

Investigation of new particle formation at the summit of Mt. Tai, China

Ganglin Lv et al.

We are very grateful to the detailed comments offered by the Referee #1. We have revised the manuscript accordingly, and listed below in red are our point-by-point responses.

Response to Referee #1

1. The language requires polished. I highly suggest that the authors ask a native speaker to edit this manuscript. Some sentences in this manuscript are too obscure to understand.

Answer: The manuscript has been revised by a native English speaker. The sentences have been marked in red.

2. P1, Line 14, campaign I and II seem overlapped. Please check the campaign period.

Answer: We have checked the campaign period, and there was a spelling mistake in campaign I. The right period of campaign I was from 25 July to 24 August 2014, and we have corrected it.

3. P1, Line 18, Mt. Tai CANNOT show larger formation rate. Besides “larger formation rate” is misleading. this work only studied less than one year NPF, it’s difficult to conclude the formation rate here is large. Considering the gas concentration, the FR for clean site should be lower.

Answer: Thanks. We have rewritten the related discussion in page 6, line 9-19. The observed NPF events at the summit of Mt. Tai were indeed very strong in our study, with the J_3 of $7.10 \pm 5.39 \text{ cm}^{-3} \text{ s}^{-1}$. The deep-analysis for its mechanisms might need the precise measurement for precursors, and we couldn’t make the accurate explanation for it because of limited measurement instruments. However, intensive precursor transport in region (eastern China) and enhanced photochemical activities at the summit of Mt. Tai could, at least partly, explain the higher formation rate values.

4. P1, Line 22, what does “limited higher PM 2.5” mean here? Usually higher particle contribution inhabits the new particle formation. Anyway, I guess the authors were trying to say that during the relatively polluted days, the GR is higher? It’s because of the gas concentration, but has nothing to do with PM concentration.

Answer: We appreciated the better understanding you made for “limited higher PM_{2.5}”, and we actually wanted to express the higher growth rate under the relatively polluted environment. However, the discussion of PM_{2.5} and particle growth has been removed in the revised manuscript.

5. P1, Line 20, what does “proxy” mean?

Answer: In the manuscript, “proxy” means “proximity for sulfuric acid”. In our study, direct measurement for gas-phase sulfuric acid was unavailable. Instead, the proxy for sulfuric acid was estimated based on solar radiation, sulfur dioxide, condensation sink and relative humidity.

6. P1, Line 22, recombination? Do author want to say “coagulation”?

Answer: Thanks. We actually wanted to show the “self-coagulation”. However, the related sentences have been removed in the revised manuscript.

7. P1, Line 23, “haze” is inaccurate.

Answer: Thanks. We have replaced “haze” to “hazy”

8. P2, Line 7, change “around” to “over”, what does “refer to” mean?

Answer: We have corrected “around” to “over”, and we have also changed the “refer to” to “include”.

9. Session 2.1, more information about the site should be provided, e.g. the height of the site or inlet from ground.

Answer: We have added a more detailed description about the site, seen in page 3, line 17-26. The observation site is almost the peak of Mt. Tai, so the height of the site is near 1534 m ASL. All the instruments were installed inside a large container, sampling through short inlet tubes from the container at a height of about 3 m above the ground level.

10. P3 Line 25, “Its measurement range of...” should be rewritten.

Answer: Thanks. We have rewritten the related sentences in Sect. 2.2, please see page 4, line 3-5.

11. Session 2.3.2, the sulfuric acid estimation method used here already has very large uncertainty. Besides, the accuracy of the radiation from HYSPLIT model is far from enough for sulfuric acid estimation.

Answer: In our revised manuscript, we have used the non-linear type proxies for sulfuric acid estimation in page 5, line 8-14, and both CS and RH have been taken into consideration in the new estimation method. In this study, direct measurement for solar radiation was not possessed, and the meteorological station in China did not have the related data as well. There were no studies which reported the approximate values at the adjacent locations. As the result, the HYSPLIT model is the only available for solar radiation at the summit of Mt. Tai. We made the comparisons between the reported solar radiation and estimated solar radiation from HYSPLIT in some other locations. Results showed the absolute value of solar radiation from HYSPLIT might involve some error with the real solar radiation in the atmosphere, but its diurnal variation pattern could be believable to a certain extent. Except for the calculated sulfuric acid proxy concentrations in page 7, line 24-31 and Table 1, most of results in the revised manuscript were based on the comparison between NPF days and non-NPF days. The comparison method could weaken the effect of absolute solar radiation on the results. In addition, although the calculated sulfuric acid proxy concentrations have some error, its magnitude ($\sim 10^6$ orders of magnitude for initial sulfuric acid concentrations at the summit of Mt. Tai, cm^{-3}) should be believable.

