Sensing Hazards with Operational Unmanned Technology (SHOUT)

SHOUT-2015 2016 Dropsonde Data Quality Report

June 18

2016

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 K. and H. Vömel (2015): SHOUT 2015-2016 Dropsonde Data Quality Report.

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

UCAR/NCAR - Earth Observing Laboratory. 2016. NASA Global Hawk QC Dropsonde Data, Version 1.0. UCAR/NCAR - Earth Observing Laboratory. http://dx.doi.org/10.5065/D6CN729D. Accessed 17 Jun 2016.

SHOUT Quality Controlled Dropsonde Dataset

*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
3090 Center Green Dr.
Boulder, CO 80301; USA

Document Version Control

Version	Date	Author	Change Description
1.0	6/18/2016	*K. Young*	Initial Document Release

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

SHOUT 2015-2016 Dropsonde Data Quality Report

Table of Contents

Contents

List of Tables

List of Figures

I. Dataset Overview

The Sensing Hazards with Operational Unmanned Technology (SHOUT) was a multi-phase research campaign, conducted in the Fall of 2015 over the Atlantic Ocean and Spring of 2016, also referred to as SHOUT El Nino Rapid Response (SHOUT ENRR), over the Pacific Ocean. Targeted measurements were collected using the NASA Global Hawk aircraft. Researchers hope to use these measurements to improve weather model forecasts. Maps of all dropsonde launch locations and aircraft flight tracks are provided in Figures 1 and 2. For more information on the SHOUT project please visit: https://uas.noaa.gov/shout/

