Plains Elevated Convection at Night (PECAN)
5 hPa Resolution Sounding Composite Data Set

1.0 Contacts:

NCAR/EOL Processing and Quality Control:
Scot Loehrer (NCAR/EOL)
loehrer@ucar.edu

2.0 Dataset Overview

This data set contains a composite of upper air sounding data from all sources for the Plains Elevated Convection at Night (PECAN) project interpolated to 5hPa vertical levels. The composite includes 3488 soundings from all PECAN Fixed and Mobile PISA (PECAN Integrated Sounding Array; FP and MP respectively) sounding systems and MGAUS mobile soundings as well as those from the National Weather Service (Figure 1):

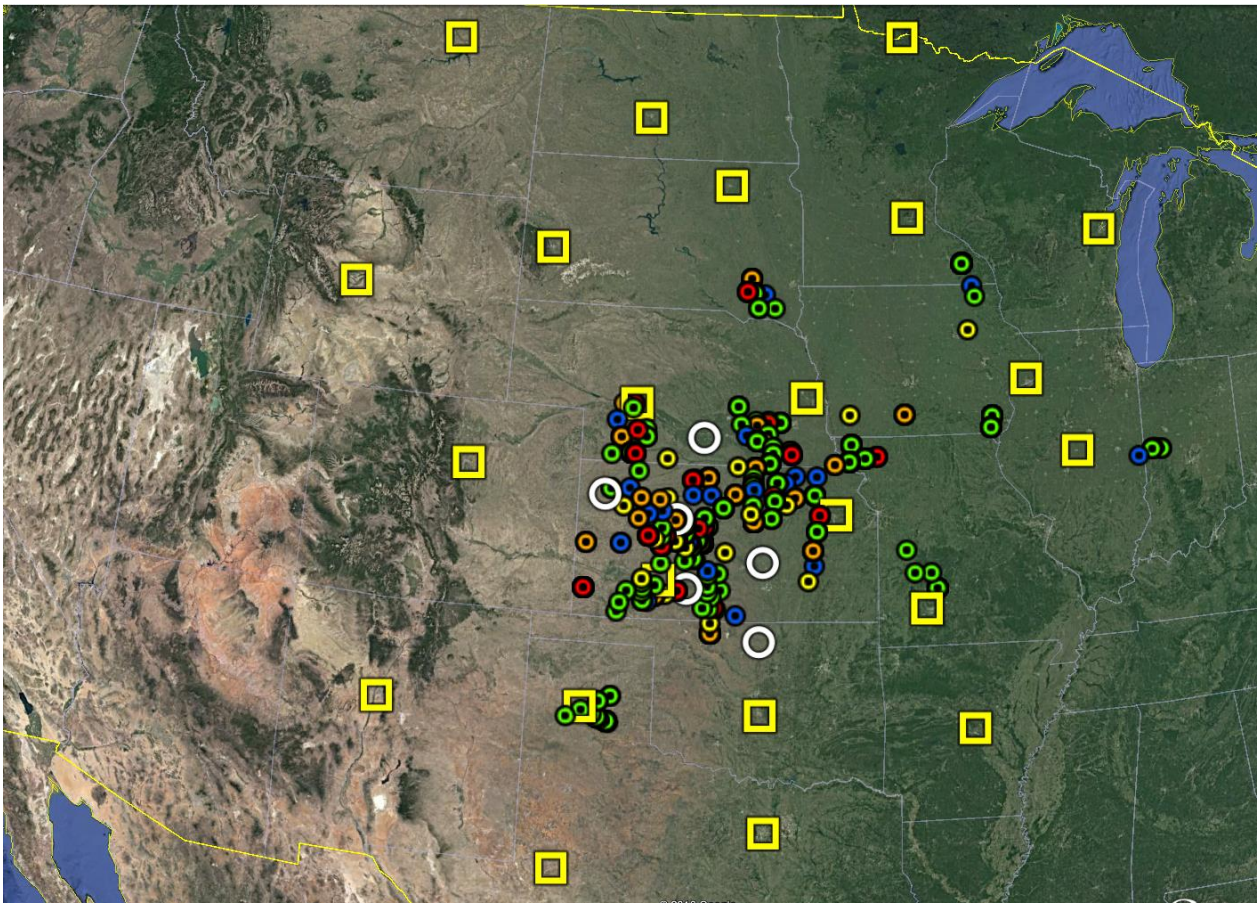

Figure 1. Locations of the soundings included in the PECAN composite data set. The NWS sites are the yellow squares. The Fixed PISAs are the white circles. The sounding sites used by the mobile sounding systems are the small color-filled circles.

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 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.

4.1 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	Type of radiosonde
7	Radiosonde Serial Number	
8	Ground Station Software	

The nominal release time for these soundings is the same as the actual time.

4.2 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")

4.3 Data Specifics

Details on the radiosonde systems included in this data set are included in this section. Links are included to the documentation for the individual sounding data sets for details on processing and quality control.

FP1 – Department of Energy (DOE) Atmospheric Radiation Measurement (ARM)
ARM Central Facility; Lamont, OK
221 soundings at 2 second resolution
http://data.eol.ucar.edu/datafile/nph-get/485.021/readme_PECAN_FP1_radiosonde.pdf

FP2 – University of Maryland – Baltimore County (UMBC) and Naval Postgraduate School (NPS)
