Department of Plant and Soil Sciences
SOIL PHYSICS

Soil Moisture Research in Oklahoma: Progress and Prospects

Tyson Ochsner
Dep. of Plant and Soil Sciences
Oklahoma State University

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2011 MOISST Workshop

Ochsner group objectives (from 2011)

- Serve the local support needs of the various MOISST research groups
- Collaborate with other MOISST investigators in areas of common interest
- Develop Oklahoma as a magnet for and center of international research and expertise in in situ soil moisture monitoring

MOISST-derived papers to date

1. Ochsner, T.E., M.H. Cosh, R.H. Cuenca, W.A. Dorigo, C.S. Draper, Y. Hagimoto, Y.H. Kerr, E.G. Njoku, E.E. Small and M. Zreda. 2013. State of the Art in Large-Scale Soil Moisture Monitoring. **Soil Sci. Soc. Am. J.** 77: 1888-1919.
2. Dong, J., T.E. Ochsner, M. Zreda, M.H. Cosh and C.B. Zou. 2014. Calibration and validation of the COSMOS rover for surface soil moisture measurement. **Vadose Zone J**. doi:doi:10.2136/vzj2013.08.0148.
3. Dong, J., S.C. Steele-Dunne, T.E. Ochsner and N. van de Giesen. 2015. Determining soil moisture by assimilating soil temperature measurements using the Ensemble Kalman Filter. **Advances in Water Resources** 86: 340-353.
4. Cosh, M.H., T.E. Ochsner, L. McKee, J. Dong, J.B. Basara, S.R. Evett, C.E. Hatch, E.E. Small, S.C. Steele-Dunne, M. Zreda and C. Sayde. 2016. The Soil Moisture Active Passive Marena, Oklahoma, In Situ Sensor Testbed (SMAP-MOISST): Testbed Design and Evaluation of In Situ Sensors. **Vadose Zone J.** 15. doi:10.2136/vzj2015.09.0122.
5. Dong, J., S.C. Steele-Dunne, T.E. Ochsner and N.v.d. Giesen. 2016. Estimating soil moisture and soil thermal and hydraulic properties by assimilating soil temperatures using a particle batch smoother. **Advances in Water Resources** 91: 104-116. doi:http://dx.doi.org/10.1016/j.advwatres.2016.03.008.
6. Dong, J., S.C. Steele-Dunne, T.E. Ochsner, C.E. Hatch, C. Sayde, J. Selker, S. Tyler, M.H. Cosh and N. van de Giesen. 2016. Mapping high-resolution soil moisture and properties using distributed temperature sensing data and an adaptive particle batch smoother. **Water Resour. Res.** 52: 7690-7710.
7. Dong, J., S.C. Steele-Dunne, T.E. Ochsner and N. van de Giesen. 2016. Determining soil moisture and soil properties in vegetated areas by assimilating soil temperatures. **Water Resour. Res.** 52: 4280-4300. doi:10.1002/2015WR018425.
8. Small, E.E., K.M. Larson, C.C. Chew, J. Dong and T.E. Ochsner. 2016. Validation of GPS-IR Soil Moisture Retrievals: Comparison of Different Algorithms to Remove Vegetation Effects. **IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing** PP: 1-12. doi:10.1109/JSTARS.2015.2504527.
9. Cheng, Y., C. Sayde, Q. Li, J. Basara, J. Selker, E. Tanner and P. Gentine. 2017. Failure of Taylor's hypothesis in the atmospheric surface layer and its correction for eddy-covariance measurements. **Geophys. Res. Lett**.: n/a-n/a. doi:10.1002/2017GL073499.

MOISST-related grants to date

1. Engle, D.M. and J.L. Steiner. 2012. Resilience and vulnerability of beef cattle production in the Southern Great Plains under changing climate, land use and markets. **USDA NIFA**. Funded. $9,567,331. 2013-2018.

