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

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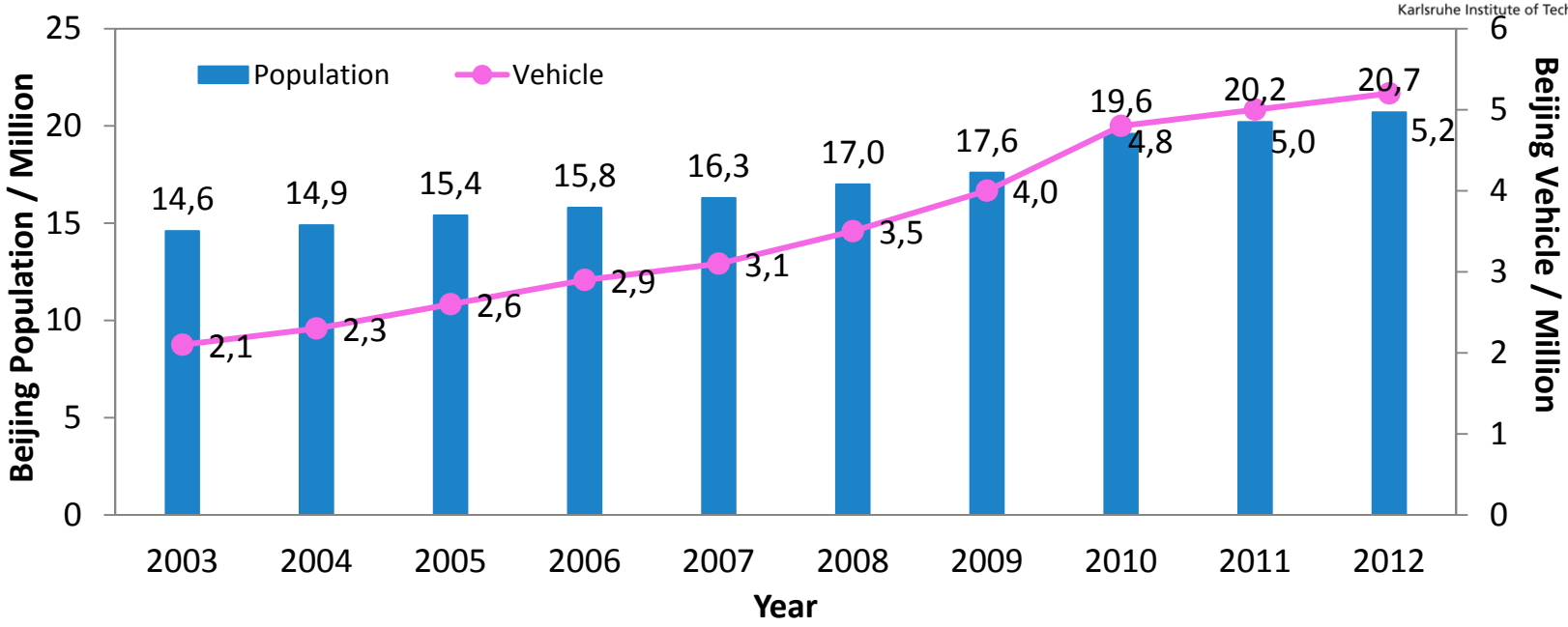
Introduction

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

Karlsruhe Institute of Technology

•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

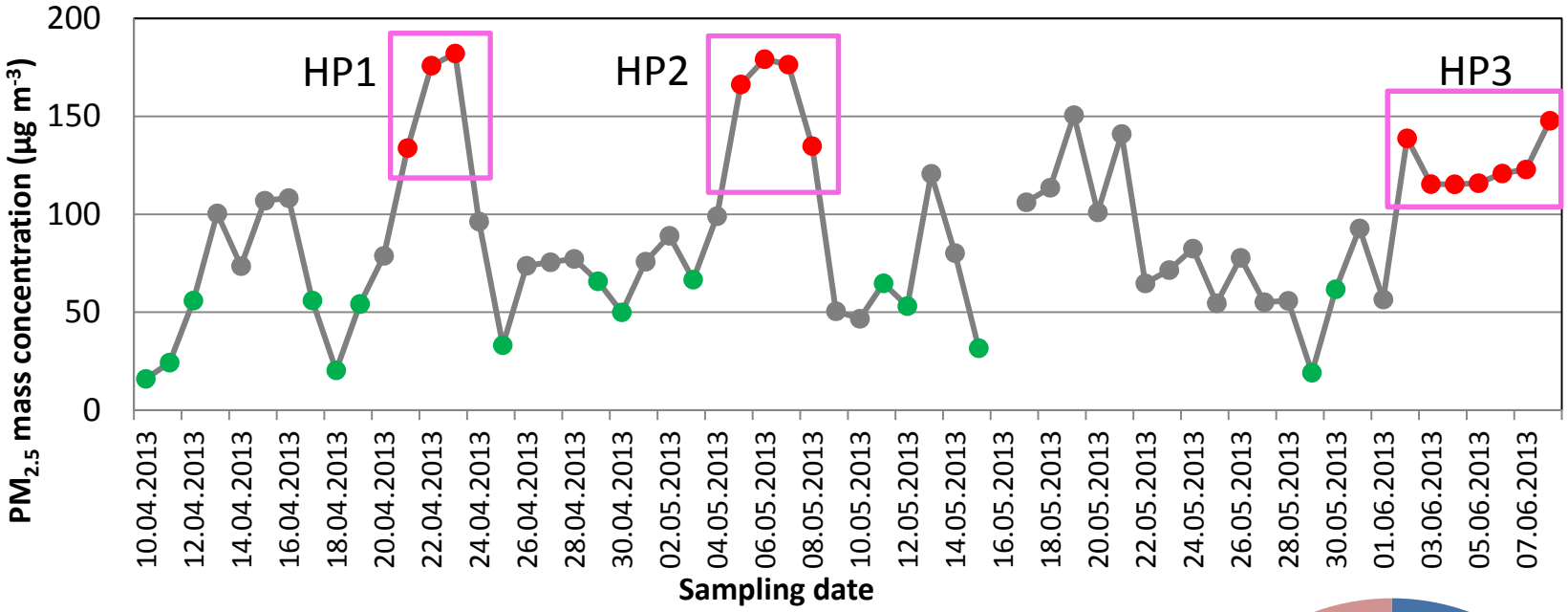
–Ion Chromatography: Cl^-, NO_3^-, SO_4^{2-}, NH_4^+, K^+, Mg^{2+}, Ca^{2+}

