

SENSITIVITY OF GLOBAL GROSS PRIMARY PRODUCTION TO ELEVATED CO₂

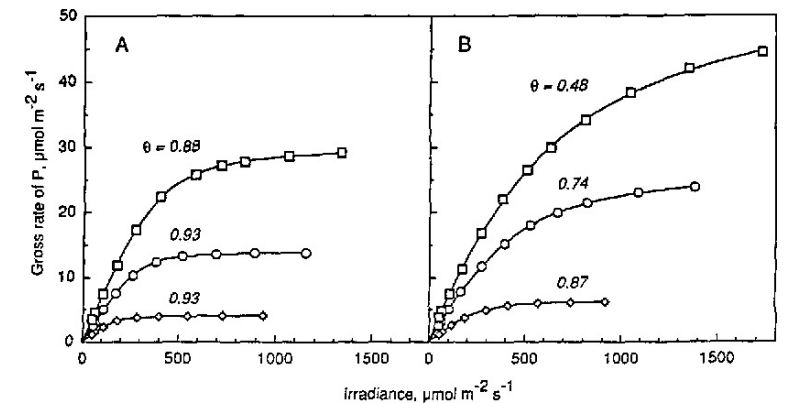
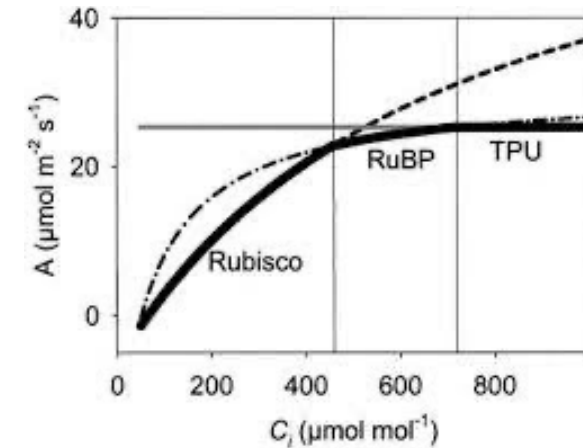
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CENTRAL PARAMETERS IN LEAF PHOTOSYNTHESIS BIOCHEMICAL MODELS

- Terrestrial photosynthetic carbon uptake is one of the largest CO_2 fluxes, subsidizing about 1/3 of the anthropogenic CO_2 emission, therefore is critical in achieving the 1.5 °C target in Paris Agreement.
- Yet the projection of terrestrial plant carbon uptake response to elevated CO_2 depends on realistically representation of biochemical models of leaf photosynthesis.
- Here we focus on two central parameters:
 - **The ratio of $J_{\text{max}}/V_{\text{cmax}}$** , which sets the transition point in A-ci curve above which photosynthesis becomes RuBP-limited (limited by J_{max}) rather than Rubisco-limited at low C_a (limited by V_{cmax}) (see top figure).
 - **The convexity of the light response curve (θ)**, which controls the shape of light response curve, thus determines the photosynthetic efficiency in light-limited conditions (see bottom figure).



SCHEME AND MODELS

Here we apply the change in **relative light use efficiency (LUE)** from three models based on fvcb model under standard condition to avoid the impact of light, temperature and drought.

relaLUE

(Normalized at 400 ppm)

CO₂ limitation term

Jmax limitation

Keenan16

$$LUE_{re} = m$$

Wang17

$$LUE_{re} = m \sqrt{1 - \left(\frac{c^*}{m}\right)^{\frac{2}{3}}}$$

Smith19

$$LUE_{re} = \frac{m\omega^*}{8\theta}$$

Reference:

Keenan et al. Nat. Commun. 2016

Wang et al. Nat. Plants. 2017

Smith et al. Ecol. Lett. 2019

$$m = \frac{c_a - \Gamma^*}{c_a + 2\Gamma^* + 3\Gamma^* \sqrt{\frac{1.6D\eta^*}{\beta(K+\Gamma^*)}}}$$

$$c^* = 4c$$

$$c = \frac{\partial A}{\partial J_{max}} = 16(c_i + 2\Gamma^*)^2 (c_i - \Gamma^*) \left(\frac{V_{cmax}}{J_{max}(c_i + K)} \right)^3$$

$$m^* = \frac{4c}{\frac{-3.4 + \sqrt{3.4^2 - 4(-3.4\theta)(-1)}}{2(-3.4\theta)}}$$

