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Investigation of meteorological influences and mixing-layer height upon ultrafine particle size distribution in the urban area of Augsburg

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INTRODUCTION

Urban regions - frequently influenced by enhanced air pollution.

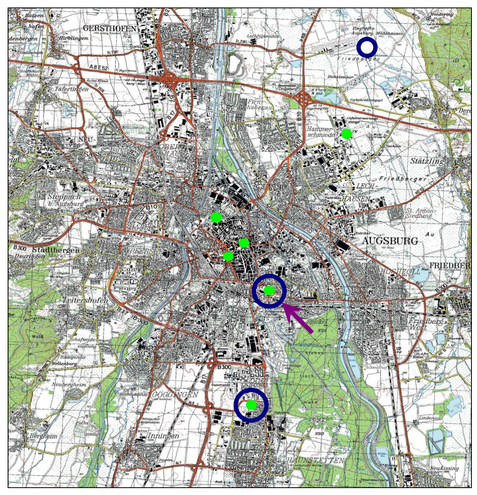
Particulate matter and especially ultrafine particles (UFP) are of high health risk.

Wind speeds and directions as well as mixing layer height (MLH) - important factors which influence exchange processes of ground level emissions.

METHODOLOGY

Particle size distribution are measured with a Twin Differential Mobility Particle Sizer by HMGU. Meteorological data are collected by the monitoring stations of the Bavarian Environment Agency and the German National Meteorological Service (DWD) . MLH is continuously determined with ceilometer in Augsburg by IMK-IFU. Vaisala ceilometers LD40 and CL31 are used which are eye-safe commercial lidar systems. In the absence of low clouds and precipitation and during broken clouds ceilometers estimate the MLH fairly well.

The results of measurements were compared during simultaneous operations.



RESULTS

Two intensive measurement periods during winter 2006/2007 and 2007/2008.

Daily variation of the particle number concentration (see Figures to the right):
3 - 10 nm: relative constant
10 - 100 nm: strong daily course
100 - 500 nm: weak daily course
>500 nm: intensity of daily course decreases

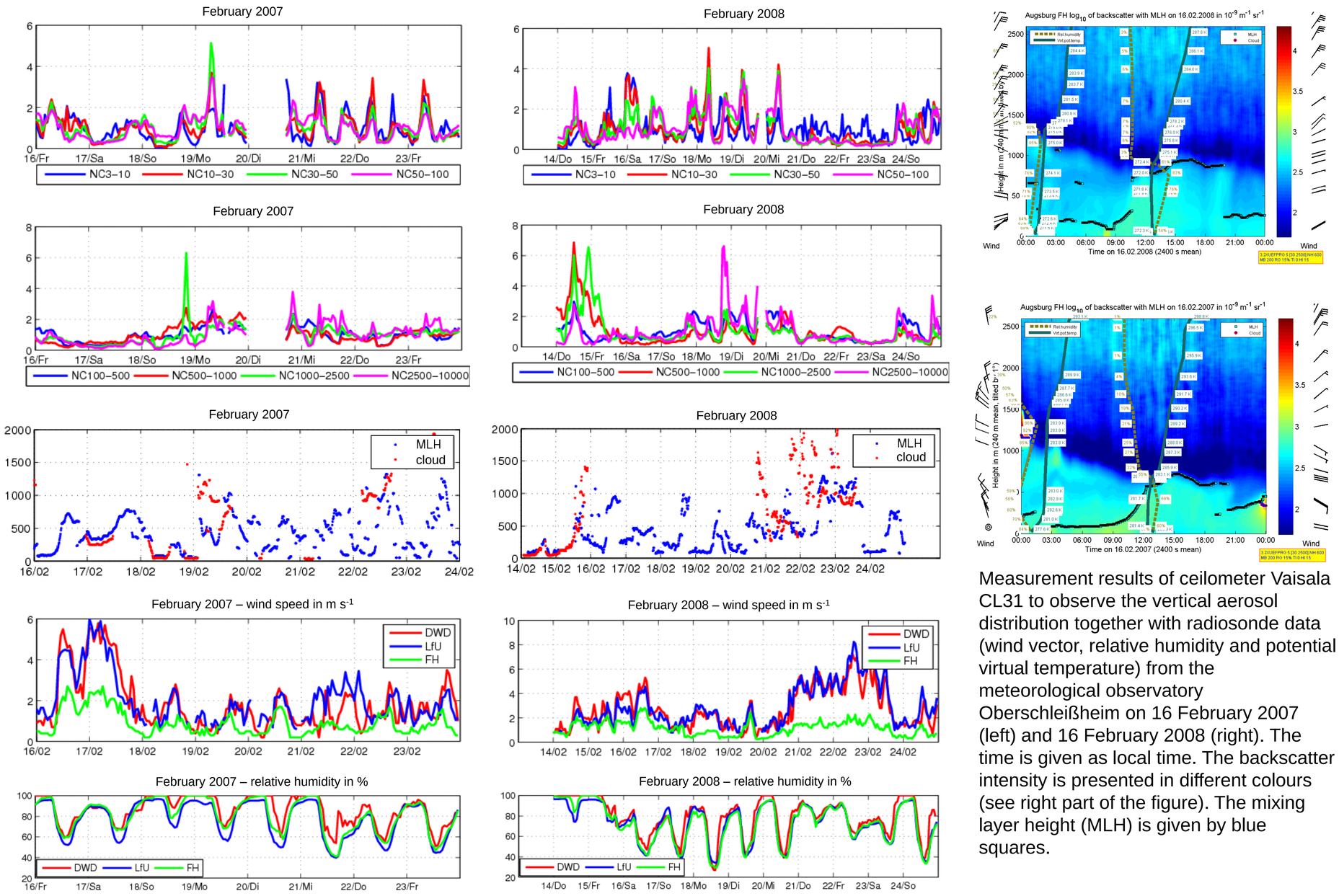
Caused by UFP formation processes which are dependent from the emission characteristics and humidity.

