CLOSING THE WATER BUDGET GAP: LEVERAGING SATELLITE-BASED INSIGHTS FOR ACCURATE IRRIGATION WATER-USE ESTIMATION ACROSS WESTERN U.S

Kelechi Igwe and Vaishali Sharda

Carl and Melinda Helwig Department of Biological & Agricultural Engineering, Kansas State University

INTRODUCTION

- One-third of cultivated lands across the United States rely on freshwater to produce approximately 40% of the nation's food
- Groundwater reserves providing freshwater for irrigation across western US regions are declining at a rate faster than recharge. Projected to decline by 70% by the year 2050.
- Accurately tracking water used to grow crops is useful for managing and sustaining water resources
- Traditional approaches (e.g. National surveys, Metering devices, etc.) for monitoring seasonal water-use are cost and labor-intensive
- Remotely sensed satellite data combined with machine learning approaches presents a unique opportunity to continuously estimate seasonal water use from irrigated areas.

STUDY AREA

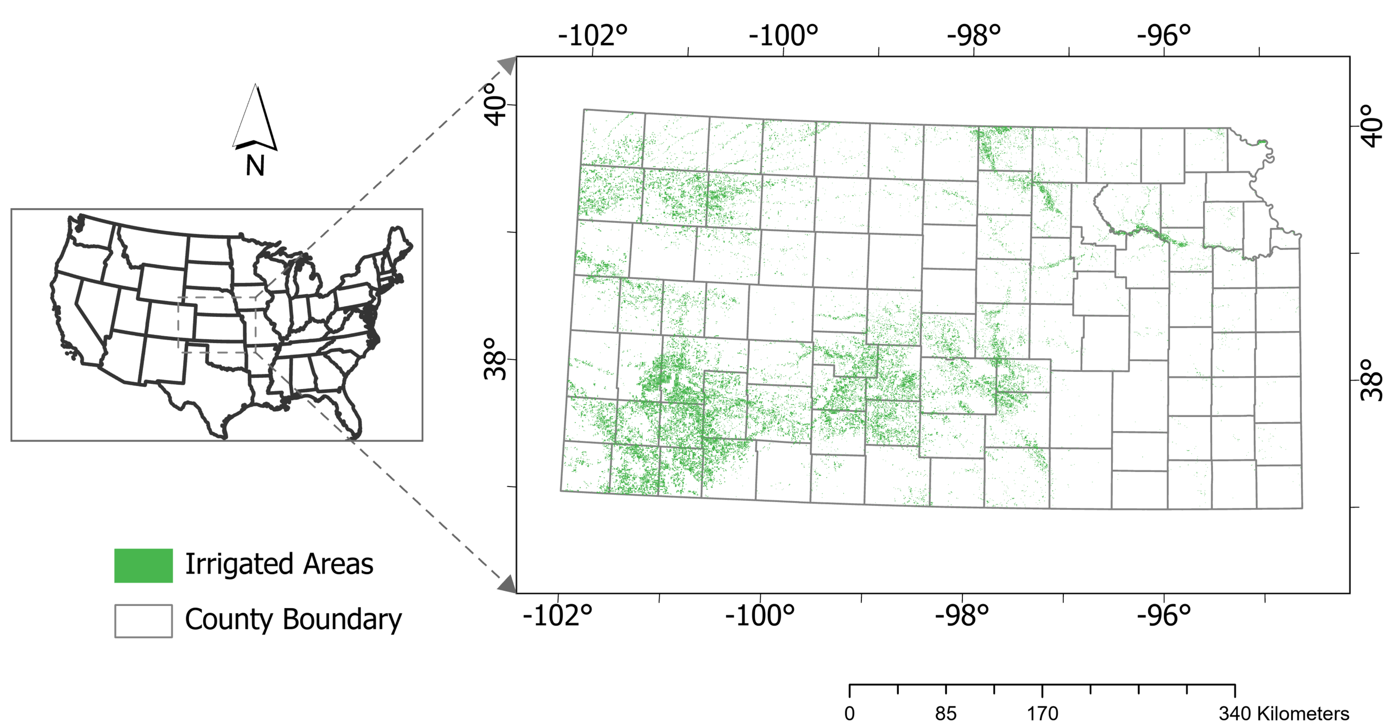

Figure 1: Map of Kansas showing irrigated areas extent across counties over 2012 – 2017 period.