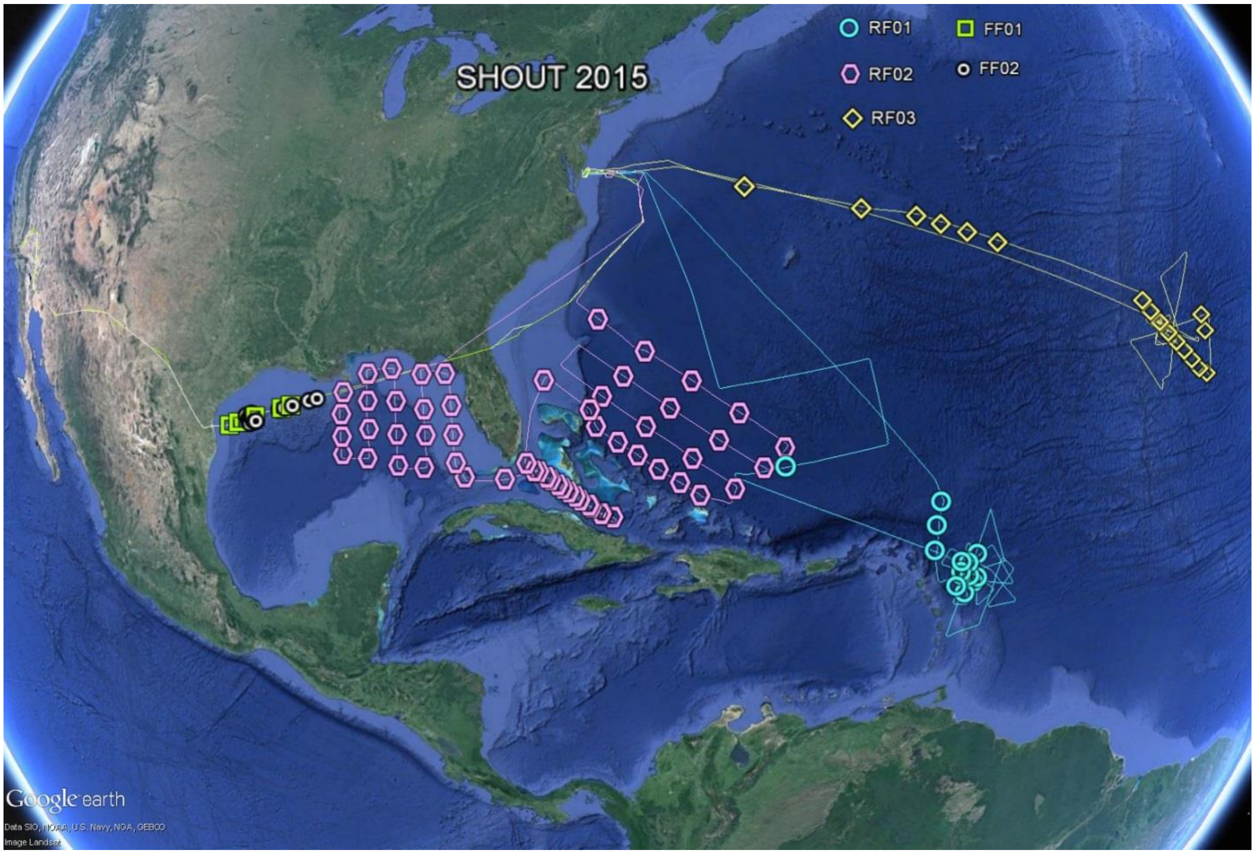

Figure 1 Map of all Global Hawk flight tracks and dropsonde launch locations from SHOUT 2015.

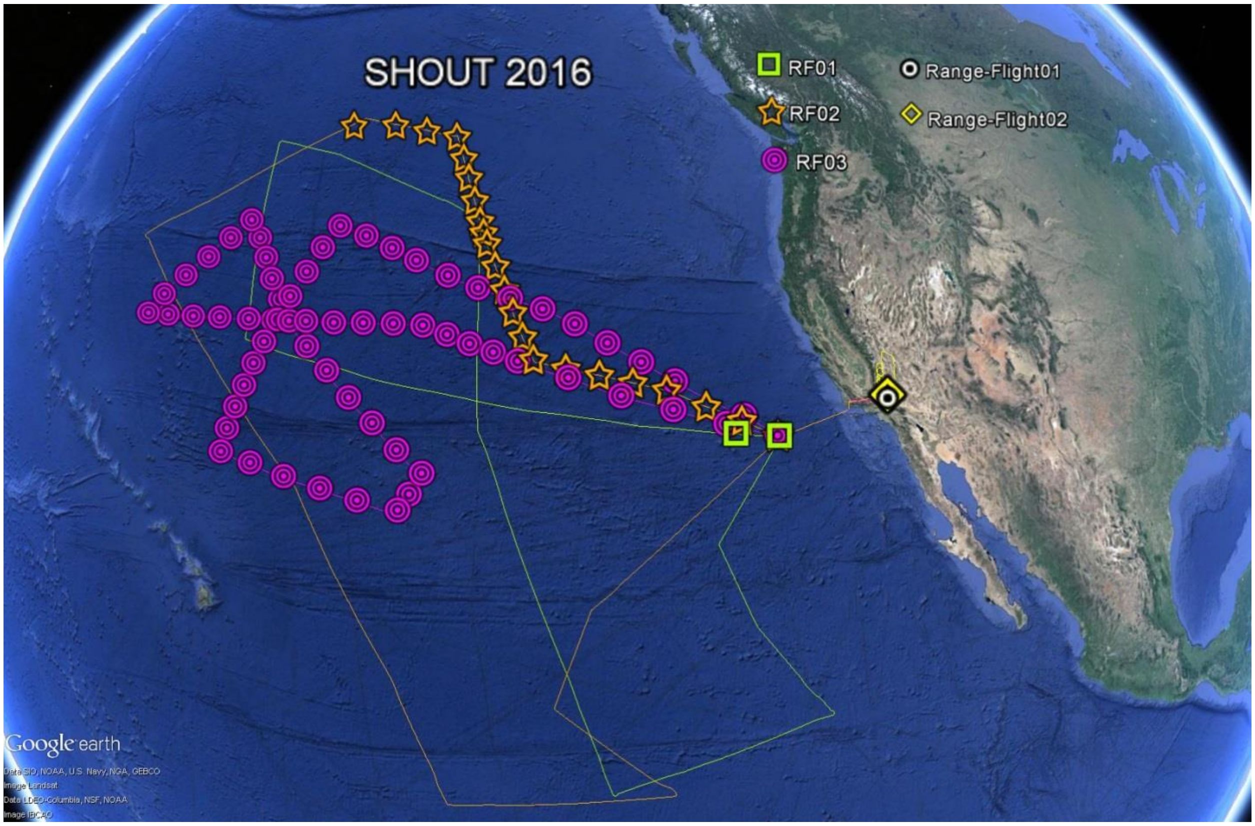

Figure 2 Map of all Global Hawk flight tracks and dropsonde launch locations from SHOUT ENRR.

One hundred ninety six dropsonde soundings were collected between August 22 and September 8, 2015 and January 27 to February 22, 2016 (Table 1). This document contains information on the data file format, data parameters included in each of the files, and details regarding the quality control measures applied to the sounding data.

