Plains Elevated Convection at Night (PECAN) CSU/NCSU/NSSL MGAUS Radiosonde Data Set

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2.0 Dataset Overview

During PECAN, Colorado State University (CSU) and the NOAA/National Severe Storms Laboratory in conjunction with North Carolina State University (NCSU) operated three Mobile GPS Advanced Upper-Air Sounding (MGAUS) radiosonde systems that released soundings during PECAN Intensive Observation Periods (IOP) around the central United States (Figure 1). During the IOPs, the MGAUS soundings would typically be released starting after 00 UTC and continue during the nights operations. A total of 251 (CSU-84, NSSL1-83, and NSSL2-84) quality-controlled, high vertical resolution (1-second) soundings are contained in the final PECAN data set.

This readme file covers the processing done to the CSU EOL Sounding Composite (ESC) format files and EOL Sounding format files as well as the NSSL/NCSU ESC format files. The NCAR/EOL processing conducted by Kate Young on the NSSL/NCSU EOL Sounding format files is described in a separate readme file.
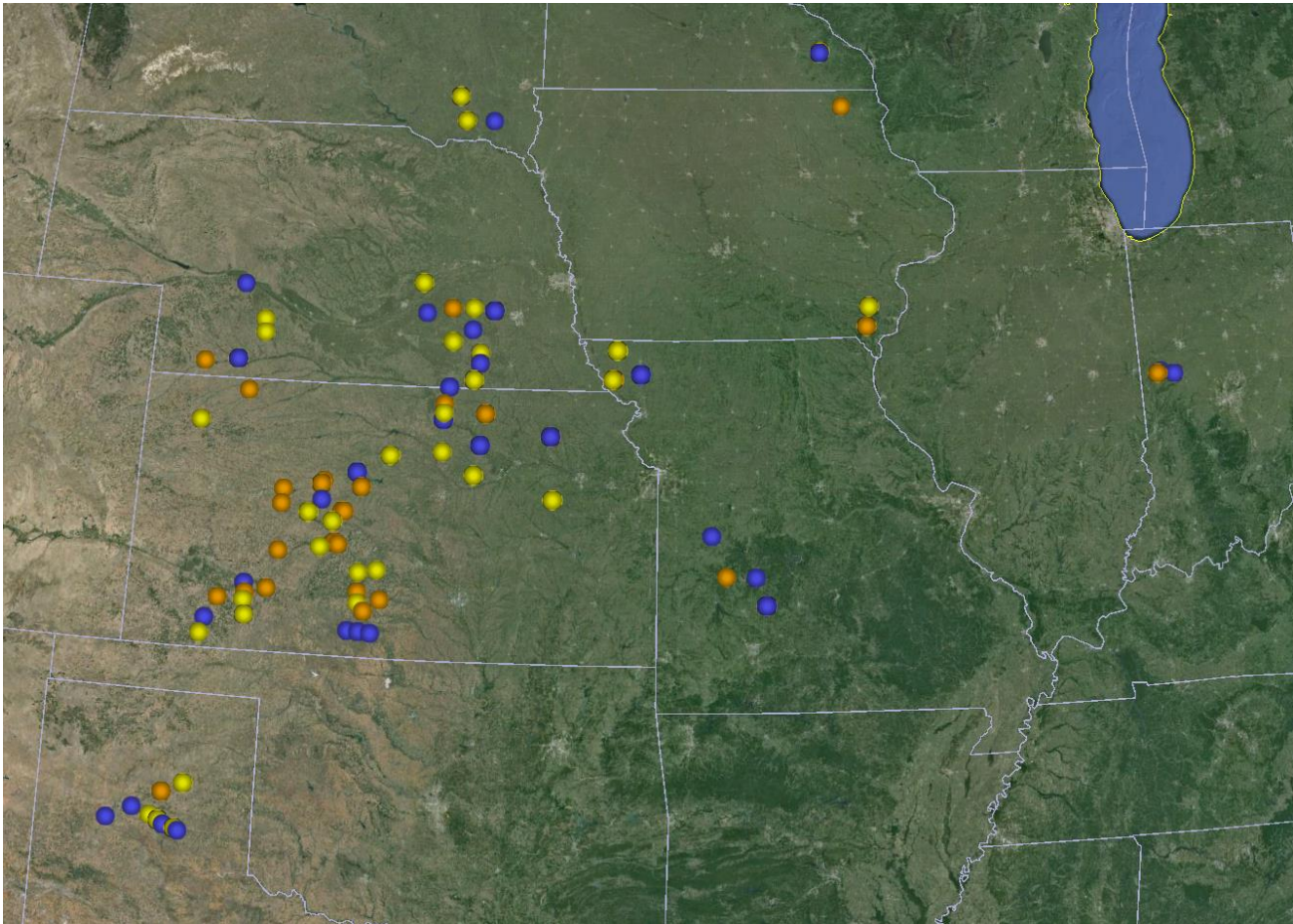
Figure 1. CSU (yellow), NSSL1 (blue), and NSSL2 (orange) MGAUS release locations during PECAN.

