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AN OVERVIEW OF THE OKLAHOMA CITY MICRONET

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1. INTRODUCTION

Between the dates of 28 June and 31 July 2003, the Joint Urban 2003 field experiment (JU2003) was conducted in Oklahoma City to collect data used for the improvement of numerical models that simulate dispersion within urban environments (Allwine et al., 2004). During the six-week period, intensive observing periods occurred within a temporary array of various instrument systems deployed in and around the central business district of Oklahoma City (Allwine and Flaherty, 2006). Because of the complex atmospheric processes involved in urban areas, field experiments such as JU2003 have been critical to the advancement of science in urban meteorology and climate. To date, much of the current understanding of the impacts of urban areas on atmospheric processes results from field programs such as JU2003 including those conducted in other North American cities including St. Louis (Metropolitan Meteorological Experiment – METROMEX (Changnon et al., 1971; Lowry, 1974), Chicago (Changnon and Semonin, 1978), Los Angeles, Vancouver, Montreal (Mailhot et al., 1998), Mexico City, Tucson, Salt Lake City (Allwine et al., 2002), and Phoenix (Grimmond and Oke, 1995). During June and July 2003, the Joint Urban 2003 field experiment (JU2003; Allwine et al. 2004) was conducted in Oklahoma City (OKC).

Unfortunately, once large field experiments complete the tasks associated with the projects, the scientific tools and instruments used to collect the necessary data are typically decommissioned. Such was the case with JU2003 whereby, upon the completion of the JU2003 activities, the temporary instrument networks were removed. At the same time, in North America, the majority of real-time, continuous, research-quality atmospheric observations are not collected within the core regions of cities. Thus, a general disconnect exists in which the majority of observing sites are collected in rural areas away from the densest populations. Yet, recent publications have addressed that urbanization has and will continue to increase worldwide (United Nations Human Settlements Program, 1997; Dabberdt et al., 2000; United Nations, 2003) and a growing need exists for improved atmospheric observations for a variety applications including public health and safety.

The success of JU2003 did provide the opportunity to assess the feasibility of a permanent urban-atmospheric monitoring network deployed across the Oklahoma City metropolitan area. Thus, following JU2003 and with the assistance of the City of Oklahoma City, the Oklahoma City Micronet (OKCNET), a dense network of automated weather stations designed to improve atmospheric monitoring across the Oklahoma City metropolitan area was deployed after nearly five years of design and testing. The OKCNET project included the deployment of three new Oklahoma Mesonet sites (McPherson et al. 2007) within Oklahoma City and the installation of sites mounted on traffic signals. The Oklahoma City Micronet was officially commissioned on 8 November 2008.

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2. OKLAHOMA CITY MESONET STATIONS

As part of a joint effort between the OKCNET project and the Oklahoma Mesonet (Brock et al. 1995, McPherson et al. 2007), three new Mesonet sites were installed within Oklahoma City in early 2007 (Fig. 1). The first site (OKCN) was installed in February 2007 approximately 7 miles north of the central business district while in April 2007 two additional sites were deployed approximately 4 miles west of the central business district and approximately 4 miles east of the central business district (OKCE). More information regarding the specifics of the new Mesonet sites deployed in Oklahoma City can be found at:

<u>*OKCW*</u>:
http://www.mesonet.org/sites/sitedescription.php?site=OKCW&dir=pr

<u>*OKCN:*</u>
http://www.mesonet.org/sites/sitedescription.php?site=OKCN&dir=pr

<u>*OKCE:*</u>
http://www.mesonet.org/sites/sitedescription.php?site=OKCE&dir=pr

3. TRAFFIC SIGNAL STATIONS

The design, testing, and deployment of stations mounted on traffic signals would not be possible nor successful without extensive collaboration with the City of Oklahoma City, which boasts the largest IEEE 802.11 "Wi-Fi"(TM) mesh network in the world. With the assistance of Oklahoma City personnel, the traffic signal stations were designed to attach to this network of wireless access points across the metropolitan area.

