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

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Introduction

- Soil moisture is an essential variable influencing climatic, hydrological, and ecological conditions (Ochsner et al., 2013).
- The majority of soil moisture monitoring networks consider only one land cover type, limiting the use of these data for applications in other cover types .
- The Oklahoma Mesonet has soil moisture sensors installed under grass at >100 sites across the state, but other land cover types which comprise >46% of the state have gone largely unmonitored (McPherson et al., 2007; National Agricultural Statistics Service; Oklahoma Forestry Service).
- It may be possible to effectively estimate root-zone soil moisture as plant available water (PAW) in these unmonitored areas using high-resolution, remotely-sensed vegetation indices (VI) data, along with in-situ meteorological data from the Mesonet by incorporating the data into a simple water balance model.

Objective

The objective of this preliminary research is to develop a useful model for estimating plant available water under multiple, intermixed vegetation types by integrating remotely sensed vegetation indices data and in-situ meteorological data into the FAO-56 crop coefficient water balance model.

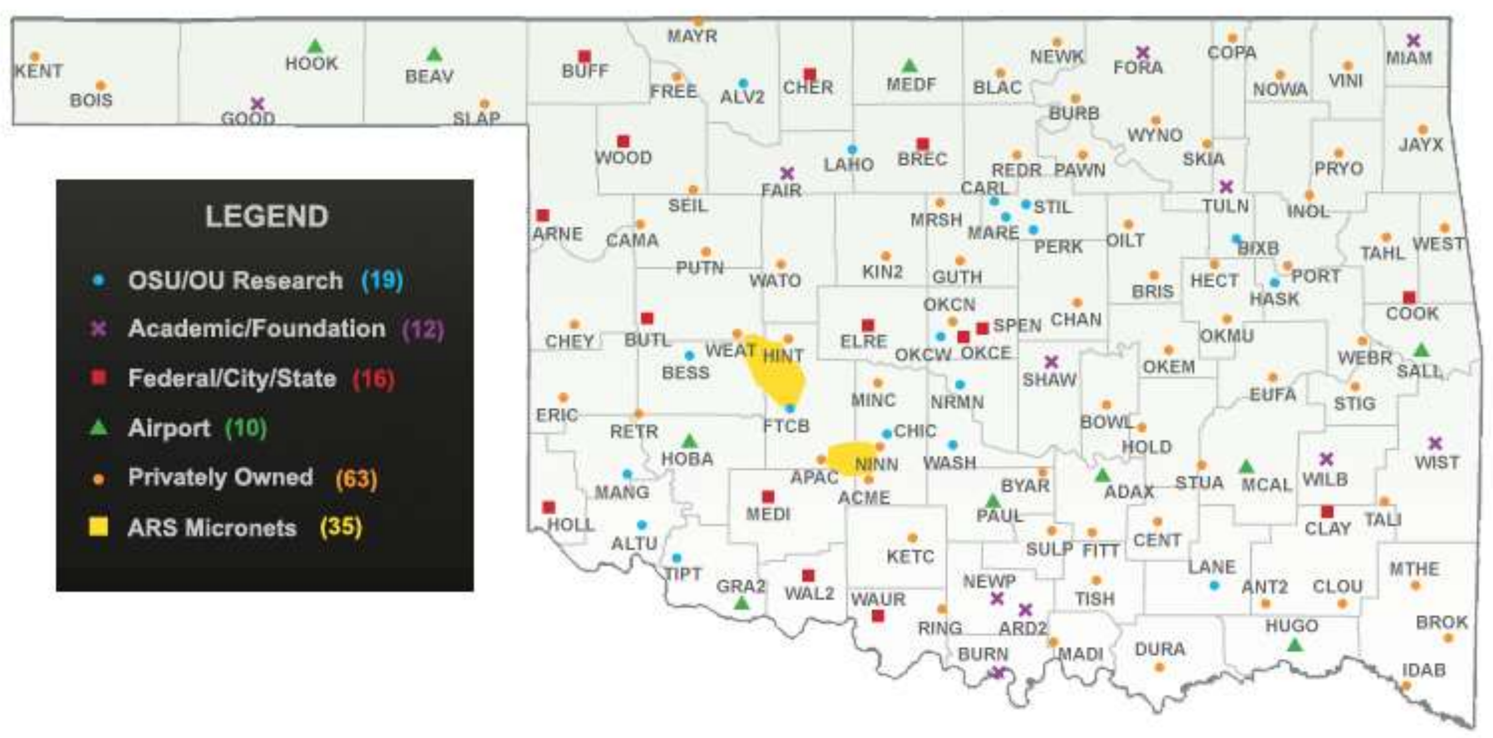

Figure 1. Map of Oklahoma Mesonet sites where PAW was estimated.

