NASA Genesis and Rapid Intensification Processes (GRIP) Experiment
2010 Quality Controlled Dropsonde Data Set

GRIP Dropsonde Data Quality Report

April 29

2011

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The GRIP dropsonde data were processed and quality controlled by the Earth Observing Laboratory at the National Center for Atmospheric Research (EOL/NCAR). NCAR is sponsored by the National Science Foundation (NSF). In the event that information or plots from this Data Quality Report are used for publication or presentation purposes, please acknowledge NSF and NCAR/EOL and make reference to Young et al. (2011, K. Young, J. Wang, T. Hock and D. Lauritsen, 2011: Genesis and Rapid Intensification Processes (GRIP) 2010 quality controlled dropsonde data set).

UCAR/NCAR - Earth Observing Laboratory. 2016. NASA DC-8 QC Dropsonde Data, Version 3.0. UCAR/NCAR - Earth Observing Laboratory. http://doi.org/10.5065/D6VX0DRT. Accessed 28 Sep 2016.

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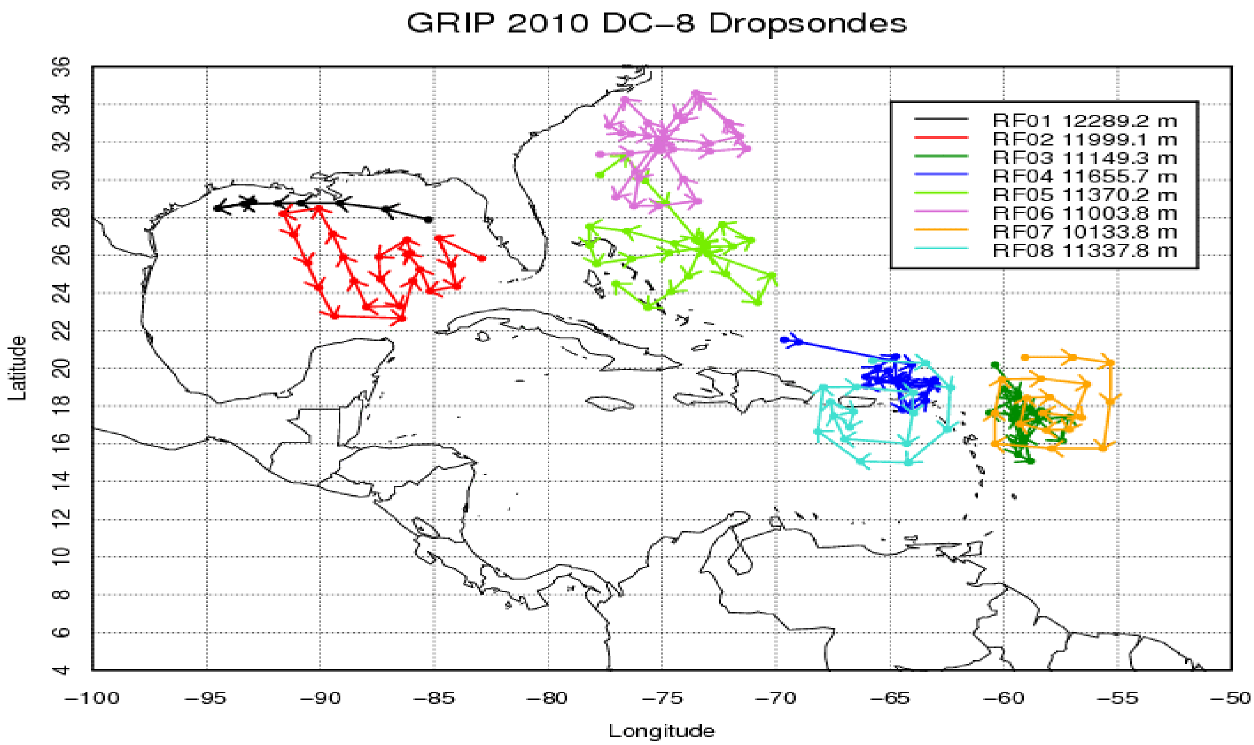
Version	Date	Author	Change Description
1.0	2011	*K. Young*	Initial Document Release
2.0	9/9/2016	*K. Young*	A dry bias in the RD94 and mini-dropsonde (NRD94) relative humidity measurements was discovered in data collected from 2010 to present, including all of the HS3 dropsonde datasets. The dry bias is strongly temperature dependent. It is considered small at warm temperatures and it becomes stronger at cold temperatures. This RH dry bias has been corrected. The dropsonde files that have received this correction contain an indicator in the header of the file, 'TDDryBiasCorrApplied'
3.0	9/28/2016	*K. Young*	Dewpoint temperature was recalculated using the corrected RH measurements (V2.0)

