National Soil Moisture Map

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Developing National Soil Moisture Products to Improve Drought Monitoring (NOAA MAPP): 2017-2019
Developing Gridded Soil Moisture Maps Using NRCS SSURGO (NRCS): 2015-2017
NIDIS Pilot: 2014

Vision

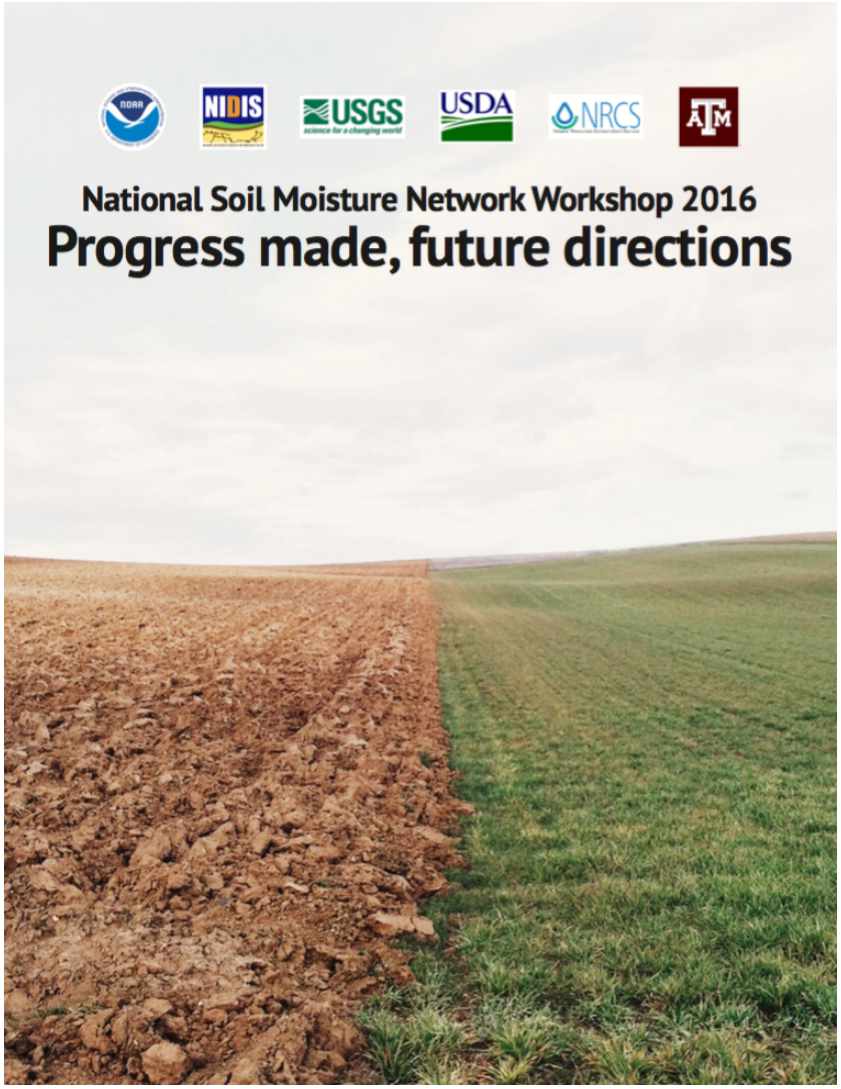
Table 2: Soil moisture products

Possible requirements and examples of products discussed during the 2016 workshop.
Requirements:

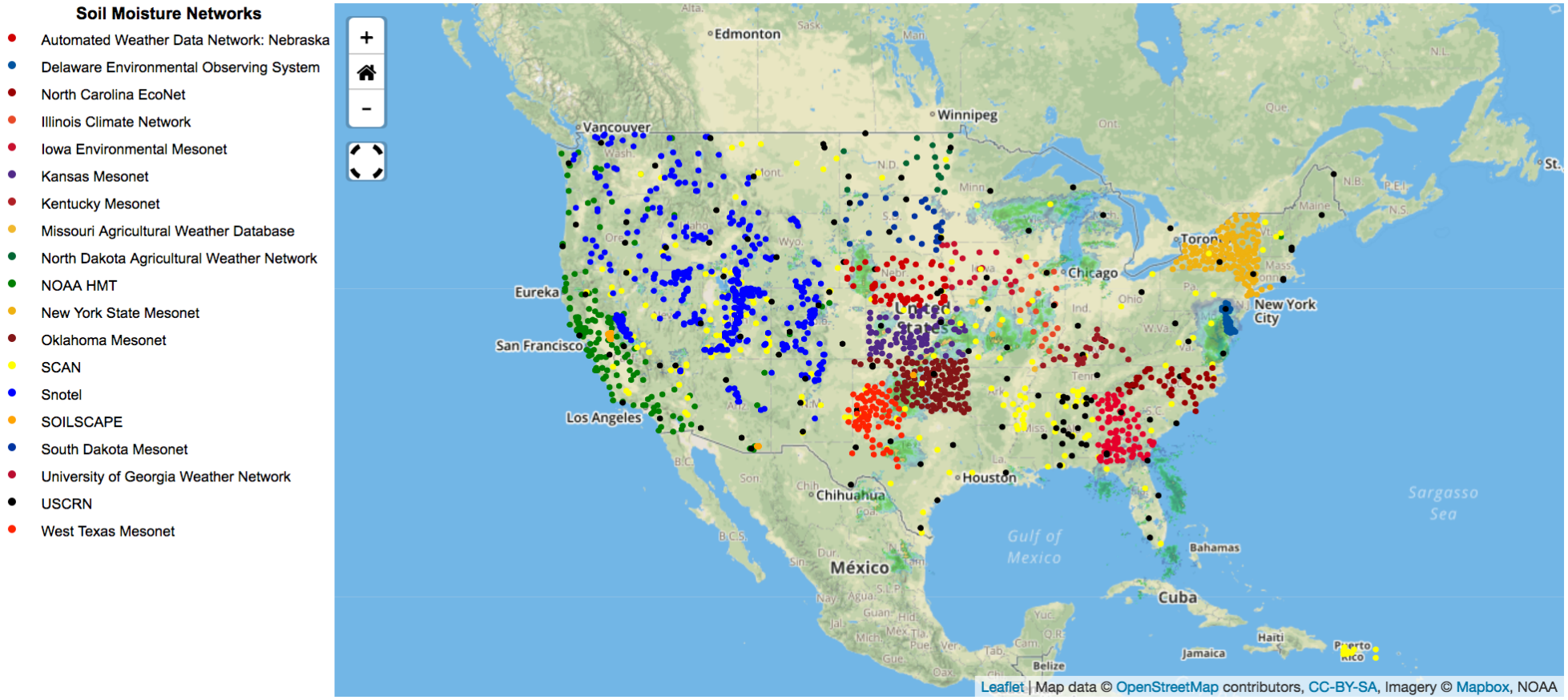
- Temporal scales: Weekly, monthly, daily
- Spatial scales: Hydrologic Unit Code, census, state/county
- In situ Depths (cm): 2,5,10, 20,50,100
- Contextual data: SSURGO points, land cover, bench mark soils, National Hydrography Dataset, state, county
- All raw data behind maps should be available: time series, water year, etc.
- Data search features: state, basin, station, time periods, network, format

Monitoring and Forecast Products:

