Reply to Anonymous Referee #3:

We sincerely appreciate for the reviewer's careful dealing of our manuscript and valuable comments. We have read and discussed these comments in detail and answer them one by one in the followings. The corresponding revisions have also been added in the manuscript.

General comments by Referee #3

This study evaluated two surface layer schemes offline, and showed that the new Li scheme presents a better performance over the classic MM5 scheme in terms of the momentum and sensible heat fluxes. Given the importance of the surface exchange processes in a pollution episode and pollution forecast, an accurate representation of the surface processes would be required in a numerical model. This manuscript gave a rather good description about the two schemes, and the results did show that Li scheme may produce better agreement with observations especially in the transition stage of a haze episode. However, I have a few major concerns about this paper:

Comment 1: *What is the scientific contribution of this paper? The authors have well-addressed my comment in the quick report about the new improved surface layer scheme. However, as a scientific paper, I think the authors should also discuss and summarize the scientific findings of this study besides discussing the performance of the two schemes. For example,*

Response:

Thanks for the referee's advice. We have added some relevant content to strengthen the scientific contribution of our paper, and rewritten the conclusion and abstract of the manuscript. The scientific findings of this study are: (1) z_{0m} and z_{0h} have important effects on turbulent flux calculation in the SL schemes and ignoring the difference between z_{0m} and z_{0h} in the MM5 scheme could lead to large errors in calculation of sensible heat fluxes. In addition, ignoring the effect of the RSL in schemes may also results in certain bias of momentum and sensible heat fluxes in megacity regions which represent the rough underlying surface; (2) the magnitude of roughness lengths has significant influence on the two schemes. The difference of momentum and sensible heat fluxes calculated by Li and MM5 was much bigger over rough surface than over smooth surface, which suggests that the MM5 scheme probably induces bigger error in megacities with rough underlying surface than it in suburban area with smooth surface; (3) Li scheme better characterized the evolution of atmospheric stratification which is closely related to the haze pollution, compared with the MM5 scheme. This advantage was the most prominent in the transition stage from unstable to stable atmospheric stratification corresponding to the $PM_{2.5}$ accumulation. The offline study of the two SL schemes in this paper showed the superiority of Li scheme for surface flux calculation corresponding to the $PM_{2.5}$ evolution during the haze episode in Jing-Jin-Ji in east China. The study results offer the prerequisite and a possible way to improve PBL diffusion simulation and then $PM_{2.5}$ prediction, which will be achieved in the follow-up work of online integrating of the Li scheme into the atmosphere chemical model.

1) *How does the roughness length affect the turbulent fluxes and hence the pollution?*

Response:

The surface parameters roughness lengths (z_{0m} and z_{0h}) directly affect the calculation of both the surface layer scheme and the turbulent flux (momentum flux and sensible heat flux) which control the atmospheric stratification closely related to the haze pollution. To be specific, ignoring the difference between z_{0m} and z_{0h} in the MM5 scheme induced an obvious overestimation in calculating sensible heat flux (Fig. 6b). Instead, reasonable values of z_{0m} and z_{0h} in the Li scheme

produced better agreement with observations (Figs. 6a-b). Furthermore, the Li scheme better characterized the evolution of atmospheric stratification from unstable to stable condition (Figs. 7-8), due to the reasonable treatment of the two parameters.

In addition, we added some new content to further discuss the important role of the roughness lengths (Figs. 9). The result showed that the differences of momentum and sensible heat fluxes calculated by Li and MM5 were much bigger in Beijing than that in Gucheng. This suggests that the MM5 scheme probably induces bigger error in megacities with rough surface (e.g., Beijing) than it in suburban area with smooth surface (e.g., Gucheng) due to the irrational algorithm of the MM5 scheme itself and the ignoring difference between z_{0m} and z_{0h}.

The study results above indicate the important role of the roughness lengths in turbulent fluxes and also suggest the improving possibility of severe haze prediction in Jing-Jin-Ji in east China by coupling the Li scheme with more reasonable treatment of roughness lengths and algorithms into the atmosphere chemical model online.

2) *Does the roughness length plays a more important role in the transition stage of a pollution episode? And why?*

Response:

Yes. The Li scheme performed the best in the transition stage of the pollution episode at Gucheng station, compared with the MM5 scheme, and the biggest difference between Li and MM5 is the treatment of roughness lengths. Therefore, it can be inferred that the roughness lengths play a more important role in the transition stage of the pollution episode at Gucheng station. The results of Jing-Jin-Ji region was similar with Gucheng (Fig. 10 added in the revised manuscript).

In addition, we have added some new experiments to illustrate the important role of this surface parameter (Figs. 4-5, which were revised and add the contrast experiments of RSL). The results showed that the roughness lengths have a much higher effect on the momentum and sensible heat transfer than other factors such as the RSL as well as the universal function. We expect to find more observations to further evaluate it.

Comment 2: *There are a lot of grammar mistakes. Please carefully edit the manuscript to improve the language to ensure a better delivery of the scientific ideas and findings to the audience.*

Response:

We are so sorry for that. We have a careful examination of the full text including the tables and figures and revised the manuscript to ensure a better delivery of the scientific ideas and findings to the audience. All the changes can be seen in the manuscript with marked-up version.