I. Project/Dataset Overview

The Genesis and Rapid Intensification Processes (GRIP) experiment was a campaign aimed at gaining a better understanding of how tropical storms develop into major hurricanes. The field project was conducted between August 17 and September 22 of 2010, during which time the NASA DC-8 aircraft completed 16 research flights (Figure 1). The DC-8 is equipped with a suite of instruments that includes an Airborne Vertical Atmospheric Profiling System (AVAPS), used for dropsonde deployment. During operations, three hundred twenty eight dropsondes were deployed over the Atlantic Ocean (Figure 2), and are included in the final quality controlled data archive. This document contains information on the sounding file format, data parameters included in the sounding files, and details regarding the quality control measures applied to the sounding data set, and our subsequent findings.



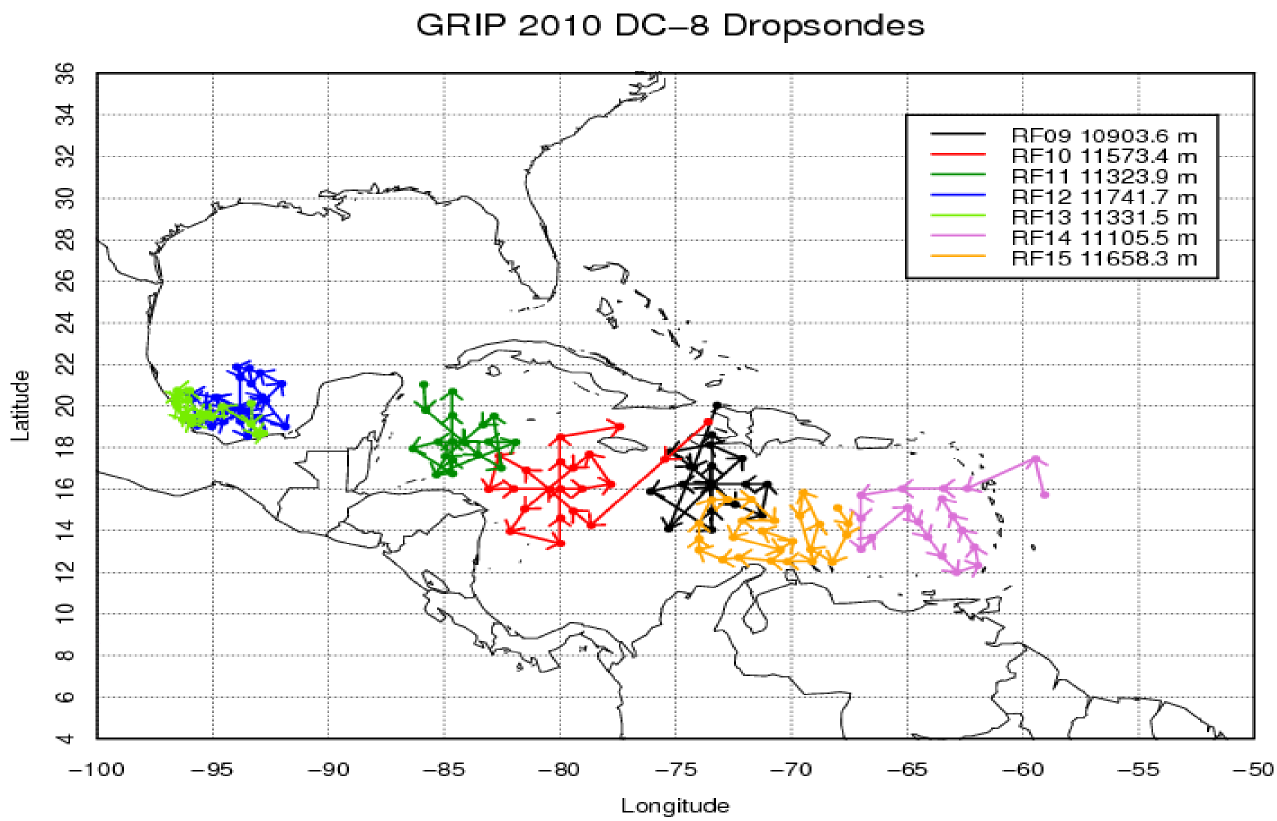


Figure 1 Flight tracks and direction for all sixteen research flights. Each flight is distinguished by a different color (shown in the legend). Each dot represents one sounding. The numbers in the legend (in meters) are average flight altitude for that flight.

Research Flight Numbers – Start dates of Flight (mm/dd)			
RF01 – 08/17	RF05 – 09/01	RF09 - 09/12	RF13 - 09/17
RF02 – 08/24	RF06 – 09/02	RF10 – 09/13, 09/14	RF14 - 09/21
RF03 - 08/29	RF07 – 09/06	RF11 - 09/14, 09/15	RF15 – 09/22
RF04 – 08/30	RF08 - 09/07	RF12 - 09/16	

