REVIEW OF DATA FROM THE PNNL OFFSHORE LIDAR BUOY NEAR VIRGINIA BEACH, VA

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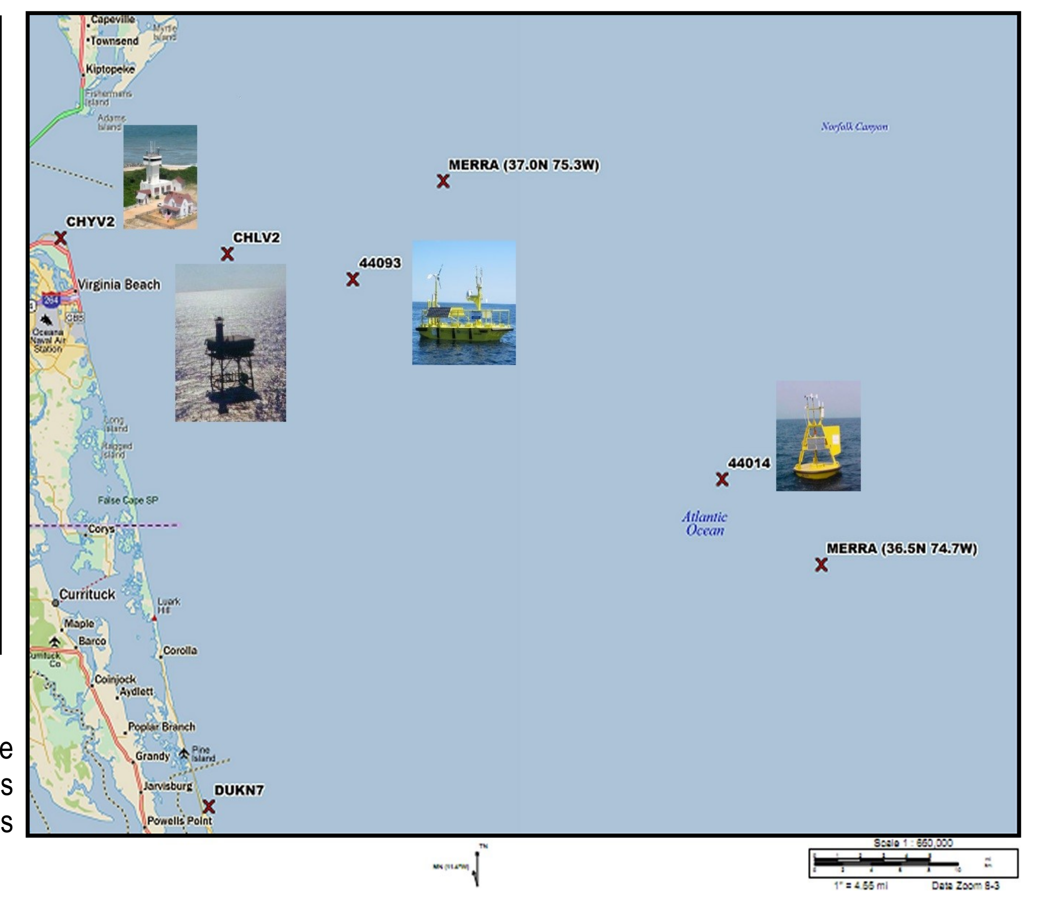
Abstract

Approximately 15 months of wind data have been collected at the Pacific Northwest National Laboratory (PNNL)[1] offshore Lidar Buoy near Virginia Beach, VA at the Dominion VOWTAP project site. Collecting wind data using a Lidar on a floating offshore buoy presents a set of technological problems and yields some surprising results about the structure of the atmosphere in the offshore environment. Careful consideration of the Lidar data processing parameters was required to get converging statistics from the data. Reprocessed data have been correlated to local data sources.

Data from the Lidar were processed to 10-minute averages by the Vindicator system. However, details of the process of data reduction were unknown. Thus, even though the data recoveries were reported to be high, the data showed some unusual characteristics such as a strong negative shear above 90 meters.

