Pre-Depression Investigation of Cloud-systems in the Tropics (PREDICT) 2010 Quality Controlled Dropsonde Data Set

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. (2011, K. Young, J. Wang and D. Lauritsen, 2011: Pre-Depression Investigation of Cloud-systems in the Tropics (PREDICT) 2010 quality controlled dropsonde data set. Available at http://data.eol.ucar.edu/master_list/?project=PREDICT.

UCAR/NCAR - Earth Observing Laboratory. 2016. NSF/NCAR GV Dropsonde Data (EOL Format), Version 3.0. UCAR/NCAR - Earth Observing Laboratory. http://dx.doi.org/10.5065/D6R78CD4. Accessed 09 Sep 2016.

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Document Version Control

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	9/14/2016	*K. Young*	Dewpoint temperature was recalculated using the corrected RH measurements (V2.0)

I. Project/Dataset Overview

The Pre-Depression Investigation of Cloud-systems in the Tropics (PREDICT) was a campaign focused on examining the multi-scale processes involved in tropical cyclone genesis. The field project was conducted between August 15 and September 30 of 2010, during which time the NCAR GV aircraft completed 26 research flights (Figures 1 and 2). The GV is equipped with a suite of instruments that includes an Airborne Vertical Atmospheric Profiling System (AVAPS), used for dropsonde deployment. Five hundred sixty eight dropsondes were deployed during 26 research flights made over the Atlantic Ocean (Figures 1 and 2). Five hundred fifty eight of those soundings 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.

