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Road traffic related influences upon $PM_{2.5}$ load in Beijing, China

Klaus Schäfer[1*], Rong-rong Shen[1], Jürgen Schnelle-Kreis[2], Yuesi Wang[3], Longyi Shao[4], Stefan Emeis[1]

[1] Institute of Meteorology and Climate Research, Atmospheric Environmental Research (IMK-IFU) at the Karlsruhe Institute of Technology (KIT), 82467 Garmisch-Partenkirchen, Germany
[2] Joint Mass Spectrometry Centre, Cooperation group „Comprehensive Molecular Analytics“, Helmholtz Zentrum München, 85764 Neuherberg, Germany
[3] Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences (CAS), 100029 Beijing, P.R. China
[4] School of Geoscience and Surveying Engineering, China University of Mining and Technology (CUMTB), 100083 Beijing, P. R. China

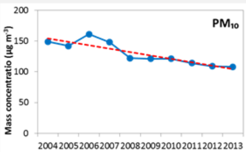
*** Contact: Klaus Schäfer – klaus.schaefer@kit.edu**

OBJECTIVES

Emission reduction measures were performed to improve air quality during the Olympic Summer Games in 2008: mainly PM_{10} reduced, haze became a problem - why?

Work program:

- Chemical composition of PM
- Characteristics of chemical compounds
- Special case studies during haze events for source apportionment



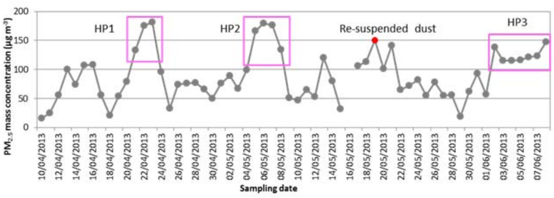
Source: Beijing environmental state report 2004-2013

METHODOLOGY

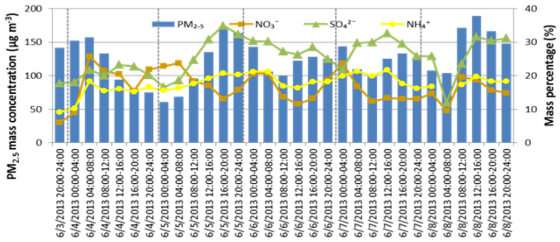
Particulate sampling on quartz fibre filters with 2 High-Volume Samplers DHA80 (Digitel) from 10 April till 8 June 2013. Sampling time 24 hours (00:00 - 24:00); 4 hours during some haze episodes. Backward trajectories calculated with HYSPLIT4. Meteorological data: ZBAA (http://weather.uwyo.edu/upperair/sounding.html) and IAP

Particle composition: Inorganic elements by ICP-MS and $PM_{2.5}$ mass concentrations by filter weighing (sampler A). Inorganic water-soluble ions, EC / OC and organic speciation by IC with continuous flow analyzer, thermal/optical carbon analyzer and GC-MS (sampler B)

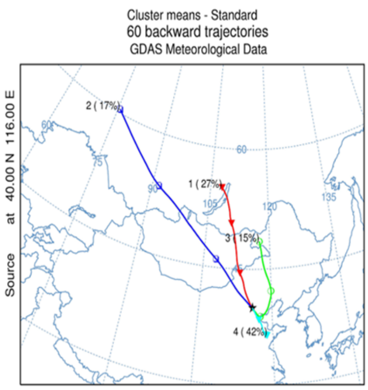
Source apportionment: Positive matrix factorization (PMF3.0, EPA)



Temporal variation of $PM_{2.5}$ mass concentration from 10 April till 8 June 2013 in Beijing with indication of three haze episodes (HP1, HP2 and HP3) and a dust episode (re-suspended dust)



Secondary inorganic pollutant mass concentrations (NO_3^-, SO_4^{2-} and NH_4^+) of $PM_{2.5}$ during high-temporal sampling (4 hours) from 3 till 8 June 2013



Cluster means of backward trajectories from 10 April till 8 June 2013

RESULTS

$PM_{2.5}/PM_{10}$ ratios:

higher values during haze days (0.68) than during clear days (0.38); fine particles and high transformation efficiency into secondary aerosol dominant factors for haze pollution

