Title: NSSL Mobile Lidar Truck PERiLS 2022

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1.0 Dataset Overview
These files contain periods of data collected from the NSSL Lidar Truck Halo Streamline XR+ Doppler lidar. These data were collected during the PERiLS 2022 project. The Doppler lidar conducts regular conical scans at a set elevation angle as well as vertically pointing stares. These data are then passed through a typical VAD algorithm to retrieve horizontal wind speed and direction profiles. This platform was nomadic, and collected data on a deployment-to-deployment basis, so availability depends on the deployment decisions made each day by the project.

These data are not final. See remark in Section 5.2

1.1 Date range: 22 March -- 13 April 2022

1.2 Region of data collection: Southeastern US (TN, AR, MS, AL)

1.3 Estimated data availability

IOP1: 2022-03-22 13:15 UTC – 2022-03-22 21:23 UTC

IOP2: 2022-03-30 14:00 UTC – 2022-03-30 23:15 UTC

IOP3: 2022-04-05 9:00 UTC – 2022-04-05 17:15 UTC

IOP4: 2022-04-13 15:15 UTC – 2022-04-13 21:45 UTC

2.0 Instrument Description
The Halo Streamline XR+ is a commercial platform. The Doppler lidar (DL) is an active remote-sensing instrument that provides range- and time-resolved measurements of radial velocity, attenuated backscatter, and signal-to-noise ratio (SNR). The principle of operation is similar to radar in that pulses of electromagnetic energy (infrared in this case) are transmitted into the atmosphere; the energy scattered back to the transceiver is collected and measured as a time-resolved signal. From the time delay between each outgoing transmitted pulse and the

backscattered signal, the distance to the scatterer is inferred. The radial or line-of-sight velocity of the scatterers is determined from the Doppler frequency shift of the backscattered radiation. The DL uses a heterodyne detection technique in which the return signal is mixed with a reference laser beam (i.e., local oscillator) of known frequency. An onboard signal-processing computer then determines the Doppler frequency shift from the power spectra of the heterodyne signal. The energy content of the Doppler spectra can also be used to estimate attenuated backscatter. The DL operates in the near-infrared (IR;1.5 microns) and is sensitive to backscatter from micron-sized aerosols. Aerosols are ubiquitous in the lower troposphere and behave as ideal tracers of atmospheric winds. In contrast to radar, the DL is capable of measuring radial velocities under clear-sky conditions with very good precision – typically ~10 cm/sec (Newsom and Krishnamurthy 2020). It is important to note that DL scans are fully user configurable, so special attention should be paid to the scan strategy applied for this dataset.

Instrument specifications:

Max range	12 km (aerosol load dependent)
Min. range	50-90m
Nyquist Limit	~39 m/s
Range gate	Configurable, 18-60m
Precision	Velocity: <0.2 m/s

2.1 Platform Configuration

For this project, one Doppler lidar was mounted onto the NSSL mobile lidar truck. This meant that one lidar shares the duty of scanning to profile horizontal winds and pointing vertically to observe vertical velocity. This data set includes only the vertical velocity information.

Figure 1. This photo shows the NSSL Doppler lidar truck as it appeared during PERiLS 2022 in deployment mode. The Doppler lidar's scanner head is visible protruding from the center of the open enclosure system in the back of the pickup truck. The truck also launched radiosondes and carried a mobile mesonet rack, which are separate datasets.

3.0 Data collection and processing:

For the PERiLS campaign, the Doppler lidar collected PPI scans at 70 deg elevation every 5 minutes. The Doppler lidar provides range-resolved, line-of-sight measurements of radial velocity, intensity (signal-to-noise ratio [SNR]+1), and attenuated backscatter. In the case of PPI scans meant for VAD analysis, these data are passed through a VAD code to produce profiles of horizontal wind speed and direction. Vertical velocity is also provided, but it is not as high quality as vertical velocity more directly measured by vertical stares. The provided files provide the intensity field (SNR+1), which can be used as a 'filter' for noise. A good rule of thumb cutoff is 1.01.

