Influence of source specific black carbon production and meteorology on spatio-temporal distribution of black carbon concentration in Central-European basin

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Keywords: black carbon, source apportionment, planetary boundary layer
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Black carbon (BC) is a product of incomplete combustion of carbonaceous fuels, with major contributions from fossil fuel and biomass combustion. Black carbon is a good indicator of primary emissions. Inhalation of BC particles is related to undesirable health outcomes (WHO, 2012) and is the second most important climate change agent (Bond et al., 2013). Atmospheric conditions play an important role in the magnitude and time evolution of atmospheric pollution.

Anthropogenic air pollutants are generally emitted from the surface and constrained in the lowest part of the troposphere - the so called planetary boundary layer (PBL), and their concentrations are significantly higher in the PBL than elsewhere (McGrath-Spangler et al., 2015; Quan et al., 2013).

Several measurement campaigns have been carried out between 2012-2016 in the Ljubljana basin (Slovenia) in order to evaluate spatio-temporal heterogeneity of air pollution within the city and its surroundings, depending on contributions from main pollution sources and the meteorology. BC was measured using the Aethalometer model AE33. The Sandradewi (2008) model was used to apportion measured BC to traffic (BC_{TR}) and biomass burning (BC_{BB}).

The highest BC concentrations were found in urban traffic zones in the city center and near highways. Urban background stations are characterized by lower BC concentrations. Source apportionment of black carbon revealed different spatial and temporal patterns for the two sources. BC from traffic emissions prevails within the city, not only at traffic stations, but also at urban background sites. The contribution of traffic to BC diminishes very quickly with the distance from the road and is reduced to the background level already at a distance of 150 m. On the other hand, homogeneous distribution of BC from biomass burning was observed within the whole city. Slightly higher contributions and greater dynamics of BC_{BB} were observed only at suburban stations, indicating the local impact of biomass burning from domestic heating. This has also been confirmed by dependence of BC on wind direction and speed.

Seasonal BC fluctuation, with higher winter and lower summer values, is governed partly by the seasonality of atmospheric stability, with planetary boundary layer height usually higher during the summer period, causing better dilution of aerosols emitted from the ground sources. While the contribution of traffic emissions does not have seasonal pattern, biomass burning in the heating season increases the BC concentrations in winter.

Mixing within the PBL causes dilution of aerosols, which is more effective in unstable atmospheric conditions and when the source of emission is not too close to the measurement station (Figure 1 - BC_{BB}). There is no correlation between traffic generated black carbon and PBL height due to the proximity of the highway (Figure 1 - BC_{TR}).

Taking into account the meteorological data – including changes in PBL height, we assessed daily production of BC in the Ljubljana basin separately for traffic and biomass burning sources.

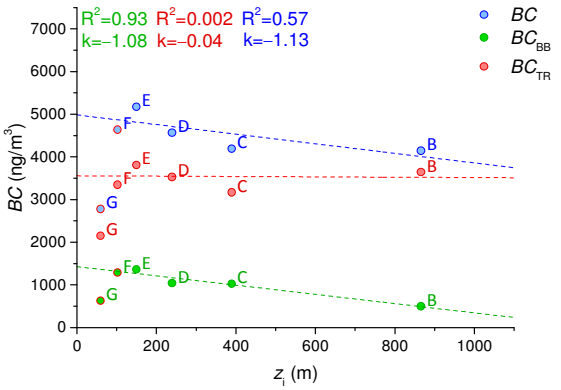

Figure 1. Correlation between black carbon (BC) and its biomass burning (BC_{BB}) and traffic (BC_{TR}) fractions with planetary boundary layer depth (z_i) for location close to the highway. Data has been grouped by PSQ stability classes; points F, G were excluded from linear fit.

This work was supported by JR-KROP grant 3211-11-000519 and JR-RK grant 3330-14-509063. We thank ARSO, Municipality of Ljubljana and Ames d.o.o for the use of their measurement sites.

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