A Deep Learning-Based Ensemble Surface Energy Balance Modeling Approach to Monitor Crop Water Use and Water Stress in drylands

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Abstract

Most remote sensing-based surface energy balance (SEB) models are limited by data availability and physical constraints to fully capture the non-linear and temporally varying nature of atmospheric, biophysical, and environmental controls on evapotranspiration (ET). As such, currently, no single SEB model is considered to work best under all conditions particularly in irrigated croplands where surface moisture conditions could change dramatically in a short amount of time. Hence, irrigation water management based on a single remotely sensed ET model is often required to cope with model limitations and data latency issues, which could lead to unsustainable and unreliable accounting of water use over time. The recent inception of ensemble-based ET modeling takes the advantage of the strengths of the several SEB models under different conditions and is found to perform better as compared to an Individual model. Yet, challenges remain in how high-temporal ET outputs from different models are accurately assembled in a way that yields the most reliable estimates of ET across any environmental and surface conditions. Specifically, existing simple or Bayesian average and machine learning-based ensemble approaches have not been able to optimally utilize the comprehensive suite of existing SEB models and the availability of multiple remotely sensed datasets. Here, we discuss the utility of convolutional neural networks (CNNs) to assemble the outputs from a host of SEB models that can robustly capture the non-linear dynamics of ET under all conditions. We will also discuss the advantage and potential limitations of using the CNN-based ensemble ET modeling framework with respect to the individual, simple or Bayesian average, and other machine learning approaches and their implications for use in allocating water use across critically dry regions. Several ensemble models will be trained using eddy covariance flux data globally and will be evaluated based on their ability to estimate ET from MODIS and Landsat sensors with both individual and fused products and minimal weather inputs. The results can provide useful insights into how multiple datasets and SEB models could be optimally utilized to accurately monitor crop water status and support sustainable water resource management in drylands.

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MODIS and Landsat sensors with both individual and fused products and minimal weather inputs. The results can provide useful insights into how multiple datasets and SEB models could be optimally utilized to accurately monitor crop water status and support sustainable water resource management in drylands.

1. Bai, Y., et al., *On the use of machine learning based ensemble approaches to improve evapotranspiration estimates from croplands across a wide environmental gradient.* Agricultural and Forest Meteorology, 2021. **298-299**: p. 108308.