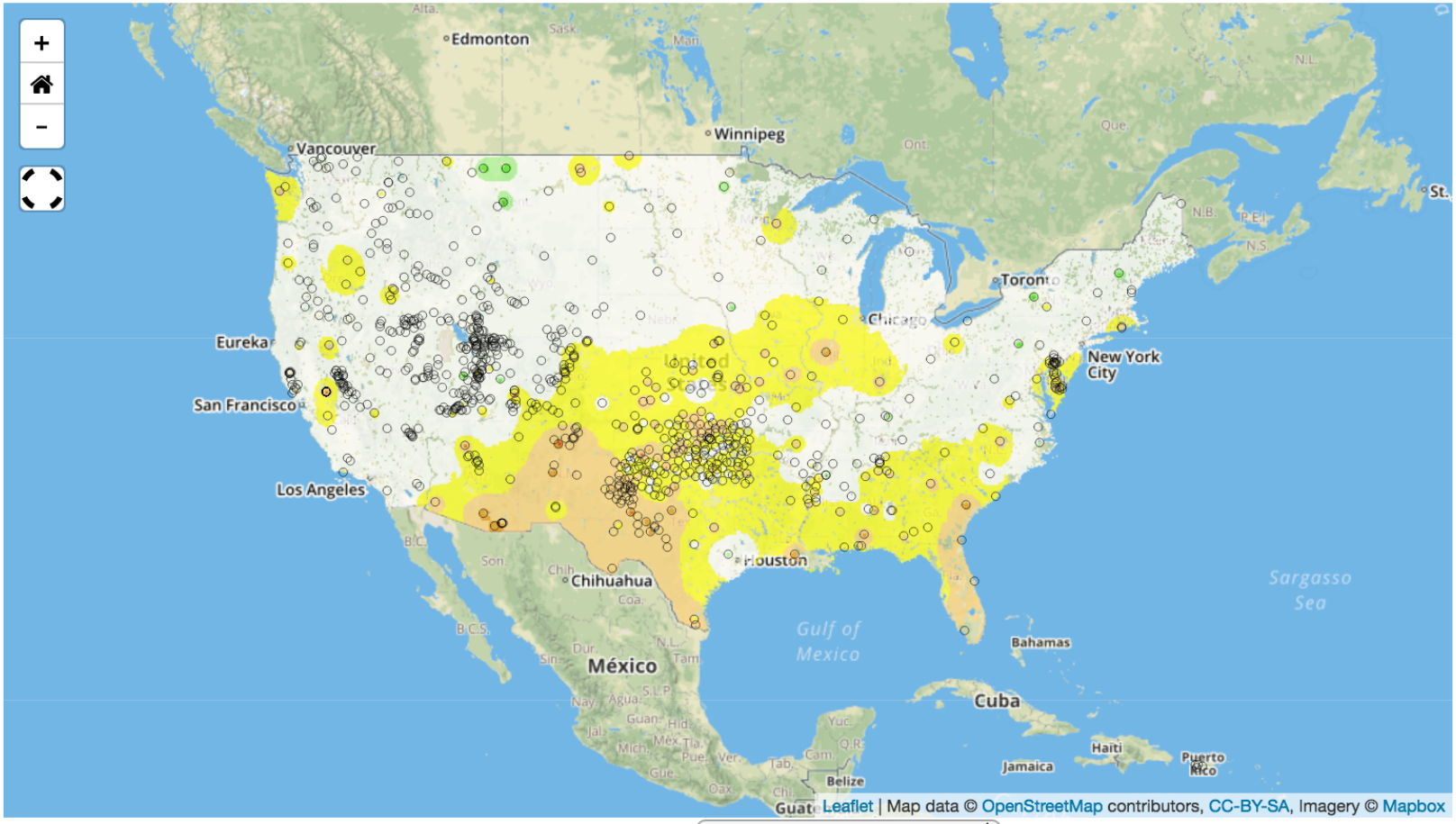
- Volumetric water content
- Percent saturation
- Soil temperature daily average max, min
- Station map using U.S. Drought Monitor color scheme (e.g. weekly averaged percentiles)
- Percent of normal gridded and point product
- Probabilistic gridded product (e.g. non-exceedance probability)



In Situ Soil Moisture Measurements: NationalSoilMoisture.com



5 cm Soil Moisture Percentile (Inverse Distance Weighting Interpolation) on Sun May 13 2018



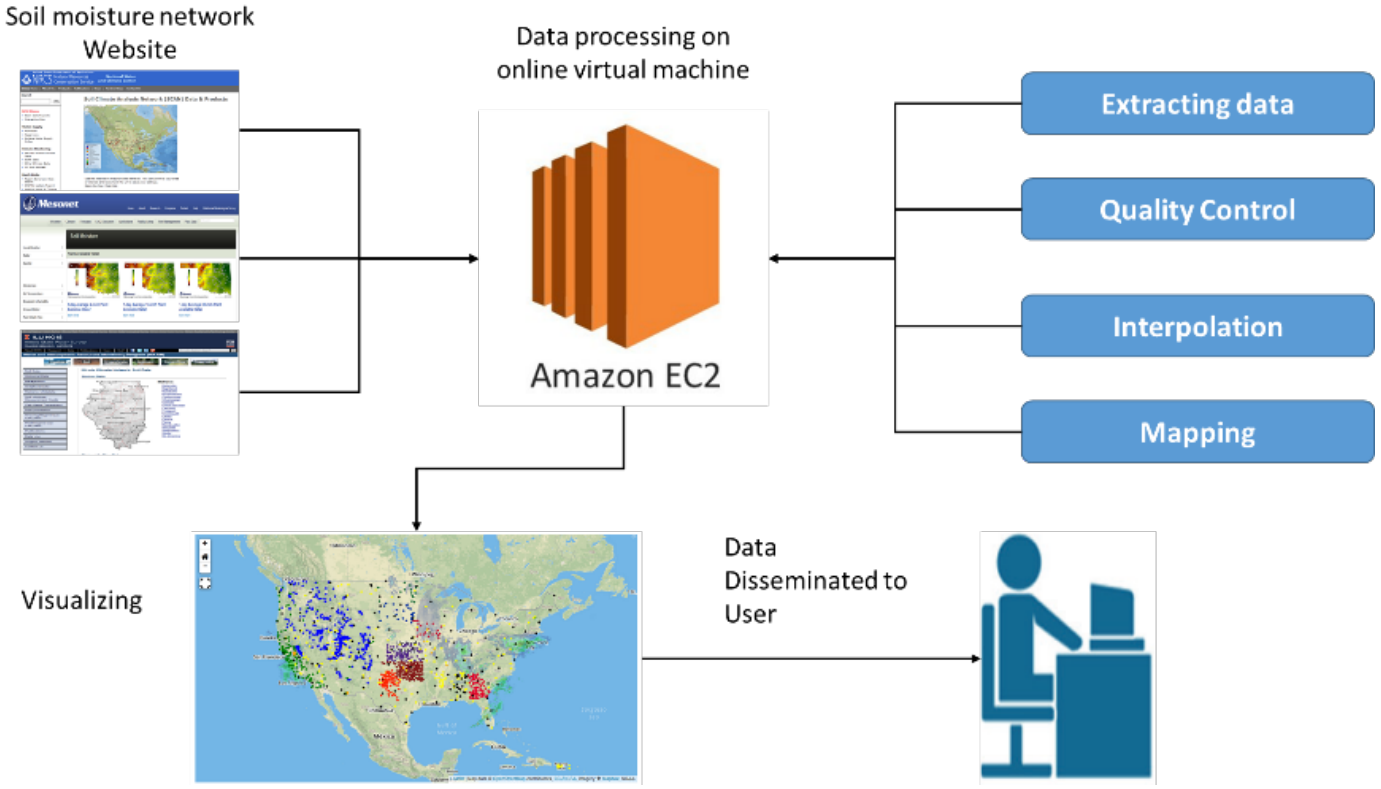
Legend

- < 2nd percentile
- 2nd - 5th percentiles
- 5th - 10th percentiles
- 10th - 20th percentiles
- 20th - 30th percentiles
- 30th - 70th percentiles
- 70th - 80th percentiles
- 80th - 90th percentiles
- 90th - 95th percentiles
- 95th - 98th percentiles
- > 98th percentile

--Select a map--

Nationalsoilmoisture.com

System Architecture for NationalSoilMoisture.com



Data Acquisition, Quality Control, & Interpolation

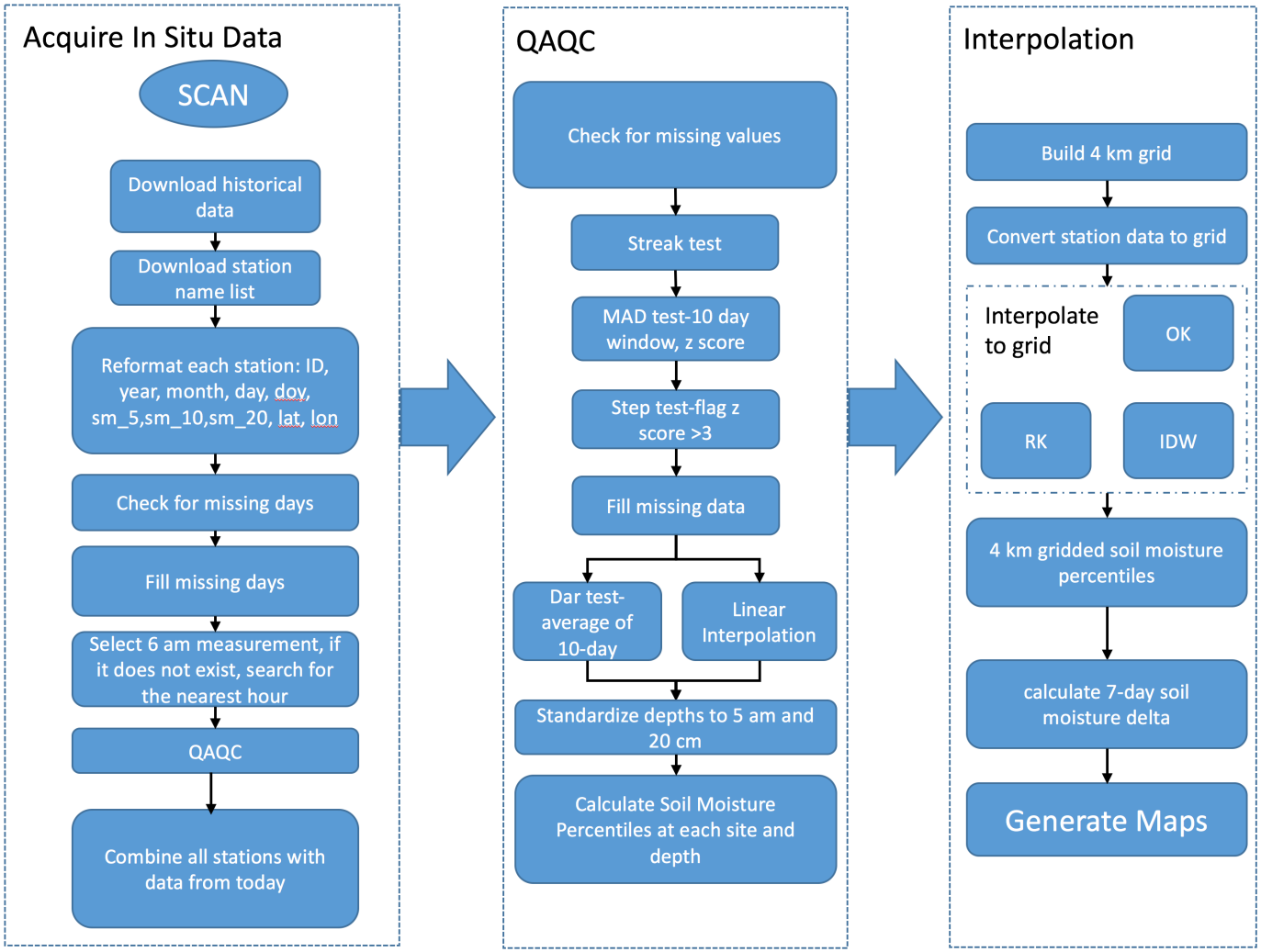
Zhang, N., Quiring, S. M., Ochsner, T. and T. W. Ford (2017) Comparison of Three Methods for Vertical Extrapolation of Soil Moisture in Oklahoma. *Vadose Zone*, 16(10): doi:10.2136/vzj2017.04.0085

