Mesoscale Predictablity Experiment

MPEX 2013 Dropsonde Data Quality Report

July 16

2013

The dropsonde 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 et al. (2013, J. Wang, T. Hock, D. Lauritsen: MPEX 2013 Dropsonde Data Quality Report.)

In the event that these data are used for research resulting in a publication, please include the following citations in your paper:

UCAR/NCAR – Earth Observing Laboratory. 2013. NSF/NCAR G-V Dropsonde High Resolution Data (EOL Format), Version 3.0. UCAR/NCAR – Earth Observing Laboratory.
http://doi.org/10.5065/D6ZS2TP6 Accessed 02 Aug 2016

Mesoscale Predictability Experiment (MPEX) 2013 Dropsonde Data Quality Report

National Center for Atmospheric Research *
Earth Observing Lab
Boulder, Colorado

Contacts:

Data Quality
Kate Young (kbeierle@ucar.edu)
Holger Vömel (voemel@ucar.edu)

System & Software Engineering
Terry Hock (hock@ucar.edu)
Nick Potts (npotts@ucar.edu)

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

Document Version Control

Version	Date	Author	Change Description
1.0	07-16-2013	*K. Young*	Initial Document Release
2.0	06-22-2016	*K. Young*	A temperature dependent dry bias in the RD94 and mini-dropsonde (NRD94) relative humidity measurements was discovered in data collected from 2010 to present. The dropsonde files that have received a correction contain an indicator in the header of the file, 'TDDryBiasCorrApplied'. For more information on the dry bias, please see line item 7 under Section II.
3.0	08-17-2016	*K. Young*	Dewpoint temperature was recalculated using the corrected RH measurements (V2.0)

* The National Center for Atmospheric Research is managed by University Corporation for Atmospheric Research and sponsored by the National Science Foundation.

MPEX 2013 Dropsonde Data Quality Report

Table of Contents

Contents

I. Dataset Overview 4
II. EOL Sounding File Format and Data Specifics 6
III. Data Quality Control Process 8
IV. Special Problems to Note (Important Information for Users) 9

List of Tables

Table 1 - Summary of Research Flights 4
Table 2 - EOL Sounding File Format (dropsonde and radiosonde) 7
Table 3 - Lists data fields provided in the EOL format ASCII soundings 7
Table 4 - Summary of Data Quality Issues 9

List of Figures

Figure 1 – Map of Research Flights 1-5 5
Figure 2 – Map of Research Flights 6-10 5
Figure 3 – Map of Research Flights 11-15 6

I. Dataset Overview

The Mesoscale Predictability Experiment (MPEX) is a multi-agency field campaign that was conducted from May 15 to June 15, 2013. MPEX employed the use of the NCAR GV, with the new automated Airborne Vertical Atmospheric Profiling System (AVAPS) dropsonde system, used for the first time, and the Microwave Temperature Profiling (MTP) system, as well as several ground-based mobile upsonde systems. The primary scientific objectives of the project are to explore how well sub-synoptic observations can improve numerical weather predication. A total of 426 quality controlled soundings are contained in the MPEX dropsonde data set. A detailed summary of the fifteen research flights is shown in Table 1.

For more information on the NCAR Dropsonde System please visit the following site: http://www.eol.ucar.edu/instrumentation/sounding/dropsonde

Table 1 - Summary of Research Flights

RF#	Dates	Soundings in final archive
RF01	May 15	27
RF02	May 16	31
RF03	May 18	16
RF04	May 19	29
RF05	May 21	27
RF06	May 23	29
RF07	May 27	29
RF08	May 28	21
RF09	May 30	27
RF10	May 31	29
RF11	June 03	31
RF12	June 08	31
RF13	June 11	33
RF14	June 12	33
RF15	June 14	33
Total # of Soundings		**426**