Greensburg, KS
114 UMBC and 10 NPS soundings all at 1 second resolution
http://data.eol.ucar.edu/datafile/nph-get/485.043/readme_PECAN_FP2_radiosonde.pdf

FP3 – Millersville University
Ellis, KS
134 soundings at 1 second resolution
http://data.eol.ucar.edu/datafile/nph-get/485.057/readme_PECAN_FP3_Ellis_radiosonde.pdf

FP4 – National Center for Atmospheric Research/Earth Observing Laboratory (NCAR/EOL)
Minden, NE
109 soundings at 1 second resolution
http://data.eol.ucar.edu/datafile/nph-get/485.015/readme_PECAN_FP4_Minden_radiosonde_ESC.pdf
http://data.eol.ucar.edu/datafile/nph-get/485.015/readme.PECAN-2015.NCAR.NSSL.radiosondes.pdf

FP5 – NCAR/EOL
Brewster, KS
112 soundings at 1 second resolution
http://data.eol.ucar.edu/datafile/nph-get/485.016/readme.PECAN-2015.NCAR.NSSL.radiosondes.pdf
http://data.eol.ucar.edu/datafile/nph-get/485.016/readme_PECAN_FP5_Brewster_radiosonde.pdf

FP6 – ARM
Hesston, KS
105 soundings at 2 second resolution
http://data.eol.ucar.edu/datafile/nph-get/485.037/readme_PECAN_FP6_Hesston_radiosonde.pdf

MP1 – University of Oklahoma (OU)/National Severe Storms Laboratory (NSSL)
Collaborative Lower Atmospheric Mobile Profiling System (CLAMPS)
98 soundings at 1 second resolution
http://data.eol.ucar.edu/datafile/nph-get/485.103/readme_PECAN_MP1_CLAMPS_radiosonde.pdf

MP2 – University of Alabama – Huntsville (UAH)
Mobile Integrated Profiling System (MIPS)
84 soundings at 1 second resolution
http://data.eol.ucar.edu/datafile/nph-get/485.054/readme_PECAN_MP2_MIPS_radiosonde.pdf

MP3 – University of Wisconsin-Madison Space Science and Engineering Center (SSEC)
SSEC Portable Atmospheric Research Center (SPARC)
82 soundings at 1 second resolution
http://data.eol.ucar.edu/datafile/nph-get/485.033/readme_PECAN_MP3_SPARC_radiosonde.pdf