3.0   Project Overview

Plains Elevated Convection At Night (PECAN) was a multi-agency project designed to advance the understanding of continental, nocturnal, warm season precipitation. It focused on nocturnal convection in conditions over the central United States plains states with a stable boundary layer (SBL), a nocturnal low-level jet and the largest convective available potential energy located above the SBL. Three aircraft (University of Wyoming King Air, NOAA P-3, and NASA DC-8) as well as a large array of fixed and mobile ground instrumentation were deployed out of Kansas from 1 June to 15 July 2015. Further information on PECAN is available at the PECAN web site: https://www.eol.ucar.edu/field_projects/pecan and information on PECAN operations is available at the PECAN Field Catalog: http://catalog.eol.ucar.edu/pecan.

4.0   File Format Description

These data were available in either the EOL Sounding Composite (ESC) format or the EOL sounding format (EOL).

4.1 EOL Sounding Composite Format

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.

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:

SITE_yyyymmdd.cls where SITE is CSU_Mobile/NSSL1/NSSL2, yyyy is the year, mm is the month, and dd is the day of the month.

4.1.1 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 the CSU soundings in this data set include the following non-standard header lines:

Line	Label (padded to 35 char)	Contents
6	Radiosonde Type	
7	Radiosonde Serial Number	

8	Ground Station Software	
9	Ground Check Pressure Corr	
10	Ground Check Temperature Corr	
11	Ground Check Humidity Corr	

Records for the NSSL1 and NSSL2 soundings in this data set include the following non-standard header lines:

Line	Label (padded to 35 char)	Contents
6	Sonde Id/Sonde Type	
7	Reference Launch Data Source/Time	
8	System Operator/Comments	
9	Post Processing Comments	

4.1.2 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")

4.1.3 Sample ESC Formatted Data

The following is a sample of the PECAN CSU/NCSU/MSSL MGAUS high resolution radiosonde data in ESC format.

```
Data Type:                        CSU Mobile Radiosonde/Ascending
Project ID:                       PECAN
Release Site Type/Site ID:        Mobile/CSU_Mobile
Release Location (lon,lat,alt):   097 18.66'W, 40 53.85'N, -97.311, 40.898, 485.0
UTC Release Time (y,m,d,h,m,s):   2015, 06, 11, 01:55:00
Radiosonde Type:                  RS92-SGP
Radiosonde Serial Number:         K2133295
Ground Station Software:          Digicora MW41 2.1.0
Ground Check Pressure Corr:       0.23
Ground Check Temperature Corr:    -0.15
Ground Check Humidity Corr:       U1: 0.4/U2: 0.5
Nominal Release Time (y,m,d,h,m,s):2015, 06, 11, 01:55:00
 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
 ------ ------ ---- ----- ---- ----- ----- ----- ----- ----- -------- ------- ----- ----- ------ ---- ---- ---- ---- ---- ----
   0.0  950.7 22.6  16.0 66.0  -0.8  -7.5   7.5   6.0 999.0  -97.311  40.898 999.0 999.0  485.0 99.0 99.0 99.0 99.0 99.0  9.0
   1.0  950.0 22.6  16.3 68.0  -0.1  -6.7   6.7   1.0   6.4  -97.311  40.898 999.0 999.0  491.4  2.0  2.0  2.0 99.0 99.0 99.0
   2.0  948.9 22.6  16.6 69.0   0.5  -6.5   6.5 356.0  10.1  -97.311  40.899 999.0 999.0  501.6  2.0  2.0  2.0 99.0 99.0 99.0
   3.0  948.0 22.5  16.7 70.0   0.7  -6.6   6.6 354.0   8.3  -97.311  40.899 999.0 999.0  509.9 99.0 99.0 99.0 99.0 99.0 99.0
```

