21 November 2019

CHEESEHEAD 2019
Radiosonde Data Quality Report

Holger Vömel, William Brown
Earth Observing Laboratory
National Center for Atmospheric Research
Boulder, CO

Earth Observing Laboratory
In situ Sensing Facility

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH
P. O. Box 3000
BOULDER, COLORADO 80307-3000

The radiosonde data for this project were quality controlled and are maintained by the Earth Observing Laboratory at the National Center for Atmospheric Research (NCAR). The National Center for Atmospheric Research is managed by the University Corporation for Atmospheric Research and sponsored by the National Science Foundation.

The radiosondes, helium, and balloons used in this campaign were supplied jointly by the National Science Foundation's Lower Atmospheric Observing Facilities deployment pool via a facility request led by Ankur Desai and by the University of Wisconsin's Space Science and Engineering Center via a proposal led by Erik Olson and Tim Wagner.

If information or plots from this document are used for publication or presentation purposes, please provide appropriate acknowledgement to NCAR/EOL and NSF and refer to the citation listed below. Please feel free to contact the authors for further information.

Contacts:

Holger Vömel (voemel@ucar.edu)
Bill Brown (wbrown@ucar.edu)

Radiosonde operators:

NCAR: Liz Bernhardt, Bill Brown, Rick Brownigg, Dan Buonome, Hendrik Gilmer, Gary Granger, Kurt Knudson, Robert Menke, John Miltzer, Steve Oncley, David Ortigoza, Matt Paulus, John Sobtzak, Isabel Suhr, Lou Verstraete, Kyle Wislinsky, Jacquie Witte
U. Wisconsin: Brian Butterworth, Ryan Clare, Ankur Desai, Leo Mikula, James Mineau, Bailey Murphy, Sreenath Paleri, Jonathan Thom
KIT: Hannes Vogelmann, Luise Wanner

Mailing Address:

NCAR/Earth Observing Laboratory
P.O. Box 3000
3090 Center Green Dr.
Boulder, CO 80301, USA

Websites:

CHEESEHEAD home page:
https://www.eol.ucar.edu/field_projects/cheesehead
Integrated sounding system home page:
https://www.eol.ucar.edu/content/iss-operations-cheesehead

To refer to this data set or report, please include the following citation:

NCAR/EOL In-situ Sensing Facility, University of Wisconsin - Space Science & Engineering Center (SSEC). 2019. NCAR/EOL ISS and UWI SPARC Radiosonde Data. Version 1.0. UCAR/NCAR - Earth Observing Laboratory. https://doi.org/10.26023/9WA4-KQKZ-9Q12. Accessed 22 Feb 2021.

Document Version Control

Version	Date	Author	Change Description
1.0	21 Nov 2019	H. Vömel	Initial Data Release
1.1	18 Feb 2021	H. Vömel	Added missing credit to University of Wisconsin

1 Table of Contents

2 Dataset Overview

The Chequamegon Heterogeneous Ecosystem Energy-balance Study Enabled by a High-density Extensive Array of Detectors (CHEESEHEAD) field campaign investigated long-standing puzzles regarding the role of atmospheric boundary-layer responses to scales of spatial heterogeneity in surface-atmosphere heat and water exchanges. From 20 June to 11 October 2019 one Integrated Sounding System (ISS) was deployed near Park Falls, WI. This document describes the quality of the data obtained from the NCAR/EOL radiosonde launches the ISS location.

Campaign staff from NCAR/EOL, University of Wisconsin, and Karlsruhe Institute of Technology successfully launched 172 radiosondes. Soundings were typically launched at 18:00 UTC (13:00 local time) for the duration of the campaign. Three intensive periods took place between 9 and 13 July, 19 and 24 August, and 23 and 28 September, with between 4 and 5 radiosonde launches per day.

Only one sounding failed shortly after launch, requiring a re-launch. The overall success rate during this campaign was 99.4%.

Figure 1 shows the flight tracks of the ascending part of all soundings.

