Supplementary materials

Disentangling contributions of CO_2 concentration and climate to changes in intrinsic water-use efficiency in the arid boreal forest in China's Altay Mountains

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Running title: Contribution of CO_2 and climate to tree *iWUE* and growth

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Supplement figures:

Figure S1. Comparison between meteorological data and CRU data for May-August (MJJA). (a) Temperature; (b) precipitation; (c) relative humidity; and (d) vapor pressure deficit (VPD). The Pearson correlation coefficient (*r*) and significant statistics (*p*) between CRU data and meteorological data were appended for the period 1961-2011. Both of the climate data from the meteorological station and CRU was z-scored using the standard deviation and mean value for the reference period 1961-2011. The dashed lines are the 30-year spline smooth that indicates decadal and multi-decadal variability. The thick dashed line represents linear regression over period 1961-2011 but 1983-2011 for precipitation. The regression slopes and significant statistics were also provided in the figure.

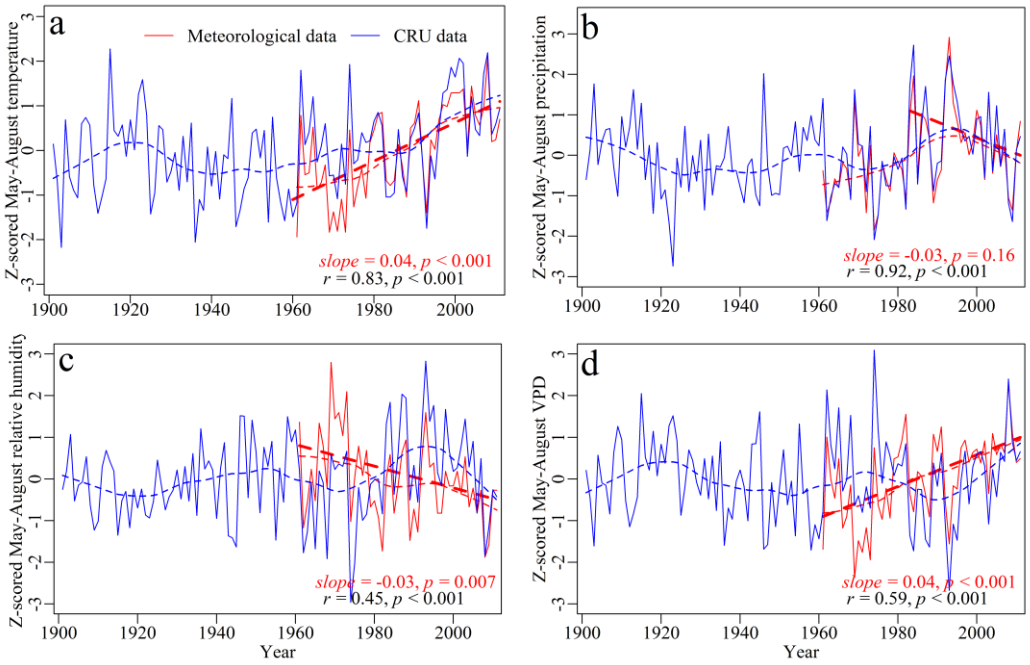


Figure S2. (a) Tree-ring $\Delta^{13}C$ estimated c_i and c_i-climate with their mean value change (dashed lines) for different periods, the change points are detected by mean and variance using the R "Changepoint" package [1]. (b) c_i/c_a ratio estimated from tree-ring $\Delta^{13}C$ and related to May-August climatic PC1 based on τ-adjusted c_i. Variability of c_a during the past 222 years. (c) The variability of tree-ring estimated *iWUE* and *iWUE* variability in the scenario of c_i/c_a constant [2] indicating the proportional changes in c_i in response to CO_2 concentration rising. Herein, we used the mean value of c_i/c_a over the past 222 years. In the figure, the vertical dotted lines indicate the changepoint years. The shaded areas in panel (a) and (c) represent the uncertainty [3].

