcium peaks occurred as well as maxima in iron and sulphur; winter was characterized by a peak in potassium. With this characteristic pattern, the sediment record from Lake Żabińskie shows a remarkable potential for a reliable varve chronology and for multiproxy paleonvironmental reconstructions.

POSTER SESSION 3

Identifying natural and anthropogenic impacts in the southern boreal forests of Europe

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Vegetation dynamics and biodiversity are driven by a complex interplay of natural and anthropogenic disturbance and the associated feedbacks between vegetation dynamics and forest disturbance. Identifying and disentangling the cause and effect of forest disturbance is challenging, especially detecting natural and anthropogenic disturbance. Holocene vegetation dynamics and disturbance history can be observed using palynological proxies e.g. pollen and charcoal and through the analysis of these proxies at varying spatial scale, we can explore forest succession, development and more specifically identify periods of high and fluctuating floristic diversity in relation to past disturbance history.

At the local scale, two forest hollows (<20 km apart) in southern Finland were analysed for high resolution pollen and charcoal analysis. Their compositional turnover and palynological richness are compared to identify unique and mutual vegetation change and disturbance history. Pollen gives an intuitive analogue of past vegetation change but does not give a spatially explicit description of land cover estimates so data from nearby regional lakes are used to quantify the vegetation reconstruction using the LRA model. At the continental scale, fire history variability was reconstructed for Fennoscandia using existing charcoal and fire scar records and compared to the Holocene distribution of Norway spruce (*Picea abies*) in five time series maps. Further, the dynamics LPJ-GUESS model was used to explore climate and fire disturbance as individual drives of Holocene biodiversity.

Early-Holocene vegetation dynamics and fire frequency are primarily driven by climatic variation. The regional expansion of Norway spruce does not coincide with local disturbance but is most likely driven by climate, specifically, continentality. The mid-Holocene decline in deciduous species and loss of floristic diversity corresponds to an increase in fire frequency at both local stand-scale sites however, this occurs 1600 years apart suggesting disturbance, not climate as the primary driver of biodiversity in Fennoscandia. This is confirmed in the modelled data. The natural re-occurring fire frequency in the southern Finnish boreal forest is approximately 400 year intervals, occurring pre- and post-spruce establishment at the local scale. However, the step-wise expansion of Norway spruce in Fennoscandia reduces biomass burning prior to the mid-Holocene increase in anthropogenic disturbance.

Disturbance dynamics of the High Tatra Mountains, Slovakia: a multiproxy approach combining palaeoecology and dendroecology

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Central European Norway spruce (*Picea abies*) mountain forests are a niche environment; situated outside of their natural boreal distribution they are at or near their ecological limit and vulnerable to short-term disturbance and long-term environmental change. Natural disturbance dynamics have a fundamental control over forest composition and structure. Understanding disturbance frequency, effect and subsequent forest recovery is essential for forest management and conservation. Recent windstorms and consequential bark beetle (*Ips typographus*) outbreaks have adversely impacted vast areas of spruce mountain forest across central Europe (e.g. the 2014 windstorm and ongoing bark beetle disturbance in the High Tatra Mtns, Slovakia). The current state of forest management is in conflict between active forest management, such as the removal of valuable timber and dead wood, and forest conservation that allows natural forest dynamics and disturbance recovery. Further, frequent disturbance and long-term climate trends may cause a switch of keystone species from Norway spruce to European beech (*Fagus sylvatica*) fundamentally transforming the ecosystem function, biodiversity and economic potential.

Real time ecological observations of disturbance events are vital to understand ecosystem functioning yet impractical on a temporal perspective during a critical time of decision making. Dendroecology offers *in situ* records of historical disturbance limited to the past few hundred years and palaeoecology gives an intuitive analogue of past disturbance dynamics. Combining palaeoecology, dendroecology and modern ecological observations provides critical knowledge exchange towards understanding the impact and recovery associated with moderate- to severe-disturbance dynamics on varying spatiotemporal scale.

Holocene vegetation succession and disturbance history is reconstructed using pollen, charcoal and macro remains from a small forest hollow environment and compared to a dendroecological record reconstructing past disturbance history. Independent chronologies are correlated for the period of overlap to compare mutual and contrasting disturbance histories and disturbance frequency is extrapolated for the duration of the palaeoecological record.

Different successional patterns in two close located cores: comparison of mire and floating mat zone (Rzecin mire, W Poland)

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The Rzecin mire, Natura 2000 site, is located in western Poland and covers an area of 236.4 ha. The peatland is located between dune areas of the Noteć Forest within the drainage basin of the Warta and Noteć Rivers. The *Sphagnum* carpet typical of the central part of the peatland was selected as a sampling area. We took two sediment cores: Rz-1 on the mire, close to the margin of the floating mat and Rz-2 inside the floating mat area to reconstruct lake-mire successions using macrofossil remains. Communities dominated by *Thelypteris palustris* started the initial succession in the Rz-1 core. Later it was followed by Bryales and *Sphagnum teres* moss cover together with many *Carex* species. In the middle part of the core a 10 cm layer of mineral matter with highly humified peat occurs. Currently *Sphagnum teres* prevails on the sampling site. The brown moss community (*Calliergon giganteum* and *Drepanocladus vernicosus*) began the mire succession in the Rz-2 core. It was followed by a Drepanocladus-Carex community with many remains typical for water environment (Chironomidae head capsule, Turbellaria cocoons, *Ceriodaphnia* ephippia, Trichoptera cases) indicating very high water levels at the mire. It was followed by Sphagnum-Bryales communities. An outbreak of *Panolis flammea* followed by deforestation of 90% of the area of the Noteć Forest occurred in 1922-24. This serious disturbance evidently affected the succession in the mire and is reflected in both cores by a layer rich in mineral matter and humified peat (in Rz-1) and the lake-layer (in the Rz-2).

Reconstruction of total phosphorous in north German lowland lakes since 500 AD

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We have carried out paleolimnological projects at more than 20 lakes in lowland regions of northern Germany. The projects are focussed on reconstruction of the total phosphorous, the main driver of lake productivity, based on sedimentary diatoms (DI-TP). Based on near natural reference conditions in the lakes, at the earliest during ~ AD 500, most of the changes in diatom communities could be justified by changes in settlement activities in the lakes catchment areas. The initial change in settlement activity and DI-TP reference values are very variable. The initial increase in settlement-associated pollen occurred in the catchments between AD ~700 and ~1820. A departure from diatom-inferred TP reference conditions occurred during periods of increased human activities during Early to Late Medieval Times (AD ~1110 – 1325), early Modern Times (AD ~1575 – 1600), after the Thirty Years' War (>AD 1650) and during the Anthropocene after AD ~1850. Only one lake has continuously TP reference values until recent days. In two cases TP reference values could not be detected, caused by insufficient sediment coring depth. Thus, we refrain from setting a fixed point in time for defining reference conditions for lakes in the European Central Plains.

