Impact of Typhoons on the Ocean in the Pacific (ITOP) 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 Loehrer et al. (2011, Loehrer, S. M., K. Young, J. Wang and D. Lauritsen, 2011: Impact of Typhoons on the Ocean in the Pacific (ITOP) 2010 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. USAF C-130 Dropsonde High Resolution Data [NCAR/EOL], Version 2.0. UCAR/NCAR - Earth Observing Laboratory. http://doi.org/10.5065/D6GT5KCD . Accessed 7 July 2016.

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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 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 two USAF C-130 aircraft completed 26 research flights with dropsondes (Figures 1 and 2). The USAF C-130 is equipped with a suite of instruments that includes an Airborne Vertical Atmospheric Profiling System (AVAPS), used for dropsonde deployment. Six hundred ninety eight dropsondes were deployed during 26 research flights made over the western Pacific Ocean (Figures 1 and 2). Six hundred eighty three 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.

ITOP 2010 Quality Controlled Dropsonde Data

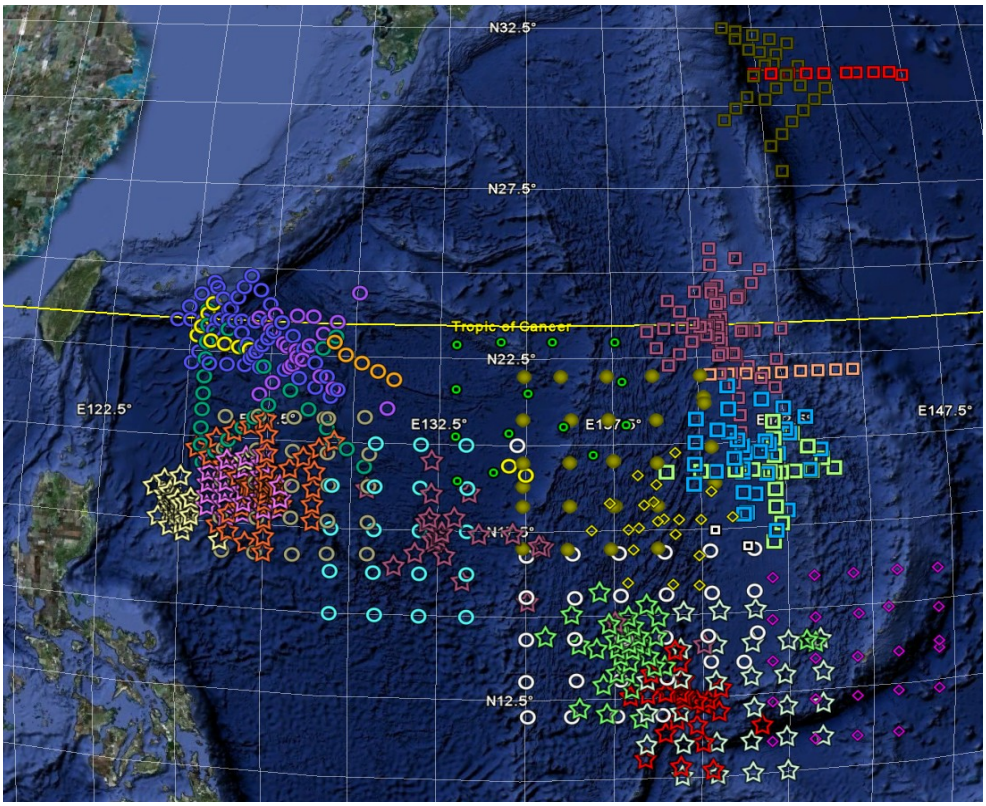
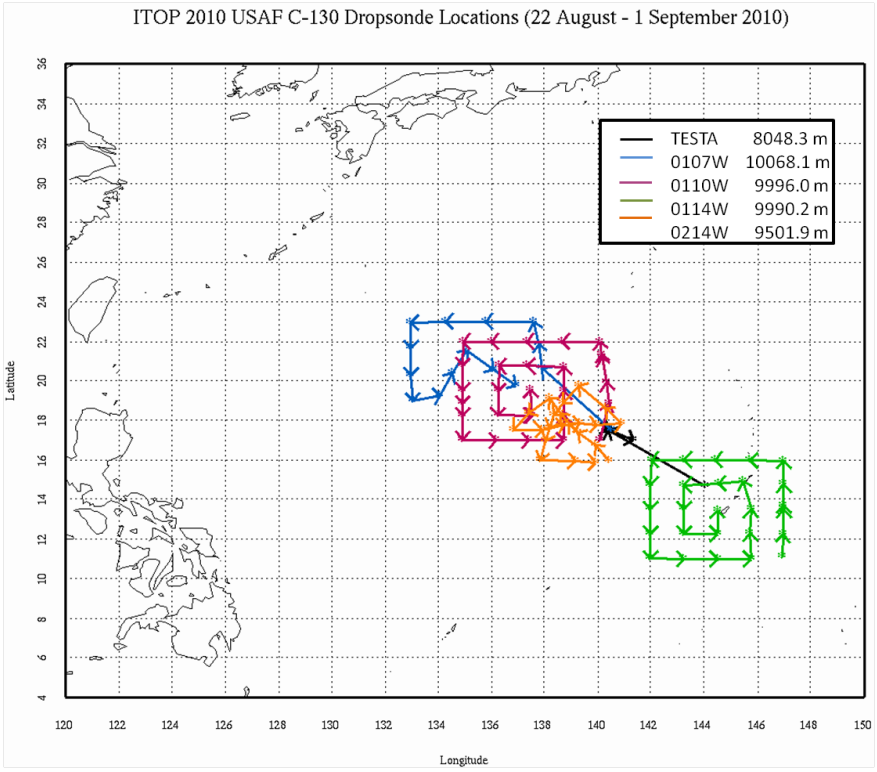


