Readme

This readme file introduces the basics of the Doppler lidar data and gives a detailed description of the variables present in the data files. If you have any further questions about the data and its interpretation, please contact either Alan Brewer (alan.brewer@noaa.gov) or Aditya Choukulkar (aditya.choukulkar@noaa.gov). It is highly recommended to discuss any planned use of this data with NOAA-CSD scientists. If the use of this data in a publication constitutes a major or reasonably significant aspect of an article, co-authorship by an ESRL scientist is appropriate. We welcome collaborations and will lend our scientific expertise in interpretation and evaluation of the data.

1. BASICS:

This section will cover some fundamentals of the Doppler lidar data. This section is written in the context of the WindCube 200S scanning Doppler lidar. The user may skip to the next section if the aspects covered in this section are familiar.

The following are the main data products that are available from a WindCube 200S scanning Doppler lidar.

1.1 Line of sight (LOS) or Radial Velocity:

The line of sight (LOS) velocity refers to the magnitude of the projection of wind vector along the lidar beam direction estimated from the first moment of the spectral information. For the NOAA 200S lidars, negative LOS velocity mean the wind direction is towards the lidar and positive LOS velocity means the wind direction is away from the lidar.

There are three main modes in which this data can be available from a scanning Doppler lidar depending on the scan geometry.

(1) Plan Position Indicator (PPI) or Conical scan: A PPI is a type of scan performed by keeping the elevation of the scanner constant and varying the azimuth resulting in a conical display of the LOS velocity measurements.
(2) Range Height Indicator (RHI) or Vertical slice scan: A RHI is a type of scan performed by keeping the azimuth of the scanner constant and varying the elevation resulting in a vertical slice of LOS velocity measurements.
(3) Stare or Fixed scan: A stare of fixed mode scan is the simplest type of lidar measurement where both the azimuth and elevation are kept constant and the LOS velocity measurements are made.

1.2 Signal to Noise Ratio (SNR):

The SNR is one measure of the quality of the quality of the LOS measurement made by the Doppler lidar. A higher SNR values implies a greater confidence in the LOS measurement while a lower value implies lower confidence in the LOS measurement. The value used to filter out bad data points is subjective. Within NOAA, a SNR threshold of -28 dB is used, i.e. all data below -28 dB are considered bad data.

1.3 Second Trip Echo or Range folding:

Due to the high pulse repetition frequency (PRF) of the WindCube 200S lidar, the unambiguous range of the lidar is 3 km for 25 m pulse (25 m range-gate), 7.5 km for 50 m pulse (50 m range-gate) and 15 km for 75 m pulse (75 m and 100 m range-gate). Therefore during particular configurations, it is possible to get an echo back from the previous pulse after the next pulse has been emitted by the lidar. This causes the lidar to mistake this echo from the previous pulse as coming from the present pulse. This phenomenon is called second trip echo or range folding.

Within the beam data, second-trip echoes are detected by a combination of fuzzy logic identification and clustering. For each scan, sharp discontinuities in SNR/radial velocity are initially flagged as possible spots where second-trip echoes may be located. After which, data points near where these discontinuities are located are clustered by radial velocity and magnitude. Generally, data points are flagged as second-trip echoes (secondTripData values: >4) if the radial velocity is sufficiently different and SNR is larger than the background value within the boundary-layer, where the background signal is generally good. For second-trip echoes that are above the boundary layer, flags are given (secondTripData values: 1 - <4) depending on the magnitude of the SNR and if the echo is apparent at other elevation angles, as outlined below.

1.4 Description of variables in beam data:

There are three types of files created for each of the scan types. Example names are given below:

PPI scan: lidar.z05.a0.20150925.030000.beamData_ppi.nc

RHI scan: lidar.z05.a0.20150925.030000.beamData_rhi.nc

Stare scan: lidar.z05.a0.20150925.030000.beamData_stare.nc

The lidar beam data files uploaded to the DAP has the following variables:

year: The year of the data collected.

scannerHeight: This is the height of the scanner (and the measured data) above the mean sea level. This is given by siteAltitude + scannerHeight. The height of the actual data depends on its range from the scanner and elevation angle of the scanner. For example, if the scanner elevation angle is 90^{o}, then the height of the data is given by siteAltitude + scannerHeight + range.

