Persistent Cold-Air Pool Study (PCAPS) 2010-11
Quality Controlled Radiosonde Data Set

Contents:

Contacts:

Data Quality
Kate Young
kbeierle@ucar.edu

Junhong (June) Wang
junhong@ucar.edu

ISS Group Leader
Bill Brown
wbrown@ucar.edu

System/Software
Dean Lauritsen
lauritsn@ucar.edu

Mailing Address: NCAR/Earth Observing Laboratory
P.O. Box 3000
1850 Table Mesa Drive
Boulder, CO 80307; USA

For more information on the NCAR Earth Observing Laboratory Integrated Sounding System (ISS), or on the GPS Advanced Upper-Air Sounding System (GAUS), please visit:
ISS: http://www.eol.ucar.edu/instrumentation/sounding/iss
GAUS: http://www.eol.ucar.edu/instrumentation/sounding/iss/gaus

I. ISS Project/Dataset Overview

The Persistent Cold-Air Pool Study (PCAPS) was a project whose aim was to examine atmospheric processes responsible for the evolution and dissolution of multi-day winter time temperature inversions, and evaluate their influence on pollutant transport and mixing. Researchers hope to use data collected from this campaign to determine how models can be improved to generate more accurate forecasts of persistent cold-air pool events. PCAPS took place between December 1, 2010 and February 7, 2011 in Salt Lake City Utah. It included the use of one Integrated Sounding System split between two sites. One site was equipped with a 915 MHz wind profiler, a 449 MHz wind profile, and a WXT surface meteorology station. A second site contained a sodar-Radio Acoustic Sounding System (RASS), a radiosonde sounding system, a surface meteorology tower, a microwave radiometer and a ceilometer.

Figure 1 shows the location of the site where the radiosondes were released. A total of 112 quality controlled radiosonde soundings are contained in the final archive. The average horizontal distance traveled by the radiosondes during this project was 83.9 km (52.1 miles) from surface to approximately 16.4 km.

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 Radiosonde launch location during PCAPS from Salt Lake City.

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.

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

```
Data Type/Direction:                   GAUS SOUNDING DATA/Ascending
File Format/Version:                   EOL Sounding Format/1.0
Project Name/Platform:                 GAUS v2.3.6/NCAR GAUS
Launch Site:                           PCAPS 2010 SLC
Launch Location (lon,lat,alt):         111 55.52'W -111.925303, 40 36.04'N 40.600703,  1324.97
UTC Launch Time (y,m,d,h,m,s):         2010, 11, 14, 19:16:10
Sonde Id/Sonde Type:                   094420884/Vaisala RS92-SGP (ccGPS)
Reference Launch Data Source/Time:     Campbell Scientific CR10/19:16:03.25
System Operator/Comments:              lou/none, Good Sounding
Post Processing Comments:              Aspen Version 3.0.0.0; Created on 14 May 2011 14:44 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
```

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

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

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 sonde. The raw wind values are subjected to a digital filter to remove low frequency oscillations due to the sonde pendulum motion beneath the balloon when run through NCAR's Atmospheric Sounding Processing ENvironment (ASPEN) software. The quality of the GPS altitude is somewhat questionable. The accuracy of the sensor is typically +/-20 m, and may show large variability. For this reason, investigators are encouraged to use geopotential altitude over GPS altitude.

IV. Data Quality Control and Results

1. Profiles of raw temperature, relative humidity, wind speed and ascent rate versus pressure are first 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. Corrections are made where possible to address these specific problems.

2. All of the soundings are then subjected to a radiation correction, which is applied to the temperature measurements, that takes into account the solar angle at time of launch and removes solar heating that could skew the 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 processed through ASPEN, which analyzes the data, performs smoothing, and removes suspect data points.

5. 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.

Performing the QC steps above allow 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. Three sounding files were removed from the final archive. One file (D20101014_153217) was a test launch made from Boulder, Colorado before the start of the project. The other two files (D20110116_170241_P.1 and D20110126_170059) were duplicates of other sounding files, but contained incorrect launch times.

2. Two soundings (D20101114_191610, D20101117_164038) were test/training soundings. These data files are included in the final quality controlled archive.

