A 5 YEAR'S SOURCE APPORTIONMENT STUDY OF BLACK CARBON FROM BIOMASS BURNING AND FOSSIL FUEL COMBUSTION AT A RURAL BACKGROUND SITE

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INTRODUCTION

The impacts of Black Carbon (BC) on adverse public health and Earth's climate system have been recognized and evidenced in recent decades (Bond et al., 2013; WHO 2012). Black carbon (BC) is a primary carbonaceous aerosol and it contributes by less than 10% to the total mass concentration of PM_{10} (particles with aerodynamic diameter smaller 10 μm) (Putaud et al., 2004). It is the most efficient light-absorbing aerosol species in the visible spectrum. The wavelength dependence of light absorption by collected aerosols has been widely used to investigate the influence of fossil fuel (e.g. traffic emissions) combustion and biomass burning in ambient air (Sandradew et al., 2008). Most of the studies on BC were conducted in urban/traffic areas. There are relatively few studies using real-time measurements of BC at rural background areas, especially in Central Europe. This study focuses on a 5-year measurement of BC at the National Atmospheric Observatory Košetice (49°35' N, 15°05' E), in central Czech Republic. We aim to identify the potential sources of EBC, especially influence of fossil fuel and biomass burning.

EXPERIMENTAL SETUP

The measurements of BC in PM_{10} were performed at 4 m above the ground with a 7-wavelength aethalometer (AE31, Magee Scientific). The BC data have been corrected for loading effect (Virkulla et al., 2007). Measurement of PM_{10} (radiometry – beta ray absorption), trace gases such as NO_2 and NO_x (chemiluminescence), SO_2 (UV-photometric) and CO (IR abs. Spectrometry), biomass burning tracers such as levoglucosan and mannosan (HPAE-PAD Chromatography) were performed at the station during the same period. The elementary (EC) and organic carbon (OC) concentrations in $PM_{2.5}$ were measured from March 2013 to December 2017 by a field Semi-Continuous OCEC Aerosol Analyzer (Sunset Laboratory Inc., USA). Meteorological parameters (temperature, wind speed and direction) were recoreded.

The aethalometer model, based on the wavelength dependence of light absorption (Angstrom coefficient), has been used to estimate BC_{bb} (BC from biomass

burning) and BC_{ff} (BC from traffic) (Sandradew et al., 2008). The location of sources for EBCbb and EBCff were identified using the Conditional Bivariate Probability Function (CBPF) analysis using OpenAir software upon R package (Uria-Tellaetxe and Carslaw, 2014). The origins and the transport patterns of the air masses affecting the receptor site have been investigated using Back Trajectory Cluster (BTC) analysis with HYSPLIT_4 model (Stein et al., 2015). The Potential Source Contribution Function (PSCF) was performed to estimate the probability of source location in a given area (Zíková et al., 2016).

RESULTS AND CONCLUSIONS

The aethalometer model (α-value) was used to estimate the contributions of fossil fuel and biomass burning on BC measured during a 5 years at a Central European rural background area (Fig. 1). Seasonal, diurnal and weekly variations of BC were observed that could be related to the sources fluctuations (ff and bb) and transport characteristic.

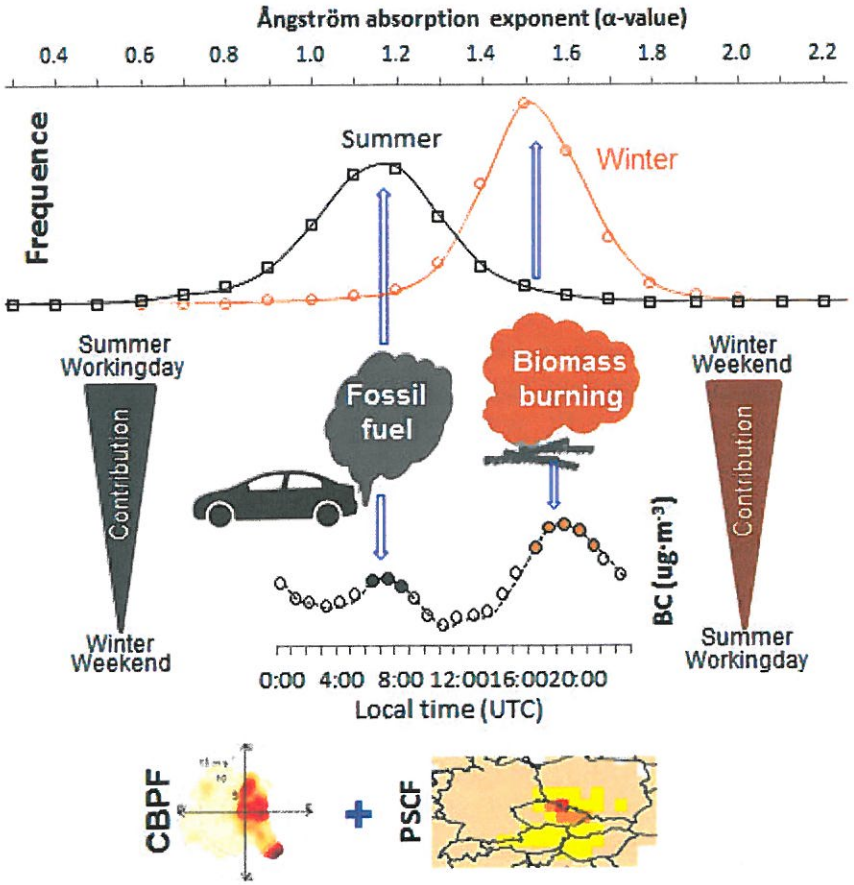

Fig. 1: Graphical abstract showing the Angstrom exponent, sources of BC and its seasonal, diurnal and weekly variations.

The α-value measured in summer is 1.1 ± 0.2, consistent with reported value for traffic, while in winter the highest value (1.5 ± 0.2) was observed due to increased contribution of BC_{bb} accounting for 40% of total BC. This result is in agreement with maximum Delta-C (proxy for biomass burning) measured during this season. In winter, a

strong correlation ($R > 0.85$) was found between BC_{bb} and levoglucosan and mannosan (organic tracers of biomass burning) and measured levoglucosan/mannosan ratio (4.8 ± 0.7) was consistent with reported values for softwoods burning (Schmidl et al., 2008). The concentrations of BC_{bb} and Delta-C reached a maximum level during the evening due to domestic heating emissions. The increased operation of domestic heating devices leads to slightly higher BC_{bb} concentration during the weekend in comparison with working days. The BC_{ff} and combustion-related elements (NOx, NO2 and SO2) show similar behavior with a typical morning peak that could be attributed to the morning traffic rush hour. The contribution of BC_{ff} tends to decrease during the weekend due to lower commuting in the rural area. The CBFP and PSCF analysis BC_{bb} and BC_{ff} reveal a high probality of sources localed in the Czech Republic and neighboring countries.

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