2. Wicksted, J.P. and A.J. Knoedler. 2012. Adapting Socio-ecological Systems to Increased Climate Variability. **National Science Foundation**. Funded. $20,000,000. 2013-2018.

3. Ochsner, T.E., S. Quiring and E.S. Krueger. 2014. Soil Moisture-Based Drought Monitoring for the South Central Region. **South Central Climate Science Center**. Funded. $232,437. 2015-2017.

MOISST-facilitated community

Department of Plant and Soil Sciences

SOIL PHYSICS

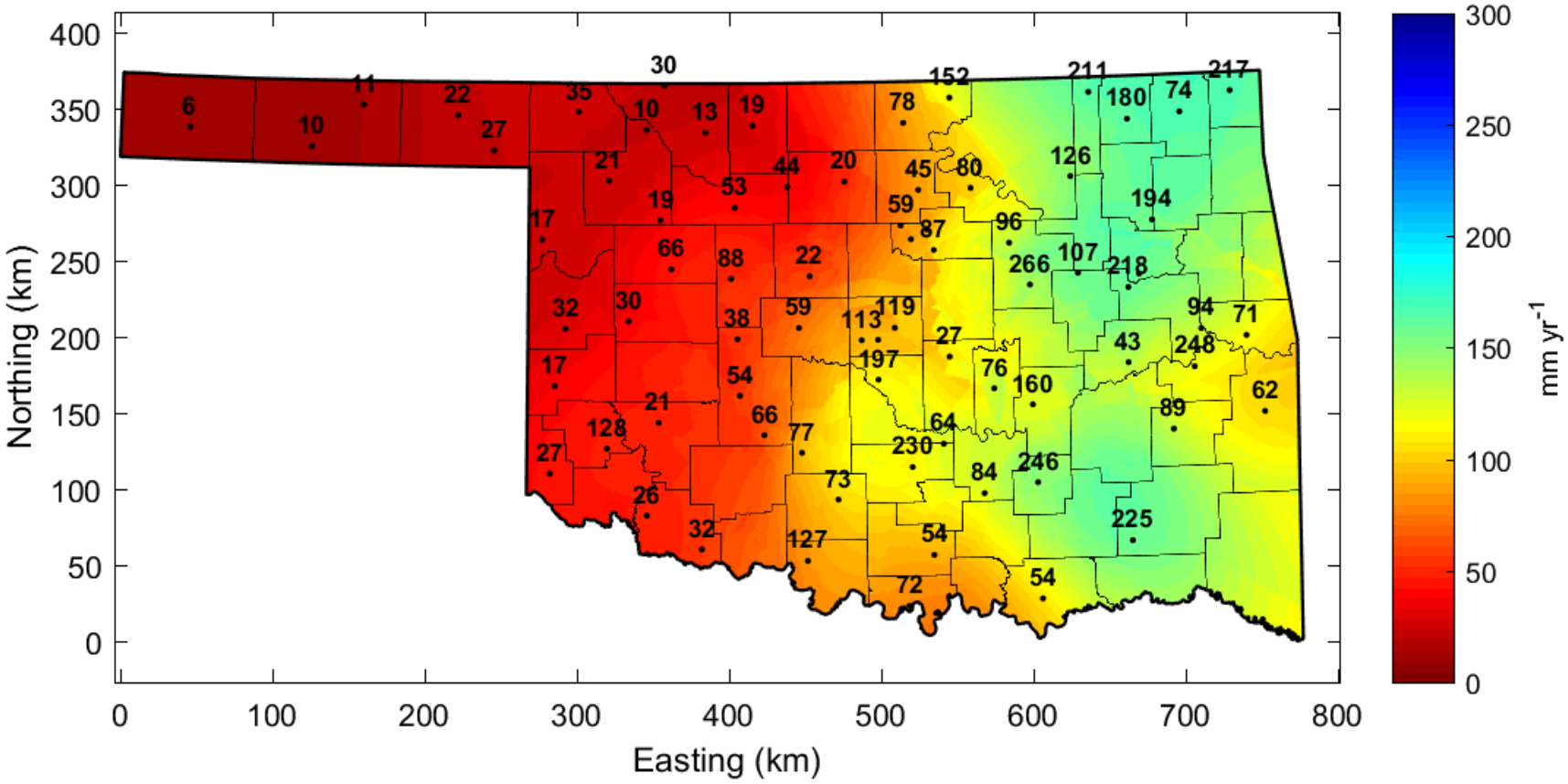
- Our primary focus is on enhanced multi-scale soil moisture monitoring and improved utilization of soil moisture observations in agriculture, ecology, hydrology, and related fields.

