Plains Elevated Convection At Night

PECAN NCAR & NSSL Radiosonde Data Quality Report

March 1

2016

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

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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
NSS2	Mobile	84
		Total: 501

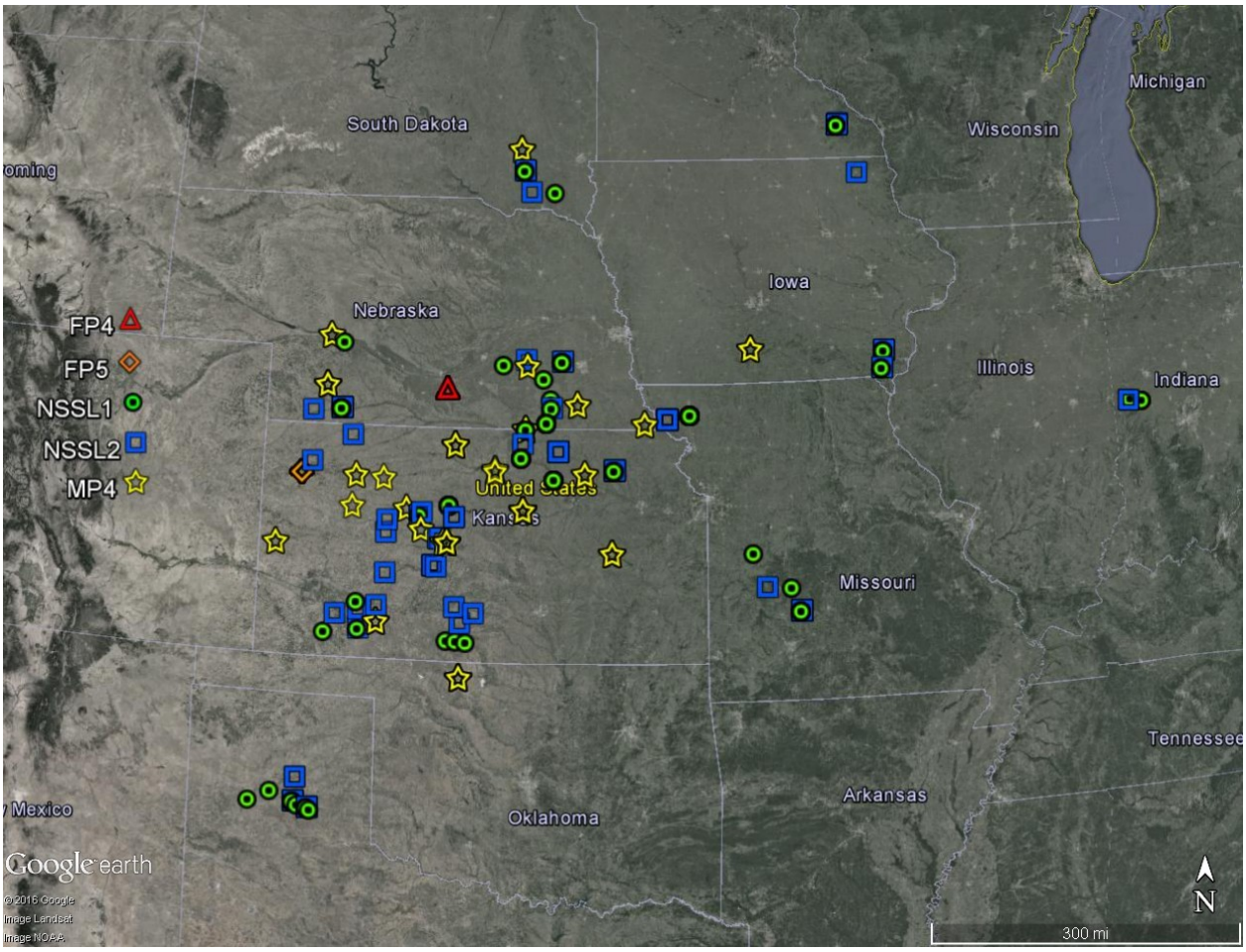

Figure 1. Map of all radiosonde launch locations from FP4, FP5, MP4, NSSL1 and NSSL2

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 (degee minute), longitude (decimal degree), latitude (degee minute), latitude (decimal degree), altitude (meters). Longitude in degee minute 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. 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/aspen

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_025947
D20150620_013154		
D20150620_03031		

2		
D20150620_043219		
D20150620_055817		

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_042529	D20150714_000041	D20150608_060308	D20150605_025947
D20150701_000103	D20150715_005959	D20150615_020937	

D20150701_030006		D20150615_033326	
D20150701_060009		D20150620_001455	
D20150701_090146		D20150622_085813	
D20150702_030004		D20150706_030349	
D20150702_060002		D20150715_070508	

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_020807	D20150611_060016
D20150716_060102	D20150710_050449	D20150626_044916
	D20150713_063126	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

		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_000023	D20150711_235959
D20150622_082653	

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_042529	D20150715_035716	D20150715_070508	D20150612_040449	D20150714_045922
	D20150620_055817	D20150706_030349	D20150605_025947	D20150713_034439
	D20150704_045923	D20150622_085813	D20150701_040005	D20150715_062259
	D20150705_002018	D20150620_001455	D20150617_030452	D20150715_052342
	D20150714_000041	D20150615_033326	D20150617_041540	D20150709_024738
	D20150622_030021	D20150615_020937	D20150714_034522	D20150611_060016
	D20150622_060009	D20150608_060308	D20150714_015959	D20150625_012958
	D20150624_000	D20150602_032	D20150716_050	D20150624_034

