Influences from weather versus emission reductions to improve air quality

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- Challenges
- Scientific questions
- Process studies
- Conclusions, outlook

Challenges

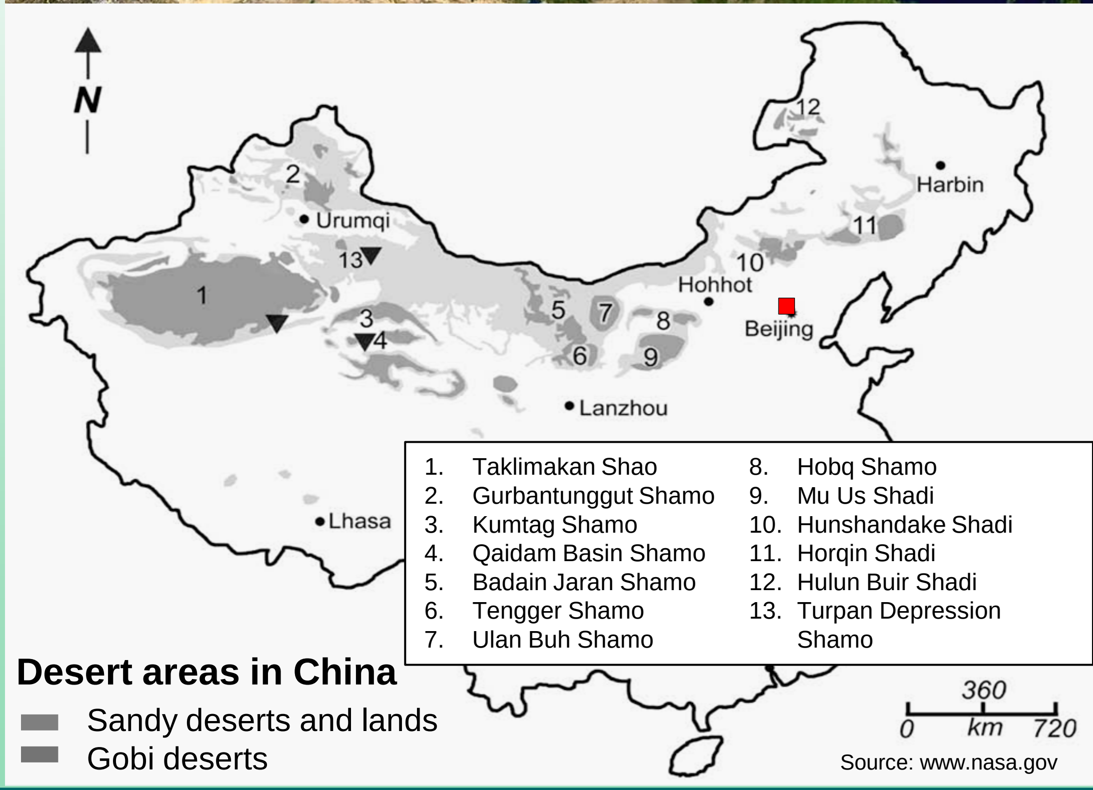
- Changing NO_2/NO_x ratios in ambient air
- Threshold exceedances - sustainable reduction of NO_2, PM_{10}, $PM_{2.5}$
- Load, character and sources of ultrafine particles (UFP) in urban background
- Air pollutants and health impact
  - Which pollutants are relevant?
  - Which concentrations/exposures influence health impacts?

Scientific questions for air quality in Beijing

Origin of frequently occurring air pollution events

Origin of pollutants and especially PM - urban agglomerations are one of the most important sources for PM

Aeolian mineral dust originated from West and Northwest during storm events – can carry pollutants and nutrients