DATA AND METHODS

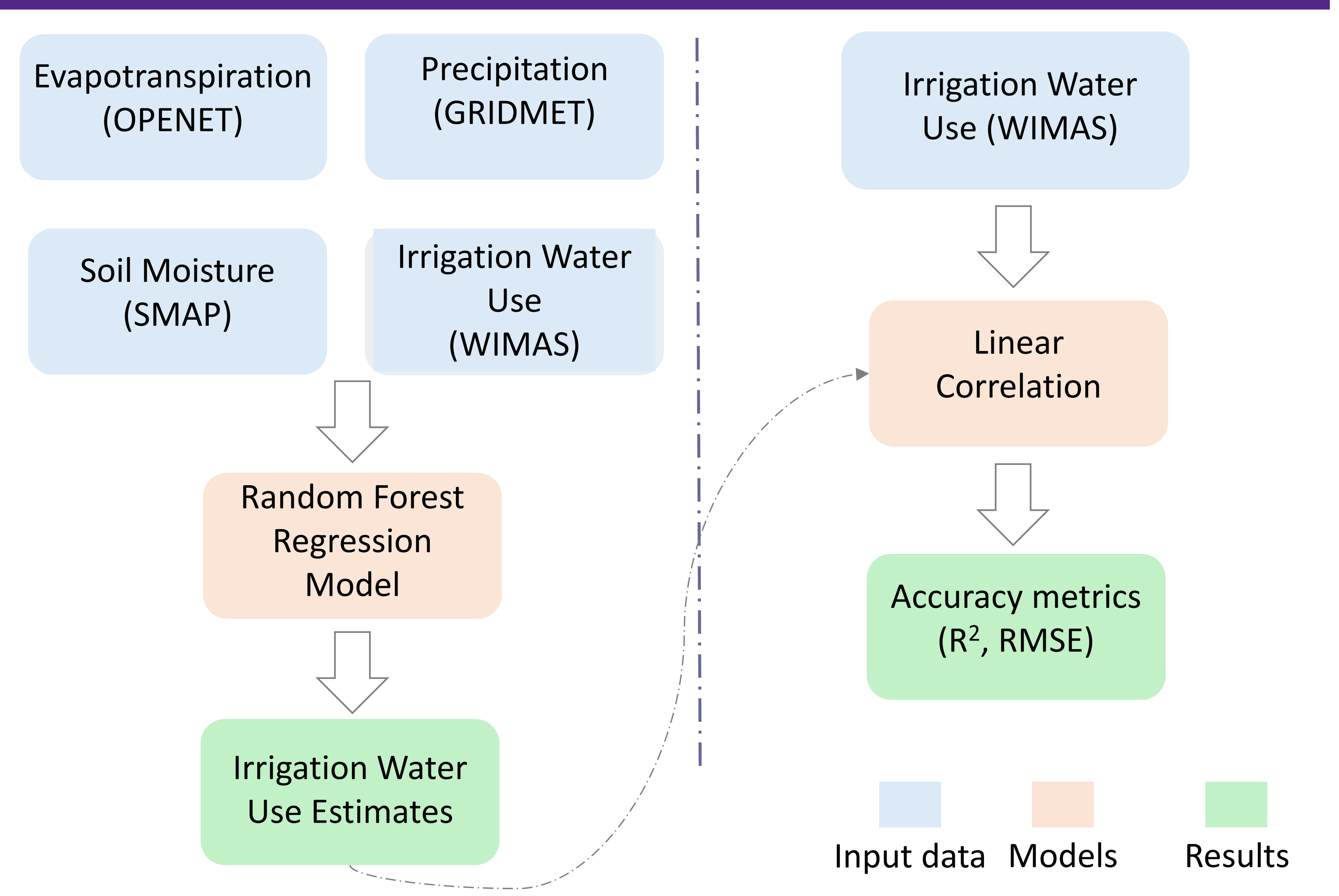

Figure 2: Workflow of input data, sources and machine learning modeling and evaluation process.

