A point-by-point response to the review

On behalf of my co-authors, we would like to express our great appreciation for your constructive comments and great efforts on our manuscript entitled "Quantifying the seasonal variations and regional transport of $PM_{2.5}$ in the Yangtze River Delta region, China: Characteristics, sources, and health risks" (EGUSPHERE-2023-489). We have studied the constructive comments carefully and have revised our manuscript. Replies to comments are in blue, and the line number in response refers to the unmarked manuscript, in which all revisions have been accepted.

Lines 87-101. Explain how the aerosol particles were sampled for the different analysis methods. Did you uses a $PM_{2.5}$ selective inlet? Which filters did you use?

Response: Thanks for your comment. We have used the $PM_{2.5}$ selective inlet and filters in this article. The information is shown below:

In the monitoring of the trace elements, we used a particle cutting head to collect particles with an aerodynamic equivalent diameter of less than 100/10/2.5 μm in the ambient air, used organic microporous filter membranes to enrich the collected particles, used the principle of β-ray absorption to detect the concentration of particles enriched on the filter membranes and used the principle of X-ray Fluorescence to detect the concentration of more than 30 types of trace elements in the particles.

In the monitoring of the soluble components, aerosols were analyzed through the wetted inner and outer tubes, and water-soluble ions were absorbed in the absorbing liquid on the inner and outer walls of the tubes due to the diffusion principle and were carried out by the flushing. Finally, the collected water samples were removed from the bubbles and filtered and then imported into the Ion Layer Analyzer to analyze the composition of the gases dissolved in water.

We reorganized the paragraph following the same order for describing $PM_{2.5}$ compositions (OC, EC, trace elements, and soluble components). Please see lines 87-106 in the revised manuscript.

Lines 102-104. Please add information on the sampling method and location relative to yours.

Response: Thanks for your suggestion. In this study, Air pollutants, including $PM_{2.5}$, PM_{10}, O_3, NO_2, SO_2, and CO, were monitored by the National Environmental Monitoring Center (NEMC) of China. The nationwide observation network began operating in 74 major cities in 2013, and it included 1597 nonrural sites covering 454 cities by 2017. The monitoring Xianlin Station (32.10 °N, 118.93 °E) collected air pollutant data and automatically measured hourly air pollutants. These data were issued hourly on the national urban air quality real-time publishing platform (https://air.cnemc.cn:18007/, last access: 7 April 2023). We have added information on the sampling method and location. Please see lines 107-110 in the revised manuscript.

Line 146. “limi”.

Response: Thanks for your comment. The word “limi” has been revised as “limit” on line 153 of the revised manuscript.

Lines 218-219. What do you mean with biomass emissions?

Response: Thanks for your comment. The term “biomass emissions” used in this article actually refers to “biomass burning”. Biomass burning, in the form of open vegetation fires and indoor biofuel use, is one of the largest sources of many trace gases and aerosols in the global atmosphere (Andreae, et al., 2019). Gaseous pollutants, and even more so the particulate matter from biomass burning, pose grave risks to human health (Tao et al., 2017).

In this study, we cited biomass burning and industrial emissions data from the references to analyze the different proportions of various potential sources of $PM_{2.5}$ in urban areas. Therefore, we have changed the word “biomass emissions” to “biomass burning” and added relevant explanations and references. Please see lines 226-230 in the revised manuscript.

The added references include:

Andreae, M. O.: Emission of trace gases and aerosols from biomass burning an updated assessment, Atmos. Chem. Phys., 19, 8523–8546, https://doi.org/10.5194/acp-19-8523-2019, 2019.

Tao, J., Zhang, L., Cao, J., and Zhang, R.: A review of current knowledge concerning $PM_{2.5}$ chemical composition, aerosol optical properties and their relationships across China, Atmos. Chem. Phys., 17, 9485–9518, https://doi.org/10.5194/acp-17-9485-2017, 2017.

Line 239. Table 2. Please add the variability ranges for the values listed.

Response: Thanks for your suggestion. We have added the variability ranges for the compositions and meteorological parameters data on lines 247-248 of the revised manuscript.

Table 2. Seasonal average concentration of components of $PM_{2.5}$, in $\mu g \cdot m^{-3}$ and % in brackets, and meteorological parameters. T, RH, WS, and BLH represent air temperature, relative humidity, wind speed and boundary layer height, respectively.

