Spatial Gradients of Particle Composition in the Rhine Valley

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Introduction

A comprehensive research program combining ambient measurements, smog chamber experiments and controlled emission studies is underway at the Paul Scherrer Institute (PSI) in Switzerland in order to identify, characterize and quantify primary and secondary aerosols in Switzerland. In February 2007 a mobile van was used to identify the chemical composition, the spatial number and mass concentration of fine particles in the Rhine valley, which connects three countries: Austria, Switzerland and Liechtenstein.

Mobile laboratory

The mobile laboratory from PSI is equipped with several instruments capable of obtaining information on the physical and chemical properties of the particulate matter with spatial and temporal distribution. The Aerodyne Aerosol Mass Spectrometer (Q-AMS) is used to measure the chemical composition of the non-refractory particle mass in real time at high time resolution. The Multi Angle Absorption Photometer (5012 MAAP, Thermo Electron Corporation) measures the black carbon (BC) content in the particles. The Fast Mobility Particle Sizer (FMPS, TSI Inc.) provides the sized resolved particle number distribution and the total particle number concentration.

Results and discussion

In Figure 1 the black carbon to the total particle mass and the mean chemical composition of the non-refractory particle mass for each route are reported.

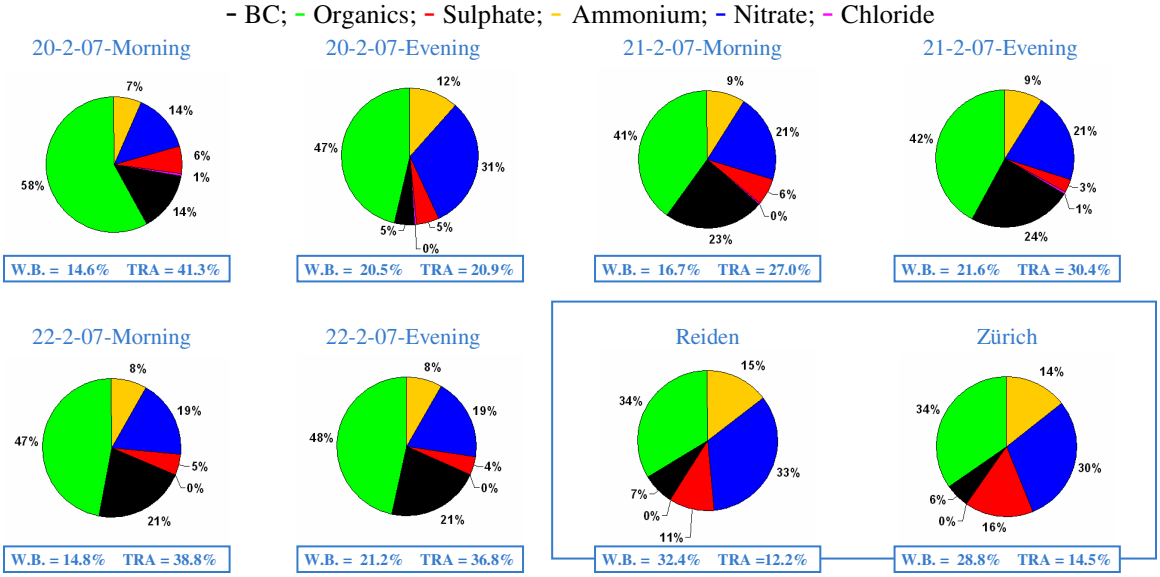

Figure 1. Black carbon and chemical composition of the non-refractory particle mass

Organics dominated the measured particle chemical composition and accounted for (41-58 %) of the total non-refractory mass. The fraction of BC was higher than 20% for 4 out of 6 routes. For measurements performed in Zürich and Reiden in 2006 the fraction of BC was around 6-7% (1). This might suggest that there is an increased fraction of primary emissions from traffic sources in the Rhine Valley. To support this conclusion the Equation 1 was used to estimate the contribution of organics from wood burning to total organics (2) while the Equation 2 was used to estimate the contribution of organics from traffic.

$$WB = (\text{mass m/z } 60 \times 36)/\text{total organics} \quad (1)$$

$$TRA = \{[\text{mass m/z } 57-(0.91 \times \text{mass m/z } 60)] \times 12.4\}/\text{total organics} \quad (2)$$

The estimated organics from traffic in the Rhine Valley (20.9 - 41.3 %) are higher compared to the values from Zürich (14.5 %) and Reiden (12.2 %). This could be due to an increased number of diesel vehicles and trucks in the Rhine Valley.
The particle number and volume size distributions measured in Switzerland (Rural road-CHR; Autobahn-CHAB) and in Austria (Rural road-ATS; Autobahn-ATAB) are shown in Figure 2. An increased small mode at around 10 nm was observed for both highways for the number size distribution compared to rural roads. Moreover, a dominant mode at around 200 nm is seen for the volume size distribution as well on the highways which shows that traffic seems to be the major contributor to particle mass in this region.