OBJECTIVES

- Predict annual irrigation water withdrawals across Kansas using a machine learning model integrated with multi-source satellite-based soil moisture data.
- Evaluate model estimates with observed irrigation water withdrawals reports from the Water information management system (WIMAS)
- Assess spatial variability of irrigation water-use across Kansas counties from 2015 to 2021.

RESULTS

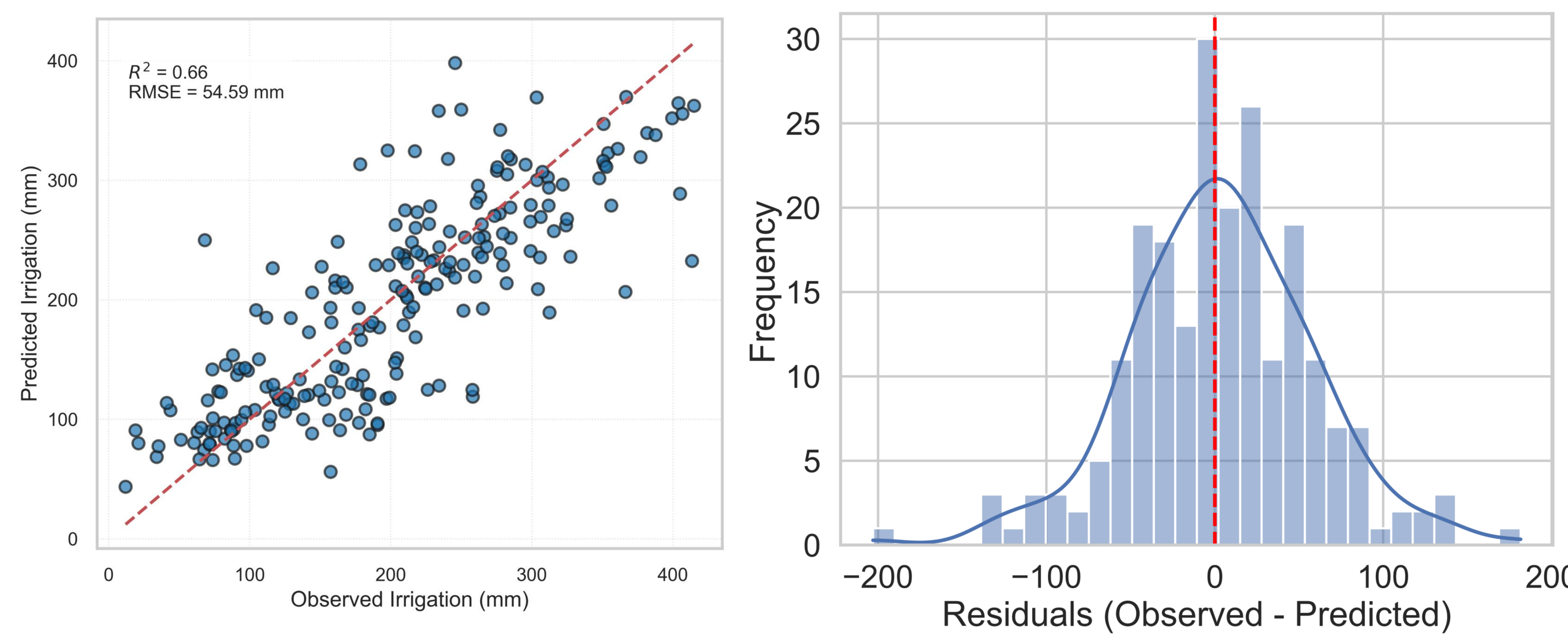

Figure 3. Model prediction accuracy defined by goodness of fit (R^2 = 0.66) and error distribution

