Long-Term Measurement of Aerosol Number Size Distributions at Rural Background Station Košetice

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ABSTRACT

Two years of SMPS data measured at the rural background station, Košetice observatory, are presented and statistically analyzed in this paper. The evaluation was performed on time scales ranging from years to days, and an overall new particle formation (NPF) frequency analysis was conducted as well. The annual average total concentration (integral value from 10 to 800 nm) was found to be $6.6 \times 10^3$ #/cm$^3$, the particle number size distribution has a well expressed accumulation mode and high variability in particle sizes below 50 nm. In the seasonal data, particles of the smallest sizes (of diameters between 10 and 50 nm) had the high concentrations in summer, in contrast to the low concentrations found in winter. The particles of the largest sizes (over 300 nm) showed the opposite behavior. The analysis of NPF events revealed a strong annual cycle peaking in spring and summer and dropping in winter. In the monthly data, the global minimal of the total concentrations was recorded in December, and the global maximum in June. Weekly cycle analysis proved that the station is suitably characterized as a rural background – the weekly cycle was statistically insignificant on most days. The typical daily cycle of total concentrations showed its minimum between 3 and 6 AM, and its maximum at about 6 PM. Particles with diameters between 10 and 50 nm in diameter, compared to particles larger than 50 nm, exhibited higher daily amplitude.

Keywords: SMPS; Two-year time series; Rural background; Particle number size distributions.

INTRODUCTION

One of the most important parts of aerosol research is the study of atmospheric aerosol (AA), as AA influences several scientific disciplines. Firstly, AA participates in heterogeneous and multiphase chemical reactions in the atmosphere – not only in the troposphere but in the stratosphere as well (Andreae and Crutzen, 1997; Ravishankara, 1997; Lelieveld and Crutzen, 1991). Secondly, AA influences the climate by changing radiative forcing via two basic classes of mechanisms: direct and indirect. The direct radiative forcing of AA changes atmospheric scattering and the absorption of radiation (IPCC, 2001). The indirect effect is connected with the role of AA as cloud condensation and ice nuclei (Haywood and Boucher, 2000). Thus, an increase in the AA number can increase the amount of reflected solar radiation from clouds. Thirdly, an increase in the AA numbers can lead to changes in precipitation and to an increase of cloud lifetimes, and thus again to an increased reflection of solar radiation (Ramanathan et al., 2001; Rosenfeld et al., 2008). The reduction in solar radiation and decrease in precipitation also have considerable consequences for regularity in the hydrological cycle. Finally, the negative effects of AA on human health have been confirmed, connected to both short-term and long-term exposure (for example Wichmann et al., 1989; Brunekreef and Holgate, 2002 and references herein; Pope et al., 2002).

For a detailed understanding of all the mentioned phenomena connected to AA, it is necessary to know not only the aerosol emissions, their concentrations and lifetimes, but the aerosol particle number size distributions (PNSD) as well. Unfortunately, all the concentrations, chemical composition and PNSD of AA are considerably variable. For example, the PNSDs (and thus the effects of AA as well) differ with the sources of aerosol particles, their chemical compositions, the time that the aerosol has spent in the atmosphere, and the state of the atmosphere, i.e., weather, as well. As the variations are observed both in space and time, the objectives of recent scientific measurements of PNSD are high-quality long-term time series covering large areas (Laj et al., 2009).

The necessity of an extended spatial coverage can be

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met in the form of extended measurement networks. There are several networks in Europe focusing on monitoring air quality including aerosol PNSD measurements, for example EUSAAR and ACTRIS (Philippin et al., 2009) or GUAN (Birmili et al., 2009). The main advantage of the networks, as compared to the local measurements, is the possibility to cover a variety of environments having various climates, ecosystems and anthropogenic influences. Within any of the networks, background stations are integral and important parts.

