Inhibition of Snowfall by Pollution Aerosols (ISPA) 2010
Quality Controlled Radiosonde Data

Contents:

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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/rtf/facilities/iss/
GAUS: http://www.eol.ucar.edu/rtf/facilities/gaus.html

I. Project/Dataset Overview

The Inhibition of Snowfall by Pollution Aerosols (ISPA) was the third phase of a field campaign performed to better quantify the amount of water in snow pack lost due to pollution aerosols. The first and second phases of ISPA took place in 2002 and 2007. The third phase was conducted during January and February 2010. ISPA was organized by the Desert Research Institute (DRI) and each phase took place near Steamboat Springs, Colorado. The primary site was located on Mount Werner at the Storm Peaks Laboratory (SPL), and a GPS Advanced Upper Air Sounding System (GAUS), operated by the National Center for Atmospheric Research, was located near the base of the Steamboat ski resort (Figure 1). A total of 32 radiosonde launches were made from the GAUS site (Figure 2). In addition to the radiosonde sounding system, there were a suite of surface meteorology instruments, a microwave radiometer, microwave rain radar and a laser distrometer.

The NCAR/EOL GPS Advanced Upper-air Sounding system (GAUS) incorporates Vaisala RS92 radiosondes, has portability, built-in test capability and flexibility for multiple channel operations, and delivers users high precision GPS measurements of radiosonde positions. The Vaisala RS92 radiosonde delivers high quality wind measurements from the ground 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.

