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Using tree rings to quantify 100 years of photorespiration decline

Brian A. Schubert[1] and A. Hope Jahren[2]

[1]*School of Geosciences, University of Louisiana at Lafayette, Lafayette, LA 70504*
[2]*Centre for Earth Evolution and Dynamics, University of Oslo, N-0315, Oslo, Norway*

Photosynthesis has dominated the biological carbon cycle for 100s of millions of years. Photorespiration, the process by which previously fixed glycine is carboxylated to CO_2 within the mitochondrion, is fundamental to all photosynthetic organisms and serves to decrease the overall efficiency of photosynthesis. Increasing atmospheric CO_2 has long been known to diminish rates of photorespiration, and thus increase the net amount of carbon available for the construction of plant tissues. Monitoring of changes in the stable carbon isotopic composition of atmospheric CO_2 at the iconic Mauna Loa Observatory suggested a global decrease in photorespiration by the terrestrial biosphere (Keeling et al., 2017, *PNAS*). This work implicated increased carbon isotope discrimination under rising CO_2 to the diminished photorespiration by the terrestrial biosphere. Growth chamber experiments confirmed the modeled effect of diminished photorespiration on carbon isotope value in C_3 land plants, but a direct measure of photorespiration within the terrestrial biosphere is lacking. Here we present a new global dataset of carbon isotope values measured on annually dated growth rings of trees growing from > 100 sites across the planet. These data reveal a significant increase in carbon isotope discrimination in forests worldwide, consistent in magnitude and trend with the predicted effect of 100+ years of CO_2 increase on photorespiration rates. We identify regions of the planet with lower and higher rates of change, and find these deviations to be consistent with changes in stomatal conductance and water use efficiency associated with regional climate change. This work provides a quantitative approach to understanding carbon isotope trends across the last 100+ years of changing climate and CO_2, by incorporating the effect of photorespiration on carbon isotope discrimination.