CFACT

NCAR/EOL ISS Lidar Products Data Report

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DMS Associate Scientist: Carol Ruchti

Web References

CFACT Homepage: https://www.eol.ucar.edu/field_projects/cfact
CFACT Field Catalog: https://catalog.eol.ucar.edu/cfact
ISS Operations during CFACT: https://www.eol.ucar.edu/content/iss-operations-cfact
ISS Homepage: https://www.eol.ucar.edu/observing_facilities/iss
Real-time Lidar Plots: https://catalog.eol.ucar.edu/cfact/lidar
Interactive VAD winds plots: http://datavis.eol.ucar.edu/time-height-plot/CFACT/iss2-lidar/vad
ISS Daily Summary Plots:
https://archive.eol.ucar.edu/docs/isf/projects/cfact/iss/realtime/summary/iss2/index.html

Dataset Version Control

Version	Date	Author	Change Description	Data Status
1.0	29 Dec 2022	M. Paulus	Initial Release	Final

Citations

If these data are used for research resulting in publications or presentations, please acknowledge EOL and NSF by including the following citations, as appropriate:

The ISS Platform
UCAR/NCAR - Earth Observing Laboratory. (1997). NCAR Integrated Sounding System (ISS). UCAR/NCAR - Earth Observing Laboratory. https://doi.org/10.5065/D6348HF9.

Lidar Raw Data
NCAR/EOL ISS Team. 2022. CFACT: NCAR/EOL ISS Windcube Lidar CF-Radial Products. Version 1.0. UCAR/NCAR - Earth Observing Laboratory. https://doi.org/10.26023/WM4E-P67A-RB0V.

Lidar VAD Winds Data
NCAR/EOL ISS Team. 2022. CFACT: NCAR/EOL ISS Windcube Lidar VAD Winds. Version 1.0. UCAR/NCAR - Earth Observing Laboratory. https://doi.org/10.26023/9Z1R-7DTK-M30D.

Lidar VAD Hourly Consensus Winds Data
NCAR/EOL ISS Team. 2022. CFACT: NCAR/EOL ISS Windcube Lidar VAD Hourly Consensus Winds. Version 1.0. UCAR/NCAR - Earth Observing Laboratory. https://doi.org/10.26023/47Y2-XG2E-V0C.

Acknowledgement

Users of EOL data are expected to add the following acknowledgement to all of their publications, reports and conference papers that use those data:

"We would like to acknowledge operational, technical and scientific support provided by NCAR's Earth Observing Laboratory, sponsored by the National Science Foundation."

Overview

NCAR/EOL operated two Integrated Sounding Systems (ISS) in the Heber Valley in Utah for the Cold Fog Amongst Complex Terrain (CFACT) winter time fog study. As part of the integrated suite of sensors, ISS operated one Leosphere (a Vaisala company), Windcube 200S scanning lidar at the Railroad Service Pad site. Please note that pre-project lidar data are available upon request, but should be used with caution due to uncertainty in instrument level.

Time period:	06 Jan - 24 Feb 2022
Location:	Heber Valley, Utah, USA

Site Description

The lidar was on top of a seatainer (approximately 4 m AGL) at the railway sliding site, approximately 350 meters SW of the Deer Creek Sounding site.