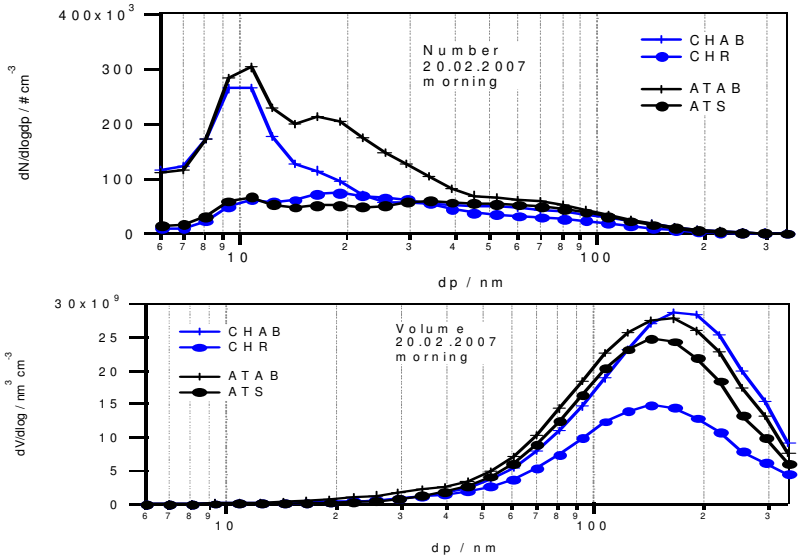

Figure 2. Size-resolved particle number and volume distributions

Conclusion
Organics and nitrate were the dominant components of fine particles in the Rhine Valley. BC was above 20% for 4 out of 6 routes and this could be attributed to higher contribution of traffic emission.
An increased particle number concentrations on highways comparing to rural roads were seen, in particular for small particle diameters (< 30 nm), and an increased particle volume concentrations were seen on highways comparing to rural roads, in particular for diameters greater than 100 nm.

References
(1) PSI Report Jan/Feb 2006: Feinstaub in Reiden und Sedel.

(2) Alfarra, M.R., A.S.H. Prevot, S. Szidat, J. Sandradewi, S. Weimer, V. Lanz, D. Schreiber, M. Mohr, and U. Baltensperger (2007), Identification of the mass spectral signature of organic aerosols from wood burning emissions, Environ. Sci. & Technol., 44, 5770-5777.

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Introduction and objectives

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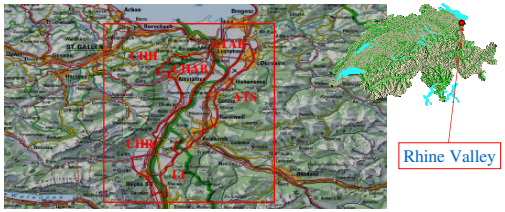
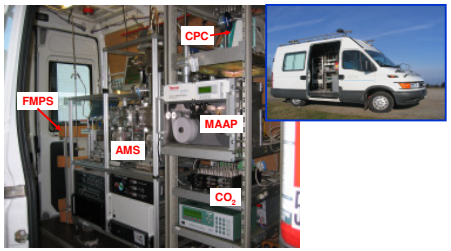
In February 2007 a mobile van was used to identify the chemical composition, the spatial number and mass concentration of fine particles in the Rhine valley, which connects three countries: Austria, Switzerland and Liechtenstein.

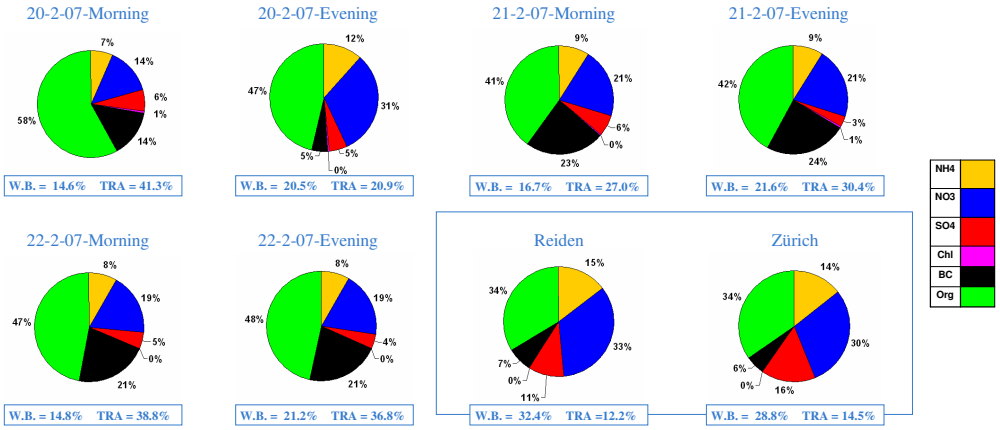


The mobile laboratory



The mobile laboratory from the PSI is equipped with several instruments capable of obtaining information on the physical and chemical properties of the particulate. A pump at the end of the roof of the van pulls air through a gas station tube and then inside a cylinder. Each instrument samples the air with its own pump power. The **Aerodyne Aerosol Mass Spectrometer** (Q-AMS) is used to measure the chemical composition of the non-refractory particle mass in real time at high time resolution. The **Multi Angle Absorption Photometer** (5012 MAAP, Thermo Electron Corporation) measures the black carbon (BC) content in the particles. The **Fast Mobility Particle Sizer** (FMPS, TSI Inc.) provides the sized resolved particle number distribution and the total particle number concentration.

