# CAESAR: High Resolution Sounding Composite

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## 1.0 Data Set Description

High vertical resolution sounding data from research and operational sources during the Cold Air Outbreak Experiment in the Sub-Arctic Region (CAESAR) campaign converted into a common format (EOL Sounding Composite format which is a columnar ASCII format). The composite includes data from 568 radiosondes and 116 dropsondes from locations around the Norwegian Sea. The radiosondes were released by the Norwegian Meteorological Institute from four sites and the dropsondes were released by NCAR/EOL from the NSF NCAR C-130 aircraft in ten research flights.

**Data Version**: 1.0

**Data Status**: Final

**Time Period**: 21 Feb to 5 April 2024

**Physical Location**: 69.2-79.0N and 17.1W to 23.1E

**Data Frequency**: Andenes typically released at 00 and 12 UTC and Ny-Alesund typically released at 12 UTC. Bjornoya and Jan Mayen typically released at 00, 06, 12, and 18 UTC with special observations at 08, 10, 14, and 16 UTC during some CAESAR flight days. The NCAR/EOL dropsondes were released at various intervals during the NSF NCAR C-130 flights.

**Vertical Resolution**: Andenes and Ny-Alesund are one second (~5m). Bjornoya and Jan Mayen are two second (~10m). The dropsondes are 0.5 sec PTH and 0.25 sec winds.

**Data Sources**: Norwegian Meteorological Institute and the NCAR Earth Observing Laboratory.

**Data Restrictions**: Limited to CAESAR investigators through 7 April 2025. Open access thereafter.

### 1.1 CAESAR Description

CAESAR was proposed to examine the structure of marine boundary layer clouds during cold air outbreaks (CAOs). CAESAR deployed the NSF NCAR C-130 aircraft, with a suite of in situ and remote sensors sampling Arctic air masses from the CAO origin at the ice edge throughout their transformation downstream. The rich array of instrumentation on-board the NSF NCAR

C-130 included airborne radars and lidars, aerosol, cloud, precipitation, and trace gas probes, all deployed during CAO events over the open waters between northern Sweden and the Arctic ice edge for 45 days in early 2024 in order to provide a detailed characterization that will form the backbone of modeling studies across a range of scales and form a long-lasting legacy dataset. Information on CAESAR operations and Intensive Observation Periods (IOPs) can be found in the CAESAR Field Catalog (https://catalog.eol.ucar.edu/caesar) and additional background information can be found at the CAESAR website (https://www.eol.ucar.edu/field_projects/caesar).

# 2.0 Instrument Description

## 2.1 Instrumentation

**Andenes** used Vaisala RS41/AUTOSONDE / Humicap capacitance sensor with active de-icing method

**Bjornoya** used a mix of Vaisala RS41/AUTOSONDE and Vaisala RS41/DigiCORA MW41 both with Humicap capacitance sensor with active de-icing method

**Jan_Mayen** used a mix of Vaisala RS41/DigiCORA MW41 (Finland) / Humicap capacitance sensor with active de-icing method and Modem M20 radiosonde w/thermistor sensor, capacitance relative humidity sensor, and derived pressure from GPS height (France) / Capacitance sensor

**Ny-Alesund** used Vaisala RS41/DigiCORA MW41 (Finland) / Humicap capacitance sensor with active de-icing method

**NSF NCAR C-130** used NCAR Research Dropsonde NRD41 mini-dropsondes.

## 2.2 Station Locations

| Site ID | Source | Site Name | Latitude | Longitude | Elev (m) |
|---|---|---|---|---|---|
| N130AR | EOL | NSF NCAR C-130 | mobile | mobile | |
| 01001 | NMI | Jan Mayen, Norway | 70.940 | -8.669 | 10 |
| 01004 | NMI | Ny-Alesund, Svalbard, Norway | 78.923 | 11.923 | 17 |
| 01010 | NMI | Andenes, Andoya, Norway | 69.315 | 16.131 | 3 |

| | | | | | |
|---|---|---|---|---|---|
| 01028 | NMI | Bjornoya, Norway | 74.503 | 19.003 | 22 |

