Cloud System Evolution in the Trades

CSET-2015 Dropsonde Data Quality Report

May 13

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): CSET 2015 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. NSF/NCAR GV (HIAPER) QC Dropsonde Data, Version 1.0. UCAR/NCAR - Earth Observing Laboratory. http://dx.doi.org/10.5065/D67H1GSR. Accessed 15 Apr 2016.

CSET 2015 Quality Controlled Dropsonde Dataset

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Document Version Control

Version	Date	Author	Change Description
1.0	4/13/2016	*K. Young*	Initial Document Release
2.0	5/13/2016	*K. Young*	Error in post-processing code reduced data from quarter second to half-second resolution.
3.0	7/25/20106	*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 6 under Section III.
4.0	8/1/2016	*K. Young*	Dewpoint temperature was recalculated using the corrected RH measurements (V3.0)

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I. Dataset Overview

The Cloud System Evolution in the Trades (CSET) campaign was a large-scale, multi-agency research project in which measurements were collected using the NSF/NCAR GV HIAPER Aircraft between California and Hawaii. The goal of the field campaign was to collect measurements of cloud, precipitation and aerosols in order to gain a better understanding of the evolution of boundary layer aerosol, cloud and thermodynamic structures along trajectories within the North-Pacific trade-wind region. A map of all dropsonde launch locations is provided in Figure 1.

One hundred twenty dropsonde soundings were collected between June 1 and Aug 12, 2015 (Table 1). A frequency histogram of flight level altitudes, from the time of each dropsonde launch, is provided in Figure 2. 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.

