Vulnerability of Norway spruce to climate change in mountain forests of the European Alps

Claudia Hartl-Meier[1,2,*], Christian Zang[3], Christoph Dittmar[4], Jan Esper[1], Axel Göttlein[2], Andreas Rothe[5]

[1]**Department of Geography, Johannes Gutenberg University, Johann-Joachim-Becher-Weg 21, 55128 Mainz, Germany**

[2]**Chair of Forest Nutrition and Water Resources, Technische Universität München, Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising, Germany**

[3]**Chair of Ecoclimatology, Technische Universität München, Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising, Germany**

[4]**Environmental Research and Education (UFB), Am Sandacker 25, 95511 Mistelbach, Germany**

[5]**Faculty of Forestry, University of Applied Sciences Weihenstephan-Triesdorf, Hans-Carl-von-Carlowitz-Platz 3, 85354 Freising, Germany**

*Corresponding author: c.hartl-meier@geo.uni-mainz.de
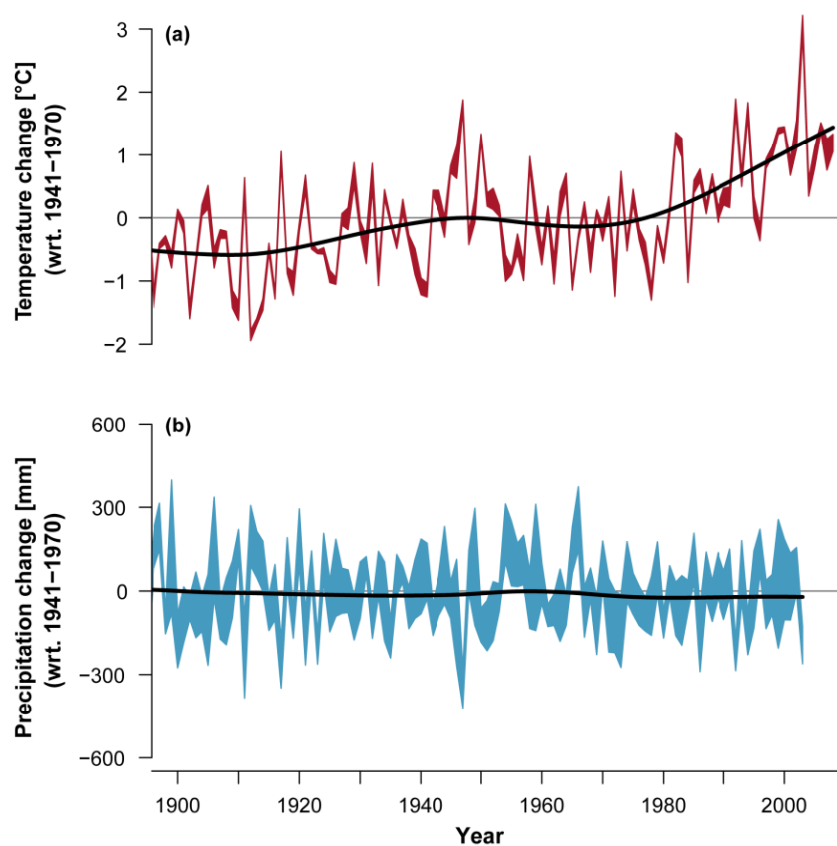
Supplement. Additional data

