THE OKLAHOMA MESONET: EVOLUTION FROM REAL-TIME WEATHER NETWORK TO CLIMATE NETWORK

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ABSTRACT

The Oklahoma Mesonet is an automated network of 120 environmental monitoring stations across the state. Commissioned in 1994, the Mesonet records air temperature, relative humidity, rainfall, winds, pressure, solar radiation, soil temperatures, and soil moisture in near real-time.

The Mesonet produces hundreds of products to aid decision-making for emergency managers, firefighters, farmers, ranchers, electric utilities, and weather forecasters across the state. As the network has matured, it has also measured a number of significant climate observations. For instance, in 2011 alone, the Mesonet observed the state's lowest temperature ever recorded (-35 °C), the state's highest wind gust (67.5 m/s), the state's second driest water year on record (average statewide rainfall of 51.45 cm), and the warmest month on record (average statewide temperature of 31.7 °C).

To aid in data quality, all sensors in the Mesonet are calibrated before they are deployed to a station. Additionally, all sensors are routinely rotated back to the calibration lab at predetermined intervals. Since sensor changes are inevitable over the long-term, the Mesonet maintains a set of continuity stations across the state that continues to employ original sensors with new models. The Oklahoma Mesonet is paving the way for regional and statewide networks to become official components of the United States climate archive.

1. INTRODUCTION

The Oklahoma Mesonet was commissioned in 1994. Today, the network consists of 120 environmental monitoring stations across the state (Fig. 1). Each station records air temperature, relative humidity, rainfall, winds, pressure, solar radiation, soil temperature, and soil moisture (Fig. 2). Mesonet data are primarily used for real-time decision making by emergency managers, fire managers, weather forecasters, farmers, ranchers, and electric utilities (McPherson et al. 2007). Now that the network is established as a stable, long-term source of weather data, Mesonet data are increasingly used for climate applications.

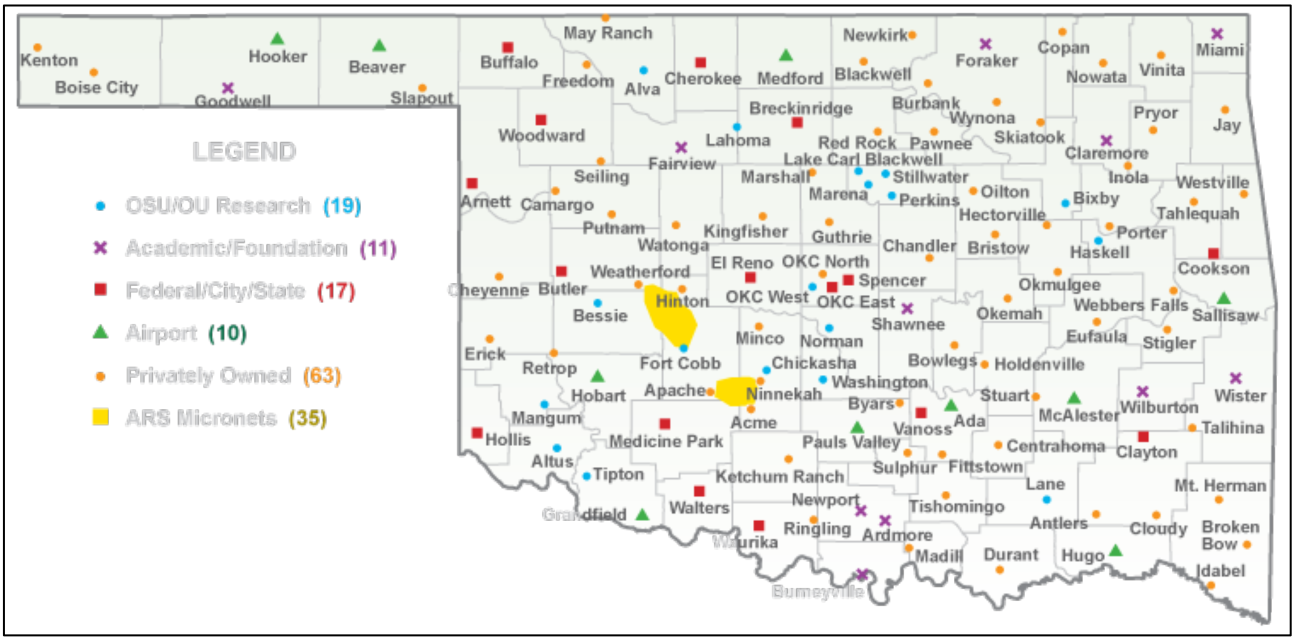

Figure 1. Location of Oklahoma Mesonet stations.

