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Drivers of stem radial variation and its pattern in peatland Scots pines: A pilot study

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ABSTRACT

Dendrometers are useful tools to analyze intra-annual variation of radial growth in trees, but have rarely been applied in marginal environments. Our aim in this study was to explore stem radial variation (SRV) of Scots pines (*Pinus sylvestris* L.) growing in a marginal environment on top of a peatland and compare it with stem radial variation of Scots pines growing in a nearby forest. We compared high-resolution (30 min) tree-growth of the peatland and forest pines in two consecutive years in two ways. First, we modeled raw SRV using site and weather parameters as predictors, to determine if and in what way stem radial variation depends on the site type. Second, we split the SRV signal into sub-series of varying length to test for differences between the time-series pattern of peatland and forest SRV with clustering methods and classifier models. We found indications that site type is influencing raw stem radial variation as: 1) an intercept, i.e. forest trees tended to grow more than peatland trees (as expected); 2) an interaction factor with structural and weather parameters, i.e. response of the forest trees to changing environmental parameters was different than the response of the peatland trees. Conversely, with regard to the temporal pattern of the stem radial variation, we found that the conditions within one year, e.g. weather patterns, were more important than site conditions, especially at short time scales. However, with increasing length of the sub-series the relative accuracy of the classifier models increased. Our results indicate that the site type was important for the raw SRV (amplitude) but not for the SRV pattern, which might be important to consider when comparing intra-annual signals from multiple sites.

1. Introduction

Automated dendrometers have been extremely useful in disentangling factors controlling stem radial variation of many tree species (Deslauriers et al., 2003; Deslauriers et al., 2007; van der Maaten et al., 2013; van der Maaten et al., 2016). They continuously measure the change of the stem radius and output a signal proportional to the sum of reversible and irreversible SRV. Reversible SRV is generally related to shrinkage and swelling of the stem due to stem water content, while irreversible SRV is usually related to radial growth. Due to the high temporal resolution of dendrometers (usually 15–30 min), they allow a detailed analysis of factors influencing SRV, both during a day and during a season. They thus complement tree-ring studies by providing highly resolved intra-annual time series of radial growth.

Up to now, SRV studies of trees growing at extreme sites were seldom (Gruber et al., 2009; Oberhuber and Gruber, 2010), although trees from extreme sites tend to be very useful, e.g. as proxies to their limiting factors (Fritts, 2012). Peatlands are one example of extreme sites, where trees are usually exposed to poor soil aeration, low nutrient availability and cold substrate (Ohlson, 1995; Macdonald and Yin, 1999), often resulting in very narrow, wedging or missing rings, or stunted growth forms of trees (Wilmking et al., 2012). Although difficulties are numerous when working with peatland trees, the availability of subfossil material buried in peatlands allows the construction of very long chronologies, making peatland trees very interesting study objects in the field of dendrochronology (Linderholm et al., 2002; Eckstein et al., 2009; Edvardsson, 2010; Edvardsson et al., 2012; Smiljanić et al., 2014; Edvardsson et al., 2015; Scharnweber et al., 2015).

However, in order to identify important factors driving peatland tree growth and to better interpret the subfossil tree ring record, it might be helpful to conduct at least some intra-annual studies (Seo et al., 2014). These temporally highly resolved studies complement classical studies on peatland trees using tree ring width data (Linderholm et al., 2002; Wilmking and Myers-Smith, 2008; Cedro and Lamentowicz, 2011; Edvardsson et al., 2015). SRV analysis, as a highly resolved, accurate and precise method for the study of intra-annual tree growth, might help us to identify factors which drive peatland tree growth as well as to analyze this relationship in greater detail, as