Table 1. Dropsonde Counts for each SHOUT Research Flight or Ferry Flight

Research/Ferry Flight	Dates	Sondes deployed
2015/FF01	8/22	4
2015/RF01	8/26-8/27	13
2015/RF02	8/29-8/30	58
2015//RF03	9/05	17
2015/FF02	9/08	15
2016/RF01	2/12	2
2016/RF02	2/15	21
2016/RF03	2/21-2/22	66
	Total	**196**

EOL Sounding File Format and Data Specifics

The EOL format is an ASCII text format that includes a header (Table 2), with detailed project/ 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, while 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, shown in Table 2. 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), GPS 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, 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 along with 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 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, geopotential altitude is integrated 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 dropsonde GPS receiver. The uncertainty of the GPS altitude is estimated to be less 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 2/Descending
File Format/Version:                EOL Sounding Format/1.1
Project Name/Platform:              NOAA/NASA SHOUT 2015,/Northrup/Grumman Global Hawk, NASA 872 (AV-6)
Launch Site:
Launch Location (lon,lat,alt):      132 38.50'W -132.641654, 35 51.19'N 35.853212, 17130.00
UTC Launch Time (y,m,d,h,m,s):      2016, 02, 21, 18:31:16
Sonde Id/Sonde Type:                101935217/RS904
Reference Launch Data Source/Time:  IWGADTS Format (IWG1)/18:31:10
System Operator/Comments:           Remote Operator/none, none
Post Processing Comments:           Aspen V3.3-236; Created on 13 Jun 2016 19:56 UTC; Configuration mini-dropsonde;
TDDryBiasCorrApplied
/
```

```
 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 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	Air 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

II. Data Quality Control Process

1) 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, or malfunctioning of any of the dropsonde sensors.

2) Profiles of pressure, temperature, RH, wind speed and descent rate from the raw D-files are examined to identify features that may warrant further investigation. Corrections are applied where appropriate.

3) A pressure correction is applied to the entire profile for each sounding during the QC process. The pressure correction value is unique for each dropsonde and is determined in the final testing of the dropsonde during production. During the final testing of the dropsonde, an independent precision pressure sensor is used as the reference for determining the pressure

offset value from the dropsonde pressure measurement. The corrected pressure $P = P_{RS} + (P_{0,REF} - P_{0,RS})$, where P_{RS} is the pressure measured by the dropsonde, $P_{0,REF}$ is the pressure as indicated by the reference sensor and $P_{0,RS}$ is the pressure as indicated by the dropsonde during calibration testing. This pressure correction is on average 1 mb (Figure 4). This correction is not implemented in real-time data in the field.

4) All dropsonde GPS altitude measurements have been improved by removing any existing real-time geoid correction and replacing it with a more accurate geoid height from the Earth Gravitational Model 1996 (EMG96). On average the difference between the two is approximately 1.6 m, but the scatter is quite significant, making this correction necessary.

5) Filtering of the GPS latitude, longitude and altitude is performed to remove spikes.

6) The raw sounding D-files with the corrected pressure offset, updated flight level data and filtered GPS data are then processed through the Batch Atmospheric Sounding Processing ENvironment (ASPEN) software which:

   i) Applies a correction algorithm to address a dry bias in the RD94 and mini-dropsonde (NRD94) relative humidity measurements, which was discovered in data collected from 2010 to present. For more information on this issues please see #7 below.

   ii) Applies a dynamic pressure correction of .4 mb

   iii) Performs smoothing, sensor time response corrections, and removes suspect data points.

   The ASPEN software version and configuration file used for this program are included in the header of each "QC.eol" sounding file. For more information on ASPEN or to download the software please visit: http://www.eol.ucar.edu/software/aspen

7) A dry bias in the relative humidity measurements was discovered, in the Spring of 2016, in all dropsondes (RD94) and mini-dropsondes (NRD94) collected from 2010 to present. This dry bias is strongly temperature dependent and is considered small at warm temperatures and becomes stronger at cold 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

8) 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.

III. Overview of issues

Performing the quality control procedures outlined above allows us to identify and 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 SHOUT Dropsonde Data

Data Quality Issue	# of soundings
Files with no useful data	3 (not included in archive)
Fast falls	2 (1 complete, 1 partial)
Data not to surface	4 (1 with PTU jumps)
PTU jumps	3

1. **Fast Falls –** One dropsonde, D20150830_040651, was classified as a “fast fall”, meaning the parachute failed to properly deploy resulting in the dropsonde falling at an accelerated rate (Figure 5). One dropsonde, 20160222_003954, was a ‘partial fast fall’, meaning that the parachute failed to open properly, but recovered at approximately 600 mb.

