

Supplemental materials

Exploring wintertime regional haze in Northeast China: role of coal and biomass burning

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1. ECD vs. ESD

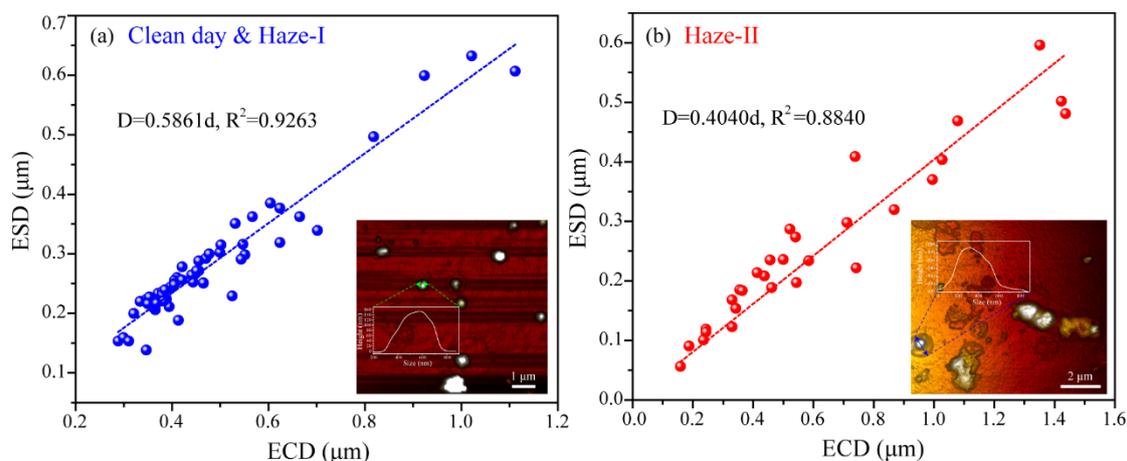


Figure S1. Linear correlations between equivalent circle diameter (ECD, d) and equivalent sphere diameter (ESD, D) and atomic force microscopy (AFM) images of individual particles during the clean day and Haze-I (a) and Haze-II (b).

2. Air quality map in Northeast China

Figure S2 shows three typical air quality maps of Northeast China on 31 October, 3 November, and 4 November, suggesting that a regional haze pollution occurred in Northeast China during the sampling period.

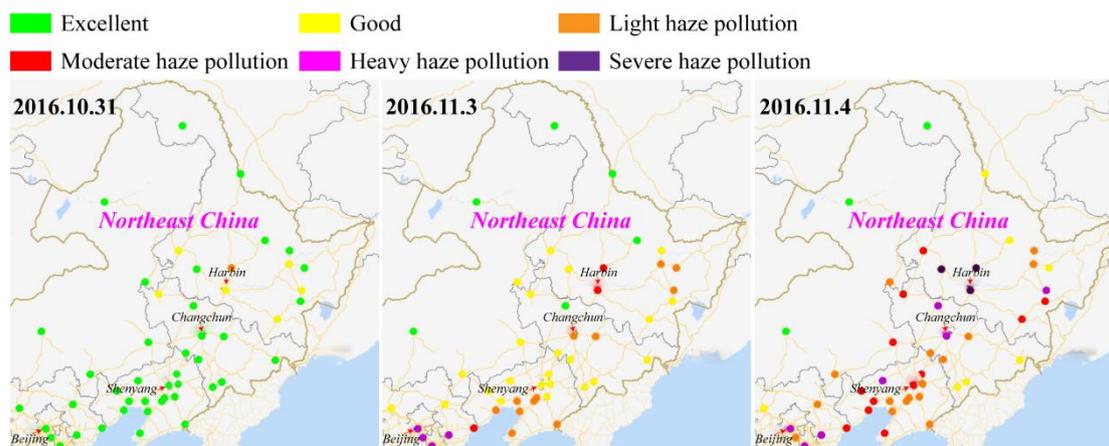


Figure S2. Daily air quality in many cities in Northeast China on 31 October, 3 November, and 4 November 2016 during the sampling period. The data are derived from China's Air Quality Online Monitoring and Analysis Platform (<https://www.aqistudy.cn/>), while the maps are from OpenStreetMap contributors 2019 distributed under a Creative Commons BY-SA License

(<https://www.openstreetmap.org/>).

