Integration of remote sensing and in-situ data to estimate soil moisture across mixed land cover types

Briana M. Wyatt[1], Tyson E. Ochsner[1], and Chris B. Zou[2]

[1]Department of Plant and Soil Sciences Oklahoma State University

[2]Department of Natural Resource Ecology and Management, Oklahoma State University

DEPARTMENT OF Plant & Soil Sciences

DEPARTMENT OF Natural Resource Ecology & Management

Introduction

- Soil moisture is an essential variable influencing climatic, hydrological, and ecological processes.
- The majority of soil moisture monitoring networks consider only one land cover type, typically grassland, limiting the use of these data for applications in other cover types .
- The Oklahoma Mesonet monitors soil moisture under grass at >100 sites across the state and recently small-scale soil moisture monitoring has been done under oak forest, but other land cover types have gone largely unmonitored.
- Current remote sensing soil moisture products capture the impacts of vegetation, but are limited due to their coarse resolutions (≈ 40 km) and shallow sensing depths (≈ 5 cm).
- It may be possible to effectively estimate root-zone soil moisture as plant available water (PAW) in unmonitored areas using high-resolution, remotely-sensed vegetation indices (VI) data, along with in-situ meteorological data by incorporating the data into a simple water balance model.

Objective

The objective of this research is to develop a useful model for estimating plant available water across multiple, intermixed vegetation types by integrating remotely sensed vegetation indices data and in-situ meteorological data.

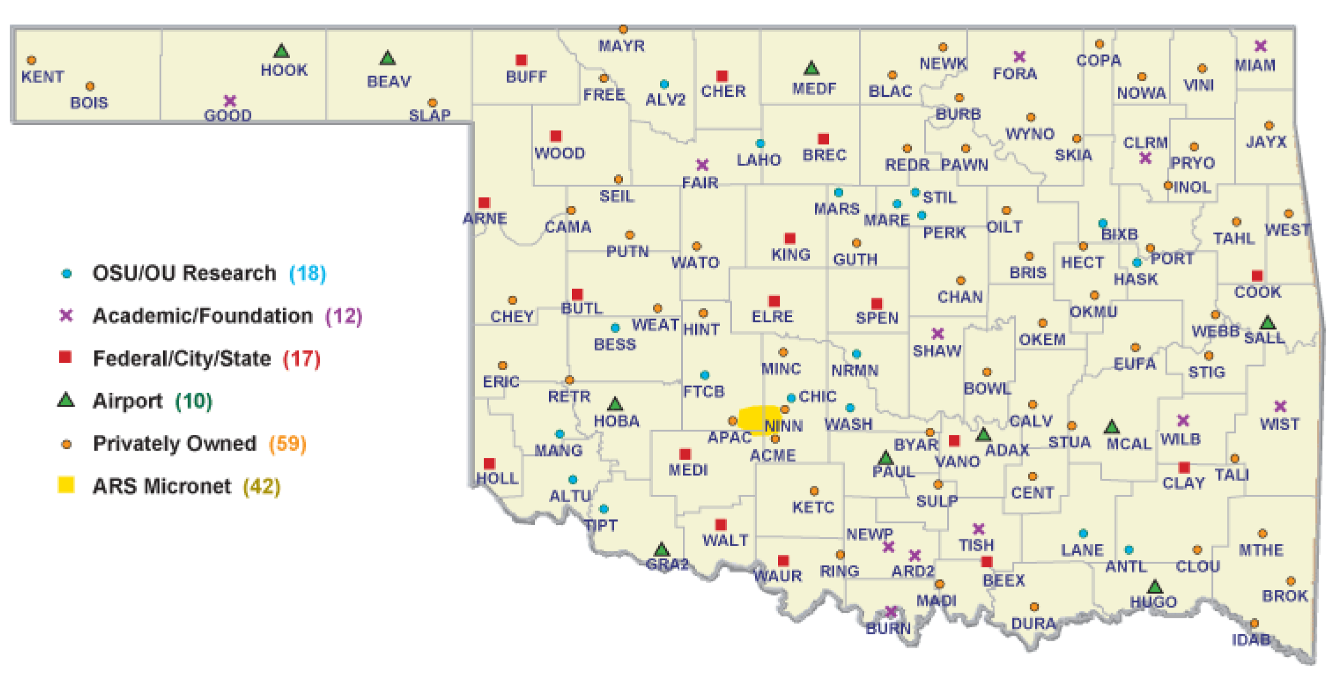

Figure 1. Map of Oklahoma Mesonet sites where PAW was estimated.