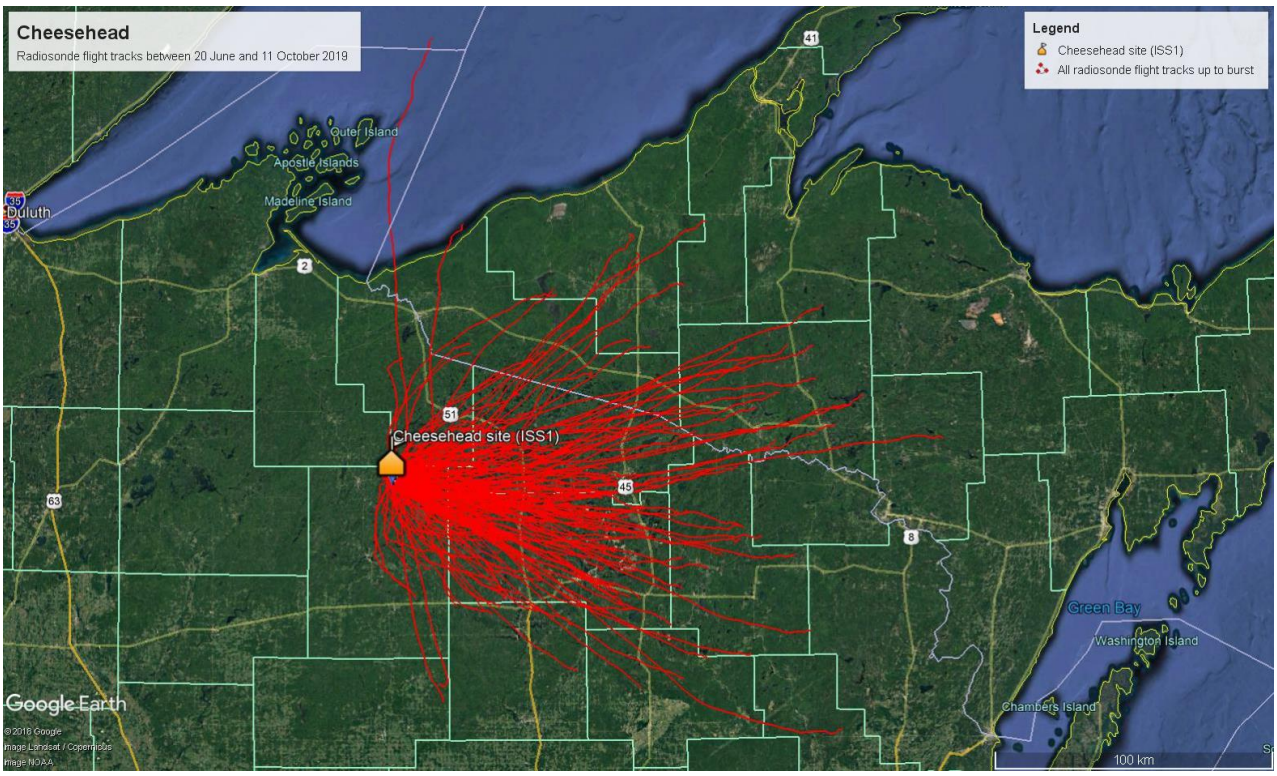

Figure 1: Location of the ISS site during CHEESEHEAD and flight tracks of all ascending radiosonde profiles. The sounding location was 12 km east of Park Falls, WI.

3 Radiosonde sounding system

This campaign used Vaisala RS41-SGP radiosondes, which were received and processed by the Vaisala MW41 sounding system using software version 2.11.0. The radiosondes used by NCAR/EOL include a pressure sensor, which provides a better altitude and pressure determination in the boundary layer and is more suitable for unstable conditions in convective environments. The sounding system was configured to meet the needs of NCAR for high-resolution data and complete metadata description. All sondes were launched using 100 g balloons supplied by Scientific Sales.

The MWX raw data files from the sounding system were saved along with the ASCII output files, which contained the initially processed profiles.

Data for some, but not all soundings were recorded also on descent; however, these data are not analyzed or archived and can be made available only upon request.

The sounding systems automatically ingest surface reference observations, which are provided by sets of reference sensors near each launch site. These observations are stored in the surface observations metadata fields of the sounding files and used in the quality control procedures of the sounding data.

The reference sensors used for the radiosonde system during CHEESEHEAD are listed in Table 1.

Table 1: Surface reference observations provided by the ISS meteorological reference sensors during CHEESEHEAD.

Parameter	Location	Sensor
Pressure	The reference pressure was installed on a mast at 2 m height near the launch site.	Vaisala PTB210
Temperature and humidity	The reference sensors for temperature, humidity, wind speed, and wind direction were installed on a mast at 2 m height near the launch site.	Lufft WS300
Wind	The reference sensor for wind speed and wind direction was installed on a mast at 10 m height near the launch site.	Gill Wind Observer (2D sonic)

4 Quality control procedures

4.1 Standard quality control

The Vaisala system performs a sequence of standard quality control procedures and corrections for all radiosonde data:

- Applies a ground check correction for pressure using the pressure correction measured during the sonde preparation to compensate for small biases inherent in this type of pressure sensor.
- Performs a coarse outlier check for all measurement parameters
- Automatically detects launch based on change in pressure
- Performs a radiation correction for the temperature measurement using the radiation correction lookup table for the Vaisala RS41 radiosonde
- Corrects for response time lag of the temperature sensor
- Smooths the temperature profile
- Corrects for response time lag of the humidity sensor
- Filters out the balloon pendulum effect in the calculation of winds
- Calculates geopotential altitude based on the measured pressure profile

4.2 Custom quality control

In addition to the standard Vaisala procedures, all metadata are verified, and all measured parameters including reference measurements are checked for consistency and for any previously unidentified issue. The radiosonde measurements before launch are compared against the reference measurements and the causes for early termination are investigated. In the CHEESEHEAD data set, the following issues were identified and corrected:

a. In three soundings (20190814_180005, 20190821_180006, 20190923_175919) the balloon was launched up to 5 s earlier than when the launch was detected. The missing data have been reprocessed from raw data and the launch time stamp has been properly adjusted. Note that the file name was not changed, only the metadata inside the file.

