Impact of Typhoons on the Ocean in the Pacific (ITOP) 2010 Quality Controlled DOTSTAR 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 Loehrer et al. (2011, Loehrer, S. M., K. Young, J. Wang, Terry Hock and D. Lauritsen, 2011: Impact of Typhoons on the Ocean in the Pacific (ITOP) 2010 DOTSTAR quality controlled dropsonde data set. available at http://data.eol.ucar.edu/master_list/?project=ITOP.

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. 2010. DOTSTAR ASTRA Dropsonde High Resolution Data [NCAR/EOL], Version 2.0. UCAR/NCAR - Earth Observing Laboratory. http://doi.org/10.5065/D6HM56NP . Accessed 5 July 2016.

Contents:

I. Contacts:

Data Quality
Scot Loehrer
loehrer@ucar.edu

Kate Young
kbeierle@ucar.edu

Junhong (June) Wang
junhong@ucar.edu

System/Software
Dean Lauritsen
lauritsn@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	3/31/2015	*K. Young*	Initial Document Release

2.0	5/25/2016	*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 ITOP 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 for. The dropsonde files that have received this correction contain an indicator in the header of the file, 'TDDryBiasCorr'.
3.0	9/30/2016	*K. Young*	Version 3.0 of the data is corrected for a temperature dependent dew point dry bias.

I. Project/Dataset Overview

The Impact of Typhoons on the Ocean in the Pacific (ITOP) was a multi-national field campaign focused on examining the ocean response to typhoons in the western Pacific Ocean. The field project was conducted between 20 August and 20 October of 2010, during which time the National Taiwan University DOTSTAR ASTRA aircraft completed 6 research flights with dropsondes (Figures 1 and 2). The DOTSTAR ASTRA is equipped with a suite of instruments that includes an Airborne Vertical Atmospheric Profiling System (AVAPS), used for dropsonde deployment. Ninety seven dropsondes were deployed during 6 research flights made over the western Pacific Ocean (Figures 1 and 2). Ninety four 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.