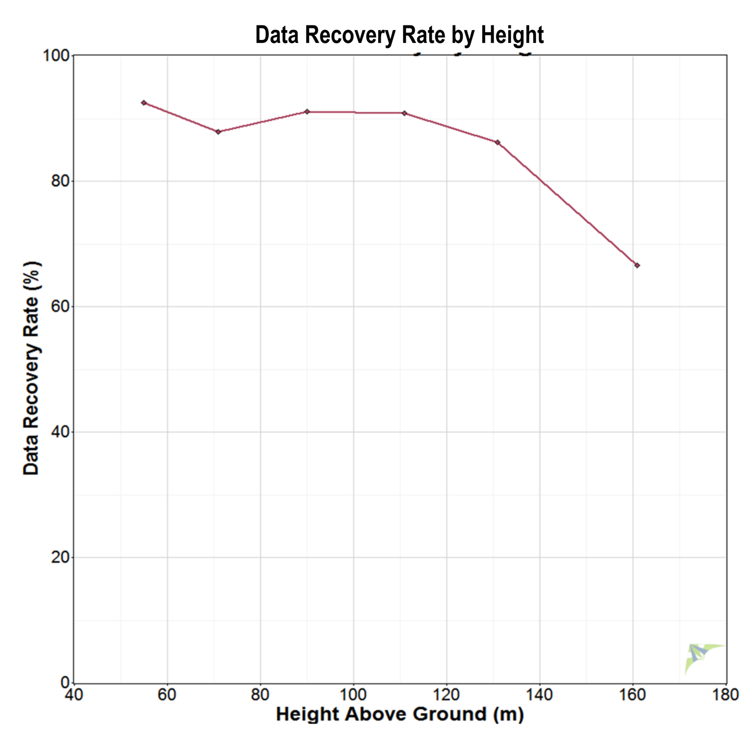
PNNL AXYS Technologies offshore Lidar buoy

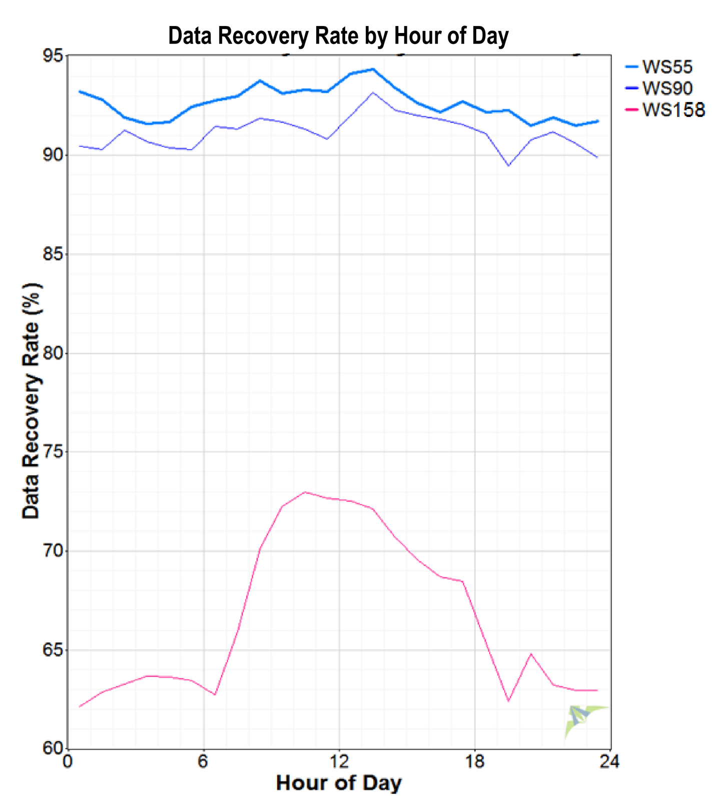


PNNL Lidar buoy **44093** relative to the Chesapeake Light Tower (**CHLV2**), surrounding MERRA nodes and National Data Buoy Center (NDBC) sites