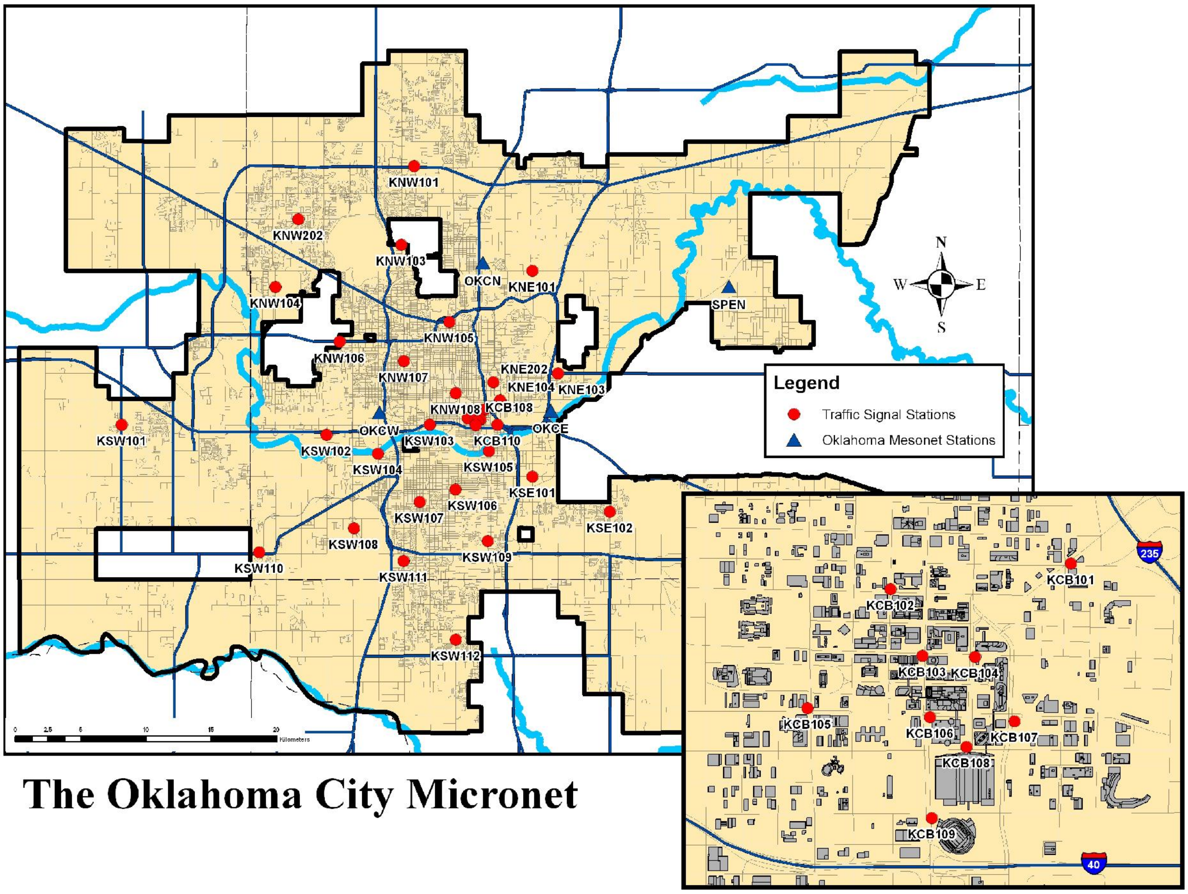

Figure 1. The location of Oklahoma City Micronet stations.

across the metropolitan area. Each traffic light station consists of a Vaisala WXT510 sensor, a Campbell Scientific CR200 datalogger, an enclosure specifically designed for the traffic signals, and hardware to facilitate power and communications across the OKC wifi network.

In December 2007, a working prototype station was completed and installed at the intersection of Main Street and Walker Drive in the central business district of Oklahoma City. A series of tests were completed and all subsequent approvals were acquired from Oklahoma City officials by mid January 2008. Given final approval from Oklahoma City, all remaining components for the traffic signal stations were fabricated during the Spring of 2008. On 8 May 2008, installation of the remaining 35 traffic signal stations began in the central business district of Oklahoma City and, by 30 May, all sites had been deployed across the metropolitan area (Fig. 1).