Briana Wyatt | Jingnuo Dong | Sonisa Sharma | Erik Krueger | Jason Patton

Ongoing soil moisture research

1. Estimating drainage and potential groundwater recharge using measured soil moisture
2. Comparing land surface vs. atmospheric controls on meso-scale spatial patterns of soil moisture
3. Understanding impacts of soil moisture on vegetation (fuel) moisture content in grassland
4. Developing effective soil-moisture based drought indicators
5. Evaluating an operational, high-resolution soil moisture mapping system for Oklahoma

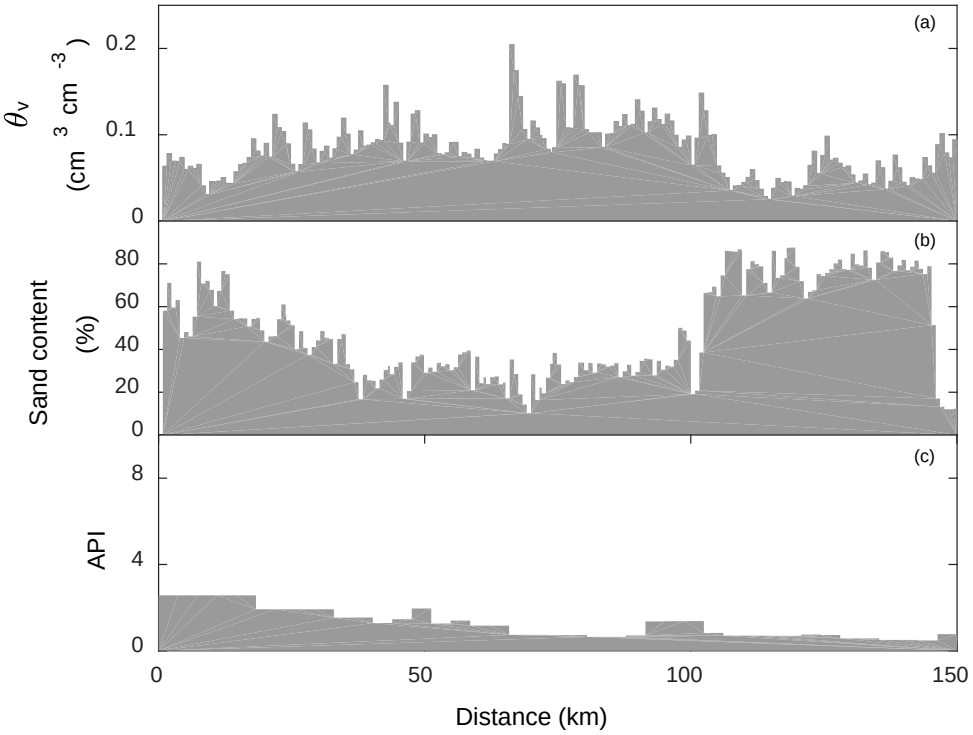