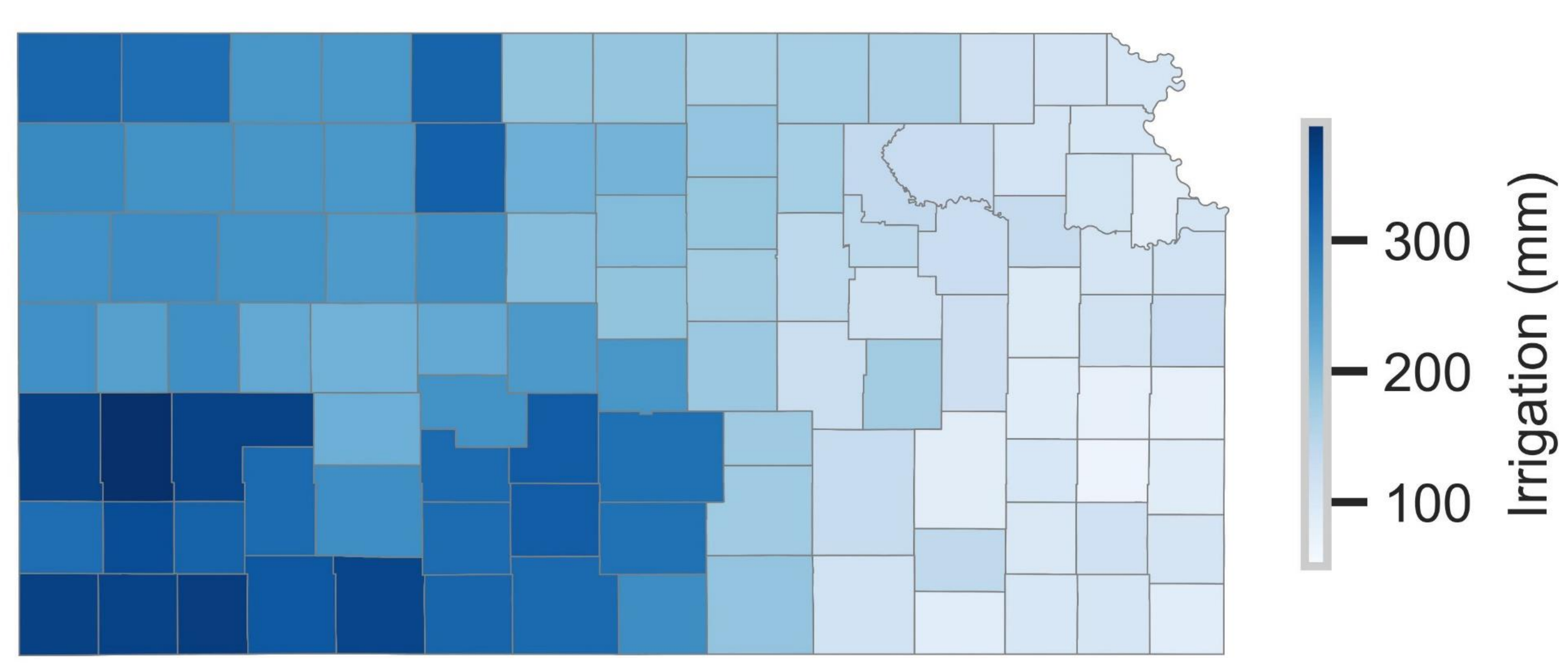

Figure 4: Spatial distribution of predicted Irrigation water use across Kansas Counties

Result Highlights:

- A Random Forest machine learning model fitted to all variables explained 66% variability in seasonal irrigation water use across Kansas counties over the 2015 to 2021 period. The normally distributed errors also improved confidence in the model accuracy (Figure 3)
- Model estimates accurately captures the east to west increasing pattern of irrigation water use in Kansas (Figure 4)
- Surface soil moisture emerged as most influential variable in irrigation water use prediction (Figure 5)
- Soil moisture variables showed stronger relationship with irrigation than precipitation and actual evapotranspiration (Figure 6)