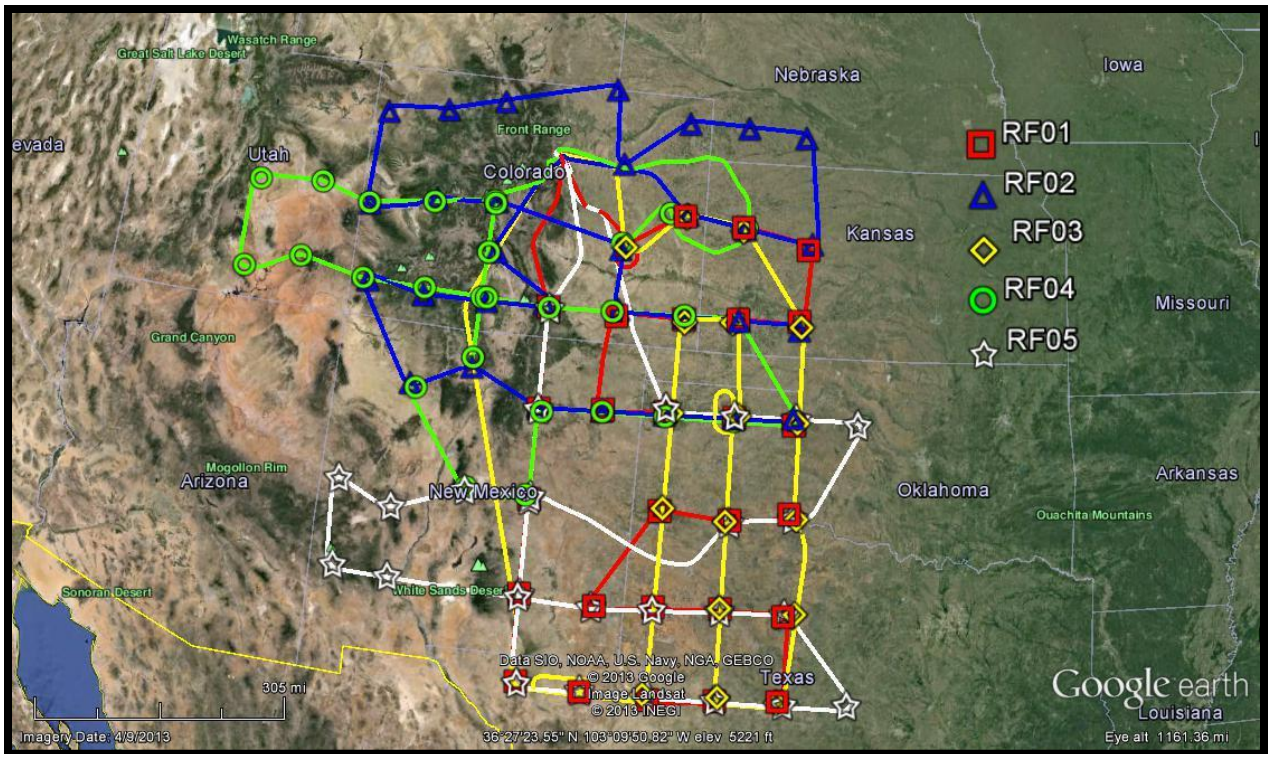

Figure 1 Map of MPEX Project Research Flights 1 through 5. Points indicate dropsonde launch locations. Lines connecting the dropsonde locations represent the aircraft flight tracks

