Source apportionment of size- and time-resolved fine ambient particles from the southeast of Beijing

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INTRODUCTION

China suffers significantly from increased particle emissions due to the rapid economic growth during the last decades.This aerosol can influence local air quality and visibility as well as cloud formation processes by serving as Cloud Condensation Nuclei (CCN). Their chemical composition affects the microphysical and optical properties of the clouds such as hygroscopic growth or droplet activation. The Hachi-project (Haze in China) aims to investigate this relation and to identify possible particle sources. Therefore an extended chemical analysis of the submicron airborne particles especially of the organic fraction is performed.

Measurement site

Fig. 1: The measurement site was located at the Wuqing Meteorological Station, China, a background site which is situated between the megacities Beijing (northwest) and Tianjin (southeast).
Winter campaign:
02/03/ - 04/04/2009
Summer campaign:
13/07/ - 13/08/2009

BULK MEASUREMENTS

Sample collection

Fig. 2: The DIGITEL DHA-80 High Volume sampler with the PM_1-inlet on the top.
24 hours system
Cutoff: 1 µm (Dp_{aer})
Quartz fibre filters

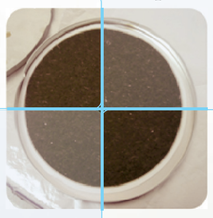
Transport from measurement site back to the institute in deep-frozen state.

Chemical analysis

Fig. 3: The DIGITEL quartz fibre filter from the 02/03/2009.

Carbonaceous material
EC, OC, WSOC
Inorganic ions.

Small polar water-soluble organic compounds
Anhydromono- and monosaccharides, sugar alcohols and dicarboxylic acids.



Non polar water-insoluble compounds
PAHs, hopanes and n-Alkanes.

Surface active substances
Saturated and unsaturated n-fatty acids.

RESULTS

PM_1 mass concentration

Fig. 4: The average campaign PM_1 concentrations for the winter and summer campaign differ in total mass concentration (Tab. 1) as well as chemical composition (Fig. 4) of main constitutes.

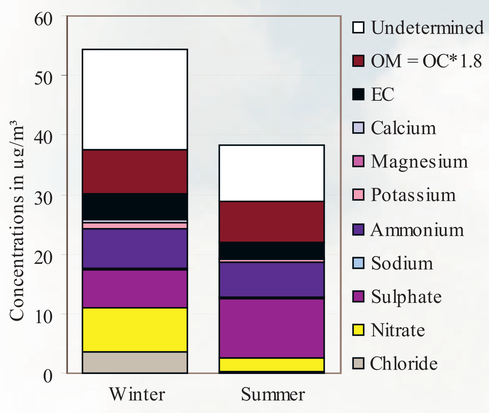


Table 1. The range and mean of mass concentrations for winter and summer campaign in µg/m³.

	Minimum - Maximum	Mean
Winter	20.4 – 121.9	53.8 ± 26.8
Summer	12.8 – 65.7	36.8 ± 13.4

Fig. 5

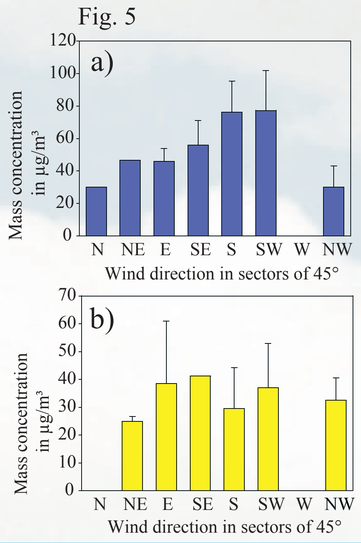


Fig. 5: The PM_1 mass concentrations in µg/m³ were averaged for 8 wind direction sectors of 45°. a) The highest mass concentration was observed from prevailing southern wind directions during the winter time, b) but during the summer time no prevailing wind direction was noted.
N: 337.6-22.5°, NE: 22.6-67.5°, E: 67.6-112.5°, SE: 112.6-157.5°, S: 157.6-202.5°, SW: 202.6-247.5°, W: 247.6-292.5°, NW: 292.6-337.5°.