3. Pressure, temperature and RH data, collected from an independent ISS surface station, located in the first data line of the sounding file was replaced with data collected from the radiosonde just prior to launch. Comparisons between temperature and RH measured by the radiosonde (on the surface just before launch) and the ISS surface met station indicate a systematic offset in the temperature and RH differences calculated (Figure 2). Comparisons with the radiosonde prelaunch data, ISS surface met and another independent temperature sensor seem to indicate the biases are contained in the data reported from the ISS surface met sensor (Figure 3).

4. The files listed below were found to have problematic RH profiles. One hygrometer experienced an offset below 450 mb (Figure 4). The problem sensor was identified as that which failed to reach 0% during the heating cycle. This profile was corrected by subtracting 4% from measurements made by the RH1 sensor, below 450 mb, bringing it into agreement with the second hygrometer. The other two files contained artificial "dry spikes" that can be attributed to under-filling of the balloon (Figure 5). This can occur if the hygrometers are not sufficiently ventilated due to the slow ascent rate (below 3 m/s) of the balloon. In these cases, the RH sensors are unable to reach equilibrium with the environment (after heating) when they are turned back on, which results in artificial "dry spikes". These files were corrected by replacing RH values where the spikes occur with missing values.
   Additionally, one of these radiosondes (D20110117_170915) encountered a vertical downdraft that caused the radiosonde to descend for intermittent periods of time during its flight. This file was processed through ASPEN, however because 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 include these unique feature in the final sounding file, we use the raw data from where the balloon descends and copy it into the quality controlled file. Data obtained during these downdraft events have not been quality controlled, however based on visual examination the data do look clean and free of significant errors.

Filename	RH Sensor Problem
D20110115_171503	4% offset (RH1)
D20110117_170915	Slow ascent rate **and downdraft**
D20100130_141450	Slow ascent rate

5. The soundings listed below experienced errors with the automatic launch detect, which relies on change in pressure to determine when the balloon release occurs. In these cases, the launch detect was triggered early. No data is lost when this occurs, however data recorded prior to launch is incorrectly recorded as "in-flight" rather than "pre-launch", and the filenames and launch times are incorrect. These soundings have all been corrected for premature launch detect and the original and new filenames are listed below.

Original Filename	Corrected Filename
D20110103_052738	D20110103_052804
D20110106_115627	D20110106_111621
D20110117_172221	D20110117_170915

6. The following sounding files needed repair because they experienced sounding system lock-up 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, and were missing the standard 19 line tail at the end of the raw data file; all things necessary in order for ASPEN to run properly. Data before the lock-up was preserved, however anything measured by the radiosonde after the lock-up was lost. Filenames for these soundings were changed to reflect the actual launch time, determined by pressure change and GPS dz/dt, and surface met data collected just prior to launch was retrieved and entered into the sounding files.

New Filenames with Corrected Launch Times
D20110111_171507
D20110126_172049
D20110116_171505