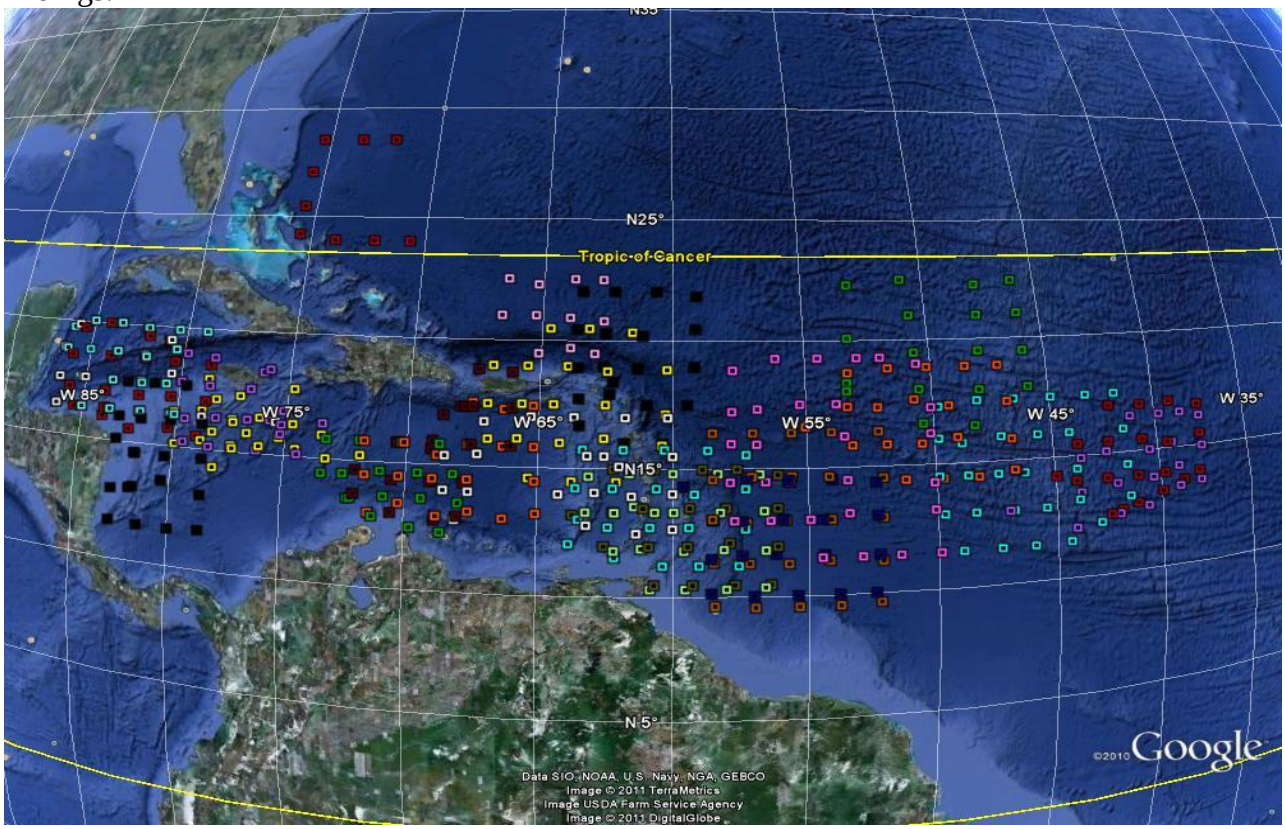
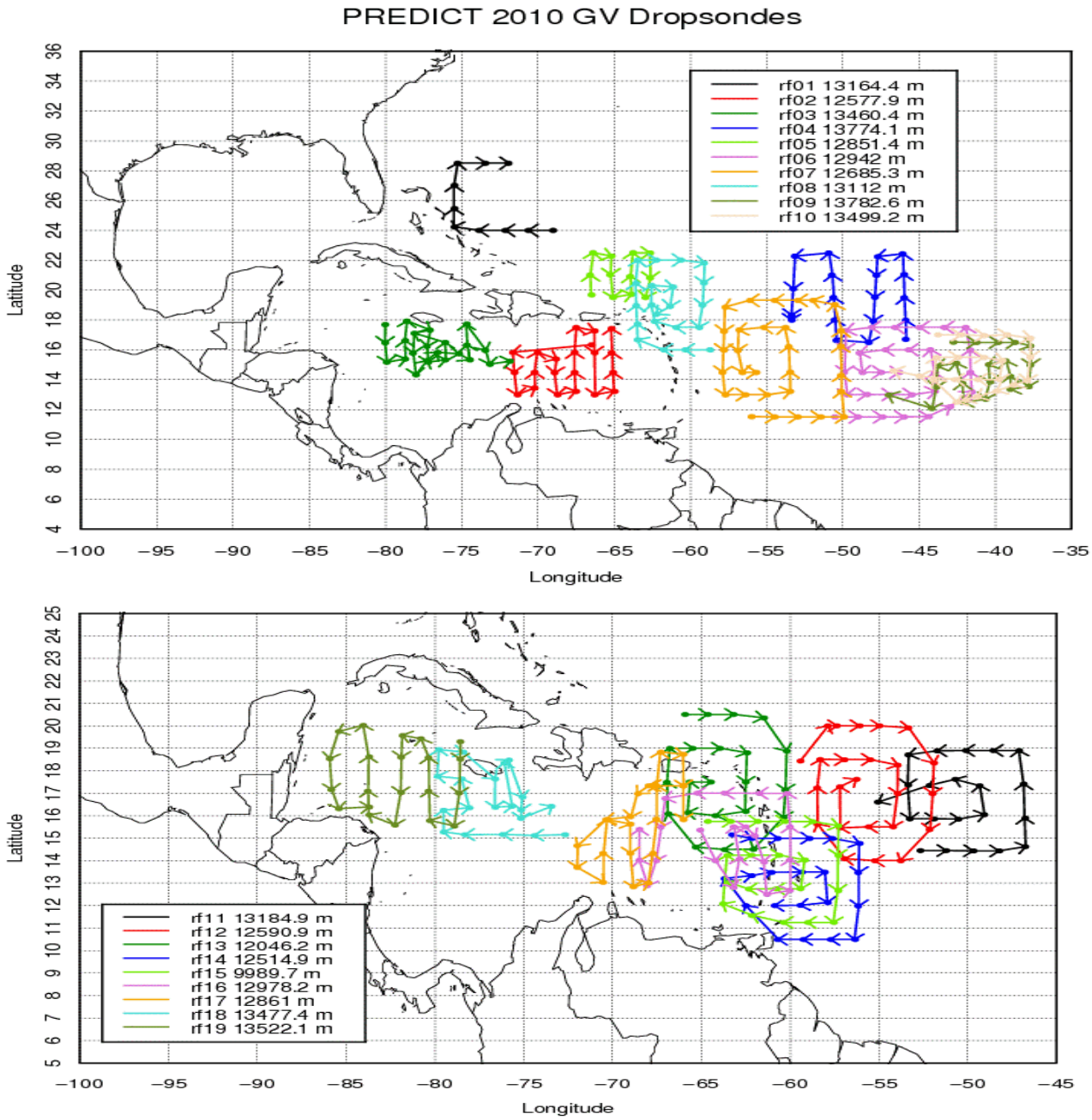