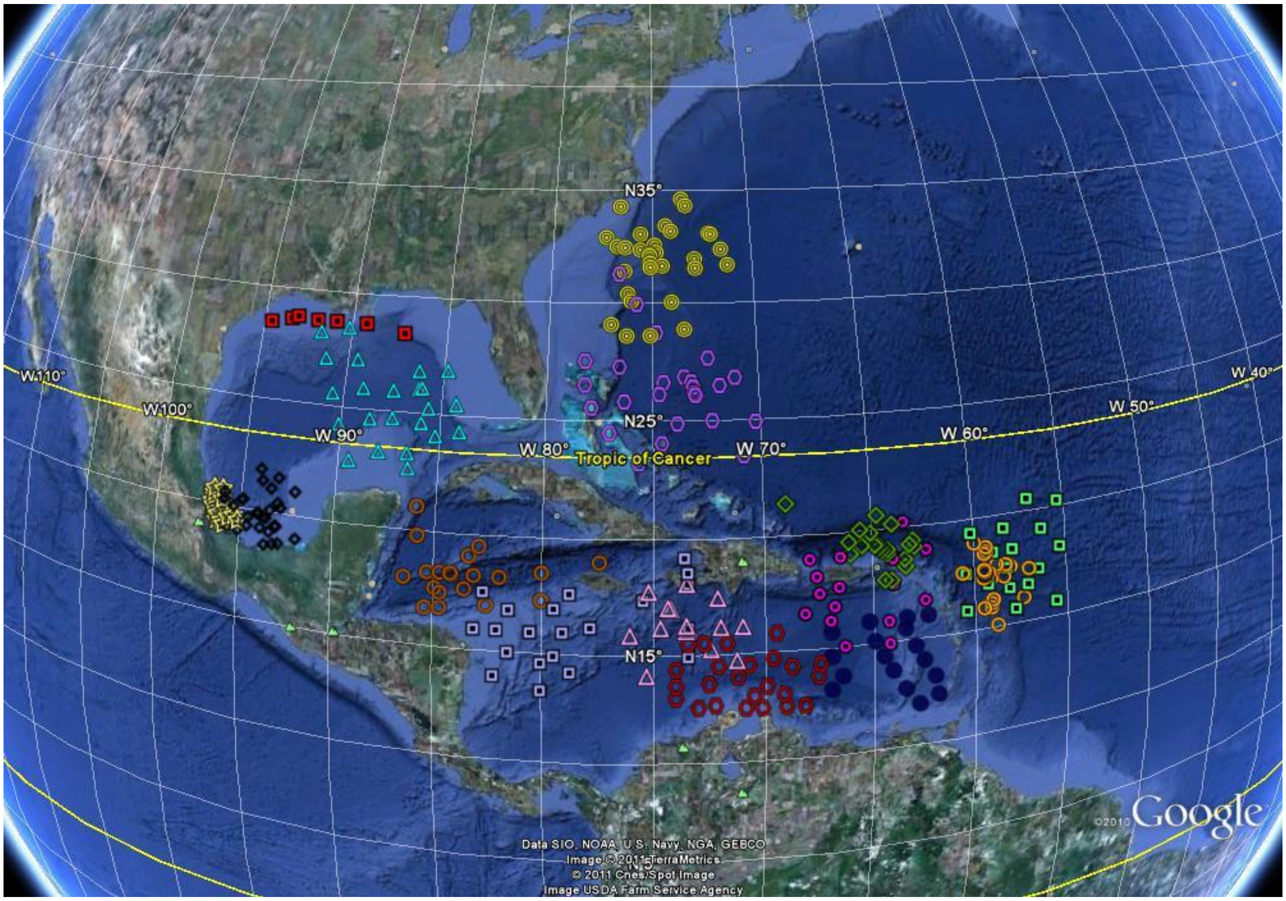


Figure 2 Map of the dropsonde launch locations from the NASA DC-8. Different symbols/colors indicate different research flights.

