



When tree rings go global: challenges and opportunities for retro- and prospective insights

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The demand for extensive empirical data on forest growth and its climate sensitivity is growing rapidly with continued anthropogenic warming of the Earth. In principal, tree-ring records are the only resource that can provide such information along large environmental gradients and over sub-annual to centennial time scales. Yet, global tree-ring archives have remained an underrepresented resource in Earth system science. Some of the major challenges that complicate the use of existing tree-ring archives in environmental change research include: i) their limited spatial representativity for global forests, ii) varying sampling schemes that often preclude absolute estimates of forest growth, iii) different spatial and temporal resolution compared to remotely sensed and in-situ Earth observations, and iv) uncertainties arising when past climate-growth relationships are extrapolated into the future.

Here we provide a perspective on possible solutions to these issues that emerged from recent and ongoing work. Regarding existing tree-ring networks, we show how spatial interpolation, statistical upscaling, and mechanistic modelling may improve their spatiotemporal coverage. An option to account for non-climatic (e.g. CO₂) effects in projections of changing climate-growth relationships is also presented. Regarding future research avenues, we advocate for intensified data collection in warm regions, improved coordination with Earth observation networks, and refined concepts to integrate tree-ring data with computational estimates of forest productivity. Such efforts are expected to elevate tree-ring data as an essential component in Earth system science.