Impacts of Weather Variability on Soil Moisture and Groundwater in Oklahoma: Interactive Geospatial Analysis and Decision-Support Tools

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2018 Oklahoma EPSCoR annual meeting
Oklahoma City, OK
April, 24, 2018

Summary of contributions to EPSCoR by WEFI team

Students supported:

Dorothy Na-Yemeh (PhD student) → OK Mesonet and emergency management

Monica Mattox (PhD student) → OK Mesonet and fire management

Jesus Zubillaga (MSc student) → OK Mesonet and agriculture in OK

Nicholas Hardersen (MSc student) → Water management in OK

Morgan Ederer (UG student) → Drought and agricultural sector in OK

OU/OSU collaborators:

Dr. Chris Fiebrich, Al Sutherland, Dr. JD Carlson, James Hocker, Dr. Mark Shafer

Reuben Reyes, Dr. Gary McManus, Kyle Davis

Summary of contributions to EPSCoR by WEFI team

Peer-reviewed journal papers (published):

1. Ziolkowska, J.R.; Peterson, J.M. (eds.) (2016): *Competition for Water Resources: Experiences and Management Approaches in the US and Europe*. Elsevier: Cambridge, MA
2. Ziolkowska, J.R.; Fiebrich, C.A.; Carlson, J.D.; Melvin, A.D.; Sutherland, A.J.; Kloesel, K.; McManus, G.D.; Illston, B.G.; Hocker, J.E.; Reyes, R. (2017): Benefits and Beneficiaries of the Oklahoma Mesonet – A Multi-Sectoral Ripple Effect Analysis. *Weather, Climate and Society* 9(3): 499-519
3. Ziolkowska, J.R.; Reyes, R. (2017): Groundwater Level Changes due to Extreme Weather - An Evaluation Tool for Sustainable Water Management. *Water* 9(2): 117
4. Ziolkowska, J.R. (2017): Profitability of Irrigation and Value of Water in Oklahoma and Texas agriculture. *International Journal of Water Resources Development*. DOI: 10.1080/07900627.2017.1353410
5. Ziolkowska, J.R.; Reyes, R. (2016): Geological and Hydrological Visualization Models for Digital Earth Representation. *Computers & Geosciences* 94: 31-39
6. Ziolkowska, J.R.; Reyes, R. (2016): Impact of Socio-Economic Growth on Desalination in the US. *Journal of Environmental Management* 167: 15-22
7. Ziolkowska, J.R. (2015): Shadow Price of Water for Irrigation – A Case of the High Plains. *Agricultural Water Management* 153: 20-31

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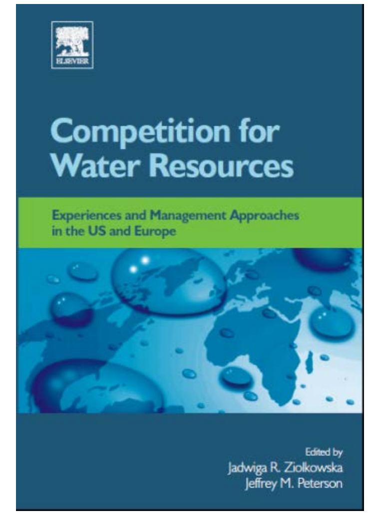
Summary of contributions to EPSCoR by WEFI team

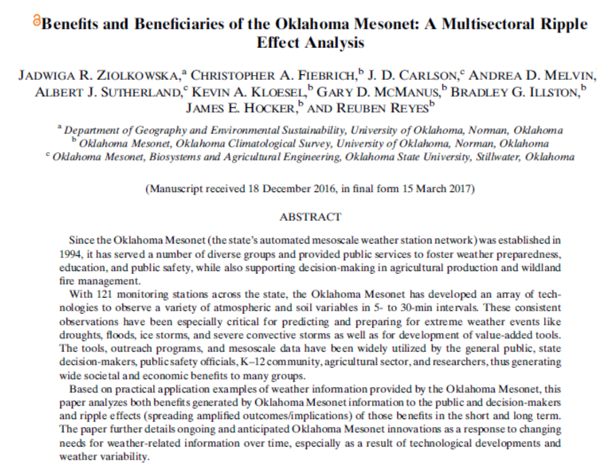
Emphasis:

Ziolkowska, J.R.; Peterson, J.M. (eds.) (2016): *Competition for Water Resources: Experiences and Management Approaches in the US and Europe*. Elsevier: Cambridge, MA

- 25 chapters (43 authors from the US and Europe)
- Collaborators from the US (27), 16 from different EU countries (Germany, Poland, Spain, Belgium, and France)
- Almost **20% of the authors (8 scholars) from OK** (OU & OSU)



Ziolkowska, J.R.; Fiebrich, C.A.; Carlson, J.D.; Melvin, A.D.; Sutherland, A.J.; Kloesel, K.; McManus, G.D.; Illston, B.G.; Hocker, J.E.; Reyes, R. (2017): Benefits and Beneficiaries of the Oklahoma Mesonet – A Multi-Sectoral Ripple Effect Analysis. *Weather, Climate and Society* 9(3): 499-519



Benefits and Beneficiaries of the Oklahoma Mesonet: A Multisectoral Ripple Effect Analysis

Jadwiga R. Ziolkowska,[a] Christopher A. Fiebrich,[b] J. D. Carlson,[c] Andrea D. Melvin,[b] Albert J. Sutherland,[c] Kevin A. Kloesel,[b] Gary D. McManus,[b] Bradley G. Illston,[b] James E. Hocker,[b] and Reuben Reyes[b]

[a] *Department of Geography and Environmental Sustainability, University of Oklahoma, Norman, Oklahoma*
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[c] *Oklahoma Mesonet, Biosystems and Agricultural Engineering, Oklahoma State University, Stillwater, Oklahoma*

(Manuscript received 18 December 2016, in final form 15 March 2017)

ABSTRACT

Since the Oklahoma Mesonet (the state's automated mesoscale weather station network) was established in 1994, it has served a number of diverse groups and provided public services to foster weather preparedness, education, and public safety, while also supporting decision-making in agricultural production and wildland fire management.

With 121 monitoring stations across the state, the Oklahoma Mesonet has developed an array of technologies to observe a variety of atmospheric and soil variables in 5- to 30-min intervals. These consistent observations have been especially critical for predicting and preparing for extreme weather events like droughts, floods, ice storms, and severe convective storms as well as for development of value-added tools. The tools, outreach programs, and mesoscale data have been widely utilized by the general public, state decision-makers, public safety officials, K–12 community, agricultural sector, and researchers, thus generating wide societal and economic benefits to many groups.

Based on practical application examples of weather information provided by the Oklahoma Mesonet, this paper analyzes both benefits generated by Oklahoma Mesonet information to the public and decision-makers and ripple effects (spreading amplified outcomes/implications) of those benefits in the short and long term. The paper further details ongoing and anticipated Oklahoma Mesonet innovations as a response to changing needs for weather-related information over time, especially as a result of technological developments and weather variability.

Summary of contributions to EPSCoR by WEFI team

Publications (cont.):

Invited showcase on Cesium:

Ziolkowska, J.R.; Reyes, R. (2016)

https://cesiumjs.org/demos/Desalination/

https://cesiumjs.org/demos/GlobalSubsurface/

https://cesiumjs.org/demos/TXGeothermal/

https://cesiumjs.org/demos/TexasGroundwater/

Accepted and under review:

1. Ziolkowska, J.R.; Zubillaga, J.: Importance of the Oklahoma Mesonet for Agricultural Decision-Making – Behavioral Economics Perspective
2. Ziolkowska, J.R.: Economic Value of Mesonet Weather Information for Oklahoma Agriculture

Summary of contributions to EPSCoR by WEFI team

Conference presentations:

International: CAN, Chile, MX, Serbia

Domestic: AK, AL, CA, CO, LA, OK, TX

Outlook:

1. Ziolkowska, J.R., Reyes, R.; McManus, G.: Modeling and Predicting Drought in Oklahoma and Texas
2. 3D model showcase of EPSCoR results → 3D technology by courtesy of DGES
   (Oklahoma Governors Conference and Water Symposium)

Impacts of Weather Variability on Soil Moisture and Groundwater in Oklahoma: Interactive Geospatial Analysis and Decision-Support Tools

Jad Ziolkowska, Reuben Reyes, Gary McManus

Research objective

Objective

Develop model to monitor and predict drought in Oklahoma in long-term

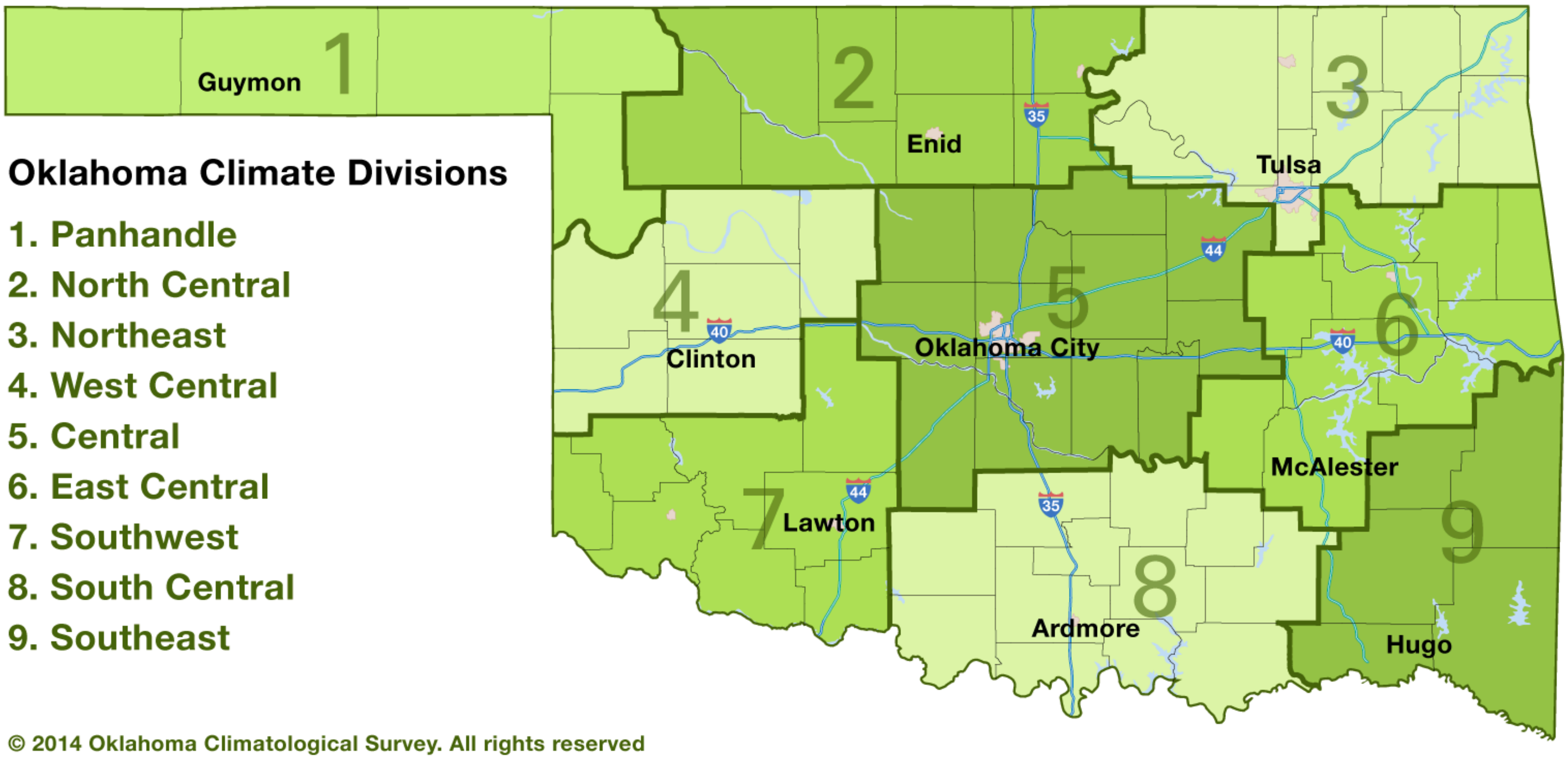
Hypothesis

Groundwater well levels and soil moisture are accurate indicators and predictors of drought in OK in 2003-2014