II. EOL File Format

The EOL format is an ASCII text format that includes a header (Table 1), with detailed project/ sounding information, and seventeen columns of high resolution data (Table 2). 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 quality controlled, 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, 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' 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, 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 1 Example of EOL format used for both dropsonde and radiosonde sounding files.

```
Data Type/Direction:                    AVAPS SOUNDING DATA, Channel 1/Descending
File Format/Version:                    EOL Sounding Format/1.0
Project Name/Platform:                  GRIP, RF01/NASA DC8, N817NA
Launch Site:
Launch Location (lon,lat,alt):          85 15.10'W -85.251675, 27
UTC Launch Time (y,m,d,h,m,s):          2010, 08, 17, 15:44:07
Sonde Id/Sonde Type:                    102015261/
Reference Launch Data Source/Time:      IWADTS/15:44:07
System Operator/Comments:               emk/none, Good Drop
Post Processing Comments:               Aspen Version 3.0; Created on 23 Mar 2011 20:12 UTC; ModEditsonde
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 2 Lists data fields provided in the EOL format ascii soundings.

Field Parameter	Units	Measured/Calculated
No.		
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	Measured
10 V Wind Component	Meters/Second	Measured
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

III. Data File Specifics

The files contain PTU and GPS position (lat, lon, alt) data at half-second intervals and GPS wind data at quarter-second intervals. The variables pressure, temperature, and relative humidity are calibrated values from measurements made by the dropsonde. The dew point is calculated from the temperature and relative humidity. The geopotential altitude value is calculated from the hydrostatic equation using first available pressure, temperature, and relative humidity. For the dropsondes specifically, if the sonde is launched over water and transmits data to the surface, the height is calculated by integrating from the surface (sea level) upward. However, if the sonde fails to transmit data to the surface or if the dropsonde is launched over land, because of unknown surface elevations, we integrate from the aircraft flight level down. The descent rate of the dropsonde is computed using the time-differentiated hydrostatic equation. All wind and position (lat, lon and alt) data are computed from GPS navigation signals received from the sonde.