	127	319	017	448
	D20150626_030008	D20150610_060544	D20150611_031449	D20150622_060008
	D20150625_030036	D20150610_001634	D20150713_041500	D20150622_043050
	D20150701_090003	D20150603_043011	D20150617_052004	D20150617_061220
	D20150701_073045	D20150605_043010	D20150701_050020	D20150617_013016
	D20150624_060018	D20150604_055907	D20150701_025951	D20150706_055834
	D20150626_041729	D20150603_025905	D20150617_063420	D20150624_051608
	D20150701_055928	D20150603_013003	D20150615_020807	D20150617_025037
	D20150620_085933	D20150602_030258	D20150611_062409	D20150617_035026
	D20150622_012949	D20150604_044116	D20150615_030001	D20150702_044409
	D20150622_090011	D20150604_034736	D20150611_040844	D20150623_214352
	D20150622_042846	D20150605_060329	D20150612_022938	D20150713_073145
	D20150620_000110	D20150603_000550	D20150713_011519	D20150713_051501
	D20150620_013154	D20150611_025527	D20150625_044402	D20150716_020328
	D20150621_235817	D20150610_025935	D20150625_033914	D20150713_061504
	D20150620_030312	D20150612_025830	D20150709_043043	D20150716_040207
	D20150620_043219	D20150612_042942	D20150625_022950	D20150714_031503
	D20150703_030020	D20150608_030311	D20150625_005940	D20150716_030051
	D20150703_060031	D20150611_043625	D20150713_024459	D20150715_074738
	D20150708_020011	D20150610_013004	D20150711_070438	D20150701_085928
	D20150706_061908	D20150606_030016	D20150711_083345	D20150624_235952
	D20150702_040518	D20150622_055923	D20150711_050003	D20150713_004452
	D20150704_070020	D20150612_012940	D20150625_054623	D20150602_030652
	D20150705_030	D20150612_060	D20150624_055	D20150711_070

	104	633	943	339
	D20150704_025933	D20150714_000046	D20150624_025947	D20150711_045932
	D20150705_055952	D20150712_055001	D20150716_005958	D20150709_034742
	D20150715_024424		D20150709_032645	D20150709_013557
	D20150715_020000		D20150711_075948	D20150709_051135
	D20150706_025935		D20150716_033925	D20150617_050006
	D20150702_022652		D20150713_063126	D20150709_061908
	D20150705_235953		D20150714_050007	D20150622_000044
	D20150626_000146		D20150709_062129	D20150622_030058
	D20150702_055910		D20150709_011502	D20150612_000043
	D20150701_022755		D20150709_072605	D20150604_043112
	D20150626_060025		D20150713_053502	D20150612_025957
	D20150624_013518		D20150713_080255	D20150612_074253
	D20150714_020000		D20150715_060346	D20150615_041523
	D20150715_055940		D20150715_235958	D20150622_013013
	D20150708_060004		D20150624_042948	D20150606_013447
	D20150716_040033		D20150709_022727	D20150625_030024
	D20150716_060102		D20150710_015504	D20150701_065935
	D20150624_030039		D20150710_004510	D20150712_195230
	D20150716_050001		D20150706_042959	D20150710_021509
	D20150709_020000		D20150710_030018	D20150701_080011
	D20150716_010001		D20150604_060009	D20150701_050121
	D20150715_070214		D20150603_000126	D20150710_042513
	D20150712_025		D20150615_041	D20150713_021

	959		448	540
	D20150709_060023		D20150603_030027	D20150604_033018
	D20150710_000001		D20150604_043114	D20150612_044300
	D20150712_054958		D20150603_042637	D20150606_030036
	D20150710_040027		D20150706_065543	D20150604_060102
	D20150712_012959		D20150706_032500	D20150611_043314
	D20150710_051539		D20150710_050449	D20150604_001100
	D20150711_000001		D20150710_040539	D20150606_043035
	D20150711_020002		D20150716_020302	D20150615_021313
	D20150711_060001		D20150604_023210	D20150615_030410
	D20150711_035958		D20150604_033433	D20150701_040027
	D20150709_040000		D20150612_051828	D20150701_055947
	D20150710_060002		D20150611_020001	D20150710_032013
	D20150715_234348		D20150603_013738	D20150626_021516
	D20150712_042958		D20150716_054939	D20150701_030000
	D20150709_000001		D20150706_022325	D20150625_041641
	D20150708_040007		D20150705_030104	D20150626_070144
	D20150715_005959		D20150701_235507	D20150625_060554
	D20150714_235959		D20150626_043010	D20150701_015924
	D20150710_015958		D20150702_031604	D20150626_034711
	D20150711_235631		D20150702_041050	D20150626_044916
	D20150710_070001		D20150702_020137	D20150709_072622
	D20150716_030028		D20150701_012957	D20150706_030507
	D20150714_060		D20150701_065	D20150710_011

	001		955	508
	D20150716_020002		D20150626_030057	D20150706_040818
	D20150714_040001		D20150702_060422	D20150705_030414
			D20150701_090024	D20150702_005923
			D20150701_060000	D20150702_024733
			D20150702_065941	D20150702_063721
			D20150626_061349	D20150702_034449
				D20150706_014418