4.2 EOL Sounding Format

The EOL format is an ASCII text format that includes a header (Table 1), with detailed project and sounding information, and seventeen columns of high resolution data (Table 2).

The naming convention for these files is "D", followed by "yyyymmdd_hhmmss_P.1.eol" where yyyy = year, mm = month, hh = hour of the day UTC, mm = minute of the hour, ss = second of the hour (which refer to the launch time of the radiosonde).

The header (Table 1) contains 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 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.

Table 1 - EOL Sounding File Format (dropsonde and radiosonde)

```
Data Type/Direction:              GAUS SOUNDING DATA/Ascending
File Format/Version:              EOL Sounding Format/1.1
Project Name/Platform:            DEEPWAVE Hokitika/NCAR GAUS
Launch Site:                      20140528
Launch Location (lon,lat,alt):    170 59.11'E 170.985127, 42 42.87'S -42.714538,    68.92
UTC Launch Time (y,m,d,h,m,s):    2014, 05, 27, 23:17:10
Sonde Id/Sonde Type:              004823082/Vaisala RS92-SGP (ccGPS)
Reference Launch Data Source/Time: Manual Entry/23:05:25.61
System Operator/Comments:         Bill/Used sonde for surface met, Good Sounding
Post Processing Comments:         Aspen Version 3.1-7741; Created on 18 Nov 2014 22:06 UTC; Configuration upsonde-1s
/
 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
------- -- -- -----  ------- ----- ----- -----  ------ ------ ------ ------ ----- -------- ----------- ----------- ------
 -1.00 23 17  9.00  1019.32  8.46  7.61 94.36 -999.00 -999.00 -999.00 -999.00 -999.00   68.95 170.985127 -42.714538  68.92
  0.00 23 17 10.00  1019.39  8.55  7.33 91.97   0.09   0.12   0.15  218.77   1.29   68.41 170.985200 -42.714440  65.73
```

Data fields are listed below in Table 2.

Table 2 - Lists data fields provided in the EOL format ASCII soundings

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	Descent Rate	Meters/Second	Calculated
14	Geopotential Altitude	Meters	Calculated
15	Longitude	Degrees	Measured
16	Latitude	Degrees	Measured
17	GPS Altitude	Meters	Measured

4.3 Data Specifics

The files contain data at one-second intervals.

The CSU/NCSU/NSSL MGAUS used Vaisala RS92-SGP radiosondes during PECAN.

An additional file is included in this data set that contains release notes from the CSU Mobile crew: PECAN_CSU_Mobile_Launch_Notes.xlsx

One of the CSU Mobile soundings (CSU_Mobile_201506110404) had an incorrect release location and thus incorrect altitude data. The correct location

was obtained using the radiosonde GPS location (once the values settled in) and the surface elevation for that location was obtained from Google Earth. The geopotential heights in the file were then derived using this new surface value. For consistency, the same geopotential height calculations were run for every CSU Mobile sounding. Note that due to limited data resolution, there are issues with point to point variability in the height values above ~175mb.

