Response to Anonymous Reviewers #1

General comment:

This manuscript analyzes the trends of six pollutants (PM2.5, PM10, CO, NO2, SO2 and O3) at the station scale across China and explores the seasonal-scale relationships between ozone and the other five pollutants. Overall, most of the conclusions presented are already well-established in the existing literature, and the novelty of this study is quite limited. Regrettably, I was unable to identify the most important novel contribution or key new insight that this work aims to deliver. I propose that this version does not meet the high-quality standards expected by Atmospheric Chemistry and Physics.

Response:

We thank the reviewer for this critical assessment. We agree that the national-scale decline in $PM_{2.5}$, PM_{10}, SO_2, NO_2 and CO and the contrasting increase in O_3 are, by themselves, well-established features of recent air-quality evolution in China. Our intention was not to present these national trends as the principal novelty of the study. Rather, the central contribution is the identification of substantial city-level divergence in O_3 responses under comparable reductions in conventional pollutants.

In particular, our analysis shows that cities with almost identical reductions in the five conventional pollutants can exhibit sharply contrasting O_3 responses. For example, Type I and Type II cities have nearly identical median five-pollutant reduction indices (42.4% and 42.7%, respectively), whereas their median O_3 changes differ substantially (−2.4% versus +14.3%). We agree that this central result was not sufficiently emphasized or developed in the original manuscript, which made the study appear primarily as another description of national pollutant trends.

We will therefore substantially revise the framing of the manuscript so that the national and regional trends provide the context for the main scientific question: why do cities experiencing comparable improvements in conventional pollutants exhibit markedly different O_3 responses? We will also strengthen the analysis of the spatial and environmental characteristics associated with these divergent city-level responses and make clearer which findings represent new results of this study and which confirm previously reported national trends.

Comment 1:

The manuscript demonstrates limited innovation across data, methodology, and conclusions. I believe that merely investigating the trends and superficial relationships among six parameters is unlikely to yield significant scientific novelty, particularly given the extensive body of related research already published.

Response:

We agree that trend and correlation analyses alone would provide limited scientific advancement given the extensive literature on air-quality changes in China. In the revised manuscript, these analyses will therefore no longer be presented as the principal contribution of the study. Instead, they will serve as the observational basis for the city-level divergence analysis.

We will strengthen the manuscript around the finding that the magnitude of conventional pollutant reduction alone explains only a limited fraction of the spatial variability in O_3 response. The weak relationship between the five-pollutant reduction index (R5) and O_3 change (Spearman's $\rho = 0.197$) and, particularly, the contrasting O_3 responses among cities with nearly identical R5 values indicate that improvements in conventional air pollutants do not translate uniformly into O_3 improvement at the city level. We will revise the Introduction, Results and Discussion, and Conclusions to make this divergence, rather than the already established national trends, the central scientific question of the study.

Comment 2:

If the authors intend to explore underlying mechanisms, I strongly recommend incorporating regional modeling approaches into the analysis. Without such tools, the interpretations remain largely speculative and lack persuasive power.

Response:

We appreciate this important point and agree that the observational dataset used in the current manuscript cannot by itself provide a definitive attribution of the chemical mechanisms responsible for the observed O_3 changes. A comprehensive regional chemical transport modeling experiment would indeed provide a powerful framework for quantitative source and process attribution. However, such modeling would constitute a substantially different study and is beyond the scope of the present observational analysis.

Rather than making mechanistic claims unsupported by the available data, we will revise the manuscript in two ways. First, we will substantially moderate statements attributing O_3 changes to specific chemical mechanisms and explicitly distinguish observational associations from causal attribution. Second, we will strengthen the observational constraints by examining additional information on precursor-related and meteorological conditions, including satellite-based formaldehyde and NO_2 indicators and meteorological/radiative variables. These additional analyses will be used to evaluate whether the identified city-level O_3 divergence is systematically associated with changes in precursor conditions and meteorological environment.

We will therefore interpret the resulting evidence as observational support for potential mechanisms rather than as a substitute for chemical transport modeling. The limitations of mechanism attribution without regional chemical modeling will also be explicitly stated.

Comment 3:

For instance: The classification of ozone–other species relationships into four categories lacks explanation of what these categories represent and what physical or chemical driving mechanisms underlie them.

Response:

We thank the reviewer for identifying this ambiguity. We would like to clarify that the four categories were not intended to represent four O_3 chemical regimes or four types of ozone–species relationships. They are an empirical classification of city-level divergence between conventional pollutant reduction and O_3 response. The classification is based on two independent dimensions: the mean relative reduction in five conventional pollutants (R5) and the relative change in O_3 between the early and late study periods.

Accordingly, the four types represent: (I) strong conventional pollutant reduction with a weak O_3 response; (II) strong conventional pollutant reduction with a strong O_3 increase; (III) weaker conventional pollutant reduction with a strong O_3 increase; and (IV) weaker conventional pollutant reduction with a weak O_3 response. Their purpose is therefore to identify different empirical trajectories of air-quality evolution rather than to diagnose NO_x-limited, VOC-limited, or other chemical regimes.

We agree that this distinction was insufficiently clear in the original manuscript. We will revise the Methods and Discussion accordingly and avoid assigning specific chemical regimes to these categories without direct evidence. We will also investigate whether the four divergence types differ systematically in precursor-related proxies and meteorological/radiative conditions. This additional analysis will provide a more physically informed interpretation of the observed divergence while preserving the empirical nature of the classification.

Comment 4:

And the finding that urban-scale changes are most pronounced in the Fenwei Plain is not accompanied by an explanation of the core causes behind this pattern.

Response:

We agree that the original discussion of the Fenwei Plain was insufficient to establish the underlying causes of its pronounced O_3 response. The current manuscript shows that the Fenwei Plain experienced the largest regional O_3 increase (+14.3%) while simultaneously undergoing particularly strong reductions in several conventional pollutants, including SO_2 (−80.5%) and $PM_{2.5}$ (−37.4%). However, these concurrent changes alone cannot demonstrate that aerosol reduction caused the observed O_3 increase.

We will therefore revise this interpretation to avoid causal attribution based solely on pollutant trends. We will further examine whether the Fenwei Plain differs from other regions in changes in precursor-related indicators and meteorological/radiative conditions. This will allow us to assess whether its pronounced O_3 response is associated with a combination of changes in precursor conditions, aerosol loading, radiation and meteorology rather than attributing the pattern to a single mechanism.

Accordingly, the revised discussion will distinguish clearly between the observed result the particularly strong O_3 divergence in the Fenwei Plain and possible mechanisms that are consistent with, but not uniquely demonstrated by, the observational evidence.