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Something old, something new, something borrowed: New insights to human-environment interaction in medieval Novgorod inferred from tree rings

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ABSTRACT

Updating archaeological tree-ring collections for calibrations and verifications with instrumental data is an essential step in 'updating' also our understanding of the climate signals in archaeological tree-ring data. Here we delve into the Novgorod tree-ring archives by supplementing the classical medieval chronology with tree-ring data from recently harvested timber. A large, random set of saw logs from the region of archaeological site, hypothetically mimicking the sampling of archaeological timber by medieval people, was used instead of conventional sampling by dendrochronologists on carefully selected sites, to enhance the reciprocal comparability of the datasets. Our tree-ring chronologies provide calibration data explaining 32% of variance in observed February–May temperature and, along with archaeological tree-ring data, a new temperature reconstruction over the medieval period 1160–1416 CE. In the context of the agricultural subsistence economy, we found indications of altering resilience to argue that changes from generally shorter to longer recurrence interval of frost and crop failure events from early (pre-1300) to late (post-1300) period, evident in historical-documentary sources, corresponds with tree-ring evidence. Decreasing amplitude of cool events and growth curtailments and increasing growth rates from early to late period demonstrate long-term change in climate conditions becoming more favorable to agricultural subsistence economy, with implication that the pan-European Great Famine (1315–1322 CE) did not probably extent into NW Russia. Tree-ring data provide means beyond the dating of wooden objects, relevant to the ways in which archaeologists, historians and natural scientists may collaborate in the study of past climate-society nexus.

1. Introduction

Archaeological sites often provide a wide variety of wooden materials and objects which have been collected, processed and used by human beings inhabiting the site through time. Such materials can be suitable for tree-ring analyses to provide useful insights into archaeological and historical investigations in revealing the various aspects of forest history and cultural heritage as well as the societal responses to past environmental and climatic changes (Turney et al., 2006; Haneca et al., 2009; Génova et al., 2011; Stahle and Dean, 2011; Domínguez-Delmás et al., 2015). Tree rings represent the annual growth layers of arboreal growth. An underlying principle of tree-ring science (i.e. dendrochronology) is that a common environmental or climatic factor, or a mixture of factors, limits the growth, generate a synchrony of wide and narrow rings within a tree population, and that the variations of such factors can be inferred back in time by reading the growth records of mean chronologies (Fritts, 1976; Baillie, 1982). Already Douglass (1914, 1921, 1935) presented the feasibility of tree rings to portray past climate variability beyond the era of direct, meteorological observations. Today, a century after the early steps of modern dendroclimatology, an increasing number of paleoclimate reconstructions are derived from tree-ring chronologies comprising data from archaeological, historical and recent samples, these records providing insights of late Holocene climate variability over the past millennium (St. George and Nielsen, 2002; Génova et al., 2011; Cooper et al., 2013; Wilson et al., 2013) or even millennia (Zhang et al., 2003; Büntgen et al., 2011).

The medieval city of Novgorod in North-West Russia (Fig. 1) is a

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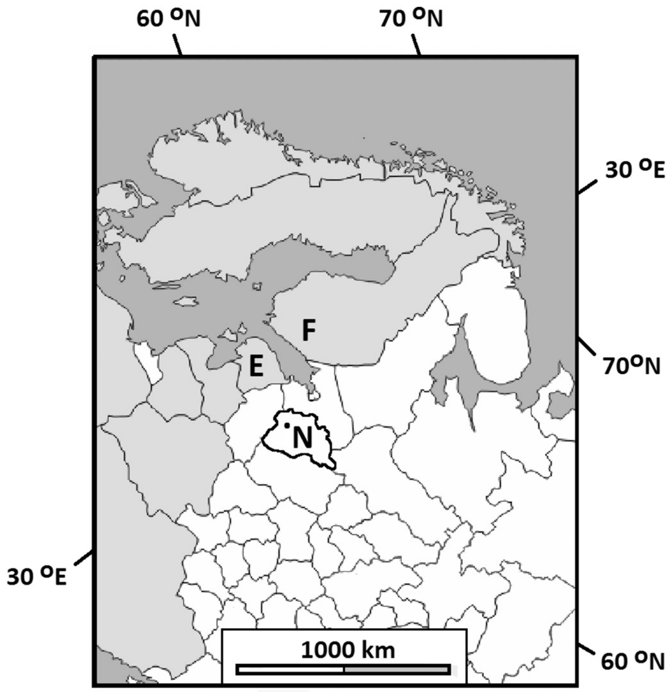

Fig. 1. Location of the Novgorod city (N) in the Novgorod oblast with the source regions of tree-ring chronologies from south-eastern Finland (F) and Estonia (E).