Figure 1 Map of the dropsonde launch locations from the NCAR GV. Different colors indicate different research flights.



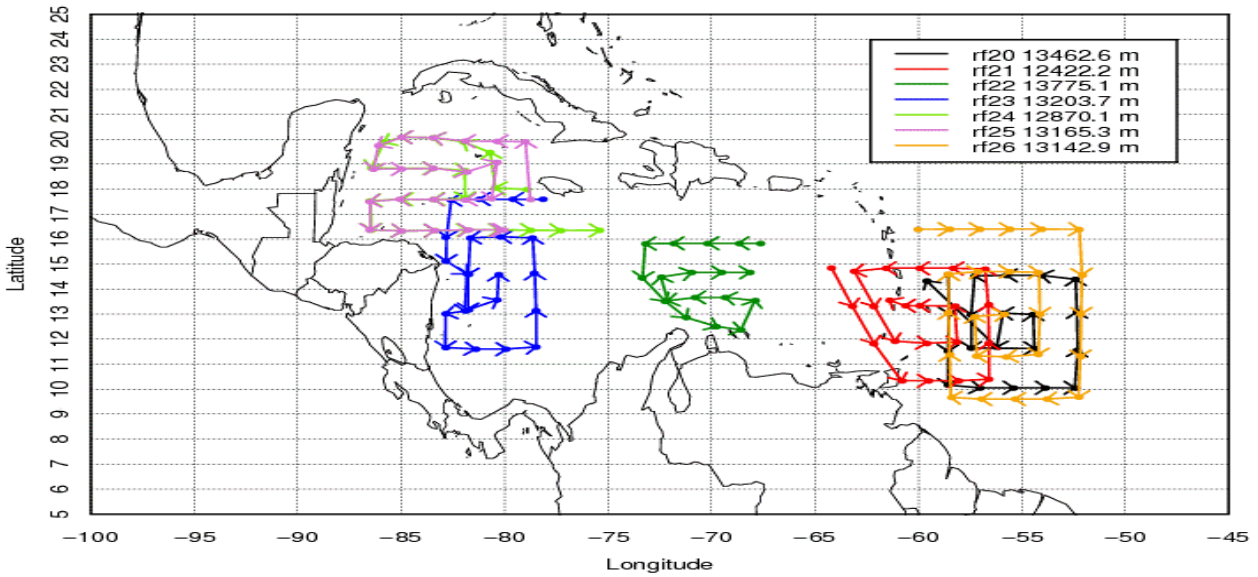


Figure 2 Flight tracks and direction for all twenty-six research flights. Each flight is distinguished by a different color (shown in the legend). Each dot represents one sounding. The numbers in the legend (in meters) are average flight altitude for that flight.

Research Flight Numbers – Dates of Flight (mm/dd)			
RF01 – 08/15	RF08 - 09/01	RF15 - 09/10	RF22 – 09/22
RF02 – 08/17	RF09 - 09/02	RF16 - 09/11	RF23 – 09/24
RF03 - 08/18	RF10 – 09/03	RF17 - 09/12	RF24 – 09/27
RF04 – 08/21	RF11 - 09/05	RF18 – 09/13	RF25 – 09/28
RF05 – 08/23	RF12 - 09/06	RF19 - 09/14	RF26/- 09/30
RF06 - 08/30	RF13 - 09/07	RF20 - 09/20	
RF07 - 08/31	RF14 - 09/10	RF21 – 09/21	