Fig. S1. Range of vegetation period (May to September) temperature (a) and precipitation (b) anomalies (w.r.t. 1941 to 1970) for the entire study region. Smoothed curves are 10 yr low-pass filters
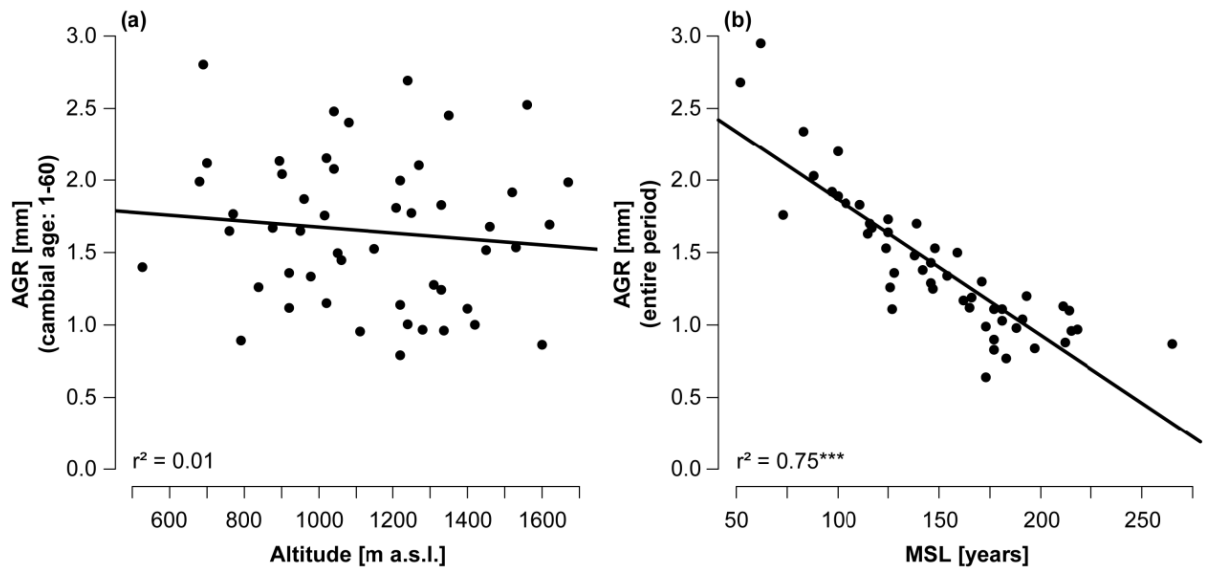
Fig. S2. Relationship (a) between average growth rate (AGR) calculated over the common first 60 yr of the trees' lifespans (cambial age 1 to 60) and site elevation and (b) between AGR calculated over the full individual lifespans and mean segment length (MSL) at each site (***$p < 0.001$)
