Department of Plant and Soil Sciences
SOIL PHYSICS

Progress and prospects for soil moisture monitoring and applications in Oklahoma and beyond

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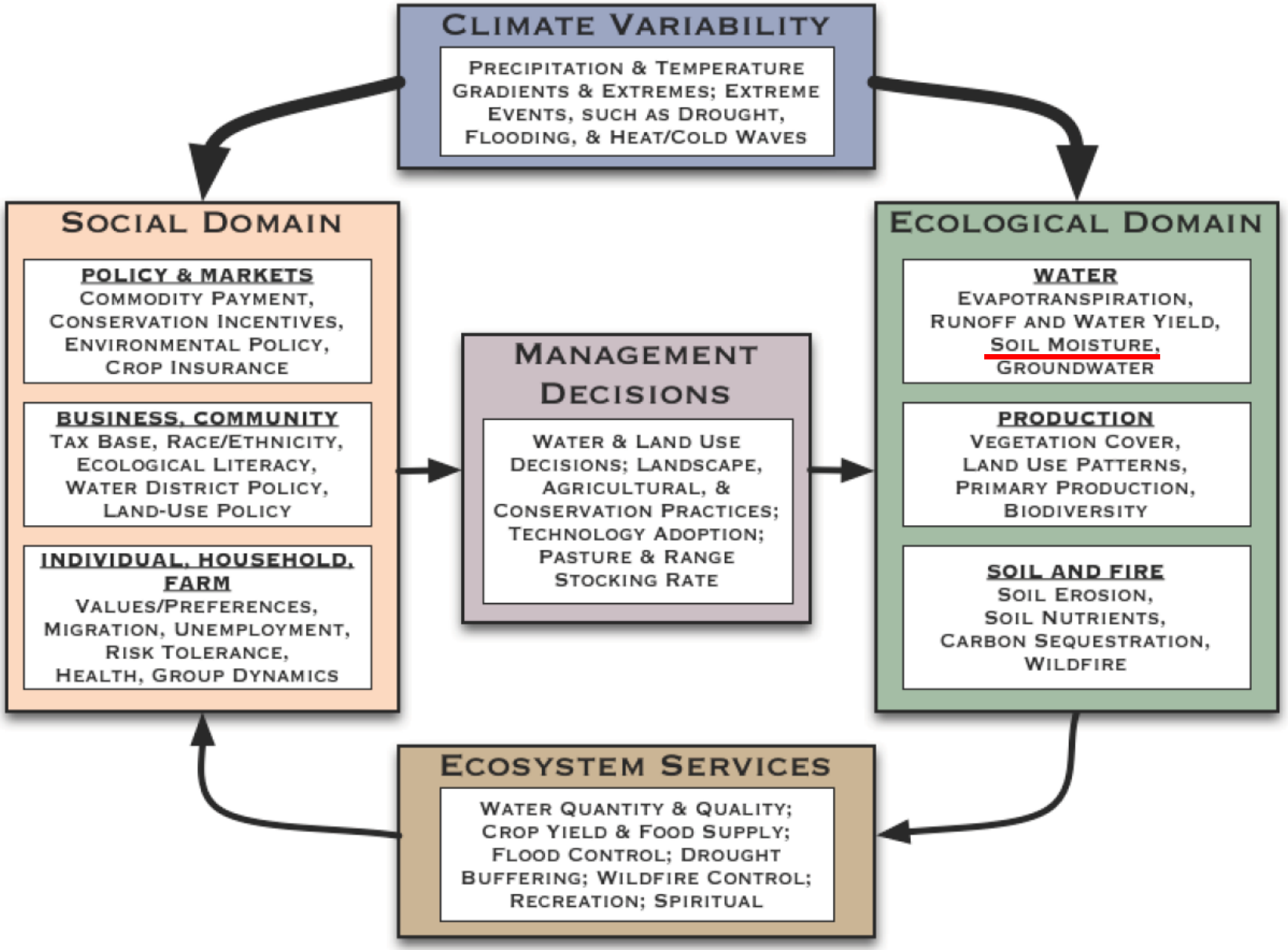
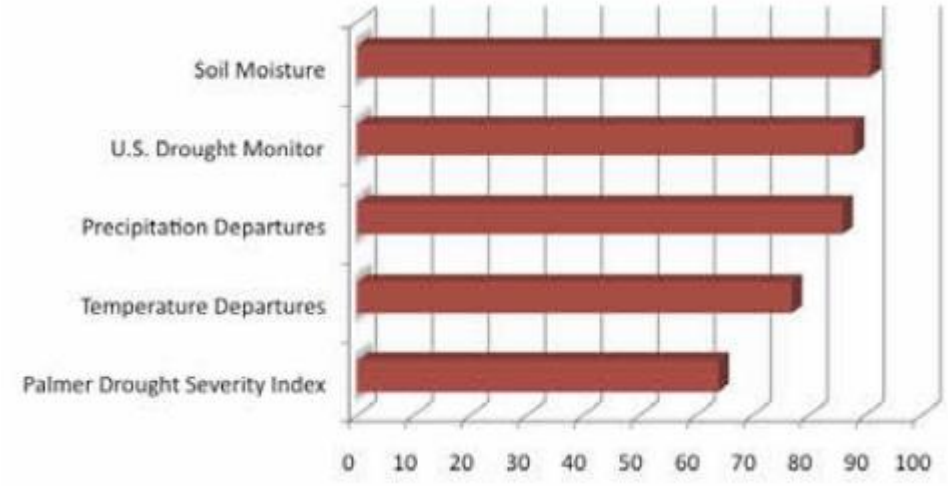
Soil Moisture Information in a Socio-ecological Context



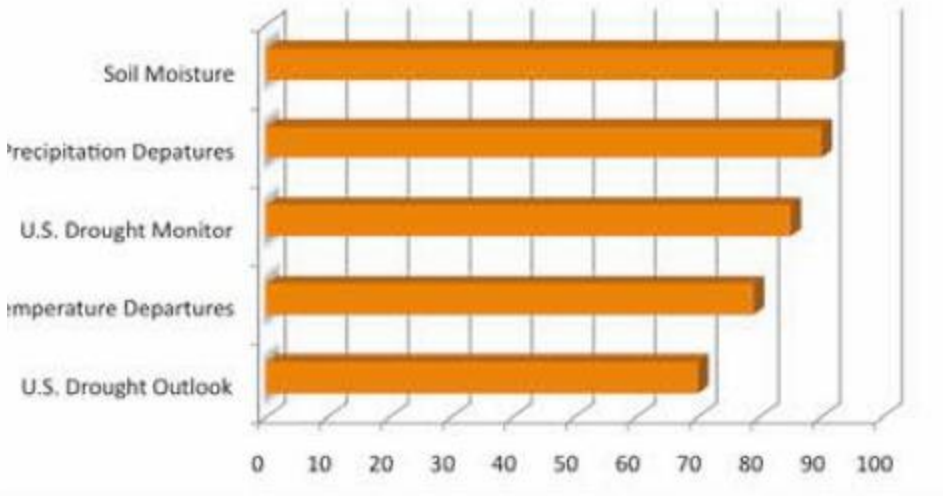
People want soil moisture information

- Stakeholders in US Great Plains prefer soil moisture over all other drought indicators (Shafer and Quiring, 2016).

