



Plains Elevated Convection At Night

PECAN

NCAR & NSSL

Radiosonde Data Quality Report

March 1

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The radiosonde data for this project were quality controlled and are maintained by the Earth Observing Laboratory at the National Center for Atmospheric Research (NCAR). NCAR is sponsored by the National Science Foundation (NSF). In the event that information or plots from this document are used for publication or presentation purposes, please provide appropriate acknowledgement to NSF and NCAR/EOL and make reference to Young K. and H. Vömel (2015): PECAN 2015 Radiosonde Data Quality Report.

In the event that these datasets are used for research resulting in a publication, please include the following citations in your paper:

UCAR/NCAR - Earth Observing Laboratory. 2016. **MP4** - QC Radiosonde Data, Version 1.0. UCAR/NCAR - Earth Observing Laboratory. <http://dx.doi.org/10.5065/D6707ZNV>. Accessed 15 Mar 2016.

UCAR/NCAR - Earth Observing Laboratory. 2016. **FP4** - QC Radiosonde Data, Version 1.0. UCAR/NCAR - Earth Observing Laboratory. <http://dx.doi.org/10.5065/D63776XH>. Accessed 15 Mar 2016.

UCAR/NCAR - Earth Observing Laboratory. 2016. **FP5** - QC Radiosonde Data, Version 1.0. UCAR/NCAR - Earth Observing Laboratory. <http://dx.doi.org/10.5065/D6ZG6QF7>. Accessed 15 Mar 2016.

Ziegler, C., Coniglio, M., Parker, M., Schumacher, R. 2016. **CSU/NCSU/NSSL** MGAUS Radiosonde Data, Version 2.0. UCAR/NCAR - Earth Observing Laboratory. <http://dx.doi.org/10.5065/D6W66HXN>. Accessed 07 Mar 2016

PECAN 2015 Quality Controlled Radiosonde Dataset

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PECAN 2015 Radiosonde Data Quality Report

Table of Contents

Contents

I. Dataset Overview.....	6
II. EOL Sounding File Format and Data Specifics.....	7
III. Data Quality Control Processes.....	9
IV. Overview of Issues.....	0

List of Tables

Table 1 - Radiosonde Counts for NCAR and NSSL Sounding Systems.....	4
Table 2 - EOL Sounding File Format.....	6
Table 3 - Lists Data Fields Provided in the EOL ASCII Format.....	6
Table 4 - Summary of Corrections and Data Quality Issues.....	9
Table 5 - Mean Magnitude and Standard Deviations of Radiosonde Corrections.....	9

List of Figures

Figure 1 – Map of Radiosonde Launch Locations.....	5
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I. Dataset Overview

The Plains Elevated Convection at Night (PECAN) campaign was a large-scale, multi-agency research project conducted in the Central United States with operations centered at Hays, Kansas. Participating agencies included the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA) and the US Department of Energy (DOE). The goal of the field campaign was to collect nighttime measurements of convection with stable boundary layers, low-level jets and large convectively available potential energy. The National Center for Atmospheric Research’s Earth Observing Laboratory (NCAR/EOL) deployed two, fixed Integrated Sounding Systems ([ISS](#)) and one Mobile GPS Atmospheric Upper-Air Sounding System ([MGAUS](#)). The fixed sites were located in Minden, NE, also known as Fixed PECAN Integrated Sounding Array (PISA) 4 (FP4), and Brewster, KS, also known FP5. The MGAUS was referred to as Mobile PISA 4 (MP4). NOAA’s National Severe Storms Laboratory ([NSSL](#)) operated two mobile sounding systems, known as NSSL1 and NSSL2. A map of all radiosonde launch locations is provided in Figure 1.

Five hundred and one balloon-borne radiosondes were launched between June 2 and July 16, 2015. This document contains information on the sounding file format, data parameters included in each of the files, and details regarding data quality and the quality control routines applied to the sounding data.

