Investments in renewable energy are increasing due to climate change and opportunities for economic growth. Wind energy in particular has become a leader of renewable energy owing to an abundant amount of wind resource as well as on- and offshore research through numerical modeling. Most numerical studies however, interpret winds with coarse resolution, and thus neglect the variability of winds at the scale of a turbine. As a result, little is understood about how local changes in wind impact wind farm power performance and turbine degradation. To overcome this obstacle, long-term measurements of wind and turbulence profiles are required to determine turbine type and locations best suited for wind farm installations.

Most turbines currently built in Wind Energy Areas (WEAs) exceed the measurement capability of platforms such as buoys and meteorological towers. In addition, the variability of wind—both in time and space—is not well known for offshore locations, particularly for cases where power law relationships no longer apply, i.e. when the surface layer sits beneath portions of the turbine rotor diameter. As a result of the inability for traditional methods to measure wind across current turbines, investigations utilizing remote sensing instruments have been performed as alternative measurement tools for detecting wind near the surface to high altitude.

Measurement field campaigns onshore have extensively demonstrated that Doppler LIDAR (LIght Detection and Ranging) instruments in particular, can accurately determine properties of wind such as wind shear and turbulence—aspects which are important when considering the impact of structural integrity on a turbine. Recently however, research utilizing Doppler LIDARs has shifted towards offshore due to an increased investment in offshore wind energy, which is the result of better wind resource estimates and lesser resistance from communities for wind farm construction over open water.

The research presented contributes to offshore efforts by providing a measurement case study of a Low-Level Jet (LLJ) during July 19th, 2013 in the Maryland Wind Energy Area (MDWEA), from a research vessel, using a pulsed Doppler LIDAR system to remotely sense winds from near the surface to 220 meters. Changes in the vessel's orientation and position relative to the wind incorporated motion artifacts that had to be removed using a motion compensation algorithm. The Line of Sight (LOS) wind was compensated for both translational and rotational velocities where the corrected wind speed, wind shear, and turbulent kinetic energy (TKE) was derived at all heights. Wind speed profiles of the LLJ, shows an increase of jet strength from 20:00 LST, which maximizes at 02:00 LST, followed by a collapse of the jet at 03:00 LST. During the jet's evolution, strong shear produces intermittent turbulent bursts, which are evident in the TKE profiles. The maximum amount of turbulence occurs during the time of collapse, which is nearly an order of magnitude greater than the other turbulent features.

In addition to analyzing the compensated results of the Doppler LIDAR, the back scatter ratio (BSR) profiles from an aerosol LIDAR—positioned near the Doppler LIDAR—was analyzed and compared with features in the wind data for the first 2 ½ hours of the LLJ. According to the BSR, a clearing of aerosols occurred after the first hour near the surface, which is coincident with the time turbulence production began. As a result, the marine boundary layer (MBL) height—calculated using the location of wind maximum (Doppler LIDAR) and gradient in BSR (aerosol LIDAR)—displayed an increase, where mixing occurred as the result of shear producing turbulence near the surface and above the boundary layer.

Both methods used for estimating the MBL height show reasonable agreement, where the largest source of error is contributed to the relatively coarse resolution of the Doppler LIDAR (20m) compared to the fine resolution of the aerosol LIDAR (1.5m).