Latitude: 40.48644°N
Longitude: 111.4725°W
Elevation: 4 m AGL

CFACT ISS Sites

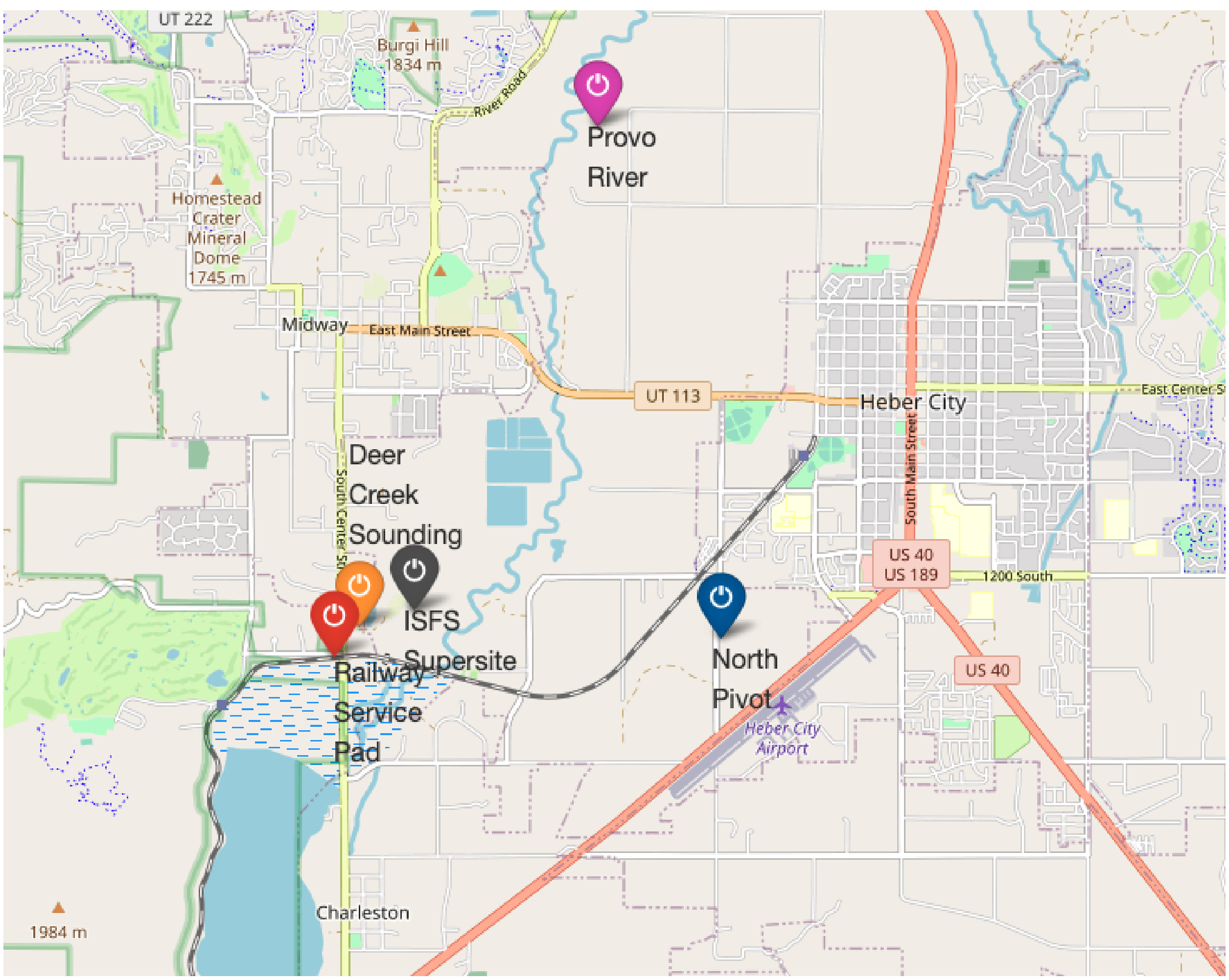

Figure 1. *ISS lidar location at the Railroad Service Pad site. Also shown are the ISS1 North Pivot site, the ISS2 Deer Creek sounding site, and the Integrated Surface Flux System (ISFS) Supersites at Deer Creek and Provo River.*

Instrument Description

Leosphere/Vaisala Windcube 200S Scanning Lidar

The Leosphere/Vaisala Windcube 200S scanning lidar is a commercial instrument designed to measure wind and aerosol backscatter at distances up to 10 km across a variety of scanning geometries. The scanning strategies and measurement parameters are customizable to perform a wide range of research applications.

Instrument Fact Sheet:
https://www.vaisala.com/sites/default/files/documents/WEA-MET-WindCube-Scan-Lidar-Product-Spotlight-B212058EN-A.pdf

Data Set Description

Leosphere/Vaisala Windcube 200S Scanning Lidar CF-Radial

Dataset Name: NCAR/EOL ISS Windcube Lidar CF-Radial Products
Data format: NetCDF4, each scan strategy assigned numeric Scan ID (SID)

(1) Vertical Stare (VER)
cfrad.YYYYMMDD_hhmmss_WLS200s-181_SID_VER_100m.nc
(2) Plan-position indicator (PPI)
cfrad.YYYYMMDD_hhmmss_WLS200s-181_SID_PPI_100m.nc
(3) Range Height Indicator (RHI)
cfrad.YYYYMMDD_hhmmss_WLS200s-181_SID_RHI_100m.nc
(4) Manual Stare (MAN)
cfrad.YYYYMMDD_hhmmss_WLS200s-181_SID_MAN_100m.nc

Data file frequency: single file per sweep/stare
Data version: v1.0
Data status: final
Data access: public
Resolution: variable depending on scan strategy, see Table 2

Refer to the global metadata attributes below:

```
// global attributes:
                :Conventions = "CF-1.7" ;
                :Sub_conventions = "CF-Radial instrument_parameters lidar_parameters" ;
                :version = "CF-Radial 2.0 , CF-1.7" ;
                :title = "Leosphere Windcube data" ;
                :institution = "Leosphere" ;
                :references = "" ;
                :source = "Lidar measurements" ;
                :history = "Windcube Lidar server 3.3.2" ;
                :comment = "" ;
                :original_format = "CFRADIAL2" ;
                :driver = "RadxConvert(NCAR)" ;
```