Table 1. Radiosonde Counts for PECAN NCAR and NSSL Sounding Systems

System Name	Site Location	Number of Soundings
Fixed PISA 4 (FP4)	Minden, NE	109
Fixed PISA 5 (FP5)	Brewster, KS	112
Mobile GAUS (MP4)	Mobile	113
NSSL1	Mobile	83
NSSL2	Mobile	84
		Total: 501

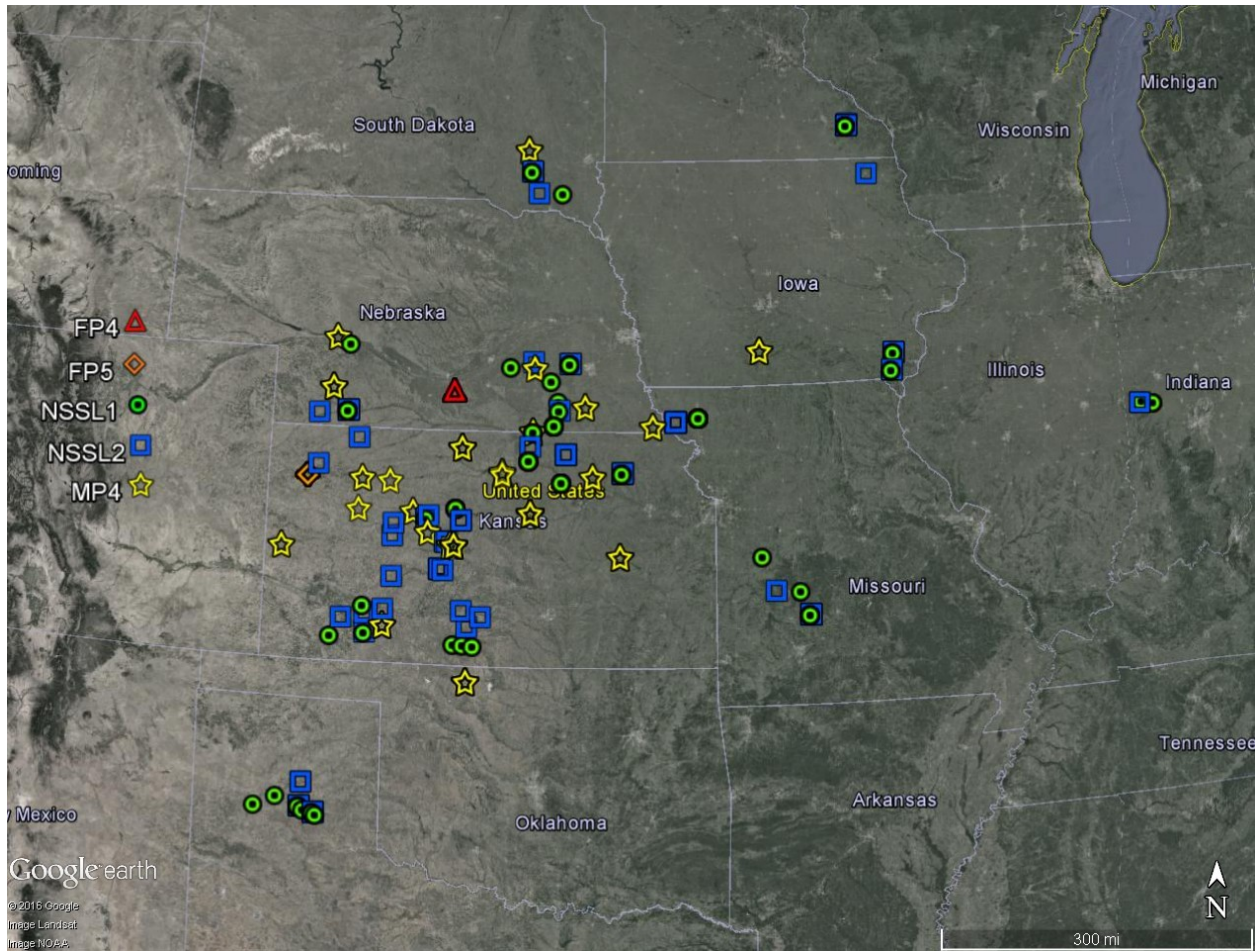


Figure 1. Map of all radiosonde launch locations from FP4, FP5, MP4, NSSL1 and NSSL2

