8.3 THE QUALITY ASSURANCE AND DISSEMINATION OF SOIL MOISTURE DATA FROM THE OKLAHOMA MESONET

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1. INTRODUCTION

Oklahoma suffered warm-season droughts in 1998 and 2000, and an extended "dry spell" in 2001. While the Oklahoma Mesonet's soil moisture network was readily available to the Oklahoma Climatological Survey's research scientists during the 1998 drought event, it was not easily accessible by the state's decision makers. The daily-averaged data were available to pertinent state agencies for the latter two events and proved to be a valuable resource. The soil moisture network is currently utilized by several state agencies, including the Oklahoma Department of Agriculture's forestry and agricultural-statistics divisions. The Oklahoma Water Resources Board also analyzes the data to contribute to its bi-weekly to monthly publication: *The Oklahoma Water Resources Bulletin*. The daily-averaged dataset is actually a by-product of the 30-minute dataset provided to the research community.

This manuscript describes the soil moisture research team's response to the arduous task of quality assuring and disseminating six million soil moisture values reported per year; a task complicated by the desire of both the research and policy-making user communities to have the data tailored to fit their separate needs.

2. THE SOIL MOISTURE NETWORK

The Oklahoma Mesonet's soil moisture network began as a research initiative funded by the National Science Foundation's (NSF) Experimental Program to Stimulate Competitive Research (NSF-EPSCoR) in 1995. Operational since 1997, the network was later augmented by the Oklahoma Atmospheric Surface-layer Instrumentation System (OASIS).

The Oklahoma Mesonet has a total of 332 soil moisture sensors deployed at 102 Mesonet sites. Dependent upon each site's sub-surface soil profile, sensors are placed from 1 to 4 depths: 5, 25, 60, and 75 cm. The sensors report soil moisture and temperature data every 30 minutes, 24 hours each day, totaling approximately 16,000 reports per day.

The soil moisture network employs the Model 229L Matric Potential Sensor, manufactured by Campbell Scientific, Inc., to provide indirect measurements of the soil matric potential (MP) and volumetric water content (WC). The quantity measured by the sensor is DeltaT (a change in temperature over time after a heat pulse is introduced to the soil). Data from the sensors have been carefully calibrated to provide estimates of soil matric potential as a function of DeltaT reference (TR). This latter quantity is the value of DeltaT normalized for individual sensor response. Since the soil moisture sensor acquires a temperature measurement before (ST) and after (FT) a heat pulse is applied, the "pre-heating" temperature is a valid measurement of soil temperature co-located with the moisture measurement. Due to an existing temperature bias found in ST and FT, a reference thermistor is used to remove this bias. The measurement returned from the reference thermistor (TREF) is used only for QA purposes.

3. QUALITY ASSURANCE

The Oklahoma Mesonet performs several routine QA procedures on the parameters ST, FT, TR, and TREF listed above. The procedures consist of range, freeze, and step tests. The range test is used to ensure that ST, FT, TR, and TREF do not go beyond normal pre-determined limits. The freeze test is applied to ST and FT to identify possible frozen sensors. The step test checks for spikes in TR values (a large change in consecutive readings). The change in TR values is calculated as the TR value for the current time period minus the TR value from the preceding time period. Only the endpoints of the run of suspicious data are flagged. Visual inspection is necessary to determine the duration of the event.

Any datum that fails the quality assurance tests above is flagged as "bad", and will result in the corresponding TR value for that record to be flagged as "bad". With 48 possible TR values for each 24-hour period, if the total number of valid values is less than 36 (i.e., 75% valid), the daily average value will be discarded.

4. DISSEMINATION

The task faced by the soil moisture research team was certainly not unique amongst data providers: to provide separate versions of the same dataset to two user communities. The prime concern of the team was to ensure that the data disseminated were of prime quality. An important subsidiary concern, however, was to provide the data to both communities in an easily accessible manner, tailored to satisfy the needs of both.

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The optimal solution was to provide the daily-averaged data through a web-based graphical interface, while distributing the 30-minute research dataset on compact disc.

