Response to the Editor

(1)Selection of uptake coefficients.

I agree with the reviewers. The fact that "the parameterization of heterogeneous reaction of SO2 on soot, organics, and SNA aerosols are not well established" can't justify the selection. In fact, there are established kinetic parameters available in literature, e.g., uptake of NO2 on soot, organics, etc (Kalberer et al., 1999). Strictly speaking, the uptake coefficient of SO2 is determined through model-observation comparison rather than from Wang et al 2012. Therefore, I would suggest the authors to clearly mention that the selection of uptake coefficients from Wang et al. 2012 is arbitrary.

Response: Thanks. In the revised manuscript, we clarify that the selection of uptake coefficients is arbitrary in the abstract and Sect. 2.2.

(2)Double counting of heterogeneous reactions

After including new mechanisms, the reactions of NO2 are represented in both R14 and R20. This will result in a double counting if both reactions happen on the same aerosol surfaces.

Response: After adding R16-R24, R14 and R15 were removed from the original model. We added a footnote in Table 1 to clarify this.

(3)Aerosol hygroscopic growth

Do the aerosols in Table 1 refer to dry aerosol particles? Was aerosol hygroscopic growth taken into account and how?

Response: The aerosols in Table 1 refer to wet particles. The effective diameter (d_p) and aerosol surface area per unit volume of air (S_p) of wet aerosols are used to calculate rate constant k of heterogeneous reactions in Eq. (1). The d_p and S_p of the wet particles are estimated from aerosol water content in the heterogeneous module using the ZSR method developed by Kim et al. (1993).

Kim, Y. P., Seinfeld, J. H., and Saxena, P.: Atmospheric gas-aerosol equilibrium I. Thermodynamic model, Aerosol Sci. and Technol., 19, 157-181, doi: 10.1080/02786829308959628, 1993.

(4)Abrupt increase in PM2.5/sulfate concentration

Zheng et al. 2014 suggests an important role of regional transport for the abrupt increase/decrease in January 12. In Fig. 3, the modelled wind speed seems to be lower than the observations. If so, it may explain the underestimated the peak concentration and overestimated minimum on 12 January (Fig. 4). To get a better idea, I would suggest the authors to provide comparison for other sites (e.g., Chengde, Shijiazhuang and Langfang).

Response: We agree. We have added the following paragraph in the revised manuscript. "It should be noted that the revised CMAQ model still significantly underestimated the peak $PM_{2.5}$ concentration on January 13, 2013. Zheng et al. (2014) argued that the abrupt increase of $PM_{2.5}$ concentration on January 13 represented rapid recovery from an interruption to the continuous pollution accumulation over the region rather than local chemical production. Our model also

failed to predict the high $PM_{2.5}$ concentration on January 13 over the polluted region (e.g., Langfang and Shijiazhuang, see supplementary information) but agreed well with observation in upwind cities (e.g., Chengde). In this case, the model may have underestimated the regional transport in polluted areas given the fact that the wind speed was underestimated at THU site."

(5) Format and figure resolution

Please comply with the reference style of the journal using Zhao et al., 2013a or 2013b (instead of X., J. Zhao et al., 2013). Please check the following link for details:
http://www.atmospheric-chemistry-and-physics.net/submission/manuscript_preparation.html

Please use higher resolution for Figs. 6-8. Make sure that all labels are legible.

Please use consistent date format (Fig. 1, 3, 4). A mixture of year and hour is hard to follow.

Response: All corrected in the revised manuscript.

Reference:

Kalberer, M., Ammann, M., Arens, F., Gaeggeler, H. W., and Baltensperger, U.: Heterogeneous formation of nitrous acid (HONO) on soot aerosol particles, J. Geophys. Res., 104, 13825, 1999.

Wang, K., Zhang, Y., Nenes, A., and Fountoukis, C.: Implementation of dust emission and chemistry into the Community Multiscale Air Quality modeling system and initial application to an Asian dust storm episode, Atmos. Chem. Phys., 12, 10209–10237, doi: 10.5194/acp-12-10209-2012, 2012.

Zheng, G. J., Duan, F. K., Ma, Y. L., Cheng, Y., Zheng, B., Zhang, Q., Huang, T., Kimoto, T., Chang, D., Su, H., Pöschl, U., Cheng, Y. F., and He, K. B.: Exploring the severe winter haze in Beijing, Atmos. Chem. Phys. Discuss., 14, 17907-17942, 10.5194/acpd-14-17907-2014, 2014.