Comparing the observed and predicted actual evapotranspiration in lumped conceptual hydrological models

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Abstract: Water resources are crucial for various human activities and industrial processes, with hydrological models playing an important role in simulating catchment water balances and estimating future water availability. Lumped conceptual models, which simplify hydrological features and processes using a limited set of equations and parameters, are widely used due to their efficiency and reduced computational time. However, climate change challenges their effectiveness, as conceptual hydrological models assume hydrological processes are stationary over time, while in reality such processes are sensitive to climate shifts. Studies reveal that hydrological models struggle to accurately simulate different climate conditions, particularly during dry periods. A potential contributing factor to non-stationarity in lumped conceptual hydrological models could be inaccuracies in actual evapotranspiration (AET) predictions. Accurately predicting AET is vital for computing the water balance and predicting stormflow, but the current approach often leads to oversimplification of the complex evapotranspiration process.

This study compares observed actual evapotranspiration (AET) with simulated AET in two unimpaired Australian catchments characterized by contrasting climatic conditions and hydrological regimes. Eddy covariance flux towers from TERN provided observed AET. This study examines four hydrological models, including GR4J, AWBM, HBV and HYMOD, all operating on a daily time step. Nash-Sutcliffe Efficiency (NSE) and Kling-Gupta Efficiency (KGE) were used as the objective functions for the model calibrations.

Results show that (1) All four models have limited ability in accurately simulating AET on a daily scale. Both the timing and magnitudes of simulated AET deviate from the observed AET values. For instance, in the case of the Daly catchment, the NSE values for the daily AET simulations peaked at 0.13, demonstrating a substantial disparity. (2) The selected hydrological models can represent the cumulative AET as the models try to close the water balance in the long term. As a result, differences between simulated AET and observed AET at the monthly scale is less pronounced than that on the daily scale. In the Daly catchment, the NSE values for the monthly AET simulations hovered around 0.6 for AWBM, HBV, and HYMOD, indicating a better fit. Meanwhile, the GR4J model displayed a shift from negative NSE values for daily AET to a slightly above 0 NSE for monthly AET. Pearson's Correlation Coefficient increased by at least 0.1 when transitioning from daily to monthly AET. The Warra catchment showed a similar trend. (3) Simulated AET is not sensitive to the objective function used for the model calibration. The difference in NSE values for daily AET simulations due to different objective functions was a maximum of 0.06 and 0.1 in the Daly and Warra catchments, respectively. Further research will involve a detailed analysis of the AET algorithms within the conceptual models, aiming to identify potential improvements and enhance the accuracy of evapotranspiration predictions.

Keywords: *Lumped conceptual models, actual evapotranspiration, eddy covariance flux tower*