# Inter-comparison of Vertical Profiling Instruments for Boundary Layer Measurements in an Urban Setting

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Abstract

A collection of surface based remote sensing instruments have been deployed In the NYC metro area for the purpose of characterizing the lower atmosphere and investigating air flow and atmospheric dispersion. With the addition of a network of rooftop surface stations and by ingesting data from various other available observational networks as well as assimilated data from modeling systems, we are able to compare the vertical profiling instruments to one another, identifying the strengths and weaknesses of the various assets that comprise the network of urban environmental observations. We compare the return signals from radar wind profilers (RWP), sodars and lidars. These comparisons allow us to calibrate the performance of similar instruments and they point out the issues that must be addressed when using non similar instruments for making similar observations.

# 1. Introduction

The City College of New York's Optical Remote Sensing Laboratory operates a unique urban sensor network system that measures and records various meteorological conditions using conventional meteorological stations located on high sky scraper roof tops as well as rooftop based remote sensing instruments that profile the vertical structure of the urban atmosphere in the NYC metro area. An illustration of these instruments and their locations is shown in Fig. 1 below.

**CCNY Vertical Profiling and Roof Top Stations in the NYC Metro Area**

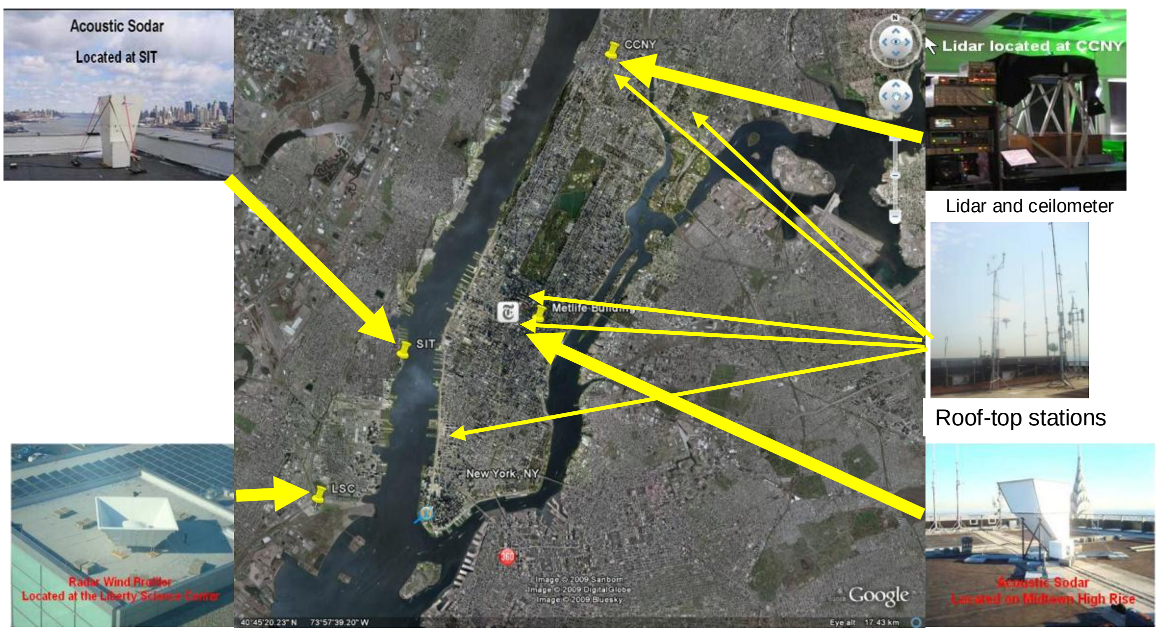
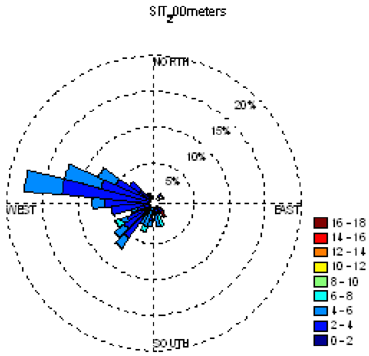



Fig. 1 Illustration of some of the CCNY remote sensing instruments and their locations