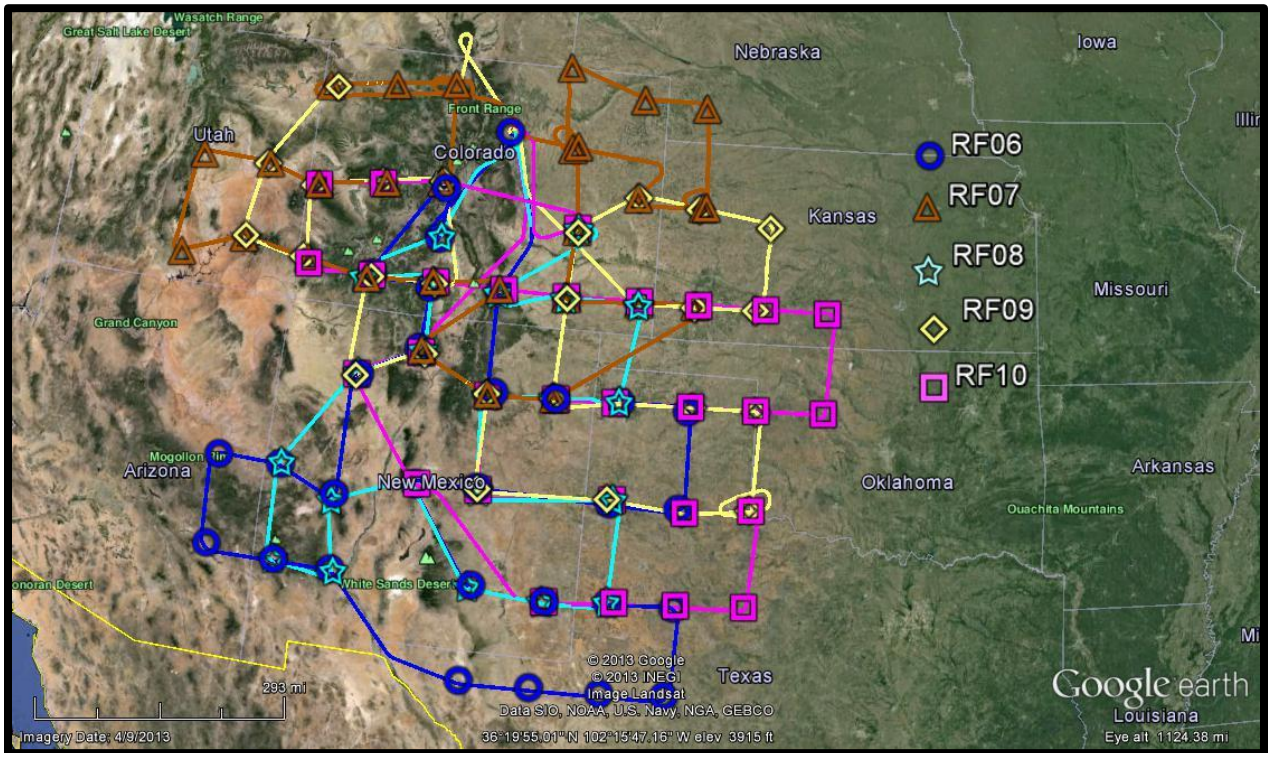

Figure 2 Map of MPEX Research Flights 6 through 10. Points indicate dropsonde launch locations. Lines connecting the dropsonde locations represent the aircraft flight tracks