Preferred drought indices: Oklahoma

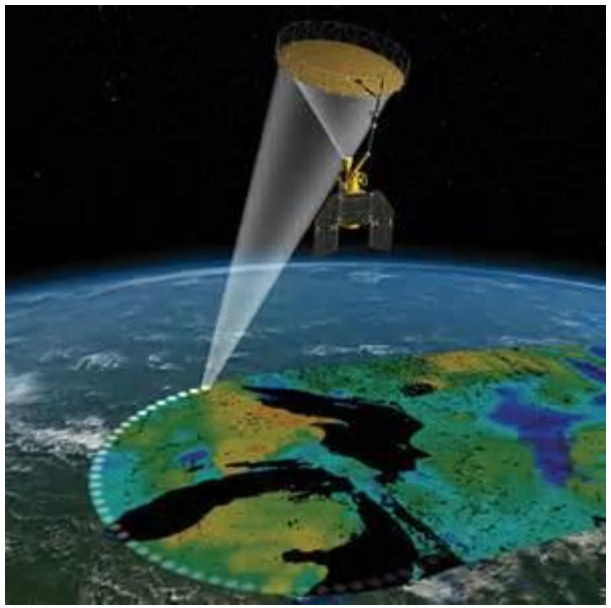


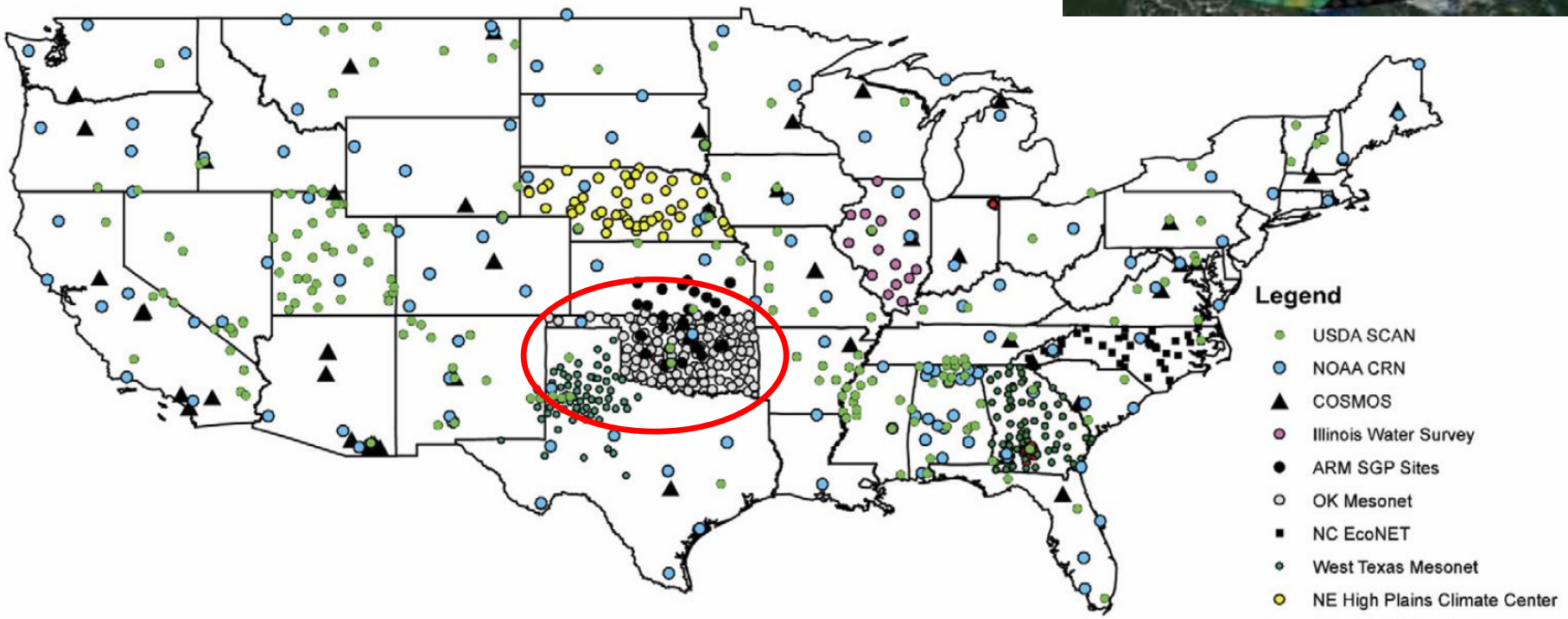
Preferred drought indices: Texas



Current soil moisture information is limited

- Exceptional spatial variability
- In-situ observations sparse
- Satellite observations shallow, low resolution





Ochsner et al. 2013. Soil Sci. Soc. Am. J. 77: 1888-1919.

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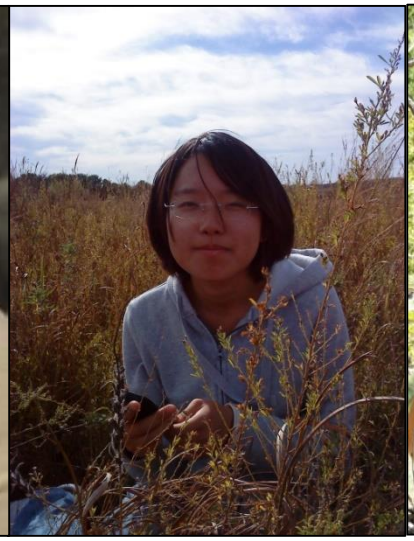
- Our primary focus is on enhanced multi-scale soil moisture **monitoring** and improved **utilization** of soil moisture observations in agriculture, ecology, hydrology, and related fields.


Briana Wyatt


Jingnuo Dong


Destiny Kerr


Erik Krueger

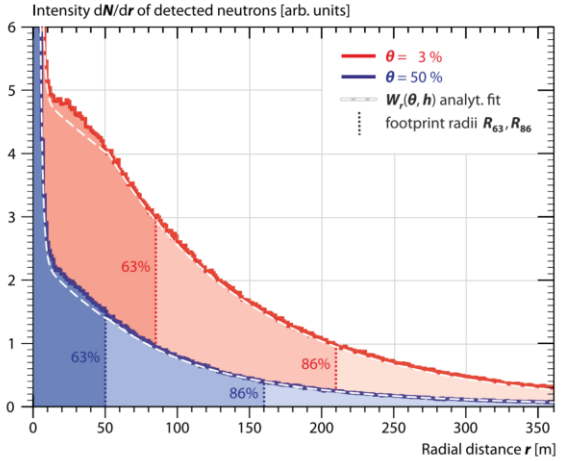

Jason Patton

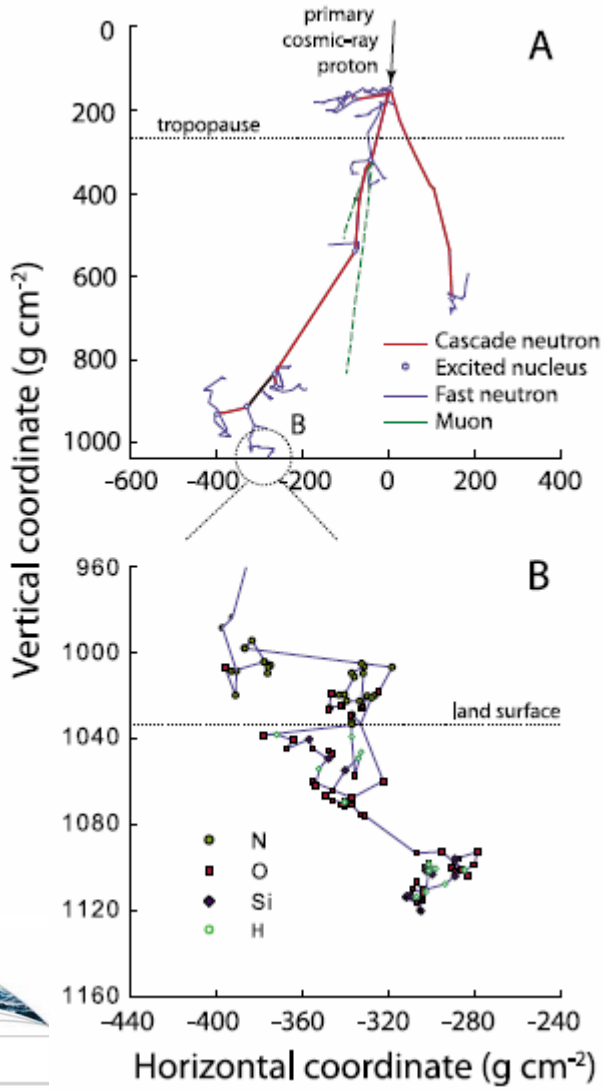
EPSCoR-enabled* progress and prospects

1. *Comparing land surface vs. atmospheric controls on meso-scale spatial patterns of soil moisture
2. *Developing and evaluating an operational, high-resolution soil moisture mapping system for Oklahoma
3. Exploring uses of soil moisture information for:
   - Estimating potential groundwater recharge
   - Predicting wildfire danger
   - Monitoring agricultural drought/crop yield forecasting
   - Forecasting streamflow for surface water management and emergency responses
4. *Supporting broader impacts through the MOISST workshop

At what scales do atmospheric versus land surface factors dominate the spatial pattern of soil moisture?

- Cosmic-ray neutron method
- Large mobile neutron detector, the “rover”