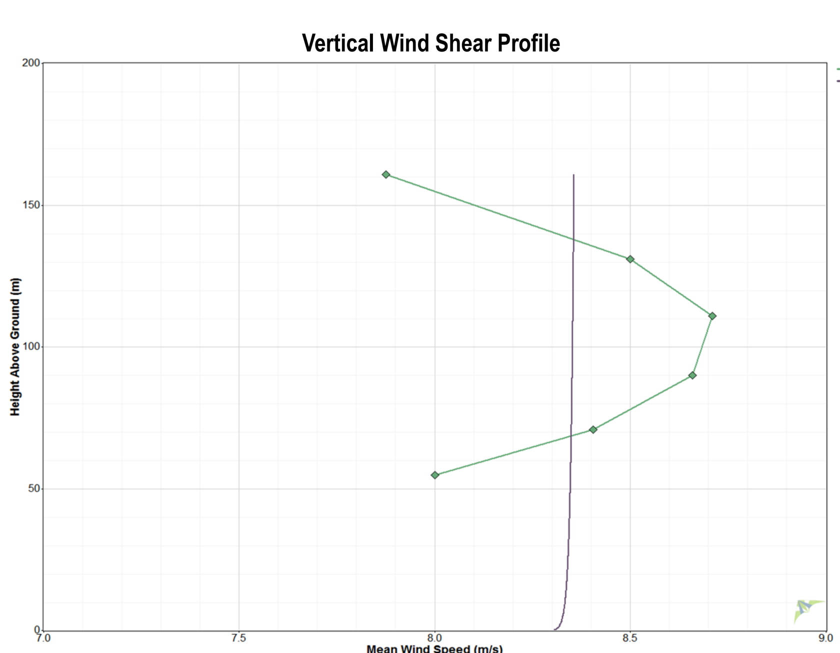
Initial Vindicator dataset

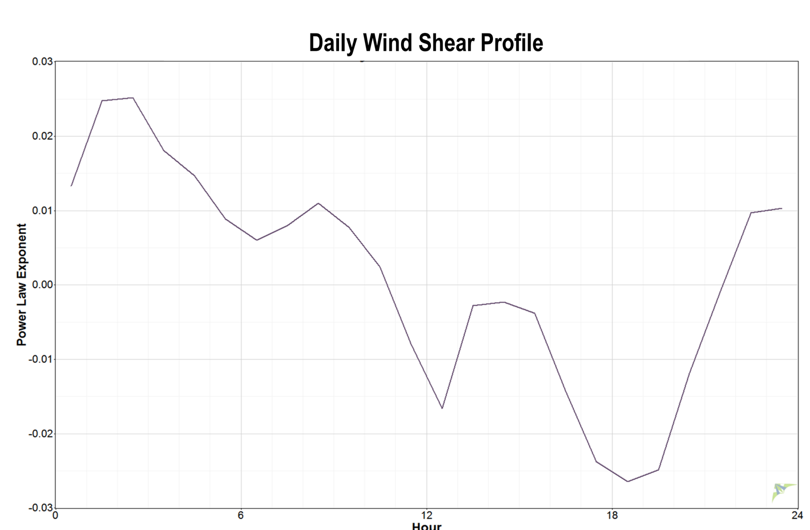
Range gate	Lidar 55.7m	Lidar 71.1m	Lidar 89.4m	Lidar 109.7m	Lidar 128.7m	Lidar 157.7m
Data recovery rate (%)	92.6%	87.9%	91.2%	90.9%	86.3%	66.6%
Mean wind speed (m/s)	7.90	8.35	8.55	8.51	8.27	7.97





The very unusual shear profile and the apparent 'low level jet' and negative shear were not expected at this site. Therefore further study was initiated.





The raw 1-second data were reprocessed to produce new 10-minute averages. The data recovery rates were very strongly dependent on the Signal Strength Threshold (SST). SST is one of the parameters used to process the Doppler signals and is a measure of the quality of the signal. Further, the statistical quality of the averages was influenced by the data recovery.