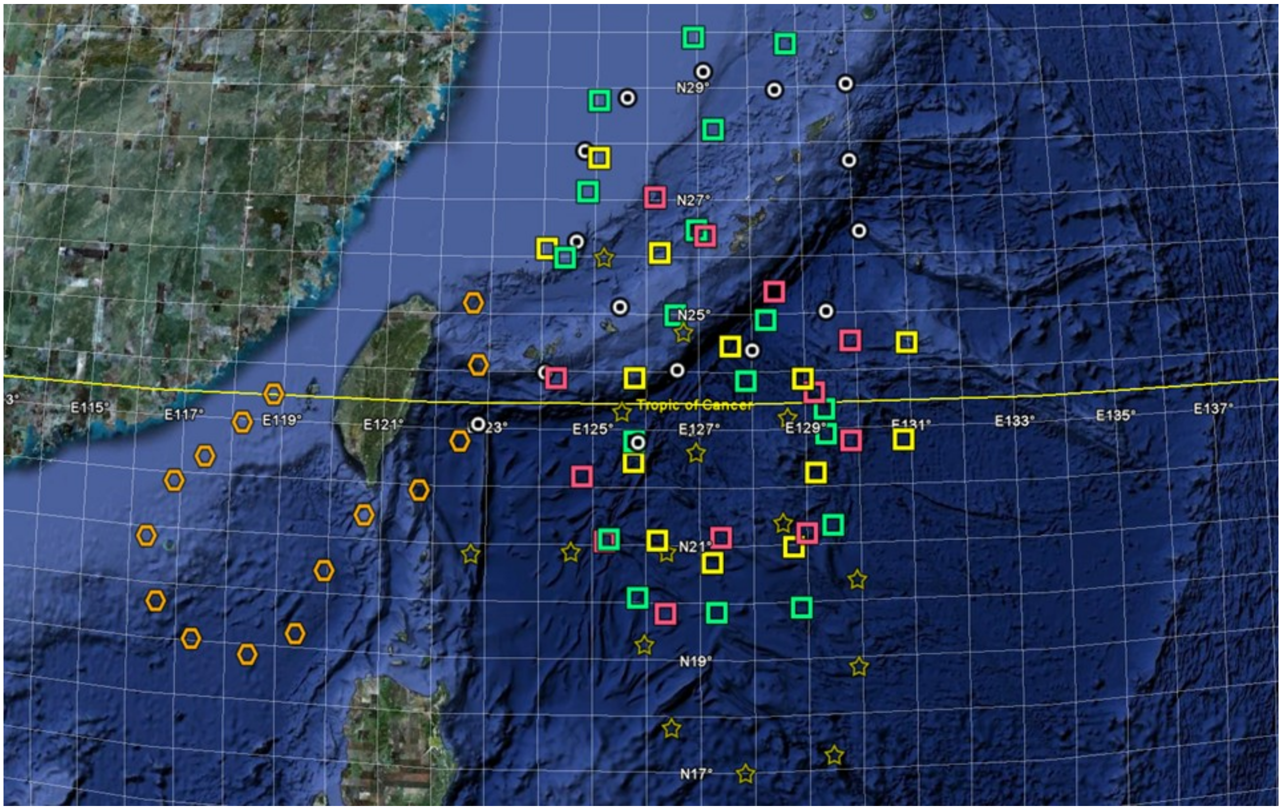

Figure 1 Map of the dropsonde launch locations from the DOTSTAR ASTRA. The symbols indicate different tropical cyclones and colors different research flights (white closed circles for 907 Kompasu, open orange pentagons for 908 Lionrock, open green/yellow/red squares for 910/911/912 Fanapi and brown stars for 926 Megi.

