Tropical Cyclone Intensity (TCI) Experiment
GTS Radiosonde Data Set

1.0 Contacts:

NCAR/EOL Processing and Quality Control:
Scot Loehrer (NCAR/EOL)
loehrer@ucar.edu

Original Data Source:
NCAR/EOL

2.0 Dataset Overview

National weather agencies around the world routinely release radiosondes at 00 and/or 12 UTC with occasional special releases. This data set includes the quality controlled TCI GTS soundings released at sites near the locations of TCI flown tropical cyclones. TCI flew two storms in the Atlantic (Erika and Joaquin) and two storms in the eastern Pacific basin (Marty and Patricia). For Erika this data set includes soundings from 25-30 August 2015 from Cape Canaveral, Nassau, Kingston, Grand Cayman, Saint Maarten, and Guadeloupe (Figure 1). For Joaquin the included soundings are from 25 September to 6 October 2015 from Bermuda, Cape Canaveral, Nassau, Kingston, Grand Cayman, and Saint Maarten (Figure 2). For Patricia the included soundings are from 19-24 October 2015 from Monterrey, Guadalupe, Guadalajara, Manzanillo, Mexico City, Acapulco, La Paz, Mazatlán, and Veracruz (Figure 3). For Marty the included soundings are from 25 September to 1 October 2015 from Guadalupe, Guadalajara, Manzanillo, Mexico City, and Acapulco (Figure 4). A total of 349 quality-controlled, mandatory and significant level resolution soundings are contained in the final TCI data set.

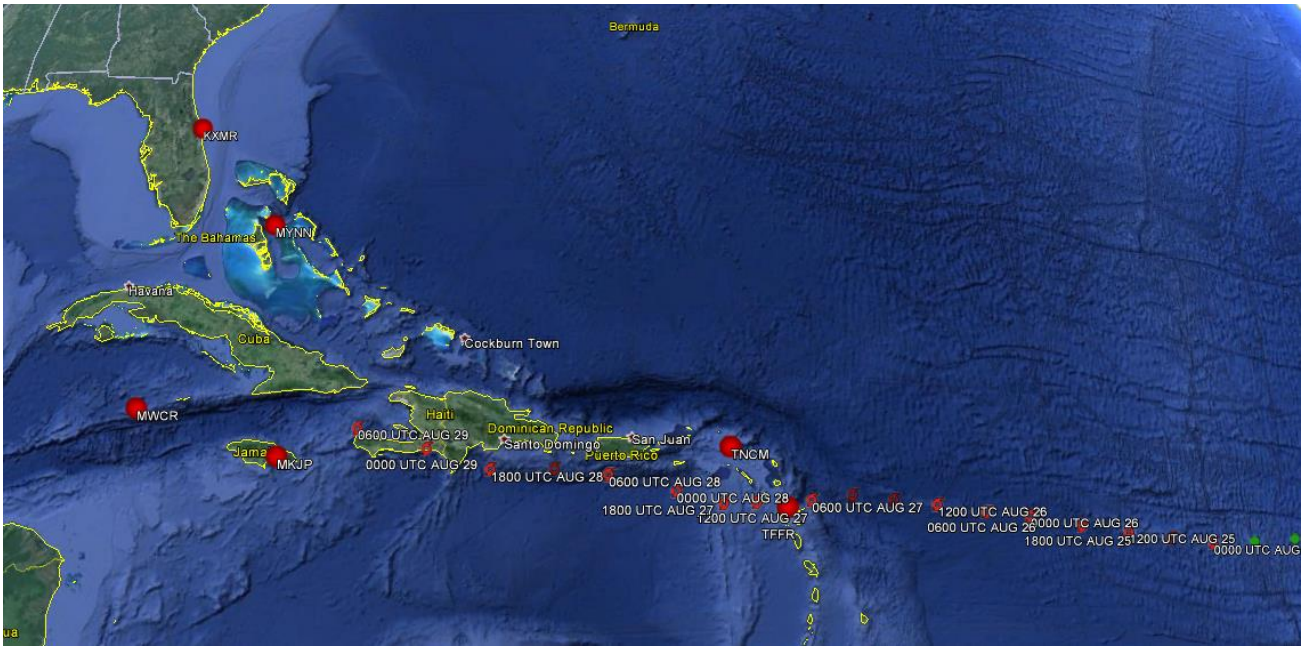

Figure 1. Tropical Storm Erika best track and GTS sounding locations.