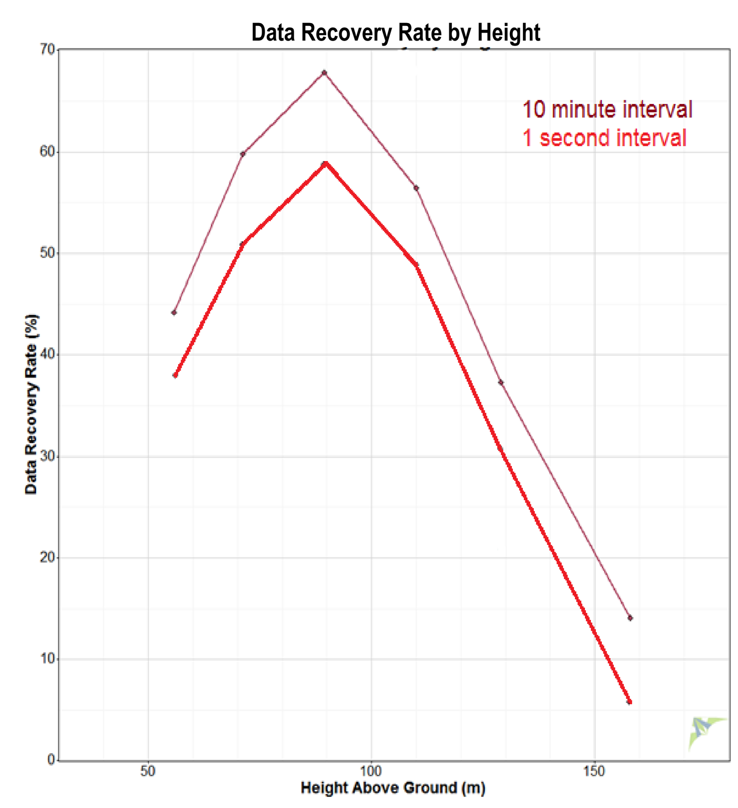
A range of SST values from 20 to 120 were studied. For high SST values (resulting in very few data points in a given 10-minute average) the data recovery plummeted. Data recovery improved as the threshold was lowered (i.e. more data accepted). Additionally, two biases were introduced for the higher SST values; one towards higher average wind speeds and a diurnal bias in data recovery towards mid-day.

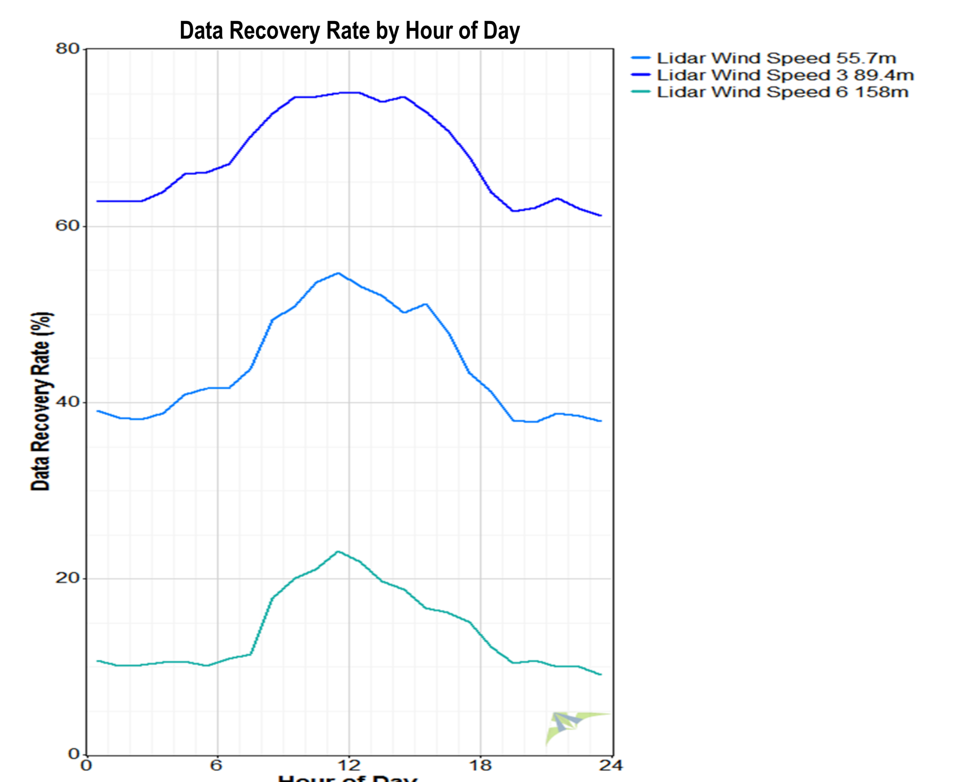
Therefore, a tradeoff between acceptable data recovery and stable or convergent statistics was required. The wind speed averages and other statistics were shown to be generally stable for higher SST values. For example, the SST 60 dataset showed an average increase in data recovery of 141% over the SST 100 dataset. Even though the wind speed averages based on the SST 60 dataset still indicate a bias, they were acceptably convergent.