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

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



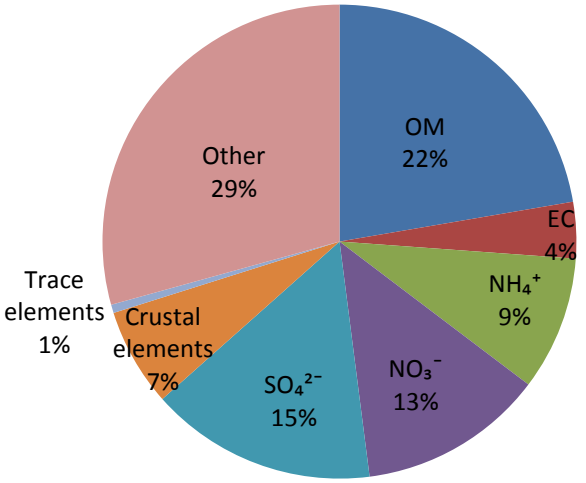
Average: 89 µg m^{-3}

24 h $PM_{2.5}$ threshold values:

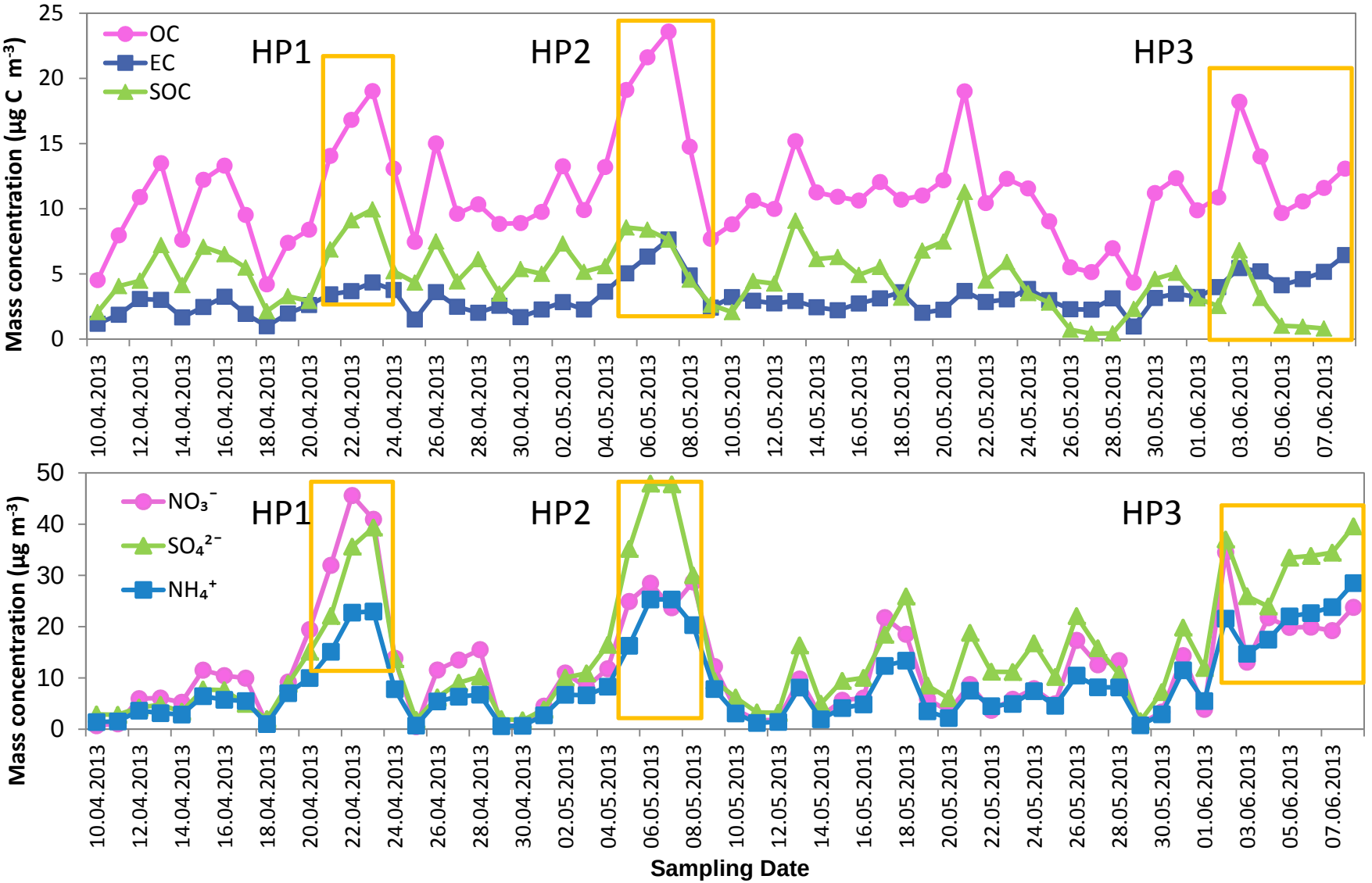
WHO: 25 µg m^{-3}
US-EPA: 35 µg m^{-3}
China (Grade II): 75 µg m^{-3}