RESULTS

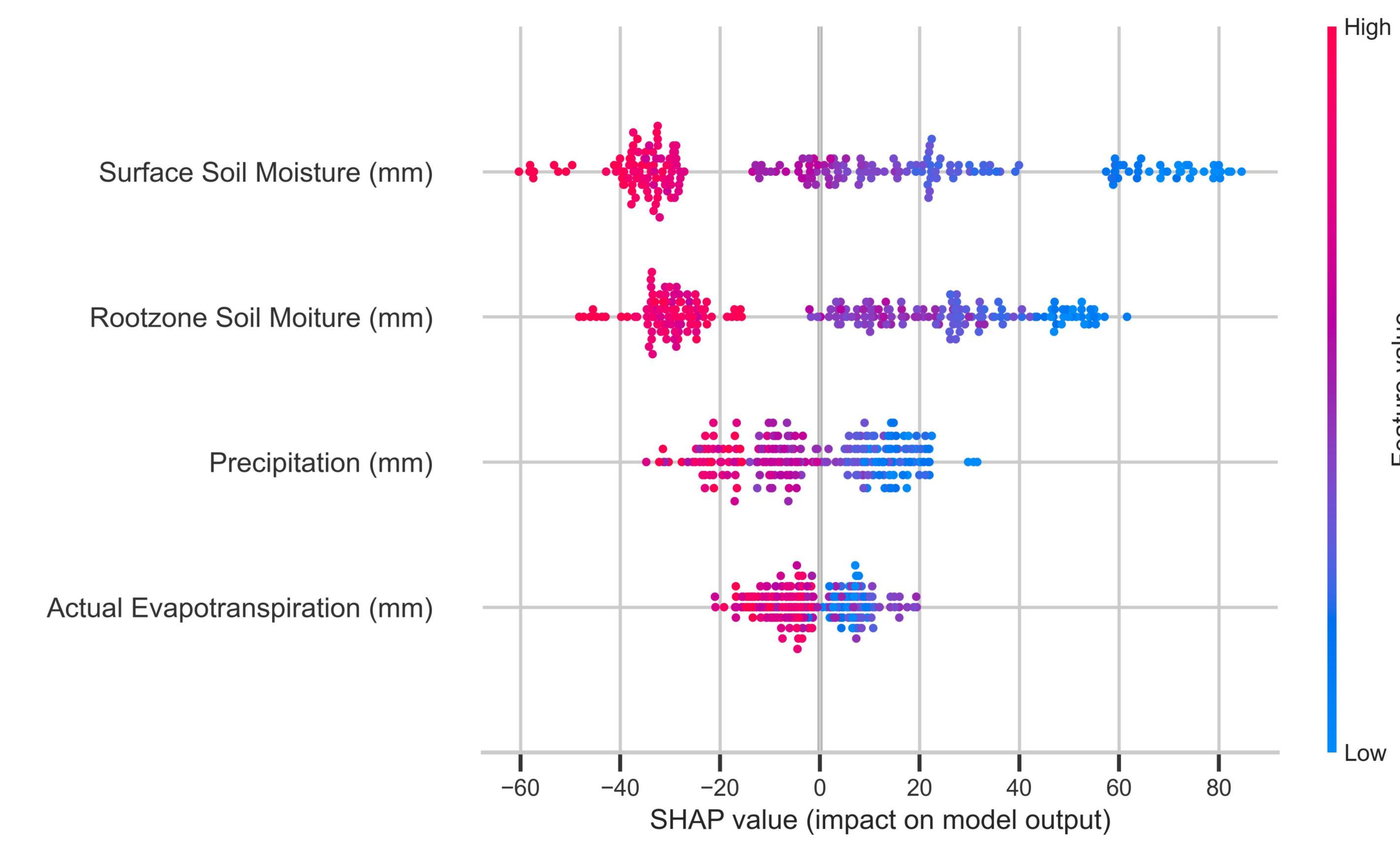

Figure 5: Importance of variables for predicting Irrigation ranked based on impact on model output

