Referee #2

This study examined the impacts of sub-grid particle formation (SGPF) in point source plumes on 20 aerosol particles over eastern China in IAP-AACM. By implementing a SGPF scheme into the model and optimizing the key parameter in the scheme, the authors found that the model performance in simulating aerosol components and new particle formation processes was improved, indicating that SGPF processes are important in chemical transport model. This study can contribute to the CTM community and the results are solid. It can be considered to be accepted after addressing my comments below.

There are two steps for improving the model in this study. First, coupling the P6 sub-grid parameterization scheme with the global nested aerosol model IAP-AACM. Second, modifying the key parameter of the scheme, effective OH concentration in the plume, to fit the local chemical background on the basis of extensive field observations in eastern China. Four simulations are performed including SG and F0 for 2014 and SG and noSG(fox 2.5?) for winter 2016. I don't get what questions were the authors trying to answer. Why did they design these two sets of simulations? Why don't they directly use SG and original model setup in all places, which should represent the improvement of the model.

Reply: We greatly appreciate the reviewer for insight comments on the manuscript. There are two groups of comparisons in the manuscript, one is between SG and F0, and the other one is between SG and F2.5. The SG experiment represented the simulation with the localized SGPF scheme. The F0 and F2.5 are without SGPF scheme, but employed fox=0% (without sub-grid particles) and fox=2.5%, respectively. The comparison between SG and F0 were conducted to evaluate the sub-grid particles' impact on aerosol mass concentration simulation. The comparison between SG and F25

were conducted to explore the impact of SGPF scheme on the model performance in PNSD. The description is added in Line 336-344 and we have added a table (see in Table 1) to describe the experiments conducted in the paper.

Specific comments:

Lines 29, 31, 35: reduced and increased from xx to xx.

Reply: As the reductions and increases in different areas were different, we used a range to represent the variations between the simulation with sub-grid scheme and without sub-grid scheme.

Line 32: Since here is the diurnal cycle, the overestimation is for a specific time or for the whole day.

Reply: The overestimation of particle number concentration is at night. The time has been added in Line 33.

Line 46: Suggest to include some recent studies (e.g., Yang et al., 2019, 2020)

Reply: Thanks a lot for your good suggestion, some recent references have been added in Line 47.

Lines 80-83: Is 0-5% of SO2 emitted as H2SO4? Is the 0-15% of H2SO4 from 0-5% of total SO2 or the 0-15% of new partial from the total H2SO4?

Reply: Yes, 0-5% of total SO2 emitted as H2SO4, and 0-15% of H2SO4 is taken as the newly formed particles through nucleation. The sentences about this issue have been made more clear to avoid misunderstanding (see in Line 84-87)

Line 93: What does the "tens seconds of kilometers" mean?

Reply: It means a spatial scale of 10s km^{-1} that the gas-to-particle process is very fast, the unit has been changed to numeric description in Line 97.

Line 315: Suggest to add a table describing the detail of the simulation and what they are used for.

Reply: Thanks for the good suggestion. A table has been added to describe the experiments conducted in the paper (see in Table 1).

Line 341: Do you mean emergy and industry sectors were emitted into the first "five and three" layers of the model, "respectively"?

Reply: Yes, it is. The sentence was revised in Line 353.

Lines 343 and 345: Why the emissions in 2014 are from HTAP2 together with a scaling factor and the emissions in 2016 are directly from MEIC? MEIC also provides 2014

emissions.

Reply: The scaling factors of the emissions in 2014 are from the study by Zheng et al. (2018), and the variations of emissions during 2010-2017 in his study were based on the MEIC inventory.

Line 526: "Nodeling" to "Modeling"

Reply: Thanks, the typo has been corrected in Line 537.

Line 575: "nornalize" to "normalize"

Reply: Thanks, it has been corrected in Line 586.

Line 635:   What does the "OD" represent?

Reply: "OD" means optical depth. The explanation was shown in Line 157.

References:

Yang, Y., S. J. Smith, H. Wang, C. M. Mills, and P. J. Rasch, Variability, timescales, and nonlinearity in climate responses to black carbon emissions, Atmos. Chem. Phys., 19, 2405–2420, doi:10.5194/acp-19-2405-2019, 2019.

Yang, Y., Ren, L., Li, H., Wang, H., Wang, P., Chen, L., Yue, X., and Hong, L., Fast climate responses to aerosol emission reductions during the COVID-19 pandemic, Geophys. Res. Lett., 47, e2020GL089788, doi:10.1029/2020GL089788, 2020.