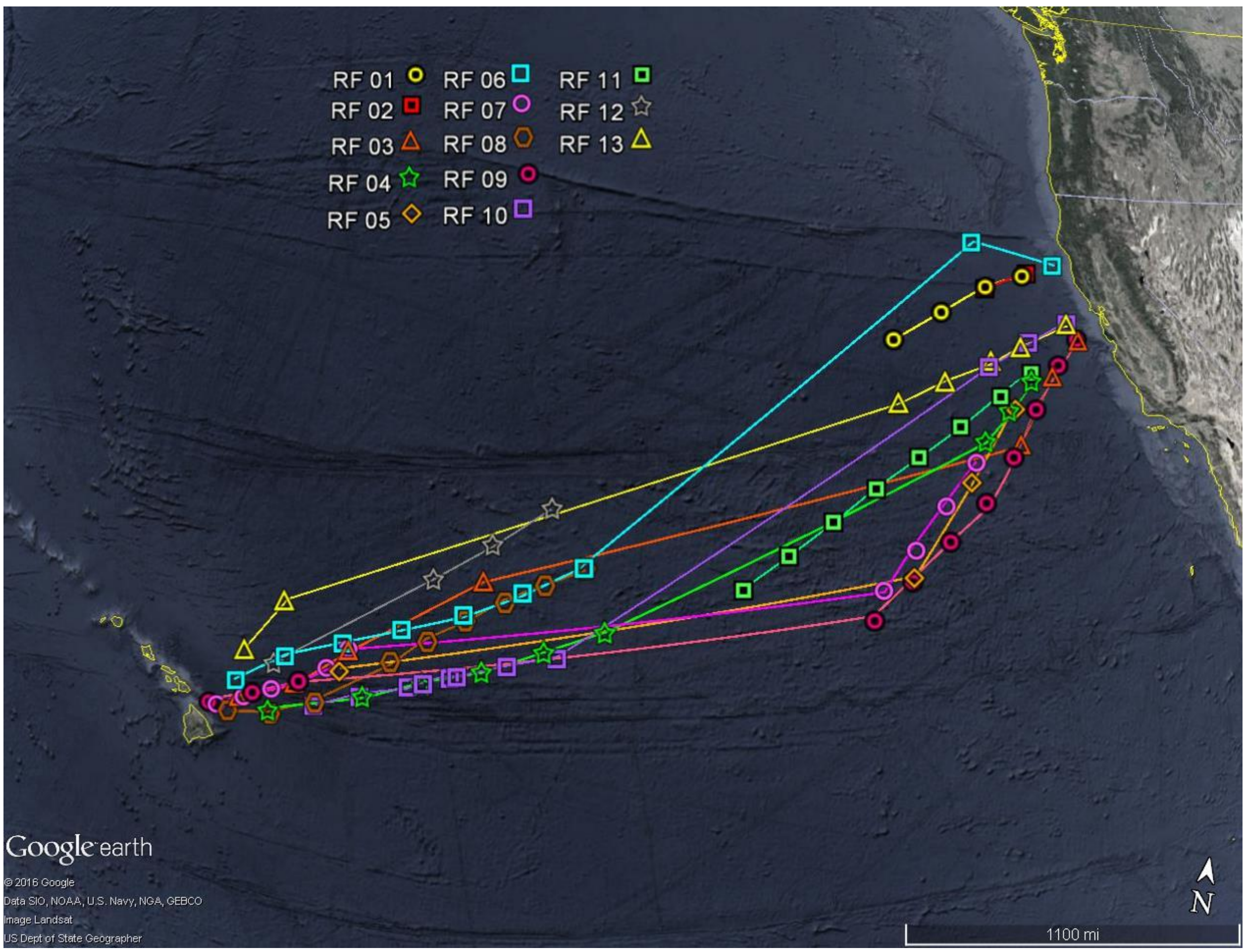

Figure 1 Map of all GV flight tracks and dropsonde launch locations.

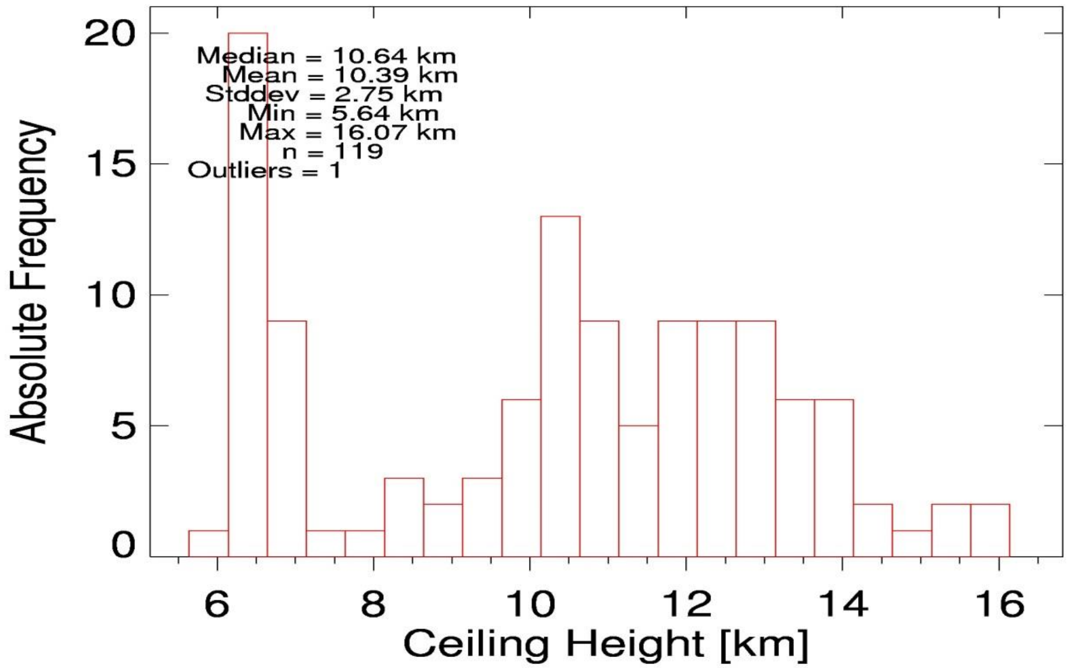

Figure 2 Frequency histogram of flight level altitudes at dropsonde launch times.