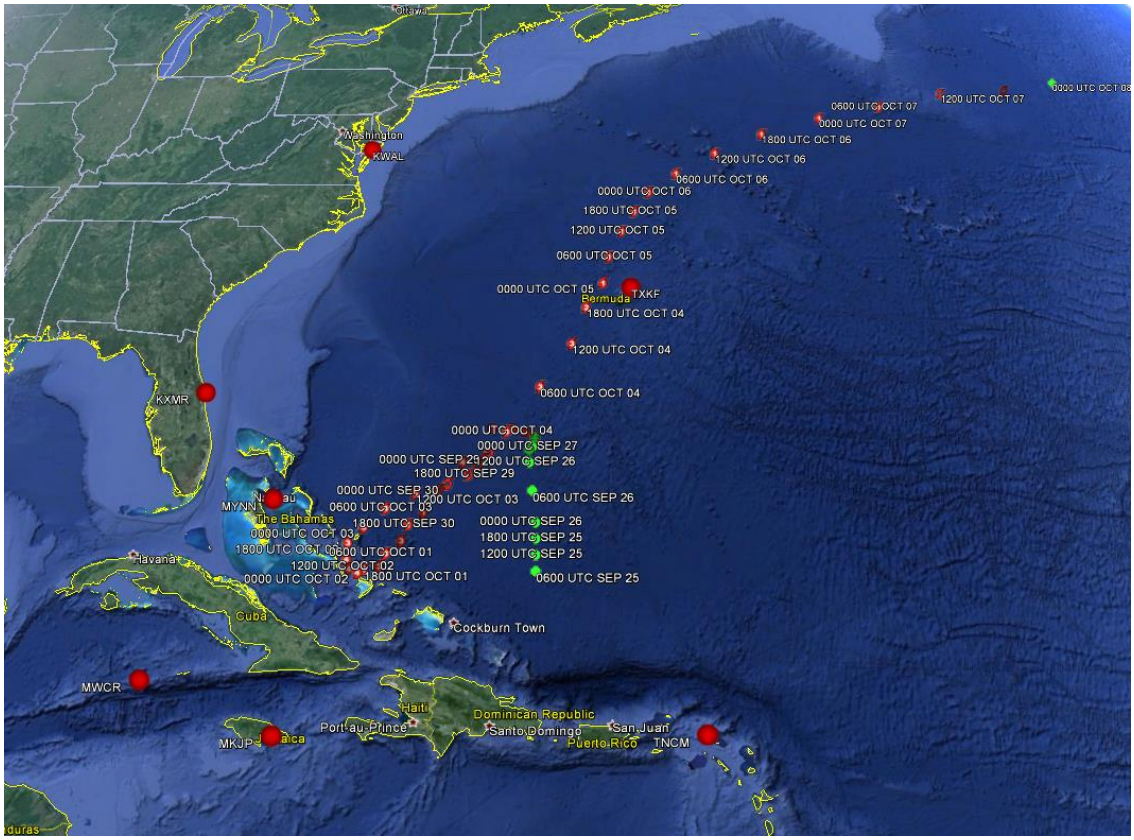

Figure 2. Hurricane Joaquin best track and GTS sounding locations.

Figure 3. Hurricane Patricia best track and GTS sounding locations.