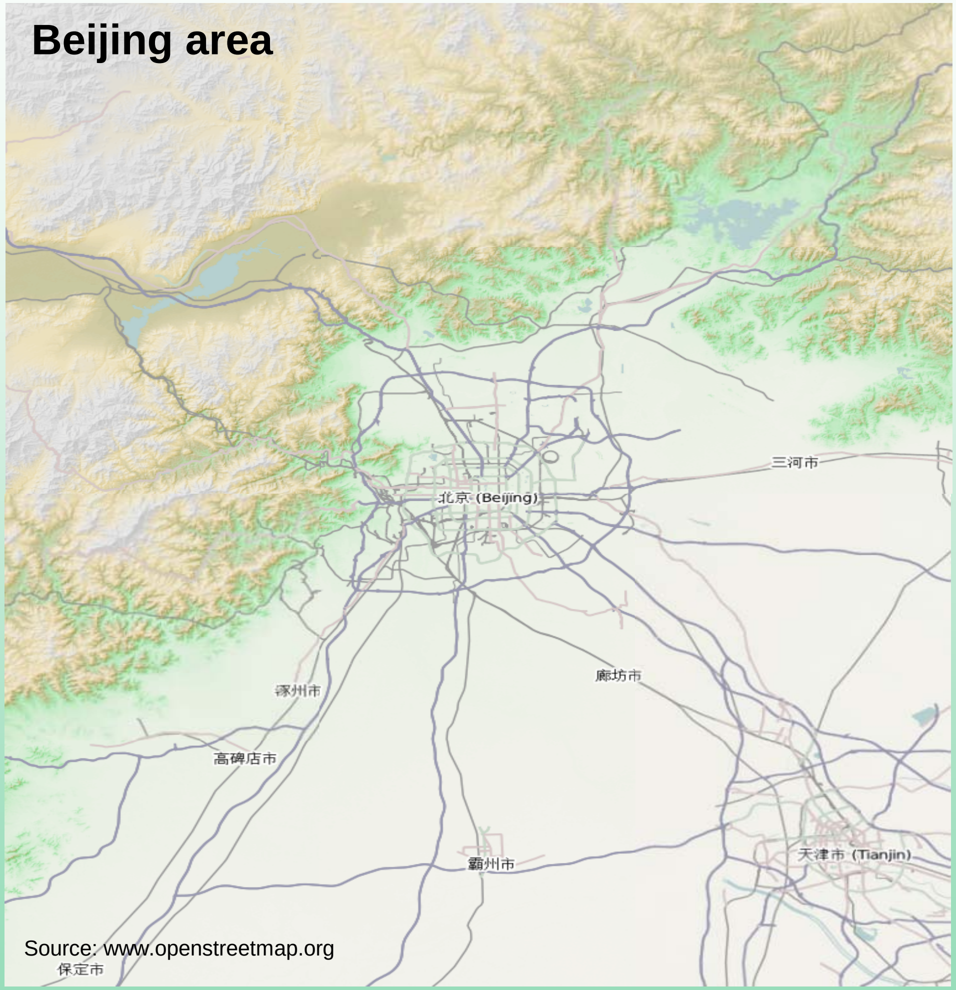


Scientific questions for air quality in Beijing

Local and regional wind systems - can bring fresh air masses and limit air pollution: westerly wind directions

Role of mixing layer height - mountains are West to North

Heat island effect



Air quality **process studies** in Beijing

tower: meteorology, air quality; DOAS 04/09 – 03/11: NO_2, NO, SO_2, O_3, NH_3, benzene, toluene, xylene, HCHO; ceilometer: MLH

Optical remote sensing:
Ceilometer
Vaisala LD40 or CL31
wave length: 855 or 910 nm
range: 4000 m
resolution: 10 or 7.5 m

Institute of Atmospheric Physics (IAP), LAPC: monitoring at 325 m tower

Air quality **process studies** in Beijing

Daily $PM_{2.5}$ filter sampling by 2 HVS DHA80 at CUGB,

06/10 – 06/11 by KIT/IMK-IFU

Main and trace elements analyzed by PEDXRF (Polarized energy dispersive X-ray fluorescence) from KIT/IMG