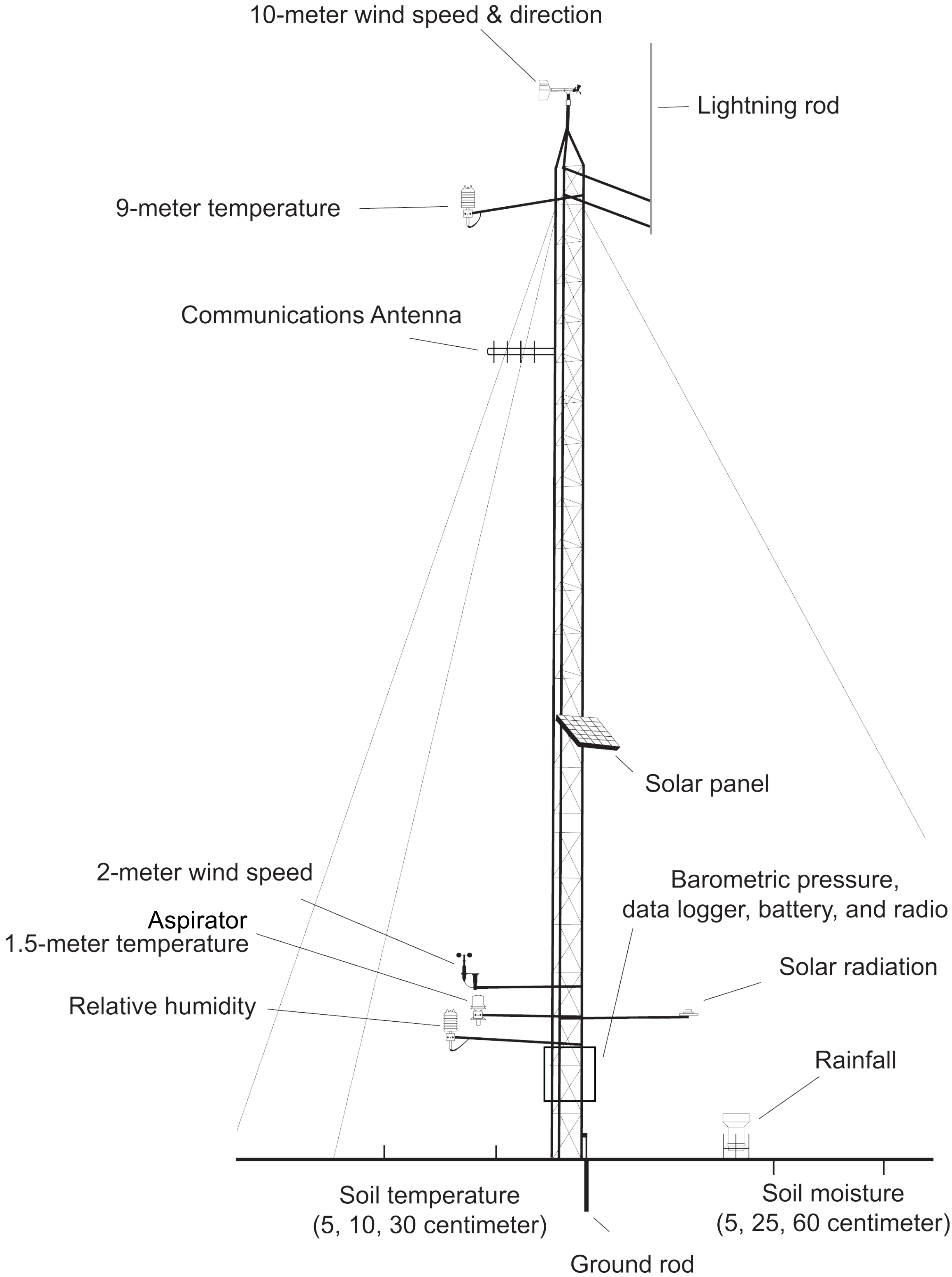

Figure 2. A schematic of an Oklahoma Mesonet tower and associated equipment.

2. DATA QUALITY ASSURANCE

Personnel at the Mesonet strive to obtain research-quality observations in real time. They follow a systematic, rigorous, and continually maturing protocol to verify the quality of all measurements (Shafer et al. 2000). The procedures described below ensure that the data archive is accurate for long-term climate analyses:

a. Sensor calibration: Mesonet staff test or calibrate every sensor before deployment to a station. Additionally, each sensor at a station is routinely rotated back into the Mesonet calibration lab to be tested at defined intervals (McPherson et al. 2007). Sensors are tested over their full operating range to ensure accuracy. If a sensor is found to have a bias, appropriate data are flagged in the Mesonet archive.

b. Routine in-field sensor maintenance and tests at each site: Every Mesonet station is visited at least once each Spring, Summer, and Fall so that a technician can perform standardized tasks, including cleaning and inspecting sensors, verifying depth of subsurface sensors, cutting and removing vegetation, taking photographs, and conducting sensor tests (Fiebrich et al. 2006).
c. Automated quality control: Automated tests evaluate the real-time feed of Mesonet data every five minutes. The algorithms are comprised of sensor-based range tests, climate-based range tests, step tests, persistence tests, spatial tests, like-instrument tests, and internal consistency tests (Fiebrich et al. 2010). Any data deemed erroneous by the automated quality control are flagged in the archive and not delivered to users.
d. Manual quality control: The Mesonet employs a full-time quality assurance meteorologist to perform manual data quality control. The quality assurance meteorologist reviews the outputs from the automated tests and also performs details analyses (Fiebrich and Crawford 2001). Data flagged as erroneous by the quality assurance meteorologists are flagged in the archive and not delivered to users.