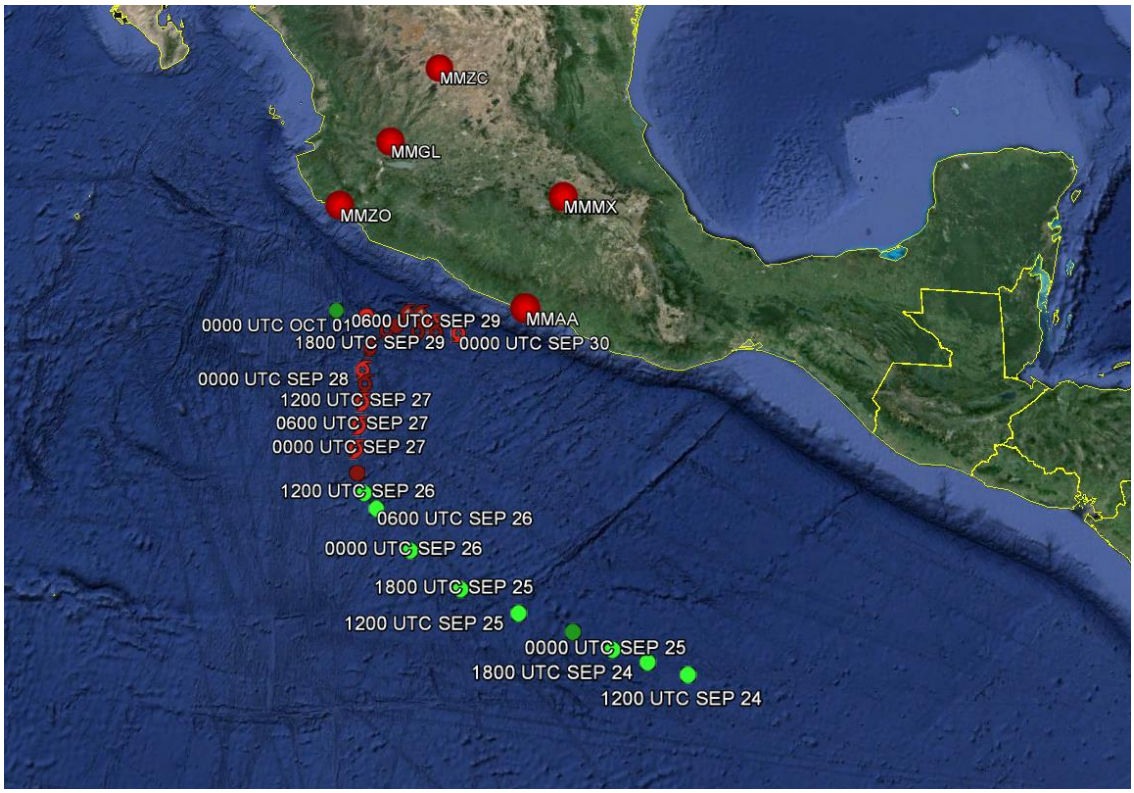

Figure 4. Hurricane Marty best track and GTS sounding locations.

3.0 Project Overview

The goal of the Tropical Cyclone Intensity (TCI) initiative was to improve the prediction of tropical cyclone intensity and structure changes with a specific focus on an improved understanding of tropical cyclone upper-level outflow layer processes and dynamics. The primary TCI observations were taken by the NASA WB-57 aircraft and the High Definition Sounding System (HDSS) dropsondes and Hurricane Imaging Radiometer (HIRAD). TCI worked closely with the NOAA SHOUT (Sensing Hazards with Operational Unmanned Technology) project which utilized a NASA Global Hawk. TCI also partnered with the routine operations of the USAF C-130, NOAA P-3, and NOAA G-IV aircraft.

4.0 EOL File Format Description

The EOL format is an ASCII text format that includes a header (Table 1), with detailed project and sounding information, and seventeen columns of high resolution data (Table 2).