For more information on the PECAN project please visit:
https://www.eol.ucar.edu/field_projects/pecan

EOL Sounding File Format and Data Specifics

The EOL format is an ASCII text format that includes a header with project/sounding information (Table 2) and seventeen columns of high-resolution data (Table 3). The "QC.eol" 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_PQC.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 "QC.eol" refers to the EOL file format type.

The header 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: longitude (degree minute), longitude (decimal degree), latitude (degree minute), latitude (decimal degree), altitude (meters). Longitude in degree minute is in the format: ddd mm.mm'W where ddd is the number of degrees from True

PECAN Radiosonde Data Quality Report

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. Lines 8 through 10 contain information about the surface met instrumentation used, operator comments about the sounding and the version of NCAR's Atmospheric Sounding Processing Environment ([ASPEN](#)) software used during post-processing. 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 3. Information about the current version of ASPEN and its configuration used for the final Data QC is also included in the header of each sounding file.

The files contain data calculated at one-second intervals. The variables pressure, temperature, and relative humidity are measured by the radiosonde. The dew point is calculated from the relative humidity and temperature using the vapor pressure equation (Bolton, 1980). The geopotential altitude is calculated from the hydrostatic equation using pressure, temperature, and relative humidity (RH). The rate of ascent is calculated from pressure. The radiosonde position (lat, lon, GPSAlt) and winds are measured by the GPS receiver in the sonde. The raw wind values are subjected to a digital filter to remove high frequency oscillations due to the sonde pendulum motion beneath the balloon. The uncertainty of the GPS altitude is estimated to be less 20 m. Investigators should follow meteorological convention and use geopotential altitude.

Table 2 - EOL Sounding File Format (dropsonde and radiosonde)

```
Data Type/Direction:      GAUS SOUNDING DATA/Ascending
File Format/Version:      EOL Sounding Format/1
Project Name/Platform:    PECAN / Brewster/NCAR GAUS
Launch Site:              20150601
Launch Location (lon,lat,alt): 101 22.24'W -101.370688, 39 21.45'N 39.357488, 1047.00
UTC Launch Time (y,m,d,h,m,s): 2015, 06, 01, 15:35:44
Sonde Id/Sonde Type:      144863110/Vaisala RS92-SGP (ccGPS)
Reference Launch Data Source/Time: Campbell Scientific CR10/15:35:45.00
System Operator/Comments: Brewster Team/System check and training, Good Sounding
Post Processing Comments:  Aspen Version 3.2-172; Created on 03 Aug 2015 20:20 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 12 37 25.00 8910 21.67 16.56 72.30 -0.36 -1.68 1.72 121 -999.00 12864.22 -109.951000 33.083000 1025.88
0.00 12 37 26.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.000000 -999.000000 -999.00
0.25 12 37 26.25 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.000000 -999.000000 -999.00
```

Table 3 - 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	Air 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

