Title: NSSL Mobile Lidar Truck TORUSLItE Single Lidar Wind Profile Data
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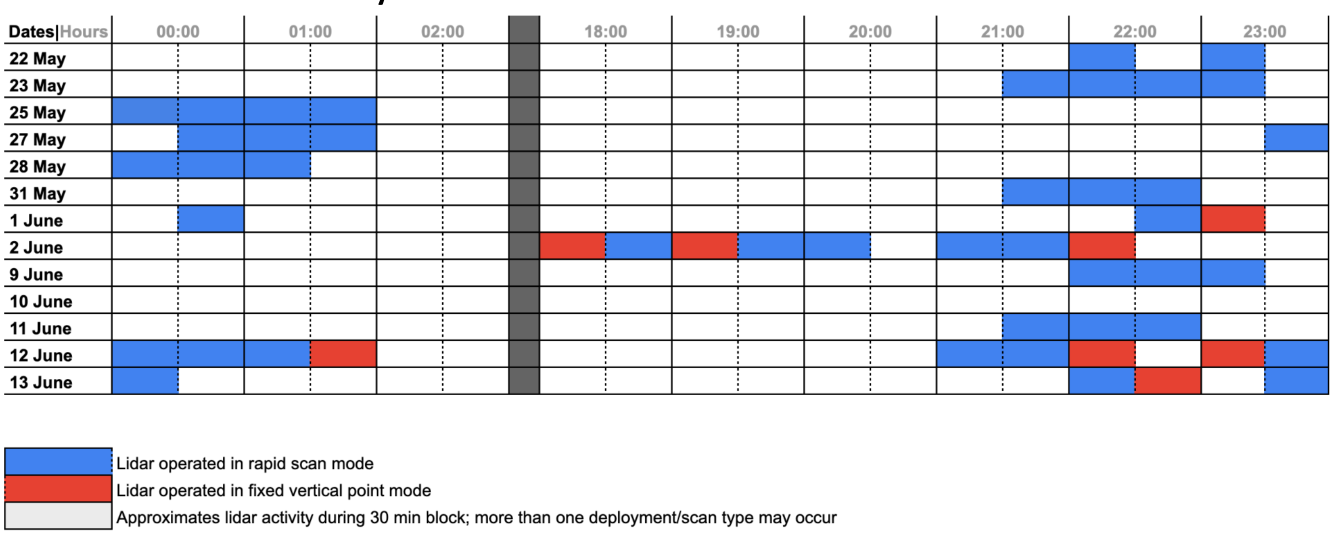
1.0 Dataset Overview

These files contain 24 hour periods of data collected from the NSSL Lidar Truck Halo Streamline XR+ Doppler lidar. These data were collected during the TORUS-LItE project. Generally, the Doppler lidar operated in Continuous Scan Mode (CSM). For this dataset these scans were post-processed into 10 second wind profile retrievals using an iterative method based on Steinheuer et. al. (2022). In select weather scenarios the lidar scan mode was switched to the more traditional "step-stare" and pointed vertically to collect direct information about vertical velocity as features of interest passed over or near the mobile lidar truck position. *These datasets are provided separately from these wind profile retrievals.* 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.

1.1 Date range: 22 May -- 13 June 2023
1.2 Region of data collection: Nomadic; US Great Plains general region; see TORUS-LiTE field catalog for listing of missions
1.3 Estimated data availability



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. Scan configuration choices must be made to prioritize or account for how to observe various components of flow. With one lidar mounted for TORUS-LItE, it was decided that the default scan configuration would be CSM rapid scan operation to enable high temporal resolution profiling of horizontal winds with reasonable accuracy estimation of vertical velocity in most situations. In select instances when platform position relative to storm features was advantageous (e.g., gust fronts, cold pools, updraft cores, etc.), the lidar scan mode was switched to the more traditional “step-stare” and pointed vertically to collect direct information about vertical velocity as features of interest passed over or near the mobile lidar truck position. As noted previously, these datasets are provided *separately* from these wind profile retrievals.

Figure 1. This photo shows the NSSL Doppler lidar truck as it appeared during PERiLS 2022 in deployment mode. This configuration is generally representative of the TORUS-LItE 2023 configuration. 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 available datasets. The field catalog entries offer documentation of collocated radiosonde launches from the onboard system and occasional notes about Windsond launches from NSSL/CIWRO teams coordinating with our location.

3.0 Data collection and processing:

The horizontal winds were produced using the Continuous Scan Mode (CSM) feature available on Halo Streamline DLs. In this mode, the scanner head does not stop moving to take a measurement which allows rapid retrieval of the horizontal wind (and vertical velocity) using the Plan Position Indicator (PPI) scan strategy. The real-time visualizations shown in the field catalog are coarse time resolution (approximately 6-minute retrievals). Quick look images have been created as part of this dataset that are more representative of the processed data. The collected data were post-processed into 10 second wind retrievals using an iterative method based on Steinheuer et. al. (2022).

4.0 Data format:
Data are provided in netcdf format. The typical naming convention is *[platform][instrument][data stream][instrument version].[data level].YYYYMMDD.HHmmss.cdf* following closely to ARM file naming convention. Data levels are typically a=raw data, b=ingested or minimally processed data, and c=value added products. The number in a data level refers to the data version. The 'fp' refers to 'fixed point,' which is our case zenith. The files have time and height dimensions.

Variables provided in *dlcsm* files

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
rows	rows	Rows of covariance matrix
cols	cols	Columns of covariance matirx
u, v, w	Time, Height	m/s, each individual component of the wind
wspd	Time, Height	m/s, wind speed
wdir	Time, Height	Deg, wind direction
wspd_sigma	Time, Height	m/s, Wind speed 1-sigma uncertainty
wdir_sigma	Time, Height	Deg, wind direction 1-sigma uncertainty
rms	Time, Height	m/s, RMS between obs PPI velocities and fitted values
covariance_matrix	Time, Height, Rows, Cols	m^2/s^2, covariance matrix of wind
cn	Time, Height	Condition Number
r_sq	Time, Height	Coefficient of determination, measure of homogeneity
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
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.

5.1. Specific Data Notes
Some users may find this resolution to contain more variability than required or desired for their needs and prefer to add temporal smoothing. A multi-point window approach is usually a good place to start.

5.2 More Info/Getting Started
More information about the platforms included in this dataset are discussed on the BLISS research team's webpage, bliss.science under the resources tab. There are some startup code tools for working with datasets similar to this one. Check out BLISS Code Resources.

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.

Steinheuer, J., Detring, C., Beyrich, F., Löhnert, U., Friederichs, P., and Fiedler, S., 2022: A new scanning scheme and flexible retrieval for mean winds and gusts from Doppler lidar measurements, Atmos. Meas. Tech., 15, 3243–3260, https://doi.org/10.5194/amt-15-3243-2022, 2022.

7.0 Appendix

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