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 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 files contain data calculated at one-second intervals. We have utilized the processed PTU and GPS data from the Radiosonde Replacement System (RRS) sounding systems to generate these files. The raw position, temperature and RH data are normalized by linear interpolation into 1 second processed data. The raw pressure data are normalized by least square interpolation into 1 second processed data. The pressure data are smoothed over 11 seconds of corrected pressure and the result is applied to the 6th corrected pressure within the 11 second spread. The temperature data are smoothed over 9 seconds of uncorrected temperature and the result is applied to the 5th uncorrected temperature within the 9 second spread. There must be at least 2 good raw temperature elements with the 9 second spread.

The following corrections were applied by the RRS sounding system.

Pressure correction - pressure correction is used to compensate for offsets of the radiosonde pressure sensor as compared to the station's pressure sensor. The pressure offset is determined during the radiosonde baseline operations. The correction is applied to the uncorrected pressure prior to pressure smoothing.

This correction is defined as:

Pc = Pu * (Pstn/Psonde)
where Pc is the corrected pressure
Pu is the uncorrected pressure
Pstn is the station pressure
Psonde is the radiosonde surface pressure

Temperature correction - temperature correction is used to compensate for solar radiation. The correction is applied to the smoothed temperature. These corrections are proprietary to Sippican.

Table 1 - EOL Sounding File Format (dropsonde and radiosonde)

```
Data Type/Direction:                    GAUS SOUNDING DATA/Ascending
File Format/Version:                    EOL Sounding Format/1.1
Project Name/Platform:                  DYNAMO/NCAR GAUS
Launch Site:                            Diego Garcia
Launch Location (lon,lat,alt):          72 25.59'E 72.426578, 7 18.85'S -7.314117, 2.0
UTC Launch Time (y,m,d,h,m,s):          2011, 11, 27, 14:15:07
Sonde Id/Sonde Type:                    001434642/Vaisala RS92-SGP (ccGPS)
Reference Launch Data Source/Time:      Campbell Scientific CR10/14:15:03
System Operator/Comments:               Steph S/none, Good Sounding
Post Processing Comments:               Aspen Version 3.1; Created on 22 June 2012 15:11 UTC; Configuration upsonde-ls

/
  Time    -- UTC --    Press    Temp    Dewpt     RH     Uwind    Vwind    Wspd     Dir      dZ     GeoPoAlt     Lon          Lat       GPSAlt  Uwind  Vwind_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 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	Calculated
10	V Wind Component	Meters/Second	Calculated
11	Wind Speed	Meters/Second	Measured
12	Wind Direction	Degrees	Measured
13	Descent Rate	Meters/Second	Calculated
14	Geopotential Altitude	Meters	Calculated
15	Longitude	Degrees	Measured
16	Latitude	Degrees	Measured
17	GPS Altitude	Meters	Measured

4.1 Data Specifics

The files contain data at mandatory and significant levels.

The file naming convention is XXXXX_DYYYYMMDD_HHmmSS_P.1.eol

Where XXXXX is the WMO Site ID, D is the letter D, YYYY is the year, MM is the month, DD is the day of the month, HH is the hour, mm the minute and SS the seconds. All times are UTC.

The time and UTC data columns have invalid times included so that the files can be imported as is into ASPEN if desired. Those times should be ignored.

4.2 Sample Data

The following is a sample of the TCI GTS mandatory and significant resolution radiosonde data in EOL format.

