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Studying on the Transpiration of Urban Shrubs by the Three-Dimensional Three-Temperatures Model and Isotopic Method

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Shrub vegetation is one of most important component of urban green space and its transpiration (T) plays an important role for improving the urban environmental quality. However, because there is no suitable method to measure the T rate of urban shrubs, leading this field been blank for a long time. To overcome this challenge, we first improved the original "three-temperature model (3T model) + infrared (IR) remote sensing" method to "three-dimensional (3D) 3T model + IR remote sensing" method, considering the top, bottom, and side surfaces of the canopy that all have transpiration. Then we using the improved methodology to measure T rate of several shrub hedges in urban. Finally, we verified the improved method by using isotopic method with eddy covariance (EC).

Results show that the reference leaf (a leaf without transpiration) temperature in the 3T model could be well estimated by using the maximum surface temperature in the temperature imaging (measured by thermal camera), which is also well tested by our Bowen ratio measurement for an urban lawn field. The accuracy of the 3D-3T model is also test by using urban arbor tree in which its T rate could be measured by sap flow method. Regression analysis shows a good correlation between sap flow method and the 3D-3T model method in arbor tree, indicating good applicability for 3D-3T model to estimate transpiration under urban condition. For further research to direct verify the 3D-3T model for urban shrubs, we use the combination of stable isotope and EC. This method can determine the magnitudes of evaporation and transpiration and can serve as a direct verification to the result of 3D-3T model method. And finally convert energy consumption to equivalent electricity consumption through air conditioner to compare transpiration cooling effect of urban shrubs.

To the best of our knowledge, this is the first study in the world that the transpiration rate of urban shrub hedges can be accurately measured. The improved "3D-3T model + IR remote sensing" could be powerful ways for urban transpiration measurement.