   When a fast fall occurs, GPS wind measurements can be unreliable (due to irregular motion of the dropsonde) and a lag in the response of the T/RH and sensors may occur. We caution data users about the increased uncertainty of Wind Speed, Wind Direction, U/V Winds, Temperature and RH data contained in these data files.

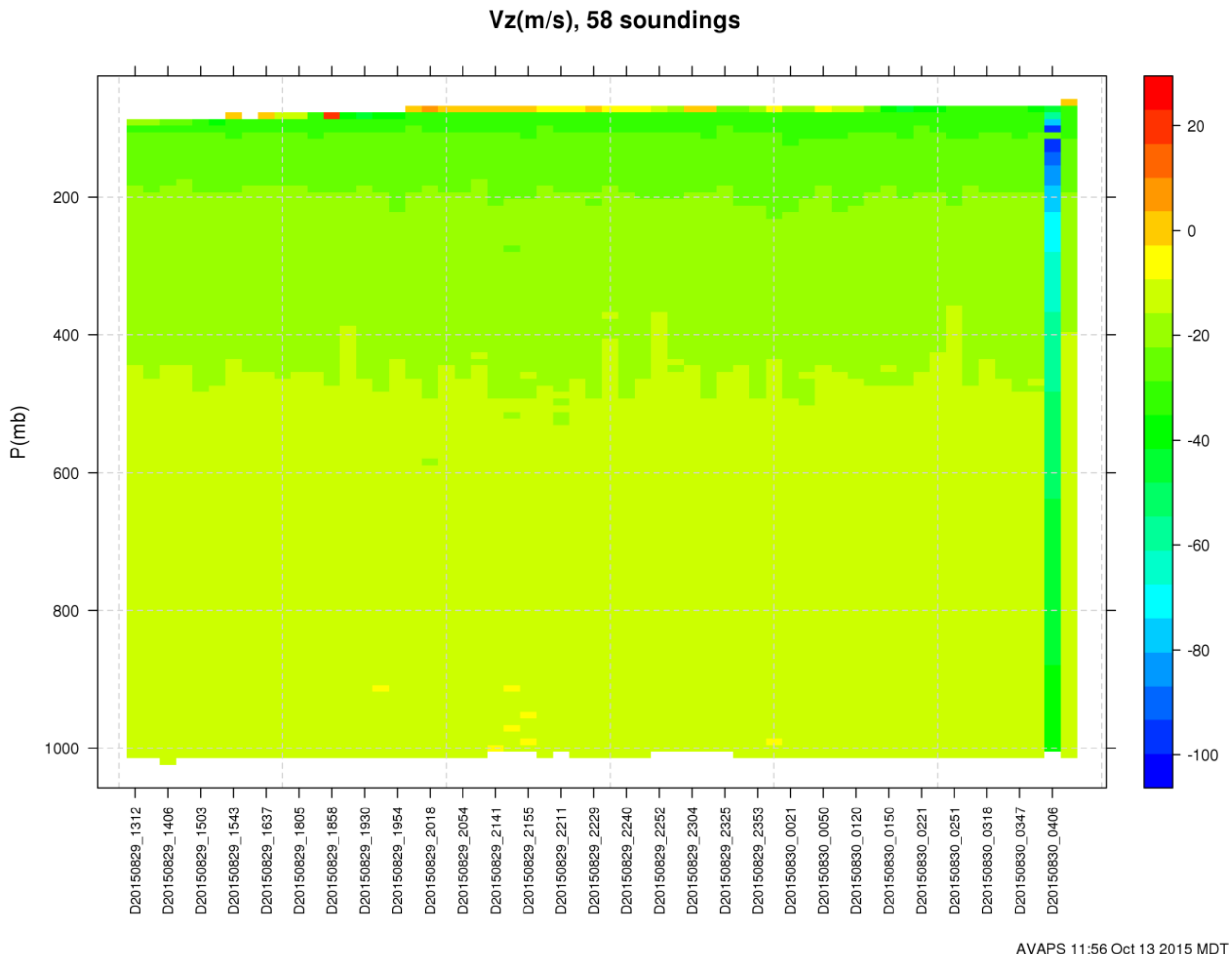

Figure 3 GPS descent rates of dropsondes launched from Research Flight 02 in 2015. Sounding file D20150830)040651 was a “fast fall sounding”, with an accelerated fall speed caused by failure of the parachute to properly deploy.