Ford, T. W., Wang, Q. and S. M. Quiring (2016) The observation record length necessary to generate robust soil moisture percentiles. *Journal of Applied Meteorology and Climatology,* 55: 2131-2149. DOI: 10.1175/JAMC-D-16-0143.1

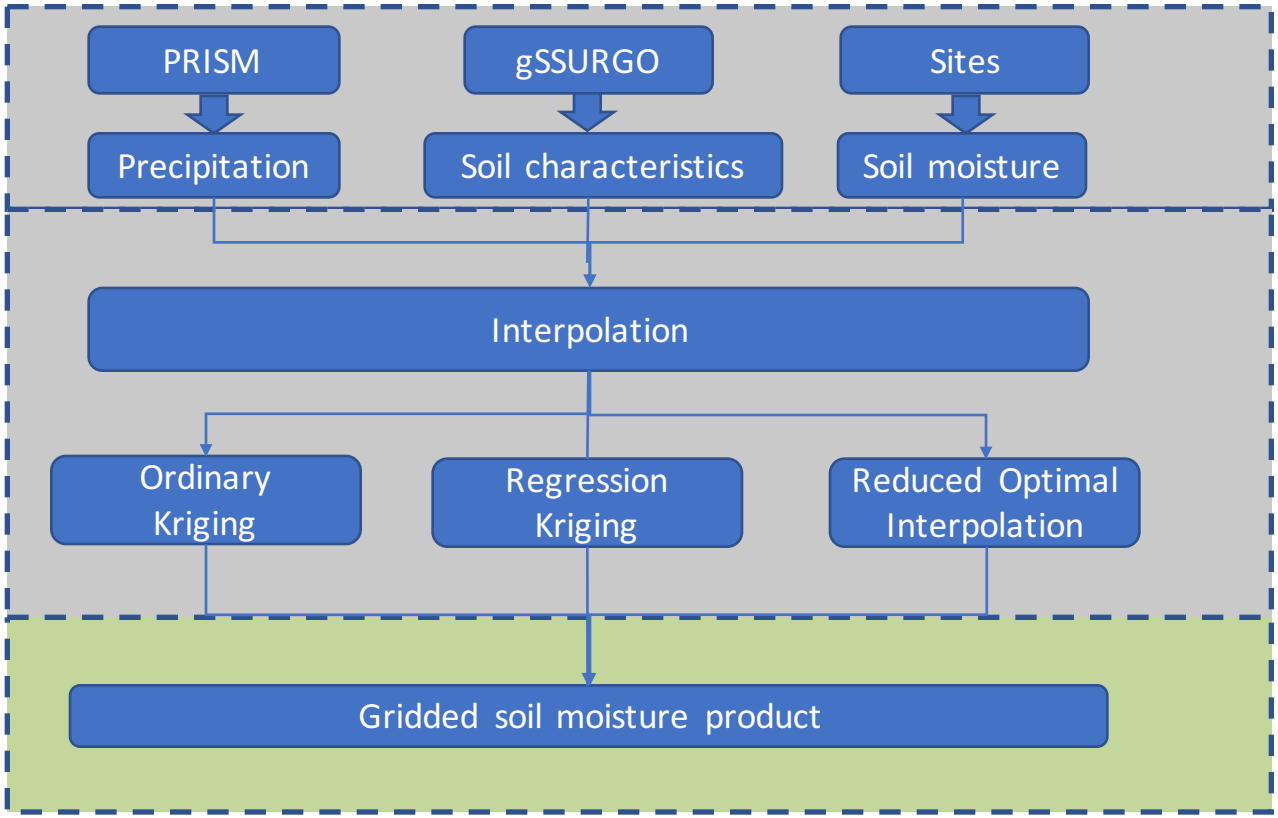
Yuan, S. and S. M. Quiring (2017) Comparison of three methods of interpolating soil moisture in Oklahoma. *International Journal of Climatology*, 37: 987–997. DOI: 10.1002/joc.4754

Quiring S. M., Ford T. W., Wang J. K., Khong A., Harris E., Lindgren T., Goldberg D. W., Li Z. (2016) North American Soil Moisture Database: Development and Applications. *Bulletin of the American Meteorological Society*, 97: 1441–1459, doi: 10.1175/BAMS-D-13-00263.1

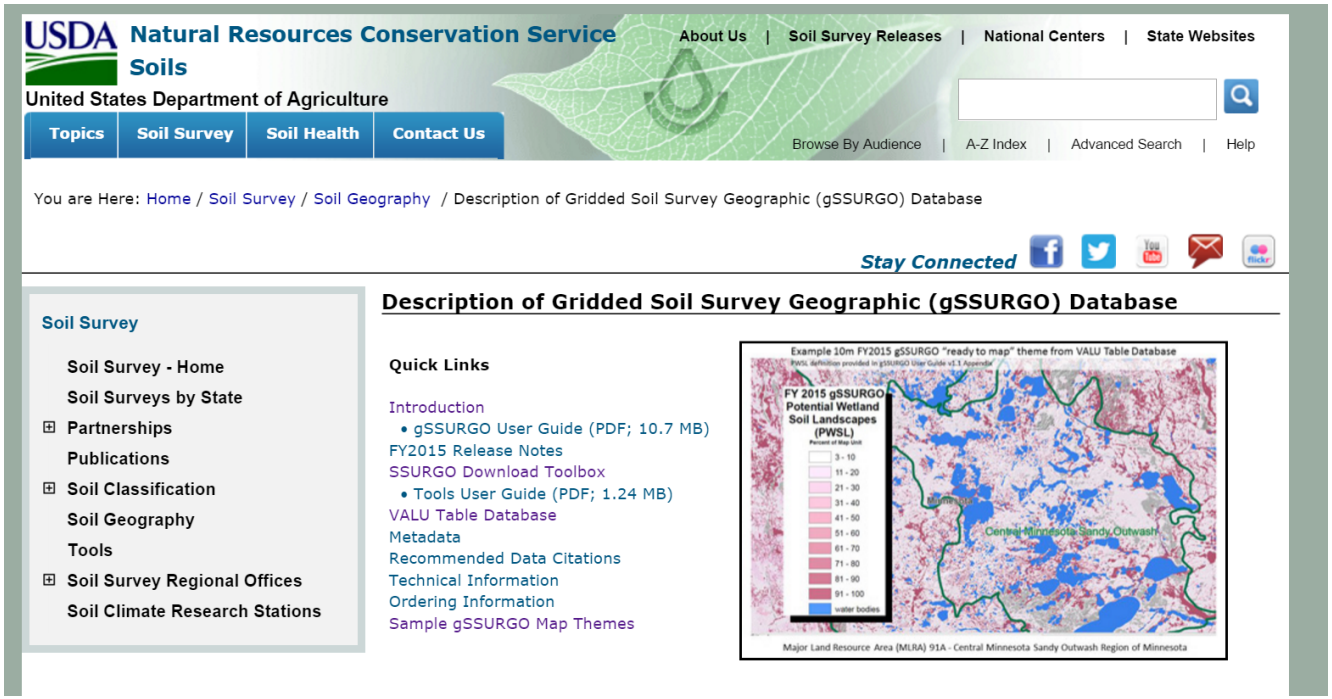
Forthcoming = sensor standardization, methods for developing a national SM map, etc.



