Wintertime Investigation of Transport, Emission, and Reactivity (WINTER) 2015 NWS Radiosonde Data Set

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2.0 Dataset Overview

The National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) routinely releases radiosondes two times per day (00 and 12 UTC) and does occasional special releases at other times of day (usually 18 UTC) from sites across the United States. This data set includes the quality controlled NWS soundings released from 22 stations (Figure 1 and Section 3.5) located within the WINTER domain for the WINTER field phase (1 February 2015 to 15 March 2015). A total of 1934 quality controlled, high resolution (1-second) soundings are contained in the final WINTER data set.

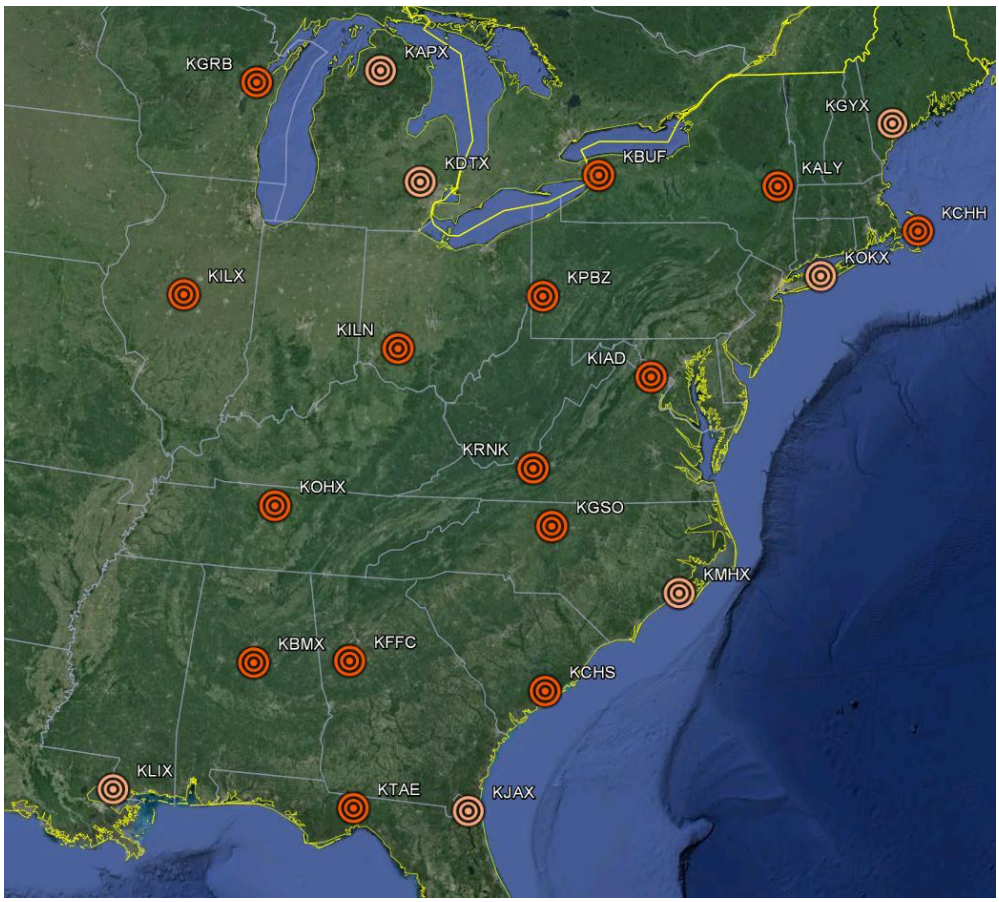

Figure 1. Locations of the 22 NWS release locations included in the WINTER data set. The orange (pink) stations used LMS-6 (VRS92) radiosondes.

Wintertime Investigation of Transport, Emission, and Reactivity (WINTER) was an atmospheric chemistry field campaign that was focused on wintertime emissions and chemical processes in the northeastern United States. The goals of WINTER included 1) characterize the chemical transformations of wintertime emissions; 2) assess the dominant mechanism of secondary aerosol formation and quantify the distribution of inorganic and organic aerosol types in winter; and 3) provide constraints on wintertime emission inventories for urban areas, power plants, and agricultural areas and characterize the export pathways of primary pollutants to the North Atlantic. WINTER was based out of NASA Langley in Hampton, VA and utilized the NSF/NCAR C-130 aircraft. Further information on WINTER is available at the WINTER web site: https://www.eol.ucar.edu/field_projects/winter and information on WINTER flights and operations is available in the NCAR/EOL WINTER Field Catalog: http://catalog.eol.ucar.edu/winter.

3.0 EOL Sounding Composite (ESC) File Format Description

The ESC is a columnar ASCII format consisting of 15 header records for each sounding followed by the data records with associated data quality flags.

