Title: NSSL Mobile Lidar Truck TORUS-LItE Single Lidar Vertical Stare Data

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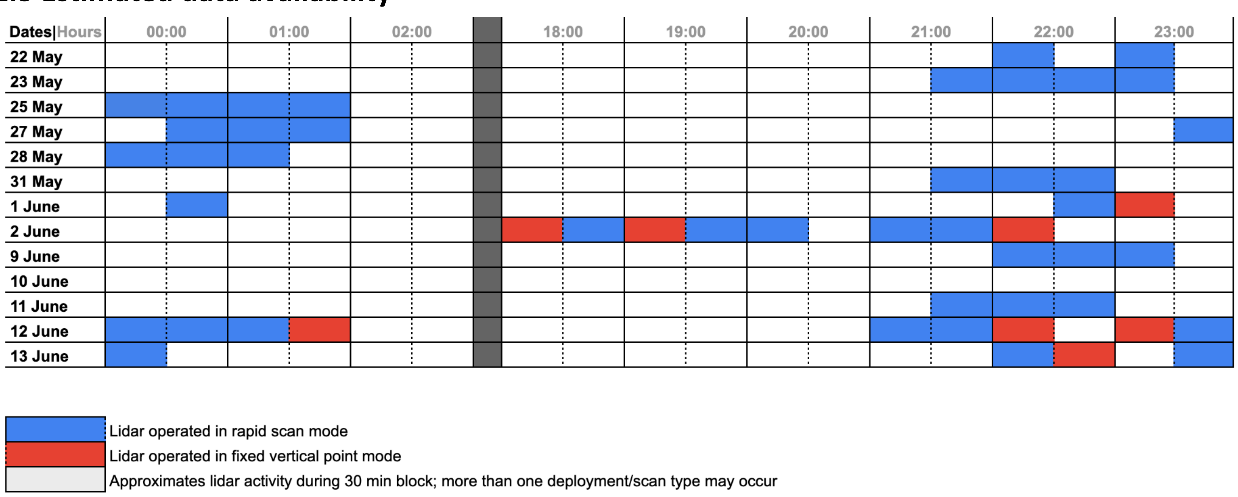
1.0 Dataset Overview

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. 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. This dataset includes the resulting vertical velocity profiles from the vertical stares. Generally, the Doppler lidar operated in Continuous Scan Mode (CSM)*. The wind profile retrievals from those scans are provided separately from these vertical velocity 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.

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, the wind profile datasets are provided *separately* from these vertical velocity profiles.

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 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 more direct than that provided in the horizontal wind profile retrievals. 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, but this is a starting point and should be assessed before applying uniformly.

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 *dlfp* 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
azimuth	Time	Deg, azimuth angle of the scanner
elevation	Time	Deg, elevation angle of the scanner
velocity	Time, Height	m/s,
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

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