Traffic emission

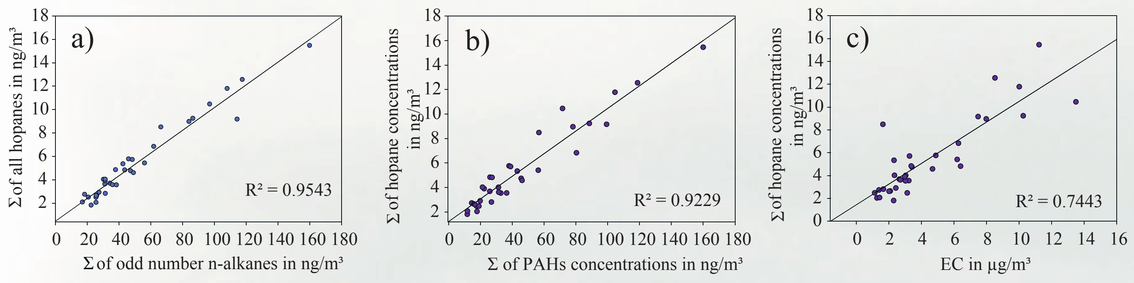


Fig. 6: Hopanes, n-alkanes and EC are anthropogenically emitted from the combustion of fossil fuel. The correlations between the hopanes to a) the sum of odd number n-alkanes, b) the sum of PAHs and c) the EC for the winter campaign suggest that engine combustion (diesel) is an important source for PM_1 particle mass.

Table 2: Coefficients of determination of exhaust originated to potential traffic originated compounds.

		Σ of odd number n-alkanes	Σ of PAHs	EC
Winter	Σ of hopanes	0.9543	0.9229	0.7443
Summer	Σ of hopanes	0.7149	0.3815	0.4539

Biomass burning emission

Levoglucosan is known as a biomass burning tracer and was detected as the most abundant saccharide during both campaigns. The PAH retene can originate from combustion of conifers (Li et al., 2009, Simoneit 1999) and was observed only during the winter measurements. Apparently both compounds are not originated from the same sources (Fig. 7, 8). Another possible source for levoglucosan is the biomass burning of grass related plants as indicated by the ion ratios in Table 3.

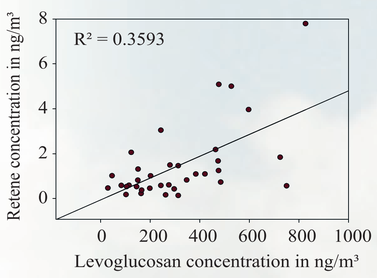


Fig. 7: The correlation of levoglucosan and retene concentrations for winter measurements.

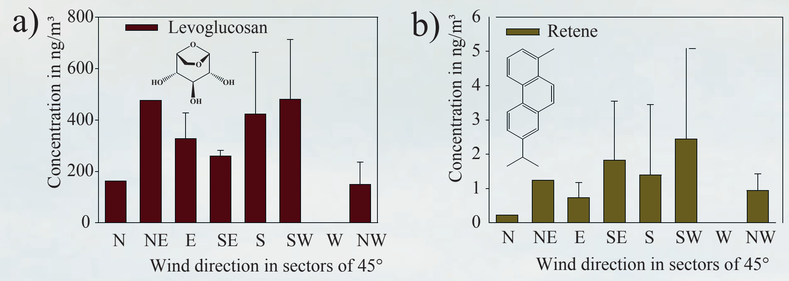
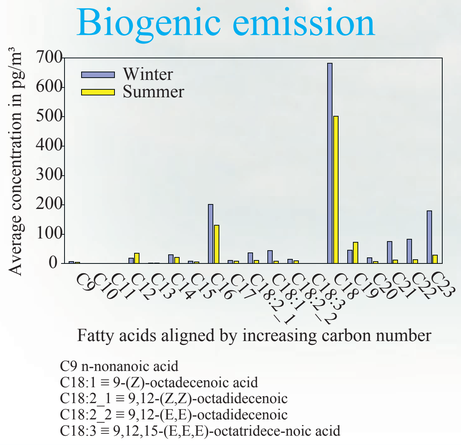


