

Towards a High Resolution Soil Moisture Map of Oklahoma

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Introduction

Large scale (> 1 km²) estimates of soil moisture have often been validated using data from long-term networks with sparse soil moisture measurements and/or using data from short-term experiments with dense measurements. The Oklahoma Mesonet is a network of ~120 automated weather and soil monitoring stations. The Mesonet covers Oklahoma at an average spacing of one station per 30 km and has been maintained for >20 years. Statistical methods may be used to combine Mesonet data with other sources of data (e.g. soil properties, radar precipitation estimates) to create high resolution (800 m) maps of soil moisture for the state of Oklahoma. With validation, these maps may be used to validate other, large scale soil moisture estimates, e.g. from the SMAP and SMOS satellites.

Method

1. Define a grid
2. Get soil texture data^[1] at each grid point (x, y) and Mesonet station (i with grid position x_i, y_i)
3. Get accumulated precipitation data^[2] at each grid point and Mesonet station
4. Get soil moisture data^[3] at each Mesonet station
5. Regress soil moisture (θ_i) against x_i, y_i , sand content (S_i), and 5- and 30-day accumulated precipitation (P_i)

$$q_i = \left\{ 1, x_i, y_i, S_i, \sum_{d=1}^{5d} P_i, \sum_{d=1}^{30d} P_i \right\}$$

$$\hat{\theta}_i = q_i \hat{\beta}$$

OLS regression (θ vs. q) $\rightarrow \hat{\beta}$

6. Calculate residuals (e_i)

$$e_i = \theta_i - \hat{\theta}_i$$

7. Krig the residual soil moisture values

$$\text{kriged}(e) \rightarrow \hat{e}_{(x,y)}$$

8. Estimate soil moisture at each grid point by combining kriged residual values with soil moisture estimates from the regression model