4.5 Station List

Site ID	WMO ID	Site Name	State	Latitude	Longitude	Elev (m)
CSU_Mobile	N/A	CSU Mobile	Mobile	Mobile	Mobile	Mobile
NSSL1	N/A	NSSL1 Mobile	Mobile	Mobile	Mobile	Mobile
NSSL2	N/A	NSSL2 Mobile	Mobile	Mobile	Mobile	Mobile

5.0 Data Quality Control Procedures

1. Each sounding was converted from its original format into the ESC format described above.

2. 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.

3. Each sounding was visually examined utilizing the NCAR/EOL XQC sounding quality control software. This is further described in Section 4.2.

5.1 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).

5.1.1 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	RH	Q
	> T	T, RH	Q
Wind Speed	< 0 or > 100	U, V	Q
	> 150	U, V	B
U Wind	< 0 or > 100	U	Q
	> 150	U	B
V Wind	< 0 or > 100	V	Q
	> 150	V	B
Wind Direction	< 0 or > 360	U, V	B
Ascent Rate	< -10 or > 10	P, T, RH	Q

5.1.2 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

5.2 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.

5.3 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.

Updraft Soundings –
      CSU_Mobile_201506110155
      CSU_Mobile_201507060350
      CSU_Mobile_201507060516
      CSU_Mobile_201507090403
      CSU_Mobile_201507160357
      NSSL1_201507020410 – also periods of slow ascent especially around 580mb
      NSSL1_201507130631 – also spotty RH data 878-522mb, no data above 506mb, winds
      NSSL1_201507140500 – also spotty RH data 882-480mb
      NSSL2_201507020444 – also no RH data
      NSSL2_201507130615 – also several periods of descent
      NSSL2_201507150622

Limited Data –
      CSU_Mobile_201506170547 – no data above 812mb.
      CSU_Mobile_201506260542 – no GPS/wind data above 726mb
      CSU_Mobile_201507090724 – no data above 571mb
      CSU_Mobile_201507150722 – no data above 929mb
      NSSL1_201506050259 – no data above 534mb
      NSSL1_201506110314 – no data above 740mb
      NSSL1_201506110408 – no data above 542mb
      NSSL1_201506250339 – no data above 767mb
      NSSL1_201506260613 – no data above 607mb
      NSSL1_201507010900 – little data above 637mb
      NSSL1_201507020604 – no data above 781mb
      NSSL1_201507060429 – no data above 757mb, little RH data above 824mb
      NSSL1_201507090430 – little data above 718mb
      NSSL1_201507090621 – spotty RH data 760-470mb
      NSSL1_201507090726 – spotty RH data 840-536mb, periods of descent ~529 and 492mb
      NSSL1_201507100504 – no data above 620mb
      NSSL2_201506110600 – no data above 564mb
      NSSL2_201506120742 – no data above 637mb
      NSSL2_201507020637 – no RH data
      NSSL2_201507060408 – no data above 522mb
      NSSL2_201507090726 – no data above 689mb
      NSSL2_201507130731 – no data above 573mb
      NSSL2_201507150747 – no data above 808mb (little above 872mb)

Other Items –
      CSU_Mobile_201506250200 – questionable wind speed spike ~150mb.
      CSU_Mobile_201506250525 – RH cycling issue for much of sounding, flagged questionable.
      NSSL1_201506110200 – wetbulbing ~663 and 551mb

NSSL1_201506110408 – wetbulbing ~710 and 668mb
NSSL1_201506120406 – no RH data
NSSL1_201506120518 – little data above 661mb
NSSL1_201506150208 – no RH data, wetbulbing ~581mb
NSSL1_201507020316 – wetbulbing ~520mb
NSSL2_201506170350 – wetbulbing ~447mb
NSSL2_201506260449 – long period of descent ~310mb, a couple other periods higher up, little RH data 930-505mb
NSSL2_201507090511 – long period of descent 610mb
NSSL2_2015100115 – periods of bad data 268-303 and 492-505 seconds.

6.0 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.