3.1 Vertical Velocities

The Doppler lidar provides range-resolved, line-of-sight measurements of radial velocity, intensity (signal-to-noise ratio [SNR]+1), and attenuated backscatter. This measurement of vertical velocity is much more direct than that provided within the CSM wind files, described below. The provided files provide the intensity field (SNR+1), which can be used as a 'filter' for noise. A good rule of thumb cutoff is 1.01.

3.2 Horizontal Winds

The horizontal winds were produced using the Step-Stare mode feature available on Halo Streamline DLs. In this mode, the scanner head stops at each point in a scan to capture its sample. These scans were post-processed using the VAD method to get the horizontal wind speed and direction.

4.0 Data format:

Data are provided in netcdf format. The typical naming convention is dltruckdlfpDL1.c1.YYYYMMDD.HHmmss.cdf and dltruckdlvadDL1.c1.YYYYMMDD.HHmmss.cdf, following closely to ARM file naming convention. The files have time and height dimensions.

Variables provided:

Vertical Velocity (dlfp)

Name	Dimension	Unit
base_time	Single value	Seconds (since 00 UTC 1 Jan 1970)
time_offset	Time	Second (since base_time)
hour	Time	Hours since 00UTC this day
height	Height	km AGL
azimuth	Time	Deg, azimuth angle of the scanner
elevation	Time	Deg, elevation angle of the scanner
velocity	Time, Height	m/s, **NOTE that this is the *w* field, so positive is up, negative is down despite the netcdf comment**
intensity	Time, Height	Unitless, SNR+1
backscatter	Time, Height	km^{-1} sr^{-1}, attenuated backscatter
cbh	Time	km AGL, cloud base height
internal_temp, internal_rh, tec_flag, and tec_voltage are all 'housekeeping' variables noting the instrument temperature and rh and the thermoelectric cooler status		
lat	Time	Deg N, latitude
lon	Single value	Deg W, longitude
alt	Single value	m MSL, altitude above mean sea level

Horizontal winds (dlvad)

Name	Dimension	Unit
base_time	Single value	Seconds (since 00 UTC 1 Jan 1970)
time_offset	Time	Second (since base_time)
hour	Time	Hours since 00UTC this day
height	Height	km AGL
wspd	Time, Height	m/s, wind speed

wdir	Time, Height	Deg, wind direction
rms	Time, Height	m/s, RMS between observed velocity & VAD fitted value
intensity	Time, Height	Unitless, SNR+1
lat	Time	Deg N, latitude
lon	Single value	Deg W, longitude
alt	Single value	m MSL, altitude above mean sea level

5.0 Data Remarks

5.1. Data should be consistently available, but note that periods of precipitation, fog, or other very low cloud may limit the level to which good data are collected. Note also that vertical velocity in light precipitation will be contaminated by the fall speed of the precipitation itself.

5.2. A quick comparison with the radiosondes launched from the NSSL Lidar Truck shows that there is a persistent wind direction offset to the horizontal winds in the current dataset (5-10 degrees). This is likely due to how the post processing of the winds takes place. To ease operator burden during deployments, the FluxGate on the Mobile Mesonet rack fixed to the truck is used to correct the wind direction of the lidar instead of having to manually input the lidar heading into the lidar software. We hypothesize that the heading from the FluxGate is offset slightly from the true direction. This is something that is currently being investigated and we will provide a corrected dataset in the future.

6.0 References

Newsom, R. K., R. Krishnamurthy, 2020: Doppler lidar (DL) handbook. DOE Office of Science Atmospheric Radiation Measurement (ARM) Program (United States). DOE/SC/ARM/TR-101.

7.0 Appendix

GCMD Science Keywords: WIND PROFILES; WIND VELOCITY/SPEED PROFILES; WIND DIRECTION PROFILES; VERTICAL WIND VELOCITY/SPEED