Continuous observations of particle size distributions at the Frohnau Tower in Berlin with an altitude of 320 m

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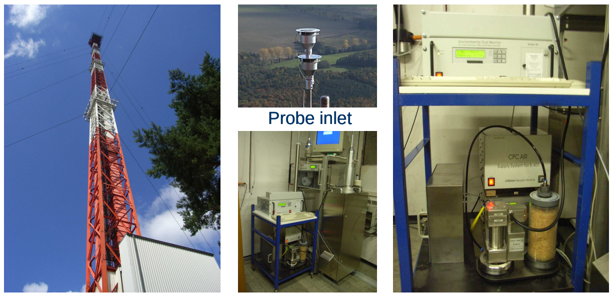
Introduction

The department of environmental engineering of the TU-Berlin carries out a 1-year PM2.5 measurement campaign (01.12.06 - 30.11.07) which is granted by the Senate of Berlin. The measurements were taken at four different sites to determine local, urban and regional sources of fine particulate matter in Berlin. One measurement site is the "Frohnau tower", a tower at the northern outskirt of the city with an altitude of 345 m over ground. At the height of 320 m a measurement cabin was equipped with a filter sampler for daily gravimetric PM2.5-measurements, a continuous measurement device and a Scanning Mobility Particle Sizer (SMPS+C, type Vienna-DMA, GRIMM Aerosol Technik GmbH). The SMPS in combination with an aerosol spectrometer (EDM190) allows the detection of wide range particle size distributions from 5 nm to 32 µm. The tower cabin at 320 m equipped with different aerosol samplers is shown in figure 1.



Frohnau tower (345 m)

Cabin at the tower plat-form with PM-equipment (GRIMM, Thermo, Leckel)

DMA+CPC and EDM190 (GRIMM Aerosol Technik)

Figure 1: Measurement site "Frohnau tower"

Results

The measurements of particle size distributions at the Frohnau tower show that even at an altitude of 320 m high numbers of ultra fine particles occur. Figure 2 shows an example of the 25th of June 2007.

On some days, a good correlation between the total number of particles and the PM2.5 concentration over time was observed (figure 3). There are also days, where a high number of ultra fine particles were measured, but the level of PM2.5 was relatively low. Depending on the atmospheric turbulences above Berlin fine particles might be mixed up and down. Sources for ultra fine particles are combustion processes, e.g. soot emissions caused by traffic and power plants and organic components formed by photochemical reactions. The interesting question is, whether fine particles are emitted from the urban agglomeration or from sources outside of the city. The measurement site Frohnau tower is in certain weather conditions (often during a clear night) above the stable atmospheric boundary layer. With sunrise the mixing layer increases and aerosols from the urban agglomeration are mixed up as shown in figure 4. High number of particles as well as PM2.5 concentrations were observed on June, 7th 2007, see figure 5. The calculated 2-dimensional backward trajectories of this day show that the air masses came from the East and crossed over several large power plants in Poland (figure 6). Sulphate as a secondary aerosol is a suitable tracer for combustion processes, especially for coal combustion of power plants. Air masses transporting high loadings of sulphate mainly come from Eastern and South Eastern directions to Berlin (figure 7). In these directions judge power plants fuelled with coal in Poland and Czech Republic emit high levels of SO_2 and particulate matter. Figure 2 shows an example of the wide range measurements for the June, 25th 2007. High numbers of ultra fine particles (dp smaller 0,1 µm) could be detected. This example demonstrates that even at an altitude of 320 m high densities of fine particles are transported and mixed.

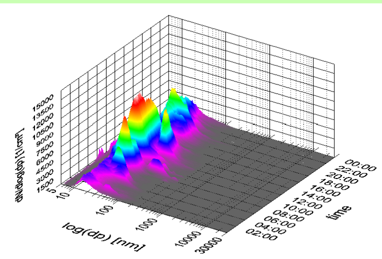


Figure 2: Particle size distribution on 25.06.2007

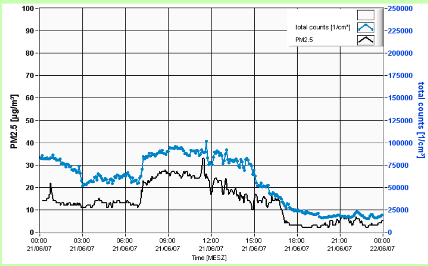


Figure 3: Total counts and PM2.5 on 21.06.2007

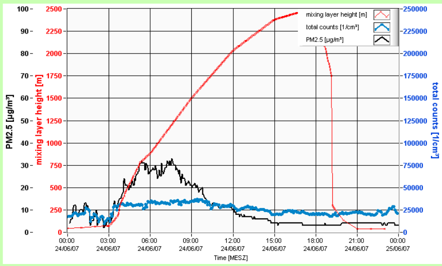


Figure 4: Increasing of the mixing layer and fine particles

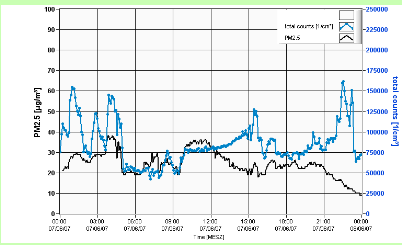


Figure 5: High concentration of particle number and PM2.5, 07.06.2007

Figure 6: 2-dimensional backward trajectories, 07.06.2007

Figure 7: Origin of high sulphate transported to Berlin, 01.12.2006-31.05.2007

Outlook

The aim of further research is to determine the main sources and meteorological parameters leading to high particle concentrations over Berlin. Therefore we will add the results of simultaneous NO_x, SO_2 and ozone measurements at the Frohnau tower.

The correlation of elastic backscatter Lidar data with ultra fine particle concentrations considering relative humidity, diurnal as well as annual variations will be investigated as well.

It is also aimed to investigate whether the traffic restrictions set by the Berlin government starting at January, 1st 2008 will significantly reduce the number of ultra fine particles in down town Berlin.

References

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