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MULTI-DOPPLER RADAR OBSERVATIONS OF BOUNDARY LAYER WINDS IN SUPPORT OF THE SECOND TEXAS AIR QUALITY FIELD STUDY (TEXAQS II)

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1. INTRODUCTION

The Second Texas Air Quality Study (TexAQS II) is a comprehensive research initiative to better understand the causes of air pollution and ultimately to improve regulatory analysis and prediction tools for developing ozone and regional haze State Implementation Plans. Air pollution events are the consequence of complex processes involving both atmospheric chemistry and meteorology on local to regional scales. An important component of this research initiative is to provide enhanced meteorological measurements during an 18-month period (May 2005 – October 2006) over eastern Texas, including the urban environments of Houston and Dallas-Fort Worth.

A key objective of the enhanced meteorological monitoring is to quantify the transport into, within, and out of Texas so that the formation and accumulation of ozone and regional haze can be better predicted. As part of this objective, the Texas Commission on Environmental Quality (TCEQ) and the Texas Environmental Research Consortium (TERC) have sponsored the participation of the Shared Mobile Atmospheric Research and Teaching (SMART) radars (two, C-band, Doppler; Biggerstaff et al. 2005) in TexAQS II to measure clear-air winds in the boundary layer for the purpose of quantifying mesoscale transport in and around urban environments.

The purpose of this paper is to present a brief overview of the experimental design, including radar deployment and scanning strategies, quality control, and radar data processing. At the meeting, we will also present preliminary radar observations and dual-Doppler analyses from the summer (July-September) 2005 field campaign.

2. EXPERIMENTAL DESIGN

Radar site selection was based on a number of competing scientific and logistical factors, including in decreasing order of priority: 1) a secure site (e.g., gated access) 2) availability of a site with a hard surface (e.g., cement, asphalt, hard-parked dirt/grass) that can accommodate the 33 foot long radar facility, 3) placement of each C-band Doppler radar within 20-40 km of nearby Weather Surveillance Radar - 1988 Doppler (WSR-88D) to maximize the ozone precursor source, ozone accumulation and/or wind data sparse

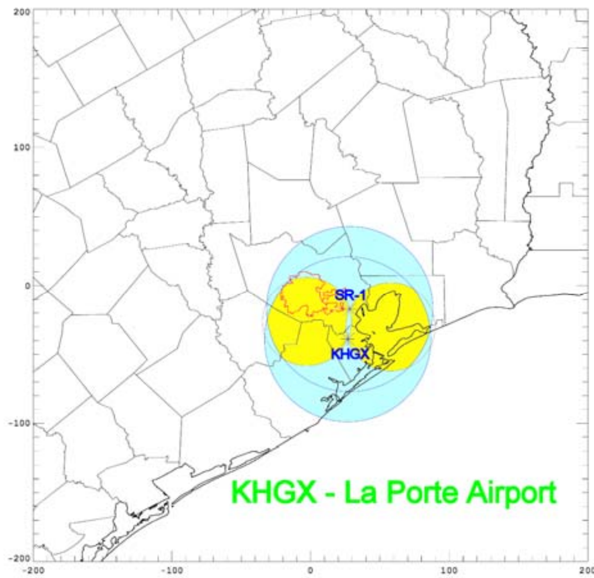

Figure 1. Single and dual-Doppler radar lobes in the Houston, Texas area. The WSR-88D radar is located at League City (KHGX). The C-band radar (SR-1) location is at the La Porte Municipal Airport. The outer rings define the 60 km range rings. The inner rings define the 20° beam-crossing areas. The union of the 4 rings defines the dual-Doppler area and is shaded yellow. Single Doppler radar coverage is highlighted by blue shading. The red boundary indicates the Houston urban area. County and coastal boundaries are shown.

regions within the dual-Doppler radar lobes while maintaining acceptable horizontal resolution of the radar data (e.g., < 1.5 km), 4) minimal line of sight obstructions from the radar location (especially above 1° above local horizon), 5) availability of power, and 6) availability of high speed communications.

The radar site must be secure to insure personnel safety and equipment integrity while deployed. The mobile radars can deploy on most hard surfaces, including cement, asphalt, and hard packed dirt/grass areas that are not flood prone. Dual-Doppler radar lobes define the area in which 3-D winds can be estimated from the radial velocity data from two nearby Doppler radars. The dual-Doppler lobes within each urban area are determined by the union of the areas defined by the 60 km range ring from the WSR-88D and C-band SMART radars and the areas in which the radar beam-crossing angle is greater than 20° (see Figs. 1 and 2 for examples in Houston and Dallas-Fort Worth, respectively).