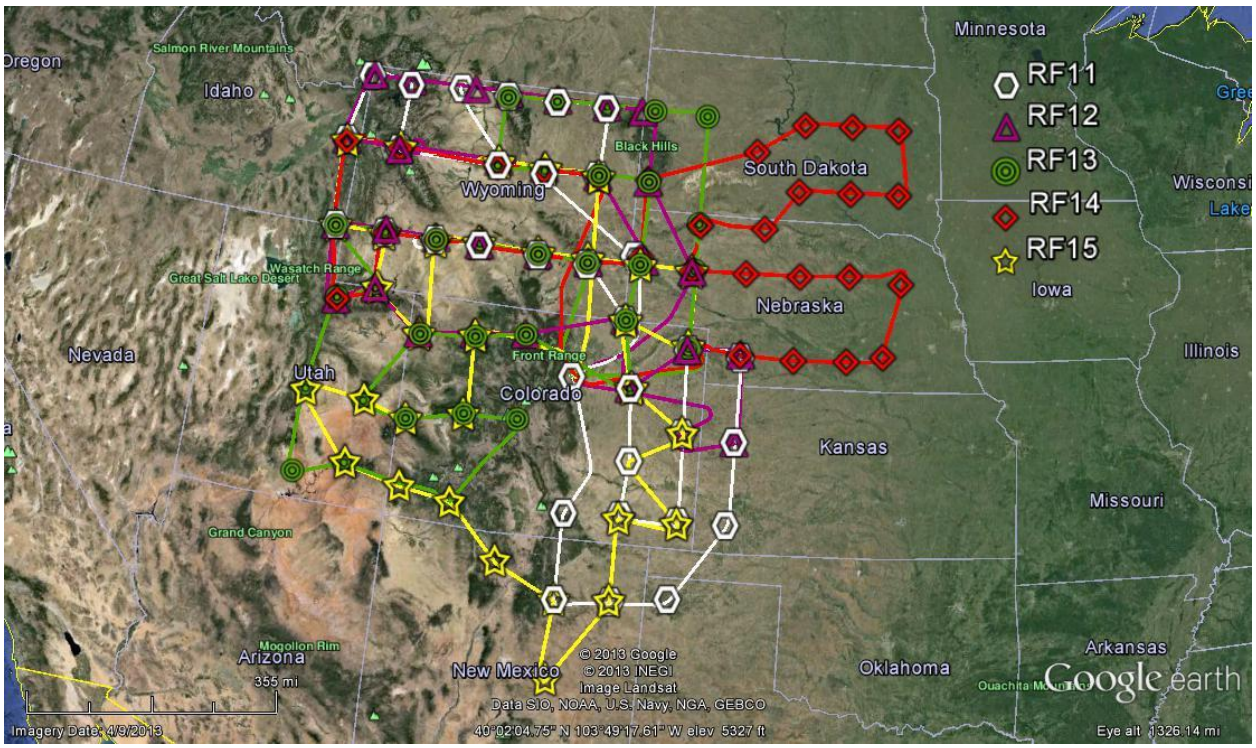

Figure 3 Map of MPEX Research Flights 11 through 15. Points indicate dropsonde launch locations. Lines connecting the dropsonde locations represent the aircraft flight tracks

II. EOL Sounding File Format and Data Specifics

The EOL format is an ASCII text format that includes a header (Table 2), with detailed project and sounding information, and seventeen columns of high resolution data (Table 3). The "QC.eol" files are quarter-second resolution data files with appropriate corrections and quality control measures applied. Note that the thermodynamic data (pressure, temperature and humidity (PTU)) are only available at half-second resolution and wind data is available at quarter-second resolution. 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: 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 3. The last line of the header contains information about the current version of ASPEN and its configuration used for the final data QC. It also contains a flag, 'TDDryBiasCorrApplied', indicating the files have been corrected for a temperature dependent dry bias in the relative humidity measurements (for more information, please see 'Data Quality Control Process' in Section II.

The variables pressure, temperature, and relative humidity are calibrated values from measurements made by the dropsonde. The AVAPS software applies a .4 mb dynamic correction to the pressure measurements, in real time.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, typically from the ocean's surface upward. For dropsondes that failed to transmit useful data to the surface, we integrate geopotential altitude from flight level down. The descent rate of the sonde is computed using the time-differentiated hydrostatic equation. The position (lat, lon) and wind data come directly from the GPS sensor. The uncertainty of the GPS altitude is estimated to be less than 20 m. Investigators should follow meteorological convention and use geopotential altitude.

