TORUS_2022 National Weather Service High Resolution Radiosonde Data

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1.0 Data Set Description

High vertical resolution radiosonde data from National Weather Service radiosonde stations within and near the TORUS_2022 domain. High resolution (1 second vertical levels) are included from 17 stations and three stations do not have high resolution available so the mandatory/significant level data are used.

Data Version: 1.0

Data Status: Final

Time Period: 16 May to 15 June 2022

Physical Location: 20 point locations within 29.375 to 48.206N and 93.402 to 108.477W

Data Frequency: Soundings were typically every 12 hours at 00 and 12 UTC

Vertical Resolution: 1 second (~5m) or mandatory/significant level

Data Source: NOAA/National Weather Service and NOAA/ESRL (man/sig data)

Data Restrictions: None

2.0 Instrument Description

2.1 Instrumentation

KABQ, , KABR, KAMA, KBIS, KDVN (from 2058 UTC 13 June to end of campaign), KGGW, KLBF, KMAF, KMPX, KOAX, KRIW, KSGF, and KUNR used Graw DFM-17 radiosondes with a capacitance humidity sensor.

KEWX used Vaisala RS41/AUTOSONDE radiosondes with a Humicap capacitance humidity sensor with active de-icing method.

KDDC, KFWD used Vaisala RS41 radiosondes (DigiCORA MW41) with a Humicap capacitance humidity sensor with active de-icing method.

KEPZ used Vaisala RS92-NGP/Intermet IMS-2000 radiosondes with a twin alternatively-heated humicap capacitance humidity sensor

KDNR, KDVN (prior to 20 58 UTC 13 June), KOUN, and KTOP radiosonde equipment is unknown.

2.2 Station Locations

Site ID	WMO ID	WBAN	Site Name	State	Latitude	Longitude	Elevation (m)
KABQ	72365	23050	Albuquerque	NM	35.038	-106.623	1619
KABR	72659	14929	Aberdeen	SD	45.455	-98.414	398
KAMA	72363	23047	Amarillo	TX	35.233	-101.709	1095
KBIS	72764	24011	Bismarck	ND	46.772	-100.762	506
KDDC	72451	13985	Dodge City	KS	37.762	-99.969	790
KDNR	72518	23062	Denver	CO	39.770	-104.880	1611
KDRT	72261	22010	Del Rio	TX	29.375	-100.918	314
KDVN	74455	94982	Davenport	IA	41.613	-90.580	230
KEPZ	72364	03020	El Paso	TX	31.873	-106.697	1254
KFWD	72249	03990	Fort Worth	TX	32.835	-97.298	195
KGGW	72768	94008	Glasgow	MT	48.206	-106.627	693
KLBF	72562	24023	North Platte	NE	41.134	-100.700	849
KMAF	72265	23023	Midland	TX	31.943	-102.190	874
KMPX	72649	94983	Chanhassen	MN	44.849	-93.564	290
KOAX	72558	94980	Omaha	NE	41.320	-96.366	351

KOUN	72357	03948	Norman	OK	35.230	-97.470	362
KUNR	72662	94043	Rapid City	SD	44.073	-103.210	1029
KRIW	72672	24061	Riverton	WY	43.065	-108.477	1699
KSGF	72440	13995	Springfield	MO	37.236	-93.402	391
KTOP	72456	13996	Topeka	KA	39.070	-95.620	268

3.0 Data Collection and Processing

3.1 Data Collection

Data were collected via two methods. Data from KABQ, KABR, KAMA, KBIS, KDDC, KDRT, KDVN (from 2058 UTC 13 June to end of campaign), KEPZ, KFWD, KGGW, KLBF, KMAF, KMPX, KOAX, KUNR, KRIW, and KSGF were collected via the Global Telecommunications System. These data were in the WMO GTS BUFR radiosonde standard format.

The data from KDNR, KDVN (prior to 2058 UTC 13 June), KOUN, and KTOP were collected from the NOAA/ESRL Radiosonde Database website: https://ruc.noaa.gov/raobs/

3.2 Data Processing

The WMO GTS BUFR data were decoded using the ECMWF ECCODES software package.

The NOAA/ESRL data were in their ASCII format.

All data were converted to the EOL Sounding Composite (ESC) format using EOL software. ESC is a columnar ASCII format that consists of 15 header records for each sounding with the remaining records containing the radiosonde data and their associated data quality flags. ESC is further described in section 4.0.

3.3 Quality Control Processing

Each sounding was passed through a two-step quality control process. First a series of automated data quality checks were conducted including basic gross limit checks as well as rate of change checks as described in section 3.3.1. Second, each sounding was visually examined utilizing the NCAR/EOL XQC sounding QC software as described in section 3.3.2.

3.3.1 Automated Data Quality Checks

Each sounding in this dataset was passed through a set of automated data quality checks. This procedure includes both gross limit checks (section 3.3.1.1) on all parameters as well as rate-of-change checks (section 3.3.1.2) on temperature, pressure, and ascent rate. A version of these checks is described in Loehrer et al. (1996) and Loehrer et al. (1998).

3.3.1.1 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 were 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

3.3.1.2 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	P, T, RH	Q
	> 1mb/s or < -1mb/s > 2mb/s or < -2mb/s	P, T, RH	Q
		P, T, RH	B
Temperature	< -15ºC/km	P, T, RH	Q
	< -30ºC/km	P, T, RH	B
	> 50ºC/km	P, T, RH	Q
	> 100ºC/km	P, T, RH	B
Ascent Rate	> 3m/s or < -3m/s	P	Q
	> 5m/s or < -5m/s	P	B

3.3.2 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.