II. EOL File Format and Data Specifics

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 4/Descending
File Format/Version:                EOL Sounding Format/1.0
Project Name/Platform:              PREDICT, RF01/NCAR GV
Launch Site:
Launch Location (lon,lat,alt):      94 14.12'W -94.235300,47 06.13'N 47.102100,  6717.42
UTC Launch Time (y,m,d,h,m,s):      2010, 09, 10,  09:51:15
Sonde Id/Sonde Type:                1010655025/
Reference Launch Data Source/Time:  IWADTS/09:51:15
System Operator/Comments:           Tudor
Post Processing Comments:           Aspen Version 3; Created on 28 Jan 2011 :26 UTC, Configuration Mod Editsonde
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
----    -------  -------  -----  -------  -------  -----  ----   ----  ------ -------  ------  -------  -----  ----------
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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	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 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 run 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.

7. Lastly, we examine skew-t diagrams from each sounding.

IV. Results

1. Ten 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.

2. Eleven sounding files contained significant noise, or oscillations, in the pressure, temperature (Figure 3) and RH data (Figure 4). The cause of the noise was partially a change in the Vaisala firmware and is still under investigation. The following soundings contained excessive noise, of varying degrees. To correct these data files, they were run 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, however small 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.

Filename			
D20100815_130754	D20100818_140254	D20100831_123520	D20100906_122237
D20100817_112152	D20100818_154351	D20100902_153245	D20100930_151452
D20100817_141433	D20100831_120148	D20100902_174548	

3. One sounding, D20100928_151946, experienced brief interference from another dropsonde, in flight, that had been set to the same frequency. The PTU and winds for this sounding, during the time of frequency interference, were set to missing values.

4. Nine soundings exhibited large, temporary offsets in the pressure, temperature and humidity (Figure 5). The PTU values in the affected regions were set to missing values, and the final data products show no evidence of the offsets.

Filename		
D20100815_111749	D20100903_152003	D20100912_121353
D20100902_190625	D20100907_151230	D20100922_165439
D20100903_150813	D20100907_155831	D20100924_152933

5. Eight dropsondes experienced a loss of signal and failed to transmit data to the ground. The geopotential altitude in these soundings was calculated from flight level downward.

Filename			
D20100821_145145	D20100906_162944	D20100924_171624	D20100928_142455
D20100903_181909	D20100922_160020	D20100927_151112	D20100928_160312

6. Twenty one soundings were classified as "fast fall drops", and twenty 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"**
D20100818_153520	D20100818_143349
D20100821_134735	D20100830_153922
D20100830_124817	D20100901_140218
D20100901_135245	D20100902_190625
D20100901_141439	D20100905_184211
D20100901_151234	D20100906_132612
D20100903_145612	D20100910_103936
D20100906_144417	D20100912_113324
D20100906_160545	D20100912_114431
D20100907_140450	D20100912_135116
D20100907_144349	D20100912_114600
D20100910_102913	D20100922_150338
D20100910_120829	D20100922_153758
D20100910_124723	D20100922_162152
D20100913_120356	D20100922_165439
D20100913_114706	D20100924_143022
D20100913_134316	D20100928_152855
D20100914_151929	D20100928_160312
D20100920_153200	D20100930_155246
D20100927_180033	D20100930_173006
D20100928_153901	

7. The following dropsondes experienced problems with one or more of the following sensors: pressure, temperature and RH. The table below includes the file names and the sensor failures which resulted in loss of data.

Filename	Sensor error
D20100815_113933	Broken pressure sensor. File contains no pressure data.
D20100901_161736	Broken T sensor. File contains no T data, calculated dz/dt or

	geopotential altitude
D20100906_162944	Broken T sensor. File contains no T data, calculated dz/dt or geopotential altitude
D20100911_164437	Suspicious loss of data at top of profile between flight level and 256 mb.
D20100920_155711	Loss of data at the top of profile caused by temporary loss of signal. Signal was reacquired 20 mb below flight level.
D20100921_163330	Broken RH sensor. File contains no RH data
D20100928_155055	Broken T sensor. File contains no T data, calculated dz/dt or geopotential altitude

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 completed. 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. Majority of the late launch detects are minor (on the order of around 3-5 seconds) and are a result of the improved performance of the dropsonde. These new sensors are able to acquire a signal almost instantaneously after launch, where as with previous versions of dropsonde there was a lag in the time between launch and signal acquisition. The sounding files listed below were corrected and the original and new filenames are provided.