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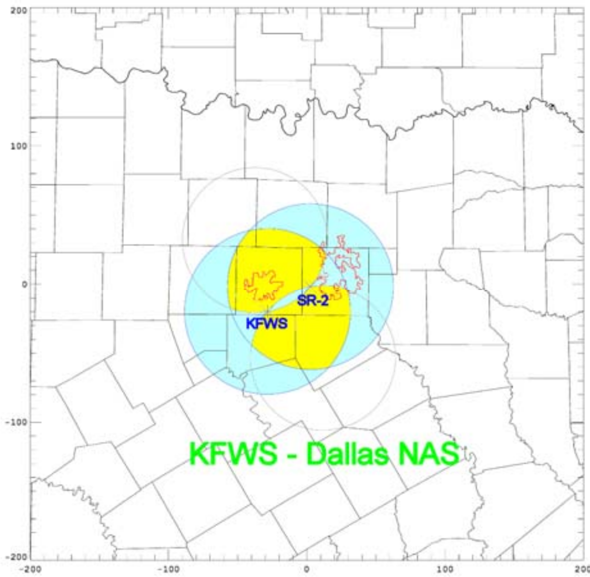

Figure 2. Same as Fig. 1 except for the Dallas-Fort Worth, Texas area. The WSR-88D radar is located at Forth Worth Spinks Airport (KFWS). The C-band radar (SR-2) location is at the Dallas Hensley Field, which is owned and operated by the City of Dallas. The red boundaries indicate the Dallas and Fort-Worth urban areas. County and state boundaries are shown.

Line of sight obstructions above the horizon at candidate locations were evaluated using a hand held inclinometer. The location should have minimal obstructions more than 1° above the horizon, especially in the direction of the ozone precursor source, ozone accumulation, or wind data sparse regions. However, some obstructions and associated beam occultation were inevitable given the urban, treed, and, in the case of Dallas, hilly locations. Land line power was desirable but not required since the C-band radars can run on on-board diesel-generator power. On-site broadband communication (T1, DSL, cable line) was also desirable for near real-time data transfer but not required.

Given the requirement for open space in an urban environment, small airports were the favored candidate sites. The size and orientation of the dual-Doppler lobes were designed to sample ozone hotspots, pollution precursor sources, and areas with sparse surface wind observations. For both locations, dual-Doppler (DD) radar coverage of the urban areas, which often experience high ozone accumulation, was a top priority. Over Houston, DD radar coverage over the data sparse Galveston Bay was an additional priority. After visiting multiple candidate airports on the southeast side of Houston, the La Porte Municipal Airport, which is owned and operated by the city of La Porte, was chosen for the first SMART radar (SR-1). As shown in Fig. 1, the La Porte SR-1 site, in combination with KHGX, which was 22 km to the south, provides good DD radar coverage over the Houston urban area and Galveston Bay.

The Dallas-Fort Worth (DFW) metropolis covers a much larger area then Houston. As a result, it was not possible to cover all of the urban regions with DD radar measurements. Given a climatological bias for ozone hotspots just north of Fort Worth and suspected ozone precursor sources south of Dallas, the search for a suitable location for the second SMART radar (SR-2) focused on the southwest side of Dallas and surrounding satellite cities. The hilly and heavily treed terrain of the southwest Dallas area proved to be a significant obstacle to finding a suitable radar location. After visiting over ten candidate airports, the Dallas Hensley Field, which is formerly known as the Dallas Naval Air Station (NAS) and is currently owned and operated by the City of Dallas, was chosen for the SR-2 location (Fig. 2) because it provided the best compromise between the logistical and scientific requirements discussed above. The larger DD baseline (37 km) between KFWS and SR-2 was necessary to maximize the DD areal coverage over DFW.

During clear-air operations, SMART radar scanning consisted of a six-tilt PPI surveillance (i.e., 360° in azimuth) volume. The clear air PPI volume focused on low-level boundary layer winds (i.e., with elevation angles of 0.75°, 1.5°, 2.5°, 3.5°, 4.5°, and 6°), took about 3-4 minutes to complete, and was repeated continuously.

The SMART radars began continuous operations at the La Porte and Dallas locations on July 11th and 18th, respectively and ran nearly continuously until September 23rd, providing DD radar coverage during several ozone events over both cities. During the writing of the extended abstract, the SR-1/KHGX and SR-2/KFWS DD radar data were being quality controlled and synthesized into maps of low-level horizontal winds over both the Houston and Dallas-Fort Worth areas. During the meeting, preliminary results of the DD radar inferred boundary layer winds will be set in context of the evolving meteorological and pollution conditions over both cities for several ozone events.

3. FUTURE WORK

Both single-Doppler (e.g., VAD/VVP wind profiles) and dual-Doppler wind products will be used to validate, constrain and improve the numerical models used to predict the buildup of ozone and transport of regional haze. For selected cases over Houston, we will explore assimilation of SMART radar observations with an Ensemble-Kalman Filter (EnKF) for the modeling of air pollution meteorology and compare the results to traditional dual-Doppler synthesis and other assimilation techniques such as nudging.

4. REFERENCES

Biggerstaff, M. L., L. J. Wicker, J. Guynes, C. Zeigler, J. M. Straka, E. Rasmussen, A. Doggett, L. D. Carey, and J. L. Schroeder, 2005: The Shared Mobile Atmospheric Research and Teaching (SMART) Radar: A collaboration to enhance research and teaching. *Bulletin of the American Meteorological Society*, **86**, 1263-1274.