Review of “Mixing-layer-height-referenced ozone vertical distribution in the lower troposphere of Chinese megacities: Stratification, classification, meteorological, and photochemical mechanisms” by Liao et al.

In this paper, Liao and the co-authors presented a new way to investigate vertical ozone variation in lower troposphere below ~5 km, which is to scale the ozone vertical profile by the mixing layer height (H). In this way, the authors separate the ozone profiles into two parts: in the mixing layer (ML) and free troposphere (FL), taking ozonesonde observation in Beijing and Hong Kong from 2000-2022. Therefore, the authors are able to obtain some new understanding of ozone vertical variation in the two layers, in the interface of the two layers, and at the surface. Otherwise, such understanding may be lost if the conventional height scale is used. Using the H-referenced scale, the authors further characterized three types of vertical ozone profiles in the lower troposphere: FL-ozone dominated, ML-ozone dominated, and uniform distribution. Through meteorological and photochemical interpretations, the authors attempted to explain the vertical ozone variations in the three types of profiles.

Understanding vertical ozone variation is of importance to ozone pollution management at the surface. This paper provides some new understanding in this regard. The topic is also suitable to this journal. The paper overall read well. I recommend acceptance of this paper and provide the authors with the following suggestions for them to consider when revising their paper.

The authors did a good job in the first part of their paper (Figs. 1-7). The second part is also well-written, but a more in-depth investigation is necessary. For example, the meteorological interpretations for the three types of vertical profiles (Fig. 7) also contain signals of the seasonal variations in the meteorological variables. In addition, it is unclear how the Asian monsoon and associated large scale vertical motions impact the H-referred ozone profiles in different seasons. In the end, the mechanisms for the three kinds of ozone vertical profiles are not clearly articulated.

Reply: Thank you for your positive and constructive comments. We have carefully considered your suggestions and comments, and made corresponding modifications and explanations as follows:

In order to prevent the disturbance from seasonal signals in the meteorological variables, we made a large adjustment in Section 3.3 from previous annual scale to only polluted season scale (summer in Beijing and autumn Hong Kong). We excluded other seasons because those seasons are dominated by single ozone profile pattern (FTO_3-dominated pattern). In contrast, summer in Beijing and autumn in Hong Kong correspond to comparable occurrence of different O_3 profile patterns. Therefore, the focus on polluted seasons will lead to a more in-depth understanding of ozone pollution in Beijing and Hong Kong.

Due to the abovementioned adjustment, we re-plotted figures and re-wrote section

3.3. We added a new chart to characterize the lower-tropospheric ozone in polluted season (Fig. 7 in the revised manuscript) and a new chart to characterize the large-scale meteorological conditions associated with different ozone profile patterns (Fig. 8 in the revised manuscript). Meanwhile, we deleted the previous Figure 9 because the available sample numbers of OMI-based ozone precursors are very limited in summer of Beijing and autumn of Hong Kong.

You suggested that the influences from the Asian monsoon and associated large scale vertical motions should be considered in explaining the different ozone profile patterns. However, we found that the vertical motions played a very limited role in shaping the different lower-tropospheric ozone profile patterns. Two evidences are listed as follows: 1) In summer Beijing or autumn Hong Kong, the three ozone profile patterns are characterized by significant difference in MLO3 concentrations but similarity in FTO3 concentrations (Fig. 7 in the revised manuscript). The similar FTO3 concentrations indicate that downward transport of O3-rich air masses from upper level is not a decisive factor for the formation of different ozone profile patterns. 2) Vertical velocity had no significant difference among the different ozone profile patterns (Seeing Figure shown below). The large-scale meteorology (e.g., the Asian monsoon) may play a role through changing photochemistry-related local meteorology, the horizontal transport of ozone and its precursors, rather than through modulating the vertical exchange of O_3 between free troposphere and mixing layer. That is to say, it is the mixing layer ozone production (weak or strong production) that shapes the different ozone profile patterns. So, more attentions were paid to photochemistry-related conditions (including local and regional meteorology, ozone precursors and ozone production sensitivity) in the revised manuscript.

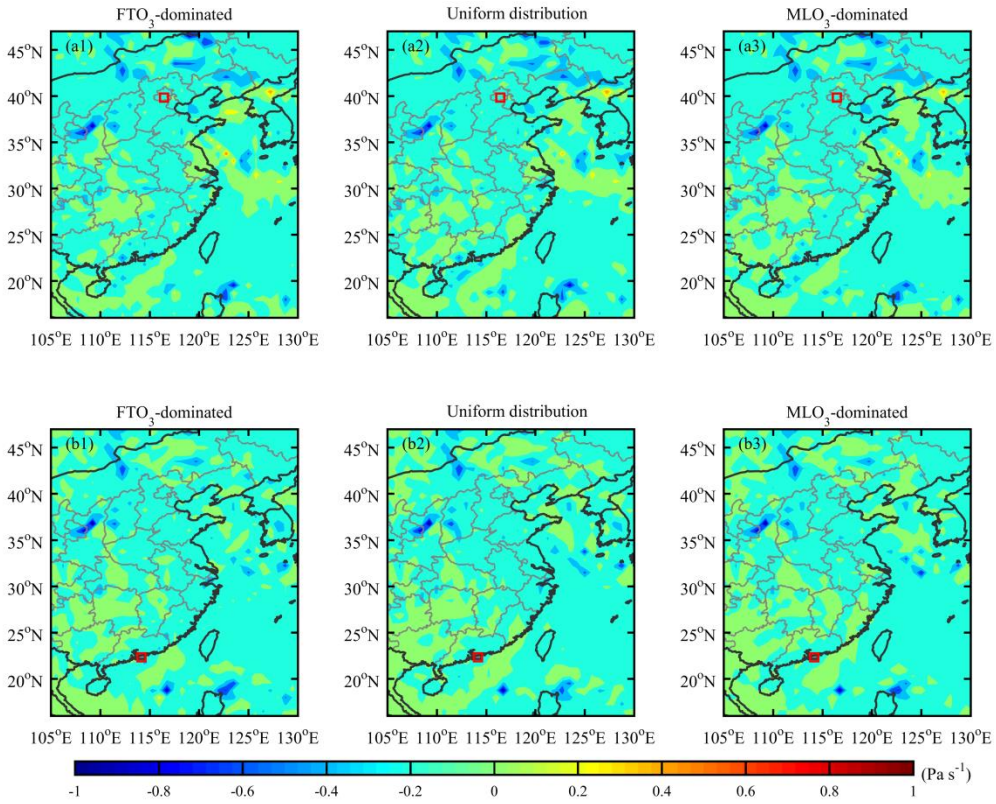

Figure S1. Composited vertical velocity at 850 hPa according to different ozone profile patterns in (a) summer of Beijing and (b) autumn of Hong Kong. The red boxes indicate the locations of Beijing and Hong Kong.

Minor points:

Fig.8, please explain the numbers at the top of each panel in the caption.

Reply: Thank you for pointing out our carelessness. The numbers denote the sample numbers. We clarify it in the revised manuscript.

L510, Surface ozone, not lower tropospheric ozone, is autumn-high/summer low in Hong Kong. Ozone in the lower troposphere below 5 km is also high in spring in Hong Kong.

Reply: Thanks for pointing out this false description. We correct it in the revised manuscript.