There are several types of background stations available in Europe, for example arctic, high-altitude, coastal, rural, and urban (Van Dingenen et al., 2004). A common feature of all of them is the absence of direct anthropogenic activities. Therefore, the changes in chemical composition are of lower relative variability, based on the assumption that background concentrations are well mixed over large areas. According to Laj et al. (2009), a background station can be representative for up to hundreds of kilometers, in the case of remote sites. In Tuch et al. (2003), the relative homogeneity was confirmed also for Central European urban background stations. Henne et al. (2010) identified the equivalent radius of a catchment area of the Central European rural background stations (Košetice, K-puszta, Sniezka) exceeding 100, 250 and 400 km for 12, 24 and 48 h catchment.

In the area of the Czech Republic, there are only two background sites providing long-term measurements of aerosol PNSDs. The first site is an urban background site, Prague Suchdol (Římnáčová et al., 2011). The second one is the Košetice observatory, a rural background station. The Košetice observatory is a part of the EUSAAR/ACTRIS measurement network, thus its proper description needs to be easily comparable with other stations within the network. Asmi et al. (2011) already produced such a comparative paper, in which the Košetice observatory was one of the few stations that still lacked a detailed publication on it. In this paper, we present a description of the Košetice dataset based on several statistical descriptions. The paper is divided into three parts. The first part of the paper describes the site, its experimental equipment and data coverage. The second part, the results and discussion, is further divided into two main parts. Firstly, annual, seasonal, monthly, weekly and diurnal descriptions are presented and then a frequency of new particle formation events is characterized. The last part consists of the conclusions.

**METHODS**

**Experimental Site and Instrumentation**

The data evaluated in this work were collected during the first two years of measurements (2008–2010) at the Košetice observatory (49°35' N, 15°05' E, altitude 534 m a.s.l., see Fig. 1). The district to which Košetice belongs is the 7th least populated district in the Czech Republic, having only 57 inhabitants/km² (the average in the Czech Republic is 133 inhabitants/km²) (Czech Statistical Office, 2009). The landscape is mainly agricultural, with some forests. The observatory itself lies in a remote place, making it suitable for background measurements.

At the observatory, there is a background meteorological station connected to the national professional meteorological measurement network, operated by the Czech Hydrometeorological Institute. Moreover, within the network, the station is specialized in environmental quality monitoring. In 2008, the observatory became a part of the EUSAAR network and was equipped with an IfT-SMPS (Scanning Mobility Particle Sizer) provided by the Leibnitz Institute for Tropospheric Research (IfT, recently renamed TROPOS) in Leipzig.

An SMPS consists of an electrostatic classifier (EC) and a condensation particle counter (CPC). A crucial part of the EC is a differential mobility analyzer (DMA), sorting aerosol particles on the principle of electrostatic classification. Via a quasi-continuous increase of the DMA voltage, increasing particle sizes are segregated and counted in the CPC. The CPCs were commercial instruments and the EC was made by TROPOS. In total, two different types of CPCs were used during the two years of measurements in question. From the start of the measurements in May 2008, a CPC 3775 (TSI, USA) was in operation. In August 2008, it was replaced by a CPC 3022 (TSI, USA). The 3022 CPC has been in use (with some minor exceptions due to CPC repairs) until April 2011. Later (the time period is not included in

![Fig. 1. Location of Košetice observatory; Maps from OpenStreetMaps, http://www.openstreetmap.org/](http://www.openstreetmap.org/).
this paper), it was replaced by a CPC 3772 (TSI, USA). During the years of measurement, regular checks and maintenance of both the CPCs and EC were performed, including calibration workshops with each of the CPCs, guaranteeing correct calibration values and the SMPS’s comparability with other instruments within the EUSAAR network. The individual CPCs differ in counting efficiencies and cut-offs as well (according to the calibrations made in TROPOS, these asymptotically reach 88.6% with a 50% cut-off at 6.8 nm for the CPC 3022, 93.1% with a 50% cut-off at 7.8 nm for the CPC 3775 and 100% with a 50% cut-off at 7.9 nm for the CPC 3772). However, during the data inversions, the efficiencies were considered, and thus the changes in CPC should not influence the results.