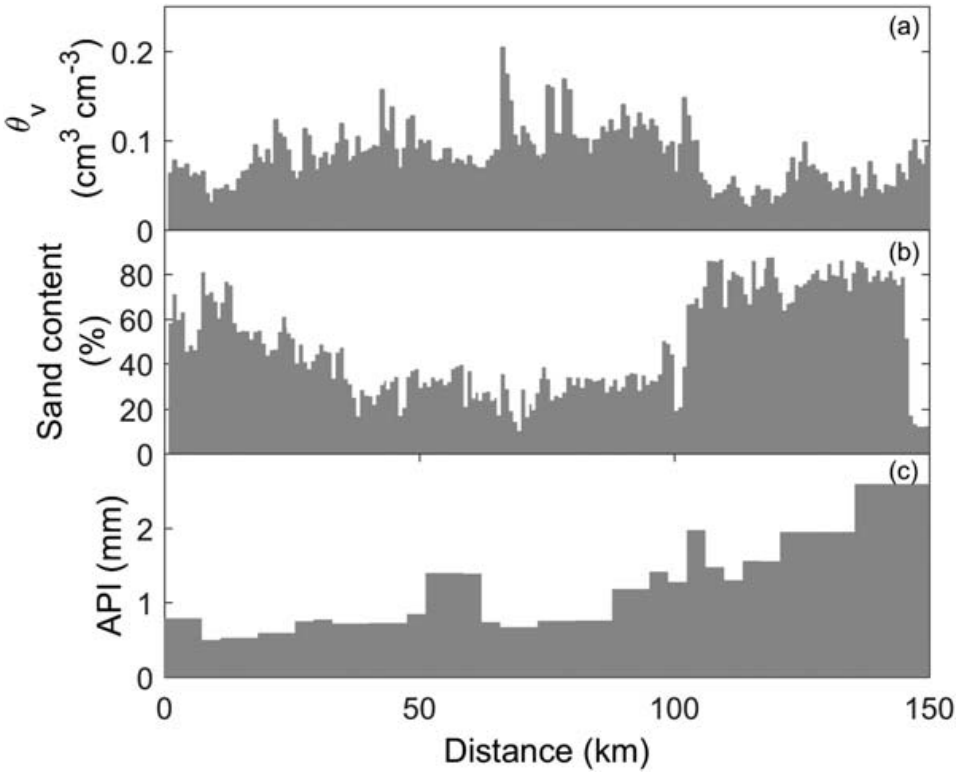


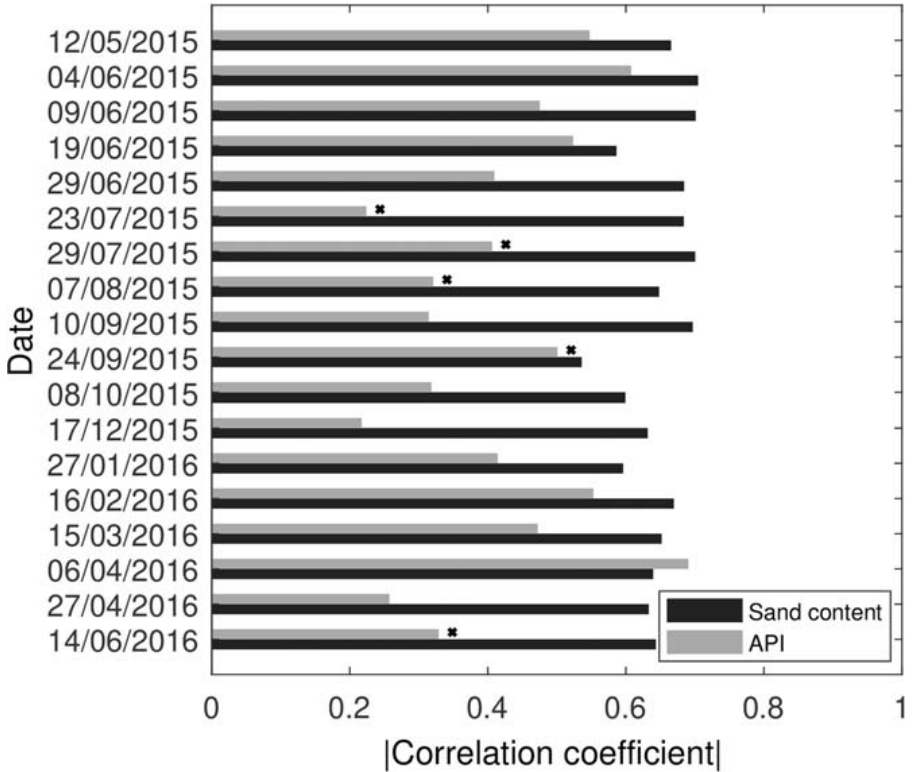
Dong and Ochsner (2018) link

Water Resources Research

Soil texture often exerts a stronger influence than precipitation on mesoscale soil moisture patterns

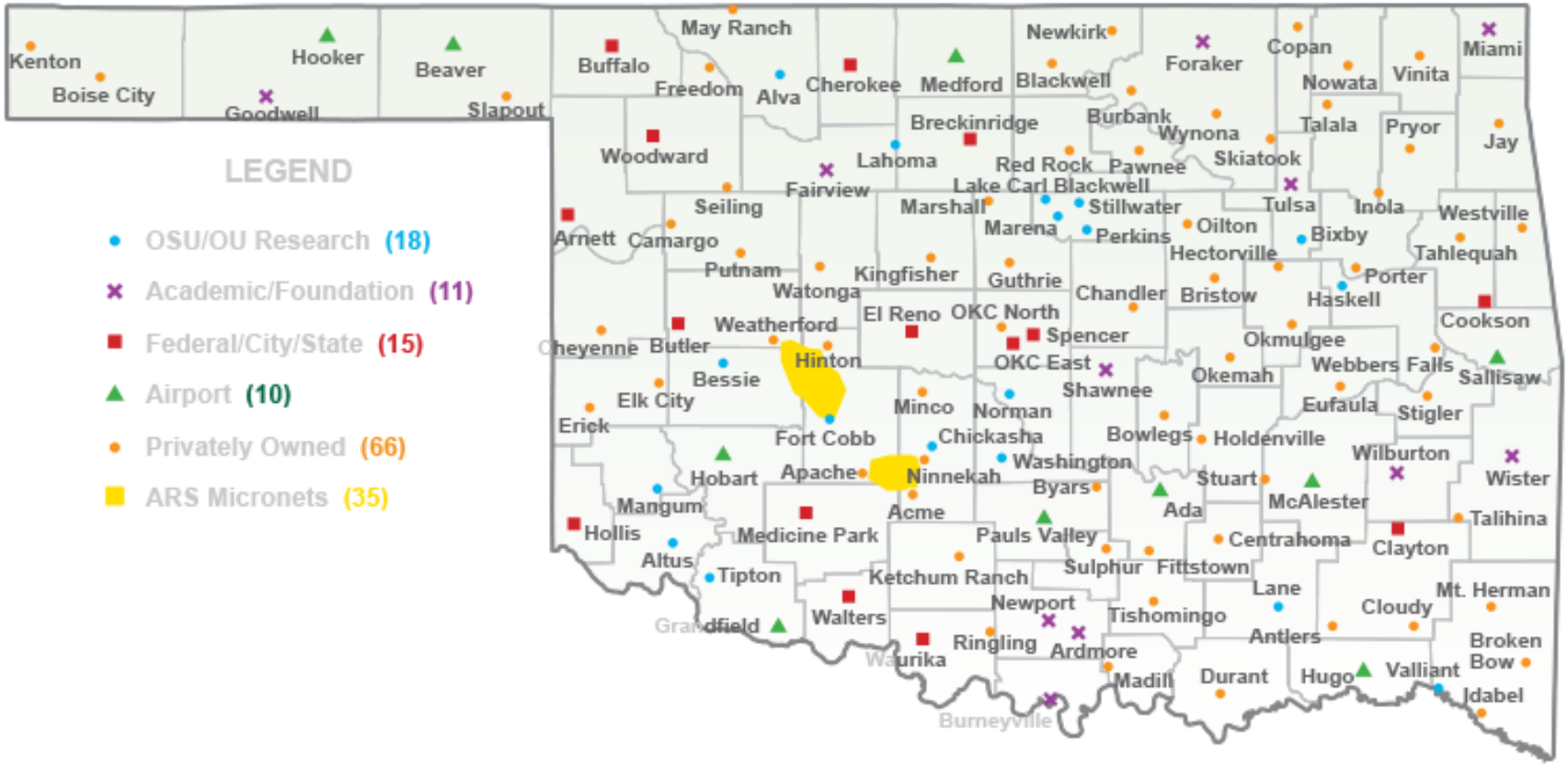
- High sand contents overlying the Cimarron River alluvial aquifer
- Soil moisture – sand content, strong inverse correlation
- Soil moisture – antecedent precipitation index (API), correlations were weaker and less stable



