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New York State Mesonet Profiler Network Data

The data described here are created by New York State Mesonet at University at Albany.
In the event that the data are used for any form of publications, please cite Shrestha et al (2021, 2022) and use the following statement in the acknowledgement:

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Details about the Profiler Network, instrumentations and their retrieval methods can also be found at Shrestha et al., 2021, "Overview and Applications of New York State Mesonet Profiler Network", Journal of Applied Meteorology and Climatology.

The evaluation of the Profiler Network data is presented at Shrestha et al., 2022, "Evaluation of the New York State Mesonet Profiler Network data", Atmospheric Measurement Techniques.

1. Introduction

The New York State (NYS) Mesonet (http://nysmesonet.org) is a new advanced, statewide weather station network that provides unprecedented weather information across the state. This network is the first of its kind in New York. Unique in the world is a subset of 17 stations known as the Profiler Network (see map below). Site metadata including latitude, longitude, elevation, county, and commissioned date are listed in Appendix A with additional information provided at: http://nysmesonet.org/about/sites#network=profiler&stid=prof_alba

2. Instrumentation

The 17 station Profiler Network sites are equipped with sensors for measuring vertical profiles of wind, temperature, moisture, and liquid water. These sensors include a Doppler LiDAR, microwave radiometer, and environmental sky imaging radiometer (eSIR).

Every Profiler station consists of two deployment suites: (1) A Standard Site installed at ground level; and (2) A Profiler Site installed on a nearby rooftop, or as in the case at Albany, at the local airport. Most Profiler sites are deployed within 0.5 km of a Standard site. Profiler site sensors are connected directly to utility power and Ethernet. This ensures that the high volume of data at each Profiler site can be accessed in real-time. Some processing of the Profiler data is done at the site before transmission to UAlbany.

