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Markus J. Schwab, Martin Theuerkauf, Achim Brauer,
Martin Wilmking, Reinhard Lampe (eds.)

3rd Annual ICLEA Workshop 2014

Dynamics of Climate and Landscape Evolution of Cultural Landscapes in the Northern Central European Lowlands since the Last Ice Age

Abstract Volume & Excursion Guide

Scientific Technical Report STR14/02

www.gfz-potsdam.de

HELMHOLTZ
GEMEINSCHAFT

Recommended citation:

Schwab, M. J., Theuerkauf, M., Brauer, A., Wilmking, M., Lampe, R. (2014), 3rd Annual ICLEA Workshop 2014: Abstract Volume & Excursion Guide. *Scientific Technical Report 14/02, GFZ German Research Centre for Geosciences*.

Citation example for individual chapters:

Obremska, M. (2014) Late Glacial and Early Holocene vegetation development recorded in Lake Czechowskie sediments - preliminary results. In: Schwab, M. J., Theuerkauf, M., Brauer, A., Wilmking, M., Lampe, R. (2014), 3rd Annual ICLEA Workshop 2014: Abstract Volume & Excursion Guide (p.31). *Scientific Technical Report 14/02, GFZ German Research Centre for Geosciences*.

Imprint

Helmholtz Centre Potsdam
GFZ German Research Centre for Geosciences

Telegrafenberg
D-14473 Potsdam

Published in Potsdam, Germany
March 2014

ISSN 1610-0956

DOI: 10.2312/GFZ.b103-14028
URN: urn:nbn:de:kobv:b103-14028

This work is published in the GFZ series
Scientific Technical Report (STR)
and electronically available at GFZ website
www.gfz-potsdam.de

Virtual Institute of Integrated Climate and Landscape Evolution Analyses

-ICLEA-

A Virtual Institute within the Helmholtz Association

3rd Annual ICLEA Workshop 2014

Dynamics of Climate and Landscape Evolution of Cultural Landscapes in the Northern Central European Lowlands since the Last Ice Age

Abstract Volume & Excursion Guide

Edited by
Markus J. Schwab, Martin Theuerkauf,
Achim Brauer, Martin Wilmking & Reinhard Lampe

March 25 – 28, 2014 in Hansestadt Greifswald, Germany

Contents

Welcome note

We cordially welcome all members of the ICLEA community and of the scientific advisory board as well as our guests and external partners to our third annual assembly held in the attractive vicinity of Greifswald-Wieck. After the first two workshops held in Templin (Germany) in 2012 and in Stara Kiszewa (Poland) in 2013 we now extend our terrestrial view by getting a glimpse of the nearby Baltic Sea, especially during the field excursion, which will lead us to the beautiful Island of Rügen to discover its glacial and postglacial history. Thereby, we follow our well established tradition to discuss new results not only in lecture rooms but also in front of those objects which we are investigating.

This has been made possible by the Helmholtz Association through funding of the Virtual Institute for Integrated Climate and Landscape Evolution Analyses (ICLEA) within the Initiative and Networking Fund for which we are especially grateful. All partner institutes, the GFZ German Research Centre for GeoSciences in Potsdam, the Ernst Moritz Arndt University Greifswald (UG), the Brandenburg University of Technology Cottbus-Senftenberg (BTU) and the Polish Academy of Sciences (PAN) have gained substantial benefits not only in terms of scientific perspectives but also in terms of new and stimulating personal contacts and sometimes even friendships.

We are active since a bit more than two years and impressive advances have been made in our five Work Packages and now the right moment has come to synchronise and integrate these results, which is a major goal and the particular strength of ICLEA. Therefore, we adjusted the workshop concept compared to the previous ones by adding a special session on first integrating talks from different Work Packages. These talks are intended as nuclei for further linking data and information from the different disciplines involved in ICLEA. This will be the main task for the second phase of our virtual institute in 2015-2016 after a hopefully successful intermediate evaluation by the Helmholtz Society in June 2014. Obviously, we will intensively use this workshop also for preparing ourselves for this important upcoming event.

In the first two years we made extremely good progress not least through the dedicated work of our early stage scientists and their enthusiasm and curiosity. We are on a very good way and if we continue like this we will be able to fulfil our long-term mission formulated in the original proposal, which is providing a substantiated data basis for sustained environmental maintenance based on a profound process understanding at all relevant time scales.

We thank all the participants for their contributions and enthusiasm, the members of the scientific advisory board for their support and wish all of us fruitful discussions, new ideas and collaborations, good weather for the field day and an enjoyable time in Greifswald.

Achim Brauer (ICLEA Spokesman)

Markus Schwab (ICLEA Coordinator)

Sebastian Lorenz and Martin Theuerkauf (Greifswald Organization Committee)

Scientific Technical Report STR 14/02
DOI: 10.2312/GFZ.b103-14028

Chapter I: Program Overview

Venue: Hotel majuwi in Greifswald-Wieck, Pomerania, Germany
Address: Yachtweg 3, 17493 Greifswald/Wieck, Germany

Tuesday, 25.3.2014	Wednesday, 26.3.2014
	8:30 - 10:00 Overview Talk & Poster Presentation **WP2 & WP4**
	10:00 - 10:30 Coffee Break
	10:30 - 11:30 Continuous **WP2 & WP4** Poster Presentations & Discussion
13:00 - 14:00 Arrival, Check In @ majuwi and Poster Installation all WP	**11:30 - 12:30** Poster Session **WP2 & WP4**
14:00 Picnic	**12:30 - 13:30** Lunch
14:30 Opening and Welcome	**13:30 - 14:50** Overview Talk & Poster Presentation **WP5**
15:00 - 15:45 Overview Talk & Poster Presentation **WP1**	**14:50 - 15:30** Poster Session **WP5** with Coffee
15:45 - 17:00 Overview Talk & Poster Presentation **WP3**	**15:30 - 18:30** Excursion Field Sites WP3 @ Eldena Forest
16:50 - 17:15 Coffee Break	
17:15 - 18:30 Poster Session **WP1 & WP3**	
18:30 Dinner	**18:30** Dinner
20:00 Public ICLEA lecture @ Pommersches Landesmuseum Greifswald *Thomas Terberger "Settlement and land use history in the Baltics"*	**19:30** WP Internal Meetings *Discussion of Plans for the 3rd Year of the 1st ICLEA Phase & Ideas for the Future*

Thursday, 27.3.2014		Friday, 28.3.2014
8:30 - 10:10 Synthesis Talks *4 invited ICLEA talks*		**7:30** Bus Excursion to Rügen Island
10:10 - 10:40 Coffee Break		
10:40 - 11:40 Presentation Results WP Internal Meetings & General Discussion		
11:40 - 12:30 Poster Session **all WP** *Individual Discussions*		
12:30 - 13:30 Lunch		
13:30 - 15:30 Meetings: Scientific Advisory Board SAB / Steering Committee	For all others: Wieck Excursion	
15:30 - 16:00 Coffee Break		**16:30** Ends in Stralsund **17:00** Arrival in Greifswald
16:00 - 17:30 Remarks by the SAB and Discussion Future Plans *Plans 2nd ICLEA Phase & 2016+*		
17:15 - 17:30 Coffee Break		
17:30 - 18:30 Closing Session Plans & Perspectives		
19:00 ICLEA Dinner		
21:00 Come Together @ Students Club Geokeller		

Scientific Technical Report STR 14/02
DOI: 10.2312/GFZ.b103-14028

Chapter II: Poster Abstracts

The Virtual Institute of Integrated Climate and Landscape Evolution Analyses - ICLEA

Schwab, Markus J.[1], Brauer, Achim[1], Błaszkiewicz, Mirosław[2], Raab, Thomas[3], Wilmking, Martin[4] & the ICLEA Team[5]

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The GFZ, Greifswald University and the Brandenburg University of Technology together with their partner the Polish Academy of Sciences strive for focusing their research capacities and expertise in a Helmholtz Virtual Institute for Integrated Climate and Landscape Evolution Analyses (ICLEA). The Coordination Team is based at the GFZ in Potsdam and consists of a permanent scientific manager and administrative personnel. ICLEA offers young researchers an interdisciplinary and structured education and promote their early independence through coaching and mentoring. Postdoctoral rotation positions at the ICLEA partner institutions ensure mobility of young researchers and promote dissemination of information and expertise between disciplines. Training, Research and Analytical workshops between research partners of the ICLEA virtual institute are another important measure to qualify young researchers.

The long-term mission of the Virtual Institute is to provide a substantiated data basis for sustained environmental maintenance based on a profound process understanding at all relevant time scales. Aim is to explore processes of climate and landscape evolution in an historical cultural landscape extending from northeastern Germany into northwestern Poland. The northern-central European lowlands will be facilitated as a natural laboratory providing an ideal case for utilizing a systematic and holistic approach.

In ICLEA five complementary work packages (WP) are established according to the key research aspects. WP 1 focus on monitoring mainly hydrology and soil moisture as well as meteorological parameters. WP 2 is linking present day and future monitoring data with the most recent past through analysing satellite images. This WP will further provide larger spatial scales. WP 3-5 focus on different natural archives to obtain a broad variety of high quality proxy data. Tree rings provide sub-seasonal data for the last centuries up to few millennia, varved lake sediments cover the entire research time interval at seasonal to decadal resolution and palaeosoils and geomorphological features also cover the entire period but not continuously and with lower resolution. Complementary information, like climate, tree ecophysiological and limnological data etc., are provided by cooperation with associated partners.

WP1: Hydrological and climate data

The outflow conditions and circulation of the dissolved substances within the Czechowskie lake basin - preliminary results

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The main objective of the hydrological studies realised in the framework of the ICLEA project conducted in the fluvial-lacustrine drainage basin of the Czechowskie lake (Tuchola Pinewood Forest) is to determine the structure of the lake water recharge and the characteristics of the circulation of water and dissolved matter in this catchment area. In 2012-2013 the hydrological and hydrochemical monitoring of surface water and groundwater was conducted on the basis of a network of piezometers and gauging stations.

A small variation in the position of the first groundwater level was recorded. Between May 2012 and January 2014 it ranged from 0.17 to 0.92 m. The smallest variation of the groundwater levels were found in the deepest piezometers located in the watershed area, while the greatest – in the shallow waters within the lake terrace used for farming. The insignificant dynamics of the groundwater table corresponds to a small variation of water level in the Czechowskie lake, which was 0.33 m.

Hydrometric measurements showed that the mean value of the discharge at the outflow from the Czechowskie lake was 30 dm^3s^{-1}, and was similar to the total volume of the surface inflow to the lake. The average specific runoff from the whole basin was 3 $dm^3s\text{-}1km^{-2}$.

Hydrochemical studies have shown that the conductivity of water ranges from approximately 80 to 800 $\mu S \bullet cm^{-1}$. The most mineralised (700-800 $\mu S \bullet cm^{-1}$) is the shallow groundwater in the mineral-organic-carbonate deposits of paleolakes and in the watercourses draining them. The lowest mineralisation was recorded in shallow groundwater of the sandy outwash plains. Both surface water and groundwater represent a bicarbonate-calcium-sulphate type characteristic of the young glacial environment. The zones of water enrichment in salts are associated with fossil lake basins filled with the organic-carbonate sediment, while the salt precipitation zones with the modern lakes. This situation creates a specific, cascade model of the transformation of chemical properties of the water circulating in the catchment.

Spatio-temporal patterns of fall/winter throughfall under beech and oak forest (Müritz National Park)

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Rain falling on a forest is redistributed in the canopy: it is intercepted by the canopy and later evaporated, it falls through canopy gaps or drips from leaves and branches once the interception storage is filled (throughfall (TF)), or it is channeled to the tree stems and delivered to the soil as stemflow. Throughfall is usually the largest fraction, followed by evaporation. The amounts and spatial patterns of rainfall redistribution by forest canopies vary for different tree species and can play an important role for soil moisture distribution and subsequently for groundwater recharge. Therefore we quantified the fractions of throughfall on gross rainfall for different forest types and for different meteorological parameters and rainfall characteristics. This will improve our ability for predicting future impacts of climate and forest structural changes on the water balance of forest stands.

Two TF monitoring sites, one in a beech and one in a mixed beech-oak stand were installed in September 2013. The investigated 2000m²-plots are situated in the center of the TERENO/ICLEA monitoring site at Lake Hinnensee in the Müritz-Nationalpark / Germany. TF on each plot was collected with 5 trough systems, each consisting of 3 troughs connected to one tipping bucket. The total collecting area per plot was 6.6m². Gross precipitation, i.e. rainfall above or outside of the forest, was measured in a nearby forest clearing with an identical setup of 3 troughs.

Differences in TF between events under leaf-on and leaf-off conditions in autumn 2013 and winter 2013/2014 were investigated.

Canopy structure is likely to have a major influence on TF distribution. Therefore ground-based leaf-area index (LAI) measurements were conducted to assess the seasonal variation of leaf coverage. In addition, the LAI data was examined with respect to spatial patterns within a plot and possible relations to TF distribution. The forest structure was characterized by mapping of tree species, stem positions and stem diameters.

Knowledge about the time lags between rainfall outside of the forest and TF can provide information about water storage properties of the forest canopy. An important factor influencing the time of TF initiation should be the amount of water that is already stored in the canopy at the onset of rainfall. Since this is hard to assess directly, the events are divided into groups based on their time lag to the previous event.

Lag times are likely to decline with increasing early rainfall intensities. Therefore correlations between the intensity of the initial phase of the event to the lag time between the start of the rainfall event and TF are investigated.

These ICLEA studies are supported by TERENO infrastructure of the Helmholtz Association.

Measurement of soil moisture with cosmic-ray neutrons in deciduous forests

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In deciduous forests the calibration of cosmic-ray soil moisture sensors is difficult since the amount of water stored inside and on vegetation (leaves, branches, stems) varies seasonally. A one-time calibration conducted during summer can therefore introduce errors to the method that are especially pronounced in the winter season. We performed calibration in a deciduous forest at the TERENO observatory in north-eastern Germany at different times throughout the year to capture the changing influence of water in the vegetation on the calibration results. Additionally, we calibrated the cosmic-ray neutron sensor with soil samples from different soil depths (0-10 cm, 0-20 cm, 0-30 cm). We compared the resulting soil moisture time series with time series of FDR-based soil moisture point measurements at different depths. This allows us to estimate the error introduced by the influence of organic layers at the soil surface (litter, decomposed organic material) which can vary temporally. The same sensor setup was also used to look at time-lags between the cosmic-ray soil moisture signal and measurements of precipitation, intercepted water and soil moisture point measurements at different depths. Recorded time lags between point measurements and cosmic-ray soil moisture results can potentially help in tracking precipitation on its way through the canopy, the organic layer and into the soils.

These ICLEA studies are supported by TERENO infrastructure of the Helmholtz Association.

Lacustrine Groundwater Discharge at Lake Hinnensee – Spatial Patterns and their Temporal Stability

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Lacustrine groundwater discharge (LGD) can play an important role for the lake water balance and lake water quality of enclosed lakes. Measuring groundwater- lake interactions is generally challenging and spatial exchange patterns are seldom explored in detail. This study aims at a) identifying spatial patterns of lacustrine groundwater discharge along the shoreline of Lake Hinnensee, b) identifying spatial patterns of LGD along several cross-sections through the lake and c) investigating the temporal dynamics of these flow patterns for both the seasonal and event time scales.

The lake under investigation is located in the lowlands of northeast Germany. The lake has a surface area of 49 ha and the length of the shore line is about 4 km. To monitor LGD at Lake Hinnensee short piezometer transects (2-4 piezometers) were installed every 250 m around the lake. Additional piezometers were installed where major inflow was expected. Vertical hydraulic gradients indicating strength and direction of exchange are measured continuously with pressure sensors. To identify small scale spatial variability vertical temperature profiles were measured every 10 m along 2.35 km of the total shoreline. LGD rates can be determined by fitting the heat transport equation to these profiles. Measurements were repeated (summer 2011, 2012, 2013 and winter 2013) to investigate the temporal stability of the observed patterns.

It is generally assumed that the majority of groundwater inflow occurs in the immediate vicinity of the shore line (the focus area of the temperature surveys and piezometer transects). Strength of hydraulic gradients measured in the piezometers decrease considerably within the first few meters from shore und thus support the general assumption, but no information on groundwater discharge is available within the lake basin itself. To test the hypothesis of minimal off-shore groundwater inflows we installed a 500 m long distributed-temperature-sensing cable on the lake sediment resulting in several transects across the northern part of the lake. Measurements will be carried out in February when temperature differences between lake and groundwater are expected to be strongest.

