# HRD GPS-DROPWINDSONDE EXTERNAL DATA ARCHIVE

High-resolution, operationally-processed sonde data (**operproc**), transmitted messages (**transmit**) and graphics (**skewt/synmap**) from NOAA aircraft hurricane season flights since 2002 currently reside on HRD's public ftp server. Unprocessed (**raw**) data from both NOAA and United States Air Force 53rd Weather Research Squadron (USAF) is available as far back as 1996. Some operationally processed USAF data is also available, mainly since 2017. These are accessible by clicking on the respective links for each data type or via anonymous ftp by entering:

**Web Clients: ftp://ftp.aoml.noaa.gov/hrd/pub/data/dropsonde**
**Terminal Clients: ftp ftp.aoml.noaa.gov**
**user: anonymous**
**password: your e-mail adress**
**cd hrd/pub/data/dropsonde**

All sonde data files for each hurricane season are placed in a separate folder (directory), e.g., **HURR03** for **2003** sondes, and then in one of five embedded folders, depending on the data type. Operationally processed data are located in the folder named **"operproc**.", transmitted messages are found in **"transmit"** and raw data in **"raw"**. For most flights Skew-T log P diagrams and station map graphics are also produced. When available these figures can be found in the **"skewt"** and **"synmap"** folders respectively. The data file names are based on a "Flight ID" consisting of the takeoff date (year, month, and day with respect to UTC), a letter indicating the NOAA aircraft: **H--N42RF (P-3)**, **I--N43RF (P-3)**, **N--N49RF (Gulfstream-IV),** and a sequence number following the plane indicator. Example: 20040914I1 is the flight ID for the first NOAA N43RF P-3 mission into Hurricane Ivan on 14 September 2004. Detailed information about the individual data formats follows.

**Operproc:**
Within the operproc folder are **two** types of files: **catalog** and compressed and packed **full-resolution data**. Each of these is explained below.

**(1) Catalog Files (CAT)**
These contain an **ASCII-tex**t listing of all the sondes processed for a particular flight, including each sonde's unique serial number; the date, time, location, and aircraft pressure level at launch; and any pertinent comments, such as storm region. The naming convention of the files is **FlightID.cat**.
Below is an example of the first few lines of a CAT file, **20180903H1.cat**

```
------------------------------------------------------------------------
       CATALOG OF PROCESSED DROPWINDESONDES FOR 20180903H1
------------------------------------------------------------------------
Seq  Serial #     Date/Time      Lat    Lon   Pr   Comments
                    (UTC)        (N)    (W)  (mb)
------------------------------------------------------------------------
  1   163535005  180903 /221956   26.48   82.96  696.0   COMMENT: Center, Good Drop; TDDryBiasCorrApplied
  2   163835047  180903 /211611   25.98   84.00  504.7   COMMENT: Point #3, Good Drop; TDDryBiasCorrApplied
  3   163845013  180903 /212112   25.51   84.00  505.1   COMMENT: Point #4, Good Drop; TDDryBiasCorrApplied
  4   163845021  180903 /214234   25.46   81.96  505.6   COMMENT: Point #7, Good Drop; TDDryBiasCorrApplied
  5   164015068  180903 /211819   25.78   84.00  504.8   COMMENT: Point #5, Good Drop; TDDryBiasCorrApplied
  6   164015092  180903 /224025   27.77   83.81  695.6   COMMENT: Endpoint, Good Drop; TDDryBiasCorrApplied
  7   164015166  180903 /210504   26.98   84.00  547.5   COMMENT: Point #2, Good Drop; TDDryBiasCorrApplied
```

**(2) Full-Resolution Data Files (FRD)**
These contain the operationally QC'd, 4-Hz (0.25-second) resolution observations in fixed-length, long **ASCII-text** records for an individual dropwindsonde. The records in this format can easily be imported into a **spreadsheet** program. All available full-resolution data files of sondes released during a particular flight are packed into a **Unix/Linux-tar aggregate** and stored as **GNU-zip compressed files**. The naming convention of these files is **FlightID_FRD.tar.gz**. Although manual and

software based QC procedures were performed, the processing of these data was performed on the aircraft, under time constraint and may occasionally contain erroneous data.