In Central European lowlands a serious temperature time series for the last millennium has not been published so far. So it could not detected the additional influence of temperature on DI-TP reconstruction in this area. We will present first results for this question, based on a previous temperature reconstruction from northern Poland.

Human impact and past climate changes - records in lake sediments of two Pamir lakes

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The bottom sediments accumulated in two Pamir lakes, Yashilkul and Rangkul, have been analysed using the interdisciplinary methods. The cores for multi proxy analyses have been taken using the UWITEC auger (1,20 m from Yashilkul and 0,74 m from Rangkul – each core was divided into single sample of 1 cm each, giving 120 and 74 samples respectively). The lakes are of the same tectonic origin and are located at the similar altitude some 3700-3800 m a.s.l. They differ in morphometric characteristics e.g. the area, length or volume and especially maximum depth. The Yashilkul lake has area of 35,6 km^2 and average depth some 12,5 m (maximum 52 m) while Rangkul has only 7,8 km^2 and average depth reaching some 1,5 m. The lakes also differ in geology, geomorphology and vegetation of the surrounding areas. The Yashikul Lake is supplied by waters and mineral material from over a dozen tributaries (transporting igneous and sedimentary grains of different size), while water supply to the Rangkul Lake is limited due to its location on the wide and flat platform. This platform formerly was a lake bottom (littoral part) but due to the water level changes it became dry land (in the eastern part it is an extensive fen meadow). Nowadays, this flat area, locally with vegetation, acts as a barrier stopping finer and coarser sediments.

Although the lakes function under different geologic and geomorphologic conditions, we found some similarities in the vertical changes of physical and chemical properties that can be correlated with climate alterations of the regional or global scale. In case of the Rangkul Lake, changes of water supply were recorded in the type of sediments i.e. water level caused the change from lake sediments to peat – we found 5 of such episodes. This changes were also recorded in geochemical properties of sediments (e.g. carbonates, C, N contents) and in sediments texture observed in SEM analyses. Changes in the type, geochemical and physical properties of the sediments accumulated on the lake bottom were also observed in the Yashilkul lake – not so excessive but also clearly marked.

Possible some of the textural and geochemical changes in sediments of the examined lakes, especially in their top parts, can be explained by the human economic activity both in prehistoric and modern periods (e.g. animal breeding).

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Human impact on the landscape of the Mrągowo Lake District (Masuria, NE Poland) in the Iron Age

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Pollen, NPPs, charcoal and geochemical analyses were conducted on sediments from Lake Salęt being the central point of the settlement microregion. The investigations were restricted mainly to the Iron Age, and covered the period from the second half of the seventh century BC to the beginning of the tenth century AD. The palaeoecological data, together with a well-established chronology, made it possible to correlate local environmental changes with archaeological finds of human settlements, and confirmed the long-lasting existence of the West Balt tribes in the Mrągowo Lake District.

The results obtained provided new data to assess the dynamics of settlement and economic changes of the prehistoric inhabitants of the Mrągowo Lake District (NE Poland). The whole Iron Age in the studied region was characterized by the almost continuous existence of the West Balt tribes, which was connected with the West Balt Barrow culture, and then with the Bogaczewo culture and the Olsztyn Group. Correlation of palaeoecological data with the local archaeological data was a reliable basis for the interpretation of man-environment interactions.

The diversification of the use of the environment by humans is quite clearly marked in particular periods of the Iron Age. In the Early Iron Age (West Balt Barrow culture) the mainstay of the economy was animal husbandry, and cultivation was of rather less significance (probably mainly *Triticum* was grown). In the Roman Period (Bogaczewo culture) animal husbandry and cultivation were of more or less similar economic importance, and *Secale* cultivation was introduced on a large scale. Slash-and-burn cultivation developed, particularly in the middle part of the Roman Period, after ca. AD 200. In the Migration Period (Olsztyn Group) the economic activity of the Roman Period was continued and judging from the pollen record, human impact on vegetation persisted until the ninth century. Regeneration of woodlands, mainly *Betula* woodlands and *Alnus* woods took place only in the period after ca. AD 830, and was accompanied by a decrease of all indicators of agriculture. This observation is not in accordance with the most of archaeological data about the diminishing of the settlement activity in the Salęt microregion as early as the seventh century AD.

The most characteristic feature of the studied area during the whole Iron Age was a high representation of semi-natural *Betula* woodlands which was probably linked with the shifting agriculture. However, strong reduction in *Betula* took place between ca. 650 and 450 cal. yrs BC and was connected with the appearance of the West Balt Barrow culture.

Plausibly, climate changes were a major factor shaping changes in settlement and land-use patterns in the Iron Age. Broadly, at around 400 BC there was a marked increase in the number of Balts settlements in the area around Lake Salęt connected to climate warming. Moreover, the economic and societal crisis at about AD 540-590 might have been aggravated by climate deterioration in the Migration Period.

Impact of land-use changes in small catchments on lake sedimentation: case study of Lake Jaczno, northeastern Poland

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Land-use changes caused by human activity are well recorded in natural archives such as lake sediments. Using annually laminated sediments from Lake Jaczno (NE Poland), our goal was to track changes in agricultural activity in the catchment during the last ca. 200 years and their impact on the sedimentation in this lake.

Postglacial Lake Jaczno (53°51'18'' N, 21°57'07'' E, 163.9 m.a.s.l, 40.6 ha, 25.7 m max depth) is situated in the Suwałki Lakeland. This non-industrial area has been used mostly for agriculture and recently also for tourism. To reconstruct recent human impact on this lake, we retrieved a gravity core from the northern basin (20 m water depth). The core was analyzed with non-destructive XRF scanning and then subsampled for discrete analyses. Sediment chronology was established by varve counting validated with ^{210}Pb and ^{137}Cs dating. Geochemical (TOC, TIC, TN, TS, BSi) and pollen analyses were performed with 3- and 6-year resolution, respectively.

