Isotopic Fractionation in Snow

IFRACS 2014 Radiosonde Data Quality Report

July 7

2014

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., J. Wang, W. Brown and D. Lauritsen, 2014: IFRACS 2014 quality controlled radiosonde data set.

Isotopic Fractionation in Snow (2014)
Quality Controlled Radiosonde Dataset

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I. Dataset Overview

The Isotopic Fractionation in Snow experiment (IFRACS) is a meteorological research program conducted near Steamboat Springs, CO (Figure 1). This campaign was designed to investigate whether or not the degree of riming on the snow crystals could be determined by measuring the isotopic content of the snow. Riming is important because it greatly influences the amount of water content the snow crystals hold. The amount of riming depends on many factors such as temperature, humidity, aerosols, and pollution. Isotopic, cloud droplet, aerosol, and other in-situ measurements were made at the Desert Research Institute's (DRI) Storm Peak Lab on top of Mt. Werner in Steamboat Springs. For this project, NCAR/EOL deployed one GPS Atmospheric Sounding System (GAUS). For more information on this system please visit: https://www.eol.ucar.edu/node/148.

The sounding system was located approximately 2.2 miles southeast of downtown Steamboat Springs (Figure 2). Sixty-four radiosonde launches were performed from between January 17 and February 28, 2014. 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.

For more information on the IFRACS project please visit: https://www.eol.ucar.edu/field_projects/ifracs.

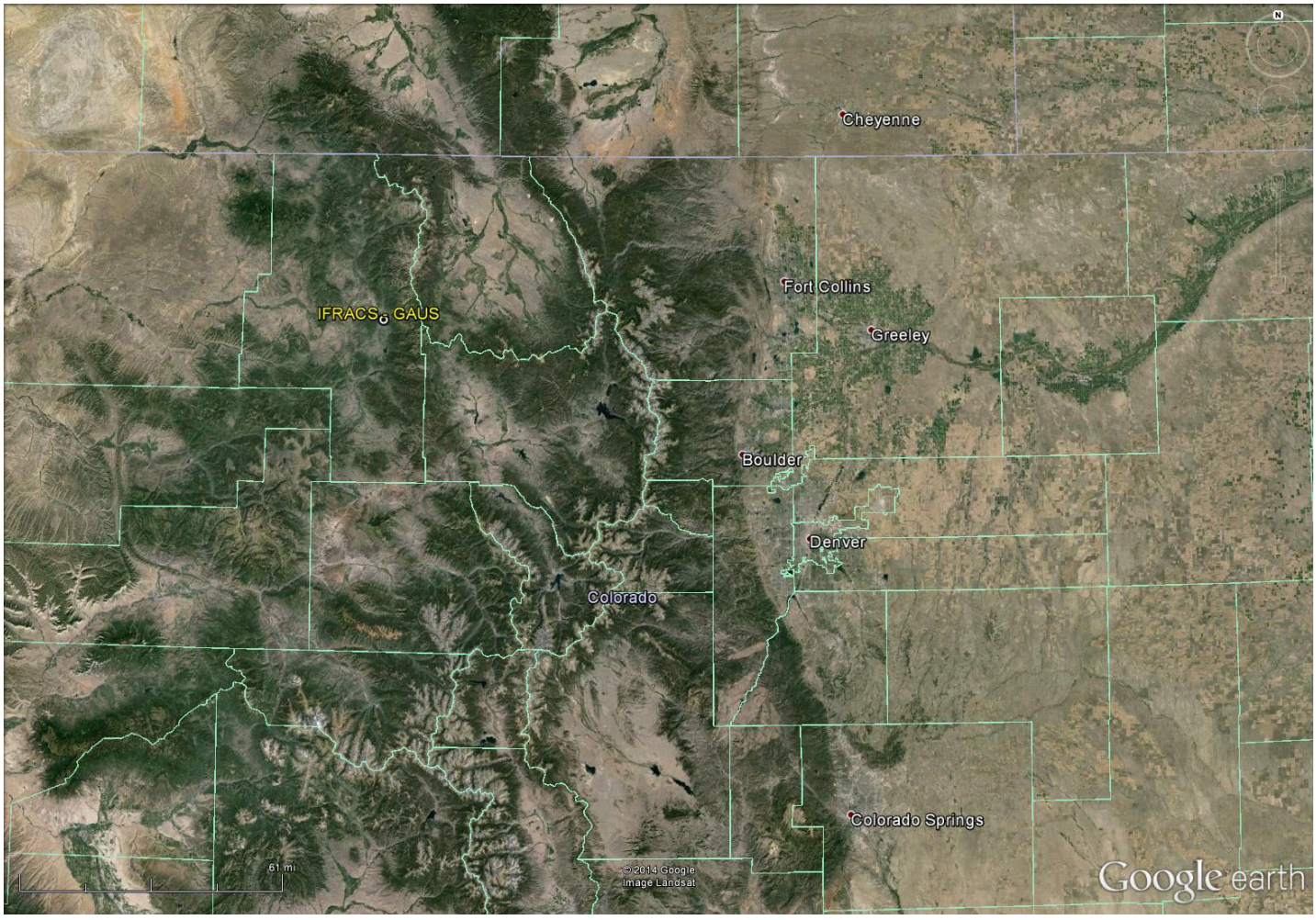

Figure 1. Regional map showing IFRACS location in Colorado

Figure 2. Satellite image of Steamboat Springs showing location of the GAUS and Storm Peak Laboratory