MP4 – NCAR/EOL
Mobile Integrated Sounding System (MISS)
113 soundings at 1 second resolution
http://data.eol.ucar.edu/datafile/nph-get/485.014/readme_PECAN_MP4_MISS_radiosonde_ESC.pdf
http://data.eol.ucar.edu/datafile/nph-get/485.014/readme.PECAN-2015.NCAR.NSSL.radiosondes.pdf

MGAUS – Colorado State University (CSU); North Carolina State University (NCSU); NSSL
Mobile GPS Advanced Upper-Air Sounding (MGAUS)
251 soundings at 1 second resolution
http://data.eol.ucar.edu/datafile/nph-get/485.061/readme_PECAN_MGAUS_radiosonde.pdf
http://data.eol.ucar.edu/datafile/nph-get/485.061/new.readme.PECAN-2015.NCAR.NSSL.radiosondes.docx

NWS – National Weather Service
2055 soundings from 22 sites
http://data.eol.ucar.edu/datafile/nph-get/485.053/readme_PECAN_NWS_radiosonde.pdf

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:

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

4.4 Sample Data

The following is a sample of the 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):     101 12.18'W, 39 30.70'N, -101.203, 39.512, 1005.0
UTC Release Time (y,m,d,h,m,s):     2015, 06, 02, 03:03:00
Radiosonde Type:                    RS92-SGP
Radiosonde Serial Number:           K2333016
Ground Station Software:            Digicora MW41 2.1.0
Ground Check Pressure Corr:         0.80
Ground Check Temperature Corr:      -0.05
Ground Check Humidity Corr:         U1: -0.1/U2: -0.1
Nominal Release Time (y,m,d,h,m,s):2015, 06, 02, 03:03:00
```

Time sec	Press mb	Temp C	Dewpt C	RH %	Ucmp m/s	Vcmp m/s	spd m/s	dir deg	Wcmp m/s	Lon deg	Lat deg	Ele deg	Azi deg	Alt m	Qp code	Qt code	Qrh code	Qu code	Qv code	QdZ code
0.0	901.0	20.8	17.2	80.0	-2.6	3.1	4.0	140.0	999.0	-101.203	39.512	999.0	999.0	1005.0	1.0	1.0	1.0	1.0	1.0	9.0
1.0	900.4	20.6	17.2	81.0	-2.4	3.8	4.5	148.0	5.8	-101.203	39.512	999.0	999.0	1010.8	1.0	1.0	1.0	1.0	1.0	99.0
2.0	899.8	20.6	17.4	82.0	-2.4	4.4	5.0	151.0	5.8	-101.203	39.512	999.0	999.0	1016.6	2.0	2.0	2.0	1.0	1.0	99.0

4.5 Station List

Site ID	WMO ID	Site Name	State	Latitude	Longitude	Elev (m)
FP1	74646	Central Facility (Lamont)	OK	36.61N	97.49W	315
FP2	GREEN	Greensburg	KS	37.606N	99.276W	680
FP3	ELLIS	Ellis	KS	38.94N	99.565W	646
FP4	MIND	Minden	NE	40.516N	98.951W	676
FP5	BREW	Brewster	KS	39.357N	101.371W	1036
FP6	HESS	Hesston	KS	38.140N	97.430W	451
MP1	N/A	CLAMPS	Mobile	Mobile	Mobile	Mobile
MP2	N/A	MIPS	Mobile	Mobile	Mobile	Mobile
MP3	N/A	SPARC	Mobile	Mobile	Mobile	Mobile
MP4	N/A	MISS	Mobile	Mobile	Mobile	Mobile
MGAUS	N/A	MGAUS	Mobile	Mobile	Mobile	Mobile
KABQ	72365	Albuquerque	NM	35.038N	106.623W	1619
KABR	72659	Aberdeen	SD	45.455N	98.414W	398
KAMA	72363	Amarillo	TX	35.233N	101.709W	1095
KBIS	72764	Bismarck	ND	46.772N	100.762W	506
KDDC	72451	Dodge City	KS	37.762N	99.969W	790
KDNR	72469	Denver	CO	39.768N	104.870W	1611
KDVN	74455	Quad Cities	IA	41.612N	90.582W	230
KFWD	72249	Fort Worth	TX	32.835N	97.298W	195
KGGW	72768	Glasgow	MT	48.206N	106.627W	693
KGRB	72645	Green Bay	WI	44.498N	88.112W	209
KILX	74560	Lincoln	IL	40.151N	89.338W	179
KINL	72747	International Falls	MN	48.565N	98.397W	357
KLBF	72562	North Platte	NE	41.134N	100.700W	849
KLZK	72340	Little Rock	AR	34.836N	92.260W	173
KMAF	72265	Midland	TX	31.943N	102.190W	874
KMPX	72649	Minneapolis	MN	44.849N	93.564W	290
KOAX	72558	Omaha	NE	41.320N	96.366W	351
KOUN	72357	Norman	OK	35.181N	97.438W	345
KRIW	72672	Riverton	WY	43.065N	108.477W	1699
KSGF	72440	Springfield	MO	37.236N	93.402W	391
KTOP	72456	Topeka	KS	39.073N	95.630W	268
KUNR	72662	Rapid City	SD	44.073N	103.210W	1029

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.

4. Each sounding was interpolated to 5 hPa vertical resolution.

