Accounting for Geographical and Seasonal Variation into Tall to Short Crop Reference ET Ratios Across CONUS Using Machine Learning

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Why do we need ET_r to ET_o ratios?

- The crop coefficient (K_c) values for alfalfa or grass reference surfaces cannot be used interchangeably with ET_o or ET_r to estimate actual crop water use. It's specific to regions and weather networks typically only report either of them.
- The ASCE Standardized Penman-Monteith model uses a correction factor (K_r) (ET_r/ ET_o ratio) to account for differences in reference surface characteristics and environmental factors. Understanding and predicting this ratio and its variation is important for standardization.
- One method proposed in FAO-56 (Allen et al., 1998) estimates K_r values based on climate variables.

Is the FAO-56 K_r equation adequate for predicting daily variation in observed K_r across different climates?

Is it possible to develop a more effective method for predicting daily K_r?

How did we evaluate this?

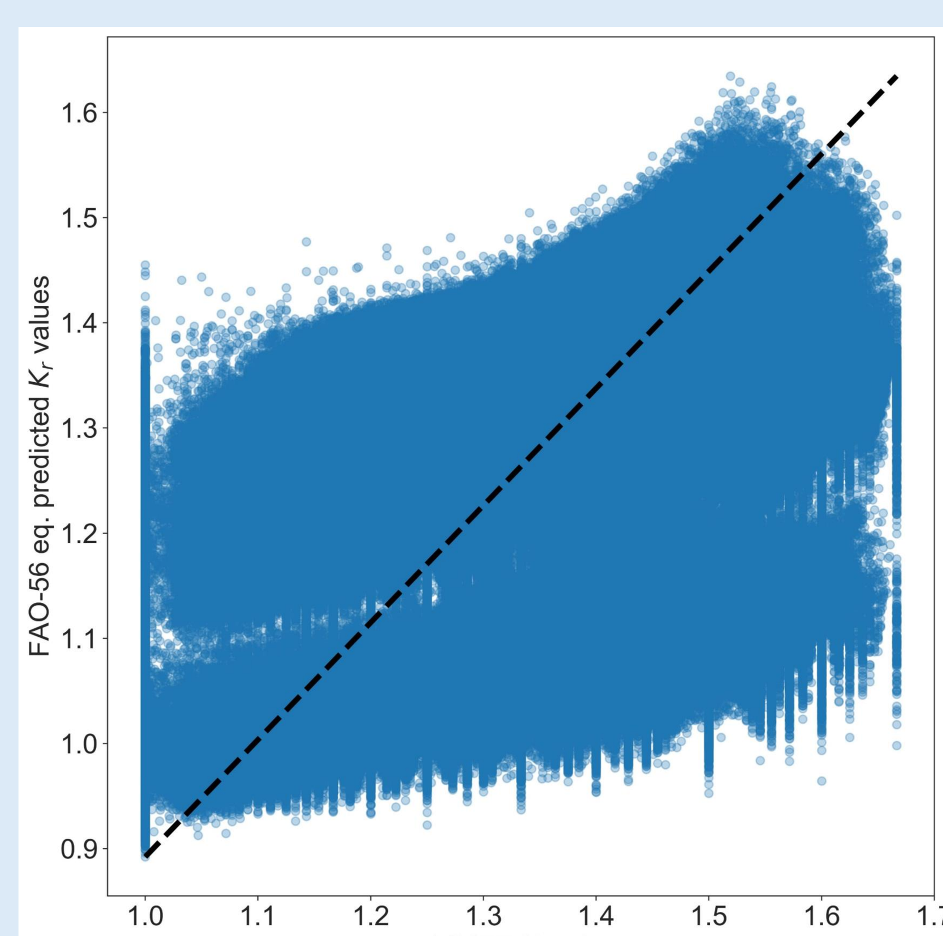
- A uniform grid of 1830 point locations was created across the contiguous United States (CONUS), and the points were categorized into four groups based on climatic conditions.
- Daily wind speed, RH_{min}, and K_r for all points were collected from gridMET (Abatzoglou, 2013) for over 40 years. Elevation data at these points was obtained from STRM (Farr et al., 2007).
- The K_r values were computed based on climate conditions using the equation recommended in FAO-56.
- A random forest (RF) model with 150 estimators was trained using six features. Day of Year (DOY) was used for seasonality, while latitude, longitude, and elevation were utilized to capture spatial patterns in the model.
- A total of 13.68 million samples were used to train and test the model with an 80:20 split, and 3.9 million samples were used for model validation.
- RMSE and R^2 were utilized to assess the performance of both methods.

What did we find?

- RMSE and R^2 for RF model testing were 0.03 and 0.91, respectively.
- The RMSE and R^2 values for the FAO-56 equation were 0.17 and -1.1, respectively, on the validation dataset, and for the RF model they were 0.04 and 0.88.
- RF model feature importance was calculated using the permutation method. RH_{min} had the highest importance, followed by DOY, while longitude had the least impact on model predictions.