yDay: This is the decimal day of the year given by the “year” variable.

siteLatitude: Latitude of the lidar location

siteLongitude: Longitude of the lidar location

siteAltitude: Altitude of the lidar location above the mean sea level

worldAz: Azimuth of the lidar beam measured clockwise from North in the world frame. This includes any offsets that may be present in the scanner orientation with respect to the world frame.

worldEl: Elevation of the lidar beam in the world frame. This accounts for any offsets that may be presented in the scanner orientation with respect to the world frame.

range: This is the distance of the center of the data-gate from the lidar.

velData: This is the line of sight (LOS) velocity measured by the lidar

snrData: This is the wide band signal to noise ratio (SNR) of each data point

swData: This is the spectral width or the second moment of the spectral data measured by the lidar

stData: Leosphere derived data status

secondTripData: This is the second trip flag set for each LOS velocity measurement which expresses its probability of being a legitimate measurement or a second trip measurement. Meaning of second-trip flags in beam data:

0-<1 – Data is likely good quality within the boundary-layer, not a second-trip echo.

1-<2 – Data is likely a cloud.

2-<3 – Data is within a low SNR region. Difficult to determine if observation is first- or second-trip echo.

3-<4 – Data is likely a range folded cloud, due to anomalously high SNR for the given height that does not appear at all elevation angles.

4-5 – Data is a second-trip echo within the boundary-layer, due to sharp discontinuity in radial velocity/snr or high spectrum width.

2. Second Order Products:

Wind Profiles: The wind profiles are created by binning the LOS velocity data with height. Assuming homogeneity of the wind in the horizontal, a least squares fit of the LOS data to the radial velocity equation yields the horizontal components of the wind (used to derive the wind speed and direction). The following are the variables in the wind profile files:

version: The version number of the algorithm used to create the wind profiles.

year: Year data was collected

yDay: This is the decimal day of the year given by the “year” variable.

latitude: Latitude of the lidar location

longitude: Longitude of the lidar location

height: Height of the wind speed/dir reported above the ground

speed: Horizontal wind speed

direction: Horizontal wind direction

dSpeed: Horizontal wind speed uncertainty. Lower values are better.

dDirection: Horizontal wind direction uncertainty. Lower values are better.

secondTripWP: Quality control flag for possibility of wind speed/dir measurement to be contaminated by second trip

-1 – Cannot tell if observation is second-trip echo or not. No vertical stare data for comparison.
0 – Wind observation is likely good. Observation is within region where an echo is present in the vertical staring data.
1 – Wind observation is likely due to a second-trip echo, since it is located at a height where there is no echo present in vertical staring data.

secondTripWpVersionNum: Version of the second trip algorithm used.

count: Number of points used in the VAD fit. More points are better.

residVar: Variance of the residuals of the fit. Lower values are better

avgR: Average horizontal radius of the points that went into the VAD fit. Used as a measure of the horizontal footprint of the measurement.

3. Recommended QA/QC Procedure:

3.1 For Line of Sight (LOS) Product:

For the LOS data the following two step procedure is recommended.

1) Filter out the second trip data by using the "secondTripData" flag. An optimal threshold is to remove data with flag value above 3. For more conservative QC, data with flag value above 2 can be removed.
2) Filter data based on SNR threshold. For optimal results, data with SNR below -28 dB and above 0 dB can be filtered out. For more conservative QC, remove data with SNR below -25 dB and above -5 dB.

For further details on the use of the LOS data and QC procedure, please contact the instrument owners.

3.2 For Second Order Products:

The recommended QA/QC procedure for the wind speed and wind direction profiles is given below:

1) First filter out data suspected of being second trip contaminated. For this remove data that has secondTripWP flag of 1 for optimal QC and for more conservative QC remove data with flags 1 and -1.
2) Remove data that does NOT meet the following criteria:
    a. residVar/sqrt(count) <= 0.15
    b. count >= 20
    c. dSpeed >= 0.002

Current tests reveal that the above QC procedure removed almost all outliers. More testing is underway and the above numbers will be tweaked if a better QC procedure is available. Please contact the instrument owners to check if a newer QC is available or if there are questions about how the above procedure was determined.