Leosphere/Vaisala Windcube 200S Scanning Lidar VAD Winds

Dataset Name: NCAR/EOL ISS Windcube Lidar VAD Winds
Data format: NetCDF4; VAD_SID_YYYYMMDD.nc
Data file frequency: 1 daily file per PPI scan strategy used for VAD generation
Data version: v1.0
Data status: final
Data access: public
Resolution: variable depending on scan strategy, see Table 2
Variables:

```
int base_time ;
        base_time:string = "2022-02-11 00:07:50 UTC" ;
        base_time:long_name = "Base time in Epoch" ;
        base_time:units = "seconds since 1970-01-01 00:00:00 UTC" ;
        base_time:ancillary_variables = "time_offset" ;
double time_offset(time) ;
        time_offset:long_name = "Time offset from base_time" ;
        time_offset:units = "seconds since 2022-02-11 00:07:50 UTC" ;
        time_offset:ancillary_variables = "base_time" ;
double time(time) ;
        time:long_name = "Time offset from midnight" ;
        time:units = "seconds since 2022-02-11 00:00:00 UTC" ;
        time:bounds = "time_bounds" ;
double time_bounds(time, bound) ;
float height(height) ;
        height:long_name = "Height above ground level" ;
        height:units = "m" ;
        height:standard_name = "height" ;
float lat ;
        lat:missing_value = -9999.f ;
        lat:long_name = "North latitude" ;
        lat:units = "degree_N" ;
        lat:valid_min = -90.f ;
        lat:valid_max = 90.f ;
        lat:standard_name = "latitude" ;
float lon ;
        lon:missing_value = -9999.f ;
        lon:long_name = "East longitude" ;
        lon:units = "degree_E" ;
        lon:valid_min = -180.f ;
        lon:valid_max = 180.f ;
        lon:standard_name = "longitude" ;
float alt ;
        alt:missing_value = -9999.f ;
        alt:long_name = "Altitude above mean sea level" ;
        alt:units = "m" ;
        alt:standard_name = "altitude" ;
float u(time, height) ;
        u:missing_value = -9999.f ;
        u:long_name = "Eastward component of wind vector" ;
```

```
        u:units = "m/s" ;
float v(time, height) ;
        v:missing_value = -9999.f ;
        v:long_name = "Northward component of wind vector" ;
        v:units = "m/s" ;
float w(time, height) ;
        w:missing_value = -9999.f ;
        w:long_name = "Vertical component of wind vector" ;
        w:units = "m/s" ;
float wind_speed(time, height) ;
        wind_speed:missing_value = -9999.f ;
        wind_speed:long_name = "Wind speed" ;
        wind_speed:units = "m/s" ;
float wind_direction(time, height) ;
        wind_direction:missing_value = -9999.f ;
        wind_direction:long_name = "Wind direction" ;
        wind_direction:units = "degree" ;
float residual(time, height) ;
        residual:missing_value = -9999.f ;
        residual:long_name = "Fit residual" ;
        residual:units = "m/s" ;
float correlation(time, height) ;
        correlation:missing_value = -9999.f ;
        correlation:long_name = "Fit correlation coefficient" ;
        correlation:units = "unitless" ;
float mean_snr(time, height) ;
        mean_snr:missing_value = -9999.f ;
        mean_snr:long_name = "Signal to noise ratio averaged over nbeams (derived from CNR)" ;
        mean_snr:units = "unitless" ;
float u_error(time, height) ;
        u_error:missing_value = -9999.f ;
        u_error:long_name = "Sampling uncertainty in eastward component of wind due to azimuths used
                assuming 1 m/s error in radial velocities" ;
        u_error:units = "m/s" ;
float v_error(time, height) ;
        v_error:missing_value = -9999.f ;
        v_error:long_name = "Sampling uncertainty in northward component of wind due to azimuths used
                assuming 1 m/s error in radial velocities" ;
        v_error:units = "m/s" ;
float w_error(time, height) ;
        w_error:missing_value = -9999.f ;
        w_error:long_name = "Sampling uncertainty in vertical component of wind due to azimuths used
                assuming 1 m/s error in radial velocities" ;
        w_error:units = "m/s" ;
float scan_duration(time) ;
        scan_duration:missing_value = -9999.f ;
        scan_duration:long_name = "PPI scan duration" ;
        scan_duration:units = "second" ;
float elevation_angle(time) ;
        elevation_angle:missing_value = -9999.f ;
        elevation_angle:long_name = "Beam elevation angle" ;
        elevation_angle:units = "degree" ;
```

```
int nbeams(time) ;
        nbeams:long_name = "Number of beams (azimuth angles) in each PPI" ;
        nbeams:units = "unitless" ;
int nbeams_used(time, height) ;
        nbeams_used:missing_value = -9999 ;
        nbeams_used:long_name = "Number of beams (azimuth angles) used in wind vector estimations" ;
        nbeams_used:units = "unitless" ;
```

