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Urban aerosols in the city and county of Salzburg – Particle concentration, size distribution and air quality data

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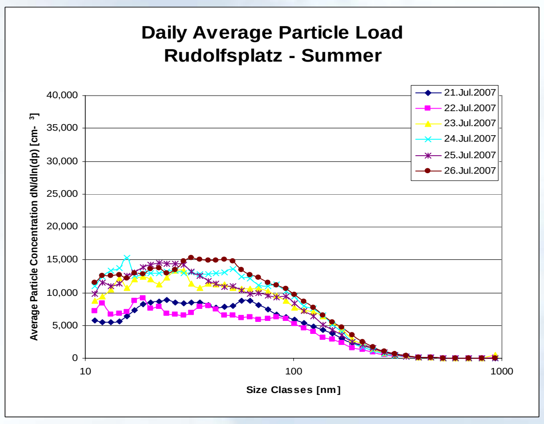
Abstract

This Scanning Mobility Particle Sizer (SMPS) sampling campaign included four different sites – two of them located within the city of Salzburg, the others being situated in rural areas. Samplings were carried out during both summer and winter periods and took place at existing environmental monitoring stations of local authorities. This set-up made it possible to directly correlate meteorological and other environmental air quality data with the sampled nano-particle inventory (below 1 µm). At all sites, distinct 24-hour fluctuations have been observed, along with lower concentrations on weekends or holidays. Traffic density and wind showed the greatest influence on the composition and amount of nano-particles.

Fig. 1: Photo of the downtown investigation site Rudolfsplatz; (modified from Google Earth)

Introduction

The primary objectives of this study were (i) to examine the particle size distributions at different locations, and (ii) its relation to environmental factors (CO, PM_{10}, NO_X, NO_2, O_3, SO_2, wind speed, wind direction) recorded by the local authorities. The campaign investigated the particle number concentration in the range below 1 µm. In order to detect daily fluctuations, measurements at each site were carried out over several days. Of particular interest was the relation of the nano-particle inventory to the measured amounts of PM_{10} and the nitrogen oxides (NO_X, NO_2) in ambient air.



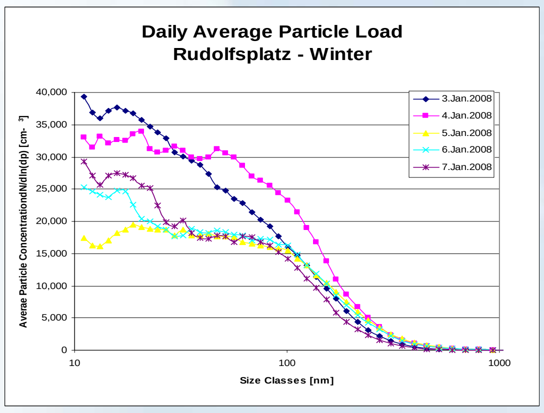


Fig. 2 a & b: Daily average particle concentration over the measurement range 11-1080 nm at the urban site Rudolfsplatz; (a) summer sampling, (b) winter sampling

Methods

Of the four measurement sites, two were situated outside of Salzburg. One at a rural mountain (Haunsberg, 30 km north of Salzburg), the other next to a major highway (TAB, 15 km south of Salzburg). The two downtown sites were split into one at a residential area (Lehen, northern sector) and one at a traffic circle of a main city street (Rudolfsplatz, city center). This set-up was planned to compare heavy traffic to low traffic areas in and outside the city.

For the measurements, an SMPS was used to monitor the particle size inventory. The SMPS is a mobile continuous nano-particle counter, which combines a CPC and a DMA. The majority of measurements were taken at a size range between 11.1 nm – 1083.3 nm, whereas the site next to the highway (TAB) monitored the detection window between 5.5 nm to 354 nm, to shift the focus of the measurement to the smaller nano-particles which originate from the high-speed traffic nearby.

At each measurement site, data were collected for several successive days, always including a weekend, with one set of data taken in summer and one in winter. Parallel to recording the nano-particle inventory, local authorities are monitoring a range of environmental data. The multiple environmental data compared with the nano-particles were climate data, actual weather, air quality data (PM_{10}, NO_X, NO_2 CO, O_3, SO_2,) and, at the site TAB, traffic flux (number, speed and type of vehicles).

Results

A comparison of the collected nano-particle inventory showed significant differences between summer and winter measurements at most observed sites. The differences reflect both the total particle concentration as well as the size compositions over the observed size range. Most obvious is the increase of particles in the smallest size ranges, which are almost twice as high as compared with summer measurements. This is most visible at the downtown site "Rudolfsplatz", where continuous heavy traffic occurs.