4. Site Description:

The NOAA-ESRL 200S scanning Doppler lidar is deployed at the Wasco airport, north of the runway, at Lat: 45.590134; Lon: -120.672018. A photograph of the instrument as installed and the site map are shown in Figure 1 and 2 respectively.

Figure 1. Photograph of the lidar installation at Wasco looking North-Northeast

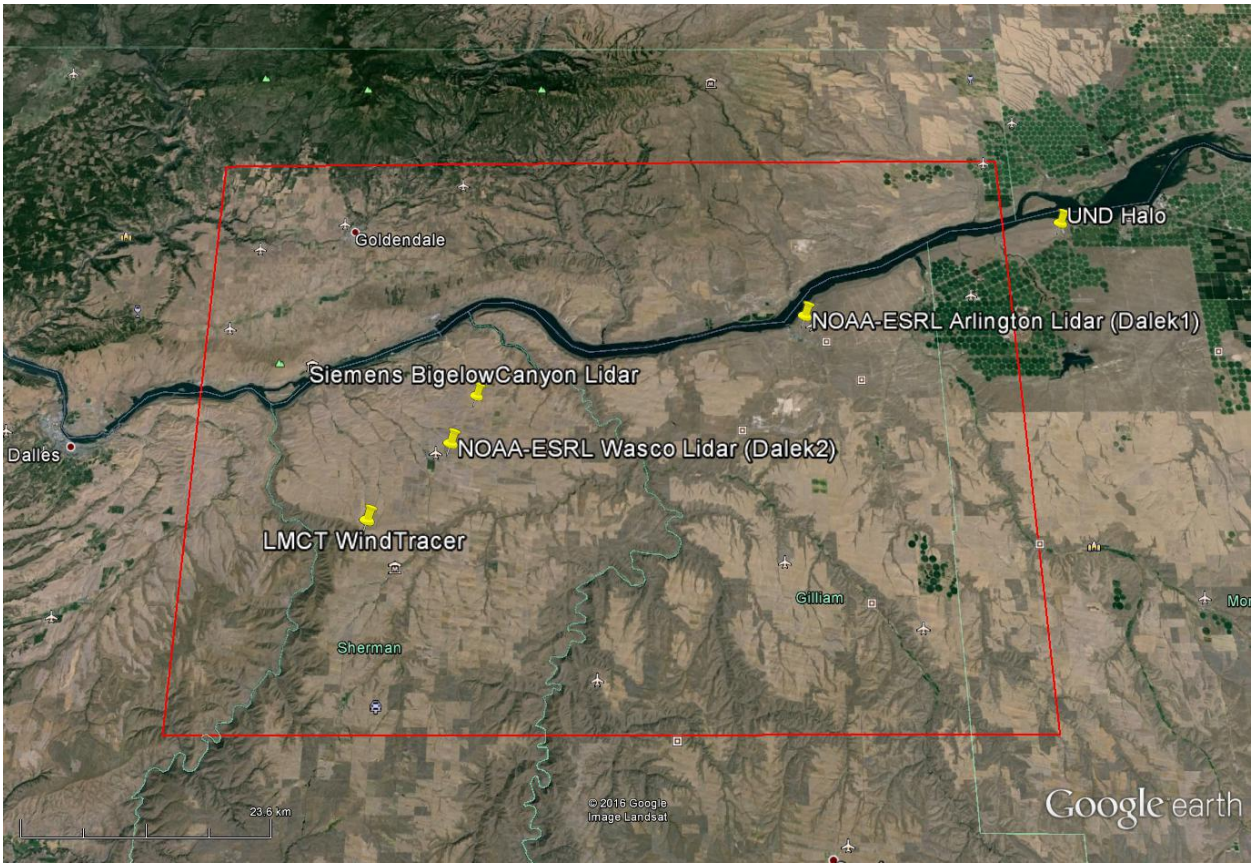

Figure 2. Scanning lidar locations (yellow pins) and the approximate boundary of the Eastern Gorge study area (red).