Verification of the Origins of Rotation in Tornadoes Experiment (VORTEX) 2009 Quality Controlled Radiosonde Data Set

Contents:

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For more information on the NCAR Earth Observing Laboratory Integrated Sounding System (ISS), or on the GPS Advanced Upper-Air Sounding System (GAUS), please visit:
ISS: http://www.eol.ucar.edu/instrumentation/sounding/iss
GAUS: http://www.eol.ucar.edu/instrumentation/sounding/iss/gaus

I. ISS Project/Dataset Overview

The Verification of the Origins of Rotation in Tornadoes Experiment (VORTEX) is a project aimed at investigating tornado genesis and examining tornado structure and evolution using a suite of atmospheric instruments. The hope is that the data collected may be used to help researchers improve tornado forecast and warning times. The VORTEX field campaign included the use of four mobile GPS Advanced Upper-Air Sounding (GAUS) systems. Two of the systems were operated by the NOAA Storm Systems Laboratory (NSSL), and the other two systems were operated by the National Center for Atmospheric Research (NCAR). A total of 224 quality controlled ascending radiosonde sounding are contained in the final archive. Twenty-six descending profiles, not subjected to any quality control

measures, are available as well. The soundings were collected between May 11 and June 14, 2009. Radiosonde launch locations are provided below in Figure 1.

The NCAR/EOL GPS Advanced Upper-air Sounding system (GAUS) incorporates Vaisala RS92 radiosondes, has portability, built-in test capability and flexibility for multiple channel operations, and delivers users high precision GPS measurements of radiosonde positions. The Vaisala RS92 radiosonde delivers high quality wind measurements from the ground with code-correlating GPS technology, as well as pressure, temperature and humidity measurements all transmitted digitally to the receiving station. Digital technology reduces missing data due to noise and increases overall reliability of the system. The Vaisala RS92 provides much better humidity measurements with a heated twin-sensor design and incorporates a reconditioning procedure before launch.

