Profiling of Winter Storms (PLOWS) 2009-2010
Quality Controlled Radiosonde Data Set

Contents:

I. Project/Sounding Dataset Overview
II. EOL file format
III. Data File Specifics
IV. Data Quality Control and Results

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For information on the NCAR/EOL Mobile In-Situ Sounding System (MISS) used at this project please visit: http://www.eol.ucar.edu/instrumentation/sounding/iss/mobile-iss-miss

I. MISS Project/Dataset Overview

The Profiling of Winter Storms (PLOWS) project was a study focused on examining winter cyclones and associated fronts and precipitation bands, in Illinois and surrounding states (Figure 1). The project included two field phases. The first phase was conducted during February and March of 2009, during which time 14 radiosonde sounding files were collected. The second phase of PLOWS took place between November 2009 and March 2010. Both phases employed the use of a Mobile Integrated Sounding System (MISS), which is a suite of instruments that includes a GPS Advanced Upper-air Sounding System (GAUS). During this most recent PLOWS campaign, 105 radiosondes were deployed and each is contained in the final quality controlled archive. This document contains information on the sounding file format, data parameters included in each of the files, and details regarding the quality control measures applied to the sounding data set.

The NCAR/EOL GPS Advanced Upper-air Sounding system (GAUS) incorporates Vaisala RS92 radiosondes, has portability, built-in test capability, and delivers users high precision GPS measurements of radiosonde positions. The Vaisala RS92 radiosonde delivers high quality wind measurements with code-correlating GPS technology, as well as pressure, temperature and humidity measurements all transmitted digitally to the receiving station. Digital technology reduces missing data due to noise and increases overall reliability of the system. The Vaisala RS92 provides much better humidity measurements with a heated twin-sensor design and incorporates a reconditioning procedure before launch.