IV. Data Quality Control

1. Profiles of the raw pressure, temperature, RH, wspd and DZ/DT are first examined to determine if all of the files contain data, and to ensure that nothing looked suspicious. Doing this allows us to determine if there were any errors with the automatic launch detect, if a sounding was started up, but not launched, or if the data contain any features that warrant further investigation.

2. The raw soundings files are then processed through the Atmospheric Sounding Processing ENvironment (ASPEN) software, which analyzes the data, performs smoothing, and removes suspect data points.

3. Time series plots of temperature, RH, wind speed, and fall rate with respect to altitude, 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.

4. Profiles of temperature, RH, wind speed and vertical velocity from the quality controlled soundings are visually evaluated for outliers, or any other obvious issues.

5. 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

6. Histograms of pressure, temperature, relative humidity, wind speed and wind direction are then created to examine the distribution, range, and characteristics of each parameter.

V. Results

1. Three hundred forty two sounding files were created during the project, however fourteen sounding files were removed from the final archive for one of the following reasons: the dropsonde was started up but never launched, the file contained no data, or the files contained very little data of poor quality. Three hundred twenty eight files were quality controlled and archived for GRIP.

2. Two files (D20100829_18452 and D20100921_215958) were launched with the protective temperature and relative humidity cap left on. The cap is meant to protect the sensors before flight, and should be removed prior to launch by the operators. When left on, it prevents the thermometer and hygrometers from accurately measuring the atmosphere. For these files, temperature and relative humidity were changed to missing values, but pressure and GPS data remain.