Early Launch Detect	
Original Filename	**Corrected Filename**
D20100903_162831	D20100903_164454
D20100911_195604	D20100911_195742
D20100912_123624	D20100912_124126
D20100928_181718	D20100928_182836
D20100913_140233	D20100913_140700
D20100913_142516	D20100913_143654
D20100927_150909	D20100927_151112
Failed Launch Detect	
Original Filename	**Corrected Filename**
D20100927_152225	D20100927_153040
D20100928_140630	D20100928_141646
Late Launch Detect	
Original Filename	**Corrected Filename**
D20100817_115936	D20100817_115933
D20100902_154415	D20100902_154413
D20100902_184314	D20100902_184312
D20100903_150817	D20100903_150813
D20100903_174621	D20100903_174618
D20100905_164706	D20100905_164703
D20100906_130227	D20100906_130224

D20100907_161103	D20100907_161102
D20100907_170938	D20100907_170937
D20100910_103938	D20100910_103936
D20100910_110437	D20100910_110434
D20100910_123311	D20100910_123309
D20100912_114635	D20100912_114600
D20100912_114758	D20100912_114431
D20100912_115441	D20100912_115437
D20100912_120306	D20100912_120249
D20100913_110541	D20100913_110534
D20100913_111811	D20100913_111806
D20100913_113103	D20100913_113056
D20100913_132410	D20100913_132359
D20100913_142043	D20100913_142041
D20100914_152532	D20100914_152531
D20100920_145418	D20100920_145417
D20100920_151850	D20100920_151848
D20100920_165629	D20100920_165627
D20100920_170803	D20100920_170800
D20100921_122718	D20100921_122715
D20100924_172759	D20100924_172758
D20100927_164805	D20100927_164803

9. Twelve soundings are suspected of having a dry bias of the RH sensor (Figure 6). These were identified, by visual inspection of the humidity profiles, as dropsondes that passed through clouds but failed to reach saturation. The magnitudes of the biases appear to vary from sounding to sounding. Given that only twelve soundings (that we were able to identify) exhibited this behavior, and because it is impossible to determine if other dropsondes, which did not travel through clouds layers, also contain a bias, no corrections were applied to these data files.

Filename		
D20100818_150628	D20100913_113056	D20100928_141646
D20100902_161411	D20100922_170313	D20100928_142455
D20100903_170731	D20100924_173911	D20100928_163043
D20100910_174019	D20100928_140616	D20100928_171534

10. 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.

RF02	**RF14**
D20100818_140254	D20100910_095115
RF04	**RF17**
D20100821_130702	D20100912_114431
D20100821_131932	D20100912_132840

D20100821_133148	**RF19**
D20100821_134735	D20100914_162309
D20100821_135821	**RF25**
D20100821_141006	D20100928_164035
D20100821_142215	
D20100821_143430	
D20100821_145145	

