# 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 Hayes, 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 night time 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 May 25 and July 28, 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 |

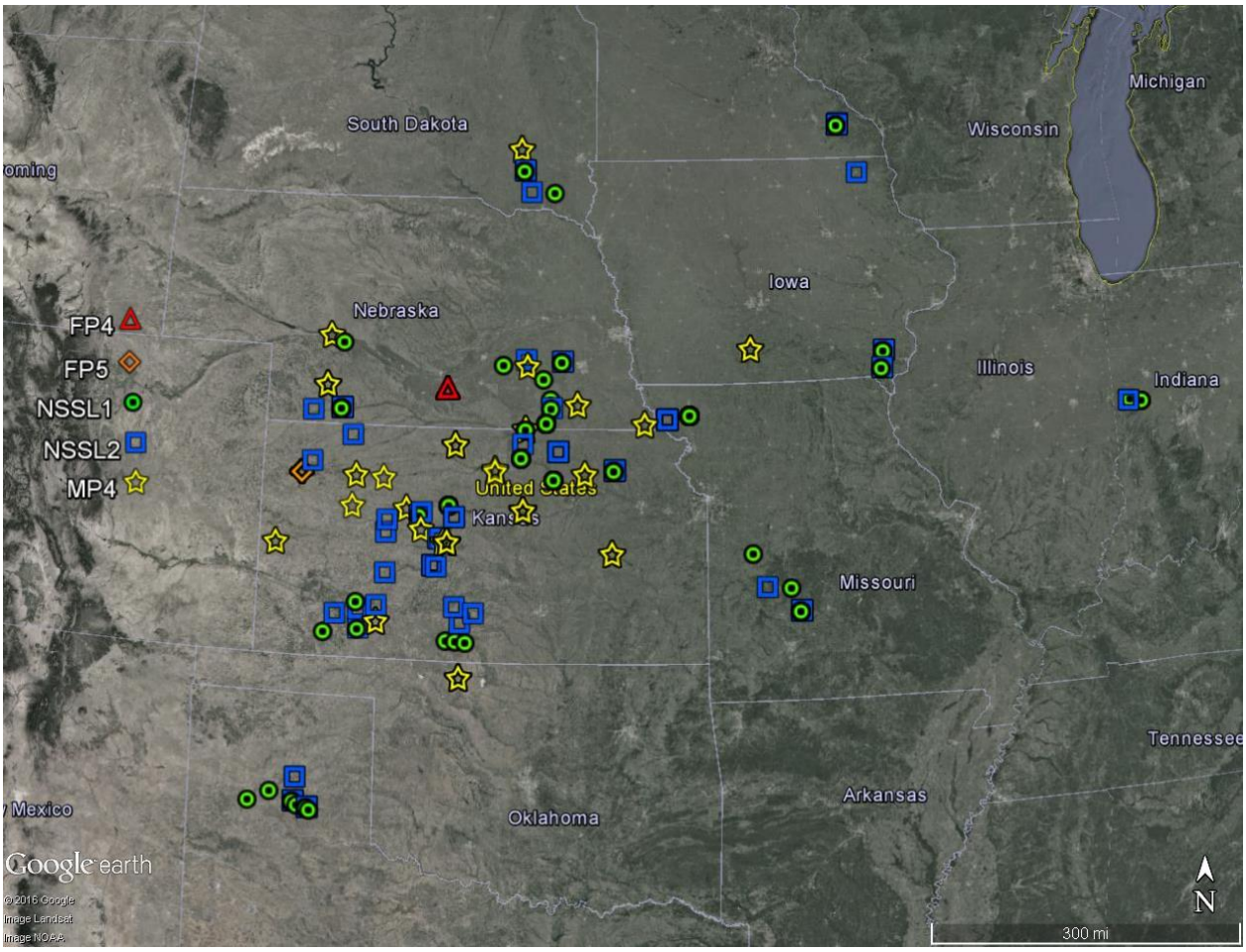


**Figure 1. Map of all radiosonde launch locations from FP4, FP5, MP4, NSSL1 and NSSL2**

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_P.QC.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 establisted 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 Vaisala RS92 humidity sensors are heated by the sun during daytime and as a result report humidity values, which 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 | NSSL1 | NSSL2 |
|---|---|---|---|---|---|
| **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, which 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, which 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_030312 | | |
| 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_000127 | D20150602_032319 | D20150716_050017 | D20150624_034448 |
| | 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_030104 | D20150612_060633 | D20150624_055943 | D20150711_070339 |
| | 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_025959 | | D20150615_041448 | D20150713_021540 |
| | 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 |
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