Components and meteorological parameters	Spring	Summer	Autumn	Winter

$PM_{2.5}$	99.1 ± 29.5	23.7 ± 12.2	38.9 ± 20.6	113.9 ± 43.6
SO_4^{2-}	20.5 ± 5.9 (20.7)	5.2 ± 2.1 (21.9)	7.3 ± 4.8 (18.8)	31.5 ± 8.7 (27.7)
NO_3^-	16.9 ± 11.4 (17.1)	5.3 ± 1.2 (22.4)	9.8 ± 3.3 (25.2)	27.2 ± 17.5 (23.9)
NH_4^+	15.1 ± 6.1 (15.2)	3.2 ± 1.7 (13.5)	7.1 ± 2.1 (18.3)	11.5 ± 4.6 (10.1)
OM	11.7 ± 6.1 (11.8)	1.6 ± 0.7 (6.8)	4.1 ± 1.1 (10.5)	11.0 ± 5.8 (9.7)
EC	2.3 ± 0.8 (2.3)	0.8 ± 0.3 (3.4)	1.6 ± 1.2 (4.1)	3.6 ± 1.5 (3.2)
Mineral dust	13.2 ± 4.5 (13.3)	2.3 ± 0.8 (9.7)	2.7 ± 1.0 (6.9)	8.7 ± 2.7 (7.6)
Trace metals	2.7 ± 1.5 (2.7)	0.5 ± 0.1 (2.1)	0.5 ± 0.2 (1.3)	1.6 ± 0.9 (1.4)
Cl^-	2.7 ± 0.9 (2.7)	1.6 ± 0.6 (6.8)	0.8 ± 0.2 (2.1)	1.7 ± 0.4 (1.5)
T (°C)	18.8 ± 4.3	27.6 ± 5.4	19.4 ± 4.9	4.9 ± 2.2
RH (%)	86.5 ± 12.9	58.2 ± 6.3	73.1 ± 8.5	79.6 ± 10.4
WS ($m \cdot s^{-1}$)	3.5 ± 0.6	2.9 ± 0.5	2.7 ± 0.5	2.1 ± 0.3
BLH (m)	469.7 ± 40.9	520.4 ± 58.9	443.6 ± 32.4	419.7 ± 23.5

Line 359. Table 3. This table is hard to read. Please consider converting it to a plot e.g. with bars.

Response: Thanks for your suggestion. We have converted Table 3 to Figure 4 (bar chart). Please see line 370 in the revised manuscript.

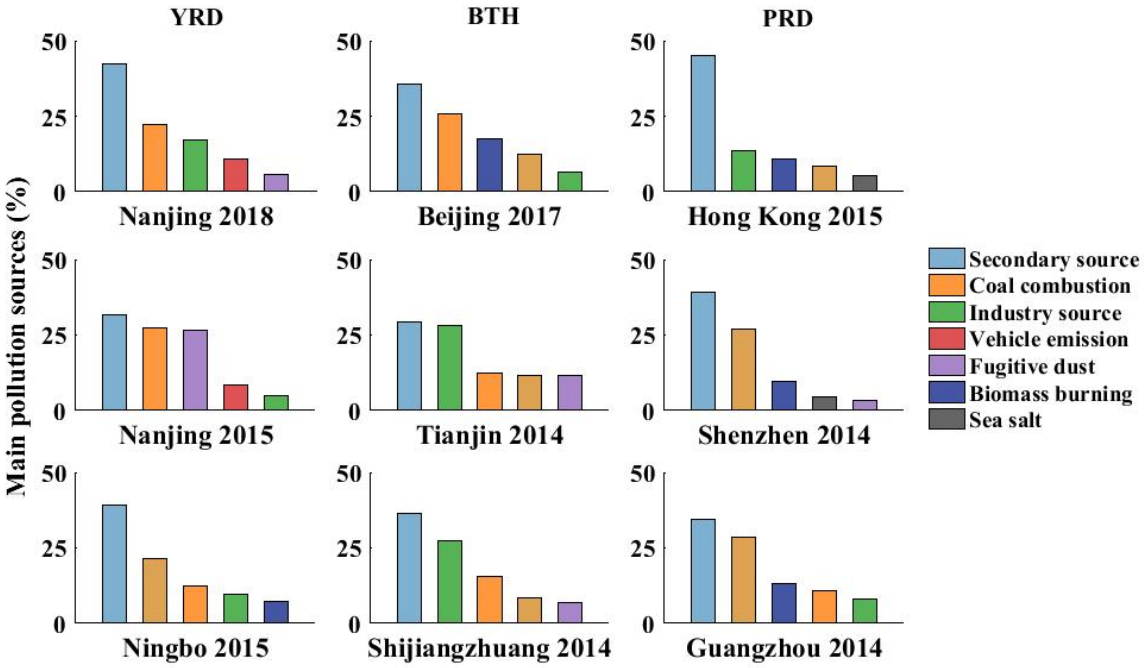

Figure 4. Comparisons of source apportionment for $PM_{2.5}$ among different cities.

