

# Verification of the Origins of Rotation in Thunderstorms Experiment-Southeast 2016 (VORTEX-SE\_2016) ULM Mobile Radiosonde Data Set

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## 2.0 Dataset Overview

The University of Louisiana at Monroe (ULM) utilized a mobile radiosonde system to release radiosondes at locations around northern Alabama and south-central Tennessee (Figure 1) during VORTEX-SE\_2016 Intensive Observation Periods (IOPs). The choices for the locations and times of the releases were made in collaboration with other VORTEX-SE PIs. ULM released radiosondes in all but one of the VORTEX-SE\_2016 IOPs (IOP1 on 13-14 March). This data set includes the 31 high vertical resolution (5-second), quality controlled ULM mobile soundings released for the VORTEX-SE\_2016 field phase (13 March to 1 May 2016).

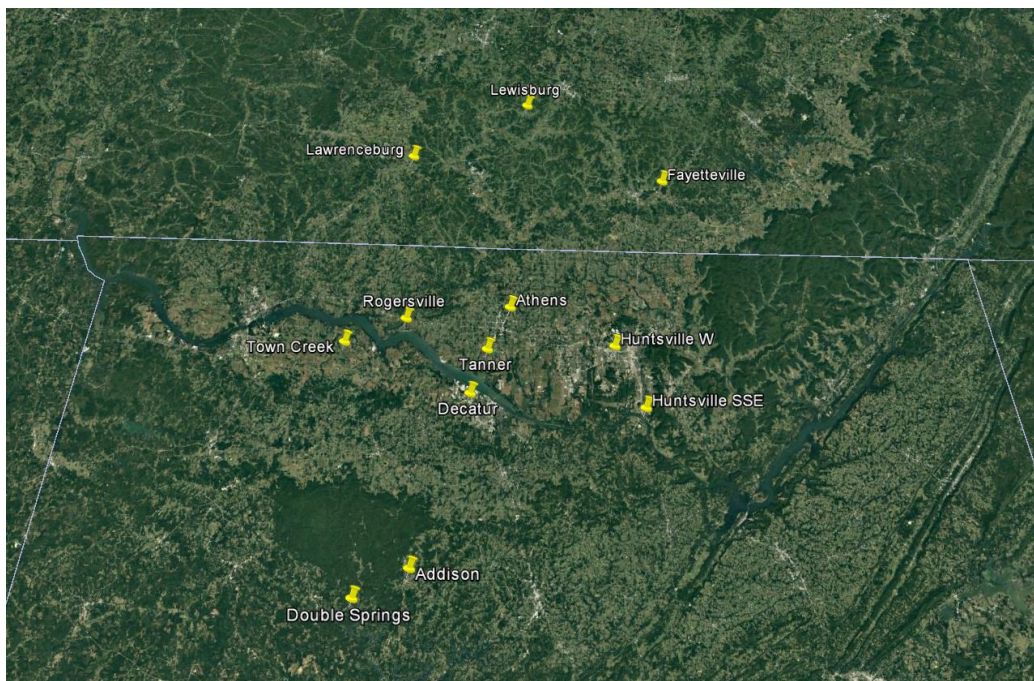


Figure 1. Location of the ULM mobile radiosonde sites.

### 3.0 Project Overview

The **Verification of the Origins of Rotation in Tornadoes Experiment-Southeast (VORTEX-SE)** is a research program to understand how environmental factors characteristic of the southeastern United States affect the formation, intensity, structure, and path of tornadoes in this region. VORTEX-SE will also determine the best methods for communicating forecast uncertainty related to these events to the public, and evaluate public response. For the 2016 field season a large array of fixed and mobile ground instrumentation were deployed around Huntsville, AL from 1 March to 1 May 2016. Further information on VORTEX-SE is available at the VORTEX-SE web site at NCAR/EOL: [https://www.eol.ucar.edu/field\\_projects/vortex-se](https://www.eol.ucar.edu/field_projects/vortex-se) and information on the VORTEX-SE\_2016 deployments is available at the VORTEX-SE\_2016 Field Catalog: [http://catalog.eol.ucar.edu/vortex-se\\_2016](http://catalog.eol.ucar.edu/vortex-se_2016).

### 4.0 EOL Sounding Composite (ESC) File Format Description

The ESC is a columnar ASCII format consisting of 15 header records for each sounding followed by the data records with associated data quality flags.

#### 3.1 Header Records

The header records (15 total records) contain a variety of metadata about the sounding (i.e. location, time, radiosonde type, etc). The first five header lines contain information identifying the sounding, and have a rigidly defined form. The following 7 header lines are used for auxiliary information and comments about the sounding, and may vary from dataset to dataset. The last 3 header records contain header information for the data columns. Line 13 holds the field names, line 14 the field units, and line 15 contains dashes ('-' characters) delineating the extent of the field.

