Title: Verification of the Origins of Rotation in Tornadoes Experiment-Southeast 2018 (VORTEX-SE_2018) KULM Radar Data Set

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1.0 Dataset Overview

The University of Louisiana Monroe (ULM) conducted VORTEX-SE operations on four days between 10 March 2018 and 13 April 2018 within the VORTEX-SE operations domain in north Louisiana. These operations were anchored by the ULM polarimetric S-band Doppler weather radar (KULM). This document outlines the KULM platform and data collected during VORTEX-SE 2018.

2.0 Instrument Description

KULM was manufactured by Enterprise Electronics Corporation (EEC) and represents their DWSR-8501S SIDPOL radar system. KULM is a polarimetric S-band Doppler radar with an operating frequency of 2950 MHz and horizontal (vertical) half-power beam width equal to 0.93° (0.91°). A summary of the major KULM specifications is given in Table 1. KULM began operating in October 2016 and helps to fill a coverage gap in the NEXRAD network over northeastern Louisiana and southeastern Arkansas. The radar is located approximately 3 km northeast of the Monroe Regional Airport, and 6 km due east of the ULM campus. The KULM domain is given in Figure 1. KULM user control and data transmission are accomplished through a 10Gbps fiber line from the radar site to ULM's campus. The radar is operated by faculty and students at ULM in both classroom and research environments. Real-time data are provided to the National Weather Service Weather Forecast Offices in Shreveport, LA, Jackson, MS, Little Rock, AR and to the Storm Prediction Center. Raw, volumetric data are not publicly available; however, base reflectivity and velocity images/loops are available at http://wxdata.geos.ulm.edu/ULMradar/.

Table 1: Table of specifications for KULM

Location	32.529392°, –92.012115°
Altitude (antenna MSL)	55 m
Transmit Frequency (Wavelength)	2950 MHz (10.1624 cm)
Transmitter/Peak Power	Magnetron, 850 kW
Pulse Width	0.5, 0.8, 1.0, 2.0 μs
Maximum PRF	200–1180 Hz
Dual PRF Ratios	3/2, 4/3, 5/4
Antenna Diameter	8.5 m (28 ft CF Parabolic)
Antenna Beam Width	0.93° (horiz); 0.91° (vert)
Maximum/Typical Rotation Rate	36° s^{-1} (15–20° s^{-1})
Transmit Polarization	Simultaneous H and V, or H
Signal Processor	EEC iQ2
Gate Spacing	≤ 250 m (125 m typical)
Sensitivity	–20 dBZ @ 30 km
Minimum Detectable Signal	–114 dBm
Processing Modes	Pulse-pair, DFT Processing, DFT Filtering, Multilag

3.0 Data Collection & Processing

KULM serves as an operational radar, so data collection occurs 24/7/365. When not manned by a radar operator, KULM runs continuously in either a "clear air" mode, or a general surveillance, five tilt scan strategy (0.7, 1.8, 3.1, 4.0, and 5.1° to 150 or 250 km). During VORTEX-SE 2018 operation periods, KULM was manned and ran a combination of full volume scans, as well as the two scan strategies highlighted above. For most operation periods, the main goal was to sync volume scans with the mobile radars operating in the domain. Details on each scan strategy employed during VORTEX-