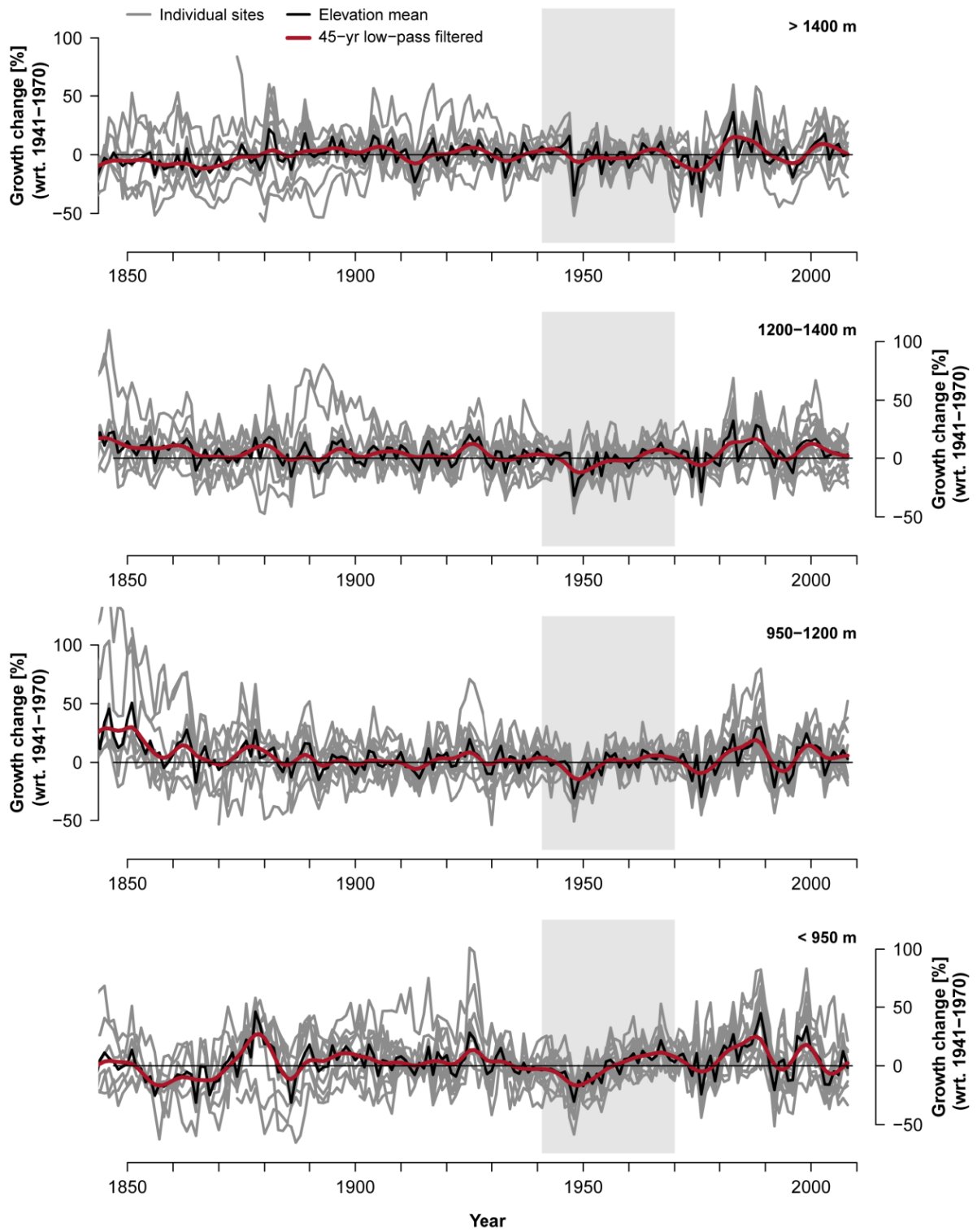
Fig. S3. Percentage growth change (RWI$_{RCS}$ chronologies) of the individual spruce sites (grey) and their elevation means (black). Red curves are 45 yr low-pass filters. Grey bars indicate the 1941–1970 reference period
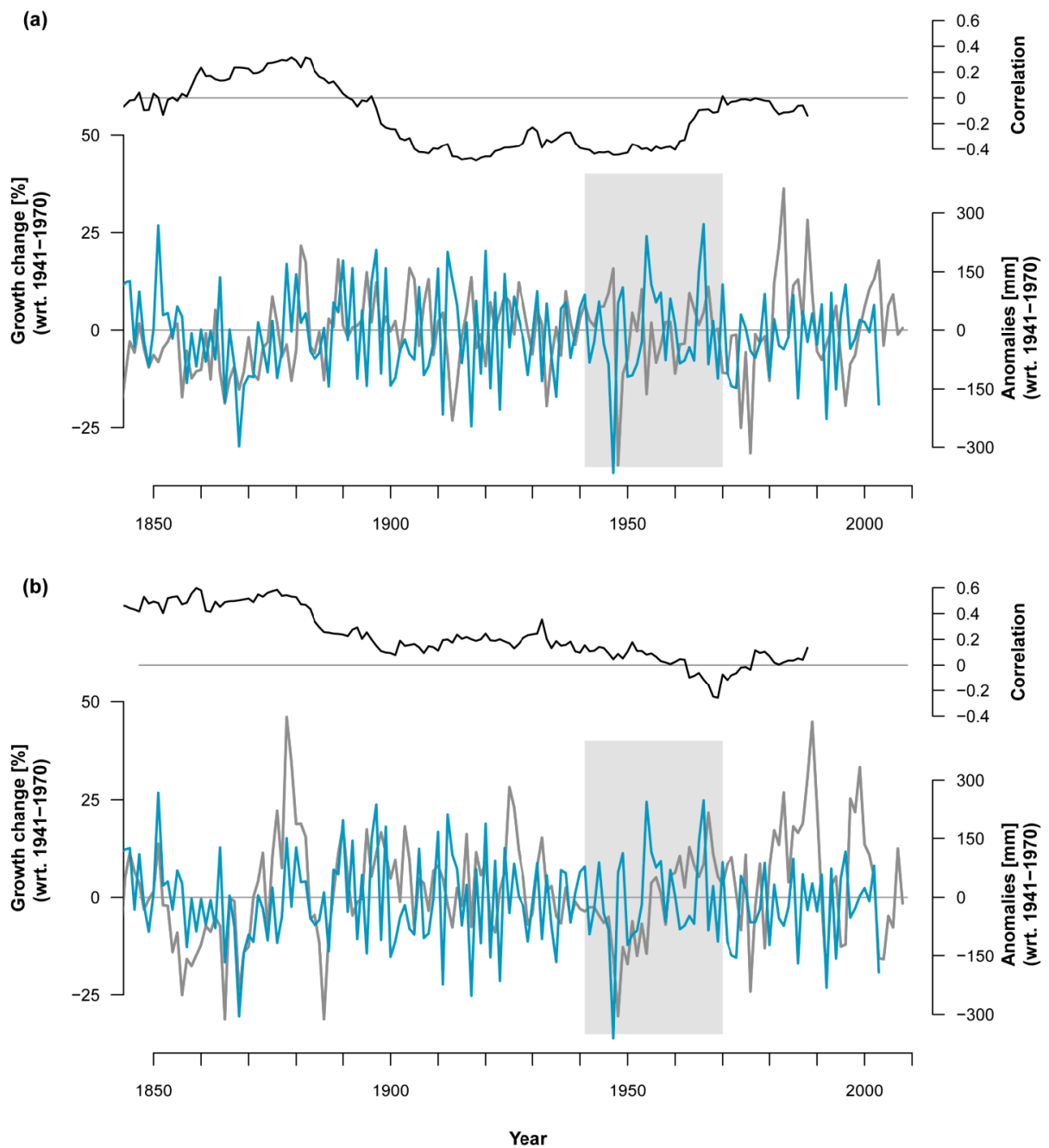
Fig. S4. Comparison of RCS-detrended percentage growth change (grey curves) and precipitation anomalies (blue curves) in the (a) subalpine and (b) lower montane belts. Top panels