These ICLEA studies are supported by TERENO infrastructure of the Helmholtz Association.

The hydrogeological system of Lake Hinnensee

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Groundwater and lake levels have been decreasing at many locations in northeastern Germany for the last 30 years. However, the reasons for this decline are still unclear. Our investigation aims at a better understanding of this hydrogeological system: its structures, dynamics and control mechanisms. Focus area is the domain of Lake Hinnensee, which is located in a young moraine area in Mecklenburg-Vorpommern. The investigation area consists of the Pommeranian main terminal moraine in the north and the outwash plain in the south.

First field campaigns were carried out in 2012. The establishment of twelve observation wells and a groundwater level monitoring system, electric resistivity tomography measurements as well as the investigation of subsurface characteristics such as hydraulic conductivity supplied important first insights into the hydrogeological system. But still, only little knowledge about groundwater flow directions and dynamics is available for the Lake Hinnensee region. However, as we are looking at a purely groundwater controlled lake system (no surface inflows or outflows), this information is essential for a better understanding of the ongoing processes.

From recharge to discharge, groundwater is subject to many different chemical reactions and physical changes. Therefore, chemical data is an adequate tool to analyze groundwater residence times, flow paths and origin. The stable isotopes oxygen-18 and deuterium and the radioactive radon are used as tracer. In addition, the physico-chemical parameters temperature, electrical conductivity, pH, oxygen content and redox potential are measured. For this purpose the observation wells were pumped every six weeks between May 2013 and November 2013 and every eight weeks from November 2013 to March 2014. Even if an aquifer seems to be geologically homogeneous hydrochemical groundwater composition can vary significantly in time and space. The unconfined aquifer in the Lake Hinnensee area consists mainly of glacial medium sands and shows a relatively high homogeneity. From analyses of isotope and radon contents as well as of physico-chemical parameters spatial patterns of different groundwater regions can be determined. These regions may indicate areas of different groundwater origin and residence time. Furthermore, groundwater levels in the surroundings of Lake Hinnensee are measured in the observation wells using pressure loggers. The highest water levels are monitored in April and May, the lowest in October and November. In 2012/13 the maximum water level difference between autumn and spring was 18 cm observed in the area between Lake Hinnensee and Güsterpohl. In general the hydrographs of the twelve observation wells are relatively similar in their seasonal dynamics. However, examined in more detail they show slightly different trends pointing at different groundwater origins. The water level developments, first results of the isotope and radon measurements as well as an overview of the spatio-temporal distribution of the physico-chemical parameters in the area are presented.

These ICLEA studies are supported by TERENO infrastructure of the Helmholtz Association.

WP2: Archive remote sensing data

TerraSAR-X assessment of ground surface deformation due to lake level changes in Neustrelitz region, Germany

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Monitoring of surface deformation and landscape changes associated with water level fluctuations in lakes could provide important constraints on rheological properties of the crust and lithosphere. The extent and complexity of surface motion in unstable areas is also important for designing preventive and remedial measures in regions subject to surface loading and unloading.

In this paper, we assess ground surface deformation in response to lake level changes in Neustrelitz in Germany using Synthetic Aperture Radar (SAR) data. We use an archive of TerraSAR-X SAR images covering 2008-2013 time interval, and process them using the time-series technique of Small BAseline Subset (SBAS) to map areas of ground deformation. The processing chain, analysis and preliminary results are discussed in this poster.

Reconstruction of former shorelines of Großer Fürstenseer See using remote sensing archive data

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Groundwater influenced lakes in Northeast Germany revealed massive fluctuations in their water levels during the last decades. However, precise water level measurements were only recorded for few lakes. In this study we evaluate the use of remote sensing archive data to determine former water surface areas and the estimation of former water levels.

The main test area for the evaluation is “Großer Fürstenseer See” near Neustrelitz. The evaluation of the data used and the methodology are based on water level data that were recorded since 1985. We are using multi-spectral imagery (RapidEye) and SAR imagery (TerraSAR-X) for the time period from 2009 to 2013. After the pre-processing of the images, water surface areas are extracted from the images. These former water surface areas can be used to analyze the seasonal and annual variations of water levels. The decrease and increase of water levels and surface areas is especially visible at shallow shorelines, whereas vegetation at the shorelines hinders accurate extraction of water surface areas. Additional tests concerning the accuracy of the water level estimation are based on aerial photography of “Krummer See” and “Redernswalder See.” Former water levels can be estimated by the combination of former water surface areas with high-resolution digital elevation and bathymetric data.

WP3: Tree-ring data

Only the fittest will survive – the case of Quercus robur after groundwater withdrawal

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In 1970 a dike establishment close to the village of Ahrenshoop (Darß, NE-Germany) lead to a successive groundwater withdrawal, finally resulting in a pronounced dieback of trees (mainly Quercus robur) within an adjacent forest. However, a part of the former Q. robur population has survived until today causing a rather patchy structure of the forest today, as live trees and remnants of dead trees stand in close proximity to each other. Such a differing behavior of neighboring trees belonging to the same species raises the question which factor has determined their contrasting fate. To help answer this question, we dendrochronologically investigated 30 Q. robur specimen of differing vitality classes (12 dead or almost dead, 18 alive but with different vitality).

Our results show, that all investigated trees were affected by the groundwater withdrawal. Successive metadata analyses including age, tree height, diameter at breast height, as well as spatial analyses were not able to identify clear differences between the different vitality classes. However, the specific reactions were mainly explained by the growth performance of the trees before the dike establishment. I.e. trees that have survived also expressed a better growth performance (i.e. larger ring widths) before 1970, compared to trees of recent low vitality or trees that already died. This suggests that the determining factor is either internal (e.g. genotype) or related to possibly heterogeneous soil properties. Therefore, we intend to further investigate soil conditions, and – if they are not able to explain the observed discrepancies – possibly also genetics of the examined trees.

Our findings contribute to dendroclimatological reconstructions undertaken within ICLEA, as they show that tree reactions to groundwater fluctuations (in our case withdrawal) very much depends on the performance of the individual tree (which we assume to be related to either genotype or soil features). Therefore the selection of trees for such reconstructions has to be chosen carefully, even if the trees originate from a common, apparently homogeneous site as in our study. By further dendrochronological analyses focusing on e.g. cell components, wood density, and element concentrations (as measured by XRF) we hope to be able to identify specific markers, that could help to estimate the suitability of archeological wood originating from Q. robur for dendroclimatological reconstructions of groundwater (and thus also lake-level) fluctuations.

SINOMA – a better tool for proxy based reconstructions?

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Our knowledge on past environmental conditions largely relies on reconstructions that are based on linear regressions between proxy variables (e.g. tree-rings, lake sediments, ice cores) covering a comparably long period (centuries to millennia) and environmental parameters (e.g. climate data) of which only rather short measurement series exist (mostly decades). In general, the corresponding measurements are prone to errors. For instance, air temperature records that are to be prolonged by reconstruction from tree-rings are normally not measured in situ, i.e. where the trees used for reconstructions are growing. In contrast, the variation of tree-ring properties which are used as proxies does not only depend on temperature variations but also on other environmental variables and biological effects. However, if regressions are based on noisy data, knowledge on the noise intensity of both predictor and predictand is needed and model parameter estimates (slope and intercept) will be erroneous if information on the noise is not included in their estimation (Kutzbach et al., 2011).

Here, we investigate the performance of the new Sequential Iterative Noise Matching Algorithm (SINOMA; Thees et al., 2009; and Thees et al., submitted) on a variety of typical proxy-data of differing temporal resolution (hourly (dendrometers, piezometers), seasonally (tree-rings), and annually (tree rings and varved lake sediments)). For each of the investigated proxies a number of pseudo-proxy datasets is generated. I.e. to each proxy variable two different noises are added, resulting in two noisy variables that originate from a common signal (the proxy) and of which the respective error noises and the true model parameters (slope and intercept) between both are known. SINOMA is applied to each of these pseudo-proxy datasets and its performance is evaluated against traditional regression techniques. The recent contribution thus focuses on the applicability of SINOMA rather than on its mathematical background which has been presented at the ICLEA workshop 2013.

On average, SINOMA performs better than or, under specific error noise conditions, equal to the traditional modeling techniques. However, some of the investigated data reveal constraints of SINOMA, which have to be considered in 'real-world' applications. Nevertheless, our results indicate that SINOMA likely is a more reliable tool for estimating regression parameters if compared to traditional techniques. Based on the generally noisy characteristics of proxies used typically, applications of SINOMA to already existing reconstructions will probably result in different model parameter estimates, most likely leading to differing amplitudes of reconstructed past environmental conditions. Therefore, SINOMA has the potential to reframe our picture of the past.

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Dendroclimatology of *Pinus sylvestris* in N-Poland

Heinrich, Ingo[1], Knorr, Antje[1], Beck, Wolfgang[2], Wazny, Tomasz[3] & Heußner, Karl-Uwe[4]

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Scots pine (*Pinus sylvestris*) was sampled near Lake Czechowskie, northern Poland. Our new well-replicated tree-ring width chronology of 200 year length was combined with two sets of regional Scots pine samples, collected from nearby archaeological sites and from forests in the region of Masuria. The chronology now extends back to the year 1084AD. The climate sensitivity of Scots pine at this new site has been evaluated and late winter temperatures have been reconstructed back to 1165AD successfully for the first time at a lowland site in Poland. Various detrending techniques were applied to sustain high- and low-frequency climate signals.

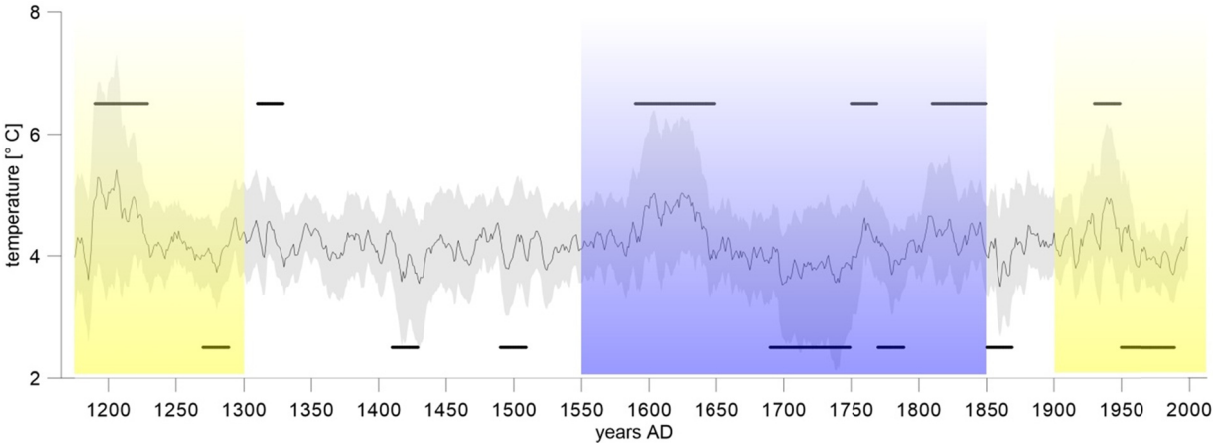

Figure: Reconstruction of maximum Feb-Mar-temperatures; yellow and blue indicate medieval warm period / modern warming period and little ice age, respectively; black bars represent coldest and warmest periods as reconstructed by pines from N-Poland; grey zone around the black mean curve illustrate detrending errors due to different detrending techniques applied.

The reconstruction correlates with winter NAO, however, this correlation is not stable in time, e.g. since the mid-1990s and during the LIA the correlations disappear. During those periods other climate indices might have been more influential to the climate in N-Poland. Spatial analysis and comparison with documentary data also confirm our reconstruction results.

The reconstruction suffered from relatively short sample lengths, which resulted in the loss of some low-frequency signals. As a solution to this dilemma we now focus on cell structure measurements such as tracheid lumen. In a preliminary pilot-study, cell structures of the pines from N-Poland were measured for the last 70 years. The new series showed strong climate correlations as well and thus they will be the focus of our research, since cell structure data series do not need detrending and therefore can sustain in better fashion the low-frequency climate signals partly lost in the tree-ring width data.

Long-term growth trends and time series of elemental wood composition from two old-growth forests – natural versus anthropogenic influences

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In contrast to extreme environments with low human impact, where often one specific (climatic) factor is limiting tree growth, dendrochronological research in the temperate zone has to cope with a wide variety of climatic and non-climatic drivers. Sophisticated statistical tools, like various detrending and filtering techniques, allow for a rather precise analysis of high-frequency (annual) climate–growth relationships. However, as almost all forests in the temperate zone are to some degree influenced by human activities, it is difficult to separate anthropogenic from climatic influence on the lower time-frequencies of decades to centuries. Footprints of human activity in time series of tree-ring parameters might be caused directly through forest utilization (logging) or indirectly through environmental changes such as eutrophication or atmospheric pollution. The former can be elucidated by traditional dendrochronological techniques based on ring parameters; evaluation of the latter requires additional proxies such as dendrochemical data. For the interpretation of long-term trends and the calibration of tree-ring based reconstructions it is therefore necessary to study tree growth in as undisturbed forest environments as possible. Comparison with dendrochronological time series from managed forest might then allow separation of climatic- from anthropogenic signals.

Here, we present long-term growth trends for the broadleaved tree species common beech, pedunculate oak and sycamore maple, from two protected old-growth forests in northern Germany (one with a documented last logging activity dating back to 1527), and compare those with well-replicated regional chronologies from other, mostly managed forests. Our results indicate that several low frequency trends that can be found in many regional chronologies are likely caused by synchronous periods of heavy loggings as for example during the years following World War II, and do not relate to climatic drivers.

In addition, elemental wood composition of trees growing on an island relatively isolated from agricultural depositions or direct atmospheric pollution is compared to elemental concentrations in the wood of trees from a forest surrounded by intensive agriculture in the vicinity of Greifswald, a medium-sized town in Germany. The aim is to detect historical changes in soil chemistry attributable to either atmospheric depositions or groundwater input of nitrogen or sulphur. Therefore, high-resolution (50 µm) X-ray fluorescence (XRF) analysis is carried out and species-specific annual chronologies of relative concentrations of the most abundant elements as well as of different indicative element-ratios are built. We discuss our findings in the light of ongoing soil acidification that might be responsible for some of the detected trends (e.g. decrease in base cations like Ca or Mn), while considering possible radial translocation processes in the wood that might blur the obtained dendrochemical data.

Similarities and discrepancies of Quercus petraea along a topographic gradient

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In recent decades, lake level fluctuations have been observed in the lake area of north eastern Germany. However our knowledge on these fluctuations mostly date back until the 1970ies when gauge records were initiated. To deepen our understanding of the observed lake level fluctuations, proxies which provide longer records of measurement would be of help.

Here, we dendrochronologically investigate whether sessile oak (*Quercus petrea*) is a suitable proxy for lake-level fluctuations. Several specimen were investigated at two sites along a steep topographical gradient, ranging from the lake shore of lake Hinnensee to a nearby situated glacial sander deposition. By this, we assume to represent differing tree sensitivities to lake level fluctuations (at the lake shore) and summer droughts (on top of the sander).

The obtained tree ring width series (spanning 1750-2010) as well as series of earlywood vessel parameters (number of cells, average lumen area, total lumen area, spanning 1900-2010) were compared between the two sites. Preliminary results indicate a differing low frequency behavior between the two sites in both ring-widths and earlywood vessel parameters. Possible causes (lake level fluctuations, human impact, and climate change) are discussed and the potential of sessile oak as a proxy for lake level fluctuations is evaluated.

Drowning trees – influence of rising lake levels on wood characteristics of lakeshore beeches (*Fagus sylvatica* L.)

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Within the ICLEA project, proxy data combined with instrumental monitoring data are used to extend time series into the past. In this context, tree-ring data could help to reconstruct lake levels.

In our study we used dendrochronological methods to analyse the reaction of beech to a rising lake level.

Flooding induces a number of physiological and consequently morphological reactions in trees. The influence of waterlogging has been intensively studied on seedlings of common beech under experimental conditions but only a few studies focus on *in vivo* growth reactions of adult trees. It has been shown that seedlings generally have a very low tolerance to soil waterlogging (Schmull and Thomas 2000). However, it is questionable if these results can be transferred to adult trees easily. Scharnweber et al. (2013) discovered that mature beeches demonstrate a relatively low sensitivity to periods of high soil water saturation.