Green: Clear days
Red: Heavy haze days

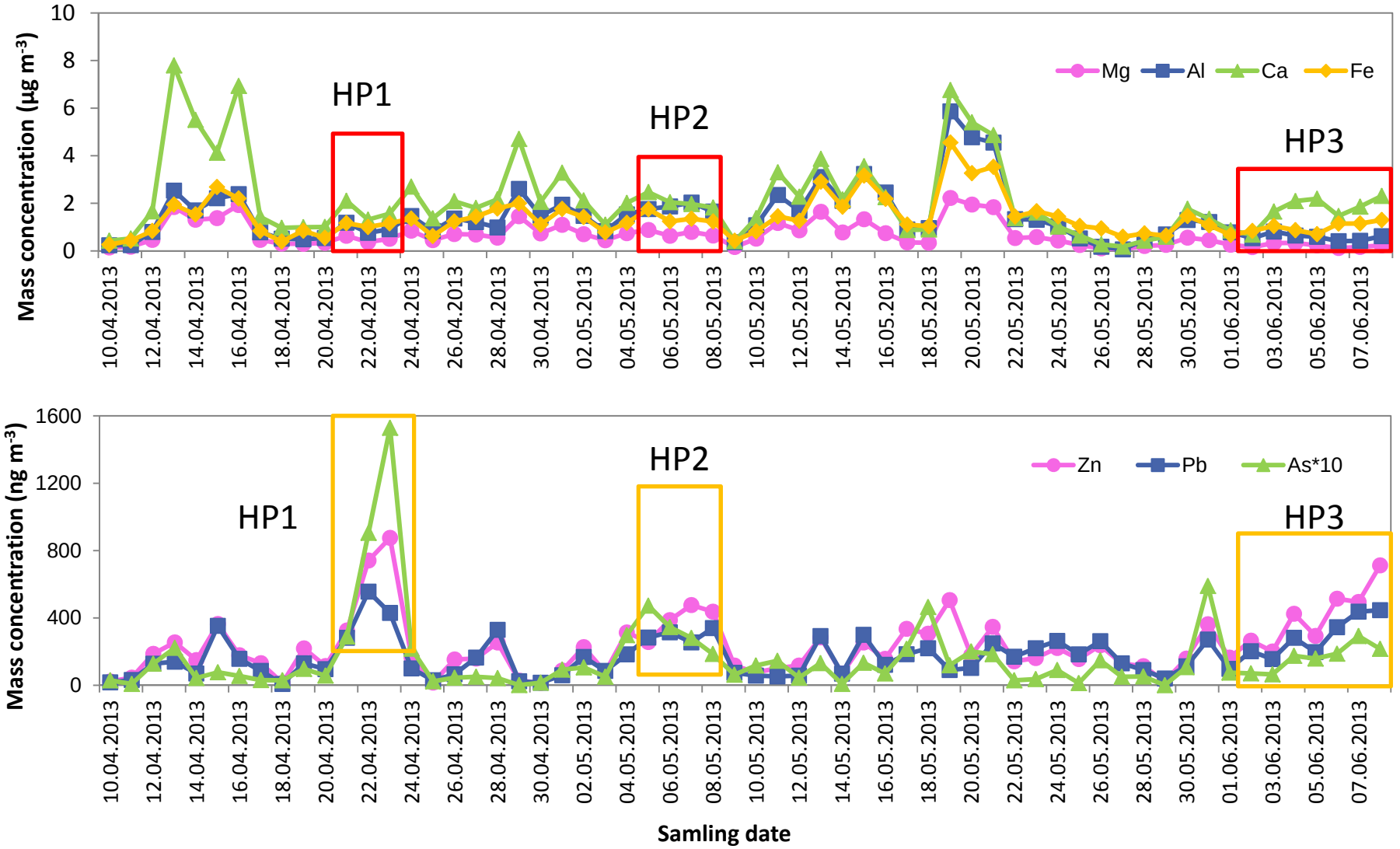
HP1: 164 µg m^{-3}
HP2: 164 µg m^{-3}
HP3: 125 µg m^{-3}
Clear: 45 µg m^{-3}