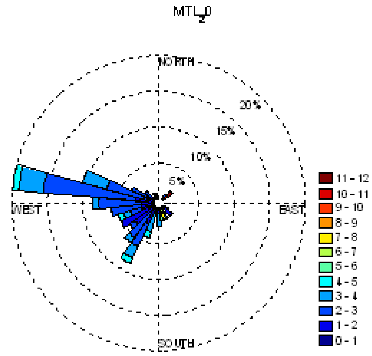
This equipment is located on or near the tops of high buildings, some of them many hundreds of meters above ground level. The network consists of two sodar wind profilers each capable of measuring up to 200 m above the instrument, a Radar Wind Profiler capable of reaching up to 2 km horizontal and a vertically pointed aerosol profiling lidar capable of reaching 10 km above ground. Some strategically located MET stations make point measurements from towers located on the tops some of the highest buildings in the city. In addition, wind and other weather data from a network of hundreds of standard MET stations in the region (not shown) is being ingested in to our data collection archives. The wind profilers measure and record both vertical and horizontal wind speeds and directions continuously. In addition, conditions of the atmospheric boundary layer are being monitored using the wind profile information in conjunction with the vertical profiles from the lidar. The observations from these remote sensing and building top instruments and the hundreds of Met stations across the region are accessible via the web and are being archived in support many modeling efforts underway both at CCNY and amongst our partner organizations.

# 2. Intercomparison of vertical profiling instruments

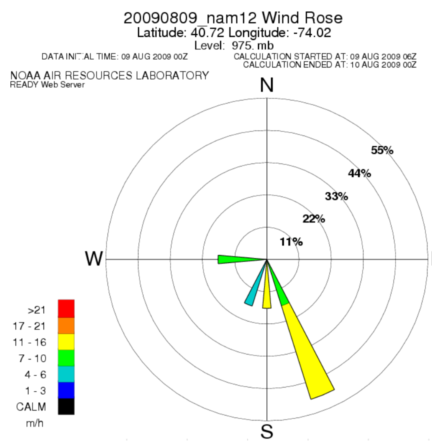
We compare the return signals from radar wind profilers (RWP), sodars, lidars and the building top met stations. As an example, the wind rose plots from two roof top mounted sodars are shown in Fig. 2. Fig. 2(a) shows the wind rose from the Sodar on top of a building (about 100 m above sea level and 200 m above the sodar) at Steven's Institute of Technology in Hoboken, NJ and Fig 2(b) is the wind rose from the Sodar on top of a midtown Manhattan high rise (about 240 m above sea level and 20 m above the sodar). This particular day (August 9$^{th}$, 2009) gave very similar observations however, a noticeable discrepancy between the observed wind roses and the wind rose generated at the closest grid point of the 12 km NAM output on this day is shown in Fig 2(c).




(a) Wind rose from SIT




(b) Wind rose from MTL




(c) 12 km NAM output

Fig 2 Comparing wind roses from two closely located sodars to the 12 NAM output

These observations are also being compared to the return signals from two Radar wind Profilers in the area and various observations from surface stations. In addition to the mean wind field observations, these instruments are also capable of providing information on atmospheric stability and boundary layer heights. We are comparing observations from the surface networks and Doppler profilers to aerosol concentration vertical profiles and by using automated algorithms we determine mixing layer heights. This correspondence between mixing layer heights determined from aerosol lidar backscatter and convective mixing layer heights as measured by the radar wind profilers is usually very good during daytime where convective heating is dominant. However, the aerosol layer approach is still being investigated. Comparisons between Lidar returns and Ceilometer returns are illustrated in Fig 3. We have used both an edge detection filter approach and a wavelet approach for determining the mixing layer heights. We find that the edge detection filters used for processing lidar is not well suited for the low SNR of the ceilometer and the wavelet approach is more robust there.

