A point-by-point response to the reviews

Thank you for your valuable comments. The followings are our responses to your comments.

Response to Reviewer #2

Comment 1: The air pollution is very serious in China especially the North China during winter. Moreover, the rapid formation of $PM_{2.5}$ is more frequency, and the reason of this phenomenon is not very clearly. This article studied the concentration, composition, and the correlations of the key species of $PM_{2.5}$ in four sampling sites of North China. The study demonstrated that the residential coal combustion was dominant source of atmospheric OC, EC, Cl^-, NO_3^-, SO_4^{2-} and NH_4^+ in both rural areas and cities in the four sites of North China. The author also used the CMC method to calculate the contributions of the primary particle emission from residential coal combustion to $PM_{2.5}$ at the four sites during winter. The article is suitable to be published in this Journal. I recommended it to be accepted after minor revision.

Answer: Thank you for your positive evaluation of our work. The followings are our responses to your comments.

Comment 2: line 361: The author demonstrated that the formation rate of SO_4^{2-} via heterogeneous or multiphase reactions might be slower, so the correlation between OC (or EC) and SO_4^{2-} was insignificant. This conclusion is not convinced. The author should give more evidence to support this point, such as some analyzing of trace gases (SO_2, CO, NO_x and so on) during the period in four sites or reference some laboratory studies on the formation rate of SO_4^{2-} via heterogeneous or multiphase reactions.

Answer: Thank you for your valuable suggestion. The reactive uptake coefficients of SO_2 oxidation by O_3 were reported to be from 4.3×10^{-8} to 7×10^{-7} on different mineral aerosols and from 1×10^{-6} to 6×10^{-6} on soot particles (Wu et al., 2011; Song et al., 2012), which were at least one order of magnitude less than those of NO_2 (1.03×10^{-2}-3.43×10^{-3} on soot particles and 1.03×10^{-6}-1.2×10^{-5} on mineral aerosols) (Underwood et al., 2001; Esteve et al., 2004; Ma et al., 2011; Ma et al., 2017). The information has been added in the revised manuscript.

Comment 3: There are some grammar error, the author should improve the English of the article.

Answer: According to your suggestion, the English of the manuscript has been improved through carefully correcting grammar errors, which has been marked in the revised manuscript.

References

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Underwood, G. M., Song, C. H., Phadnis, M., Carmichael, G. R., and Grassian, V. H.: Heterogeneous reactions of NO_2 and HNO_3 on oxides and mineral dust: A combined laboratory and modeling study, Journal of Geophysical Research: Atmospheres, 106, 18055-18066, 10.1029/2000jd900552, 2001.

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