Table 1. Dropsonde Counts for each CSET Research Flight

Research Flight	Dates	Sondes deployed
RF01	July 1	4
RF02	July 7	2
RF03	July 9	5
RF04	July 12	9
RF05	July 14	4
RF06	July 17	9
RF07	July 19	10
RF08	July 22	9
RF09	July 24	11
RF10	July 27	11
RF11	July 29	8
RF12	Aug 1	4
RF13	Aug 3	7
RF14	Aug 7	8
RF15	Aug 8	5
RF16	Aug 12	14
Total		**120**

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

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/ 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.QCeol" 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. 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 III)

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, 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:                  CSET, Gulfstream V, N677F
Launch Site:
Launch Location (lon,lat,alt):          127 56.22’W -127.937000, 35 53.53’N 35.892200, 6437.45
UTC Launch Time (y,m,d,h,m,s):          2015, 07, 27, 15:58:18
Sonde Id/Sonde Type:                    135155156/
Reference Launch Data Source/Time:      IWGADTS Format (IWG1)/15:58:19
System Operator/Comments:               Remote Operator/none, none
Post Processing Comments:               Aspen Version 3.2-172; Created on 12 Apr 2015 17:40 UTC; Configuration mini-dropsonde
/
```

```
  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

III. 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 $P = P_{RS} + (P_{0REF} - P_{0RS})$, where P_{RS} is the pressure measured by the dropsonde, P_{0REF} is the pressure as indicated by the reference sensor and P_{0RS} is the pressure as indicated by the dropsonde during calibration testing. This pressure correction is on average 1 mb (Figure 3). 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) The raw soundings D-files with the corrected pressure offset and updated flight level data are then processed through the Batch Atmospheric Sounding Processing ENvironment (ASPEN) software, which analyzes the data, applies a dynamic pressure correction of .4 mb, 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

6) A dry bias in the relative humidity measurements was discovered, in the Spring of 2016, in all RD94dropsondes 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 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.

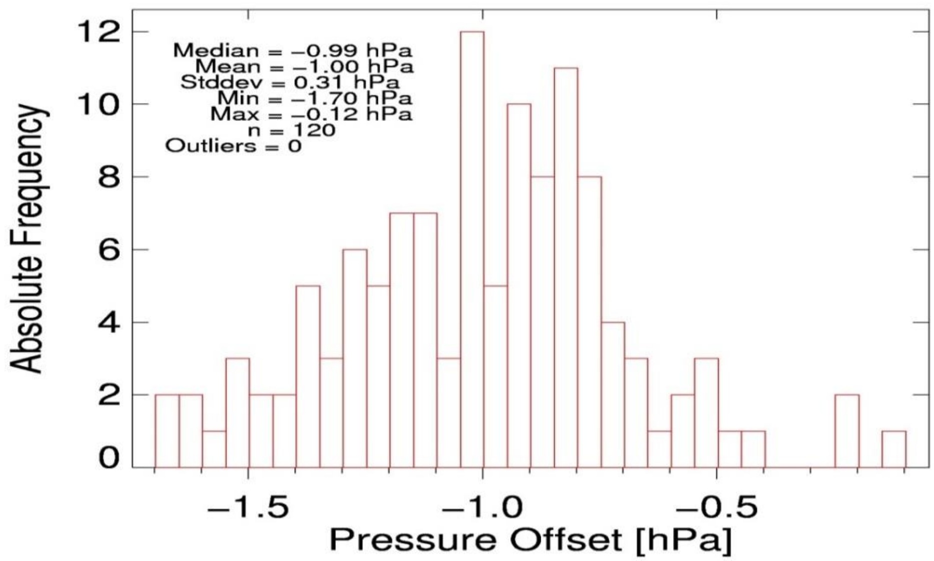

Figure 3 Frequency histogram of pressure correction applied to the dropsondes.

IV. Overview of issues

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 CSET Dropsonde Data

Data Quality Issue	# of soundings
Files with no useful data	2 (not included in archive)
Fast Falls	3
Launch Detect Error	1
Warm Temperature Bias	2

1. **Fast Falls –** Three dropsondes were classified as "fast fall drops" (Figures 4 and 5), meaning the parachute failed to properly deploy resulting in dropsondes falling at an accelerated rate. 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.

Fast Fall Soundings

RF04	D20150712_155535
RF07	D20150719_223011
RF10	D20150727_204303

2. **Launch Detect Error –** One dropsonde, D20150807_165625 experienced failure of the launch detect mechanism, which determines the time at which the sonde was released. This resulted in all in-flight sounding data being flagged as pre-launch, an incorrect timestamp being entered into the filename, and no aircraft data recorded at the time of the sondes release.