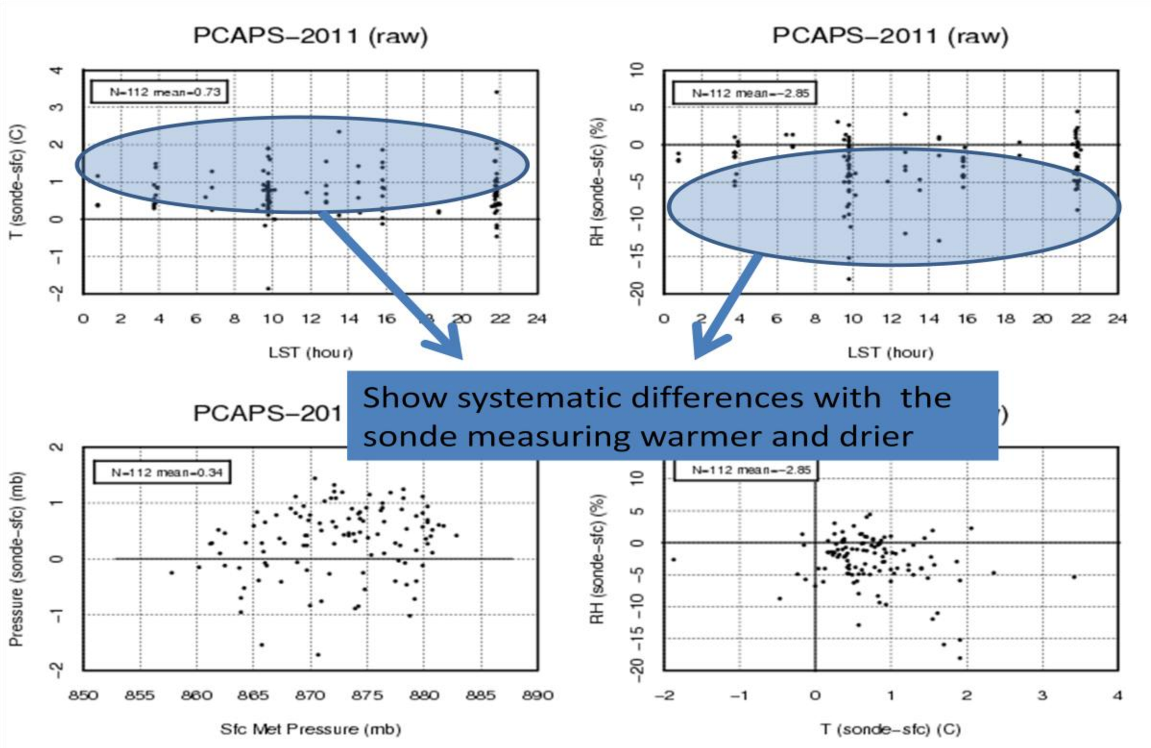

Figure 2 Comparisons between radiosonde data collected just prior to launch and the ISS surface met data. The upper left plot shows differences in temperature versus local standard time (LST). The upper right shows RH differences versus LST. The bottom left show differences in surface pressure, and the bottom right show temperature differences versus RH differences. The upper most plots indicate a systematic bias with the radiosondes measuring warmer and drier than the surface met data.