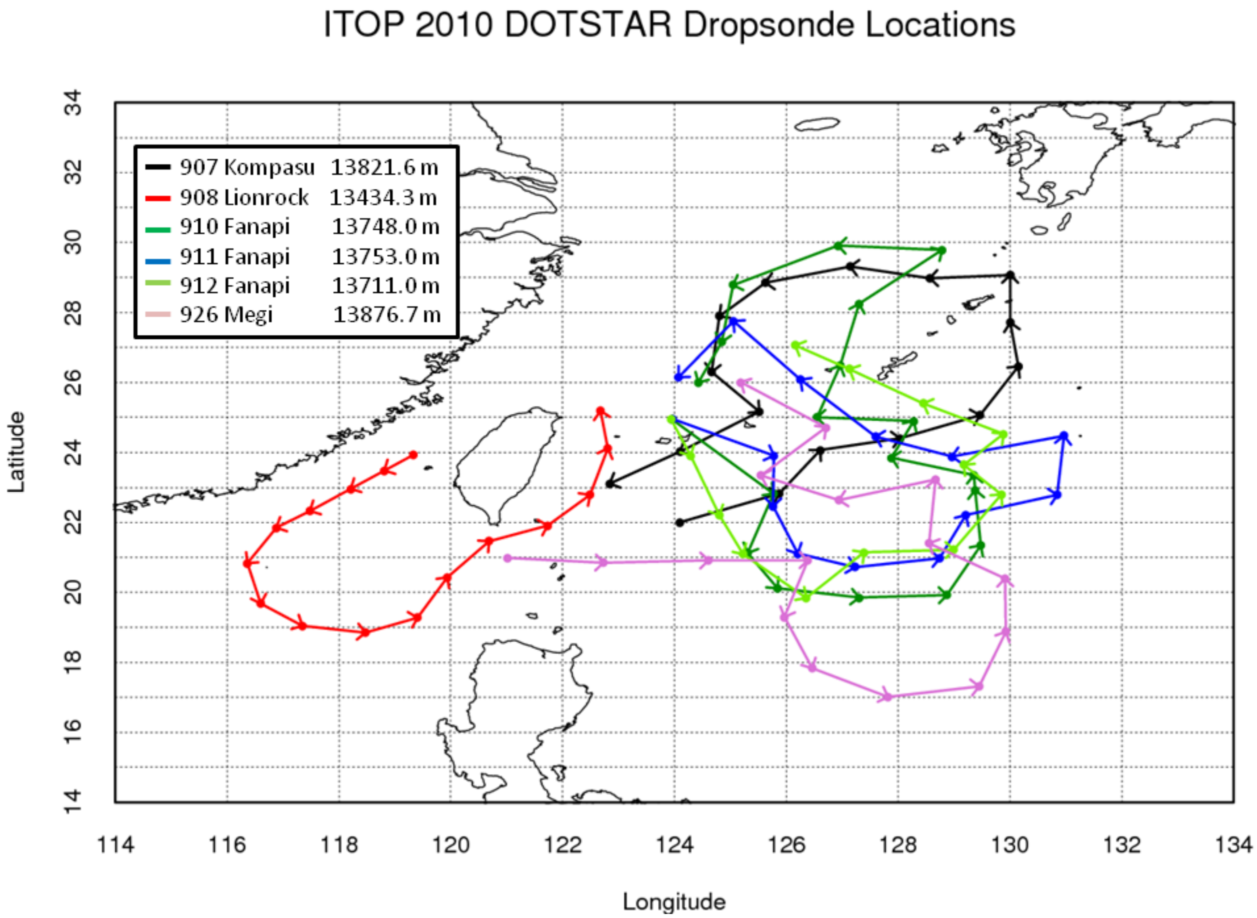

Figure 2 Flight tracks and direction for all six research flights. Each flight is distinguished by a different color (shown in the legend). The flight identifiers are as defined in the table below. Each dot represents one sounding. The numbers in the legend (in meters) are average flight altitude for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

Research Flight Numbers – Dates of Flight (mm/dd)

907 Kompasu – 8/31	911 Fanapi – 9/16
908 Lionrock – 8/31	912 Fanapi – 9/17
910 Fanapi – 9/15	926 Megi – 10/16

II. EOL File Format (with vertical wind)

The EOL format is an ascii text format that includes a header, with detailed project and sounding information, and seventeen columns of high resolution data (Table 1). The "D" files are one second resolution data files with appropriate corrections and quality control measures applied. The naming convention for these files is - "D", followed by "yyyymmdd_hhmmss_PQC.eol.Wwind" 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 ".eol" refers to the file format type

The header records contain 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 aircraft 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 2. The typical EOL file format has been extended for these dropsondes to include the vertical wind and filtered vertical wind columns at the end of each record.

```
Data Type/Direction:                    AVAPS SOUNDING DATA, Channel 3/Descending
File Format/Version:                    EOL Sounding Format/1.0
Project Name/Platform:                  10101800304 0930W MEGI, 10101800304 0930W MEGI/Lockheed C-130J, - Enter Tail Number Here -
Launch Site:
Launch Location (lon,lat,alt):          126 22.00'E 126.366700, 19 23.18'N 19.386300,  2353.10
UTC Launch Time (y,m,d,h,m,s):          2010, 10, 18, 05:02:50
Sonde Id/Sonde Type:                    094735112/
Reference Launch Data Source/Time:      AFRC WC-130J (ARWO)/05:02:54
System Operator/Comments:               stack/none, Good Drop
Post Processing Comments:               Aspen Version 3.0.0.0; Created on 11 Mar 2011 14:54 UTC; Configuration ModEditsonde
/
 Time   -- UTC  --   Press    Temp   Dewpt    RH    Uwind   Vwind   Wspd     Dir     dZ   GeoPoAlt     Lon         Lat      GPSAlt   Wwind Wwind_f
  sec   hh mm   ss     mb       C       C      %     m/s     m/s     m/s     deg    m/s       m        deg         deg         m      m/s     m/s
------- -- -- ----- ------- ------- ------- ------- ------- ------- ------- ------- ------- -------- ----------- ----------- -------- ------- -------
```

Table 1 Example of EOL format used for both dropsonde and radiosonde sounding files.

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
18	Vertical Wind	Meters/Second	Calculated
19	Filtered Vertical Wind	Meters/Second	Calculated

Table 2 Lists data fields provided in the EOL format ascii soundings.