Line 428. Figure 7. Explain the abbreviations on the figure in the caption e.g. HQ, LCR, SIS, IS, VM, FD, OS.

Response: Thanks for your comment. We have added the explanation of abbreviations (HQ, LCR, SIS, CC, IS, VM, FD, and OS) on the figure in the caption. Please see lines 442-446 in the revised manuscript.

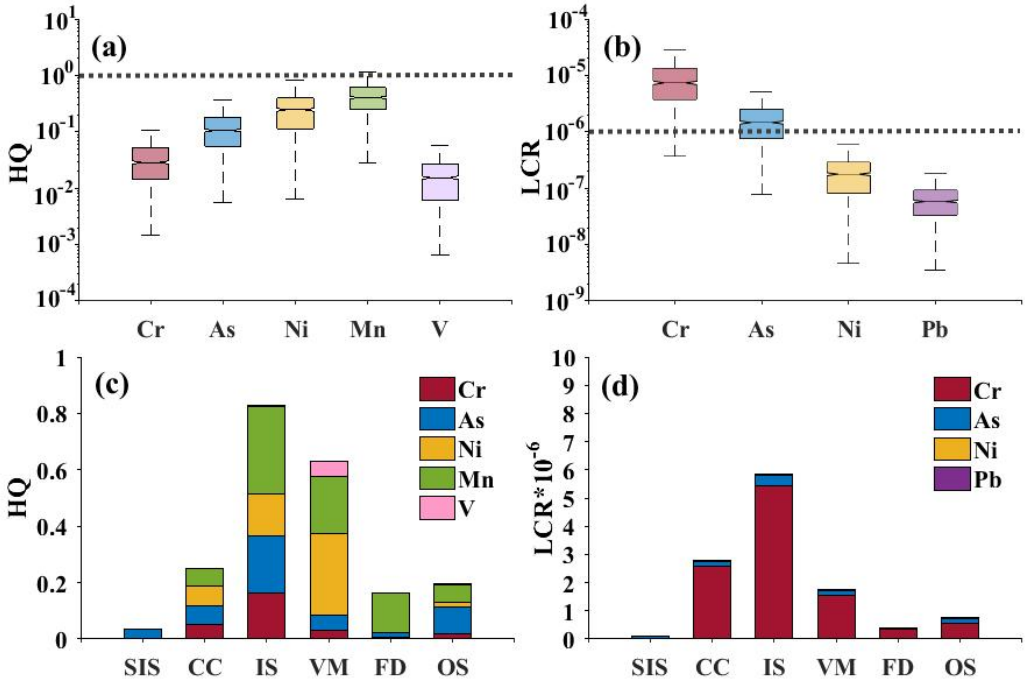

Figure 7. Non-carcinogenic (a) and carcinogenic (b) risks of toxic elements. Non-carcinogenic (c) and carcinogenic (d) risk of the sources identified for $PM_{2.5}$ in Nanjing. HQ, LCR, SIS, CC, IS, VM, FD, and OS represent hazard quotient, lifetime carcinogenic risk, secondary inorganic aerosol source, coal combustion, industry source, vehicle emission, fugitive dust, and other sources, respectively.

Lines 455-456. Explain or give a link to were you make the results of your measurements available for other scientists.

Response: Thanks for your suggestion. The $PM_{2.5}$ composition data used in this article is measured by our team. We have added mailbox information to provide data. Please see lines 473-479 in the revised manuscript.

$PM_{2.5}$ composition data were collected by the atmospheric heavy metal Monitor and the In-situ Gas and Aerosol Compositions Monitor in the School of Atmospheric Sciences, Nanjing University (The data presented in this article are available upon request from Yangzhihao Zhan (zyzh1049744276@gmail.com)). Air quality monitoring data were acquired from the official NEMC real-time publishing platform (https://air.cnemc.cn:18007/, last access: 7 April 2023). Meteorological data were obtained from the University of Wyoming website (http://weather.uwyo.edu/, last access: 7 April 2023). The NCEP FNL data were taken from the NCEP (https://rda.ucar.edu/datasets/, last access: 7 April 2023). These data can be downloaded for free as long as one agrees to the official instructions.