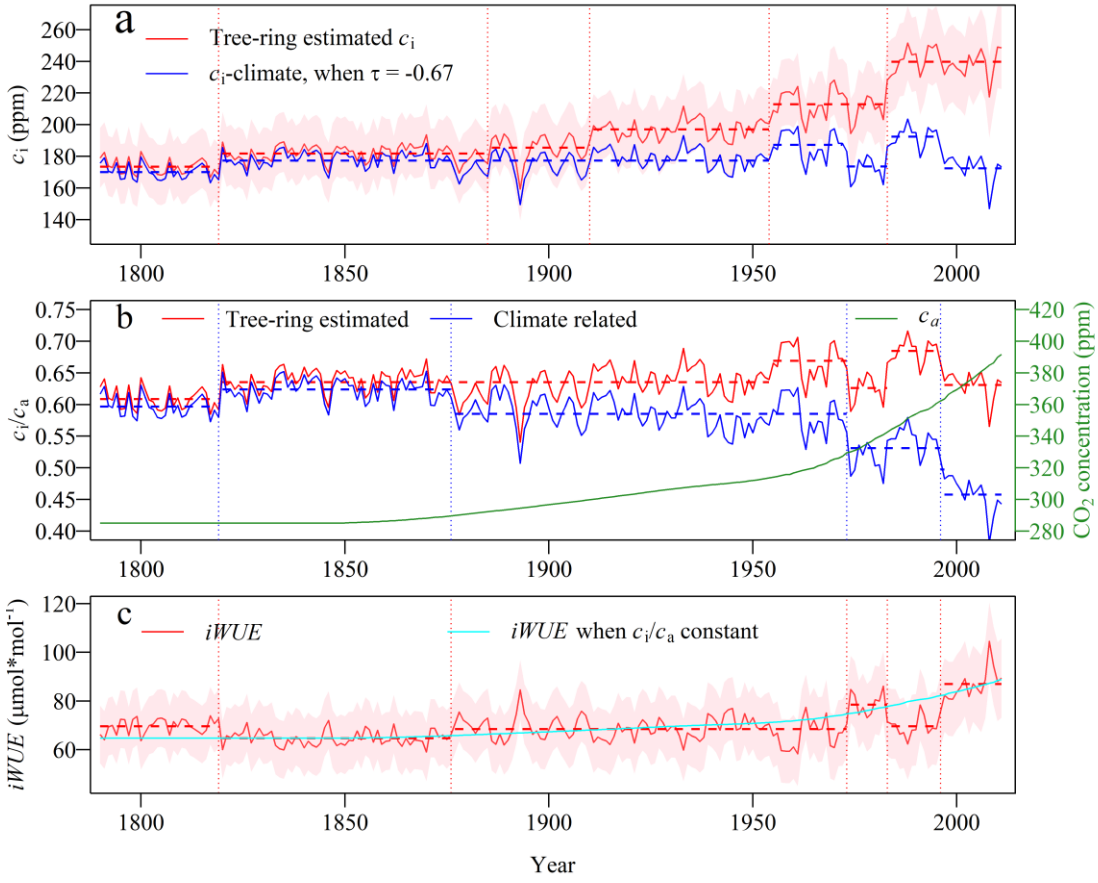


Figure S3. Scatter plots and linear regressions between percent change of *iWUE* and tree-ring width for medium-aged trees during each period at a high-frequency (FOD) time scale. Each core's regression line is indicated by colors and the mean tree-ring width regression line is indicated by black for each period. Only the significant ($p < 0.05$) trends (slope) are labeled.