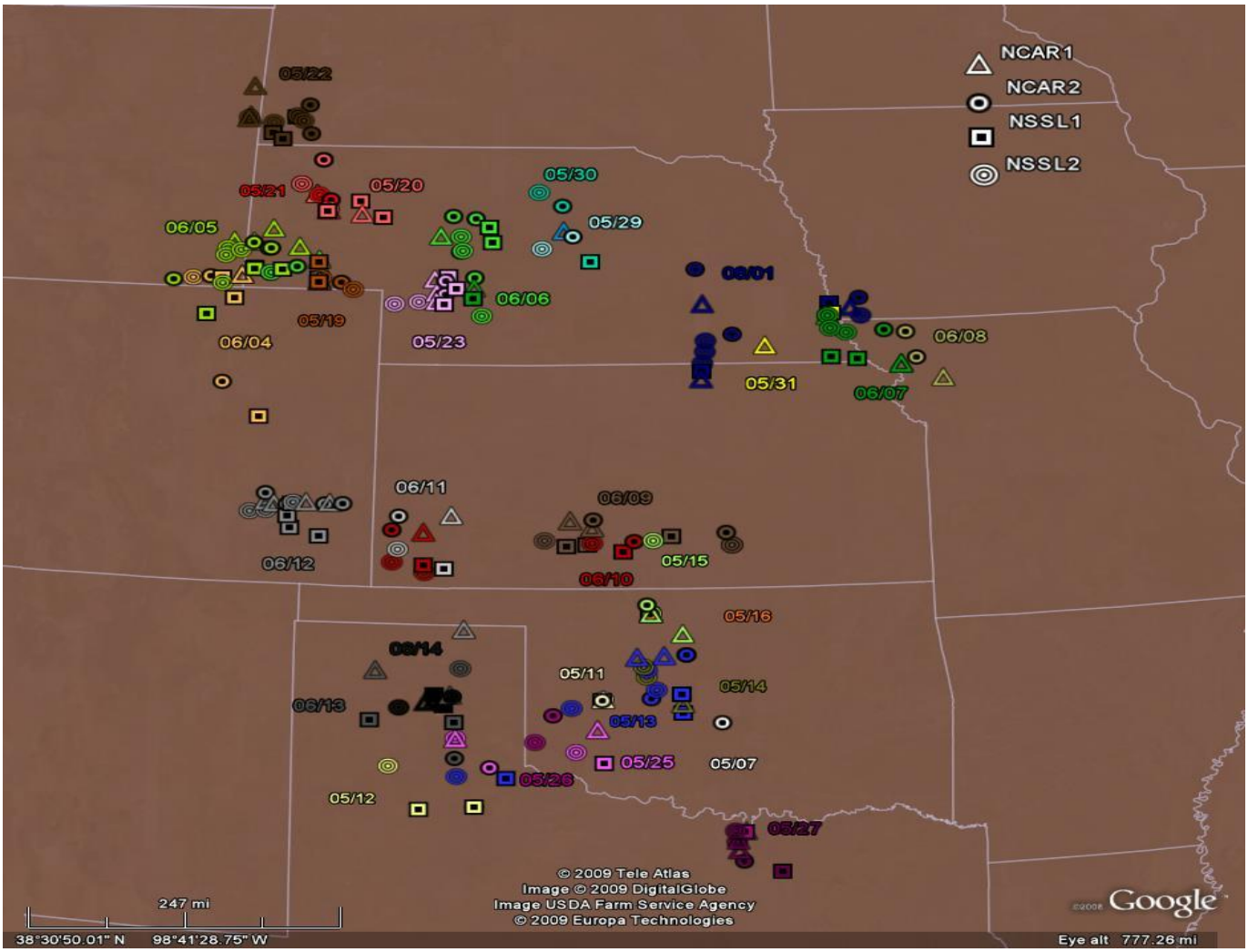


Figure 1. Radiosonde launches performed by four sounding systems, two operated by NSSL, and two operated by NCAR. The legend shows the symbol indicating the sounding system, and each color on the map indicates launches that occurred on a particular day.

II. EOL File Format

The EOL format is an ascii text format that includes a header, with detailed project and sounding information, and seventeen columns of high resolution data (Table 1). The "D" files are one second resolution data files with appropriate corrections and quality control measures applied. The naming convention for these files is - "D", followed by "yyyymmdd_hhmmss_P.1QC.eol" where yyyy = year, mm = month, hh = hour of the day GMT, mm = minute of the hour, ss = second of the hour (which refer to the launch time of the sonde) and ".eol" refers to the file format type. The descending profiles follow the same naming convention; however they end with a ".b".

The header records contain information including data type, project name, site location, actual release time, and other specialized information. The first seven header lines contain information identifying the sounding. The release location is given as : lon (deg min), lon (dec. deg), lat (deg min), lat (dec. deg), altitude (meters). Longitude in deg min is in the format: ddd mm.mm'W where ddd is the number of degrees from True North (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 following three header lines contain information about the aircraft data system and auxiliary information and comments about the sounding. The last 3 header lines contain header information for the data columns. Line 12 holds the field names, line 13 the field units, and line 14 contains dashes (--- characters) signifying the end of the header. Data fields are listed below in Table 2.

```
Data Type/Direction:                          GAUS SOUNDING DATA/Ascending
File Format/Version:                          EOL Sounding Format/1.0
Project Name/Platform:                        VOCALS/NCAR GAUS
Launch Site:                                  20081027
Launch Location (lon,lat,alt):                70 07.84'W -70.1307, 20 16.25'S -20.2708, 71.71
UTC Launch Time (y,m,d,h,m,s):                2008, 07, 30, 18:03:02
Sonde Id/Sonde Type:                          082033941/Vaisala RS92-SGP (ccGPS)
Reference Launch Data Source/Time:            Campbell Scientific CR10/18:03:03.25
System Operator/Comments:                     Brad & Lou/test flight, Good Sounding
Post Processing Comments:                     Aspen Version
/
Time --UTC--   Press Temp Dewpt RH Uwind Vwind Wspd  Dir dZ  GeoPoAlt Lon Lat  GPSAlt
sec  hh mm ss   mb    C    C     %  m/s   m/s   m/s  deg m/s    m     deg deg    m
```

Table 1. Example of the EOL format used for both dropsonde and radiosonde sounding files

Field No.	Parameter	Units	Measured/Calculated
1	Time	Seconds	----------
2	UTC Hour	Hours	----------
3	UTC Minute	Minutes	----------

4	UTC Second	Seconds	----------
5	Pressure	Millibars	Measured
6	Dry-bulb Temp	Degrees C	Measured
7	Dewpoint Temp	Degrees C	Calculated
8	Relative Humidity	Percent	Measured
9	U Wind Component	Meters/Second	Calculated
10	V Wind Component	Meters/Second	Calculated
11	Wind Speed	Meters/Second	Measured
12	Wind Direction	Degrees	Measured
13	Ascension Rate	Meters/Second	Calculated
14	Geopotential Altitude	Meters	Calculated
15	Longitude	Degrees	Measured
16	Latitude	Degrees	Measured
17	GPS Altitude	Meters	Measured

Table 2. Lists all parameters provided in the sounding files, their unit of measurement, and if the values are measured or calculated.

