Karlsruher Institut für Technologie

Campus-Alpin
IMK-IFU: Atmosphärische Umweltforschung

Source apportionment studies on particulate matter in Beijing/China

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Problem & Motivation

More than 15 million people in the greater area of Beijing are still suffering from severe air pollution levels caused by sources within the city itself but also from external impacts like severe dust storms and long range advection from the southern and central part of China.

Within this context particulate matter (PM) is the major air pollutant in the greater area of Beijing (Garland et al., 2009). PM did not serve only as lead substance for air quality levels and therefore for adverse health impact effects but also for a strong influence on the climate system by changing e.g. the radiative balance..

In order to discriminate the composition of the particulate matter levels, the different behavior of coarser and smaller particles investigations on source attribution, particle characteristics and external impacts on the PM levels of the city of Beijing by measurements and modeling are performed.

Methodology

Measurements

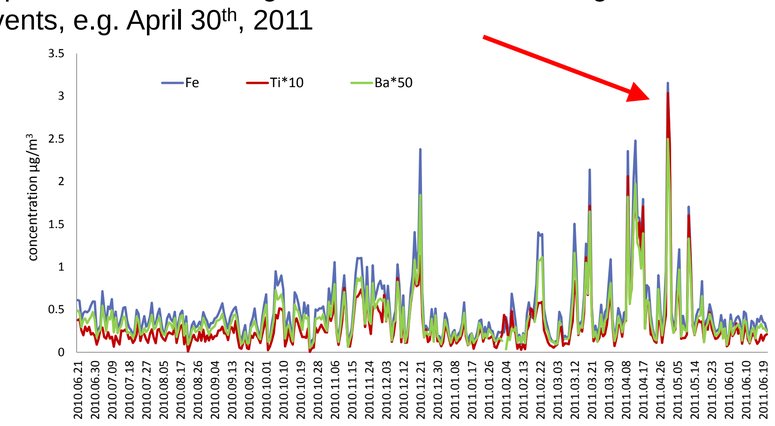
- **Particulate concentrations:** Daily PM filter sampling on quartz fiber filters with 2 High-Volume Samplers DHA80 (Digitel)
- **Particle composition:** Main and trace elements analyzed by PEDXRF (Polarized energy dispersive X-ray fluorescence)
- **Period:** One years episode from **June 2010 to June 2011**

Modeling

- **Meteorology:** COSMO weather forecast model of the German Weather Service
- **Gases & Aerosols:** simulation in ART (developed at KIT) of 80 gaseous species, 5 anthropogenic aerosol modes, mineral dust, sea salt and pollen
- **Feedbacks:** meteorology, aerosols, gas phase, dynamics, clouds
- **Period:** 9-days episode from **April 23rd to May 2nd, 2011**

Measurements

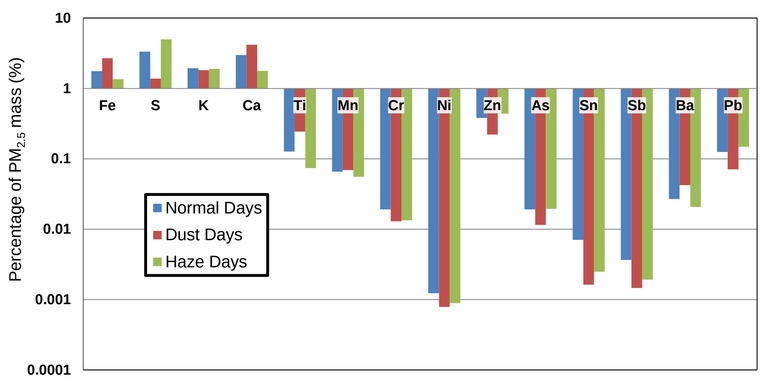
Annual course of concentrations of natural sources (**Fe, Ti** and **Ba**) in particulate matter. Highest concentrations during dust storm events, e.g. April 30th, 2011



Element	Factor 1	Factor 2	Factor 3
PM	**0.684**	**0.647**	0.129
Fe	**0.944**	0.261	0.107
S	0.009	**0.874**	-0.009
K	**0.620**	**0.653**	0.097
Ca	**0.885**	0.218	0.124
Ti	**0.954**	0.040	0.117
Mn	**0.843**	0.417	0.137
Cr	**0.520**	**0.514**	-0.078
Ni	**0.467**	**0.564**	0.060
Zn	0.367	**0.814**	0.273
As	0.132	**0.677**	0.419
Sn	0.008	0.174	**0.792**
Sb	0.172	0.068	**0.680**
Ba	**0.947**	0.240	0.110
Pb	0.348	**0.850**	0.236

Source apportionment - Factor Analysis:
Factor 1: Geogenic sources
Factor 2: Fossil fuel combustion (oil and coal combustion) and waste incineration
Factor 3: Brake wear

See also poster on "Chemical composition of PM in a residential area of Beijing, China"



Particle composition:
S, Zn and **Pb** refer to anthropogenic influences - highest amount during haze days.