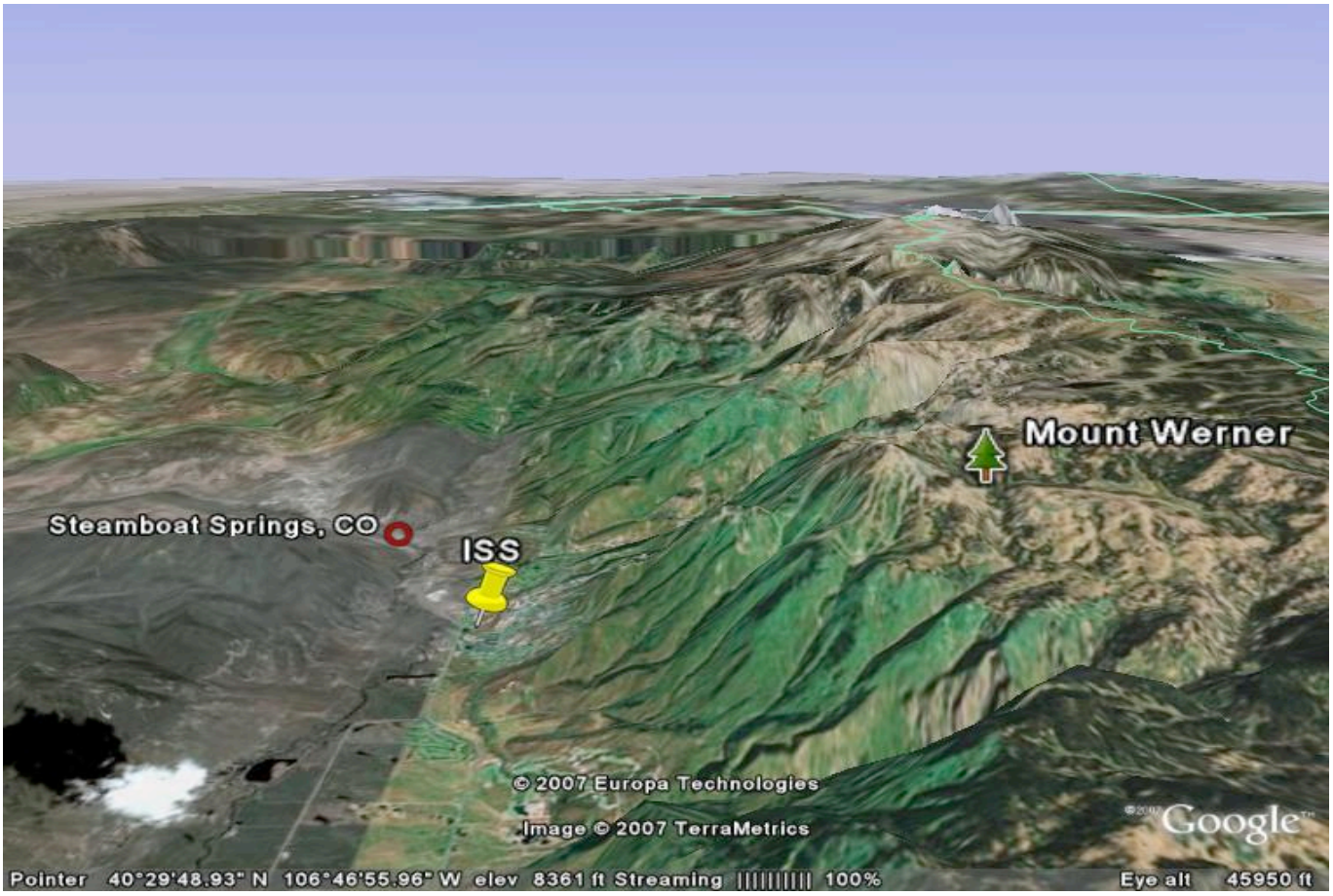

Figure 1 Radiosonde launches were made from the GAUS site in Steamboat Springs, CO. This map shows the proximity of the GAUS location to DRI's Storm Peak Lab located on Mount Werner.