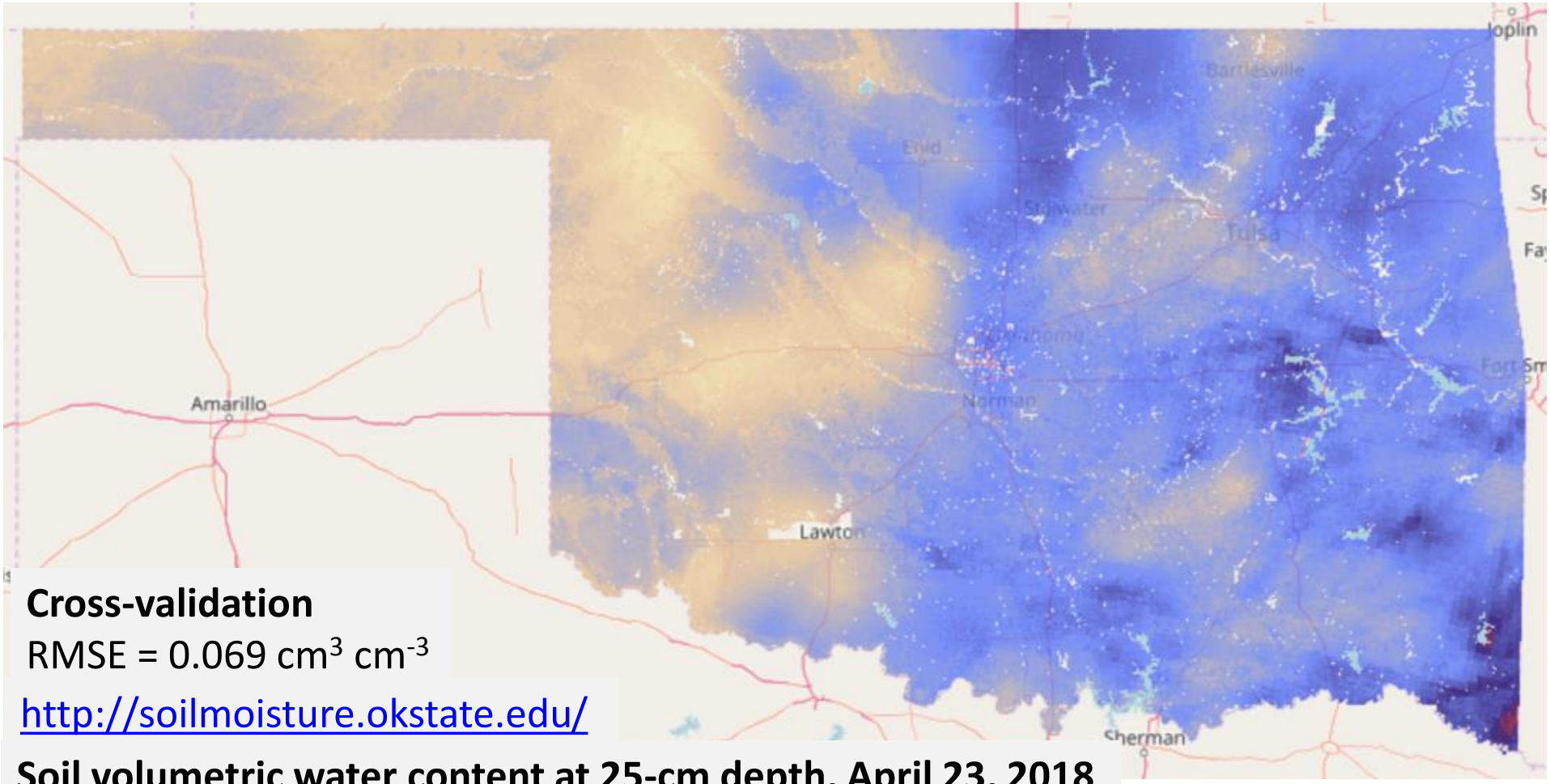


How effectively can we map dynamic soil moisture conditions statewide with existing information?

- Average of one in-situ measurement per 1680 km^2
- Existing in-situ sensors have measurement volume of ~100 cm^3



Delivering daily, 800-m resolution maps



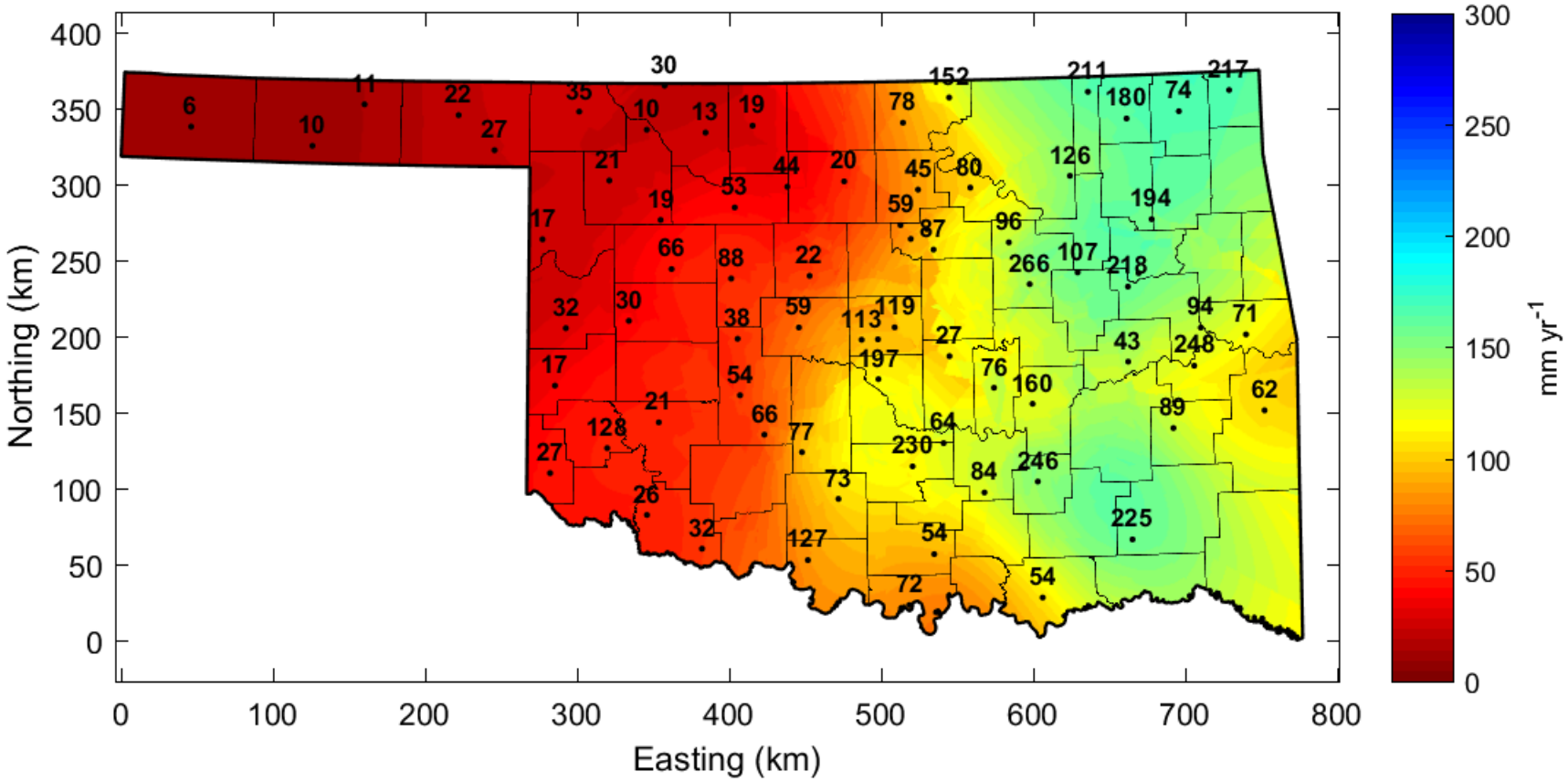
Cross-validation

RMSE = 0.069 cm^3 cm^{-3}

http://soilmoisture.okstate.edu/

Soil volumetric water content at 25-cm depth, April 23, 2018

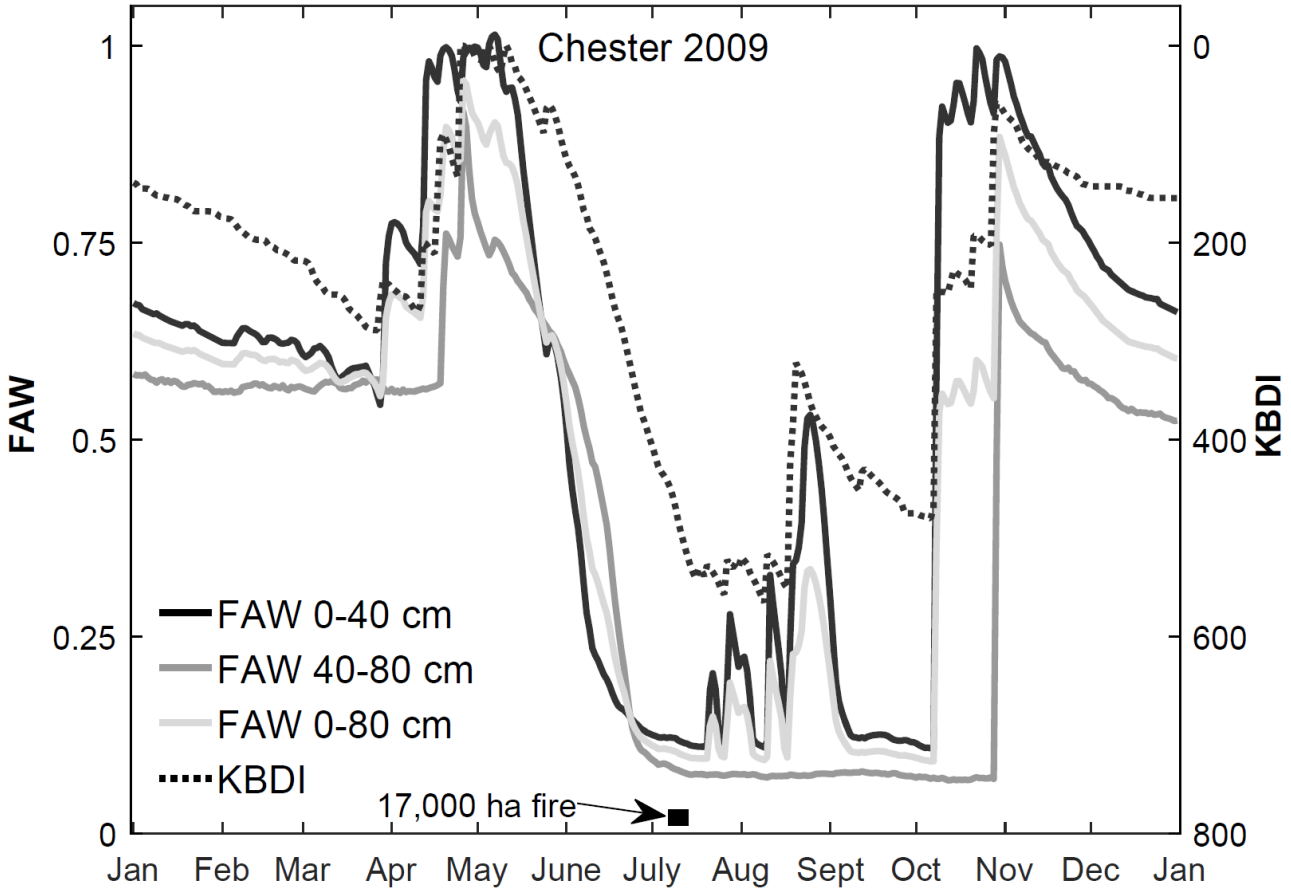
Estimating potential recharge using soil moisture information



Statewide mean annual soil moisture-based drainage rates for the years 1998-2014. Drainage rate labels for the Stillwater, Oklahoma City East, Porter, and Marena sites were excluded for clarity, but were 214, 82, 166, and 66 mm yr^{-1}, respectively.