Reprocessed SST 60 dataset

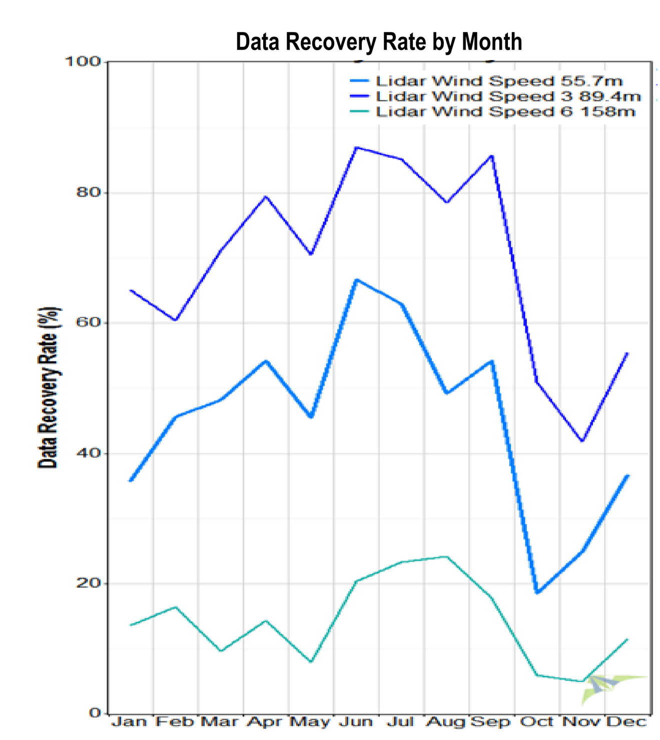
Range gate	Lidar 55.7m	Lidar 71.1m	Lidar 89.4m	Lidar 109.7m	Lidar 128.7m	Lidar 157.7m
Data recovery rate (%)	44.2 / 37.0 %	59.8 / 51.0 %	67.9 / 58.2 %	56.5 / 48.0 %	37.3 / 30.7 %	14.1 / 10.8 %
Mean wind speed (m/s)	9.33	9.60	9.81	9.93	9.94	9.84

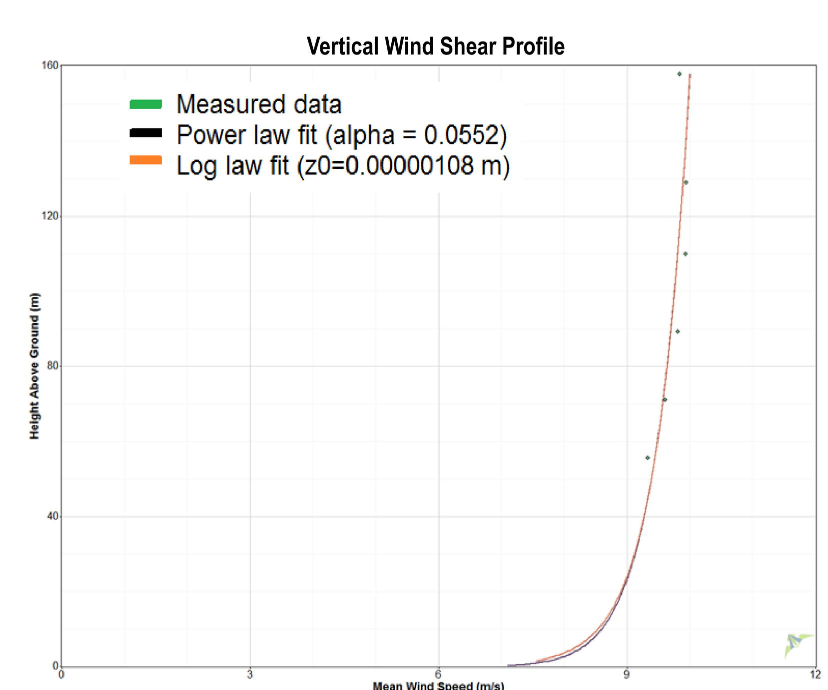
Data recoveries for both 10 minute average / 1 second intervals concurrent at all heights



