Long-term change in the sensitivity of tree-ring growth to climate forcing in *Larix decidua*

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Summary

• Tree rings are widely used long-term proxy data which, if combined with long-term instrumental climate records, can provide excellent information on global climate variability. This research aimed to determine whether interannual climate–growth responses in Alpine treeline forests are stationary over time.

• We used tree-ring width chronologies of *Larix decidua* (European larch) from 17 sites and monthly temperatures and precipitation data for the period 1800–1999. Climate–growth relationships were assessed with correlation and response functions, and their stationarity and consistency over time were measured using moving correlation.

• Tree-ring chronologies showed similar interannual variations over the last two centuries, suggesting that the same climatic factors synchronously limited growth at most sites. The most sensitive variables showed significant transient responses varying within the time period, indicating a possible deviation from the uniformitarian principle applied to dendroclimatology.

• If these findings are confirmed in future studies on other species and in other regions, we suggest that time-dependent variables should be taken into account to avoid overestimation of treeline advance, future forest carbon storage in temperature-limited environments and inaccurate reconstruction of past climate variability.

Key words: climate–growth responses, dendroclimatology, *Larix decidua* (European larch), moving correlation function, tree ring, uniformitarian principle.

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Introduction

One of the key questions concerning climate change is whether the temperature increase recorded over the last few decades is really unprecedented. In order to answer this question without bias, it is essential to place current global warming within the context of longer-term climate variability. The main drawback of this up-scaling process is the sparseness of instrumental climate records before the 20th century, requiring the use of 'proxy' indicators to estimate global climate variability during past centuries [see Bradley (1999) for a review; IPCC, 2001].

Tree rings are the most important and widely used sources of long-term proxy data. Their major strengths as climate change indicators are (i) their annual resolution, (ii) the existence of large geographic-scale patterns of synchronic interannual variability, (iii) the increasing availability of extensive networks of tree-ring chronologies, and (iv) the possibility of using simple linear models of climate–growth relationships that can be easily verified and calibrated (Hughes, 2002). Their weaknesses include: (i) an intrinsic sampling bias, given that tree-ring information is available only for terrestrial regions of the globe, (ii) the fact that methods used to extract growth signals from tree-ring series retain only certain wavelengths of climate variability (IPCC, 2001), (iii) the complexity of biological responses to climate forcing, and (iv) the presence of nonclimatic variability in the series attributable to intrinsic growth trends and other nonclimatic disturbances (Fritts, 1976).

Regardless of the biological nature of tree-ring information, James Hutton's principle of uniformitarianism (Britannica