For this study, lake 'Schweingartensee', situated in the Müritz National Park, offered suitable conditions. The lake level has risen about 2.5 m since the mid-1990s due to the blocking of the only outlet by the national park's administration. Thus, the forest around the lakeshore was flooded quite suddenly. The monitoring of the lake level began in the early 1990s. For our study, we chose sample sites which showed a slight descent towards the lakeshore. Increment cores from ~45 beeches, divided into three physiognomically defined groups, were extracted: a) dead trees with virtually no leaves standing in the water, b) living trees with smaller and fewer leaves growing at the shoreline, and c) living and healthy trees growing further away and above lake level. Since beeches develop only a shallow root system, those trees growing close to the shore might have already been influenced by the higher groundwater level. The cores were prepared and annual tree-ring widths were measured using CooRecorder. Until now, preliminary chronologies for the study groups have been built using established detrending and standardization methods. First results show that the trees were surprisingly old, some dating back to the early 1800s. All groups appear to have a decline in ring width corresponding with the rising lake level since the mid-1990s. During the first half of the 20th century there is also a noticeable depression in ring width. Climate correlations demonstrate a typical pattern for beeches in this area: a positive influence of wet summers and a negative influence of dry summers on annual ring width.

These preliminary findings have to be analysed further and results will be presented. Whether beech ring patterns could be used as a proxy for reconstruction of lake levels remains to be seen.

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Dendrochronology and lakes: using tree-rings of alder to reconstruct lake levels

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Climate change is considered a major threat for ecosystems around the world. Assessing its effects is challenging, amongst others, as we are unsure how ecosystems may respond to climate conditions they were not exposed to before. However, increased insight may be obtained by analyzing responses of ecosystems to past climate variability. In this respect, lake ecosystems appear as valuable sentinels, because they provide direct and indirect indicators of change through effects of climate. Lake-level fluctuations of closed catchments, for example, reflect a dynamic water balance, provide detailed insight in past moisture variations, and thereby allow for assessments of effects of anticipated climate change.

Up to now, lake-level data are mostly obtained from gauging records and reconstructions from sediments and landforms. However, these records are in many cases only available over relatively short time periods, and, since geoscientific work is highly demanding, lake-level reconstructions are lacking for many regions. Here, we present and discuss an alternative method to reconstruct lake levels, which is based on tree-ring data of black alder (*Alnus glutinosa* L.). This tree species tolerates permanently waterlogged and temporally flooded conditions (i.e. riparian vegetation), and is often found along lakeshores. As the yearly growth of trees varies depending upon the experienced environmental conditions, annual rings of black alder from lakeshore vegetation likely capture information on variations in water table, and may therefore be used to reconstruct lake levels. Although alder is a relatively short-lived tree species, the frequent use of its' decay-resistant wood in foundations of historical buildings offers the possibility of extending living tree-chronologies back in time for several centuries.

In this study, the potential to reconstruct lake-level fluctuations from tree-ring chronologies of black alder is explored for three lake ecosystems in the Mecklenburg Lake District, northeastern Germany. Tree-ring data were collected from black alder forests surrounding the lakes 'Tiefer See', 'Drewitzer See' and 'Großer Fürstenseer See'. At all research sites, increment cores were extracted from at least 15 trees (2 cores per tree) using an increment borer. In the tree-ring lab DendroGreif, these cores were prepared and annual tree-ring widths were measured. Thereafter, site-specific tree-ring chronologies were built using established detrending and standardization procedures. Preliminary results show that the growth of alder reacts upon water level fluctuations. We visually and statistically compare the developed tree-ring chronologies with historical lake-level records, and retrospectively model lake levels. Findings will be presented while critically reflecting upon the quality of these reconstructions.

From process to proxy: Ecological challenges and opportunities of tree-ring based environmental reconstructions

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Trees are sessile, long-living organisms and as such constantly need to adapt to changing environmental conditions. Accordingly, they often show high phenotypic plasticity (the ability to change phenotypic traits, such as allocation of resources) in response to environmental change. This high phenotypic plasticity is generally considered as one of the main ingredients for a sessile organism to survive and reach high ages.

Precisely because of the ability of trees to reach old age and their in-ability to simply run away when conditions get worse, growth information recorded in tree rings has long been used as a major environmental proxy, covering time scales from decades to millennia. Past environmental conditions (e.g. climate) are recorded in i.e. annual tree-ring width, early- and latewood width, wood density, isotopic concentrations, cell anatomy or wood chemistry. One prerequisite for a reconstruction is that the relationship between the environmental variable influencing tree growth and the tree-growth variable itself is stable through time. This, however, might contrast the ecological theory of high plasticity and the trees ability to adapt to change.

To untangle possible mechanisms leading to stable or unstable relationships between tree growth and environmental variables, it is helpful to have exact site information and several proxy variables of each tree-ring series available. Although we gain insight into the environmental history of a sampling site when sampling today, this is extremely difficult when using archeological wood. In this latter case, we face the additional challenge of unknown origin, provenance and (or) site conditions, making it even more important to use multiple proxy time-series from the same sample.

Here, we review typical examples, where the relationship between tree growth and environmental variables seems 1) stable and 2) instable through time, and relate these two cases to ecological theory. Based on ecological theory, we then give recommendations to improve the reliability of environmental reconstructions using tree rings.

WP4: Lake sediment data

Development of fluvio-lacustrine systems within the Weichselian moraine belt as reconstructed on the middle section of the River Wda (N Poland)

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The River Wda valley is a classic example of a polygenetic valley, consisting of former lake basins joined by erosive gap sections. In its middle section, which was the subject of our research, a fragment of an abandoned late glacial river valley is conserved, which is unique for the Weichselian moraine belt in the Central Polish Lowlands. The analysis of the relationship between the lacustrine and fluvial sediments, as well as landforms enabled the authors to report many evolutionary connections between the initial period of the river system formation and the emergence of lakes during the Weichselian late glacial.

The surface drainage essentially determined the progress of melting of dead ice blocks buried in the glacial depressions, which finally led to lake formation there. Most of the lake basins in the study area were formed during the Bølling-Allerød period. However, one section of the subglacial channel was not exposed to the thermokarst conditions and was therefore preserved with dead ice lumps throughout the entire Late Glacial. The decay of this ice at the beginning of the Holocene, as well as the emergence of another lake, created a lower base level of erosion in the close vicinity of the abandoned valley and induced a change of the river's course.

Both, fluvial and lacustrine deposits, and landforms distributed in the central section of the River Wda valley indicate two processes, which proceeded simultaneously: (1) emergence of fluvially joined lake basins within a glacial channel, (2) the degradation of the river bed in the gap sections interfering between the lakes.

The eroded sediments formed delta fans within the lakes and determined successional fluvial processes, for example the formation of wide undisturbed meanders after a lake basin was entirely filled with sediments. In the gap sections of the river valleys erosive processes, mainly degradation, dominated.

During the late glacial degradation phase single-bed rivers with an insignificant but growing level of winding dominated in the River Wda valley. Only during the Younger Dryas the erosional tendency of deepening the river bed diminished and the lateral erosion intensified. At the Younger Dryas-Holocene transition the last major changes in the river's course appeared. At the same time, after a short phase of degradation, the erosive-accumulative processes in their bottoms stabilised, while the lateral migration of the river beds widened the floodplains.

The processes described for the central section of the River Wda valley indicate a very dynamic river valley development during the Weichselian late glacial and the early Holocene. The valley formation was tightly interwoven with the morphogenesis of the primary basins within the valley, mainly with the melting of the buried blocks of dead ice and the development of lakes.

This study is a contribution to the Virtual Institute of Integrated Climate and Landscape Evolution (ICLEA) of the Helmholtz Association and National Science Centre, Poland (grant No. 2011/01/B/ST10/07367).

Studying lake level changes with a transect of lake sediment cores from Lake Fürstenseer See, northeastern Germany

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In the context of future climatic changes especially the hydrological system is a vulnerable landscape component that showed considerably large changes in the recent past. Analysis of lake sediment archives can help to infer long-term dynamics of regional lake and groundwater levels, although sedimentation and sediment preservation may react to further environmental forcings.

Lake Großer Fürstenseer See (GFS: 53°19'N, 13°12'E, ~2 km² large, zmax = 24.5 m, lake level in 2009: 63.3 m a.s.l.) formed after the retreat of the Weichselian ice sheet in a subglacial channel directly in front of the Pommerian ice margin. The lake catchment includes other smaller lakes and peatlands, which were connected to GFS during higher lake stands. In the past, the lake system was artificially dammed for the operation of water mills. Located within the well-drained sandur substrate, the lake levels vary with groundwater levels in response to hydrological and catchment-related groundwater recharge. Surficial inflow is negligible.

In order to reconstruct regional water level changes we analysed four lake sediment cores along a transect down to 23 m water depth. First results show distinct sediment facies patterns. Typical sediment facies were stratigraphically and microscopically described using thin sections. A robust cluster and factor analysis was performed on the centered log-ratio transformed -XRF scan data set to consider the compositional nature of the data. Together with the quantification of total organic and inorganic matter the relevant (post-) depositional processes of the main sediment units could be disentangled. Discontinuous plant macro-remains, diatom and Cladocera analysis of these units deciphered the biological history and provided information on water-level related habitat changes. A high amount of non-reworked terrestrial plant remains and concentrated pollen samples from prominent facies shifts were AMS-14C-dated and allowed to link the cores to assess individual sedimentation rates and to evaluate sediment focusing in the lake.

The sediments mainly consist of carbonatic and organic gyttjas derived from authigenic production (represented by calcium counts, TIC, TOC). Potential post-depositional alterations occurred by anoxic processes (indicated by Fe and S fluctuations). In a few intervals, carbonates are related to elements used as proxies for allochthonous components (mainly K, Ti) derived either by reworking of shore and slope material or by aeolian transport. Sandy facies dominate only at near-shore, steep sites and form distinct layers at the current limit of sediment accumulation. Combining the indications for lake level changes from water depth-related habitat changes and from allochthonous sediment components allows to propose a first lake level reconstruction from the Mid-Holocene to recent times, which is discussed in terms of climatic and anthropogenic causes.

These ICLEA studies are supported by TERENO infrastructure of the Helmholtz Association.

Disentangling climate and human influences on varve preservation in a 1200-year lake record from Lake Tiefer See (NE Germany) – A multi-proxy approach

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Annually laminated (varved) lake sediments represent unique archives in continental areas providing both, precise chronologies and up to seasonally resolving proxy data. Sediment sequences with alternations of varved and poorly or even non-varved sections enable the opportunity to study influences on varve preservation in a natural-laboratory-situation. Lake Tiefer See in NE Germany provides such an archive.

Lake Tiefer See is located within the Pomeranian terminal moraine belt of the Weichselian glaciation and is part of the Klocksin Lake Chain which formed as a sub-glacial gully system. Coring at the deepest part of the lake (~60 m depth) provided 7 sediment profiles, 3 of which reached glacial sand deposits at the base. From these individual profiles a ~10,5 m long continuous composite profile has been established. The chronology of the core sequence is based on varve counting, AMS 14C dating of terrestrial plant remains and identification of cryptotephras (e.g. the AD 1875 Askja eruption). Tephra layers of Eifel- and Icelandic provenance in the lowermost part of the core sequence suggest an onset of lake sedimentation in the late Allerød at about 13 000 years BP and an onset of varve preservation at the beginning of the Holocene.

A combined approach of microfacies analyses using thin sections, µ-XRF analyses on split sediment cores, pollen, diatom and cladocera analyses has been carried out to characterize well varved and non-varved intervals and their transitions during the last ~1200 years. Varves are preserved in 3 microfacies zones: MZ I AD 2013 – AD 1924, MZ III AD 1180 – AD 1040 and MZ V AD 940 – AD 750. Microfacies zones with poor varve preservation last from AD 1925 to AD 1180 (MZ II) and from AD 1040 to AD 940 (MZ IV). All transitions have a duration of approximately 10 years. In contrast to varved intervals, in sections with poor varve preservation pollen assemblages indicate increased forest clearance and farming in the catchment and µ-XRF data show higher Ti and K count rates suggesting an increased detrital matter flux into the lake by surface runoff and/-or aeolian transport.

The overarching goal within the ICLEA objective is to compare the sediment records from Lake Tiefer See and Lake Czechowskie which provides an almost continuously varved sequence. Further investigations include a detailed multi-proxy comparison of both lake records of the last 1200 years in order to figure out why varve preservations ceased during certain periods in Lake Tiefer See and not in Lake Czechowskie. We discuss possible mechanisms including local influences (e.g. lake size, lake level and anthropogenic disturbances on the vegetation in the lake catchment), maritime influences of the North Atlantic decreasing towards more continental regions in the East and a close interplay of these factors with climatic changes and, in particular, variations in atmospheric circulation and wind strength.

These ICLEA studies are supported by TERENO infrastructure of the Helmholtz Association.

Linking diatom bloom development with the NAO index in March and the spring temperature gradient at Lake Tiefer See (NE Germany)

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Monitoring of Lake Tiefer See indicated earlier and stronger development of the diatom spring bloom in 2013 compared to 2012, following strikingly different weather and lake conditions in February and March. Westerly winds predominated in 2012, air temperatures increased gradually to reach a band between 10°C an 5°C at Julian day 112 that lead to lake stratification. In contrast, easterly flow brought negative temperatures in February and March 2013 and the lake was ice covered. An abrupt change to westerly flow in early April caused warming to 10°C within a week at Julian day 104 leading to ice breakup, followed by lake turnover and stratification.

Wind and temperature development can be integrated by a positive index of the NAO in March 2012 and a negative (lowest on record) NAO index in March 2013. The 2013-diatom spring bloom developed immediately (at Julian day 105) with a manifold of *Stephanodiscus medius* individuals compared to 2012. In 2012, it was not before Julian day 122 that a bloom of *Aulacoseira subarctica* developed with *S. medius* as a minor component. The strong spring bloom in 2013 seems to benefit from the rapidly improved light conditions following the turnover that replenished the nutrient pool.

The exemplified relation of increased diatom production in years with negative March NAO can be verified against the subannually laminated recent sediment record (1924 – 2010; Kienel et al. 2013) yielding negligible amounts of detrital Si. More than 42% of the diatom bloom production, translated to annual Si count average, can be explained by the March NAO in a linear regression of 3-yr averages. The percentage of explanation increases when the rapidity of spring warming i.e., the temperature gradient (0 to 10°C) is introduced in the regression. In a next step we intend to apply the Sequential Iterative Noise Matching Algorithm (SINOMA; Thees et al., submitted) to get an unbiased estimate of the regression parameters, this possibly allowing for a more precise reconstruction of past NAO amplitudes if compared to traditional modelling techniques.

These ICLEA studies are supported by TERENO infrastructure of the Helmholtz Association and co-financed by the DFG funded project "TSK Link".

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Origin of the Chechowskie Lake in the light of sedimentological analyses in glacifluvial, glacilimnic, colluvial and limnic sediments in its vicinity

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Czechowskie Lake draws attention for long climatic record in its laminated sediments. However, in its vicinity there are conducted also investigations related to the genesis of the lake basin. They consists in sedimentological analyses of available outcrops in glacifluvial, glacilimnic and glacial sediments supplemented by bore-holes with undisturbed structure in limnic and colluvial deposits. Till now 13 outcrops were documented and 11 such boreholes. They all were examined in respect to sedimentary structures, granulometry, carbon and mineral, noncalcareous content. Some, relevant for the reconstruction of the lake evolution were sampled for palynology, isotope analyses and radiocarbon age determinations.

Czechowskie Lake has actually the area of 76,6 ha. Actual water level is at 109,9 m a.s.l. The average depth is 9,59 m, maximal 32 m. The lake occupies a large subglacial channel, reproduced within the glacifluvial sediments of the Pomeranian Phase of the last glaciation. In the widest place it has the width of 1 kilometer. The maximal depth of the channel (counting from the channel edges to the reconstructed deepest lake mineral floor (after removal of the limnic sediments)) may reach 70 meters. Inside of the channel some throughs and small hills do exist which are built of outwash sediments but, considering internal structures, they bear some similarity to the dead ice moraines and kames. The vicinity of the channel consists of two outwash plain levels. The lower one was created on the dead ice blocks.

The maximum infilling with the limnic and telmatic sediments reaches over 12 m. On the floor of the lake there is a marked presence of many overdeepenings with the diameter of dozen or several dozen meters and the depth of up to 10 m with numerous, distinct throughs between them. They favoured the preservation of the lamination in the deepest parts of the lake due to waves hampering and stopping of the density circulation in the lake waterbody.