b. The sounding 20190730_175824 did not record any data for the first 1.4 min after launch. The sounding system interpolated over this time. In the quality-controlled data set, these data have been removed.

c. The reference wind sensor had been incorrectly configured during system setup and all reference wind directions were offset by 180°. This error was corrected in the quality controlled data. Due to the filtering of the balloon pendulum motion, this error also influenced the winds reported by the radiosonde up to 20 s after launch. These data have also been corrected by analyzing the raw data.

d. Sounding 20190827_180005 stopped data processing early due to failure of the radiosonde GPS. A full profile up to 16.1 km was recorded. The balloon continued to transmit thermodynamic data up to 20.8 km, but was unable to measure any winds after that point. The data have been limited to 16.1 km.

e. Sounding 20190803_180205 encountered a period of descent for about 12 s, during which the sonde fell 20 m. Since only ascending data are reported, this descending motion causes a data gap of about 25 s at an altitude of 10.14 km.

The final quality controlled data are provided in NetCDF format following the CF-1.6 metadata convention for climate and forecasting. For a detailed description of the data format, refer to Vömel et al., 2018, https://doi.org/10.5065/D65X27SR.

5 Sounding metrics

At the CHEESEHEAD site, about 12 km east of Park Falls, WI, 172 successful radiosondes were launched between 20 June and 11 October 2019. Soundings were launched daily at 18:00 UTC and at higher frequency during three intensive observation periods. Between 9 and 13 July 2019, sondes were launched nominally at 10:20, 12:00, 14:15, 18:00, and 21:45. Between 19 and 24 August, sondes were launched nominally at 11:10, 14:15, 18:00, and 21:45, and between 23 and 28 September, sondes were launched at 11:45, 14:15, 18:00, and 21:45 (all times UTC).

Only one sonde failed shortly after launch (3 October 2019), requiring a re-release of a second sonde with a delay of 17 min off the nominal schedule.

The distribution of ceiling heights is shown in Figure 2. Burst heights below 14 km occurred on 5 consecutive days between 2 and 6 July, where a bad batch of balloons was suspected to be the main factor for the early bursts. Sounding 20190923_214509 reached the highest burst altitude at 24.27 km.

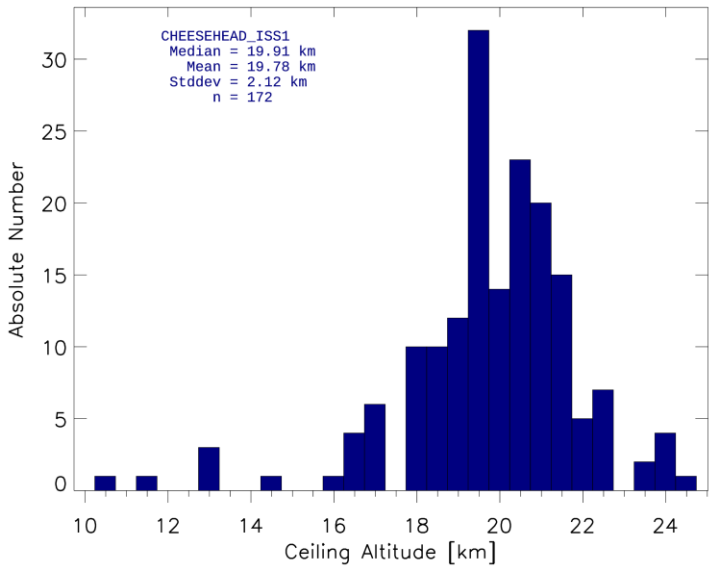

Figure 2: Distribution of ceiling heights for all radiosondes launched during CHEESEHEAD.