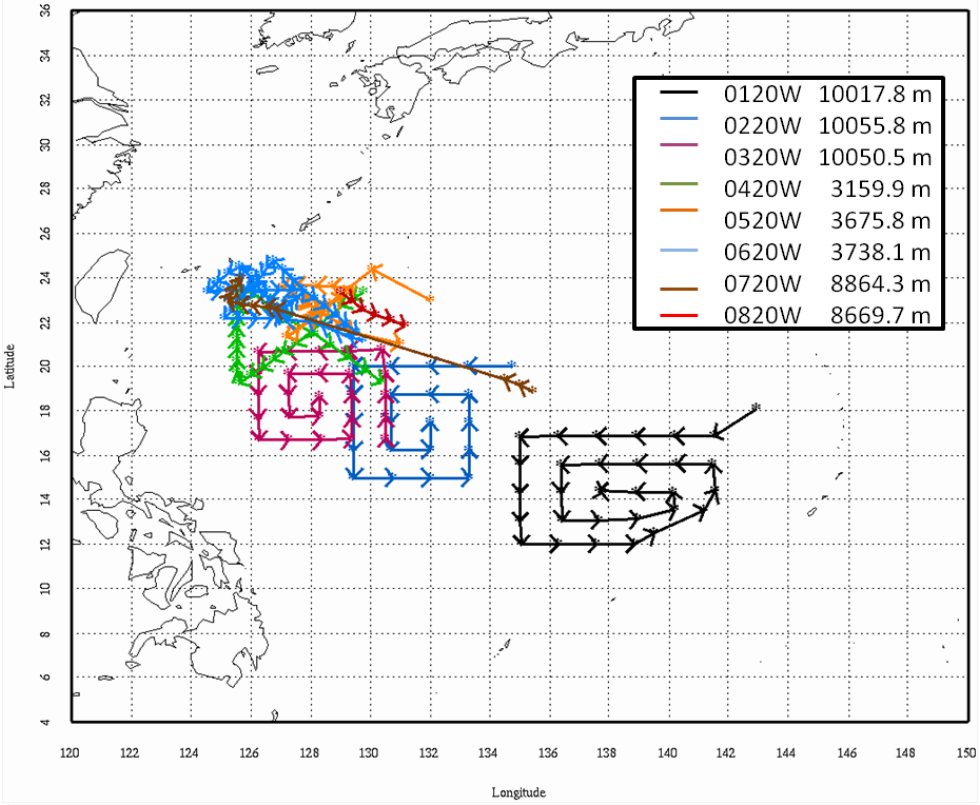
Figure 1 Map of the dropsonde launch locations from the USAF C-130. The symbols indicate different tropical cyclones (large open circles for Fanapi, large open squares for Malakas, stars for Megi, small diamonds for ITOP14, closed circles for ITOP10, small open circles for ITOP07 and small open squares for TESTA) and the colors indicate different research flights.