The sampling was carried out with a PM10 sampling head. The nominal flow of 1 cubic meter per hour (16.7 L/min) was achieved with an auxiliary pump, supplying 15.7 L/min, and SMPS sampling 1 L/min via isokinetic subsampling. Further, the aerosol sample was dried by a Permapure nafion dryer with mild vacuum (0.2 kPa) on the outer side of the membrane. Based on the quality checks conducted prior to this publication (more details in the section Data handling), another nafion dryer was added to the sheath air flow in 2011.

**Data Handling**

The SMPS data were sampled in a mobility size range from 9.5 nm to 909 nm in a 5-minute time step. However, only data in the size range from 10 to 800 nm were considered for analysis, to exclude data with poor signal-to-noise ratio or data influenced by high voltage sparks. Furthermore, several steps were taken to provide the checked and homogenized time series of the PNSDs presented here.

Firstly, an inversion of the raw data provided by the software operating the SMPS was performed with a TROPOS non-commercial inversion routine. The routine uses a multiple charge correction for negatively charged particles based on Wiedensohler (1988), and the inversion also includes a correction for particle losses based on the equivalent pipe length, i.e., particle losses by diffusion in various parts of the SMPS described as losses in straight pipes having the same particle penetration as the whole SMPS system (Wiedensohler et al., 2012). The equivalent pipe lengths of plumbing, nafion dryer, bipolar diffusion charger and DMA were considered. Losses in the CPC were included via CPC efficiency curves based on calibrations.

Secondly, a quality check of the original 5-minute data was performed. Missing, incorrect or incomplete scans were flagged and commented on according to the problem found in the data. The flagging was done using the flag list and recommendations published in Wiedensohler et al. (2012), and the limits for individual variables were chosen so that it was in accordance with EUSAAR standards. The standards require the relative humidity to be between 0 and 40%, sample temperature between 10 and 30°C, and sheath and sample flow not to differ by more than 5% from its optimal value (5 L/min for the sheath flow and 1 L/min for the aerosol flow). The only difference from the recommended settings was applied on the aerosol and sheath flow temperature flagging. The recommendation says that the temperature should be within 10–30°C interval; many of our summer samples, however, were slightly above the threshold. Since the air flow is heated up to 35°C in a CPC saturator anyway, we set the 35°C as our limit over which we flagged data as unsuitable. Afterwards, all the flagged data were excluded from the dataset and only the unflagged scans were used for further analysis.

Finally, the checked data were averaged into one-hour arithmetic means of particle number concentration. However, only if at least 8 from the 12 theoretically available scans were available in the one-hour period was the average considered.

**Data Coverage**

This paper presents the results from the first two years of measurement, i.e., from 5/2008 to 4/2010. There are some minor missing data periods in the presented dataset, and a few continuous missing periods as well. The main reasons for the measurement interruptions were instrument calibrations, failures or upgrades of individual parts of the equipment.

Despite the breaks, the data coverage is quite high; we have more than 87% of the available data. There is a further variability in the data coverage in seasons and individual months as well. As for the seasonal data coverage, the best covered seasons are autumn and winter, when more than 94% of the quality assured data is present; during the spring months, more than 91% data were collected. Summer is covered almost 69%. The coverage in monthly data is minimal during Junes (64.7%) and Julies (52.8%); on the other hand, the highest data coverage was during Februarys, 100% (Fig. 2).

**RESULTS AND DISCUSSION**

**Annual Data**

The arithmetic average total concentration during the two years of the measurement was found to be 6.6 × 10^3 #/cm^3. Standard deviation reached the value 4.6 × 10^3 #/cm^3.

We considered 12 months starting in May (beginning of measurement) as a “year”. The variability of the annual average and standard deviations, and median and 25th and 75th percentiles within the two years, compared to the two-year values, can be seen in Table 1. The differences between the individual years are negligible, within a few percentage

![Fig. 2. Data coverage in individual months, summed over the two years.](image-url)
points. Thus, the whole dataset was handled as one; all the characteristics were computed from the 24-month time series.