Leosphere/Vaisala Windcube 200S Scanning Lidar VAD Hourly Consensus Winds

Data set Name:	NCAR/EOL ISS Windcube Lidar VAD Hourly Consensus Winds
Data format:	NetCDF4; 60min_winds_YYYYMMDD.nc
Data file frequency:	daily
Data version:	v1.0
Data status:	final
Data access:	public
Resolution:	hourly
Variables:	

```
int base_time ;
        base_time:string = "2022-01-11 00:00:00 UTC" ;
        base_time:long_name = "Base time in Epoch" ;
        base_time:units = "seconds since 1970-01-01 00:00:00 UTC" ;
        base_time:ancillary_variables = "time_offset" ;
double time_offset(time) ;
        time_offset:long_name = "Time offset from base_time" ;
        time_offset:units = "seconds since 2022-01-11 00:00:00 UTC" ;
        time_offset:ancillary_variables = "base_time" ;
double time(time) ;
        time:long_name = "Time offset from midnight" ;
        time:units = "seconds since 2022-01-11 00:00:00 UTC" ;
        time:bounds = "time_bounds" ;
double time_bounds(time, bound) ;
float height(height) ;
        height:long_name = "Height above ground level" ;
        height:units = "m" ;
        height:standard_name = "height" ;
float lat ;
        lat:missing_value = -9999.f ;
        lat:long_name = "North latitude" ;
        lat:units = "degree_N" ;
        lat:valid_min = -90.f ;
        lat:valid_max = 90.f ;
        lat:standard_name = "latitude" ;
float lon ;
        lon:missing_value = -9999.f ;
        lon:long_name = "East longitude" ;
        lon:units = "degree_E" ;
        lon:valid_min = -180.f ;
        lon:valid_max = 180.f ;
        lon:standard_name = "longitude" ;
```

```
float alt ;
        alt:missing_value = -9999.f ;
        alt:long_name = "Altitude above mean sea level" ;
        alt:units = "m" ;
        alt:standard_name = "altitude" ;
float u(time, height) ;
        u:missing_value = -9999.f ;
        u:long_name = "Eastward component of wind vector" ;
        u:units = "m/s" ;
float v(time, height) ;
        v:missing_value = -9999.f ;
        v:long_name = "Northward component of wind vector" ;
        v:units = "m/s" ;
float w(time, height) ;
        w:missing_value = -9999.f ;
        w:long_name = "Vertical component of wind vector" ;
        w:units = "m/s" ;
float wind_speed(time, height) ;
        wind_speed:missing_value = -9999.f ;
        wind_speed:long_name = "Wind speed" ;
        wind_speed:units = "m/s" ;
float wind_direction(time, height) ;
        wind_direction:missing_value = -9999.f ;
        wind_direction:long_name = "Wind direction" ;
        wind_direction:units = "degree" ;
float residual(time, height) ;
        residual:missing_value = -9999.f ;
        residual:long_name = "Fit residual" ;
        residual:units = "m/s" ;
float correlation(time, height) ;
        correlation:missing_value = -9999.f ;
        correlation:long_name = "Fit correlation coefficient" ;
        correlation:units = "unitless" ;
float mean_snr(time, height) ;
        mean_snr:missing_value = -9999.f ;
        mean_snr:long_name = "Signal to noise ratio averaged over nbeams (derived from CNR)" ;
        mean_snr:units = "unitless" ;
float u_npoints(time, height) ;
        u_npoints:missing_value = -9999.f ;
        u_npoints:long_name = "Number of points used in consensus averaging window for eastward
                component of winds" ;
        u_npoints:units = "unitless" ;
float v_npoints(time, height) ;
        v_npoints:missing_value = -9999.f ;
        v_npoints:long_name = "Number of points used in consensus averaging window for northward
                component of winds" ;
        v_npoints:units = "unitless" ;
float w_npoints(time, height) ;
        w_npoints:missing_value = -9999.f ;
        w_npoints:long_name = "Number of points used in consensus averaging window for vertical component
                of winds" ;
        w_npoints:units = "unitless" ;
```

Data Collection and Processing

Raw CF-Radial Product

Lidar control and data processing was performed by proprietary Leosphere/Vaisala Windcube software (see versions in Table 1 below). The raw data produced by the lidar software was stored directly to a disk drive at the lidar location and transmitted to servers at EOL for archival and added back-up. The raw data were then converted into the CfRadial (CF-1.7) compliant, netCDF4 format included in this data release. This format conversion was performed in near real-time by RadxConvert, which is part of a Lidar Radar Open Software Environment (LROSE) data processing package jointly developed by Colorado State University and NCAR/EOL. LROSE was also used to produce data visualizations, which can be browsed on the CFACT Field Catalog (link provided in Web References section above). In most cases, no data quality control was performed to these data, with the exception being to correct azimuth and elevation angles of certain Range Height Indicator (RHI) scans. These corrections were only applied to RHI scans that went beyond 90 degrees (Scan ID's 193, 194) and are indicated by "_v2" appended to the filenames.

Lidar Hardware	Windcube 200S	S/N: WLS200s-181
Lidar Software	Package	20.e
	WindForge	3.3.2
	API	1.2.0
	Tools	1.1.0
	OS	3.2.0
VAD/Consensus Processing	Software	1.1

Table 1. *Windcube lidar model, serial number, and software versions.*

Lidar Scan Strategy Settings

During the project a variety of scan strategies were used to make measurements. These included Plan Position Indicator (PPI) scans at various elevations, sectors, and resolutions; Range Height Indicator (RHI) scans at various azimuths, vertical stares (VER), and horizontal stares at manually prescribed azimuth and elevation angles (MAN). A summary of pertinent lidar parameters for each scan strategy is included in Table 2 below. Some of these scan strategies were used sparingly, while others were implemented over longer periods of time.