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 > 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

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 5 hPa Interpolation Procedures

The surface data point was kept as the initial level in each sounding. The first interpolated data point was at the next lowest pressure evenly divisible by 5 and then every 5 hPa pressure level beyond that point to either 50 hPa or the lowest pressure level reached by the radiosonde, whichever came first. The first 15 lines of each file (the header information) were kept without change.

For the interpolation, the software searched for two data points around the desired pressure level. The search was conducted by looking for two valid (i.e. non-missing) data points around the desired pressure level, while also paying attention to the time difference between the two data points as well as their quality control flags. There was a search for the two best possible data points to use in the interpolation. If the desired pressure level was within the original dataset, that data point was used without interpolation.

There was first a search for values flagged as good within some time range (50 sec for temperature, humidity, and wind and 100 sec for pressure; hereafter termed the

ARANGE) and the interpolated data point was flagged as good. Failing that, it searched for values flagged as estimated within the same time range and the interpolated data point was flagged as estimated. Then the search went for good values within a wider time range (100 sec for temperature, humidity, and wind and 200 sec for pressure; hereafter termed the BRANGE) the flag for the interpolated data point here was then degraded (even though two `good' data points were used there was a significant time difference between them) to questionable. Then, in turn, estimated values within the BRANGE were used (flag set to questionable), questionable values within the BRANGE (flag set to bad), good values greater than the BRANGE apart (flag set to bad), estimated values greater than BRANGE apart (flag set to bad), questionable values greater than BRANGE apart (flag set to bad), finally any bad values (flag set to bad). This search was conducted separately for each interpolated variable (pressure, temperature, relative humidity, and the u and v wind components.

Thus for each interpolated data point, the quality control flag was set to the worst case among the data points used in the interpolation, except, for each time range apart, the quality control flag was degraded one level (i.e. good to questionable, etc).

The quality control flags should be carefully heeded in these files. While some of the data may look good, it may have been interpolated over large pressure intervals, and thus be suspect.

For each interpolated data point the dew point was calculated from the temperature and relative humidity (Bolton 1980) and the total wind speed and direction were calculated from the interpolated u and v component values. Also, the altitude and time were interpolated using the same data points used for the pressure interpolation. The ascension rate was recalculated based on the time and altitude values from the two data points used to interpolate the 5 hPa data point. Thus the ascension rate values do not reflect the values based on the interpolated data. The latitude and longitude values were interpolated using the same data points used in the wind component interpolation.

5.4 Data Quality Issues of Note

See the readme files linked above for details on the data quality issues in each individual sounding data set.

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.