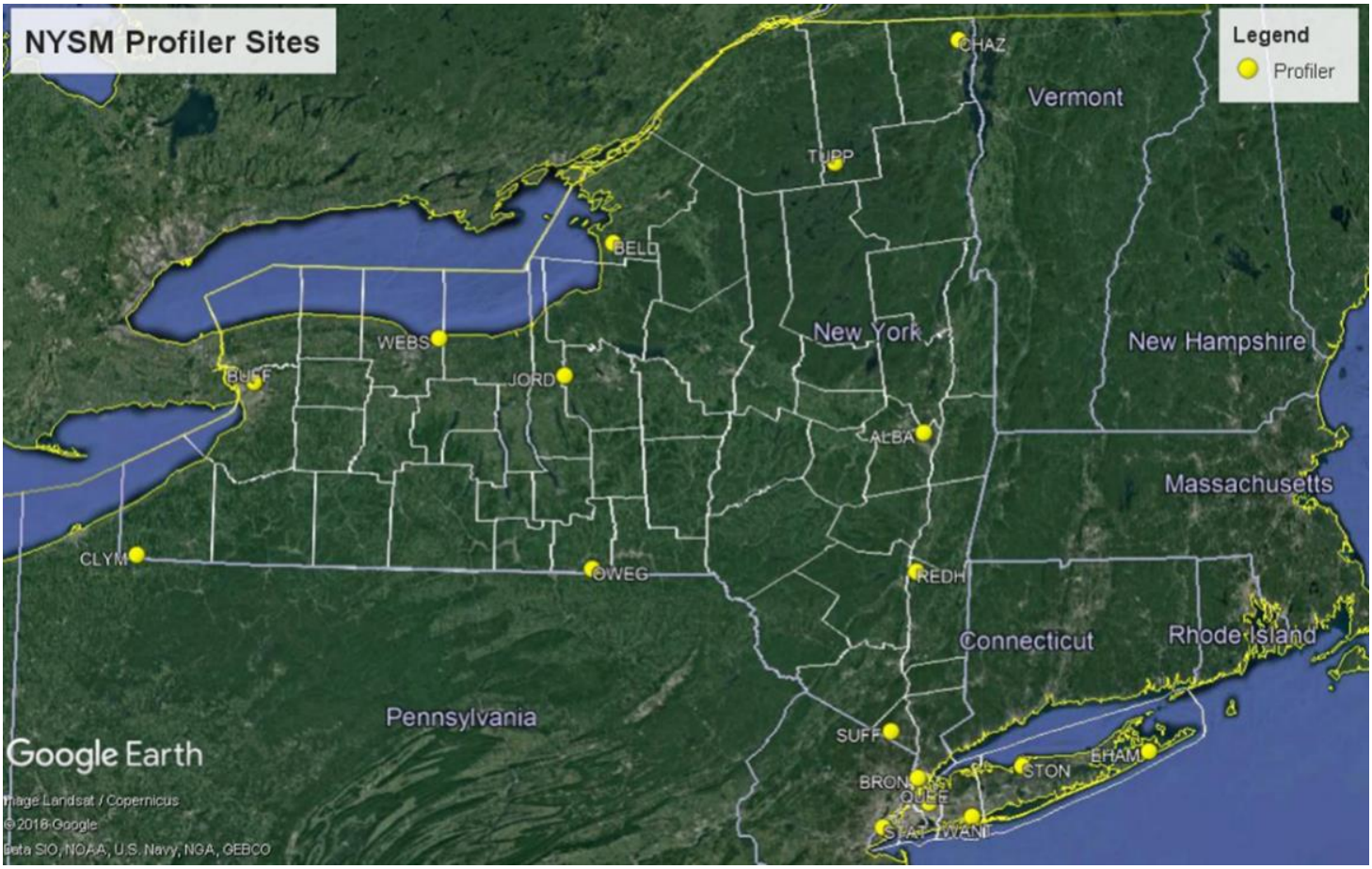

Fig. 1: Network of 17 Profiler stations, each equipped with a LiDAR, microwave radiometer and environmental sky imager radiometer (eSIR).

A **Doppler LiDAR** (Light Detection and Ranging) WLS-100S, a product of Leosphere, is an active remote sensing instrument that uses eye-safe laser pulses in the near infrared ($\lambda = 1540$ nm). The LiDAR emits short laser pulses into the atmosphere and records the signal backscattered from moving particles such as aerosols and clouds along the line of sight. Using the heterodyne detection technique, Carrier-to-Noise Ratio (CNR) is calculated from the backscattered signal strength, radial wind speed is calculated from Doppler frequency shift and range is calculated from time of flight. The CNR is directly related to aerosol backscatter (β). The primary output from the instrument includes radial wind speed and CNR (a modulated signal for Signal-to-Noise Ratio or SNR). The LiDAR is set to collect data using the Doppler Beam Swinging (DBS) scan mode which makes four cardinal direction scans at elevation of 75° and one vertical scan in about 20 s. The three-dimensional wind fields (u, v, and w) are derived using simple trigonometric relations from those DBS scans. The data availability and the maximum measurement range depend upon the aerosol concentration and/or meteorological conditions.

The LiDAR weighs 232 kg (511 lbs), and measures approximately 1008 x 814 x 1365 mm (3.3' x 2.7' x 4.5') (L x W x H). The LiDARs are maintained in collaboration with Renewable NRG Systems and Vaisala.

The LiDAR has a vertical range up to 7 km AGL with a vertical resolution of 25-50 m and a temporal resolution of 4-5 s. The manufacturer applies the CNR threshold value of -27 dB to obtain a radial wind speed accuracy of approximately 0.5 m/s with a range of -30 to +30 m/s and a wind direction accuracy of about 2º. It can operate in temperatures from -30° C to +45° C and humidity from 10% to 100%. All data above the CNR threshold value are averaged over 10-min periods.

Averaged data are displayed in real-time and typically provided to users, whereas 4-5 s data are available upon special request.