To access FRD files, a flight tar aggregate must first be expanded using compatible decompression software, such as Winzip, or by entering the command **gunzip [filename]** in a Unix/Linux terminal session. The expanded tar file will then be of the form, ***FlightID*.frd.tar**. This file next needs to be unpacked, again using appropriate software, or by entering the Unix/Linux command **tar xvf [filename]**. All the individual FRD files from the flight will now be available and have the nomenclature of **gSondeID.frd**, in which the **Sonde ID** corresponds to a sonde's nine-digit serial number provided in the CAT file.

Each FRD file consists of **two parts**:

(A) the **header** (20 lines)

(B) the 4-Hz **processed data records** (amount varies depending on drop altitude and rate of sonde descent).
Pressure, temperature and humidity data are only reported every 0.5 seconds or every other line.
Prior to year 2008 the resolution of the data is 2-HZ (0.5 second).

(A) Header

The header comprises **four** sections: **basic information**, **sonde processing parameters**, **comment line**, and **aircraft flight-level data**.

*(1) Basic information.* This contains the sonde serial number, date is was processed, date and time of launch, and aircraft from which it was deployed.

*(2) Sonde processing parameters*. Information in this section includes:

- any bias corrections applied to the sonde's pressure (mb), temperature (□C), and relative humidity (%)observations
- any pressure baseline correction (offset) introduced prior to the sonde's launch (mb)
- the cutoff wavelengths of the low-pass time filter used to smooth the pressure, temperature, and humidity (PTH) observations and wind observations (s)
- if dynamic temperature, dynamic relative humidity, or wind shear (WSHR) corrections have been applied
- if an estimated pressure profile is used
- the computed mean GPS vertical velocity error (m/s) - -999.00 if missing
- the height correction (WGACORR) assigned to the wind observations (m)
- the anchor for the hydrostatic geopotential-height calculation--SFC - surface (upward integration), FLT - flight level (downward integration), MSG - missing
- the sonde splash pressure (mb) - -999.0 if missing
- the hydrostatically-determined surface pressure (mb) - -999.0 if missing
- any adjustment to the aircraft geopotential altitude applied when integrating heights downward (m)

*(3) Comment line.* This is the same as the remarks in the CAT file for the corresponding sonde.

*(4) Aircraft flight-level data*. The following information and flight-level measurements at launch are contained in this section (missing values are assigned -999.0):

Date six-digit date of sonde launch (yymmdd) RH flight-level relative humidity (%)
Time six-digit time of sonde launch (hhmmss) PS flight-level pressure (mb)
SID sonde ID nine-digit serial number GA flight-level geopotential altitude Lat latitude of aircraft (hundreths of degrees) WD flight-level wind direction (□) Lon longitude of aircraft (hundreths of degrees) WS flight-level wind speed (m/s)
TA flight-level temperature (□C) Navaid aircraft navigational aid system (GP for GPS) TD flight-level dew point (□C)

(B) Processed Data Records

A **Fortran Equivalent Format** for reading data records is "(I4.4,2(2X,F6.1),3X,F7.2,3X,F6.1,2X,I6,2X,I4,2X,3(F7.2,3X),I3,2X,F6.1,2X,I6,5X,I1,3(3X,I1),4X,F8.3,2X,F8.3)"
After a column header line, the processed sonde observations are provided in 0.25-s interval sequential records. Each includes the following fields (missing values are assigned -999 or -999.0). The columns consist of the following.

(1) IX four-digit record index number (last value is the total number of observation records)
(2) t (s) elapsed time from launch
(3) P (mb) pressure
(4) T (□C)temperature
(5) RH (%) relative humidity
(6) Z (m) geopotential height of the thermodynamic measurements (P, T, and RH)
(7) WD (E) wind direction
(8) WS (m/s) wind speed
(9) U (m/s) zonal (x-axis) component of wind
(10) V (m/s) meridional (y-axis) component of wind
(11) NS number of GPS satellites used in wind computation (usually 4-8)
(12) WZ (m/s) vertical velocity (NOTE: this is only an estimate based on the sonde fall rate and theoretical fall rate--use with caution)
(13) ZW (m) geopotential height of wind measurement (usually slightly different than Z)
(14) FP pressure measurement flag
(15) FT temperature measurement flag
(16) FH relative humidity measurement flag
(17) FW wind measurement flag
(18) LAT (N) latitude (degrees north) of sonde location as determined by GPS
(19) LON (E) longitude (degrees east) of sonde location as determined by GPS
(20) ZW (ft) geopotential height of wind measurement in feet
(21) WS (kt) wind speed in knots
(22) WS (mph) wind speed in miles per hour
(23) THETAE (K) equivalent potential temperature (computed from P, T, and RH measurements)

