Direct observations of particulate matter dispersion over an urban area in Helsinki

V. Vakkari[1], E. J. O'Connor[1,2], A. Hirsikko[1] and A. Kousa[3]

[1]Finnish Meteorological Institute, Research and Development, FI-00101 Helsinki, Finland.
[2]Meteorology Department, University of Reading, Reading, UK
[3]Helsinki Region Environmental Services Authority HSY, FI-00066 HSY, Finland
Keywords: PM10, traffic emissions, lidar, urban aerosol.
Presenting author email: ville.vakkari@fmi.fi

Air quality in urban areas is strongly dependent on both the sources of gaseous and particulate pollutants and their dispersion and advection in the atmosphere. A scanning Doppler lidar provides direct observations of horizontal wind and turbulent mixing profiles. Furthermore, low elevation angle scanning enables the observation of the spatial distribution of particulate matter within approximately 1 km radius of the device. Here we utilised a scanning Doppler lidar to investigate the horizontal dispersion of particulate matter from a busy intersection in Helsinki, Finland.

A Halo Photonics scanning Doppler lidar was located on the roof of the Finnish Meteorological Institute (FMI) building on the Kumpula campus (60.20°N, 24.96°E) in March-April 2015. Two consecutive sector scans at elevation angles of 0° and 5° from horizontal were taken every 20 minutes during the campaign. The aerosol backscattering signal was corrected first for background profile (Manninen *et al*, 2015), telescope function and calibrated. The backscatter coefficient, β, was then obtained by correcting recursively for attenuation assuming a constant lidar ratio of 40 sr. On average, the attenuation correction was 2 %. Additional scan routines for horizontal wind profiles and vertically-pointing stares are then utilised to determine the turbulent properties of the boundary layer.

The FMI building is located on a hill next to one of the major roads leading to the city centre from the north; approximately 300 m southeast of the building the road diverges into one branch to the southeast and another to the southwest. The sector scans we applied covered this intersection and extended over recreational areas to the east and west of the intersection.

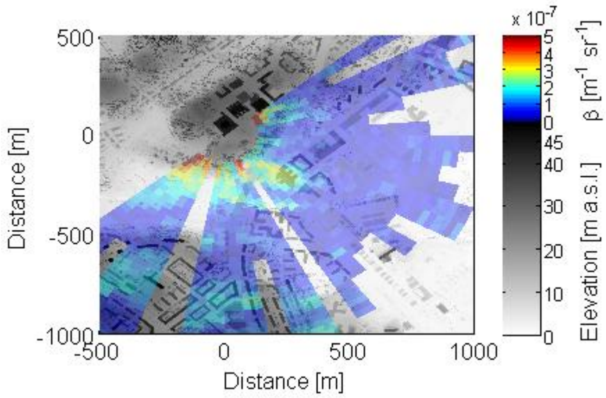

Figure 1. Horizontal distribution of β from a 5° elevation angle scan on 26 March 2015 at 08:40 local time overlaid on terrain elevation map. Positive y-axis is to the north; the lidar is located at (0, 0).

Figure 1 displays β from a 5° elevation angle scan. On this day fresh air is advected by easterly winds from the nearby Vanhankaupunginlahti bay recreational area and the increase in β over the intersection is clear. Furthermore, Figure 1 shows how the region of elevated β extends at least 500 m downwind of the intersection.

A comparison of hourly mean PM_{10} concentration from HSY Kallio monitoring station (1.9 km southwest of the lidar location at Kumpula) with hourly mean β from 0° elevation angle sector scanning on 26 March 2015 shows surprisingly good agreement (Figure 2). It should be noted that the relative humidity was less than 65 % for most of the day, reaching 75 % only shortly during early morning hours. At higher relative humidity, hygroscopic growth of the aerosol particles can dominate changes in observed β, as can intermittent cloud and precipitation.

In conclusion, low elevation angle scanning with a lidar opens up a new way of studying the spatial variability in PM_{10} over urban areas. For instance, applying the linear fit in Figure 2 to β in Figure 1 suggests that PM_{10} is less than 10 µg m^{-3} upwind of the intersection, but downwind of it PM_{10} may reach 50 µg m^{-3} or even higher.

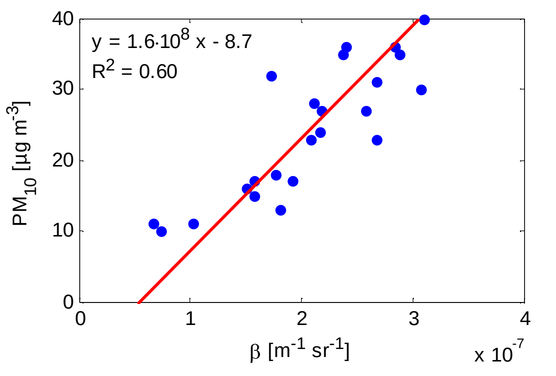

Figure 2. Comparison of hourly mean β obtained from 0° elevation angle scan due east of the FMI building and *in-situ* PM_{10} from HSY Kallio station on 26 March 2015.

This work was financially supported by the Nessling foundation (grants 2013006 and 201500326) and Academy of Finland (grant 272041).

Manninen, A. J., O'Connor, E. J., Vakkari, V. and Petäjä, T. (2015) *Atmos. Meas. Tech. Discuss.* **8**, 11139-11170.