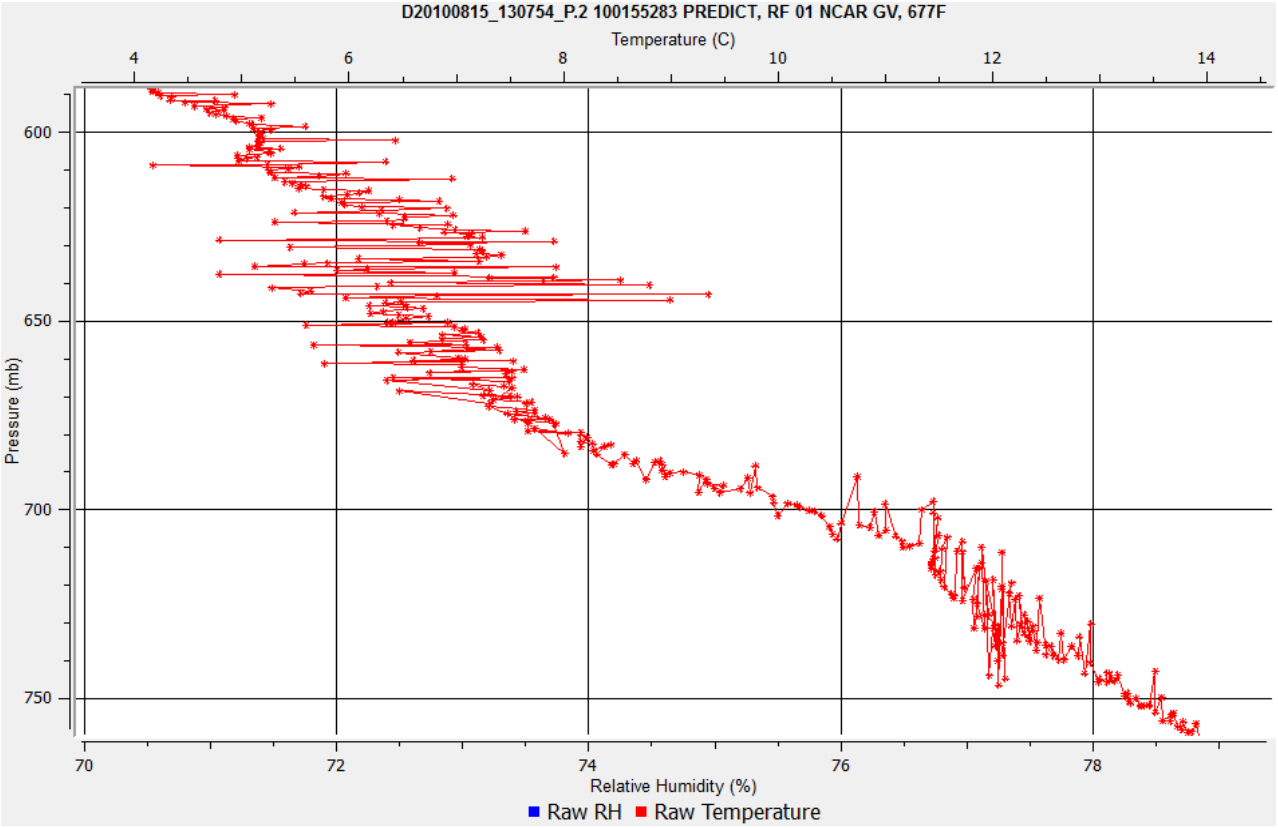

Figure 3 Profile of raw temperature versus pressure, from file D20100815_130754, shows evidence of the PTU oscillation error.