```
Data Type/Direction:                    GTS Sounding/Ascending
File Format/Version:                    EOL Sounding Format/1.1
Project Name/Platform:                  TCI
Launch Site:                            72402 WAL
Launch Location (lon,lat,alt):          075 28.80'W -75.480000, 37 55.80'N  37.930000,    13.00
UTC Launch Time (y,m,d,h,m,s):          2015, 09, 24, 23:00:00
Sonde Id/Sonde Type:
Reference Launch Data Source/Time:
System Operator/Comments:
Post Processing/Comments:
/
  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
-------- -- -- ----- ------- ------- ------- ------- ------- ------- ------- ------- ------- -------- ---------- ---------- -------
-
   -1.00 23  0  0.00 1022.00   20.80   16.80   77.90   -5.90   -4.90    7.70   50.00 -999.00    13.00  -75.480000   37.930000  -
999.00
    0.00 23  0  1.00 1018.00   21.00   16.00   73.10 -999.00 -999.00 -999.00 -999.00 -999.00    47.00 -999.000000 -999.000000  -
999.00
    1.00 23  0  2.00 1000.00   19.80   14.80   72.90   -8.80   -6.20   10.80   55.00 -999.00   199.00 -999.000000 -999.000000  -
999.00
```

4.3 Station List

Site ID	WMO ID	Site Name	State or Country	Latitude	Longitude	Elev (m)
KWAL	72402	Wallops Island	VA	37.93	-75.48	13
KXMR	74794	Cape Canaveral	FL	28.48	-80.55	5
MMAN	76394	Monterrey	MX	25.87	-100.20	450
MMLP	76405	La Paz	MX	24.07	-110.33	14
MMMZ	76458	Mazatlan	MX	23.18	-106.42	4
MMZC	76526	Guadalupe	MX	22.75	-102.51	2265
MMGL	76612	Guadalajara	MX	20.68	-103.33	1551
MMZO	76654	Manzanillo	MX	19.07	-104.33	3
MMMX	76679	Mexico City	MX	19.43	-99.07	2309
MMVR	76692	Veracruz	MX	19.17	-96.12	13
MMAA	76805	Acapulco	MX	16.76	-99.93	3
TXKF	78016	Bermuda	BM	32.37	-64.68	37
MYNN	78073	Nassau	BS	25.05	-77.47	2
MWCR	78384	Grand Cayman	KY	19.30	-81.37	3
MKJP	78397	Kingston	JM	17.93	-76.78	1
TNCM	78866	Saint Maarten	AN	18.05	-63.12	3
TFFR	78897	Guadeloupe	GP	16.27	-61.52	8

5.0 Data Quality Control Procedures

1. Each sounding was converted from its original format into the EOL Sounding Composite (ESC) format.

2. Each sounding was passed through a set of automated data quality checks which included basic gross limit checks as well as rate of change checks. This is further described in Section 4.1.

3. Each sounding was visually examined utilizing the NCAR/EOL XQC sounding quality control software. This is further described in Section 4.2.

4. Each sounding was then converted to the EOL sounding format described above.

5.1 Automated Data Quality Checks

This data set was passed through a set of automated data quality checks. This procedure includes both gross limit checks on all parameters as well as rate-of-change checks on temperature, pressure, and ascent rate. A version of these checks is described in Loehrer et al. (1996) and Loehrer et al. (1998).

5.1.1 Gross Limit Checks

These checks were conducted on each sounding and the data quality flags in the ESC files were adjusted as appropriate. Only the data point under examination was flagged. All checks also produced warning messages that specified the location of the problem and the severity of the issue. These warning messages where then summarized statistically and examined to determine any consistent issues.

For this data set NCAR/EOL conducted the following gross limit checks. In the table P = pressure, T = temperature, RH = relative humidity, U = U wind component, V = V wind component, B= bad, and Q = questionable.

Parameter	Check	Parameter(s) Flagged	Flag Applied
Pressure	<0 or > 1050	P	B
Altitude	< 0 or >40000	P, T, RH	Q
Temperature	< -90 or > 45	T	B
Dew Point	< -99.9 or > 33 > T	RH T, RH	Q Q
Wind Speed	< 0 or > 100 > 150	U, V U, V	Q B
U Wind	< 0 or > 100 > 150	U U	Q B
V Wind	< 0 or > 100 > 150	V V	Q B
Wind Direction	< 0 or > 360	U, V	B
Ascent Rate	< -10 or > 10	P, T, RH	Q

5.1.2 Vertical Consistency Checks