10 - 20 m distance to

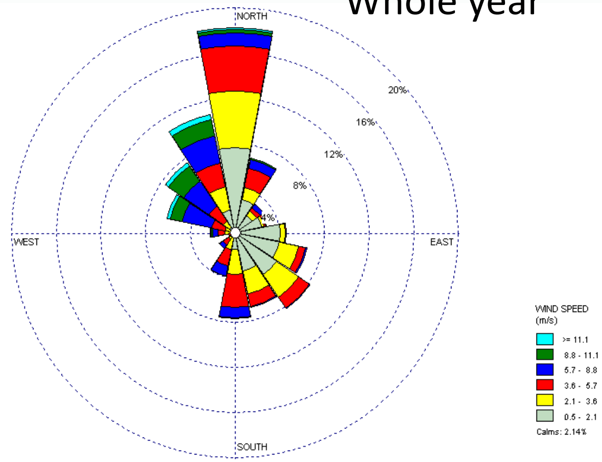
$PM_{2.5}$ weekly MVS and LVS by KIT/IMG and

passive sampling by DWD

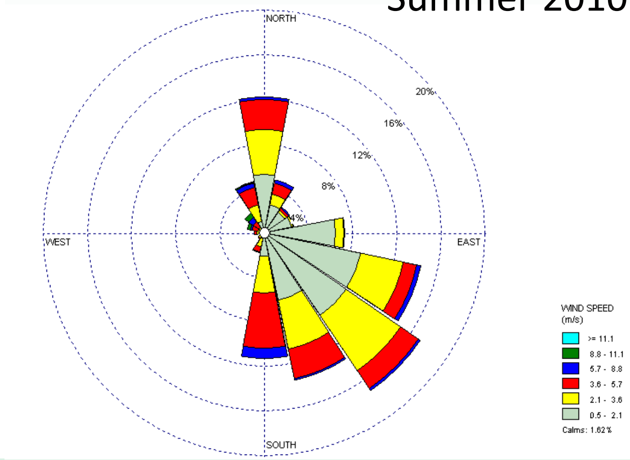
Meteorological data: IAP, ZBAA

Wind influences in Beijing

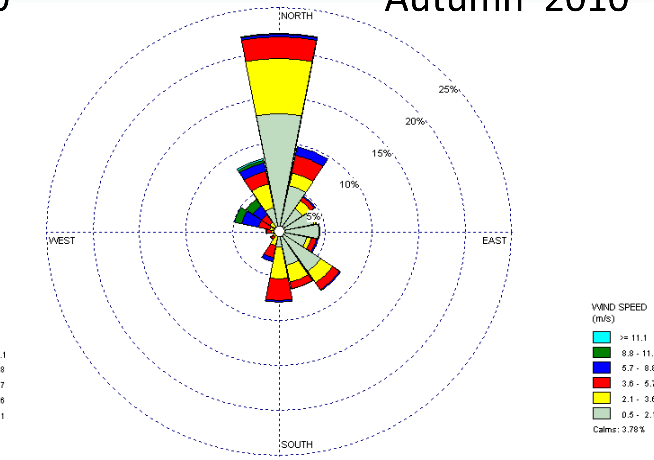
Whole year



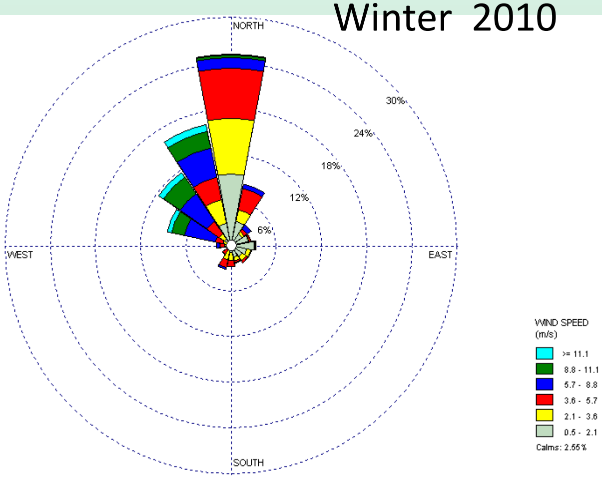
