Particle Size Distribution in the Ambient Air during a Period of High PM10 Immissions

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The ambient air PM10 immission limit was highly exceeded in large parts of Switzerland for a longer period in January and February 2006. The daily averages reached values of up to 150 µg/m^3, which is a factor of three of the limit value 50 µg/m^3. The situation can be attributed to a stable weather period with low vertical mixing, i.e. the presence of an inversion layer in the lower atmosphere. The composition and origin of the unusual high dust loadings, however, remained unclear. As an attempt to counteract the high immission, a general speed limit of 80 km/h was imposed at several motorways in Switzerland for a limited time period.

The aim of the present investigation is to use particle size measurements for a qualitative assessment of the main sources by correlation of immission data with typical emission spectra. Diesel engines generate an emission peak in number size distribution near 90 nm, and, dependant on fuel quality and cooling history, an additional secondary aerosol peak near 20 nm. Gasoline engines emit fewer particles which are predominantly in the size range < 50 nm. Particles from abrasion of tires and breaks are mainly found in the coarse particle region.

A Scanning Mobility Particle Sizer (SMPS) and an optical particle counter (OPC) were used at the station Reiden, a site of the Monitoring of Supporting Measures - Environment (MSM-E) project, next to a main transit highway in a rural area close to Lucerne, Switzerland. For the measurement layout, special care was taken to a conversion to mass size distribution. The calculated mass spectra resulted in good agreement with the official PM10 and PM2.5 data, which were measured in parallel at the same station.

The analysis of the time resolved mass size distributions revealed that the majority of particles that caused the high immissions were less than 1 µm, i.e. PM1. Coarse particles did not contribute significantly to mass concentration. Therefore particles from re-entrainment of dust have a negligible effect on the observed immission levels. During the phase with immissions of 150 µg/m^3, a particular high contribution of particles between 0.3 µm to 1 µm could be observed. These particles are very likely not traffic related. One of the possible sources can be incomplete wood combustion under bad conditions. Further investigations on that topic are covered in a separate conference presentation.

During the temporary speed limit on the motorway, a lower concentration of particles < 50 nm was observed at the first weekend in February. The particle concentration rose immediately on the following Monday at 5:00 a.m., when the night time driving ban for heavy vehicles ended, while the general speed limit was still in place. However, the effect during the weekend cannot be unambiguously attributed to the speed limit, because a change in wind direction occurred at the same time. The contribution of the particle fraction < 50 nm to the overall mass immissions is ≤ 1 µg/m^3.

