Review Report on the Manuscript Entitled "Optimising ozone control strategies for Chinese megacity clusters under the influence of stratospheric intrusion" submitted by Zhao et al.

General Comments

In this manuscript, the authors present an interesting study on an important topic by evaluating the influence of stratospheric intrusion (SI) on tropospheric ozone (O₃) pollution in China, particularly within megacity clusters such as the Beijing-Tianjin-Hebei (BTH), Yangtze River Delta (YRD), and Pearl River Delta (PRD). The study provides valuable insights into the seasonal and spatial variations in SI contributions and discusses their implications for ozone control strategies.

While the manuscript is methodologically sound, there are several areas that require further improvement. The alignment between the abstract, results, discussion, and conclusions could be strengthened to ensure their consistency in messaging. Some methodological details, such as the data sources, criteria for SI identification, and emission reduction scenarios, require further elaboration. Additionally, the clarity of figures, captions, and data citations can be improved to enhance the manuscript's overall readability and scientific rigor. Therefore, a **major revision** is recommended to address the comments outlined below.

Major Comments

- 1. The abstract states that SI contributions peak in spring and are minimal in summer. However, the results in Lines 179–181 and 265–267 indicate seasonal variations that are not entirely consistent with this claim. For example, while O₃ enhancement is noted in spring, peak O₃ concentrations at higher latitudes occur in June. The authors should reconcile these discrepancies and clarify the findings in both the abstract and results to ensure alignment.
- The manuscript references WACCM outputs in Line 116 and WRF/Chem simulations in Line 134 to assess SI contributions. However, it is unclear which model outputs were used specifically to attribute SI contributions to surface O₃ levels and exceedance events. This critical methodological aspect needs to be explicitly detailed.
- 3. Lines 186–188 mention three criteria for defining SI occurrences, but it remains unclear how these criteria were operationalized, what specific data were used (e.g., hourly ERA5 data), and the intervals of the data files. Further elaboration on the methods for identifying SI events, particularly for Table 1, would enhance reproducibility and clarity.
- 4. Section 2 mentions 39 emission reduction scenarios involving AVOCs and NOx reductions. The manuscript lacks a detailed description of how these scenarios were designed, their specific purposes, and how they were implemented. A more comprehensive explanation would improve the manuscript's methodological rigor.
- 5. Evaluations of WACCM and WRF/Chem simulations are scattered across the Methods and Results sections. Consolidating this information and clearly presenting the evaluation metrics and findings in the Results section would improve the paper's structure and readability.
- 6. Lines 360–363 suggest that policymakers in BTH and PRD should prioritize specific industrial emissions reductions when SI contributions exceed local control capacity.

However, the text elsewhere states that SI impacts on surface O₃ in PRD are negligible. These statements appear contradictory and should be clarified.

- The conclusion discusses the impact of climate change on SI and O₃ mitigation policies, but this topic is not introduced earlier in the manuscript. Including a brief discussion of climate change in the Introduction and Methods sections would provide context for its mention in the conclusion.
- 8. Figure 4: Please add regression lines to demonstrate the increasing trend of SI contributions over time. If necessary, include supplementary figures
- 9. Figure 5: Please improve figure quality and clarify the legends for better readability.
- 10. Table 1: Please provide a more detailed caption explaining how SI events were identified and what datasets were used.

Specific Comments

- 1. Ensure that all abbreviations (e.g., BTH, PRD, YRD, VOC, SI) are defined upon their first use in the manuscript and conform to JGR formatting requirements. For instance, WACCM should be defined in Line 94, not Line 129.
- 2. Website Link (Line 61): Verify and correct the provided link, as it currently appears invalid.
- 3. AIRS Satellite Data (Line 141): Specify the time frequency of the AIRS satellite retrievals for O₃ vertical profiles.
- Threshold for O₃ Exceedance (Lines 235–236): Review the threshold values (e.g., 100 μg/m³ or 50 ppb) used to define O₃ exceedance events. These thresholds may not align with standard definitions.
- 5. Add the following references after "typhoon" in Line 226:
 (a) <u>https://doi.org/10.1029/2004JD004914</u>
 (b) <u>https://doi.org/10.1029/2005JD007012</u>
- 6. For Figure S2, clarify the observational data used to verify WRF/Chem simulations and the time period analyzed.
- 7. Present Panel (a) of Figure S3 earlier, as its content is mentioned earlier in the text.
- 8. Figure 4 Caption (Lines 288–290): Correct the color descriptions in the caption to match the actual colors used in the figure.