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Reply on CC1

Hossain M. S. Hoque et al.

Author comment on "MAX-DOAS observations of formaldehyde and nitrogen dioxide at three sites in Asia and comparison with the global chemistry transport model CHASER" by Hossain M. S. Hoque et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-815-AC1>, 2021

We thank Mr. Vinod Kumar for his comments on the article. It has indicated more scope of discussion in some sections of the manuscript. We are providing our responses to the comments. The responses the marked in bold alphabets.

The study by Hoque et al., 2021 presents MAX-DOAS measurements of NO₂ and HCHO at three different sites in south-Asia and compareS the vertical distributions with simulations from the chemical transport model CHASER. I have a few comments regarding the study.

- In the introduction (lines 88-93), the authors mention that it is the first study to evaluate the CHASER model simulated NO₂ and HCHO profiles using MAX-DOAS observations in three atmospheric environments. They also mention that no relevant literature in the past has described the use of MAX-DOAS datasets to evaluate global CTMs in southern and southeastern Asian regions. In this context, the study by Kumar et al. (2021) should be mentioned, which proposed a robust method to evaluate the vertical distribution of trace gases in an atmospheric chemistry model using MAX-DOAS measurements.

Response: Thank you very for notifying the article. We will include this relevant information in the revision.

- In lines 145-146, the authors mention that the reference spectra were recorded at elevation angle of 70° instead of 90° to minimize variations in the signals measured at each elevation angle. I find it difficult to understand. How would a reference at 70° minimize the variation in signals and what advantage does it have?

Response: Our spectrometer operated on a fixed integration time. The intensity of the measured radiation varies with the elevation angle(EL). Therefore, significant variability in the light intensity can potentially occur at all ELs within 15 minutes, which corresponds to the time for one complete scan, which can lead to saturation at the reference EL. To avoid such saturation, the reference EL at 70° were preferred to 90°. Notably, information on the EL settings was fully considered during the differential air mass factor computation. Thus, the sensitivity of the retrieved profile on the choice of reference EL is minimal. The profile retrieval is explicitly explained in the work of Irie et al. 2011, 2015.

- In lines 147-148, the authors mention that the off-axis elevation angles were limited to $< 10^\circ$ to reduce the systematic error in the in-oxygen collision complex (O_4) fitting results. This statement is not so clear and should be explained.

Response: The study by Irie et al. (2015), reported the following findings:

(a) measurements at off-axis ELs $< 10^\circ$ and adopting an EL-dependent correction factor for oxygen collision complexes minimized the effects of temperature-dependent O_4 cross-sections and subsequently reduced the uncertainty in the DOAS-fit.

(b) The aerosol profiles retrieved on the conditions (a), showed better agreement with the coincident cavity ring-down spectrometer (CRDS), LIDAR, and sky radiometer observations.

The current study has adopted the findings. In addition, the clarity of the sentences will be improved in the revised version.

- The authors mention that they have used the anthropogenic emissions from HTAP_v2.2 for 2008, while the model simulations were performed almost a decade later. I wonder why EDGAR v5AP (https://edgar.jrc.ec.europa.eu/emissions_data_and_maps) was not used, which includes the anthropogenic emissions for up to 2015.

Response: In the standard CHASER simulations, the anthropogenic emissions are kept constant to the 2008 values for consistency in the simulations period. General bottom-up inventories provide data for intermediate years. However, using such inventories, dealing with uncertainty becomes a complex issue. CHASER NO_2 simulations based on the inventories used in the current study have been validated in the work of Sekiya et al. (2018). However, we will discuss this issue in the revised manuscript.

- Sections 3.1.1 and 3.1.2 show the seasonal variability of HCHO and NO_2 , respectively, in two different vertical layers at Pantnagar located in the Indo-Gangetic plain and discuss the impact of crop residue burning in this region. The Study by Kumar et al. (2020) have also shown more than four years long vertically resolved measurements of the same species from a regionally representative site in the Indo-Gangetic plain and highlighted the impact of crop residue burning in the pre-monsoon and post-monsoon period. It is unfortunate to have no mention of the findings of Kumar et al., 2020 in this context.

Response: Thank you very for notifying the article. We will include this relevant information in the revision.

- Again, in section 3.1.3, HCHO/ NO_2 ratios are investigated to determine the ozone production sensitivity for the site Pantnagar in the Indo-Gangetic plain. Yet, there is no mention of two very relevant studies (Kumar et al., 2020; Kumar and Sinha, 2021) in this context that discusses the ozone production sensitivity on VOC and NO_x using various indicators, including HCHO/ NO_2 . Here, I would like to point out that the threshold values used for HCHO/ NO_2 ratios are valid for tropospheric columns and using the same for concentrations might lead to inappropriate inferences (Martin et al., 2004). This aspect should be discussed by the authors.

Response: Thank you very for notifying the article. We will include this relevant information in the revision. Yes, the threshold value can affect the HCHO/ NO_2

ratio, estimated from the concentration values. We will conduct a sensitivity study and include the discussion in the revised manuscript.

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