Reviewer #1：

This paper studies the city scale NO_x and CO_2 emissions on a very high spatial and temporal resolution. It provides insights into the real-time and detailed emission quantification and control of NO_x and CO_2. This work is interesting from a scientific point of view and is well organized and developed. Some minor revisions are suggested:

1. Only the photochemical loss of NO_2 is considered in the establishment of the superposition column model, how does the other pathways of NO2 loss? Are they also play a role in NO_x chemistry?

Response: In the daytime, NO_x are mainly subjected to photochemical reaction with the hydroxyl radical (OH) to produce nitric acid (HNO_3), which is quickly converted to nitrate aerosols (NO_3^-). In some rural regions with substantial VOCs emissions, NO_x may also react with VOCs : $CH_3O_2 + NO_2 + M <-> PAN + M$ (e. g. Fischer et al., 2014). We have compared the GEOS-Chem model simulated HNO_3+NO_3^- and PAN concentrations over our study domain in daytime:

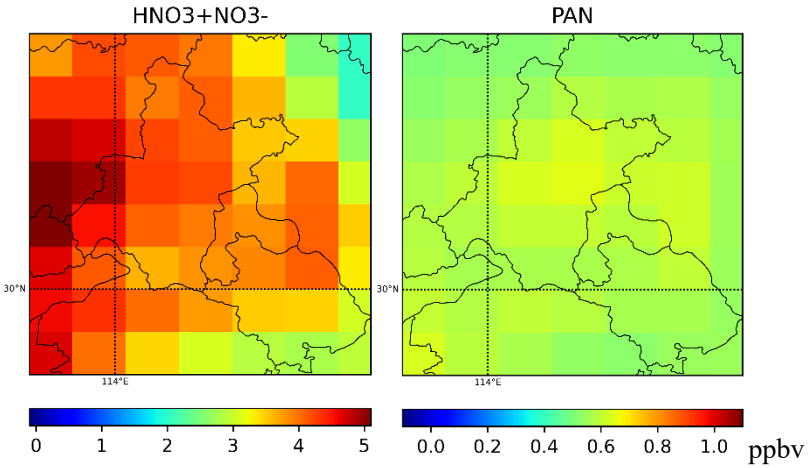

Figure S3: GEOS-chem model simulated monthly mean HNO3+NO3- (left) and PAN (right) concentration for July 2020.

The modeled HNO_3+NO_3^- concentration is 5-10 times higher than PAN over Wuhan, indicating that NO_x loss via OH is the driving pathway of NO_x chemistry over our study domain in the daytime.

At night, NO_2 is oxidized to HNO_3 through the formation of N_2O_5 and NO_3 and heterogeneous reactions including water vapor and aerosols (Shah et al., 2020; Lamsal et al., 2010). The overpass time of the satellite is 13:00–13:30 local time when NO_x chemistry over the city is dominated by the photochemical process, so we consider the

reaction between NO_x and OH in the superposition column model as the main loss pathway. We have clarified this point in the revised manuscript in Page 5, Line 133-134 and in the Text S2 and Fig. S3 in the revised supplementary material.

2. It is not clear to me how the 'starting background NO_2 value' is determined.

Response: For each day, we calculate the mean NO_2 line density value within the 5 (for summer, spring and autumn) or 10 (for winter) cells upwind of the starting cell of the study domain as the starting background NO_2 value. Please refer to Page 5, Line 144-145 in the revised manuscript.

3. In line 140-145, the authors say that the negative α value reflects the decay of upwind NO_2 pollution along the wind, how come there are still positive α values?

Response: In addition to the upwind NO_x pollution, NO_x emitted from natural sources like soil may also contribute to the background NO_2 value. Soil NO_x emissions are not influenced by wind direction, so on some days, when the background NO_2 value is dominated by soil NO_x rather than the upwind NO_x, we may obtain a positive or zero value of α.

4. The study obtains only 50 out of 365 days of valid data to quantify the NO_x and CO_2 emissions, isn't it too few to estimate the daily variation of NOx and CO2 emissions?

Response: To assure the performance of the model, we filter out the days when cloud fraction is greater than 0.2 and the days when the wind direction shows substantial spatial or temporal variation within the study domain, and obtained 81 clear sky days with full satellite NO_2 coverage within our study period. Then we excluded the days with fluctuating wind direction (if wind direction changes more than 45 degrees within 4 hours before TROPOMI overpass or over the study domain), which would lead to a less good correlation between modeled and observed NO_2 line density (R less than 0.85). Finally, we obtain 50 out of the 365 days with reliable NO_x and CO_2 emissions estimation. The fraction of useful days is comparable to what Lorente et al. (2019) obtained for Paris, which is 27 days in 5 months. These 50 days covers at least 2 days for each month (except for December 2019). For 2019, it includes 9 workdays, 3 weekend days and 2

holiday days, which are enough to investigate the 'weekend reduction effect' and 'holiday reduction effect' in NO_x emissions. It also covers 12 days across the lockdown period and 24 days after that, allowing us to monitor the large reduction and recovery of NO_x and CO_2 emissions from Wuhan due to the COVID lockdown. Therefore, these 50 days provide useful information to investigate the temporal emission patterns of NO_x and CO_2 from Wuhan and help to monitor the effectiveness of emission reductions in large urban centers. We have added this discussion in the revised manuscript in Page 16-17, Line 363-371.

5. Is there a difference in the overpass time of the TROPOMI and OCO-2 satellites? And how is this considered in the study?

Response: Both the TROPOMI and OCO-2 satellites overpasses at 13:00 – 13:30 local time, the difference is small, so we didn't consider this difference in the study.

6. According to Fig. S1, the predicted NO_x emission pattern is 'smoother' compared to the bottom-up emissions, do the authors think about the reason?

Response: We agree to the reviewer that the predicted NO_x emission pattern is smoother compared to the bottom-up emissions. It is caused by two reasons. First, the spatial resolution of the bottom-up emission inventories is 1 km × 1 km, while it is 5 km × 5 km for the estimated emissions. Second, the spatial pattern of the bottom-up emission inventories is used as a first guess for the estimated emissions, but we let it shift along with the wind during the fitting, and the final predicted NO_x emission pattern is determined by the mean of all the valid days. This is discussed further in the Section 1 of the revised supplementary material.

7. Fig. S4 shows that when the study domain is smaller, the estimated NOx lifetime is longer, how come?

Response: In the robustness test with respect to the area of study domain, we chose a smaller domain which encompasses the central part of Wuhan. The NO_2 column density within this smaller domain is higher than outside. The OH radial is the major oxidizing agent to convert primary pollutants to secondary ones in the atmosphere, so the

concentration of OH radical concentration is lower inside because of titration (Tan et al., 2018; Lorente et al., 2019). Consequently, the lifetime of NO_x inside the smaller domain will be longer. We have added this information in the revised supplementary material in Section 4.

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