Methods

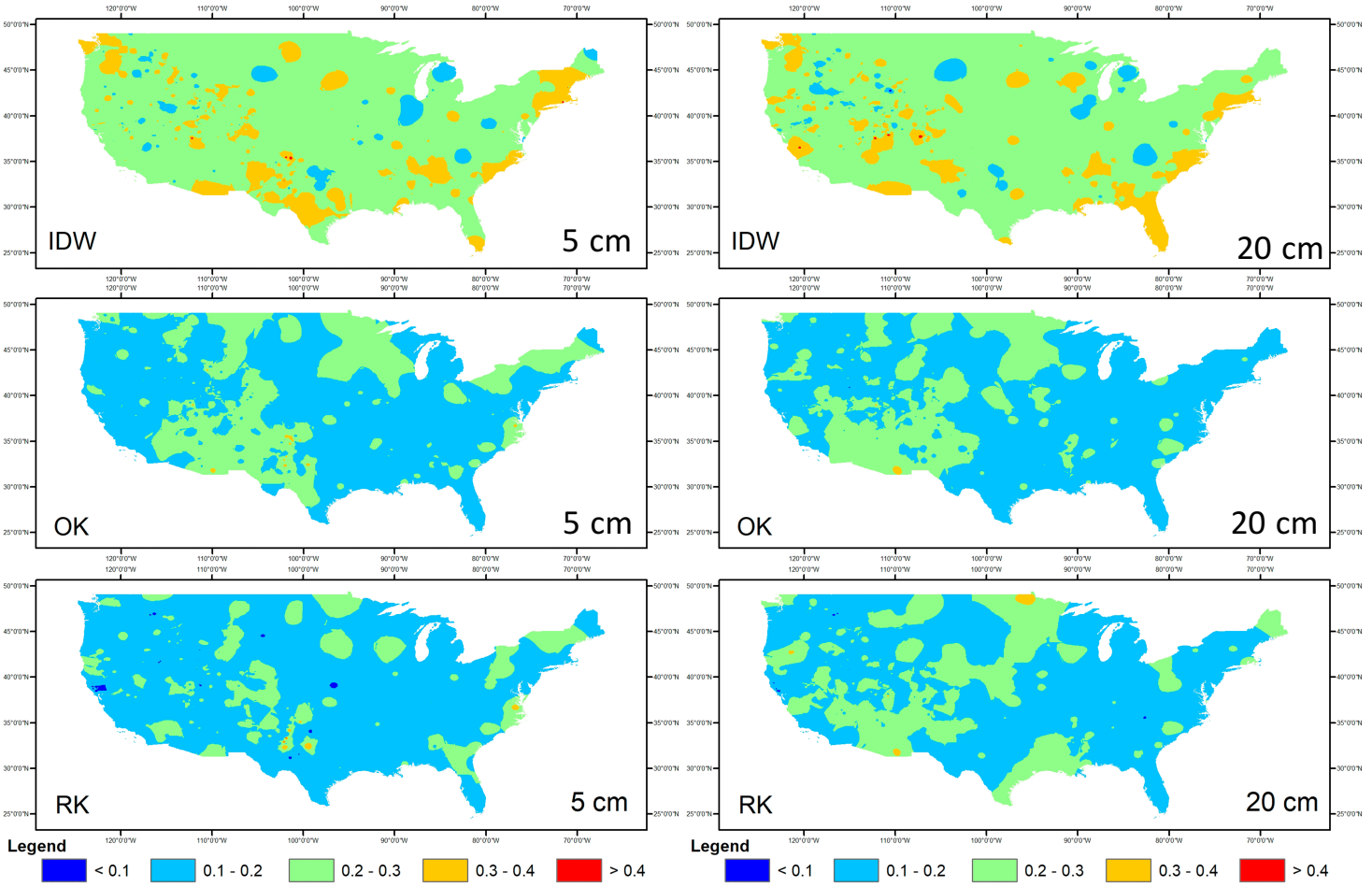

PRISM
gSSURGO
Sites
Precipitation
Soil characteristics
Soil moisture
Interpolation
Ordinary Kriging
Regression Kriging
Reduced Optimal Interpolation
Gridded soil moisture product

gSSURGO Data

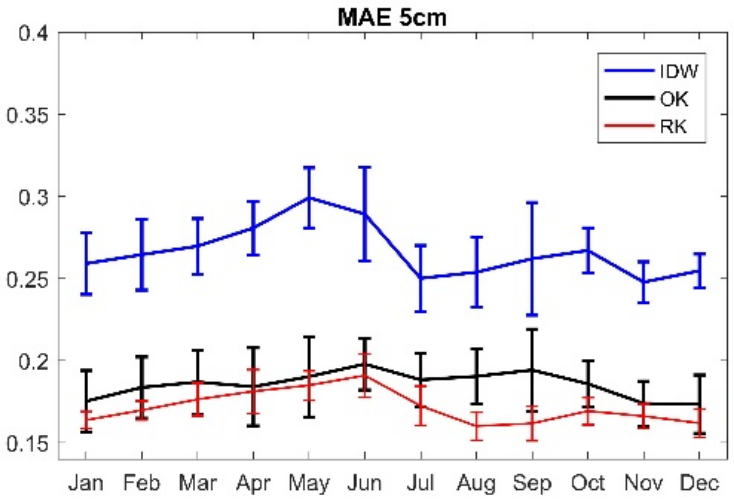


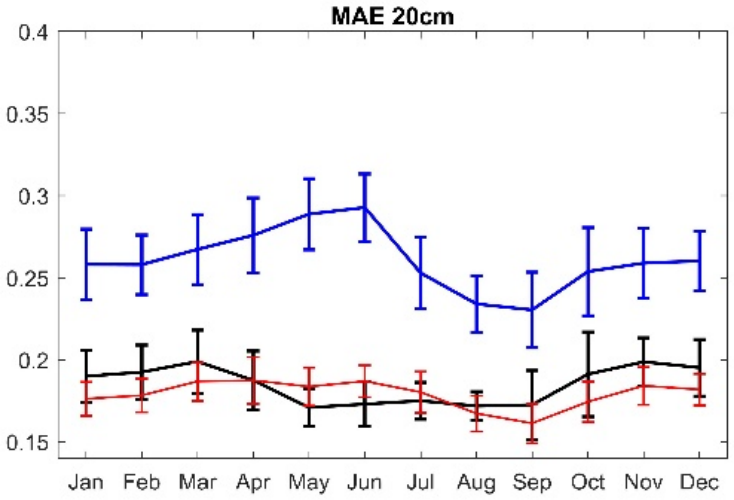
- 10 m resolution, resampled to 4 km, to match with PRISM
- numerous soil characteristics (soil texture, AWC, organic matter)

Accuracy Assessment



Monthly Variations in MAE

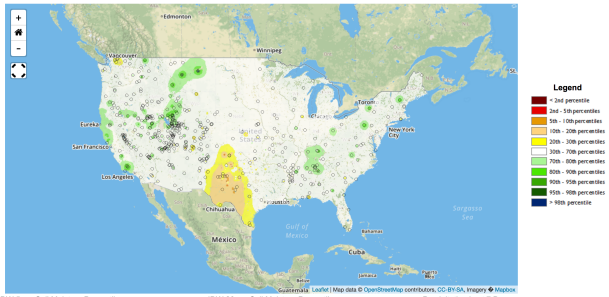




Multi-year (2005 to 2017) monthly mean MAE based on soil moisture percentiles interpolated by IDW, OK and RK at 5 cm and 20 cm

National Soil Moisture:
Near Real-Time Experimental Products

5 cm Soil Moisture Percentile (Inverse Distance Weighting Interpolation) on Sun Mar 25 2018

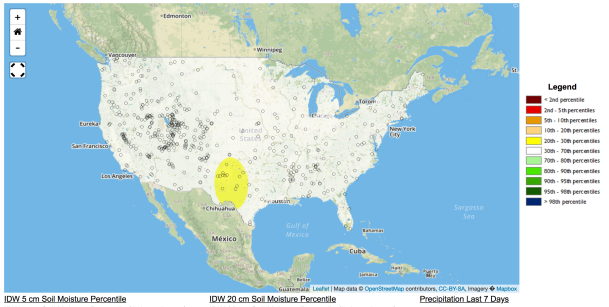


IDW 5 cm Soil Moisture Percentile
IDW 5 cm Soil Moisture Percentile (7 days change)
OK 5 cm Soil Moisture Percentile
OK 5 cm Soil Moisture Percentile (7 days change)
RK 5 cm Soil Moisture Percentile

IDW 20 cm Soil Moisture Percentile
IDW 20 cm Soil Moisture Percentile (7 days change)
OK 20 cm Soil Moisture Percentile
OK 20 cm Soil Moisture Percentile (7 days change)
RK 20 cm Soil Moisture Percentile

Precipitation Last 7 Days

5 cm Soil Moisture Percentile (Ordinary Kriging Interpolation) on Sun Mar 25 2018



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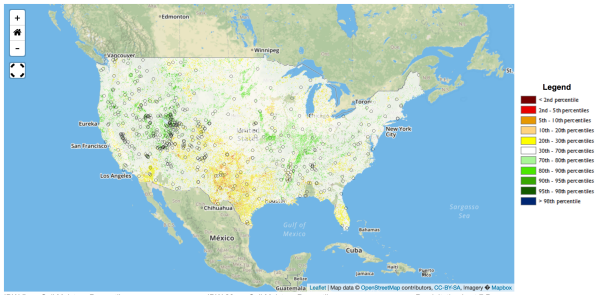
OK 20 cm Soil Moisture Percentile
OK 20 cm Soil Moisture Percentile (7 days change)
RK 20 cm Soil Moisture Percentile

Precipitation Last 7 Days

5 cm Soil Moisture Percentile (Regression Kriging Interpolation) on Sun Mar 25 2018



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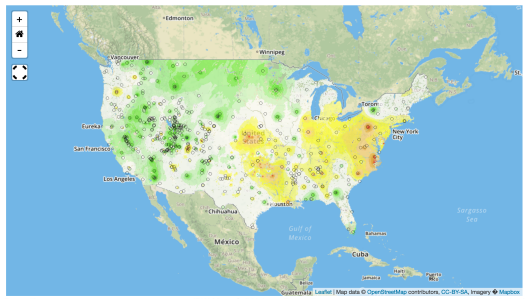
OK 20 cm Soil Moisture Percentile (7 days change)
RK 20 cm Soil Moisture Percentile

Precipitation Last 7 Days

Data products:
-percentiles
-delta (7 day change)
-soil temperature

Future products:
-VWC anomalies
-others?