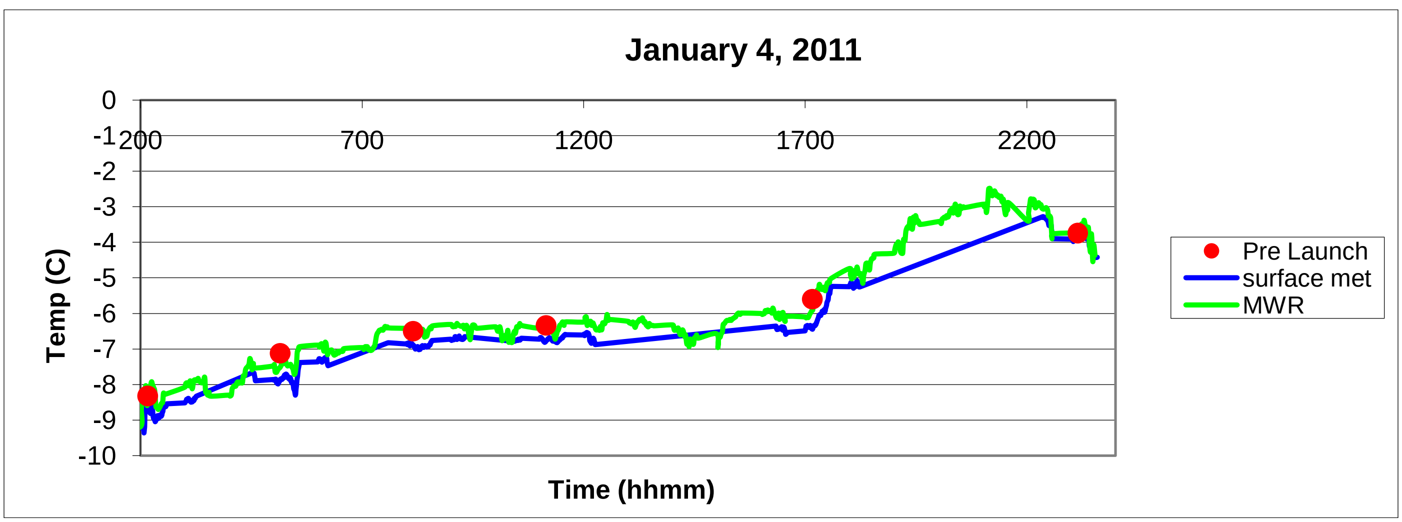

Figure 3 Graph shows temperature comparisons versus Universal Time between the pre-launch radiosonde data (red), the ISS surface met station (blue) and an independent temperature sensor mounted on a microwave radiometer (green). Results seem to indicate a bias in the measurements coming from the ISS surface met station.

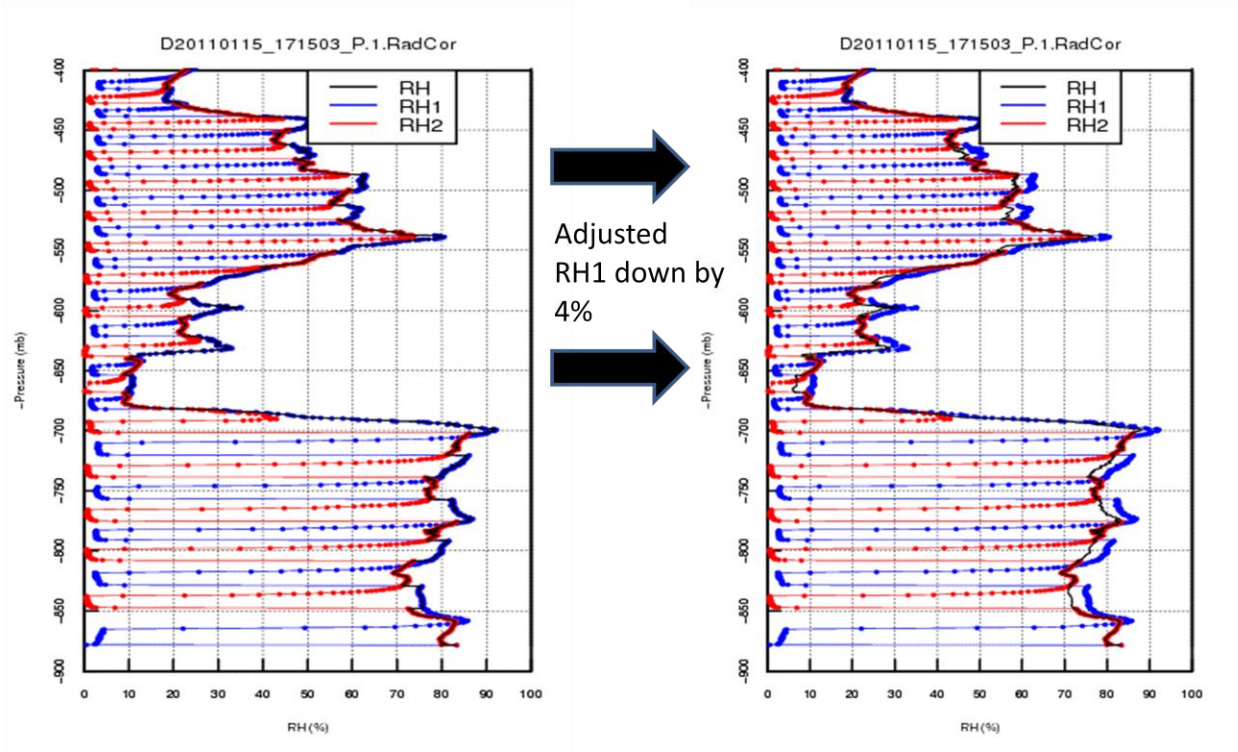

Figure 4 Panel on the left shows a 4% offset of the RH1 sensor (blue) below 450 mb. Figure on the right shows combined RH profile (black) after -4% correction is applied to RH1 to bring it into agreement with RH2.