II. Data Quality Control Process

- 1) Profiles of raw temperature, relative humidity, wind speed and ascent rate versus pressure are examined to determine if there are problematic sounding files which could be a result of malfunctioning of the launch detect, sounding system lock-up (a result of weakening of the sonde signal in flight), sensor failure, sensor offsets or biases, and slow radiosonde ascent rates (can result in RH errors). Corrections are made where possible to address these specific problems.
- 2) 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 to find biases in the radiosonde data. These plots allow us to determine if the ground check pressure correction (see #4 below) is needed, and they allow us to investigate large differences in temperature and relative humidity related to Local Standard Time (LST)
- 3) All altitudes were initialized to the correct surface heights. A geometric surface height, from each site, is obtained and then converted to geopotential height by taking into account latitude. This ensures an accurate starting point for the geopotential altitude calculation.
- 4) All sondes launched by NCAR were passed through the Vaisala required GC25 ground check unit. This ground check uses a reference temperature sensor to recalibrate the radiosonde temperature sensor and a desiccant to test the RS92 humidity sensors at near zero percent relative humidity.
The comparison of the radiosonde temperature sensor with the GC25 reference temperature sensor provides a temperature offset correction, which is applied following the method used by Vaisala. If no GC25 reference temperature measurement is available the median values of the prelaunch radiosonde data (corrected on the ground) is used for the correction (see files listed in #9 under Section III)

The humidity reading in the GC25 ground check unit was only used to verify the proper functioning of both the humidity sensors. This method follows the procedures established by the GCOS Reference Upper Air Network (GRAUN).

- 5) A pressure correction is applied, as a direct offset, to the entire profile for most soundings. The surface pressure measured by an independent surface reference sensor at launch is used as a reference for this correction. The corrected pressure $P = P^{RS} + (P_0^{REF} - P_0^{RS})$, where P^{RS} is the pressure measured by radiosonde, P_0^{REF} is the reference pressure, and P_0^{RS} is the pressure as indicated by the radiosonde on the ground near the reference sensor.
- 6) All temperature measurements are corrected for a solar and infrared radiation error using the Vaisala radiation correction table RSN2010 and the solar angle and pressure at time of measurement.
- 7) All daytime soundings have been corrected for the Vaisala RS92 dry bias (Vömel et al. 2007). This correction adjusts the observations for the fact that the sun heats the Vaisala RS92 humidity sensors during the daytime and result in report humidity values that are biased low. The NCAR correction algorithm has been described by Wang et al. (2013).
- 8) The raw soundings are processed through Batch ASPEN, which analyzes the pressure, temperature, relative humidity and GPS wind data, performs smoothing, and filters out suspect data points.

For more information on ASPEN or to download the software please visit: <http://www.eol.ucar.edu/software/aspn>

- 9) Profiles of quality controlled temperature, RH, wind speed and wind direction versus geopotential altitude are examined. These enable us to visually evaluate the final data product for outliers, or any other obvious problems that may have previously gone undetected.

III. Overview of issues

Performing the quality control procedures outlined above allows us to identify and, in many cases, resolve issues that could potentially impact research performed using these data sets.

The following issues, noted in Table 4, were found. The mean magnitude of the corrections and standard deviations are shown in Table 5. Where necessary, corrections have been applied. Following the table are more detailed descriptions of the data quality issues discovered and information on how they were addressed.

Table 4 – Summary of Data Quality Issues Found with PECAN Soundings from each system

Data Quality Issue	FP4 # of soundings	FP5 # of soundings	MP4 # of soundings	NSSL1 # of soundings	NSSL2 # of soundings
Early Launch Detects	4	2	1	2	7
Premature Launch	3		2		
No GPS Data	2		1		
Bad RH Data	1		1	3	2
Sounding System Lockup	7	2	7	1	
Loop Soundings		2		3	4
No Sfc Met		8	1	1	

Table 5 – Shows the mean magnitude and standard deviations of the pressure and GC25 temperature corrections applied to soundings from each system

Standard Radiosonde Corrections	FP4	FP5	MP4	NSSL 1	NSSL 2
Mean Pressure Correction (hPa)	.88	.84	.68	.07	.34
Std Dev (hPa)	.40	.30	.33	6	.64
Mean GC25 Temperature Correction (deg K)	.36	.30	.34	.38	.38
Std Dev (deg K)	.33	.38	.21	.05	.05