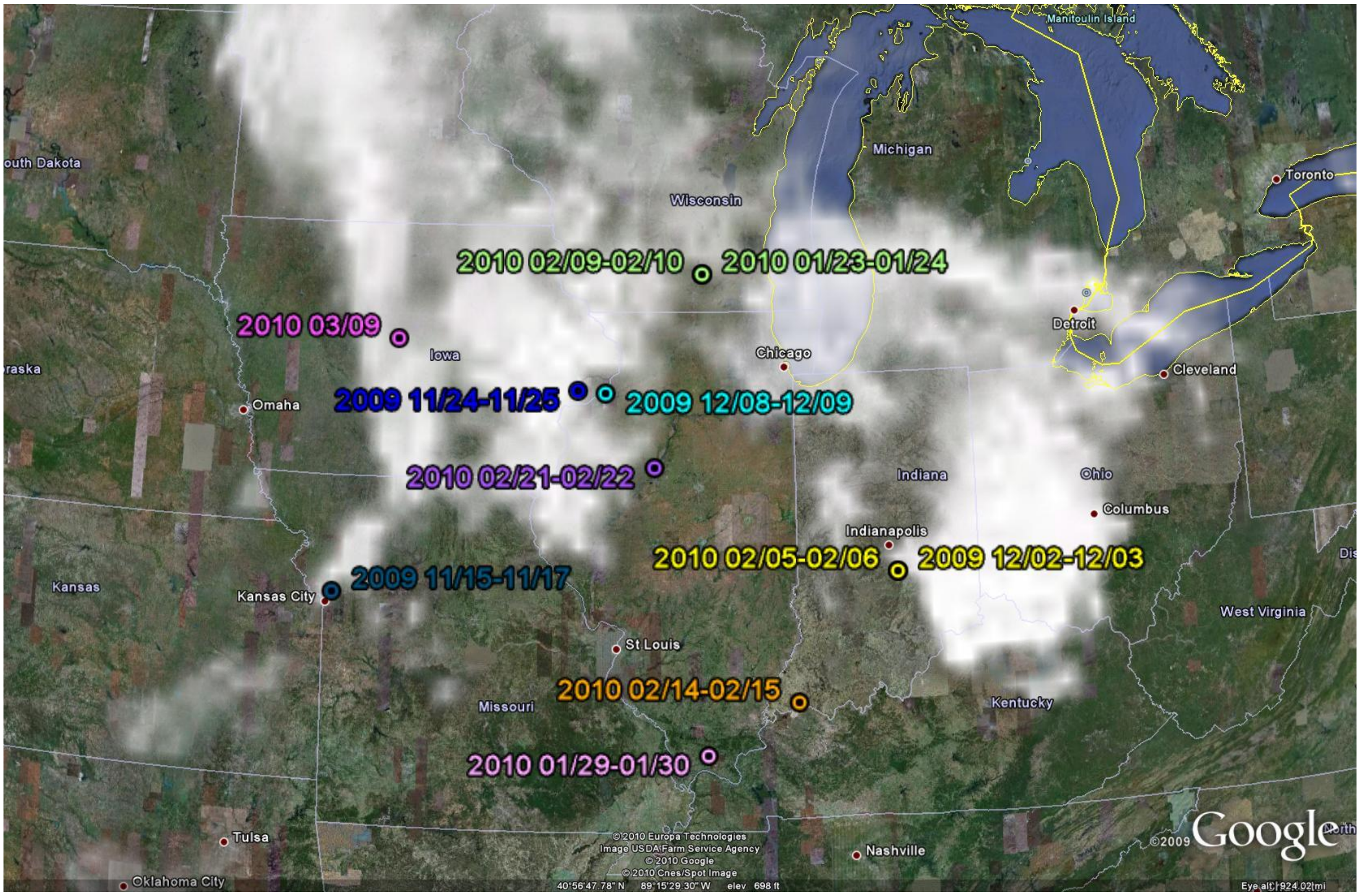

Figure 1. Map shows radiosonde launches performed by the MISS system. Each color on the map indicates launches made on a particular set of days.

II. EOL File Format

The EOL format is an ascii text format that includes a header, with detailed project and sounding information, and seventeen columns of high resolution data (Table 1). The "D" 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.1QC.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 ".eol" refers to the file format type

The header records contain information including data type, project name, site location, actual release time, and other specialized information. The first seven header lines contain information identifying the sounding. The release location is given as : lon (deg min), lon (dec. deg), lat (deg min), lat (dec. deg), altitude (meters). Longitude in deg min is in the format: ddd mm.mm'W where ddd is the number of degrees from True North (with leading zeros if necessary), mm.mm is the decimal number of minutes, and W represents W or E for west or east longitude, respectively. Latitude has the same format as longitude, except there are only two digits for degrees and N or S for north/south latitude. The following three header lines contain information about the aircraft data system and auxiliary information and comments about the sounding. The last 3 header lines contain header information for the data columns. Line 12 holds the field names, line 13 the field units, and line 14 contains dashes (--- characters) signifying the end of the header. Data fields are listed below in Table 2.

```
Data Type/Direction:                    GAUS SOUNDING DATA/Ascending
File Format/Version:                    EOL Sounding Format/1.0
Project Name/Platform:                  PLOWS/NCAR GAUS
Launch Site:                            IOP 3
Launch Location (lon,lat,alt):          90 29.60'W -90.493405, 44 01.30'N 44.021598,   305.30
UTC Launch Time (y,m,d,h,m,s):          2009, 02, 26, 19:07:08
Sonde Id/Sonde Type:                    082033957/Vaisala RS92-SGP (ccGPS)
Reference Launch Data Source/Time:      Campbell Scientific CR10/19:07:26.00
System Operator/Comments:               lou/lost everything at approx 675mb, No PTH
Post Processing Comments:               Aspen Version 2.8.1.8, 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
```

Table 1. Example of the EOL format used for both dropsonde and radiosonde sounding files

Field No.	Parameter	Units	Measured/Calculated
1	Time	Seconds	-------------
2	UTC Hour	Hours	-------------
3	UTC Minute	Minutes	-------------
4	UTC Second	Seconds	-------------
5	Pressure	Millibars	Measured
6	Dry-bulb Temp	Degrees C	Measured
7	Dewpoint Temp	Degrees C	Calculated
8	Relative Humidity	Percent	Measured
9	U Wind Component	Meters/Second	Calculated
10	V Wind Component	Meters/Second	Calculated
11	Wind Speed	Meters/Second	Measured

12	Wind Direction	Degrees	Measured
13	Ascension Rate	Meters/Second	Calculated
14	Geopotential Altitude	Meters	Calculated
15	Longitude	Degrees	Measured
16	Latitude	Degrees	Measured
17	GPS Altitude	Meters	Measured

Table 2. Lists all parameters provided in the sounding files, their unit of measurement, and if the values are measured or calculated.