4.1 GRAPHICAL DISPLAYS

Historical archives and real-time Mesonet soil moisture data are provided to customers via a web-based interface. Quantities provided are daily-averaged ST, MP, and WC. Daily rainfall totals are also available for comparison with soil moisture values. Users are able to view a time series for any particular station, with the capability to overlay any combination of the 12 soil moisture parameters available for all depths, along with the daily rainfall totals. The selection for time series beginning and ending points is simplified by allowing the user to choose from three options: current year-to-date, current month-to-date, or custom beginning and ending dates. Figure 1 shows an example of the graphical display of a soil moisture time series.

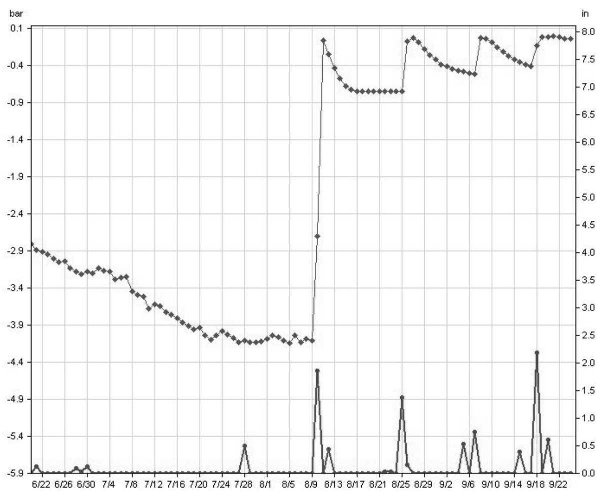

Figure 1. The 60cm daily-averaged values of matric potential (bars -- upper curve), along with daily rainfall (inches -- lower curve) for Norman, OK, from June 22 to September 24, 2001.

A statewide snapshot of current soil moisture conditions is available to users as well (see Figure 2). MP is categorized as “dry”, “limited”, “adequate”, or “moist/wet” (detailed in Table 1) and displayed on a state map, station-by-station. Categorized MP data is also available in an historical archive, and gives the user the ability to quickly view past soil moisture conditions. This tool provides an expedient view of soil moisture to the policy-making and agricultural communities.

4.2 SOIL MOISTURE CD

The 30-minute soil moisture data are provided to the research community in daily files via CD, with each disc containing one year of network-wide data. Quantities provided for each available depth are:

- DeltaT reference
- Soil matric potential
- Quality-assurance flags

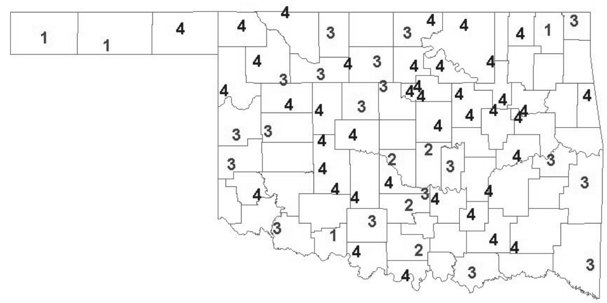

Figure 2. The categorized 60 cm daily-averaged values of matric potential from September 24, 2001. Physical descriptions of the categories are given in Table 1.

Because the coefficients used to convert soil water potential to volumetric water content are subject to change as the knowledge of soil properties at Mesonet sites (soil texture, bulk density, porosity, etc.) increases, estimates of volumetric water content are not provided in this dataset. However, the empirical relationship to estimate volumetric water content and the latest coefficients are provided in a comprehensive README file included on the CD. As new coefficients are developed, they will be provided to the research community.

Category	Range (bars)	Description
4	0.0 to -0.30	Moist/wet, some vegetation potentially affected by inadequate aeration
3	-0.30 to -1.0	Adequate, with most vegetation experiencing minimal water stress.
2	-1.0 to -4.0	Limited, with most vegetation experiencing some water stress.
1	< -4.0	Dry, with most vegetation experiencing significant water stress.

Table 1. Physical descriptions of categorized matric potential.

5. CONCLUSION

The Oklahoma Mesonet’s soil moisture network is a powerful tool for use by research scientists and the state’s decision-makers. The challenge faced by the Mesonet's soil moisture research team was to make this research-quality dataset available to both user communities in an easily-accessible form. The resulting graphical display tools from that effort have already proven their usefulness to several state agencies.

One of the lessons we have learned, and perhaps the most daunting challenge we face, is the state of soil moisture knowledge is in continual flux. As the research community receives and analyzes the data, improvements are made upon the quality assurance and data-calculation processes. In turn, these improvements require implementation into the dissemination process.

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