Table 2 - EOL Sounding File Format (dropsonde and radiosonde)

```
Data Type/Direction:                    AVAPS SOUNDING DATA, Channel 3/Descending
File Format/Version:                    EOL Sounding Format/1.1
Project Name/Platform:                  MPEX 2013/Gulfstream V, N677F
Launch Site:
Launch Location (lon,lat,alt):          109 57.06'W -109.951000, 33 04.98'N 33.083000, 12896.00
UTC Launch Time (y,m,d,h,m,s):          2013, 05, 23, 12:37:26
Sonde Id/Sonde Type:                    102015070/
Reference Launch Data Source/Time:      IWGADTS Format (IWG1)/12:37:27
System Operator/Comments:               Remote Operator/none, none
Post Processing Comments:               Aspen Version 3.1; Created on 16 Jul 2013 03:07 UTC; Configuration ModminiDropsonde
/
  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  178.91  -64.87  -72.21   38.67   26.39   13.64   29.71  242.66 -999.00 12864.22 -109.951000   33.083000 12896.00
    0.00 12 37 26.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.000000 -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 -999.000000 -999.000000  -999.00
    0.50 12 37 26.50 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -109.950826   33.082335 12869.25
    0.75 12 37 26.75 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.000000 -999.000000  -999.00
    1.00 12 37 27.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -109.951515   33.083080 12871.29
    1.25 12 37 27.25 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.000000 -999.000000  -999.00
    1.50 12 37 27.50 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -999.00 -109.952195   33.083817 12874.72
```

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	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 pressure, temperature, RH, wind speed and descent rate from the raw D-files are examined to determine if all of the files contain data, and to ensure that nothing looks suspicious. Doing this allows us to determine if a sounding was started up, but not launched, or if the data contains any features that warrant further investigation. Corrections are applied where appropriate.

2. All flight level data contained in the sounding files are subjected to an altitude correction that converts GPS altitude (ieEllipsoid height) to geopotential altitude. Ensuring an accurate flight level geopotential altitude is particularly important for soundings made over land that require calculation of the geopotential altitude from flight level downward; as was the case with MPEX dropsondes. Additionally, because these drops were made over land, approximately 13% of the dropsondes continued to transmit after hitting the surface. It's likely the sensors were damaged or broken upon impact, based on the poor quality of the data, so any surface collected has been removed from the final archive.

3. A pressure ground check (GC) correction was applied to the entire profile for each sounding. The surface pressure measured by an independent surface sensor for each dropsonde at the NCAR laboratory (prior to the project) was 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 pressure as indicated by the reference sensor in the lab, and P_0^{RS} is the pressure as indicated by the sonde in the lab.

4. The raw soundings D-files are then processed through the Atmospheric Sounding Processing ENvironment (ASPEN) software, which analyzes the data, performs smoothing, sensor time response corrections, and removes suspect data points.

5. Time series plots of quality controlled temperature, RH, wind speed, and fall rate, are used to examine the consistency of soundings launched during each flight, and to show the variability of soundings from different missions. These plots are also used to determine if the

sounding did not transmit data to the surface, or if there was a "fast fall" caused by failure of the parachute to properly deploy.

6. A dry bias in the relative humidity measurements was discovered, in the Spring of 2016, in all RD94 dropsondes from 2010 to present and all mini-dropsondes (NRD94) collected. This dry bias is strongly temperature dependent and most significant at cold temperatures. It is considered small at warm temperatures. All sounding files undergoing post-processing have been corrected for this error and contain the flag, 'TDDryBiasCorrApplied', in the last line of the header to confirm that this correction has been applied. For more information on the dry bias, please access the technical note, linked below, which contains information on the origin, magnitude and impact of the dry bias.

   NCAR/EOL Technical Note: Dropsonde Dry Bias

   https://www.eol.ucar.edu/system/files/software/Aspen/Windows/W7/documents/Tech%20Note%20Dropsonde_Dry_Bias_20160527_v1.3.pdf

7. Profiles of temperature, RH and winds from the quality controlled soundings are visually evaluated for outliers, or any other obvious issues.

8. Finally, histograms of pressure, temperature, relative humidity, wind speed and wind direction are created to examine the distribution, range, and characteristics of each parameter.

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, noted in table 4, were found. 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 the MPEX Dropsonde Data

Data Quality Issue	# of soundings	% of dataset
Sounding files removed from archive	5	.01
Fast Falls (complete)	36	8.5
Fast Falls (partial)	26	6
No Temp Data	1	-
No RH Data	1	-
No Geopotential Altitude	1	-

1. **Data files removed from final archive:** Five were created, but contained no useful information and were removed from the final archive. The dropsondes were started and collected prelaunch data on the aircraft, but were never launched.