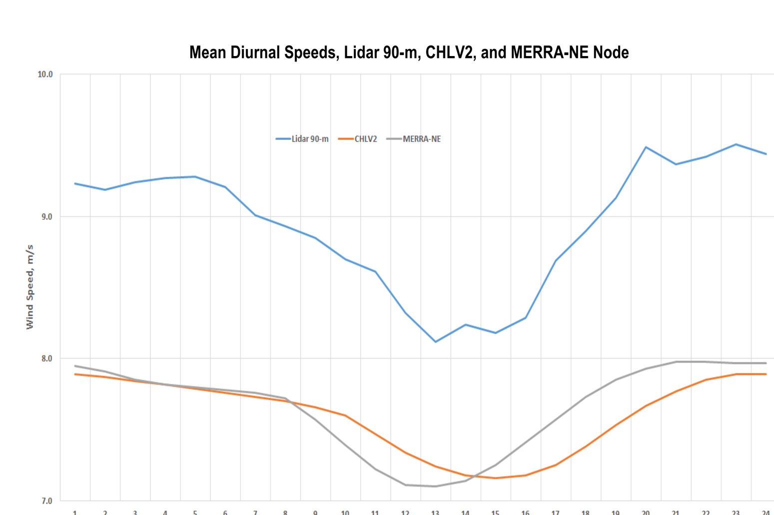


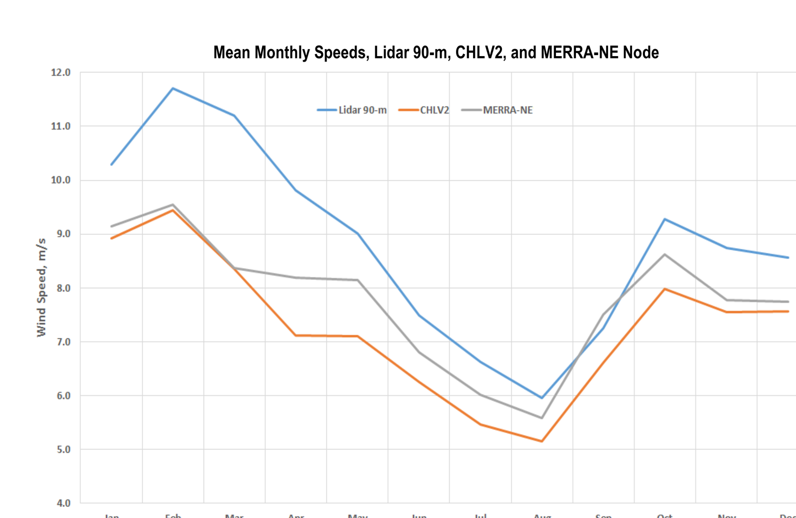
In the SST 60 data set, bias is noted in the diurnal data recovery pattern with the highest data recovery occurring at noon. However, the peculiar negative shear that showed up in the original data set is now gone. Additionally, there is increased data recovery during the summer months.





