

Impact of Vertical and Seasonal Variation in Leaf Traits on Simulating Soybean Canopy Photosynthesis via 1D and 3D Modeling

Background/Objective

Accurate modeling of photosynthesis is crucial for predicting crop productivity, with leaf traits being essential inputs in these models. However, many existing models use fixed values to parameterize leaf traits, neglecting their vertical profiles and seasonal changes. This may introduce significant uncertainties in the estimation of gross primary productivity (GPP). This study tests the effects of vertical and seasonal variation in key leaf photosynthetic traits in the simulation of soybean GPP.

Approach

This study tested the effects of maximum carboxylation rate at 25°C ($V_{cmax_{25}}$), leaf chlorophyll content (LCC), and leaf mass per area (LMA) in the 1D-SCOPE and 3D-Helios models. Data from weekly field measurements supported the model simulations. Researchers designed ten leaf trait parameterization schemes by incorporating different combinations of vertical profiles and seasonal changes, while assuming homogenous canopy architecture in both models.

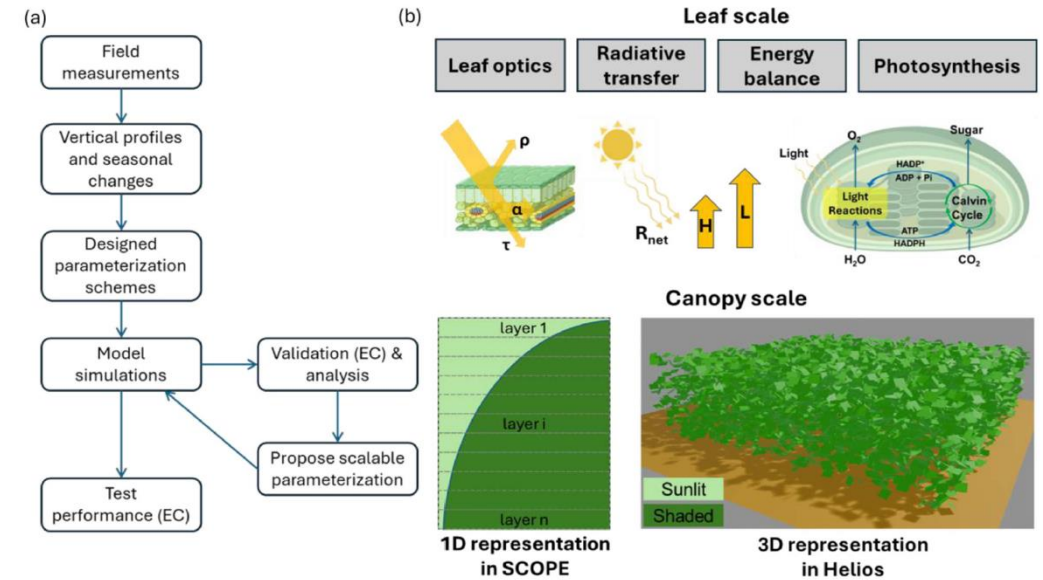
Results

Results showed the $V_{cmax_{25}}$ vertical and seasonal variation had the strongest influence on simulated GPP in both models while LCC and LMA effects were minimal. The scheme with an empirically parameterized $V_{cmax_{25}}$ profile achieved comparable performance to the scheme with the measured $V_{cmax_{25}}$ profile. Both models accurately modeled GPP under the most complex scheme and their responses to vertical and seasonal variation in leaf traits were consistent, demonstrating the robustness of our findings.

Significance/Impacts

This work proposes a scalable framework for parameterizing leaf traits for improved GPP simulations and contributes to improving representation of leaf trait dynamics in canopy-level photosynthesis models, potentially enhancing our ability to predict crop productivity and understand agroecosystem carbon dynamics.

Wang et al. 2026. "Impact of Vertical and Seasonal Variation in Leaf Traits on Simulating Soybean Canopy Photosynthesis via 1D and 3D Modeling." *Agricultural and Forest Meteorology*. DOI: 10.1016/j.agrformet.2025.110941.



(a) Overall workflow and (b) Model processes involved in this study (ρ : reflection, α : absorption, τ : transmission, R_{net} : net radiation, H : sensible heat, L latent heat, EC: eddy covariance)