Response to Referee #2

Review of Li et al., 2025

In this paper, the authors discuss ozone measurements and trends over East and Southeast Asia. This data was collected as part of the Tropospheric Ozone Assessment Report (TOAR) project and includes surface measurements and vertical profiles of ozone. The authors compute ozone distribution, trends, and exceedances for many regions of Asia which were previously under-sampled. The authors also highlight the role of stratospheric ozone intrusions and the reality of long-term ozone exposure over much of East and Southeast Asia. I believe this paper is scientifically sound and presents actionable results for air quality regulation in the participating countries.

Therefore, I recommend that this paper be accepted with the following **minor** revisions.

Thank you very much for your very constructive comments. We have addressed them carefully and please find our point-by-point response in blue.

Specific Comments:

1) The introduction is very comprehensive about why we should care about tropospheric ozone, and it does a good job summarizing ozone trends over Asia. However, I would like the authors to go into further details about why the TOAR database is important. Does it fill data gaps in space and/or time? Is it a convenient new dataset available to the community? This paper was my first exposure to the TOAR project, and I was still left with some of these basic questions. Especially since the intro does such a thorough job explaining ozone trends and the paper continues to split ozone metrics/trends by country, it is unclear to me what value the TOAR dataset adds. Could you comment in the conclusions/discussion as well on what future work could do with the TOAR data? Some ideas which come to my mind that TOAR could be useful for are to analyze ozone trend by lat/lon bins, rural/urban bins, and coastal/inland bins, where political boundaries are less important and some physics questions can be answered.

The TOAR (https://igacproject.org/activities/TOAR/) was created by the IGAC on 2014 and it's goals are to assess tropospheric ozone from available measurements and constructed a freely accessible ozone database. The TOAR provides the global largest database for surface ozone records and we can examine global ozone levels within the same time frame.

We have added some description about the importance of TOAR in Lines 127-132: "The TOAR data portal archives a global comprehensive and freely accessible data collection of surface ozone observations (https://igacproject.org/activities/TOAR/TOAR-II), which supports TOAR's assessment report of global ozone distributions and trends from surface to the tropopause. The TOAR database keeps updated to include all recent observations since 2014. To give an up-to-date assessment of tropospheric ozone over East Asia and Southeast Asia, here we take advantage of TOAR database to examine ozone levels in different countries within the same time frame".

Thanks for your great suggestion for future work. In fact, more analysis using TOAR data have been or is being conducted by other researcher. For example, more papers from Tropospheric

Ozone Assessment Report Phase II (TOAR-II) Community Special Issue (https://amt.copernicus.org/articles/special_issue10_1256.html). And key TOAR-II Assessment papers on global ozone levels with focused analysis (e.g., lat/lon bins) are being developed by TOAR II team (https://igacproject.org/activities/TOAR/TOAR-II). As such, to avoid confusion, we decide not to comment on future studies in our manuscript.

2) Section 3.1.2: How "new" is the WHO peak season ozone trend? Are there previous studies you can compare to or does the TOAR data allow this to be calculated in a unique way. If this is brand new, highlight this very useful finding!

Thanks for noting this! The WHO peak season ozone standard was introduced in September 2021 and no previous studies assessed this metric in Asia as far as we know.

We highlighted this in Lines 258-260: "we apply the new WHO standard for peak season ozone that was introduced in September 2021 to assess risks of long-term ozone exposure over East Asia and Southeast Asia, which has not been examined in previous studies."

3) I really like the spatial maps of seasonal ozone concentrations and exceedances. These are very clear and well-explained. At the same time, the paper could benefit from some figures being reorganized or removed. Please see below.

a. Figure 10: I would recommend moving this to Figure 1 since it is the first figure referenced in the flow of the paper

Thanks for the suggestion. Figure 10 only provides information for ozone profile measurements and we would like to introduce it after the surface ozone part. To avoid confusion, we revised the text in Line 175: "Location of all ozonesonde sites and the IAGOS region will be detailed in Section 4.1"

b. Figure 3: is this figure necessary? The ozone standards are already mentioned in section 2 and in the supplement S2. I can also see how it be helpful to mention this figure or Figure S2 in section 2 if the authors want to keep this information in the paper visually.

Yes, we want to keep it to demonstrate this diverse ozone AQ standard. In particular, we want to highlight that in Lines 495-496: "The diverse short-term ozone air quality standards in Southeast Asian countries (Figure 3) suggest a great challenge to call for regional joint ozone control."

c. Figure 6 (and other trend figures): There is a lot of information contained in these figures, and it took me a bit to get a handle on what was being shown. I think the following might help to make these figures more digestible: 1) small + and – signs added above the colors, to indicate that blue is decreasing and red is increasing. 2) increase the size of the arrow legend showing the trend per year.

Well taken! The trend plots have been updated as suggested!

3) make colored arrows smaller/thinner. These arrows often sit on top of each other and obscure regional variability.

We have made them thinner but there are still some overlaps due to regional dense stations.

4) Overall, please refer to specific figure panels when appropriate.

Added.

5) I would recommend a different title for section 4 that makes it clearer that the paper will be discussing vertical profiles.

We have changed it to: “4. Present-day distribution and long-term trends in tropospheric ozone profiles”

6) Lines 428-442: The idea of the ozone climate penalty seems to me to be more in line with “current ozone distributions” or “ozone trends”. Maybe consider highlighting the climate penalty earlier in the paper.

Agreed. Now we have moved this part in Section 3. Please find it in Lines 278-294.

Technical Corrections:

Line 146: change “8h average” to “1h average” since you are computing MDA1

Line 160: replace “continued” with “operational” or “ongoing”

Line 161: remove “for utilizing”

Line 174: “regress” should be “regression”

Line 319: change “Figure 10” to “Figure 1” if the figure gets moved

Line 327: change “is used to be strongly intruded” to “is strongly intruding”

Line 398: remove “In a same way”

Line 407: replace “whole” with “to an overall”

Line 411: delete “At surface,”

Line 433: “slop” should be “slope”

Many thanks and we have walked through these grammar corrections.