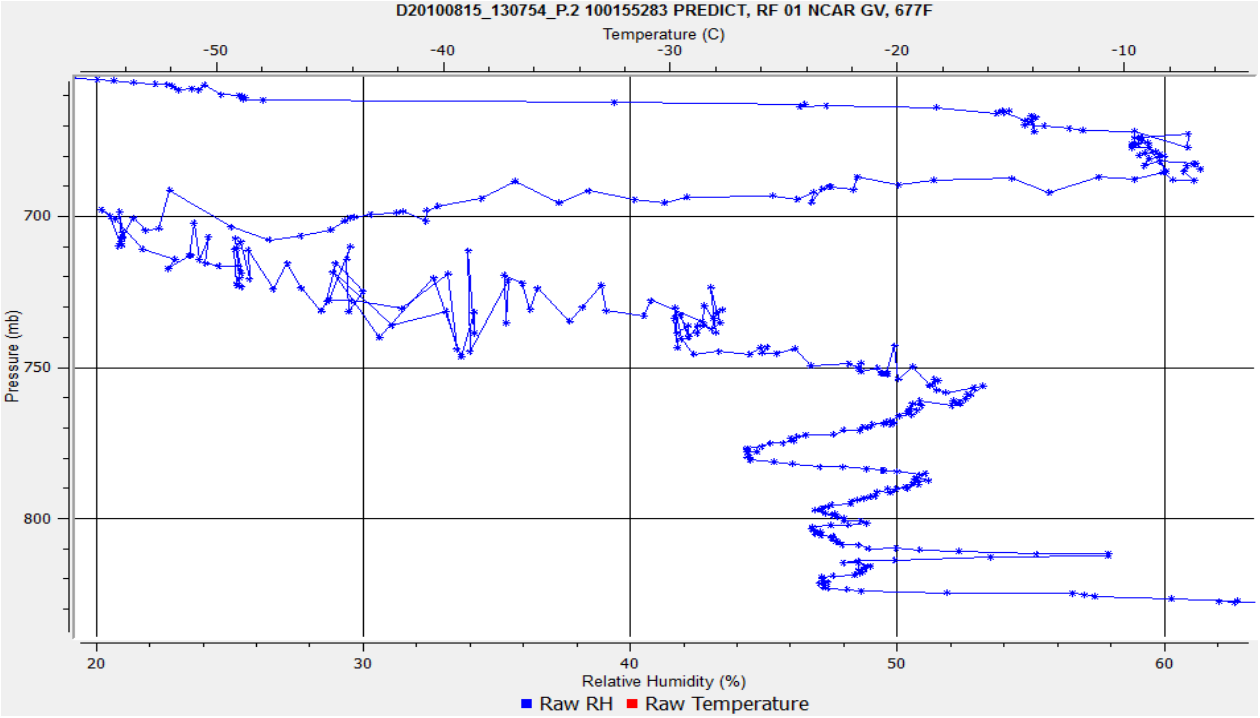

Figure 4 Profile of raw RH data versus pressure, from file D20100815_130754, shows noise caused by the PTU oscillation error.

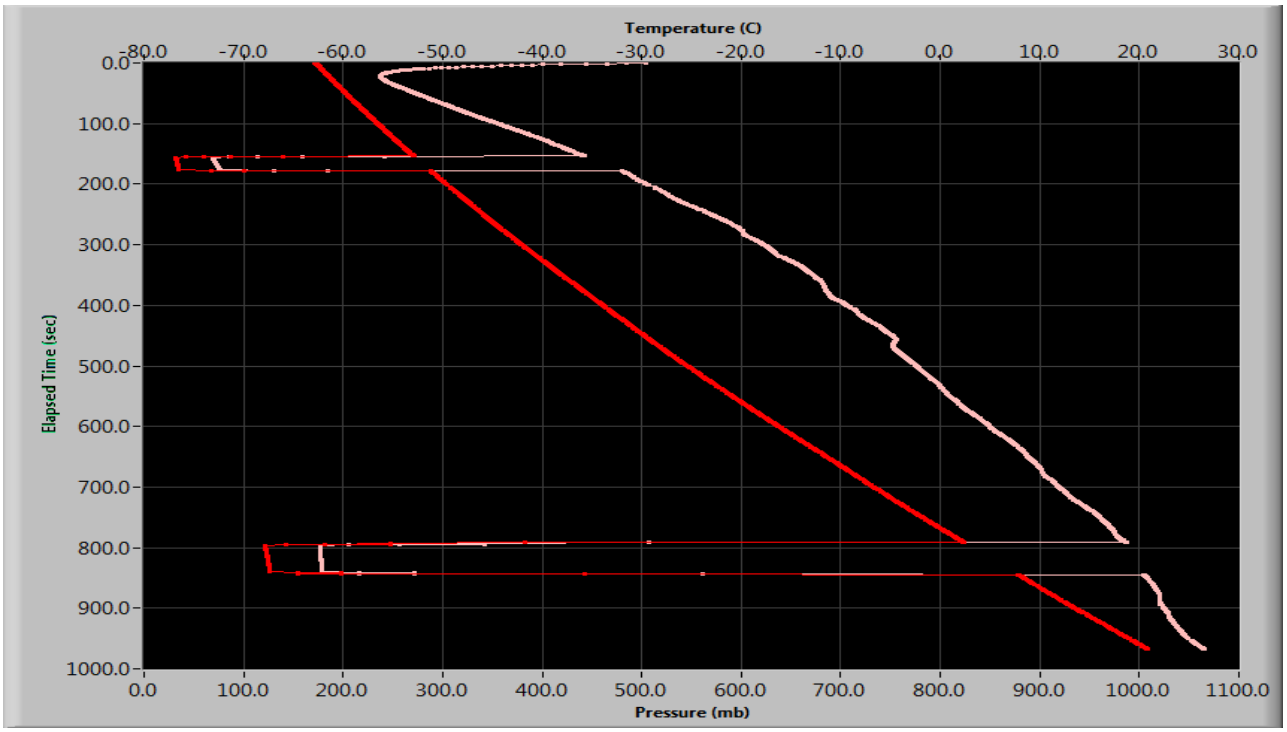

Figure 5 Plot shows significant offsets in the raw temperature (pink) and pressure (red) profiles versus time.

