General comments

This work analyzed the different responses of haze events over the northern and southern NCP during COVID lockdown. The analyses and interpretation were conducted through sensitivity tests of emissions and meteorological fields. It was demonstrated that pervasive emission reduction during COVID lockdown synergistically reduced the $PM_{2.5}$ pollution in the southern NCP, while it was counteracted by unfavorable meteorological conditions in the northern NCP leading to worse haze events. The methods are sound, and conclusions are important, while the interpretation needs to be strengthened. I recommend minor revisions before publishing at ACP.

Specific comments

1. It is argued in the title the work contains insights from six-year simulations, while the main text is heavily based on the analysis for the 3-week (Jan 21 to Feb 16 in the year of 2020) simulation. To avoid exaggerating insights, it is better to remove "Insights from six-year simulation" in the title.
2. There are two observational datasets used in the paper. The location of the IAP sites should be marked in the map as other sites shown in Figure 1.
3. Line 109, what are the temporal and spatial resolutions of the emission input?
4. For lines 110-114, it is argued that SNCP has significantly higher emissions than the NNCP, which is not evident from Figure S1. The spatial coverage of SNCP is larger than NNCP. The comparison should be done for region-averaged emission flux per square meter per second. Please show the direct statistical evident of higher emission flux in SNCP than NNCP.
5. For lines 115-118, this is not directly related to dataset description, but rather comments for the topographical characteristics. Consider removing it.
6. What is the spin-up time for the WRF-Chem simulation? Please clarify.
7. For lines 137-139, besides the initial and boundary meteorological conditions, are the meteorological fields within the spatial domain directly simulated by the WRF-Chem, or is it externally provided by NCEP FNL? If it is directly simulated by the WRF-Chem, please provide more details such as the advection, convection, and boundary layer mixing schemes as the effects of meteorological conditions are a main part of this paper. If it is externally provided by NCEP FNL, please add clarification.
8. For lines 146-157, how are the scaling factors determined for emission sensitivity test? Please provide rational for the determination of scaling factor. Is it determined relative to certain emissions? Consider adding demonstration that the emissions are back to normal after the scaling? How are the scaling factors applied for emission sensitivity test? Are they applied as a constant for each city?
9. Line 187-193, the low-biased sulfate concentrations were attributed to incomplete SO_2 oxidation pathway in the WRF-Chem in the paper. But the author showed that SO_2

shows great agreements against observations in Figure S3d with NMB 4.8%. If the sulfate underestimation were due to incomplete SO_2 oxidation, underestimation of SO_2 would be introduced. Please explain.

10. For section 3.1, are the simulated concentrations sampled at each site, or each city and then averaged to get regional mean, or directly simulation average for each region? Please clarify.
11. It is better to show the corresponding scatter plot for each region of NNCP and SNCP as that for all sites in Figure 2.
12. Figure 2 caption indicates simulated wind fields which are not shown in Figure 2.
13. Line 228, please add the definition of haze events. Is the criterion of 100 μg/m^3 $PM_{2.5}$ used?
14. Line 268, the statement of $PM_{2.5}$ levels of -50 μg/m^3 is confusing as concentration will never be negative. Consider clarifying that it is the effects of meteorological fields on the $PM_{2.5}$ concentration difference.
15. Line 292-294, the statement of regional transport of $PM_{2.5}$ from SNCP to NNCP does not have strong evidence. There is no prior $PM_{2.5}$ pollution outbreak in advance in SNCP showed in Figure 3 before EP2 pollution in NNCP. Northward winds are not necessarily indicating pollution transport from SNCP to NNCP when SNCP is clean. Direct evidence may be needed by conducting a sensitivity test by eliminating SNCP emissions and evaluate the $PM_{2.5}$ differences from that with SNCP emissions.
16. Line 301-308, please add more specific evidence of how the increased T2 improves which chemical reaction rates and how higher RH promote particle formation? Is there any direct evidence in this study?
17. Line 319-321, is there any direct evidence that for COVID lockdown period in this study it is also true that it is in a NO_x-saturated regime with reduced HO_x concentrations? Please add direct evidence in this study.
18. Line 326-327, if the prior argument that NNCP is in a NO_x-saturated regime is true, then reduction of NO_x does not necessarily lead to a change of O_3 concentration.

Technical corrections

1. Line 245, replace the bell symbol by bell-shaped.