SCAN ID	Type	Elevation Angle (deg)	Sweep Azimuth (deg)	N Rays	Angular Resolution (deg)	Gate Spacing (m)	Gate Start Range (m)	Scan Duration (s)
192	PPI	35	0-360	144	2.5	50	100	72
232	PPI	5	203-245	15	3	20	50	14
265	PPI	0	0-360	359	1	100	200	359
266	PPI	1	0-360	360	1	100	200	180
267	PPI	0	0-360	360	1	100	200	180
268	PPI	2	0-360	360	1	100	200	180
269	PPI	1	5-15	100	0.1	12	50	100
273	PPI	75	0-360	144	2.5	50	100	73
274	PPI	0	150-240	90	1	100	200	23
275	PPI	2	0-360	360	1	100	200	90
276	PPI	75	0-360	120	3	50	100	60
285	PPI	1.5	52-62	100	0.1	12	600	99
291	PPI	75	0-360	60	6	100	200	119
292	PPI	0	152-240	45	2	100	200	88
294	PPI	2	0-360	180	2	100	200	360
305	PPI	2	0-360	180	2	100	200	359
316	PPI	2	0-360	120	3	200	200	239
325	PPI	2	0-360	180	2	100	200	359
329	PPI	0	0-90	90	1	50	100	45
193	RHI	0-180	0/180	88	2	50	100	43
194	RHI	0-180	90/270	88	2	50	100	44
271	RHI	-1-10	199	200	0.1	100	200	55
277	RHI	1-10	26.41	90	0.1	100	200	45
278	RHI	0-10	57.54	100	0.1	100	200	50
280	RHI	0.5-40	87	80	0.5	100	200	40
281	RHI	0-10	110.64	100	0.1	100	200	51
296	RHI	1-10	26.41	45	0.2	100	200	89
297	RHI	1-10	199	45	0.2	100	200	88
302	RHI	1-7	26.41	28	0.2	100	200	54
303	RHI	0-12	199	60	0.2	100	200	60
304	RHI	1-12	110.64	55	0.2	100	200	108

SCAN ID	Type	Elevation Angle (deg)	Sweep Azimuth (deg)	N Rays	Angular Resolution (deg)	Gate Spacing (m)	Gate Start Range (m)	Scan Duration (s)
306	RHI	-1-12	199	65	0.2	100	200	128
307	RHI	0.2-12	26.41	60	0.2	100	200	119
308	RHI	0.2-12	110.64	60	0.2	100	200	119
317	RHI	0.4-12	26.41	30	0.4	100	200	59
319	RHI	0.4-12	110.64	30	0.4	100	200	59
321	RHI	0.4-12	199	30	0.4	100	200	59
195	VER	90	na	300	na	50	100	300
282	VER	90	na	120	na	50	100	119
289	VER	90	na	240	na	50	100	239
290	VER	90	na	53	na	100	200	105
311	VER	90	na	30	na	100	200	290
312	VER	90	na	24	na	100	200	116
327	VER	90	na	30	na	50	100	29
181	MAN	1.5	190	30	na	100	200	29
283	MAN	0	199	30	na	100	200	30
288	MAN	0	199	20	na	100	200	20

Table 2. *Windcube lidar settings according to the scan ID.*

VAD Winds Product

In addition to the CfRadial data, a Velocity-Azimuth Display (VAD) wind profile product was generated and is available as part of this dataset. These data are available in daily files, calculated using select PPI scans (192, 276, 291), as indicated in the filenames. These netCDF files follow the convention produced by the U.S. Department of Energy Atmospheric Radiation Measurement (ARM) user facilities (Newsom et al. 2015).

To create the VAD product, profiles of wind speed and direction are calculated from radial velocities, using an algorithm adapted from ARM (Newsom et al. 2015). In the algorithm, CF-Radial files corresponding to a selected scan ID are read and radial velocities are filtered by a threshold value for signal-to-noise ratio (SNR), such that no radial velocities are used for SNR values below this threshold. Please note that the SNR values referenced herein are actually carrier-to-noise, as used by the lidar community, but are always depicted as SNR in keeping with the ARM conventions noted above. After this initial filtering, a sinusoid is fit to the data at each range gate (a given range gate will be at a constant height at all azimuths in a PPI scan). From this analysis, estimates of wind vector components, speed, direction, and uncertainty estimates are obtained. The uncertainty values can be found in the netCDF error values for each wind component (u_error, v_error, w_error). These uncertainties assume a 1 m/s error in radial velocities, and are based on the location and number of azimuth angles used. Thus, if all azimuth angles are available for a given range gate, then the errors will be the same for all range gates that also use all the azimuth angles. Additionally, the quality of the fit is provided as residual and correlation coefficient quantities using standard numerical matrix inversion methods. The quality of the least squares fit is assessed using the fit residual and the linear correlation coefficient. This process is repeated at each range gate (and corresponding height) to produce a profile of winds.