Mixing layer heights

In most cases (see Figures to the right outside) decreasing relative humidity and increasing potential virtual temperature with height (radiosonde data) correlated well with the height of the near-surface layer determined from ceilometer data.

Correlations

Significant correlation of the hourly-mean values of PM number concentrations in the size range 100 – 500 nm with MLH and wind speeds (see Figures to the right).



Measurement results of ceilometer Vaisala CL31 to observe the vertical aerosol distribution together with radiosonde data (wind vector, relative humidity and potential virtual temperature) from the meteorological observatory Oberschleißheim on 16 February 2007 (left) and 16 February 2008 (right). The time is given as local time. The backscatter intensity is presented in different colours (see right part of the figure). The mixing layer height (MLH) is given by blue squares.

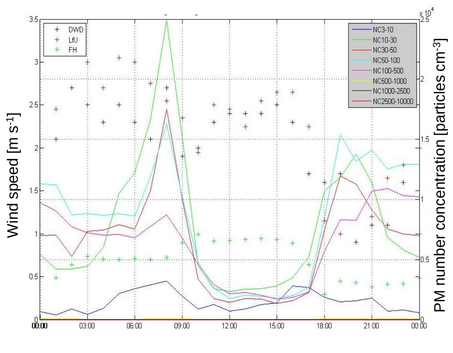
Temporal variation of different UFP number concentrations (NC) in different size modes, mixing layer height(MLH) and cloud height from ceilometer CL31 measurements, wind speed and relative humidity during both campaigns (both at three different stations across the city area: FH inner city, LfU outer city, DWD at Augsburg airport).

CONCLUSIONS

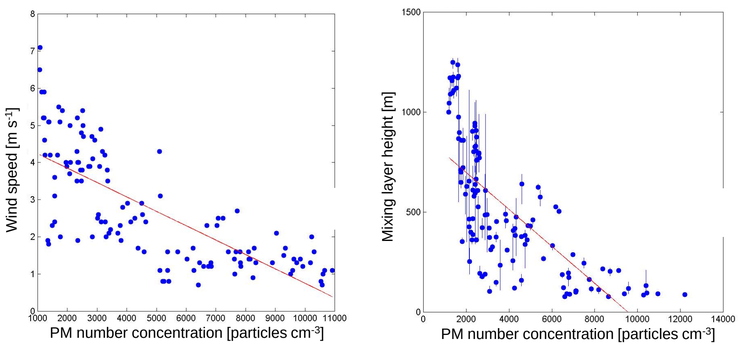
Mainly during winter MLH determines near-surface concentration of air pollutants by about 50 % in areas not influenced by strong emissions and during time periods without strong vertical mixing and advection.

Most appropriate temporal averaging period for correlation of concentrations with MLH is a daily mean, due to missing data (well-mixed conditions and some very rapid temporal variations of MLH).

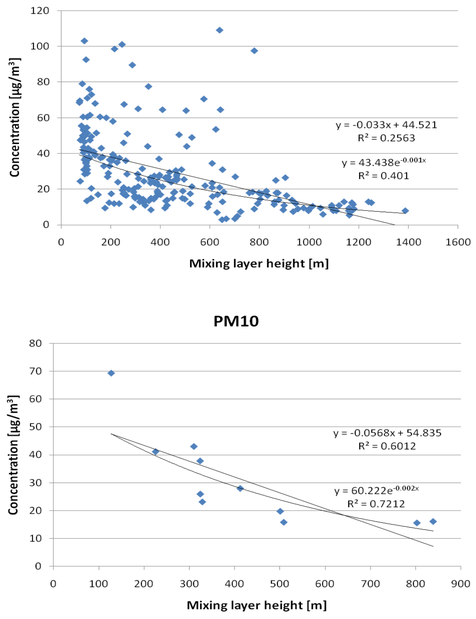
Exponential dependence of concentrations on MLH shows a better correlation than a linear dependence (Figure to the right outside): hint for a relatively good mixing of pollutants in the boundary layer after emission.



Daily course of PM number concentration of different size ranges and wind speed on 18 February 2006.



Comparison of the hourly-mean values of PM number concentrations in the size range 100 – 500 nm with hourly-mean mixing layer height (MLH) values (left) and wind speeds (right) during winter 2008. As an example a linear regression function is given.



Comparison of the hourly-mean (above) and daily-mean values of PM_{10} concentrations (below) and mixing layer heights during winter 2008. As an example the parameters of a linear and exponential regression function and the square of the correlation coefficients are given.