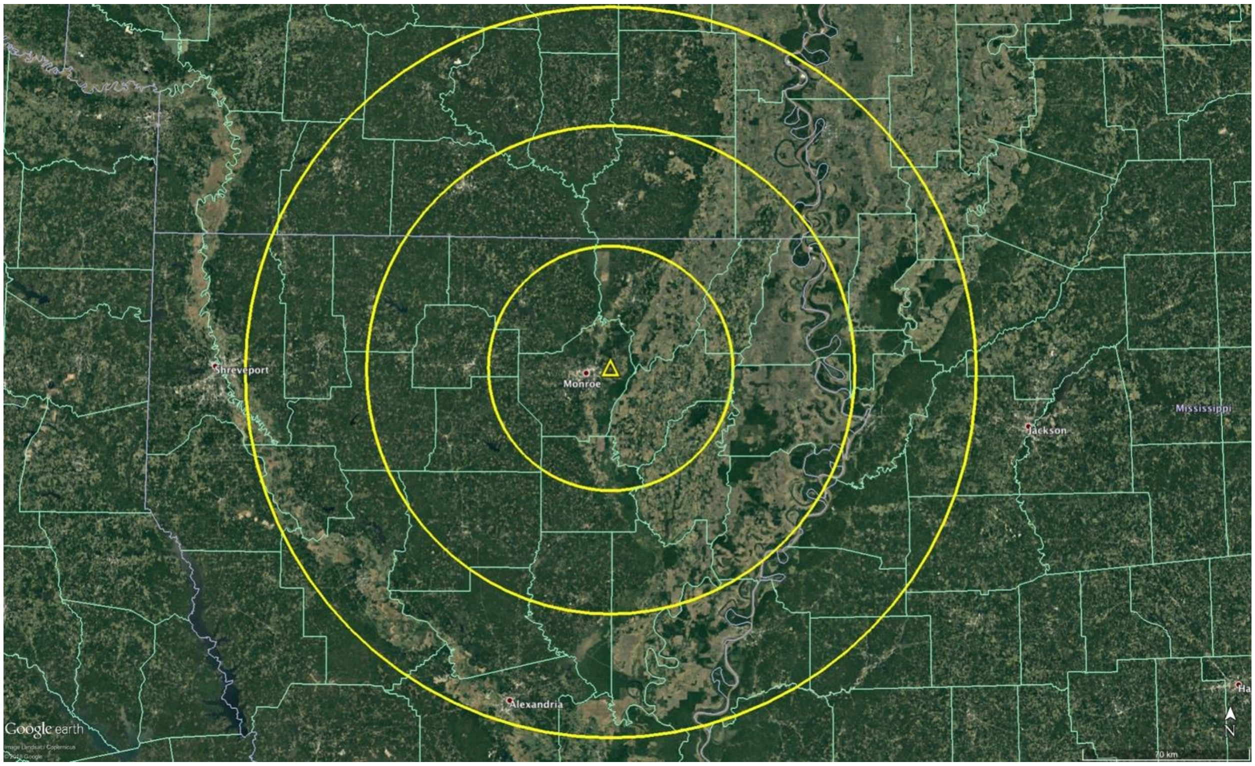

Figure 1: KULM domain centered over north Louisiana. The yellow triangle denotes KULM's location and the yellow circles are 50, 100, and 150 km range rings.

SE 2018 are provided in Table 2. Intensive observation periods (IOPs) during VORTEX-SE 2018 where KULM data was collected are provided in Table 3. Coordinated radar operations between KULM and ground based mobile radars occurred for all north Louisiana deployments with the exception of the 13 April 2018 event. Vertically pointing ZDR calibration scans were conducted as often as weather permitted. Minimal processing and post-processing were performed and the data provided are nearly equivalent to the raw radar volumes.

Table 2: KULM VORTEX-SE 2018 Scan Strategies

Tsk Name	Mode	Pulse Duration (µs)	PRF (Hz)	Polar	Rotation Rate (° s^{-1})	Bin Space (m)	R_{max} (km)	V_{max} (m s^{-1})	Elevation Angle Sequence (°)
VSE_CLR1	Full PPI	1.0	400	H+V	14	250	375[1]	10	0.8, 1.8, 2.2, 3.0, 3.8, 4.6, 5.4, 6.2, 7.0, 10.0
VSE_CLR2	Full PPI	2.0	225	H+V	7	125	666[1]	6	0.8, 1.8, 2.2, 3.0, 3.8, 4.6, 5.4, 6.2, 7.0, 10.0
R20_Full	Full PPI	0.5	1100	H+V	27-30	250	136	28	0.8, 1.3, 2.0, 2.8, 3.8, 4.6, 5.7, 7.0, 8.6, 10.6, 13.5, 16.6, 19.6, 22.6, 26.0, 29.2, 32.6, 35.8, 39.5, 43.0
R45_Full	Full PPI	0.5	1100	H+V	20-30	250	136	28	0.5, 0.9, 1.3, 1.8, 2.3, 3.1, 4.1, 5.2, 6.6, 8.0, 9.5, 11.0, 12.5, 13.8, 15.2, 16.6, 18.2
Gen_Sur	Full PPI	0.5	1000	H+V	20	125	150	25.41	0.7, 1.8, 3.1, 4.0, 5.1

[1] The maximum data range for both VSE_CLR1 and VSE_CLR2 were hard set by the operating software at 250 km.