The data flags, **FP**, **FT**, **FH**, **FW**, for pressure, temperature, humidity, and winds are respectively assigned one of the following numbers:
0 - good data value
3 - interpolated value
4 - value is doubtful or of questionable
accuracy 5 - subjectively determined value
6 - ten-meter value

Below is a sample partial listing extracted from a 20180903H1 flight FRD file, **g164615116.frd**. Lines 4-72 have been removed in order to include valid data.

```
================================================================================
 DROPWINDSONDE PROCESSING RECORD                              Sonde: 164615116
 FRD file written by Aspen V3.3-668, 03 Sep 2018 22:01 UTC
 Aircraft: WP-3D Orion, N42RF               Date: 180903   Time: 213521 UTC
 --------------------------------------------------------------------------------
 Bias corrections:  PR =   0.0 mb  TE =   0.0 C  RH =   0.0 %  PRB =  0.0 mb
 Filters (LPF):     PTH =
 Dyn RH correction =
 Estimated PR used =
 Dyn T correction  =
 --------------------------------------------------------------------------------
 COMMENT: Point #6, Good Drop; TDDryBiasCorrApplied
 ================================================================================

 ================================================================================
 Date: 180903   Lat:  25.50 N   TA:   -4.2 C   PS:  505.1 mb   WD:   313 deg
```

```
 Time: 213521   Lon:  82.65 W   TD:   -9.3 C   GA:   5824 m    WS:   2.8 m/s
 SID:  164615116               RH:   68.0 %   Navaid:   GP
 ============================================================================
```

| IX | t (s) | P (mb) | T (C) | RH (%) | Z (m) | WD | WS (m/s) | U (m/s) | V (m/s) | NS | WZ (m/s) | ZW (m) | FP | FT | FH | FW | LAT (N) | LON (E) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0001 | 0.0 | -999.0 | -999.00 | -999.0 | -999 | -999 | -999.00 | -999.00 | -999.00 | 8 | -999.0 | -999 | 0 | 0 | 0 | 0 | 25.499 | -82.652 |
| 0002 | 0.3 | -999.0 | -999.00 | -999.0 | -999 | -999 | -999.00 | -999.00 | -999.00 | 8 | -999.0 | -999 | 0 | 0 | 0 | 0 | -999.000 | -999.000 |
| 0003 | 0.5 | -999.0 | -999.00 | -999.0 | -999 | -999 | -999.00 | -999.00 | -999.00 | 8 | -999.0 | -999 | 0 | 0 | 0 | 0 | 25.499 | -82.652 |
| 0073 | 18.0 | 520.0 | -2.84 | -999.0 | 5558 | 248 | 1.72 | 1.60 | 0.63 | 11 | -0.3 | 5558 | 0 | 0 | 0 | 0 | 25.499 | -82.651 |
| 0074 | 18.3 | -999.0 | -999.00 | -999.0 | -999 | 247 | 1.71 | 1.58 | 0.67 | 11 | -999.0 | -999 | 0 | 0 | 0 | 0 | -999.000 | -999.000 |
| 0075 | 18.5 | 520.5 | -2.85 | -999.0 | 5552 | 245 | 1.71 | 1.55 | 0.71 | 11 | -0.4 | 5552 | 0 | 0 | 0 | 0 | 25.499 | -82.651 |
| 0076 | 18.8 | -999.0 | -999.00 | -999.0 | -999 | 244 | 1.70 | 1.53 | 0.75 | 11 | -999.0 | -999 | 0 | 0 | 0 | 0 | -999.000 | -999.000 |
| 0077 | 19.0 | 520.9 | -2.86 | -999.0 | 5545 | 242 | 1.70 | 1.51 | 0.79 | 11 | -0.5 | 5545 | 0 | 0 | 0 | 0 | 25.499 | -82.651 |

**Transmit:**

Within the transmit folder are **two** types of files: **HRD Spline Analysis (HSA)** and **Temp Drop** messages. These files contain the data which was processed in real time and transmitted to the National Centers for Environmental Prediction (NCEP) and other units of the National Weather Service in World Meteorological Organization (WMO) format. The resolution of these data is somewhat limited, comprising manadatory levels (surface, 1000mb, 925mb, 850mb, 700mb, 500mb, 400mb, 300mb, 250mb, 200mb, 150mb and 100mb) and significant levels (where there are local extrema of thermodynamic and/or wind data).