As the distribution of data was not found to be normal, the averages are not sufficient descriptors of the shape of the distribution, and further investigation is necessary. This is valid not only for the total number concentrations, but for the concentrations in individual size bins as well. Thus, for the PNSD evaluation, the 5 most commonly used percentiles, 5th, 25th, 50th, 75th and 95th were computed (Fig. 3).

The median of the PNSD shows a well-developed accumulation mode, some inkling of a nucleation mode, and a strong decrease at concentrations of particles over 300 nm in diameter. Further, the variability in the concentrations in the individual size bins of the spectrum was evaluated. The amplitude was studied as a measure of variability. The amplitude was defined as the difference between the 5th and 95th percentile. The amplitude changes considerably with particle size; the highest, reaching almost two orders of magnitude, was found in the smallest size ranges, i.e., between 10 and 20 nm. With increasing particle sizes, the amplitude decreases. The trend changes at about 300 nm, where any further increase in particle sizes slightly increases the amplitude again. It is due to the influence of the high time variability of droplet mode. The mode is defined as particles between 300 and 800 nm in size (Costabile et al., 2009). Finally, the 5th percentile of the spectra shows a well expressed bimodal spectrum, visible clearly in the seasonal spectra as well (Fig. 4). It is the contribution of very clean air masses, generally coming from polar areas. Similar spectra were recorded for example in Birkenes in Norway (58°23' N, 8°15' E, 190 m a.s.l.) or at the SMEAR II station in Finland (61°51’ N, 24°17’ E, 181 m a.s.l.) (Asmi et al., 2011).

### Seasonal Data

The number size distributions do not vary only from year to year, but in individual seasons of the year as well (Fig. 4). As a measure of variability, the median and 25th and 75th percentiles were used in every size bin and season.

The differences between the individual seasons are mainly at the edges of the distribution; on the contrary, the smallest differences were found to be between 80 and 300 nm. In this size range (i.e. within the accumulation mode), the concentrations do not differ from one another in the individual seasons, especially in terms of the maxima of the concentration medians. The seasonal differences in the 25th and 75th percentiles are also weak, only with some decrease in the 25th percentile in autumn and an increase in the 75th percentile in winter.

The changes in the smallest particles’ size concentrations are almost diametrically opposed to those in the largest sizes. In the sizes from 10 to 20 nm, the summer concentrations are about twice as high as those in spring or autumn, and almost four times as high as in winter. It is the case not only for medians, but for the other two discussed percentiles as well. The spring and autumn size distributions of the concentrations of the smallest particles correspond to each other quite well in terms of the median and 25th percentile; the 75th percentile is about 50% higher in the spring months. In the sizes from 20 to 80 nm, a strong seasonal variability was found as well. The mode is quite distinct in the spring and summer PNSDs; it is evident in autumn, and negligible in winter. According to Costabile et al. (2009), this mode, also called the Aitken mode, is typical for rural background stations and originates from the aging of the particles generated during NPF (new particle formation) events. Thus, the seasonal cycle of the Aitken mode concentrations with the maximum in the spring and summer months is closely connected to the NPF events’ seasonal cycle, and agrees well with further analyses of the frequencies of NPF events conducted in Section 3.7.

For particles between 300 and 800 nm, the situation changes considerably. By far the highest concentrations of particles between 300 and 800 nm were recorded in winter, when the 25th percentile’s value is approximately the same as the spring and autumn medians. Furthermore, the winter’s 25th percentile is even higher than the summer’s 75th percentile. Like the concentrations of particles in the accumulation mode’s sizes, the distributions of particles over 300 nm in autumn and spring are similar to each other; nevertheless, the 75th percentile is higher in autumn. The summer concentrations are well below other seasons’ values – the 75th percentile of concentrations of the largest particles in summer equals the 25th percentile value in spring.

