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Comparison of water-use efficiency estimates based on tree-ring carbon isotopes with simulations of a dynamic vegetation model

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Tree-ring d13C-based estimates of intrinsic water-use efficiency (iWUE, reflecting the ratio of assimilation A to stomatal conductance gs) generally show a strong increase during the industrial period, likely associated with the increase in atmospheric CO_2. However, it is not clear, first, if tree-ring d13C-derived iWUE-values indeed reflect actual plant and ecosystem-scale variability in fluxes and, second, what physiological changes were the drivers of the observed iWUE increase, changes in A or gs or both. To address these questions, we used a complex dynamic vegetation model (LPX) that combines process-based vegetation dynamics with land–atmosphere carbon and water exchange. The analysis was conducted for three functional types, representing conifers, oaks, larch, and various sites in Europe, where tree-ring isotope data are available. The increase in iWUE over the 20th century was comparable in LPX-simulations as in tree-ring-estimates, strengthening confidence in these results. Furthermore, the results from the LPX model suggest that the cause of the iWUE increase was reduced stomatal conductance during recent decades rather than increased assimilation. High-frequency variation reflects the influence of climate, like for example the 1976 summer drought, resulting in strongly reduced A and g in the model, particularly for oak.