1. All radiosondes that were not passed through the GC25 ground check unit, listed below, were corrected using the median offset correction of all radiosondes, which were passed through the ground check. With this correction applied to all sondes the mean bias of the entire set of radiosondes has been removed. However, the sondes that were not passed through the GC25 ground check unit will have a residual offset, which follows the distribution established by the properly recalibrated sondes.
2. **No Surface Met Data** - These sounding files contain no surface meteorological data. **No pressure correction could be applied due to missing reference pressure data.**

FP5	MP4	NSSL1
D20150620_000110	D20150611_025527	D20150605_02594 7
D20150620_01315 4		
D20150620_03031		

2		
D20150620_04321		
9		
D20150620_05581		
7		

3. **Early Launch Detect** - Occurs when a large, abrupt change in pressure prematurely triggers the launch detect while the radiosonde is still on the ground. Data collected by the radiosonde before launch is incorrectly flagged as ‘in-flight’ data and the time stamp associated with the launch time is incorrect. All of the early launch detect soundings, listed below, have been corrected to reflect the actual time of launch.

System	Radiosonde ID	New Filename
FP4	144873245	D20150701_030006
	144933561	D20150708_020024
	144953811	D20150712_001451
	144913071	D20150608_042529
FP5	144863103	D20150604_030123
	144863109	D20150605_235943
MP4	144873236	D20150710_030037
NSSL1	142413329	D20150612_040449
	142414957	D20150713_080255
NSSL2	142423071	D20150709_013557
	142413369	D20150709_024738
	142423062	D20150709_061908
	142423297	D20150709_034742
	142423314	D20150709_051135
	142443078	D20150709_072622
	142343399	D20150715_062259

4. **Sounding System Lockup** - is caused by weakening or loss of the radiosonde signal. The original sounding files were not saved in the correct format or to the correct file names. They contained no LAU (launch) or A00 (surface met) data lines, prelaunch data was incorrectly flagged as sounding data and the standard 19 line tail at the end of the raw data file was missing. Data before the lock-up was preserved, however if the sonde signal was not reacquired anything measured by the radiosonde after the lock-up has been lost. These files were corrected and the filenames were changed to reflect the actual launch time. Surface met data collected at the time of launch were retrieved and entered into the sounding files.

FP4	FP5	MP4	NSSL1
D20150608_04252	D20150714_00004	D20150608_06030	D20150605_02594
9	1	8	7
D20150701_00010	D20150715_00595	D20150615_02093	
3	9	7	

D20150701_03000 6		D20150615_03332 6	
D20150701_06000 9		D20150620_00145 5	
D20150701_09014 6		D20150622_08581 3	
D20150702_03000 4		D20150706_03034 9	
D20150702_06000 2		D20150715_07050 8	

5. **Loop Soundings** - Radiosondes listed below encountered either vertical downdrafts or balloon icing that caused descent of the balloon package for a period of time during ascent. These are referred to as ‘loop’ soundings because of the loop feature seen when altitude is temporarily lost and the ascent rate becomes negative for some time before resuming ascent.

FP5	NSSL1	NSSL2
D20150626_041729	D20150615_02080 7	D20150611_060016
D20150716_060102	D20150710_05044 9	D20150626_044916
	D20150713_06312 6	D20150713_061504
		D20150713_073145

6. **Premature Launch** – This describes when launch takes place before all steps of the sounding computer software had been completed and it results in data loss near the surface. The time indicated in the filename is the time at which the first sonde data point was collected and not the time of the actual launch. Surface met data, from the time that the first sonde data point is retrieved are entered into the sounding data file. **No pressure correction could be applied to these data files because the correction requires pressure data collected by the radiosonde on the ground prior to launch.**

FP4	MP4
D20150603_03011	D20150625_013010
D20150610_032705	D20150715_060038
D20150715_050016	

7. **Bad RH** – These soundings were found to have bad relative humidity profiles due to a damaged sensor.

