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ORIGINAL ARTICLE

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Growth/climate response shift in a long subalpine spruce chronology

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Abstract A new Norway spruce (*Picea abies* (L.) Karst.) tree-ring width chronology based on living and historic wood spanning the AD 1108–2003 period is developed. This composite record combines 208 high elevation samples from 3 Swiss subalpine valleys, i.e., Lötschental, Goms, and Engadine. To retain potential high- to low-frequency information in this dataset, individual spline detrending and the regional curve standardization are applied. For comparison, 22 high elevation and 6 low-elevation instrumental station records covering the greater Alpine area are used. Previous year August–September precipitation and current year May–July temperatures control spruce ring width back to ∼1930. Decreasing (increasing) moving correlations with monthly mean temperatures (precipitation) indicate instable growth/climate response during the 1760–2002 period. Crucial June–August temperatures before ∼1900 shift towards May-July temperature plus August precipitation sensitivity after ∼1900. Numerous of comparable subalpine spruce chronologies confirm increased late-summer drought stress, coincidently with the recent warming trend. Comparison with regional-, and large-scale millennial-long temperature reconstructions reveal significant similarities prior to ∼1900 (1300–1900 mean r=0.51); however, this study does not fully capture the commonly reported 20th century warming (1900–1980 mean r=−0.17). Due to instable growth/climate response of the new spruce chronology, further dendroclimatic reconstruction is not performed.

Keywords Alps · Dendroclimatology · Growth/climate response · High–low frequency · Standardization

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Introduction

Tree-ring analyses provide empirical evidence on how trees respond to internal (biotic) and external (abiotic) forcings (e.g., Fritts 1976). Identifying high- to low-frequency wavelengths embedded in long, annually resolved ring width series contributes to a better understanding of past terrestrial ecosystem productivity, e.g., mountain regions (Beniston 2003; Keller et al. 2000; Kienast et al. 1998), with high elevation vegetation being particularly sensitive to temperature changes (e.g., Büntgen et al. 2005a; Frank and Esper 2005a; Schweingruber 1996), and low-elevation vegetation being particularly sensitive to precipitation changes (e.g., Cook et al. 2004; Stahle and Cleaveland 1994; Woodhouse and Overpeck 1998). However, due to the interaction of several climatic forcings (e.g., Nemani et al. 2003), and a complex plant physiology (e.g., Tranquillini 1964), the discrimination of growth response to a single controlling parameter often fails (e.g., Fritts 1976; Schweingruber 1996; Tessier 1989). In the upper and northern timberline ecotone, a thermal boundary for tree growth is generally given (e.g., Körner 1998; Esper and Schweingruber 2004). However, when temperatures are already high, water availability during the relatively short vegetation period becomes key for tree growth (e.g., Anfodillo et al. 1998; Carrer et al. 1998; Masson-Delmotte et al. 2005; Tranquillini 1964).

With ∼74% abundance, Norway spruce (*Picea abies* (L.) Karst.) is the dominant tree species in the Alps, commonly found in montane and subalpine forests (Ellenberg 1996). Recent publications describe the growth/climate response of high-elevation Alpine spruce trees from annual