Fig. 8: The chemical structures and mass concentration distributions of a) levoglucosan and b) retene for the winter campaign.

Table 3: Ion ratios for biomass burning indication

	Chloride/Potassium	Chloride/Ammonium	PM
Engling et al., 2009	2 – 3 (Rice straw)	1.1	2.5
Iinuma et al., 2007	6 (Savannah Grass)	3.4	1
This Study	4	0.6	1

Biogenic emission



C9 n-nonanoic acid
C18:1 ≡ 9-(Z)-octadecenoic acid
C18:2_1 ≡ 9,12-(Z,Z)-octadidecenoic
C18:2_2 ≡ 9,12-(E,E)-octadidecenoic
C18:3 ≡ 9,12,15-(E,E,E)-octatridece-noic acid

Fig. 9: The average campaign concentrations of 19 fatty acids (FA) in pg/m³. The C18 and C16 saturated n-fatty acids are the dominant fatty acids during both measurement periods and are mostly of microbiological origin.

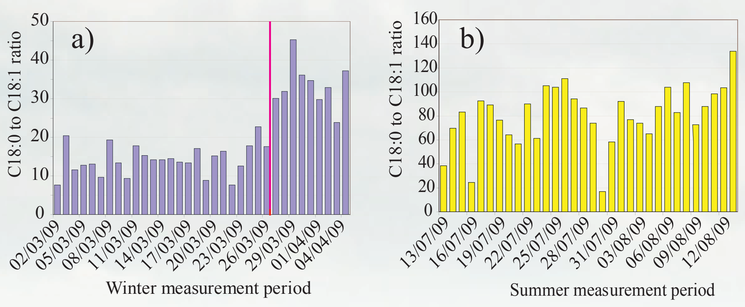


Fig. 10: The C18:0 to C18:1 ratio can serve as an processed aerosol indicator. During a) the winter campaign two different periods are observed. For b) the summer period no such effect was observed.

SIZE- AND TIME-RESOLVED MEASUREMENTS

Sample collection

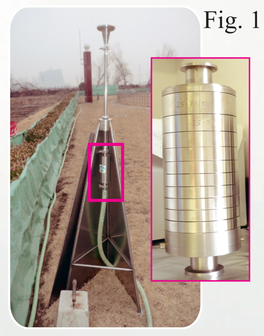


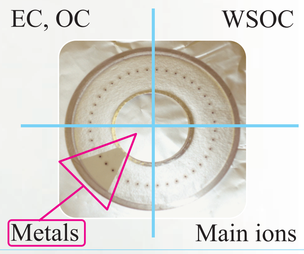
Fig. 11: Using an 11-stage low pressure Berner impactor a day and night sample were collected for 6 hours, respectively.

Table 4: Cutoffs of the Berner impactor

Stage	$D_{(aer)}$ in µm
1	0.015 - 0.03
2	0.03 - 0.06
3	0.06 - 0.125
4	0.125 - 0.25
5	0.25 - 0.5
6	0.5 - 1
	Σ PM_1

Chemical analysis

Fig. 12: The Berner aluminium foil of the 4th stage from the day measurement of the 02/03/2009.