Following the ARM methodology, a SNR threshold was applied prior to calculation of VAD wind profiles. Through experimentation and consideration of the atmospheric conditions present throughout the campaign, a threshold of -30 dB was chosen. As part of our quality control process, additional threshold parameters were applied in order to filter VAD winds from the netCDF files after the ARM algorithm was applied. In order to fine-tune selection of filtering parameters and threshold values, VAD wind profiles were compared to radiosonde soundings launched nearby. A total of 120 Vaisala RS41 soundings were launched, primarily at night when the fog conditions of interest to CFACT were predicted. An example of this analysis is shown in Figure 2. This example examines the distribution of the correlation coefficient of the VAD fit for wind estimates that agree with the radiosondes and those that disagree. Most of the agreeing samples had a correlation coefficient of 0.5 or more, so this threshold was chosen as an indicator of a good measurement. Similar analyses were performed for the mean SNR (leading to a threshold of -28 dB), fit residuals (threshold of 2 m/s), and the percentage of raw samples around a VAD circle (threshold of 80%). All thresholds used in creating a VAD winds data file are included as global attributes within the netCDF file.

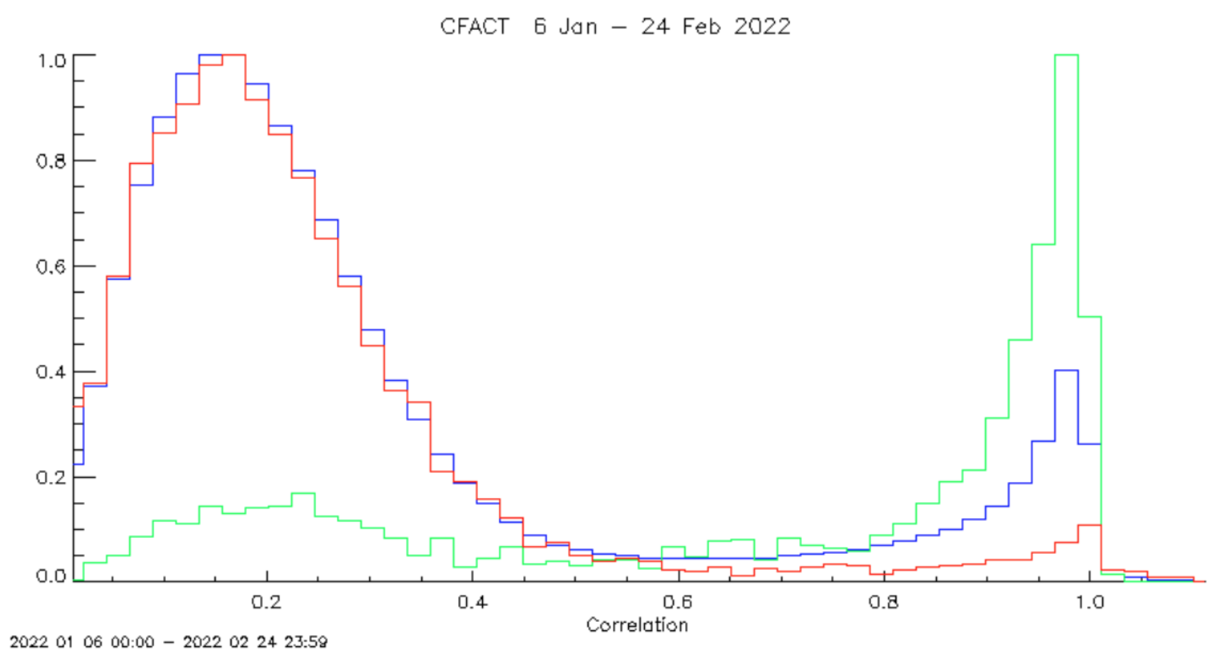

Figure 2. *Histograms of the VAD fit correlation coefficient. The green histogram indicates VAD samples that agree with nearby soundings, the red histogram indicates those that disagree, and the blue indicates the entire population of samples. Agreement is defined as points where VAD winds agree within 2 m/s.*

Figure 3 compares the VAD winds from the lidar with the above thresholding filtering applied with winds measured by the radiosonde soundings. The median and standard deviations for speed were 0.45 m/s and 0.71 m/s, and for direction they were 11.6 and 17.0 degrees. The best fit slopes were 0.971 for speed and 1.04 for direction. As compared with similar comparisons for other field campaigns, this is a very good agreement.