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 record at -1.0 seconds is typically aircraft flight level data at the time of sonde release. However, for these DOTSTAR dropsondes the dropsonde data system was not linked to the flight level data system. So for the dropsondes that reached the surface, this -1.0 second record contains the first latitude/longitude/altitude from the dropsonde. For those that did not reach the surface, the -1.0 second record contains the first data from the dropsonde after the temperature sensor has equilibrated to the environment to improve the geopotential altitude calculations. 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 failed to transmit data to the surface, or if the dropsonde is launched over land, because of unknown surface elevations, we integrate from the 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. At the request of the PIs', the vertical wind velocity was added to the data files. It was calculated from the pressure-calculated and theoretical dropsonde fall rates. The filtered vertical wind is the smoothed values. Note that the vertical wind is first interpolated and then filtered, so the filtered data at lines where the vertical wind is not available should be ignored. The algorithm for calculating the vertical wind is described in details in Wang et al. (2009, Wang, J., J. Bian, W. O. Brown, H. Cole, V. Grubišić, K. Young, 2009: Vertical Air Motion from T-REX Radiosonde and Dropsonde Data. *J. Atmos. Oceanic Technol.*, **26**, 928–942.).

IV. Data Quality Control

1. Profiles of the raw pressure, temperature, RH, wind speed and descent rate (DZ/DT) are first examined to determine if all of the files contain data, and to ensure that nothing looks 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. Time series plots of temperature, RH, wind speed, and DZ/DT 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.

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

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

5. 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:

    a. 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 these issues please see #6 below.

    b. Applies a dynamic pressure correction of .4 mb

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

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

V. Results

1. Three sounding files were removed from the final as the dropsonde was started up but never launched.
2. Eight sounding files contained significant noise of varying degrees (also referred to as oscillations), in the pressure, temperature (Figure 3) and RH data (Figure 4). GPS wind data were not affected. 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 was identified and has been 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 removed virtually 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. A skewt showing the quality controlled data from D20100916_224645 (also shown in Figures 3 and 4) is displayed in Figure 5. These files are identifiable in the "Post Processing" comment line of the data file header by the text "Configuration PTUoscillQC".

Filename	
D20100831_102655	D20101016_222805
D20100916_224645	D20101016_231249
D20100918_001736	D20101016_232743
D20101016_214026	D20101017_014631

3. Ten dropsondes dropsondes did not provide useful data to the surface due to a loss of signal (9 soundings) or PTU oscillations (1 sounding) near the lower portion of the sounding. The geopotential altitude in these soundings was calculated from flight level downward.

Filename		
D20100831_110723	D20100915_224324	D20101016_234309
D20100831_231553	D20100916_215656	D20101016_235650
D20100915_220141	D20100918_001736	
D20100915_221521	D20101016_225900	

4. Four soundings were classified as "fast fall drops", and five 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, wind direction and the vertical wind parameters are set to missing, where the dropsonde was falling at an accelerated rate.

Parachute Failure "Fast Fall"	**Late Parachute "Partial Fast Fall"**
D20100831_220659	D20100831_114505
D20100831_232841	D20100831_214503
D20100901_001131	D20100831_222357
D20100916_214344	D20100916_233523
	D20101017_010839

5. A number of dropsondes experienced issues with the launch detect mechanism. In these cases the launch detect was either triggered early (1 file) or late (11 files), or it failed completely (1 file). 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. For these files, corrections were made to adjust the launch times, and correctly flag data that was collected from the dropsonde in flight. The sounding files listed below were corrected and the original and new filenames are provided.

Early Launch Detect			
Original Filename	**Corrected Filename**	**Original Filename**	**Corrected Filename**
D20100831_225611	D20100831_230351		
Late Launch Detect			
Original Filename	**Corrected Filename**	**Original Filename**	**Corrected Filename**
D20100831_122251	D20100831_122248	D20100831_223512	D20100831_223501
D20100831_123425	D20100831_123417	D20100831_225425	D20100831_225416
D20100831_124909	D20100831_124907	D20100916_212940	D20100916_212936
D20100831_133046	D20100831_133040	D20100916_214440	D20100916_214344
D20100831_220715	D20100831_220659	D20101016_224433	D20101016_224429
D20100831_222448	D20100831_222357		
Failed Launch Detect			
Original Filename	**Corrected Filename**	**Original Filename**	**Corrected Filename**
D20100916_215522	D20100916_222110		