The vertical resolution of the LiDAR is 25 m from 100 m to 1000 m and 50 m from 1000 m to 7000 m and the temporal resolution is ~20 s (full DBS scan) which can vary sometimes due to dwell time, wipes, lubrication etc.

A **microwave radiometer** (MWR) MP-3000A, a product of Radiometrics, is a passive remote sensing instrument with 35 factory calibrated channels of 21 K-band (22-30 GHz) and 14 V-band (51-59 GHz) that measures brightness temperature in water vapor and oxygen bands. Vertical profiles of temperature, relative humidity, water vapor density and liquid density are retrieved using a combination of a neural network and radiative transfer model, trained by radiosonde data. In addition, the MWR also provides cloud base height (CBH), integrated water vapor, total liquid water path (LWP), and cloud liquid water content.

The MWR weighs 27 kg (60 lbs) and measures approximately 86 x 53 x 31 mm (L x W x H).

The MWR has a vertical range up to 10 km AGL with a vertical resolution of 50 – 250 m and a temporal resolution of ~2 minutes. The temperature accuracy is about 0.5 – 2°C and the relative humidity accuracy is about 2%, with both decreasing from the surface upward. It can operate in temperatures from -40° C and +45° C, with a total power consumption of < 500 W. The data collected and archived include: (i) Level 0 – raw data; (ii) Level 1 – meteorological sensor data and brightness temperature; (iii) Level 2 – Temperature, water vapor, liquid water, RH profiles and column integrated vapor and liquid; and (iv) Calibration data. The Level II data are derived by the vendor using the Level I data and the neural network method trained by the historical radiosonde data (Solheim, et al., 1998, Ware et al., 2003).

Solheim, F., Godwin, J. R., Westwater, E. R., Han, Y., Keihm, S. J., Marsh, K., and Ware, R.: Radiometric profiling of temperature, water vapor, and liquid water using various inversion methods, Radio Science, 33(2), 393–404, https://doi.org/10.1029/97RS03656, 1998.

Ware, R., Carpenter, R., Güldner, J., Liljegren, J., Nehrkorn, T., Solheim, F., and Vandenberghe, F.: A multichannel radiometric profiler of temperature, humidity, and cloud liquid, Radio Science, 38(4), 8079, https://doi.org/10.1029/2002RS002856, 2003.

Vertical profiles are generated from averages of observations calculated over 10-minute periods. Raw data are collected from across the network and transmitted to the University at Albany, where the data are averaged into 10-minute periods, organized into a given file format, and then archived and disseminated to users. The list of variables archived, and their units are described in Section 3 below. As placeholders for bad/missing data, netCDF files use the FillValue attribute "NaN".

MWR sensors require regular calibration. The K-band is calibrated using a "tip calibration", which is done approximately every 3 weeks and is applied remotely. The V-band is calibrated using a liquid nitrogen calibration. This must be done on site and is completed about once every 6 months. During sensor calibration, the MWR data are not collected. The dates of sensor calibrations are kept online at http://nysmesonet.org/networks/profiler/calibration.

The vertical resolution of the MWR data is 50 m from 0 to 500 m, 100 m from 500 to 2000 m and 250 m from 2000 to 10000 m with the temporal resolution of ~2 minutes. Ten minutes averaged data are provided to the users.

An **environmental Sky Imaging Radiometer** (eSIR) is a multi-channel (415, 500, 610, 670, 870, 940, and 1020 nm) sensor that measures spectral direct and diffuse irradiance during the daylight hours using a shadow band technique. Such spectral irradiances can be converted into aerosol optical depth (AOD) and Angstrom Exponent (AE) for the application in aerosol studies. In addition, it also provides fish-eye sky images along with sensors for temperature, pressure,

humidity and a GPS sensor for latitude, longitude, and elevation. Each sun photometer has been built in-house by research scientists in the New York State Mesonet and Atmospheric Sciences Research Center (ASRC).