Wyatt et al. (2017) -- Vadose Zone Journal (link)

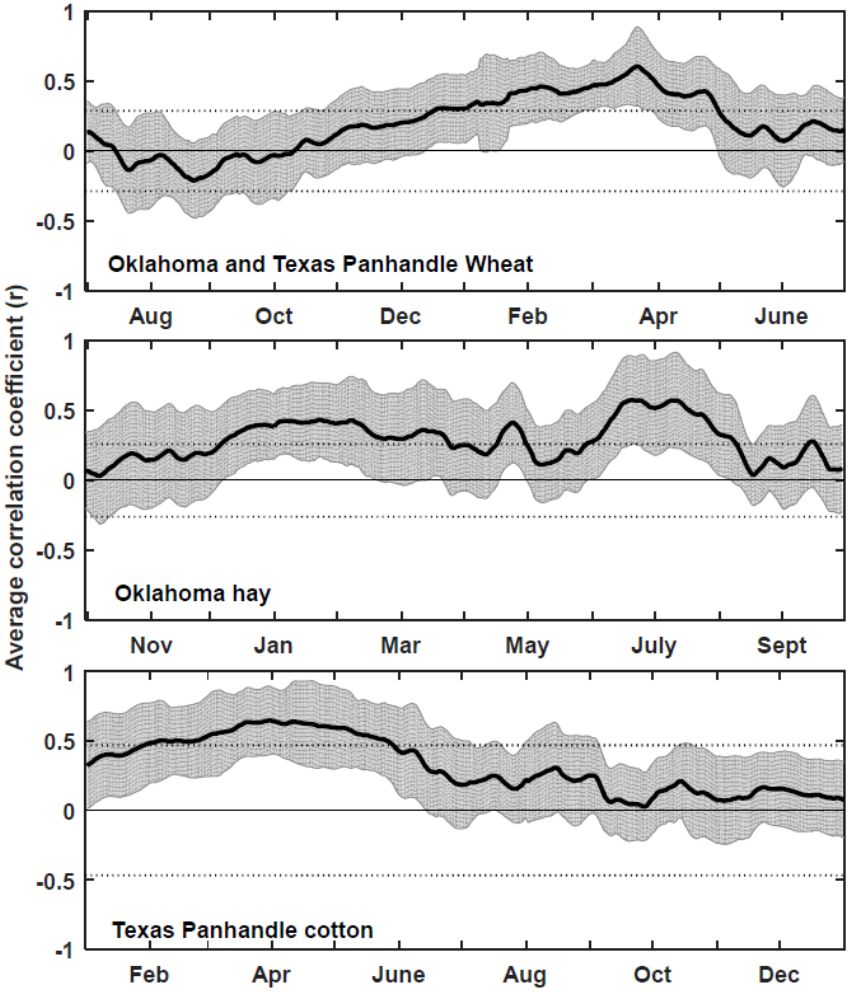
Predicting large growing season wildfires using soil moisture information



Fraction of available water capacity (FAW) for the 0-40, 40-80, and 0-80 cm soil layers as well as the Keetch-Byram Drought Index (KBDI) near Chester, Oklahoma in 2009. Also displayed is the 17,000 ha Chester wildfire that occurred near Chester, Oklahoma on 10 July, 2009.
Krueger et al. (2017) – Soil Science Society of America Journal (link)

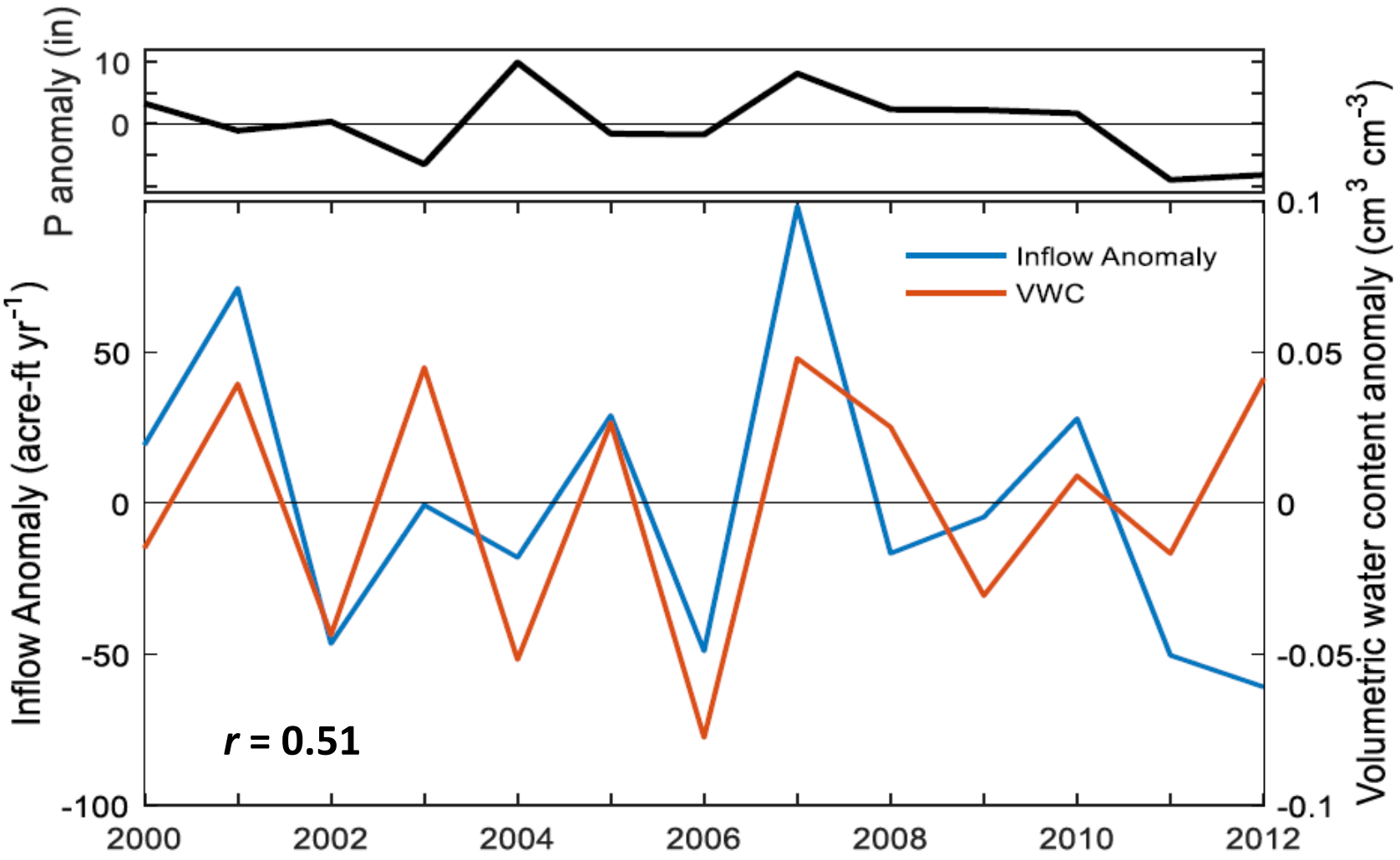
Monitoring agricultural drought using soil moisture information

- Data from monitoring networks in OK and TX
- Soil moisture anomalies strongly correlated with crop yields ($r > 0.6$)
- Soil moisture conditions show predictive potential 3-6 months before harvest



Average (black line) and standard deviation (shaded) of the correlation coefficients between soil moisture anomalies and crop yields.

Forecasting streamflow using soil moisture information



Anomalies in annual precipitation, annual lake inflow, and soil volumetric water content (VWC) on Jan. 1 for Lake Altus-Lugert watershed.