3. **Warm Temperature Bias –** Two sounding files were found to have a warm temperature bias. For sounding file, D20150727_204303 (Figure 6) majority of the temperature profile was affected. Data near the surface was deemed questionable as well. Therefore, all temperature values were set to missing. For sounding, D20150803_225458 (Figure 7), temperatures measured above approximately 610 mb were affected, and subsequently set to missing. It's important to note that geopotential altitudes where temperature is missing cannot be calculated.

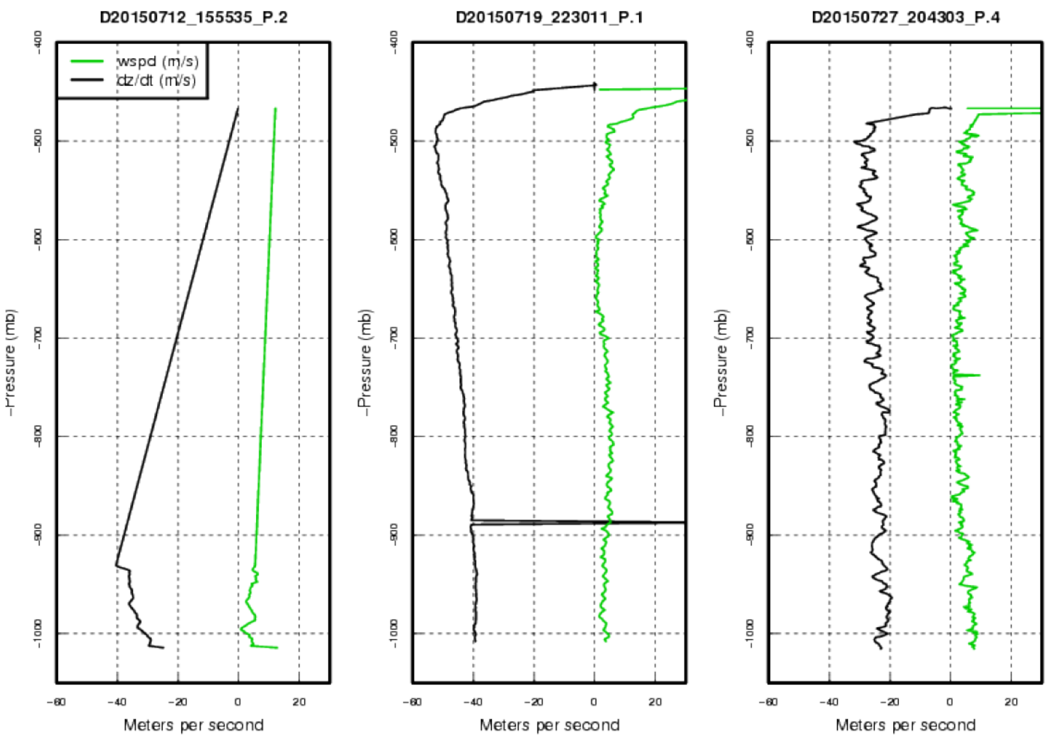

Figure 4 Raw GPS wind speed and GPS descent rate profiles of three 'fast fall' soundings.