Last 7 days change: 5 cm Soil Moisture Percentile (Inverse Distance Weighting Interpolation) ending on Sun Mar 25 2018



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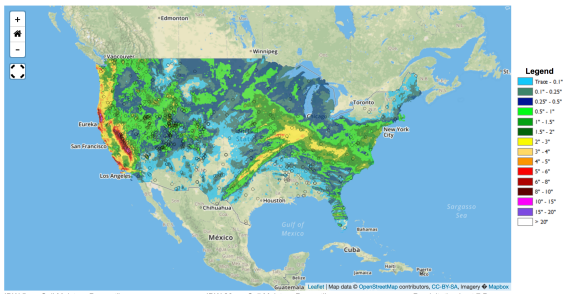
OK 20 cm Soil Moisture Percentile
OK 20 cm Soil Moisture Percentile (7 days change)
RK 20 cm Soil Moisture Percentile

Precipitation Last 7 Days

7-Day PRISM Precipitation Total ending on Sun Mar 25 2018



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IDW 20 cm Soil Moisture Percentile
IDW 20 cm Soil Moisture Percentile (7 days change)
OK 20 cm Soil Moisture Percentile
OK 20 cm Soil Moisture Percentile (7 days change)
RK 20 cm Soil Moisture Percentile

Precipitation Last 7 Days

Current data formats:
-web maps
-CSV
-GeoTIFF

What other formats are desired?

Latency: 24 hours
Resolution: daily soil moisture

Next Steps

1. Incorporate more in situ measurements (CoCoRaHS, South Dakota, North Carolina, Georgia, Kentucky, etc.)
2. Improve interpolation accuracy
3. Complete the assessment of the fidelity of various *in situ* soil moisture observations and satellite remote sensing- and model-based soil moisture products (SIU)
4. **Integrate remote sensing (SMAP) and modeled (NLDAS or NWM?) soil moisture information with *in situ* measurements to develop a national-scale, near-real time soil moisture product for drought monitoring (OSU) **[We will present this at MOISST next year]****
5. Deliver operational gridded soil moisture products (USGS)

Challenges to Developing a National Soil Moisture Map

1. Data sharing and support
   - How can we support data collection, calibration and quality control (mesonets)?

2. Coordination and communication
   - How do we coordinate with and leverage other similar efforts (CRN, SMERGE, etc.)?

3. Leadership
   - Who decides? Where is the long-term home for these products? Who will provide the care and feeding?

Acknowledgements

Chen Zhao, Shanshui Yuan, Zack Leasor, Ning Zhang, Paul Dirmeyer, Angelina Arcuri, Makenzee Loft, Jordan Read

Funding

Developing Gridded Soil Moisture Maps Using NRCS SSURGO (NRCS)
Developing National Soil Moisture Products to Improve Drought Monitoring (NOAA MAPP)
NIDIS

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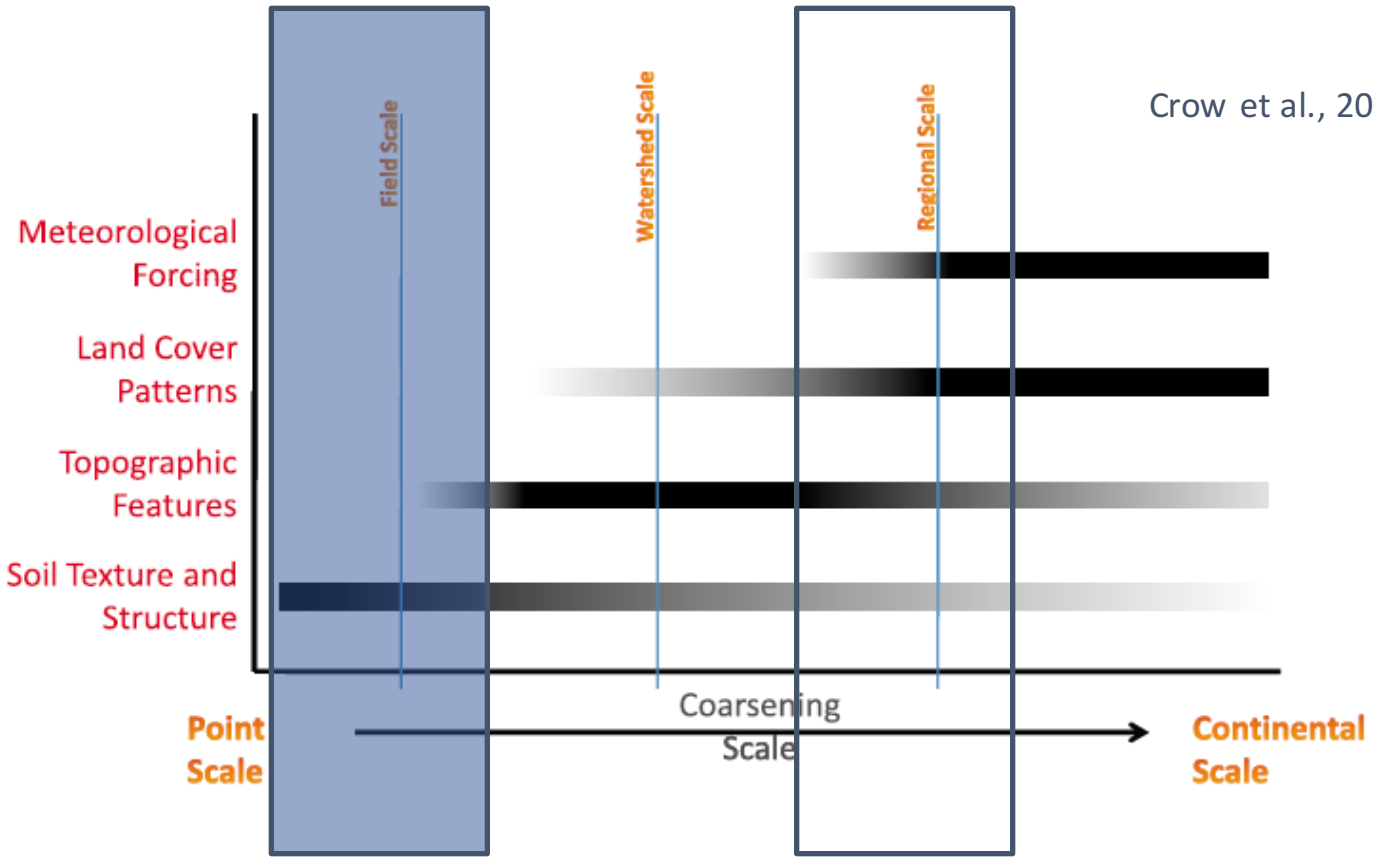
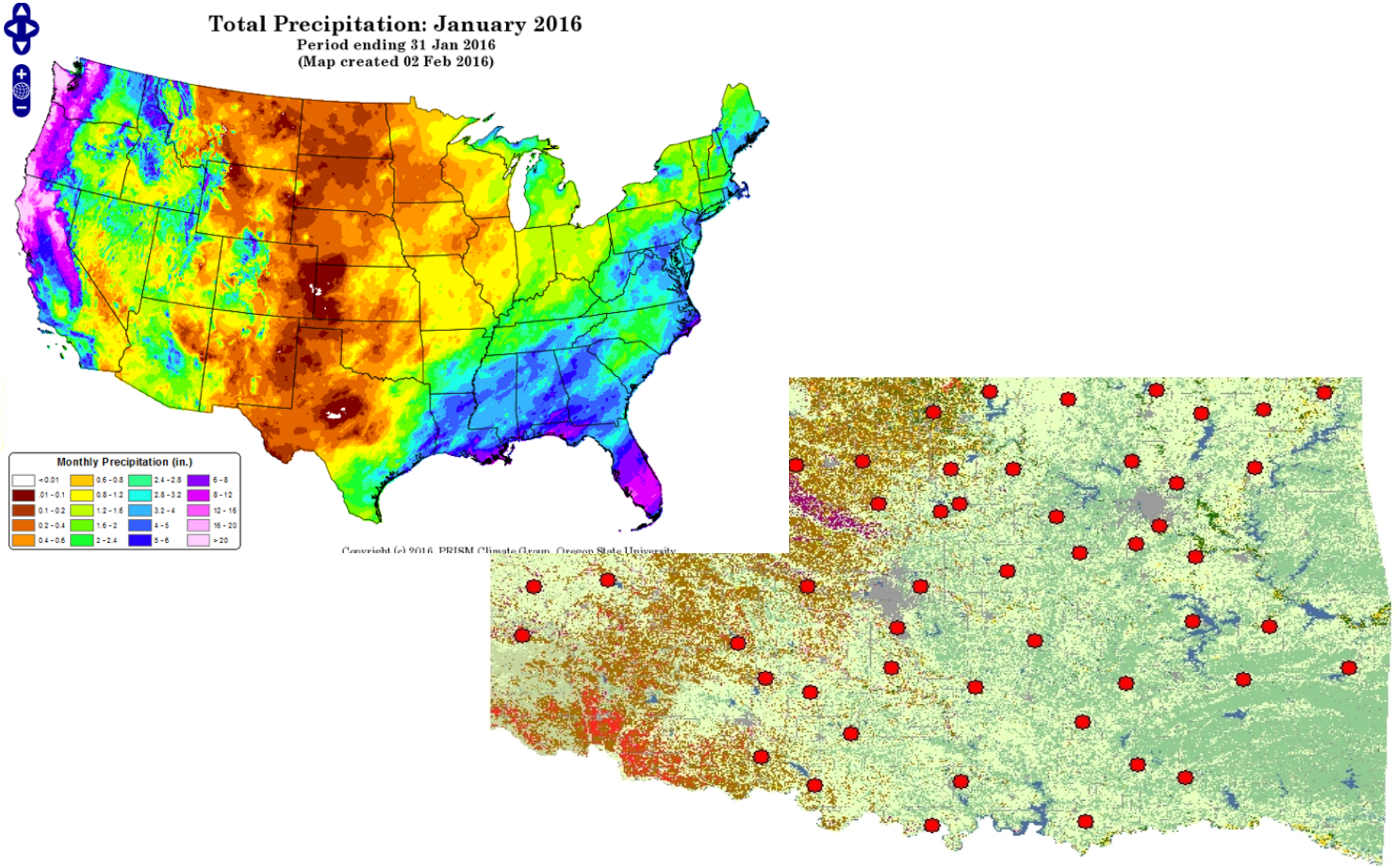