All conducted analyses revealed that some of the glacifluvial deposits were deposited in subglacial conditions in supercritical flow regime. The deposition was accompanied by periodic decrease of subglacial pressure which led to deposition of thin layers of calcareous sinter. In some outcrops some depositional features do exist which may be interpreted as originated in the permafrost conditions. The analysis of limnic sediments proved considerable spatial and temporal variability mainly in dependance of the area of the water body and actual water level. Increase of colluvial deposition took place about 200 years ago due to transient deforestation of the lake vicinity.

Environmental changes in Lake Czechowskie: a new insights from the diatom

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Lakes systems respond physically, chemically and biologically to environmental changes and these reactions are registered in various ways in lake sediment records.

One of the most used bio-proxy for such lake development in the past are subfossil diatoms Variations in the species composition of the diatom flora are often used to reconstruct changes in the environmental conditions that occurred after the period of deglaciation.

Czechowskie Lake is located in the northern part of the Tuchola Forest region (Northern Poland). Lacustrine sediments of the Czechowskie Lake are laminated, so these sediments are a valuable and unique archive to reconstruct climate and environmental changes Northern Polish Lowland in high resolution.

Diatoms, pollen and geochemistry were analysed from laminated sediment cores from the last 2000 years. The chronology has been confirmed by additional ^{14}C AMS dating of terrestrial macro remains, ^{137}Cs activity measurement and varve counting.

Diatoms assemblages showed that the diatom communities from the 2000 years were rich and mostly very well preserved. A characteristic feature of the diatom communities is the dominance of typically planktonic species of the spring phytoplankton, as the oligo to mesotraphent *Cyclotella comensis* but also the eutraphent *Stephanodiscus parvus.*

Palaeoecological methods based on quantitative transfer functions have been used successfully to reconstruct the history of freshwater acidification and eutrophication. Transfer function are based on the assumption that the modern biological proxies, which ecological requirements are known, can be used to quantitative reconstructions of the past changes.

The aim of the study is to identify reference conditions (pH, nutrient status and diatom assemblages) in Lake Czechowskie during the last 2000 years.

The impact of climate and local environmental conditions on vegetation pattern in the Czechowskie Lake catchment (Northern Tuchola Pinewoods) during the Younger Dryas

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Lake Czechowskie is located in Northern Poland in a young glacial landscape. This region is a key site for investigating Late Glacial vegetation changes because of the LST ash and laminated sediments reported not only in Lake Czechowskie itself but also in the adjacent Trzechowskie palaeolake deposits (Wulf et al. 2013). The large number of sub-basins filled with biogenic sediments in the close vicinity of the present day Lake Czechowskie is a unique source of information for reconstructing environmental changes in the past and, in particular, for distinguishing between local and regional effects. The aim of this study is to reconstruct past landscape and vegetation responses to the Younger Dryas cooling. We present the results of palaeoecological analyses from six core locations comprising biogenic sediments (tab. 1, fig. 1). Our main interest is to identify local factors influencing the vegetation succession and sedimentation rate at that time.

Tab. 1 List of palynological profiles

No	Site	Symbol	Analyses
1	Lake Czechowskie small basin	JC-12-s	pollen, Diatomae, loss-on-ignition, $CaCO^3$ content,
2	Lake Czechowskie terrace	TK	Pollen
3	Lake Czechowskie vicinity	„Oko”	Pollen
4	Lake Czechowskie vicinity	Cz/80	Pollen, Diatomae
5	Trzechowskie palaeolake	T/trz	pollen, macrofossils, Cladocera, Diatomae, loss-on-ignition, $CaCO^3$ content
6	Valley between palaeolake Trzechowskie and Lake Czechowskie	DTCZ-4	Pollen

The results show, that the dominant plant communities during the Younger Dryas in the Lake Czechowskie region are heliophytes xeric herb vegetation with juniper shrubs and birch and pine. All pollen diagrams show the same dominant patterns for the cool Younger Dryas period. However, we noticed large differences in the participation of the dominant taxa. Juniper percentages, for example, although always high varied from18 to 37%. On the other hand, average birch pollen concentrations were lower than in Alleroed but still reached values between 17-27%.

In addition, the thickness and type of the sediment accumulated during the Younger Dryas in the studied profiles differ significantly, thus indicating local effects on the depositional systems. In those profiles comprising the entire Younger Dryas succession („Oko”, T/trz, JC-12-s) the thickest sediments appear in the “Oko” profile (1 m) while the thinnest are found in the small basin of Lake Czechowskie (core JC-12-s) (45 cm). In the Cz/80 profile lake sedimentation stopped at the beginning of the Younger Dryas.

In conclusion, we can prove that local factors have influenced both, sediment type and sedimentation rate as well as the vegetation cover as reflected in different contributions of taxa among sites. The combined

approach of pollen data and sediment distribution in the basins allowed reconstructing Younger Dryas vegetation patterns and their relation to relief in the Czechowskie Lake region.

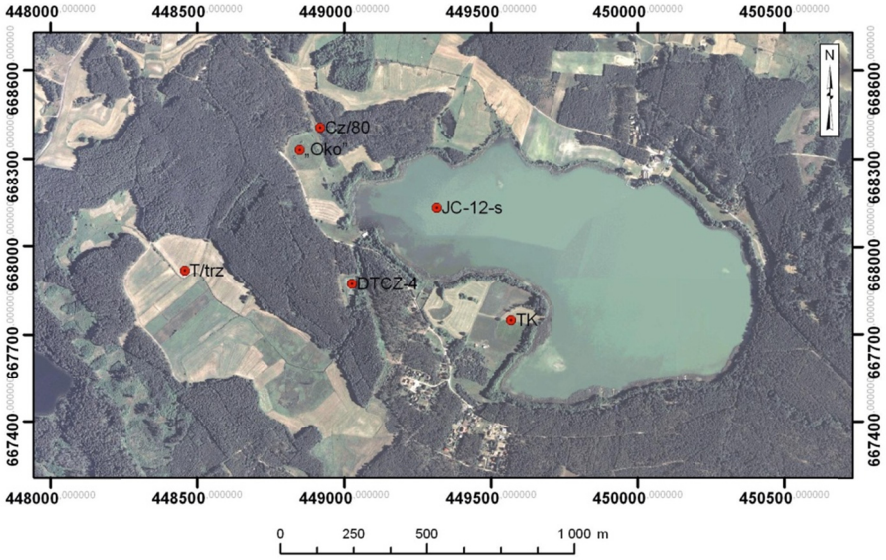

Fig. 1. Location of the investigated profiles in several sub-basins in the Czechowskie Lake region; Symbols according to table 1

This study is a contribution to the Virtual Institute of Integrated Climate and Landscape Evolution Analysis – ICLEA– of the Helmholtz Association and National Science Centre, Poland (grant No. 2011/01/B/ST10/07367).

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Wulf S., Ott F., Słowiński M., Noryśkiewicz A. M., Drager N., Martin-Puertas C., Czymzik M., Neugebauer I., Dulski P., Bourne A., Błaszkiewicz M., Brauer A. 2013. Tracing the Laacher See Tephra in the varved sediment record of the Trzechowskie palaeolake in central Northern Poland. Quaternary Science Reviews, s. 129–139.

Late Glacial and Early Holocene vegetation development recorded in Lake Czechowskie sediments - preliminary results

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The main goal of this research was to reconstruct vegetation changes recorded in Lake Czechowskie sediment and to set the biostratigraphy boundaries within the Late Glacial and between Late Glacial and the Holocene.

The first results of pollen analysis of the bottom part of the Lake Czechowskie sediments suggested that biogenic accumulation began before Allerød. The bottom thin layer of sediments contain pollen grain of *Hippophae rhamnoides*, species characteristic for the Allerød/Bølling stadial in Tuchola Pinewoods. During Allerød period lake surrounding was dominated by sparse pine-birch forests. In the lake ecosystem developed green algae colony with the numerous population of *Tetraedron*. The Younger Dryas cooling caused the transformation of the vegetation in the region and in the vicinity of the lake. The area was covered mostly by open habitats dominated by herbs. The light-demanding species (*Helianthemum, Dryas octopetala, Artemisia, Juniperus) appeared.* In the lake *Tetraedron* population declined and appeared *Pediastrum kawraiskyi*, which is associate with cool, clear water and a low trophy. At the end of Younger Dryas the temperature began to rise as it is evidenced in the appearance of *Typha latifolia* (species demanding minimum 16°C in summer season), variable increase presences of *Pinus* and *Betula* pollen, decline share of *Juniperus*. At the beginning of Preboreal sparse birch-forest began to be dominant component of the vegetation.

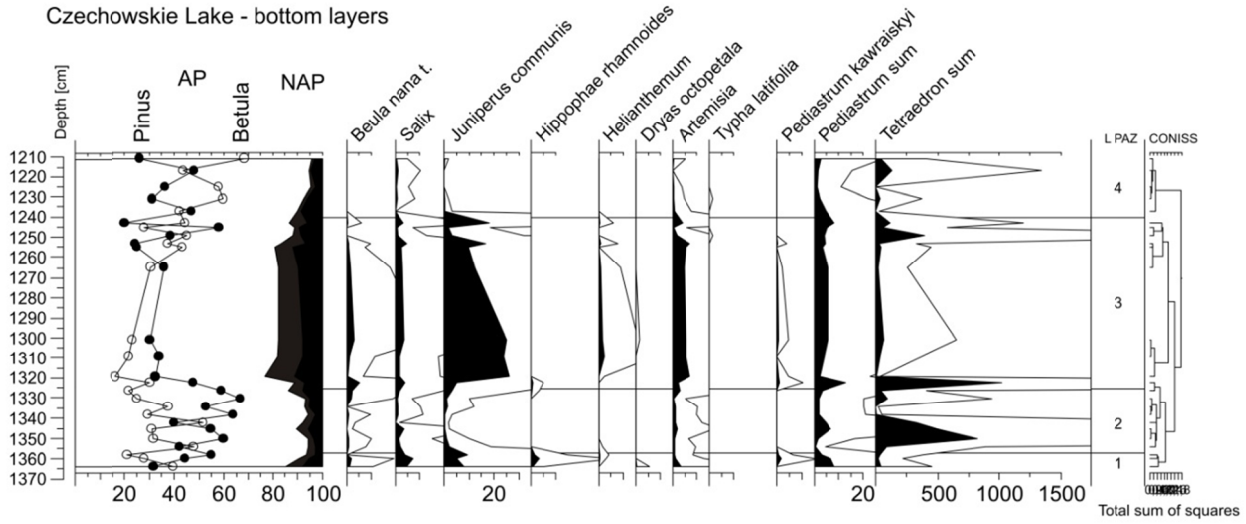

Fig. 1 Pollen diagram from Czechowskie Lake – selected taxa trees, herbs and gree algae.

The human activity during the last two millennia in Tuchola Pinewoods (northern Poland)

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During the last 2000 years human activity together with varying climate conditions strongly influenced landscape scale changes. Especially within palaeoecological records these environmental responses are well expressed. For the evaluation and interpretation of biotic proxies great importance has the age control.

We present a record from the annually laminated (varved) sediments of Lake Czechowskie, located in northern Poland. The investigated record covers the past 2000 years and demonstrates the continuous vegetation history and human activity in the Northern part of the Tuchola Pinewoods.

The chronology was established by varve counting and confirmed by AMS ^{14}C dating, ^{137}Cs activity measurement and a tephra layer (Askja 1875). We used high-resolution biotic (pollen, green algae and diatom 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. Based on different spatial sampling and measuring increments the temporal resolution varies between subseasonal (µ-XRF), annual (varves) up to five-varveresolution (biotic proxies) making it possible to trace even short lasting local and regional changes.

Our results display visible human pressure in this area between 70- 360 yr. AD (Roman Period) exerted by tribes related to the Wielbark Culture. The development of persisting settlements and agriculture took place at expense of surrounding hornbeam forests. An intensification of lake productivity (expressed as an increase of varve thickness) started after 250 AD. If this lake ecosystem response relates to an intensified agriculture (and a possible transport of nutrients from neighboring rural lands) or to a climate shift will be further discussed. 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.

The second time of a significant increase of human activities began in Late Medieval time and lasted to the modern time. Pollen analysis shows the beginning of strong deforestation since XV century with the most intensification during industrial revolution (second part XIX century) where pine trees became the dominant species. Intense clear cutting in the lake's vicinity removed its natural "windshelter" and exposed the lake to longer lasting water column mixing. As a result varves nearly disappeared whereas the detrital indicators (e.g. Ti) increased due to an open landscape around the lake. The diatom analysis shows that in the lake ecosystem followed temporary changes. The most visible fluctuation occurred in presences of two species: *Cyclotella comensis* and *Stephanodiscus parvus*. Appeared the similarity in occurrences of *Cyclotella comensis* and *Tetraedron* (Chlorophyta).

This study is a contribution to the Virtual Institute ICLEA funded by the Helmholtz Association. The research was supported by the National Science Centre Poland (grant NCN 2011/01/B/ST10/07367).

Constructing a precise and robust chronology for the varved sediment record of Lake Czechowskie (Poland) – An example for the last 1000 years

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Annually laminated (varved) sediment records are essential for detailed investigations of past climate and environmental changes as they function as a natural memory far beyond instrumental datasets. However, reliable reconstructions of past changes need a robust chronology. We investigated the varved sediments of Lake Czechowskie (JC, 53°52' N/ 18°14' E, 108 m a.s.l.), northern Poland, to establish a precise time scale.

Here we present a multiple dating approach for the entire sediment record of Lake Czechowskie and demonstrate the use of a precise time scale for the youngest sediments (last 1000 years). The chronology comprises varve counting for the Holocene time period and AMS ^{14}C dating (19 plant macro remains and two bulk samples) reaching back to 14.0 cal ka BP. Additionally, independent chronological anchor points derived from (i) ^{137}Cs activity measurements for the last ca. 50 years and (ii) newly detected tephra layers of the Askja AD 1875 eruption and the Laacher See Tephra (12880 varve yrs BP) are used as precise dated isochrones.

Detailed investigations have been carried out applying micro-facies analyses combined with X-ray fluorescence element scanning, pollen and heavy metal (last 200 years) analyses.The robust age control for the youngest part of the sediment profile is a crucial precondition as this is not continuously varved. Moreover, pollen analyses show an intense deforestation since 1500 AD with the strongest increase around 1850. Detected heavy metal contaminations display the industrial development of northern Poland since this time. Possible sources for the increase of industrial pollutants are a nearby railway construction site or the growing heavy industry (e.g. Gdańsk Shipyard) at the Baltic coast.

The overarching goal within the ICLEA objectives is to synchronize the sediment record from Lake Czechowskie with its counterpart from Lake Tiefer See (TSK), located 378 km further west in NE Germany based on common age scale. The finding of identical volcanic ash layers in JC and TSK, respectively, will be used as independent tie points to synchronize and correlate these lake records in order to investigate regional differences to climatic and environmental changes along a W-E transect in the southern Baltic realm.

This study is a contribution to the Virtual Institute of Integrated Climate and Landscape Evolution Analysis – ICLEA– of the Helmholtz Association and the Helmholtz Association climate initiative REKLIM topic 8 "Rapid climate change derived from proxy data".

Littoral vegetation changes as indicators of Late Glacial and Holocene lake-level changes in Lake Tiefer See

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Lake Tiefer See (N 53.59°, E 12.53°) is one of the rare lakes with a long sequence of annually laminated Holocene sediments in northern Central Europe. The lake has no superficial drainage so that its water level fluctuates; at present by about 1 m. In the past, lake level fluctuations may have even been stronger and could have affected varve formation. The aim of our investigations is to reveal Late Glacial and Holocene lake level changes using sediment cores from the lake shore.

Present poster focuses on long peat sequences found in two sediment cores from the SE bay of Lake Tiefer See. TS2 is located in *Phragmites* reed vegetation, TS3 in an alder carr in about 100 m distance. Microfossils analysis reveals that this peat section represents several periods of high and low water levels. For example, layers with high concentrations of *Thelypteris palustris* spores and wood cells indicate the presence of forest vegetation at the site and thus low water levels while layers rich in *Pediastrum* algae point at higher water levels. To reveal water level fluctuations in more detail we additionally apply macrofossil analysis. In the upper part of TS2, first results show two layers with seeds from *Juncus articulatus*-Typ and *Cyperus fuscus*. *Juncus* and *Cyperus* are plants adapted to fluctuating water level, and thus indicate such conditions at Lake Tiefer See during the formation of these layers. In TS3 we started the investigation at the lower part of the peat layer at around 550 cm depth. That basal layer is rich in seeds of *Nymphaea alba* and *Najas*, i.e. aquatic plants which prefer shallow water until 1.5 m depth. The section from 550 to 500 cm is rich in *Betula* nutles and fruits of *Phragmites*. Macrofossil composition changes at 509 cm with the appearance of nutles of *Carex paniculata/appropoinquata* and of *Urtica dioica*, seeds of *Typha* and *Thelypteris palustris*. These remnants represent a terrestrial vegetation and thus indicate a shift towards dryer conditions.