ITOP 2010 Quality Controlled Dropsonde Data

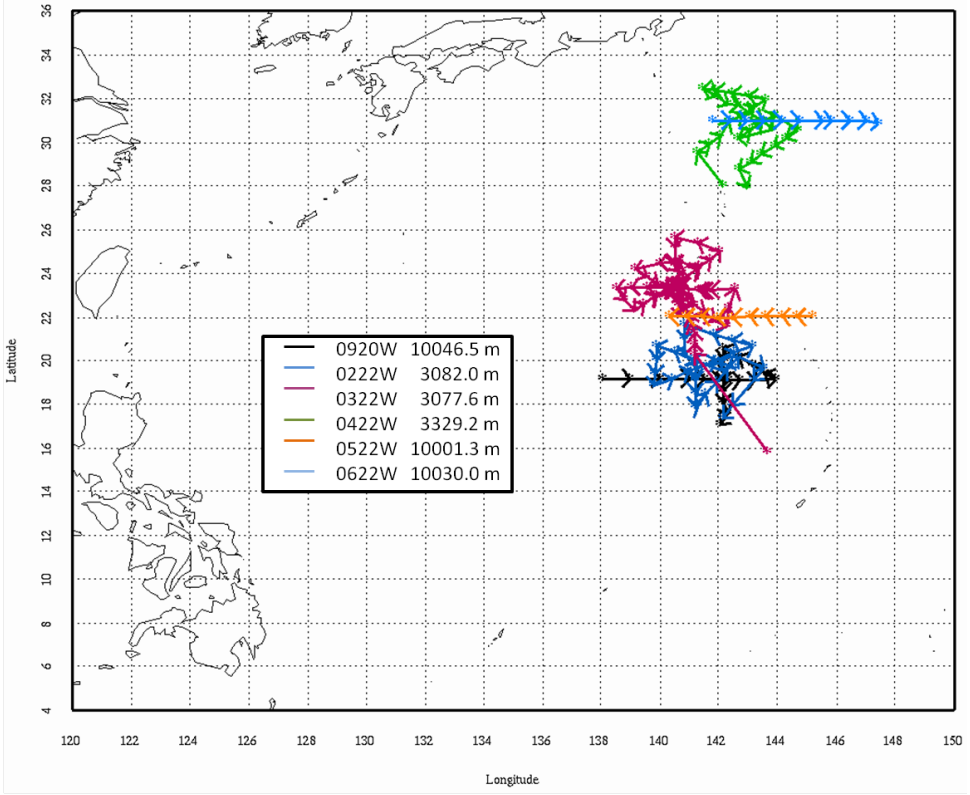


ITOP 2010 Quality Controlled Dropsonde Data

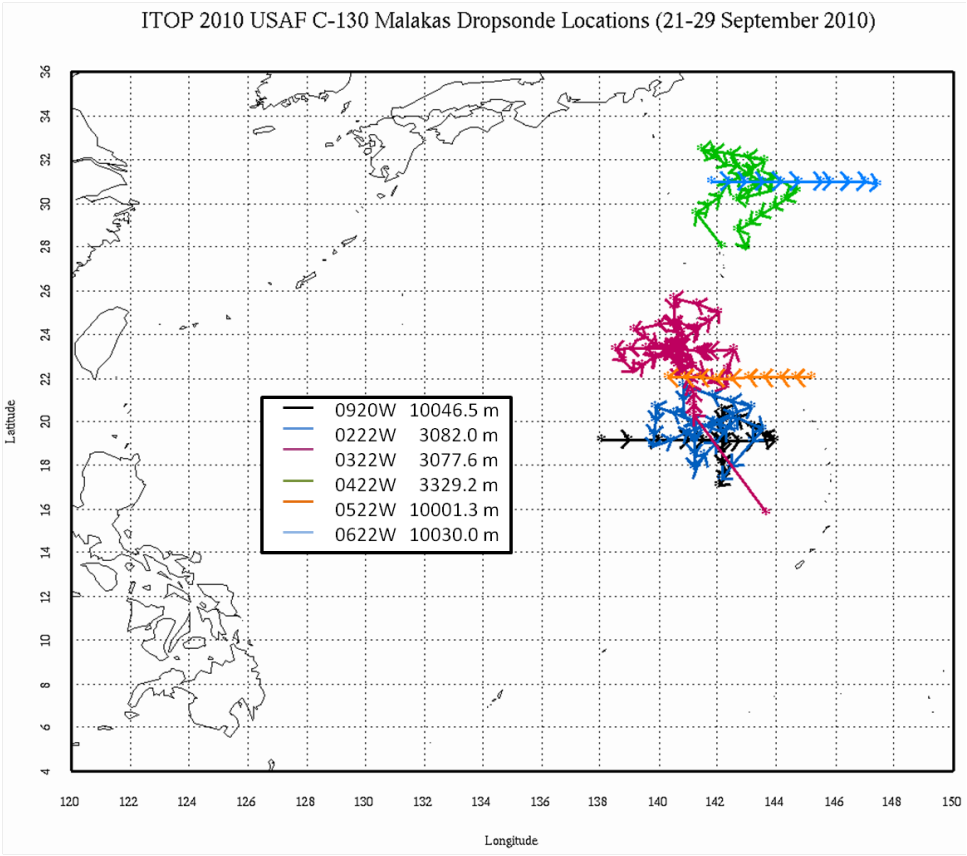
ITOP 2010 USAF C-130 Fanapi Dropsonde Locations (12-19 September 2010)



ITOP 2010 USAF C-130 Malakas Dropsonde Locations (21-29 September 2010)



