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Late Holocene spatiotemporal hydroclimatic variability over Fennoscandia inferred from tree-rings

Kristina Seftigen
Institutionen för geovetenskaper
Naturvetenskapliga fakulteten

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ABSTRACT

There is a broad scientific consensus that the global climate is changing, and that human activity is a significant factor contributing to the change. The response of the hydrological cycle to the warming is far reaching, including increases in the intensification and frequency of extreme hydroclimatological events. The underlying physical mechanisms driving this changes are poorly understood, and the observational record, which rarely predates the 20th century, is too short to resolve the full range of natural moisture variability or make predictions of longer-term hydroclimatic patterns. Tree-rings provide precisely dated and annually resolved paleoclimatic archives, which can be used to infer climate in the pre-instrumental era. Focused on the Fennoscandian region, the core efforts of this dissertation work are (1) to examine the potential of Fennoscandian tree-ring data as proxies of past moisture variability, (2) to increase the network of moisture sensitive tree-ring chronologies in the region, and finally (3) to combine the newly sampled data with already existing dendrochronological material to develop a first spatiotemporal reconstruction of Fennoscandian hydroclimatic variability spanning over the past millennium.

A unique network of twenty-seven moisture sensitive chronologies was provided for southern and central Scandinavia. A subset of the network, combined with existing tree-ring data, was used to produce the first regional hydroclimatic reconstruction, as expressed by the Standardized Precipitation Index (SPI), for southeastern Sweden, spanning the last 350 years. The reconstruction revealed decadal scale alterations in wet and dry regimes, and proved xeric-site tree-ring data from the region to contain valuable hydroclimatic information. Moreover, a pilot study using Scots pine tree-ring carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) measurements from the central Scandinavian mountains assessed the potential of each record as a proxy of local moisture conditions. Results showed that both isotope ratios recorded the moisture signal strongly enough to be used as a proxy of past hydroclimatic conditions. Based on these results, the potential of using multi-parameter tree-ring data (including ring-width, maximum latewood density, stable isotopes) from Fennoscandia to make spatiotemporal reconstructions of past moisture variability was first tested, and then applied to produce an "atlas" of past hydroclimatic conditions, defined by the Standardized Precipitation-Evapotranspiration Index (SPEI), spanning back to 1000 CE. The resulting reconstruction gave a unique opportunity to examine the frequency, severity, persistence, and spatial characteristics of Fennoscandian climate variability in the context of the last 1000 years. The reconstruction highlighted the 17th century as an epoch of frequent severe and widespread hydroclimatic anomalies, and the 15th-16th centuries as surprisingly free from any spatially extensive droughts/pluvials. No explicit shifts towards more frequent and intense extremes over the region were observed in the reconstructed data over the most recent century. Moreover, the analysis suggests that the spatial hydroclimatic patterns over Fennoscandia may be divided into two major modes, remarkably stable over the past seven centuries, and that the controls on these patterns may come from the summer North Atlantic Oscillation.

Keywords: Tree-rings, Fennoscandia, hydroclimate, SPEI, SPI, ring-width, maximum latewood density, stable isotopes, field reconstruction, Point-by-point regression.