III. Data File Specifics

The files contain data calculated at one-second intervals. The variables pressure, temperature, and relative humidity are calibrated values from measurements made by the radiosonde. The dew point is calculated from the relative humidity and temperature. The geopotential altitude is calculated from the hydrostatic equation using pressure, temperature, and relative humidity. The rate of ascent is calculated from pressure. The radiosonde position (lat, lon, GPSAlt) and winds are measured by use of a GPS receiver in the sonde. These raw wind values are subjected to a digital filter to remove low frequency oscillations due to the sonde pendulum motion beneath the balloon when run through NCAR's Atmospheric Sounding Processing ENvironment (ASPEN) software.

IV. Data Quality Control and Results

1. Profiles of the raw soundings are first examined to determine if there are any errors with the launch detect, or if system lock-up occurred, as a result of weakening of the sonde signal, which could result in a loss of data and an incorrect launch time.

2. All of the soundings are then subjected to a radiation correction that takes into account the solar angle at time of launch, and removes solar heating that could skew the temperature measurements.

3. Scatter plots of the raw data are created to check differences in pressure, temperature and RH between the surface met and the last available surface radiosonde measurement before launch.

4. The raw soundings are run through ASPEN, which analyzes the data, performs smoothing, and removes suspect data points.

5. We create profiles of temperature, RH, wind speed and wind direction of the quality controlled soundings which enable us to visually evaluate the soundings for outliers, or any other obvious problems.

6. Lastly, we examine skew-t diagrams of each sounding.

Performing the QC steps above allows us to identify and, in some cases, correct errors that could potentially impact research performed using these data sets. During processing of the sounding data the following issues were found, and where possible, corrections were applied:

1. The 26 available descending profiles have not undergone any quality control since ASPEN only retains radiosonde data with monotonically decreasing pressure. Very few of these files contain data to the surface and that data may be quite sporadic. Please use these data with caution. The winds have not been subjected to filtering, however due to the lack of "pendulum swing", seen in the ascending profiles, the wind speed and direction look reasonable. The relative humidity profile may contain a slight delay given the inability of the sensor to keep up with the radiosondes high fall speed during descent, without a parachute. Additionally, the ascending and descending profiles may differ given that the radiosonde was sampling different air masses. These profiles are contained in there own separate files. They follow the same naming convention as the ascending sounding (see Section II), followed by ".b".

2. The following soundings were removed from the final archive. They either contained little or no data.

NCAR2	**NSSL1**	**NSSL2**
D20090513_185528_P.1	D20090513_165029_P.1	D20090515_232245
	D20090513_185495_P.1	
	D20090515_212333_P.1	

3. Five soundings experienced strong vertical winds or icing on the balloon that caused the radiosonde to descend for a brief period of time during its ascent. These files were processed through ASPEN, but since ASPEN can only handle monotonically changing pressure, it removes any portion of the file where the radiosonde experiences increasing changes in pressures. In order to include these unique features in the final sounding file, we used the raw data from the descending portion and copied it into the quality controlled file. Data obtained during these downdraft or icing events have not been quality controlled, but based on visual examination the data do look clean and free of significant errors. The following provides a list of the files and a suspected cause of descent.

NCAR1	**NCAR2**	**NSSL1**
D20090527_014322_P.1	D20090515_230722_P.1	D20090520_235521_P.1
D20090607_235017_P.1		
D20090612_005027_P.1		

4. Data from one NCAR 1 sounding was contained in two separate files. The radiosonde signal was either lost or the system experienced a loss of power during the radiosondes flight and a file was generated. When the signal was reacquired, two minutes later, that data was stored in a separate sounding file. These two files were merged and assigned the name from the original launch time (D20090613_195902_P.QCeol).

5. The soundings listed below have short periods of missing data just above the surface, after launch. This was most likely caused by release of the balloon before all steps of the sounding system software were complete. Additionally, none of these soundings contain geopotential altitude, which is calculated from the surface upward.

NCAR1	**NCAR2**
D20090513_222416_P.QCeol	D20090608_000016_P.1
D20090515_201523_P.QCeol	

6. The soundings listed below experienced errors with the automatic launch detect. This occurs most often when the sonde is not able to collect a sufficient amount of surface data prior to launch, causing a delay in the launch detect mechanism which relies on change in pressure to determine when the balloon release occurs. No data is lost when this occurs, but data recorded prior to launch detect is recorded as "pre-launch" rather than "in-flight", and the filenames and launch times are incorrect. These soundings have all been corrected for delays in the launch detect and the original and new filenames are listed below.