**(1) Temp Drop (XMT)**

A header line consisting of the unique sonde id and date and time of release is added to each of the Temp drop messages, which are then concatenated into a single file named **"FlightID.xmt".** Appendix G of the U.S. Department of Commerce National Hurricane Operations Plan contains a full description of how to read the messages. That document can be accessed at https://www.ofcm.gov/publications/nhop/fcm-p12-2019.pdf.

An example of a single message from **20180903H1.xmt** is given below.

```
Sonde # 164615106  2052 UTC  03 Sep 18
UZNT13 KWBC 032139
XXAA  53217 99280 70840 08184 99016 25219 06016 00143 25025 07019
92825 20409 09029 85552 16008 09531 70183 07822 09526 88999 77999
31313 09608 82052
61616 NOAA2 0207A GORDON       OB 99
62626 MBL WND 07522 AEV 33668 DLM WND 09026 016546 WL150 06518 08
0 REL 2797N08396W 205206 SPG 2797N08403W 205949 =
XXBB  53218 99280 70840 08184 00016 25219 11850 16008 22684 07028
33578 00704 44546 02724
21212 00016 06016 11950 08528 22850 09531 33652 10521 44586 07023
55546 09027
31313 09608 82052
61616 NOAA2 0207A GORDON       OB 99
62626 MBL WND 07522 AEV 33668 DLM WND 09026 016546 WL150 06518 08
0 REL 2797N08396W 205206 SPG 2797N08403W 205949 =
```

**(2) HRD Spline Analysis (HSA)**

These files consist of the Temp Drop messages, written out in column format and concatenated into a single file.

**Fortran Equivalent Format** for HSA files is "I2, X, F7.0, X, I4, X, F7.3, X, F8.3, X, 3(F.6.1, X), F7.1, 2(2X, F5.1), X, A4"

The data columns contain:

(1) Sounding identifier, "1" for dropsonde
(2) Date (YYmmdd)
(3) UTC time (hhmm)
(4) Latitude (degrees north)
(5) Longitude (degrees west)
(6) Pressure (hPa) (see WMO document for Pressure > 1050 )

(7) Temperature (C)
(8) Relative humidity (%)
(9) Geopotential height (m)
(10) Zonal wind component
(11) Meridional wind component
(12) Level flag

A partial listing of **20180903H1.hsa** which corresponds to the Temp Drop message example above is given below. Missing data is assigned a value of -99.0.

```
 1 180903. 2100  28.000   84.000 1099.0  -99.0  -99.0   781.0  -13.4    0.0 DLMW
 1 180903. 2100  28.000   84.000 1070.0   25.2   88.7  1016.0   -7.1   -4.1 MANL
 1 180903. 2100  28.000   84.000 1016.0   25.2   88.7   -99.0  -99.0  -99.0 SIGL
 1 180903. 2100  28.000   84.000 1016.0  -99.0  -99.0   -99.0   -7.1   -4.1 SIGL
 1 180903. 2100  28.000   84.000 1000.0   25.0   85.3   143.0   -9.2   -3.3 MANL
 1 180903. 2100  28.000   84.000  950.0  -99.0  -99.0   -99.0  -14.3   -1.3 SIGL
 1 180903. 2100  28.000   84.000  925.0   20.4   94.3   825.0  -14.9    0.0 MANL
 1 180903. 2100  28.000   84.000  850.0   16.0   94.8  1552.0  -15.9    1.4 MANL
```

**Skewt:**
Skew-T, log-P diagrams for all the sondes processed from a particular flight in Portable Network Graphics (png) image format. Each sounding is plotted separately and depicts a sonde's vertical profile during its descent. The images are aggregated into a single compressed file named FlightID_SKEWT.tar.gz.