ITOP 2010 Quality Controlled Dropsonde Data



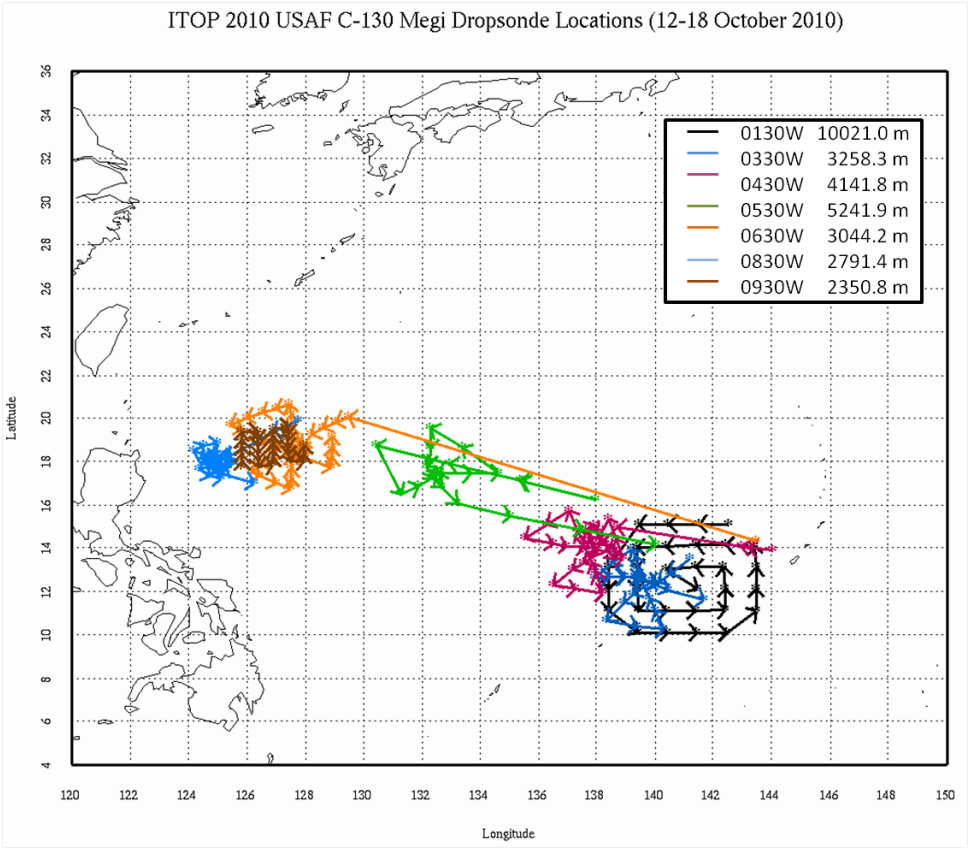


Figure 2 Flight tracks and direction for all twenty-six research flights. Each flight is distinguished by a different color (shown in the legend). The flight identifiers are xxyyW, where yy is the ITOP system number and xx is the flight number for that system (e.g. 0830W is the eighth ITOP flight into ITOP system #30. 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)

TESTA – 08/22	0320W - 09/14	0222W - 09/22	0430W – 10/14
0107W – 08/25	0420W - 09/15	0322W - 09/23	0530W – 10/15
0110W - 08/28	0520W – 09/16	0422W - 09/24	0630W – 10/16
0114W – 08/31	0620W - 09/17	0522W – 09/28	0830W – 10/17
0214W – 09/01	0720W - 09/18	0622W - 09/29	0930W – 10/18
0120W - 09/12	0820W - 09/19	0130W – 10/12	
0220W - 09/13	0920W - 09/21	0330W – 10/13	

