Hygroscopic Growth and Chemical Composition
First Results from Combined Measurements with a HTDMA and an ATOFMS

L. Kammermann[1], H. Herich[2], D. Cziczo[2], M. Gysel[1], E. Weingartner[1], U. Lohmann[2], U. Baltensperger[1]

[1]Laboratory of Atmospheric Chemistry, Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland
[2]Institute for Atmospheric and Climate Science, ETH Zürich, CH-8092 Zürich, Switzerland

Introduction

Water uptake of an aerosol particle - and therefore its hygrocsopic growth - influences both the cloud albedo effect and the direct effect of an aerosol [1]. In this first field study in February 2007 the chemical difference between particles in different hygroscopic growth modes of an urban aerosol is explored by attributing single particle mass spectrometry data to different growth modes.

Instrumentation

A custom built HTDMA (Humidified Tandem Differential Mobility Analyzer) measured the hygroscopic growth factor (GF) of aerosol particles (Figure 1). The instrument, based on the one used in [2], uses a first DMA (Differential Mobility Analyzer) to separate out a specific size of aerosol particles at low humidity (D0). A subsequent humidified section is used to set the relative humidity (RH) at which the GF is to be determined in the second DMA. The resulting size distribution is distinguished with a CPC.
For this project, a part of the aerosol selected by GF was fed into an ATOFMS (Aerosol Time of Flight Mass Spectrometer, TSI, Model 3800). With this setup (Figure 2), all particle spectra could be attributed to a hygroscopic growth factor.

Field Campaign at ETH Zürich

Ambient aerosol was sampled into a lab at ETH Zürich from February 1 to February 4, 2007 and it was possible to get 3000 ATOFMS spectra showing the GF dependent chemical content of an urban aerosol.
Elemental carbon (EC) and fresh biomass burning particles were predominantly found in the less hygroscopic mode (GF ~ 1), i.e. about 50% of these particles contained EC, about 70% contained potassium. In contrast, only 25% of all more hygroscopic particles (GF ~ 1.4) contained EC but still 50% - 60% contained potassium, which is a proxy for particles derived from biomass burning (Figures 3a and 3b).
It is hypothesized that the EC containing particles with GF ~ 1 are emitted from local sources (e.g. diesel vehicles) whereas atmospheric aging processes increased the hygroscopicity of the EC present in the particles with a GF of 1.4. The presence of a GF ~ 1 and GF ~ 1.4 for an urban aerosol at an RH between 82% and 85% is in good agreement with other studies as e.g. [3], [4].

Conclusions

• The connected HTDMA-ATOFMS setup gives good growth factor dependent information of single particle chemical content on sites where high particle concentrations are present.
• The growth factor dependent data on the presence of EC and potassium presents the potential of this novel instrument setup.

References

[1] Solomon S. et al. (eds). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the IPCC. Cambridge Univ. Press, Cambridge, 2007.
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[4] Mc Figgans G. et al. The effect of physical and chemical aerosol properties on warm cloud droplet activation. Atmospheric Chemistry and Physics, 6:2593–2649, 2006.

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Figures

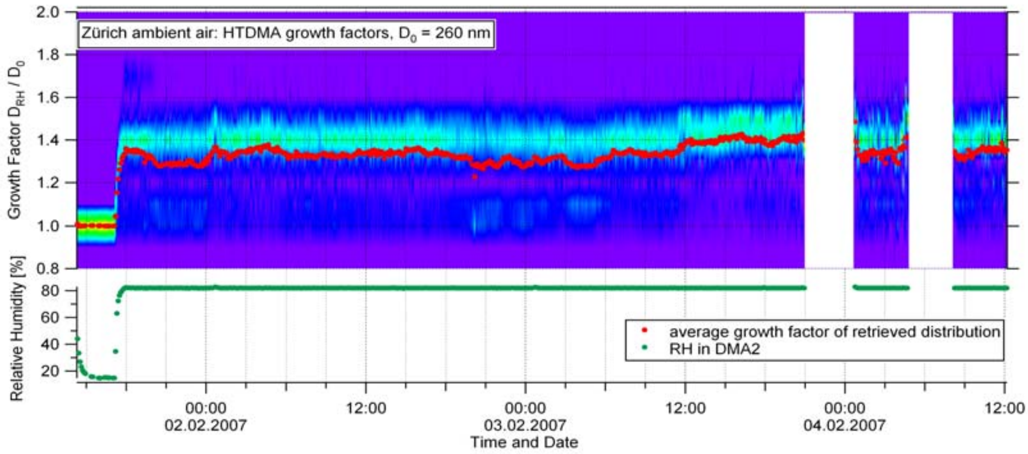


Figure 1
Time series of all HTDMA-scans: The color code indicates the peak height of the GF-scans (top panel). A time series of the humidity the particles were exposed to is shown in the bottom panel. Majority of the particles obtained during the campaing had a GF of 1.4 at 82% RH.

