**Review**

Atmospheric Chemistry and Physics

**Title**

Temporally–resolved sectoral and regional contributions to air pollution in Beijing: Informing short–term emission controls

**Authors**

Tabish Umar Ansari, Oliver Wild, Edmund Ryan, Ying Chen, Jie Li, and Zifa Wang

**Summary**

This study analysed the sectoral, regional, and temporal contributions to two air pollution episodes in October 2014 across Beijing, China. Chemical transport model simulations were used to determine the temporal, regional, and individual emission sector contributions to ambient fine particulate matter ($PM_{2.5}$) concentrations, in addition to training emulators to predict air quality based on multiple emission sector variations. The paper explored the impacts of various controls under different meteorological conditions and found the local and regional importance of residential and industrial emissions. The topic of this paper is relevant to the scope of Atmospheric Chemistry and Physics. The paper used a relatively novel approach to provide an interesting understanding of how short–term emission controls influence air pollution episodes in Beijing, China.

My main criticisms regard further discussions and clarifications.

The authors emphasise the importance of short–term emergency measures for air pollution episodes, whilst convincingly demonstrating their minor role relative to meteorology and their limited effectiveness even at stringent implementations. This dichotomy should be further discussed, relative to long–term emission reductions and their implications for public health. For example, the authors found key contributions from residential and industrial emissions, similar to previous studies, and mentioned the large impacts of recent long–term emission reductions in China, which mainly focused on industrial and power emissions (Zheng *et al* 2018). However, these previous long–term emission reductions did not explicitly control for residential emissions, despite their key importance to both ambient and household $PM_{2.5}$ exposure (Zhao *et al* 2018). Current policies in Beijing and surrounding municipalities aim to specifically address the largely neglected and substantial emissions from residential solid fuel use (National Development and Reform Commission of China 2017), with large potential public health benefits (Meng *et al* 2019). These are especially important considering that the risks to public health from air pollution exposure are significantly larger at longer time scales.

The authors mention that emissions in and around Beijing are under rapid change and that individual air pollution episodes are dependent on specific meteorological conditions. Hence, the generalisability of this framework for future air pollution episodes need to discussed.

Overall, this well–written paper provides an interesting application of a relatively novel method to important issues surrounding the control of substantial air pollution exposure. The paper would be improved from enhanced discussions and clarifications.

## Comments

1. The authors should state the focus on *ambient* air quality, as China still experiences poor *household* air quality, which is confirmed by this studies finding of the importance of residential emissions.
2. Page 2 line 4, page 4 lines 6 and 10, page 11 lines 4, 6, and 7: Define acronyms at first use.
3. It would aid the reader to specify $PM_{2.5}$ *concentrations* or *emissions*, rather than using $PM_{2.5}$ alone (e.g. page 2 line 27, page 6 line 4, page 7 lines 28 and 29, Figure 4, page 7 line 1, Figure 6, page 9 line 12, and other instances).
4. Figure 8 and 11: The baseline daily–mean $PM_{2.5}$ concentrations are more than the sum of the local, near–neighbourhood, and far–neighbourhood sources. For example, after removing all emission sources for all three regions daily–mean $PM_{2.5}$ concentrations remain at 79 $\mu g\ m^{-3}$. It would be useful to discuss what is contributing to this remaining large exposure.
5. Section 5: Methods, evaluation, and results are combined. The clarity would be improved if these were separated.
6. Figure 8 and 11: Perceptually–uniform colour maps would improve the clarity of the Figures (e.g. viridis, ColorBrewer 2.0).
7. The paper has many figures, which may dilute key findings. Some of the figures could be moved to the Supplementary.
8. Page 16 lines 7–10: References needed.
9. Figure S2: Define D02 and D03.

## References


Arriagada N B, Palmer A J, Bowman D M J S, Morgan G G, Jalaludin B B and Johnston F H 2020 Unprecedented smoke-related health burden associated with the 2019–20 bushfires in eastern Australia *Med. J. Aust.* 2019–20

GBD 2017 Risk Factor Collaborators 2018 Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Stu *Lancet* **392** 1923–94

Grange S K, Carslaw D C, Lewis A C, Boleti E and Hueglin C 2018 Random forest meteorological normalisation models for Swiss PM10 trend analysis *Atmos. Chem. Phys.* **18** 6223–39

Liu J, Kiesewetter G, Klimont Z, Cofala J, Heyes C, Schöpp W, Zhu T, Cao G, Gomez Sanabria A, Sander R, Guo F, Zhang Q, Nguyen B, Bertok I, Rafaj P and Amann M 2019 Mitigation pathways of air pollution from residential emissions in the Beijing-Tianjin-Hebei region in China *Environ. Int.* **125** 236–44

Meng W, Zhong Q, Chen Y, Shen H, Yun X, Smith K R, Li B, Liu J, Wang X, Ma J, Cheng H, Zeng E Y, Guan D, Russell A G and Tao S 2019 Energy and air pollution benefits of household fuel policies in northern China *Proc. Natl. Acad. Sci.* 201904182

Ministry of Environmental Protection of China 2017 Beijing-Tianjin-Hebei and surrounding areas 2017 Air Pollution Prevention and Control Work Plan *Gov. China* Online: http://dqhj.mee.gov.cn/dtxx/201703/t20170323_408663.shtml

National Development and Reform Commission of China 2017 Work plan for clean heating in winter in northern China (2017–2021) *Gov. China* Online: http://www.gov.cn/xinwen/2017-12/20/content_5248855.htm

Qin Y, Wagner F, Scovronick N, Peng W, Yang J, Zhu T, Smith K R and Mauzerall D L 2017 Air quality, health, and climate implications of China's synthetic natural gas development *Proc. Natl.*

*Acad. Sci.* **114** 4887–92

Venter Z S, Aunan K, Chowdhury S and Lelieveld J 2020 COVID-19 lockdowns cause global air pollution declines *Proc. Natl. Acad. Sci. U. S. A.* **117** 18984–90

Zhao B, Zheng H, Wang S, Smith K R, Lu X, Aunan K, Gu Y, Wang Y, Ding D, Xing J, Fu X, Yang X, Liou K-N and Hao J 2018 Change in household fuels dominates the decrease in PM2.5 exposure and premature mortality in China in 2005–2015 *Proc. Natl. Acad. Sci.* **115** 12401–6

Zheng B, Tong D, Li M, Liu F, Hong C, Geng G, Li H, Li X, Peng L, Qi J, Yan L, Zhang Y, Zhao H, Zheng Y, He K and Zhang Q 2018 Trends in China's anthropogenic emissions since 2010 as the consequence of clean air actions *Atmos. Chem. Phys.* **18** 14095–111