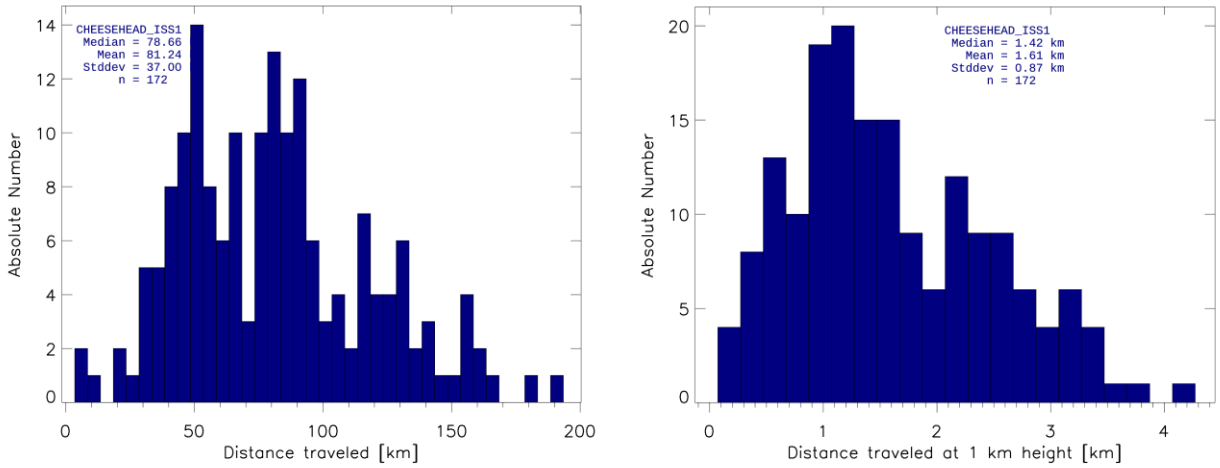

Figure 3: Distribution of balloon distance at end of data recording (left panel) and at 1 km above ground (right panel).

At burst, data were received up to a distance of 192 km. The distribution of balloon distances at ceiling altitude and at 1 km above ground is shown in Figure 3. The median distance at which a sounding was terminated was 79 km and the closest distance was 3.5 km. At 1 km above ground, the median distance was 1.4 km from the launch site and all balloons were closer than 4.5 km at that altitude.

Balloons were filled with 23 ft^3 of helium until 14 September and with 20 ft^3 of helium until the end of the campaign. During CHEESEHEAD balloons filled with 23 ft^3 rose with an average rise rate of 4.35 m/s to an average burst height of 19.6 km, and those filled with 20 ft^3 rose with an average rise rate of 4.15 m/s to a burst height of 21.2 km. The average rise rate profiles for the two different fill volumes is shown in Figure 4. The distribution of rise rates for all soundings is shown in Figure 5.

The sequence of all balloon rise rates (Figure 6) shows that during CHEESEHEAD this type of balloon rises faster in the lowest 2 km with an average rise rate of about 5.1 m/s shortly after launch

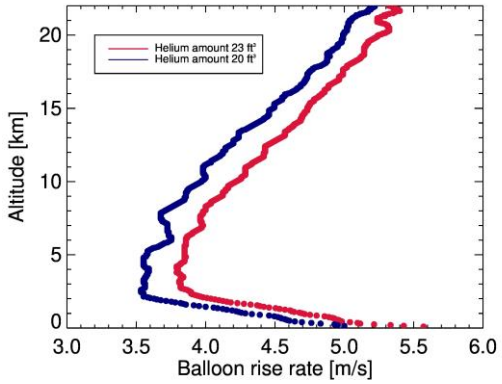

Figure 4: Average rise rates profiles for the two different helium fill values used during CHEESEHEAD.

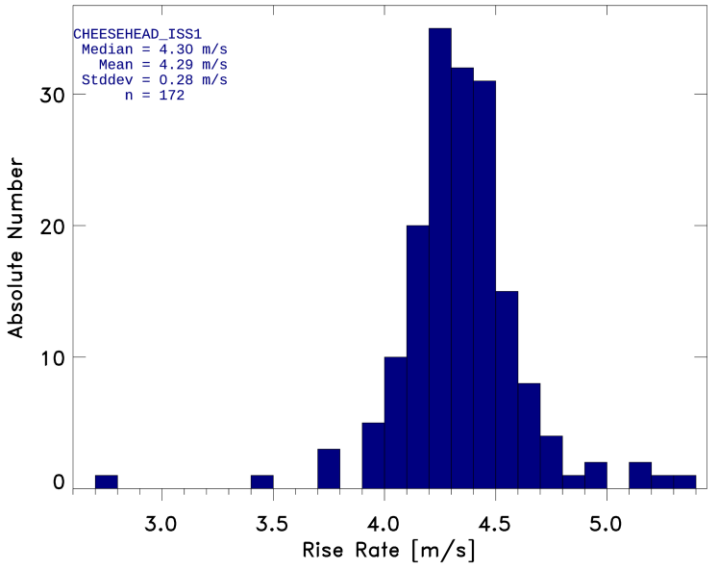

Figure 5: Distribution of rise rates for all radiosondes launched during CHEESEHEAD.

and a minimum of 3.7 m/s at about 3 km altitude. As a result, the vertical resolution of measurements in the lowest troposphere increases from about 5.1 m to 3.7 m between the surface and 3 km altitude.

Two cases were observed, where the balloon encountered fast updrafts in some layers. These cases are shown in red colors in the lower troposphere. Sounding 20190803_180205 was launched in rain and was caught in a series of updrafts and downdrafts. The largest balloon rise rate was 18 m/s indicating an updraft velocity of about 14 m/s. In this sounding the region of strong rise rate variations extended up to 14 km. Sounding 20190626_180028 showed a peak rise rate 12 m/s at about 3 km. Other soundings also showed smaller rise rate excursions indicated by the lighter colors in the middle troposphere.