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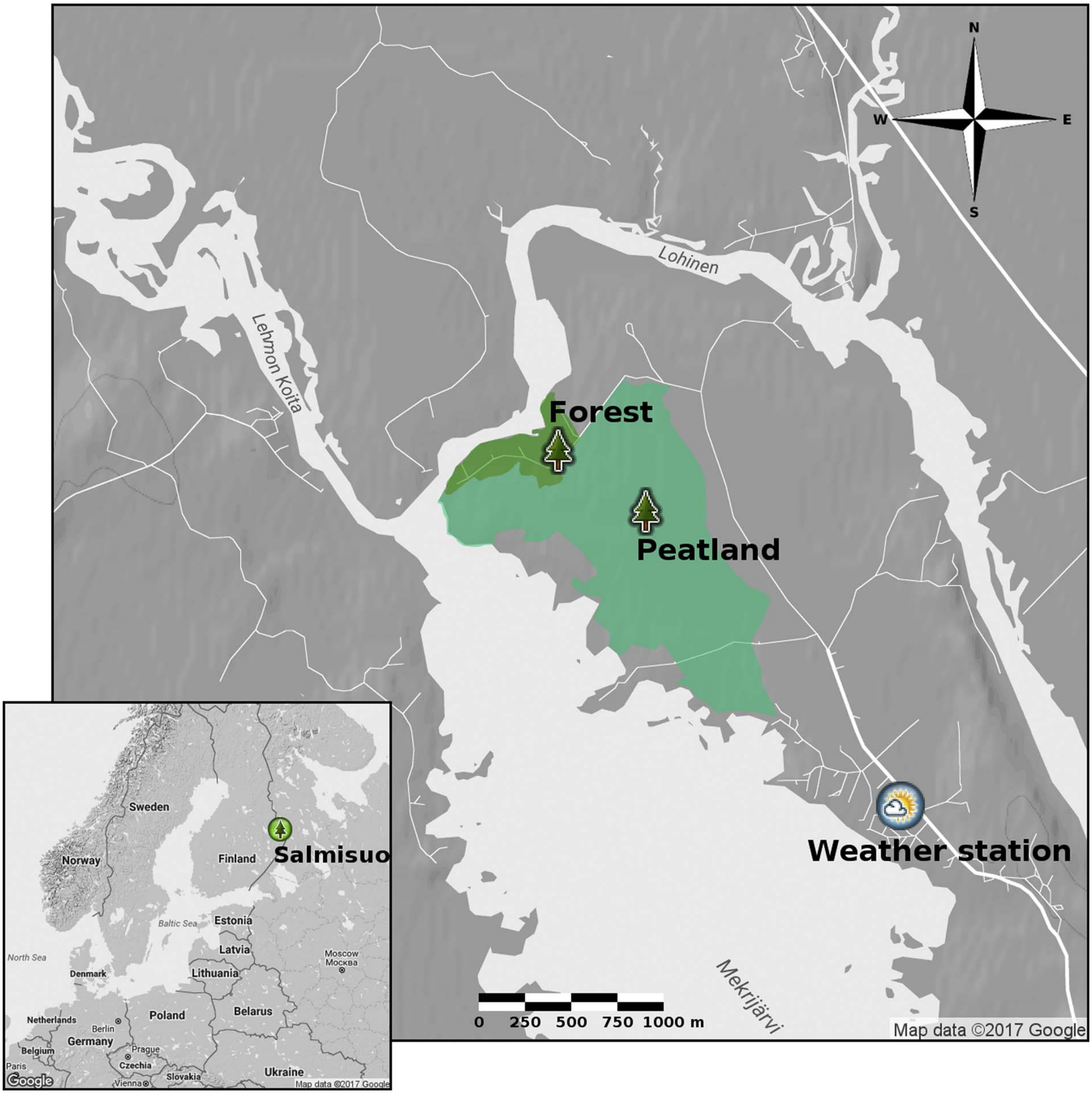

Fig. 1. Location of the Salmisuo peatland and our study sites.

suggested in Edvardsson et al. (2016). Therefore, our aim with this study was to initially explore peatland SRV, and to compare it to SRV of trees growing in a nearby forest to better understand the influence of site type on SRV.

2. Materials and methods

2.1. Site information

For our study site we selected Salmisuo (62.79 N; 30.94 E), a peatland located near the town of Ilomantsi in the North Karelia province, Finland (Fig. 1; Map). Salmisuo is an oligotrophic low-sedge pine fen with some minerotrophic strips (Saarnio et al., 1997). The climate at the study site is humid, continental subarctic, and classified as Dfc, according to the Köppen-Geiger climate classification system (Kottek et al., 2006).

2.2. Data collection

For this study we monitored SRV of Scots pine (*Pinus sylvestris L.*) at the peatland and an adjacent forest site. In the peatland, pines grew only on organic soils on top of small hummocks, elevated and comparatively dry areas (Becker et al., 2008). At the forest site, pines grew on sandy substrate. We installed circumference dendrometers, (DC type, Ecomatik, Germany) on five dominant Scots pine trees per site (Fig. 1). The sensors were connected to Campbell Scientific CR-850 dataloggers in the half-bridge configuration in the summer of 2011. We configured the system to measure the dendrometer signal every 60 s averaged over 30 min (Supplement Code 1).

Before the growing season of 2012 started, two sensors at the forest site and one at the peatland site had broken down, probably due to the low temperatures outside the safe operating ranges of the sensors during the winter (lower than −35 °C). In general, the system worked until July 2012, when we had equipment and power failures on site, due to rodent activity. We were able to repair the damages for the peatland part of the system in the 2012 field campaign, which worked