

We appreciate the valuable comments and suggestions that greatly helped us improve our work. You will find point by point responses addressing all the issues in the following text.

Answers to Referee #1's comments and suggestions:

- 1) *In 2.4.1, the dry deposition velocity of SO₂ was taken from Tsi (2010), it should be described if it was suitable to NCP area.***

Thank you for the suggestion. The following few sentences were added to the revised manuscript to describe that it is suitable to use the dry deposition velocity from Tsai et al. (2010) in our work: “The dry deposition velocity in the NCP is ranges from 0.2-0.8 cm s⁻¹, showing no significant seasonal variations (Pan et al., 2013), which conforms well with the result of Tsai et al. (2010). Thus, it is believed to be appropriate to use the diurnal pattern measured by Tsai et al. (2010) for the NCP region.”

- 2) *In 2.4.2, the radiation data were not described.***

Thanks for your comment. The NCAR MM2.4 model is coupled with a Tropospheric Ultraviolet and Visible Radiation (TUV) model, which calculates the photolysis rates needed for photolytic reactions. The radiative properties of the 1st Jul 2009, 1st Oct 2009 and 1st Jan 2010 were modelled to represent the summer, autumn and winter cases, respectively. This information was added to the text in 2.4.2.

- 3) *For gaseous oxidation, the VOCs data taken in summer season were used in three seasons. A sensitivity test of VOCs should be done, since it could be a non-linear process.***

This is a very good point. According to your suggestion, we performed a sensitivity test with doubled/tripled summertime VOCs concentrations while reducing the isoprene concentrations to a half/a third of its summertime values. Results are shown in the revised Table 4. The increased VOCs concentrations during autumn and winter will lead to increased SO₂ oxidized amounts, however, the relative increase of group 2 and group 3 to that of group 1 decreases only slightly with increasing VOCs concentrations. Overall, the VOCs concentrations have little influence in the inter-comparison between the three groups.

Table 1 Simulated SO₂ gaseous oxidation amount for the three different SO₂ diurnal variation patterns, the occurrence frequency (of the three groups) weighting averaged value and the relative increase compared to the nighttime peak case. Case1, Case2 and Case3 respectively represent cases using summertime VOCs concentrations, doubled summertime VOCs concentrations with half of the summertime isoprene concentrations and tripled summertime VOCs concentrations with a third of the summertime isoprene concentrations.

Case	SO ₂ gaseous oxidized amount (ppbv day ⁻¹)						
	[Increase relative to nighttime peak case (%)]						
	summer	autumn			winter		
	Case1	Case1	Case2	Case3	Case1	Case2	Case3
Nighttime	2.3	3.1	3.7	4.0	3.0	4.0	4.5
Noontime	2.6 (15%)	3.9 (26%)	4.6 (23%)	4.8 (21%)	3.7 (23%)	4.7 (18%)	5.2 (16%)
Noontime+Nighttime	2.9 (28%)	4.3 (39%)	5.1 (36%)	5.4 (35%)	4.5 (50%)	5.9 (49%)	6.7 (49%)
Weighting Average	2.5 (9%)	3.8 (21%)	4.5 (19%)	4.7 (19%)	3.7 (23%)	4.8 (21%)	5.4 (20%)

4) In 2.4.3, the haze process had not been described.

The aqueous oxidation process of SO₂ in clouds are believed to be more important than that in haze, due to the large liquid water content of clouds. During noontime, aerosol liquid water content (Bian et al., 2014) is especially low, hence contributing far less to SO₂ aqueous oxidation than clouds. The aqueous oxidation process of SO₂ in haze is more complicated than that in clouds, it is highly influenced by the aerosol composition, liquid water content and pH value. The haze-SO₂ interaction is studied therefore in another work of ours and will not be further discussed in this study.

5) In page 5662 line 4-7, the uncertainties were discussed for assuming the trace gas concentration. The conclusion was that will not have influences in the intercomparison between the groups. In fact, this conclusion could be suitable to other two processes, if there were linear. There is a suggestion that the uncertainty discussion should be done in all of three processes.

Thank you for this valuable comment. The uncertainty for the gaseous oxidation process was added according to comment 3.

6) In Fig.5, there are more lines and dots with different colors, which could be identified in electronic version. For paper publication, it would be difficult to identify. Maybe a large figure should be shown in paper publication.

Thank you for this suggestion. Since the printed paper publications will also be in colour, we did not change the figure. However, we will suggest the editorial office to make the figure larger in the ACP version, to make the lines easier to identify.

7) *In page 5662 line 17-18, the language is not clear.*

To make this clearer, the sentence “At SDZ, high SO₂ concentrations in all but the winter season occur during noontime (Fig. 2a).” was rephrased as “At SDZ, high SO₂ concentrations occur during noontime in all seasons, except for the winter season (Fig. 2a).”

8) *For abbreviation sem (in page 5657 line 21 and page 5663 line 4) it's better to write in capitals SEM.*

Thank you for pointing this out, the abbreviations were changed accordingly to capital letters in our revised manuscript.

Reference:

Bian, Y. X., Zhao, C. S., Ma, N., Chen, J., and Xu, W. Y.: A study of aerosol liquid water content based on hygroscopicity measurements at high relative humidity in the North China Plain, *Atmos. Chem. Phys. Discuss.*, 14, 4089-4118, 10.5194/acpd-14-4089-2014, 2014.

Pan, Y. P., Wang, Y. S., Tang, G. Q., and Wu, D.: Spatial distribution and temporal variations of atmospheric sulfur deposition in Northern China: insights into the potential acidification risks, *Atmos. Chem. Phys.*, 13, 1675-1688, 10.5194/acp-13-1675-2013, 2013.

Tsai, J.-L., Chen, C.-L., Tsuang, B.-J., Kuo, P.-H., Tseng, K.-H., Hsu, T.-F., Sheu, B.-H., Liu, C.-P., and Hsueh, M.-T.: Observation of SO₂ dry deposition velocity at a high elevation flux tower over an evergreen broadleaf forest in Central Taiwan, *Atmospheric Environment*, 44, 1011-1019, 10.1016/j.atmosenv.2009.12.022, 2010.