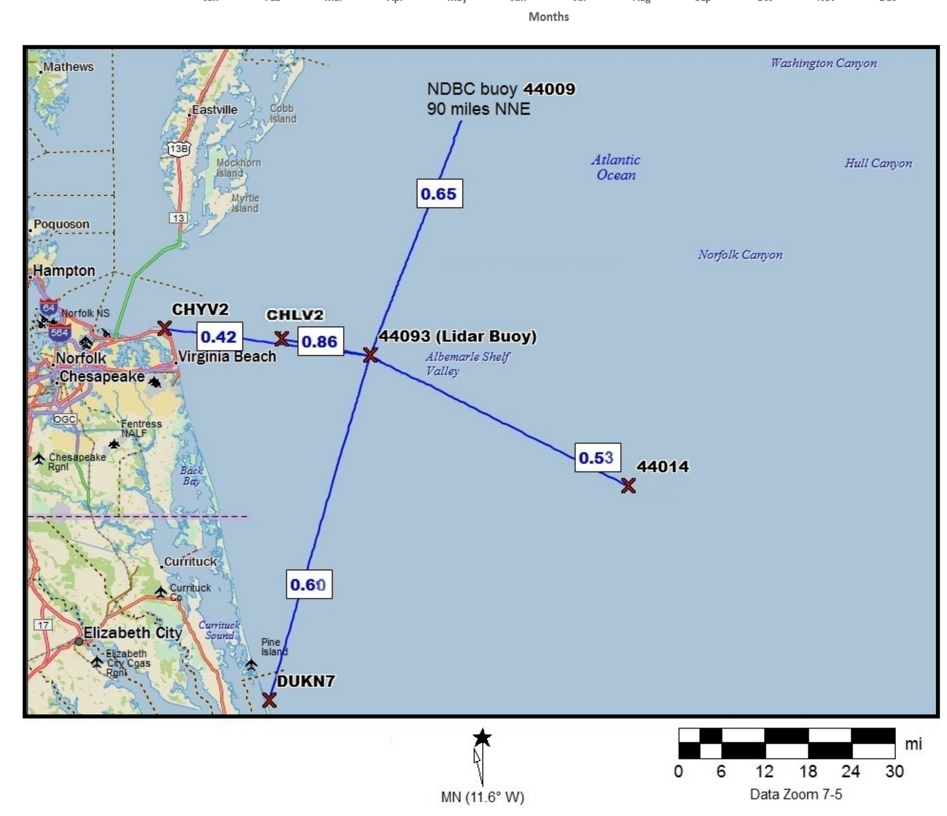
The reprocessed Lidar data were correlated to several long term references. Shown below are the average diurnal and monthly wind speeds for the Lidar, Chesapeake Light Tower and a MERRA node NE of the Lidar buoy. As shown on the map, the Lidar correlated best to the Light Tower which was* a very important long term reference in this region as it was the only long term offshore reference station with data above 10 meters. Future project revenue could be adversely affected due to the increased uncertainty inherent in the lack of a suitable long term reference station.





Conclusions

Remote sensing with Lidar is an important tool in wind resource assessment for both onshore and offshore applications, but has significant challenges. The Lidar is influenced by atmospheric conditions, aerosols, and the complexity of the equipment and signal processing. Additionally, offshore applications are subject to ocean conditions, waves, salt spray, and pitch and roll. Meteorological data collected with remote sensing tools, such as Lidar and Sodar, as with conventional tools (met masts and anemometers) require a highly qualified individual to review and evaluate the data. Some data sets may appear valid, but might not be consistent with expected meteorological conditions (i.e. strong negative shear over the ocean in this case). A stable platform such as the Chesapeake Light Tower may have eliminated some of the issues that were experienced. Additionally, the loss of the Chesapeake Light Tower may have a serious impact on possible future projects as well as the nearby MERRA nodes.



[1] Special thanks to Dr. Rob Newsom of PNNL for his insight and assistance in reprocessing the Lidar data.

*On 8/26/16, the Chesapeake Light Tower was disestablished due to deteriorating structural conditions. NBDC.Station CHLV2 - Chesapeake Light, VA. http://www.ndbc.noaa.gov/station_page.php?station=chlv2. accessed 9/20/2016.