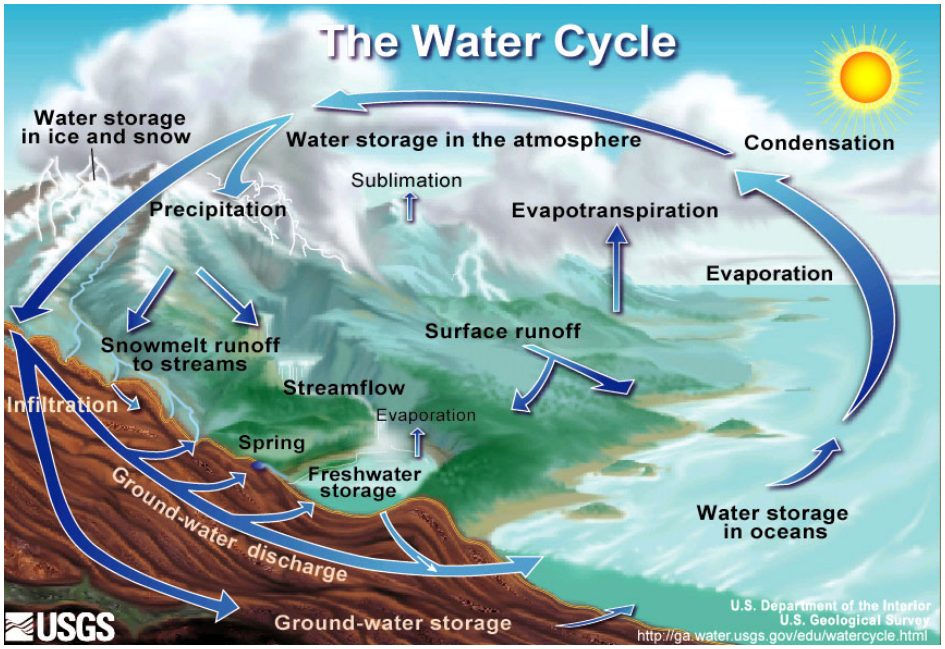
Crow et al., 2012

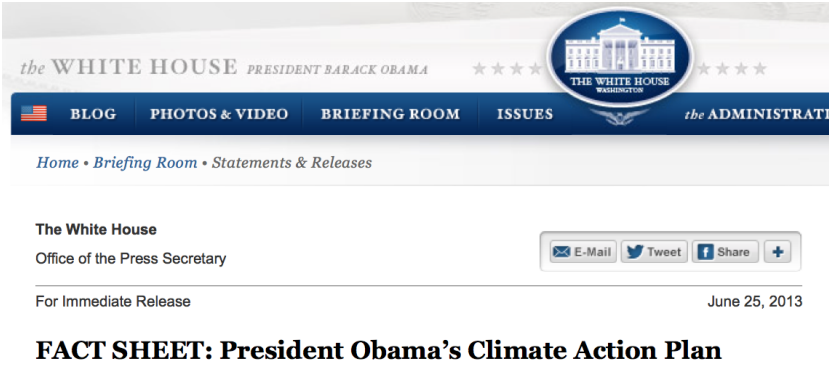
Land Cover, Elevation, Slope, etc.



What is the National Soil Moisture Network?

- President Obama's Climate Action Plan (2013)
- Missing piece of hydrologic observational data





Managing Drought: Leveraging the work of the National Disaster Recovery Framework for drought, the Administration will launch a cross-agency National Drought Resilience Partnership as a "front door" for communities seeking help to prepare for future droughts and reduce drought impacts. By linking information (monitoring, forecasts, outlooks, and early warnings) with drought preparedness and longer-term resilience strategies in critical sectors, this effort will help communities manage drought-related risks.

Who is the NSMN?

Monitoring Forest Soil Moisture for a Changing World

Workshop Agenda, May 15-17, 2018

Kiva Conference Room, 3600 Green Court, Suite 100, Ann Arbor, MI 48105

Michigan Tech Research Institute

Appendix 2: Workshop Participant List

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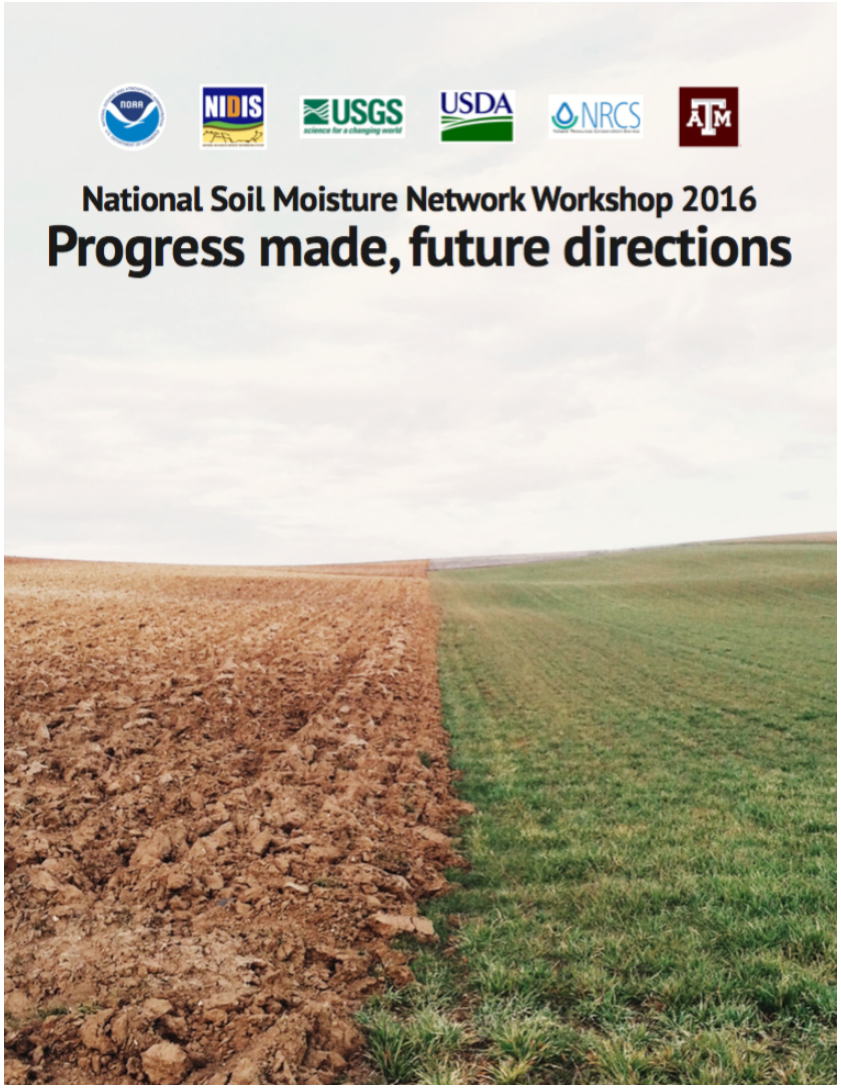
Vision

- Where do we want to be in 5 years?

