Deep Convective Clouds and Chemistry (DC3) 2012 Oklahoma/Texas NSSL MGAUS Radiosonde Data Set

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2.0 Dataset Overview

For the Deep Convective Clouds and Chemistry (DC3) project the National Severe Storms Laboratory (NSSL) deployed a Mobile GPS Advanced Upper-Air Sounding System (MGAUS) to release radiosondes from locations around Oklahoma and West Texas (Fig. 1) from 19 May to 21 June 2012. A total of 39 quality controlled soundings are contained in the final DC3 data set.

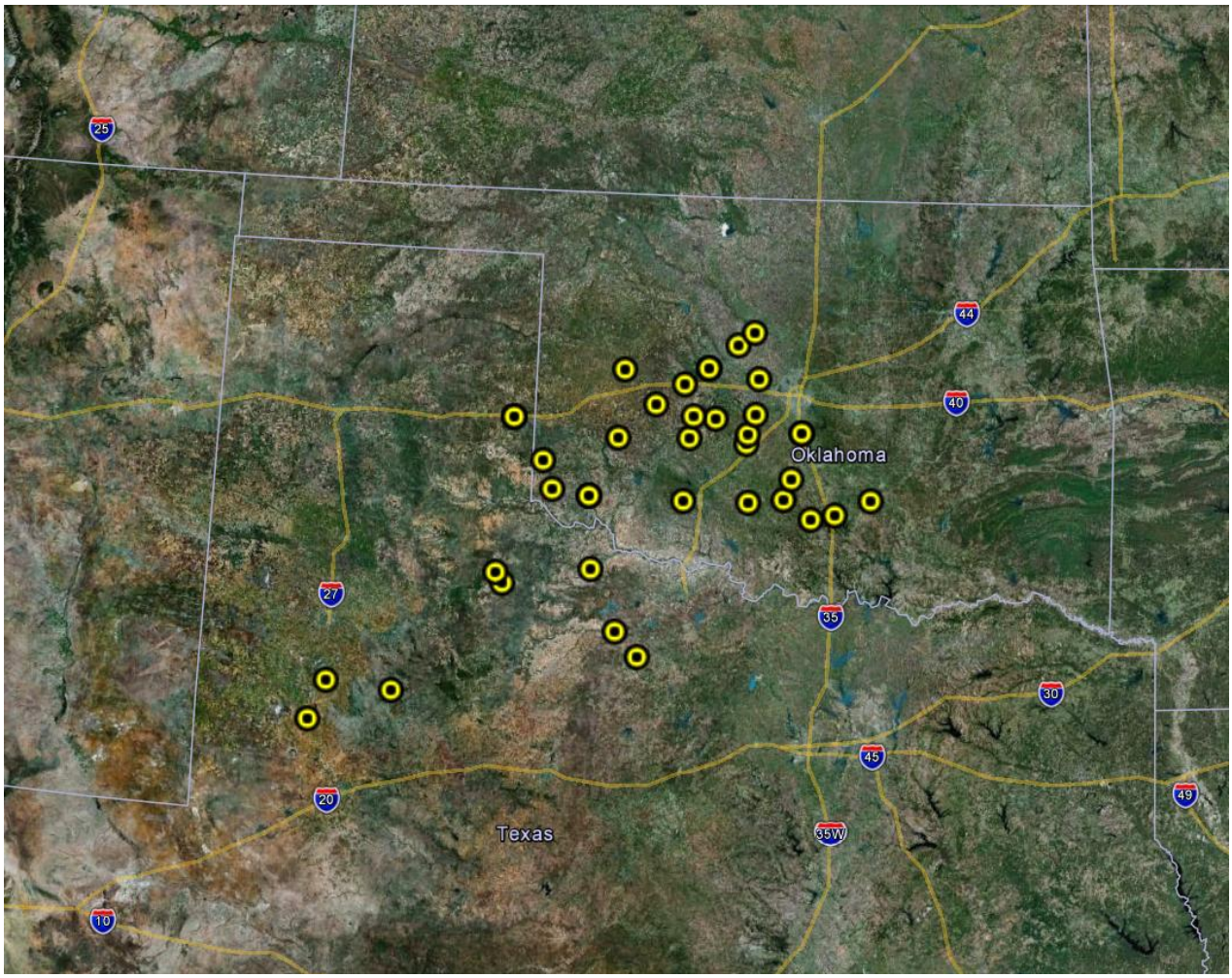

Figure 1. Map of the NSSL MGAUS radiosonde launch locations.

The Deep Convective Clouds and Chemistry Project (DC3) was a field campaign aimed at investigating the impact of deep, mid-latitude continental convective clouds, including their dynamical, physical, and lightning processes, on upper tropospheric (UT) composition and chemistry. The NSF/NCAR Gulfstream-V (GV) aircraft was the primary platform to study the high altitude outflow of the storms. The project also employed the use of the DLR Falcon, the NASA DC-8, a network of ground-based radar, as well as lightning mapping arrays. Further information on DC3 is available at the DC3 web site: http://www.eol.ucar.edu/projects/dc3/ and information on DC3 operations are available at the DC3 Field Catalog: http://catalog.eol.ucar.edu/dc3/.

3.0 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	Sonde Id/Sonde Type:	Radiosonde serial number
7	Reference Launch Data Source/Type:	Surface data source.
8	System Operator/Comments:	Any comments entered by the operator.
9	Post Processing Comments:	Information on the post-processing.
10		
11		
12	Nominal Release Time (y,m,d,h,m,s):	Nominal release time

For this data set the nominal release time is the same as the actual release time as there was no set schedule for releases.