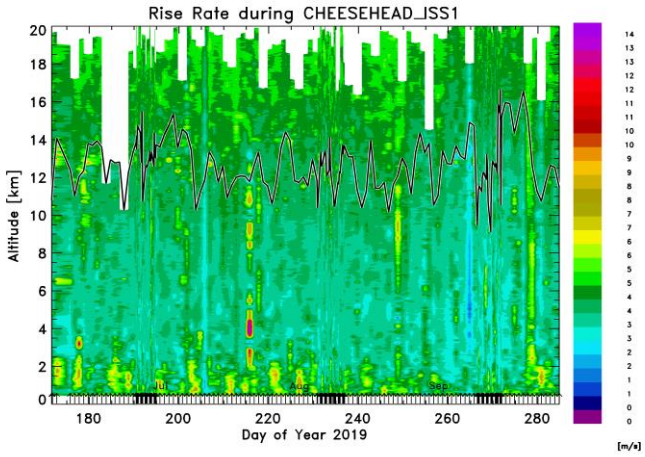

Figure 6: Time series contours of rise rate profiles for all radiosondes launched during CHEESEHEAD. Each launch is indicated by a small arrow at the bottom of the diagram. The intensive observation periods are indicated by the higher density of launch arrows. For a list of all soundings, see Section 7.

6 Atmospheric Measurements

Air temperature and relative humidity measurements from all radiosondes are shown in Figure 7. The period of soundings with burst altitudes below 12 km during the early part of July is most likely due to poorly performing balloons. The soundings span a period of three months, during which surface temperatures changed from on average +25°C to +10°C. The tropopause (shown as thin black line) ranged between about 9.1 and 16.7 km with the most common altitude around 12.6 km. It is also indicated by the rapid drop of relative humidity to values of less than 5%. As is customary, all relative humidity profiles are clipped at 100 % relative humidity over liquid.

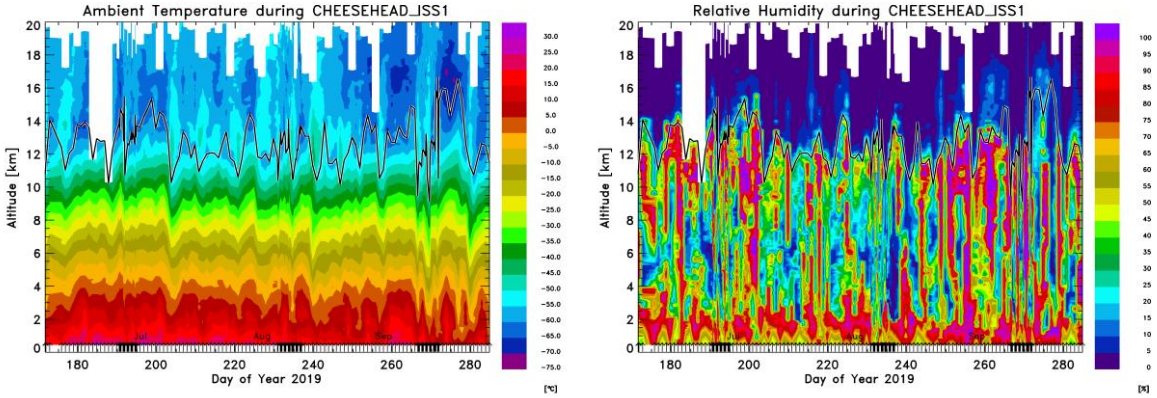

Figure 7: Time series contours of temperature profiles (top) and relative humidity profiles (bottom) from all radiosondes launched during CHEESEHEAD. The tropopause is shown as thin black line typically between 12 and 14 km.

The zonal wind speed measurements are shown in Figure 8. The proximity of the jet stream is indicated by high wind speeds in the upper troposphere reaching up to 80 m/s.

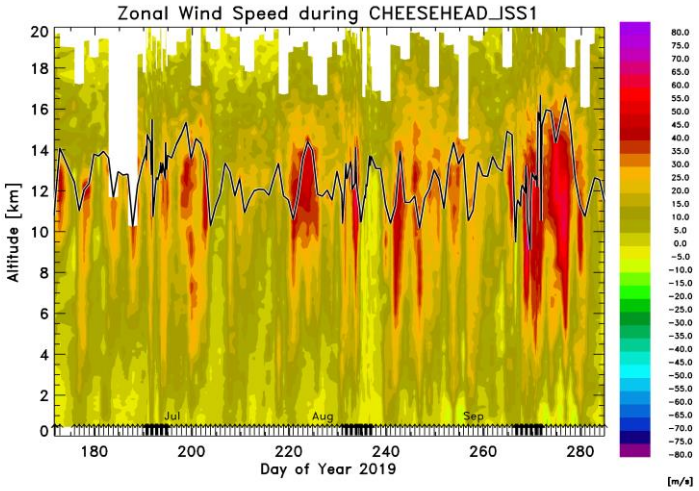

Figure 8: Time series contours of zonal wind speed profiles for all radiosondes launched during CHEESEHEAD.

