Referee #1

The authors develop a simple method based on the most recent statistical data for estimating the anthropogenic emissions of air pollutants in China during the period from January to August in 2020. They report for the first time the changes in air pollutants emissions caused by the COVID-19 lockdowns in China using a bottom-up approach. Additionally, the relative changes in monthly emissions from 2019 to 2020 are compared with the satellite and ground-based observations. The emission datasets developed in this study provide essential and important information for the analysis of the COVID-19 pandemic in China.

Consequently, the contents of this manuscript and datasets developed in this study are suitable for "Earth System Science Data". However, there are some points which should be analyzed and clarified. The reviewer recommends the acceptance of this manuscript after minor revisions.

Response:

We appreciate the referee's positive and constructive comments. Our point-by-point responses are given as follows.

(Major comments) (1) Lines 100-112: To what extent can the simple method developed in this study reproduces the changes of emissions in the past years? For example, by comparing with the MEIC in the emission changes from 2018 to 2019, it might be possible to validate the method and estimate its uncertainties. Such analysis should be added for identifying the application of the method to other cases and other regions.

Response:

We thank the reviewer's suggestions and agree that the validation of our method will identify the application possibilities in other cases. Our method relied on the monthly statistical data to track emissions, which have already been used by the MEIC model to reconstruct the monthly variation of emissions in the past years. The only difference is that MEIC has more constraints on energy consumption and emission factors in the past years than in the COVID period. To evaluate our method and the uncertainties based on an independent method and dataset, we discussed with the editor and decided to run an air quality model driven by our estimated emissions to simulate the interannual changes in air pollutant concentrations and evaluate the simulation results against surface observations. The comparison results reveal a broad consistency, suggesting

that our emission estimates can reproduce air pollution changes well. The discrepancies and implications for uncertainties have also been discussed in the revised manuscript.

(2) Figure 4: Some differences among six pollutants are found in the industrial emissions. The values for CO and NMVOCs are small positive in January and May to August while the values for SO_2, NO_x, and BC are negative in the same period and the value for $PM_{2.5}$ is positive in January only. These differences should be discussed.

Response:

The emissions of air pollutants tended to be lower in 2020 than in 2019 due to the reduced industrial activities during the lockdown. However, the activities of part of the industrial sources before and after the lockdown were larger in 2020 than in 2019, which drove up emissions of specific air pollutants. For example, the productions of iron, steel, and non-ferrous metals during January and February were 3.1%, 3.1%, and 2.2%, respectively, higher in 2020 than those in 2019, which have generated higher emissions of CO and $PM_{2.5}$ in January 2020. The productions of iron and steel from May to August in 2020 were 2.4–9.1% higher than the corresponding months in 2019, leading to higher CO emissions in 2020. The productions of crude oil and petrochemical products such as ethylene during January and February were 3.7% and 5.6% higher in 2020 than those in 2019, which explains the higher NMVOCs emissions in Jan 2020. From May to August, the productions of crude oil and the total volume of crude oil refineries process were 0.6–12.4% higher in 2020 than in 2019, which caused more NMVOCs emissions. These monthly changes in industrial activities have been shown in Table S2, which have also been clarified in the main text of the revised manuscript.

(3) Figure 5: In January, there are big differences between emissions and observations for SO_2 and NO_x while their differences for CO and $PM_{2.5}$ are smaller. The authors should discuss the reasons more carefully. The regional background largely affected the observed CO as the authors pointed out in lines 227-229. However, it is surprising that the differences between emissions and observations are relatively small in Figure 5(c). Further discussion is needed.

Response:

To account for the impact of regional background, we run the air quality model WRF-CMAQ to simulate surface concentrations of air pollutants and compared the changes in modeled concentrations to surface observations in Figure 5 in the revised manuscript.

The comparison suggests that the model simulations driven by our estimated emissions reproduced the changes in surface observations well. The results also reveal some discrepancies between simulations and observations, probably caused by uncertainties in emissions and modeling, which have been discussed in the revised manuscript.

(Minor comments) (1) Lines 118-120: Is there no observation data of NMVOC or NMHC concentration in China?

Response:

Not yet, the surface measurement network in China does not report NMVOC or NMHC.

(2) Line 128: For NMVOC (and NO_x), the emission declining from January to August seems to be not found in Figure 1.

Response:

This sentence has been rewritten as follows.

"China's emissions of SO_2, CO, $PM_{2.5}$, and BC in 2019 reveal an evident seasonal variation with emissions declining from January to August…"

(3) Line 210: Is "surface emissions" correct?

Response:

We have changed "surface emissions" to "anthropogenic emissions" in the revised manuscript.

(4) Lines 226-229: It looks like small differences between emissions and observations in Figure 5d. If the effects of regional background are large, the differences may be more increasing.

Response:

Please refer to our response to the major comment (3).

(5) Figure 1: It's better that the monthly emissions are decomposed into source sectors like Figure 4.

Response:

Done.