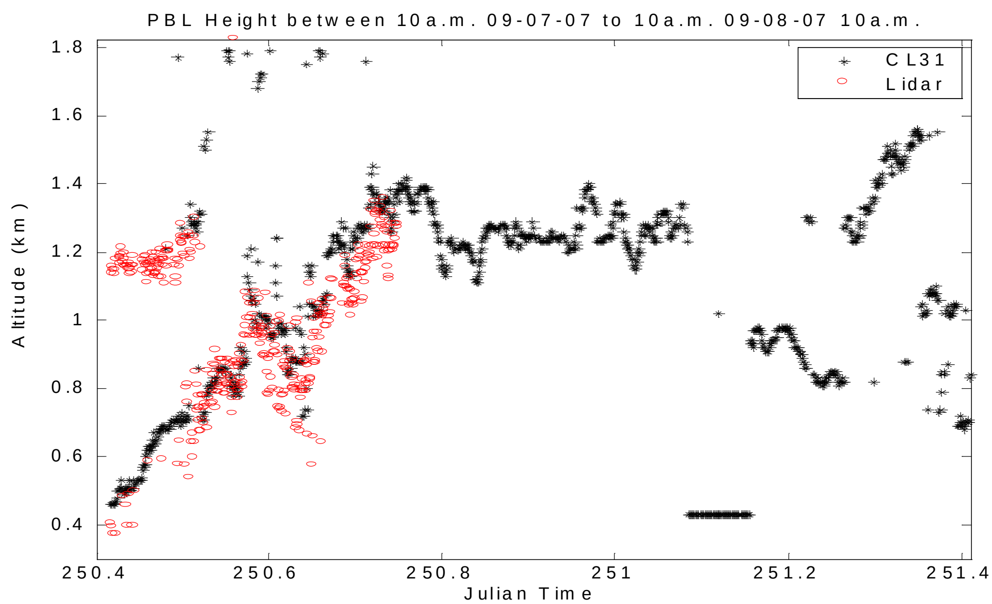



Fig. 3 Comparing the mixing height derived from the Ceilometer using a wavelet approach to the lidar derived mixing height using an edge detection approach.

An archive of the Lidar derived PBL mixing height in the NYC metro area is being kept and we are in the process of looking at seasonal variations. Fig. 4 shows a plot of this data for 2006. A general trend displaying higher mixing heights in the summer months is observed

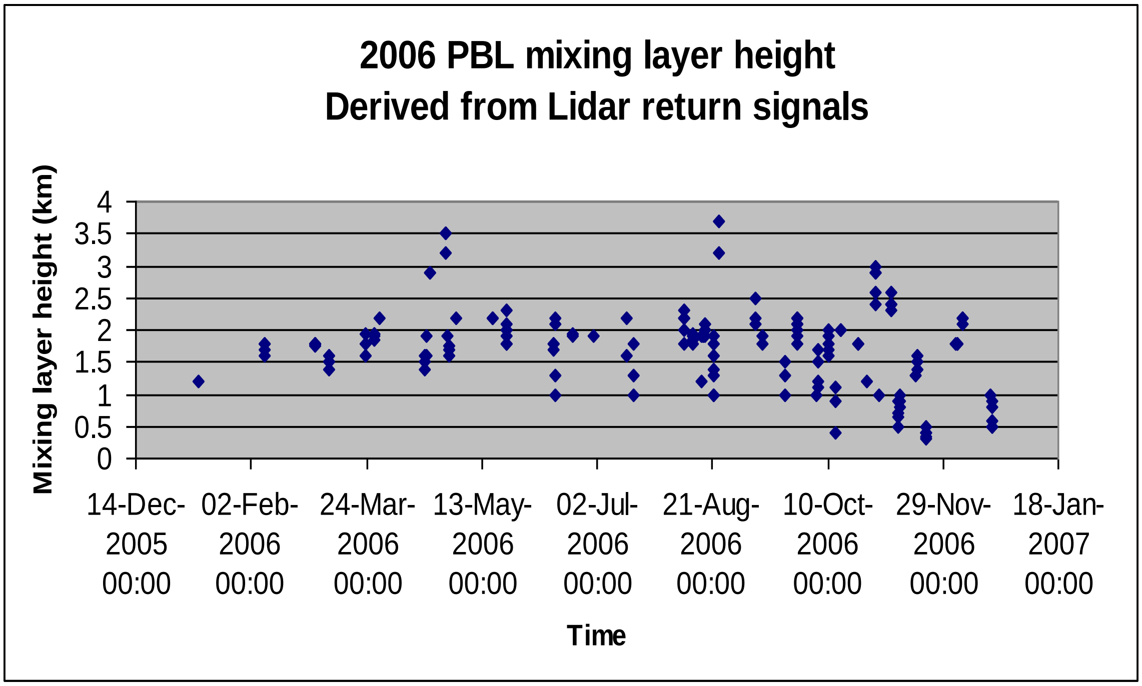



Fig. 4 PBL mixing eight derived from backscatter lidar returns

# 3. Conclusion

Besides providing an important service to the New York City Metropolitan Area by supplying useful and timely air transport information, the CCNY network of remote sensing instruments and the NYC MetNet may act as a test bed for advanced studies of the dispersion of air particles under complex conditions with applications such as air pollution monitoring and support for emergency management. Acknowledgement: This work was partially supported by the NOAA Interdisciplinary Scientific Environmental Technology (ISET) Cooperative SCIENCE Center under grant # NA06OAR4810187