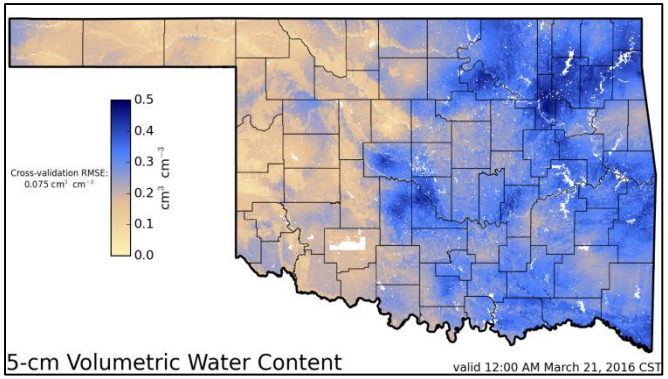
Marena, Oklahoma, In Situ Sensor Testbed (MOISST)

EPSCoR sponsored MOISST workshops

2018 MOISST Workshop Information
http://snr.unl.edu/research/projects/MOISST/workshop2018.asp

Acknowledgments

- Supported by:
  - **NSF EPSCoR (Grant No. OIA-1301789)**
  - NASA Terrestrial Hydrology Program
  - Joint Fire Science Program
  - Oklahoma Water Resources Center
  - Oklahoma Agricultural Experiment Station
  - USGS
  - South Central Climate Science Center



http://soilmoisture.okstate.edu/

- Partners include:
  - OSU Soil Physics group
  - NSF EPSCoR team
  - Mike Cosh
  - MOISST collaborators
  - JFSP project team
  - Oklahoma Mesonet staff
  - Oklahoma Water Resources Board staff

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Thank you!

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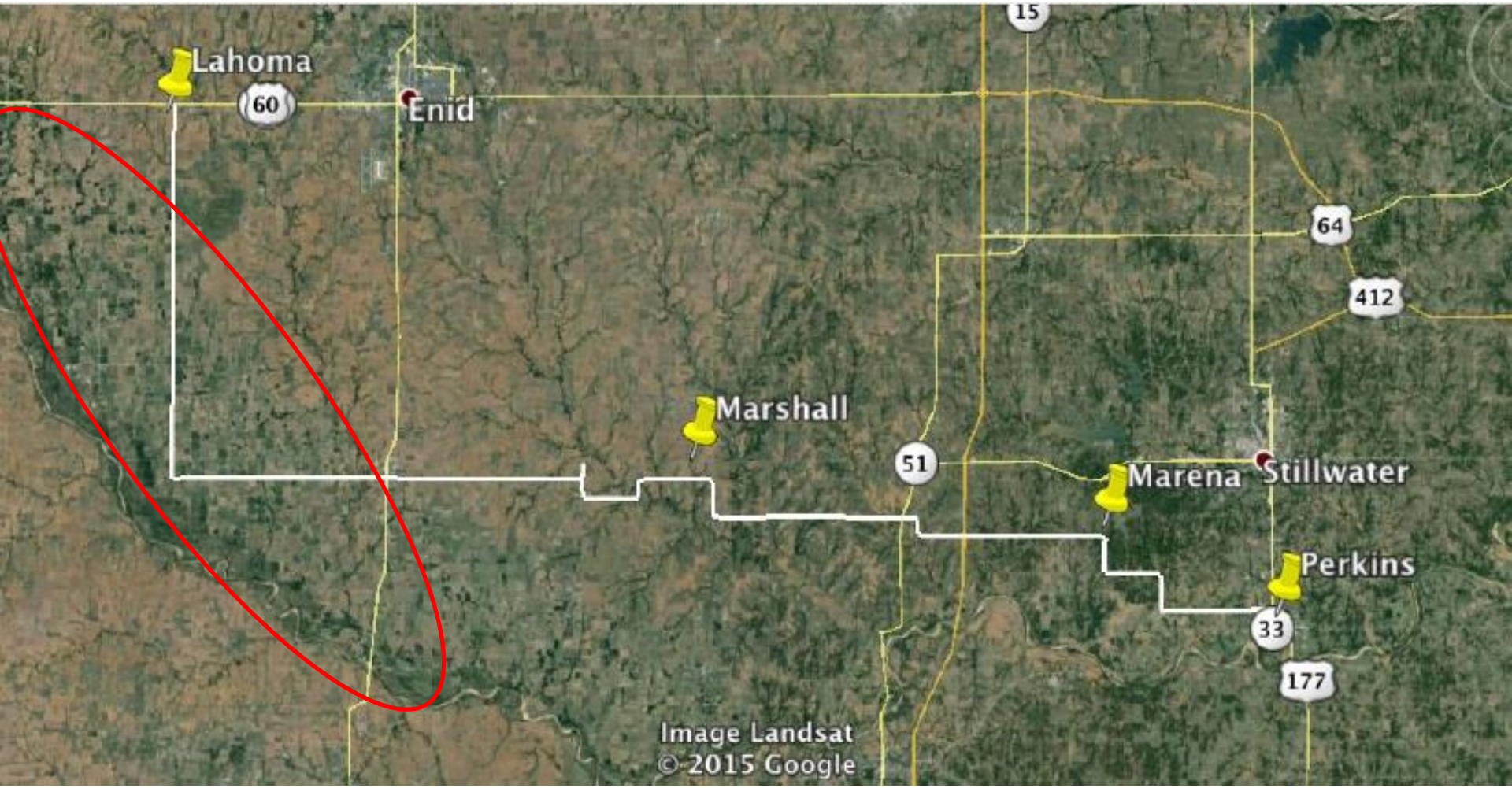
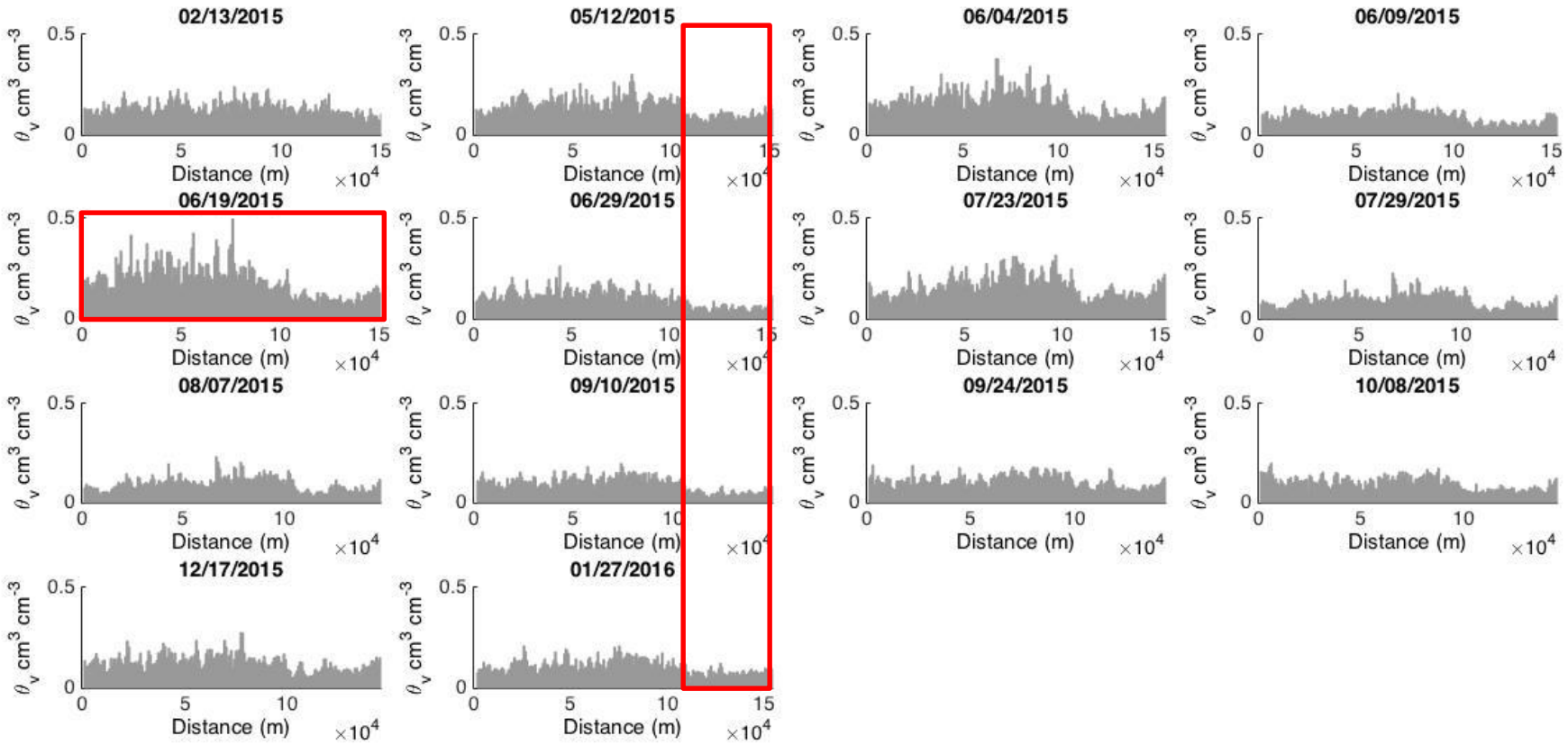
http://canopeoapp.com/