The sediment record includes three different units separated by two lithologically distinct event layers. The bottom part of the core covers almost 90 years of clastic-organic lamination. The composition of pollen spectra suggests that the catchment was largely deforested (high abundance of pollen of cultivated and ruderal plants). Arboreal pollen is well represented by light-demanding species such as *Pinus* and *Juniperus*. High concentrations of fungal spores (e.g. *Glomus*), numerous corroded pollen grains and high clastic input (K, Ti and Si) indicates unstable soil conditions. The middle section of the core covers ca. 20 years, before and during the World War II. Minerogenic content and the sum of anthropogenic indicators in the pollen record are still high. In contrast to the lower units, the topmost section (AD 1968-2012) shows a strongly reduced minerogenic input. The gradual increase in TC, TN, and BSi contents and a higher abundance of macrophytes indicates higher trophic status of the lake. Simultaneously, a regeneration of forest communities is documented by a higher proportion of arboreal pollen (*Betula, Alnus* and *Carpinus*) and a considerable decrease of herb pollen (especially cereals).

Lacustrine ecosystem response to medieval hemp-retting practices – an example of three hard water lakes from SE Poland

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Hemp (*Cannabis sativa*) is one of the oldest and most multipurpose crops, yet, the basic use of hemp is in fibre production. The earliest findings of hemp products in Europe date back to the Hallstatt culture (800 - 400 B.C.). The traditional fibre extraction technique involves 6-8 weeks of water retting of plant stems to dissolve the pectin, binding the fibres to the stalk. For this purpose natural water-bodies, mostly small lakes, were used. Paleolimnological studies confirmed hemp retting episodes in many European lakes, however, the detailed mechanisms of lake ecosystem response to overall activities connected to this practices remain unknown.

We present the results of multi-proxy (Cladocera, Chironomidae, pollen analysis, sediment chemistry) paleolimnological studies of three, shallow, closely situated, hard-water lakes, encountering the hemp retting episodes from 5th to 8th century. In the course of previous research we diagnosed that these lakes were used as retteries, most likely, by the inhabitants of the Early-Medieval Busówno settlement. Our aim was to disentangle the mechanisms in the lake ecosystems response to retting. Obtained results clearly point to the role of hemp-retting in facilitating rapid eutrophication. The obvious factors disrupting the lake status, resulting from retting are: (1) high input of allochthonous organic matter and additional nutrient supply to the lake, (2) worsening oxygen conditions, (3) hydrological changes, aimed to increase the water exchange. Furthermore, the hemp-retting episodes seemed to be important factor in shaping further ecological status of the lakes.

The human activity during the first five centuries AD recorded in the laminated sediments of the Lake Czechowskie (northern Poland)

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We present a record from the annually laminated (varved) sediments of Lake Czechowskie, located in northern Poland (north-eastern part of the Tuchola Forest). We used high-resolution pollen analysis, sedimentological (varve and sublayer thickness variations) and geochemical (μ-XRF data) proxies to reconstruct the environmental changes within a time of increasing human activity and fluctuating climatic conditions. The chronology was established by varve counting and confirmed by AMS ^{14}C dating, ^{137}Cs activity measurement and a tephra layer (Askja 1875). Based on different spatial sampling and measuring increments, the temporal resolution varies between subseasonal (μ-XRF), annual (varves) up to five-varve resolution (biotic proxies) making it possible to trace even short lasting local and regional changes. In relation to the archaeological data from the region we focused on the progress of human activity from the mid-1st century BC up to the mid-6th century AD. According to the archaeological chronology this period corresponds with the Late pre-Roman Age, Roman Age and Migration Period. About the end of 1st century the Wielbark Culture tribes appeared in the Tuchola Forest. Archaeological research demonstrated that during the Late pre-Roman Age till about 70 AD there was a general lack of traces of human activity in the region. The highest development of local community occurred between 150–250 AD.

Our results display phases of human activity and their influence on the environment in vicinity of the Lake Czechowskie. The visible deforestation and changes in the forest composition due to human pressure took place between 70–360 yr. AD. The first changes (70–150 yr. AD) caused by appearing of human tribes showed the development of ruderal and meadow and pastures plant communities. In the second half in of the 2nd century the settlements were in full swing. Between 150–360 yr. AD the share of human indicators proved that grazing, pasturing and crop cultivation was highest. An intensification of lake productivity (expressed as an increase of varve thickness) started after 250 AD. The rapid decline of human indicators about 360 years AD at the transition to the migration period might be related to cooler conditions forcing the people to give up their settlement and move.

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Anthropogenic changes of vegetation over the last millennium in NE Poland; a case study on the varved sediments from Lake Żabińskie

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The last millennium is an important period for the development of modern vegetation types in northeastern Poland. A distinct change of plant cover occurred, which was manifested by a transition from predomination of woodland communities to partly open environment with high proportion of agrocenosis and semi-natural woods. This was accompanied by an increased intensity of settlement. The transformation of vegetation was quite well reflected in the pollen diagrams from the Great Mazurian Lake District. The correlation of palynological sequences revealed significant spatio-temporary differences in the beginning of large scale woodland clearings in that area. Three groups of pollen sites were distinguished based on time of deforestation. First of them represents the sites strongly deforested by the old Prussian tribes, which correspond to the period until the conquest by the Teutonic Order that occurred at the end of the 13th century AD. The second group consists of sites which registered the clearance during the Monastic State existence (from the end of the 13th century AD until AD 1525), while the last one belongs to sites that stayed afforested after AD 1525. The latter one is represented by Lake Żabińskie.

Our palynological studies conducted on annually laminated sediments from Lake Żabińskie provide a ca. 6-years resolution reconstruction of vegetation and land-use changes. This approach, for the first time in this region, allowed to obtain very detailed insight into chronology, rate, extent and permanence of changes as well as provided a precise correlation of noted phenomena with the local historical events.

According to the results from Lake Żabińskie, this area was strongly forested until the turn of the 16th and 17th centuries AD. The slight disturbances of local woodlands were observed from the pre-Teutonic Order time, but the increase in local agriculture started after AD 1450. Co-domination of pine forests with spruce and deciduous forests of Tilio-Carpinetum type on dry habitats near the lake, as well as the presence of birch and alder woods on wet surfaces, lasted until AD 1610.

The most intensive anthropogenic impact on environment began from AD 1806 and lasted at least until the World War II. Since the 60s of the 20th century AD the phenomenon of reforestation and decline of herbaceous plants was registered and interpreted as a possible result of changes in farming techniques and the recessions of agriculture.

