Referee #2

Zheng et al. (2020) developed a bottom-up approach to estimate anthropogenic emissions over mainland China during and after covid-19 lockdown. The results suggest the reduced anthropogenic emissions due to covid-19 lockdown are mainly from industry and transportation sectors. Despite all the merits of this approach mentioned in the manuscript, the emission estimates need thoroughly evaluated to better support the conclusion. Therefore, the reviewer recommends a major revision before accepted for publication.

Response:

We thank the referee for his/her effort to improve our manuscript. We provide point-by-point responses to the comments as follows.

General comments:

In this work, changes in the emission are evaluated against changes in surface observations and satellite retrievals. However, the changes in the surface concentrations do not necessarily reflect the similar changes in the emission. There are many processes/factors that could affect surface concentrations. This kind of evaluation does not provide much information on the uncertainty of the emission estimates. As mentioned in the manuscript, meteorology plays a significant role on surface concentrations, which is not considered in this work. A better way to evaluate the emission estimates would be comparing surface concentrations from an emission-driven model simulation with surface observations. It would be interesting to see a combination of a top-down approach (via observational constraints) and a bottom-up approach (used in this work) to better assess the emission estimates and to add more value to this work.

Response:

We agree with the reviewer that it is a better way to evaluate our emission estimates through a model simulation. In the revised manuscript, we have run the air quality model WRF-CMAQ driven by our estimated emissions for 2019 and 2020, simulated the interannual changes in surface concentrations of air pollutants, and compared the modeling results with surface observations in Fig. 5. The comparison results suggest that the model simulations driven by our estimated emissions reproduced the changes in surface observations well. The text in the discussions has been revised accordingly.

Following the reviewer's suggestions integrating top-down and bottom-up approaches, we have collected the top-down estimated air pollutant emissions from previous literature, which are broadly consistent with our bottom-up estimates. The consistency between top-down and bottom-up results proves the reliability of the emission results.

Specific comments:

Page 3, line 75-76, are the emissions from cooking included in residential sector?

Response:

Yes, the emissions from cooking stoves have been included in the residential sector.

Page 3, line 89-94, does EF2019/EF2018 have monthly variability? Or should EFm2019/EFm2018 be used?

Response:

Only the power sector in the MEIC model has monthly variability in EF2019/EF2018, mainly caused by the improvement of air pollution control efficiencies (e.g., via installing new devices). Since the change in emission factors may not occur in the same month of different years, we use the ratio of annual average emission factors to represent the continuous improvement in the air pollution control of power plants. For the other emission sources, we do not have monthly variability in the EF2019/EF2018.

Page 4, line 106-108, could you explain "assumption of no change" to "predict the 2019-to-2020 change"? Just curious, do you have estimates in cooking sources? Should be higher in 2020 than 2019?

Response:

Yes, we have estimated the emissions from cooking sources, the activities of which have been estimated based on population and energy consumed for cooking per person. The food demand per person and the associated energy use for cooking are relatively constant for two consecutive years. Therefore, we assume that both of these two factors remain unchanged in 2019 and 2020, resulting in an assumption of no change to predict the 2019-to-2020 change in cooking activities and emissions from cooking sources.

Page 5, line 141-142, is it possible to separate the impacts from Chinese New Year and COVID lockdown? As mentioned in the manuscript, one happened in Feb 2019 and one in Jan 2020. It would be interesting to see the impacts from COVID lockdown only.

Response:

The COVID lockdown overlapped with the Chinese New Year in 2020. For example, the lockdown measures in Wuhan started two days before the Chinese New Year and lasted for two months covering the entire holiday of Chinese New Year, making it difficult to separate the impacts from the holiday and COVID lockdown on emissions.

Page 6, line 178, do you have estimates for aviation emissions?

Response:

No, the aviation emissions are not included in our estimates.

Figure 4, any explanations on higher industrial sources for CO, NMVOCs, and $PM_{2.5}$, in Jan 2020 than Jan 2019?

Response:

The higher industrial source emissions of CO, NMVOCs, and $PM_{2.5}$ are due to the larger industrial activities in Jan 2020 (especially before the lockdown) than in Jan 2019. The productions of iron, steel, and non-ferrous metals during January and February are 3.1%, 3.1%, and 2.2% higher in 2020 than those in 2019, which are the major driver of higher emissions of CO and $PM_{2.5}$. The productions of crude oil and petrochemical products such as ethylene during January and February are 3.7% and 5.6% higher in 2020 than those in 2019, which explains the higher NMVOCs emissions in Jan 2020.

Figure 5, see general comments.

Response:

Please refer to our responses to the general comments.