RESULTS

Mass concentrations

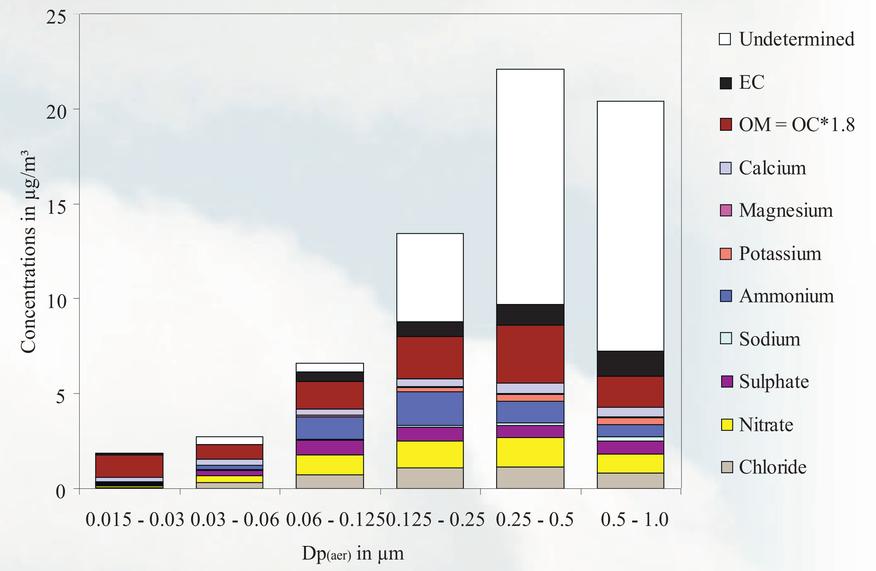


Fig. 13: The size distribution determined from the Berner stages from the day sample of 02/03/2009, winter campaign.

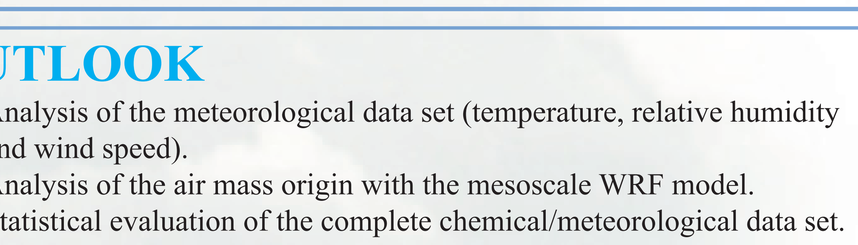


Fig. 14: Less average absolute mass concentrations for PM_1 are observed for day samples compared to night samples during a) the winter as well as b) the summer campaign.

CONCLUSION

Higher PM_1 mass concentrations are observed from prevailing southern wind direction during the winter time.
Higher absolute mass concentrations are observed for night measurments compared to day samples during both campaigns.
Traffic is suggested to be an important emission source during the winter and summer campaign as well as biomass burning.
More than one kind of emission sources for biomass burning related aerosol are possible.
Microbiological emissions during the summer time are observed.
During the winter measurement two periods of differently processed aerosol were detected.

OUTLOOK

Analysis of the meteorological data set (temperature, relative humidity and wind speed).
Analysis of the air mass origin with the mesoscale WRF model.
Statistical evaluation of the complete chemical/meteorological data set.

Literature

Li, Z.; Porter, E. N.; Sjödin, A.; Needham, L. L.; Lee, S.; Russell, A. G.; Mulholland, J. A. Atmospheric Environment 2009, 43, 4187-4193
Simoneit, B. R. T. Environ. Sci. Pollut. Res. 1999, 6, 159-169
Engling, G.; Lee, J. J.; Tsai, Y. W.; Lung, S. C. C.; Chou, C. C. K.; Chan, C. Y. Aerosol Sci. Technol. 2009, 43, 662-672
Iinuma, Y.; Brüggemann, E.; Gnauk, T.; Müller, K.; Andreae, M. O.; Helas, G.; Parmar, R.; Herrmann, H. J. Geophys. Res. 2007, 112, D08209

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