2. **PTU Jumps –** Three soundings contained jumps (or spikes) in the pressure, temperature and RH measurements caused by a firmware error in the PTU module of the dropsondes (Figure 6). These jumps were filtered out during post-processing and are not present in the final data products, however the geopotential altitude calculation may have a larger uncertainty due to large gaps of missing data.

PTU Jumps
D20160221_215121
D20160222_040232
D20160222_091420

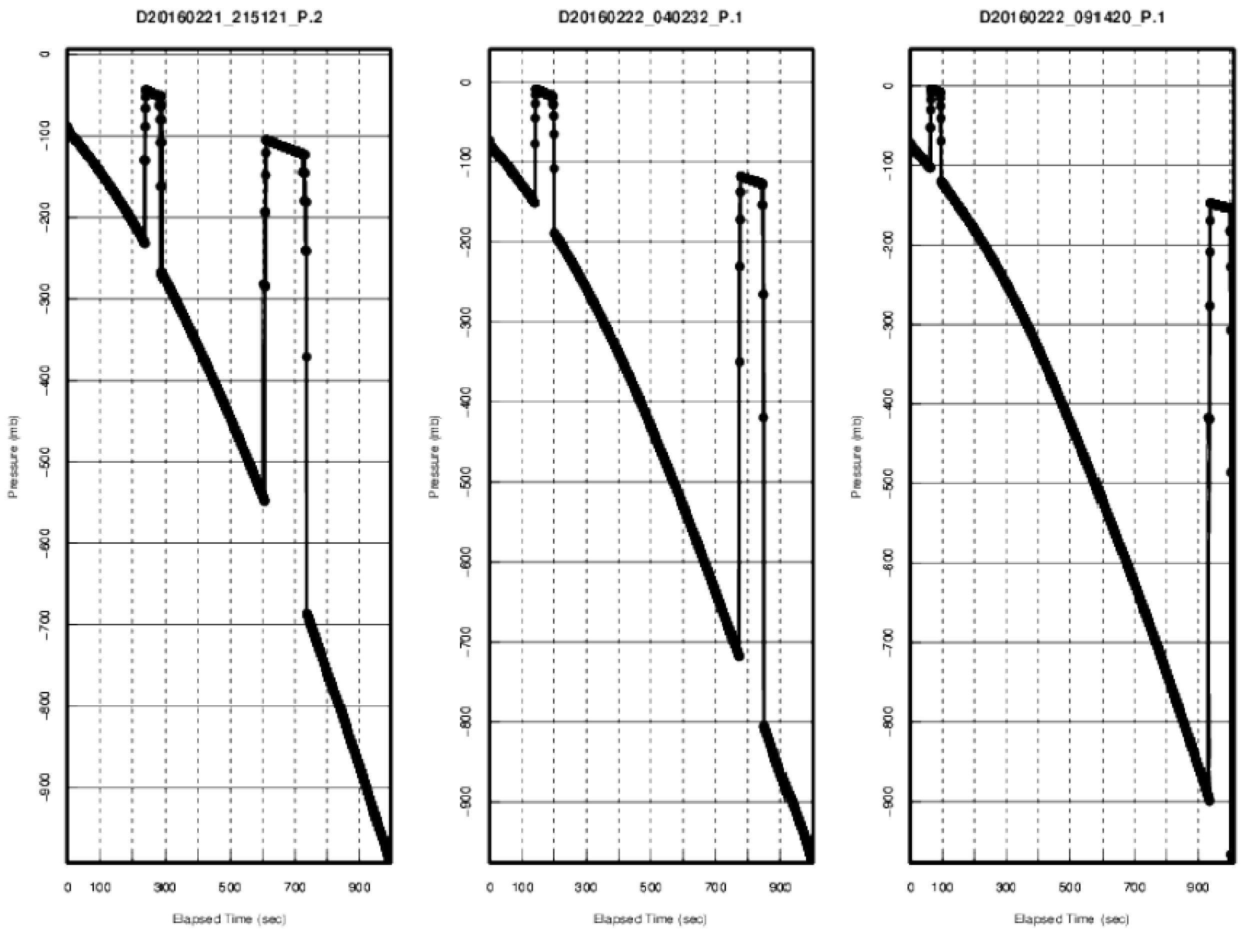

Figure 6 Three soundings contained an firmware error in the PTU module that resulted in jumps in pressure, temperature and relative humidity. The plots show elapsed time (sec) versus pressure (mb). The jumps were filtered out in post-processing.