3.1 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 (padded to 35 char)	Contents
1	Data Type:	Description of the type and resolution of data
2	Project ID:	Short name for the field project
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. The labels are padded to 35 characters to match the standard header lines. Records for this data set include the following non-standard header lines:

Line	Label (padded to 35 char)	Contents
6	Ascension Number:	Radiosonde ascension number
7	Radiosonde Serial Number:	Radiosonde serial number
8	Balloon Manufacturer/Type:	
9	Balloon Lot Number/Weight:	
10	Radiosonde Type/RH Sensor Type:	
11	Surface Observations:	
12	Nominal Release Time (y,m,d,h,m,s):	Nominal release time

The nominal release time is 00, 06, 12, or 18 UTC.

3.2 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	F6.1	Time since release	Seconds	9999.0
2	6	F6.1	Pressure	Millibars	9999.0
3	5	F5.1	Dry-bulb Temperature	Degrees C	999.0
4	5	F5.1	Dew Point Temperature	Degrees C	999.0
5	5	F5.1	Relative Humidity	Percent	999.0
6	6	F6.1	U Wind Comp	m/s	9999.0
7	6	F6.1	V Wind Comp	m/s	9999.0
8	5	F5.1	Wind speed	m/s	999.0
9	5	F5.1	Wind direction	Degrees	999.0
10	5	F5.1	Ascent Rate	m/s	999.0
11	8	F8.3	Longitude	Degrees	9999.0
12	7	F7.3	Latitude	Degrees	999.0
13	5	F5.1	Elevation Angle	Degrees	999.0
14	5	F5.1	Azimuth Angle	Degrees	999.0
15	7	F7.1	Altitude	Meters	99999.0
16	4	F4.1	QC for Pressure	Code	99.0
17	4	F4.1	QC for Temperature	Code	99.0

18	4	F4.1	QC for Humidity	Code	99.0
19	4	F4.1	QC for U Wind	Code	99.0
20	4	F4.1	QC for V Wind	Code	99.0
21	4	F4.1	QC 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. ("MAYBE")
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")

3.3 Data Specifics

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 the radiosonde manufacturer.

The data are in files by day, so all soundings for a particular day are concatenated into a single file ordered by time. The file naming convention is:

NWS_yyyymmdd.cls where yyyy is the year, mm is the month, and dd is the day of the month.

Two radiosonde and RH sensor types are used by the NWS stations included in this data set.

The Lockheed Martin Sippican LMS-6 GPS Radiosonde with the Capacitance RH sensor.

The Vaisala RS92-NGP Radiosonde /Intermet IMS-2000 with the Twin alternatively heated Humicap capacitance RH sensor.

See Section 3.5 for details on radiosonde type by station.

All stations utilized GPS windfinding.

3.4 Sample Data

The following is a sample of the WINTER NWS high resolution radiosonde data in ESC format.

```
Data Type:                          National Weather Service Sounding/Ascending
Project ID:                         WINTER
Release Site Type/Site ID:          KALY Albany, NY / 72518
Release Location (lon,lat,alt):     073 49.96'W, 42 41.53'N, -73.833, 42.692, 95.0
UTC Release Time (y,m,d,h,m,s):     2015, 01, 31, 23:03:13
Ascension Number:                   63
Radiosonde Serial Number:           88060626
Balloon Manufacturer/Type:          Totex / GP26
Balloon Weight:                     0.600
Radiosonde Type/RH Sensor Type:     Lockheed Martin Sippican LMS-6 GPS Radiosonde / Capacitance sensor
Surface Observations:               P: 1010.6, T: -17.0, RH: 50.0, WS: 3.6, WD: 318.0
Nominal Release Time (y,m,d,h,m,s):2015, 02, 01, 00:00:00
```

Time	Press	Temp	Dewpt	RH	Ucmp	Vcmp	spd	dir	Wcmp	Lon	Lat	Ele	Azi	Alt	Qp	Qt	Qrh	Qu	Qv	QdZ
sec	mb	C	C	%	m/s	m/s	m/s	deg	m/s	deg	deg	deg	deg	m	code	code	code	code	code	code
0.0	1010.7	-9.6	-17.6	52.0	1.5	-0.5	1.6	288.4	999.0	-73.833	42.692	999.0	999.0	95.0	1.0	1.0	1.0	1.0	1.0	9.0
1.0	1010.0	-9.6	-17.7	51.8	1.7	-0.7	1.8	292.4	5.0	-73.833	42.692	999.0	999.0	100.0	1.0	3.0	3.0	1.0	1.0	99.0
2.0	1009.4	-9.6	-17.7	51.5	2.0	-0.9	2.2	294.2	5.0	-73.832	42.692	999.0	999.0	105.0	1.0	3.0	3.0	1.0	1.0	99.0