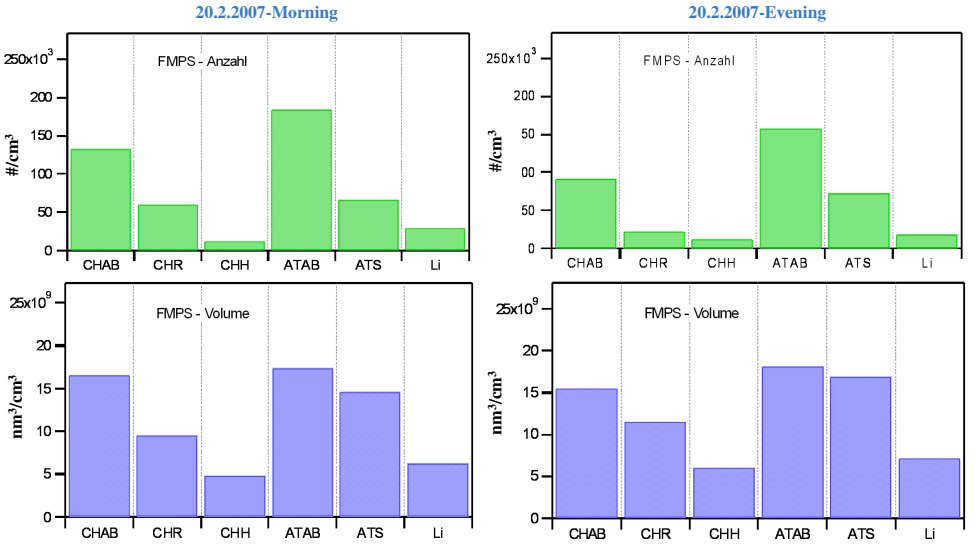
BC and chemical composition of the non-refractory particle mass



Estimated contribution of organics from wood burning to total organics (**WB**) = (mass m/z 60×36)/total organics (*)
Estimated contribution of organics from traffic to total organics (**TRA**) = {[mass m/z 57-(0.91×mass m/z 60)]×12.4}/total organics
(*) Alfarra et al., submitted 2007.

Organics dominated the measured particle chemical composition and accounted for (41-58 %) of the total non-refractory mass. The fraction of BC was higher than 20% for 4 out of 6 routes. For measurements performed in Zürich and Reiden in 2006 the values or the fraction of BC was around 6-7%. This might suggest that there is an increased fraction of primary emissions from traffic sources in the Rhine Valley. This conclusion is supported by the fact that the estimated contribution of organics from traffic is higher comparing to the values from Zürich and Reiden.

Particle number and volume concentrations



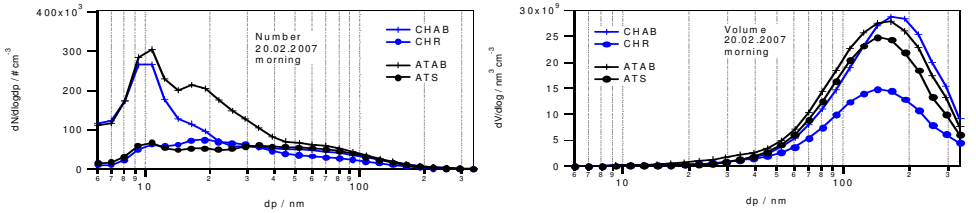
Switzerland: Rural road (CHR)
Autobahn (CHAB)
Background (CHH)

Austria: Rural road (ATS)
Autobahn (ATAB)

Liechtenstein (LI)

The highest number and volume concentrations were seen in the highways in Switzerland and Austria.

Size-resolved number and volume distributions



Number concentrations increased for smaller particle diameters on highway

Volume concentration increased on highways while lower concentrations were seen in rural areas

Conclusions

- Organics and nitrate were the dominant components of fine particles;
- BC was above 20% for 4 out of 6 routes and this could be attributed to higher contribution of traffic emission in the Rhine Valley;
- Increased particle number concentrations on highways comparing to rural roads and background, in particular for small particle diameters (< 30 nm);
- Increased particle volume concentrations on highways comparing to rural roads and background, in particular for diameters greater than 100 nm.