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Environmental changes recorded in Lake Żabińskie (Masurian Lake District) based on the subfossil diatom flora, AD 1888-2010

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Diatoms, being the major component of algal assemblages, are excellent bioindicators for assessing the state of lake ecosystems. They are usually abundant, diverse and sensitive to numerous environmental variables, including physical (light, temperature, water transparency) and chemical (pH, alkalinity, trophy) factors. Changes of environmental parameters, for example concentration, supply rates, and ratios of nutrients (N:P, Si:P) impact the variability of the structure of diatom assemblages. Therefore, diatom analysis is one of the best methods that has been used widely for resolving anthropogenic eutrophication problems.

The aim of this study was to reconstruct environmental changes including the human impact recorded in the upper part of sediment core from Lake Żabińskie covering the last 120 years. Samples for quantitative and qualitative analyses were prepared following the standard procedure. To estimate the concentration of siliceous microfossils per unit weight of dry sediment (absolute abundance), a random settling technique was used. The analysis was performed with a NIKON microscope under a 100× oil immersion objective. In each sample 500 to 800 valves were counted in order to estimate percentage abundance of particular taxa. The raw counts were transformed to relative abundance of the total frustules counted.

The diatom flora is abundant, quantitatively rich and well preserved. The absolute abundance ranging between $1.8x10^7$ and $1x10^9$ valves/g dry sed. A total of 210 species, varietes, and forms belonging to 47 genera were recorded. The diatom assemblages were predominated by planktic taxa. Five diatom assemblage zones (DAZ I-V) based on floristic spectrum and the relative abundance of dominant and subdominant taxa.

In AD 1888-1920 the highest frequency of lightly silicified small *Stephanodiscus minutulus* and *S. parvus* was noted. These species are known as eutrophication indicators with the high the phosphorus requirement and low ratio Si:P. They are also described as low-light species well developed in periods with intense of lake mixing. This type of environmental conditions is favorable for growing *Aulacoseira ambiqua* and *A. granulata* noticed in DAZ-I.

In AD 1921-1940 the content of nutrients increase, which is documented in DAZ-II by the abundance of *Stephanodiscus* spp. and *Aulacoseira* spp. and disappearance of *A. islandica* species associated with nutrient-poor conditions. Moreover, at the end of 1920s a peak of hypertraphentic species *S. hantzschii* was recorded.

In next period AD 1941-1958 the visible decrease of P influx is recorded by lower frequency of eutraphentic *Stephanodiscus* spp. combined with the occurrence of oligotraphentic diatom taxa e.g. *Cyclotella polymorpha*, *Fragilaria nanana* in DAZ-III. Since 1960s the nutrient content gradually increased, therefore in DAZ-IV small *Cyclotella* spp. is replaced by *Stephanodiscus* spp. The most important components of the diatom assemblage are *Asterionella formosa*, *Fragilaria crotonensis* and *Tabellaria flocculosa*, species reported as indicators of anthropogenic eutrophication. The occurrence of these elongate shape species as well as of *Aulacoseira* spp. being indicators of light deficiency, can be a signal of deterioration in the water transparency of epilimnion. This phenomenon was particularly strong in 1980s and 90s which is documented by mass occurrence of *A. ambigua* and *A. granulata*.

Until AD 2010 as nutrient loadings increased small Stephanodiscus taxa once more dominated in DAZ-V. However, at the beginning of 21st century the higher frequency of taxa of lower nutrients requirements such as *C. polymorpha* and *F. nanana* can indicate short term reduction of P influx.

Diatom biostratigraphy of the last millennium sediments of Lake Żabinskie (Masurian Lake District)

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Fossil diatom flora preserved in annually-laminated lacustrine sediments of Lake Żabinskie has been used to infer both past trophic state and climate conditions. Żabińskie Lake, a kettle-hole type, located in the central part of the Masurian Lake District is a dimictic, hardwater, highly eutrophic lake with strong stratification of the water column and a well isolated and anoxic hypolimnion. The 361 cm thick sediment sequence covering the time interval AD 947-2010 was collected within the framework of Polish – Swiss Project CLIMPOL (Climate of northern Poland during the last 1000 years: Constraining the future with the past).

The sediment samples for quantitative and qualitative diatom analysis were taken at each varve. The diatom samples were prepared according to the standard methods (Battarbee 1986) and performed using a NIKON microscope, using a 100x oil immersion objective. To estimate the concentration of siliceous microfossils per unit weight of dry sediment (absolute abundance), a random settling technique was used. The raw counts were transformed to relative abundance of the total frustules counted. For qualitative analysis the counting method of Schrader and Gersonde (1978) was used, and in each sample from 500 to 1000 valves were counted in order to estimate percentage abundance of particular taxa. All identified taxa were classified according to their ecological preferences such as: habitat (benthic, planktic), pH of water (alkalibiontic, alkaliphilous, indifferent, acidophilous, acidobiontic), trophy (eutraphentic, eu-mesotraphentic, mesotraphentic, meso-oligotraphentic, oligotraphentic, dystraphentic), saprobity (polysaprobous, α-mesosaprobous, β-mesosaprobous, oligosaprobous, saproxenous). A total of 250 species, subspecies and forms belonging to 52 genera were observed in sediment sequence.

Diatom taphocoenoses were dominated by planktic alkaliphilous, mostly eutraphentic and eu-mesotraphentic forms. However, in the lower part of sequence diatoms preferring nutrient-poor waters were observed. Nine diatom assemblages zones (ZAB A-I) were distinguished based on variations in the species composition, relative frequency of identified taxa and diatom flux. There are respectively: ZAB-A *S. parvus – C. cyclopuncta – A. formosa* DAZ (AD 947-1150), ZAB-B *S. parvus – Cyclotella spp. – T. flocculosa* DAZ (AD 1151-1280), ZABC *S. minutulus – S. parvus – C. radiosa – C. bodanica* DAZ (AD 1281-1360), ZAB-D *S. minutulus – A. ambigua – A. formosa – C. radiosa* DAZ (AD 1361-1470), ZAB-E *S. minutulus – A. ambigua* DAZ (AD 1471-1590), ZAB-F *S. minutulus – A. islandica – A. formosa* DAZ (AD 1591-1650), ZAB-G *S. minutulus – S. neoastraea – T. flocculosa* DAZ (AD 1651-1770), ZAB-H *S. minutulus – S. binderanus – A. ambigua* DAZ (AD 1771- 1887), ZAB-J *S. minutulus – S. parvus – A. formosa – T. flocculosa* DAZ (AD 1888-2010). In addition, the last zone is divided into five subzones (ZAB-J I-V). Until the beginning of 18th century diatom production is relatively low, whereas after AD 1718 is very changeable but much higher, which is connected with human impact. In ZAB AE oligo- and mesotraphentic diatoms mostly represented by *Cyclotella* spp. are replaced by eutra- and eutramesotraphentic *Stephanodiscus* spp., which indicates significant trophic state increase until the end of 16th century. Simultaneously, the higher frequency of *Aulacoseira ambigua* known as a warm water species, is coincident with warmer climate in 13th and the first half of 14th century and the second half of 15th century. Two peaks of cold-water meso-oligotraphentic species A. islandica noted in the first half of 17th century in ZAB-F DAZ can be a signal of nutrient level decrease due to climatic cooling (Little Ice Age). Since the second part of 17th century the abundance of diatoms typical for cultural eutrophication (i.e. *A. granulata*, *A. formosa*, *S. binderanus*, *T. flocculosa*) clearly indicates direct and indirect human impact.

