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DOE/SC-ARM-TR-230

Oklahoma Mesonet Soil Moisture (OKMSOIL) Value-Added Product Report

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ARM

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Acronyms and Abbreviations

ARM	Atmospheric Radiation Measurement
BNL	Brookhaven National Laboratory
CF	Central Facility
OKM	Oklahoma Mesonet
OKMSOIL	Oklahoma Mesonet Soil Moisture
QC	quality control
PTF	pedotransfer function
SGP	Southern Great Plains
VAP	value-added product

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1.0 Introduction

Land surface and subsurface state characteristics (e.g., soil moisture) are critical measurements for ongoing weather and climate analyses of land-atmospheric interactions and processes. Knowledge of the variation in soil moisture across the U.S. Department of Energy Atmospheric Radiation Measurement (ARM) user facility's Southern Great Plains (SGP) observatory domain is anticipated as a key quantity for assessing the potential impact of these interactions. This Oklahoma Mesonet Soil Moisture (OKMSOIL) value-added product (VAP) has been developed in response to growing demand for delivering a long-term measurement record of soil moisture (over an extended area) for such land-atmospheric studies.

The Oklahoma Mesonet (OKM) started as a joint project between Oklahoma State University and the University of Oklahoma (Brock 1995). The OKM currently operates over 100 surface Mesonet stations across the state of Oklahoma, with an operational data record that extends into the early 1990s. This dense network of atmospheric and surface state instrumentation enables representation of land surface/subsurface conditions over this region and extended record. Algorithms introduced by previous Oklahoma Mesonet activities (e.g., Scott et al. 2013) are implemented in this documented OKMSOIL VAP to derive a key soil moisture quantity, the volumetric water content (volume of water per volume of soil in units, cm^3/cm^3), from measurements of soil matric potential. These algorithms use a soil hydraulic parameter database (Meso-Soil Database) provided by the Oklahoma Mesonet scientists to estimate this quantity and several additional Mesonet station/sample details.

2.0 Input Data

This VAP requires the following variables from the "sgp30okm.b1" Oklahoma Mesonet datastream:

Table 1. Input variables.

sgp30okm.b1	
Name	**Long Name**
trise	Sensor temperature rise
qc_trise	QC flag for sensor temperature rise
depth	Sensor depth below surface
platform	Oklahoma Mesonet site ID

The following additional input parameters are read in from the Meso-Soil Database and incorporated into the VAP as the contents of a configuration file: Theta_r, Theta_s , Alpha , N. These quantities correspond to θr, θs, α, and n in equation (2) below, respectively.

3.0 Methodology

The motivation to conduct a comprehensive field soil sampling survey for each of the OKM stations was outlined by Scott et al. (2013), who derived volumetric water content from measurements of soil matric potential. The conversion between matric potential and water content is based on the site- and depth-specific soil water retention curve. The equation for soil matric potential, ψ_m (kPa), from van Genuchten (1980) is:

$$\psi_m = -c \exp(a \, \Delta T_{ref}) \tag{1}$$

where ΔT_{ref} is the normalized temperature rise (K) and c and a are calibration constants equal to 0.717 kPa and 1.7880 K^{-1}, respectively. A normalization process is performed to remove the variability that typically exists from sensor to sensor. This is accomplished by applying a linear regression to normalize the sensor to that of an idealized reference sensor (following Illston et al. 2008).

Using the soil matric potential, the volumetric water content, θ (m^3/m^3) can be calculated using the van Genuchten (Van Genuchten 1980) equation:

$$\theta = \theta_r + (\theta_s - \theta_r)/[1 + (-\alpha\psi_m)^n]^m \tag{2}$$

where θ_r (cm^3/cm^3) is the residual volumetric water content, θ_s (cm^3/cm^3) is the saturated volumetric water content, and α (1/kPa), n (unitless), and m (unitless) are fitting parameters. These values are estimates of the van Genuchten parameters using the Rosetta pedotransfer function (PTF), an artificial neural network model (Schaap et al. 2001). Each of these estimated parameters, except m, are reported in the Meso-Soil Database (version 1.1), and are provided as a function of the soil depth for each OKM station. For the parameter m, we employ a simplified expression following Scott et al., (2013) of the form,

$$m = 1 - 1/n \, . \tag{3}$$

4.0 Output Data

The OKMSOIL VAP produces a daily NetCDF file. Table 2 lists the major output variables from the VAP. The primary OKMSOIL quantity volumetric water content at 30-minute temporal resolution.

Table 2. Major output variables from OKM Soil Moisture (sgpokmsoilXl.cl).