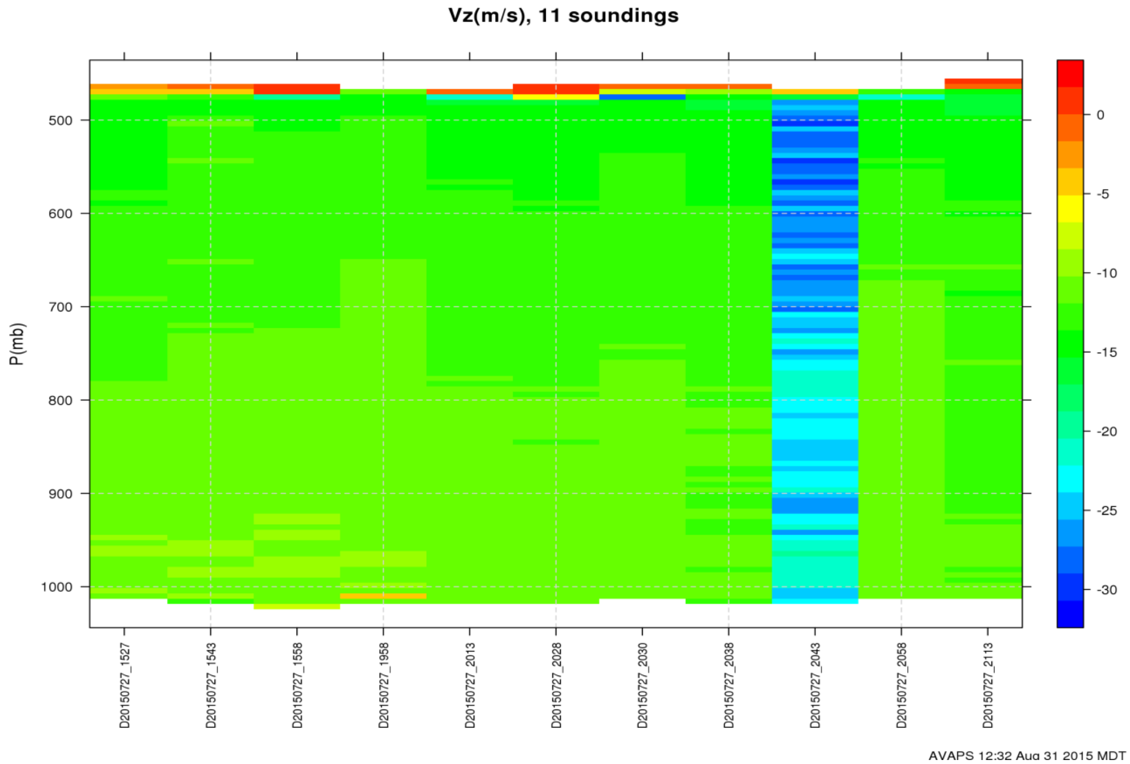

Figure 5 GPS descent rates of dropsondes launched from Research Flight 11. Sounding file D20150727_2043 was a "fast fall sounding", with an accelerated fall speed caused by failure of the parachute to properly deploy.

