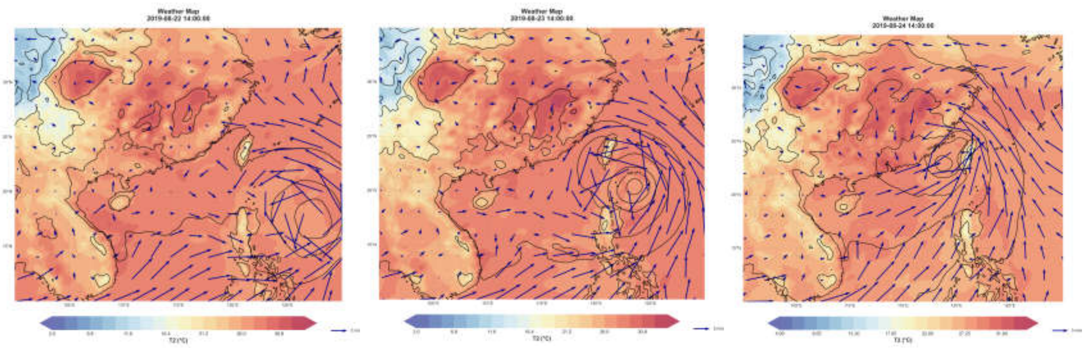
Reviewer #2 This study examines the three-dimensional transport characteristics of ozone (O3) pollution in the Greater Bay Area (GBA) under the influence of tropical cyclones (TCs). The integration of wind profiler radar observations, surface measurements, and model analysis is a key strength, offering valuable insights into how TC-induced circulation modulates both horizontal and vertical O3 transport. The impacts of TCs on O3 pollution exhibit a systematic variation with distance from the GBA: horizontal advection dominates at distant locations (1800–2000 km), enhanced subsidence and downward transport become significant at intermediate distances (1000–1700 km), and strong vertical wind shear drives boundary-layer mixing and coastal O3 enhancement when TCs move within 800 km of the region. The manuscript is generally well-organized, and the identification of three transport phases provides an important understanding of the dynamic processes influencing O3 variability during TC events. However, I have several suggestions to improve the study.

Response: We greatly appreciate the time you devoted to providing us with valuable feedback that has considerably enhanced the quality of our manuscript. Following your remarks and recommendations, we have revised our manuscript and prepared a detailed list of responses, as provided below.

Major comments:

(1) How did the authors isolate the impact of tropical cyclones on O3 pollution from other synoptic-scale weather systems?

Response: Thank you for your suggestion. As shown in the weather map below, the Greater Bay Area was predominantly influenced by the typhoon system during the study period, with no other weather systems exerting significant effects. This aligns with existing literature, which demonstrates that typhoon-induced dynamical processes typically dominate over other factors during such events (Huang et al., 2021). Therefore, we conclude that the typhoon system played the dominant role throughout the period examined in this study.



(2) What datasets were used to validate the WRF-Chem model outputs, and how was the evaluation conducted?

<u>Response:</u> Thank you for your suggestion. To evaluate the accuracy of the meteorological field simulation, we compared the innermost nested results of the simulation with observational data from domestic surface weather stations by interpolating the simulated data to the station locations. The accuracy of the ozone simulation was assessed using ozone monitoring data obtained from the National Environmental Monitoring Center's National Urban Air Quality Platform and the Hong Kong Environmental Protection Department's Environmental Protection Interactive Center. The manuscript has been revised to clarify this information (263 – 266):

This was achieved by comparing the simulated meteorological fields with observational data from domestic surface weather stations, and by evaluating the ozone simulation results against monitoring data from the National Environmental Monitoring Center's National Urban Air Quality Platform and the Hong Kong Environmental Protection Department's Environmental Protection Interactive Center.

(3) Why was the role of VOCs in O3 formation and pollution during TC events not analyzed in the study?

<u>Response:</u> Thank you for raising this important point regarding the role of photochemical processes in ozone formation. We fully acknowledge that ozone generation fundamentally relies on photochemical reactions involving local emissions

of volatile organic compounds (VOCs) and nitrogen oxides (NO_x), particularly in the middle and upper boundary layer. Furthermore, near the surface, ozone is affected by dry deposition and may be titrated by NO during nighttime or under VOC-limited regimes, highlighting the complexity of its chemical lifecycle.