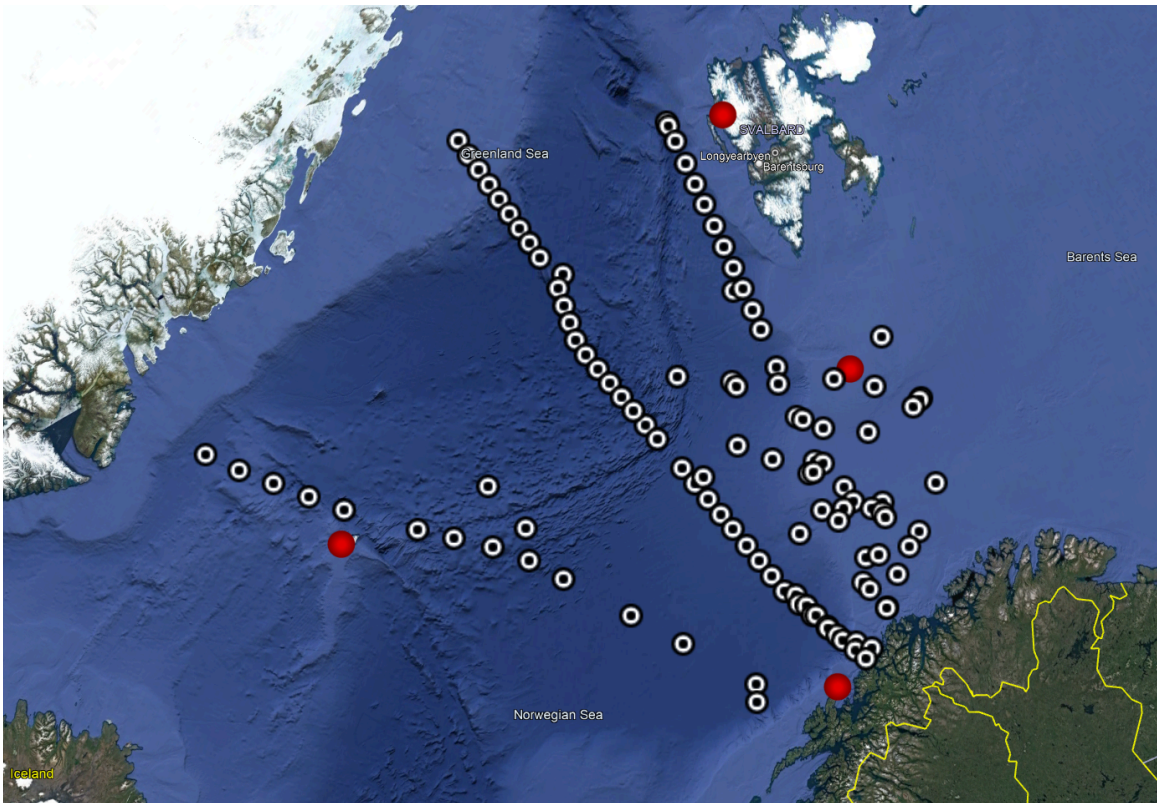


**Figure 1.** Map of CAESAR radiosonde composite locations. Red circles are NMI radiosonde sites and white circles are NSF NCAR C130 dropsonde locations.

The NSF NCAR dropsondes were released only during CAESAR research flights and at varying intervals during flights. A total of 116 dropsondes are included in this dataset.

The NMI stations standard releases varied by station as follows: Andenes 00 and 12 UTC, Ny-Alesund at 12 UTC, and Bjornoya and Jan Mayen at 00, 06, 12, and 18 UTC with special releases during some CAESAR operations at 08, 10, 14, and 16 UTC. A total of 568 NMI radiosondes are included in this dataset as follows: Andenes (88), Bjornoya (233), Jan Mayen (205), Ny-Alesund (42).

## 3.0 Data Collection and Processing

### 3.1 Data Collection

The NMI Radiosonde data were collected via the Global Telecommunications System (GTS).

Complete information on the collection procedures at each site can be found in the documentation at their respective dataset pages in the NCAR/EOL Field Data Archive:

NSF NCAR C-130 Dropsonde: https://doi.org/10.26023/4KSV-GMKT-AT0R

## 3.2 Data Processing

The NMI radiosonde data were in BUFR format and were converted to the NCAR/EOL Sounding Composite Format using the ECMWF ecCodes software package and local EOL software.

Complete information on the collection procedures at each site can be found in the documentation at their respective dataset pages in the NCAR/EOL Field Data Archive:

NSF NCAR C-130 Dropsonde: https://doi.org/10.26023/4KSV-GMKT-AT0R

## 3.3 Quality Control Processing

Each sounding underwent initial quality control processing by their respective radiosonde systems described above.

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 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 | < -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: CAESAR_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 (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

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

The GPS sensor completely failed for two dropsonde releases during IOP1 and therefore the release location in the header and any reported lat/lon in the data section are incorrect. The impacted dropsondes are: 1224 and 1409 UTC on 28 February.

## 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.

NSF NCAR/EOL Dropsonde Team. 2024. CAESAR: AVAPS Dropsonde Profiles. Version 1.0. UCAR/NCAR - Earth Observing Laboratory. https://doi.org/10.26023/4KSV-GMKT-AT0R. Accessed 22 Aug 2024.