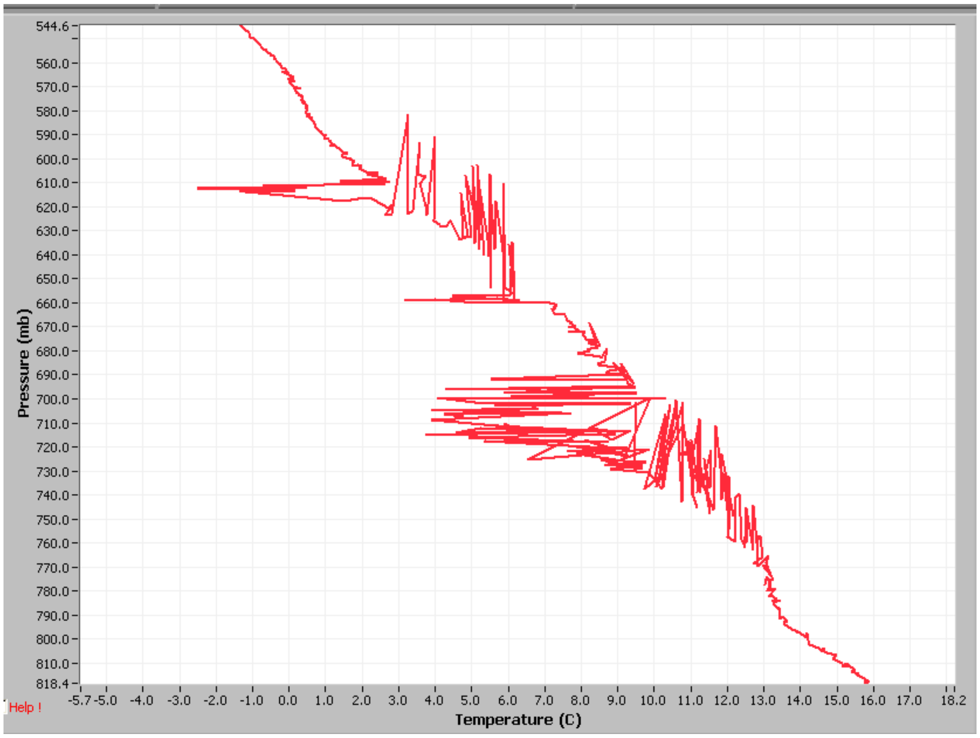

Figure 3 Profile of raw temperature versus pressure, from file D20100916_224645, shows evidence of the PTU oscillation error.