7 List of all soundings

#	Date [UTC]	Time [UTC]	Radiosonde serial number	Ceiling altitude [km]	Rise rate [m/s]	Duration [min]
1	20 Jun 2019	15:01:24	N4511167	18.9	4.9	63.1
2	20 Jun 2019	19:08:26	N4510856	19.6	4.3	74.4
3	21 Jun 2019	18:22:33	N4511165	20.3	4.6	72.1
4	24 Jun 2019	18:01:50	N4440153	19.0	4.0	77.4
5	25 Jun 2019	17:59:44	N4510843	17.2	4.4	63.7
6	26 Jun 2019	18:00:28	N4440151	19.3	4.7	66.9
7	27 Jun 2019	17:59:38	P5010075	21.4	4.6	76.4
8	28 Jun 2019	17:59:02	P5010595	18.5	4.4	68.9
9	29 Jun 2019	18:03:27	P5010073	19.4	4.3	74.1
10	30 Jun 2019	18:03:31	P5010596	22.3	4.5	81.1
11	01 Jul 2019	17:59:47	P4930466	19.4	4.4	71.3
12	02 Jul 2019	17:57:41	P4930496	11.7	4.1	46.0
13	03 Jul 2019	17:59:17	P4930474	13.0	4.1	50.3
14	04 Jul 2019	17:57:49	P5010076	12.8	4.4	46.8
15	05 Jul 2019	18:18:04	P4930486	12.8	4.3	48.0
16	06 Jul 2019	17:59:23	P5010077	10.2	4.0	40.9
17	07 Jul 2019	17:57:09	P4930487	18.6	4.4	69.0
18	08 Jul 2019	17:58:11	P4930484	20.0	4.2	77.4
19	09 Jul 2019	10:37:22	P4930473	17.8	4.3	66.9
20	09 Jul 2019	12:11:56	P4930421	21.3	4.2	82.3
21	09 Jul 2019	14:07:02	P4930323	20.7	4.5	74.4
22	09 Jul 2019	18:00:01	P4930471	18.9	4.4	70.3
23	09 Jul 2019	21:47:36	P4930521	19.9	4.3	75.4
24	10 Jul 2019	10:20:20	P4930522	20.4	4.1	80.9
25	10 Jul 2019	11:59:01	P4930493	21.7	4.3	81.4
26	10 Jul 2019	14:16:27	P4930492	18.8	4.3	71.9
27	10 Jul 2019	18:00:03	P4930489	20.3	4.3	76.6
28	10 Jul 2019	21:45:02	P4930498	19.6	4.2	74.9
29	11 Jul 2019	10:23:27	P4930491	19.5	4.2	76.0
30	11 Jul 2019	11:58:06	P4930488	20.6	4.3	77.2
31	11 Jul 2019	14:14:02	P5010560	18.0	4.1	70.9
32	11 Jul 2019	17:59:59	P4930472	20.8	4.3	78.9
33	11 Jul 2019	21:45:56	P4930482	19.3	4.1	77.4
34	12 Jul 2019	10:20:12	P4930485	19.9	4.2	77.7
35	12 Jul 2019	11:59:18	P4930422	21.5	4.4	79.4
36	12 Jul 2019	14:14:31	P4930324	21.4	4.4	78.8
37	12 Jul 2019	17:58:13	P4930434	17.8	4.9	58.4
38	12 Jul 2019	21:45:02	P4930435	21.1	4.5	76.1
39	13 Jul 2019	10:20:06	P4930464	18.9	4.2	72.9
40	13 Jul 2019	12:00:02	P4930517	19.8	4.6	70.1
41	13 Jul 2019	14:15:13	R2320707	20.7	4.2	80.0
42	13 Jul 2019	18:00:03	R2320706	18.0	4.3	67.6
43	13 Jul 2019	21:45:17	R2320705	20.9	4.2	81.9
44	14 Jul 2019	18:00:04	R2340941	18.6	4.4	68.6
45	15 Jul 2019	18:00:02	R2340943	20.2	4.5	73.8
46	16 Jul 2019	18:00:01	R2340935	19.3	4.4	72.0
47	17 Jul 2019	18:00:11	R2320704	19.9	4.2	76.7
48	18 Jul 2019	18:00:03	R2340934	20.9	4.4	78.0
49	19 Jul 2019	18:00:05	P4930467	17.1	4.3	64.4
50	20 Jul 2019	18:01:57	P4930497	21.3	4.5	76.7
51	21 Jul 2019	18:00:08	R2340948	20.9	4.6	74.1

