Modeling and Performance Evaluation of Photosynthetic Active Radiation (PAR) using Satellite-based Data: Application to CROPGRO Model

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INTRODUCTION

- PAR is the component of shortwave irradiance in the visible spectral region (400-700 nm) which is the driver of plant growth and biomass production.
- Green vegetation utilizes PAR via photosynthesis to produce chemical energy required for growth and development (Junior et al., 2022).
- An important input to crop simulation models, however not usually measured just like other standard climate variables.

OBJECTIVES

- Study and evaluate the use of satellite-based data for estimating PAR in Eastern Kansas River Basin.
- Study the impact of PAR estimates on Soybean yield simulation using DSSAT-CROPGRO model.

METHODOLOGY

- Satellite-based CERES PAR products from 1984-2013 were acquired from NASA POWER for Riley and Shawnee counties.
- Climate variables (Minimum and Maximum Temperatures, Relative Humidity, Dew Point Temperature, Clearness Index [kt], and Solar Radiation [SRAD]) were downloaded from NASA POWER and Kansas Mesonet for PAR modeling.
- Linear modeling using R programming was done for model fitting and evaluation. 80% of data was used for model fitting, and 20% for evaluation.
- 12 regression models (model 1 to model 12 in series) were assessed, having different combinations of climate variables.
- DSSAT-CROPGRO model was calibrated and evaluated for comparison with USDA NASS yield data.
- Best PAR model selected based on evaluation statistics was used in DSSAT-CROPGRO to simulate soybean yield for Riley and Shawnee counties.
- Yield simulations from DSSAT-CROPGRO PAR (DSSAT default) and best regression model for PAR estimation were compared amongst each other and with observed yields from USDA NASS.
- Test statistics were used to assess model fitting, evaluation, and yield comparison.

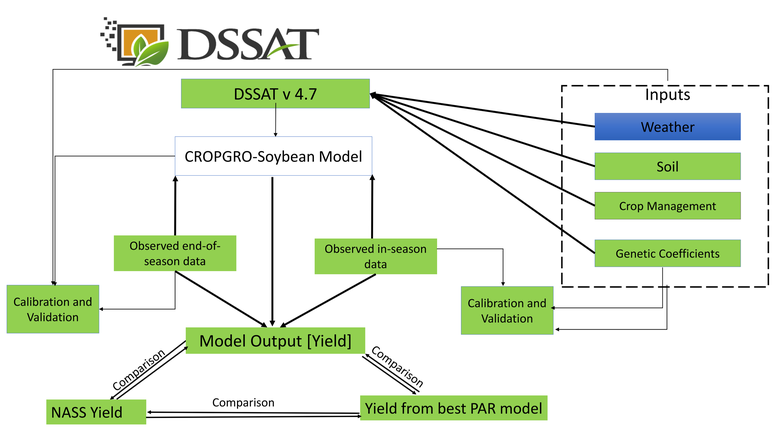

Figure 1. Structural Model Diagram

RESULTS

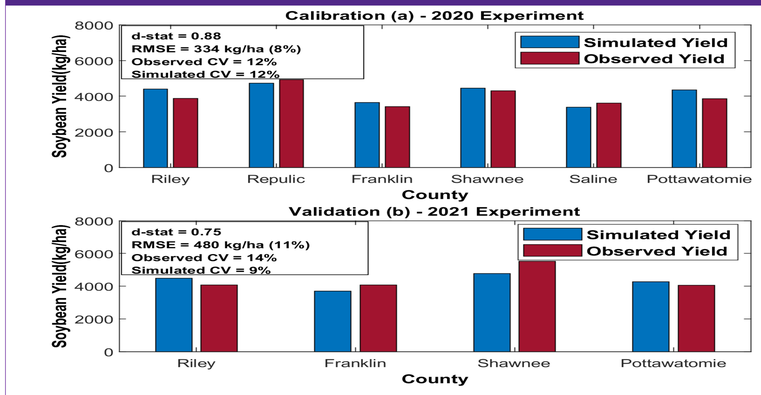

Figure 2. DSSAT CROPGRO model calibration (a) and Evaluation (b)

