Western Wildfire Experiment for Cloud Chemistry, Aerosol Absorption and Nitrogen (WE-CAN) National Weather Service Radiosonde Data Set

1.0 Contacts:

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

Original Data Source:
NOAA/NWS

2.0 Dataset Overview

The National Weather Service (NWS) routinely releases radiosondes at 00 and 12 UTC with occasional special releases at sites throughout the United States. This data set includes the quality controlled WE-CAN NWS soundings released at 14 sites (Figure 1) throughout the western United States region during the WE-CAN field phase (20 July to 19 September 2018). One of the stations was only available at the mandatory and significant levels (KDNR). A total of 1608 1-second vertical resolution and 118 mandatory/significant level soundings are contained in the final WE-CAN data set.

Figure 1. Location of WE-CAN NWS radiosonde sites. Stations with white dot have one second vertical resolution data and those with red dots have mandatory and significant level data.

3.0 Project Overview

The **Western Wildfire Experiment for Cloud Chemistry, Aerosol Absorption and Nitrogen (WE-CAN)** is a field program focused on understanding the chemistry in western wildfire smoke and its role on air quality, nutrient cycles, weather, and climate. The project systematically characterized the emissions and first day evolution of western U.S. wildfire plumes, focusing on fixed nitrogen, absorbing aerosols, and cloud activation and chemistry in the plumes. Operations occurred from 24 July to 28 August 2018 with the NSF/NCAR C-130 aircraft based out of Boise, Idaho. There was an additional education deployment based out of Broomfield, Colorado from 6-13 September 2018. There was also a cooperating project (BB-FLUX that utilized the Wyoming King Air aircraft also based out of Boise, Idaho from 21 July to 17 September 2018. Further information on WE-CAN is available at the WE-CAN web site at NCAR/EOL: https://www.eol.ucar.edu/field_projects/we-can and information on the WE-CAN and BB-FLUX deployments is available at the WE-CAN Field Catalog: http://catalog.eol.ucar.edu/we-can.

4.0 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.

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 (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	Number sounding this year
7	Radiosonde Serial Number	
8	Balloon Manufacturer/Type	
9	Balloon Lot Number/Weight	
10	Radiosonde Type/RH Sensor Type	
11	Surface Observations	

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	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	Geopotential 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")

4.3 Data Specifics

The files contain data at one-second intervals.

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.

The KBOI, KGJT, KLKN, KOAK, KOTX, KREV, KRIW, KSLC, KSLE, and KVEF stations utilized the Lockheed Martin Sippican LMS-6 Radiosonde with the capacitance RH sensor and GPS windfinding during WE-CAN.

KDNR utilized the Lockheed Martin Sippican LMS6 with the chip thermistor, external boom mounted capacitance relative humidity sensor, and derived pressure from GPS height during WE-CAN.

The KMFR, KTFX, and KUIL stations utilized the Vaisala RS92-NGP radiosonde with twin alternatively heated Humicap capacitance RH sensors and GPS windfinding during WE-CAN.

4.4 Sample Data

The following is a sample of the WE-CAN NWS radiosonde data in ESC format.

```
Data Type:                          National Weather Service Sounding/Ascending
Project ID:                         WE-CAN_2018
Release Site Type/Site ID:          KBOI Boise, ID / 72681
Release Location (lon,lat,alt):     116 12.66'W, 43 34.06'N, -116.211, 43.568, 873.0
UTC Release Time (y,m,d,h,m,s):     2018, 07, 19, 23:00:34
Ascension Number:                   401
Radiosonde Serial Number:           89008613
Balloon Manufacturer/Type:          Totex / GP26
Balloon Lot Number/Weight:          2017 / 0.600
Radiosonde Type/RH Sensor Type:     Lockheed Martin Sippican LMS-6 GPS Radiosonde / Capacitance sensor
Surface Observations:               P: 913.8, T: 18.5, RH: 12.0, WS: 4.1, WD: 314.0
Nominal Release Time (y,m,d,h,m,s):2018, 07, 20, 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  913.6  35.7   1.9  12.0    4.1   -4.7   6.2 318.9 999.0 -116.211  43.568 999.0 999.0   873.0  1.0  1.0  1.0  1.0  1.0  9.0
   1.0  913.0  35.5   2.0  12.2    4.0   -4.7   6.2 319.6   6.0 -116.211  43.568 999.0 999.0   879.0  1.0  3.0  3.0  1.0  1.0 99.0
   2.0  912.5  35.3   2.0  12.3    4.0   -4.7   6.2 319.6   5.0 -116.211  43.568 999.0 999.0   884.0  1.0  3.0  3.0  1.0  1.0 99.0
```

4.5 Station List

Site ID	WMO ID	Site Name	State	Latitude	Longitude	Elev (m)
KBOI	72681	Boise	ID	43.568	-116.211	873
KDNR	72469	Denver	CO	39.770	-104.880	1611
KGJT	72476	Grand Junction	CO	39.120	-108.524	1474
KLKN	72582	Elko	NV	40.860	-115.742	1593
KMFR	72597	Medford	OR	42.377	-122.882	398
KOAK	72493	Oakland	CA	37.745	-122.224	3
KOTX	72786	Spokane	WA	47.682	-117.627	729
KREV	72489	Reno	NV	39.568	-119.795	1518
KRIW	72672	Riverton	WY	43.065	-108.477	1699
KSLC	72572	Salt Lake City	UT	40.773	-111.955	1289
KSLE	72694	Salem	OR	44.910	-123.010	62
KTFX	72776	Great Falls	MT	47.461	-111.385	1134
KUIL	72797	Quillayute	WA	47.935	-124.560	57
KVEF	72388	Las Vegas	NV	36.047	-115.185	697

5.0 Data Quality Control Procedures

1. Each sounding was converted from its original format 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.

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.

KBOI 201807312302 – no GPS/wind data
KDNR 201808131200 – bad surface RH
KMFR 201808132301 – little GPS/wind data particularly below 360mb
KOAK 201808222301 – no GPS/wind data
KRIW 201808041117 – no GPS/wind data
KSLC 201808021107 – temperature data bad above 500mb
KTFX 201809142307 – no RH data
KUIL 201808032300 – bad near surface RH
KUIL 201809081115 – no RH data

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.