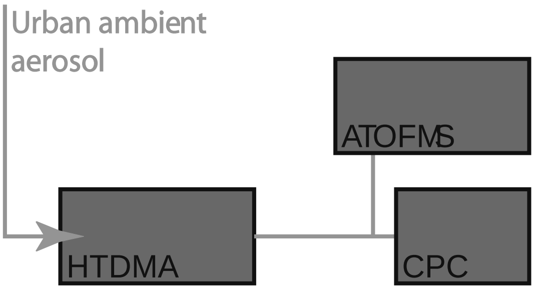
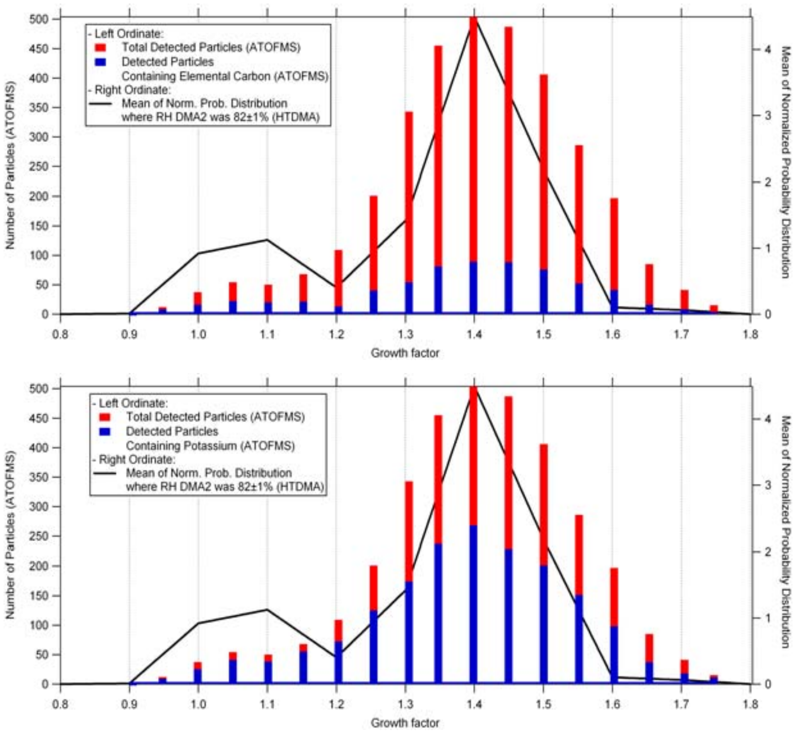


Figure 2
Sketch of the connected HTDMA-ATOFMS setup during the campaign.



Figures 3a and 3b
Each particle witch the ATOFMS detected was attributed to a GF-bin. Red bars indicate the total number of particles detected in the according GF-bin, the blue bars indicate how many of all particles contained EC (top panel) and potassium. The latter is a proxy for biomass-particles (bottom panel). The mean normalized probability distribution of all HTDMA scans at a RH of 82±1% is shown in black.

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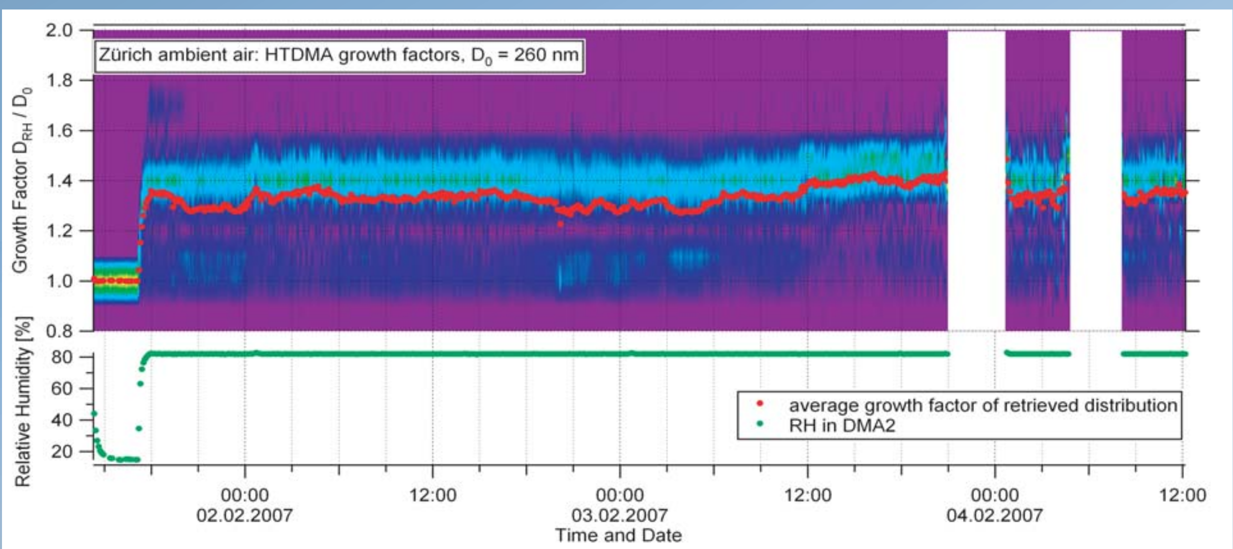