The low summer concentrations of particles in the size bins over 300 nm can be a consequence of two independent processes. Firstly, the frequency of precipitation in the Czech Republic in the summer months is generally higher when compared to the rest of the year (Tolász, 2007; Váha and Holoubek, 2009). Precipitation is particularly effective in scavenging particles either smaller than 30 nm or larger than 400 nm (Laakso et al., 2003); however, the influence on the particles under 30 nm is compensated by the increased NPF event frequency, thus the effect of precipitation is better seen at the right-hand side of the distribution. Secondly, due to the enhanced convection, the boundary layer is thicker in the summer months, diluting AA concentrations considerably.

<table>
<thead>
<tr>
<th></th>
<th>1st year</th>
<th>2nd year</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>arithmetic mean [#/cm³]</td>
<td>6.7 × 10⁴</td>
<td>6.5 × 10⁴</td>
<td>6.6 × 10⁴</td>
</tr>
<tr>
<td>standard deviation [#/cm³]</td>
<td>4.9 × 10⁴</td>
<td>4.3 × 10⁴</td>
<td>4.6 × 10⁴</td>
</tr>
<tr>
<td>median [#/cm³]</td>
<td>5.5 × 10⁴</td>
<td>5.4 × 10⁴</td>
<td>5.5 × 10⁴</td>
</tr>
<tr>
<td>25th percentile [#/cm³]</td>
<td>3.8 × 10⁴</td>
<td>3.9 × 10⁴</td>
<td>3.8 × 10⁴</td>
</tr>
<tr>
<td>75th percentile [#/cm³]</td>
<td>7.9 × 10²</td>
<td>7.8 × 10³</td>
<td>7.8 × 10³</td>
</tr>
</tbody>
</table>

Table 1. The annual arithmetic mean and standard deviations, and median and 25th and 75th percentile in the two years of measurement, together with the total arithmetic mean and standard deviation, and total median and 25th and 75th percentiles.
Monthly Data

As already shown in Section 3.2, the variability in data is quite high during the year. To cover it in better detail, the monthly data of the total number concentrations were considered (Fig. 5). The values of median in individual months differ from the annual median (5.4 × 10^3 #/cm^3); a clearly pronounced simple annual cycle was found, with the minimum in winter and the maximum in late spring to summer. The minimal value of the monthly median was measured in December, 3.8 × 10^3 #/cm^3, the highest in June, 7.1 × 10^3 #/cm^3. A similar annual cycle is visible in all five described percentiles. This cycle is due to NPF events, influencing the number concentration mainly during the warm half of the year.

Compared to the other percentiles, the 95th percentile of total concentration shows the largest variability (Fig. 5). In the warm half of the year, the 95th percentiles reach double values as compared to those in the cold half. (The only

Fig. 3. The size-dependent median, 25th and 75th percentile, 5th and 95th percentile of the complete dataset, i.e., two years of measurement.

Fig. 4. The 25th, 50th and 75th percentiles of the number size distributions in the individual seasons of the year. The area between the 25th and 75th percentile (interquartile span) was filled for better readability, the 50th percentiles (medians) are denoted with dashed lines.
exception is July, when a local minimum was recorded. Unfortunately, the significance of the fact is lowered by the low data coverage in July, which is just over 50% (Fig. 2 bottom). The strong increase in the 95th percentile in the spring and summer months is caused by an increased frequency of NPF events. The same can be seen also in 75th percentile, but it is almost invisible in the median or lower percentiles of concentrations.

**Weekly Data**

In order to describe the influence of local sources and/or long-range transport to concentrations at the station, weekly variations were derived. The assumption was that, should the difference between aerosol concentration in weekdays and weekend be negligible, it is a sign of a station’s position being distant enough from the source areas to be classified as a background station (Asmi, 2012).