II. EOL File Format

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_P.1QC.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 ".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.

```
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 0.25 sec 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 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 calculated vertical wind subjected to a 20 second low pass filter. Note that the vertical wind is first interpolated and then filtered, so the filtered data at lines where the veritical 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, 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. Filtering of the GPS latitude, longitude, and altitude is performed to remove spikes.

3. 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 #4 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

4. 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

5. 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.

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

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. Fifteen 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. Twenty-seven 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. A skewt showing the quality controlled data from the examples shown in Figures 3 and 4 is shown in Figure5.

Filename			
D20100828_203458	D20100912_205424	D20100915_004146	D20101014_182301
D20100828_213643	D20100912_222521	D20100916_032258	D20101014_232800
D20100828_220559	D20100912_235525	D20100918_205614	D20101014_234958
D20100901_225156	D20100913_002350	D20100923_181137	D20101017_112253
D20100901_235715	D20100913_005245	D20100924_183121	D20101017_133003
D20100902_013015	D20100913_025228	D20100924_195234	D20101018_071113
D20100912_195519	D20100914_233050	D20101014_034839	

3. Six soundings exhibited large, temporary offsets in the pressure, temperature and humidity (Figure 6). The PTU values in the affected regions were set to missing values, and the final data products show no evidence of the offsets.

Filename		
D20100915_223443	D20100917_232202	D20100922_015038
D20100917_215222	D20100920_033949	D20101012_184710

4. Fourteen dropsondes experienced a loss of signal and failed to transmit data to the ground or had PTU oscillation problems at the surface. The geopotential altitude in these soundings was calculated from flight level downward.

Filename			
D20100828_213643	D20100919_011748	D20100929_174921	D20101016_035209
D20100831_190348	D20100923_164024	D20101012_195808	D20101017_011809
D20100901_222742		D20101012_224526	D20101018_071113
D20100919_011344	D20100928_180144	D20101014_034839	

5. Twenty-five 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, 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”**
D20100825_212448	D20100916_023539
D20100831_194442	D20100917_011441