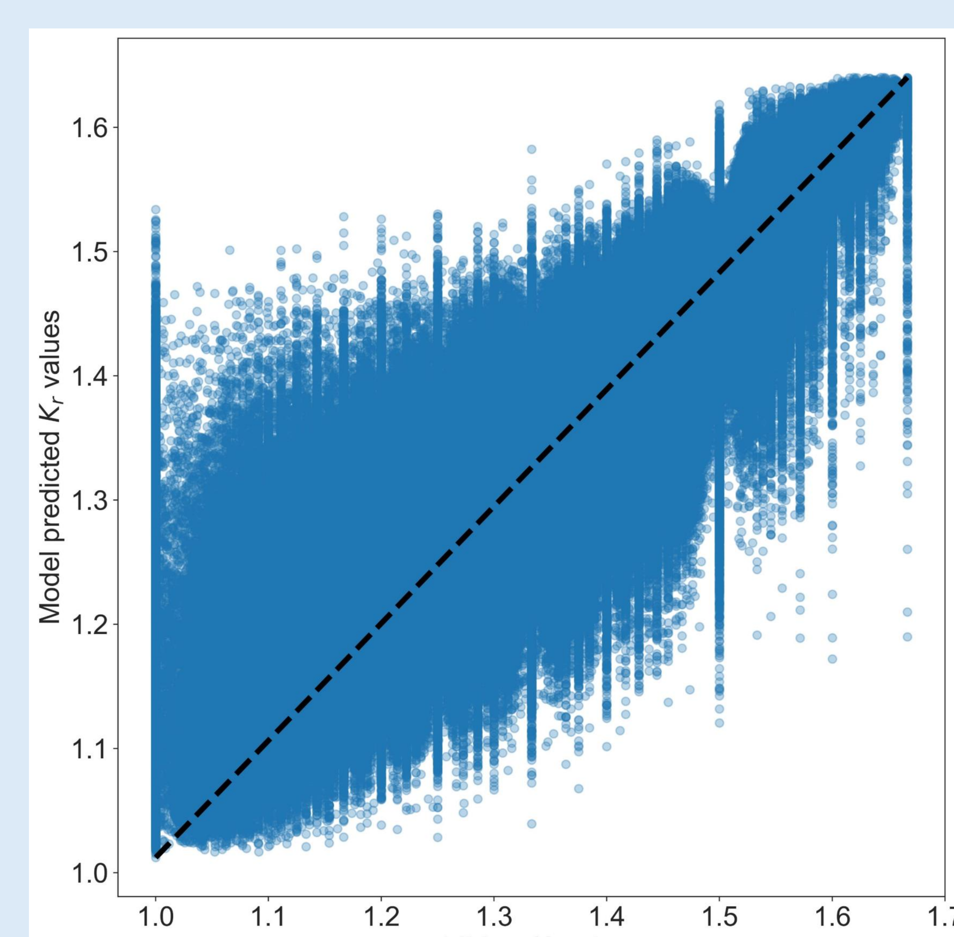
ML model-assisted translation of ET_r to ET_o enables accounting for seasonality observed in K_r values, otherwise not possible with the use of FAO-56 suggested approach