unique site that has interested archaeologist for generations. The city was built largely from wood and thus wooden samples dominate the structural and artefactual archaeological remains (Brisbane and Gaimster, 2001). The long-term progress of dendrochronological investigations of wood samples from constructions of Novgorod has resulted in extensive collections of tree-ring samples (Tarabardina, 2001, 2009) since the late 1950s. Already the early phase of the excavation revealed the promise of this material as a total amount of 1038 samples was reported by Kolchin (1967), this collection including samples from street deckings, other decking and fence stakes, houses and other buildings, and free-lying logs and half-logs. Continuation of the fieldwork has later enabled a further extension of the material that brought together a collection of more than fifteen thousand tree-ring samples (Tarabardina, 2001, 2009). Unfortunately, the dendrochronological potential of the full set of samples may be limited, considering the preservation of the wood, the multitude of species involved, and the shortness of a majority of the series. For example, more than three quarters of the series (77%) contain < 100 rings, the shortness of the series making it difficult to find their unique chronological position against the reference chronology. These limitations notwithstanding, the tree-ring collection of Novgorod represents an auspicious dataset for dendroclimatic and palaeoenvironmental investigations. To date, Baillie (1982) and Kuniholm (2001) have highlighted this tree-ring material as an example for the value of a dendrochronological approach for archaeology. Despite the increasing role of tree-ring materials to supplement studies on past cultural and societal changes (Büntgen et al., 2011, 2016), the Novgorod tree-ring data have remained hitherto unstudied with regard to its potential for recording the past environmental variations and climatic events.

Here we explore the classical tree-ring chronology of Kolchin (1967) that spans the medieval times. Our main target is to examine the value of this tree-ring collection for revealing the past climatic variability in the region of Novgorod. To do so, the medieval dataset needed to be accompanied with recent tree-ring data for quantifying the climate-growth relationships in the region and for building a transfer function capable of transforming the estimates of medieval tree growth into a palaeoclimatic reconstruction. To further explore the value of these datasets, the new composite tree-ring data was examined in the context of historical-documentary analysis as recently detailed for the same region. The historical-documentary analysis was retrieved from contemporary chronicles and annals by Huhtamaa (2015), her data including written evidence of frost damages and crop failures on timescale of calendar years, similarly to our unwritten, tree-ring evidence. With these regards, the previous archaeological investigations have shown that the Novgorodian diet was largely based on grain products: rye, barley, wheat (bread wheat, emmer, and spelt), oats, and millet (Kiryanov, 1967; Alsleben, 2001; Alsleben, 2012; Maltby, 2012; Monk and Johnston, 2012). Significant role of climate variability behind the past agricultural output and economy has recently been highlighted using the evidence of historical statistics available from adjacent areas (Holopainen et al., 2012; Huhtamaa et al., 2015). We anticipate the use of our new tree-ring reconstruction to further evaluate this role over earlier times, especially in the context of the agricultural subsistence economy in medieval Novgorod.

Previously, the potential problems of updating archaeological chronologies with recent tree-ring materials were emphasized with central European example (Tegel et al., 2010). It was suggested that the comparability of these two types of tree-ring data may be less sizeable than expected, especially since the site conditions of ancient trees representing the archaeological chronologies are unknown, this impreciseness potentially resulting in degradation of their climatic signal, in comparison to recent data obtained from selected living trees. Similar to the central European example, the provenance of the archaeological tree-ring data from Novgorod is not precisely known (Tarabardina, 2009). Thus, our approach to mitigate these caveats follows a strategy proposed for updating the historical tree-ring chronologies in central Europe, where timber was randomly sampled at sawmills and lumberyards in the region of archaeological sites, to reduce ecological understanding of the modern samples (Tegel et al., 2010). To this end, the chronology of Kolchin (1967) was updated by a collection of tree-ring data representing recently harvested logs known to originate from the Novgorod region, as this area has been registered as the network of railway stations from where the saw logs were transported for this study, while no more accurate information of the provenance exists (Hautamäki et al., 2010). We also note that the sampling height (pertaining to a tree stem) of archaeological material can be impossible to determine. To investigate the potentially differences in tree-ring statistics at different heights, our logs were sampled separately at lower and upper stem sections and tree-ring series representing both of these sections were produced.

Collectively, this study aims at elucidating and quantifying the climatic effects on tree growth in northeastern Europe, twentieth century Novgorod, and making use of these relationships to transform the data from medieval tree-ring materials into estimates of climatic variability for the site and period under investigation, to further trace the ways the past agricultural changes, as revealed from historical-documentary analysis, may have been influenced by climate anomalies. The hypotheses of updating tree-ring chronologies from timber of unknown provenance and varying sampling heights are tested using the data of harvested logs, by examining and comparing the value of these 'unselected' trees to portray growth variations in relation to those observed in climate. More generally, our aim is to contribute to the long-lasting development of archaeological dendrochronology in this region by quantifying the dendroclimatic significance of available datasets and, most importantly, evaluate the extent the past environmental variations may have had on medieval societies through climate-mediated effects on agriculture.

2. Materials and methods

2.1. Archaeological tree-ring data

Archaeological tree-ring material (*Pinus sylvestris* L.) originates from