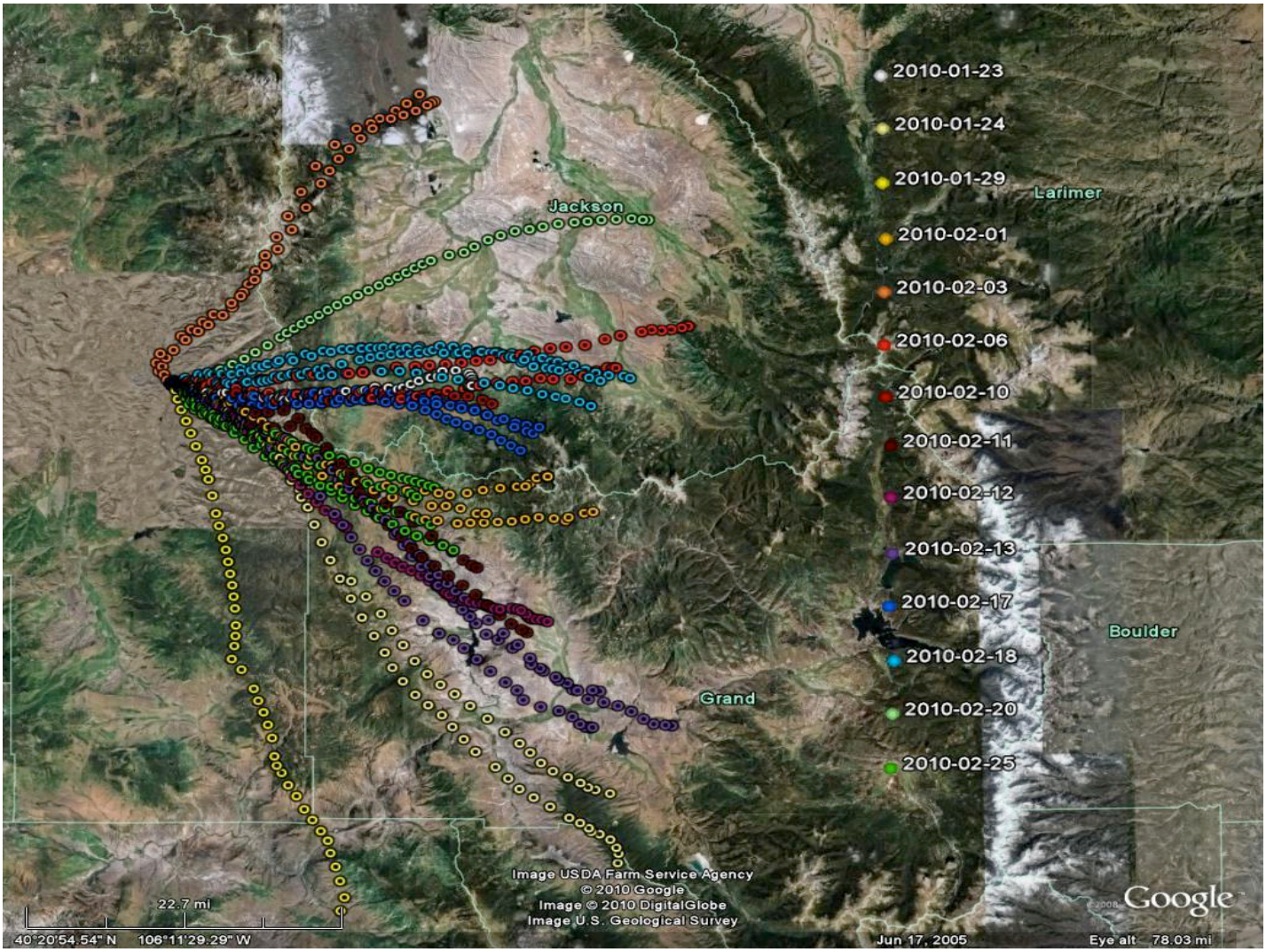

Figure 2. Shows flight tracks of soundings launched during the ISPA 2010 project

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:                  ISPA 2010/NCAR GAUS
Launch Site:                            Steamboat Springs, CO
Launch Location (lon,lat,alt):          106 49.02'W -106.816973, 40 27.85'N 40.464107,
2096.50
UTC Launch Time (y,m,d,h,m,s):          2010, 01, 23, 17:08:54
Sonde Id/Sonde Type:                    082023890/Vaisala RS92-SGP (ccGPS)
Reference Launch Data Source/Time:      Vaisala WXT510/17:08:54.23
System Operator/Comments:               Tim/small band of snow showers 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 new 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 sonde. These 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.

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, which could result in a loss of data near the surface and an incorrect launch time, or if system lock-up occurred, resulting in loss of data at higher altitudes

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 (Figure 2) of the raw data are created to check differences in pressure, temperature and RH between independent surface met measurements and the last available surface radiosonde measurement before launch.

4. The soundings are run through EOL's Atmospheric Sounding Processing ENvironment (ASPEN), which analyzes the data, performs smoothing, and removes suspect data points.

5. Lastly, we create profile plots of the quality controlled temperature, RH, wind speed and wind direction, versus both pressure and geopotential altitude. These enable us to visually evaluate the soundings for outliers, or any other obvious problems.

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 corrections were made:

1. One sounding, D20100124_193345_P.1QC.eol, experienced a loss of signal which caused termination of the data stream at 365 mb. The signal was later reacquired, at 285 mb; however data retrieved above that pressure level was stored in a separate sounding file. These data files were concatenated into one file, however measurements made between 365 mb and 285 mb could not be recovered.

2. Three soundings, listed below, needed repair because of a "rushed launch", where launch occurs before all steps of the sounding software have been completed. This caused an error in the automatic launch detect, which uses pressure change to determine time of release and requires at

least one minute of surface data to accurately detect launch. For these, some of the data near the surface was lost.

