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Summer Climate Variability during the Past 1200 Years in Central Scandinavia

– A Tree-Ring Perspective

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ABSTRACT

To set the current 20th century warming in a long-term context, significant efforts have been made to reconstruct hemispheric-to-global temperatures beyond the instrumental period. Tree-rings, which have annual resolution and can be precisely dated, have been widely used to infer past climate variability. In Fennoscandia, tree-ring maximum latewood density (MXD) provides so far the best high-resolution natural archive of summer temperature, and has been used to infer regional temperature variability for the last millennium. However, most of the temperature reconstructions have been based on data from northern Fennoscandia. In central Scandinavia, MXD based temperature reconstructions have not been able to reach the Medieval Climate Anomaly (MCA) when the climate conditions in some regions are analogue to the current warming, but without strong influences from human activities. This is a key period to evaluate if current warming can be reached without anthropogenic influences.

To improve our understanding of past summer climate variability in central Scandinavia, in this thesis work, efforts were made to 1) find Scots pine (Pinus sylvestris L.) tree-ring samples from the central Scandinavian Mountains to increase the sample replication before 1750 CE and to extend it over the MCA, 2) examine if tree-ring data can represent annual conditions by comparing annual and summer temperature variability at different timescales in central Scandinavia. The results show that the local tree line in central Scandinavia during the MCA and early Little Ice Age (LIA) was about 140 m higher than at present. The temperature sensitivity of pine growth might be dampened by more humid growth condition. The result implies that temperature reconstructions predominantly based on the tree-ring widths from lake-shores may need to be re-evaluated. Focusing on tree-ring density, it was shown that mean absolute MXD values varied notably with elevation, with higher elevation having lower MXD values due to occurrence of the temperature gradients along altitudes. Heterogeneous temporal distribution of tree-ring samples at different elevations could seriously bias the long-term trend of the temperature reconstruction based on these samples. A mean-adjustment method was developed to overcome this bias. The reconstruction based on unadjusted data yielded 0.4°C lower average warm-season temperature during the period 850-1200 compared to the mean-adjusted reconstruction. The new warm-season (April-September) temperature reconstruction in central Scandinavia covering 850-2011, suggests a MCA during ca. 1000-1100, followed by a transition period before the onset of the LIA proper in the mid-16th century. During the past 1200 years, the late 17th century to early 19th century was the coldest period in central Scandinavia, and the warmest 100 years occurred during the 20th century. The new reconstruction suggests lower temperature during the late MCA (ca. 1100-1220) and higher temperature during the LIA (1610-1850) than the previous reconstruction, and shows regional differences in temperature evolution between northern and central Scandinavia before 1300 CE. Overall colder climate conditions are recorded in central Scandinavia before 1200 CE and warmer conditions during 1200-1300 leading to a mismatch in phase at multidecadal to century timescales before 1300 CE. During 1100-1250, central Scandinavia is dominated by warm, cloudy and wet summer conditions, while during the LIA the region was dominated by cold and sunny summers and partly wet conditions. The transition period between the MCA and LIA (around 1350-1550) was dominated by relatively dry conditions. During this period, temperatures were positively correlated with sunshine hours at multidecadal to century timescales, which was different from MCA and LIA. For central Scandinavia, the summer temperature overall is not a good 'proxy' for the annual temperature especially at the 2-16 year timescales.

Keywords: Central Scandinavia, climate variability, dendroclimatology, maximum latewood density, Medieval Climate Anomaly, model-proxy data comparison, *Pinus sylvestris* L., temperature, tree-ring width