Title: SJSU_lidar

Kiera Malarkey, kiera.malarkey@sjsu.edu, San Jose State University, Graduate Research Assistant

Alan Huston, alan.huston@sjsu.edu, San Jose State University, Graduate Research Assistant

Craig Clements, PhD, craig.clements@sjsu.edu, San Jose State University, 408-924-1677, Department Chair and Directory of the Wildfire Interdisciplinary Research Center (WIRC)

1.0 Data Set Description

For the duration of the Sundowner Winds Experiment (SWEX) a Halo Photonics Doppler LiDAR was running and operational from March 29, 2022 to May 15, 2022. During each event wind profiles were taken continuously every 10 minutes for 5 second intervals, RHI scans were taken every 5 minutes for 7 second intervals, and Stare scans were taken continuously in 1-second intervals for 1-hour. A complete list of the temporal period for each type of LiDAR scan is provided in section 5.0 Data Remarks.

Version 1. March 14, 2023- Final

Temporal Period: March 29, 2022 16:30:09 UTC to May 15, 2022 16:06:28 UTC

Physical location of LiDAR: -120.21400 W, 34.47656 N

Data Frequency: Wind Profiles were continuously taken every 10-minutes, RHI scans were taken every 5 minutes during an official event period, Backscatter and Stare were completely continuous.

Data source: Halo Photonics Doppler LiDAR

Data set restrictions: N/A

2.0 Instrument Description

The specific instrument employed by SJSU for boundary layer wind profiling was the Halo Photonics Streamline Scanning Doppler LiDAR system. While in operation, the LiDAR emits pulses of light at 1.5 µm that detect naturally occurring aerosols in the atmosphere (Lareau & Clements 2017). These aerosols act as a distributed target and backscatter the transmitted pulses. A receiver on the LiDAR then detects the doppler shift of the aerosol detected. This provides the line-of-sight component of their velocity. The LiDAR uses this data to compute values for wind speed and direction beneath the boundary layer, along with attenuated backscatter and vertical velocity. To attain these separate variables, the LiDAR is programmed to perform three types of scanning routines while operating. The first is a stare scan routine, which collects aerosol backscatter and vertical velocity data. In this mode, the lens of the LiDAR remains in a fixed position pointed vertically upward. It continues to record data as the air passes by until a wind profile scanning routine begins. The second is wind profile scan every fifteen minutes. To complete this scan, the lens of the LiDAR follows a six-point velocity-azimuth display pattern,

where six azimuth points and a fixed elevation angle of 75˚ is used. The third is RHI scans from the mountains, north, to the channel, south, taking vertical cross-sections of backscatter intensity and radial velocity every 5 minutes from 0 to 180°.

https://halo-photonics.com/lidar-systems/stream-line-series/

3.0 Data Collection and Processing

Description of data collection:

The data collection includes vertical wind profiles at a fixed elevation angle of 75˚ every 10-minutes, Range Height Indicator (RHI) scans from 0° to 180° elevation taking a scan in 10° increments at an initial azimuth of 360° and ending azimuth of 180° every 5-minutes, and Stare scans at a 90° elevation and 90° azimuth.

Description of quality assurance and control procedures:

The LiDAR has a pulse range of 10,000 m but was configured to scan up to only 2,016 m. Additional range was unnecessary as our main region of focus was beneath the convective boundary layer (CBL), where naturally occurring aerosols reside. Reducing the LiDAR's scanning range was beneficial for improving the resolution of our data as well. Each LiDAR pulse is broken down into a number of gate segments that record information within each gate's range. By using a smaller measurement range, the minimum length of each gate can be decreased, which in turn leads to higher resolution data.

4.0 Data Format

Data file naming conventions:

Processed Wind Profiles: "Processed_Wind_Profile_19_yyyymmdd_hhmmss.hpl"

RHI Scans: "RHI_19_yyyymmdd_hhmmss.hpl"

Stare Scans: "Stare_19_yyyymmdd_hh.hpl"

Data format and layout:

Wind Profiles Header and File Format:

```
1344
   6 318.26   1.64
   8 307.99   1.38
   9 300.00   1.85
  11 298.32   2.18
  12 302.42   1.52
  13 304.31   0.85
  15 308.95   0.82
  16 324.51   0.77
  18   0.01   0.67
  19   0.01   0.59
  20   5.82   0.63
  22  16.99   0.66
```

RHI Header:

```
Filename:   RHI_19_20220511_023255.hpl
System ID:  19
Number of gates:  1344
Range gate length (m):  18.0
Gate length (pts):      12
Pulses/ray: 10000
No. of rays in file:    19
Scan type:  RHI - overlapping
Focus range:      65535
Start time: 20220511 02:33:00.83
Resolution (m/s): 0.0760
Altitude of measurement (center of gate) = (range gate + 0.5) * Gate length
Data line 1: Decimal time (hours)  Azimuth (degrees)  Elevation (degrees) Pitch (degrees) Roll (degrees)
f9.6,1x,f6.2,1x,f6.2
Data line 2: Range Gate  Doppler (m/s)  Intensity (SNR + 1)  Beta (m-1 sr-1)
i3,1x,f6.4,1x,f8.6,1x,e12.6 - repeat for no. gates
****
```