III. Data File Specifics

The files contain data calculated at one-second intervals. The variables pressure, temperature, and relative humidity are calibrated values from measurements made by the radiosonde. The dew point is calculated from the relative humidity and temperature. The geopotential altitude is calculated from the hydrostatic equation using pressure, temperature, and relative humidity. The rate of ascent is calculated from pressure. The radiosonde position (lat, lon, GPSAlt) and winds are measured by use of a GPS receiver in the radiosonde. The quality of the GPS altitude is somewhat questionable. The accuracy of the sensor is typically +/-30 m, and may show large variability. For this reason, investigators are encouraged to use geopotential altitude over GPS altitude. These raw wind values are subjected to a digital filter to remove low frequency oscillations due to the radiosonde pendulum motion beneath the balloon when run through NCAR's Atmospheric Sounding Processing ENvironment (ASPEN) software.

IV. Data Quality Control and Results

1. Profiles of the raw soundings are first examined to determine if there are any errors with the launch detect, or if system lock-up occurred, as a result of weaken of the radiosonde signal, which could result in a loss of data and an incorrect launch time.

2. All of the soundings are then subjected to a radiation correction that takes into account the solar angle at time of launch, and removes solar heating that could skew the temperature measurements.

3. 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.

4. The raw soundings are run through ASPEN, which analyzes the data, performs smoothing, and removes suspect data points.

5. We create profiles of temperature, RH, wind speed and wind direction of the quality controlled soundings which enable us to visually evaluate the soundings for outliers, or any other obvious problems.

6. Lastly, we examine skew-t diagrams from each sounding.

Performing the QC steps above allows us to identify and, in some cases, correct errors that could potentially impact research performed using these data sets. During processing of the sounding data the following issues were found, and where possible, corrections were applied:

1. One radiosonde experienced an error with the automatic launch detect. This occurs most often when the radiosonde is not able to collect a sufficient amount of surface data prior to launch. The result is a delay in the launch detect mechanism, which relies on change in pressure to determine when the balloon release occurs. No data is lost, but data recorded prior to launch detect is recorded as “pre-launch” rather than “in-flight”, and the filenames and launch times are incorrect. This sounding file was corrected and the original and new filenames are listed below.

Original Filename	Corrected Filename
D20091203_055107_P.1	D20091203_053155_P.1

2. Four soundings required repair because the sounding system locked up during flight when the radiosonde signal was lost. The affected sounding files were not saved in the correct file format. They contained no LAU (launch) or A00 (surface met) data lines, and were missing the standard 19 line tail at the end of the file; all things necessary in order for ASPEN to run properly. Data before the lock-up was preserved, however anything measured after the lock-up has been lost. All four of the soundings reached at least 110 mb before the signals were lost. Filenames for these soundings were changed to reflect the actual launch time determined by pressure change, and accurate surface met data, from the time of launch, was retrieved and entered into the sounding files.

Original Filename	Corrected Filename
D050627.1	D20091124_053094
D081658.1	D20100124_082647
D141231.1	D20100205_142508
D232305.1	D20100214_233046

3. One file (D20091202_233256) includes data collected during a descent after icing caused the balloon package to fall for a short period of time. This file was processed through ASPEN, however since ASPEN can only handle monotonically changing pressure, it removes any portion of the file where the radiosonde experiences increasing changes in pressures. In order to preserve all of the data, the descending portion from the raw file was copied and pasted it into the quality controlled file. Data obtained during the icing event have not been quality controlled, however based on visual examination the data do look clean and free of significant errors.

4. Eight soundings, listed in the table below, were found to have problematic RH profiles. One hygrometer failed completely and returned only missing values. The other RH profiles contained artificial “dry spikes” (Figure 2) that can be attributed to one of three causes; 1. Icing on the balloon that slowed its ascent, 2. Under-filling of the balloon resulting in a slow ascent rate (below 3 m/s), 3. Extreme cold and moist environment. In cases one and two, the hygrometers were not sufficiently ventilated, because of the slow ascent. The RH sensors had not reached equilibrium with the environment (after heating) when they were turned back on, and this caused the dry spikes. For soundings in the last category, where extreme cold and moist conditions occurred concurrently, the hygrometer measurements exceeded the maximum possible relative humidity with respect to water (100%). For these soundings, RH values exceeding 100% were set to 100%. In most cases we were unable to completely correct the profiles, but did remove spikes at the affected levels, setting those values to missing or and applying additional corrections where possible (see the table below for details). We strongly urge researchers to take caution when using these RH data.