**SynMap:**
Plan view station (synoptic) maps in png image format at standard pressure levels are produced from the Temp Drop data for many of the flights. When available they are aggregated into a single compressed file names FlightID_SYNMAP.tar.gz.

**Raw:**
**Airborne Vertical Atmospheric Profiling System (AVAPS)** raw data from each mission are aggregated into a single compressed file named "**FlightID_AVP.tar.gz**" containing individual files with naming convention "**gSondeID.avp"**. Often the same files with a date and time based naming convention are also available within "**FlightID_DFILES.tar.gz**. No quality control has been applied to these data and it is not suitable for scientific research without first processing with software such as The National Center for Environmental Research (NCAR) Atmospheric Sounding Processing Environment (ASPEN) program. The **ASPEN** software is freeware and can run on any Windows, Mac or Linux compatible computer platform. To download a copy of the latest version and obtain documentation, please visit the following website from the NCAR Atmospheric Technology Division (ATD).

http://www.eol.ucar.edu/software/aspen

Each raw data file consists of 2 parts, (A) the 5 line header and (B) individual data records.
(A) Header

- *basic information* including unique sonde id and date and time of launch
- *description* of the data contained in the columns below
- continuation of description of the data contained in the columns below
- *corresponding units* for the data contained in the columns below
- line separating the header from the data

(B) Data Records (missing data are indicated by values 99999.00, 9999.00, 999.00, 999.000000 or 99.00)

The data columns consist of:

(1) AVAPS receiving channel
(2) Data source indicator
(3) Unique sonde id
(4) UTC date (YYMMDD)
(5) UTC time (hhmmss.ss)
(6) Air Pressure (h-Pa)
(7) Air Temperature (C)
(8) Relative Humidity (%)
(9) Wind Direction (Degrees with respect to North)
(10) Horizontal Wind Speed (m/s)
(11) Vertical Wind Speed (m/s) calculated from using the theoretical fall rate and vertical displacement of the sonde (m/s)
(12) GPS Longitude (Degrees E)
(13) GPS Latitude (Degrees N)
(14) Number of GPS Satellites used for wind retrieval
(15) Individual Sensor Relative Humidity (%)
(16) Individual Sensor Relative Humidity (%) not relevant for newer dropwindsondes
(17) Total Number of GPS Satellites
(18) Wind error estimated from AVAPS system (m/s)
(19) GPS reported Geometric Altitude (m)

An example of raw data from **g163525040.avp** / **D20180910_162012.1** is given below.

```
AVAPS-T01 STA 163525040 180910 154348.87
AVAPS-T01 COM          UTC    UTC      Air   Air    Rel   Wind   Wind   Vert      GPS       GPS     Geopoten GPS  Sonde  Sonde GPS Wind    GPS
AVAPS-T01 COM   Sonde   Date   Time     Press  Temp   Humid  Dir    Spd    Veloc  Longitude   Latitude  Altitude Wnd   RH1    RH2  Snd Error Altitude
AVAPS-T01 COM   ID     yymmdd hhmmss.ss  (mb)  (degC)  (%)   (deg)  (m/s)  (m/s)   (deg)      (deg)     (m)   Sat   (%)    (%)  Sat (m/s)    (m)
AVAPS-T01 COM --------- ------ --------- ------- ------ ------ ------ ------ ------ ----------- ---------- -------- --- ------ ------ --- ----- --------
AVAPS-D01 P10 163525040 180910 154356.00 9999.00  99.00 999.00 235.66 118.78  -0.16  999.000000  99.000000 99999.00   9 999.00 999.00   9  0.09 99999.00
AVAPS-D01 P00 163525040 180910 154356.25  969.89  24.67  41.08 235.62 118.77  -0.09  -59.646544  25.303265 99999.00   9  41.08  39.93   9  0.10  2352.47
AVAPS-D01 P10 163525040 180910 154356.50 9999.00  99.00 999.00 235.61 118.84  -0.23  999.000000  99.000000 99999.00   9 999.00 999.00   9  0.09 99999.00
AVAPS-D01 P00 163525040 180910 154356.75  969.96  24.69  41.23 235.61 118.83   0.06  -59.646058  25.303568 99999.00   9  41.23  40.06   9  0.08  2352.42
AVAPS-D01 P10 163525040 180910 154357.00 9999.00  99.00 999.00 235.59 118.84  -0.11  999.000000  99.000000 99999.00   9 999.00 999.00   9  0.09 99999.00
AVAPS-D01 P00 163525040 180910 154357.25  970.05  24.70  41.35 235.58 118.86  -0.10  -59.645571  25.303871 99999.00   9  41.35  40.19   9  0.09  2352.37
AVAPS-D01 P10 163525040 180910 154357.50 9999.00  99.00 999.00 235.55 118.89  -0.23  999.000000  99.000000 99999.00   9 999.00 999.00   9  0.09 99999.00
AVAPS-D01 P00 163525040 180910 154357.75  969.86  24.73  41.12 235.47 118.93  -0.40  -59.645084  25.304175 99999.00   9  41.12  40.13   9  0.09  2352.25
```