Cimarron River Transect Study

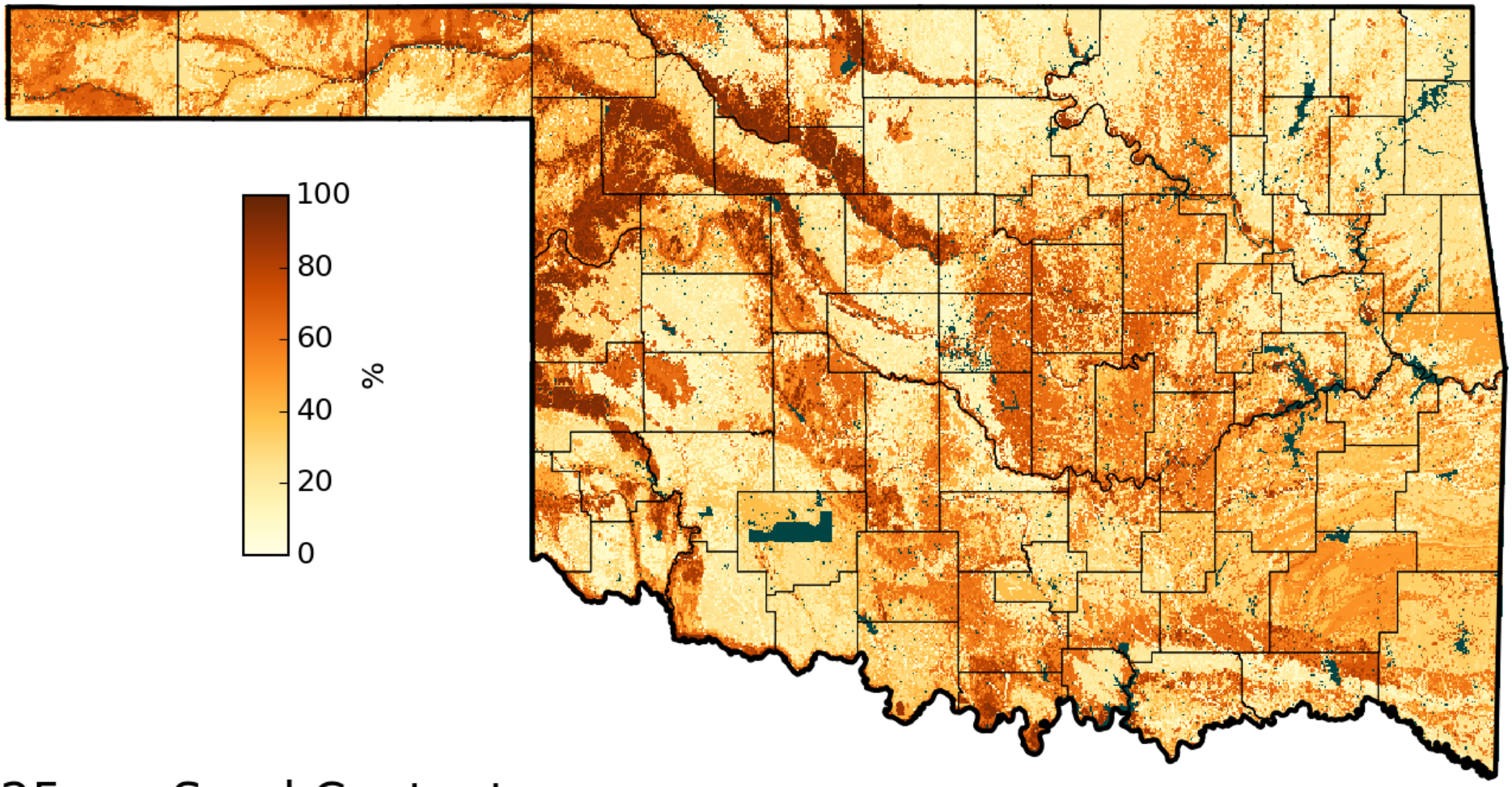


Soil moisture transects

- Persistent low soil moisture for western third
- Maximum variability after rainfall on eastern half



