Seeded and Natural Orographic Wintertime Clouds: The Idaho Experiment (SNOWIE) 5 hPa Resolution Sounding Composite Data Set

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2.0 Dataset Overview

This data set contains a composite of the upper air sounding data interpolated to 5hPa vertical levels from all sources for the Seeded and Natural Orographic Wintertime Clouds: The Idaho Experiment (SNOWIE) project. This composite includes soundings from the mobile University of Illinois Urbana-Champaign (UIUC; 34 soundings), the Idaho Power Company (IPC) Crouch (69 soundings) and Lowman (69 soundings) sites, the NCAR Horseshoe Bend site (12 soundings) as well as from 15 National Weather Service (NWS) stations across the western United States (2191 soundings). A map of all of the research radiosonde locations is in Figure 1 and a map of all of the NWS radiosonde locations is in Figure 2.

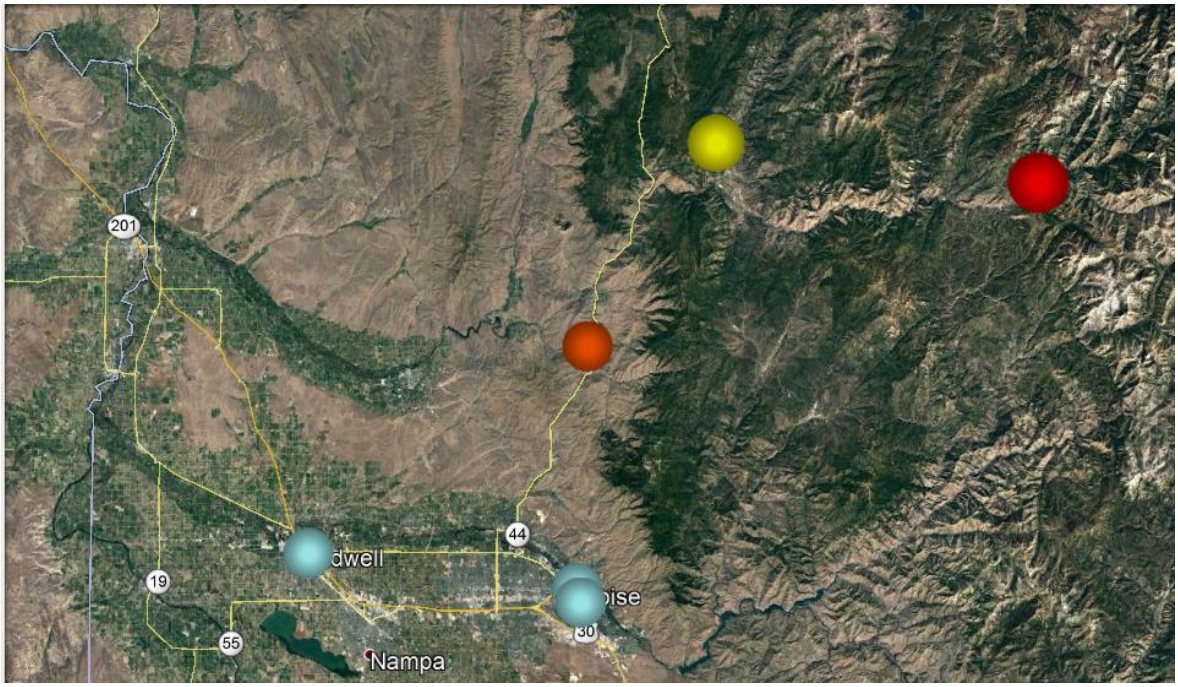

Figure 1. Locations of the research radiosonde systems included in the SNOWIE composite data set. The UIUC mobile sites around Boise and Caldwell are blue. The NCAR SLW Horseshoe Bend site is orange. The IPC Crouch site is yellow and the IPC Lowman site is red.

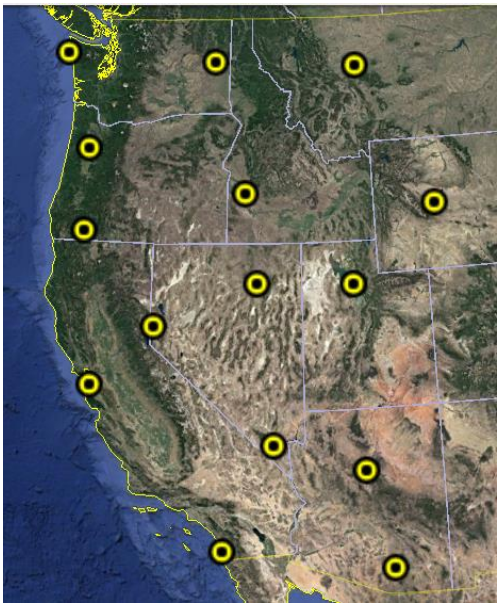

Figure 2. Locations of the NWS radiosonde stations included in this SNOWIE composite data set.