Variables for the OKMSOIL VAP	
Name	**Long Name**
sensor_temperature_rise	Sensor temperature rise
qc_sensor_temperature_rise	Quality check results on field: Sensor temperature rise
matric_potential	Matric potential; capillary force needed to retain water in the soil
qc_matric_potential	Quality check results on field: Matric potential
volumetric_water_content	Volumetric water content; total percent of water per volume of soil at 30-minute temporal resolution
qc_volumetric_water_content	Quality check results on field: Volumetric water content
fractional_water_index	Fractional Water Index; relative measure of soil wetness

Variables for the OKMSOIL VAP	
Name	**Long Name**
qc_fractional_water_index	Quality check results on field: Fractional Water Index
time	Time offset from midnight at 30-minute intervals
depth	Sensor depth below surface
lat,lon,alt	Coordinates for each station

5.0 Summary

The OKMSOIL VAP responds to an existing need to provide long-term measurements of the soil moisture and several related quantities. These estimates are collected at Mesonet sites that span a large area (and over 100 individual surface Mesonet stations) in Oklahoma that surround the ARM SGP Central Facility (CF). The primary scope of this product is to derive these soil moisture measurements from the raw, routine data currently available from the OKM network, which is otherwise unavailable.

6.0 Example Plots

6.1 Data Validation

To validate VAP output data, we investigated current OKMSOIL VAP results using the latest revision of the OKM quality-assured input data. The production VAP results were also compared to the plots and associated estimates as published in Illston et al. (2008) for data sets collected during 1998. Cross-comparisons with the previous Illston et al. (2008) findings indicate that the algorithm implementation matches published expectations (Figure 1). Small differences have been identified as due to small improvements in the input data quality of the current OKMSOIL VAP.

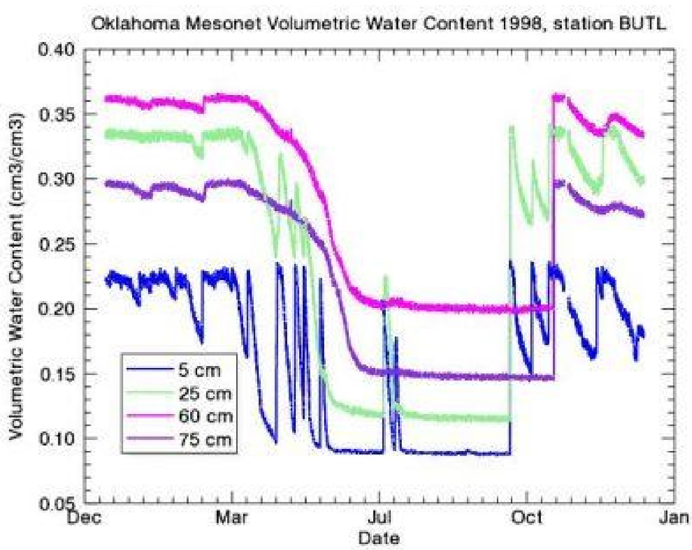

Figure 1. Soil Water Content generated by the OKMSOIL VAP from April–September, 1998 as observed at the Butler OKM station.

6.2 Area Covered by the OKMSOIL VAP

Soil moisture calculations are performed for the entire array of Oklahoma Mesonet surface stations, including those stations near the ARM CF (Figure 2):

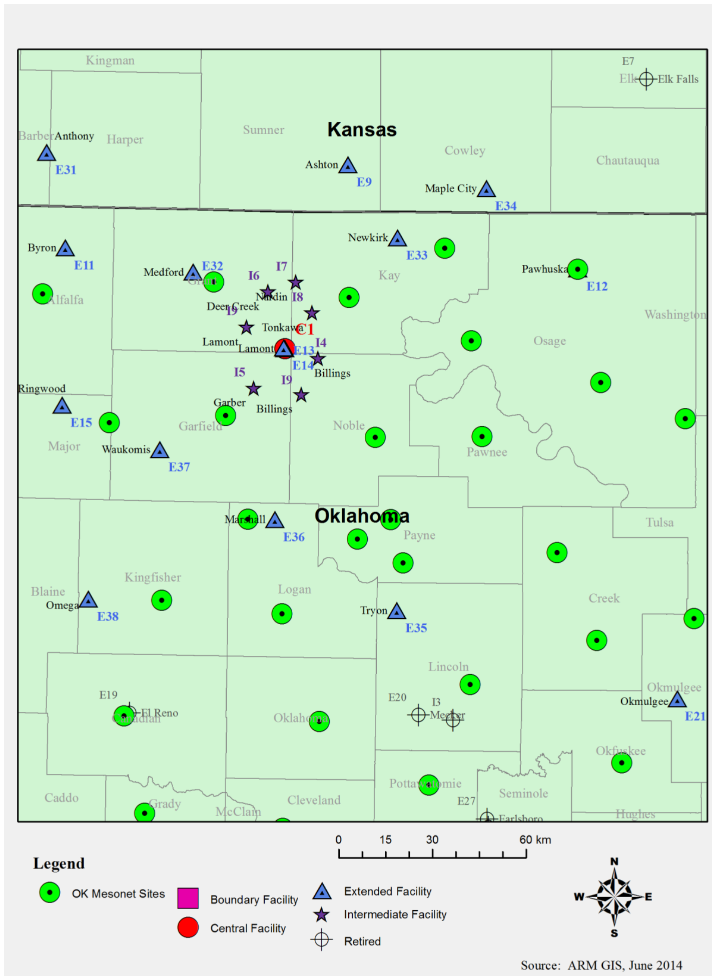

Figure 2. Map showing the subset of OKM stations that surround the ARM CF in north-central Oklahoma.

7.0 References

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