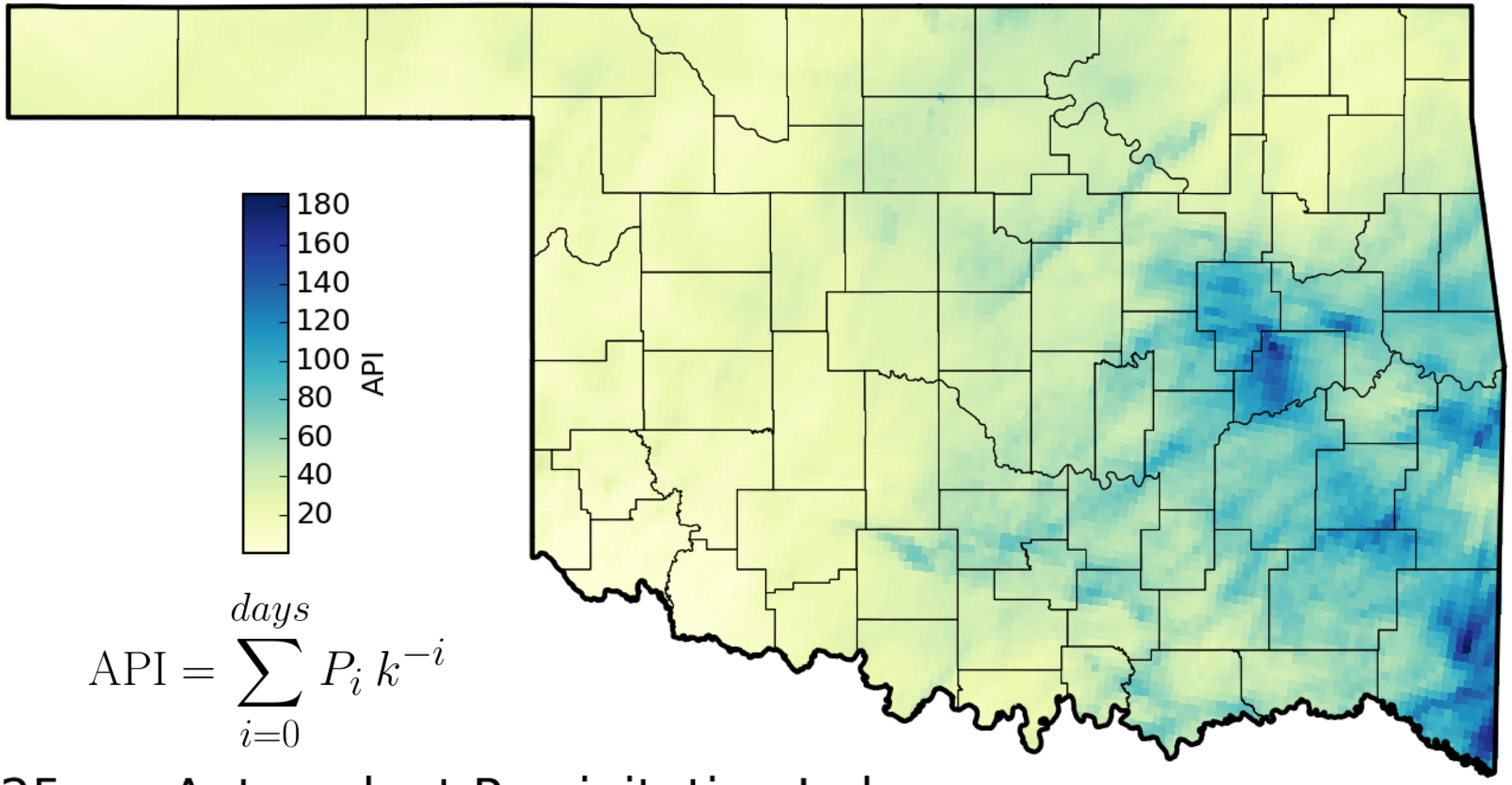
Using soil texture information



25-cm Sand Content

estimated from USDA-NRCS SSURGO

Using radar-based precipitation

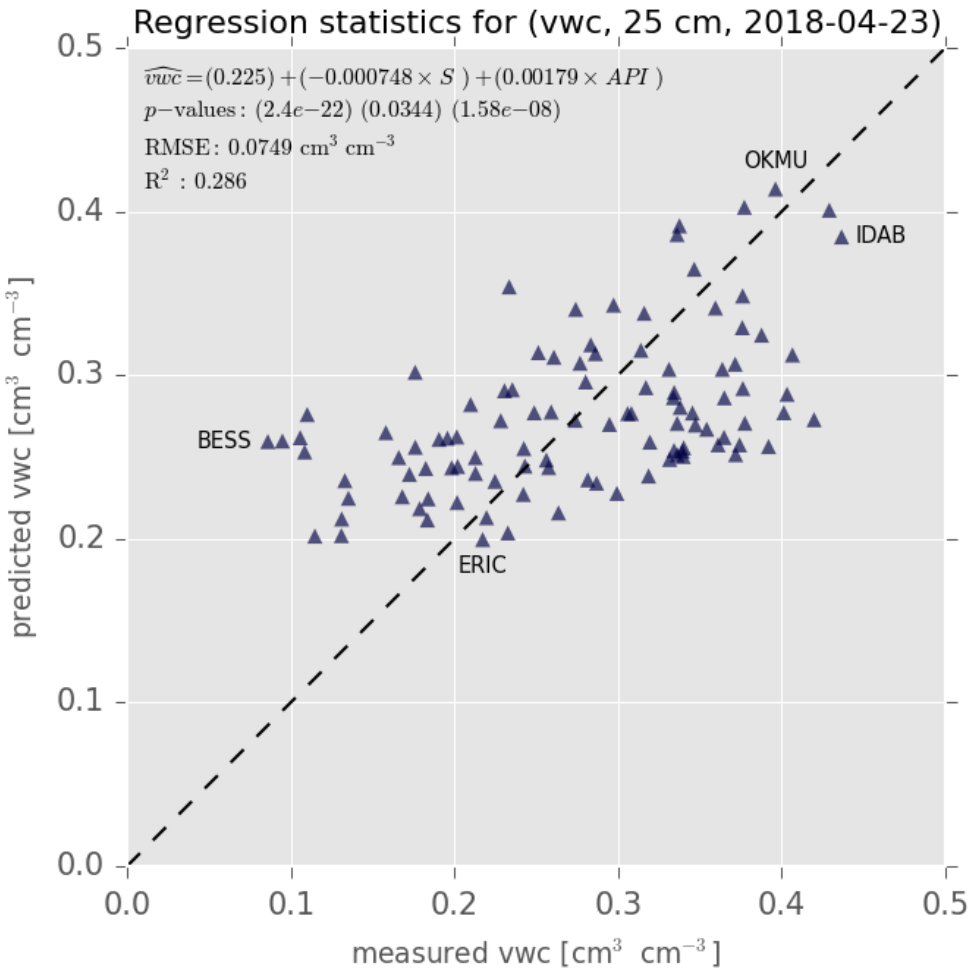


$$\text{API} = \sum_{i=0}^{days} P_i \, k^{-i}$$

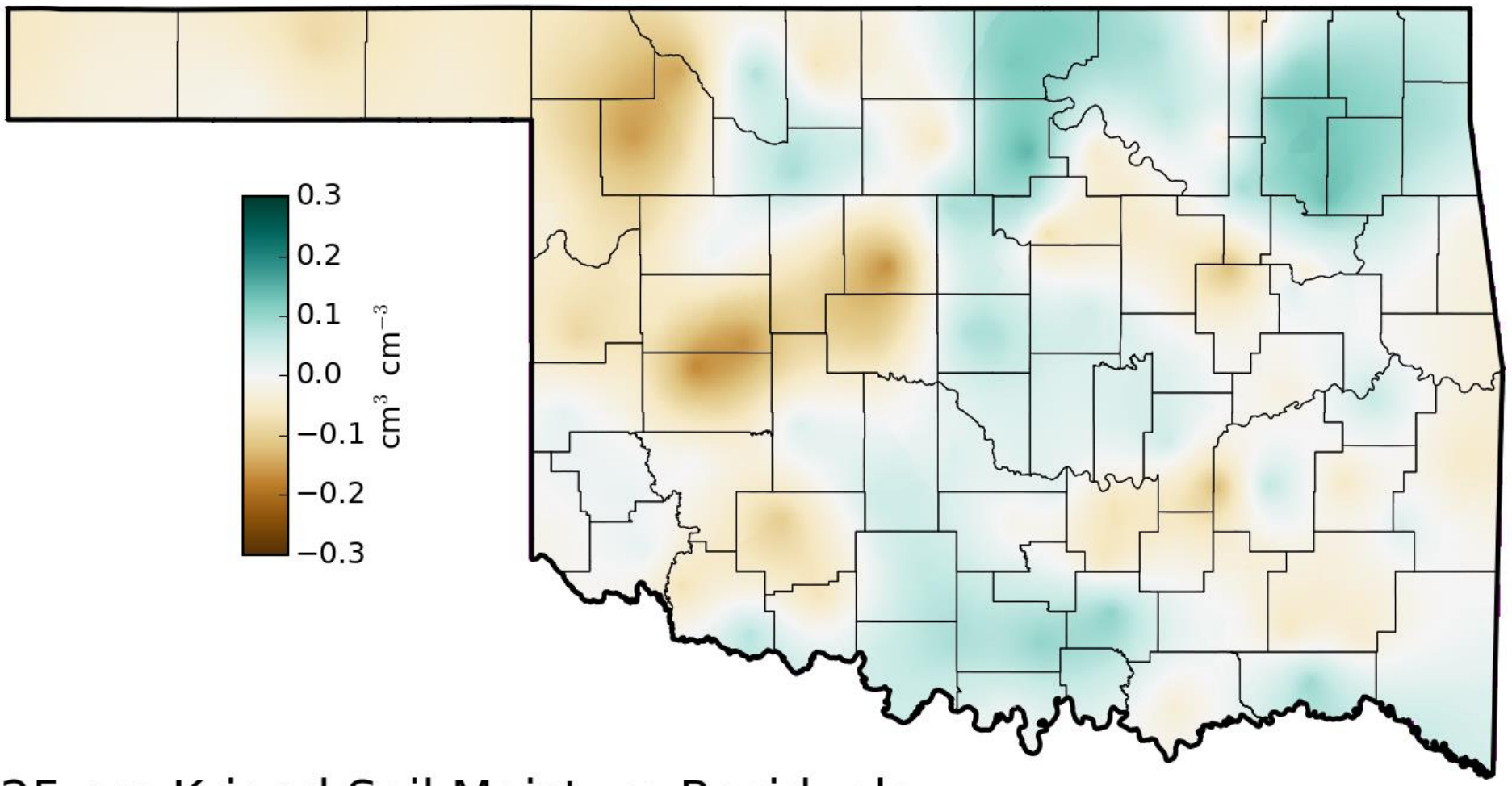
25-cm Antecedent Precipitation Index

valid 12:00 AM April 23, 2018 CST

Creating a regression model for the available observations

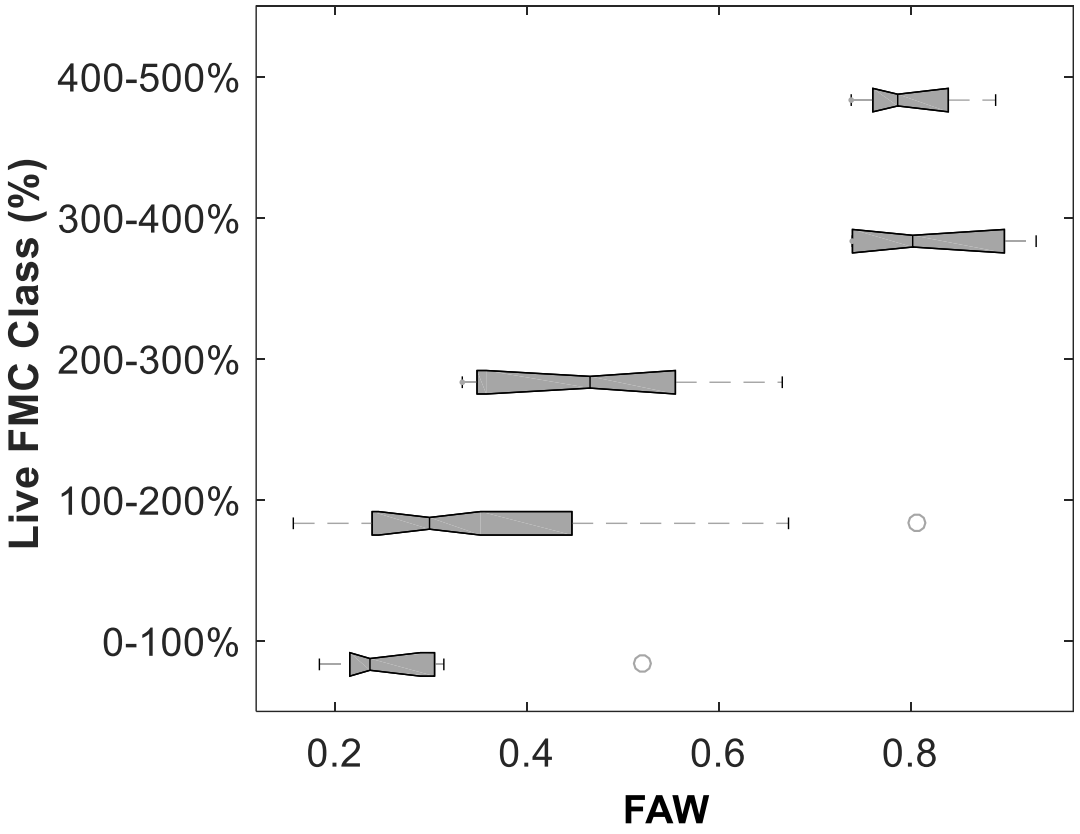


Kriging the model residuals (errors)



Grassland vegetation (fuel) moisture content

- Two growing seasons of soil and vegetation moisture measurements
- Fuel moisture exhibits a threshold-type dependency on soil moisture.



Fraction of available water capacity (FAW) measured at 0-40 cm for Live Fuel Moisture Content Classes during the growing season for tallgrass prairie in Oklahoma from 2012-2013.