

IMPROVED REPRESENTATION OF PHOTOSYNTHETIC TEMPERATURE RESPONSE IN TERRESTRIAL BIOSPHERE MODELS

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Photosynthesis, a key process of the terrestrial carbon cycle, is crucial for predicting ecosystem responses to climate change. Terrestrial biosphere models (TBMs) commonly use the biochemical model of C3 photosynthesis, which relies on two primary parameters: V_{cmax} (maximum Rubisco activity) and J_{max} (maximum electron transport rate). The temperature responses of these parameters are often modeled using the peaked Arrhenius function, relying on K_{25} (process rate at 25°C), E_a (activation energy), H_d (deactivation energy), and ΔS (entropy). To avoid overfitting, most studies assume a fixed H_d ; however, the impact of this assumption remains untested. In this study, using a global scale dataset of plant photosynthetic temperature response, we compared the temperature response of V_{cmax} and J_{max} by fitting with and without assuming a fixed H_d . For V_{cmax} , found a strong relationship between the fixed and variable H_d models for K_{25} ($R^2=0.85$, $p<0.001$), suggesting that assuming a fixed H_d moderately captures the observed variability in K_{25} . However, the relationships were weak for E_a ($R^2=0.04$, $p=0.22$) and ΔS ($R^2=0.16$, $p=0.045$), indicating limited suitability of the fixed H_d assumption for these parameters. For J_{max} , K_{25} similarly showed a moderate correlation between models ($R^2=0.66$, $p<0.001$), whereas E_a ($R^2=0.14$, $p=0.015$) and ΔS ($R^2=0.04$, $p=0.19$) displayed weak to negligible relationships, highlighting limited applicability of the fixed H_d approach. These findings suggest that while a fixed H_d assumption may be reasonable for K_{25} in both V_{cmax} and J_{max} models, it does not adequately capture the temperature dependence of E_a and ΔS , which could lead to inaccuracies in TBMs. Further investigation into the variable H_d model's benefits for temperature response accuracy is warranted.

Keywords: J_{max} , Photosynthesis, Terrestrial biosphere models, V_{cmax}