By comparing both cores we finally aim to detect shifts of alder carr, reed, floating-leaved and submerged vegetation (cf. Gaillard & Digerfeldt 1991).

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Gaillard, M.-J. & Digerfeldt, G. (1991). Palaeohydrological studies and their contribution to palaeoecological and palaeoclimatic reconstructions. Ecological Bulletin 41, 275-282.

Late Allerød climatic fluctuation reconstructed from Trzechowskie paleolake sediment

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The aim of this study is a better understanding, how local lake ecosystems responded to climate changes during the late Allerød - Younger Dryas transition. Therefore, we carried out a detailed high-resolution multi-proxy case study on the partly laminated sediments from the Trzechowskie palaeolake, located in the Pomeranian Lakeland, northern Poland (53°52'40"N, 18°12'93"E).

We reconstructed the ecosystem response to climatic and environmental changes using biotic proxies (macrofossils, pollen, Cladocera, diatoms) and classical geochemical proxies ($\delta^{18}O$, $\delta^{13}C$, loss-on-ignition, $CaCO_3$ content) in combination with high-resolution µ-XRF element core scanning. The core chronology has been established by biostratigraphy, AMS ^{14}C-dating on plant macro remains, varve counting within the laminated intervals and the Laacher See Tephra (12880 varve yrs BP) as a precise isochrone.

Framework of our investigation is a period covering 367 varve years of the late Allerød and the beginning of the Younger Dryas period where varve preservation gradually ceases. The pronounced changes at the late Allerød - Younger Dryas transition is well-reflected in all environmental indicators but with conspicuous leads and lags reflecting complex responses of lake ecosystems to climate variation.

This study is a contribution to the Virtual Institute ICLEA (Integrated Climate and Landscape Evolution Analysis) funded by the Helmholtz Association. The research was supported by the National Science Centre Poland (grants No. NN 306085037 and NCN 2011/01/B/ST10/07367).

Late-Glacial to early Holocene basin development of annually laminated Lake Tiefer See

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Lake Tiefer See (N 53.59°, E 12.53°) is one of the rare lakes with a long sequence of annually laminated Holocene sediments in northern Central Europe.

The lake is thus of great potential for past climate, vegetation and human land use studies. It furthermore provides a valuable link between laminated lakes in more oceanic climates of the Eifel region and NW Germany and laminated lakes in the more continental climate of Poland. The sediments of Lake Tiefer See are not uniform but show repeated changes in varve composition and include several non-varved sequences. Interpreting these changes requires a sound understanding of the deposition processes in the lake and the development of the lake basin itself. While modern sediment deposition is studied in an extensive monitoring program, we explore lake basin development using numerous cores from the lake margins down to the bottom of the lake.

The lake is exceptionally deep (62 m) with steep slopes and may thus be susceptible to sediment re-deposition and focusing. Most marginal cores, which reach down to 10 m water depth, show a prominent basal peat layer. This peat layer indicates that basin development started by paludification of an originally flat surface following dead-ice melting. However, even in neighboring cores the timing of the onset of peat formation appears to differ substantially. While in some cores, the prominent Laacher See Tephra (12.880 cal. BP) is found at the bottom of the peat layer, it is found well above the peat basis in other cores. Dead-ice melting may thus initially have produced a pattern of shallow depressions with ongoing peat formation within a still terrestrial surface. The formation of the deep lake is than indicated by an abrupt shift to calcareous gyttjas, which show an initially increased silicate content. The lake obviously only developed long after first peat deposition, possibly in the early Holocene. Further dates to verify this hypothesis are expected. In several marginal cores, further peat layers are found within calcareous gyttjas. These layers point at lake level low stands during the early and mid Holocene.

50 years of lake-level, shore and vegetation dynamics at Lake Briesensee (NE Germany)

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The water level of Lake Briesensee (Schorfheide, NE Germany) has fluctuated by as much as 4 m over the last decades. For this period there are useful integrated climatic, hydrological and environmental data are available. Therefore, the lake is well suited to study mechanisms and causes of lake level changes and their influence on the shore and, with that, climate fluctuations and human impact on the hydrological regime.

Following high stands in the 1970s, the water level of Lake Briesensee was sinking since ~1980 to reach a minimum in 2006. Since then, the water level has increased again by 2 m. The main driver for these fluctuations is precipitation. By 2006, an up to 100 m wide fringe around Lake Briesensee has fallen dry, allowing natural vegetation succession. The lake shore is thus a natural habitat to a specialised small sedge vegetation with rare species including *Juncus alpinoarticuluatus* and *Gnaphalium luteo-album*, which are adjusted to open conditions with regular flooding. Using vegetation sampling data from 1994, 1999, 2005 and 2013 and aerial photographs, we explore vegetation development on the lake shore, including several generations of beach ridges, and compare that to lake level changes.

The results show three modes of vegetation development. Small sedge vegetation only establishes shortly above the water line. It follows sinking water levels but is overgrown by developing bushes (birch and willow) under stagnating water levels. With rapidly increasing water levels in recent years this vegetation type has completely vanished, but the species supposedly survive in the seed bank. During the long period of low lake levels the dry shore has been invaded by trees, mainly birch and pine. Trees established in a suspicious, linear patter, which is obviously determined by the lake level dynamics. Birch mainly established during periods of slowly sinking or stagnating water levels. During such periods, the accumulation of beach ridges with organic material (including birch seeds) along the drift line allows birch to germinate. Rapidly sinking water levels instead produced open sandy areas, which are slowly invaded by pine.

This understanding of present day water level, shore and vegetation dynamics helps to understand the palaeoecological and sedimentological fingerprint of these changes in lake sediment records, which in the next step will be used to reconstruct past lake levels changes from such palaeoenvironmental archives.

Holocene lake-level changes in the Schorfheide region (Lake Warnitzsee and Lake Briesensee, NE Germany)

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Several lakes in the Schorfheide area fluctuated by 4 m or more over the last decades – and possible also did in the past. These lakes are thus potentially well suited to reconstruct long term Holocene lake level changes. During a first coring campaign in August 2013 we explored whether sediments reflecting past lake level changes are preserved. The campaign focused on Lake Warnitzsee, where seven cores were taken along two transects. All cores show several alternations of peat layers, indicating low lake levels, and (calcareous) gyttjas, indicating high lake levels. A maximum of seven peat layers was found in two cores (WAR2 and WAR5). A similar stratigraphy was found in a core taken on the western shore of Lake Briesensee, indicating similar (connected) hydrological effects in the region. Dating using AMS C14 dating and pollen analysis is in progress. These first results underline the great potential of the two lakes to study Holocene lake level and climate fluctuations in the Schorfheide region.

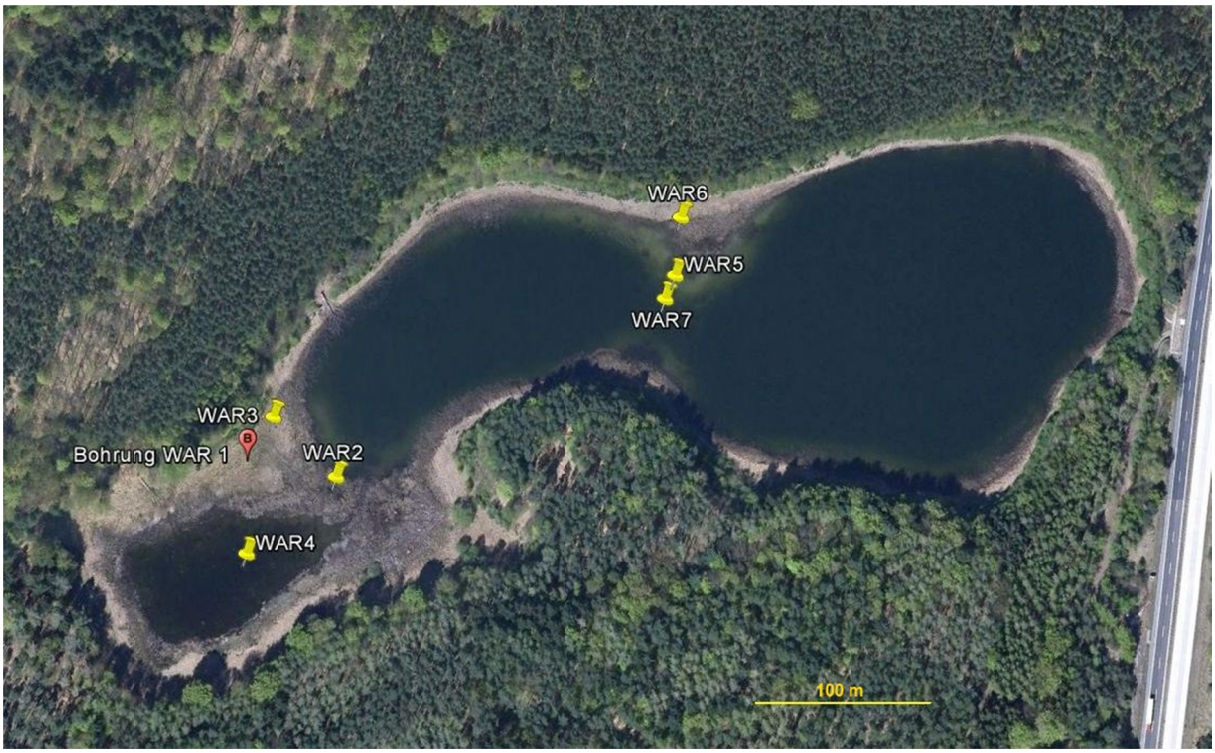

Fig. 1 Coring sites in Lake Warnitzsee (Schorfheide, NE Germany).

Tephra dating and synchronisation of high-resolution lake sequences from NE Germany and N Poland

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Identification of tephras (volcanic ash) intercalated in sedimentary repositories has become a crucial point for dating purposes and for synchronization and comparison of multi-proxy data sets of different archives in order to investigate regional differences in lake responses to rapid climatic and environmental changes. Especially Northeastern Germany and Northern-central Poland were episodically impacted by ash clouds of larger eruptions from Icelandic (ca. 2000-2300 km distance) and Eifel volcanoes (ca. 500-840 km distance) during the Late Glacial and the Holocene and thus offer great prospects for tephrochronological studies.

We have started an intense search for visible and non-visible (crypto-) tephras in the palaeoclimate records of Lake Tiefer See, Lake Großer Fürstenseer See, Lake Czechowskie and Trzechowskie palaeolake in order to verify the radiocarbon and ^{14}C supported varve chronologies and to carry out a detailed comparison of these sequences over a 380 km W-E transect. All archives are either located within or close to terminal moraines of the Pomeranian ice advance of the last glaciation and encompass continuous sediment records since the Late Glacial. The occurrence of the phonolitic Laacher See Tephra (LST, Eifel Volcanic Field; 12,880 ± 40 varve years BP) in basal sediments of the studied Polish and NE German lake records provides an ideal isochrones to test synchroneity of the onset of the Younger Dryas which earlier has been dated in varved lake records in the Eifel and Switzerland at 200 varve years after the LST. Very low glass concentrations (2 shards/cm^3) of the Icelandic Hässeldalen Tephra (11,380 ± 216 cal yr BP) were found in the TSK deep-core providing an important time marker for Preboreal sediments. We furthermore identified a microscopic visible layer of the basaltic Saksunarvatn Ash (SA; Iceland; 10,210 ± 35 cal yr BP) right below the transition from poorly to well laminated Boreal sediments in the deep-core of Lake Tiefer See (TSK) and its potential cryptotephra counterpart at a similar stratigraphic position in Lake Czechowskie (JC). Further findings of the SA tephra in the marginal cores of Tiefer See (TS), Lake Großer Fürstenseer See (GFS) and Trzechowskie palaeolake (TRZ) will provide an important isochron for the interpretation of potential lake level changes during this time period. Late Holocene sediments of TSK and JC cores in addition revealed a cryptotephra finding of the rhyolitic Askja AD 1875 tephra right below a transition between a poorly varved section and the uppermost well laminated sediments. Its occurrence in poorly laminated sediments provides a precise temporal anchor point for the comparison and interpretation of multi-proxy data from the recent and most likely human impacted environmental past.

WP5 Soil and Geomorphological Data

Extending and simplifying the standard Köhn-pipette technique for grain size analysis

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Grain size distribution is a fundamental parameter to characterize physical properties of soils and sediments. Manifold approaches exist and according to the DIN ISO 11277 soil texture is analyzed by default with the combined pipette sieving and sedimentation method developed by Köhn. With this standard technique subfractions of sand and silt as well as the total clay content can be determined but the differentiation of clay subfractions is impossible. As the differentiation of the clay subfractions yields relevant information about pedogenesis, we present a protocol basing on standard techniques of granulometry with easy to handle and low cost equipment. The protocol was tested on a set of soil samples to cover the range of grain size distributions.

We used a three-step procedure for achieving the grain size distribution of soil samples taking into account the subfractions of sand, silt and clay by a combination of sedimentation, centrifugal sedimentation and wet sieving. The pipetting was done with a piston-stroke pipette instead of the referred complex pipette from the DIN ISO 11277.

Our first results show that the applied protocol is less prone to operating errors than the standard Köhn-pipette technique. Furthermore, even a less experienced laboratory worker can handle 10 samples in one day. Analyses of a luvisol profile, sampled in high spatial resolution, showed that the lessivation process is characterized by translocation of fine clay from the eluvial horizon to the illuvial horizon. Therefore our protocol is a fast alternative to detect lessivation, which is otherwise only clearly identifiable by micromorphological investigation and not by the standard Köhn-pipette technique.

Influence of charcoal burning induced pyrolysis on soils

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In Lusatia, Northeastern Germany, the production of ironware between the 16th and 19th century left behind a remarkable amount of charcoal kilns in the forests north of Cottbus. Remote sensing surveys, underpinned by archaeological studies, show that charcoal was gained around Cottbus from several thousand charcoal kilns which had internal diameters up to 20 m. For the study site with 35 km^2 area, the until now prospected total ground area below the charcoal kilns which was potentially affected by the pyrolysis is about 0,5 km^2. Historic data indicates that the pyrolysis in the charcoal kiln took up to several weeks, for the kilns with a diameter of 20 m about 20 days. To characterize the depth of thermal alteration of soils below the kiln our current focus is on the differentiation of the iron hydroxides by small-scale vertical analysis of soil profiles.

The study site is situated 16 km northeast of Cottbus at the opencast mine Jänschwalde. Field work was done during the archaeological rescue excavation of a charcoal kiln in a 50 m long trench crossing an about 15 m wide charcoal kiln. One vertical profile outside the charcoal kiln and two vertical profiles below the charcoal kiln were chosen for analysis. The magnetic susceptibility was measured in situ on the undisturbed profile and ex situ on stepwise heated samples (105, 350, 550, 750 and 950°C). The total iron content was quantified ex situ by x-ray fluorescence.

Our first results indicate a change in the magnetic susceptibility in the contact area of the mineral soil and the charcoal kiln. The influence of the pyrolysis on the soil is restricted to areas where the soil was not shielded against the heat by ash or organic material.