12. Equation 6, the literatures here are old. For the current knowledge, sulfuric acid is considered to contribute to the nucleation, but negligibly to the particle growth. The authors should rethink about the discussion about this.

Answer: Many recent researches, such as Meng et al. (2014), showed that sulfuric acid made a minor contribution on particle growth and the oxidation production of VOCs accounted for the major contribution. In consideration of the inaccurate estimation of absolute sulfuric acid values, the discussion of sulfuric acid contribution on the NPF has been removed in the revised manuscript.

13. P5, Line 10, change “each” to “every”

Answer: We have corrected it.

14. Session 3.1, authors should analyze what controls the occurrence of NPF, source or sink?

Answer: Thanks very much. Multiple factors affecting the occurrence of NPF have been added in Sect. 3.2, page 6-11, including condensation sink, sulfuric acid proxy, sulfur dioxide, ozone, temperature, relative humidity, wind direction and air mass transport. In Sect. 3.2.1, we focus on the effects of sulfuric acid source and condensation sink, seen in page 7, line 1-31 and page 8, line 1-21.

15. Fig. 1, y should be $\text{SO}_2 \cdot \text{OH}$ to present NPF source. Comparing SO_2 with CS makes no sense.

Answer: Thanks. $\text{SO}_2 \cdot \text{OH}$ may not be possessed in this study, but we use the sulfur dioxide proxy concentration as the Y axis in Fig. 2 to compare the source and sink on NPF days and non-NPF days.

16. Fig. 3, change the color bar so that one can see the “banana curve” clearly.

Answer: We have changed the color bar and used the ORIGIN 9.0 to make the contour plot in our revised manuscript.

17. Session 3.2, because the sulfuric acid estimation has large uncertain, author should reconsider how to analyze this part.

Answer: Thanks. As the 11th answer, we focus on the comparisons between NPF days and non-days in the revised manuscript, and avoid involving absolute values as possible as we can. Detailed discussion was seen in Sect. 3.2.1, page 7, line 24-31 and page 8, line 1-30.

18. P7, Line 22, this interpretation has no evidence. It's more from author's guess, not from data. There are a few interpretations like this, e.g. line 25.

Answer: There might be confused expression in our manuscript, and new discussion for sulfur dioxide was seen in page 9, line 1-16. Because photochemical reactions of SO_2 are the major source for sulfuric acid at the summit of Mt. Tai (direct sulfuric acid could be neglected) and NPF was indeed favorable to the high SO_2 concentration, it is plausible that higher SO_2 concentration can increase the possibility of rich precursors for NPF.

19. Session 3.4, $\text{PM}_{2.5}$ is not directly related to NPF. Again, it should be discussed that it is source or sink that control the occurrence of NPF.

Answer: In the revised manuscript, the discussion for $\text{PM}_{2.5}$ variation has been removed. Instead, we focused on the NPF event during hazy episodes, and one NPF event on 11 November 2014 was analyzed in detail to explore the factors affecting its occurrence. Please see in Sect. 3.3, page 11, line 15-31 and page 12, line 1-17.

20. Session 3.5, how to combine the NAIS and WPS data. Especially these two instruments have overlapped size range. Maybe this should be included in the experimental session.

Answer: Thanks very much. Combination of the NAIS and WPS is a very good suggestion. It was a pity that the particle number size distributions measured by two instruments matched not very well in this study, and the WPS data were discontinuous because of frequent instrument maintaining. Therefore, we mainly used the NAIS data in the analysis of the NPF events, and the WPS data were the assist. However, we can adopt the combination of the NAIS and WPS in our future study.

21. Session 3.6, the definition of “haze” here is unclear. Visibility is not a crucial criterion for haze. The PM concentrations are similar for so called haze and non-haze days. Can it be haze or fog? Also it seems redundant and reduplicated to session 3.5.

Answer: In the revised manuscript, the hazy episode can be identified when the atmospheric visibility is less than 10 km and the RH is less than 80 % simultaneously, seen in page 11, line 17-19. The fog episode is identified when the atmospheric visibility is less than 10 km and the RH is more than 90 %. The crucial criterion between haze and fog is the RH. In the revised manuscript, we focus on the factors affecting the occurrence of NPF, and the related discussion for particle behaviors has been removed.