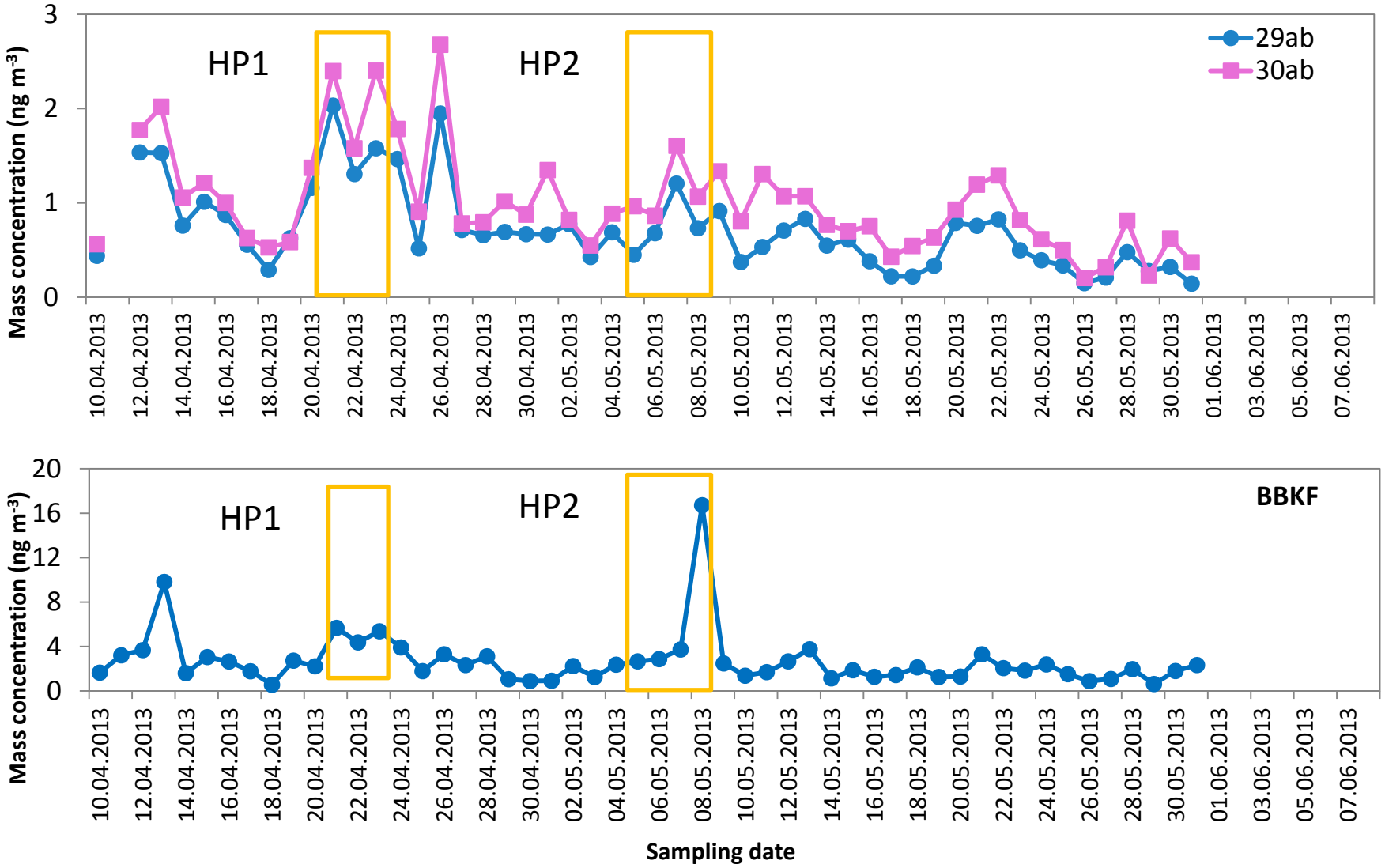
Variations of compounds



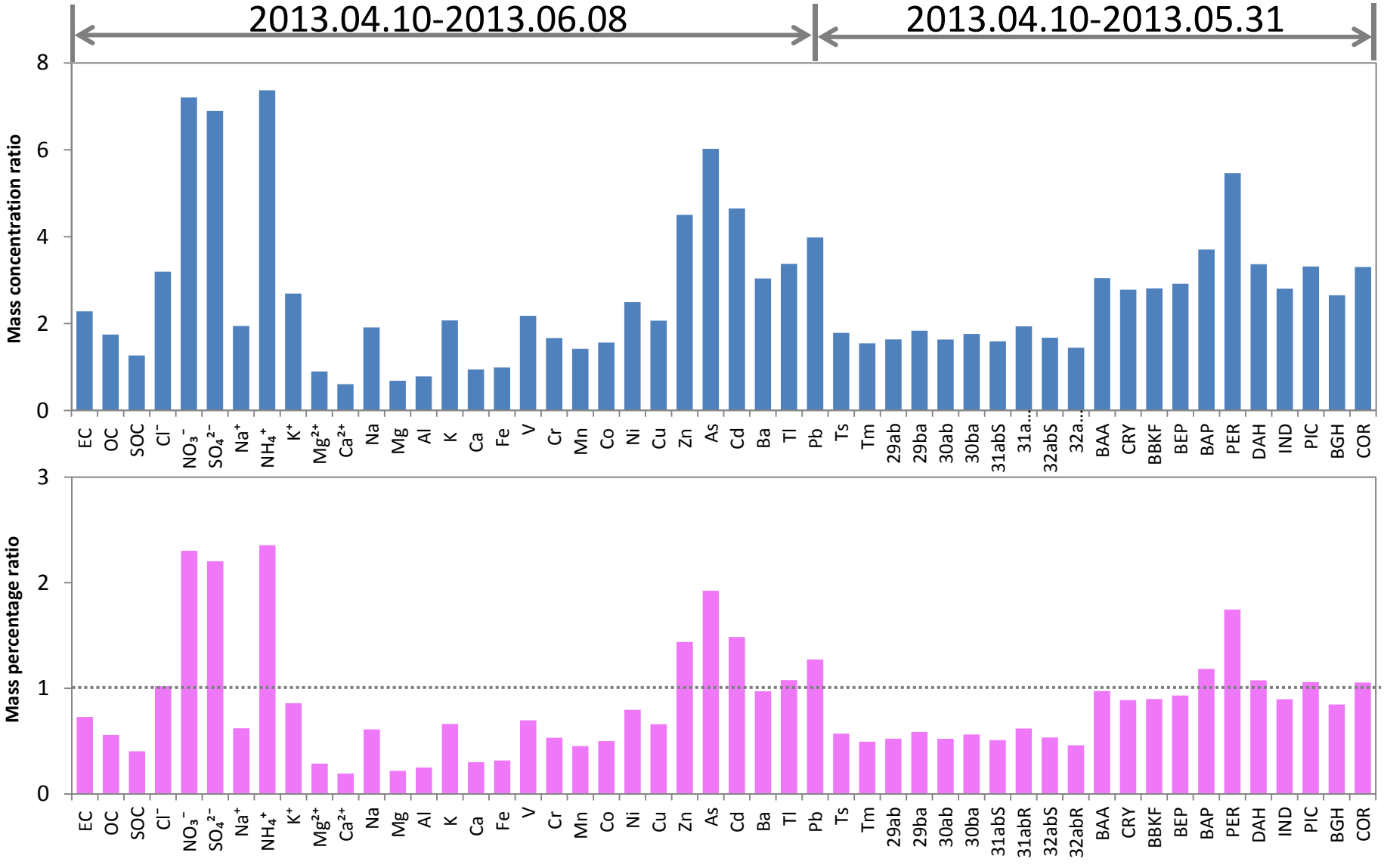
Variations of compounds



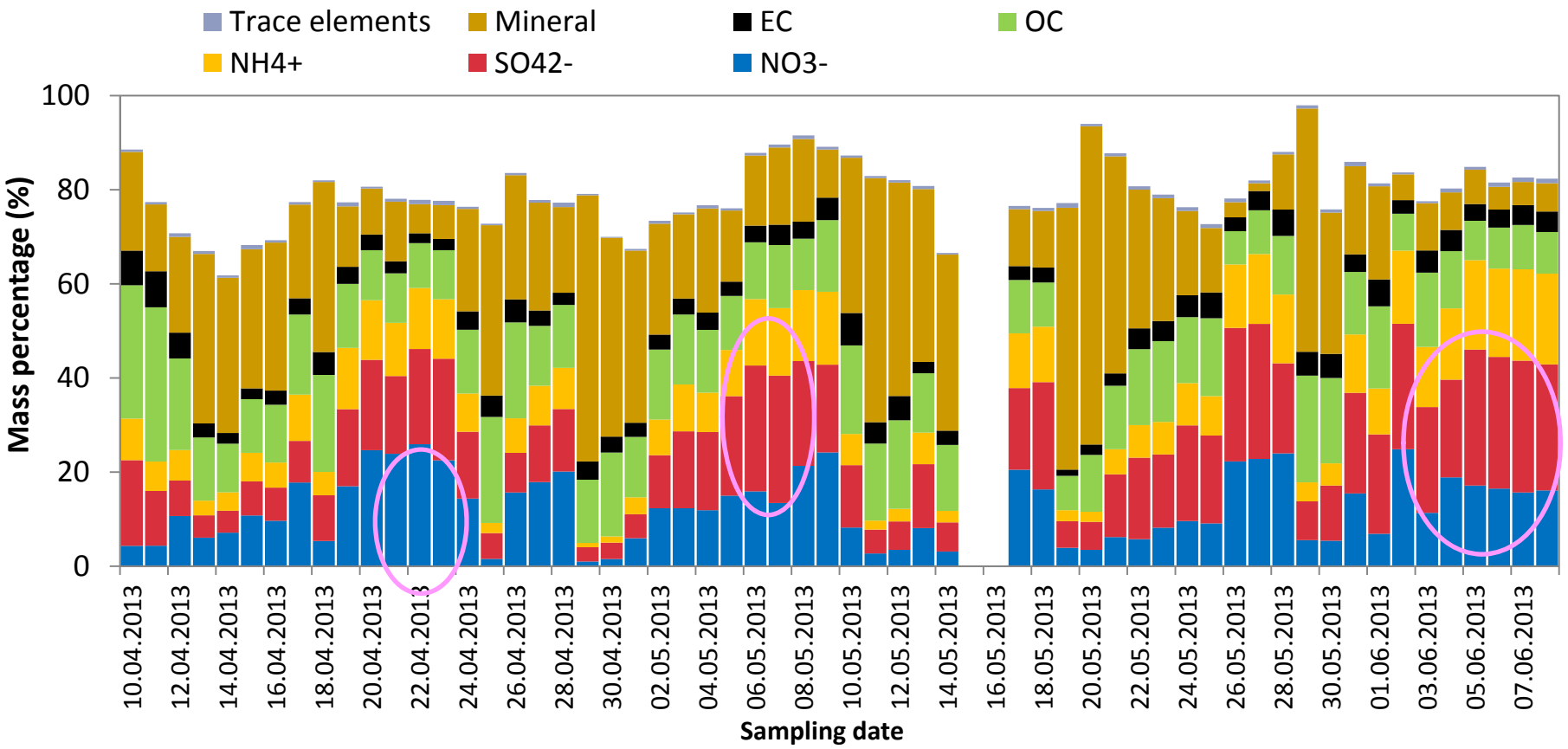
Variations of compounds



Haze/Clear


2013.04.10-2013.06.08
2013.04.10-2013.05.31
Mass concentration ratio
0
2
4
6
8
Mass percentage ratio
0
1
2
3
EC OC SOC Cl⁻ NO₃⁻ SO₄²⁻ Na⁺ NH₄⁺ K⁺ Mg²⁺ Ca²⁺ Na Mg Al K Ca Fe V Cr Mn Co Ni Cu Zn As Cd Ba Tl Pb Ts Tm 29ab 29ba 30ab 30ba 31abS 31abR 32abS 32abR BAA CRY BBKF BEP BAP PER DAH IND PIC BGH COR