3.0 Project Overview

The Seeded and Natural Orographic Wintertime Clouds: The Idaho Experiment (SNOWIE) project is a research program to understand the natural dynamical and microphysical processes by which precipitation forms and evolves within orographic winter storms and to determine the physical processes by which cloud seeding with silver iodide (AgI), either from ground generators or aircraft, impacts the amount and spatial distribution of snow falling across a river basin. SNOWIE was conducted from 7 January to 17 March 2017 in the Payette Mountains located to the northeast of Boise, ID. Further information on SNOWIE is available at the SNOWIE web site at NCAR/EOL: https://www.eol.ucar.edu/field_projects/snowie and information on the SNOWIE deployments is available at the SNOWIE Field Catalog: http://catalog.eol.ucar.edu/snowie.

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. In this data set the non-standard header records vary depending on the data source.

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	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

Details on the radiosonde systems included in this data set are included in this section. Links are included to the documentation for the individual sounding data sets for details on processing and quality control.

UIUC Mobile Radiosondes

34 total radiosondes from 8 January to 9 March 2017
GRAW DFM-09 radiosondes (10 second vertical resolution)
http://data.eol.ucar.edu/datafile/nph-get/534.026/readme_SNOWIE_UIUC_radiosonde_ESC.pdf
http://data.eol.ucar.edu/datafile/nph-get/534.001/UIUC_MOBILE_README.pdf

National Weather Service Radiosondes

2191 total radiosondes from 7 January to 17 March 2017
KBOI, KLKN, KOAK, KOTX, KREV, KRIW, KSLC, KSLE, and KVEF utilized the Lockheed Martin Sippican LMS-6 Radiosonde with the capacitance RH sensor and GPS windfinding
KFGZ, KMFR, KNKX, KTFX, KTWC, and KUIL utilized the Vaisala RS92-NGP radiosonde with twin alternatively heated Humicap capacitance RH sensors and GPS windfinding
All at 1 second resolution
http://data.eol.ucar.edu/datafile/nph-get/534.004/readme_SNOWIE_NWS_radiosonde.pdf

IPC Crouch Radiosondes

69 radiosondes at 1 second resolution
Lockheed Martin LMS6 Radiosondes using GPS for windfinding

http://data.eol.ucar.edu/datafile/nph-get/534.023/readme_SNOWIE_IPC_Crouch_radiosonde_ESC.pdf
http://data.eol.ucar.edu/datafile/nph-get/534.019/SNOWIEUpperAir_readme.pdf

IPC Lowman Radiosondes

69 radiosondes at 1 second resolution
Lockheed Martin LMS6 Radiosondes using GPS for windfinding
http://data.eol.ucar.edu/datafile/nph-get/534.024/readme_SNOWIE_IPC_Lowman_radiosonde_ESC.pdf
http://data.eol.ucar.edu/datafile/nph-get/534.020/SNOWIEUpperAir_readme.pdf

NCAR SLW Horseshoe Bend Radiosondes

12 radiosondes at 3 second resolution
iMet-1-RSB radiosondes
http://data.eol.ucar.edu/datafile/nph-get/534.027/readme_SNOWIE_NCAR_SLW_radiosonde_ESC.pdf
http://data.eol.ucar.edu/datafile/nph-get/534.002/SNOWIE_SLW_Data.pdf

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:

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

4.4 Sample Data

The following is a sample of the 5 hPa vertical resolution radiosonde data in ESC format.

```
Data Type:                          IPC Radiosonde Data/Ascending
Project ID:                         SNOWIE
Release Site Type/Site ID:          Crouch, ID/KCRH
Release Location (lon,lat,alt):     115 59.40'W, 44 08.94'N, -115.990, 44.149, 1082.6
UTC Release Time (y,m,d,h,m,s):     2017, 01, 10, 23:01:00
Radiosonde Type:                    Lockheed Martin LMS6 Radiosonde
/
/
/
/
/
Nominal Release Time (y,m,d,h,m,s):2017, 01, 10, 23:01:00
 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
------ ------ ----- ----- ----- ------ ------ ----- ----- ----- -------- -------- ----- ----- ------- ---- ---- ---- ---- ---- ----
  -1.0  877.7   0.2  -1.2  90.5    0.4   -0.1   0.4 278.9 999.0 -115.990  44.149 999.0 999.0  1082.6  1.0  1.0  1.0  1.0  1.0  9.0
   7.2  875.0  -0.4  -1.6  91.3    0.6    0.1   0.6 260.5   4.2 -115.990  44.149 999.0 999.0  1107.1  1.0  1.0  1.0  1.0  1.0 99.0
  21.0  870.0  -0.6  -1.8  91.3    1.0   -0.4   1.1 291.8   2.7 -115.990  44.149 999.0 999.0  1152.8  1.0  1.0  1.0  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
KFGZ	72376	Flagstaff	AZ	35.231	-111.820	2179
KLKN	72582	Elko	NV	40.860	-115.742	1593
KMFR	72597	Medford	OR	42.377	-122.882	398

KNKX	72293	San Diego	CA	32.845	-117.124	137
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
KTWC	72274	Tucson	AZ	32.228	-110.956	741
KUIL	72797	Quillayute	WA	47.935	-124.560	57
KVEF	72388	Las Vegas	NV	36.047	-115.185	697
KLOW	N/A	Lowman	ID	44.100	-115.459	1315
KCRH	N/A	Crouch	ID	44.149	-115.990	1082
NCAR SLW	N/A	Horseshoe Bend	ID	43.909	-116.202	793

The UIUC radiosondes were from a mobile system and were released from several locations.

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.

4. Each sounding was interpolated to 5 hPa vertical resolution.

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 5 hPa Interpolation Procedures

The surface data point was kept as the initial level in each sounding. The first interpolated data point was at the next lowest pressure evenly divisible by 5 and then every 5 hPa pressure level beyond that point to either 50 hPa or the lowest pressure level reached by the radiosonde, whichever came first. The first 15 lines of each file (the header information) were kept without change.

For the interpolation, the software searched for two data points around the desired pressure level. The search was conducted by looking for two valid (i.e. non-missing) data points around the desired pressure level, while also paying attention to the time difference between the two data points as well as their quality control flags. There was a search for the two best possible data points to use in the interpolation. If the desired pressure level was within the original dataset, that data point was used without interpolation.

There was first a search for values flagged as good within some time range (50 sec for temperature, humidity, and wind and 100 sec for pressure; hereafter termed the ARANGE) and the interpolated data point was flagged as good. Failing that, it searched for values flagged as estimated within the same time range and the interpolated data point was flagged as estimated. Then the search went for good values within a wider time range (100 sec for temperature, humidity, and wind and 200 sec for pressure; hereafter termed the BRANGE) the flag for the interpolated data point here was then degraded (even though two `good' data points were used there was a significant time difference between them) to questionable. Then, in turn, estimated values within the BRANGE were used (flag set to questionable), questionable values within the BRANGE (flag set to bad), good values greater than the BRANGE apart (flag set to bad), estimated values greater than BRANGE apart (flag set to bad), questionable values greater than BRANGE apart (flag set to bad), finally any bad values (flag set to bad). This search was conducted separately for each interpolated variable (pressure, temperature, relative humidity, and the u and v wind components.

Thus for each interpolated data point, the quality control flag was set to the worst case among the data points used in the interpolation, except, for each time range apart, the quality control flag was degraded one level (i.e. good to questionable, etc).

The quality control flags should be carefully heeded in these files. While some of the data may look good, it may have been interpolated over large pressure intervals, and thus be suspect.

For each interpolated data point the dew point was calculated from the temperature and relative humidity (Bolton 1980) and the total wind speed and direction were calculated from the interpolated u and v component values. Also, the altitude and time were interpolated using the same data points used for the pressure interpolation. The ascension rate was recalculated based on the time and altitude values from the two data points used to interpolate the 5 hPa data point. Thus the ascension rate values do not reflect the values based on the interpolated data. The

latitude and longitude values were interpolated using the same data points used in the wind component interpolation.

5.4 Data Quality Issues of Note

See the readme files linked above for details on the data quality issues in each individual sounding data set.

6.0 References

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