3.5 Station List

Site ID	WMO ID	Site Name	State	Latitude	Longitude	Elev (m)	Sonde Type	#
KALY	72518	Albany	NY	42.692	-73.833	95	LMS6	87
KAPX	72634	Gaylord	MI	44.908	-84.719	448	VRS92	87
KBMX	72230	Birmingham	AL	33.180	-86.783	174	LMS6	93
KBUF	72528	Buffalo	NY	42.940	-78.725	218	LMS6	87
KCHH	74494	Chatham	MA	41.657	-69.959	15	LMS6	87
KCHS	72208	Charleston	SC	32.895	-80.028	13	LMS6	87
KDTX	72632	White Lake	MI	42.699	-83.472	330	VRS92	87
KFFC	72215	Peachtree City	GA	33.356	-84.567	245	LMS6	90
KGRB	72645	Green Bay	WI	44.498	-88.112	209	LMS6	83
KGSO	72317	Greensboro	NC	36.098	-79.943	276	LMS6	93
KGYX	74389	Gray	ME	43.893	-70.257	124	VRS92	89
KIAD	72403	Sterling	VA	38.977	-77.486	88	LMS6	88
KILN	72426	Wilmington	OH	39.421	-83.821	323	LMS6	86
KILX	74560	Lincoln	IL	40.151	-89.338	179	LMS6	87
KJAX	72206	Jacksonville	FL	30.483	-81.701	10	VRS92	87
KLIX	72233	Slidell	LA	30.338	-89.825	10	VRS92	89
LMHX	72305	Newport	NC	34.776	-76.878	11	VRS92	88
KOHX	72327	Nashville	TN	36.247	-86.562	180	LMS6	87
KOKX	72501	Upton	NY	40.865	-72.863	20	VRS92	87
KPBZ	72520	Pittsburgh	PA	40.532	-80.218	360	LMS6	88
KRNK	72318	Blacksburg	VA	37.206	-80.414	639	LMS6	89
KTAE	72214	Tallahassee	FL	30.446	-84.300	53	LMS6	88

4.0 Data Quality Control Procedures

1. Each sounding was converted from its original format (BUFR) into the ESC format described above.

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.

4.1 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).

4.1.1 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

4.1.2 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

4.2 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.

4.3 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.

1. No high resolution data are available for the following 00/12 UTC sounding times:
   KGRB 12 Feb at 12 UTC, 19 Feb at 00/12 UTC, and 9 Mar at 00 UTC
   KFFC 24/25 Feb at 00/12 UTC.
   KILN 7 Mar at 00 UTC
   KMHX 13 Feb at 00 UTC

2. Significant wet-bulbing (superadiabatic layers near cloud top) was evident for short periods and the temperature data were flagged as questionable in the following soundings:
   KALY 20150209 at 2302 UTC (560-520mb)
   KBMX 20150222 at 2309 UTC (640-475mb)
   KFFC 20150302 at 2311 UTC (570-555mb)
   KFFC 20150303 at 1114 UTC (680-630mb)
   KGYX 20150208 at 2300 UTC (570-530mb)
   KRNK 20150304 at 1104 UTC (535-460mb)
   KRNK 20150305 at 2334 UTC (660-600mb)

3. Significant GPS/wind data gaps in the following soundings:
   KAPX 20150226 at 1120 UTC (no GPS sfc-240mb)
   KJAX 20150208 at 2305 UTC (little GPS data)
   KJAX 20150220 at 2313 UTC (little GPS below 620mb, none above 300mb)
   KJAX 20150224 at 1111 UTC (little GPS data)
   KMHX 20150215 at 1101 UTC (little GPS above 340mb)
   KMHX 20150226 at 1151 UTC (little GPS below 260mb)
   KOHX 20150302 at 2309 UTC (no GPS)
   KTAE 20150206 at 1101 UTC (no GPS above 630mb)
   KTAE 20150211 at 1101 UTC (little GPS data)

4. Significant RH data gaps in the following soundings:
   KILX 20150218 at 1104 UTC (no RH data)
   KOHX 20150304 at 2301 UTC (880-540mb)
   KTAE 20150313 at 1102 UTC (985-820mb)

5. Two soundings stopped data transmission below 500 mb:
   KFFC 20150222 at 2309 UTC (810mb)
   KGRB 20150223 at 1121 UTC (790mb)

6. Periods of falling radiosonde:
   KLIX 20150305 at 1431 UTC (several periods below 705mb, interspersed with periods of high ascent rates of 15-20m/s)

7. Bad low level temperature data:
   KTAE 20150219 at 2301 UTC (first few sonde temperatures are very high)
   KTAE 20150220 at 2312 UTC (first few sonde temperatures are very high)
   KTAE 20150314 at 2303 UTC (first few sonde temperatures/RH are cold/dry)

5.0 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.