POSTER SESSION 4

Water level changes in the lake-mire ecosystem of humic lake Płotycze Sobiborskie reflected in Testate Amoebae and Cladocera analysis: preliminary results

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The 200-years history of hydrological changes in the vicinity of the small, shallow humic lake Płotycze Sobiborskie (Eastern Poland, Western Polesie Region) were traced with the combined use of paleozoological analyses: Testate Amoebae and Cladocera. Booth proxies are considered a good indicators of hydrological changes (e.g. Woodland et al., 1998; Lamentowicz et al. 2009; Hofmann 1998; Korhola et al., 2005). Two sediment cores (from the central part of the lake and nearby peat bog) were analyzed, with the high resolution. The results were confronted with the data concerning the land-use, obtained from GIS analysis of historical maps. Main local drivers of identified hydrological changes were (1) catchment de- and reforestation (2) construction of the lake outflow (3) damming the outflow by beaver engineering. In addition, the consequences of hydrological alterations for the lake ecosystem (mainly changes of the color and trophy of waters) were pointed out.

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Forest response to human impact in Białowieża Primeval Forest during the last two millennia

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Białowieża Primeval Forest is the largest and best-preserved lowland forest complex in temperate Europe, extending along the border between Poland and Belarus. It belongs to the most precious elements of the European natural heritage. Being royal property since the medieval times, designed mainly to royal hunting, both the forest and game were protected from usual exploitation. The unique preservation of the forest and rich historical documents describing use of the forest resources during last several hundred years, make Białowieża Forest of special value as a subject for long-term ecological studies. It is unique source of knowledge of natural ecological processes of forest succession in long temporal scales.

The interdisciplinary Project "The natural history of the Białowieża Forest in the light of palaeoecological studies" was implemented to reconstruct history of the forests in the conditions of various forms of human impact and climate change. Eight, small mires, filled up with relatively young sediments, have been sampled for palaeoecological study in the Białowieża National Park, strictly protected since 1921. The best preserved sediment sections reflect environmental history of the past ca. 2000 years. Chronostratigraphy is based on radiocarbon dates and ^{210}Pb models.

Five phases of economic activity, different in scale and character, have been described based on the pollen diagrams. The palaeoecological data corroborate well with the information derived from the archaeological excavations and historical documents. The stages in the forest history were characterized by different intensity and methods in wood-use and in consequence, in different reaction of the main tree taxa involved in regeneration and succession of forest communities. 1- The Roman Iron Age occupation phase concerned development of agriculture and iron production; at that time the oak-hornbeam forest habitats undergone the most severe exploitation involving the use of fire. 2- In the Migration Period and in the Early Medieval times, the economic impact was of much lower intensity, especially as concerns agricultural activity, what does not mean, however, total cessation in the forest exploitation. 3-5- The effects of the historical regulations by law, concerning methods and restrictions in economic use of this area, are reflected by the pollen data. In comparison to other areas, an increase of deforested land and development of agriculture were very limited. However, strong fluctuations of micro- and macrocharcoal content in the investigated sediments and other palynological traces of transformations of forest habitats, document different stages of the economic development based on forest products. In comparison to other areas in lowland Europe, the woodland, now protected within the Białowieża National Park, even in some periods seriously affected by man, probably never lost integrity of its forest cover.

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Directions of changes in the use of peatlands of the Tuchola Pinewoods from the end of the 19th to the end of the 20th century

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The main goal of the research was to identify the trends in the use of peatlands from the end of the 19th century to the present day. The research was conducted in the north of Poland, in one of the largest complexes of pine forests in Poland – the Tuchola Pinewoods (Bory Tucholskie), which covers a large outwash plain area. The region has a surface area of 3550 km^2 and an afforestation rate of 70.3%. During the Prussian partitions, in the 18th and the 19th century, the region served as the main source of timber for many of Prussian investments and the forests were converted into a pine monoculture. A characteristic feature of the study area landscape is the presence of numerous depressions of various origins (largely glacial and subglacial channels, as well as kettles) filled with lake waters and biogenic formations – mainly peat.

The results and conclusions were based on the Prussian topographic maps from the end of 19th century in the scale of 1:100000 and the Polish topographic maps from the 90s of the 20th century in the scale of 1:50000. They allowed for establishing a data base, which included peatland boundaries at the end of the 19th century, information regarding their use, as well as current hydrological conditions by the end of the 20th century. The area marked on the Prussian map as wetlands (moor) was assumed to have been an active peatland in the initial part of the study period. As far as the Polish maps are concerned, an assumption was made that if an area was marked as wetlands, the prevailing hydrological conditions were favourable for peat formation.

A total of 744 peatlands were identified in the Tuchola Pinewoods. Their combined surface area amounted to 10762 ha, which constitutes 3% of the surface area of the entire region. The peatlands were found to be unevenly distributed and proved to be most dense in the upper part of the Wda catchment area, in the vicinity of lake Wdzydze, in the watershed areas of the Wda and Brda, as well as Wda and Mątwa rivers (Fig. 1). Only 37 peatlands were indicated as showing no tendency of changes (Table 1). These few constitute 5% of combined surface area of all peatbogs under analysis. On the other hand, 73.4% of all peatland surface area was either completely or partially turned into arable land. The dominant direction of transformations was established in relation to five areas studied in detail (Fig. 1): area I – partially altered; area II – transformed into midforest meadows; area III – transformed into woods; area IV and V – transformed into arable lands.

As indicated in the study, peatlands found in the Tuchola Pinewoods have been largely transformed with regard to their use and hydrological conditions as they were drained for agricultural purposes. The succession of forests onto the wetlands occurred where adjacent areas were subject to draining. It can be thus assumed that the decrease in the groundwater table within a larger area constituted favourable conditions for the forest succession where land was not being cultivated.