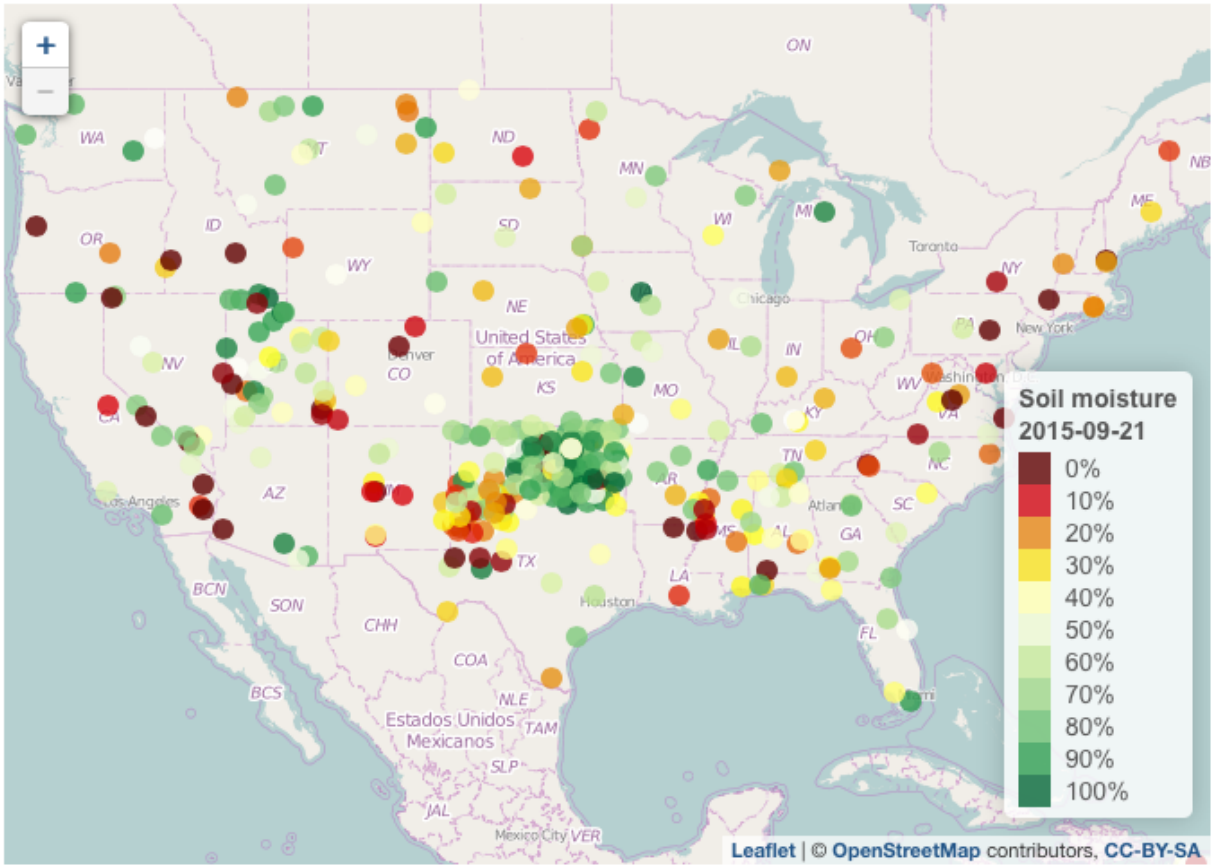


Next Steps (outlined in 2016 report)

- **Develop a soil moisture community of practice (CoP) that includes soil moisture data providers, groups that are developing products and tools, and users of the data and information.** The CoP would include citizen science initiatives and the private sector. Specific activities could include a "sensor challenge" for developing low-cost soil moisture/soil temperature probe alternatives, and developing case studies that highlight different approaches for integrating multiple sources of soil moisture data for specific issues and sectors.
- **Establish a working group to begin the process of developing a strategic framework for building an integrated national network.** The framework would consider issues around standardizing soil moisture measurements and metadata requirements, scale and spatial distribution for monitoring in observing networks, remote sensing platforms, and modeling efforts.
- **Develop a nationwide product from existing soil moisture data to demonstrate the potential usefulness of a coordinated effort.** The product and the investment of time by individuals who collect, process and store these data would guide how the process could be integrated on a broad spatial and temporal scale.

Standardizing Soil Moisture Measurements

0-10cm



Measurement Depth

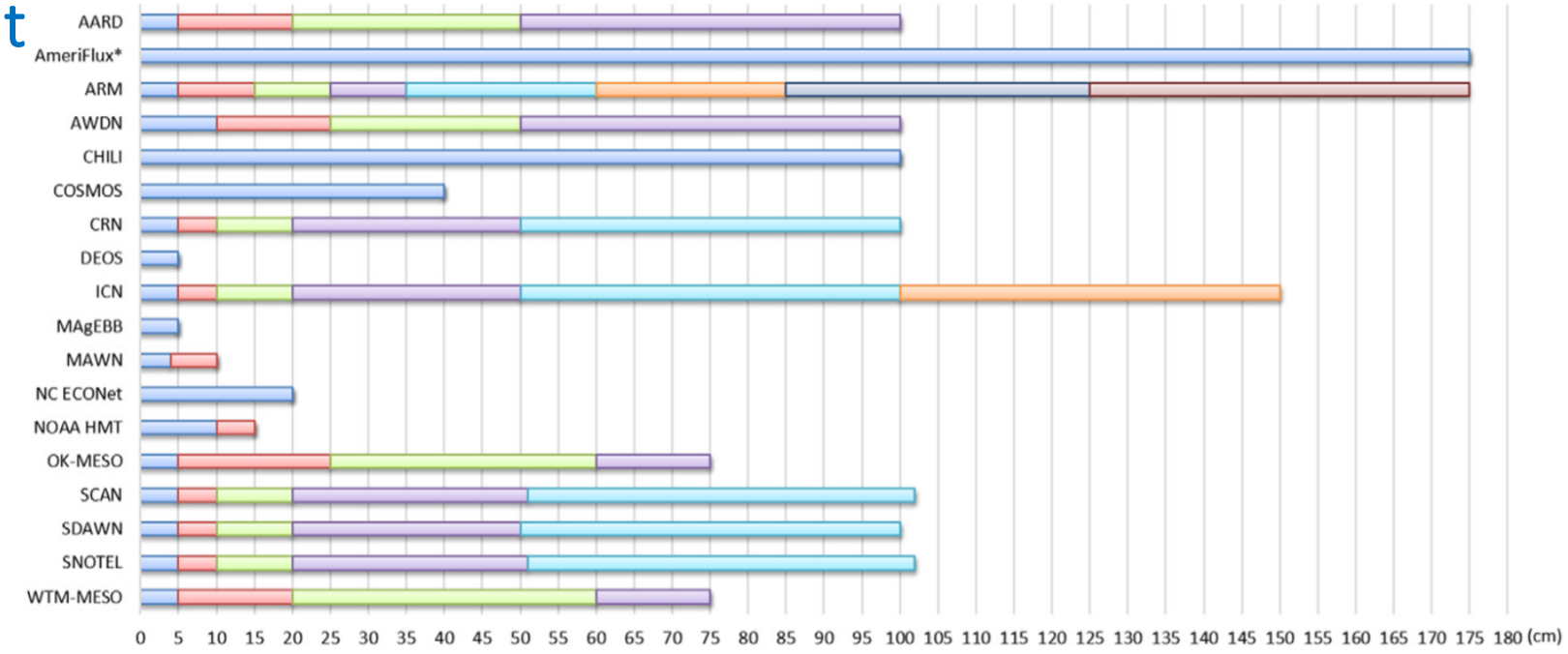


Fig. 1. Measurement depths used by 18 of the soil moisture monitoring networks that were archived in the North American Soil Moisture Database from 1 Jan. 2000 to 31 Dec. 2013. The different colors indicate different depth intervals for each network, and the exact depth is where the colored bar ends. The depths of soil moisture measurement in the AmeriFlux network varied from station to station; here we provide only the general range (0–175 cm) of the records. The networks included Alberta Agriculture and Rural Development (AARD), Atmospheric Radiation Measurement (ARM), Automated Weather Data Network (AWDN), Center for Hurricane Intensity and Landfall Investigation (CHILI), Cosmic Ray Soil Moisture Observing Station (COSMOS), Climate Reference Network (CRN), Delaware Environmental Observing System (DEOS), Illinois Climate Network (ICN), Missouri Agricultural Electronic Bulletin Board (MAgEBB), Michigan Automated Weather Network (MAWN), North Carolina Environment and Climate Observing Network (NC ECONet), NOAA Hydrometeorology Testbed Observing Network (NOAA HMT), Oklahoma Mesonet (OK-MESO), Soil Climate Analysis Network (SCAN), South Dakota Automated Weather Network (SDAWN), Snowpack Telemetry Network (SNOTEL), and West Texas Mesonet (WTM-MESO).