Table 3: KULM VORTEX-SE 2018 Operating Periods

Date	Time (UTC)	Scan Strategy Tsk Name
20180310	1800 – 2017	R45_Full
20180310	2017 – 2301	VSE_CLR1
20180310-11	2301 – 0410	VSE_CLR2
20180311	0410 – 0530	VSE_CLR1
20180328	1900 – 2009	Gen_Sur
20180328	2009 – 2145	R45_Full
20180328	2145 - 2228	R20_Full
20180406	1930 – 2115	VSE_CLR1
20180406	2115 – 2200	R45_Full
20180406-07	2200 – 0200	R20_Full
20180413	2129 – 2238	VSE_CLR1
20180413-14	2238 – 0900	Gen_Sur

4.0 Data Format

The raw KULM radar volumes were converted to CF/Radial compliant netcdf files and includes the radar parameters listed in Table 4. This dataset is compatible with NCAR's RadX software library for conversion into multiple formats, including the NCAR Dorade sweep (swp) format. An example of the KULM file naming convention is as follows:

1295MON-20180413-233935-PPIVol-0049.nc

where 1295MON indicates the internal instrument name, 20180413 indicates the date (YYYYMMDD), 233935 indicates the UTC time (HHMMSS), PPIVol indicates the scan type, and 0049 is a netcdf conversion sequence number.

Table 4: KULM Radar Parameters

Identifier	Units	Description
DBZH	dBZ	Horizontal equivalent reflectivity factor (Z_H)
DBZV	dBZ	Vertical equivalent reflectivity factor (Z_V)
ZDR	dB	Differential reflectivity (Z_{DR})
RHOHV	Unitless	Correlation coefficient (ρ_{hv})
PHIDP	°	Differential propagation phase (Φ_{DP})
SNRHC	dB	Horizontal signal-to-noise ratio (SNR_H)
SNRHV	dB	Vertical signal-to-noise ratio (SNR_V)
VELH	$m\ s^{-1}$	Horizontal radial velocity ($V_{R,H}$)
VELV	$m\ s^{-1}$	Vertical radial velocity ($V_{R,V}$)
WIDTHH	$m\ s^{-1}$	Horizontal spectrum width (σ_H)
WIDTHV	$m\ s^{-1}$	Vertical spectrum width (σ_V)
CCORH	dB	Measure of horizontal clutter rejection
CCORV	dB	Measure of vertical clutter rejection

5.0 Data Remarks

Known Issues:

Tree blockage occurs between approximate azimuths 323° and 70° and negatively affects data up to approximately 1.5° elevation.

An intentional 10° sector blank is inserted between 175° and 185° azimuths and affects all elevations < 2.4°. The sector blank is removed at and above 2.4° elevation. This sector blank is inserted to prevent interference to a nearby airport surveillance radar.

20180310: Raw radar volumes are unavailable. The data provided are derived from our "operational" dataset, which only includes a subset of the radar parameters listed in Table 4 (DBZH, VELH, WIDTHH, ZDR, RHOHV, & PHIDP). In addition, these data have been censored for $Z_H \leq -20$ dBZ

20180328: The last full radar volume provided is at 2217 UTC due to a power failure. Sweeps from the 2223 UTC volume scan, up to the point of power failure, may be available in a future update to this dataset.

Data can be accessed and viewed using the following software:

NCAR's RadX software library (https://ral.ucar.edu/projects/titan/docs/radial_formats/radx.html)
NCAR's solo3 (https://www.eol.ucar.edu/software/solo3)
Python ARM Radar Toolkit (Py-ART) (https://github.com/ARM-DOE/pyart)

A locally modified version of RadxConvert is able to convert the data to the NEXRAD level2 msg31 format and is compatible with the Gibson Ridge Analyst radar viewing program. These data are available upon request.

The full, raw radar volumes are available upon request.