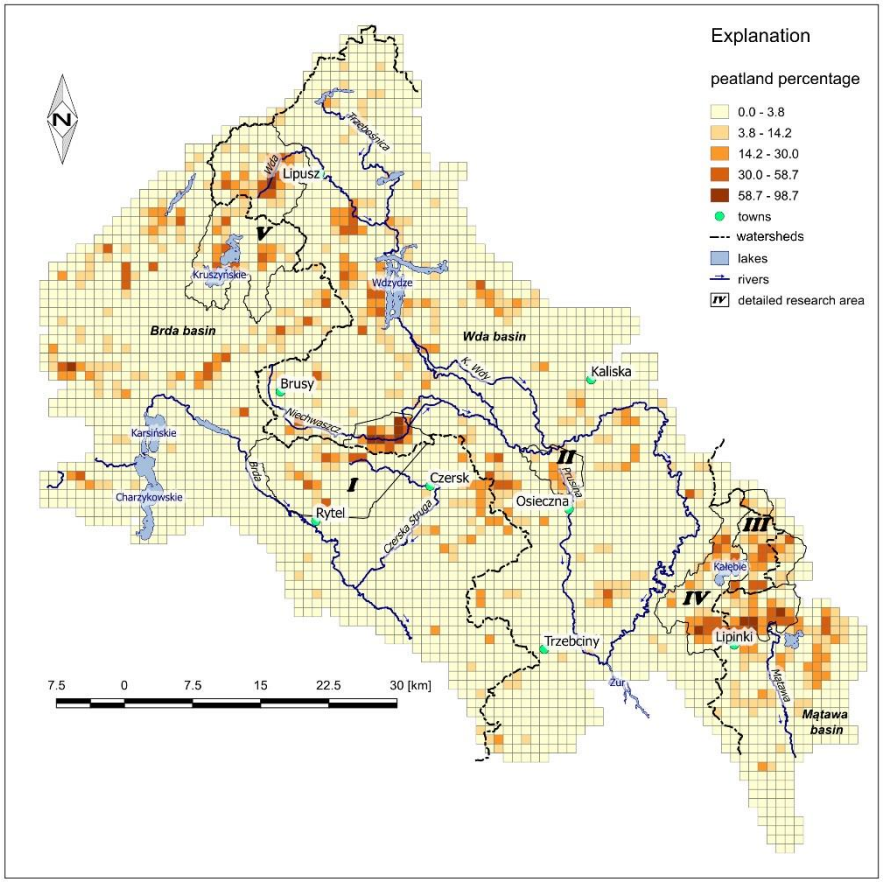

Fig 1. Percentage of peatlands in the Tuchola Pinewoods

Table 1. Trends in the use of peatlands in the Tuchola Pinewoods

Trend	Number		Area	
	Total	[%]	[ha]	[%]
no distinctive change	37	5,0	273,7	2,5
partial change into forests	88	11,8	1457,0	13,5
partial change into arable lands	123	16,5	4004,6	37,2
partial change into water bodies	8	1,1	27,8	0,3
complete change into forests	201	27,0	1076,0	10,0
complete change into arable lands	275	37,0	3892,8	36,2
complete change into water bodies	12	1,6	30,1	0,3
Total	**744**	**100**	**10762**	**100**

Two millennia of forest habitats transformations as a result of land use and climatic shifts (Gdańsk Upland, N. Poland)

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The study concerns the stand-scale palaeoecological reconstruction of the subsequent stages of late Holocene vegetation development under conditions of variable anthropogenic pressure and climate change. For our research we have selected the area recently covered by beech-dominated woodland in the Gdańsk Upland close to the southern Baltic coastal zone. The data are based on pollen, non-pollen palynomorphs, macrofossil and charcoal analyses from two small mires located close each other.

During the reported period, the vegetation has transformed from hazel and oak dominated forest, through oak-hornbeam plant community, to the modern beech dominated woodland. The data indicate that the final *Corylus* decline and concurrent *Carpinus* expansion at c. 2247±94 cal. BP have been initiated mainly by the intensive settlement activity of the Pommeranian culture. The proper expansion of hornbeam was clearly related to the higher land opening resulting from crop cultivation and animal husbandry. Increasing animal pasturing in coppiced woods could be one of the potential factors for this shift. After the settlement collapse, the deforested land was subject to secondary forest succession with subsequent dominance of *Betula*, *Pinus* and then *Carpinus*. The later replacement of *Carpinus* by *Fagus* (c. 1100-941±107 cal. BP) was most probably caused by the coupled effect of climate change and human made disturbances. The *Fagus* population started to increase slowly along with the oak–hornbeam forest development in a period of low human activity. However, up to about 1100 cal. BP, beech remained a minor forest constituent. The beginning of the *Fagus* expansion was preceded by man-made forest disturbances with fire and then selective removal of oak. Our data seem to illustrate rather specific human activity around the sites in the beginning of the early medieval period and in the more recent times. It was limited to different kinds of forest management, like animal grazing, coppicing or timber harvesting. The woodland continuity in this area is also documented by all available historical maps. On the other hand, the palaeoecological data indicate generally wetter trends from 1747±117 to about 1280 cal. BP and a short wet event which took place immediately before 941±107 cal. BP. Therefore, a climate with higher moisture is suggested among the triggers for more vigorous *Fagus* expansion.

Our research demonstrates that during the last two millennia, each of the major shifts in the forest communities took place during relatively short periods and they were caused by human impact coupled with climatic events. In each case the subsequent vegetation shifts were caused not by an arrival of a new species to the forest communities, but due to expansion of a sub-ordinate tree species population which was already present for a long time but expanded due to a change in the factors balancing contemporary interspecies competition. Our data confirm the important role of episodic disturbances as turning points initiating long-term vegetation changes.

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Pedosedimentary record of human impact and climate changes in the Holocene - evidences from closed depressions in loess areas of Lublin Upland

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Closed depressions are a characteristic small landforms of the loess plateau and constitute local, closed sedimentation basins. It enables to preserve colluvial sediments along with the complete record of human activity in the Holocene. In the pedosedimentary archives from closed depressions the markers of climate changes also occurred.