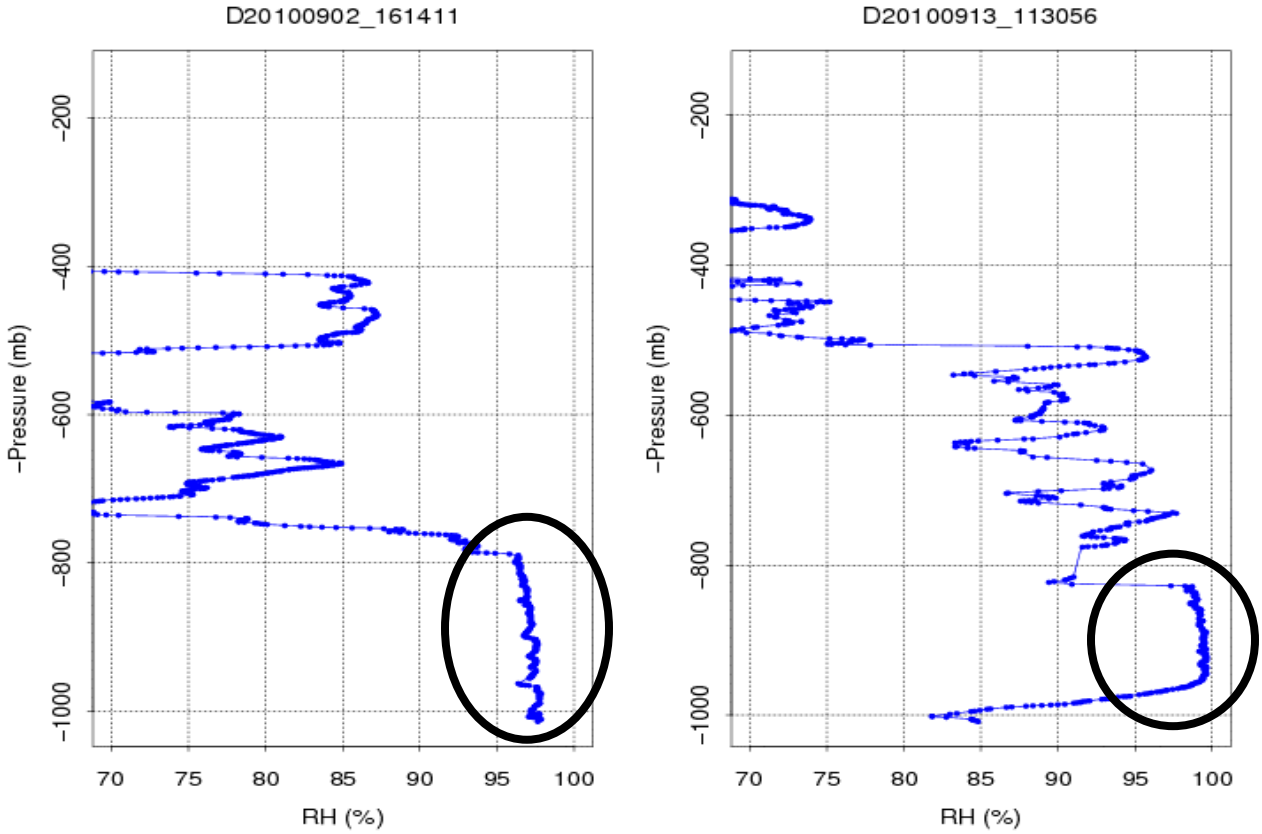

Figure 6 Plots show evidence of a dry bias in the relative humidity sensor where the dropsonde likely passed through a cloud, but failed to reach saturation.