Littoral landforms and pedosedimentary sequences indicating late Holocene lake-level changes in northern central Europe – a case study from northeastern Germany

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A multidisciplinary study was carried out at Lake Großer Fürstenseer See (LFS) in order to explore the potential of littoral sediments, palaeosols and landforms as indicators of historical lake-level changes. This research was initiated to investigate the extent to which lakes in northern central Europe responded hydrologically to climatic and land-use changes in the last millennium. The c. 2.5 km^2 large lake is located in a glacial outwash plain and fed predominantly by precipitation and groundwater. Specific landforms investigated comprise lake terraces, beach ridges, local basins/peatlands and dunes, revealing a local wealth of sedimentary sub-environments at the lakeshore. Eleven sections were recorded with subsequent sedimentological-pedological, geochronological (OSL, ^{14}C) and palaeobotanical (pollen, macro remains) analyses. Most of the pedosedimentary littoral sequences show a succession of basal glacial sand, intermediate palaeosols and lacustrine sand on top. A broader number of (semi-) terrestrial buried palaeosols along the lakeshore were systematically identified and analysed, providing evidence for changing hydrological site conditions during the late Holocene. Additional historical data from the last centuries (e.g. maps, aerial photos, public records) allow the lake-levels reconstructed from geoarchives to be connected with modern gauging data. All local data sources available enable a tracing of lake-level changes of the LFS during the last millennium, comprising periods of relatively low (c. 1200 AD, 2000s AD) and relatively high water levels (c. 1250-1450 AD, c. 1780 AD, 1980s AD). The amplitude of lake-level changes during the last c. 1000 years amounts to c. 3 m, so that the fluctuations of the last 30 years recorded by lake-level monitoring only reflect a small amount of the potential variability. Regional climate and local land-use history suggest that the Medieval lake-level dynamics of LFS were primarily governed by climate and secondarily influenced by human impact on the drainage system. At present the lake level is additionally influenced by the impact of highly water-consuming man-made pine forests in the catchment area. The regional significance of the local development at LFS can be demonstrated by comparison with other regional and supra-regional lake-level data. The present study underlines the potential of a closer examination of the littoral zone for lake-level reconstructions with high altitudinal precision.

A review of geochronological data from northeastern Germany: evaluating late Quaternary soil formation and land surface dynamics

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A comprehensive review of Late Quaternary terrestrial stratigraphical records from northeastern Germany requires the collection, evaluation and statistical processing of preferably all geochronological data from palaeosols and corresponding sediments available so far. Therefore work on a database has started, comprising a multitude of published and unpublished data and its analysis. In some respects, the setup and use of this database is methodically comparable with the concept of 'data mining', which aims at the discovery of previously unknown information from a larger collection of individual data sources. The database regionally covers the entire Weichselian glacial belt ('young morainic' area) and the immediately adjacent Saalian glacial belt ('old morainic' area) of northeastern Germany. The collected ages comprise a time interval of the last approx. 150,000 years. A large quantity of the dataset has not been published in international journals yet and is thus only hardly available for the scientific community so far.

The overall question to be addressed by this database is: What can palaeosols and corresponding sediments tell us about Late Quaternary environmental changes in the region? More specifically we pursue the following aspects: (1) identification of the spatiotemporal pattern of dated palaeopedological and geomorphological records; (2) dating of certain types of buried palaeosols; (3) dating of corresponding sediments, (4) dating of charcoal and fossil wood extracted from palaeosols and terrestrial sediments contributing to the question whether Late Quaternary vegetation changes and fire dynamics are detectable; (5) identification of geoarchaeological facts offering the possibility of tracing human impacts on the geomorphic system.

At the moment we have collected a total of 329 radiocarbon datings (AMS, conventional) and 391 luminescence datings (OSL, IRSL, TL) from a total of 163 sites. Each date is characterised by specific dating attributes (age with standard error, lab number, dated material) and by further information (e.g. coordinates, stratigraphy, references). Most of the radiocarbon and luminescence data were collected in the 1990s to 2010s (93 %). Among the radiocarbon dates charcoal (53 %) and peat (19 %) dominate the dated materials. Holocene ages prevail with a majority within the last 5000 years. Most dated palaeosols are developed from peat (Histosols) as well as from glacial and aeolian sands (Arenosols, Podzols). Most luminescence dates come from aeolian (84 %) and colluvial sand (11 %), which are scattered over the whole Lateglacial-Holocene and the Holocene period, respectively.

The presented database is still certainly incomplete and analysis is in its infancy, but it offers a promising starting point to assist systematic work on soil formation and land surface dynamics on a regional scale.

Surficial water properties of the lower Vistula fluvial lakes compared with Vistula and its tributaries (Grudziądz Basin, North Central Poland)

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Regarding the outflow the Vistula River is the largest river in the Baltic catchment. In its lower course, below Bydgoszcz, in the Late Holocene Vistula channel adopted a weakly anastomosing fluvial pattern destroyed by intensive human hydrotechnical activity and by the regulation which have intensified about 200 years ago. Channel regulation have left many artificially separated fluvial lakes. Part of them infilled rapidly but the majority have persisted to present day almost unchanged. It has also arised the question: what drives the resistence for silting? To solve the problem there were conducted simultaneous hydrological and geomorphological investigations, because there were two concepts: one that the mineral material is removed from fluvial lakes while high stands by flood waters and second that the material is removed due to high groundwater “exchange” rate when the fluvial lake has a sufficient hydrological connectivity to the main Vistula channel.

The Vistula valley crosses morainic plains of the last glaciation. On the average it has about 10 km width and is incised about 70 - 80 m deep, compared to neighbouring plains, dissecting all the Quaternary aquifers. On the floodplain area the Quaternary sediments lay with a layer of only 10-20 m thickness over Miocene and Oligocene sands. In favourable conditions, particularly while a low water stand there exists the possibility of Tertiary water migration toward the surface of fluvial lakes provided they have not continuous flood sediments cover on their floors.

As an example of such a lake with an intensive water exchange rate by supposed deep groundwaters was chosen the Old Vistula lake (Stara Wisła) near Grudziądz town. The lake has an area of 40 ha, mean depth 1,73 m, maximum depth 8 m, length about 4 km and medium width about 100 m. In the years 2011-2014, with two weeks frequency, in its surficial water layer were conducted measures which included temperature, pH, Eh, suspended matter amount, total and carbonaceous mineralization. Similar measurements were also conducted in other fluvial lakes and Vistula tributaries.

Investigations carried proved the general similarity between physical and chemical properties of lakes and watercourses analysed. However, there exists distinct gradient of carbonaceous mineralization from small values in the Vistula channel to high values at the valley edges. PH and Eh parameters in the Old Vistula lake were different than in all other surveyed sites what leads to conclusion that it is fed by deeper groundwaters than in the case of other fluvial lakes and Vistula tributaries, particularly in low water stand times.

Thickness of biogenic sediments in the vicinity of the Czechowskie Lake in the light of ground penetrating radar (GPR) study

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The paper present results of the georadar research in the vicinity of Lake Czechowskie included about 30 ha of the peat plain in the north-east from the lake and about 4 ha peat plain situated west from the lake. The basin of Lake Czechowskie occupies a deep depression located in the immediate hinterland of the maximum range of the Pomeranian Phase ice sheet in the northern part of Poland (Błaszkiewicz 2005). Drillings carried out within the peat plain in the western part of the lake basin indicate that there are relatively diversified lake sediments of up to 12 m in thickness.

To tests was used GSS'I SIR SYSTEM-2000™ radar with two monostatic transmitting-receiving antennae - the high resolution 400 MHz central frequency – for shallow prospecting of the subsurface layers and the low resolution 35 MHz – for determining the shape of the mineral bedrock. Overall, 33 GPR profiles was made all in all more than 3000 meters along and crosswise the longer axis of the biogenic plain. The range of penetration was adjusted to 200 ns two way time for 400 MHZ antenna, what is an equivalent of 4,2 meters in depth of peat and 600 ns for 35 MHz antenna, what is an equivalent of 12,7 meters (with assumed dielectric constant about 55). Horizontal scaling was made by GSSI survey wheel.

The thickness of biogenic sediments recognized by GPR reaches 10-12 meters (35 MHz antenna). In the case of the 400 MHz antenna, relatively high conductivity water-saturated peat and gyttja did not allow for the achievement of greater thickness than 2,5 meters. In a large part of the profiles was able to see the shape of the mineral bedrock in the form of a former lake basin. Also were observed elevations and thresholds in the bedrock. Depth to the mineral deposits forming former lake bottom was confirmed by drillings.

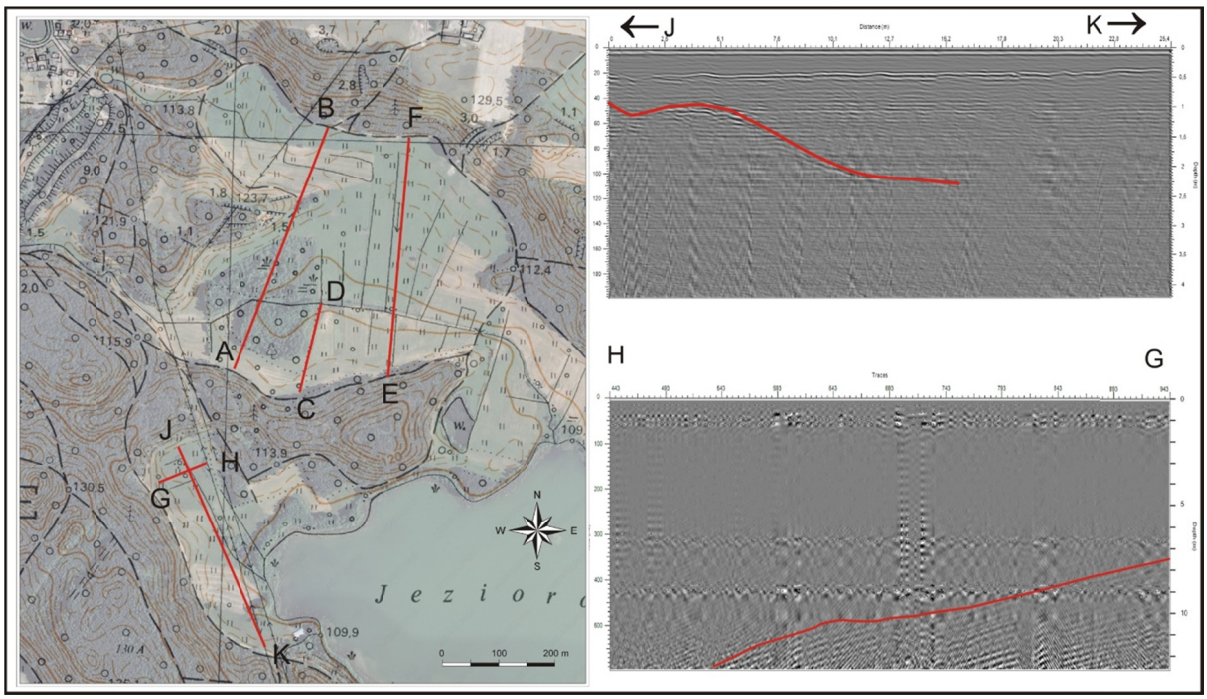

Figure. Location map of the GPR profiles (left). Examples of the profiles (right). Red lines indicates bottom of the biogenic sediments.

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Late-glacial to Early Holocene lake basin and river valley formation within Pomeranian moraine belt near Dobbertin (Mecklenburg-Vorpommern, NE Germany)

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In central Mecklenburg-Vorpommern vast areas between the terminal moraine belts of the Frankfurt (W1F) and Pomeranian Phase (W2) were covered by glaciolacustrine basins which were embedded in the outwash plains. With deglaciation of the Pomeranian Phase around 17-18 ka BP the basins north to the villages Dobbertin and Dobbin were part of a glaciofluvial river system in combination with ice-dammed lake basins. During the late-glacial after ~14 ka cal BP the melting of buried dead ice reshaped the lake basin morphology by new depressions, in- and outlets. We study late-glacial basin and landscape development using cores collected along a pipeline trench crossing the Dobbin-Dobbertin basin. Core analysis includes sedimentological (carbon content, grainsize distribution) and palaeoecological (pollen, plant macrofossils, Cladocera) proxies.

Radiocarbon dates indicate that peat formation started soon after the start of the Weichselian late-glacial. High resolution analysis of a basal peat layer indicates that initial organic and lacustrine sedimentation started in shallow ponding mires, evolving from buried dead ice sinks in the glaciofluvial sequence, in which telmatic plants (Carex aquatilis, Schoenoplectus lacustris) dominated. Chydorus sphaericus, the only cladocera species recorded, is ubiquitous and can survive in almost all reservoir types in very harsh conditions. Findings of Characeae than point at the formation of shallow lakes (Chara nitella oogonia). The expansion of rich fen communities, including Scorpidium scorpoides, and a decline in Cladocera diversity show that these lakes soon again terrestrialised with peat formation. The appearance of Alona costata points at a lowering of pH values in that process. A tree trunk of birch (14.2 ka cal. BP) shows that first trees established during this first telmatic period.

At this position in the basin, the basal peat layer is covered by minerogenic sediments, which points at a period of higher water levels and fluvial dynamics, possibly related to a cold period with permafrost formation. At other positions in the basin, the basal peat layer is covered directly by calcareous and silicate gyttias. These parts may (1) either not have been affected by assumed fluvial activity or (2) peat formation as such only started later here. Finally, an extended lake filled the basin from the later parts of the late-glacial on. Its sedimentation history is well recorded in calcareous and silicate gyttjas, whereas sedimentary units derived from organic and inorganic carbon content as well as grain size distribution allows a stratigraphical comparison of different profiles. Several delta cones in lake sediments give evidence of still considerable fluvial influx.

High lake levels are indicated by lake terraces at 51 m and 43 m a.s.l., yet the timing of these high stands is still unclear. A third terrace at 41 m a.s.l. represents lower water level in historic times, during which two smaller lakes (‘Dobbiner Plage’ and ‘Klädener Plage’) existed in the basin. Both lakes vanished due to drainage after 1798. The uppermost sediment sequence in the basins is represented by a pattern of strongly decomposed peat and lacustrine sand.

Evidence of (pre-) historic to modern landscape development and land use history in Lower Lusatia (Brandenburg, Germany)

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In the apron of three active lignite opencast pits in Lower Lusatia (Brandenburg, Germany), archaeological survey trenches were investigated in areas where Quaternary aeolian sand deposits are widespread. The investigated palaeoenvironmental archives in Jänschwalde, Cottbus-Nord and Welzow contain evidence of fluvial and aeolian morphodynamics, soil formation and agricultural land use from (pre-)historic to modern times. To study the age and the causes of sand drifting and landform stabilization, standard soil physical and chemical laboratory analyses as well as optically stimulated luminescence (OSL) and radiocarbon dating (14C) were carried out. Two main sedimentological units were identified: Unit 1 consists of glacio-fluvial and Late Weichselian aeolian sands representing the parent material for the native Podsol-Braunerde and Podsol development, while Unit 2 represents the Late Holocene aeolian deposits. Four periods of Late glacial and Holocene aeolian activity and three phases of geomorphological stability have been identified: (i) Aeolian sedimentation during the Late glacial, (ii) Mesolithic reactivation of aeolian processes, (iii) soil formation until Late Roman Iron Age settlers intensified the agricultural land use, (iv) intensive drift sand formation during the High Middle Ages due to agricultural expansion, (v) stabilization of the drift sands and weak soil formation, (vi) reactivation of aeolian processes due to the increasing wood consumption and charcoal production from the early 16th until the mid-19th century, (vii) surface stabilization and formation of Regosols since the mid-19th century due to afforestation.

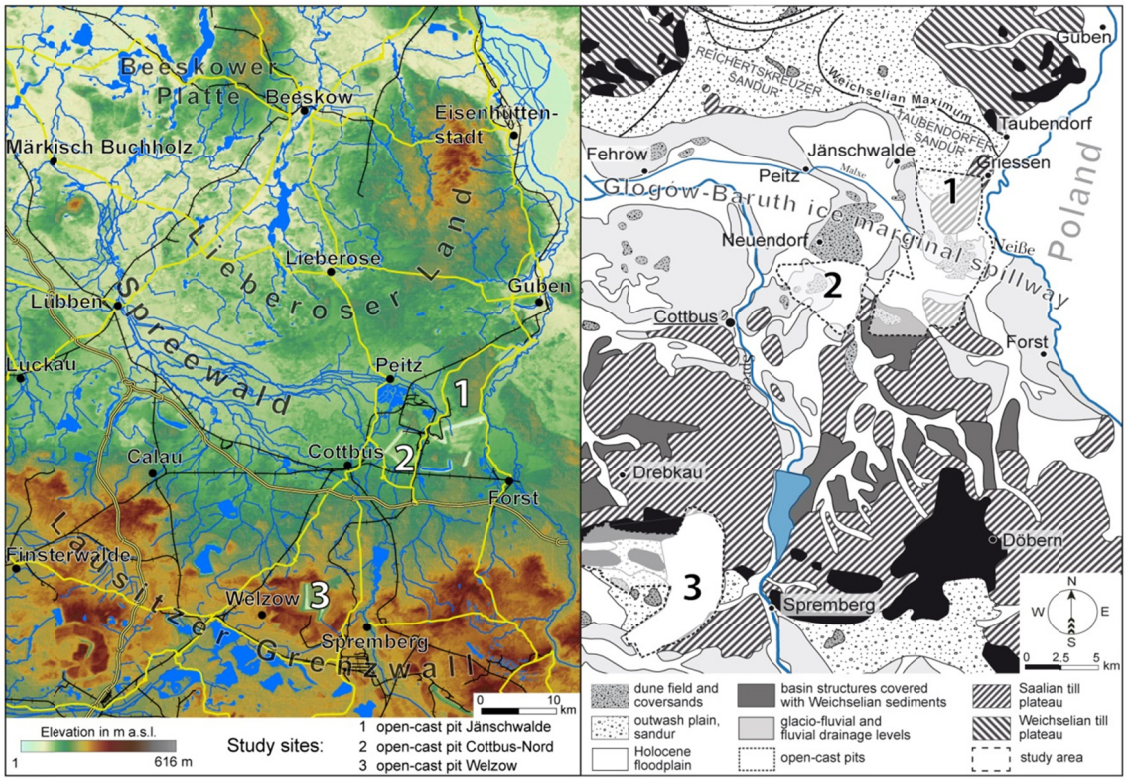

Fig. Locations of the study sites Jänschwalde, Cottbus-Nord and Welzow (south-east Brandenburg).