Three closed depressions, located within agricultural land of Lublin Upland, were chosen for detailed studies. Sediments infilling closed depressions were subjected to detailed paleopedological study. The analysis of morphological, physicochemical, micromorphological, geochemical features and ^{14}C dating were performed. Studied closed depressions are filled up with soil-sediment sequences, which consist of two layers of colluvial sediments, separated by fossil soils horizons. They lie on a Late Vistulian-Holocene subfossil soil, covering the primary bottom of the depressions, having formed in the loess in situ. In profile the Early to Middle Holocene climate conditions were reflected. They are recorded as clearly exhibit redoximorphic features formed under excessive humidity of the deposits related to periodic water stagnation in the closed depression. The changes of water conditions in the closed depressions were also associated with conversion of forested areas into croplands by the first agricultural cultures. Two series of colluvial sediments in closed depressions are separated by the humic horizon of a younger subfossil soil. The subfossil soil developed from about the 12^{th} to 14^{th} century due to the settlement recession. It may have resulted from crop failures caused by the unfavourable climate conditions of first stages of the Little Ice Age.

The main phases of colluvial sedimentation developed since Neolithic until Early Middle Ages, and since 15^{th} until 21^{st} c. They correlate clearly with colonization and agriculture development since Neolith to recent times.

Geochemical and isotopic records of anthropogenic impact and natural environmental change in the Romanian Carpathians during the last millennia

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The characteristics, distribution patterns and effects of recent pollution are well known over most of Europe; concerning the estimates of long-term pollution however, important issues remain. Examples include the existence of strong regional differences in the magnitude and temporal and spatial shifts in past emission sources, the insufficient constraints on the isotopic signatures of various ores exhausted or in use, the irregular distribution of comparable data on long-term pollution trends, and the insufficiently explored relationship between human impact and natural causes of environmental changes, especially over Eastern Europe. These limitations strongly suggest that for improved assessments on the past pollution load, variability, and change, more sites shall be investigated regionally, and particularly over regions with mineral wealth and long-term human presence such as the Carpathian-Balkan area.

Here we present newly acquired data at high-resolution using a multi-proxy geochemical (major and trace elements), lead isotopic, and sedimentological (XRF core-scanning) approach on several peat (Semenic; Mluha; Sureanu) and lacustrine sediments (Ighiel; Sf. Ana) with the main aim at disentangling between mining/pollution evidence and natural cycling of elements in the Romanian Carpathians, for the last millennia. To date, in the Carpathian-Balkan region information concerning past metallurgy has largely been limited to the archaeological record. Using stable lead isotopes coupled with the stratigraphy of selected metals (ie., Pb, Sb, Bi, Ag, Sn, Pb, Au, Hg) associated with smelting and reference element ratios (e.g. Pb/Ti) from peat/lake records deposited nearby the major regional metal exploitation centers we attempt at reconstructing also the metallurgical activity in the Carpathian region, with a focus on the last 2000 years, distinguishing between natural and contaminant Pb and other metals released during mining/smelting. Our results present a new view on the human impact through resource exploitation, and the results, in conjunction with existing geological, archaeological, and archaeometric evidence, allow for a comprehensive assessment on the history of metal-use development in the Carpathian region.

Hypothesis on the relation between the late humid period of the Little Ice Age and the culmination of the Hungarian arable lands

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The Great Hungarian Plain that lays on the border of hot and warm summer subtypes of the humid continental zone was transformed into a homogeneous grain-producing region during its modernization that linked to river regulations. As I see the challenge of humid period between the mid-1870s and the mid-1940s in the Carpathian Basin had a fair importance in procession of this landscape transformation. On the one hand, the late 19th century Hungarian elite replied to the increasing flood-hazard with the intensification of river regulation. On the one hand, the relative precipitation surplus of the humid cycle palpably reduced drought-proneness of the landscape, so provided a low risk opportunity for conversion of wetlands into tillages in some ten thousand square kilometres. Amount of arable lands reached their saturation level at 1913 that culminated until the mid-1940s, as far as the end of the humid climatic cycle accurately. However, the 1920s and 1930s saw some years with drastically decreasing grain production from drought events, in a period like that, when the majority of the Hungarian export constituted some grain products that had outstanding importance for the balance of public finance. As a response to this climatic challenge the Irrigation Act 1937 of the Horthy regime was the point since the Hungarian agrarian and water management policy has been characterised by a split personality: fight with water surplus and defence from the results of the fight. As a consequence of implementation of the Act the most extensive secondary salinized terrestrial areas of Europe developed in Hungary. Another, since the late 1940s has taken part decline of the amount of croplands in Hungary. As a part of this process due to certain serious droughts or excess surface water inundations led to abandonment of arable farming in huge areas.

Vegetation Change by Pollen, Macro and Microfossil Analysis in an Archaeological Site in Northwest Hungary

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Pollen and macrofossil analyses were carried out on samples derived from an archaeological site in Northwest Hungary to study and reconstruct the past environment of the area and the possible human impact on vegetation. The combination of differenet palaeoecological investigations provide more reliable results on the former vegetation of the site. Pollen analysis was complemented by microcharcoal analysis using the Clark point count method. Interpretation of the results was aided by comparison with recent vegetation composition in the study region. Radiocarbon dating of the bottom of the studied material indicates that it correlates with the Late Bronze age of the Carpathian basin (1300-900 BC).

The sample is a 41 cm long undisturbed core collected from a hollowed out trunk of an oak tree. At the bottom of the trunk a ritual archaeological object was found. 19 samples were taken at 2 cm intervals for pollen analysis and 41 samples at 1 cm interval for macrofossil analysis. During pollen extraction, *Lycopodium* spores were added for calculation of pollen concentrations and accumulation rates. Modified QLCMA method was used in the course of macrofossil analysis.

Besides the large number of *Pinus sylvestris* and *Betula*, *Quercus*, *Fraxinus* and *Ulmus* pollen occured. Large amount of *Filipendula* pollen and remains of *Phragmites australis* and other plants, which grow under humid or aquatic conditions, indicate wet environment in the investigated area. As we move towards the top of the core, the number of *Corylus* pollen increase as well as some of hydrophyte species which may suggest a more humid environment, in addition the increased value of *Corylus* refer to human impact on the environment.

The Slavic expansions: Evidence from linguistics and paleoenvironmental archives

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The Slavic expansions were one of the most important migration events in European history. Emerging from an Iron Age proto-Slavic homeland, Slavic-speaking people expanded north to the Baltic, west to Germany, south to the Balkans and east to the Eurasian steppe in less than a millennium. This migration period is a critical event in world history: it was unprecedented in scale and never repeated, and it led to the development of languages, cultures, and nations that persist to the present day. Despite the importance of the Slavic expansions for European and world history, its spatial and temporal pattern are poorly understood. Historical linguists have debated for more than a century about the routes and timing of the migrations that led the establishment of Slavic populations around central and eastern Europe.