The file standard header lines are as follows:

Line	Label (padded to 35 char)	Contents
1	Data Type:	Description of the type and resolution of data
2	Project ID:	Short name for the field project
3	Release Site Type/Site ID:	Description of the release site.
4	Release Location (lon,lat,alt):	Location of the release site.
5	UTC Release Time (y,m,d,h,m,s):	Time of release.

The release location is given as:

lon (deg min), lat (deg min), lon (dec. deg), lat (dec. deg), alt (m)

Longitude in deg min is in the format: ddd mm.mm'W where ddd is the number of degrees (with leading zeros if necessary), mm.mm is the decimal number of minutes, and W represents W or E for west or east longitude, respectively. Latitude has the same format as longitude, except there are only two digits for degrees and N or S for north/south latitude.

The time of release is given as: yyyy, mm, dd, hh:nn:ss.

Where yyyy is the year, mm is the month, dd is the day of month, and hh:nn:ss are the UTC hour, minute, and second respectively.

The seven non-standard header lines may contain any label and contents. The labels are padded to 35 characters to match the standard header lines. Records for this data set include the following non-standard header lines:

Line	Label (padded to 35 char)	Contents
6	Radiosonde Type	
7	Ground Station Software	

### 3.2 Data Records

The data records each contain time from release, pressure, temperature, dew point, relative humidity, U and V wind components, wind speed and direction, ascent rate, balloon position data, altitude, and quality control flags (see the QC code description). Each data line contains 21 fields, separated by spaces, with a total width of 130 characters. The data are right-justified within the fields. All fields have one decimal place of precision, with the exception of latitude and longitude, which have three decimal places of precision. The contents and sizes of the 21 fields that appear in each data record are as follows:

Field	Width	Format	Parameter	Units	Missing Value
1	6	F6.1	Time since release	Seconds	9999.0
2	6	F6.1	Pressure	Millibars	9999.0
3	5	F5.1	Dry-bulb Temperature	Degrees C	999.0
4	5	F5.1	Dew Point Temperature	Degrees C	999.0
5	5	F5.1	Relative Humidity	Percent	999.0
6	6	F6.1	U Wind Comp	m/s	9999.0
7	6	F6.1	V Wind Comp	m/s	9999.0
8	5	F5.1	Wind speed	m/s	999.0
9	5	F5.1	Wind direction	Degrees	999.0
10	5	F5.1	Ascent Rate	m/s	999.0
11	8	F8.3	Longitude	Degrees	9999.0
12	7	F7.3	Latitude	Degrees	999.0
13	5	F5.1	Elevation Angle	Degrees	999.0
14	5	F5.1	Mixing Ratio	g/kg	999.0
15	7	F7.1	Altitude	Meters	99999.0
16	4	F4.1	QC for Pressure	Code	99.0
17	4	F4.1	QC for Temperature	Code	99.0
18	4	F4.1	QC for Humidity	Code	99.0
19	4	F4.1	QC for U Wind	Code	99.0
20	4	F4.1	QC for V Wind	Code	99.0
21	4	F4.1	QC for Ascent Rate	Code	99.0

Fields 16 through 21 contain the data quality flags from the NCAR/Earth Observing Laboratory (EOL) sounding quality control procedures. The data quality flags are defined as follows:

Code	Description
1.0	Checked, datum seems physically reasonable. ("GOOD")
2.0	Checked, datum seems questionable on a physical basis. ("MAYBE")
3.0	Checked, datum seems to be in error. ("BAD")
4.0	Checked, datum is interpolated. ("ESTIMATED")
9.0	Checked, datum is missing. ("MISSING")
99.0	Unchecked (QC information is "missing".) ("UNCHECKED")

### 3.3 Data Specifics

The files contain data at five second intervals.

The data are in files by day, so all soundings for a particular day are concatenated into a single file ordered by time. The file naming convention is:

ULM\_yyyymmdd.cls where yyyy is the year, mm is the month, and dd is the day of the month.

ULM utilized InterMet's iMet-1-ABxn 403 MHz radiosondes with pressure sensor and GPS wind finding and the iMetOS-II software version 03.48.1C during VORTEX-SE\_2016.