Proxies of pre-industrial charcoal production and land use in lake sediments from South Brandenburg, Germany

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During the last decades, archaeological research revealed that large-scale charcoal burning was carried out in Lower Lusatia (South Brandenburg) situated within the North Germany Lowlands. Charcoal burning in the area was mainly carried out from the 17th to the 19th century to provide energy for the ironwork in Peitz (operation time 1554 to 1856), where bog iron ore was smelted. To study the impact of pre-industrial charcoal burning on the environment, lake sediments from Byhleguhrer See and Großsee are investigated.

The investigation area is situated c. 15 km ne of Cottbus in the Tauerscher Forst. The climate is continental with a mean annual air temperature of 8-9 °C and a mean annual precipitation sum of 565 mm. The geology and geomorphology were formed by Quaternary glaciations. Therefore, sandy substrates are widespread. Today, the area is forested with mainly pine. Großsee (51° 56,007' N, 14° 28,282' E, 63 m a.s.l., max. 9 m water depth) is c. 0.31 km^2 large and is situated in the central part of the Tauersche Forst. Byhleguhrer See (51° 55,41' N, 14° 9,922' E, 50 m a.s.l., max. 1 m water depth) lies in c. 22 km linear distance west of Großsee at the western margin of the Tauersche Forst. It is c. 0.89 km^2 large and only about 1 m deep. During the last 50 years Byhleguhrer See was intensively used for fishing and wastewater was discharged into the lake. The surrounding was intensively used for agriculture.

In 2013, three short sediment cores in each lake were drilled (coring systems Ghilardi Freefall Corer KGH 94 and Uwitec Freefall Corer). In the laboratory, all cores were opened, described and photographed. Magnetic susceptibility (split-core logger, second generation) and total element contents (µXRF, Itrax corescanner) were measured on selected cores. Based on the first data, one sediment core per lake was selected for further analyses (CNS, ^{14}C-dating etc.).

The sediment core from Großsee (GR13-SH-PO56) is 77 cm long. The sediments had a high water content, a quite homogenous structure and only minor colour variations. Plant macro remains are present in the whole core. Respectively, the C and N values are high (C%: 20-37%, N%: 2-3,5%). S values (up to 2%) are high too in the upper part (10-30 cm sediment depth) correlating with the high magnetic susceptibility and iron values which hint on the occurrence of pyrite in the sediment. ^{14}C-dating from plant macro remains at the core base (71-75 cm sediment depth) resulted in 1110±40 BP, 778-1018 AD (2σ), Poz-58091). The sediment core from Byhleguhrer See (BHG-13-1) is 107 cm long. Again, the sediments had a high water content and are quite homogenous with only minor colour variations. Plant macro remains are incorporated in the sediment. CNS analyses are in progress. The base of the sediment core (100-107 cm sediment depth) was ^{14}C-dated to 3350±35 BP (1739-1531 BC (2σ), macro remain, Poz-58092) and to 4070±7 BP (2872-2471 BC (2σ), macro remains, Poz-58093). First tests on charcoal particle contents were carried out on both cores.

In conclusion, the sediments of Großsee and Byhleguhrer See are quite homogenous and organic-rich. An anthropogenic disturbance of the uppermost sediment part cannot be excluded. But, the ^{14}C-datings resulted in reasonable ages, even though we cannot rule out a hardwater effect on the radiocarbon ages of Byhleguhrer See. Most probably, the cores contain the relevant time span from the 17th to the 19th century, when charcoal burning was carried out in the surroundings of both lakes. Besides the CNS analyses and absolute age determinations, at present the focus lies on microscopic charcoal analyses.

Automated detection of small-scale anthropogenic relief features from high-resolution ALS data

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Wood consumption by charcoal production played an important role in land use during the last centuries. The extent of historic charcoal production has hardly been analyzed and described for the Northern European lowlands. High-resolution digital elevation data from airborne laser scanning (ALS) allow for the mapping of characteristic small-scale relief features that remain at former charcoal kiln sites. Mapping and analyzing the spatial distribution of such man-made features can help to develop a model of past land use systems.

The aim of our study is to determine the number and spatial distribution of historic charcoal kiln sites in the area around Cottbus, Germany, and in other areas of Northeastern Germany, in order to assess the extent and effects of forest use for charcoal production. To efficiently detect and quantify small-scale relief features from high-resolution DEMs for large areas, (semi-)automated mapping routines are required.

We developed a GIS-based routine for the detection and mapping of charcoal kiln remnants from ALS elevation models with a resolution of 1 or 2 meters. The method is based on a template matching algorithm, using a combination of morphometric parameters, and is implemented within ArcGIS. The mapping results could be validated against a comprehensive database of kiln sites and diameters recorded from archaeological excavations in the forefield of the opencast mine Jänschwalde and from manual digitization of kiln remnants from Shaded Relief maps for the Jänschwalder Heide and the Tauersche Forst, north of Cottbus.

A considerably high number of charcoal kiln sites could be detected in ALS data, and the diameters of the identified charcoal kilns are remarkable large in the area. For the Jänschwalder Heide, more than 5000 kiln sites in an area of 32 km^2 were detected by manual digitization, with 1355 kiln sites that are wider than 12 m. These relatively large kiln sites could be mapped with detection rates that are close to those of manual digitization using the automated routine. Detection quality was improved by the combination of several morphometric parameters used for template matching, as compared to a mapping based on elevation values only. In comparison to manual digitization, a combination of the described detection routine and a manual removal of falsely detected sites can considerably facilitate the mapping and distribution analysis of kiln sites or other small-scale relief features.

The role of dead ice melting on landscape transformation in the Lateglacial and early Holocene in Tuchola Pinewoods, North Poland

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The aim of the research was to decipher impacts, how dead ice melting can influence landscape transformation in the Lateglacial and early Holocene in Central Europe. Here, we present the paleoecological results from the middle section of the Wda river located in northern Poland (Central Europe), on the outwash plain formed during the Pomeranian phase of the last (Vistulian) glacial period ca 16,000 14C yrs BP. The Wda river has a typical polygenetic valley in young glacial areas of the northern central European lowlands.

We reconstructed environmental changes using biotic proxies (plant macrofossil and pollen analyses) and geomorphological investigations. Abrupt changes in lithology and sediment structures show rapid changes and threshold processes in environmental conditions. The AMS 14C dating of terrestrial plant remains reveals an age for the basal sediments of 11 223±23 cal yr BP coinciding with the Preboreal biozone.

The results show the existence of buried ice blocks in northern Poland even at the beginning of the Holocene proving that locally discontinuous permafrost was still present at that time. Our study demonstrates a strong influence of melting buried ice blocks on the geomorphological development, hydrological changes in the catchment, and the biotic environment even in the early Holocene.

This study is a contribution to the Virtual Institute of Integrated Climate and Landscape Evolution (ICLEA) of the Helmholtz Association. Financial support by the COST Action ES0907 INTIMATE is gratefully acknowledged. The research was supported by the National Science Centre Poland (grants No. NN 306085037 and NCN 2011/01/B/ST10/07367).

Forestry and charcoal burning in the vicinity of the ironwork Peitz (South Brandenburg, Germany) – What do we know from historical and archaeological data?

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The former royal forest districts around Peitz (South Brandenburg, Germany) were used to produce charcoal for the ironwork Peitz (1554 to 1856). More than 800 archaeologically excavated ground plans of charcoal kilns give evidence of the burning activity in the study area "Jänschwalde Heide" which is only a small part of the whole forest district.

The study area in the apron of the active lignite mine Jänschwalde comprises the royal forest "Jänschwalder Heide" and the surrounding community forests. Our study approach combines archaeological research, a GIS-based approach (historical maps, airborne laser scanning (ALS) data, etc.) and archival studies.

The charcoal kilns have been registered since 1990 and since 2005 they are systematically excavated and documented. First dendrochronological data reach from the 17th to the 19th century confirming charcoal burning during the operation period of the iron work. Moreover 5000 additional kilns were identified and digitized from Shaded Relief Maps (SRM) created from ALS data (resolution 1p m^{-2}; height accuracy +- 15 cm). A kiln field of such a dimension has not been documented and investigated for the North German Lowlands so far. It raises the question about the effects of charcoal burning on the forests and the landscape during the last three hundred years.

Here we present the evaluation of the kiln data with regard to their size, frequency and spatial distribution. Besides the large number, the kilns have also large diameters (modal value 17 m, mean 12,5 m). Outside the boundaries of the royal forest the kilns are smaller and they were probably used to produce charcoal for local handcraft. These findings are compared to historical records from the first forest inventories (18th/19th century) like forest age and area, with historical forest laws and wood consumption data of the iron work. There is growing evidence that despite of the large extent of the kiln field the wood reserves in the forest districts about 1800 were still vast and deforestation was only a local phenomenon caused e.g. by insect calamities.

In a next step the wood consumption will be calculated based on the kiln diameters and the calculation will be set into relation with consumption data of the former ironwork. A further aspect is the comparison of the kilns field with selected digitized landscape elements like forest boundaries, forest structures and transportation network from georectified historical maps (Urmeßtischblatt 1845, Schmettausche Karte 1767-1787) and the evaluation of the kiln distribution in relation to physio-geographic and socio-economic parameters.

Chapter III: Excursion and fieldtrip 2014

EXCURSION TO FOREST RESERVE „ELDENA“

Wednesday, 26th March 2014

The forest reserve Eldena comprises an area of 407 ha and is located 5 km southeast of Greifswald. With its species-rich and close-to-nature deciduous forest communities on poorly drained hydromorphic and nutrient-rich soils it is among the most valuable remnants of old-growth forests in the lowlands of northeastern Germany.

Figure 1: Entrance to the forest reserve “Eldena”

GEOLOGY, GEOMORPHOLOGY AND SOILS

The forest reserve is located in a rather flat-ground moraine formed during the youngest glaciation, the Mecklenburg phase of the Weichselian (ca. 15–12 ka BP). The retreating glaciers left behind a landscape of meltwater channels, small mounds and depressions like dead-ice holes. From the flat northern part of the area (4 m a.s.l.) the relief slowly rises to the highest southern point, the Ebertberg (29 m a.s.l.).

Thick glacial depositions of calcareous, loamy till (“Geschiebemergel”) form the parent material and are covered by sands of varying layer thickness that subsequently developed in the periglacial environment of the active layer of the permafrost (Kwasniowski, 2001). Weathering and decalcification are responsible for the characteristic sandy loam (“Geschiebelehm”), the substrate of the upper soil layer. At the well-drained

higher sites brunification, loamification and leaching are the dominating soil forming processes. Hydromorphic soils (stagnosols or gleysols) prevail at the lower sites due to the poorly draining, loamy substrate with a high water-holding capacity. In depressions and dead ice holes, peat and humus accumulation took place and organic soils developed. In general, soils are characterized by a high base saturation and a good nutrient supply. Especially in spring after snowmelt many depressions are filled with water, but dry out during summer. Since the implementation of regular forestry in the beginning of the 19th century an intensive grid of ditches strongly influences the water budget and subsequently the soil processes and species composition of the forest in the area.

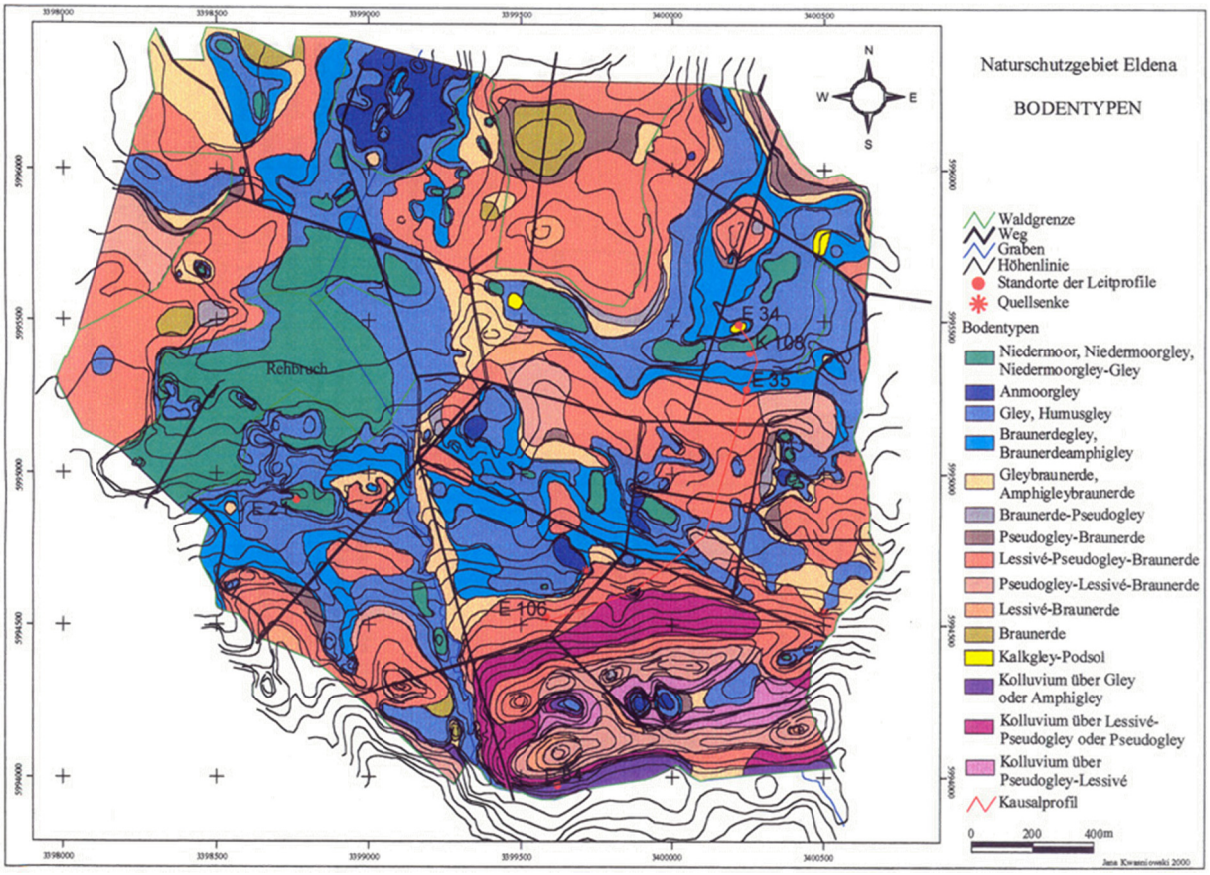

Figure 2: Soil map of the area illustrating the predominance of hydromorphic soil types; source: Kwasniowski (2001)

VEGETATION

Water and nutrient supply facilitate a highly productive common ash (*Fraxinus excelsior*) and European beech (*Fagus sylvatica*) dominated forest type (*Fraxino-Fagetum*) intermixed with sycamore maple (*Acer pseudoplatanus*), hornbeam (*Carpinus betulus*), wild cherry (*Prunus avium*), Scots elm (*Ulmus glabra*) and pedunculate oak (*Quercus robur*) of which oak and hornbeam are mostly remnants of former 'coppice with standards' forest practice and do not rejuvenate under the current management. In spring, flowering geophytes like *Anemone nemorosa*, *Ranunculus ficaria*, *Viola reichenbachiana* or *Corydalis cava* use the short time-window with warmer temperatures and high light-availability before budbreak of the crown trees to form an impressive flower carpet. In holes where waterlogged soil conditions prevail until summer black alder (*Alnus glutinosa*) and ash dominate.

