

Chemical characteristics and sources of PM_{2.5} during haze pollution events in Beijing

R.R. Shen¹, K. Schäfer¹, Y.S. Wang², J. Schnelle-Kreis³, S. Emeis¹, P. Suppan¹, L.Y. Shao⁴

Institute of Meteorology and Climate Research. Atmospheric Environmental Research (IMK-IFU)



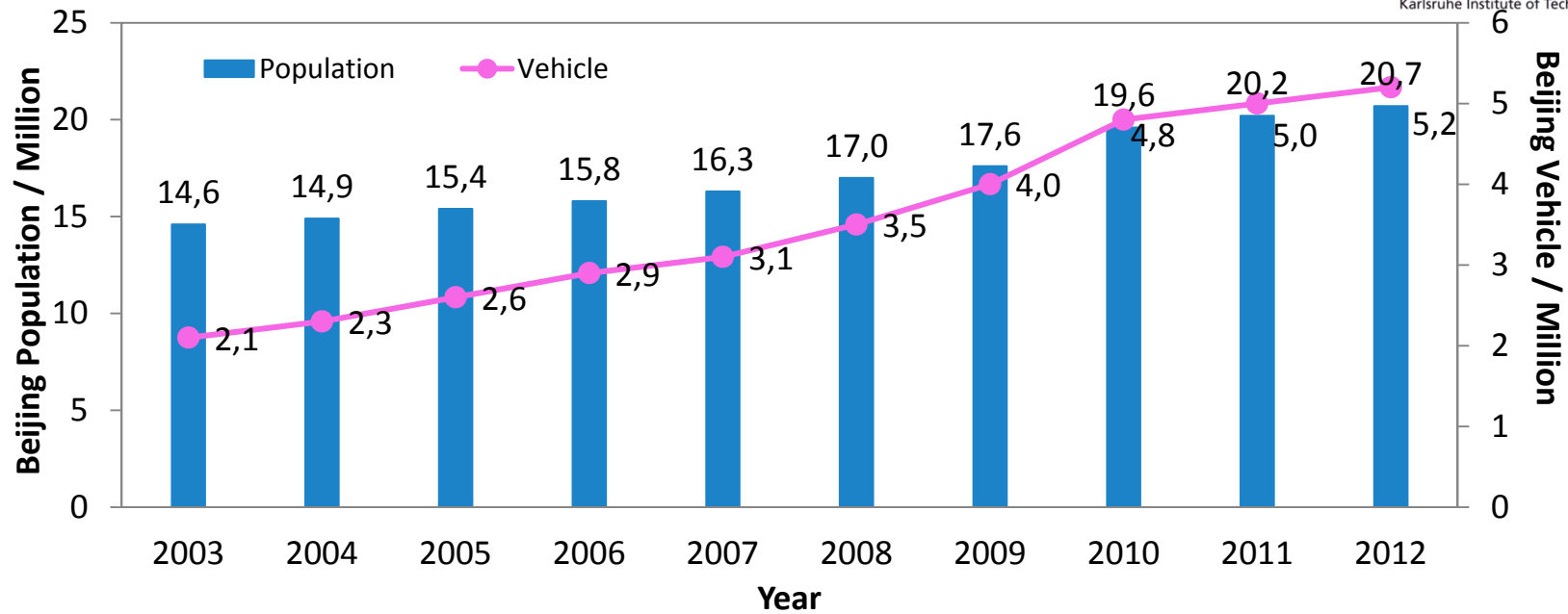
1. Institute of Meteorology and Climate Research (IMK-IFU) at the Karlsruhe Institute of Technology (KIT), 82467 Garmisch-Partenkirchen, Germany;
2. Institute of Atmospheric Physics, Chinese Academy of Sciences (CAS), 100029 Beijing, P. R. China;
3. Joint Mass Spectrometry Centre, Comprehensive Molecular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

Introduction



The orographic condition and surrounding of Beijing (*Source: Google map*)

Introduction



Source: Beijing Municipal Bureau of Statistics, 2013



Beijing, 2013

Methodology



- **Sampling methods**

- Sampling period: 2013.04.10 – 2013.06.08

- Samplers: 2 high volume samplers DHA-80 (500 l min⁻¹)

- Filters: Quartz fiber filters (Ø 150 mm)

- Sampling time: 24 h (00:00-24:00) (4 h during some haze episodes)

- **Meteorological parameters**

ZBAA: T, RH, P, WD, WS

IAP: Precipitation, MLH

- **Visibility**

ZBAA

Methodology



• Analytical methods

– Thermal/Optical Carbon Analyzer: EC/OC

– Inductively Coupled Plasma Mass Spectrometry: K, Ca, Na, Mg, Al, Fe, V, Cr, Mn, Ni, Cu, Zn, As, Cd, Ba, Tl, and Pb

– Ion Chromatography: Cl^- , NO_3^- , SO_4^{2-} , NH_4^+ , K^+ , Mg^{2+} , Ca^{2+}

– Gas Chromatography-Mass Spectrometry: 11 hopanes and 11 polycyclic aromatic hydrocarbons (PAHs)