show running 31 yr correlations (black lines) between the tree-ring and instrumental data. Grey bars indicate the 1941–1970 reference period
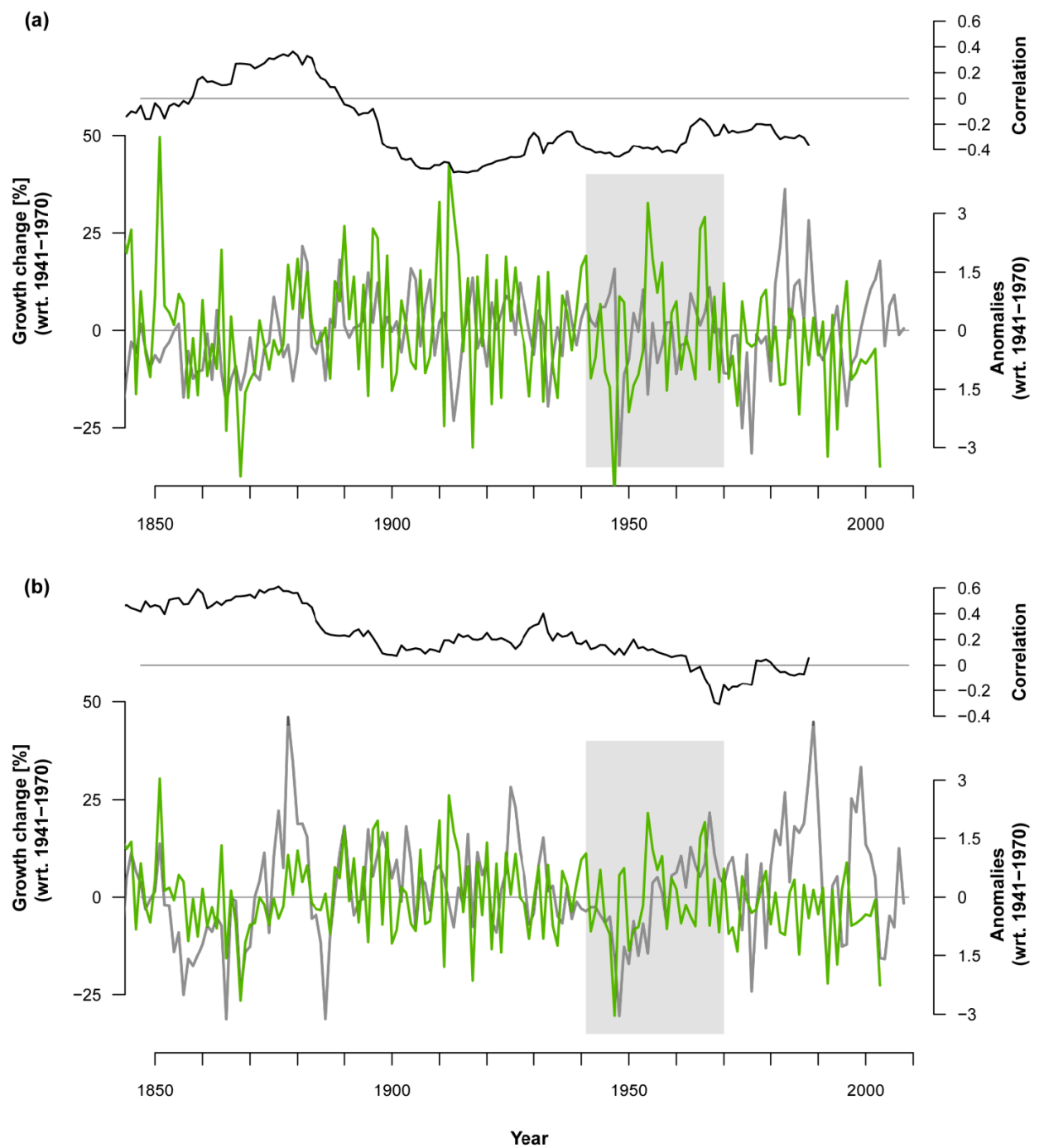
Fig. S5. Comparison of the RCS-detrended percentage growth change (grey curves) and Humidity Index anomalies (green curves) in the (a) subalpine and (b) lower montane belts. Top panels show running 31 yr correlations (black lines) between the tree-ring and instrumental data. Grey bars indicate the 1941−1970 reference period