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Dynamic light extinction coefficient: A key to improve evapotranspiration partitioning for orchards in diverse climates

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Abstract: Evapotranspiration (*ET*) and its components (Transpiration *T* and evaporation *E*) are important processes associated with water, energy, and carbon cycles, and play a vital role in water demand-supply relationships that are key factors affecting agricultural production. Accurate estimation of *ET* and its components is necessary for developing practical and efficient water management technologies.

T depends largely on available energy, the interception of solar radiation by the plant canopy. Light extinction coefficient (*C*) describes the efficiency of light intercepted by the plant canopy. Therefore, accurately quantifying *C* is a primary premise for appropriate partitioning of radiant energy between a vegetation canopy and the soil surface. Numerous previous studies have clearly shown that measured *C* varied widely with season, even within a day (Liu et al., 2021). However, *C* is commonly set as a fixed constant in most *ET* related models, resulting in large potential prediction uncertainty. Some scholars have attempted to quantify *C* variations based on relationships between *C* and leaf area index (*LAI*). However, *C* has been also reported to be affected by environments (Stocker et al., 2018). Thus, we focused on more effective quantification of *C* dynamics, aiming to achieve more accurate estimations of *ET* and its components by considering *C* variation patterns.

In this study, observations were conducted from multiple sites across different climates and orchard types in China, i.e., an orange orchard located in the hot-dry valley region of southwest China, three orchards (jujube, apple and grape) located in the Loess Plateau region of northwest China, and a grape greenhouse located in the northeast China Plain. It was found that measured *C* indeed varied considerably with growth status (*LAI*) and environmental conditions (Net radiation, air temperature and soil water content) over the growing seasons at different study sites. Based on these relationships, a new method was proposed to capture *C* dynamics. Although the main factors driving *C* variation differed from site to site, the new proposed method successfully captured *C* dynamics based on multiple influencing factors. Additionally, more than 10 dynamic *C* and fixed *C* schemes were individually embedded in the Penman-Monteith model and Shuttleworth-Wallace model for both daily and hourly simulation. Then comprehensive comparisons were made to determine the most effective *C* scheme for simulating *ET* and its components based on a Bayesian framework.

Results showed that compared with the model using the fixed *C* scheme, all dynamic *C* models achieved better performance than constant ones by increasing transpiration or evaporation estimation accuracy and decreasing model uncertainty. However, considering dynamics of *C* only improved components but not total *ET* estimation performance, so it is beneficial just for *ET* partitioning. Because, the total energy, which is a determined value without influence from *C*, is used to drive ET. While the total energy partitioned to the part intercepted by the canopy (drive *T*) and transmitted to the soil (drive *E*) are variable depending on *C*. Moreover, model performance improvement was more significant at sites with more serious environmental stresses. The results of our study emphasize the necessity for considering dynamic *C* patterns in water consumption research, particularly for regions facing severe abiotic stresses that are likely to occur in many regions under future climate conditions.

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