The determination of the location for each site was accomplished via a number of critical criteria. These included:

- In partnership with the City of Oklahoma City, sites were distributed across the populated areas of Oklahoma City.
- A concentration of stations were deployed within the urban core for various research purposes.
- Sites were also deployed to form transects spanning the rural-to-urban-to-rural zones.

At the same time, a number of practical aspects were considered during final site placement including:

- Sites could only be deployed at locations with wifi access points.
- Potential locations with overhanging power lines were avoided.
- The location of potential, critical public landmarks in the area (e.g., schools, roadways, etc.) were considered for final site deployment.

Figure 2. An OKCNET technician installs a traffic signal station.

During the deployment phase a conceptual model was developed to identify potential site locations. However, final locations were determined following extensive field surveys to determine the suitability of each individual location.

Once final site locations were determine, the deployment of the traffic signal stations was accomplished whereby a trained Oklahoma City technician operated a truck with a lift as a Micronet technician installed each station (Fig. 2). During the installation procedure, a safety line was attached as the site was lifted into place. Next, each site was secured to the pole via stainless steel straps and the station linked to an Oklahoma City wireless access point via an ethernet cable. The link to the access point established both communications and the power needed to operate the station by use of IEEE 802.3af "Power over Ethernet" technology. Once secured and connected, the technician verified communications with Oklahoma Mesonet personnel and panoramic site photos were collected. The deployment of each station spanned approximately one hour, which allowed for multiple stations to be deployed in a single day.

4. PRELIMINARY RESULTS

The spatial and temporal density of observations collected by the Oklahoma City Micronet have already shed new insights regarding atmospheric processes across the metropolitan area. For example, because the Micronet spans the gradient from quasi-rural to urban land use conditions, the Micronet has consistently detected an urban heat island with magnitudes as great as 5.5^{o}C and associated gradient of air temperature due to the varying surface conditions. However, the air temperature gradient (and associated maximum/minimum values) is often impacted by the magnitude and direction of the near-surface wind conditions whereby locations downstream of the urban core were warmer than locations upstream of the central business district of Oklahoma City.

The network has also captured the impacts of significant weather events that moved across Oklahoma City. For example, on 27 May 2008, a severe thunderstorm complex with a bow echo propagated through the metropolitan area during the early morning hours. Severe winds were observed along the leading edge of the gust front in advance of the heavy precipitation including a gust to 29 m s^{-1} at the OKCNET site located at SE 15th St. and Central Blvd. (KSW105) just 1.5 km from the central business district of Oklahoma City. In addition, on 14 December 2008 a very strong cold front propagated through Oklahoma City whereby temperature values plunged nearly 25^{o}C over a 6-hour period and individual sites cooled as much as10^{o}C in 5 minutes immediately following the frontal passage. Further, OKCNET observations captured the significant thermal gradient (approximately 10^{o}C) as the front moved across the Oklahoma City metropolitan area (Fig. 3).

5. SUMMARY

With an average station spacing of approximately 3 km, the Oklahoma City Micronet observes atmospheric conditions at a fine spatial resolution. Additionally, a key component of OKCNET is rapid collection and dissemination of research quality observations. Every minute, atmospheric conditions at each traffic signal station are measured, transmitted to a central facility, and made available to users via the Internet. Similarly, every 5 minutes, the observations at the Oklahoma City Mesonet stations are collected, transmitted to a central facility, and made available to users. All observations receive real-time and archived quality assurance prior to distribution or display. As a result, approximately 640,000 research quality observations are collected each day across Oklahoma City.