D20100831_195830	D20100917_015441
D20100914_234326	D20100917_221912
D20100916_030803	D20100918_011937
D20100916_035249	D20100918_021118
D20100917_010119	D20100918_021759
D20100917_024145	D20100922_040038
D20100923_002422	D20100922_214140
D20100923_005407	D20100923_164941
D20100923_191319	D20100923_170711
D20100923_203610	D20100923_185529
D20100923_212714	D20100923_191517
D20100923_221004	D20100923_204759
D20100923_222737	D20101012_235315
D20100924_183847	D20101014_033704
D20101014_034604	D20101014_041018
D20101014_231423	D20101016_233938
D20101016_033208	D20101017_002100
D20101016_220831	D20101017_012028
D20101017_011832	
D20101017_120611	
D20101017_132834	
D20101018_064021	
D20101018_064738	

6. 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
D20100919_011344	Experienced system lockup; no data below 698mb
D20100919_011748	Experienced system lockup; no data below 457mb

D20100928_175501	No pressure, T, RH, calculated dz/dt or geopotential altitude for first 283mb after release
D20101014_230412	No GPS signal. File contains no winds, latitude, longitude or GPS altitude.

7. A number of dropsondes experienced issues with the launch detect mechanism. In these cases the launch detect was either triggered early (4 files) or late (89 files), or it failed completely (18 files). 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 number of late launch detects during ITOP was significant, totaling 440. The majority of the late launch detects (79%) were minor (on the order of 1-5 seconds) and are a result of the improved performance of the dropsonde. The 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. Since data collected within that 1-5 second window is routinely discarded by ASPEN, as the dropsonde sensors adjust to equilibrium with the environment, no corrections where applied to these soundings. For data files that experienced launch detect delays of more than 5 seconds, corrections were made to adjust the launch times, input the temporally matched flight level aircraft data 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**
D20100913_012313	D20100913_012402	D20101014_035441	D20101014_042206
D20100917_231621	D20100917_233815	D20101015_002745	D20101015_003043
Failed Launch Detect			
Original Filename	**Corrected Filename**	**Original Filename**	**Corrected Filename**
D20100831_185446	D20100831_190348	D20100923_185640	D20100923_191319
D20100917_004936	D20100917_010119	D20100923_202203	D20100923_203610
D20100922_235908	D20100923_002422	D20100923_215835	D20100923_221004
D20100923_003058	D20100923_005407	D20100923_221807	D20100923_222737
D20100923_161552	D20100923_163411	D20100929_174459	D20100929_174921
D20100923_163635	D20100923_164024	D20101012_195526	D20101012_195808
D20100923_163725	D20100923_164113	D20101016_215822	D20101016_220831