Materials and Methods

- MODIS Terra satellite enhanced vegetation index (EVI) data and in-situ meteorological data were used to estimate PAW for all grassland Mesonet sites and for a site under oak forest at the Cross Timbers Experimental Range (CTER), and results were compared to measured PAW.
- Vegetation indices data (250-m resolution) were retrieved at 16-day intervals for all sites, linearly interpolated between sensing dates, and normalized by:

$$VI^* = 1 - \left[\frac{VI_{max} - VI}{VI_{max} - VI_{min}}\right] \quad (1)$$

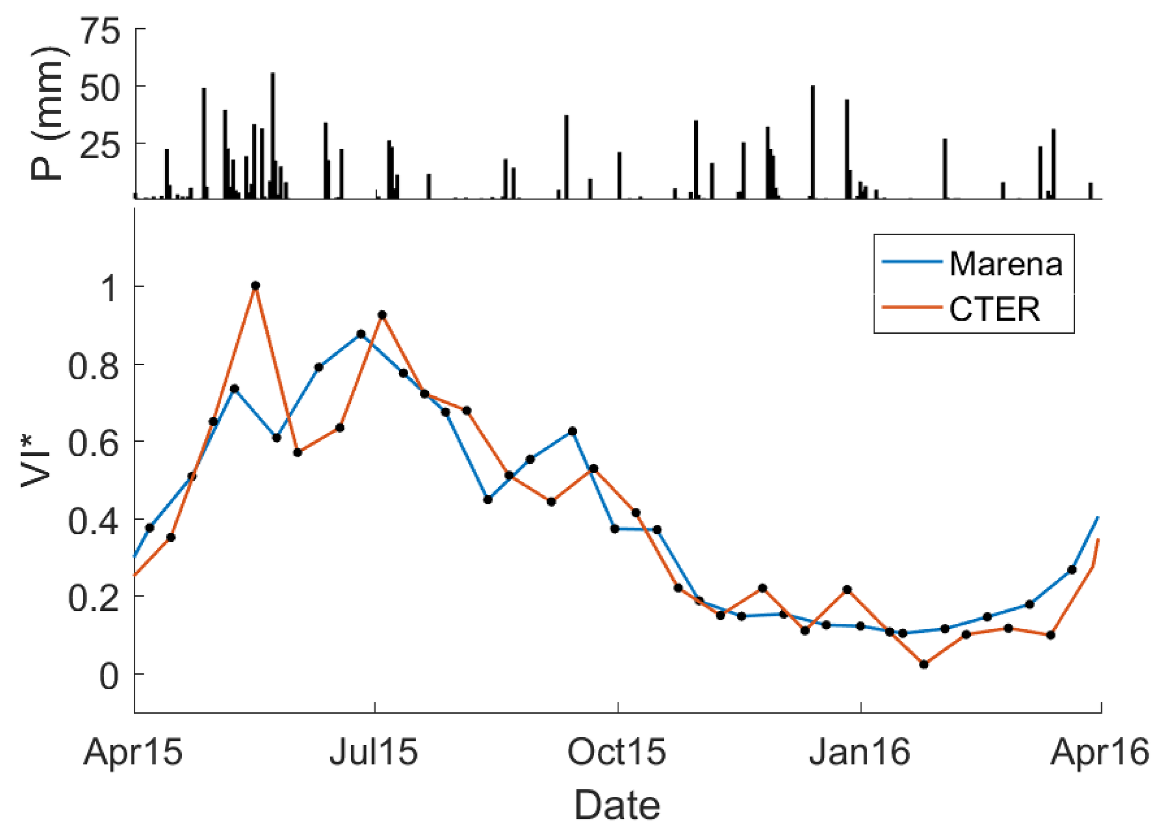

Figure 2. Precipitation (top), normalized observed VI (bottom, black points) and linearly interpolated daily VI (bottom, lines) between MODIS observation dates for the grassland Marena Mesonet and oak forest CTER sites.

- Normalized VI data were then incorporated into the FAO-56 evapotranspiration model as an analog for the crop coefficient following the method of Choudhury et al. (1994):

$$ET = ET_0(VI^*)^{\eta}, \text{ where } \eta = 1 \quad (2)$$

- Plant available water from 0 – 80 cm was then estimated as:

$$PAW = TAW - D_r \quad (3)$$

where TAW is total available water and D_r is root zone depletion which was calculated by a simple daily water balance.