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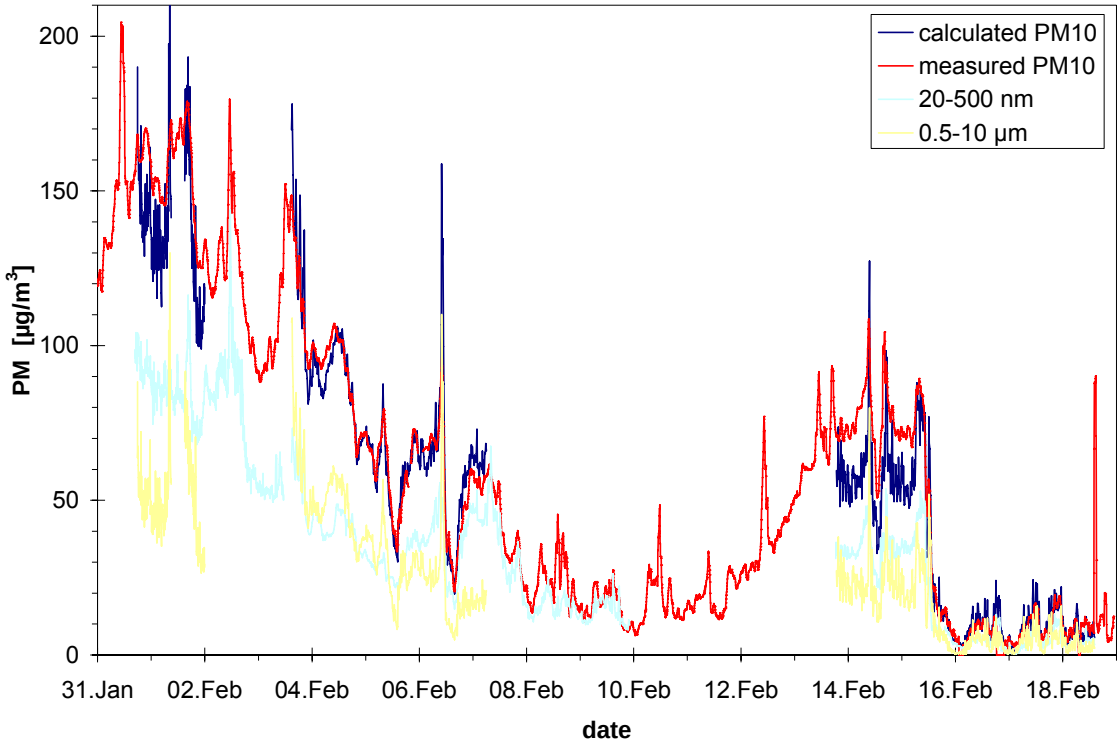
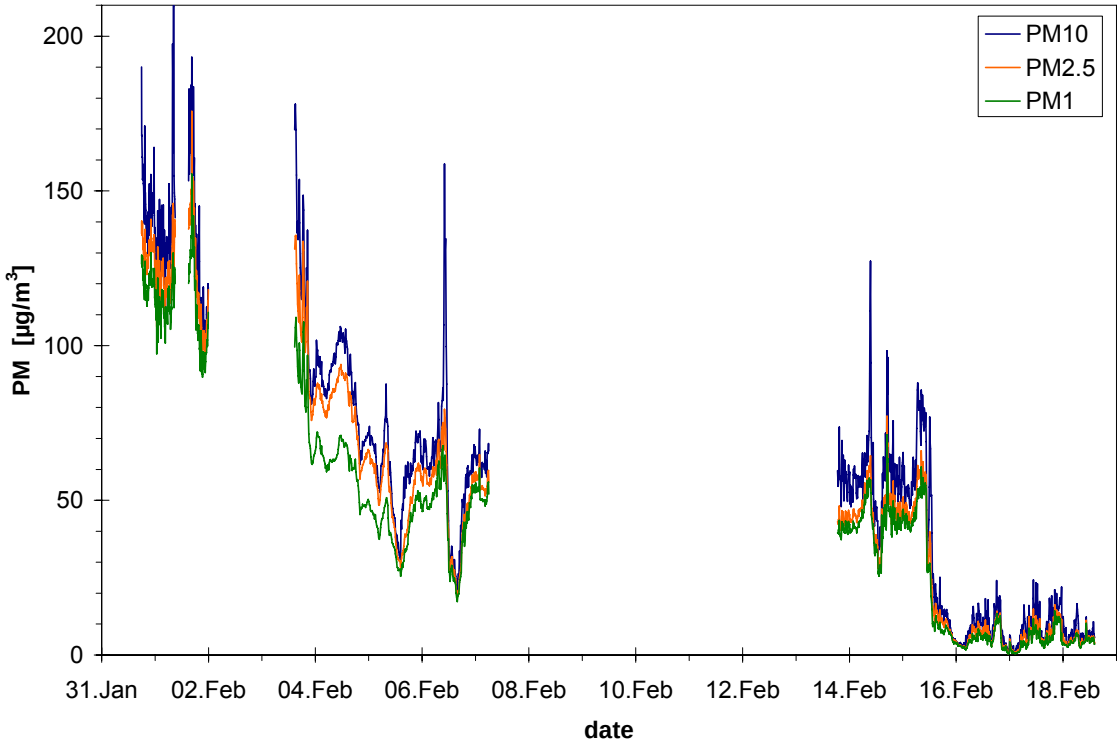