The other heavy traffic site, next to the highway (TAB), does not reflect seasonal changes to such an extend (neither in total particle concentration nor does a significant difference in particle distribution appear to be present). Both heavy traffic sites show a decrease in particle concentration on the weekends. In case of the highway, this decrease could be linked to less heavy vehicles traffic on the weekends. At the measurement sites with less traffic, the influence of season as well as of weekdays is less expressed in the total particle load. The composition of particle sizes shows – as do the heavy frequented sites – a higher amount of small particles.

Comparing particle load with different environmental data showed a high correlation with NO_X and NO_2 . Although the PM_{10}, values do show a close relation to the total particle load as well, there are fluctuations and opposing trends.

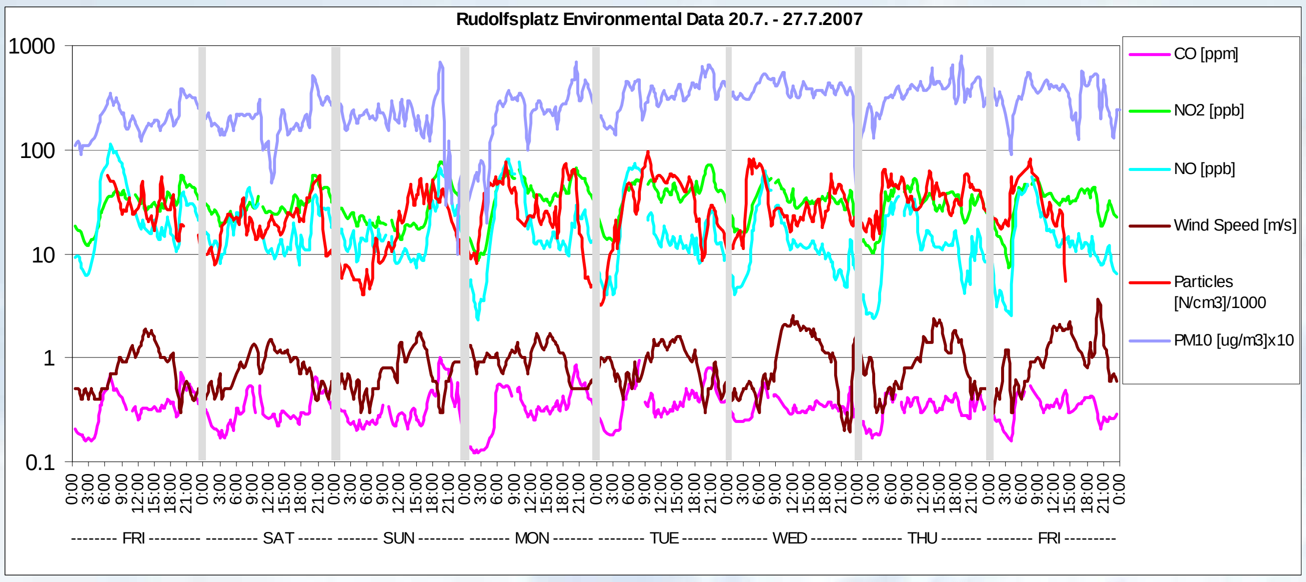


Fig. 3: Diagram of several environmental factors measured and the total particle load at the downtown site Rudolfsplatz.

Conclusion

This study has shown that there is a significant difference in the size distribution of particles depending on the season. As expected, sites closely located to areas with heavy traffic were highly impacted. The comparison between the slow city traffic to the high speed highway traffic revealed a shift of the particle towards the smaller particle sizes for the highway traffic.

The measurement site 30 km outside of Salzburg (Haunsberg) more closely approached the background concentrations of anthropogenic produced aerosols. Although it did not closely follow the day/night and weekend patterns, the fluctuations and influence of traffic exhaust was still recognizable and was most likely associated with the long-range transport of aerosols (Dorsey et al., 2002).

Although PM_{10} seemed to be correlated with trends in ultrafine particles, it did not provide enough evidence that ultrafine particle behavior can be considered simply as a fraction of PM_{10} (Rosenbohm et al., 2005).

On the other hand, traffic related exhaust pollutants like NO and NO_2 indeed unveiled a close link to the measured ultrafine particle concentrations. Hence, such exhaust chemicals can be used as an indicator for ultrafine particles in close proximity to road traffic conditions (Janhäll et al., 2006).

Considering the health effects of the smallest nano-particles observed in this study, the difference in seasonal particle-size composition should play a roll in exposure and health assessments, in particular, as the winter measurements revealed a significantly higher amount in the spectrum of particles which easily penetrate into deeper lung areas.

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