Zhang, N., S. Quiring, T. Ochsner, and T. Ford. 2017. Comparison of three methods for vertical extrapolation of soil moisture in Oklahoma. Vadose Zone J. 16(10). doi:10.2136/vzj2017.04.0085

Soil Moisture Percentiles: How Much Data is Needed?

Ford et al. (2016) The observation record necessary to generate robust soil moisture percentiles. Journal of Applied Meteorology and Climatology, 55: 2131-2149.

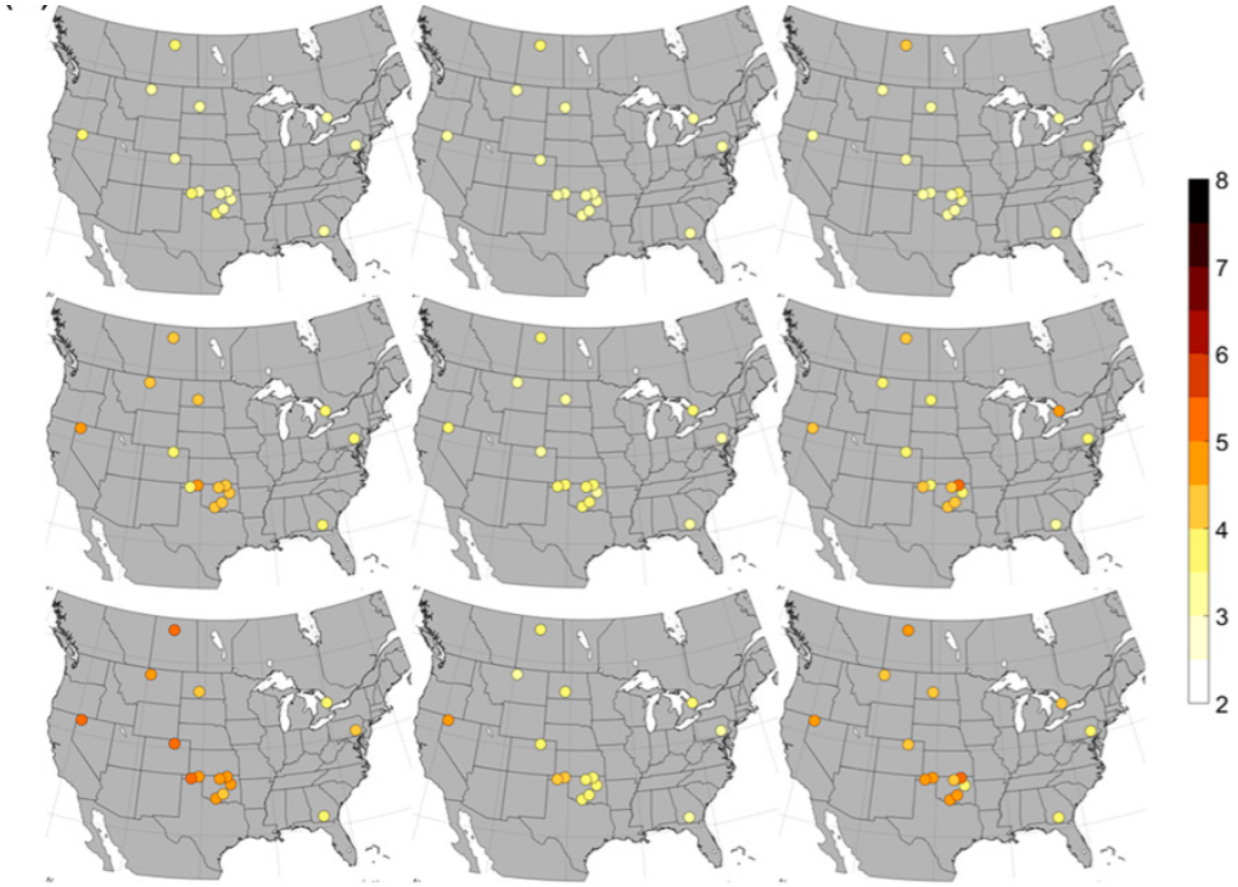
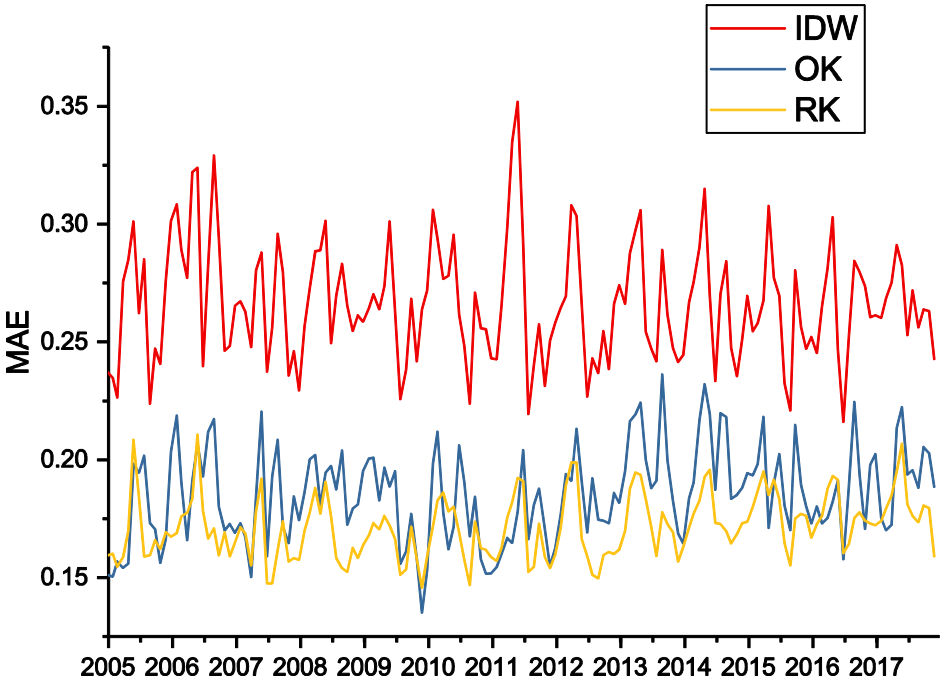


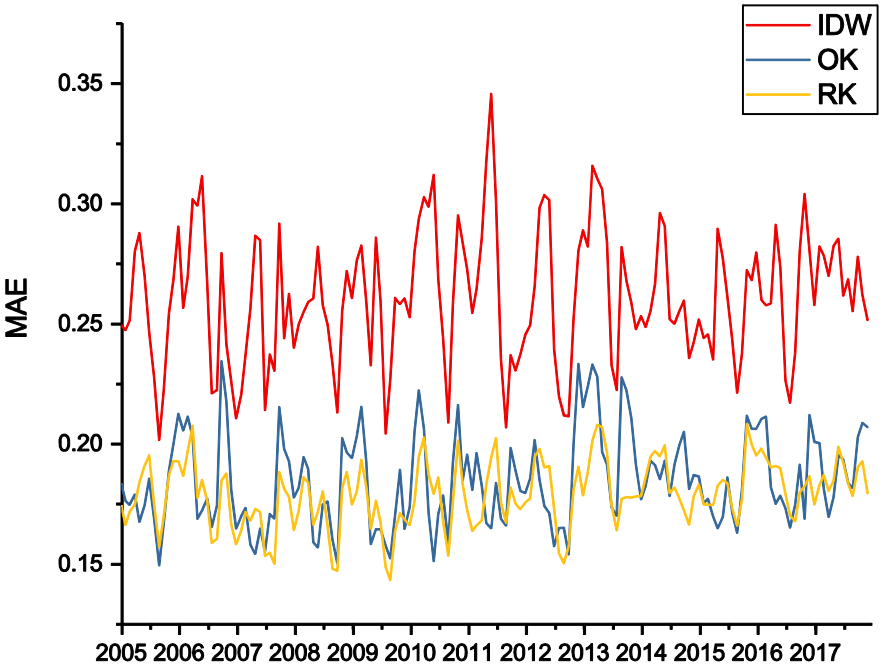
FIG. 4. Depth of measurement variations: the average number of years of data that are necessary to generate stable soil moisture percentiles at each station. The record length thresholds are determined using the Anderson–Darling test (a) with and (b) without a Bonferroni adjustment. In (a) and (b), the results are presented for the first, second, and third quartiles from left to right and for the 5–10-, 20–30-, and 50–60-cm measurement depths from top to bottom.

Temporal variations in monthly MAE based on IDW, OK and RK

5 cm soil moisture percentiles in the continental U.S.



20 cm soil moisture percentiles in the continental U.S.



How can you get involved in NSMN?

1. Join the NSMN community and contribute your knowledge and expertise

2. Contribute soil moisture data. We need more measurements in forests!

3. Provide feedback regarding the type of national soil moisture products that you would find most useful

4. Support soil moisture-related data collection and research

Developing National Soil Moisture Products to Improve Drought Monitoring

1. Assess the fidelity of various *in situ* soil moisture observations and satellite remote sensing- and model-based soil moisture products

2. Integrate remote sensing and modeled soil moisture information with *in situ* measurements to develop a national-scale, near-real time soil moisture product for drought monitoring

3. Design and develop a proof-of-concept cyber infrastructure for delivery of the gridded soil moisture product