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No evidence for triose phosphate limitation of light-saturated leaf photosynthesis under current atmospheric CO_2 concentration

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Abstract

The triose phosphate utilization (*TPU*) rate has been identified as one of the processes that can limit terrestrial plant photosynthesis. However, we lack a robust quantitative assessment of *TPU* limitation of photosynthesis at the global scale. As a result, *TPU*, and its potential limitation of photosynthesis, is poorly represented in terrestrial biosphere models (TBMs). In this study, we utilized a global data set of photosynthetic CO_2 response curves representing 141 species from tropical rainforests to Arctic tundra. We quantified *TPU* by fitting the standard biochemical model of C_3 photosynthesis to measured photosynthetic CO_2 response curves and characterized its instantaneous temperature response. Our results demonstrate that *TPU* does not limit leaf photosynthesis at the current ambient atmospheric CO_2 concentration. Furthermore, our results showed that the light-saturated photosynthetic rates of plants growing in cold environments are not more often limited by *TPU* than those of plants growing in warmer environments. In addition, our study showed that the instantaneous temperature response of *TPU* is distinct from temperature response of the maximum rate of Rubisco carboxylation. The new formulations of the temperature response of *TPU* derived in this study may prove useful in quantifying the biochemical limits to terrestrial plant photosynthesis and improve the representation of plant photosynthesis in TBMs.

KEYWORDS

A/C_i curves, C_3 photosynthesis, maximum carboxylation capacity, potential electron transport rate, temperature, terrestrial biosphere models

1 | INTRODUCTION

Terrestrial biosphere models (TBMs) are one of the principal tools used to estimate the impact of climate change on terrestrial vegetation (Medlyn et al., 2011; Mercado et al., 2018; Rogers, Serbin, et al., 2017). Plant photosynthesis is one of the key components in these models. Robust representation of photosynthesis and its response to climate change are important for predicting the response of terrestrial vegetation to global change. Many TBMs incorporate the Farquhar, von Caemmerer, and Berry (1980) biochemical model of C_3 photosynthesis (FvCB hereafter) to estimate terrestrial gross primary productivity (GPP; Rogers, Medlyn, et al., 2017). Hence, the effect of climate change on modelled GPP depends on the formulation and parameterization of the FvCB model, and in particular, on the sensitivity of the key model parameters to environmental variables such as temperature, atmospheric CO_2 concentration, and soil moisture (Smith & Dukes, 2013).