Temporal resolution of the eSIR data is 5 minutes and data are only measured during daylight hours.

3. Data format

3a. Processed data format

Profiler data are provided in CSV format by default, or NetCDF format upon request. A list of Profiler data variables is listed in Appendix B. The short names of variables are used in the data and are explained in the table below. All files are organized according to date, i.e. each file contains all data for that day at every station requested. These files are provided with 10-minute averaging and contain both LiDAR and MWR data. For CSV files, the name conventions are yyyymmdd-2d.csv and yyyymmdd-3d.csv. The "2d" files contain the variables that are **not** dependent on height. The "3d" files contain the variables that **are** dependent on height.

3b. Raw data format

Raw data are only provided on special request. For the raw LiDAR NetCDF files, the name convention is yyyymmdd.nc, where yyyy is 4-digit year, mm for numeric month, dd for date. For the MWR NetCDF files, the name convention is yyyymmdd_lv2_PROF_[station ID], where the date convention is the same, lv2 is the Level 2 MWR data, and PROF_[station ID] is the station. The date is specified as UTC (Coordinated Universal Time), not LST (local solar time). Eastern Standard Time (EST) is 5 hours behind UTC, and Eastern Daylight Time (EDT) is 4 hours behind UTC. The variable names in the NetCDF file are documented via attributes within the file.

4. Special notes on the data:

1) Sensor and/or system failures are not uncommon as the Profiler equipment are sensitive to a variety of environmental factors. Data gaps may be due to sensor failures; calibration errors; power failures; and/or communication failures. Please check the data availability as listed in Appendices C and D.
2) When using the MWR data, please note the time since last calibration. The sensor may drift out of calibration with time. TIP calibrations are done as often as every 2 weeks, whereas LN2 calibrations are done around every 6 months. The dates of sensor calibrations are kept online at http://nysmesonet.org/networks/profiler/calibration .
3) Only manufacturer-developed QA/QC procedures are applied to the data and there might still be some undetected errors. Please make your own judgement on questionable data.

APPENDIX A: SITE INFORMATION

STID	NAME	LAT (DEG)	LON (DEG)	ELEVATION	COUNTY	COMMISSION DATE
PROF_ALBA	Albany	42.75175	-73.81128	83.07	Albany	2017-09-01 00:00:00 UTC
PROF_BELL	Belleville	43.78823	-76.11765	152.1	Jefferson	2017-03-03 00:00:00 UTC
PROF_BRON	Bronx	40.87248	-73.89352	59.31	Bronx	2017-09-12 22:00:00 UTC
PROF_BUFF	Buffalo	42.99359	-78.79461	185.39	Erie	2017-03-29 20:00:00 UTC
PROF_CHAZ	Chazy	44.889	-73.46634	74.29	Clinton	2017-03-02 16:30:00 UTC
PROF_CLYM	Clymer	42.02143	-79.62746	457.45	Chautauqua	2017-03-22 23:00:00 UTC
PROF_EHAM	East Hampton	40.97039	-72.20094	22.97	Suffolk	2017-04-27 19:00:00 UTC
PROF_JORD	Jordan	43.06874	-76.46999	129.46	Onondaga	2016-11-21 17:57:00 UTC
PROF_OWEG	Owego	42.02493	-76.25307	464.45	Tioga	2017-05-02 14:00:00 UTC
PROF_QUEE	Queens	40.73433	-73.81585	52.89	Queens	2017-06-09 19:00:00 UTC
PROF_REDH	Red Hook	41.99983	-73.88412	72.85	Dutchess	2017-04-17 20:17:43 UTC
PROF_STAT	Staten Island	40.60401	-74.14849	34.43	Richmond	2017-06-08 20:35:07 UTC
PROF_STON	Stony Brook	40.91957	-73.13328	55.1	Suffolk	2018-04-12 22:00:00 UTC
PROF_SUFF	Suffern	41.13303	-74.08597	191.87	Rockland	2017-02-25 02:15:00 UTC
PROF_TUPP	Tupper Lake	44.22425	-74.44105	525.2	Franklin	2017-01-30 21:00:00 UTC
PROF_WANT	Wantagh	40.65025	-73.5054	18.25	Nassau	2017-04-26 21:00:00 UTC
PROF_WEBS	Webster	43.2601	-77.41238	95.6	Monroe	2017-03-23 17:00:00 UTC

APPENDIX B: VARIABLE LIST

The variable list differs for processed and raw data requests.

