Dear reviewer:

Thank you for your comments concerning our manuscript entitled “The interaction between urbanization and aerosols during the typical haze event”. The comments are all valuable for improving the manuscript and also have great guiding significance for our research. We have studied the comments carefully and made corrections that we hope will be met with your approval. One version of the revised manuscript is highlighted with Track Changes. In the following we quoted each review question and added our response after each paragraph.

Reviewer #1:

General comments:

1. *A general description of physical processes between aerosols or $PM_{2.5}$ and warming and cooling are missing in the abstract. A more general discussion of the atmospheric physics which is studied here is required to understand what the authors want to tell us.*

Thank you for your suggestion. We added a general description of warming and cooling processes by aerosols or $PM_{2.5}$ in the Abstract to improve the expression of physical mechanisms in the revised manuscript.

The new part was added in Lines 27-29 in the revised manuscript:

Aerosols cause cooling at the surface by reducing shortwave radiation, while urbanization causes warming by altering the surface albedo and releasing anthropogenic heat. The combined effect of the two phenomena needs to be studied in depth.

2. *This topic is much better handled in the chapter Introduction. But the last sentence of the Introduction is producing questions so that this statement should be deleted here but discussed in the chapter Conclusions.*

We deleted the last sentence of the Introduction and added it to the Discussion section in the revised manuscript.

3. *The description of methods is missing an overall statement which data are required and why. There it is necessary also to show what is available and which*

data are missing. It should be explained why the data basis is complete for this study. Then the algorithms and models should be discussed by the same view: why you do what and why this way can provide the expected results or answers to the hypothesis. The description of results is very detailed so that more information for understanding is required as mentioned above.

Thank you for your suggestion. We added more information and reorganized the Methods section to explain the data basis.

The revised Methods section is as follows (the added parts are shown in red):

2 Methods

2.1 Observational data

To investigate the interaction between urbanization and aerosols, observation data on basic meteorological elements, air quality, radiation and surface heat flux and the mixing layer height (MLH) are very important to reveal the impact of urbanization and aerosols during haze events.

The basic meteorological elements were obtained from 309 national basic weather stations in the BTH region and were provided by the China Meteorological Administration (http://data.cma.cn/). The locations of the national basic weather stations are shown in Fig 1 (red dots). The mass concentrations of fine particulate matter ($PM_{2.5}$) were recorded by 251 environmental monitor stations managed by the Ministry of Ecology and Environment of the People's Republic of China (http://hbk.cei.cn/aspx/default.aspx) (Fig 1, black dots). We also used radiation and surface heat flux data to analyze the urban surface energy budget obtained from the Beijing meteorological tower (39.97°N, 116.37°E). The tower is 325 m high and is operated by the Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences (CAS). The heat flux data were measured by a fast response eddy covariance sensor system that was sampled at 10 Hz using CR500 (Campbell Scientific Inc., USA). The radiation data were provided by Kipp & Zonen (Netherlands) four-component unventilated CNR1 radiometers. Radiation and surface flux data from 140 m of the tower were used in this study. In addition, the MLH is an important factor affecting pollutant diffusion and is also affected by both urbanization and aerosols. Because the

MLH is not a routine observation, we obtained the data from only one site. The MLH and backscattering coefficient were measured by enhanced single-lens ceilometers (Vaisala, CL51, Finland) deployed by the IAP (Tang et al., 2016). Backscattering coefficient profiles were calculated by referencing the attenuation strobe laser LiDAR technique (910 nm), which is cited in Tang et al. (2015).

2.2 Model description and experimental design

To investigate the respective effects of urbanization and aerosols and further determine the interaction between urbanization and aerosols, a high-resolution regional model with satisfactory performance is necessary for sensitivity tests.

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4. *The chapter Conclusions are a summary, a discussion and some conclusions. The discussion is missing the relation of the study results to the overall knowledge. What is new? What are the conclusions for the overall knowledge and the study area?*

Thank you for your suggestion. We added a Discussion section to show the innovations and the relation of the study results to the overall knowledge.

The Discussion section is as follows:

5 Discussion

In this study, it was easier to distinguish the impacts of aerosols and urbanization by using RMAPS-ST with AOD hourly inputs than with RMAPS-Chem. One reason for this difference is that the model performance of RMAPS-ST is much better than that of RMAPS-Chem in meteorological fields. Although real-time feedback in modeling is not provided, RMAPS-ST is more efficient and more suitable for short-term operational forecasting.