Firstly, the medians of the total number concentrations were derived for every day of the week (Fig. 6). Variations are plotted in relative numbers, i.e., the daily value compared to the weekly average. However, the weekly cycle is generally only weakly expressed, no matter which season of the year is considered. A bootstrap method with 5000 randomizations (Howel, 2013) was used to test the statistical significance (at the significance level $\alpha = 0.05$) of the differences between medians on the yearly and seasonal data as well. According to the test, in all cases, the variability in the weekly cycles is statistically insignificant at the given significance.

The low variability of the weekly cycles in the total number concentrations suggests that the influence of anthropogenic activities in the close vicinity of the station is negligible. Thus, from the point of view of particulate matter concentrations, the classification of the station as rural background was proved to be suitable, with results similar to those of Henne et al. (2010).

**Diurnal Data**

To see the daily cycles, the cumulative concentrations of the particles in sizes between 10 and 50 nm, 50 and 300 nm and between 300 and 800 nm were calculated, as representatives of the different size modes of aerosol particles (like in Section 3.1). All three modes exhibit a simple daily cycle, but while 10 to 50 nm mode peaks between 2 PM and 6 PM, the other two have the exactly opposite daily cycle (Fig. 7).

The smallest particles (less than 50 nm in diameter) show a high daily amplitude because of the broader variability in concentrations due to NPF events (starting close to 11 AM and continuing until late afternoon, Fig. 7), and also effective removal mechanisms. The concentrations of particles larger than 50 nm are maximal at night and in the early morning,
between 2 AM and 7 AM. The particles between 50 and 300 nm in size, the accumulation mode, show only a weak daily cycle (changes within 20%), confirming their semi-persistence in the atmosphere. The daily pattern is connected to the boundary layer daily cycle. Particles between 300 and 800 nm have a daily cycle similar to the accumulation mode. The difference is mainly in a greater variability in concentrations during the day because of the more effective removal during the day hours; for example losses connected to evaporation, gravitational settling or losses due to the convective movements.

Diurnal changes in the particle number size distributions are described in greater detail in Fig. 8. During the day, the main variability is due to two main features – accumulation mode and nucleation mode. The accumulation mode reaches its maximum during the evening to night hours, culminating at 10 PM. Further towards night, as all the sources decay, the number concentrations in all size ranges start decreasing, until 4 AM, when at small size ranges the decrease stops, however it continues at accumulation mode particle sizes.

From 6 AM on, the concentrations in the accumulation mode fall only slowly; on the other hand, an increase in the smallest particles sizes starts and continues until 2 PM. At the same time, there is still some slight decrease in the accumulation mode concentrations. From 4 PM on, the nucleation mode concentrations do not change; there is only some increase in 20 nm particles’ concentrations, as well as some increase in the concentrations in accumulation mode sizes. Later on, a decrease in the size ranges under 30 nm in diameter continues, and there is an increase in concentrations of particles of sizes between 30 and 300 nm.

**New Particle Formation Events Frequency Analysis**

Finally, in the analysis of the PNSD, the frequency of new particle formation (NPF) events was evaluated. Firstly, the 50th, 25th and 75th percentiles of number size distributions in individual hours of the day were plotted, in order to see the typical daily PNSD of concentrations, and mainly to see the frequency of the occurrence of NPF events (Fig. 9).

