Aerosol source apportionment in a European air pollution hot spot with both aerosol chemical composition and number size distribution

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Atmospheric aerosol particle concentrations continue to be above the European Union limit values in large part of the EU (EEA Report 2016). The Moravian-Silesian region in the Czech Republic represents one of the EU air pollution hot spots. Proper identification and quantification of the main PM sources is needed to improve the air quality. This is particularly challenging in Ostrava, due to the presence of several sources, some of them large and situates in the vicinity of the urban settlements.

The application of receptor models can be highly effective for the source apportionment. Receptor models analyse data matrices of aerosol chemical and physical characteristics of samples collected at a given locality, the receptor, to apportion their sources. Recently, the source apportionment started to focus not only on chemical composition, but on particle number size distribution (NSD) data. In fact, the toxicity of particles also depends on the particle size, not only on the chemical composition. The analysis of the chemical composition data is able to distinguish components contributing largely to particle mass, whereas the particle NSD data set is more effective for identifying components making an appreciable contribution to particle number. The chemical composition has been largely used in receptor modeling, while only few studies use particle NDS (Masiol et al., 2016, Sowlat et al., 2016, Beddows et al., 2015). The aim of this study is to make a comprehensive source apportionment in one of the most important air pollution hot spots in the EU, using receptor modeling on both particle chemical composition and number size distribution.

A monthly campaign was performed in winter 2014 in a residential district of Ostrava with a large metallurgy complex located 1.5 km south-west. Five-minute integration time particle number size distributions within the size ranges 14 nm – 10 μm (SMPS-3936L25 and APS-3321, TSI Inc.), gaseous pollutant and meteorological variables were registered. 2-h samples of size segregated PM was collected with a Davis Rotating-drum Uniform-size-cut Monitor (DELTA Group UC-Davis), in 8 size ranges, from 1.15 to 0.09 μm. The samples were analyzed for 24 elements with synchrotron X-ray fluorescence. Organic molecules in PM₁ (levoglucosan and homohopane) were measured with 24-hour time resolution (DHA-80 Digital, GC-MS).

US EPS PMF model version 5 was used for source apportionment. The preliminary results on mass chemical composition modeling showed five factors: coal combustion and secondary inorganic aerosol – S.I.A (39%), biomass burning (28%), re-suspended road dust (18%), raw iron production (9%) and sintering/steel production (6%). The preliminary results on spectra modeling show five factors associated with following modes: accumulation 1 (27%), accumulation 2 (10%), nanoparticles (31%), Aitken mode particles (28%), coarse particles (4%). The nanoparticles and the coarse particles have industrial origin, the accumulation 2 is related with coal combustion, the accumulation 1 with biomass burning. Contributions of the traffic and the long-range transport are still unclear.

In conclusion, the NSD modelling allows to resolve sources in the ultrafine size range, that is not possible with the aerosol particle mass concentration/chemical composition modelling alone. The two approaches appear to be complementary. The industry produces important source of ultrafine particles.

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