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Plant photorespiration reconstructed with isotopic clumping in wood methoxyl groups

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The amount of carbon in the atmosphere is determined by the fluxes that add carbon to the atmosphere and those that draw it out. One flux of particular importance is photorespiration of land plants. The enzyme Rubisco is used by organisms to fix CO_2 and release O_2, but about one third of Rubisco's activity in land plants instead fixes O_2 and releases CO_2 in the process termed photorespiration. Simple models and laboratory experiments suggest that photorespiration rate depends on temperature and atmospheric pCO_2. Photorespiration rates in nature should therefore vary with climate in the present and past.

Here we present a new potential proxy for plant photorespiration rate based on the abundance of wood methoxyl groups (R-O-CH_3) containing two rare isotopes, $^{13}CH_2D$. Methoxyl groups can be formed from metabolic intermediates of both photosynthesis and photorespiration. Thus, the isotopic composition of methoxyl groups in an individual plant may depend on the relative contribution from each pathway. We tested this hypothesis with natural experiments where we fixed one parameter (T or pCO_2) and varied the other. Among trees growing at similar pCO_2 levels but in different climates, methoxyl clumping correlates with temperature. The direction of the correlation appears to depend on water availability. For trees grown at similar temperatures but different pCO_2 levels in water-replete environments, methoxyl clumping positively correlates with pCO_2. The correlation between pCO_2 and methoxyl clumping held for different trees grown outdoor enrichment chambers, and in rings from a single tree that has changed its metabolism over the industrial era. These relationships are consistent with simple models of plant metabolism if methoxyl clumping is a proxy for relative photorespiratory export. We will discuss implications of this proxy for how plant photorespiration rate varies today, and how it differed in the past.