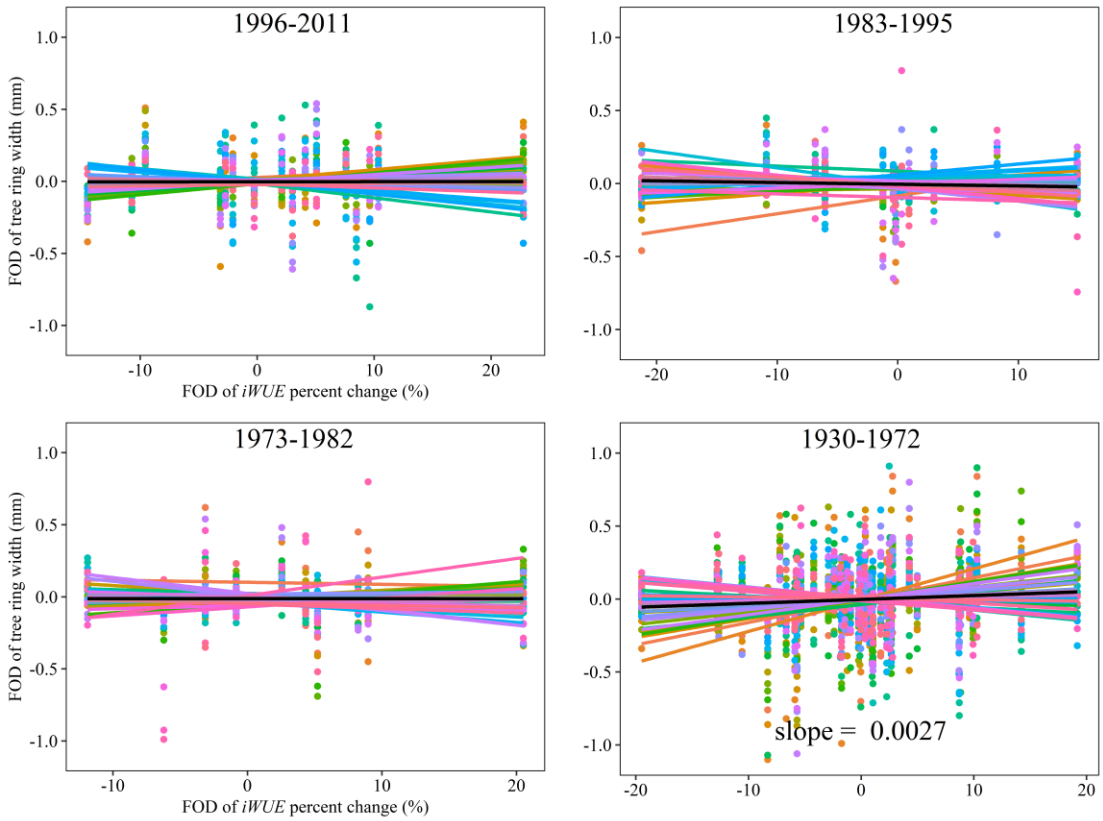


Figure S4. Scatter plots and linear regressions between percent change of *iWUE* and tree-ring width for the nine trees that were used in stable isotope measurements during each period at the annual scale. Each core's regression line is indicated by colors and the tree-ring width mean's regression is indicated by black. The gray shaded area denote the significant intervals of the linear regression between percent change of *iWUE* and mean tree-ring width. Only the significant ($p < 0.05$) trends (slope) are labeled.