**Table 1:** Manufacturer-stated accuracy and resolution for each of the variables sampled by the iMet-1-ABxn radiosondes (available from [http://intermetsystems.com/ee/pdf/iMet-1-ABxn\\_Data\\_150316.pdf](http://intermetsystems.com/ee/pdf/iMet-1-ABxn_Data_150316.pdf) )

Temperature resolution	0.01°C
Temperature accuracy	0.2°C
Humidity resolution	0.1%
Humidity accuracy	5%
Pressure resolution	0.01 hPa
Pressure accuracy	0.5 hPa
Geopotential height acc	<10 m
Wind speed accuracy	1.0 m s <sup>-1</sup>
Horizontal position acc	10 m
Altitude position acc	15 m

### 3.4 Sample Data

The following is a sample of the ULM mobile high resolution radiosonde data in ESC format.

```

Data Type:          ULM Mobile Sounding Data/Ascending
Project ID:         VORTEX-SE_2016
Release Site Type/Site ID: Lewisburg, TN
Release Location (lon,lat,alt): 086 54.48'W, 35 22.33'N, -86.908, 35.372, 262.0
UTC Release Time (y,m,d,h,m,s): 2016, 03, 24, 12:08:00
Radiosonde Type:   iMet-1-ABxn
Ground Station Software: iMetOS-II software version 03.48.1C.
/

```

```

/
/
/
Nominal Release Time (y,m,d,h,m,s):2016, 03, 24, 12:08:00
Time  Press  Temp  Dewpt  RH      Ucmp   Vcmp   spd   dir   Wcmp   Lon   Lat   Ele   MixR   Alt   Qp   Qt   Qrh   Qu   Qv   QdZ
sec   mb     C     C      %      m/s    m/s    m/s   deg  m/s    deg  deg  deg   g/kg   m    code code code code code code
-----
0.0  9999.0  999.0  999.0  999.0  9999.0  9999.0  999.0  999.0  999.0  -86.908  35.372  999.0  999.0  262.0  9.0  9.0  9.0  9.0  9.0  9.0
59.0  981.4  15.3  14.3  93.8   -1.0    2.9    3.1  162.0  0.0  -86.908  35.372  999.0  10.5  262.0  99.0  99.0  99.0  99.0  99.0  99.0
64.0  978.2  15.0  14.1  94.4   -2.0    8.9    9.1  167.0  5.5  -86.908  35.372  999.0  10.4  289.7  99.0  99.0  99.0  99.0  99.0  99.0

```

### 3.5 Station List

IOP	Site Name	Latitude	Longitude	Elev (m)
2	Lewisburg, TN	35.37211	-86.90797	263
2	Fayetteville, TN	35.16039	-86.50137	221
3	Lawrenceburg, TN	35.21895	-87.24405	311
3	Rogersville, AL	34.78539	-87.23278	189
3	Athens, AL	34.81824	-86.94143	212
4	Huntsville, AL	34.57613	-86.5621	169
5,6	UAH SWIRLL	34.72475	-86.64632	208
5	Town Creek, AL	34.72489	-87.39978	175
5	Decatur, AL	34.60457	-87.04391	178
6	Double Springs, AL	34.14127	-87.32254	192
6	Addison, AL	34.20658	-87.18084	244
7	Tanner, AL	34.71229	-87.00117	183

### 4.0 Data Quality Control Procedures

1. The raw iMet data were initially processed using the iMetOS-II software. ULM performed additional post-processing that included filtering obvious outlier data as well as removing any data after balloon burst.
2. NCAR/EOL converted each sounding from its original format into the ESC format described above.
3. NCAR/EOL passed each sounding through a set of automated data quality checks which included basic gross limit checks as well as rate of change checks. This is further described in Section 4.1.
4. NCAR/EOL visually examined each sounding utilizing the NCAR/EOL XQC sounding quality control software. This is further described in Section 4.2.

### 4.1 Automated Data Quality Checks

This data set was passed through a set of automated data quality checks. This procedure includes both gross limit checks on all parameters as well as rate-of-change checks on temperature, pressure, and ascent rate. A version of these checks is described in Loehrer et al. (1996) and Loehrer et al. (1998).

#### 4.1.1 Gross Limit Checks

These checks were conducted on each sounding and the data quality flags in the ESC files were adjusted as appropriate. Only the data point under examination was flagged. All checks also produced warning messages that specified the location of the problem and the severity of the issue. These warning messages were then summarized statistically and examined to determine any consistent issues.

For this data set NCAR/EOL conducted the following gross limit checks. In the table P = pressure, T = temperature, RH = relative humidity, U = U wind component, V = V wind component, B= bad, and Q = questionable.