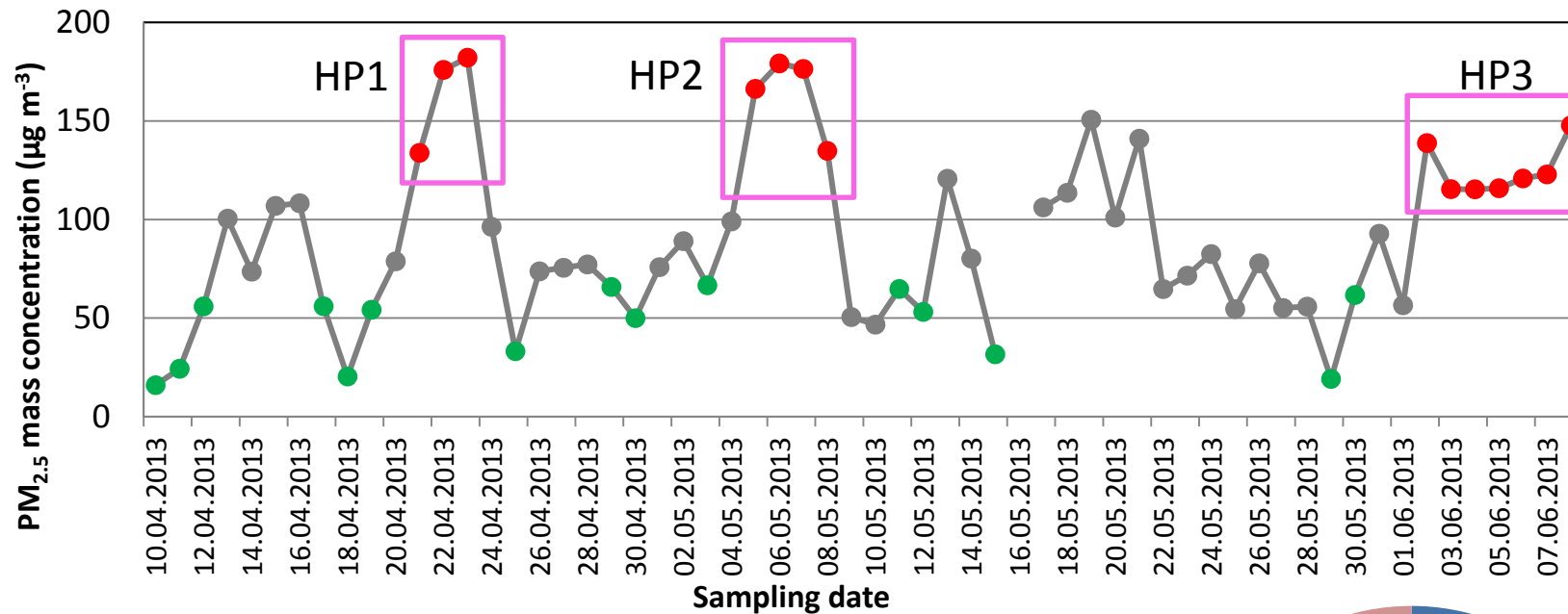
Hopanes:

18 α (H)-22,29,30-Trisnorhopane (Ts)
17 α (H)-22,29,30-Trisnorhopane (Tm)
17 β (H)-22,29,30-Trisnorhopane (27b)
17 α (H)21 β (H)-30-Norhopane (29ab)
17 β (H)21 α (H)-30-Norhopane (29ba)
17 α (H)21 β (H)-Hopane (30ab)
17 β (H)21 α (H)-Hopane (Moretan) (30ba)
22S-17 α (H)21 β (H)-Homohopane (31abS)
22R-17 α (H)21 β (H)-Homohopane (31abR)
22S-17 α (H)21 β (H)-Bishomohopane (32abS)
22R-17 α (H)21 β (H)-Bishomohopane (32abR)

PAHs:

benz(a)anthracene (BAA)
chrysene (CRY)
benz(bk)fluoranthene (BBKF)
benzo(e)pyrene (BEP)
benzo(a)pyrene (BAP)
perylene (PER)
dibenz(a,h)anthracene (DAH)
indeno(1,2,3,c,d) pyrene (IND)
picene (PIC)
benz(g,h,i)perylene (BGH)
coronene (COR)

Results



Average: 89 µg m⁻³

24 h PM_{2.5} threshold values:

WHO: 25 µg m⁻³

US-EPA: 35 µg m⁻³

China (Grade II): 75 µg m⁻³

Green: Clear days

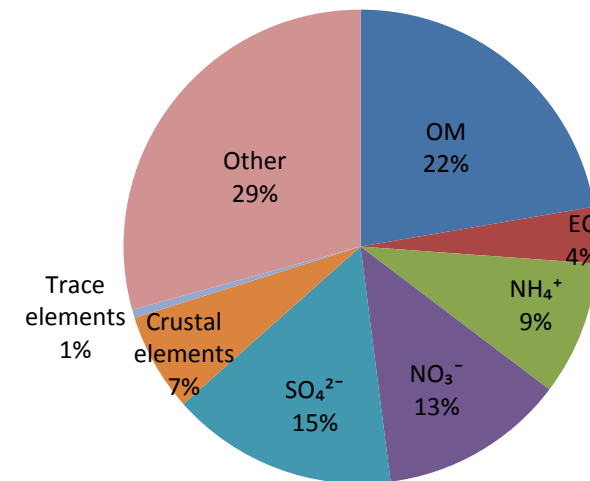
Red: Heavy haze days

HP1: 164 µg m⁻³

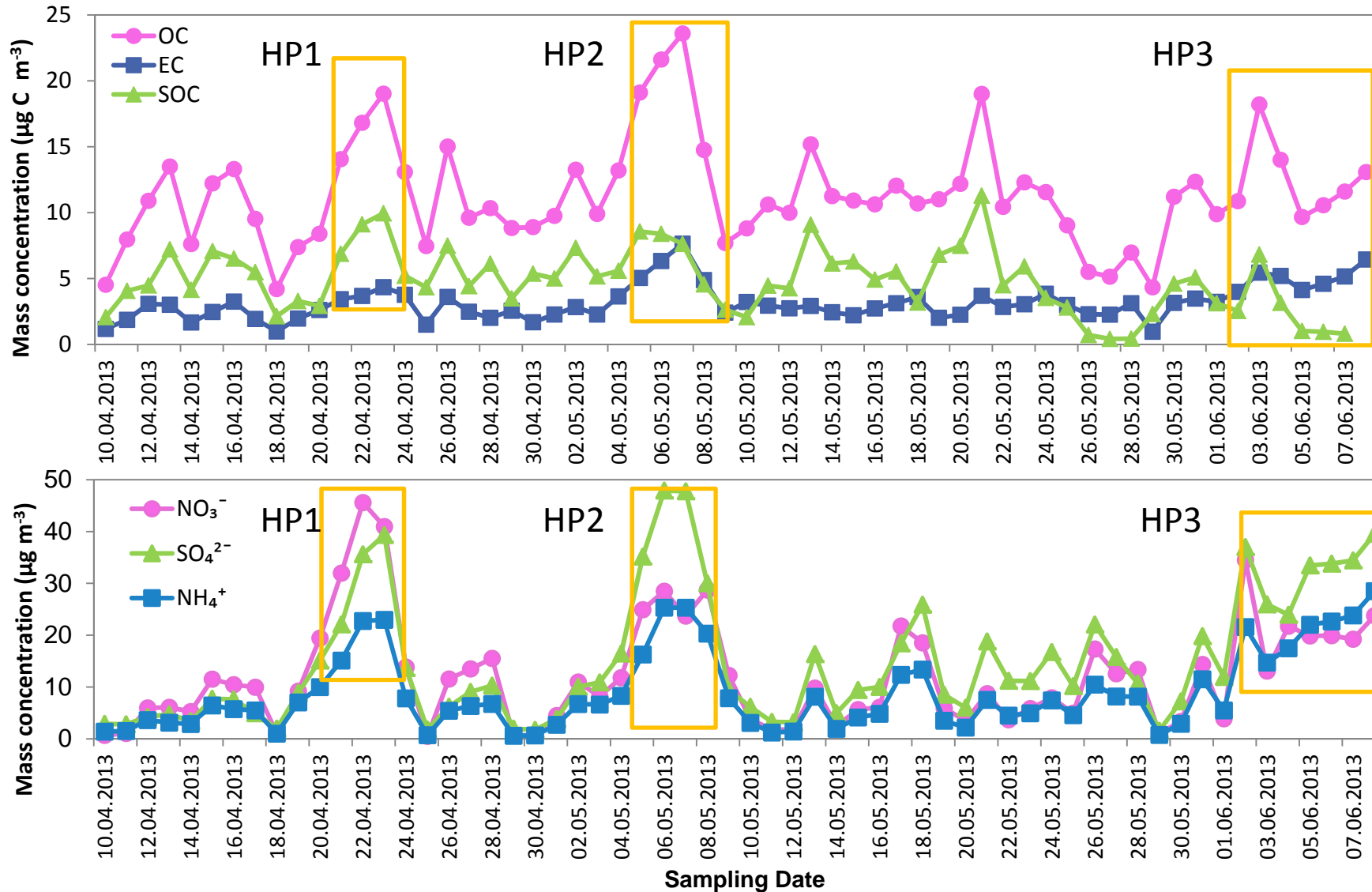