Summer 2010



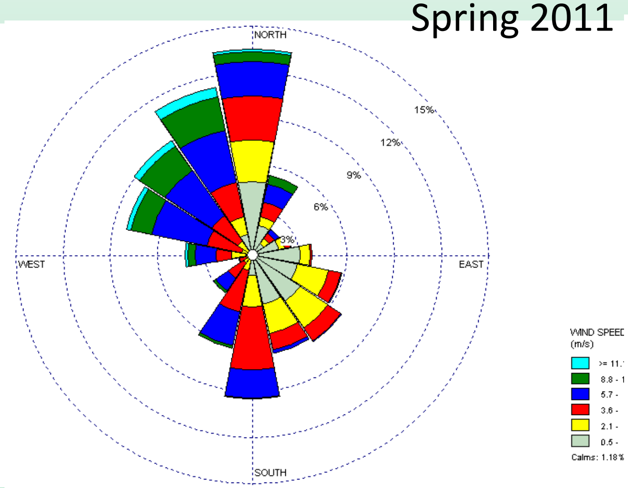
Autumn 2010



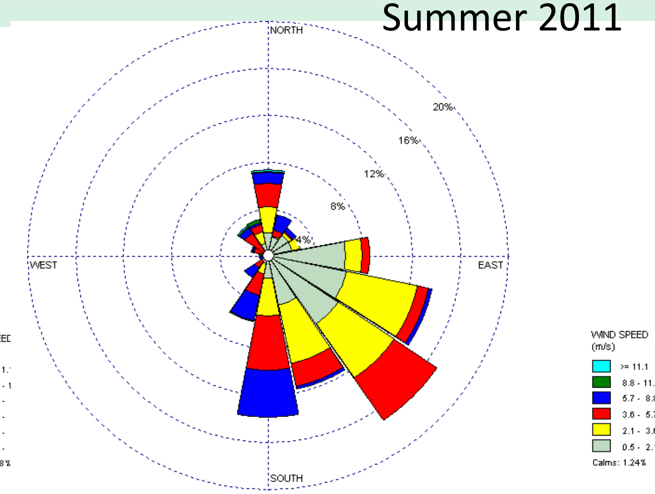
Winter 2010



Spring 2011



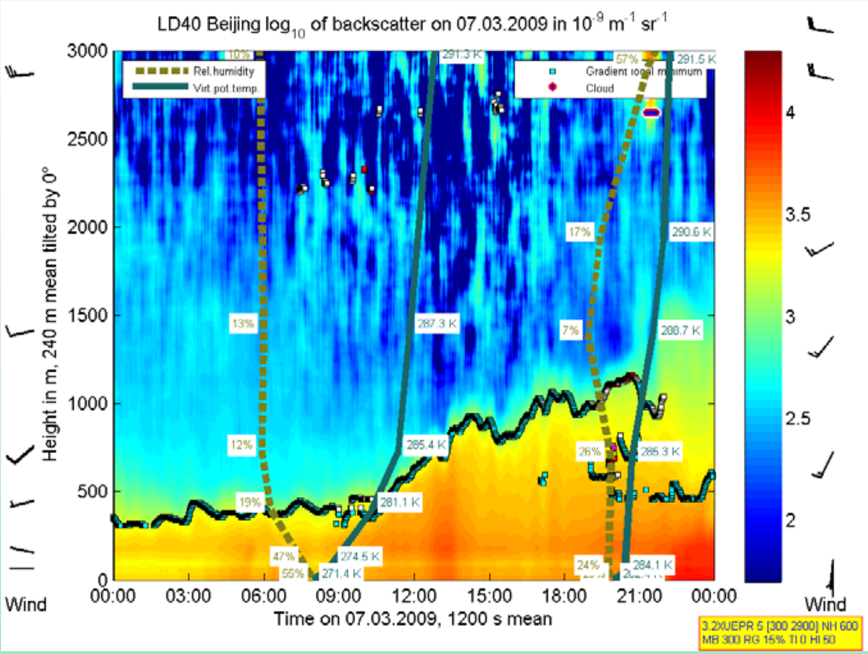
Summer 2011



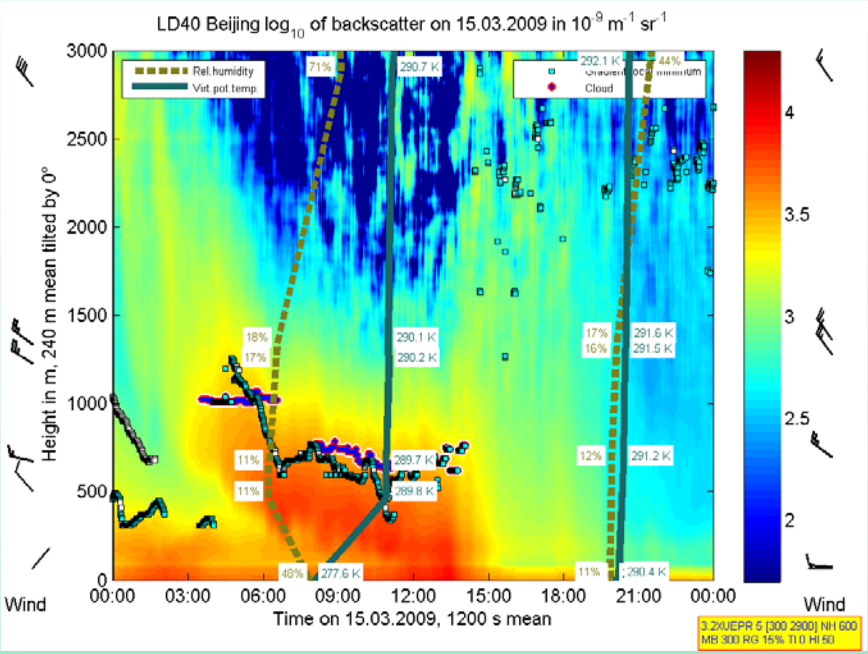
Influences upon NO_2, CO, $PM_{2.5}$, and PM_{10} concentrations in the order of 20 %

Evaluations in Beijing

Higher particulate loads during winds from South-West



Desert dust clouds, winds from West, dry air



MLH > 1000 m: often multiple layering, < 1000 m: often one layer

High $PM_{2.5}$ load (40 – 140 µg/m^3): MLH much lower than 1000 m

Mixing layer height - air quality

Beijing:

Influence of MLH upon element mass concentrations

If the origin of the elements is

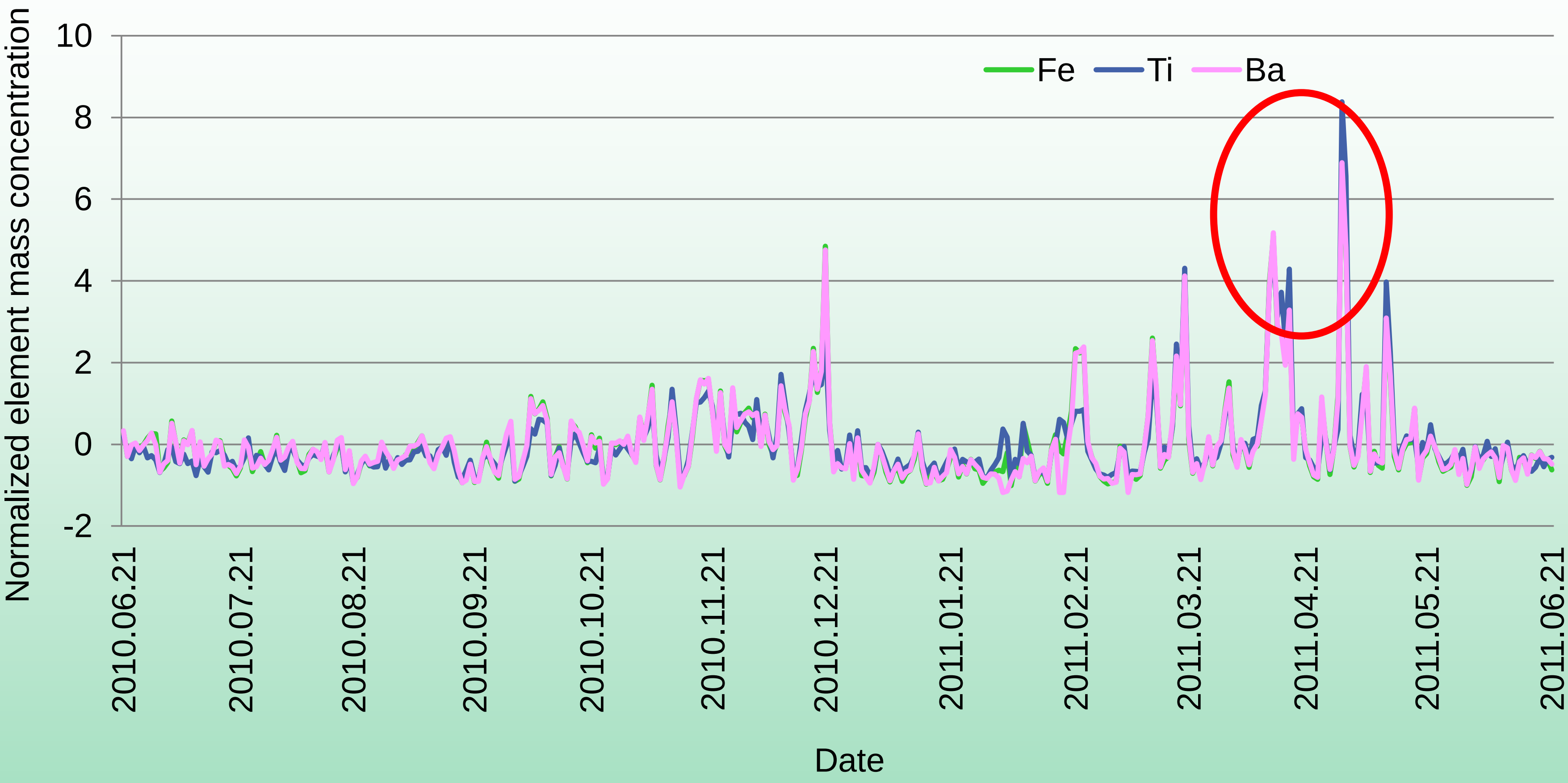
- the soil this source dominates the concentrations (Al, K and Ca no MLH influence),
- the traffic and industry the air transport dominates (no MLH influence in higher altitudes) and
- a widespread area source the MLH dominates (Cu, Zn)

Augsburg, Germany:

NO_2, CO, PM_{10}, $PM_{2.5}$: MLH influence 20 - 50 %

PNC / PMC 100 - 500 nm diameter: MLH influence max 45 %

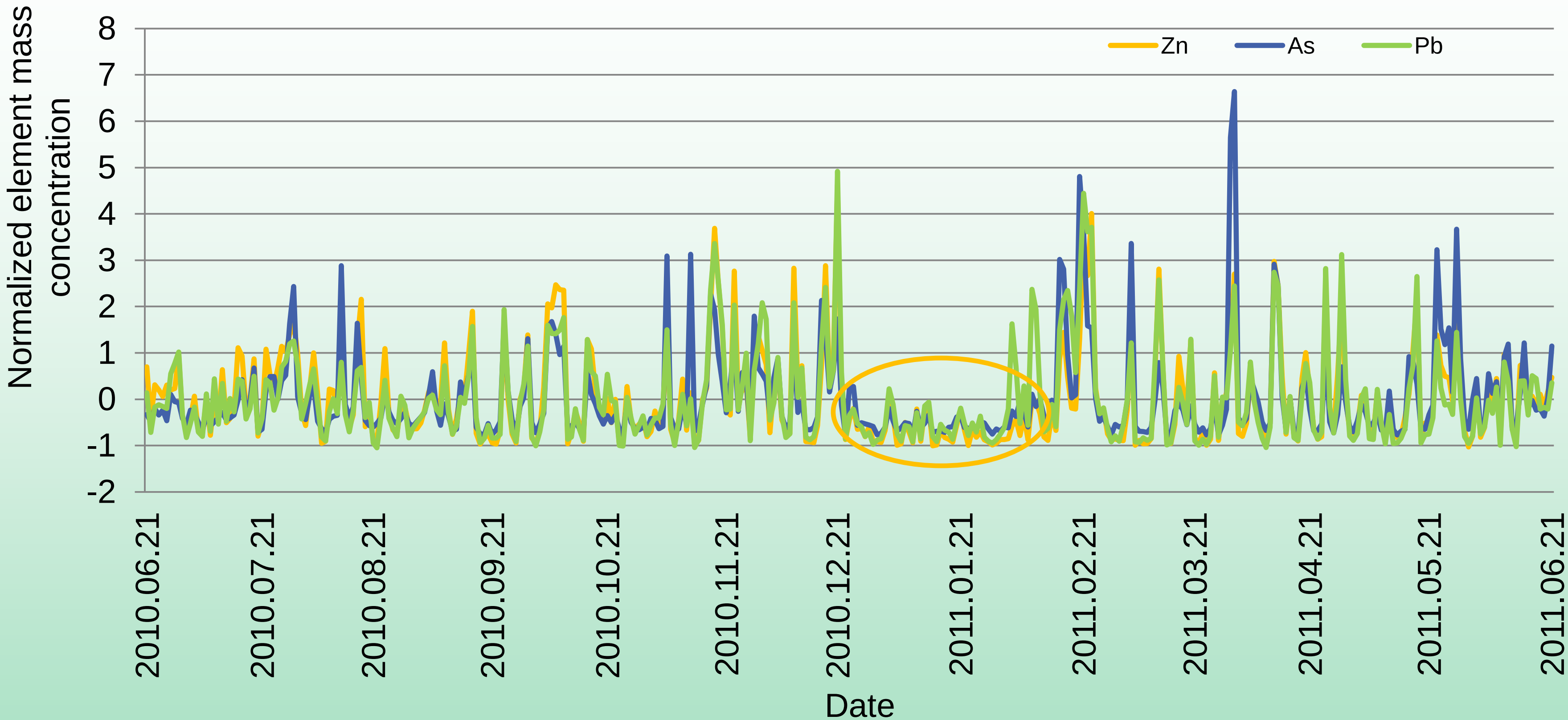
Variation of Fe, Ti and Ba in Beijing



Highest in April because of dust storm (originated from Gobi desert) and re-suspended road dust

Dust events: different natural sources

Variation of Zn, As and Pb in Beijing



Fossil fuel combustion (oil and coal combustion) and waste incineration, lowest in January - Spring Festival holidays

Haze days: highest PM mass concentration from anthropogenic activities, air pollution event during all seasons

Conclusions

- Wind conditions influence urban air quality -> contribution of surrounding emissions: e.g. source apportionment of $PM_{2.5}$
- MLH influenced by future climate change – quality of living in cities
- Only holistic and multidisciplinary approaches provide a deeper understanding
- We have to investigate
  - Traffic emissions and its development (e.g. UFP, BC)
  - Feedback mechanisms climate change & air quality
  - Consequences to human health: $PM_{2.5}$, PSD -> UFP
- Study future developments and recommendations relevant for decision makers and stakeholders to improve air quality and to limit climate change impacts

Outlook

- Regional Climate Change Impact: high resolution climate-chemistry simulations, as done for a 10-years variation in Mexico City

- Aerosol Feedback Mechanisms: temperature, humidity, cloudiness and precipitation change

- Aerosol Influence on Atmospheric Radiative Characteristics

Forkel, R., etal., 2012: Effect of aerosol-radiation feedback on regional air quality - A case study with WRF/Chem. Atmospheric Environment, 45, doi:10.1016/j.atmosenv. 2011.10.009 (special issue about the AQMEII initiative)

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