RHI File Format:

```
0.03813333 360.00  -0.00 0.40 0.50
  0 -5.2416 1.030256  1.703537E-6
  1 -5.1656 1.032715  1.842081E-6
  2 -5.1656 1.035303  1.987924E-6
  3 -5.1656 1.043737  2.462933E-6
  4 -5.0137 1.059189  3.333271E-6
  5 -5.0897 1.067617  3.808103E-6
  6 -5.3935 1.071282  4.014731E-6
```

Stare Header:

```
Filename:   Stare_19_20220511_23.hpl
System ID:  19
Number of gates:  1344
Range gate length (m):  18.0
Gate length (pts):      12
Pulses/ray: 10000
No. of rays in file:    1
Scan type:  Stare - overlapping
Focus range:      65535
Start time: 20220511 23:01:23.88
Resolution (m/s): 0.0760
Altitude of measurement (center of gate) = (range gate + 0.5) * Gate length
Data line 1: Decimal time (hours)  Azimuth (degrees)  Elevation (degrees) Pitch (degrees) Roll (degrees)
f9.6,1x,f6.2,1x,f6.2
Data line 2: Range Gate  Doppler (m/s)  Intensity (SNR + 1)  Beta (m-1 sr-1)
i3,1x,f6.4,1x,f8.6,1x,e12.6 - repeat for no. gates
****
```

Stare File Format:

```
0.02762778  90.05  90.08 0.40 0.50
  0 -3.6463 1.021269  1.197544E-6
  1 -3.7223 1.023941  1.348055E-6
  2 -3.5704 1.026690  1.502921E-6
  3 -3.5704 1.034883  1.964358E-6
  4 -3.8742 1.050371  2.836669E-6
  5 -4.1781 1.058769  3.309790E-6
  6 -4.5579 1.061608  3.469879E-6
```

	Unit	Intervals	Resolution
Processed Wind Profiles	ms^{-1}	Every 10-minutes for 5- second intervals	0.0760 ms^{-1}
RHI Scans	ms^{-1}	Every 5-minutes for 7-second intervals	0.0760 ms^{-1}
Stare Scans	Vertical Velocity: ms^{-1} Attenuated Backscatter: $m^{-1}Sr^{-1}$	1-second intervals for 1-hour	0.0760 ms^{-1}

5.0 Data Remarks

Missing data periods:

04052022 20:46:33 to 23:51:35 UTC

05112022 02:51:44 to 17:31:01 UTC

Programming language compatible to manipulate data:

Python

Data for each IOP:

	Wind Profiles	RHI	Stare
IOP1	04042022 17:08 to 04052022 14:01	04042022 17:04 to 04052022 14:03	04042022 17:00 to 04052022 14:00
IOP2	04052022 23:51 to 04062022 08:03	04052022 23:45 to 04062022 07:59	04052022 23:00 to 04062022 08:00
IOP3	04132022 17:04 to 04142022 14:03	04132022 17:27 to 04142022 14:03	04132022 17:00 to 04142022 14:00
IOP4	04182022 17:02 to 04192022 14:04	04182022 17:04 to 04192022 14:03	04182022 17:00 to 04192022 14:00
IOP5	04232022 17:02 to 04242022 14:05	04232022 23:39 to 04242022 14:03	04232022 17:00 to 04242022 14:00
IOP6	04282022 17:05 to 04292022 08:02	04282022 17:25 to 04292022 08:05	04282022 17:00 to 04292022 08:00
IOP7	05072022 23:06 to 05082022 05:36	05072022 23:02 to 05082022 05:28	05072022 23:00 to 05072022 05:00
IOP8	05082022 17:07 to 05092022 13:59	05082022 17:04 to 05092022 14:03	05082022 17:00 to 05092022 14:00
IOP9	05102022 16:59 to 05112022 02:51	05102022 17:00 to 05112022 02:52	05102022 17:00 to 05112022 02:00
IOP10	05122022 23:03 to 05132022 14:04	N/A	05122022 23:00 to 05132022 14:00
EOP1	04172022 17:09 to 04182022 14:02	04172022 17:00 to 04182022 14:04	04172022 17:00 to 04182022 14:00
EOP2	04252022 17:02 to 04262022 14:04	04252022 17:03 to 04262022 14:02	04252022 17:00 to 04262022 14:00
EOP3	05042022 17:05 to 05052022 14:06	05042022 17:01 to 05052022 14:04	05042022 17:00 to 05052022 14:00

6.0 References

Halo Photonics Web Page: https://halo-photonics.com/lidar-systems/stream-line-series/

Neil Lareau and Craig Clements. "The Mean and Turbulent Properties of a Wildfire Convective Plume" *Journal of Applied Meteorology and Climatology* (2017): 2289-2299. https://doi.org/10.1175/JAMC-D-16-0384.1

Halo Photonics Streamline Lidar Manual:
file:///C:/Users/Kiera/Downloads/Lidar%20Manual%20.pdf

7.0 Appendix

Doppler LiDAR, Range Height Indicator, Wind Profiles, Vertical Velocity, Attenuated Backscatter, SWEX