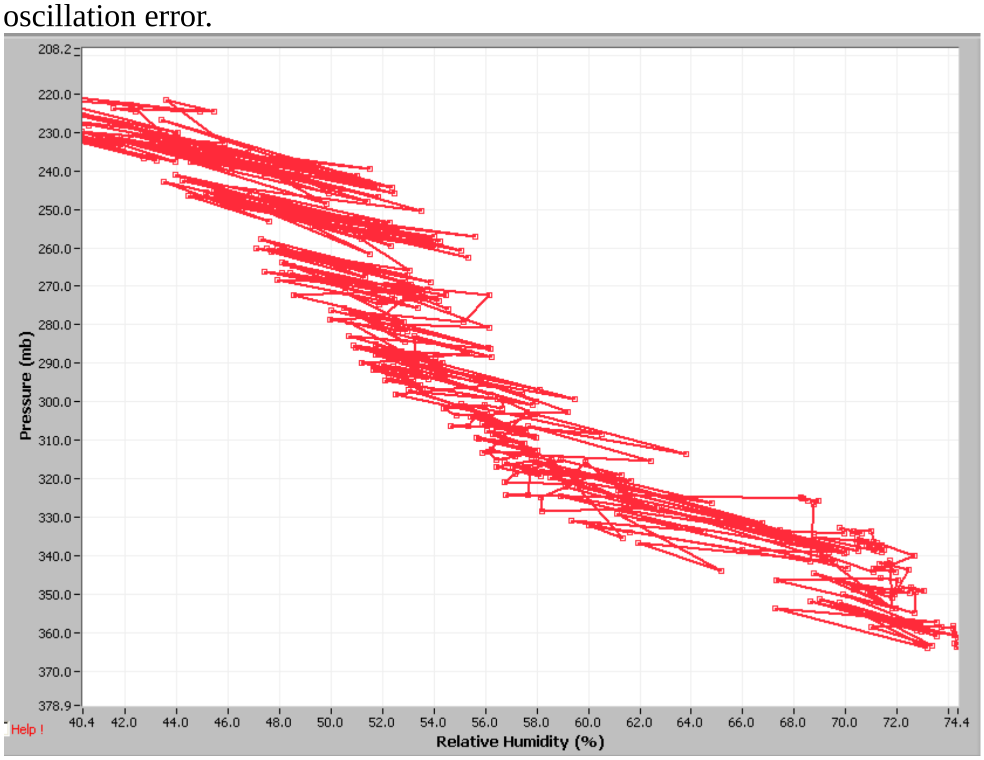

Figure 4 Profile of raw RH data versus pressure, from file D20100916_224645, shows noise caused by the PTU oscillation error.

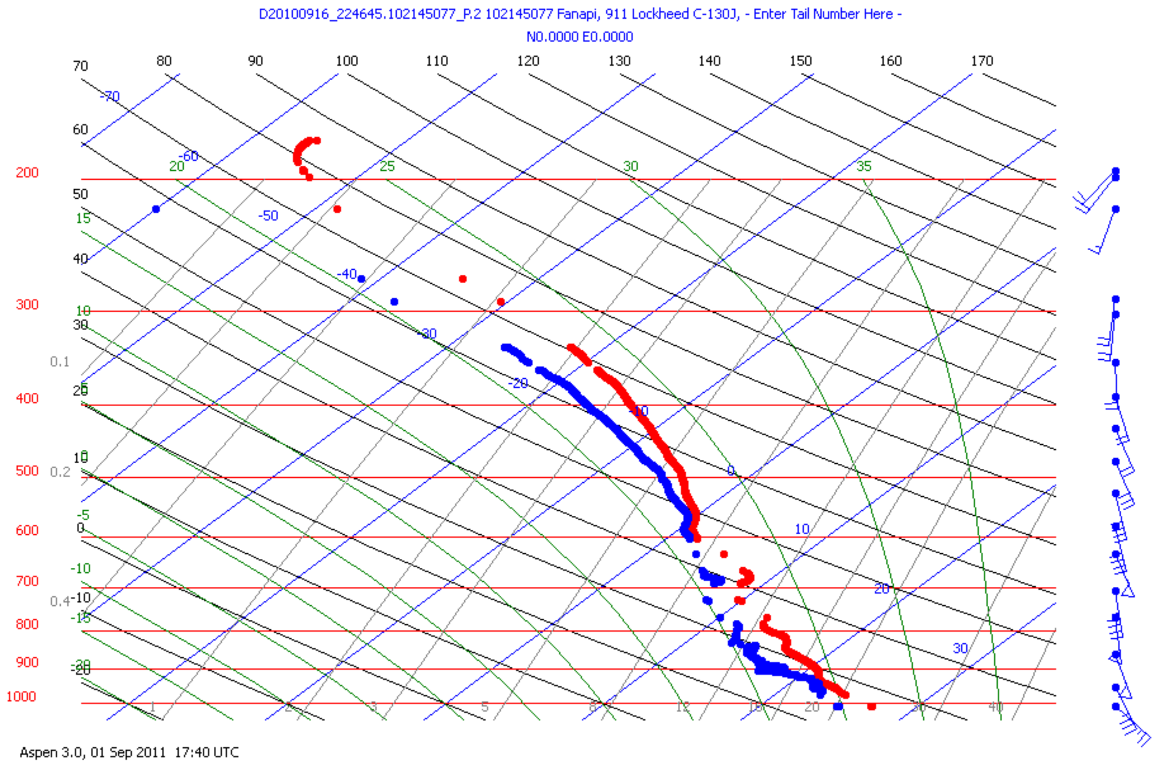

Figure 5 Skew-T diagram (temperature in red and dew point temperature in blue) of the quality controlled data from D20100916_224645 showing the sparse quality controlled data in the regions impacted by the PTU oscillation error. Figures 3 and 4 show the raw temperature and RH data for this sounding.