System	Filename	RH Sensor Issue
FP4	D20150715_235953	Offset between RH1 and RH2 of approximately 3%
FP5	D20150626_041729	Offset between RH1 and RH2 of

PECAN Radiosonde Data Quality Report

		approximately .5%. Slowed ascent rate resulted in noisy RH profile
MP4	D20150706_045708	Sensors froze up. RH all set to missing
NSSL1	D20150612_040449	Sensors froze up. RH all set to missing
	D20150615_020807	Sensors froze up. RH all set to missing
	D20150625_054623	Offset between RH1 and RH2 of approximately 2%.
NSSL2	D20150702_044409	Vary sparse, terribly noisy data. RH all set to missing
	D20150702_063721	RH offsets of approximately 5%. All RH set to missing

8. No GPS Data - The following soundings contained no wind speed, wind direction, and position data due to GPS failure on the sonde.

FP4	MP4
D20150705_00002 3	D20150711_235959
D20150622_08265 3	

9. Default Median Correction – The files listed below had no GC25 surface reference temperature recorded, so in order to apply a correction the median pre-launch radiosonde data was used instead.

FP4	FP5	MP4	NSSL1	NSSL2
D20150608_042 529	D20150715_035 716	D20150715_070 508	D20150612_040 449	D20150714_045 922
	D20150620_055 817	D20150706_030 349	D20150605_025 947	D20150713_034 439
	D20150704_045 923	D20150622_085 813	D20150701_040 005	D20150715_062 259
	D20150705_002 018	D20150620_001 455	D20150617_030 452	D20150715_052 342
	D20150714_000 041	D20150615_033 326	D20150617_041 540	D20150709_024 738
	D20150622_030 021	D20150615_020 937	D20150714_034 522	D20150611_060 016
	D20150622_060 009	D20150608_060 308	D20150714_015 959	D20150625_012 958
	D20150624_000	D20150602_032	D20150716_050	D20150624_034

PECAN Radiosonde Data Quality Report

	127	319	017	448
	D20150626_030 008	D20150610_060 544	D20150611_031 449	D20150622_060 008
	D20150625_030 036	D20150610_001 634	D20150713_041 500	D20150622_043 050
	D20150701_090 003	D20150603_043 011	D20150617_052 004	D20150617_061 220
	D20150701_073 045	D20150605_043 010	D20150701_050 020	D20150617_013 016
	D20150624_060 018	D20150604_055 907	D20150701_025 951	D20150706_055 834
	D20150626_041 729	D20150603_025 905	D20150617_063 420	D20150624_051 608
	D20150701_055 928	D20150603_013 003	D20150615_020 807	D20150617_025 037
	D20150620_085 933	D20150602_030 258	D20150611_062 409	D20150617_035 026
	D20150622_012 949	D20150604_044 116	D20150615_030 001	D20150702_044 409
	D20150622_090 011	D20150604_034 736	D20150611_040 844	D20150623_214 352
	D20150622_042 846	D20150605_060 329	D20150612_022 938	D20150713_073 145
	D20150620_000 110	D20150603_000 550	D20150713_011 519	D20150713_051 501
	D20150620_013 154	D20150611_025 527	D20150625_044 402	D20150716_020 328
	D20150621_235 817	D20150610_025 935	D20150625_033 914	D20150713_061 504
	D20150620_030 312	D20150612_025 830	D20150709_043 043	D20150716_040 207
	D20150620_043 219	D20150612_042 942	D20150625_022 950	D20150714_031 503
	D20150703_030 020	D20150608_030 311	D20150625_005 940	D20150716_030 051
	D20150703_060 031	D20150611_043 625	D20150713_024 459	D20150715_074 738
	D20150708_020 011	D20150610_013 004	D20150711_070 438	D20150701_085 928
	D20150706_061 908	D20150606_030 016	D20150711_083 345	D20150624_235 952
	D20150702_040 518	D20150622_055 923	D20150711_050 003	D20150713_004 452
	D20150704_070 020	D20150612_012 940	D20150625_054 623	D20150602_030 652
	D20150705_030	D20150612_060	D20150624_055	D20150711_070