These checks were conducted on each sounding and the data quality flags in the ESC files were adjusted as appropriate. These checks were started at the surface and compared each neighboring data record. In the case of checks that ensured that the values increased/decreased as expected, only the data point under examination was flagged. However, for the other checks, all of the data points used in the examination were flagged. All items within the table are as previously defined. All checks also produced warning messages that specified the location of the problem and the severity of the issue. These warning messages where then summarized statistically and examined to determine any consistent issues.

Parameter	Check	Parameter(s) Flagged	Flag Applied
Time	Decreasing/equal	None	None.
Altitude	Decreasing/equal	P, T, RH	Q
Pressure	Increasing/equal > 1mb/s or < -1mb/s > 2mb/s or < -2mb/s	P, T, TH P, T, TH P, T, TH	Q Q B
Temperature	< -15°C/km < -30°C/km > 50°C/km > 100°C/km	P, T, RH P, T, RH P, T, RH P, T, RH	Q B Q B
Ascent Rate	> 3m/s or < -3m/s > 5m/s or < -5m/s	P P	Q B

5.2 Visual Data Quality Checks

Each sounding was visually examined using the NCAR/EOL XQC sounding data quality control software. This software allows the user to view a skew-t/log-p diagram of each sounding and apply data quality flags as appropriate. The user can zoom in on sections of soundings for detailed examination and can adjust the data quality flags for an individual point, sections of soundings, or entire soundings for each parameter individually. The software also allows the user to override the quality flags applied by the automated procedure.

5.3 Data Quality Issues of Note

The data quality control procedures outlined above allows us to identify and, in some cases, resolve issues that could potentially impact research performed using these data sets. The following issues were noted in these soundings.

72402_201509271200 – wetbulbing ~819mb
74794_201508270100 – no data above 625mb
76654_201509262241 – bad temp value just above surface
76654_201509282251 – temperature biased high to 450mb
76654_201509301200 – bad temp just above surface
76654_201510211200 – no data above 538mb.
76654_201510211200 – temperature biased high
76654_201510230600 – bad temp value just above surface
76654_201510231800 – no data above 536mb, no wind data above 850mb
76679_201509281200 – temperature biased high
76805_201509291200 – no data above 863mb
76805_201510241200 – no data above 897mb, temperature spike above surface
78016_201509262339 – no data above 644mb
78016_201509291200 – temp spike ~374mb
78016_201510041800 – no data above 527mb; no wind data above 700mb
78073_201508281200 – bad winds below 900mb
78384_201508301200 – bad winds 850-590mb
78384_201509291200 – no data 975-404mb.
78384_201510051200 – bad surface RH
78397_201508252322 – winds below 660mb questionable
78397_201509282336 – winds bad 910-848mb
78397_201510031300 – winds bad 875-681mb
78397_201510041200 – temperature bad below 560mb
78397_201510061200 – winds bad 790mb and 271-237mb
78866_201509251200 – no data above 611mb
78866_201509252308 – no data above 556mb
78866_201509301200 – no winds above 790mb
78866_201510011200 – bad winds 634-610mb
78866_201510012307 – bad winds 205-203mb and 60mb
78866_201510032316 – little wind data
78866_201510041200 – no wind data above 821mb
78866_201510050000 – no data above 535mb

6.0 References

Loehrer, S. M., T. A. Edmands, and J. A. Moore, 1996: TOGA COARE upper-air sounding data archive: development and quality control procedures. Bull. Amer. Meteor. Soc., 77, 2651-2671.

Loehrer, S. M., S. F. Williams, and J. A. Moore, 1998: Results from UCAR/JOSS quality control of atmospheric soundings from field projects. Preprints, Tenth Symposium on Meteorological Observations and Instrumentation, Phoenix, AZ, Amer. Meteor. Soc., 1-6.