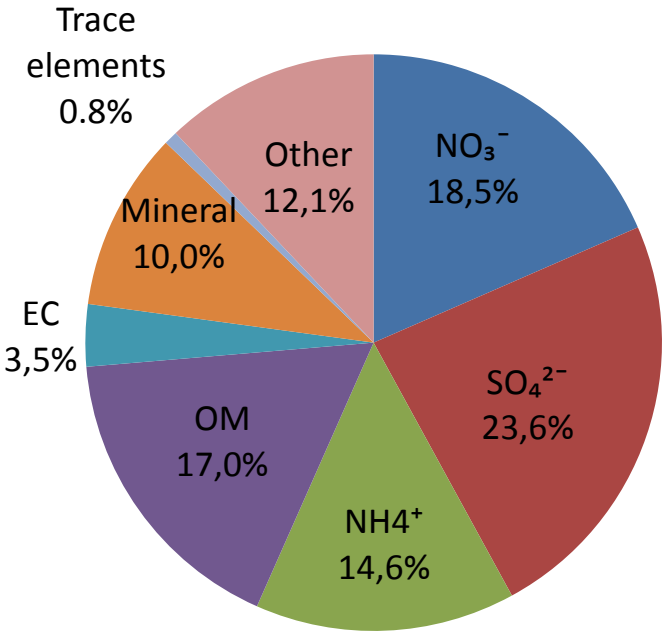
Variation of compounds mass percentages



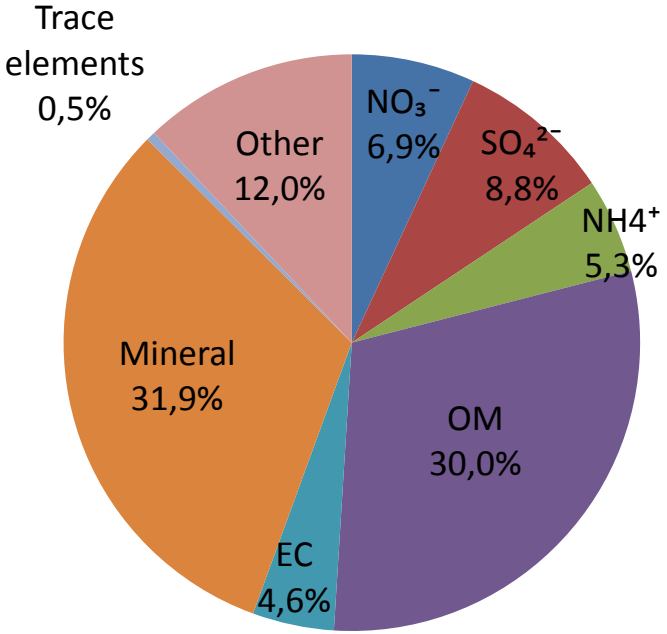
HP1: NO_3^-

HP2 & HP3: SO_4^{2-}

Average mass balance



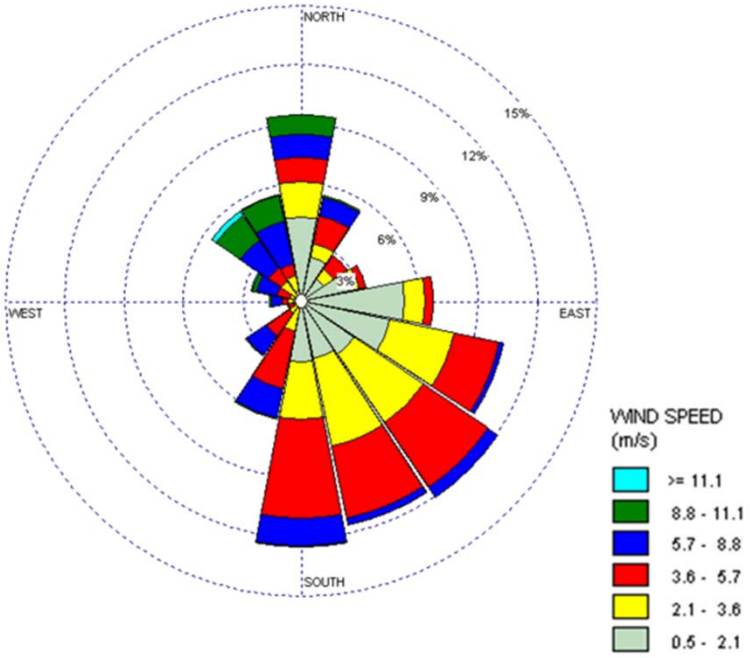
Haze: 146 µg m^{-3}



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

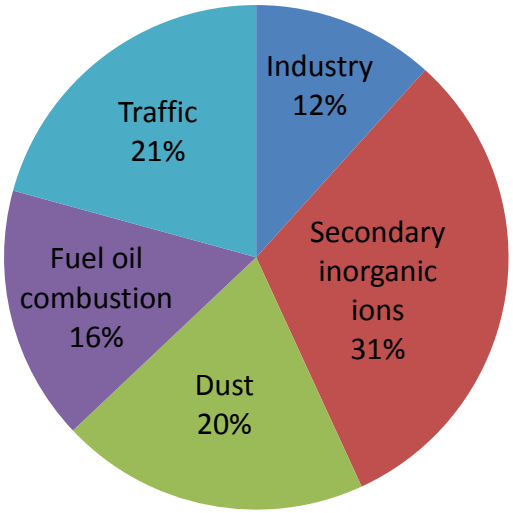
Visibility correlates negative with anthropogenic compounds, especially NO_3^-, SO_4^{2-}, and NH_4^+