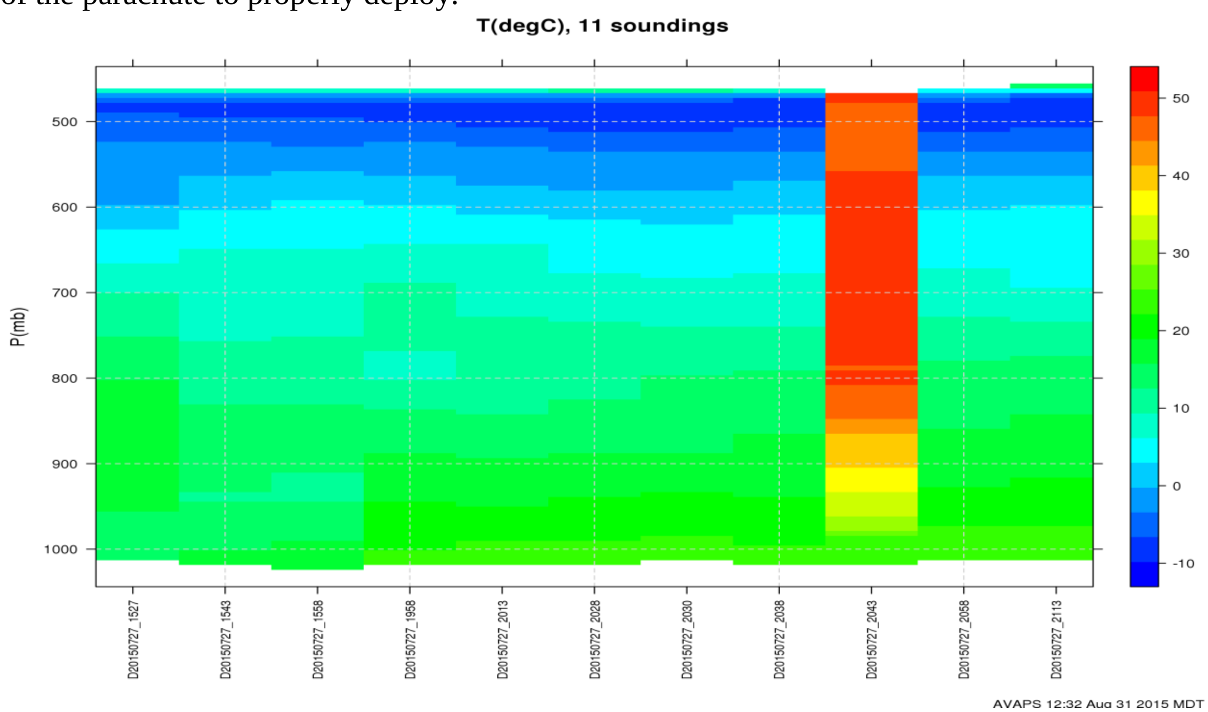

Figure 6 Temperature profiles for eleven dropsondes deployed during Research Flight 10. A warm temperature bias was found in D20150727_204303. These biased values were set to missing.

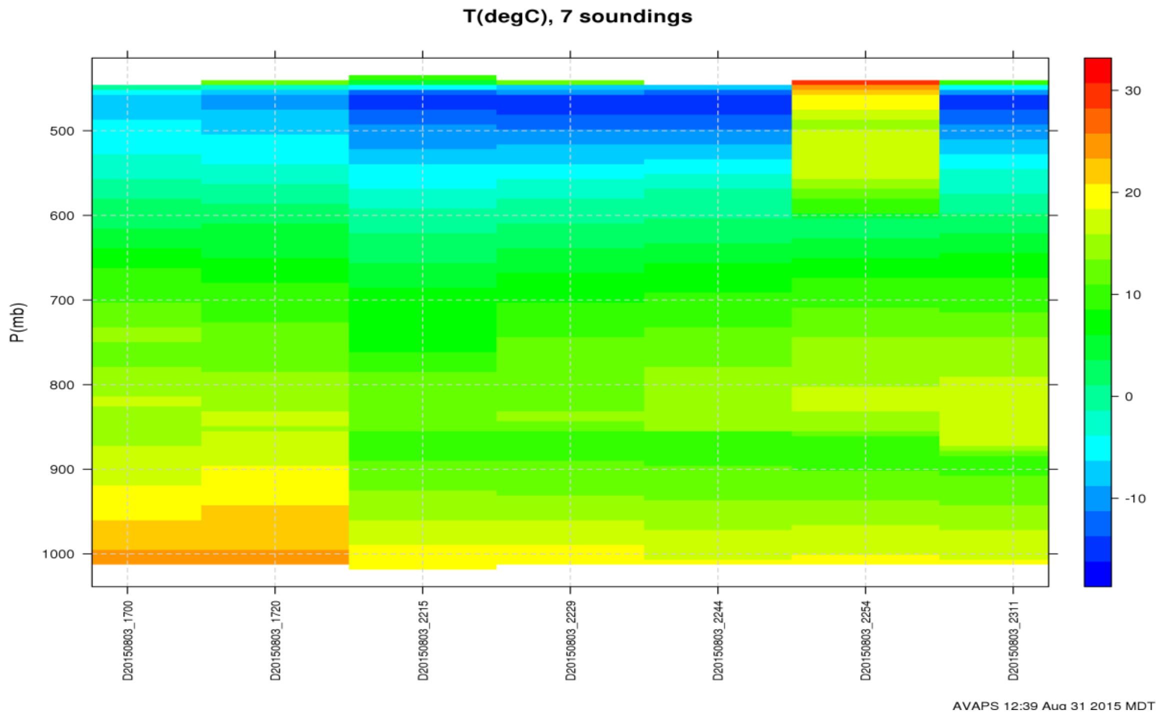

Figure 7 Temperature profiles for seven dropsondes deployed during Research Flight 13. A partial warm temperature bias was found in D20150727_204303, above approximately 610 mb. These biased values were set to missing.