3. Meteorological fields

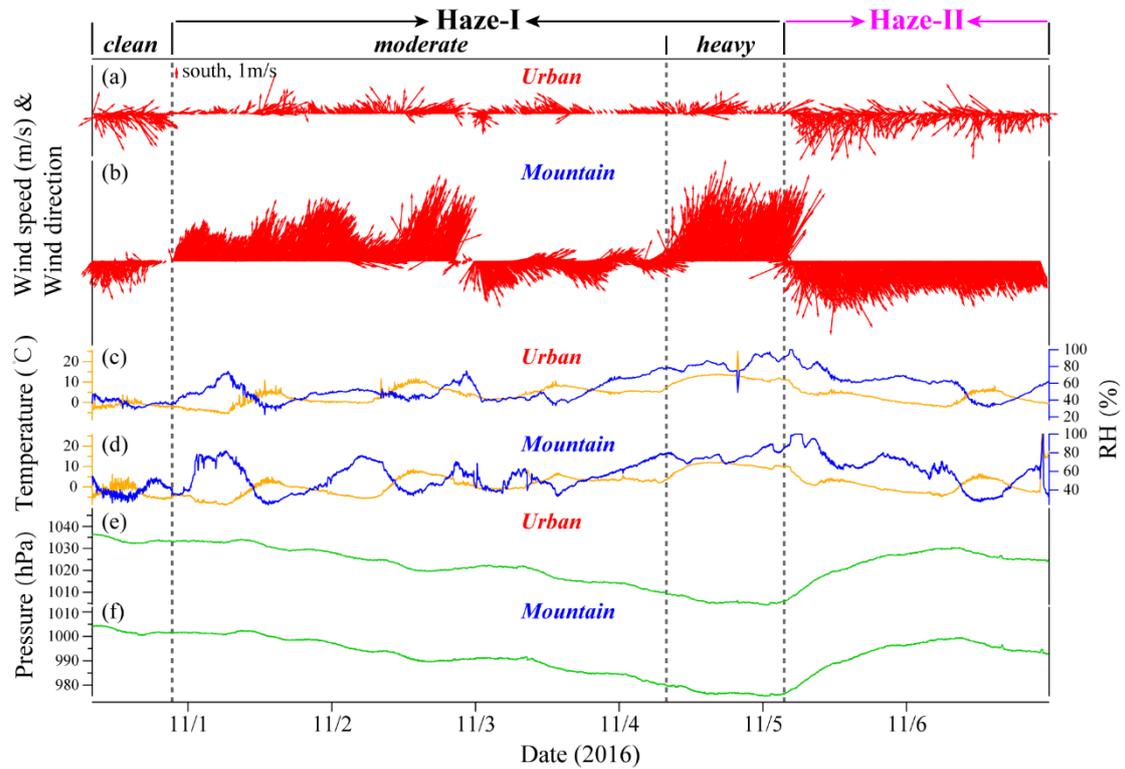


Figure S3. Time series of meteorological parameters at the urban and mountain sites from 31 October to 6 November 2016: **(a-b)** wind speed and wind direction; **(c-d)** temperature and relative humidity (RH); **(e-f)** pressure.

4. Air mass backward trajectories

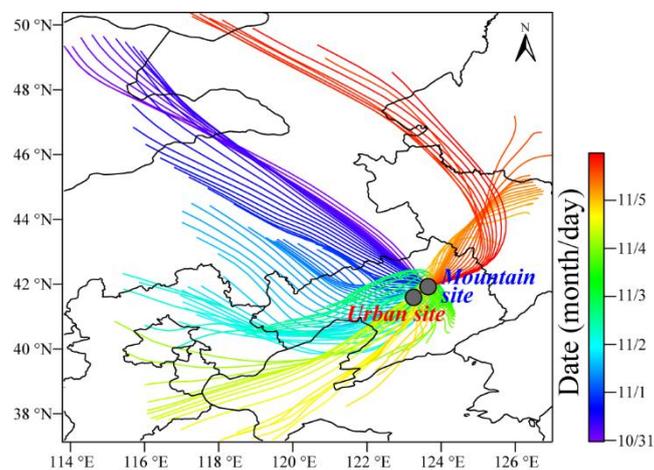


Figure S4. 24-h air mass backward trajectories before arriving at Shenyang during the sampling periods.