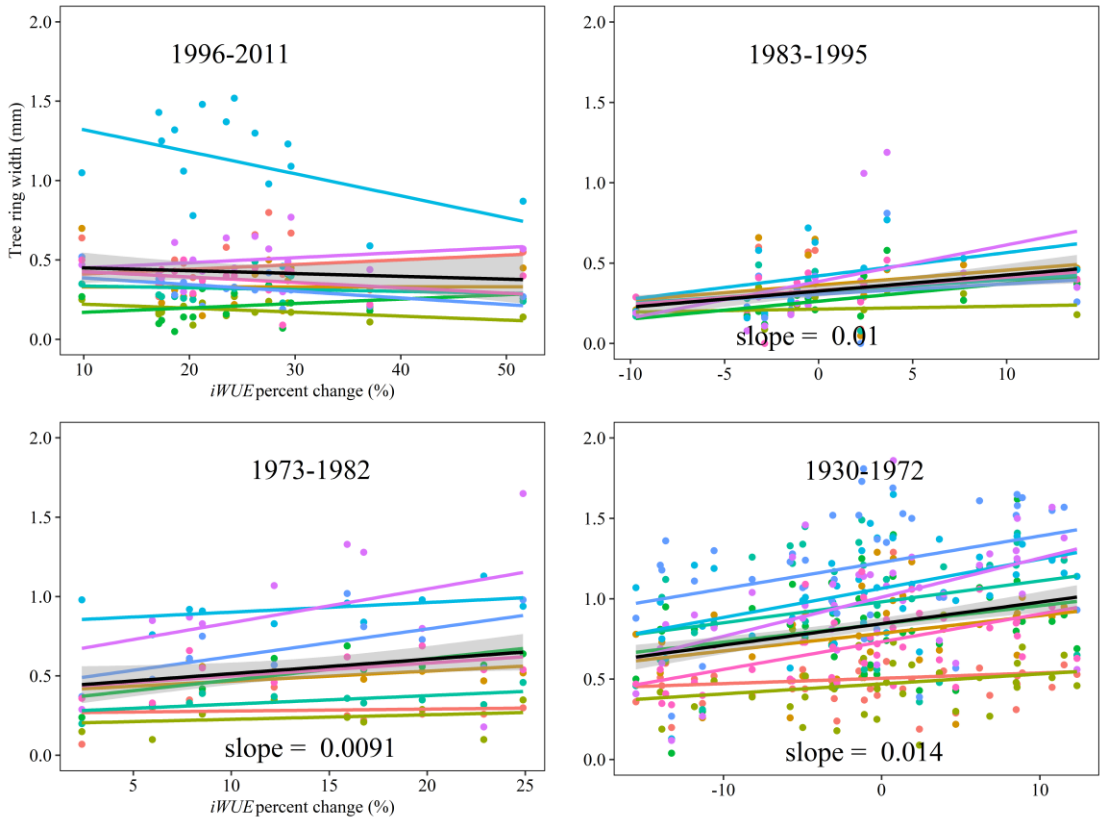
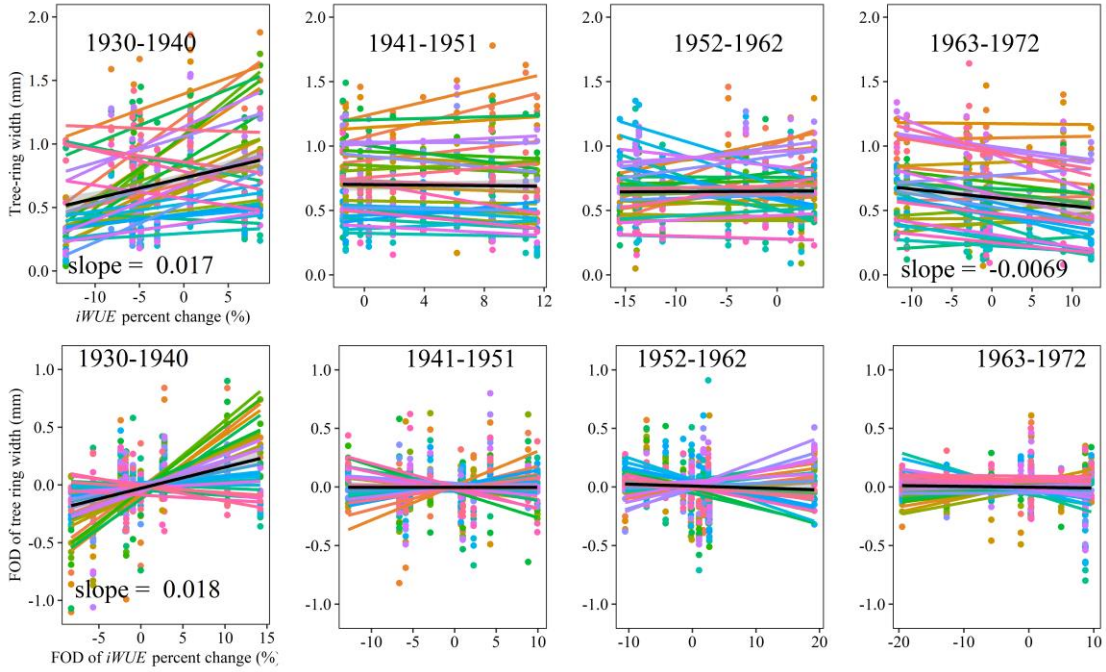


Figure S5 Scatter plots and linear regressions between *iWUE* and tree-ring width for ~11-year consecutive interval for the period 1930-1972 at annual (top) and FOD (lower) time scales. Each core's regression line is indicated by colors and the tree-ring mean's regression is indicated by black. Only the significant ($p < 0.05$) trends (slope) are labeled.



References:

1. Killick, R.; Eckley, I.A. changepoint: An R Package for Changepoint Analysis. *J Stat Softw* **2014**, *58*, 1-19.
2. Saurer, M.; Siegwolf, R.T.W.; Schweingruber, F.H. Carbon isotope discrimination indicates improving water-use efficiency of trees in northern Eurasia over the last 100 years. *Glob. Change Biol.* **2004**, *10*, 2109–2120.
3. Frank, D.C.; Poulter, B.; Saurer, M.; Esper, J.; Huntingford, C.; Helle, G.; Treydte, K.; Zimmermann, N.E.; Schleser, G.H.; Ahlstrom, A., *et al.* Water-use efficiency and transpiration across European forests during the Anthropocene. *Nature Clim. Change* **2015**, *5*, 579-583.