Soil moisture-based drainage rates

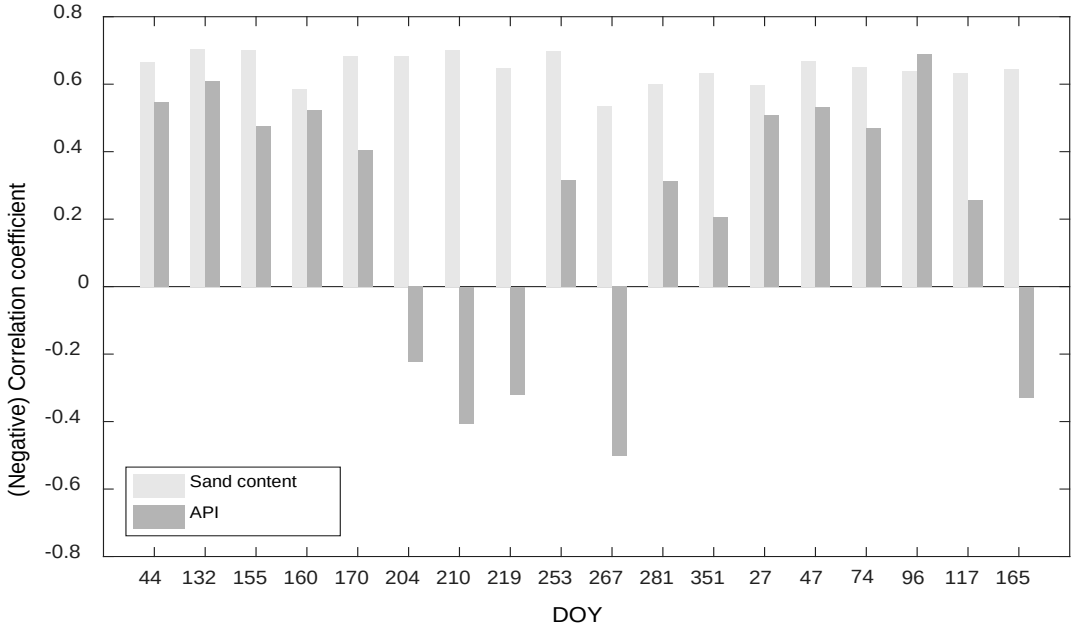


Statewide mean annual soil moisture-based drainage rates for the years 1998-2014. Drainage rate labels for the Stillwater, Oklahoma City East, Porter, and Marena sites were excluded for clarity, but were 214, 82, 166, and 66 mm yr^{-1}, respectively.

Mesoscale spatial patterns in soil moisture

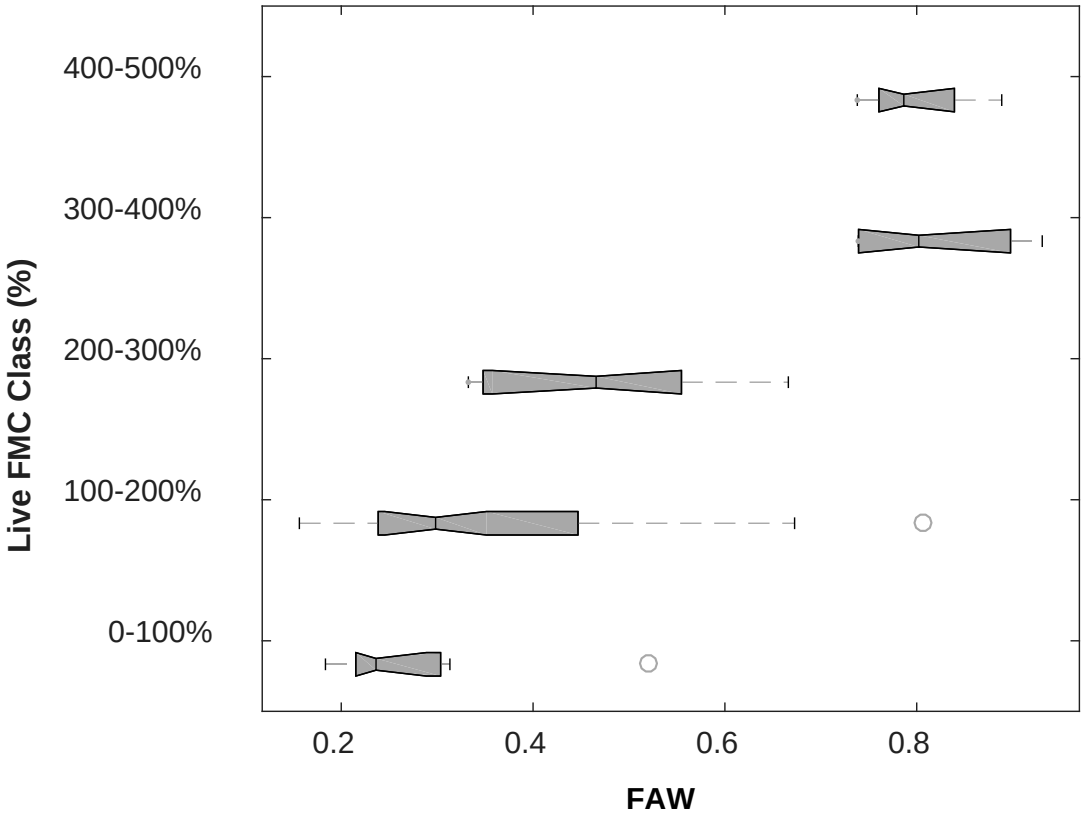
- One year of repeated cosmic-ray neutron measurements on a 150 km transect
- Strong and persistent mesoscale correlation between soil texture and soil moisture