52	22 Jul 2019	17:58:41	P4930802	19.3	4.6	68.3
53	23 Jul 2019	17:59:09	P4930469	18.9	4.5	68.2
54	24 Jul 2019	17:58:47	P4930470	21.9	3.4	104.5
55	25 Jul 2019	17:58:03	R2340947	20.5	4.7	70.7
56	26 Jul 2019	18:01:37	R2340946	19.6	4.2	75.2
57	27 Jul 2019	18:00:01	R2340945	19.5	4.3	74.5
58	28 Jul 2019	18:00:50	P4930494	20.8	4.6	74.4
59	29 Jul 2019	17:57:05	R2320504	18.1	4.5	65.9
60	30 Jul 2019	17:58:24	R2340933	17.8	4.4	66.1
61	31 Jul 2019	17:56:33	R2340953	19.4	4.7	66.5
62	01 Aug 2019	18:00:02	R2340942	19.6	4.2	75.0
63	02 Aug 2019	18:00:02	R2340954	20.4	4.4	76.4
64	03 Aug 2019	18:02:05	R2340932	19.3	5.1	61.2
65	04 Aug 2019	18:02:26	R2340950	19.9	4.2	76.7
66	05 Aug 2019	17:58:18	R2340949	19.9	4.8	68.1
67	06 Aug 2019	17:59:21	R2320223	16.7	4.2	65.2
68	07 Aug 2019	18:00:07	R2320110	18.7	4.1	74.0
69	08 Aug 2019	17:59:20	R2320126	20.5	4.4	75.6
70	09 Aug 2019	18:00:02	R2320102	19.0	4.5	68.0
71	10 Aug 2019	17:57:04	R2320099	19.3	4.3	72.4
72	11 Aug 2019	17:57:37	R2320122	21.7	4.2	83.7
73	12 Aug 2019	17:59:42	R2320097	18.6	4.4	68.8
74	13 Aug 2019	18:08:51	R2320098	17.2	4.1	67.2
75	14 Aug 2019	18:00:05	R2320106	16.7	4.5	60.6
76	15 Aug 2019	18:00:17	R2320101	18.5	4.4	68.3
77	16 Aug 2019	18:00:04	R2320112	19.2	4.3	73.5
78	17 Aug 2019	18:03:27	R2320100	21.1	4.4	77.7
79	18 Aug 2019	18:00:30	R2340931	18.6	4.3	69.8
80	18 Aug 2019	21:34:51	R2320114	19.3	4.1	76.4
81	19 Aug 2019	11:10:47	R2320113	21.1	4.2	82.3
82	19 Aug 2019	14:15:09	R2320107	20.4	4.4	76.2
83	19 Aug 2019	18:00:26	R2320108	22.2	4.4	82.0
84	19 Aug 2019	21:45:13	R2320111	19.8	4.1	78.7
85	20 Aug 2019	11:10:34	R2320109	20.8	4.4	77.9
86	20 Aug 2019	14:07:15	P4930445	20.5	4.4	75.8
87	20 Aug 2019	18:00:02	P4930436	19.5	4.3	74.4
88	20 Aug 2019	21:45:06	P4930437	20.3	4.1	80.7
89	21 Aug 2019	11:12:49	P4930463	19.7	4.4	73.5
90	21 Aug 2019	14:15:02	P4930520	19.4	4.5	70.8
91	21 Aug 2019	18:00:06	P4930458	21.1	4.7	73.8
92	21 Aug 2019	21:45:04	P4930438	19.6	4.4	71.9
93	22 Aug 2019	03:47:21	P4930457	18.9	4.3	71.9
94	22 Aug 2019	11:10:58	P4930459	20.2	4.3	76.8
95	22 Aug 2019	14:15:01	P4930460	20.5	4.3	77.2
96	22 Aug 2019	18:00:10	P4930461	22.6	4.4	83.4
97	22 Aug 2019	21:45:17	P4930446	20.6	4.5	75.2
98	23 Aug 2019	11:10:34	P4930462	16.6	4.1	66.2
99	23 Aug 2019	14:15:16	P4930448	20.2	4.0	81.2
100	23 Aug 2019	18:00:08	P4930447	17.2	4.2	66.1
101	23 Aug 2019	21:46:14	P4930426	21.3	4.4	79.1
102	24 Aug 2019	11:13:27	P4930490	20.4	4.3	76.6
103	24 Aug 2019	14:15:05	P4930423	19.6	4.2	75.5
104	24 Aug 2019	18:00:06	P4930450	18.1	4.2	70.6
105	24 Aug 2019	21:45:07	P4930146	18.5	4.2	70.7
106	25 Aug 2019	18:00:03	P4930148	16.8	4.2	65.3
107	26 Aug 2019	18:00:10	P4930145	18.1	4.1	70.9