Materials and Methods

- MODIS Terra satellite enhanced vegetation index (EVI) data and in-situ meteorological data were used to estimate PAW for each Mesonet site, and results were compared to measured PAW.
- Vegetation indices data (250 m^2) were retrieved at 16-day intervals for all Mesonet sites for the years 2000-2010, linearly interpolated between sensing dates and normalized by:

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

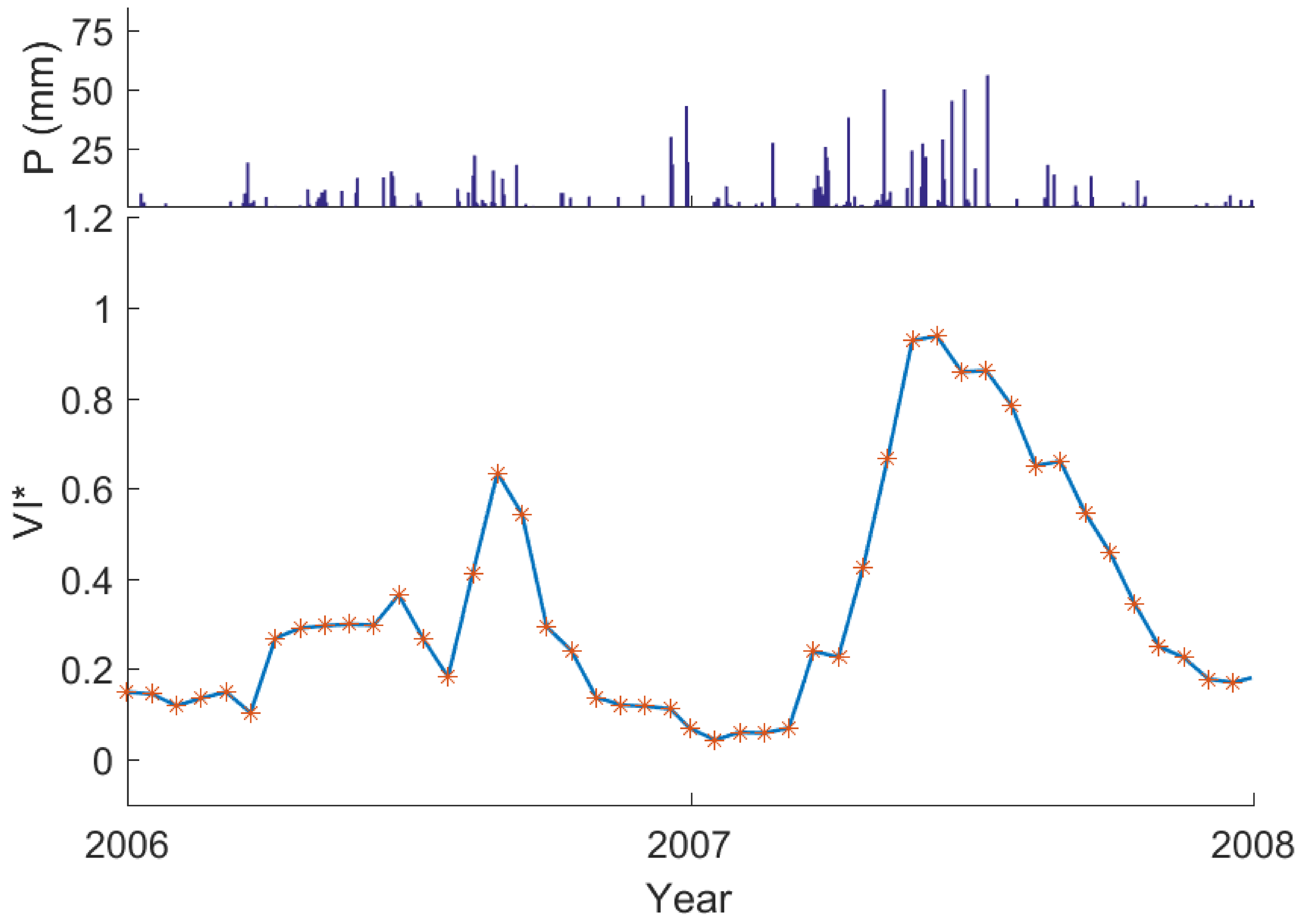

Figure 2. Precipitation (top), normalized observed VI (bottom, orange points) and linearly interpolated daily VI (bottom, blue line) between MODIS observation dates for the Woodward Mesonet site.

