26th International Congress on Modelling and Simulation, Adelaide, SA, Australia, 30 Nov–4 Dec 2025
mssanz.org.au/modsim2025

A new physics-guided deep learning model for improving plant transpiration estimation under water-limited conditions

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Abstract: Plant transpiration (E_c) plays a key role in land-surface energy and water balance. Although a simplified physical E_c estimation model (hereafter BTA) has recently been proposed and performs well under sufficient water conditions, it fails during water stress periods. To address this limitation, we develop a new physics-guided deep learning (PGDL) model for improving daily E_c estimation. The PGDL model couples a DL model, which estimates the environmental stress function from observations as an intermediate variable, with the BTA in an end-to-end setting. The proposed model is evaluated on forest sites globally using the FLUXNET dataset, and the interpretable stress function is further investigated to understand how various forests respond to drought across diverse bioclimatic characteristics.

A preliminary test shows that the proposed PGDL model enhances the estimation accuracy of both baselines, with NSE (RMSE) increasing (decreasing) by 0.06–0.61 (0.04–0.31 mm/d) relative to the BTA, and by 0.01–0.06 (0.01–0.04 mm/d) relative to the DL, across all eleven selected sites. Fig. 1 shows the potential of PGDL model to overcome the limitation of the BTA model.

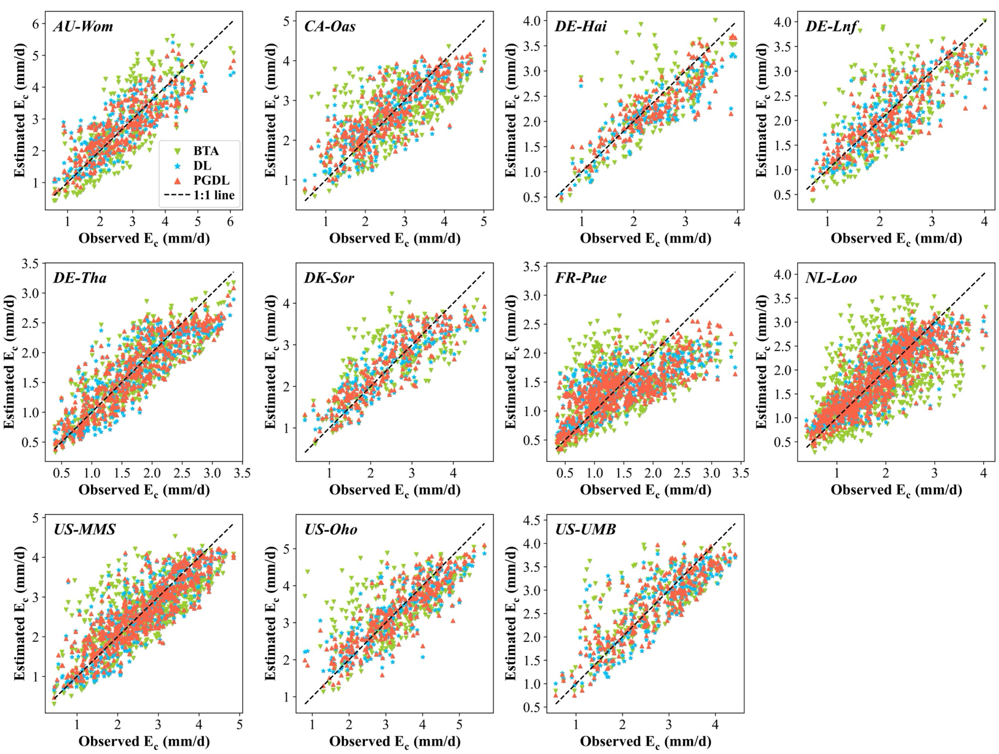

Fig. 1 Scatter plots between the observed and estimated E_c from the PGDL and two baseline models on the test sets for eleven selected sites.

Keywords: *Plant transpiration, physics-guided deep learning, water stress function*