ReadMe for **PECAN FP2 UMBC Doppler Lidar Horizontal Winds**

Note: This documentation file is based on the documentation file of the line-of-sight data for this instrument (Delgado et al. 2016). The only major addition here is Section 3.2 describing the retrieval of horizontal winds.

Brian Carroll*, Ruben Delgado
Department of Physics
University of Maryland, Baltimore County
1000 Hilltop Circle
Baltimore, MD 21250

*Carroll – brian.carroll@umbc.edu
Delgado – delgado@umbc.edu

*Questions about the data set can be directed to Brian Carroll.

1.0 Data Set Overview

- This data set has taken the line-of-sight (LOS) winds as produced by the commercial Leosphere software and calculated horizontal wind profiles based on the velocity-azimuth-display (VAD) technique (Browning & Wexler, 1968).
- This dataset spans 3 June to 14 July 2015, 24 hours a day, with rare interruptions.
- The instrument was at FP2 in Greensburg, Kansas. lat/lon: 37.605915/-99.275718. Elevation was ground level, 681m ASL.

2.0 Instrument Description

- The Leosphere 200s is a commercially manufactured coherent Doppler lidar. The manufacturer website is *http://www.leosphere.com/products/3d-scanning/windcube-100s200s400s-turbulence-wind-lidar* (not very informative scientifically). The instrument produces line-of-sight wind speeds derived from the Doppler frequency shift in backscattered light from atmospheric aerosols.

Table 1. Instrument parameters.

Parameter	Laser/lidar value
Wavelength	1.54 micron
Pulse Energy	0.1 mJ
Pulse Rate	10 kHz
Range Resolution	50 m
Minimum Range	0.1 km
Maximum Range	6 km

3.0 Data Collection and Processing

3.1 Data Collection and line-of-sight winds

The conical scan routine for the duration of PECAN was constant, except for rare changes to the vertical stare duration (to 300 or 600 seconds). The scan routine is presented in Table 2 and had a runtime of approximately 25/20 minutes per cycle. Range resolution of 50m was used, with the first bin centered 100m from the lidar, second at 150m, and so on out to a maximum of 6km in ideal conditions.

PPI is a conical scan. RHI is a vertical slice. LOS is a single pointing direction, i.e. zenith stare.

Table 2. Lidar scan routine.

Iterations	Mode	Start Az. (°)	End Az. (°)	Start Elev. (°)	End Elev. (°)	Accumulation Time (s)	Speed (°/s)
1	PPI	0	360	5.0	-	1.00	2.5
1	PPI	0	360	7.5	-	1.00	2.5
1	PPI	0	360	10.0	-	1.00	2.5
1	PPI	0	360	20.0	-	1.00	2.5
1	PPI	0	360	45.0	-	1.00	2.5
1	RHI	80	-	0.0	60.0	1.00	2.5
1	RHI	80	-	60.0	0.0	1.00	-2.5
1	RHI	170	-	60.0	0.0	1.00	-2.5
1	RHI	170	-	0.0	60.0	1.00	2.5
600/300	LOS	0	-	90.0	-	1.00	-

- Degrees are measured clockwise from lidar compass heading (approximately magnetic north). Lidar heading is recorded in the header of each data file. NOAA has the appropriate magnetic declination from true north as 5.10°E±0.35°.

3.2 Creating profiles of horizontal wind

Horizontal winds were calculated using a modified approach to the common VAD technique (VAD first introduced by Browning & Wexler 1968), wherein all PPIs were incorporated into creation of a single wind profile. This was done to increase vertical resolution and decrease the minimum observation altitude while still resolving the entire depth of the boundary layer. The radial velocity measurements from the five PPIs were projected to the horizontal plane and considered equally when performing the VAD technique on each height bin. Height bin size was chosen to be 15m, with the first bin center 15m AGL. The two highest PPIs (20 and 45 degrees) were omitted from wind retrievals below 300 m; otherwise all points with good SNR are considered for the VAD.

The Doppler lidar's line-of-sight wind data (Delgado et al., 2016) was initially filtered to omit points below -27.5 dB SNR, then performing VAD retrieval if at least 30 points remained in the given altitude bin. Then R^2 and RMS of the VAD fit were used for additional quality control, removing points in the wind retrieval that had both an $R^2 < 0.85$ and RMS > 2 m/s for high wind

speed (> 10 m/s) or RMS > 4 m/s for low wind speeds (< 10 m/s). The variable RMS threshold accounts for the higher RMS in weak-wind, high-turbulence environments as may be found in the daytime convective boundary layer; the turbulence can result in high RMS despite confidence in accurate retrieval of low horizontal wind speeds. The R^2 and RMS are available in the dataset for further user-defined quality control if desired.

The final step in wind profile creation is interpolation. Bins are centered every 15 meters, but not all get populated (particularly at higher altitudes, beyond the reach of low-elevation scans). Hence, gaps of 5 bins or less (75 m) have interpolated wind speed and direction. In case you want to remove these interpolated points: Values characterizing the VAD fit (e.g. RMSE) have NaNs that correspond to the interpolated points in spd & dir.

4.0 Data Format

Each day's wind profiles are in a separate .nc file. The data file naming convention is *FP2_200S_VADmultiPPI-yyyymmdd.nc*, where *yyyymmdd* is the date. The .nc files contain the following variables:

spd - [m/s] wind speed
dir - [degrees] wind direction, e.g. 180 is coming from south
timeHr - [hours from 00 UTC] mean time of all measurements used in retrieving wind profile
height - [m AGL] altitude of the bin centers
avgSNR - [dB] mean SNR of all measurements used in a given wind retrieval
rsquare - R-squared for the VAD fit
rmse - [m] RMSE for the VAD fit
var - [m^2/s^2] variance of the residuals of the VAD fit
numPointsInFit - number of measurements that went into a given VAD retrieval
minFitPts - if fewer measurements than this in bin, no wind retrieval was performed (constant)
date - YYYYMMDD

5.0 Data Remarks

This dataset is ready for preliminary research. We recommend contacting the author before using in publication to ensure proper interpretation.

Other notes:

- This dataset has not been thoroughly filtered for second-trip echo effects (only a few cases were manually filtered). This rarely impacts the dataset, with the most notable cases being the choppy appearance of the wind profiles around 800m at 10 UTC on 11 June, and the apparent discontinuity in wind direction at 1.3km around 19UTC on 7 July. This type of issue can be addressed further if necessary for a particular study.
- We recommend cautious consideration of data at higher altitudes (i.e. > 1.5km) that do not have continuous data to the surface. These could be cloud returns or second-trip echo not representative of the wind speed.

References

Browning, K. A., & Wexler, R. (1968). The determination of kinematic properties of a wind field using Doppler radar. *Journal of Applied Meteorology and Climatology*. https://doi.org/10.1175/1520-0450(1968)007<0105:TDOKPO>2.0.CO;2

Delgado, R., Carroll, B., & Demoz, B. (2016). FP2 UMBC Doppler Lidar Line of Sight Wind Data. Version 1.1 (Version 1.1) [Data set]. UCAR/NCAR - Earth Observing Laboratory. https://doi.org/10.5065/d6q81b4h.