

Interactive comment on “Enhancement of nanoparticle formation and growth during the COVID-19 lockdown period in urban Beijing” by Xiaojing Shen et al.

Anonymous Referee #1

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In this study, the authors compare observations before, during and after the lockdown period in China during January and February 2020. They observe an enhancement of the nucleation and growth process of nanoparticles during the lockdown in Beijing. From this, they conclude that these findings were caused by the lockdown period, mainly due to lower concentration of Aitken mode aerosols that reduces the condensation sink. In contrast, accumulation mode particles increased and caused pollution events, due to new particle formation events with subsequent growth. This enhanced particle nucleation and growth is attributed to enhanced values of H₂SO₄ and VOC oxidation products, which were calculated from available data.

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The subject of this study is certainly suited for ACP.

However, I have two major concerns regarding this study that need to be addressed in a revised version. These concerns are a) meteorological representativeness and b) statistical significance. I explain my concerns in detail in the following.

Major issues:

a) Meteorological representativeness

A major problem when comparing air pollution data from different periods is the influence of meteorology. This needs to be considered to ensure that the observed differences are not coincidence. High and low pressure systems may prevail for a certain time, leading to differences in cloud coverage and thereby to enhanced or reduced radiation. Wind speed and direction influences transport of pollution from sources, either regional or even from long distances. Meteorological parameters are available. I suggest conducting something like a 5-year climatology of the available parameters to check the variability of the atmosphere and the representativeness of the Jan-Feb 2020 period, especially the lockdown period, compared to the same period in previous years. In line 40-41, the authors state that "Furthermore, particle accumulation was favored by stagnant airflow and vertical meteorological conditions during LCD (Zhong et al., 2020)." So apparently, they are aware of unusual meteorological conditions during the LCD period. But, since the Zhong et al. reference is still in preparation, the reader can't retrieve this additional but important information.

b) Statistic significance

The changes in NPF event frequency seem not to be significant, because the number of NPF events is small. The authors report on differences of "10 out of 23 days (43%)", "8 out of 24 days (33%)", and "5 out of 13 days (38%)". These are small numbers. A simple estimation based on Poisson statistics suggests that these differences may not be significant. Here a detailed statistical analysis has to be presented, and it may be

that the results will be that these differences are not significant.

Similar analyses have to be done for pollutants NO₂ and SO₂, because Fig. 3 shows that both are highly variable during the pre-LCD, LCD, and post-LCD periods.

The linear regressions between H₂SO₄, J₂, and GR are significant (Fig 5), but that's not new. And since H₂SO₄ is mainly calculated from global radiation, the meteorological influence on this parameter is high. The different growth rates when comparing pre-LCD, LCD and post-LCD for the different size ranges presented in Fig 6 may also not be significant, regarding the error bars.

Minor comments

Line 20: Please explain the meaning of J₂ also in the Abstract.

Line 34-35: Reformulate this sentence to: The number of Aitken mode particles (d ~ 25 – 100 nm), which is related to traffic emissions (Deventer et al., 2018) is also expected to decrease.

Line 38: Change "Air pollution is driven by the enhancement of secondary particles," to "Secondary particles contribute significantly to air pollution"

Line 41: The reference to Zhong et al. in preparation is not sufficient. If you do not want to show these data now, then I suggest to wait until the Zhong et al. paper is submitted as well. The meteorological situation (e.g. the inversion layer) is of great importance (see my major comment above).

Line 107 – 113: H₂SO₄ estimation: This is a very rough estimation. What are usual values for k, and what is the dimension of k? In Figure 4 no units are given on the right y-axis, but shouldn't that be cm⁻³?

Lines 123-130: So, to infer VOC oxidation capacity, you don't have OH measurements, thus you approximate OH, but you don't have UVB, so you approximate by global radiation. This seems like many uncertainties. Can you comment a little more on the

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uncertainties and the influence they might have on your interpretation?

Line 126, Equ. 6: There is a ratio of two numbers ($8.4\text{e-}7/8.6\text{e-}10$). Are these numbers rate coefficients that should have units? Or are they just empirical fit parameters? If they are just parameters, you can replace them by $9.8\text{e}2$.

Line 132-135: What are the exact criteria to define the NPF events?

Line 140-142 & 178: As already commented above: "The NPF event occurred on 10 out of 23 days (43%) during pre-LCD, 8 out of 24 days (33%) in LCD, and 5 out of 13 days (38%) in post-LCD, respectively". The frequencies of 43% or 33% are based on a very low number of events. Please add the total number of events to the table, and calculate Binomial or Poisson statistics for these numbers. It may be that the differences are too small to be significant, just by the small number of events.

Line 150: Please refer to Fig 2a here and replace "...were discussed in detail." by "are discussed in detail in the following". Otherwise it is hard for the reader to follow this discussion.

Line 170/171: Refer to Fig 2b here.

Line 174: Refer to Fig 2c.

Line 180: What is J3? Should it read J2? Or does this refer to measurements from 2015 where 3 nm was the lower size? If so, please explain.

Line 182-184: "in this study", "The previous study". Please make clear which study is which.

Line 191: "As discussed separately for LCD and pre-LCD during the NPF event occurrence (9:00–16:00 LT),...". Which NPF event are you talking about? You specify the time period 9:00 – 16:00 LT. But Fig. 4 shows a time series of the whole campaign. Individual events can not be seen here. The whole paragraph line 191 until line 200 can not be understood, because you refer to one NPF event that is not shown. Which day

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is that? I assume that this text describes an event that was discussed in Huang et al 2020, but if that is so, this discussion does not belong here in this paper. Please include a time series of the measured parameters for this event here or skip this paragraph.

Line 201: "...was indicated by different VOC_{ox},capacity levels" seems not to be the right expression here. I suggest to rephrase the whole sentence: "Both the H₂SO₄ proxy and the VOX_{ox},capacity were correlated to J_{2,tot} and to GR (Fig 5)."

Line 205-207: This is again a result from another study. Make that clear at the beginning of the sentence, like "Stolzenburg et al. (2020) showed that sulfuric acid could not explain. ..."

Lines 208-210: If H₂SO₄ contributed more to the nucleation process and organic vapours to the growth, would you not expect to see a better correlation between H₂SO₄ and J₂ than between H₂SO₄ and GR, and similarly a better correlation between VOC_{ox},cap and GR than between VOC_{ox},cap and J₂?

Lines 214-215: For the size range 5-10 nm, there is no significant difference between ions and neutral particles. Especially the yellow bars for 5-10 nm (Fig. 6) have almost exactly the same height. What are the error bars and what is their meaning? This should explained in the caption of Fig 6.

Line 220: What is the enhancement factor? How is it calculated?

Line 223: Replace "effect of the charger" by "effect of charge"

Lines 228-231: It would be helpful to add PM_{2.5} to one of the time series in Fig. 3, and to add the numbers of the NPF events in Fig 3 and 4 instead of or additional to the crosses. When I count the NPF events marked by the crosses, I find that event #9 is on January 23.

Lines 233-238: Please include a graph showing PM_{2.5}/CO. Please also state clearly how pollution periods were identified.

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Line 238-240: This sentence doesn't make sense. Maybe the "and" before "unfavorable" needs to be deleted?

Whole Section 3.4: What is the message of the section 3.4? The reader can not see the pollution events if there is no graph showing PM2.5, or CO, or both. Are there any conclusion drawn by section 3.4? It all seems very speculative. Meteorological conditions are mentioned as one possible reason for this pollution event, but it is not investigated by trajectory and emission source locations.

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