This study not only qualified the impacts of aerosols and urbanization on haze events but also analyzed the interaction between aerosols and urbanization during haze events. This research will help to improve air quality under the continuous urbanization and sustainable development of large cities.

The government has taken a series of emission reduction measures, including limiting

industrial emissions and vehicle plate number traffic restriction measures, to improve the air quality in the BTH region. The policies have been effective in reducing aerosols. At the same time, urbanization continues mainly in the areas around Beijing (such as the Xiongan New Area). The results of this study show that the combined impact of urbanization and decreasing aerosols will increase the downward shortwave radiation and further increase the surface temperature and ozone concentration in the boundary layer. Previous studies indicated that ozone generally increases with temperature and decreases with humidity (Camalier et al., 2007; Cardelino et al., 1990). It is well known that ozone is not only a pollutant but also a greenhouse gas. Therefore, ozone will form a positive feedback mechanism to induce warming and ozone pollution in the boundary layer. This feedback will pose a new challenge regarding how to reduce ozone pollution in urban areas. Some studies have suggested that urban greening can effectively reduce ozone pollution (Nowak et al., 2000; Benjamin and Winer, 1998). More attempts should be made to add the interaction between urbanization and ozone in regional models.

Reference

Camalier, L., Cox, W., and Dolwick, P.: The effects of meteorology on ozone in urban areas and their use in assessing ozone trends, Atmospheric Environment, 41(33), 7127-7137, 2007.

Cardelino, C. A., and Chameides, W. L.: Natural hydrocarbons, urbanization, and urban ozone, Journal of Geophysical Research, 95(D9), 13971, 1990.

Nowak, D. J., Civerolo, K. L., Rao, S. T., Sistla, G., Luley, C. J., and Crane, D. E.: A modeling study of the impact of urban trees on ozone, Atmospheric Environment, 34(10), 1601-1613., 2000.

Benjamin, M. T., Winer, A. M.: Estimating the ozone-forming potential of urban trees and shrubs, Atmospheric Environment, 32(1), 53-68, 1998.

5. *The figure captions should be improved so that these are understandable without the overall manuscript: terms must be explained, description of parameters (Fig. 2c).*

Thank you for your suggestion. The revised Fig 2 is as follows:

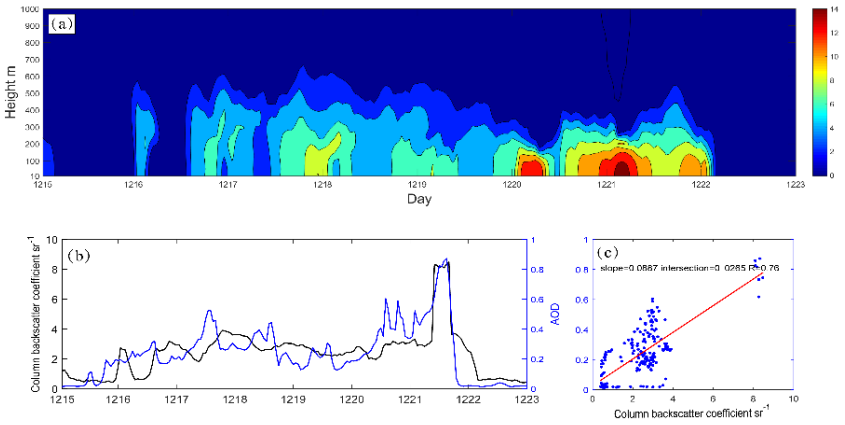

Figure 2 (a) Hourly backscattering coefficient (shading; $Mm \cdot sr^{-1}$) observed by single-lens ceilometers (39.97°N, 116.37°E) from the 15th to 23rd of December; (b) hourly column backscatter coefficient (black line; sr^{-1}) and AOD used in modeling for Beijing (blue line) and (c) scatter diagram of hourly column backscatter coefficient and AOD (blue dots) and their correlations (red line).

6. *Please follow the guidelines to write the references: the authors of papers are incomplete, after the title you set a"." or a ",", some paper references include the doi number and other not. Technical corrections Line 76 Crutzen instead of Cruten.*

Thank you for your suggestion. We unified the format and added information to improve the References section.

Special thanks to you for your good comments. We tried our best to improve the manuscript and made some changes in the manuscript. These changes will not influence the content and framework of the paper. Furthermore, to make the article more readable, we have had the manuscript polished with a professional assistance in writing.

We appreciate for Reviewer' warm work earnestly, and hope that the correction will meet with approval.

Once again, thank you very much for your comments and suggestions.

Yours sincerely,

Dr. Tang