Grassland vegetation (fuel) moisture content

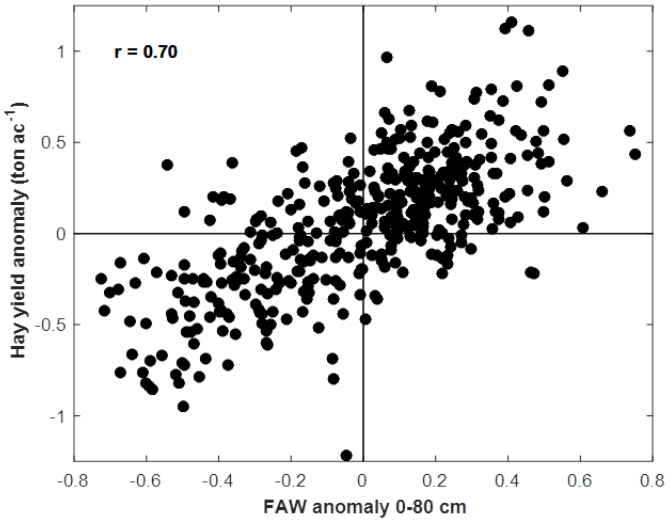
- Two growing seasons of soil and vegetation moisture measurements
- Fuel moisture exhibits a threshold-type dependency on soil moisture.