Comparing the graphs in Fig. 9, it is evident that in more than 25% of the days, an NPF event is present at the station (a burst of new particles being the most visible feature in the 75th percentile plot, see Fig. 9(a)). NPF events start usually between 11 AM and 2 PM, the growth is well visible up to 8 PM, and then slowly disappears. Some NPF features are still visible even in the median of hourly values as well, see Fig. 9(b). Not surprisingly, the feature is suppressed by the predominant accumulation mode. Even here, however, some growth in the concentrations of the smallest particles’ sizes is visible between 12 and 6 PM. The third part of Fig. 9, presenting the 25th percentile of concentrations, shows a well-expressed accumulation mode, practically uninfluenced by NPF events. Generally, if the concentrations are low during the day, the size distributions are quite stable, with the accumulation mode being the most significant feature. There is only a slight increase in the accumulation mode in the late afternoons.
Secondly, NPF event classification based on Dal Maso et al. (2005) was performed. Moreover, the results were compared to the results of the Hyytiala station, a background station with long-term time series processed with NPF events definition schemes (Kulmala et al., 2004). The results of the two stations are surprisingly similar (Table 2), although the geographical position of measurement sites (Central Europe vs. southern Finland) and also the measurement periods (1996–2003 in Hyytiala vs. 2008–2010 in Košetice) differ. According to the method used, the NPF (new particle formation) event frequency was found to be 31% in the whole dataset, the non-events day occurred in 34% of the cases. The undefined days were comparable to those without events. The results agree well with the findings from the percentiles’ analysis of the daily cycles in Fig. 9.

As already stated above, the variability in the number concentrations varies significantly not only with seasons, but with months as well. Thus, the same classification of NPF events was performed for every month in the two-year period (Fig. 10), to describe the variability of NPF events frequencies during the year. The highest frequency of NPF events (48.5%) was found to be during spring, especially in April and May. In summer, the NPF events occurred on 36.7% of days, with the maximum in August and the minimum in June. In July, the difference between the two consequent years is considerable, but the reason could be in the high number of missing days, thus we do not have enough samples to assess the discrepancy. During September, the frequency is still high; in October, however, it drops significantly. Thus, the overall frequency in autumn is a bit lower than the yearly average, 30.1 vs. 31.0%. In winter, no matter which month, the frequency is low, not higher than 18%, usually lower than 10%. The total frequency of NPF events in winter is only 9.3%.

**Table 2.** A comparison of the percentage of days according to the NPF definition from Dal Maso et al. (2005) between the Košetice and Hyytiala stations.

<table>
<thead>
<tr>
<th></th>
<th>Event</th>
<th>Non-event</th>
<th>Undefined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Košetice</td>
<td>31.0</td>
<td>34.4</td>
<td>34.6</td>
</tr>
<tr>
<td>Hyytiala</td>
<td>26.6</td>
<td>32.3</td>
<td>41.1</td>
</tr>
</tbody>
</table>

**CONCLUSIONS**

The first two years of continuous measurements of submicron aerosol number size distribution at a rural background station Košetice observatory were assessed. The evaluation was performed on time scales from years to days, and an overall NPF frequency analysis was conducted as well.

The annual arithmetic average total concentration was found to be $6.6 \times 10^3$ $\#/cm^3$, the most prevailing feature in the number size distribution was an accumulation mode. In contrast, the highest variability was found among the smallest particles.

In the seasonal data, the particles of the smallest sizes (smaller than 50 nm) had the high concentrations is summer, whereas the lowest concentrations were in winter. Their concentrations in autumn and spring were similar. The
particles of the largest sizes (over 300 nm) were of the highest concentrations in winter and of the lowest concentrations in summer. And again, there was not so much variance between the spring and autumn concentrations.

A strong annual cycle was found on the monthly data. The minimum in total concentrations was in winter (global minimum in December), the maximum was in spring to summer (the global maximum in June). It is probably due to the secondary organic aerosols forming mainly in the warmer half of the year. NPF events were like the other processes with strong annual cycles peaking in spring and summer (almost 49% of days in spring and almost 37% of days in summer showed a NPF event) and with its minimum in winter (an NPF occurrence in less than 10% of days).

A weekly cycle analysis proved that the station is comparable with other rural background stations in Europe, being distant enough from the area where the sources are - the weekly cycle was statistically insignificant for every day. This was true not only for annual data, but for seasonal data as well.

The typical daily cycle of total concentrations showed the minimum between 3 and 6 AM and the maximum at about 6 PM. The particles with diameters between 10 and 50 nm in diameter exhibited higher daily amplitude, the difference between the cumulative concentrations of particles in sizes between 50 and 300 and between 300 and 800 nm was only small.

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