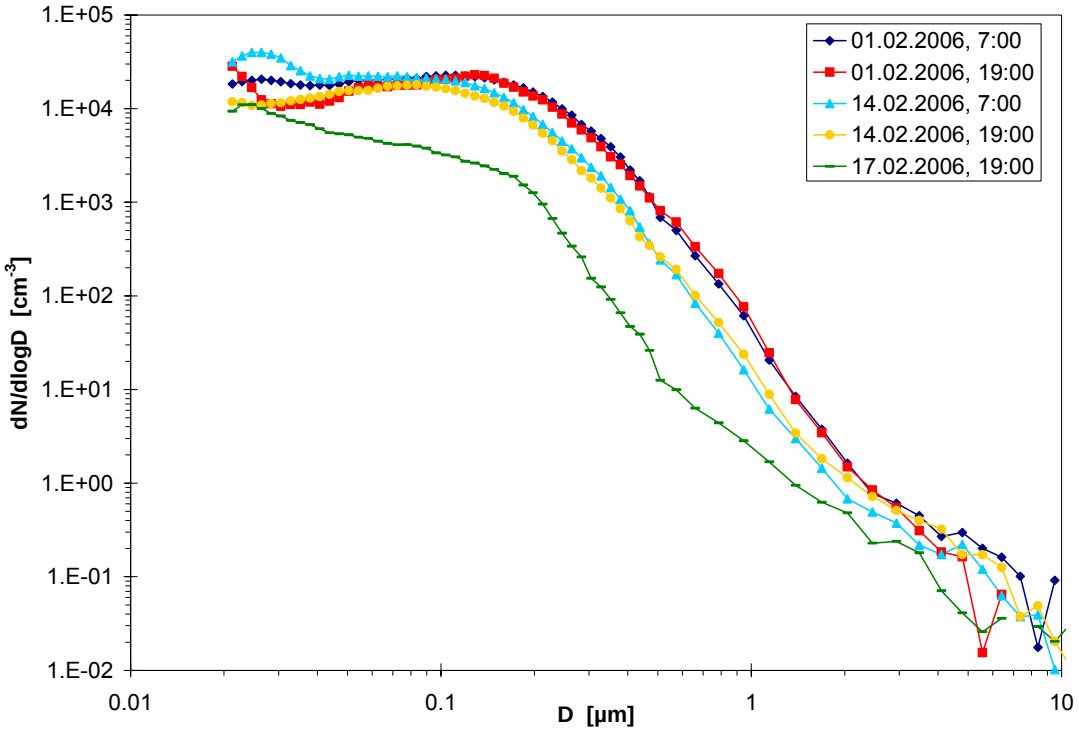
*Mass concentrations of **PM10 measured** gravimetrically (TEOM FDMS) and **calculated** from SMPS and OPC spectra.*

