Trees (2006) 20: 99–110
DOI 10.1007/s00468-005-0017-3

ORIGINAL ARTICLE

Ulf Büntgen · David C. Frank · Martin Schmidhalter · Burkhard Neuwirth · Mathias Seifert · Jan Esper

Growth/climate response shift in a long subalpine spruce chronology

Received: 6 June 2005 / Accepted: 29 June 2005 / Published online: 26 October 2005

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

U. Büntgen (✉) · D. C. Frank · J. Esper
Swiss Federal Research Institute WSL,
Zürcherstrasse 111,
8903 Birmensdorf, Switzerland
e-mail: buentgen@wsl.ch
Tel.: +41-1-739-2679
Fax: +41-1-739-2215

M. Schmidhalter
Dendrolabor Valais,
Sennereigasse 1,
3900 Brig, Switzerland

B. Neuwirth
Department of Geography, University Bonn,
Meckenheimer Allee 166,
53115 Bonn, Germany

M. Seifert
Department of Archaeology Graubünden, Schloss Haldenstein,
7023 Haldenstein, Switzerland

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