3. Ninety one sounding files or twenty-eight percent of the soundings contained significant noise of varying degrees (also referred to as oscillations) in the pressure, temperature and RH data (Figure 3). GPS wind data were not affected at all. This problem affected approximately six percent of the AVAPS II dropsondes deployed in 2010. This problem was due to RF energy from the dropsonde transmitter antenna inducing noise in the PTU module which was caused by a manufacturing change in the PTU module and tolerance of electronic components in the dropsonde. The cause of the problem has been identified and resolved for future field campaigns. To correct these data files, they were processed through ASPEN with more restrictive quality control parameters applied than are typically used for dropsondes. Tightening of the limits virtually removed all evidence of the oscillation in pressure, temperature and

relative humidity (Figure 4), however smaller scale residual effects can still be seen in the calculated fall speeds. As a result, the data for these soundings with PTU oscillations are sparse. These files are identifiable in the "Post Processing" comment line of the data file header by the text "Configuration PTUoscillQC".

4. Four soundings (D20100824_165902, D20100829_184115, D20100916_213321, and D20100917_181751) experienced brief interference from another dropsonde in flight that had been set to the same dropsonde transmitter frequency by the AVAPS operator. The PTU and winds for these soundings, during the time of frequency interference, were set to missing values.

5. Forty five dropsondes did not provide useful data to the surface due to a loss of signal or PTU oscillations near the lower portion of the sounding. The geopotential altitude, contained in these soundings, was calculated from flight level downward. Twenty seven of these files were soundings that experienced the PTU oscillation problem described in section 4. In these cases noisy data near the surface was filtered out, making it impossible to calculate geopotential altitudes from the ocean's surface upward.