Filename	**RH Sensor Problem**	**Correction**
D20091116_024559	Moist/Cold Environment	Set RH >100% to 100% Manually removed spikes
D20091117_082826	Moist/Cold Environment	Set RH >100% to 100% Manually removed spikes
D20091117_172847	One hygrometer failed completely and produced only missing values	None
D20091202_213502	Inadequate sensor ventilation caused by slow ascent	Manually removed spikes
D20091202_233256	Moist/Cold Environment	Set noisy RH between 932-670 mb to 100%
D20091209_013416	Moist/Cold Environment	Set RH >100% to 100% Manually removed spikes
D20091209_033420	Contained one bad hygrometer	Adjusted bad RH up by 4.5%, bringing it into agreement with other sensor
D20100129_142611	Moist/Cold Environment	Set RH >100% to 100% Manually removed spikes

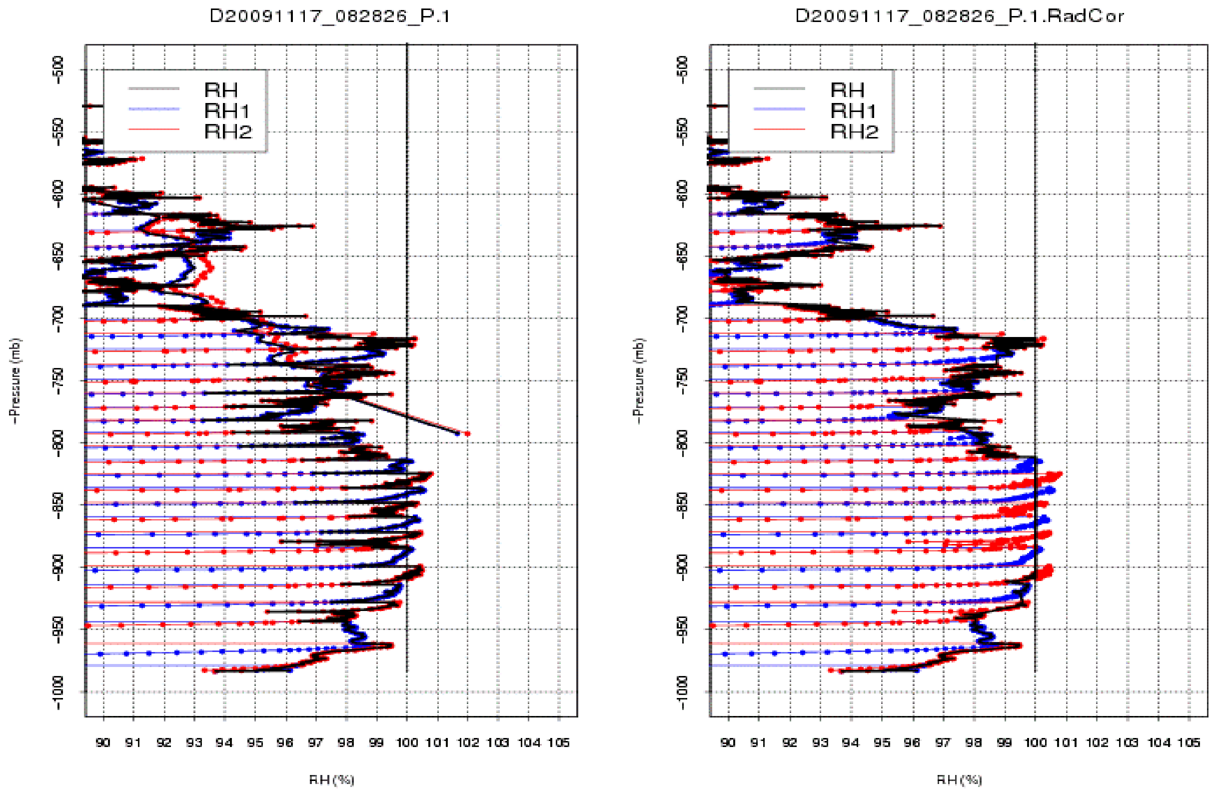

Figure 2 Left profile shows "dry spikes" caused by slow ascent which resulted in inadequate ventilation of RH sensors through a moist cloud layer. Right-hand profile shows RH (black) after corrections were applied.