Contribution of traffic to aerosolized black carbon: comparison of an emission/dispersion model and Aethalometer measurements

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Aerosol Black Carbon (BC) has adverse effects on both public health and climate. The two main sources of BC in many urban areas are traffic and biomass burning in small inefficient stoves. Separating the contribution from both sources is complex due to the many variables needed to describe the situation. The "bottom-up" approach uses emission factors (EF's) to estimate emissions based on fuel use, traffic patterns, and vehicle mix. An alternative is the "top down" approach using source apportionment models applied to measurement data. The so-called "Aethalometer Model" can discriminate between the contributions to ambient BC concentrations from traffic and biomass burning emissions, based on measurements of aerosol optical properties.

In our research we used both the "bottom-up" and the "top-down" approach to study traffic emissions in the city of Maribor (Slovenia). We present a comprehensive analysis of the real-world EF measurements and their use in an emission inventory model. First we tested the "chasing method" under controlled conditions. With this method a mobile platform follows a vehicle in use on roadway and measures its exhaust emissions. We show that the method is applicable to the present fleet of vehicles; and we evaluate the method sensitivity (Ježek, 2015). We used the "chasing method" in an on-road measurement campaign, and measured the EFs for BC and nitrogen oxides (NO_x) from 141 individual vehicles of different types. The results of the chasing campaign represent the first on-road measurement study of diesel and gasoline cars, and provide EFs for NO_x and BC measured for individual vehicles. We show that the combination of relatively simple on-road measurements with sophisticated post processing can produce representative fleet EFs. We analyzed the fleet's total emissions to show the disproportionate contribution of high emitting vehicles. We use the measured fleets EFs in a traffic emissions model (Ježek, in preparation).

The EMISENS traffic emission model was used to calculate hourly BC and NO_x emission rates on an average workday in the study area. From modeled NO_x emission rates and in-situ NO_x measurements we empirically determined the dilution of traffic emissions and applied it to modeled BC emissions. Modeled BC concentrations were then compared with in-situ BC concentration measurements which had been apportioned to traffic using the Aethalometer model. We found good agreement between the two independent approaches, in that the modeled BC concentrations overestimated the in-situ measurements by only 11%. This is the first use of the Aethalometer source apportionment model's results to evaluate traffic emissions calculated using the bottom-up modeling approach. This work demonstrates how these independent approaches yield similar results.

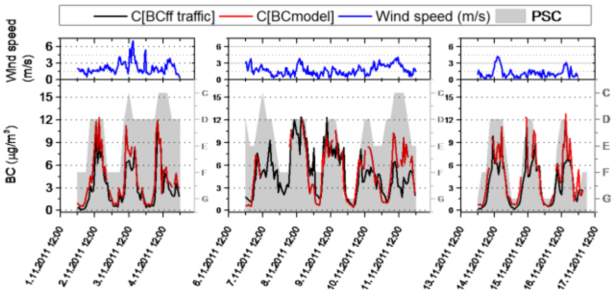

Figure 1: Measured and modeled parameters: BC apportioned to traffic with the Aethalometer model (C[BCff traffic]); BC calculated with EMISENS and diffusion model (C[BCmodel]); Pasquill stability classes (PSC); and Maribor airport wind speed.

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