While this debate continues, one aspect of the Slavic expansions that has been unexplored is the paleoenvironmental setting, in terms of land cover and climate changes, that may have determined favoured routes and settlement areas. In order to better understand the potential environmental drivers of the Slavic expansions and the impact that population migrations may have had on land cover, we combine material from historical linguistics, archaeology, palynology, and high resolution climate reconstructions in order to synthesize an unprecedented picture of the spatial and temporal pattern of the Slavic expansions.

Historical linguistics provides potential evidence for environmental setting through the study of the distribution of words and names in historical and modern Slavic languages. For example, tree names, plant names, fauna terminology, hydronyms, and other toponyms that are shared among all or sub-groups of Slavic languages may be indicative of the spatial and temporal origins of specific groups of people. To support the linguistic evidence, we map the distribution of the most important tree species in the Slavic lexicon based on an analysis of the European Pollen Database at indicative timeslices before, during, and after the major period of migrations. Further evidence for the timing and distribution of the Slavic expansions is provided in the archaeological record. Specific artefacts, architecture, and burial styles in the relevant areas are characteristic of Slavic populations. To add to the linguistic and paleoecological evidence, we are creating a geodatabase of the archaeological sites with evidence for Slavic occupation. Finally, climate change may have influenced the spatial and temporal pattern of the Slavic expansions. Our study utilizes newly available high-resolution paleoclimate reconstructions to determine if periodic drought, pluvials or other periods of enhanced climate variability may have been concurrent with linguistic and archaeological evidence for the expansions.

Our preliminary results suggest that a multi-disciplinary approach can be an effective way of refining our knowledge of important events in human history and human-environment interactions. Historical linguistics gains knowledge from the paleoenvironmental record; in turn, linguistic and archaeological data synthesis provides valuable information on the presence of certain groups of people with characteristic land use patterns that allow us to improve our understanding of the development of cultural landscapes, and the resilience and vulnerability of coupled human and natural systems to environmental change.

The correlation of soil-sediments sequences in alluvial fans and closed depressions as a sources of data about climate changes of the loess areas in the Holocene. A case study from Nałęczów Plateau (Lublin Upland, E Poland)

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The main presumption of climatic geomorphology is a thesis that the type and dynamics of erosional processes, transport, and accumulation of sediments depends on climatic factors, which occur on different time scales. However, in many cases, time and climatic factors have secondary importance, while the predominant role is played by the existing relief and human activity. On the other hand, the texture and structure of sediments is an archive with records of the climate conditions and dynamics of the sediment environment. The studies were conducted in the Nałęczów Plateau, a region of the Lublin Upland in eastern Poland. This area is characterized by varied relief and high dynamics of geomorphological processes. The main goal of the studies was to compare two different sediment environments: closed depressions and alluvial fans. Closed depressions are small forms of relief representative for poorly undulated loess plateaus. Alluvial fans are located at the mouths of gullies. Closed depressions and alluvial fans preserved pedosedimentary record of climate changes and human activity in the Holocene. Chronostratigraphy of sediments is based on archaeological data and the radiocarbon dating of organic sediments and fossil soils.

Examined closed depressions are sedimentological basins. They filled up with soil-sediment sequences, which consist of two layers of colluvial sediments, separated by fossil soils horizons. They lie on a Late Vistulian-Holocene subfossil soil, covering the primary floors of the depressions. Two major stages of infilling by colluvial sediments of closed depressions were recognized. Phases of colluvial sedimentation correlate with colonization and agriculture development. The oldest phase of colluvial sedimentation developed in a long period since Neolith until Early Middle Age. Two series of colluvial sediments are separated by the humic horizon of a younger subfossil soil. The subfossil soil developed from about the 12^{th} to 14^{th} century. The alluvial fans under study consist of a few secondary fans of varying horizontal range and varying lithology of sediments. They are built of silts, sandy silts, silty sands, sands and sands with gravels. It was established that the development of the studied alluvial fans occurred in three phases: 1) the Eneolithic; 2) the middle and late Bronze Age and the Hallstatt period; 3) the Middle Ages and the modern times. These phases were interspersed with two longer periods of stabilisation of the alluvial fan surface: Late Eneolithic/early Bronze Age and Dark Age. Soils were developed in these periods.

Differences in the lithology and chronostratigraphy of sediments forming alluvial fans and infilling the closed depressions were documented during the research. The differences in the lithology and chronostratigraphy are a results of different dynamics of the sediment processes. Secular processes are recorded in sediments in the closed depressions. The sediments in the alluvial fans indicates predominance of episodic extreme processes.

Both environments provide complementary data about the changes occurring in the loess environment in the Holocene, which are induced by climate changes and human activity.

Road construction impact on the landscape transformation during the last 700 years in NE Poland

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From way back, a connecting pathways (routes in a wider sense) play an essential role in human life and are fundamental for cultural and economic exchange. However, routes also had negative impacts on nearby settlements since they became important during war times for troop transports and may even have fostered the spread of epidemic diseases. In any case, routes are important cornerstones in the development of human settlement and landscape evolution. Commonly, historians investigate the role of routes for cultural developments, whereas environmental consequences of historical route construction so far had attained less attention.

Here, we present, for the first, time a high-resolution reconstruction of the impact of the construction of the trade route "*Via Marchionis*" on landscape evolution in Northern Poland since more than 700 years. This reconstruction is based on exploiting the annually laminated (varved) sediment record of the nearby located Lake Czechowskie.

The track "*Via Marchionis*" was built in the early 13th century and it initially led from today's territory of Germany (Brandenburg) through capital of Neumark (Myślibórz, 1298 AD) to the Castle of the Teutonic Order in Malbork (Poland, 1286 AD). In the first few centuries this track developed and became the key migratory route during the Middle Ages on the territory of Pomerania. Frequently recurring wars over the last millennium had great impact on the historical and environmental development of the southern Baltic territory. Moving armed forces often expended and devastated the region and caused changes in sovereignty and population density, all of which resulted in changes in regional vegetation and erosion processes in the lake catchment. Such environmental changes are recorded in the sediments and can be traced with novel high resolution analytical methods.

Based on a 5-year resolution pollen record combined with sub-annual resolving element scanning and precise varve dating five phases of significantly lower human activity interrupted by phases of stronger human impact were distinguished. Comparing these data with historical sources revealed a clear impact of wars and deployment through armed forces in this region. The strongest declines in anthropogenic pressure on the landscape are clearly related to periods of war and subsequent regeneration in the periods between wars. Hence, it was the construction of the *Via Marchionis* that indirectly influenced the development of Pomeranian landscape mainly due to its role as pathway for armed forces.

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