Proceeding to verify the hypothesis

1. Analyze changes in **groundwater well** and **soil moisture levels**
2. Use the **Palmer Drought Index** as validation (statistical and visual geospatial correlations)

Oklahoma climate regions



Methodology and data

1. Soil moisture data

   60 cm soil moisture measurements – Oklahoma Mesonet data set

   55 stations with complete and continuous data sets in 2003-2014 (normalization)

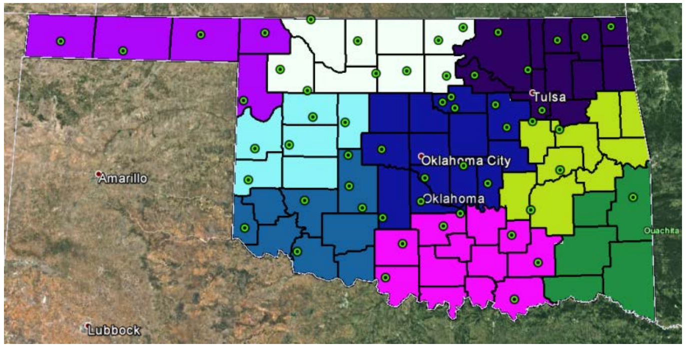
2. GW data - USGS water data base

   Identified 20,162 groundwater wells in Oklahoma

   Normalization for 390 wells (1944-2017)

3. Palmer Drought Severity Index data

   Drought Monitor, Normalization for 2003-2014



<u>Rules for selecting wells:</u>

a) At least 1 sample/ 3 time sections: 2003-2006, 2007-2010, 2011-2014

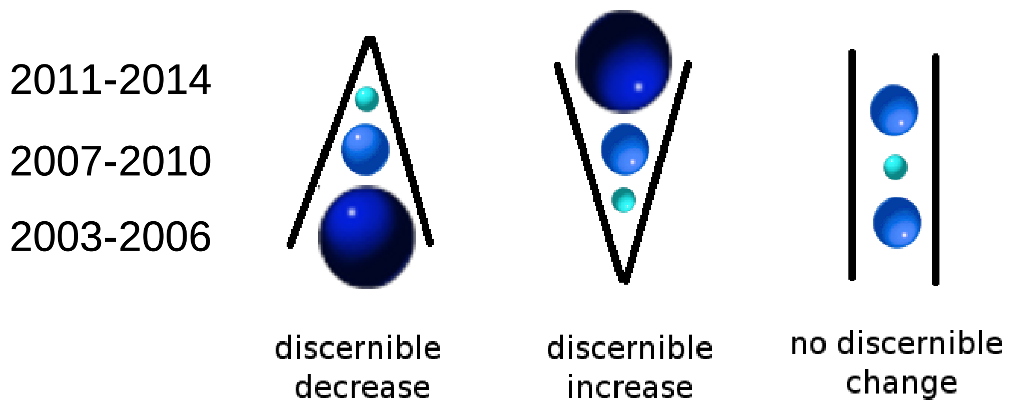
b) At least 5 samples minimum

C++ code developed for Linux, Windows, Apple Mac

Pearson correlation

Methodology – Groundwater well levels

- Natural ternary visual shape logic (NTVSL) method (compare: Russian computer Setum with 3 states: positive, negative, and neutral)



- Visual detection of statically relevant and discernible well water decreases, increases, and no discernible changes
- C++ language used to code the data, read the statistical results and output them as a KML file