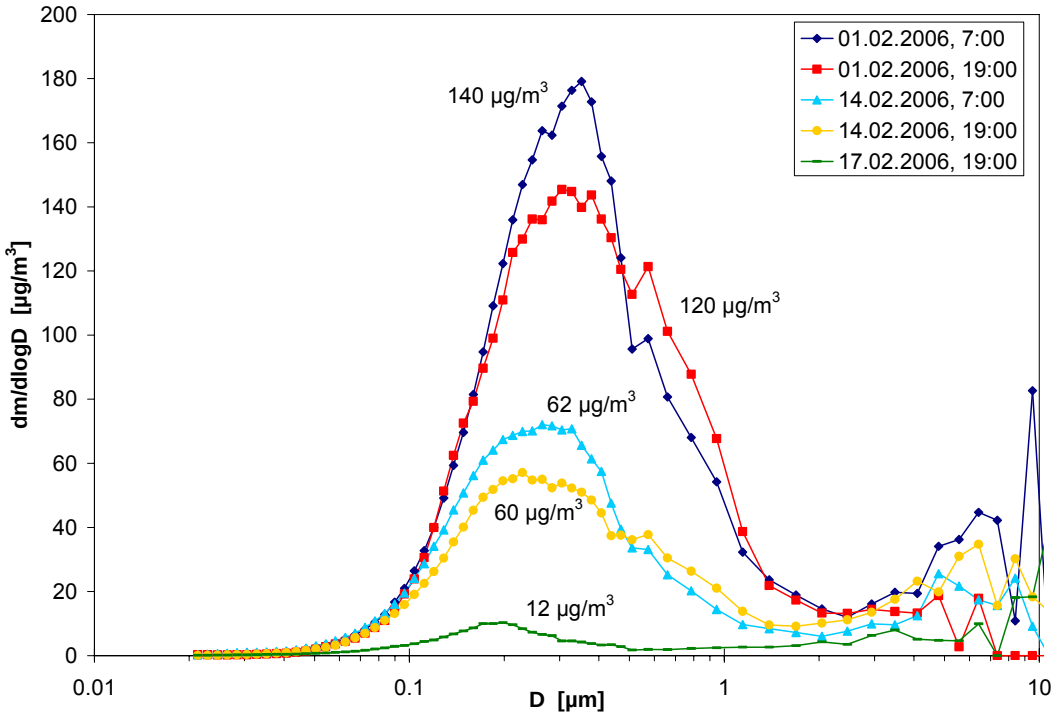


***Calculated** mass concentrations of **PM10, PM2.5, and PM1**. PM2.5 and PM1 contributed 88% and 71% to PM10.*

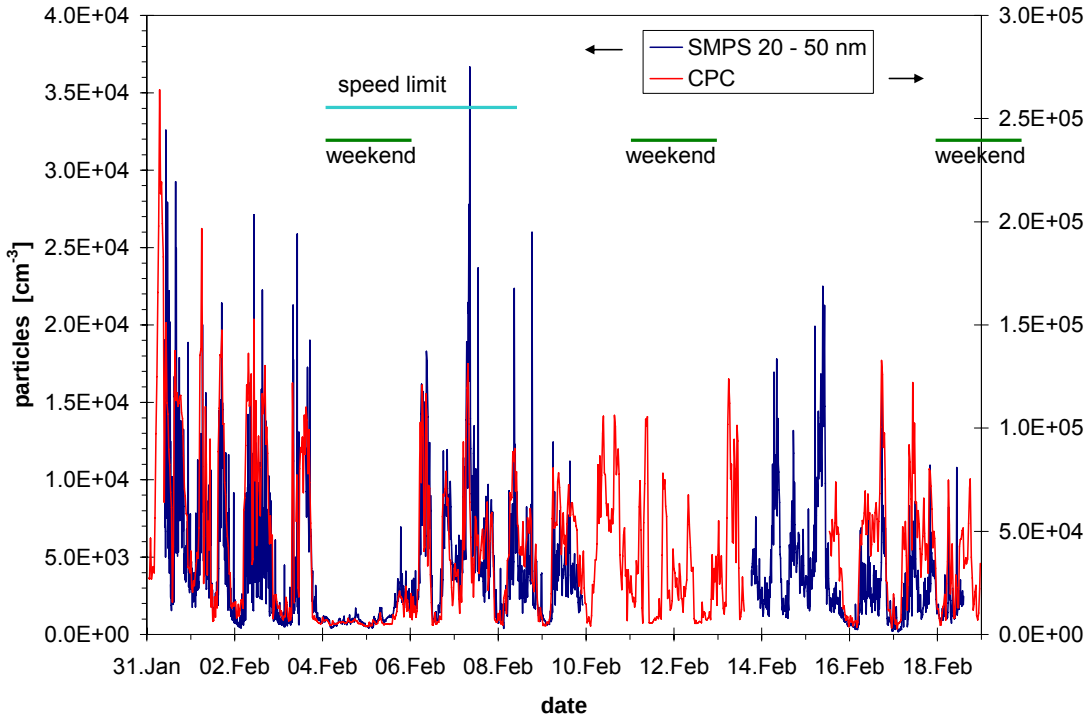


Number and mass size distribution *for three different immission levels. Mass size distributions are calculated from the combined SMPS (< 0.5 µm) and OPC (> 0.5 µm) measurements assuming a uniform particle density. Coarse particles from the abrasion of tires did not significantly contribute to the highest immission levels.*

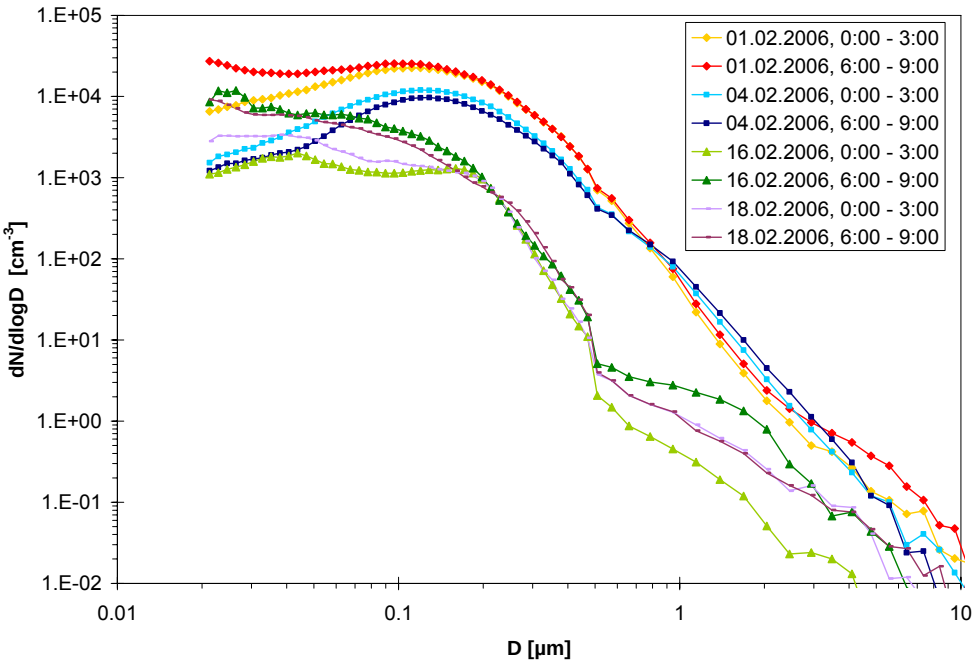




Number concentration of particles < 50 nm *with little counts on the weekend with the traffic limit. Measurements with an SMPS in the size range 20-50 nm and with a CPC, counting all particles, result in a consistent picture.*



Particle size distribution for different days*, at night without traffic, and in the morning with rush-hour traffic.*



Location of the measurement station Reiden *in a rural area close to the highway Basel-Lucerne. An open forest fire burning wood residues is visible on the top picture, which was taken during the smog situation on January 31, 2006.*