$$\hat{\theta}_{(x,y)} = \hat{e}_{(x,y)} + q_{(x,y)} \hat{\beta}$$

Results

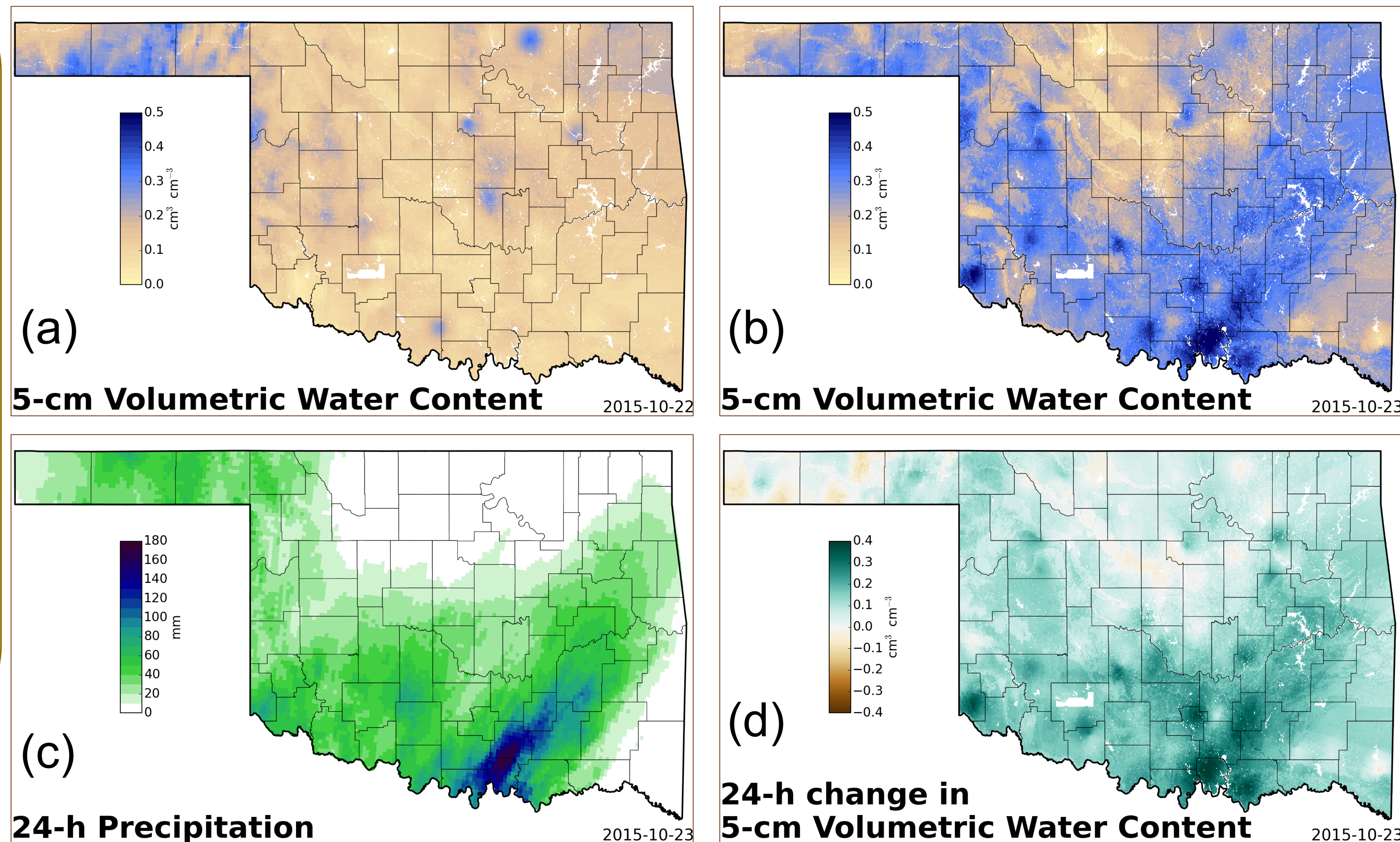


Figure 1. (a) and (b) are the resulting soil moisture maps from our current method, valid at 0600 UTC (midnight CST) on the day following October 22 and 23, 2015, respectively. (c) maps the precipitation that occurred between these periods, leading to the large 1-day change in predicted soil moisture values (d) in southern Oklahoma.

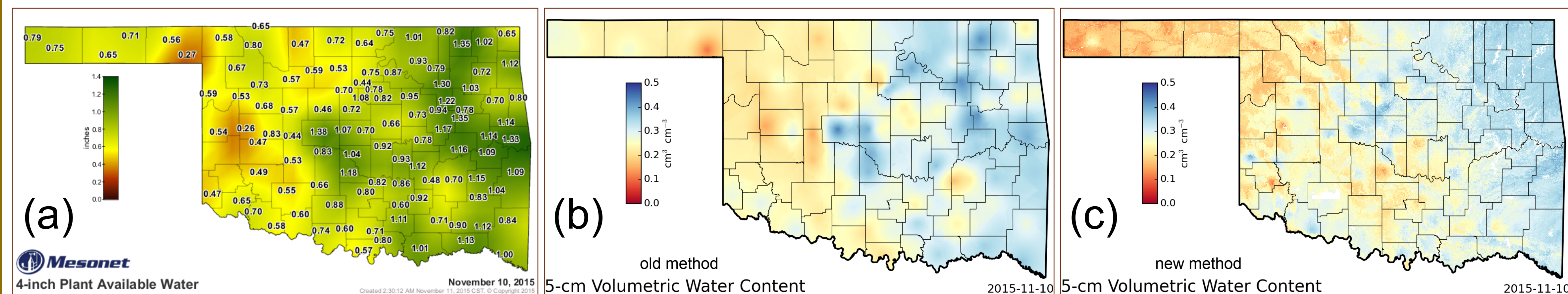


Figure 2. The Oklahoma Mesonet itself provides maps of soil moisture (a); the interpolation is done using the same method the Mesonet uses for atmospheric variables (Barnes objective analysis). Early attempts at improving the accuracy of interpolated soil moisture used ordinary kriging (b), but this method produced similar patterns as the Barnes method, perhaps with even stronger “bulls-eyes” around particularly wet/dry sites. Our current method’s results, plotted for the same day (November 10, 2015) as (a) and (b), are shown in (c).

Current Issues

- No validation (yet!)
- Poor nugget estimation in variograms
→ “bulls-eye” maps
- Precipitation handling
- Ignoring influence of land use/land cover, probably only valid for non-irrigated grasslands

Next Steps

- Compare with COSMOS rover estimates
- Include information/models for different land cover types (e.g. wheat, forest)
- Evaluate other regression, variogram modeling, and kriging techniques
- Build interactive web application to enable public and research use

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References:

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