Results

- Dynamics of MODIS-based and measured PAW align well in most cases, and a mean RMSE value of 53 mm was found for all Mesonet sites for the period from 2000 – 2016.
- MODIS-estimated PAW compares favorably with measured PAW at the Marena Mesonet site, with an RMSE of 40 mm for the period from April 2015 – April 2016 (Fig. 3, left).
- MODIS-estimated PAW also compares fairly well with measured PAW at the CTER site under oak forest, with an RMSE value of 40 mm for April 2015 – April 2016 (Fig. 3, right).

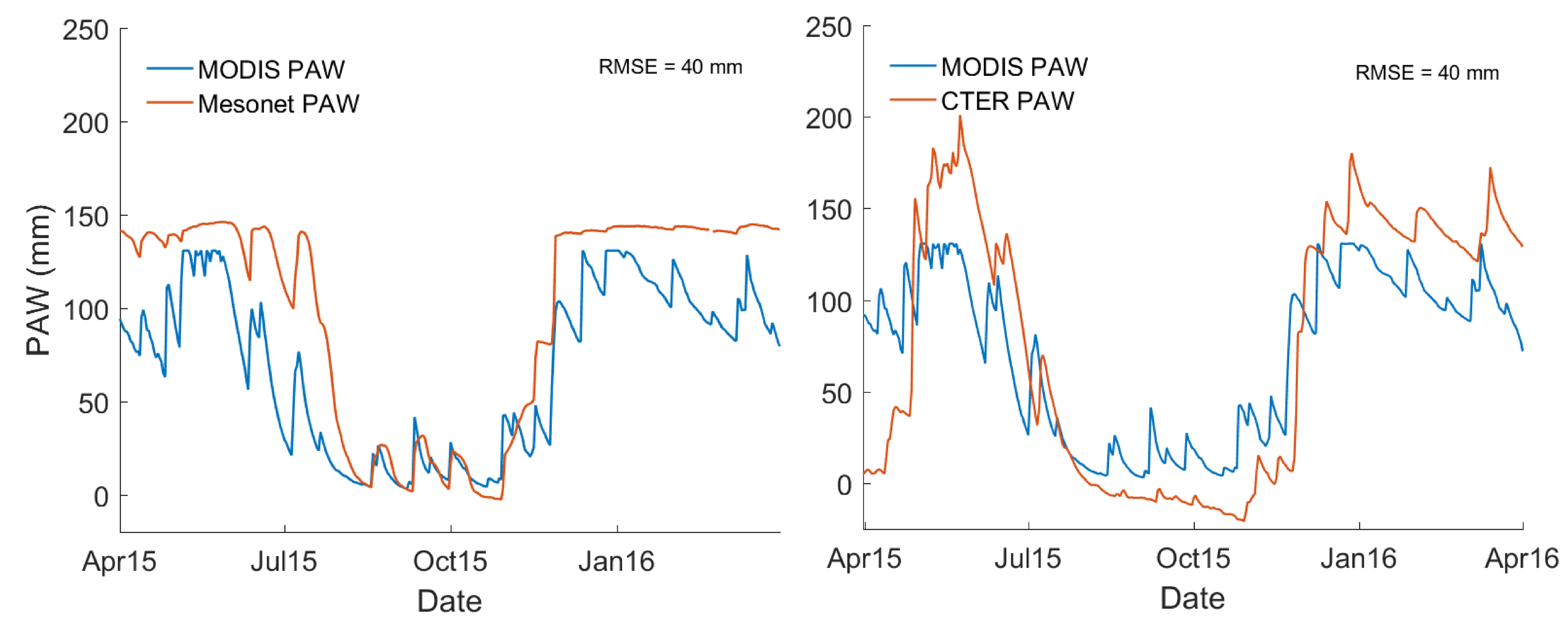

Figure 3. MODIS-estimated versus measured plant available water for the Marena Mesonet site under grassland (left) and an oak forest site (right).

Future work

- Next steps include modeling and validation of PAW for diverse vegetation types across Oklahoma.
- Large-scale modeling will be done using the HIDROMORE distributed hydrological model, which integrates ground-based meteorological data with remotely-sensed vegetation index data (Sanchez et al., 2010).
- Validation will be done by comparing model-estimated soil moisture to measured conditions under various land cover types throughout the state.
- The final goal of this research is to create an operational model capable of estimating daily plant available water for the state of Oklahoma at 250-m resolution using remotely-sensed VI data.