

# CFACT: High Resolution Radiosonde Composite

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## 1.0 Data Set Description

High vertical resolution radiosonde data from research and operational sources during the Cold Fog Amongst Complex Terrain (CFACT) campaign converted into a common format (EOL Sounding Composite format which is a columnar ASCII format). The composite includes radiosondes from the NCAR/EOL Integrated Sounding System (ISS) that was located at the Deer Creek Supersite (near Midway, Utah) as well as radiosondes from the National Weather Service Salt Lake City, Utah; Boise, ID; Elko, NV sites.

**Data Version:** 1.0

**Data Status:** Final

**Time Period:** 4 January to 24 February 2022

**Physical Location:** Four locations within 40.489 to 43.568N and 111.955 to 116.211W

**Data Frequency:** Varies by location

**Vertical Resolution:** 1 second (~5m)

**Data Source:** NCAR/EOL and NOAA/National Weather Service

**Data Restrictions:** Limited to CFACT investigators through 23 February 2023. Open access thereafter.

### 1.1 CFACT Description

The CFACT campaign investigated cold fog formation in mountain valleys and environmental conditions in complex terrain with the latest observation technology. Its goal was to improve microphysical parameterizations and visibility algorithms used in numerical weather prediction (NWP) models and to develop data-assimilation and analysis methods for current and next generation (e.g., sub-kilometer scale) NWP models. The CFACT field campaign was conducted in Heber Valley, Utah during January and February 2022.

## 2.0 Instrument Description

## 2.1 Instrumentation

**NCAR/EOL ISS Deer Creek Supersite** used Vaisala RS41-SGP radiosondes processed by the Vaisala MW41 sounding system using software version 2.17.0.

**KBOI** used Vaisala RS41 radiosondes (DigiCORA MW41) with a humicap capacitance RH sensor with an active de-icing method.

**KLKN** switched radiosonde systems during CFACT as part of the NWS transitioning from the Radiosonde Replacement System (RRS) to the Manual Radiosonde Observation System (MROS).

5 January and 00 UTC 6 January used the Lockheed Martin Sippican LMS-6 GPS radiosondes with a capacitance RH sensor

After 00 UTC 6 January used the Graw DFM-17 radiosondes with a capacitance RH sensor

**KSLC** switched radiosonde systems during CFACT also as part of the RRS to MROS transition. 5 January to 12 UTC 11 January and 00 and 12 UTC 12 January used the Lockheed Martin Sippican LMS-6 GPS radiosondes with a capacitance RH sensor

16 and 20 UTC 11 January and after 12 UTC on 12 January used the Graw DFM-17 radiosondes with a capacitance RH sensor

## 2.2 Station Locations

| Site ID | WMO ID | WBAN  | Site Name            | State | Latitude | Longitude | Elevation (m) |
|---------|--------|-------|----------------------|-------|----------|-----------|---------------|
| KBOI    | 72681  | 24131 | Boise                | ID    | 43.568   | -116.211  | 873           |
| KLKN    | 72582  | 04105 | Elko                 | NV    | 40.860   | -115.742  | 1593          |
| KSLC    | 72572  | 24127 | Salt Lake City       | UT    | 40.773   | -111.955  | 1289          |
| DC      | N/A    | N/A   | Deer Creek Supersite | UT    | 40.489   | -111.470  | 1662          |

