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Tree-ring isotopes record biome-scale net primary productivity

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Historical and future trends in terrestrial net primary productivity (NPP) and its sensitivity to global change are largely unknown because of the lack of long-term, high-resolution data. The longest flux-tower records and satellite-based estimates cover at most the last three decades, while forest inventories have multiannual to decadal gaps between measurements. For the first time, we tested whether annually resolved carbon (δ^{13}C) and oxygen (δ^{18}O) isotope ratios measured in tree rings of temperate trees could be used as a tool for inferring NPP across spatiotemporal scales. Stable isotope tree-ring chronologies from four forests within three distinct hydroclimatic environments in the eastern United States were compared against satellite-derived NPP products, including the Moderate Resolution Imaging Spectroradiometer (MODIS) NPP product (2000–2015) and the long-term Global Inventory Modeling and Mapping Studies (GIMMS3g) NPP dataset (1982–2011). Our analysis reveals strong matches between tree-ring isotopes time-series and satellite-based NPP estimates in time and space irrespective of tree species and site hydroclimatic conditions. Remarkably, tree-ring δ^{18}O shows enormous potential for inferring past variations of regional to continental terrestrial NPP at annual, decadal and multidecadal time periods. As such, our finding represents an important breakthrough for estimating long-term changes in vegetation productivity at the biome scale.