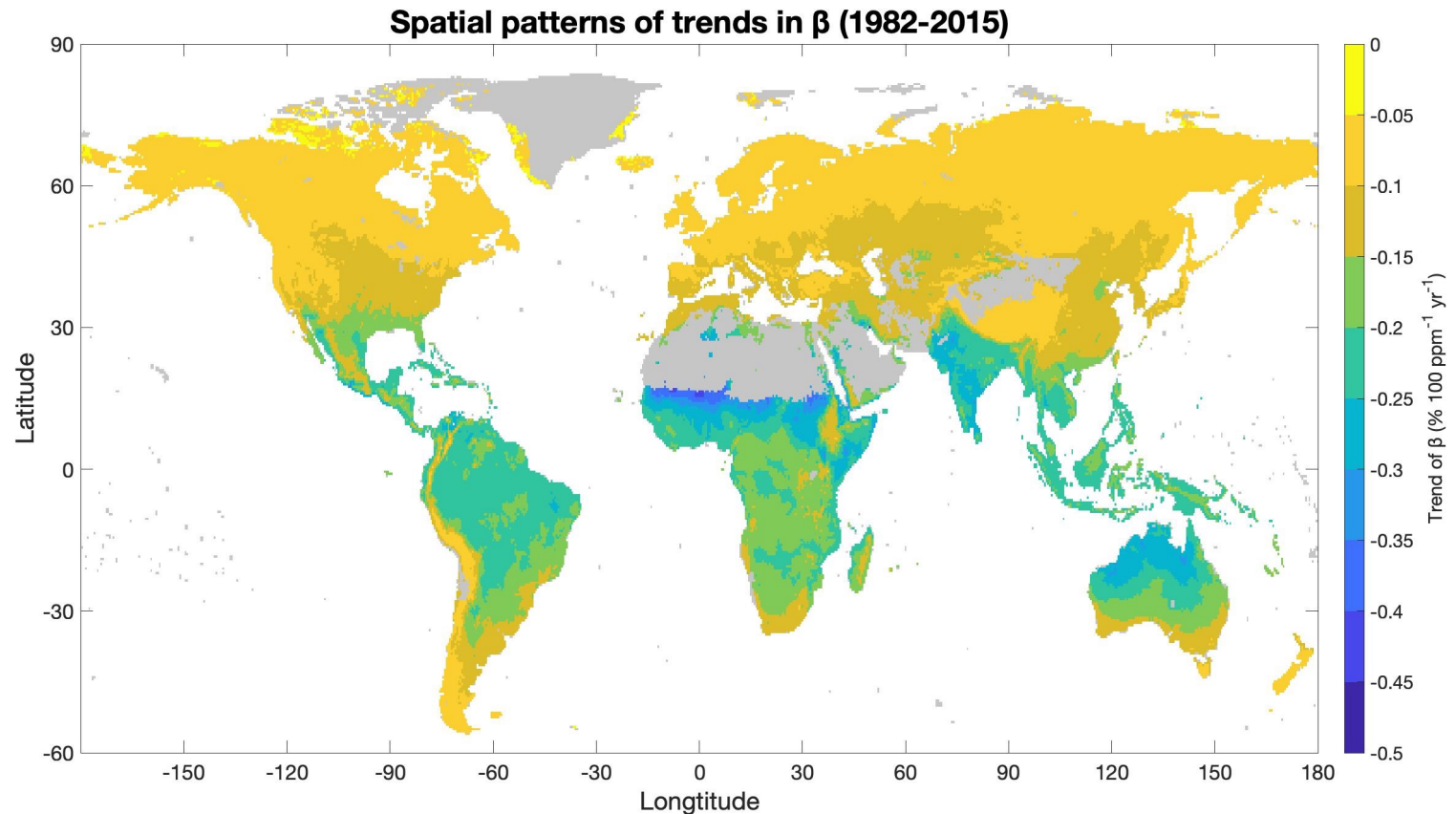
$$\omega = \begin{cases} -(1 - 2\theta) - \sqrt{(1 - \theta) \left(\frac{1}{\frac{4c}{m}(1 - \theta \frac{4c}{m})} - 4\theta \right)} & m < m^* \\ -(1 - 2\theta) + \sqrt{(1 - \theta) \left(\frac{1}{\frac{4c}{m}(1 - \theta \frac{4c}{m})} - 4\theta \right)} & m > m^* \end{cases}$$

$$\omega^* = 1 + \omega - \sqrt{(1 + \omega)^2 - 4\theta\omega}$$

Codes for analysis is available in
https://github.com/Shirleycwj/LUE_CO2

CO₂ FERTILIZATION EFFECT AT GLOBAL SCALE

- CO₂ fertilization effect (CFE) is generally defined as the relative increase in gross primary production (GPP) in response to a 100-ppm increase in atmospheric CO₂ concentration (α).
- Using GPP simulated as in Wang et al. 2017, here we quantify CFE during the period of 1982-2015 and the trend in CFE (denoted as β).
- Global β during study period is 15.43% 100 ppm⁻¹, consistent with 15.5% 100 ppm⁻¹ from the FACE experiment.
- The declining trend of β varied across the global, with near no trend in northern mid to high latitude.



CO₂ FERTILIZATION EFFECT AT GLOBAL SCALE

- We present the trend of β based on a 15-year moving window, which showed the CFE declined at a rate of $-0.16 \pm 0.002\% \text{ } 100 \text{ ppm}^{-1} \text{ yr}^{-1}$, similar to that derived from TRENDY v6 ensemble ($-0.12 \pm 0.01\% \text{ } 100 \text{ ppm}^{-1} \text{ year}^{-1}$).
- The distribution of β during the first and the last moving window is showed in histogram and box plot, suggesting that despite the trend in β is significant, β only decreased slightly across the globe. However with a narrower range of β , the overall benefits brought by elevated CO₂ might be further diminished in the future.