3. EXTREMES MEASURED IN 2011

Oklahoma's climate archive goes back to 1895. Despite the long archive, Oklahoma set numerous records in 2011. The Mesonet recorded the following extremes:

a. On the morning of 10 February 2011, the Mesonet station at Nowata recorded a low of -35 °C. This was the coldest temperature ever recorded in state history, exceeding the old state record of -33 °C. As part of a review by the State Climate Extremes Committee of the National Climate Data Center, the thermistor was retrieved from the Nowata station and verified to be accurate during calibration (McManus et al. 2012).
b. On the evening of 24 May 2011, the Mesonet station at El Reno recorded a wind gust of 67.5 m/s as an EF-5 tornado moved several hundred meters north of the station. This wind speed set the record for the strongest surface wind ever measured (non-radar) in Oklahoma.
c. The 2011 Water Year (October through September) for Oklahoma finished as the second driest ever with a statewide average precipitation total of 51.45 cm, 41.73 cm below normal as measured by the Mesonet.
d. July 2011 in Oklahoma had an average statewide temperature of 30.5 °C, which was the hottest month for any state in the United States on record. The Oklahoma Mesonet site at Grandfield recorded 101 days above 37 °C (100 °F), which broke the previous state record of 86 days, set in 1956.

4. MESONET INCLUSION IN U.S. COOP NETWORK

For more than 100 years, the U.S. COOP Network (U.S. Department of Commerce 2003) of the National Weather Service (NWS) has monitored the nation's climate. The COOP primarily consists of human volunteers to manually record daily air temperature and precipitation observations. As confidence in the data quality from the Mesonet grew, the NWS began to incorporate Oklahoma Mesonet stations into the COOP network in 2008. Today, more than 70 Mesonet stations are official COOP stations. Thus, Mesonet observations are now used to calculate official state and climate division averages.

5. CONTINUITY STATIONS

Transition to new sensors is inevitable in any long-term network. In 2008, all air temperature measurements in the Mesonet were upgraded with aspirated shelters. Additionally, the Mesonet considered changing to ultrasonic anemometers and heated rain gauges. In an effort to understand and evaluate the impact of changes in instrumentation at Mesonet sites, five stations were selected as "continuity" stations. These five continuity stations are located in five different climate divisions in the state. They were selected based on having minimal impact from anthropogenic sources, having minimal impact from wind obstructions, having minimal slope, having a history of very high data quality, and having high likelihood of long-term stability. These stations keep the original sensors used in the network plus operate new models of sensors (Fig. 3). It is intended that these five stations will provide long-term overlap of data for future assessment of changes in the climate record that may result from changes in instrumentation. In 2012, the Mesonet is also faced with finding a new relative humidity sensor for the network because the current Vaisala HMP45 sensor is no longer manufactured. New relative humidity sensors are being deployed to the continuity stations to operate side-by-side with the HMP45 sensor for evaluation.

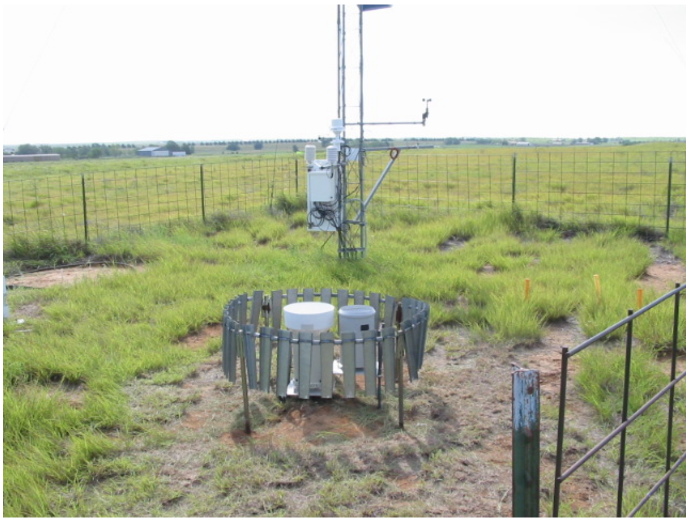

Figure 3. Site photo of the Mesonet continuity station in Beaver, Oklahoma. Both the current rain gauge and a heated gauge are deployed in the alter screen. Additionally, both a naturally ventilated and an aspirated temperature sensor are installed on the tower at 1.5 m.

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