NCAR1	
Original Filename	**Corrected Filename**
D20090527_011252_P.1	D20090527_005407_P.1
D20090530_004025_P.1	D20090530_003240_P.1
D20090614_012529_P.1	D20090614_011603_P.1
NSSL2	
Original Filename	**Corrected Filename**
D20090601_215316_P.1	D20090601_213933_P.1

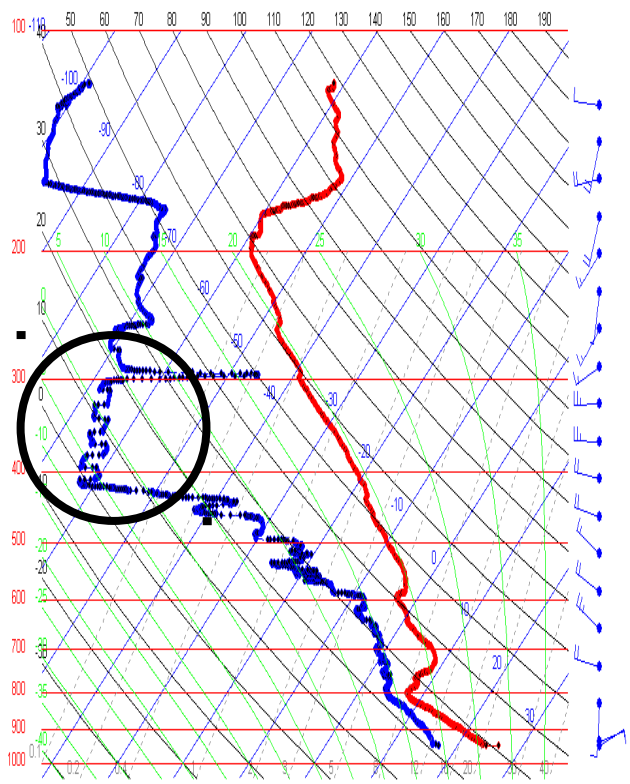
7. Nine soundings from the NSSL2 system needed repair because they experienced sounding system lock-up, caused by weakening or loss of the radiosonde signal. The affected sounding files were not saved in the correct file format or to the correct file names. They contained no LAU (launch) or A00 (surface met) data lines, and were missing the standard 19 line tail at the end of the raw file; all things necessary in order for ASPEN to run properly. Data before the lock-up was preserved, however anything measured after the lock-up has been lost. Filenames for these soundings were changed to reflect the actual launch time determined by a pressure change. One of these radiosondes (D20090609_172231_P.1) was launched by NSSL2 and lost, but then the signal was picked up by the NSSL1 system and stored under the filename D20060609_175208_P.1. The two files were concatenated under the original sounding filename under the NSSL2 archive.

NSSL2 Sounding System Lock-up Files
D20090515_221410_P.1
D20090519_225114_P.1
D20090526_005218_P.1
D20090601_215316_P.1
D20090605_004345_P.1
D20090607_234802_P.1
D20090609_172231_P.1
D20090610_004913_P.1
D20090614_004502_P.1

8. Three radiosondes reported incorrect measurements from one of their two hygrometers, during a portion of their flight (Figure 2). In all cases, we are unable to determine which hygrometer was malfunctioning, so no correction could be applied.

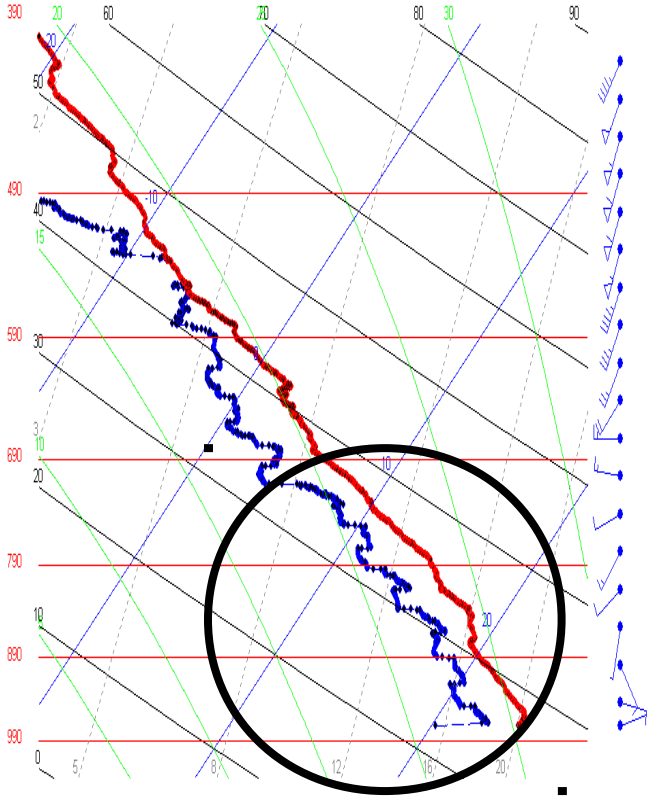
NCAR1	NCAR2	NSSL1
D20090525_234734_P.1	D20090607_225117_P.1	D20090531_235817_P.1