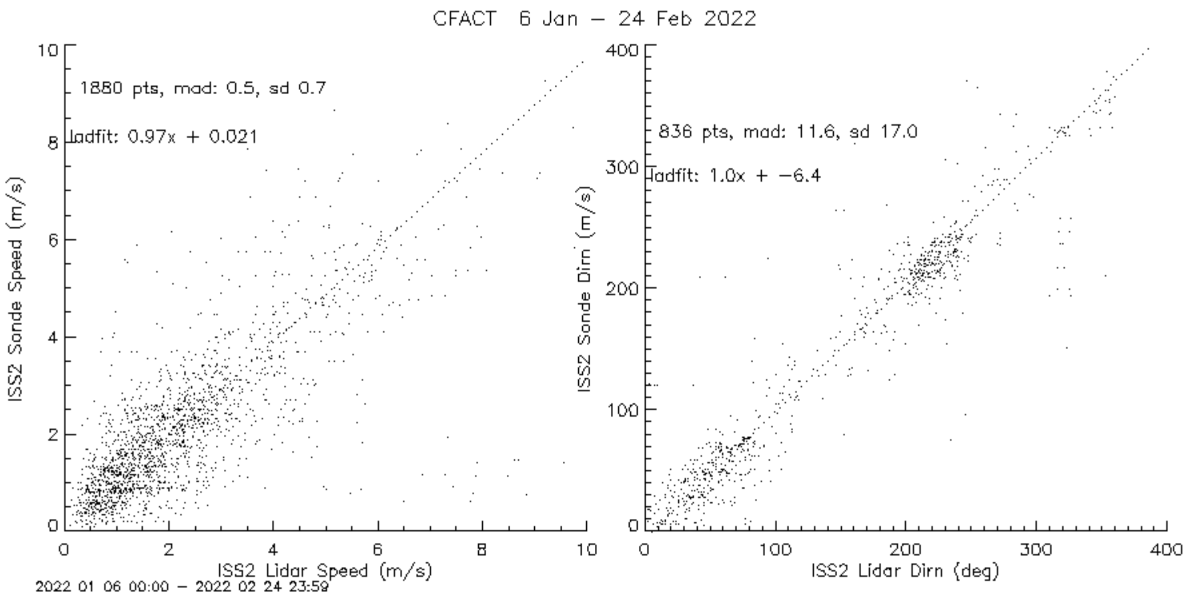

Figure 3. A comparison of post-filtering VAD winds from the lidar and winds from radiosonde soundings.

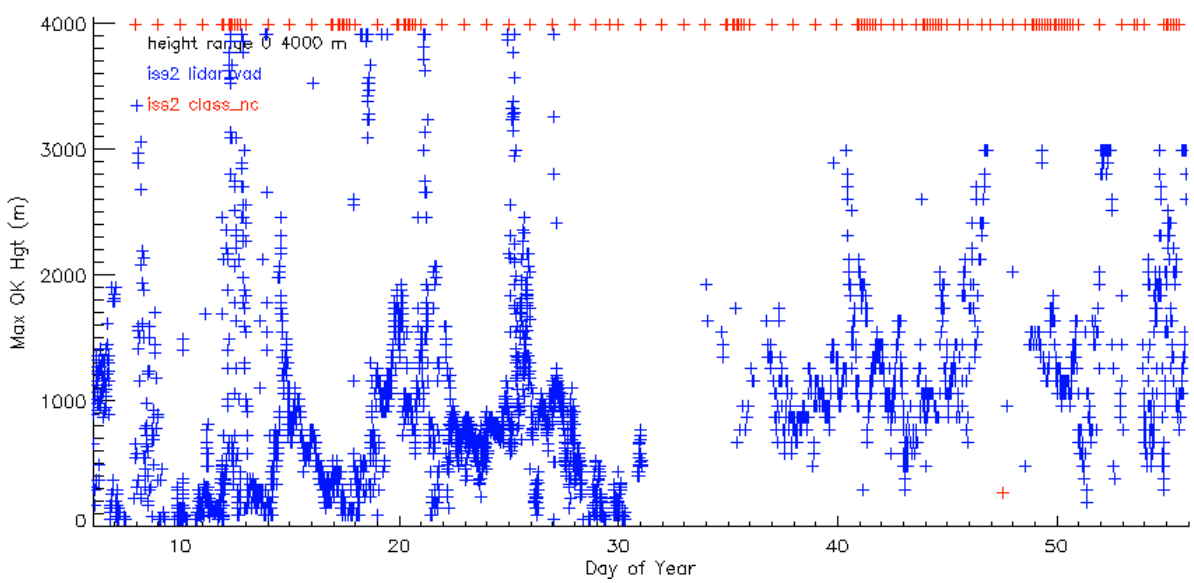

Figure 4. *The maximum height to which a VAD measurement was made over the course of the campaign (blue crosses). The red crosses indicate the times of radiosonde soundings, clustering of the red crosses represents the increased rate of soundings during IOPs.*

The scattering from the atmosphere varied considerably during the project. This can be seen in the varying range that the lidar saw, and also in the varying height to which VAD wind measurements could be determined. Figure 4 shows a time series plot of this height. On average a VAD wind measurement was made to around 900 meters, although early on in the campaign the height coverage was less. This may have been due to variations in the aerosol content of the atmosphere, however as discussed below the sampling strategy was changed during the project. Earlier in the campaign the lidar was operated at a higher sampling resolution than later in the campaign and a by-product of this may have been greater sensitivity due to more averaging.

VAD Hourly Consensus Winds Product

As a companion to the Velocity-Azimuth Display (VAD) wind profile product, an hourly consensus average wind product was generated and is also available as part of this dataset. These data were calculated from the quality-controlled VAD wind profiles described in the preceding section. These netCDF files again follow the convention produced by the U.S. Department of Energy Atmospheric Radiation Measurement (ARM) user facilities.

These data were created by consensus averaging the VAD winds, for which were calculated the mean value of all data points that lie within a given window size (5 m/s) of each other. The final values used in the average are chosen as the subset of values in the data having the most points and smallest spread in values. Included in the data files are the u, v, and w wind components, separately consensus averaged; wind speed and direction calculated from the consensus average u and v; the number of points used in the averaging; and median values of the residual, correlation, and mean SNR from the indices of points used to calculate the w consensus average.

