Title: 2023 Propagation, Evolution, and Rotation in Linear Storms (PERiLS) ULM Mobile Doppler Wind Lidar (DWL) Dataset

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1.0 Dataset Overview

ULM operated a truck-mounted DWL at locations across the Southeastern United States during the 2023 PERiLS field campaign. The ULM DWL was co-located with the ULM radiosonde system for each Intensive Observation Period (IOP). The choices for locations and operational strategy were made in collaboration with the other PERiLS PIs. The DWL location for each IOP remained fixed for the duration of the IOP. The ULM DWL operated nearly continuously for each IOP, collecting observations using two primary scan strategies: 8-point azimuth VAD scans at 70° elevation every 5-minute and continuous vertically pointing stares in between. This dataset includes both the vertical stare data and the processed horizontal wind retrievals from the VAD scans. Locations and estimated time of data availability for each IOP are given in Table 1 below.

Table 1: Locations and estimated time of data availability

IOP #	Start Date	Site Name	Latitude	Longitude	Estimated Data Availability (UTC)
1	2/16/23	Kewanee, MS	32.4262	-88.4496	1204 – 0054
2	3/3/23	Shelby, MS	33.9536	-90.7570	0046 – 1047
3	3/24/23	Oak Grove, LA	32.8462	-91.3929	1642 – 0200
4	3/31/23	Lawrenceburg, TN	35.2041	-87.3453	1929 – 0612
5	4/5/23	Wynne, AR	35.1974	-90.7923	1054 – 1716

2.0 Instrument Description

ULM utilized the Halo Streamline XR DWL during PERiLS. The DWL is an active remote-sensing instrument that uses a pulsed all-sky scanner (360° in azimuth and –180° to 180° in elevation) to provide measurements of signal-to-noise ratio (SNR), attenuated backscatter (β), and radial velocity (V_R). The DWL operates similar to a Doppler radar, except at near-infrared (IR; 1.5 microns), and is thus sensitive to micron-sized aerosol particles. Aerosols are abundant in the lower atmosphere and act as excellent tracers of wind. As such, the DWL is capable of providing precise V_R measurements in clear-sky conditions. The DWL maximum range is up to 12-km; however, actual maximum range is greatly dependent on aerosol loading, cloud base height, and precipitation. In general, the DWL signal can become attenuated by larger particles. The minimum range, or first useable gate, is typically ~60-m. The DWL offers flexible user configurable scanning modes, such as fixed azimuth/elevation stares, range height indicator (RHI) scans, plan position indicator (PPI) sector or volume scans, and scanning modes to facilitate VAD wind retrievals. In summary, the DWL provides robust observations on planetary boundary layer (PBL) evolution and kinematics through the collection of high spatiotemporal backscatter and velocity data. Table 2 lists other DWL specifications.

Table 2: ULM DWL instrument specifications:

Range	~60-m to 12-km (dependent on aerosol load; user set to 5-km during PERiLS)
Nyquist Velocity	19 m s^{-1}
Range Gate	Configurable, 18- to 120-m (30-m during PERiLS)
Velocity Precision	≤ 0.3 m s^{-1}
Sampling Resolution	~2 Hz sampling

3.0 Data Collection and Processing

Data collection occurred at the sites given in Table 1. Once on site, the DWL was approximately leveled and heading information recorded in the Halo Streamline software. For the PERiLS campaign, the ULM DWL collected 8-point PPI scans at 70° elevation every 5 minutes with the DWL switching to a vertically pointing stare scan in between. The raw DWL data are first processed via the Halo Streamline software based on a variety of user configurable selections such as the gate length and number of rays to average. Note that these raw data files are not available. For PERiLS the gate length was set to 30-m and 10,000 ray averages. The resulting processed scan files contain the range-resolved, line-of-sight measurements of V_R, intensity (as SNR+1), and β. Given the vertically pointing nature of the stare scan, it provides a direct measurement of atmospheric vertical β and vertical velocity profiles. The 8-point PPI scans were further processed through a VAD program to retrieve profiles of horizontal wind speed and direction. A VAD retrieved vertical velocity is also produced, but it is of lower quality than the directly measured vertical velocity from the stare scans. Minimal post-processing was completed on the resulting scan files and VAD retrievals. The datasets were checked for consistency and the VAD horizontal wind data were checked against the co-located radiosonde data.

4.0 Data Format

Two data types are provided for each IOP: vertical stare data and the VAD retrieved horizontal wind profiles. The data files are provided in netCDF format using the following filename format:

lidar.ULM_Mobile_Lidar.YYYYMMDDHHMM.filetype.City_State.nc

Where:

YYYYMMDDHH	→ start time of dataset as 4-digit year, 2-digit month, 2-digit day, 4-digit UTC time
Filetype	→ stare or VAD
City_State	→ nearest city/town name and State where data collection occurred

A new file is generated at 00 UTC for events that span multiple (UTC) days. In the VAD files missing data is giving as *NaN*.

4.1 Stare File Format

The stare data are given in netCDF format with the following variables provided:

Variable Name	Description/Long Name	Units	Array Structure
azimuth	Azimuth angle of scanner (0 deg is north)	deg	1D (time)
elevation	Elevation angle of scanner above horizon	deg	1D (time)
epochTime	Seconds Since 00 UTC 1970 01 01	seconds	1D (time)
time	UTC time in decimal hours since 00 UTC	hours	1D (time)
height	Height above instrument level	meter (*NOTE that netCDF says km*)	1D (height)

backscatter	Attenuated backscatter	$m^{-1}\ sr^{-1}$	2D (time, height)
intensity	Intensity computed as SNR+1	Unitless	2D (time, height)
velocity	Doppler Vertical Velocity (positive is up)	$m\ s^{-1}$	2D (time, height)

4.2 VAD File Format

The VAD data are given in netCDF format with the following variables provided:

Variable Name	Description/Long Name	Units	Array Structure
time	UTC time in decimal hours since 00 UTC	hours	1D (time)
height	Height above instrument level	meter	1D (height)
u	Zonal (U) wind component	$m\ s^{-1}$	2D (time, height)
v	Meridional (V) wind component	$m\ s^{-1}$	2D (time, height)
w	Vertical (W) wind component	$m\ s^{-1}$	2D (time, height)
wd	Horizontal wind direction	Degrees from North	2D (time, height)
ws	Horizontal wind speed	$m\ s^{-1}$	2D (time, height)
r_sq	Coefficient of determination between observed PPI radial velocities & VAD derived radial velocities; measure of wind field homogeneity	Unitless	2D (time, height)
rms	RMS between observed PPI radial velocities & VAD derived radial velocities	$m\ s^{-1}$	2D (time, height)

5.0 Data Remarks

Data Availability: Data should be consistently available for each IOP. However, during periods of very heavy rain and instances where hail was possible the DWL was shutdown to prevent damage to unit. There were instances when the DWL was left operational in precipitation; however, care should be taken when using this data since it will negatively affect data quality. Vertical velocity in precipitation will be contaminated by the fall speed of the precipitation.

Intensity: The intensity variable in the provided stare files can be used as a noise "filter". In many applications using intensity = 1.01 provides an adequate cutoff to filter noise in other variables. The provided VAD retrievals were filtered where intensity ≤ 1.01.

Usage: Users of this dataset are encouraged to reach out to the PI if they discover any data issues. Additionally, users are encouraged to give the PI an opportunity at co-authorship or acknowledgement on any publication that might result from the data.