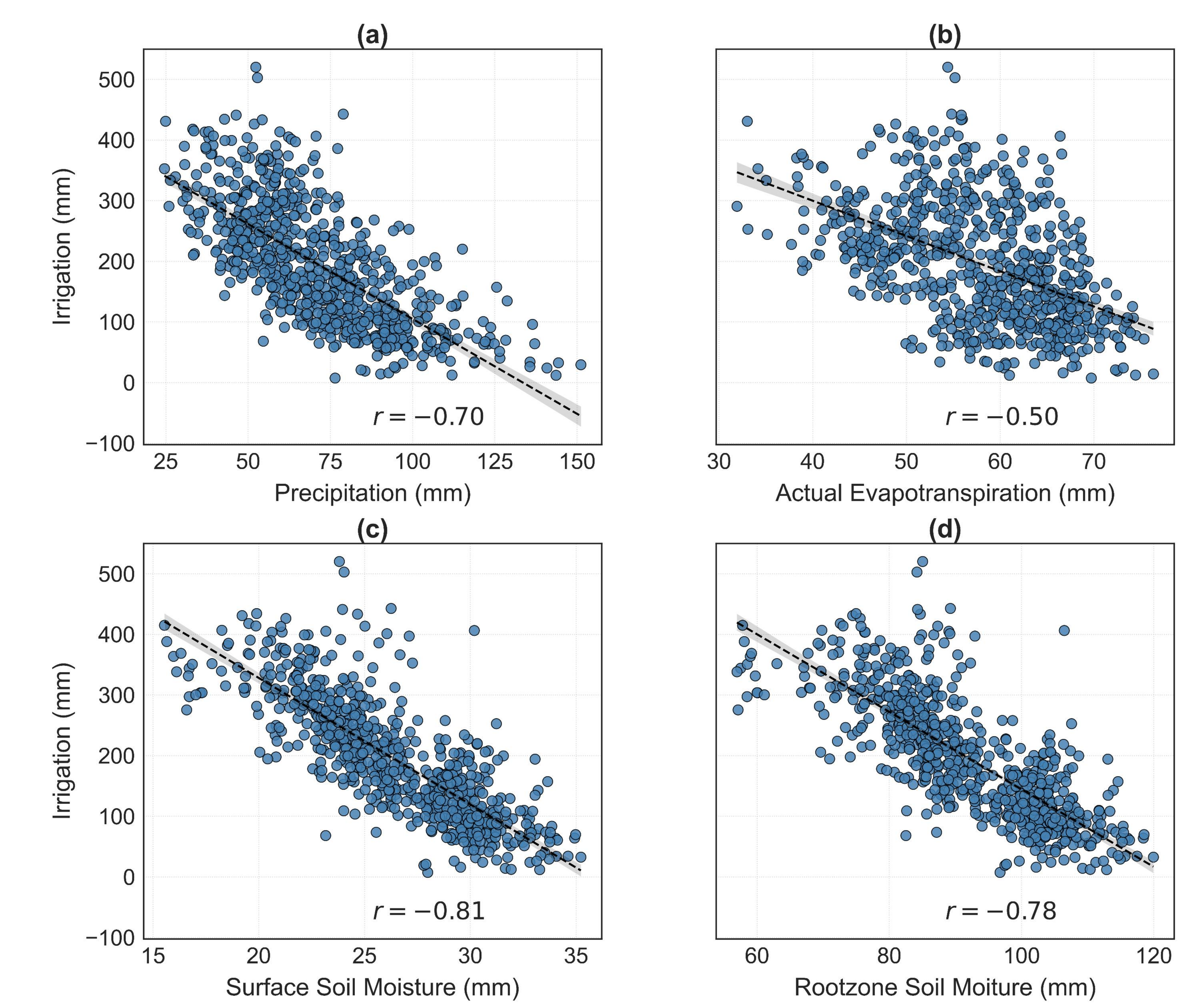

Figure 6: Pearson correlation irrigation with (a) Precipitation (b) evapotranspiration (c) Surface and (d) Rootzone soil moisture

CONCLUSION & FUTURE WORK

- Remotely sensed data integrated into machine learning model shows potential for continuous water use monitoring
- Model explained nearly 70% variation in seasonal irrigation withdrawals across Kansas counties
- Surface soil moisture is crucial to enhancing the accuracy of seasonal irrigation water use estimation.
- Future study will evaluate the influence of spatial resolution, depth of extraction and time of acquisition of soil moisture datasets on model performance accuracy

FOR FURTHER INFORMATION Contact: Kelechi Igwe (kelechi@ksu.edu)