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

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

- Plant available water was then estimated within the FAO-56 model as:

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

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

Results

- MODIS-estimated PAW compares favorably with measured PAW at most sites, with a mean RMSE of 40 mm across all sites for the period from March 2000 (when MODIS VI data are first available) until December 2010.
- Dynamics between the estimates agree well, especially at sites in the western portion of the state, where soil water is more often limited than in the east.
- RMSE for estimated versus measured PAW at the Woodward Mesonet site for the years 2006-2007 was 28 mm.

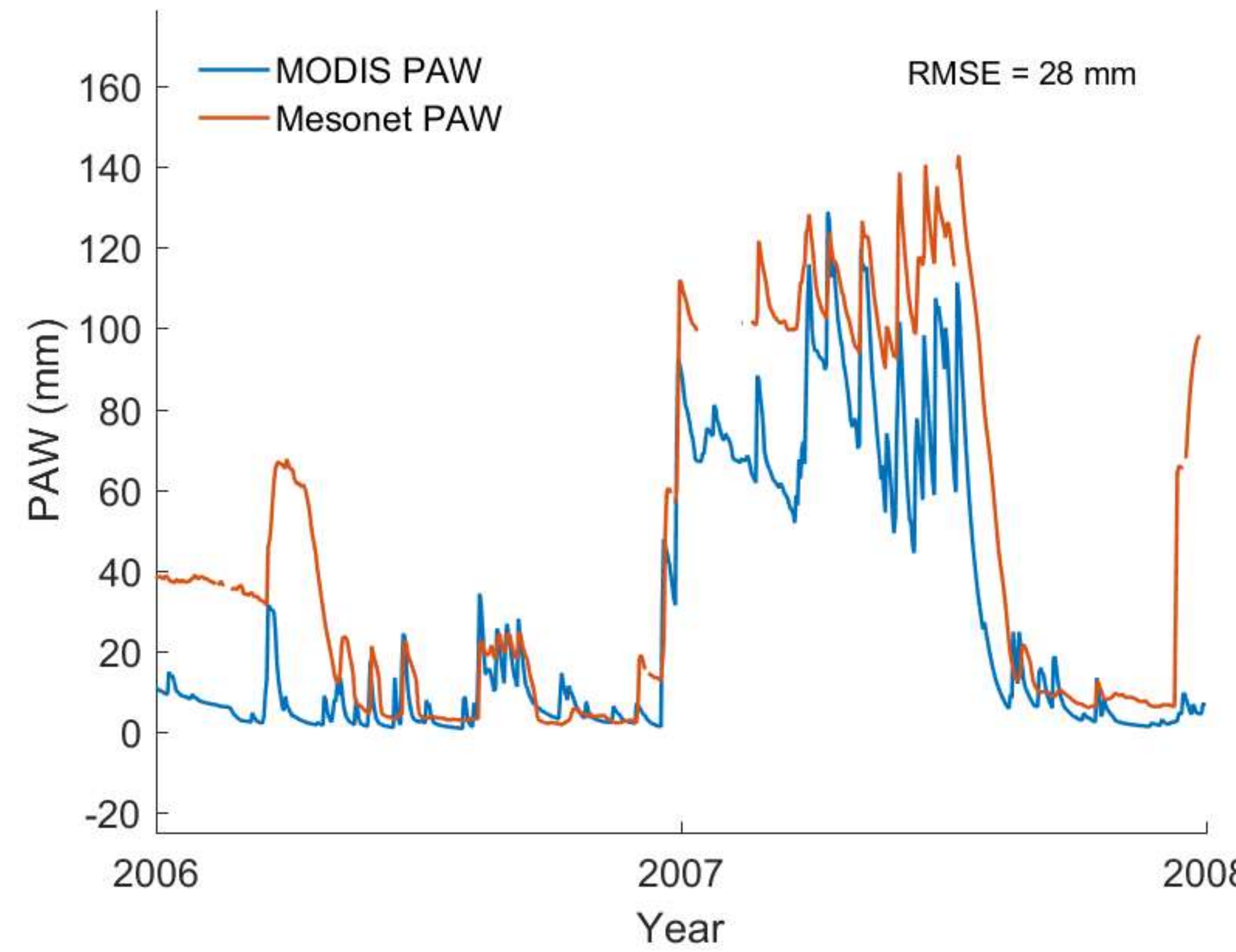

Figure 3. MODIS-estimated versus measured plant available water for the Woodward Mesonet site for the years 2006 and 2007.

Future work

- The final goal of this research is to create an operational model capable of estimating plant available water for the state of Oklahoma at 250-m resolution using remotely-sensed VI data.
- Next steps include summarizing the accuracy of the method for all Mesonet sites with measured PAW under grass and for additional monitoring stations under forest and cropland.