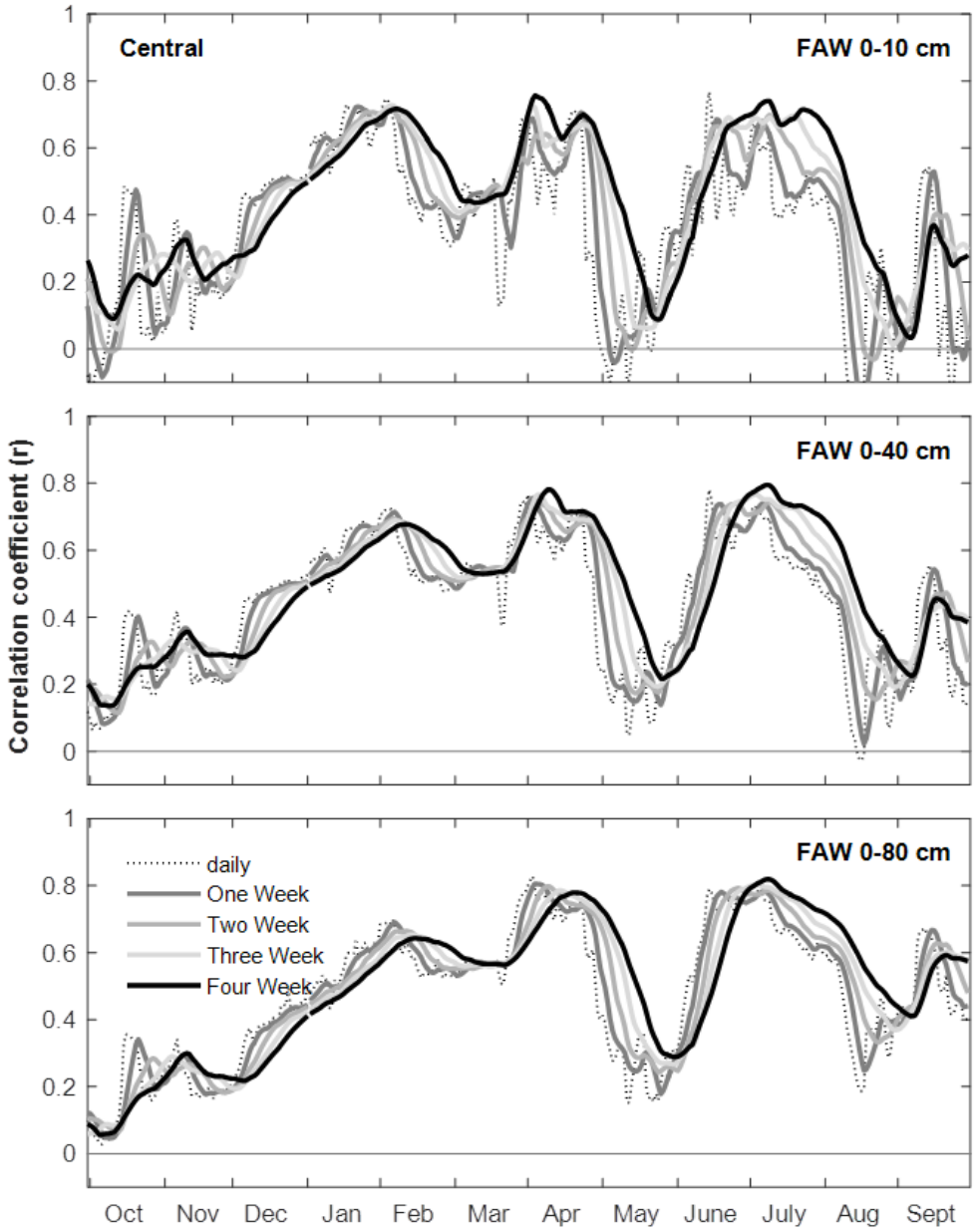
Fraction of available water capacity (FAW) measured at 0-40 cm for Live Fuel Moisture Content Classes during the growing season for tallgrass prairie in Oklahoma from 2012-2013.

Soil moisture-based drought indicators

- Spring FAW anomaly significantly correlated with subsequent hay and wheat yields