Files with a "rushed launch"
D20100206_193034_P.1QC.eol
D20100217_212328_P.1QC.eol
D20100225_210555_P.1QC.eol

3. Differences between the last radiosonde surface measurement before launch and the surface met sensor measurement can be seen in Figure 2 below. While these plots are of raw sounding data, to some degree, differences do carry over to the final product. The temperature and relative humidity plots show large variability that could likely be attributed to the radiosonde being released above ground cleared of snow, while the surface met sensor was located approximately 5 feet away from the plowed road, in a snowy field. The operators took care to aspirate the radiosondes and allow ample time for the radiosonde sensors to adjust to the environment, however significant differences can still be seen. Fairly consistent pressure differences, with the radiosondes measuring approximately 1 mb greater than the surface met (lower left-hand plot), are consistent with pressure differences seen during prior phases of ISPA, but are not fully understood. It is suspected the cause may be a bias in the surface met pressure sensor. In cases where radiosonde pressures are greater than those measured by the surface met, ASPEN will discard the data because it considers the surface met as "truth" and can only handle pressure change in one direction. In order to preserve the near surface radiosonde data, the files were run through ASPEN, but then the discarded data was reentered into the final data product.

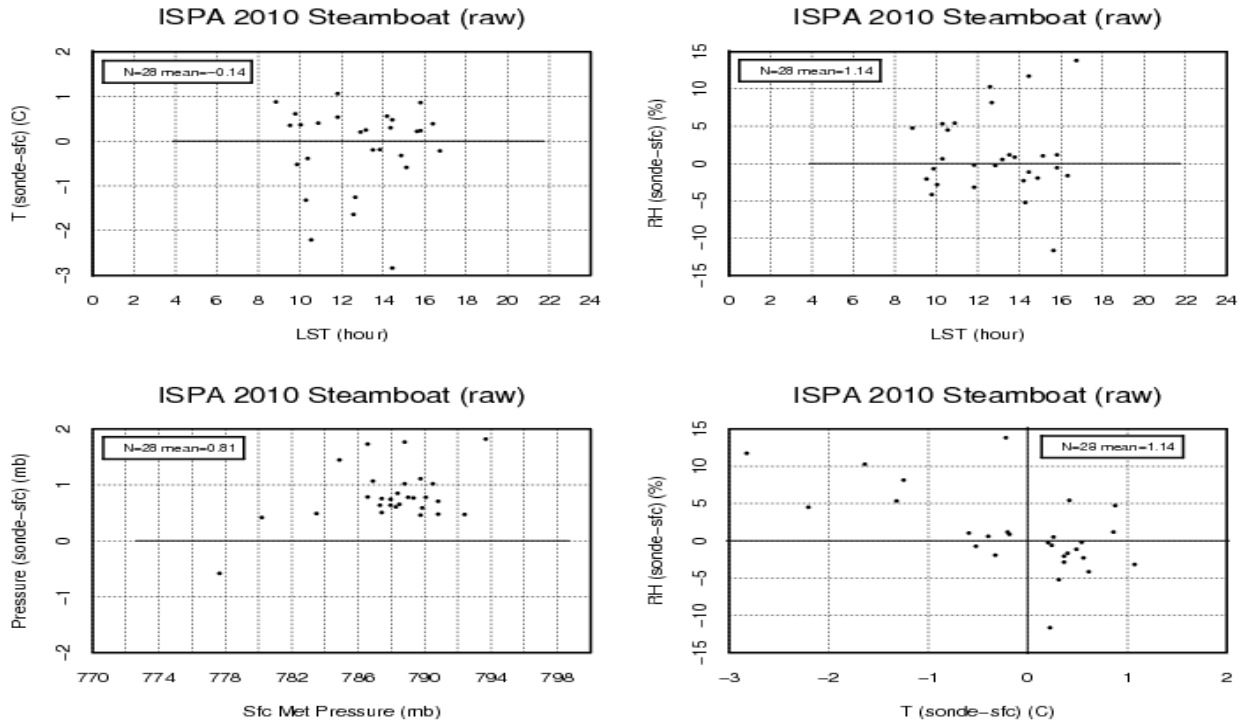

Figure 2 Scatter plots of differences calculated between the last sonde data measurement taken at the surface and the measurements taken by the surface met station show large scatter, in temperature and RH, which may be attributed to differences in ground conditions below the sensors