II. EOL Sounding File Format and Data Specifics

The EOL format is an ASCII text format that includes a header (Table 1), with detailed project and sounding information, and seventeen columns of high resolution data (Table 2). 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.1.PreCorr.SRcorr.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: 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 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.

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.

Table 1 - EOL Sounding File Format (dropsonde and radiosonde)

```
Data Type/Direction:                    GAUS SOUNDING DATA/Ascending
File Format/Version:                    EOL Sounding Format/1.1
Project Name/Platform:                  IFRACS/NCAR GAUS
Launch Site:                            clear air intercomparison
Launch Location (lon,lat,alt):          106 48.83'W -106.813863, 40 27.37'N 40.456245,  2052.00
UTC Launch Time (y,m,d,h,m,s):          2014, 01, 17, 17:54:28
Sonde Id/Sonde Type:                    001523124/Vaisala RS92-SGP (ccGPS)
Reference Launch Data Source/Time:      Campbell Scientific CR10/17:54:31.00
System Operator/Comments:               Tim and Linda danter/sounding performed in conjunction with Hayden clear wx sounding, Good Sounding
Post Processing Comments:               Aspen Version 3.1; Created on 19 Jun 2014 21:28 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 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	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	Descent Rate	Meters/Second	Calculated

14	Geopotential Altitude	Meters	Calculated
15	Longitude	Degrees	Measured
16	Latitude	Degrees	Measured
17	GPS Altitude	Meters	Measured

III. Data Quality Control Process

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 (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 (Figure 3). 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.

3. All of the data files were adjusted to correct initial geopotential surface heights. A geometric surface height, from the site, was obtained. This height was then converted to geopotential height, by taking into account latitude at the site location. This ensures an accurate starting point for the geopotential altitude calculation.

4. A pressure ground check (GC) correction is applied to the entire profile for most soundings (see exceptions in table below). The surface pressure measured by an independent surface sensor is used as a reference for the 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 ground check pressure as indicated by the reference sensor, and P_0^{RS} is the ground check pressure as indicated by the radiosonde on the ground.

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

6. 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.

7. 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.

IV. Special Problems to Note (Important Information for Users)

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 were found, and where necessary, corrections were applied:

1. Two sounding files experienced early launch detect. Below is a table provides the original filename and new filenames, based on accurate time of release. D20140209_200121 was terminated early. The ascent rate of the balloon was extremely low (~1-2 m/s) and as a result the RH profile contained artificial dry spikes cause by inadequate ventilation of the sensors after the heating cycle. All RH measurements for this one file were set to missing value (999.00).

Original Filename	New Filename
D20140209_195215	D20140209_200121
D20140213_215801	D20140213_220351*

*also a 'loop sounding', see details provided in #2 below.

2. Five radiosondes encountered either vertical downdrafts or balloon icing that caused descent of the balloon package for a period of time during flight. These are referred to a 'loop' soundings because of the loop feature shown in the dzdt profile when ascent rate becomes negative and then recovers.

"Loop" Sounding Filenames	
D20140213_220351	D20140215_000322
D20140214_000513	D20140215_020134
D20140214_214002	

3. One file, D20140210_231452, experienced brief data loss near the surface as a result of the launch taking place before all steps of the sounding computer software had been completed. As a result, 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 was collected and entered into the sounding data file. **The pressure correction could not applied to these data files because the correction requires pressure data collected by the radiosonde on the ground, prior to launch, to be used as a baseline.**

4. Seven soundings, listed in the table below, were found to have questionable RH data. One data file, D20140226_015901, contained an offset of the two hygrometers. RH data for this file was removed and replaced with missing values. The other soundings listed contained suspicious RH data resulting from turbulent atmospheric conditions which, at various time, significantly slowed the ascent rate of the balloons introducing 'noisier RH data than expected' . Additional smoothing was applied to these RH profiles, however some evidence of the noise and/or artificial dry spikes may still exist. **We strongly urge researchers to take caution when using these RH data.**

Filename	**RH Sensor Problem**	**Correction**
D20140127_152302_P.1	Turbulent Atmosphere, noisy data	Additional T/RH filtering applied
D20140127_194756*	RH offset ~3%	Set all RH to missing value
D20140127_220104	Turbulent Atmosphere, noisy data	Additional P/T/RH filtering applied
D20140127_235732	35% of the data file had ascent rates less than 3 m/s	Truncated sounding above 460 mb
D20140129_235823	RH offset and 34% of data	RH all set to missing values

	file had ascent rates less than 3 m/s	
D20140130_015826	30% of data file had ascent rates less than	Increased QC filter deviation limit to 15s
D20140226_015901	Both hygrometers report suspicious RH	All RH data set to missing

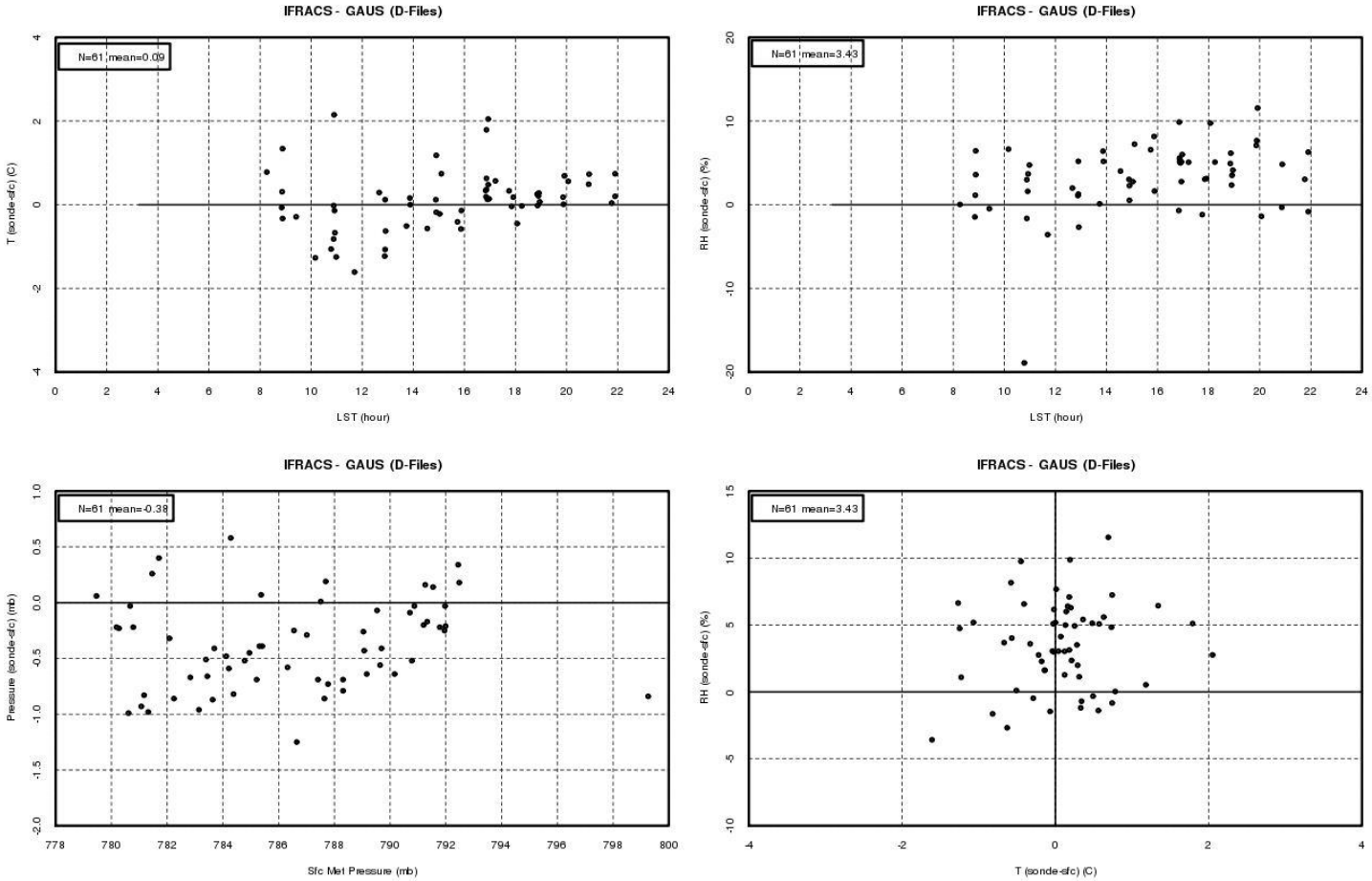

Figure 3 Plots above show measurement differences between prelaunch surface radiosonde and an independent surface met station. The upper left-hand shows differences in temperature, upper right shows RH differences, and lower left shows systematic pressure offsets on average of ~.8 mb (before correction), and lower right shows no correlation between Tdiff and RHdiff.