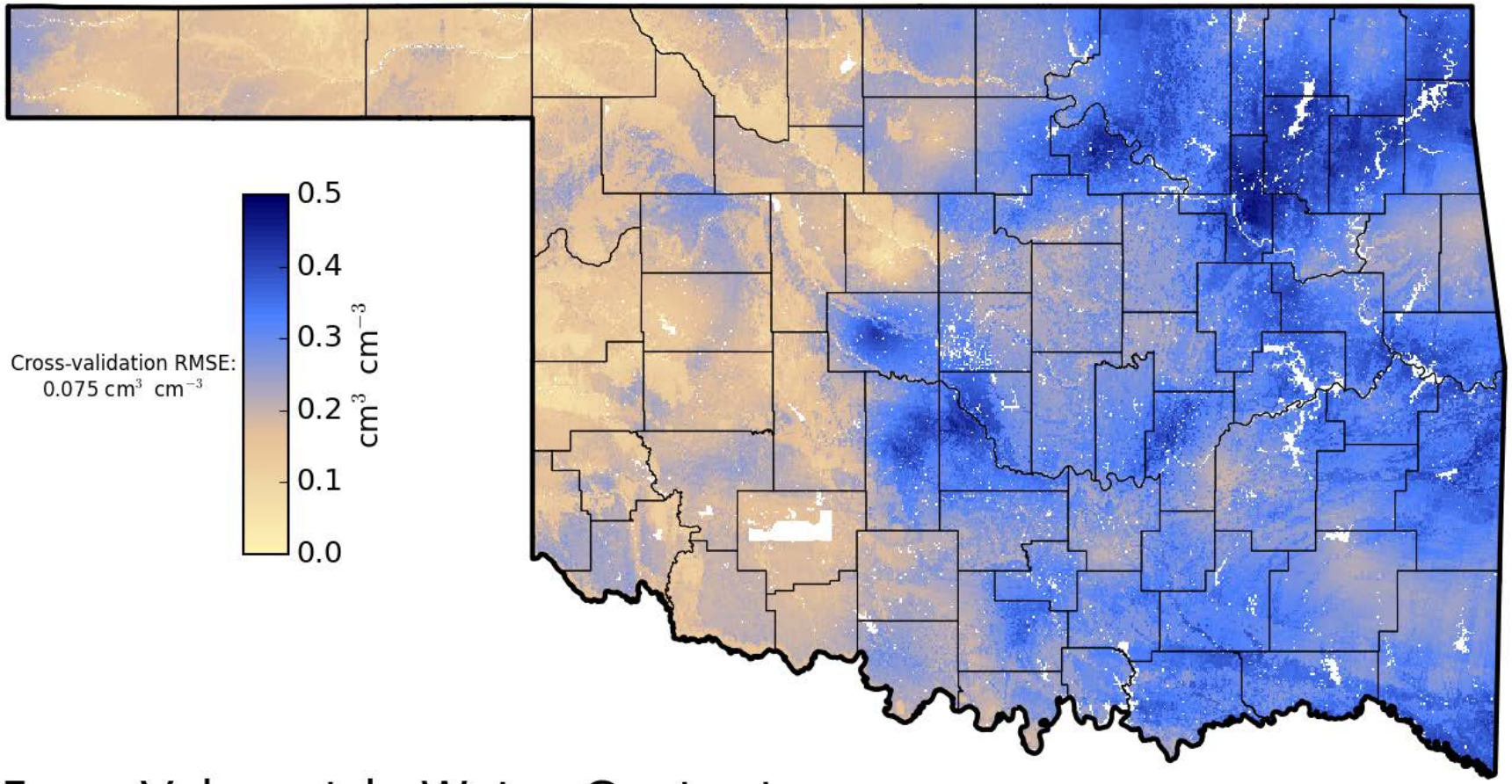


Scatterplot of hay grain yield anomaly and spring FAW anomaly (1-wk average) for 42 Oklahoma counties from 2000-2016.



Time series of correlation coefficients between FAW and hay yield for the Central agricultural district in Oklahoma.

Daily, 800-m resolution maps



http://soilmoisture.okstate.edu/

Projects in early stages

- High resolution soil moisture modeling across heterogeneous vegetation types
- Soil moisture-informed crop forecasting
- Soil moisture-informed streamflow forecasting
- Quantifying soil moisture and temperature controls on soil organic carbon
- Too many ideas, too little time…

Acknowledgments and invitations

- Supported by:
  - NASA Terrestrial Hydrology Program
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  - Joint Fire Science Program
  - Oklahoma Water Resources Center
  - Oklahoma Agricultural Experiment Station
  - USGS
  - South Central Climate Science Center

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

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Thank you!

tyson.ochsner@okstate.edu

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