$PM_{2.5}/PM_{10}$ from Tapered Element Oscillating Microbalance (TEOM) of IAP

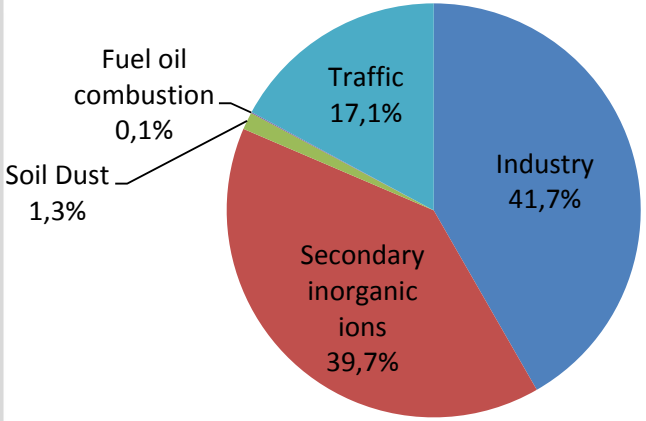
Haze: 0.68

Clear: 0.38

Source apportionment: PMF3.0

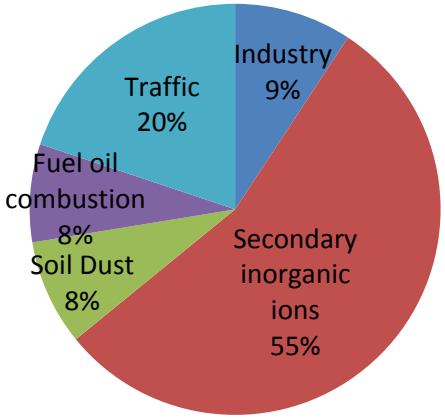


HP 1



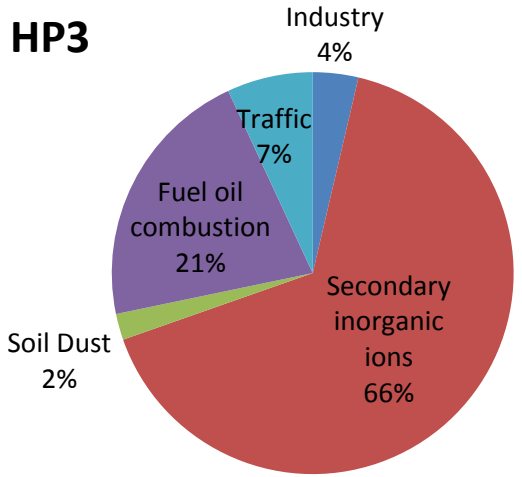
HP 1: 04.21-04.23
164 µg m^{-3}

HP2



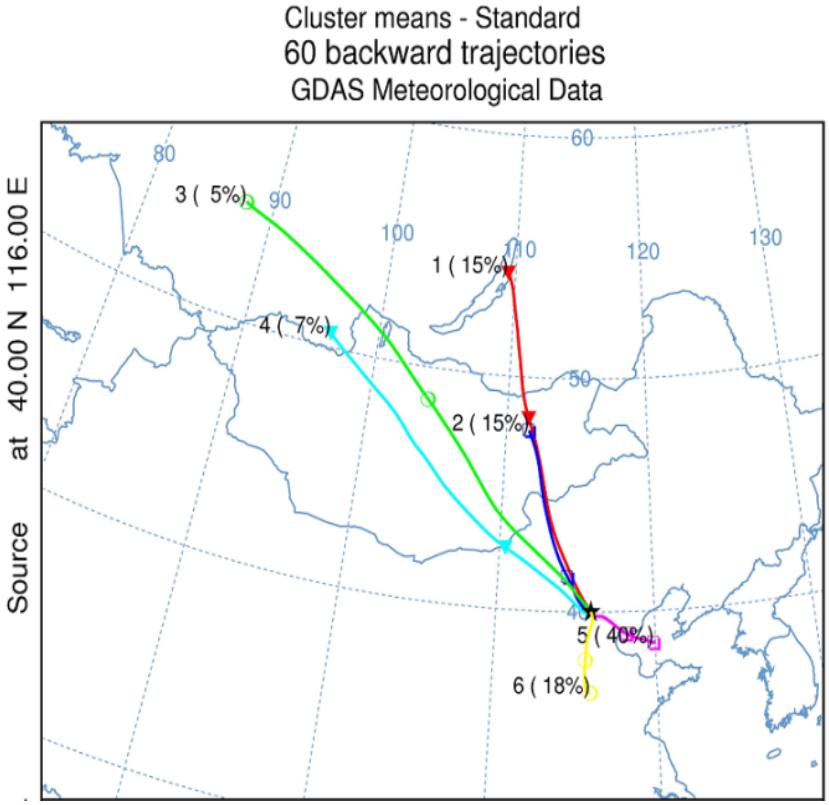
HP 2: 05.05-05.08
164 µg m^{-3}

HP3



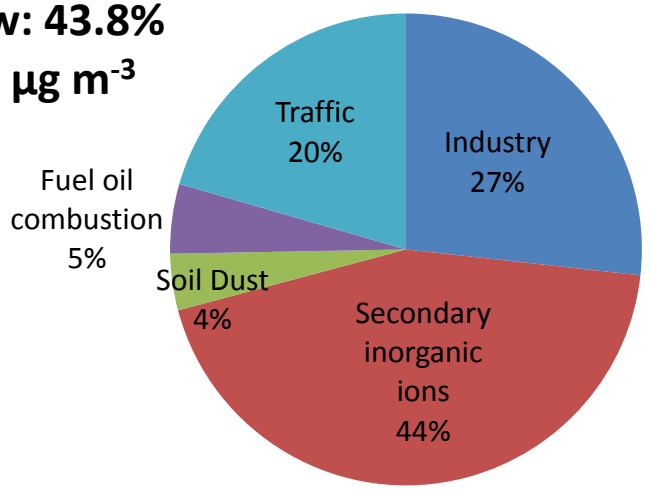
HP 3: 06.02-06.08
125 µg m^{-3}

Back trajectory – HYSPLIT 4 (NOAA)