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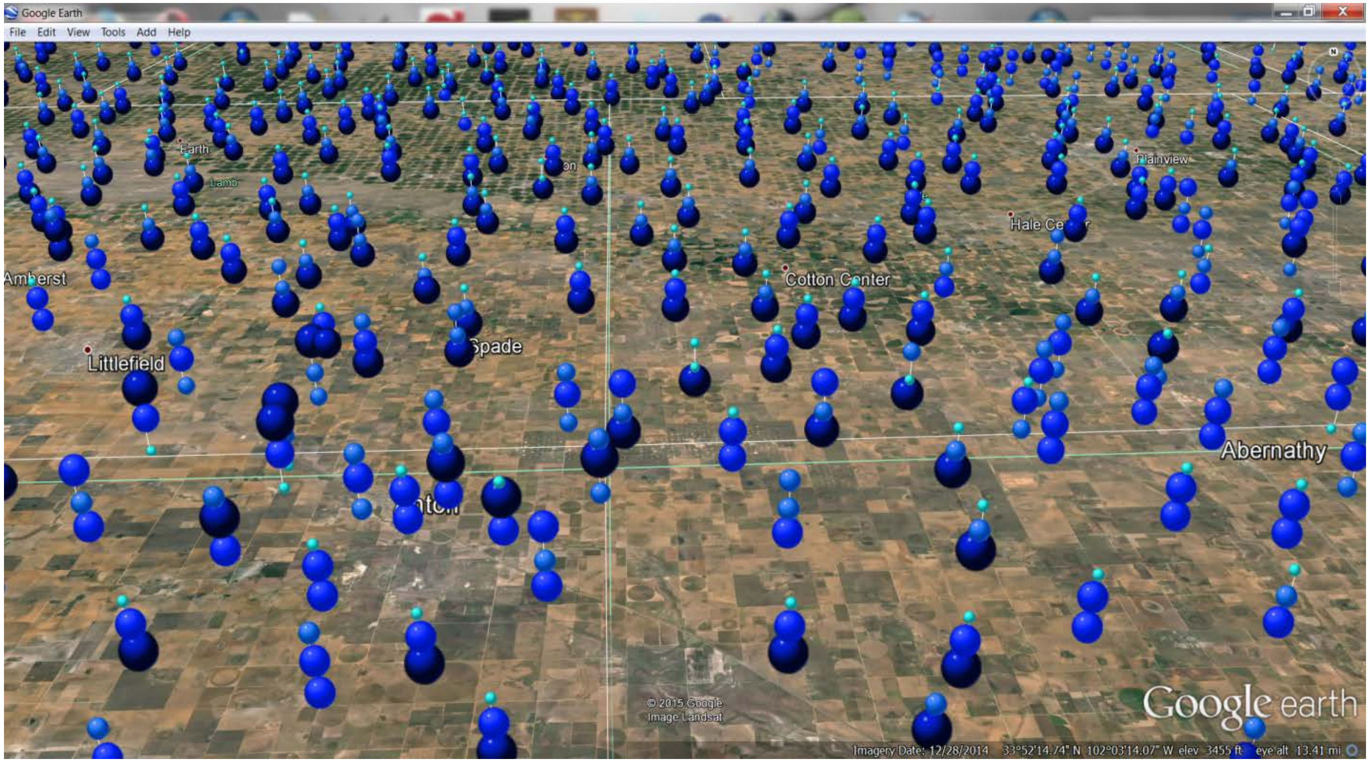
Results – Groundwater well levels in OK