HP2: 164 µg m⁻³

HP3: 125 µg m⁻³

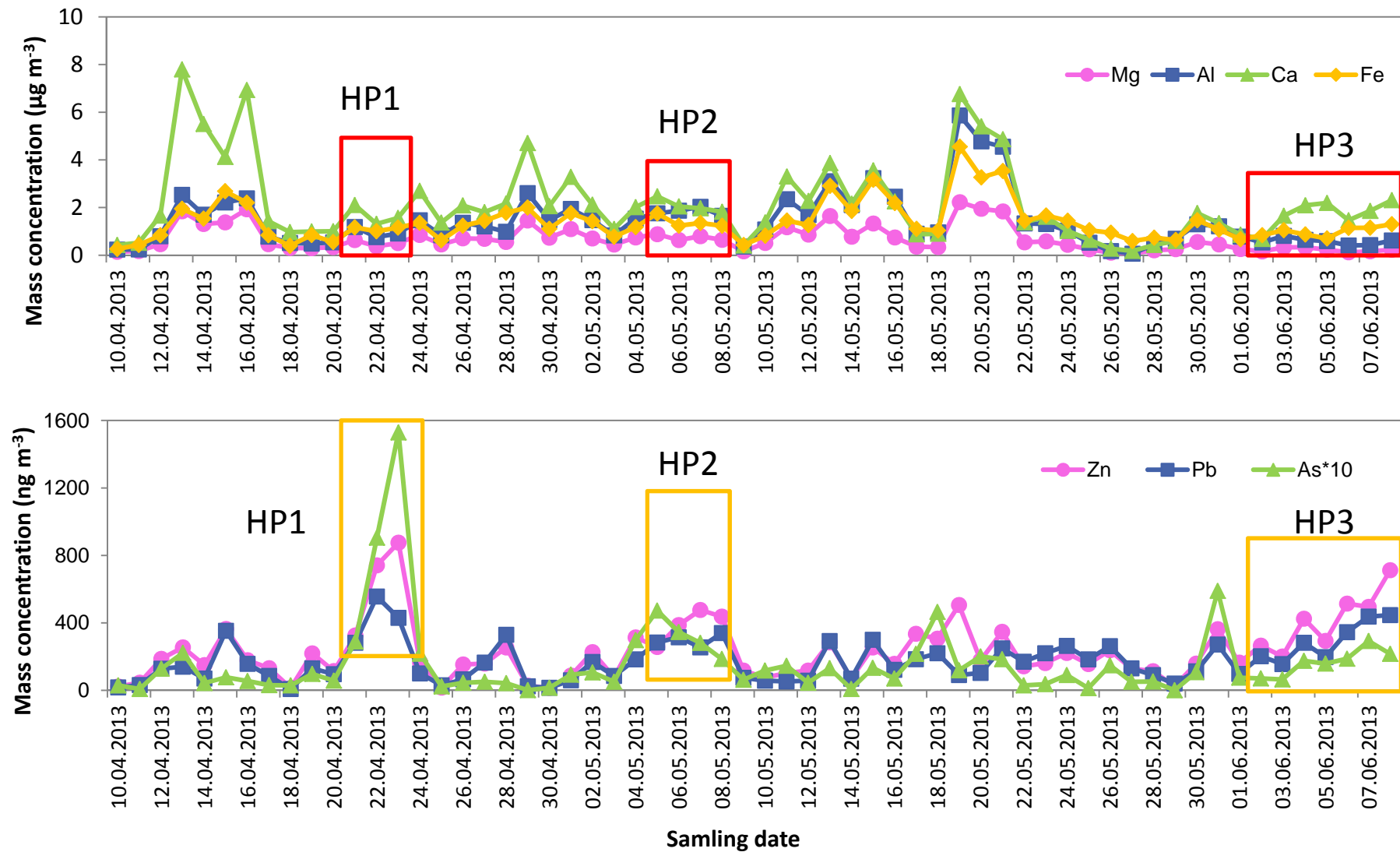
Clear: 45 µg m⁻³



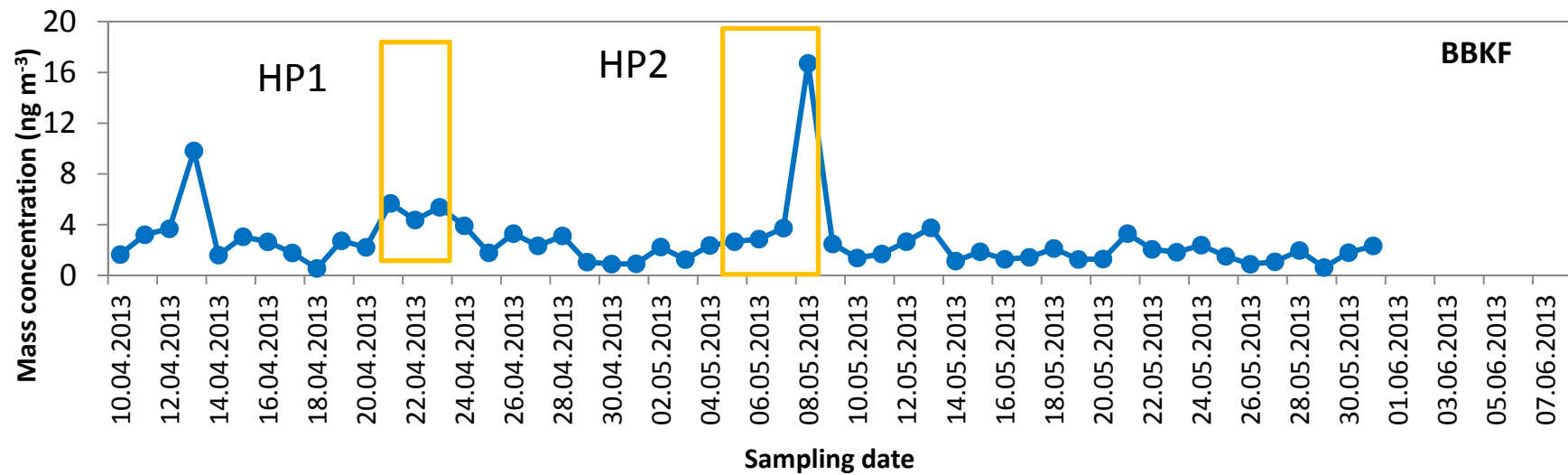
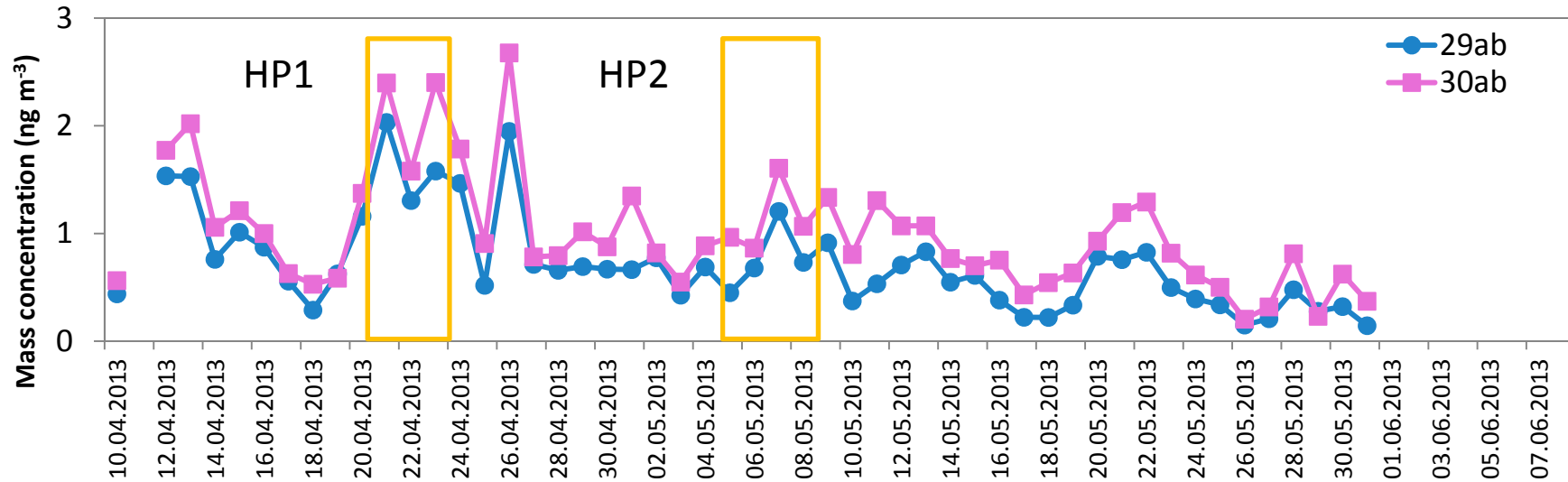
Variations of compounds