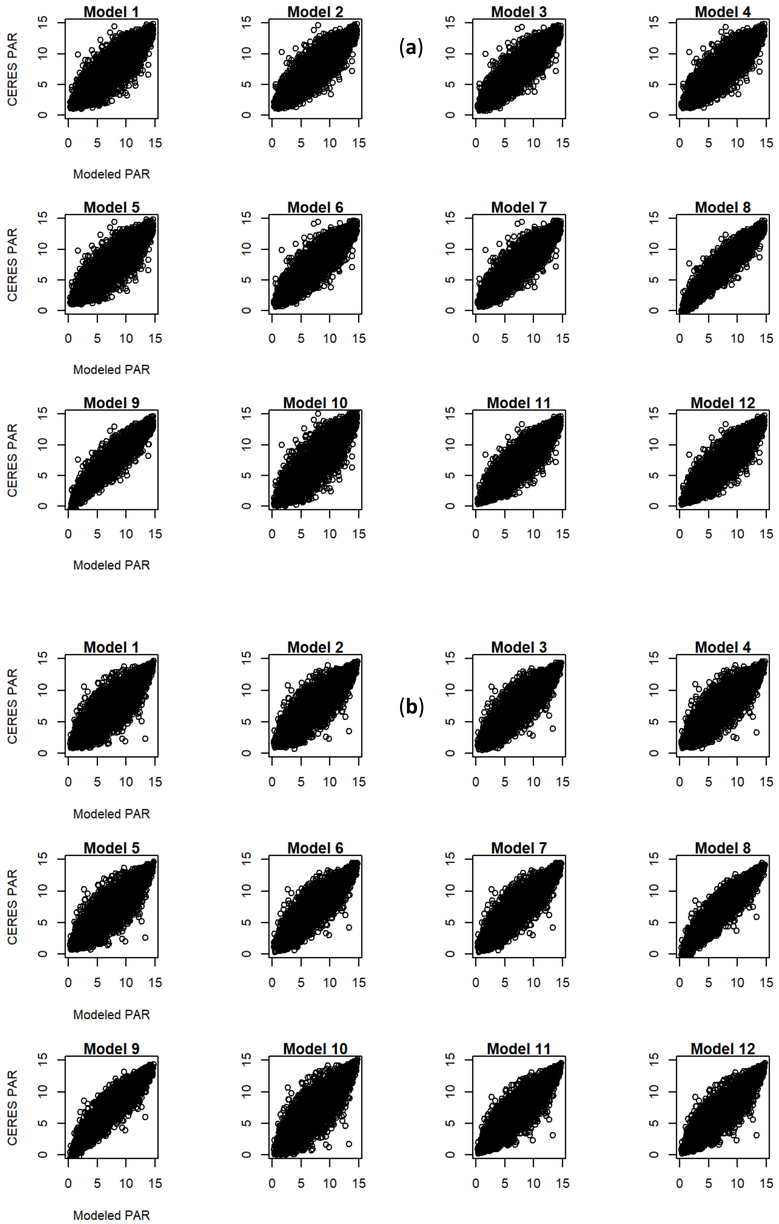

Figure 3. (a) Riley county model prediction; (b) Shawnee county model prediction. PAR unit (MJ/m²/d)

RESULTS

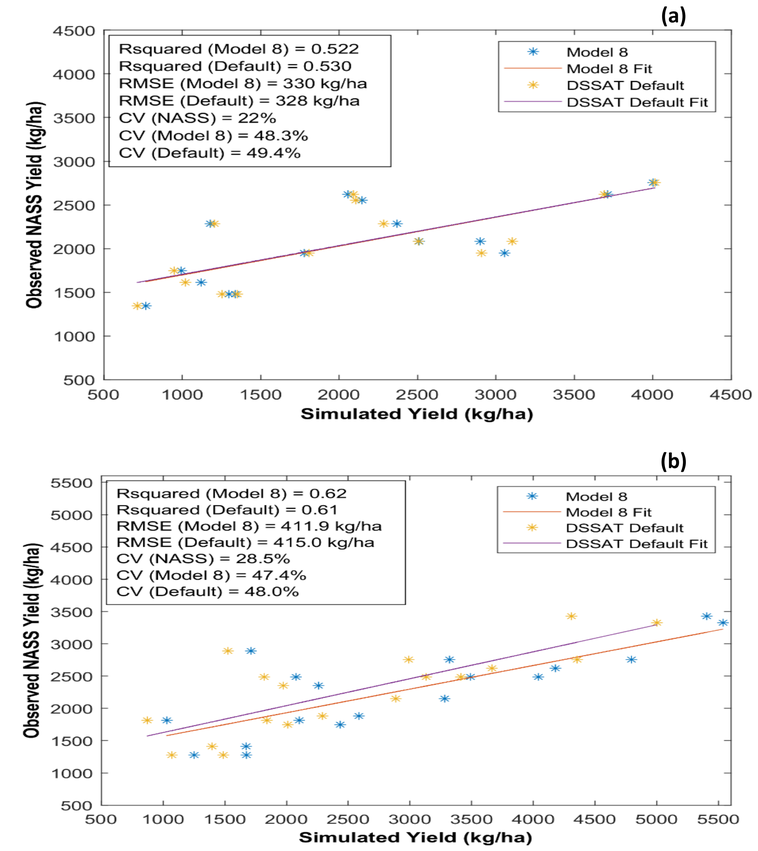

Figure 4. Yield comparison. CV (coefficient of variation). (a) Riley county; (b) Shawnee county

- Model prediction and evaluation metrics showed that model 8 performed as the best model in both counties (Figure 3).
- Result showed that DSSAT-CROPGRO model (Figure 2) was able to reproduce USDA NASS soybean yield.
- DSSAT Default, regarded as the default PAR values distributed with SRAD input in the CROPGRO model was used to estimate soybean yield. Yield from "DSSAT Default" was compared to yield using PAR estimates from model 8 (Figure 4) and USDA NASS yield in the two counties.
- Result showed that yield from model 8 matches closely to NASS yield than DSSAT Default, but not statistically significant (Figure 4).

CONCLUSIONS

- PAR datasets from NASA POWER can serve as robust inputs to crop models and other biophysical models for estimation of yield and biomass.
- A well-calibrated DSSAT-CROPGRO model reasonably reproduced observed USDA NASS yield.
- PAR model developed in this study can be use to estimate PAR in the absence of ground observation.

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