6. Eight soundings were classified as "fast fall drops", and ten were "partial fast fall drops", meaning the parachute failed to deploy or deployed late. Failure of the parachute to deploy results in dropsondes falling at a faster rate (and sometimes tumbling) causing wind speed and direction to be unreliable. For these soundings, wind speed and wind direction are both set to missing, where the dropsonde was falling at an accelerated rate.

Parachute Failure "Fast Fall"	**Late Parachute "Partial Fast Fall"**
D20100817_161109_P.3	D20100829_214343_P.3
D20100829_213504_P.2	D20100906_202251_P.4
D20100912_192640_P.1	D20100907_192422_P.1
D20100912_230952_P.4	D20100912_233901_P.3
D20100914_232604_P.1	D20100916_185733_P.1
D20100916_220247_P.4	D20100916_192412_P.2
D20100922_184853_P.3	D20100916_194600_P.4
D20100922_201214_P.1	D20100916_202946_P.2
	D20100916_230555_P.2
	D20100917_180053_P.4

7. One dropsonde (D20100921_212250) experienced failure of the temperature sensor. As a result, this file does not contain temperature, geopotential altitude or pressure calculated dz/dt.

8. The following dropsondes experienced issues with the launch detect mechanism. In these cases the launch detect was either triggered early or late, or it failed completely. No data is lost when this occurs, however raw data is incorrectly recorded as "pre-launch", for late or failed launch detect, or it is flagged as "in-flight", for early launch detect. Additionally, the filenames and launch times and flight level data recorded are incorrect. The sounding files listed below were corrected and the original and new filenames are provided.

Early Launch Detect	
Original Filename	**Corrected Filename**
D20100817_170147	D20100817_170152
D20100824_194710	D20100824_200839
D20100829_182309	D20100829_184524
D20100902_180200	D20100902_181312
D20100912_212542	D20100912_221212
D20100917_184544	D20100917_184605
D20100922_170336	D20100922_170447
D20100922_204758	D20100922_211507
Failed Launch Detect	
Original Filename	**Corrected Filename**
D20100830_211801	D20100830_214816
D20100830_210324	D20100830_211412
D20100830_221524	D20100830_222048
D20100922_195211	D20100922_202149
Late Launch Detect	
Original Filename	**Corrected Filename**
D20100913_005244	D20100913_004458

9. A number of soundings were plagued with signal drop-outs that resulted in data loss. The soundings listed below are a sample of some of the more extreme cases. These files may contain only sporadic data, but have been included in the final archive.