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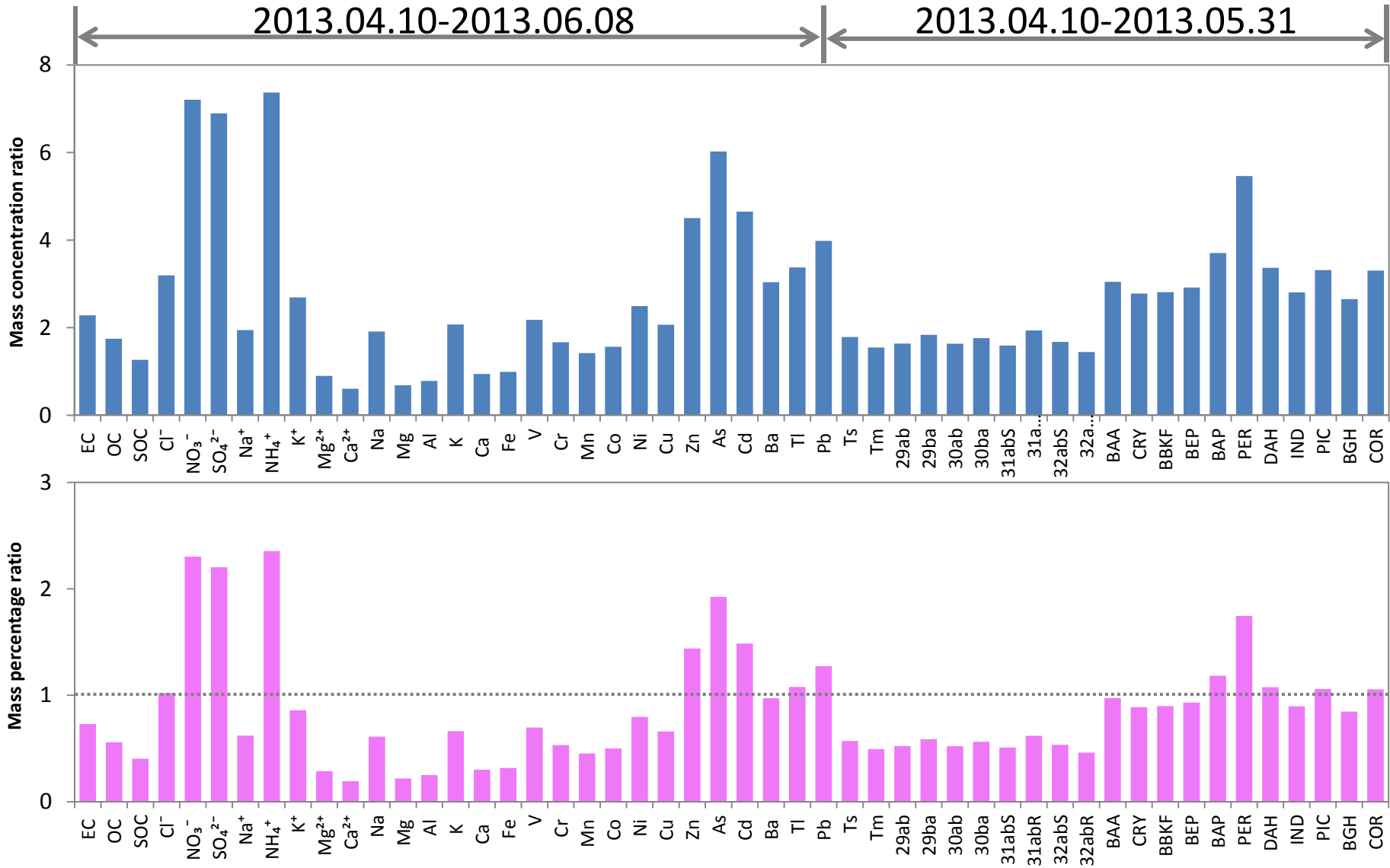