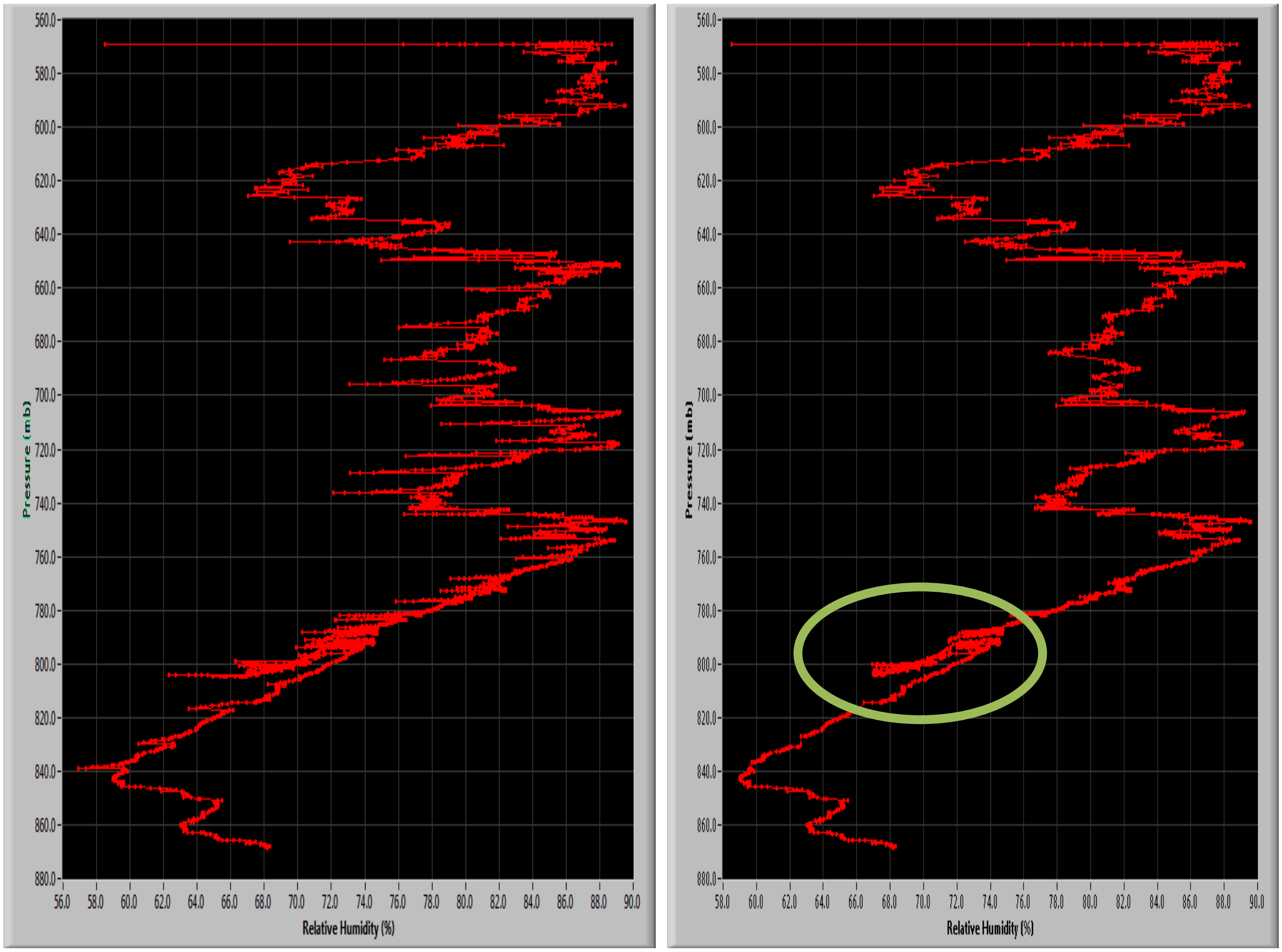

Figure 5 Plots of sounding file D20110117_170915 show the raw combined RH profile with artificial dry spikes (left) caused by slow ascent rate. Right-hand panel shows raw data where the dry spikes were manually removed by setting RH values to missing values. Additionally, this radiosonde encountered a vertical downdraft which caused the balloon to descend for a brief period of time (green circle).