108	27 Aug 2019	18:00:05	P4930409	16.4	4.2	62.5
109	28 Aug 2019	18:00:05	P4930413	19.9	4.2	76.6
110	29 Aug 2019	18:00:02	P4930425	19.1	4.3	72.5
111	30 Aug 2019	18:07:45	P5010082	19.0	4.3	71.8
112	31 Aug 2019	18:00:04	P5010081	18.4	4.3	68.6
113	01 Sep 2019	18:00:01	P5010074	20.6	4.4	76.4
114	02 Sep 2019	18:00:03	P5010083	19.7	4.4	72.2
115	03 Sep 2019	18:00:22	P5010084	20.6	4.4	76.3
116	04 Sep 2019	18:00:40	P4930412	19.5	4.3	73.5
117	05 Sep 2019	18:04:42	P4930414	19.4	5.1	61.9
118	06 Sep 2019	18:00:05	P4930424	17.1	4.6	60.4
119	07 Sep 2019	18:00:08	P4930147	20.8	4.4	76.8
120	08 Sep 2019	18:00:06	P5010079	19.7	4.1	78.1
121	09 Sep 2019	18:08:50	P4930149	19.1	4.1	75.2
122	10 Sep 2019	18:00:05	P5010080	21.1	4.2	81.8
123	11 Sep 2019	18:00:03	P4930150	18.6	4.2	72.7
124	12 Sep 2019	18:00:05	R2320105	14.5	4.2	56.2
125	13 Sep 2019	18:03:35	R2320123	21.4	4.2	83.6
126	14 Sep 2019	17:59:55	R2321349	19.6	4.4	71.9
127	15 Sep 2019	18:00:01	R2321366	19.3	4.2	75.7
128	16 Sep 2019	17:59:35	R2321346	19.8	3.9	82.2
129	17 Sep 2019	17:58:22	R2321498	24.1	4.1	95.3
130	18 Sep 2019	17:58:28	R2320125	22.5	4.2	86.7
131	19 Sep 2019	18:00:01	R2320104	20.6	4.0	83.7
132	20 Sep 2019	17:59:26	R2320124	20.4	4.0	82.8
133	21 Sep 2019	18:05:01	R2321348	18.0	2.7	109.8
134	22 Sep 2019	17:58:53	R2320103	23.6	4.3	90.0
135	23 Sep 2019	11:51:38	R2321347	21.1	4.2	82.6
136	23 Sep 2019	14:13:10	R2321493	21.7	4.2	84.5
137	23 Sep 2019	17:59:19	R1820180	21.8	4.4	81.5
138	23 Sep 2019	21:45:09	R1740035	24.3	4.1	96.5
139	24 Sep 2019	11:47:36	R2310480	22.6	4.1	89.0
140	24 Sep 2019	14:15:50	R2341026	21.7	3.9	91.1
141	24 Sep 2019	17:59:05	R1840316	22.4	4.1	89.7
142	24 Sep 2019	21:45:05	R2321497	23.9	4.2	93.5
143	25 Sep 2019	11:50:00	R2321489	20.6	4.3	77.5
144	25 Sep 2019	14:13:22	R2321495	24.1	4.0	99.2
145	25 Sep 2019	17:57:53	R2321367	21.3	4.3	80.9
146	25 Sep 2019	21:45:03	R2321364	21.4	4.3	81.8
147	26 Sep 2019	11:48:55	R2321345	22.0	3.9	91.4
148	26 Sep 2019	14:15:48	R2321363	22.6	3.7	99.8
149	26 Sep 2019	18:12:31	R2321258	19.7	4.1	78.6
150	26 Sep 2019	21:45:04	R2321500	22.4	4.5	81.8
151	27 Sep 2019	11:47:51	R2321490	20.6	4.2	80.5
152	27 Sep 2019	14:14:03	R2310479	23.5	4.2	90.9
153	27 Sep 2019	18:00:18	P5010577	21.3	4.0	85.9
154	27 Sep 2019	21:45:05	P5010524	20.2	4.5	73.6
155	28 Sep 2019	03:00:01	P5010522	20.8	3.9	86.3
156	28 Sep 2019	11:47:57	P5010523	19.7	4.1	78.9
157	28 Sep 2019	14:13:40	P5010528	21.8	4.0	88.5
158	28 Sep 2019	17:59:29	P5010526	19.6	4.3	73.5
159	28 Sep 2019	21:44:15	P5010582	20.5	4.0	84.3
160	29 Sep 2019	18:00:08	P5010520	21.0	4.0	86.2
161	30 Sep 2019	18:00:06	P5010521	21.0	3.9	87.0
162	01 Oct 2019	18:00:48	P5010019	21.1	4.5	76.3
163	02 Oct 2019	18:00:02	P5010551	20.8	4.3	78.7

164	03 Oct 2019	18:17:36	P5010527	21.1	3.8	89.5
165	04 Oct 2019	18:01:58	P5010552	18.0	5.2	56.3
166	05 Oct 2019	18:01:29	P5010525	19.4	5.3	58.9
167	06 Oct 2019	18:01:24	R2321259	21.4	4.2	82.6
168	07 Oct 2019	18:00:06	R2320205	16.0	3.7	69.6
169	08 Oct 2019	18:00:26	R2321491	19.1	4.5	68.5
170	09 Oct 2019	17:59:41	R2310477	20.3	4.6	72.0
171	10 Oct 2019	18:00:03	R1740468	24.2	4.2	93.1
172	11 Oct 2019	18:04:33	R1740098	21.2	4.3	80.7

8 References

Vömel, H., G. Granger, and I. Suhr, 2018, NCAR/EOL/ISF Radiosonde NetCDF Data Files, UCAR/NCAR - Earth Observing Laboratory. https://doi.org/10.5065/D65X27SR.