Table B.1 The variable list for **processed** 2d and 3d data from LiDAR and MWR. The temporal resolution is 10 min, and the vertical resolution is 10 hPa or 25 m.

Name	Units	2d or 3d	Variable Status
range	m	3d	Shared
cnr	dB	3d	LiDAR
u	m/s	3d	LiDAR
v	m/s	3d	LiDAR
w	m/s	3d	LiDAR
velocity	knots	3d	LiDAR
direction	degrees	3d	LiDAR
pressure_level	mbar	3d	MWR (derived)
temperature	K	3d	MWR
relative_humidity	%	3d	MWR
liquid	g/m^3	3d	MWR
vapor_density	g/m^3	3d	MWR
cloud_base	km	2d	MWR
integrated_vapor	cm	2d	MWR
integrated_liquid	mm	2d	MWR
ir_temperature	K	2d	MWR
surface_pressure	mbar	2d	MWR
surface_relative_humidity	%	2d	MWR
surface_temperature	K	2d	MWR
rain_flag	0 = no, 1 = yes	2d	MWR

Table B.2 Descriptions for **raw** environmental LiDAR data. Raw data are only provided upon special request on a case-by-case basis.

Short_name	Long_name	Units
disk_occupation	disk occupation	%
disk_occupation_samples	number of samples for disk occupation statistics	N/A
gps_lat	GPS latitude	degrees north
gps_lat_samples	number of samples for gps lat statistics	N/A
gps_lon	GPS longitude	degrees east
gps_lon_samples	number of samples for gps lon statistics	N/A
internal_dew_point	internal dew point	℃
internal_dew_point_samples	number of samples for internal dew point statistics	N/A
internal_relative_humidity	internal relative humidity	%
internal_relative_humidity_samples	number of samples for internal relative humidity statistics	N/A

internal_temperature	internal temperature	℃
internal_temperature_samples	number of samples for internal temperature statistics	N/A
pitch	pitch angle	degrees
pitch_samples	number of samples for pitch statistics	N/A
roll	roll angle	degrees
roll_samples	number of samples for roll statistics	N/A
stat	statistic performed over interval	N/A
time	time	milliseconds since start of day

Table B.3 Descriptions for **raw** radial LiDAR data. Raw data are only provided upon special request on a case-by-case basis.

Short_name	**Long_name**	**Units**	**Variable Status**
azimuth	azimuth angle	degree	From LiDAR
cnr	carrier to noise ratio	dB	From LiDAR
confidence	confidence index	percent	From LiDAR
direction	wind from direction	degree	Calculated by NYSM
drws	dispersion radial wind speed	m/s	From LiDAR
elevation	elevation angle	degree	From LiDAR
error	mean error	N/A	From LiDAR
los	line of sight index	N/A	From LiDAR
range	height	m	From LiDAR
reconstruction_status	status for reconstructed wind data	N/A	Calculated by NYSM
rws	radial wind speed	m/s	From LiDAR
sequence	sequence ID	N/A	From LiDAR
status	status	N/A	From LiDAR
time	time	milliseconds since start of day	From LiDAR
u	eastward wind	m/s	Calculated by NYSM
v	northward wind	m/s	Calculated by NYSM
velocity	wind speed	m/s	Calculated by NYSM

w	upward air velocity	m/s	Calculated by NYSM

NOTE: Each LiDAR configuration and scanning scenario gets its own radial NetCDF group. When using this data, the user should read each group's attributes to determine what the data represents. The group ID is subject to change over time, and multiple groups may exist in some instances.