Daily K_r predicted with FAO56 suggested equation

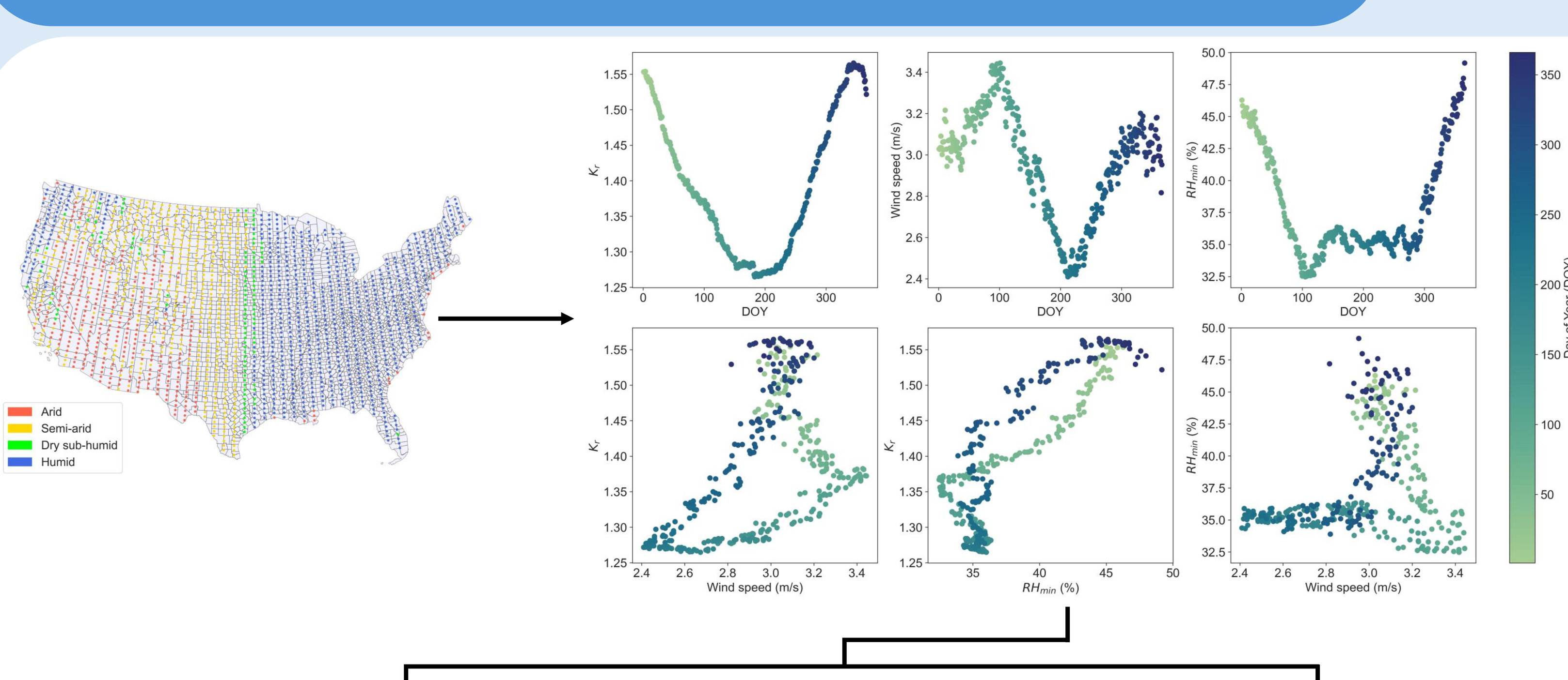


Daily K_r predicted with FAO56 against gridMET K_r on validation dataset with RMSE and R^2 0.17 and -1.1, respectively

Daily K_r predicted with ML model trained on K_r observations

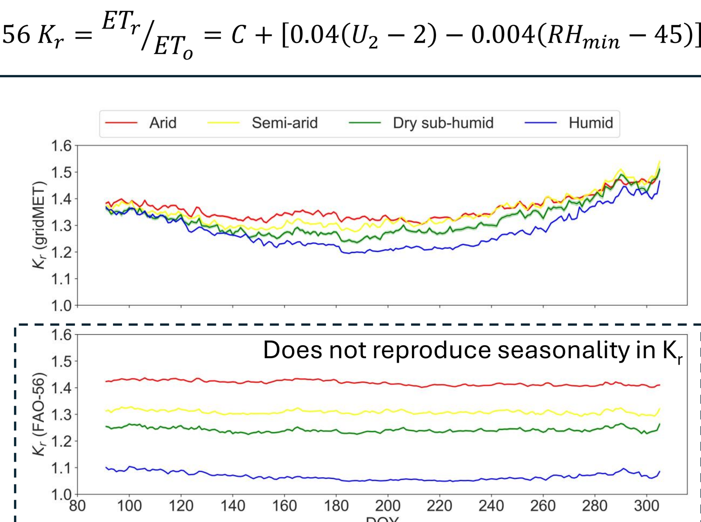


Daily K_r predicted with RF model against gridMET K_r on validation dataset with RMSE and R^2 0.04 and 0.88, respectively

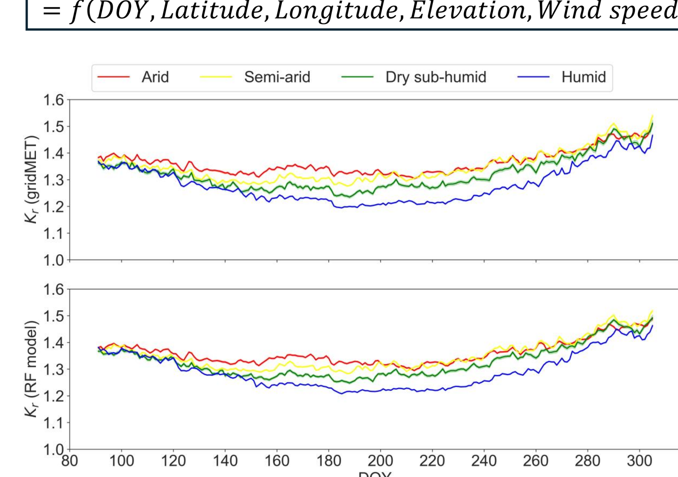


$$FAO-56\ K_r = {ET_r}/{ET_o} = C + [0.04(U_2 - 2) - 0.004(RH_{min} - 45)]\left(h/3\right)^{0.3}$$

$$ML - estimated\ K_r = f(DOY, Latitude, Longitude, Elevation, Wind\ speed\ (U_2), RH_{min})$$



Comparison of daily seasonal k_r values estimated with FAO56 eq. and gridMET for different climatic zones



Comparison of daily seasonal k_r values estimated with RF model and gridMET for different climatic zones

References

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