Filename
D20100829_172853
D20100829_181026
D20100829_191307
D20100829_193850
D20100829_200115
D20100829_211834
D20100901_190718

10. Six of the quality controlled sounding files exhibited a large singular negative spike in calculated descent rate (dz/dt) found to be caused by a small, yet abrupt, positive offset in pressure. The dz/dt spikes varied in magnitude and were found at different heights. The pressure offsets, and subsequent dz/dt spikes, were found to be caused by time tag differences between the AVAPS PC clock and GPS time from the dropsondes. This occurs if the dropsonde does not have GPS satellite lock prior to launch and the PC clock significantly drifts from UTC time. During these periods (usually about 5 seconds) only the calculated descent rates were set to missing.

Filename
D20100907_232253

D20100917_180321
D20100917_181432
D20100917_181548
D20100917_181751
D20100917_182446

11. Histograms of flight level data (Figure 5) indicate a problem with the aircrafts humidity sensor. For a large percentage of soundings, the flight level sensor measured unrealistically large RH values of 100%, corresponding to pressure levels between 250-300 mb. The flight level aircraft data is located on the first data line of the sounding file, and has a -1.0 second time stamp. Because the aircraft RH values are not used to compute derived sonde values, found in the quality controlled data files, no quality control measures were taken to correct the aircraft data, and we caution researchers about utilizing these data in their analyses.

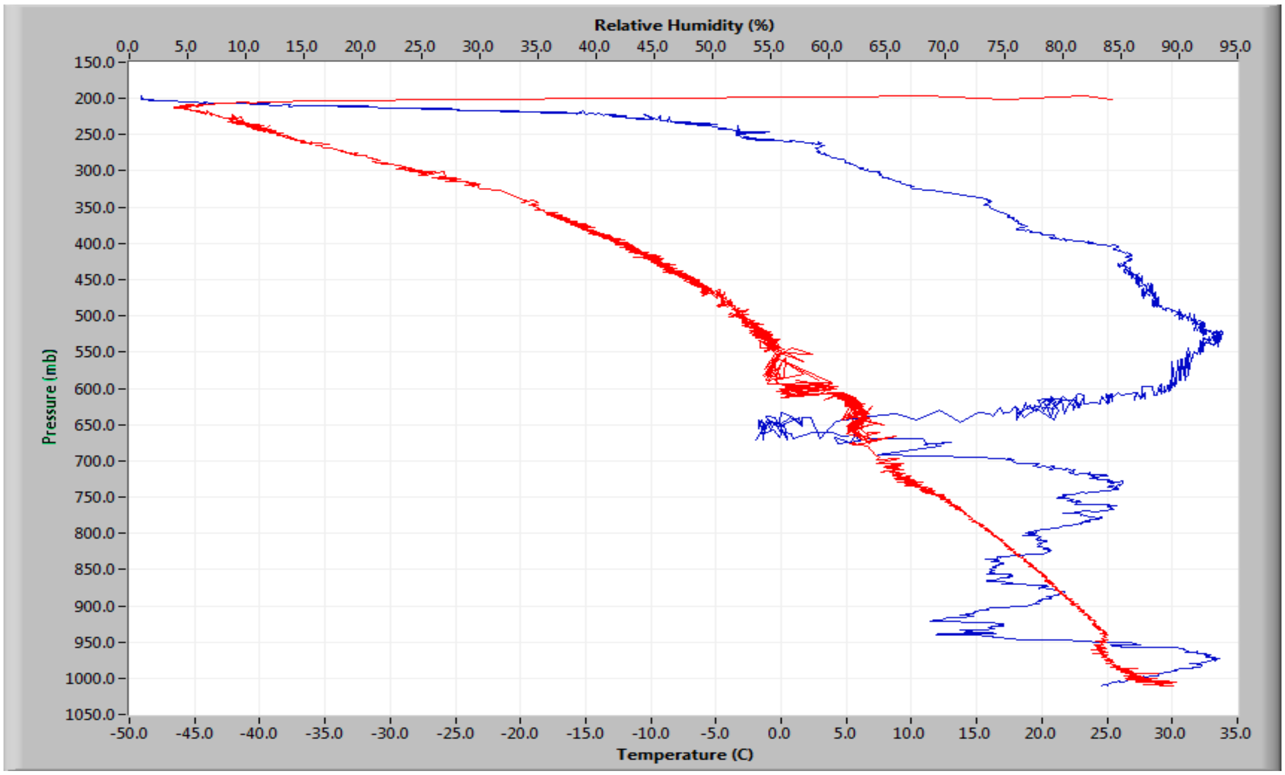


Figure 3 Profile of raw temperature (red) and RH (blue) versus pressure, from file D20100817_170152, shows evidence of the PTU oscillation error.

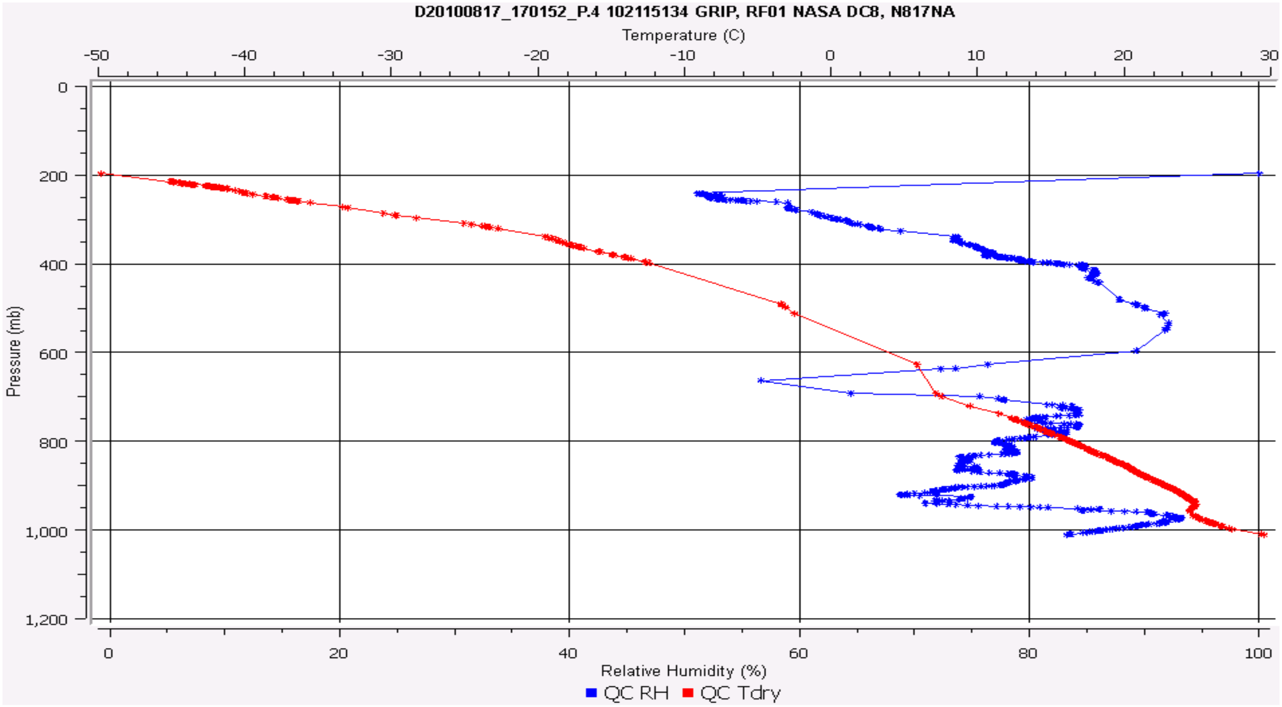


Figure 4 Profile of QC temperature and RH data versus pressure, from file D20100817_170152, shows ASPEN output with tightened parameters.

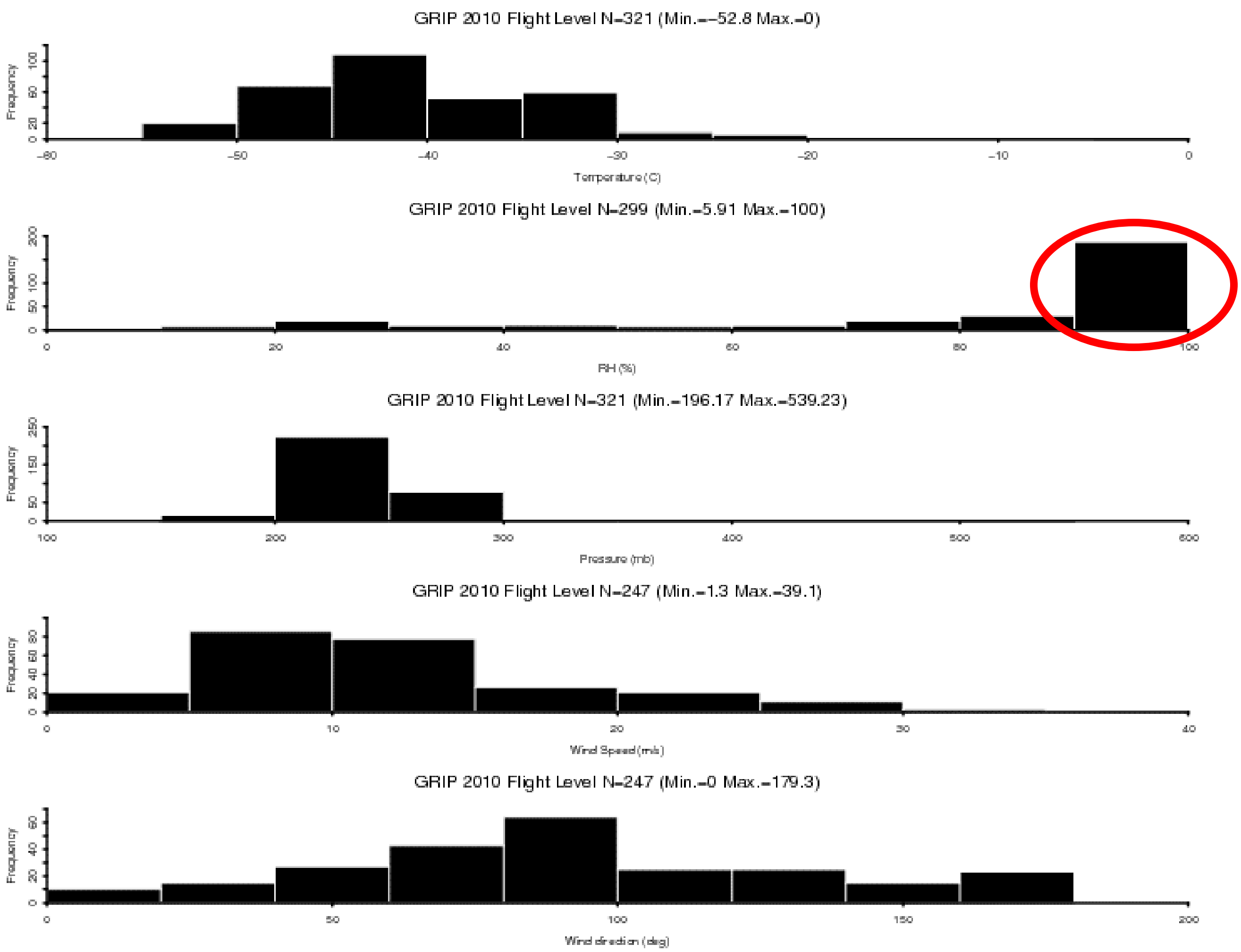


Figure 5 Flight level histograms of temperature, RH, Pressure, wind speed and wind direction. The second plot from top show unrealistically RH values, equaling 100%, for a large number of soundings.