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Diurnal cycling of urban aerosols under different weather regimes

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A one month measurement campaign was performed in summer 2014 in Ljubljana, the capital of Slovenia (population 280,000), aiming to study temporal and spatial distribution of urban aerosols and the mixing state of primary and secondary aerosols. Two background locations were chosen for this purpose, the first one in the city center (urban background - KIS) and the second one in the suburban background (Brezovica). Simultaneous measurements of black carbon (BC) and particle number size distribution of submicron aerosols (PM1) were conducted at both locations.
In the summer season emission from traffic related sources is expected to be the main local contribution to BC concentration. Concentrations of aerosol species and gaseous pollutants within the planetary boundary layer are controlled by the balance between emission sources of primary aerosols and gases, production of secondary aerosols, chemical reactions of precursor gases under solar radiation and the rate of dilution by mixing within the planetary boundary layer (PBL) as well as with tropospheric air. Only local emission sources contribute to BC concentration during the stable PBL with low mixing layer height, whereas during the time of fully mixed PBL, regionally transported BC and other aerosols can contribute to the surface measurements. The study describes the diurnal behaviour of the submicron aerosol at the urban and suburban background location under different weather regimes. Particles in three size modes – nucleation (< 25 nm, NUM), Aitken (25 – 90 nm, AIM) and accumulation mode (90 – 800 nm, ACM), as well as BC mass concentration were evaluated separately for sunny, cloudy and rainy days, taking into account modelled values of PBL height.
Higher particle number and black carbon concentrations were observed at the urban background (KIS) than at the suburban background location (Brezovica). Significant diurnal pattern of total particle concentration and black carbon concentration was observed at both locations, with a distinct morning and late afternoon peak. As a consequence of different PBL dynamics and atmospheric processes (photochemical effects, humidity, wind speed and direction), diurnal profile differs for sunny, cloudy and rainy days. Nucleation mode particles were found to be subjected to lower daily variation and only slightly influenced by weather, as opposed to Aitken and accumulation mode particles. The highest correlation between BC and particle number concentration is observed during stable atmospheric conditions in the night and morning hours and is attributed to different particle size modes, depending on the distance to local BC emission sources. In sunny weather conditions, correlation between BC and particle number concentration decreases during the day due to mixing in the atmosphere and formation of secondary aerosols. Black carbon aging and mixing with secondary aerosols was additionally studied on the aerosol samples taken from the morning to the evening of a sunny day using SEM-EDX technique.