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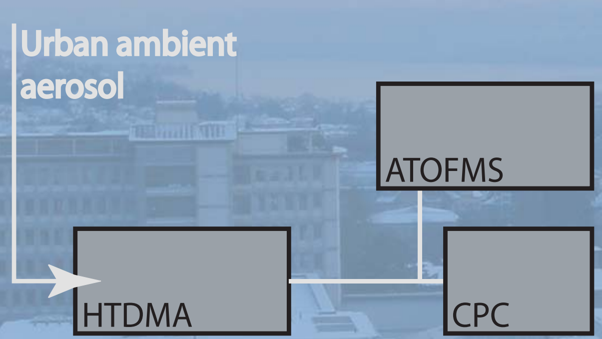

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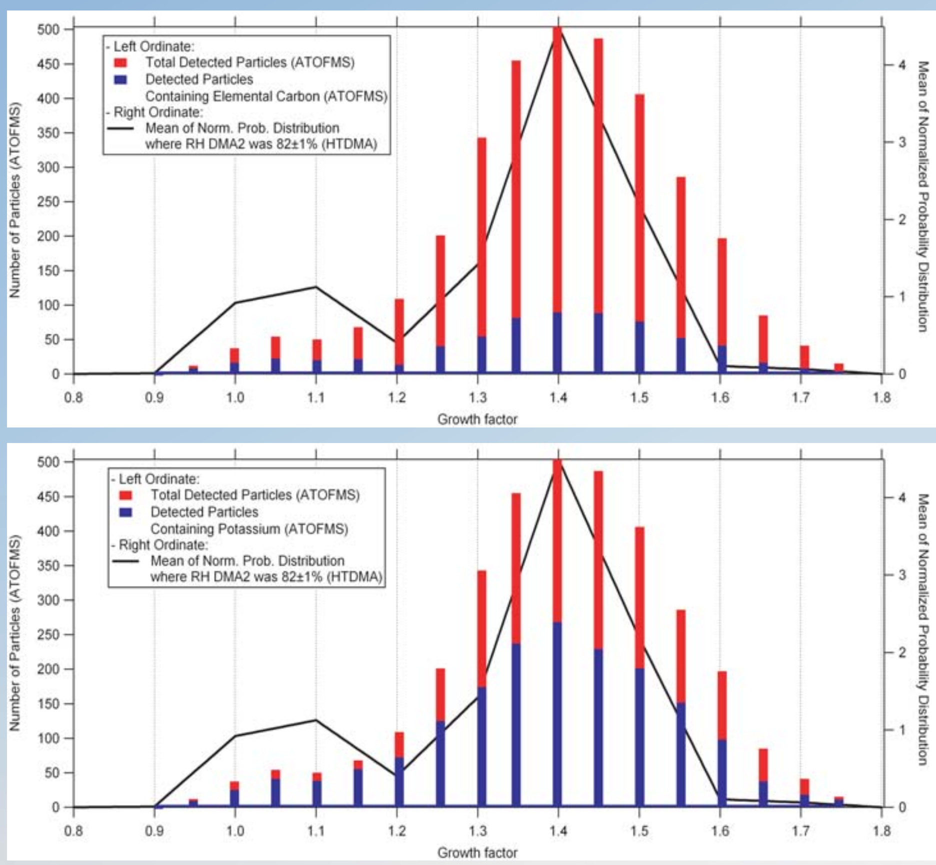

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