Haze/Clear

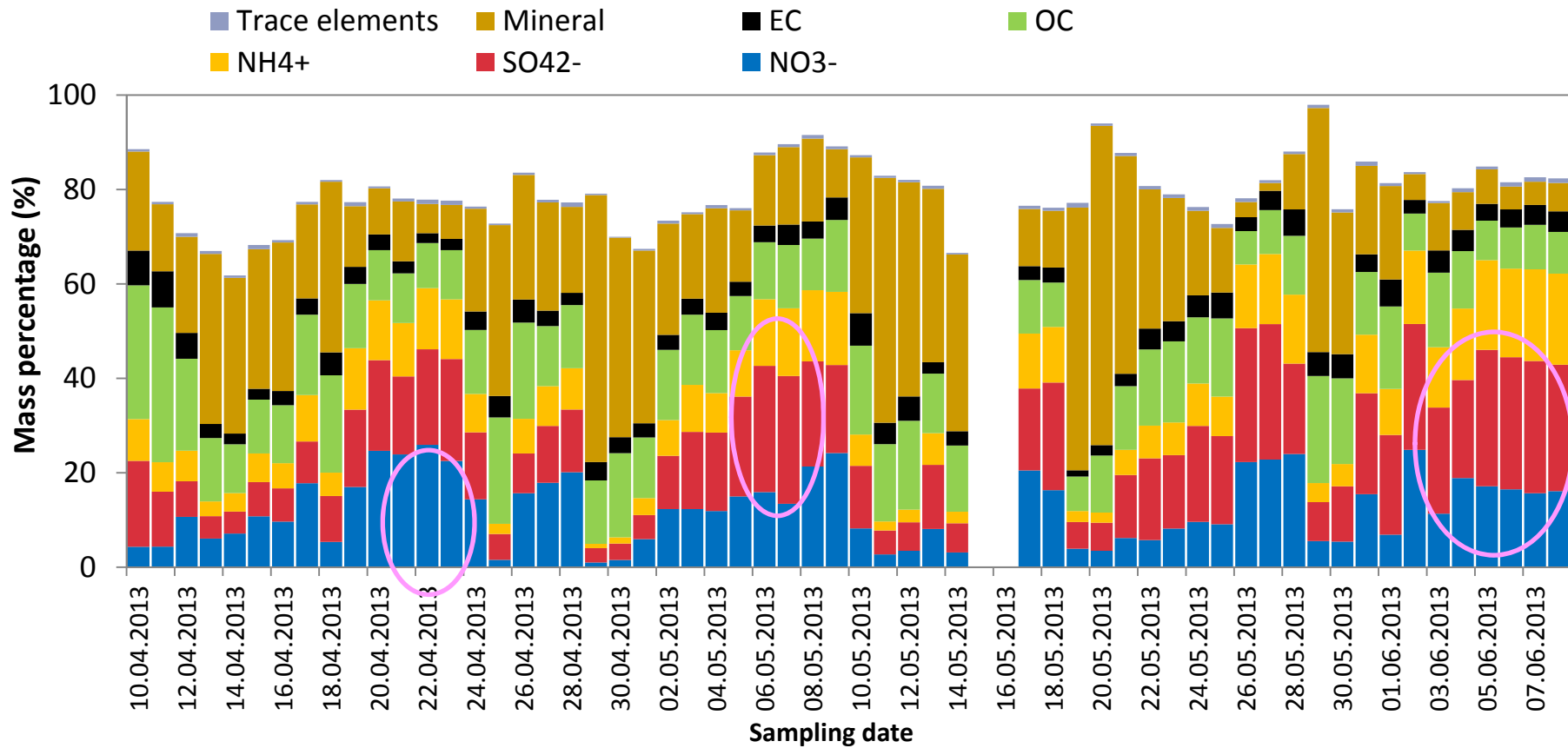


2013.04.10-2013.06.08

2013.04.10-2013.05.31

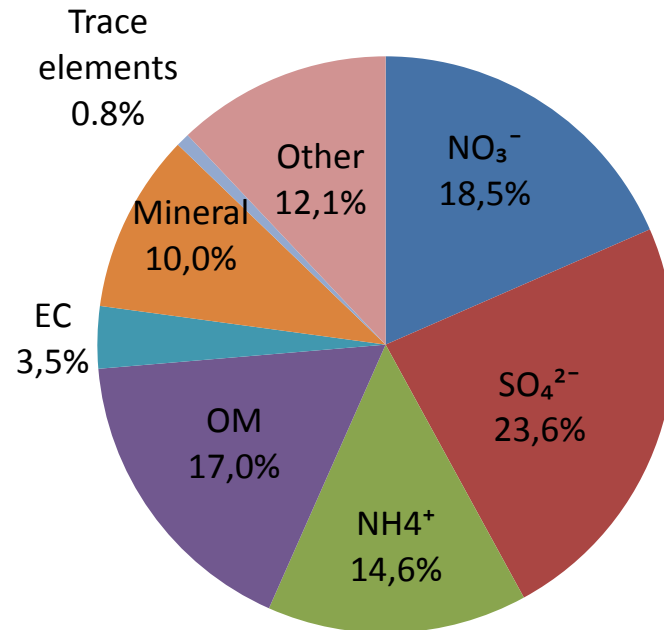


Variation of compounds mass percentages

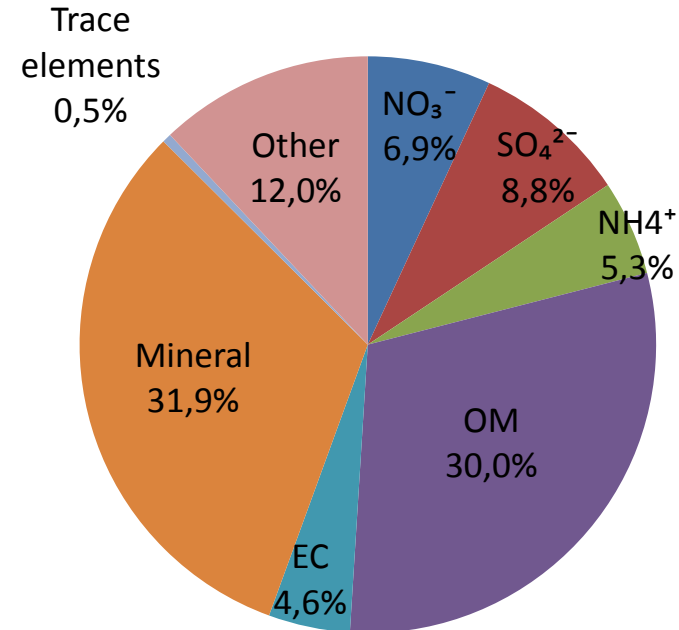


HP1: NO₃⁻
 HP2 & HP3: SO₄²⁻

Average mass balance



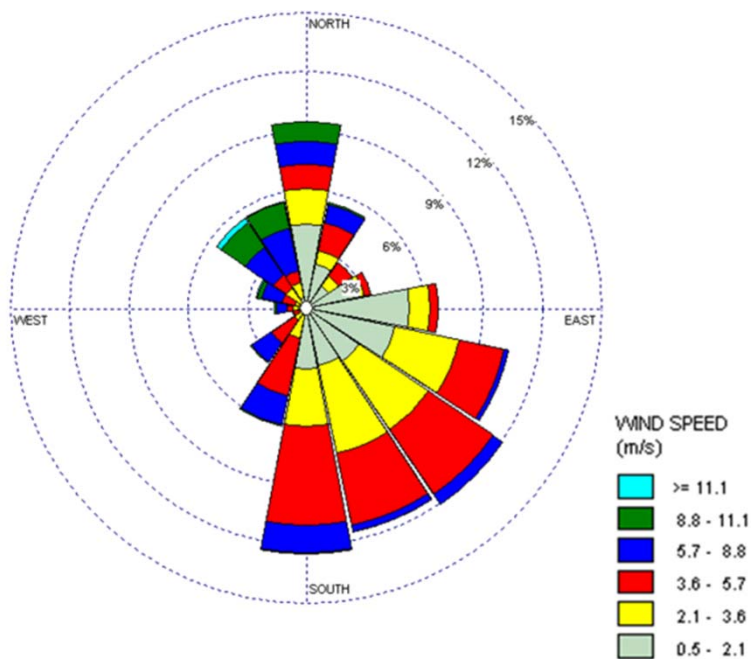
Haze: 146 µg m⁻³



Clear: 45 µg m⁻³

Meteorological influences

- T: no correlation
- RH: high RH enhances PM mass concentration
- WS: high wind speed increases dilution of pollutants
- MLH: low MLH reduces dilution of pollutants
- WD:



Haze days - stagnant weather conditions:
high relative humidity
low mixing layer height

Effect on visibility

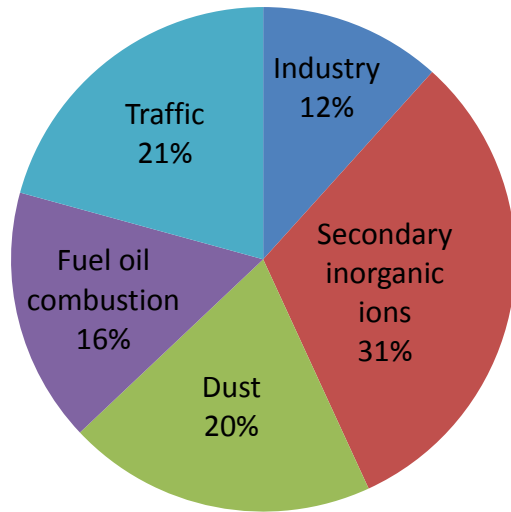
Visibility correlates negative with anthropogenic compounds, especially NO_3^- , SO_4^{2-} , and NH_4^+

$\text{PM}_{2.5}/\text{PM}_{10}$ from Tapered Element Oscillating Microbalance (TEOM) of IAP

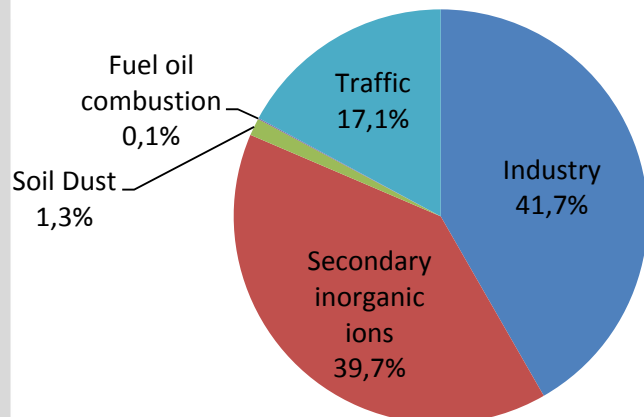
Haze: 0.68

Clear: 0.38

Source apportionment: PMF3.0

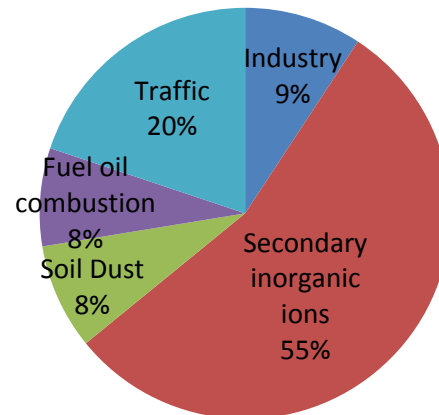


HP 1



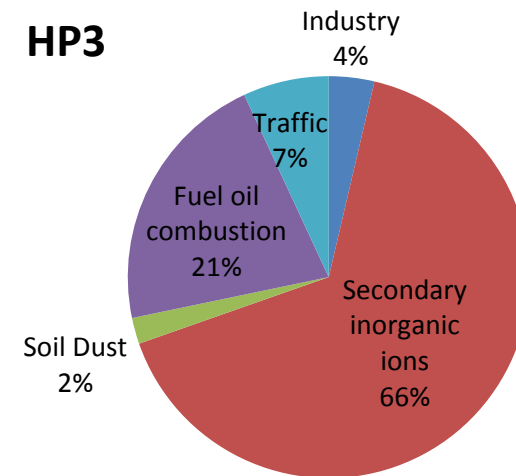
HP 1: 04.21-04.23
164 $\mu\text{g m}^{-3}$