D20100923_164234	D20100923_164847	D20101017_132041	D20101017_132834
D20100923_172908	D20100923_174534	D20101017_142939	D20101017_145302
Late Launch Detect			
Original Filename	**Corrected Filename**	**Original Filename**	**Corrected Filename**
D20100828_202048	D20100828_202037	D20100923_185544	D20100923_185529
D20100831_224748	D20100831_224737	D20100923_190949	D20100923_190936
D20100912_210934	D20100912_210920	D20100923_191550	D20100923_191517
D20100913_233837	D20100913_233826	D20100923_191629	D20100923_191616
D20100914_215804	D20100914_215723	D20100923_194526	D20100923_194517
D20100915_234346	D20100915_234341	D20100923_204547	D20100923_204539
D20100916_023552	D20100916_023539	D20100923_220915	D20100923_220904
D20100916_032309	D20100916_032258	D20100924_181205	D20100924_181200
D20100916_033912	D20100916_033906	D20100924_195814	D20100924_195807
D20100917_011508	D20100917_011441	D20100924_201805	D20100924_201754
D20100917_013359	D20100917_013352	D20100928_170117	D20100928_170103

D20100917_015520	D20100917_015441	D20100928_175511	D20100928_175501
D20100917_222000	D20100917_221912	D20100929_174346	D20100929_174339
D20100917_225858	D20100917_225851	D20100929_175151	D20100929_175142
D20100917_231522	D20100917_231514	D20101012_194652	D20101012_194645
D20100917_233149	D20100917_233143	D20101012_230816	D20101012_230804
D20100917_235115	D20100917_235113	D20101014_002322	D20101014_002315
D20100918_001616	D20100918_001611	D20101014_181951	D20101014_181933
D20100918_005857	D20100918_005849	D20101014_201757	D20101014_201641
D20100918_011944	D20100918_011937	D20101014_204307	D20101014_204239
D20100918_014010	D20100918_014003	D20101014_210455	D20101014_210448
D20100918_020124	D20100918_020118	D20101014_230419	D20101014_230412
D20100918_021809	D20100918_021759	D20101015_204139	D20101015_204130
D20100918_030520	D20100918_030511	D20101016_023540	D20101016_023533
D20100922_015041	D20100922_015038	D20101016_032948	D20101016_032942
D20100922_035204	D20100922_035153	D20101016_034254	D20101016_034204
D20100922_210308	D20100922_210256	D20101016_184130	D20101016_184124
D20100922_214146	D20100922_214140	D20101016_215133	D20101016_215123
D20100922_221121	D20100922_221056	D20101016_220356	D20101016_220347
D20100922_223349	D20100922_223344	D20101016_221653	D20101016_221647
D20100922_230515	D20100922_230502	D20101016_234001	D20101016_233938
D20100922_233151	D20100922_233145	D20101016_235704	D20101016_235701
D20100923_000220	D20100923_000211	D20101017_002234	D20101017_002100
D20100923_000432	D20100923_000403	D20101017_003511	D20101017_003503
D20100923_003606	D20100923_003545	D20101017_010139	D20101017_010131
D20100923_010312	D20100923_010251	D20101017_012039	D20101017_012028
D20100923_021703	D20100923_021658	D20101017_013535	D20101017_013528
D20100923_155318	D20100923_155311	D20101017_014454	D20101017_014448
D20100923_161415	D20100923_161408	D20101017_120619	D20101017_120611