Parameter	Check	Parameter(s) Flagged	Flag Applied
Pressure	<0 or > 1050	P	B
Altitude	< 0 or >40000	P, T, RH	Q
Temperature	< -90 or > 45	T	B
Dew Point	< -99.9 or > 33 > T	RH T, RH	Q Q
Wind Speed	< 0 or > 100 > 150	U, V U, V	Q B
U Wind	< 0 or > 100 > 150	U U	Q B
V Wind	< 0 or > 100 > 150	V V	Q B
Wind Direction	< 0 or > 360	U, V	B
Ascent Rate	< -10 or > 10	P, T, RH	Q

#### 4.1.2 Vertical Consistency Checks

These checks were conducted on each sounding and the data quality flags in the ESC files were adjusted as appropriate. These checks were started at the surface and compared each neighboring data record. In the case of checks that ensured that the values increased/decreased as expected, only the data point under examination was flagged. However, for the other checks, all of the data points used in the examination were flagged. All items within the table are as previously defined. All checks also produced warning messages that specified the location of the problem and the severity of the issue. These warning messages were then summarized statistically and examined to determine any consistent issues.

Parameter	Check	Parameter(s) Flagged	Flag Applied
Time	Decreasing/equal	None	None.
Altitude	Decreasing/equal	P, T, RH	Q
Pressure	Increasing/equal > 1mb/s or < -1mb/s > 2mb/s or < -2mb/s	P, T, TH P, T, TH P, T, TH	Q Q B
Temperature	< -15°C/km < -30°C/km > 50°C/km > 100°C/km	P, T, RH P, T, RH P, T, RH P, T, RH	Q B Q B
Ascent Rate	> 3m/s or < -3m/s > 5m/s or < -5m/s	P P	Q B

#### 4.2 Visual Data Quality Checks

Each sounding was visually examined using the NCAR/EOL XQC sounding data quality control software. This software allows the user to view a skew-t/log-p diagram of each sounding and apply data quality flags as appropriate. The user can zoom in on sections of soundings for detailed examination and can adjust the data quality flags for an individual point, sections of soundings, or entire soundings for each parameter individually. The software also allows the user to override the quality flags applied by the automated procedure.

### 4.3 Data Quality Issues of Note

The data quality control procedures outlined above allows us to identify and, in some cases, resolve issues that could potentially impact research performed using these data sets. The following issues were noted in these soundings.

**Surface data** – Independent surface data were generally not collected. In some instances, ULM launched near locations where Texas Tech University sticknet data were available and these values were used for surface data. Otherwise, the radiosonde measurements near the surface were inserted as “surface measurements” and data from a Kestrel 3500 was used as secondary confirmation.

**Relative humidity and dew point data** – The mixing ratio was the provided moisture parameter. NCAR/EOL derived the RH and dew point data from the provided mixing ratio, pressure and temperature data. The mixing ratio was provided at 0.1 g/kg resolution, so there is a “blocky” appearance (particularly at low mixing ratio values) to the derived RH and dew point data.

**Geopotential altitude data** – The raw data file contained altitude above ground level data. We used the hypsometric equation to derive the geopotential altitude values.

#### Other issues

<b>20160324 1208 Lewisburg TN</b>	wetbulbing 678mb
<b>20160324 1839 Fayetteville TN</b>	wetbulbing 580mb
<b>20160331 1856 LawrenceburgTN</b>	No data above 445 mb
<b>20160331 2201 LawrenceburgTN</b>	Missing pressure, temperature, and moisture between 500 and 425 mb
<b>20160427 1801 HuntsvilleAL</b>	Superadiabatic surface layer
<b>20160427 1959 HuntsvilleAL</b>	Superadiabatic surface layer
<b>20160427 2100 HuntsvilleAL</b>	Superadiabatic surface layer
<b>20160429 1734 HuntsvilleAL</b>	Superadiabatic surface layer
<b>20160429 1944 TownCreekAL</b>	No data above 460 mb
<b>20160429 2024 TownCreekAL</b>	Missing pressure, temperature, and moisture between 637 and 425 mb
<b>20160429 2124 DecaturAL</b>	Missing pressure, temperature, and moisture between 562 and 531 mb
<b>20160430 2145 AddisonAL</b>	No data above 245 mb
<b>20150601 1836 Tanner AL</b>	Temperature above 253mb too cold winds above 245mb constant
<b>20160501 2034 TannerAL</b>	No data above 610 mb

## **5.0 References**

Loehrer, S. M., T. A. Edmands, and J. A. Moore, 1996: TOGA COARE upper-air sounding data archive: development and quality control procedures. *Bull. Amer. Meteor. Soc.*, 77, 2651-2671.

Loehrer, S. M., S. F. Williams, and J. A. Moore, 1998: Results from UCAR/JOSS quality control of atmospheric soundings from field projects. Preprints, Tenth Symposium on Meteorological Observations and Instrumentation, Phoenix, AZ, Amer. Meteor. Soc., 1-6.