– Subset of 4 year interval sections: 2003-2006, 2007-2010, 2011-2014

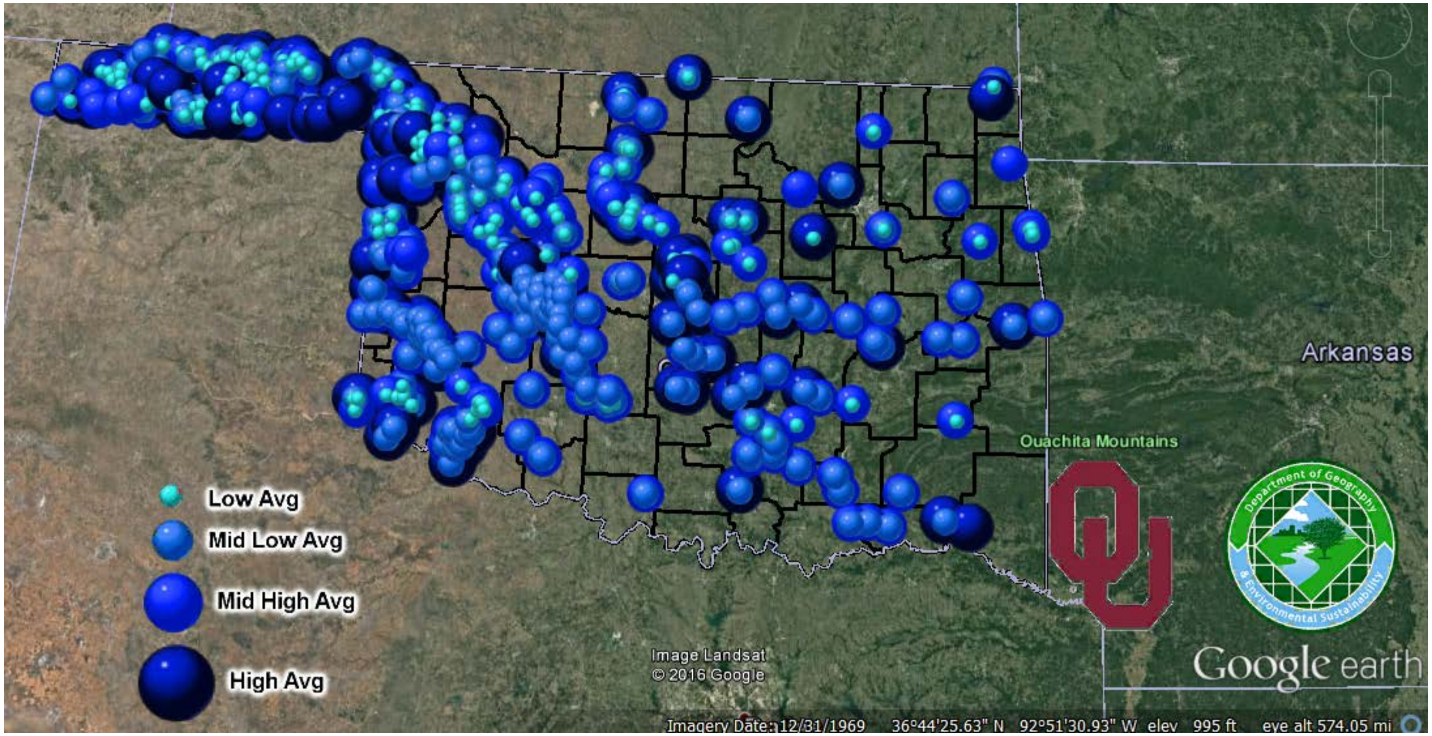
– The values for each well are normalized statistically in 2003-2014



Results – Groundwater well levels in OK

– Spheres are clickable & bring up a balloon information window with statistical information

– Water levels in most of the wells have been decreasing → potential indicator of recent droughts (witch's hat cone shape)