Files Not in Final Archive	Notes
RF01/D20130515_132234	Sonde launch called off, too close to Denver
RF03/D20130518_123558	Sonde became stuck in launcher
RF03/D20130518_124552	No launch because of previously stuck sonde
RF09/D20130530_142403	Sonde started, but not launched
RF11/D20130611_124007	Sonde became stuck in launcher

2. **Fast fall:** Sixty soundings were classified as "fast fall drops", meaning the parachute failed to properly deploy resulting in dropsondes falling at an accelerated rate (and sometimes tumbling). Twenty six of those were "partial fast falls" (indicated by an '*' in the table below) meaning that at some point during descent, the parachute deployed properly and normal descent rates were attained. The percentage of fast falls during MPEX was uncharacteristically high, compared with results from previous projects. The cause of this is still under investigation.
   When fast falls occur, data acquired from the GPS are often unreliable and a lag in the response of the RH sensor may occur, due to the accelerated fall rate (Figure 4). Normally, during post-processing, we change the wind data for fast falls to missing values however, given the large number of fast fall soundings and that evaluation of the winds indicated no obvious data quality issues, we decided to retain the wind data. For the soundings listed below, we do want to strongly caution data users about the validity of wind speed, wind direction, U/V winds and RH data contained in each profile.

Fast Fall Soundings			
D20130516_091921*	D20130523_112646*	D20130530_125315	D20130611_133348*
D20130516_100721	D20130523_124824	D20130530_141724	D20130611_134634
D20130516_104843	D20130523_135324	D20130531_134030*	D20130611_142323*
D20130516_125731	D20130527_093644	D20130531_141737	D20130612_094859*
D20130516_132816*	D20130527_094434	D20130603_122804*	D20130612_112359
D20130518_091104	D20130527_103436	D20130608_093357	D20130612_113847
D20130518_100634	D20130527_105708	D20130608_100505*	D20130612_120420*
D20130518_115750	D20130527_123337	D20130608_103828	D20130612_131218*
D20130519_103633	D20130527_141320	D20130608_104655	D20130612_133428*
D20130519_105412	D20130528_111443*	D20130608_105658	D20130612_140142
D20130519_115715	D20130528_112242*	D20130608_112256*	D20130614_093258
D20130521_094548*	D20130528_125236*	D20130608_114320*	D20130614_104246*
D20130521_101841*	D20130530_094840	D20130608_124903	D20130614_140011*
D20130521_121123	D20130530_102405	D20130608_133340	D20130614_142111
D20130521_130129*	D20130530_104250	D20130608_134012	
D20130523_111519	D20130530_113054	D20130611_101632*	

*indicates partial fast fall where parachute eventually opened and ascent rate slowed.

3. **No Temperature Data:** One sounding file (D20120914_193503) contains no temperature data. The sensor appears to have broken at launch. The values recorded in the original data files were unrealistic and therefore all temperature values were set to missing.

4. **Broken RH sensor:** One file (D20130515_105433) had a broken RH sensor. All values were changed from 1% to missing.

5. **Launch Time Reassignment** – One hundred sixteen files experienced a slight delay in the launch time, where one pre-launch data frame was flagged as if the sonde were already in flight, meaning the launch detect actually occurred 1-2 seconds after it was tagged. For each of these soundings the timestamps, both in the file and filename, were changed to reflect the correct time of launch.

6. **Geopotential Altitude Correction –** The following soundings had issues with the geopotential altitude calculation.

Filenames	Explanation
D20120914_193503	No geopotential alt computed because of broken T sensor. All values have been set to missing (-999)
D20130612_093450	Missing flight level aircraft PTU data replaced with sounding PTU for geopotential alt calculation
D20130612_114719	Missing flight level aircraft PTU data replaced with sounding PTU for geopotential alt calculation