D20090525_234734_P.1.RadCor 084610840 Hobart, OK, 20090525_ncar1_Hobart_OK



Aspen V2.8.1.8, 30 Nov 2009 20:50 UTC

D20090607_225117_P.1 083733134 Storm-Scale Burlington Junction MO, 2300 UTC, 20090607



Aspen V2.8.1.8, 30 Nov 2009 23:18 UTC

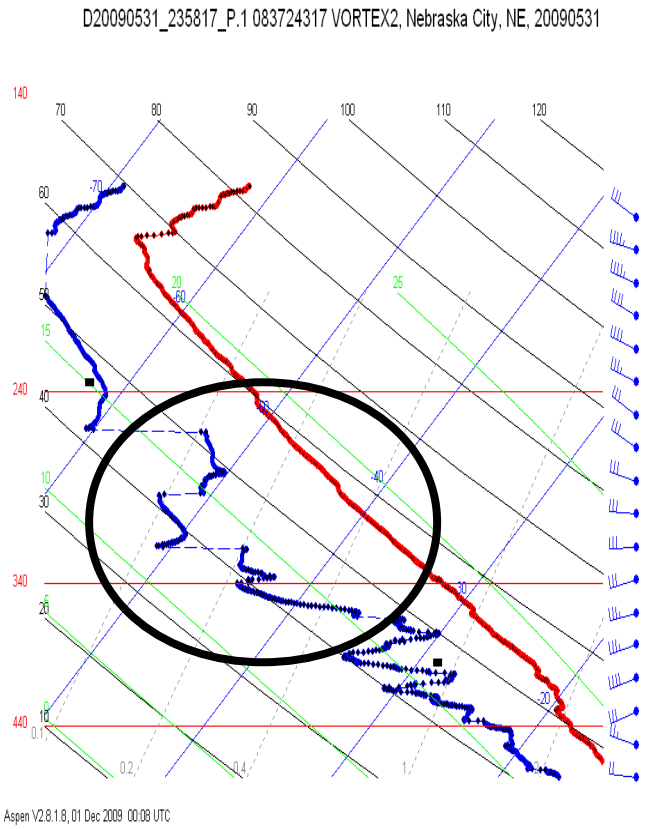


Figure 2 – Skew-t diagrams of temperature (red) and dew point temperature (blue). The step like features, seen in the dew point and circled in black, show evidence of error in the measurements from one of the two hygrometers.

9. The sounding systems were all set to mobile mode where by they obtain their surface position information (lat, lon, and altitude) from a GPS sensor. However, for the NCAR2 and NSSL2 systems, the GPS altitudes were not transferred into the surface met line of the sounding file. As a correction, the GPS altitude from the radiosonde just prior to launch was entered into the surface met data line. The surface GPS altitudes were then converted to geopotential altitude and entered into the sounding file, to be used as a starting point for the geopotential altitude calculation performed by ASPEN. This replacement of missing surface met altitude with radiosonde prelaunch altitude was also necessary for a few soundings each from the NCAR1 and NSSL1 sounding systems.

10. A number of soundings, listed below, lost temperature and RH prematurely. We suspect the T/RH sensor arm may have sustained damage, or may have broken completely, when traveling through a severe storm.

NCAR1	NCAR2	NSSL1	NSSL2
D20090515_23383	D20090605_231922	D20090516_004523	D20090601_222853
D20090523_220747	D20090606_234529	D20090520_235521	
D20090527_014322	D20090612_000631	D20090607_225717	
D20090601_010254	D20090612_005545		

D20090604_234325			
D20090605_215026			
D20090605_223751			