Mobile lidar measurement of anthropogenic atmospheric phenomenon

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Aerosols play an important role in the global climate, air pollution and aviation transportation. In the recent years, aerosol lidar has been routinely used to remotely monitor aerosol concentration. A car mounted mobile lidar offers a compact solution to study the regional inhomogeneity in the atmosphere.

Mini Micro Pulse Lidar (MiniMPL) is a miniature aerosol lidar designed by Sigma Space Corporation. It is capable of measuring aerosol up to 15km. It measures 32cm x 22cm x 50cm and weighs 13kg. The small form factor and low power consumption (<100W) make the MiniMPL ideal for mobile aerosol measurement in vehicles as small as a passenger sedan.

We mounted the MiniMPL in the trunk of a Toyota Prius with a vibration isolation mount (Figure 1). A Microsoft Surface Pro tablet controls the data acquisition. The location data of the MiniMPL is reported by a GPS and integrated into saved lidar data. The entire system is powered by a 125W car power inverter.

The first measurement was done to map how the Planetary Boundary Layer (PBL) varies around a city. The measurement route is along interstate highway 495 (Capital Beltway) which encompasses Washington, D.C. The total length and diameter of I-495 are about 100km and 27km correspondingly. The experiments occurred from 15:23EST and 17:30EST on 02/11/2014. We drove counterclockwise from the east side of the beltway (Point A in Figure 2(a)) and returned to point E.

We then compare the measured PBL height from a fixed site (Point A) to the mobile measurement in Figure 2(b). The mobile measurement follows that of the fixed site but is about 100-200 meters lower between point B and D. This difference cannot be explained by the 20 to 40 meter elevation difference from B to D as compared to A; however, the west side of the beltway is less populated than the east side. In this case, the height of PBL seems to be positively correlated with population density and/or human activities.

In another measurement we drove along highway G107 between the areas of two Chinese cities in 03/14/2014. We planned to compare the aerosol signature within the cities, in the suburb and around certain hotspots. The driving distance between the two cities is about 160km and the whole measurement takes about 9 hours (lunch break included).

From Figure 3(a) and 3(b) the data points F-G-H-I circles the city of Baoding. Their Aerosol Optical Density (AOD) is significantly higher than most other part of the route due to city emission. The section along B-C-D not only has higher average AOD than nearby area, it also has several hotspots from local clustered factories and residence. The hotspot is repeatable in both ways, indicating they are not spontaneous emission. The depolarization ratio, on the other hand, does not show any hotspot. Its value remains about 0.1 along the whole route. This value is representative of a smoggy atmosphere, which is a typical result of anthropogenic emission in China.

We show that the lidar mobile measurement is capable of remotely capture area dependent features of the atmosphere. When the features are of anthropogenic nature, we can then back trace to find related human activity and offer potential solutions.

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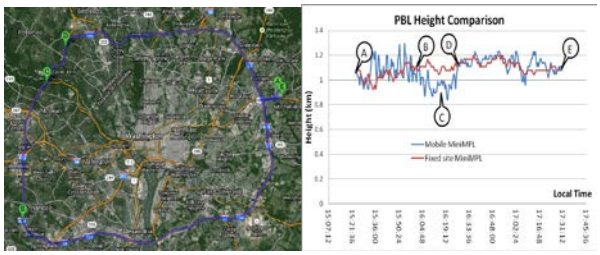
Figure 1. The mobile lidar kit consists of a MiniMPL, a car mount, power inverter, GPS and Microsoft Surface Pro tablet.



(a) (b)

Figure 2 (a) Google satellite map of the route of mobile measurement around Washington D.C. (b) Comparison of PBL height measured from fixed site and mobile station.

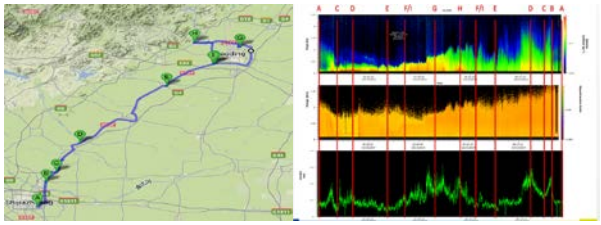


Figure 3 (a) Google terrain map of the measurement route between Shijiazhuang and Baoding in China. (b) From top to bottom, Extinction coefficient, depolarization ratio and AOD.