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	Azimuth Angle	Degrees	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 calculated at one-second intervals. The variables pressure, temperature, and relative humidity are calibrated values from measurements made by the radiosonde. The dew point was calculated from the relative humidity and temperature. The geopotential altitude was derived from the hydrostatic equation using pressure, temperature, and relative humidity. The rate of ascent was derived from the altitude and time. The radiosonde position (latitude, longitude and GPS altitude) and winds are measured by use of a GPS receiver in the radiosonde. The raw wind values were subjected to a digital filter to remove low frequency oscillations due to the radiosonde pendulum motion beneath the balloon when run through the NCAR/EOL Atmospheric Sounding Processing Environment (ASPEN) software. The quality of the GPS altitude is somewhat questionable. The accuracy of the sensor is typically +/- 20m and may show large variability. For this reason, investigators are encouraged to use the geopotential altitude over the GPS altitude.

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:

NSSL_MGAUS_yyyymmdd.cls where yyyy is the year, mm is the month, and dd is the day of the month.

The NSSL MGAUS utilized Vaisala RS92-SGP radiosondes with GPS windfinding during DC3.

3.4 Sample Data

The following is a sample of the DC3 NSSL MGAUS high resolution radiosonde data in ESC format.

```
Data Type:                          NSSL MGAUS/Ascending
Project ID:                         DC3
Release Site Type/Site ID:          NCAR GAUS
Release Location (lon,lat,alt):     099 21.49'W, 35 49.61'N, -99.358, 35.827, 575.6
UTC Release Time (y,m,d,h,m,s):     2012, 05, 19, 21:15:23
Sonde Id/Sonde Type:                001244590/
Reference Launch Data Source/Time: unknown/unknown
System Operator/Comments:           /
Post Processing Comments:           Aspen Version 3.1; Created on 03 Apr 2013 13:01 UTC; Configuration upsonde-1s
/
```

/
Nominal Release Time (y,m,d,h,m,s):2012, 05, 19, 21:15:23

Time	Press	Temp	Dewpt	RH	Ucmp	Vcmp	spd	dir	Wcmp	Lon	Lat	Ele	Azi	Alt	Qp	Qt	Qrh	Qu	Qv	QdZ
sec	mb	C	C	%	m/s	m/s	m/s	deg	m/s	deg	deg	deg	deg	m	code	code	code	code	code	code
-1.0	937.8	36.1	14.0	25.9	9999.0	9999.0	999.0	999.0	999.0	-99.358	35.827	999.0	999.0	575.4	99.0	99.0	99.0	9.0	9.0	9.0
0.0	9999.0	999.0	999.0	27.4	-2.3	1.0	2.5	113.2	999.0	-99.358	35.827	999.0	999.0	99999.0	9.0	9.0	99.0	99.0	99.0	9.0
1.0	937.6	34.0	13.4	28.2	-1.2	6.5	6.6	169.5	2.5	-99.358	35.827	999.0	999.0	576.9	99.0	99.0	99.0	99.0	99.0	99.0
2.0	937.3	999.0	999.0	28.6	9999.0	9999.0	999.0	999.0	3.5	9999.000	999.000	999.0	999.0	580.0	99.0	9.0	99.0	9.0	9.0	99.0

3.5 Station List

This was a mobile facility. Releases were conducted in Oklahoma and Texas as shown in Fig. 1.

4.0 Data Quality Control Procedures

1. Profiles of the raw temperature, relative humidity, wind speed, and ascent rate versus pressure were examined to determine if there were any problematic sounding files which could be a result of malfunctioning of the launch detect, sounding system lock-up (a result of weakening of the radiosonde signal in flight), sensor failure, sensor offsets or biases, and slow radiosonde ascent rates (can result in RH errors).

2. All of the soundings were adjusted to correct surface heights. When set to mobile mode the sounding system depends on the GPS sensor to capture accurate surface heights. During post-processing, the GPS heights from the mobile system are converted to geometric height by taking into account the geoid altitude at each launch location. Then geometric altitude and latitude are used to compute accurate surface geopotential heights.

3. A pressure ground check correction was applied to the entire profile for each sounding. The surface pressure measured by an independent surface sensor was used as a reference for the correction. The corrected pressure $P = P^{RS} * P_0^{REF}/P_0^{RS}$ where P^{RS} is the pressure measured by the radiosonde, P_0^{REF} is the ground check pressure as indicated by the reference sensor, and P_0^{RS} is the ground check pressure as indicated by the radiosonde on the ground.

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

5. Scatter plots of the raw data were created to check differences in pressure, temperature, and RH between the surface met and the last available radiosonde measurement before launch to find systematic biases in the radiosonde data.

6. The raw soundings were then processed through Batch ASPEN, which analyzes the data, performs smoothing, and removes suspect data points.

7. Profiles of quality controlled temperature, RH, wind speed, and wind direction versus geopotential altitude were examined. These allowed the visual evaluation of the final data product for outliers, or any other obvious problems that may have previously gone undetected.

8. Each sounding was passed 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.

9. Finally, each sounding skewt was visually examined 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 where 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 where 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	P, T, TH	Q
	> 1mb/s or < -1mb/s	P, T, TH	Q
	> 2mb/s or < -2mb/s	P, T, TH	B
Temperature	< -15°C/km	P, T, RH	Q
	< -30°C/km	P, T, RH	B
	> 50°C/km	P, T, RH	Q
	> 100°C/km	P, T, RH	B
Ascent Rate	> 3m/s or < -3m/s	P	Q
	> 5m/s or < -5m/s	P	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 skewt-logp 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 found, and where necessary, corrections were applied.

1. One file (26 May 2012 at 0000 UTC) did not contain any independent surface meteorological data. The initial radiosonde value was used in its place and therefore no ground check pressure correction was applied.
2. Surface GPS altitude was not provided for any soundings. A reasonable value from the radiosonde was applied in its place.

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.