3. **Not to Surface -** There were three soundings classified as dropsondes that did not transmit data to the surface (Figure 7). The loss of data at the surface was due to Radio Frequency Interference (RFI) in the 400 MHz Meteorological band.

Not to Surface
D20150826_152821
D20150827_000718
D20150827_005303
D20160222_091420 (also listed under PTU jumps)

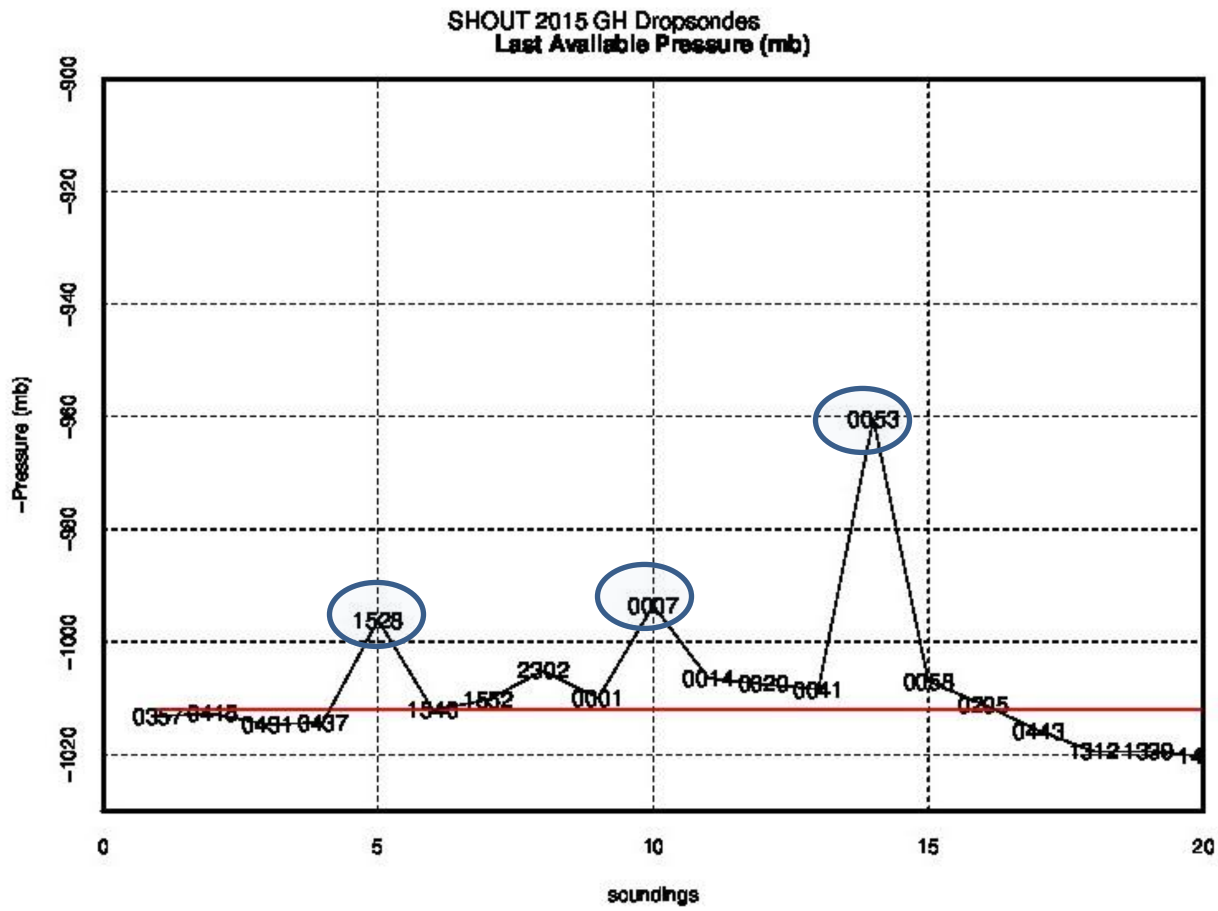

Figure 5 Four dropsondes failed to transmit data to the surface due to weak telemetry. Three of these are indicated by circled timestamp (hour, minute) showing last available pressure (mb). Geopotential altitudes for these data files were computed from flight level downward.