Table B.4 Descriptions for **raw** microwave radiometer netCDF data. Raw data are only provided upon special request on a case-by-case basis.

Short_name	**Long_name**	**Units**	**netCDF coordinates**
lv2_processor	level 2 processor, indicating data angle	N/A	Coordinate variable
range	height above the surface	m	Coordinate variable
time_integrated	time values used for integrated measurements	milliseconds since start of day	Coordinate variable
time_surface	time values used for surface measurements	milliseconds since start of day	Coordinate variable
time_vertical	time values used for vertical profile measurements	milliseconds since start of day	Coordinate variable
cloud_base	cloud base height	km	time_integrated, lv2_processor
integrated_liquid	integrated liquid	mm	time_integrated, lv2_processor
integrated_qc	quality flag for integrated quantities	N/A	time_integrated, lv2_processor
integrated_vapor	integrated vapor	cm	time_integrated, lv2_processor
surface_pressure	air pressure at radiometer level	mbar	time_surface
surface_qc	quality flag for surface observations	N/A	time_surface
surface_relative_humidity	relative humidity at radiometer level	%	time_surface
surface_temperature	air temperature at radiometer level	K	time_surface
ir_temperature	infrared temperature observed from sky	K	time_surface
liquid	liquid vertical profile	g/m^3	time_vertical, lv2_processor, range
liquid_qc	quality flag for liquid	N/A	time_vertical, lv2_processor
rain_flag	raining indicator	N/A	time_surface

relative_humidity	relative humidity vertical profile	%	time_vertical, lv2_processor, range
relative_humidity_qc	quality flag for relative humidity	N/A	time_vertical, lv2_processor
temperature	air temperature vertical profile	K	time_vertical, lv2_processor, range
temperature_qc	quality flag for temperature	N/A	time_vertical, lv2_processor
vapor_density	vapor density vertical profile	g/m^3	time_vertical, lv2_processor, range
vapor_density_qc	quality flag for vapor density	N/A	time_vertical, lv2_processor

APPENDIX C: MAJOR DATA GAPS IN MICROWAVE RADIOMETERY DATA
(updated through April 2020; some data available even during gap periods)

STID	Gap in data (Dates)	Reason
PROF_ALBA	3/15/18 – 05/9/18	Failed k-band TEC; Instrument sent to Radiometrics for repair
PROF_BELL	2/5/19 – 03/7/19	Superblower not active.
PROF_BRON	6/8/18 – 08/3/18 2/5/19 – 3/19/19 *6/14/19 – 6/17/19 & 9/13/19 – 9/16/19 & 10/4/19 – 10/8/19 & 10/11/19 – 10/14/19 & 10/28/19 – 11/5/19*	Failed v-band noise diode Failed laptop hard drive *Laptop Restart, unable to re-establish communication*
PROF_BUFF	9/17/19 – present	Roof repairs at host location.
PROF_CHAZ	3/2/17 – 4/25/18	Communication issues then a failed K-Band
PROF_CLYM	6/22/17 – 6/28/17	Unknown
PROF_EHAM	6/1/17 – 8/31/17 2/8/18 – 2/22/18 6/08/18 – 6/14/18	Communication issues. Communication issues. Failed laptop hard drive
PROF_JORD	6/1/17-8/31/17 9/24/17 – 12/21/17 1/7/18 – 5/7/18	Roof repairs; site taken offline Communication issues Laptop hard drive failure followed by communications issues.
PROF_OWEG	None	
PROF_QUEE	1/1/18 – 3/9/18 4/3/19 – 4/10/19	Failed k-band; IRT problems Laptop problems
PROF_REDH	4/11/17 – 4/14/17 2/22/19 – 6/17/19 8/7/19 – 8/29/19 2/23/20 – 3/3/20	Unhealthy K-band and V-band Failed k-band Laptop unexpected restart; hundreds of restarts. Damaged data cable.
PROF_STAT	4/13/19 – present	K-band noise diode failure and Laptop hard drive failure.
PROF_STON	6/1/18 – 6/05/18 10/11/18 – 7/26/19 8/21/19 – 8/27/19 1/22/20 – 1/27/20	Unexpected laptop restart. Failed v-band noise diode Unknown Operator Error
PROF_SUFF	9/1/17 – 9/30/17 12/19/17 – 12/31/17	Unknown Communications issues.
PROF_TUPP	1/27/17 – 7/28/17	Communication issues.