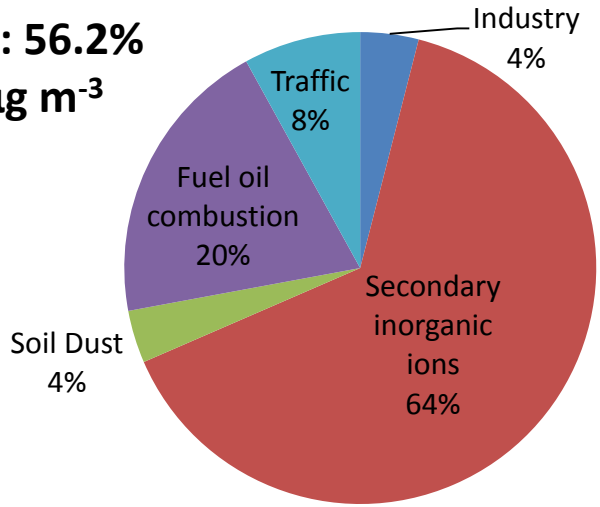


Cluster 1: Long-rang N flow
Cluster 2: N flow
Cluster 3: Long-rang NW flow
Cluster 4: NW flow
Cluster 5: SE flow
Cluster 6: S flow

S flow: 43.8%
154 µg m^{-3}



SE flow: 56.2%
126 µg m^{-3}



Fossil-fuel power station

The main anthropogenic sources of $PM_{2.5}$

Source: Google map

(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
- PM_1
- Health effect
- Emission reduction measures

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Thank you for your attention!