**Post Processed Data:**

HRD personnel post process some of the raw AVAPS data using rigorous quality control procedures for use in studies and analyses conducted by the HRD scientists and outside collaborators. These product files are generally not available to the general public. To inquire about obtaining and utilizing these data please contact the HRD Sonde Data Manager. Please include your name, affiliation, any collaborators, justification, and research plans. Each request will be considered on a case by case basis. Individuals will be required to grant co-authorship or give an acknowledgement to all HRD staff members involved in the post-processing effort for the requested flights in any manuscript produced using these data files.

**Data Usage:**
If you download any of the on-line dropsonde data files, please acknowledge HRD when appropriate in manuscripts, presentations, documents, etc. describing results obtained from the sonde observations. This can be done by including text, such as:
*GPS-dropsonde data are provided courtesy of the NOAA/AOML/Hurricane Research Division in Miami, FL (USA).*
Also, it would be greatly appreciated if you could send a message to the HRD sonde data manager explaining how you plan to utilize the data. This will keep HRD abreast of your research efforts, allow suggestions for possible collaborations, and help avoid potential conflicts or duplication with other scientists, particularly those within HRD.

Any **questions** regarding this data archive may be directed to either:

**Kathryn Sellwood**, NOAA/AOML/HRD
**Sim Aberson**, NOAA/AOML/HRD

email: Kathryn.Sellwood@noaa.gov Sim.Aberson@noaa.gov

Phone: 305-361-4320 or Phone: 305-361-4334

**REFERENCES:**
For a detailed description of GPS dropsondes and aircraft systems, please see:

- NCAR Atmospheric Technology Division
- NOAA Aircraft Operations Center
- Vaisala Corp.

For details about the nested HRD Spline Analysis, please consult:
**Franklin, J. L.**, **S. E. Feuer**, **J. Kaplan**, and **S. D. Aberson**, 1996: Tropical cyclone motion and surrounding flow relationships: Searching for Beta-gyres in Omega dropwindsonde datasets. *Mon. Wea. Rev.*, **124**, 64-84.
**Franklin, J. L.**, **S. J. Lord**, **S. E. Feuer**, and **F. D. Marks, Jr.**, 1993: The kinematic structure of Hurricane Gloria (1985) determined from nested analyses of dropwindsonde and doppler radar data. *Mon. Wea. Rev.*, **121**, 2433-2451.

Some recommended reading about the development of dropsondes and Tropical Cyclone applications:
**Hock, T.S**. and **Franklin, J.L.,** 1998: The NCAR GPS Dropwindsonde. *Bull. Amer. Meteor. Soc*., **80**, 407-420 DOI
**Franklin, J.L**., **Black, M.L**. and **Valde, K**., 2003: Dropwindsonde Wind Profiles in Hurricanes and their Operational Implications, *Mon. Wea. Rev*., **18**, 32-44
**Aberson, S.D**. and **Franklin, J.L.**, 1999: Impact on Hurricane Track and Intensity Forecasts of GPS Dropwindsonde Observations from the First Season of the NOAA Gulfstream –IV Jet Aircraft, *Bull. Amer. Meteor. Soc*., **80**. 421-428
**Christophersen, H**., **Aksoy, A**., **Dunion, J**. and **Sellwood, K**., 2017: The Impact of NASA Global Hawk Unmanned Aircraft Dropwindsonde Observations on Tropical Cyclone Track, Intensity and Structure, *Mon. Wea. Rev*., **145**, 1817-1830