Response to Anonymous Reviewer #2

General comment:

Hurynovich and co-authors provide an overview of ground-based monitoring site observations of PM2.5, PM10, SO2, NO2, CO, and O3 in 331 cities in China from 2015 to 2025. They present statistical analysis of national and regional trends in pollutant concentrations, investigate seasonal correlations between pollutants, and categorize cities in four type-groups based on the relative change in O3 and the mean relative change in the other five pollutants from 2015 to 2025. The manuscript is well-written, however the study does not provide any new findings, novel measurements, or evidence-based implications about the underlying chemistry and atmospheric processes driving the reported trends. For this reason, I suggest that the manuscript is not of a caliber suitable for publication in ACP.

Response:

We thank the reviewer for the careful assessment and for recognizing the clarity of the manuscript. We agree that the national-scale decline in $PM_{2.5}$, PM_{10}, SO_2, NO_2 and CO, together with the contrasting increase in O_3, has been extensively documented and should not be presented as the principal novelty of the study.

The main contribution that we intended to highlight is the substantial city-level divergence in O_3 response under comparable reductions in conventional pollutants. In particular, cities with nearly identical values of the five-pollutant reduction index can exhibit markedly different O_3 responses. For example, Type I and Type II cities show very similar median reductions in conventional pollutants, while their median O_3 changes differ strongly. We agree that this result was not sufficiently developed in the original manuscript and that the mechanistic interpretation remained too speculative.

In the revised manuscript, we will therefore shift the emphasis from descriptive national trends toward the city-level divergence problem and strengthen the evidence used to interpret the identified differences. In particular, we will incorporate additional observational constraints related to precursor conditions and meteorology and will revise the discussion to clearly distinguish observed statistical relationships from causal or chemical-regime attribution.

Comment 1:

While changes in NOx and heterogenous chemistry are discussed as possible drivers of changes in O3 production, trends in VOC emissions over the ten-year period are not addressed. As key precursors for both O3 and secondary PM, VOCs have been a target of recent emission reduction goals in China (e.g., Li et al., 2019). The possible impacts of changes in VOC emissions on O3 formation regime should be discussed, even if the monitoring data do not include VOC measurements. The authors could use satellite retrievals of formaldehyde as a way to estimate changes in VOC emissions from 2015–2025 (e.g., Shen et al., 2019).

Response:

We agree that the absence of VOC-related information is an important limitation of the current manuscript. Because VOCs are key precursors of both O_3 and secondary aerosol formation, discussing changes in NO_x-related chemistry without considering possible changes in VOC conditions provides an incomplete picture of the factors contributing to O_3 evolution.

Following the reviewer's suggestion, we will incorporate satellite-based formaldehyde observations as an observational proxy for changes in VOC-related atmospheric conditions over the study period. We will examine whether spatial and temporal changes in HCHO are consistent with the identified O_3 divergence patterns and whether Type I–IV cities differ systematically in their HCHO-related characteristics.

At the same time, we will explicitly acknowledge the limitations of interpreting satellite HCHO as a direct measure of VOC emissions, because HCHO columns reflect both anthropogenic and biogenic VOC oxidation as well as meteorological and chemical influences. Accordingly, the revised manuscript will avoid using HCHO alone to diagnose specific O_3 formation regimes. Instead, it will be used as an additional observational constraint for interpreting the spatial variability of O_3 response.

We will also expand the discussion of VOC-related emission changes and their possible role in modifying O_3 sensitivity during 2015–2025.

Comment 2:

The influence of meteorological trends over the ten-year period on the comparisons in the study is not mentioned. For example, what role would increasing land surface temperatures have on O3 production between the early and late period?

Response:

We thank the reviewer for highlighting this important issue. We agree that meteorological variability can substantially influence O_3 formation and that comparing the early and late periods without considering changes in meteorological conditions may confound the interpretation of long-term O_3 evolution.

In the revised analysis, we will therefore evaluate changes in key meteorological variables that are directly relevant to O_3 formation and dispersion, including temperature, solar radiation, wind speed and boundary-layer conditions. These variables will be analyzed over the same early (2015–2017) and late (2023–2025) periods used for the pollutant analysis.

We will examine whether the spatial distribution of O_3 changes and the four city-level divergence types is systematically associated with changes in these meteorological conditions. This additional analysis will help distinguish pollutant-reduction-related divergence from differences that may be partly explained by meteorological trends.

We will also revise the Discussion to clarify that the observed long-term O_3 changes reflect the combined influence of precursor changes, aerosol effects, meteorology and photochemical conditions, and that the present observational framework cannot uniquely isolate individual causal contributions.

Comment 3:

The abstract and conclusions of the manuscript emphasize that O3 increased in 76.1% of cities over the ten-year period when using the Sen's slope method to calculate national trends. However, one of the main findings of the national trends analysis in Section 3.1 is that only 19.9% of cities had statistically significant trends in O3 over the ten-year period. These two statistics are at odds — did the majority of cities have an increasing trend or no significant trend in O3 from 2015–2025?

Response:

We appreciate the reviewer for pointing out this ambiguity. The two percentages describe different aspects of the trend analysis and are not contradictory, but we agree that the current wording does not make this distinction sufficiently clear.

The value of 76.1% represents the proportion of cities with a positive Sen's slope for O_3, irrespective of whether the trend was statistically significant. In contrast, 19.9% represents the proportion of cities in which the O_3 trend was statistically significant according to the Mann–Kendall test at $p < 0.05$.

Thus, most cities exhibited a positive direction of O_3 change, but only a smaller subset showed a statistically significant monotonic increase over the 11-year period. We agree that phrases such as "positive trends were observed in 76.1% of cities" can be misinterpreted as implying statistical significance.

We will therefore revise the Abstract, Results and Conclusions to distinguish clearly between trend direction and trend significance. For example, the revised wording will state:

"Positive Sen's slopes for O_3 were observed in 76.1% of cities, whereas statistically significant O_3 trends were detected in only 19.9% of cities."

This clarification will be applied consistently throughout the manuscript.

Closing response:

We thank the reviewer for these constructive suggestions. We agree that the original manuscript did not sufficiently constrain the roles of precursor evolution and meteorological variability in explaining the observed city-level O_3 divergence. The revised manuscript will therefore strengthen the analysis with additional observational constraints, clarify the interpretation of the four city types, and substantially moderate mechanistic statements that cannot be directly supported by the available observations.