5. Concentrations of trace gases

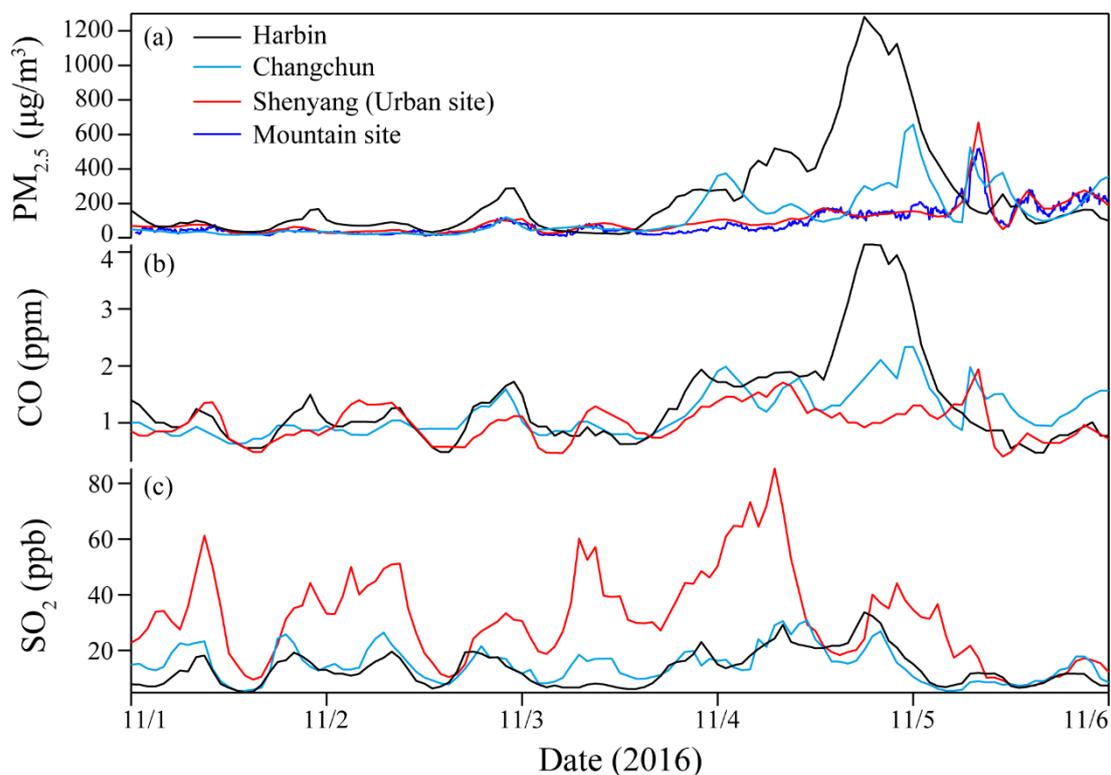


Figure S5. Time series of $PM_{2.5}$ and two trace gases (i.e., CO and SO_2) in Harbin city, Changchun city, Shenyang city (the urban site), and the mountain site from 1 to 5 November 2016: **(a)** $PM_{2.5}$; **(b)** CO; **(c)** SO_2 . These data have been obtained from China's Air Quality Online Monitoring and Analysis Platform, except for the $PM_{2.5}$ at the mountain site.

6. Size distribution of individual particles

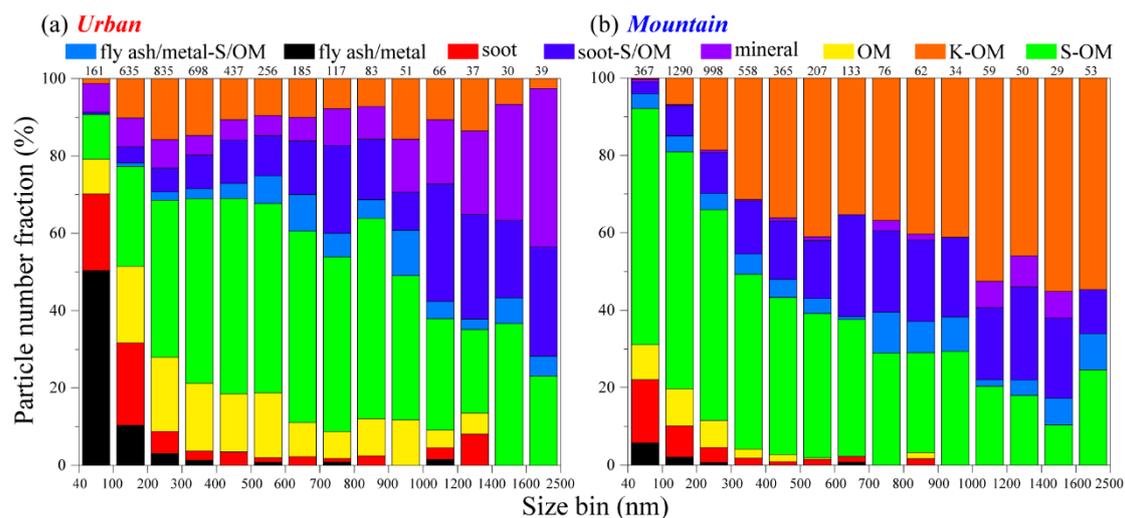


Figure S6. Size distribution of individual particles at **(a)** the urban site and **(b)** the mountain site. Analyzed particle numbers are listed on the top of each rectangle.

7. OC/EC ratios

Table S1. The ratios of OC/EC in Northeast China and North China Plain (NCP) during winter haze days.

| Sampling site | Period | OC/EC | References |
|---------------|--------------------------|-------|--------------------|
| Urban site | 31/10-4/11/2016 (Haze-I) | 8.0 | This study |
| Urban site | 4-5/11/2016 (Haze-II) | 25.4 | This study |
| Mountain site | 31/10-4/11/2016 (Haze-I) | 10.6 | This study |
| Mountain site | 4-5/11/2016 (Haze-II) | 27.9 | This study |
| Beijing city | 16-19/1/2010 | 4.5 | Zhao et al. (2013) |
| Jinan city | 13-23/12/2014 | 5.5 | Chen et al. (2017) |
| Tianjin city | 10-12/1/2013 | 5.3 | Han et al. (2014) |

References

Chen, S., Xu, L., Zhang, Y., Chen, B., Wang, X., Zhang, X., Zheng, M., Chen, J., Wang, W., Sun, Y., Fu, P., Wang, Z., and Li, W.: Direct observations of organic aerosols in common wintertime hazes in North China: insights into direct emissions from Chinese residential stoves, *Atmos. Chem. Phys.*, 17, 1259-1270, <https://doi.org/10.5194/acp-17-1259-2017>, 2017.

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