Fe, Ti, Ca, Mn, Ba refer to geogenic sources - highest amount during dust days.

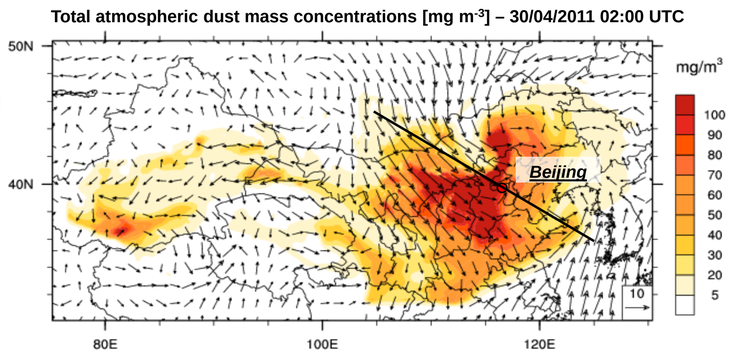
Model results

Dust event on April 30th, 2011:

The dust reached metropolitan Beijing during the night of April 29th to the early morning of April 30th

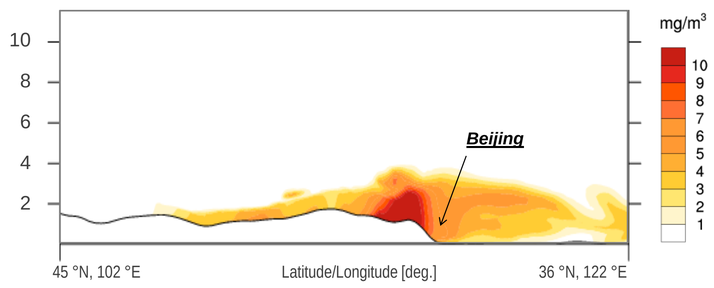
Spatio-temporal distribution of simulated mineral dust:

- The duration of the dust event in Beijing was from the late evening of April 29th till May 1st
- The total dust mass concentrations in the lower atmosphere of Greater Beijing reached values > 100 mg m^{-3}
- The dust was raised up by strong winds (> 15 m s^{-1}) over the Gobi desert



Vertical profile of mineral dust:

The simulated vertical profile shows that most of the dust is located near the ground

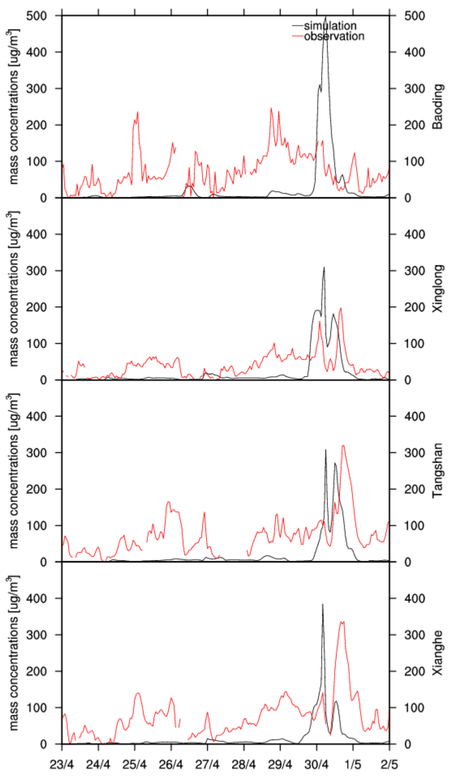


Impact of dust on local air quality:

The dust caused a strong increase of PM_{10} mass concentrations [µg m^{-3}] in the cities of Baoding, Xinglong, Tangshan and Xianghe located in the metropolitan region of Beijing

Main results:

- The dust source is the Gobi desert in Inner Mongolia
- The mineral dust event at April 30th is reproduced by the model very well
- Most of the dust is located near the surface with strong impact on air quality and the human health



Comparison of simulated PM_{10} (black line, dust only) and observed PM_{10} values (red line) for four stations in metropolitan Beijing

Outlook

- Source apportionment on the basis of organic compounds, EC, OC, carbon isotope
- Integration of anthropogenic emissions in addition to the natural ones to quantify the contributions of each source category to $PM_{2.5}$ and PM_{10} in Greater Beijing
- Consideration of interactions between dust, radiation and cloud processes

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