http://www.hitechmex.org/OK_TX/index.html

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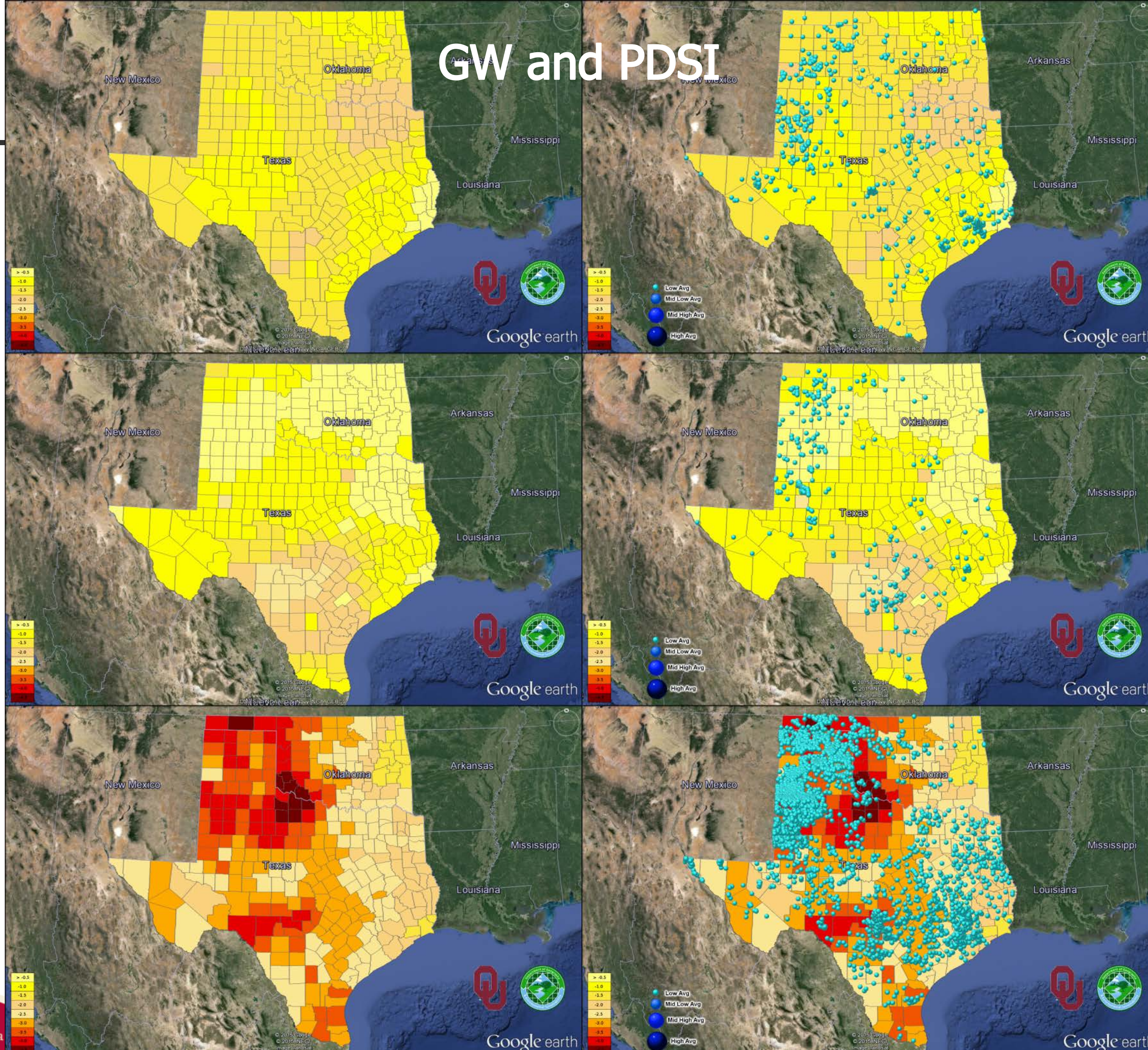
GW and PDSI

2003-2006

2007-2010

2011-2014



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Update

This presentation has been modified for website purposes as this part of the research is still work in progress.

We will make it available as soon as it is completed and published.
Thank you for your understanding.

Please contact Dr. Ziolkowska if you have questions about this research project at jziolkowska@ou.edu

Conclusions and outlook

- Less than 1 year time lapse for drought detectable on the earth surface (SM) to affect GW well levels in Oklahoma
- GW and SM are correlated with Palmer – robust indicators of drought
- Regional variability in results – regional analyses necessary

Future work

1. SM – predictor of GW changes
2. Impacts on socio-economic and environmental conditions (i.e. ecosystems) in Oklahoma

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Thank you

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