$PM_{2.5}$ characteristics:

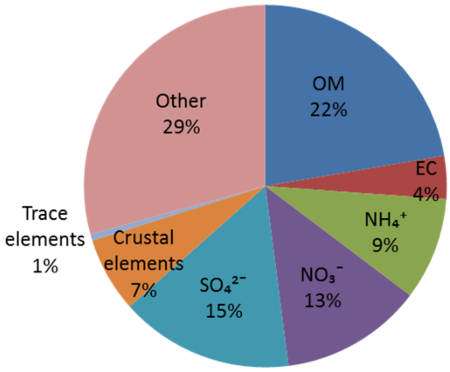
EC, OM (organic matter), Cl^-, SO_4^{2-}, NO_3^-, NH_4^+, K^+, Cu, Ni, Zn, As, Cd, Tl and Pb mass concentrations **increased during haze days** in comparison to clear days (see mass balance right). SO_4^{2-}, NO_3^-, NH_4^+ mass concentrations 6 times higher.

4 h sampling: **average $PM_{2.5}$ mass concentration highest 16:00 – 20:00**. NO_3^- mass percentage high 0:00 – 8:00 and low 12:00 – 20:00. SO_4^{2-} mass percentage varied with $PM_{2.5}$ mass concentration, highest values 12:00 - 20:00 (see left).

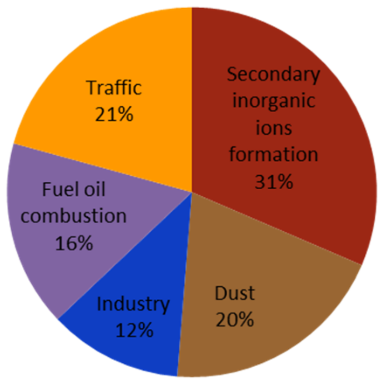
Fe, Ca and Ba (crustal elements) represent dust particles, **Zn, As and Pb indicate haze particles**.

High amount of secondary inorganics: **major chemical species of $PM_{2.5}$ during haze originated from anthropogenic sources**.

NO_3^- / NO_3^- mass ratio during haze days (0.84) higher than during 2001 - 2003 (0.80) (Wang et al., 2005) and 1999-2000 (0.58) (Yao et al., 2002): **vehicle exhaust emissions are a rational for haze days in Beijing**.



Mass balance of $PM_{2.5}$ compounds from 10 April till 8 June 2013



Result of source apportionment by PMF from 10 April till 8 June 2013

$PM_{2.5}$ emission sources:

The result of PMF analyses are (see right):

- Main sources: secondary inorganic ion formation, **traffic**, dust, fuel oil combustion and industry.
- Dust and **traffic emissions main sources during clear days,** secondary inorganic ion formation dominant sources during haze days.

Based on PAH diagnostic ratios: coal and **liquid fossil fuel combustion** dominant sources of PAHs.

Some ratios of compounds as the Hopane and Homohopane index: high amount of **vehicle exhaust emissions** and coal combustion emissions.

Enrichment factor analyses: aerosols originated from

- geogenic sources are most likely **re-suspended road dust** and dust storm and
- anthropogenic sources are **vehicle exhaust**, chemical industry, coal combustion and fertilizer application.

Backward trajectories from the South, calculated for 72 hours in 500 m altitude at the target point, were always found to be short and with high PM mass concentration (see above): southerly flows were the main source of haze particles in Beijing - industrial companies and big cities are in a distance of some 100 km.

CONCLUSIONS

Haze becomes more frequent because an increasing number of fine and anthropogenic particles is emitted.

Control of emissions of precursor gases of SO_4^{2-}, NO_3^- and NH_4^+ in the local and regional scale and thus of **road traffic emissions** is necessary for reducing haze.

Installation of **cleaning equipment in** industrial and **mobile exhaust vents, improvement of road cleaning standards** and reduction of construction dust also becomes important for improving air quality.

There is a need to do further research on formation mechanisms and sources of haze episodes during different seasons in order to improve the urban air quality.

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