D20100923_165003	D20100923_164941	D20101017_123313	D20101017_123304
D20100923_165751	D20100923_165744	D20101017_130557	D20101017_130549
D20100923_170728	D20100923_170711	D20101017_131839	D20101017_131830
D20100923_173717	D20100923_173707	D20101017_144710	D20101017_144702
D20100923_175409	D20100923_175403	D20101017_153254	D20101017_153233
D20100923_182103	D20100923_182042		

8. Twenty-four soundings experienced a loss of signal prior to launch that resulted in varying degrees of data loss. Without a signal at the time of launch, accurate launch times could not be determined

Filename	**Signal Return After Release**
D20100825_230529	10mb
D20100829_012300	25mb
D20100916_000134	60mb
D20100916_005134	45mb
D20100919_010835	2mb
D20100922_024427	2mb
D20100922_205321	40mb
D20100922_212436	25mb
D20100922_215434	35mb
D20100923_001334	25mb

D20100923_192751	3mb
D20100923_225245	10mb
D20101014_180922	45mb
D20101014_193828	70mb
D20101014_225104	25mb
D20101016_013034	30mb
D20101016_034333	30mb
D20101016_212859	2mb
D20101017_120943	50mb
D20101017_124752	65mb
D20101017_130227	20mb
D20101017_135033	30mb
D20101017_141434	35mb
D20101017_144134	35mb

9. 129 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 (see Figure 7). The dz/dt spikes varied in magnitude and were found at different heights, but appear to be strongly correlated with either initial satellite acquisition or a significant increase in the number of satellites at the level where the pressure offset occurred. During these periods (usually about 5 seconds) the calculated descent rate and vertical wind parameters were set to missing.

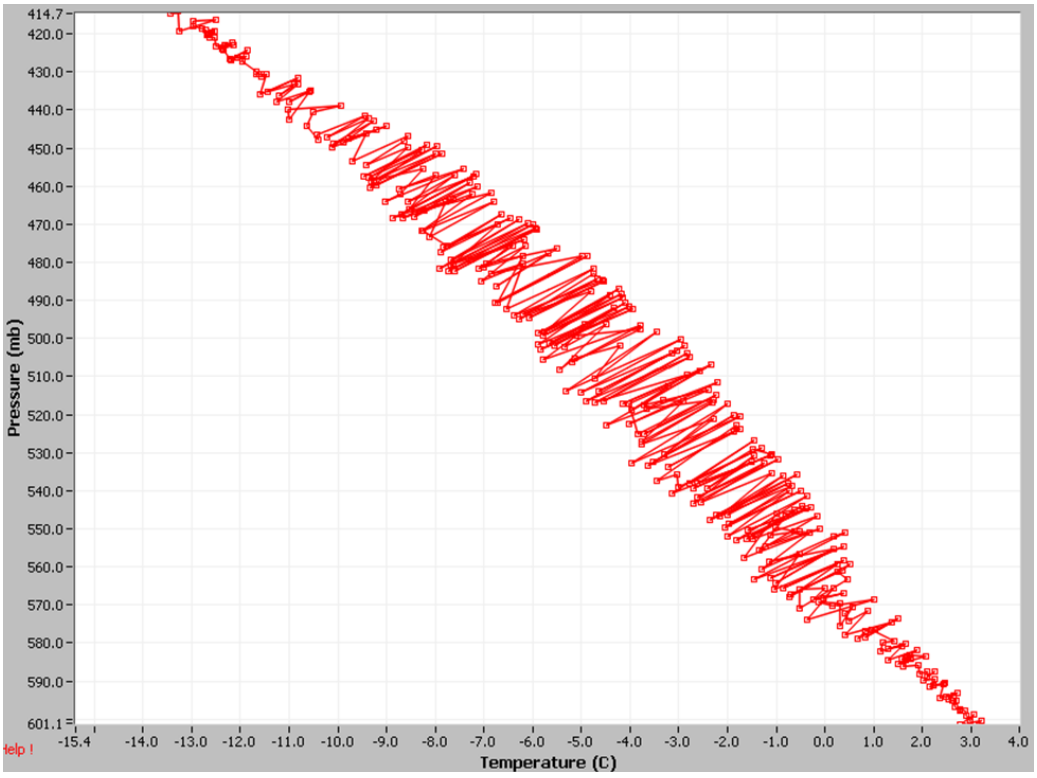


Figure 3 Profile of raw temperature versus pressure, from file D20100828_203458, shows evidence of the PTU oscillation error.

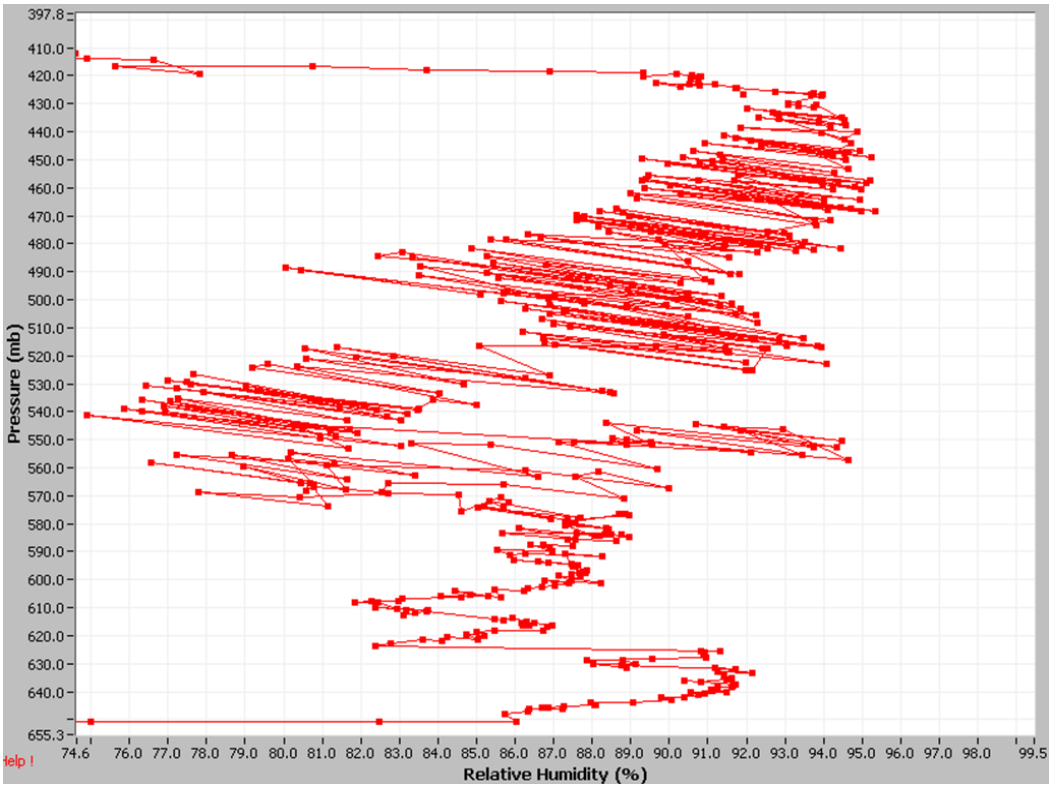


Figure 4 Profile of raw RH data versus pressure, from file D20100828_203458, shows noise caused by the PTU oscillation error.

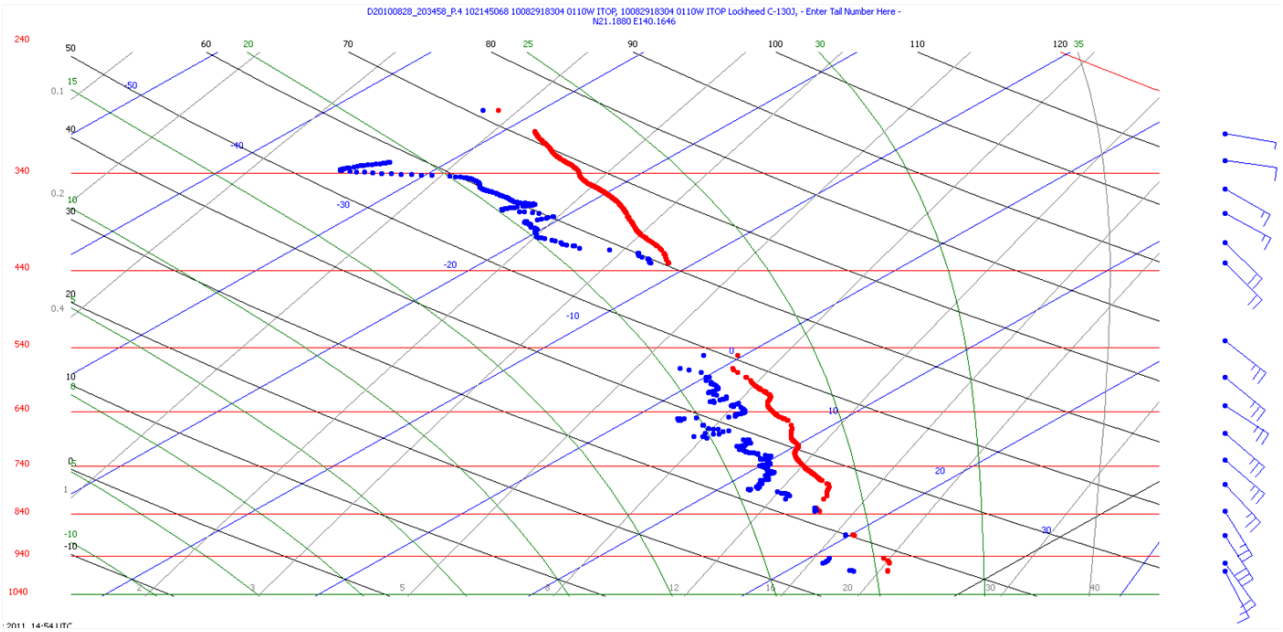


Figure 5 Skew-T diagram (temperature in red and RH in blue) of the quality controlled data from D20100828_203458 showing the sparse quality controlled data in the regions impacted by the PTU

oscillation error (~440-570mb). See Figures 3 and 4 to see the raw temperature and RH data for this sounding.

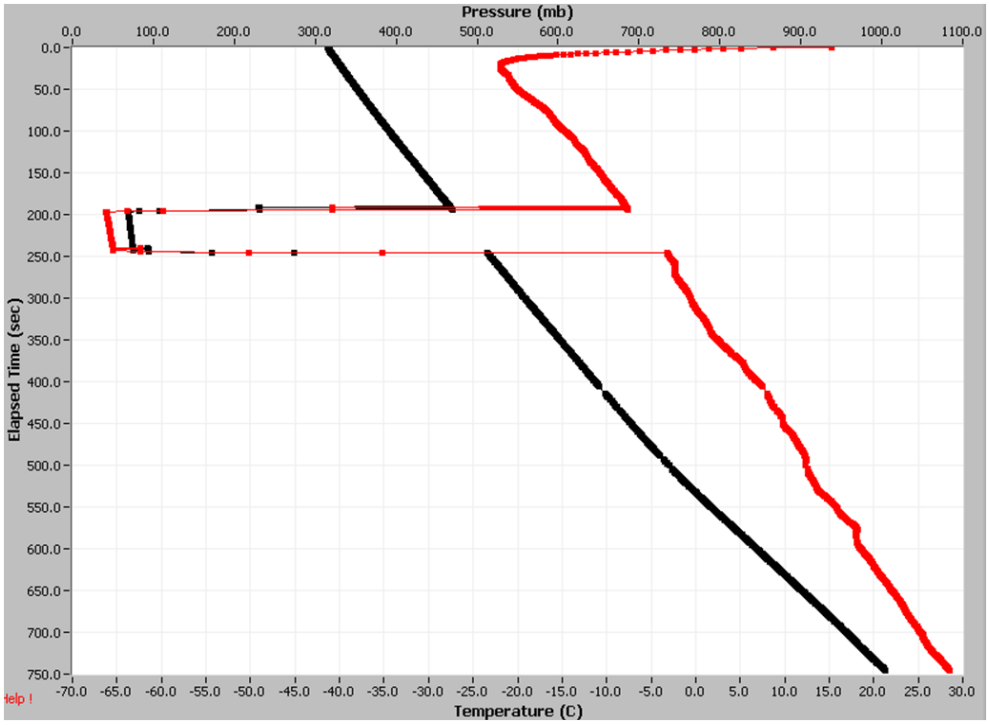


Figure 6 Plot shows significant offsets in the raw temperature (red) and pressure (black) profiles versus time in file D20100917_215222.

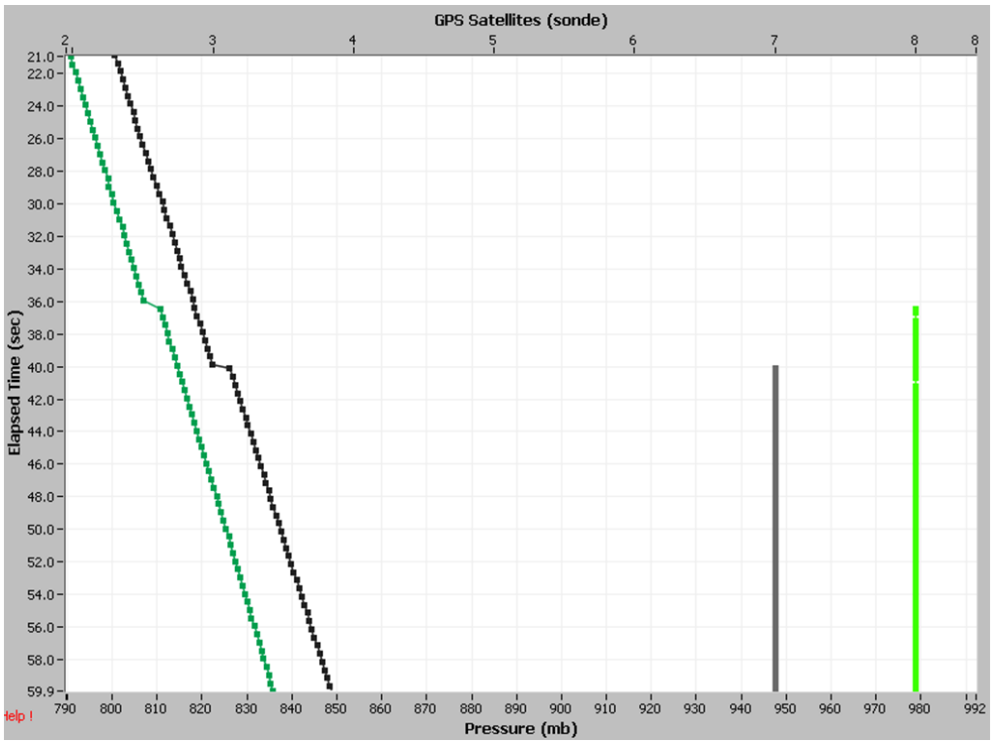


Figure 7 Plot of pressure (left side) and number of GPS satellites (right side) as a function of time for two dropsonde flights (D20101018_043125 and D20101018_045222) showing the pressure jump that sometimes occurred at the point where the number of satellites increased from zero.