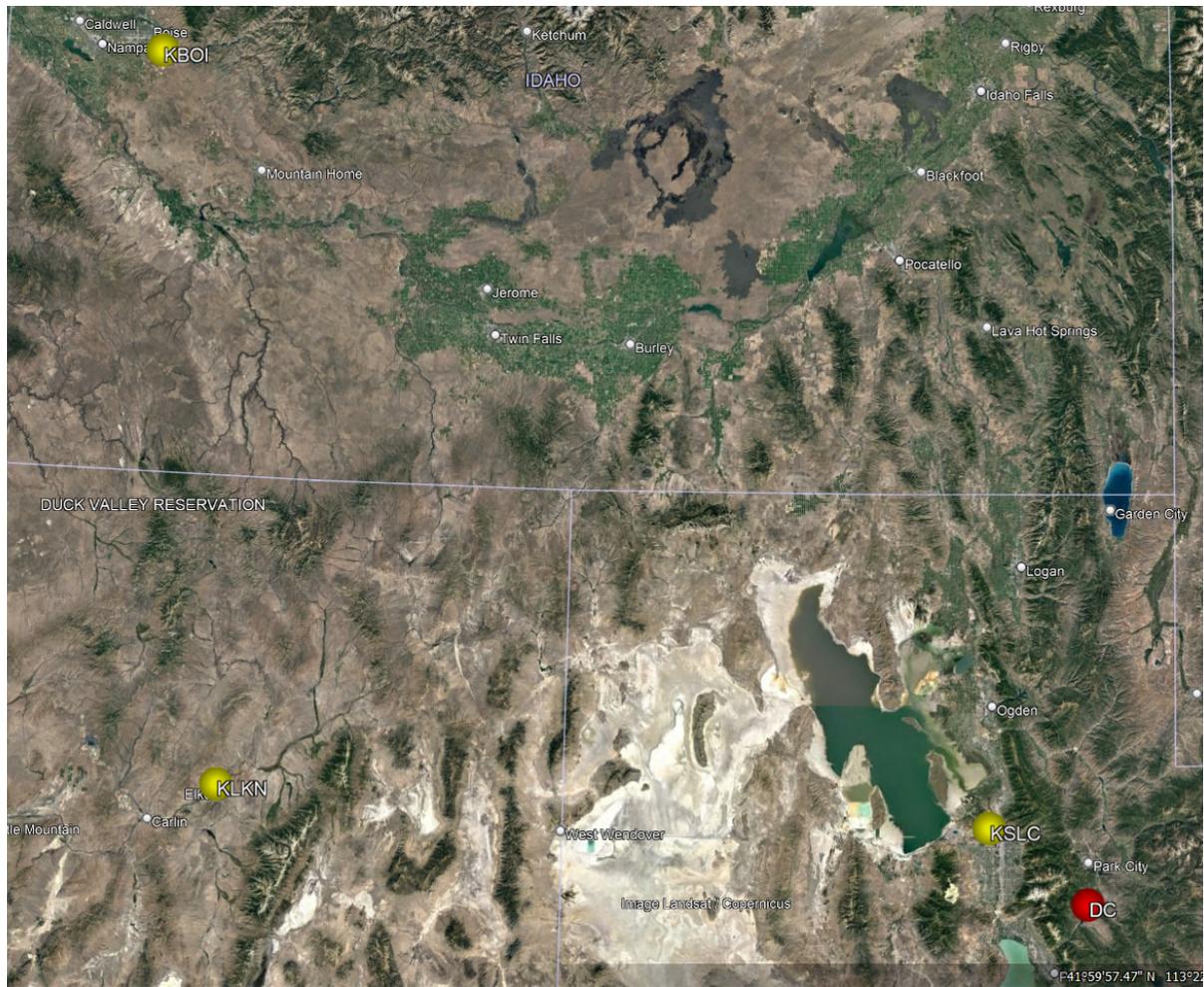


Figure 1. Map of CFACT radiosonde composite locations. Yellow circles are NWS sites and the red circle is the NCAR/EOL Deer Creek Supersite location.

### 3.0 Data Collection and Processing

#### 3.1 Data Collection

The NWS data were collected via the Global Telecommunications System. These data were in the WMO GTS BUFR radiosonde standard format. The NWS typically releases soundings at 00 and 12 UTC with occasional special releases.

The NCAR/EOL data were collected by the Vaisala MW41 sounding system. The NCAR/EOL site released soundings at varying schedules depending on operational requirements.

Additional details are available at their respective dataset pages in the NCAR/EOL Field Data Archive:

NWS: <https://doi.org/10.26023/NVPB-HBK5-2S0G>

NCAR/EOL: <https://doi.org/10.26023/6S3T-8RV0-WD07>

## **3.2 Data Processing**

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

The NCAR/EOL data were processed by the Vaisala MW41 sounding system software Version 2.17.0.

Both sets of data were then 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 underwent initial quality control processing by their respective radiosonde systems described above. Additional details on the initial quality control of the NCAR/EOL radiosonde data are available in their Data Report available here:

<https://doi.org/10.26023/6S3T-8RV0-WD07>

In addition to the quality control procedures conducted by the data source, 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<br>> T | RH<br>T, RH          | Q<br>Q       |
| Wind Speed     | < 0 or > 100<br>> 150  | U, V<br>U, V         | Q<br>B       |
| U Wind         | < 0 or > 100<br>> 150  | U<br>U               | Q<br>B       |
| V Wind         | < 0 or > 100<br>> 150  | V<br>V               | Q<br>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 were 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 | P, T, RH | Q    |
|             | > 2mb/s or < -2mb/s | P, T, RH | B    |
| Temperature | < -15°C/km          | P, T, RH | Q    |
|             | < -30°C/km          | P, T, RH | B    |
|             | > 50°C/km           | P, T, RH | Q    |
|             | > 100°C/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: CFACT\_HighRes\_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<br>(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:

| <b>Field</b> | <b>Width</b> | <b>Format</b> | <b>Parameter</b>        | <b>Units</b> | <b>Missing Value</b> |
|--------------|--------------|---------------|-------------------------|--------------|----------------------|
| 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

See the respective FDA dataset pages linked in Section 3.1 for any details on data quality issues.

## 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.

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