4.0 Data Format

The data are in files by day and include radiosonde data from all sites for the day concatenated into a single file. The file naming convention is: NWS_yyyymmdd.cls where yyyymmdd is the UTC year, month, and day of month.

The final dataset is in the EOL Sounding Composite (ESC) format. ESC is a columnar ASCII format that consists of 15 header records for each sounding with the remaining records containing the radiosonde data and their associated data quality flags.

4.1 Header Records

The header records (15 total records) contain a variety of metadata about the sounding (i.e. location, time, radiosonde type, etc). The first five header lines contain information identifying the sounding, and have a rigidly defined form. The following 7 header lines are used for auxiliary information and comments about the sounding, and may vary from dataset to dataset. The last 3 header records contain header information for the data columns. Line 13 holds the field names, line 14 the field units, and line 15 contains dashes ('-' characters) delineating the extent of the field.

The file standard header lines are as follows:

Line	Label	Contents
1	Data Type:	Description of the type and resolution of data
2	Project ID:	Short name for the field campaign
3	Release Site Type/Site ID:	Description of the release site
4	Release Location (lon,lat,alt):	Location of the release site
5	UTC Release Time (y,m,d,h,m,s):	Time of release

The release location is given as: lon (deg min), lat (deg min), lon (dec. deg), lat (dec. deg), alt (m)

Longitude in deg min is in the format: ddd mm.mm'W where ddd is the number of degrees (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 time of release is given as: yyyy, mm, dd, hh:nn:ss. Where yyyy is the year, mm is the month, dd is the day of month, and hh:nn:ss are the UTC hour, minute, and second respectively.

The seven non-standard header lines may contain any label and contents. They typically include things such as radiosonde type, radiosonde serial number, sensor information, balloon information, and/or ground station software.

4.2 Data Records

The data records each contain time from release, pressure, temperature, dew point, relative humidity, U and V wind components, wind speed and direction, ascent rate, balloon position data, altitude, and quality control flags (see the QC code description). Each data line contains 21 fields, separated by spaces, with a total width of 130 characters. The data are right-justified within the fields. All fields have one decimal place of precision, with the exception of latitude and longitude, which have three decimal places of precision. The contents and sizes of the 21 fields that appear in each data record are as follows:

Field	Width	Format	Parameter	Units	Missing Value
1	6	6.1	Time since release	Seconds	9999.0
2	6	6.1	Pressure	hPa	9999.0
3	5	5.1	Temperature	°C	999.0
4	5	5.1	Dew Point Temperature	°C	999.0
5	5	5.1	Relative Humidity	Percent	999.0
6	6	6.1	U Wind Component	m/s	9999.0
7	6	6.1	V Wind Component	m/s	9999.0
8	5	5.1	Wind Speed	m/s	999.0
9	5	5.1	Wind Direction	Degrees	999.0
10	5	5.1	Ascent Rate	m/s	999.0
11	8	8.3	Longitude	Degrees	9999.0
12	7	7.3	Latitude	Degrees	999.0
13	5	5.1	Elevation Angle	Degrees	999.0

14	5	5.1	Azimuth Angle	Degrees	999.0
15	7	7.1	Geopotential Altitude	Meters	99999.0
16	4	4.1	QC code for Pressure	Code	99.0
17	4	4.1	QC Code for Temperature	Code	99.0
18	4	4.1	QC Code for Humidity	Code	99.0
19	4	4.1	QC Code for U Wind	Code	99.0
20	4	4.1	QC Code for V Wind	Code	99.0
21	4	4.1	QC Code for Ascent Rate	Code	99.0

Fields 16 through 21 contain the data quality flags from the NCAR/Earth Observing Laboratory (EOL) sounding quality control procedures. The data quality flags are defined as follows:

Code	**Description**
1.0	Checked, datum seems physically reasonable. (“GOOD”)
2.0	Checked, datum seems questionable on a physical basis. (“QUESTIONABLE”)
3.0	Checked, datum seems to be in error. (“BAD”)
4.0	Checked, datum is interpolated. (“ESTIMATED”)
9.0	Checked, datum is missing. (“MISSING”)
99.0	Unchecked (QC information is “missing”.) (“UNCHECKED”)

5.0 Data Remarks

KABQ 24 May at 1111 UTC - no data above 785mb (a second full sounding was taken at 1159)

KABR 30 May at 1134 UTC - sonde had difficulty breaking through 0C with a couple descents

KDDC 24 May at 2301 UTC - no data above 370mb, no temp or moisture above 415mb (a second full sounding was taken at 2343)

KEPZ 14 June at 1103 UTC - very limited wind data and no winds between 790 and 320mb.

KEPZ 14 June at 2308 UTC - no wind data.

KEWX 21 May at 2305 UTC - mandatory/significant level data

KGGW 6 June at 2305 UTC - could not cross 0C layer at 694mb (a second full sounding was taken at 0007 UTC on 7 June)

KMAF 1 June at 2304 UTC - no data above 213mb

KMPX 30 May at 1112 UTC - no data above 915mb (a second full sounding was taken at 1146 UTC)

KOAX 10 June 2309 UTC - near surface moisture bad

KTOP 23 May at 1100 UTC - no data below 90mb

All data from KDNR, KOUN and KTOP as well as the KDVN data from 16 May to 13 June are mandatory/significant level only.

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.