Data Remarks

The lidar functioned mostly as expected through the first half of the project. However, frost developed inside the lidar lens at some point prior to 30 Jan (Figure 5). We have not yet been able to determine what impact this had on data quality, however the issue was resolved by 4 Feb. Additionally, the lidar was down for much of the period between 31 Jan - 3 Feb due to a database issue on the lidar computer. This problem was never completely resolved, which required an adjustment to the scan strategies through the end of the campaign. After this point, the resolution and frequency of lidar scans was generally reduced, especially during non-IOP periods. These changes in scan strategy resulted in increased gate spacing from 50 m to 100 m and decreased angular resolution for some scans (from 3 to 6 degrees in the case of one frequently used PPI scan).

In calculating VAD wind profiles, multiple PPI scan strategies were used throughout the campaign. At the beginning of the project a 360 degree sweep at 35 degree elevation angle was used (ID 192), however this elevation was determined to be too low to avoid ground clutter given the surrounding terrain. To improve data quality, additional VAD products were generated using 75 degree elevation angle scans (ID 276 and ID 291). Later in the project both the angular resolution and range gate spacing were decreased due to the data storage limitations described above. After this change in scan strategy VAD products were generated using PPI scans corresponding to scan ID 291.

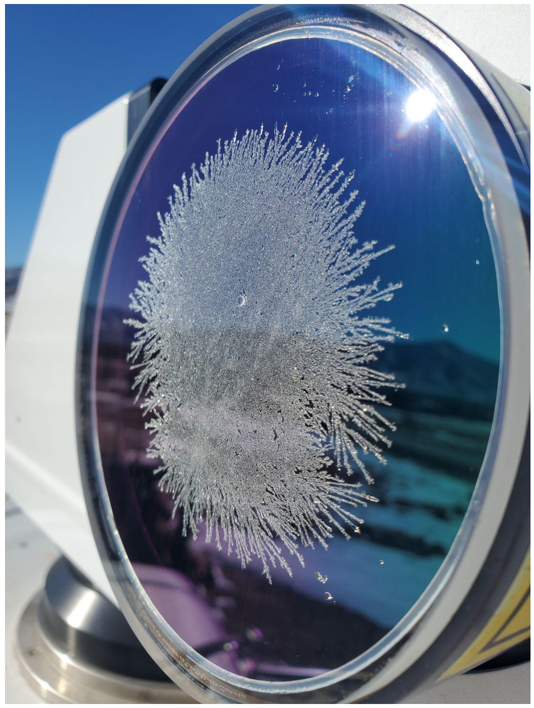

Figure 5. *Moisture crystallized inside the lidar lens during the project.*

Atmospheric Structure

In addition to standard Doppler radial velocity, spectral width and backscatter data, much of the scan data also includes a variable called atmospherical_structures_type. This is a variable derived from Leosphere's WALS atmospheric condition and cloud algorithm which analyzes CNR and radial velocity data to make inferences about the atmosphere. These data have not been verified for this campaign and should be used with caution, however they may provide some useful information about the boundary layer depth and other parameters.

Atmospherical_structures_type value	meaning
0	No data
20	Residual layer
30	Mixed layer
200 - 400	Clouds
2000 - 4000	Aerosols

Intensive Operating Periods (IOP's)

IOP1 - Ephemeral fog - Tues/Wed Jan 11-12 2022

Scan Modes
PPI - 192, 274, 275, 276, 285
RHI - 271, 277, 281
VER - 282
MAN - 283

IOP2 - Ephemeral fog - Sun/Mon Jan 16-17 2022

Scan Modes
PPI - 274, 275, 276
RHI - 271, 277, 281
VER - 282, 289
MAN - 288

IOP3 - Ephemeral fog - Wed/Thurs Jan 19-20 2022

Scan Modes
PPI - 274, 275, 276, 285
RHI - 271, 277, 281
VER - 282, 289
MAN - 288

IOP4 - Ice-crystal - Thurs/Fri Feb 3-4 2022

Scan Modes
PPI - 291, 292, 294, 305
RHI - 296, 297, 302, 304
VER - 290

IOP5 - Moisture surge - Wed/Thurs Feb 9-10 2022

Scan Modes
PPI - 291, 292, 305
RHI - 306, 307, 308
VER - 290

IOP6 - Quiescent - Sat/Sun Feb 12-13 2022

Scan Modes 290, 291, 305, 306, 307, 308

PPI - 291, 292, 305
RHI - 306, 307, 308
VER - 290

IOP7 - Thurs/Fri Feb 17-18 2022

Scan Modes
PPI - 291, 316
RHI - 302, 303, 304, 317, 319, 321
VER - 312

IOP8 - Fri/Sat Feb 18-19 2022

Scan Modes
PPI - 291, 292, 316, 325
RHI - 317, 319, 321
VER - 312

IOP9 - Wed/Thurs Feb 23-24 2022

Scan Modes
PPI - 291, 325, 329
RHI - 317, 319, 321
VER - 312, 327

References

Newsom, R. K., C. Sivaraman, T. R. Shippert, and L. D. Riihimaki, 2015: *Doppler Lidar Wind Value-Added Product*. https://doi.org/10.2172/1238069.