Thank you for your careful review and constructive suggestions. These suggestions are quite valuable to us, and help improve our manuscript a lot.

Point-to-point responses

*We appreciate the reviewers for their valuable and constructive comments, which are very helpful for the improvement of the manuscript. We have revised the manuscript carefully according to the reviewers' comments. We have addressed the reviewers' comments on a point-to-point basis as below for consideration, where the reviewers' comments are cited in **black**, and the responses are in **blue**.*

Referee #1

(1) Section 2.2, Line 131-132: the spectra measured with a solar zenith angle (SZA) of >75° to avoid the strong impact of stratospheric absorbers. Please elaborate the impact clearly.

Re: Thanks for this comment. We describe the impacts in Supplementary materials. Supplementary Section S1: "When SZA is over 75°, the scattering mainly occurs in the lower stratosphere and upper troposphere. At that time, DOAS measurements are very sensitive to stratospheric absorbers, while the sensitivity to near-surface absorbers is relatively lower. In other words, absorbers in stratosphere contribute considerably to the measurements, especially for lower elevation angles during early morning and late evening. In this study, we mainly focused on the tropospheric absorbers close to the ground surface, and thus needed to filter out the measurements with SZA > 75°."

(2) Section 2.3, Line 146-147: the clouds have large impacts on the data quality. Please describe this procedure and put it into the Supplementary materials.

Re: Thanks for this comment. We have added the following paragraph into the Supplementary materials.

Supplementary Section S2: "In the radiative transfer calculations of the aerosol and trace gas profile retrieval, the layers were assumed to be horizontally homogeneous and cloud impacts were not considered in this calculation process. Notably, the presence of cloud would result in inhomogeneous or/and rapidly fluctuating radiation transport conditions, which might bring uncertainties into the retrieval results. Therefore, we needed to filter the retrieved differential slant column densities (DSCDs) by screening out cloudy scenes before further processing for the profile retrieval (Chan et al., 2019). Since the vertical distribution of the oxygen collision complex O_4 is nearly constant, the retrieved O_4 DSCDs and (relative) intensities ought to vary smoothly with time, or with the solar and viewing geometry. Any rapid change in O_4 DSCDs and intensities suggests a sudden variation of the radiative transport condition, which is possibly linked to the presence of clouds.

Thus, to filter data influenced by inhomogeneous and/or rapidly varying radiation transport conditions, we applied a locally weighted regression smoothing filter (LOWESS) (Cleveland, 1981) with a regression window of 3 h to the O_4 DSCDs and intensity time series at each elevation angle. Data with sharp changes in O_4 DSCDs and intensities were filtered out. Only data with slowly varying O_4 DSCDs and intensities were adopted for the subsequent profile retrieval. The limitation of this cloudy scenes removing algorithm is that the algorithm is not able to distinguish between continuous and homogeneous cloud conditions. Nevertheless, it is rare that the cloud does not alter for a long time (within an hour) and the cloud layer keeps homogeneous for all viewing directions.
"

(3) Section 3.1, Line 273-275: 'After 16:00, the high-extinction air mass shifted MTL from to 300–1000 m toward the surface at SJZ, with the AEC gradually exceeding 0.5 km^{-1} (Fig. 3)'. Which shift do you want to emphasize, the shift of MTL caused by the high-extinction air mass or the shift of air mass? Please reorganize the sentence.

Re: Thank you for this correction. As shown in Fig. 3, the fact that the near-surface AEC gradually exceeded 0.5 km^{-1} after 16:00 indicated that high-extinction air mass had a tendency of moving towards the ground. According to the definition of main transport layer (MTL) in Section 2.5, MTL was determined by the concentration and wind speed in the corresponding layer. We want to emphasize that the shift of high-extinction air mass intrigued an increase in AEC in the corresponding layers, eventually causing the MTL to drop from 300-1000 m towards the surface. We have followed the suggestion and reorganized the sentence.

"In the late afternoon, aerosols gradually accumulated towards the surface, and triggered a variation in the distribution of F_i. After 16:00, the shift in the high-AEC air mass caused the transport fluxes in the lower layers (100–200 m) to increase to > 1.1 and ~ 2 km^{-1}·m·s^{-1} for the CAMS and SJZ stations, respectively."

(4) Fig. 7: Why is the data missing at NC and XH stations during March 6-22, 2021?

Re: Thank you for this comment. This Figure was comparison result between dusty day and clean days. According to Fig. S9, we knew the HCHO results of NC and XH were both sound on clean days (March 6 and 22). In contrast, the poor quality of HCHO results on dusty day (March 15) made it impossible for us to calculate growth rates here, as G=([P]dust-[P]clean)/[P]clean.

We have checked the data of these two stations. For NC station, the number of retrieved HCHO profiles was very few (only 10), and only 1 profile met the filtering standard (DOF>1, relative error<0.5). For XH station, we only obtained 7 HCHO profiles and all of them were filtered according to our standard.

Technical comments:

Line 177, 'the wind speed in the southwest-northeast direction (WS)' → 'the wind speed (WS) in the southwest-northeast direction'

Line 191-192, 'Due to the large discrepancy in their vertical distribution, the MTLs of various pollutants were bound to have different varying characteristics' → 'Due to the large discrepancy in the vertical distribution of various pollutants, their MTLs were bound to have different varying characteristics'

Line 220, 'semibasin' → 'semi-basin', 'intraregional' → 'intra-regional'

Line 264, add space between 'MTL' and 'from', the logic of this sentence needs to be reconsidered.

Line 302: 'According to the selection standards described in Supplement Sect. S3, we confirmed that March 15 was a dusty day' and 'dusty day' is used in the following paragraphs. However, in Supplement Sect. S3, the date when the dust storm happened is defined as 'dust day'. Please use the unified definition between the manuscript and the supplementary materials.

Line 360, 'two stations assigned to the dark group (DG) located on the right' → 'two stations assigned to the dark group (DG) are located on the right.'

Line 411, 'four periods: west-to-east, YRD to NCP, transformation, and NCP to YRD' → 'four periods: West-to-East, YRD-to-NCP, Transformation, and NCP-to-YRD'. To keep in accordance with captions in Fig 12.

Fig. 11: the date format of 'yyyy-mm-dd' is different from that of other figures. Please take the unified date format.

Fig. S11-15: 'surface, 500 m, 800 m, 1000 m and 1500 m' → 'surface, 500, 800, 1000 and 1500 m'

Re: Thank you for these comments. We have followed these suggestions and corrected these mistakes accordingly.

References

Cleveland, W. S.: LOWESS: A Program for Smoothing Scatterplots by Robust Locally Weighted Regression The American Statistician, 35, 54, 10.2307/2683591 1981.