	8/20/17 – 9/6/17 1/25/18 – 2/2/18 7/22/18 – 08/08/18 12/1/18 – 12/5/18	Communications issues. Laptop died due to power outage; req'd restart Laptop died due to power outage; req'd restart. Laptop died due to power outage; req'd restart.
PROF_WANT	9/23/17 – 10/4/17	Laptop died due to power outage; req'd restart.
PROF_WEBS	2/20/18 – 3/28/18 6/24/19 – 8/7/19 9/16/19 – 9/30/19 3/19/20 – 4/3/20	Failed laptop hard drive, K-Band noise diode failure. LiDAR stopped due to bad data caused by radome buckling. Communications issues.

APPENDIX D: MAJOR DATA GAPS IN DOPPLER WIND LiDAR DATA
(updated through April 2020; some data available even during gap periods)

STID	Gap in data (Dates)	Reason
PROF_ALBA	1/1/18 – 01/9/18 1/30/18 – 2/9/18 2/26/18 – 3/16/18 4/26/18 – 4/27/18 2/8/20 – 2/11/20	LiDAR PC disruptions. LiDAR PC disruptions. LiDAR moved to a new site. LiDAR PC disrptions. Internet disruption at site.
PROF_BELL	6/21/19 – 6/22/19 2/13/20 – Present	Operator Error. Scanner-head failure.
PROF_BRON	N/A	N/A
PROF_BUFF	9/17/19 – present	Roof repairs at host location.
PROF_CHAZ	10/10/19 – 10/21/19	50% Operation due to a lubrication glitch.
PROF_CLYM	8/22/18 – 9/2/18	LiDAR turned off.
PROF_EHAM	1/26/18 – 2/13/18 3/5/18 – 3/22/18	LiDAR PC disruptions. LiDAR PC disruptions.
PROF_JORD	N/A	N/A
PROF_OWEG	N/A	N/A
PROF_QUEE	1/5/19 – 1/10/19 3/19/19 – 4/1/19	LiDAR PC disruptions. LiDAR PC disruptions.
PROF_REDH	11/12/18 – 11/26/18 12/5/18 – 1/25/19 12/24/19 – 12/28/19	LiDAR PC disruptions. LiDAR PC disruptions. Power outage.
PROF_STAT	N/A	N/A
PROF_STON	8/21/19 – 8/25/19 9/8/19 – 10/1/19	LiDAR PC restart required. LiDAR power-supply failure. Replacement required.
PROF_SUFF	7/27/18 – 8/2/18 1/23/19 – present	Unknown Scanner-head failure (repaired Oct ’19) then beam failure.
PROF_TUPP	1/1/18 – 3/6/18 6/1/18 – 2/4/19 9/19/19 – 10/10/19	Communication issues and scanner PC issues. Scanner-head and Scanner-PC failure. Communication issues.
PROF_WANT	3/19/19 – 3/21/19	LiDAR PC restart required.
PROF_WEBS	5/28/18 – 6/19/18 2/28/19 – 3/14/19 3/19/20 – 4/3/20	LiDAR Ethernet switch failure. Scanner-head squeaking due to cold-snap annoyed host. Communication issues.