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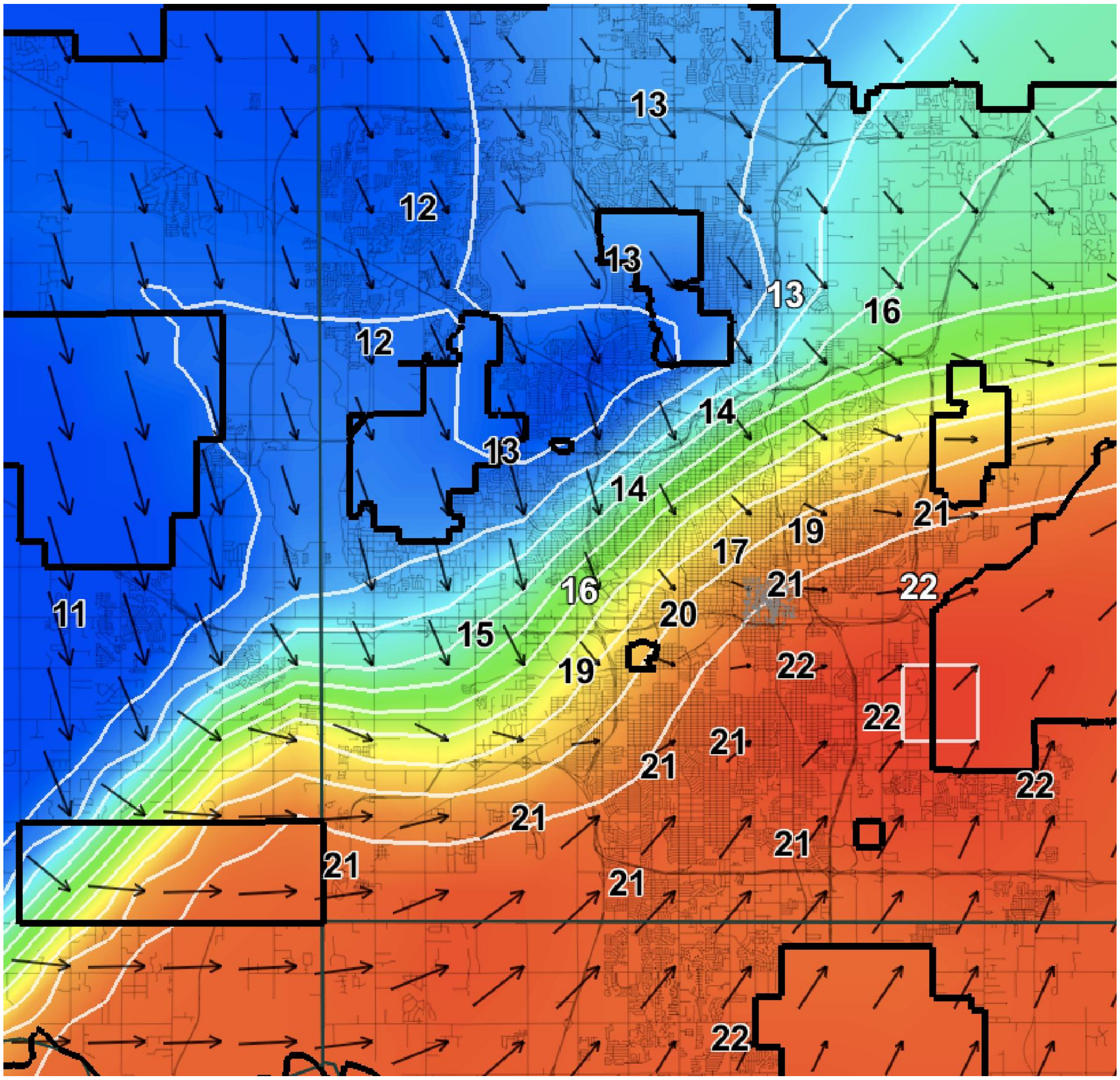

Figure 3. OKCNET observations from 14 December 2008 at 1940 UTC as a strong cold front propagated through Oklahoma City. The temperature values (°C) from traffic signal sites are displayed in black, The temperature values (°C) at 9 m at Oklahoma Mesonet sites are displayed in white, analyzed wind vectors are displayed as black arrows, and color contours highlight the analyzed temperature with isotherms contoured every 0.5 °C (white).

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