PECAN Radiosonde Data Quality Report

	104	633	943	339
	D20150704_025 933	D20150714_000 046	D20150624_025 947	D20150711_045 932
	D20150705_055 952	D20150712_055 001	D20150716_005 958	D20150709_034 742
	D20150715_024 424		D20150709_032 645	D20150709_013 557
	D20150715_020 000		D20150711_075 948	D20150709_051 135
	D20150706_025 935		D20150716_033 925	D20150617_050 006
	D20150702_022 652		D20150713_063 126	D20150709_061 908
	D20150705_235 953		D20150714_050 007	D20150622_000 044
	D20150626_000 146		D20150709_062 129	D20150622_030 058
	D20150702_055 910		D20150709_011 502	D20150612_000 043
	D20150701_022 755		D20150709_072 605	D20150604_043 112
	D20150626_060 025		D20150713_053 502	D20150612_025 957
	D20150624_013 518		D20150713_080 255	D20150612_074 253
	D20150714_020 000		D20150715_060 346	D20150615_041 523
	D20150715_055 940		D20150715_235 958	D20150622_013 013
	D20150708_060 004		D20150624_042 948	D20150606_013 447
	D20150716_040 033		D20150709_022 727	D20150625_030 024
	D20150716_060 102		D20150710_015 504	D20150701_065 935
	D20150624_030 039		D20150710_004 510	D20150712_195 230
	D20150716_050 001		D20150706_042 959	D20150710_021 509
	D20150709_020 000		D20150710_030 018	D20150701_080 011
	D20150716_010 001		D20150604_060 009	D20150701_050 121
	D20150715_070 214		D20150603_000 126	D20150710_042 513
	D20150712_025		D20150615_041	D20150713_021

PECAN Radiosonde Data Quality Report

	959		448	540
	D20150709_060 023		D20150603_030 027	D20150604_033 018
	D20150710_000 001		D20150604_043 114	D20150612_044 300
	D20150712_054 958		D20150603_042 637	D20150606_030 036
	D20150710_040 027		D20150706_065 543	D20150604_060 102
	D20150712_012 959		D20150706_032 500	D20150611_043 314
	D20150710_051 539		D20150710_050 449	D20150604_001 100
	D20150711_000 001		D20150710_040 539	D20150606_043 035
	D20150711_020 002		D20150716_020 302	D20150615_021 313
	D20150711_060 001		D20150604_023 210	D20150615_030 410
	D20150711_035 958		D20150604_033 433	D20150701_040 027
	D20150709_040 000		D20150612_051 828	D20150701_055 947
	D20150710_060 002		D20150611_020 001	D20150710_032 013
	D20150715_234 348		D20150603_013 738	D20150626_021 516
	D20150712_042 958		D20150716_054 939	D20150701_030 000
	D20150709_000 001		D20150706_022 325	D20150625_041 641
	D20150708_040 007		D20150705_030 104	D20150626_070 144
	D20150715_005 959		D20150701_235 507	D20150625_060 554
	D20150714_235 959		D20150626_043 010	D20150701_015 924
	D20150710_015 958		D20150702_031 604	D20150626_034 711
	D20150711_235 631		D20150702_041 050	D20150626_044 916
	D20150710_070 001		D20150702_020 137	D20150709_072 622
	D20150716_030 028		D20150701_012 957	D20150706_030 507
	D20150714_060		D20150701_065	D20150710_011

PECAN Radiosonde Data Quality Report

	001		955	508
	D20150716_020 002		D20150626_030 057	D20150706_040 818
	D20150714_040 001		D20150702_060 422	D20150705_030 414
			D20150701_090 024	D20150702_005 923
			D20150701_060 000	D20150702_024 733
			D20150702_065 941	D20150702_063 721
			D20150626_061 349	D20150702_034 449
				D20150706_014 418