HP2



HP 2: 05.05-05.08
164 $\mu\text{g m}^{-3}$

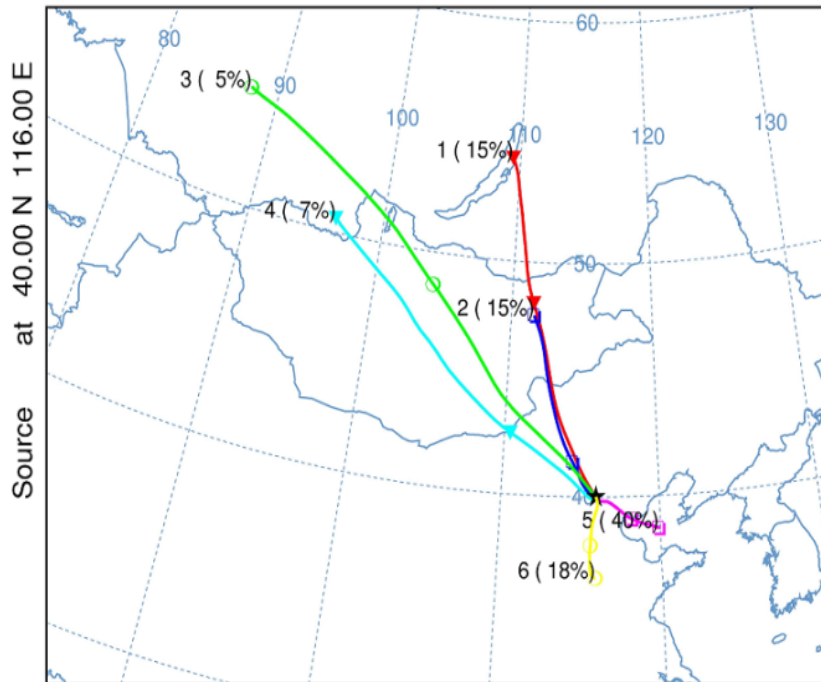
HP3



HP 3: 06.02-06.08
125 $\mu\text{g m}^{-3}$

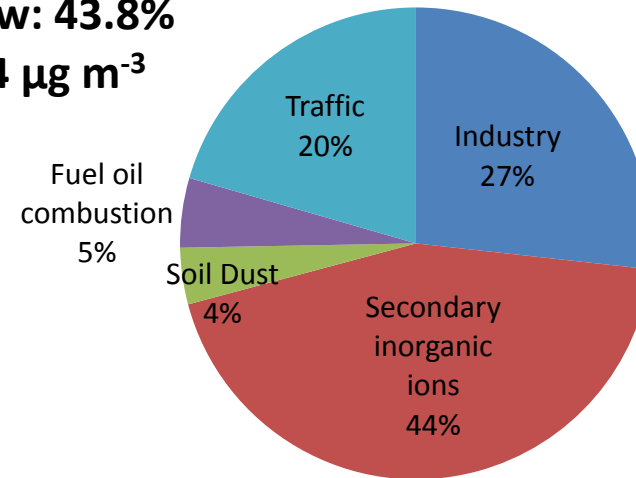
Back trajectory – HYSPLIT 4 (NOAA)

Cluster means - Standard
60 backward trajectories
GDAS Meteorological Data

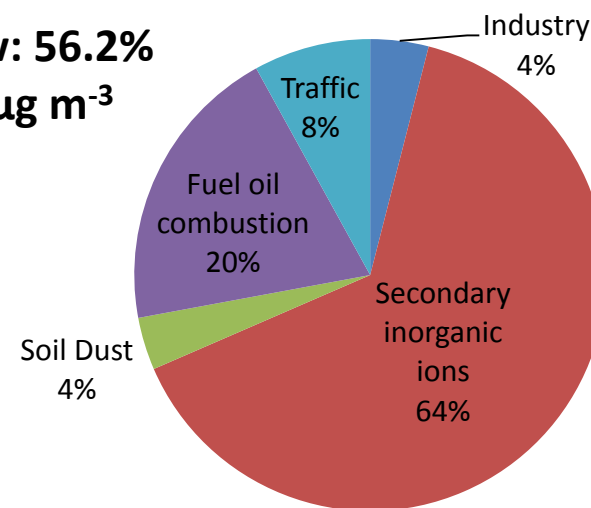


- Cluster 1: Long-rang N flow
- Cluster 2: N flow
- Cluster 3: Long-rang NW flow
- Cluster 4: NW flow
- Cluster 5: SE flow
- Cluster 6: S flow

S flow: 43.8%
154 $\mu\text{g m}^{-3}$



SE flow: 56.2%
126 $\mu\text{g m}^{-3}$



The main anthropogenic sources of PM_{2.5}

Source: Google map

Fossil-fuel power station



- (1) Beijing: electricity and heat production and supply industry, automotive manufacturing, electronic equipment manufacturing, pharmaceutical manufacturing, general equipment manufacturing, petroleum processing, coking
- (2) Tangshan: iron and steel industry, coal mining (coking coal), petroleum products, cement and porcelain
- (3) Tianjin: petrochemical, textiles, car manufacturing, mechanical industries and metalworking
- (4) Baoding: the largest photosensitive materials and magnetic recording media manufacture, vehicle manufacturing and photovoltaic cells
- (5) Shijiazhuang: pharmaceutical, textile, machinery and chemicals, building materials, light industry and electronics

Conclusion

1. Controlling the precursors of secondary inorganic ions becomes more and more important to increase the visibility
2. Sources of $PM_{2.5}$ during spring in Beijing: industry, secondary inorganic ions, traffic, soil dust and fuel oil combustion - supported by source apportionment from chemical speciation of $PM_{2.5}$
3. Improving air quality should not only consider Beijing but also the whole region, including Hebei province and Tianjin Municipality
4. Stagnant weather conditions are favorable for the formation of haze: low mixing layer height, low wind speed and high relative humidity

Outlook

- Source apportionment on the basis of high time resolution sampling results
- Source apportionment based on isotope analyses of carbon
- PM₁
- Health effect
- Emission reduction measures

Acknowledgements

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A photograph of a bright blue sky filled with various white, fluffy clouds. The clouds are scattered across the frame, with a larger, more prominent one in the upper right quadrant. The overall scene is bright and clear.

Thank you for your attention!