Since ~2004 a widespread ash-dieback caused by a very aggressive fungus decimates this formerly predominating tree species to only few surviving, apparently resistant specimens and strongly alters the

species composition of the remaining forest. A second phenomenon that recently can be observed is the strong dominance of sycamore in the natural regeneration and in juvenile stands, where it even outcompetes beech at many sites. If this situation endorses sycamore will possibly be the dominating crown tree in the near future.

FOREST HISTORY

With the foundation of the monastery of Eldena in 1199 the present forest reserve belonged to the monasteries properties. Colonialists recruited by the monks cleared big areas around Greifswald and many villages were founded. The typical "-hagen" ending (it means 'clearcut area') in the name of numerous villages points to this origin. After secularization in the 15th century parts of the monasteries property, including the forest of Eldena, came into property of the Dukes of Pomerania. In the 17th century Bogusław XIV., Duke of Pomerania donated the woodland (including other areas) to the University of Greifswald, who, with a short interruption during socialist times, is still the owner of the area.

During the Middle Age the forest was exploited heavily: coppiced woodland was used for fuel wood and charcoal production and cattle grazed in the forest. In combination with wetter soil conditions this management favored tree species like oak and hornbeam (mast-trees, rapidly resprouting shoots) and other pioneer species like silver birch (*Betula pendula*), common hazel (*Corylus avellana*), poplar (*Populus spec*.) and willow (*Salix spec*.) as recorded in the charcoal spectra of historical charcoal kiln sites by Nelle & Kwasniowski (2001) or pollen analysis by Spangenberg (2008). Accordingly, the oldest map of the forest, the Swedish land survey map from 1697 shows mostly wet forest with forest pasture and tree species like oak, alder, willow, hazel and birch.

During the first half of the 19th century regular forestry replaced the former management practices and forest pasture was banned from 1821 on. Simultaneously, the construction of an intensive network of ditches altered the hydrological situation of the woodland and facilitated late-successional tree species with a lower tolerance to waterlogged soil conditions like beech or sycamore maple. One of the oldest parts of the forest received the name 'Elisenhain' after Princess Elisabeth Ludovika of Bavaria, the wife of king Friedrich Wilhelm IV., who took a walk through the forest in 1825 and was impressed by the large beech and oak stems already at that time. Especially during the World Wars I & II heavy loggings took place and big areas were clear-cut, an event that is clearly recorded in the ring patterns of the remaining trees as a period of good growth due to competition release. In 1969 the forest of Eldena was assigned as protected area including three sections (together ~ 28 ha) where forest management is completely abandoned.

ONGOING, ICLEA-RELATED RESEARCH

Having the rare case of a natural forest development, undisturbed by management measures for ~50 years and building on the very well documented forest history, soil and vegetation mapping as well as on detailed pollen- and charcoal-based analysis of historical tree-species distribution (Bochnig, 1959; Kwasniowski, 2001; Nelle & Kwasniowski, 2001; Spangenberg, 2001, 2008), we decided to implement an intensive forest monitoring plot in Eldena in 2013. Instrumentation relates to the dendroecological monitoring set-up at Lake Hinnensee and includes high-resolution point dendrometers, sap-flow measurements, soil-moisture gauges and a climate station. The set-up is complemented by pollen traps and permanent vegetation plots. A more intensive hydrological monitoring including groundwater gauges is planned. Tree species currently monitored include beech, oak and hornbeam, all with an age > 100 years. Dendrochronological research in forest parts of differing management intensity allows for comparison of growth patterns and helps to identify the influence of management on tree-ring patterns, a step towards a better separation of the climatic from the anthropogenic influence on tree growth.

So, by combining different disciplines and sources (historical data and maps, pollen analysis, dendrochronology, soil analysis) acting on timescales from millennia (pollen) to a few minutes (dendrometer), a comprehensive picture of forest development, ecological interactions and anthropogenic footprints in forest ecosystems will evolve.

Figure 3: Old beech stem with point-dendrometer and sap-flow sensors

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Field trip to Rügen Island (Summary)

Friday, 28th March 2014

The Baltic coast with its characteristic cliffs provides excellent and unique insights into the layering and the Late Pleistocene and Holocene stratigraphy and facilitates glaciotectonic studies. The most spectacular cliffs are located on the island Rügen, which will be visited during the field trip (fig. 1).

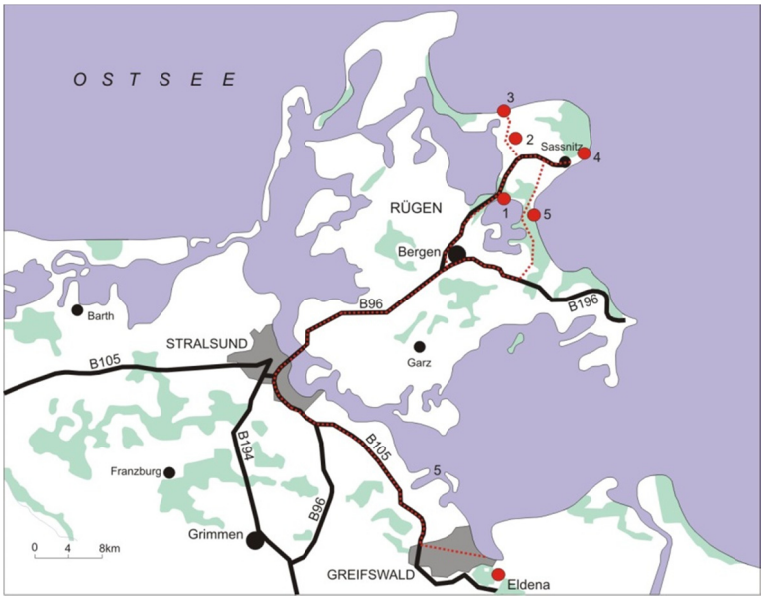

Fig. 1: Field trip to and stops on Rügen

Rügen is the largest island of Germany (area 926 km2) and shows many geological features. Numerous stratigraphical, sedimentological, structural, palaeontological and geoecological studies have been carried out during the 20th century and clarified the main geological problems. Especially the famous chalk cliffs of the Jasmund Peninsula attract visitors from all over the world. In the year 2006 the chalk coast of Jasmund has been approved as a „National Geosite" of Germany. Geologically, the northern and the eastern parts of Rügen Island are most important. The peninsulas of Wittow and Jasmund are formed of elevated chalk deposits (Cretaceous, Lower Maastrichtian) with overlying or interbedded Quaternary deposits of different glaciations (Saalian, Weichselian). They represent type localities for prograding glacier deformation structures. However, during the excursion the focus is on the Late Glacial and Holocene morphogenesis of the coastal features

Stop 1: Kleiner Jasmunder Bodden

At stop 1 the development of the coastal waters is exemplified by means of a sediment core from the Kleiner Jasmunder Bodden lagoon which represents the evolution of a lateglacial depression to a brackish lagoon. In the depression, sedimentation started already in the Meiendorf interstadial during which peat accumulated upon sandy sediment. Two thin peat layers were found in a tilted position (c. 35°) and point to thawing of buried deadice and ongoing deepening of the depression. During the subsequent period of the lateglacial silt accumulated. From the Preboreal and the Early Boreal no sediment is found, probably the depression desiccated. In the Late Boreal and Early Atlantic lake-marl and calcareous gyttja accumulated and point to a rising water table. About 7800 BP the transition to brackish-marine conditions started. Since the onset of pollen zone VII black organic mud accumulated, comprising many marine shell remains at the base. The highest salinity phase is designated by the predominant occurrence of the diatom *Paralia sulcata.* The transitions between the pollen zones VII/VIII, Xa/Xb and Xb/Xc are conspicuous. The latter marks the

Scientific Technical Report STR 14/02
DOI: 10.2312/GFZ.b103-14028

German colonization (c. 1250 AD) and coincides with the isolation of the lagoon from the sea. The resulting salinity decrease continues until today and is superposed by heavy eutrophication since the onset of the 20th century.

Stop 2: Temple Hill, Bobbin

At the "Temple Hill" close to the village Bobbin an overview about the Pleistocene development of the Jasmund Peninsula and of the main coastal features adjacent to it will be presented. The Jasmund moraine push complex developed by proglacial push-up of ridges and subsequent lateral compression between two ice lobes and thus thrusting and folding in an E-W striking N-wing and a NE-SW striking S-wing. Subsequently, the ice sheet overrode the push complex at least in large parts, thereby further deforming the subglacial sediments, and deposited the cover till belonging to the Mecklenburgian Phase (qW3). Locally, fluvial erosion, solifluidal dislocation and accumulation of clastic sediments in isolated basins occurred syngenetically. After the ice recession the complex was exposed to a periglacial milieu. Solifluction and abluation caused relief adjustment and levelling.

The subsequent landscape evolution is closely related to the development of the Baltic Sea resp. its precursors. Waterbodies related to the Baltic Ice Lake which existed during the Younger Dryas reached a level of about -10 to -15 m msl leading to accumulation of limnic sand layers in deeper depressions. During the early Holocene (Yoldia Sea, Ancylus Lake) the area belonged to the mainland. The Littorina transgression which started about 8900 cal BP reached the area off Rügen at c. 8300 cal BP at a level of -10 m. A water level of about -1 m msl at 6800 cal BP is evident. Due to the rapid sea-level rise the accommodation space below the sea level grew faster than it was filled with sediment eroded from nearby cliffs. Only after 5800 cal BP when the sea-level rise ceased

accumulation became the predominant process. Coastal barrier growth started and until 4000 cal BP beach ridge planes evolved and prograded rapidly. Due to a subsequent long lasting stagnation of the sea level the underwater profile of the coastal sediment wedge became equilibrated to the wave forces and a perfect swash aligned shoreline evolved. About 1000 to 1200 years ago the sea level started to rise again and related adjustment processes such as increased erosion along the cliffs, but sediment starvation and impending barrier breaching along the dune coast are evident.

Stop 3: Palaeolake sediments near Glowe

Since about 1990 at the cliff face near the village Glowe the sediments of a now dry lake crop out due to coastal retreat (fig. 2). Above a Weichselian till the sediment sequence starts with an organic horizon a few centimetres thick, containing wood (11842 ± 39 BP) and mosses. Towards the top, the sediment sequence mirrors the water-table rise in the early Late Glacial and the origination of a lake. The outcropping nearshore lake site silted up for the first time in the end of the Alleröd. After a subsequent water table rise in the beginning Younger Dryas it fell dry again in the early Preboreal favoured by increased input of siliciclastics. The accumulation of peat points to repeated water logging of the site in the later Early Atlantic. From the upper third of the peat layer archaeological findings were reported, e. g. several silex artefacts, a core axe of probably Bronze age and bones from wild boars and a human being. The undisturbed growth of the peat ends at the latest in pollen zone IX, the uppermost two decimetres of the peat are disturbed for unknown reason. The peat is covered by a colluvium of unknown age, its thickness getting thinner with ongoing coastal retreat.

Stop 4: Chalk cliff north of Sassnitz

Field stop 4 shows special exposures giving insight into the lithofacies and glaciotectonically controlled architecture of the Pleistocene and Upper Cretaceous chalk deposits of the Jasmund Peninsula. Both represent typical imbricational structures mainly caused by repeated glacier advances and its till (M-) and intertill (I-) deposits. The cliff shows the glaciotectonic structure of a synecline with the horizontally M-3 cover complex above a distinct unconformity, which also overrode the neighbouring chalk complexes (fig. 3). The cross section shows the typical synecline/anticline construction of the Jasmund push complex. The synecline builds one of the main structural elements. Together with the chalk the Pleistocene M-1 to I-2-strata have been folded glaciogenically. While the footwall limb of the synecline shows the structure in its original sequence and in about the primary thickness, the hangingwall limb was heavily thinned out by traction and overthrusting. In the core of the complex the strata, especially those of the I-2 laminated clay, were compressed to nearly vertical position. At many locations a boulder pavement can be observed at the base of the M-1-till, the boulders of which are pressed into the chalk´s surface. Their polished and striated surfaces are overlain by M-1. The M-3-ice has truncated the uppermost part of the synecline (development of the unconformity) and the M-3-till covers the remaining structure. From this location until the Königsstuhl structures like this can be repeatedly observed and, together with more or less steep dipping slaps, they are predominant elements within the push complex. According to the investigations on the Danish island Moen the multiphase deformation pattern of the push complex Jasmund coincides with the model of a glacigenic imbrication fan later overthrusted by the ice.

Stop 5: Pora Bay and Flint Pebble Fields, Mukran

The Prora Bay is one of the two great embayments in the northeastern and eastern side of Rügen. Exaration by repeated glaciations (Pleistocene base at c. -100 m), thawing dead-ice and erosion by meltwater formed the surface of its basement and the depressions of the present lagoon in its distal vicinity. Shortly after the ice melted the depressions hosted a system of meltwater basins which then largely desiccated due to further ice retreat. In the subsurface of the Prora Bay numerous meltwater basins were found, in which fossil bearing interbedded fine sand and silt accumulated. During the Littorina transgression the bay was rapidly inundated. Today, the thickness of the sandy marine sediments farther offshore amounts to only some decimetres while the thickness of the marine mud accumulated in more sheltered positions can reach several metres.

The Schmale Heide is one of the largest barriers of Rügen and divides the Prora Bay from the Kleiner Jasmunder Bodden (see stop 1). A distinctive feature is the high abundance of flint pebbles in its northern section, where 15-17 beach ridges in a 2.5 km long and 0.3 km wide area dominate the landscape (fig. 4). Only few boreholes give information about the construction of the barrier. The till surface is located unusually deep at -26 m. Above the till, calcareous sand follows containing freshwater diatoms and molluscs from -12 m upwards. A 20 cm thick Early Atlantic peat is covered again by freshwater sand which changes into marine at about -10 m. Flint pebbles occur at -4 m. The sequence is completed on the lagoonward side by aeolian sand sheets and peat and on the seaward side by aeolian sand forming several dune generations.

Fig. 2: Palaeolake sediment outcrop at the cliff near Glowe (Photo. R. Lampe 2009)

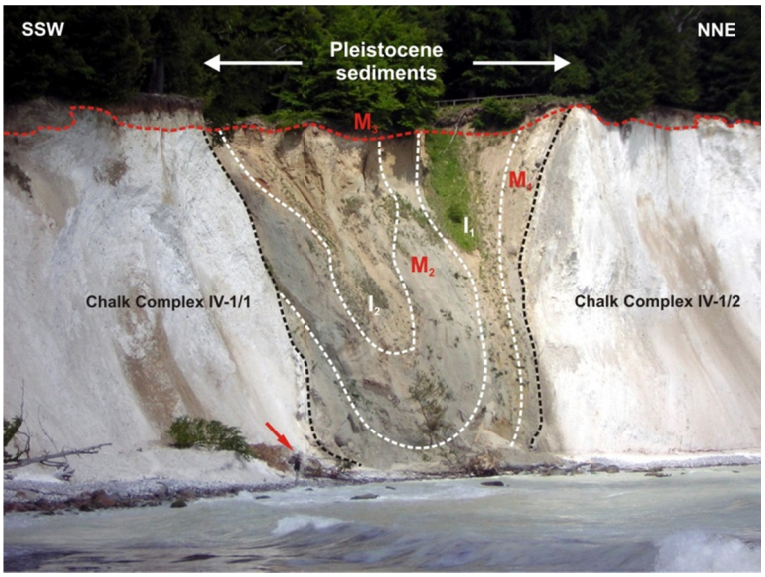

Fig. 3: Chalk cliff north of Sassnitz, showing the glaciotectonic structure of a synecline with the horizontally M-3 cover complex above a distinct unconformity. The cover complex also overrode the neighbouring chalk slabs (Photo: M. Kenzler 2010).

Fig. 4: Aerial view across Schmale Heide barrier with Flint Pebble Field ridge complex (Photo: R. Lampe 2007)

Scientific Technical Report STR 14/02
DOI: 10.2312/GFZ.b103-14028

Acknowledgements

This study is a contribution to the Virtual Institute of Integrated Climate and Landscape Evolution (ICLEA) of the Helmholtz Association and National Science Centre, Poland (grant No. 2011/01/B/ST10/07367).

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BTU Cottbus-Senftenberg *= Brandenburg University of Technology*
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(last update March 12, 2014)

ISSN 1610-0956