However, this study focuses specifically on a period dominated by the influence of a tropical cyclone (TC). During such synoptic events, meteorological forcing from the TC often surpasses local photochemical processes and becomes the primary driver of rapid and pronounced changes in ozone concentration and distribution — both horizontally and vertically. While the chemical foundation is essential and has been extensively studied in the existing literature, the objective of this paper is to isolate and examine the dynamic and transport mechanisms under such exceptional meteorological conditions, which remain relatively less explored.

Thus, we deliberately centered our analysis on dynamical processes to elucidate how TC-induced circulation reshapes ozone distribution. This focus does not imply that chemical processes are unimportant; rather, it aims to highlight the dominant role of synoptic-scale dynamics in driving short-term ozone variability in the present case. We believe this approach helps clarify the distinctive nature of our case study — namely, how a TC can primarily modulate ozone variations through physical transport during its passage. The manuscript has been revised accordingly (Lines 666 - 668):

In addition, studies have demonstrated that chemical processes also play a significant role in variations in ozone concentration. These include biogenic volatile organic compounds (BVOCs) that serve as precursors for ozone formation, elevated temperatures, enhanced solar radiation, and increased relative humidity in the peripheral regions of typhoons, creating favorable conditions for ozone production. Furthermore, the interaction between anthropogenic and biogenic sources can accelerate ozone formation (Wang et al., 2022). Although these processes have been systematically examined in the existing literature, the present study focuses primarily on the dynamic processes of ozone transport during typhoon events. We intend to further explore the underlying mechanisms in subsequent research.

(4) What are the spatial resolutions of all datasets used in the research?

<u>Response:</u> Thank you for your suggestion. The datasets used in this study include the FNL data at a 1°×1° resolution, the MEIC inventory data at 0.25°×0.25°, and the MEGAN biogenic emission data at 0.5°×0.5°. Due to the uneven spatial distribution of other observational data, a specific resolution cannot be provided for them. The relevant descriptions in the manuscript have been revised to present this information more clearly (Lines 257 - 258):

Biogenic VOCs emissions **at a 0.5°×0.5° spatial resolution** are sourced from the Megan emission inventory.

Minor comments:

(5) Page 4, Lines 110 – 112: The detection heights of the wind profiler radar differ across the three stations. Could this difference affect the vertical profile data?

<u>Response:</u> Thank you for your question. The wording in the original text was not precise; it should have stated that while the radar detection systems have varying blind zones, their overall detection ranges are sufficient to cover both the boundary layer and the layers above it. This does not affect the conclusions drawn in the manuscript. The relevant text has been revised accordingly (Lines 137 - 138):

The **blind zones** of the wind profiler radar is 100 meters in HD and GZ, while it is 300 meters in HK.

(6) Page 4, Line 119: The temporal resolution of the best-track TC dataset is 6 hours. Could you clarify how this dataset is matched with the 1-hour resolution data used in the study?

<u>Response:</u> Thank you for your suggestion. We have provided a correspondence table between time and distance in Table 1. In cases where a direct correspondence was not available in the text, linear interpolation was applied to calculate the distance.

(7) Page 4, Line 120: Please provide references defining "TC days."

<u>Response:</u> Thank you for your suggestion. The relevant literature citations have been added to the manuscript (Lines 151 - 152):

In this study, the TC days were defined as when the TC track enters the region defined by 10°N-30°N latitude and 100°E-130°E longitude **(Zhang et al., 2024)**.

(8) Page 5, Line 131: Please provide a reference for the national standard of "MDA8", e.g., doi: 10.1016/j.rse.2021.112775

Response: Thank you for your suggestion. The relevant citation has been added to the text (Lines 164 – 166):

According to the national standard in China, the maximum daily 8-hour averag e O3 concentration (MDA8) should not exceed 160 μg/m³ **(https://www.mee.go v.cn/ywgz/fgbz/bz/bzwb/dqhjbh/dqhjzlbz/201203/t20120302_224165.shtml).**

(9) Page 5, Line 132: Please provide references that define "O3 pollution" in the GBA.

Response: Thank you for your suggestion. This definition was formulated by analogy with the criteria for heatwaves adopted in several previous studies. The relevant description in the text has been revised to clarify the source of the definition (Lines 168 – 171).

The criterion for O_3 pollution in the GBA is defined as occurring when more than one-third of the selected stations record concentrations exceeding th e threshold, **drawing on an analogous approach used in previous studies to define regional heatwave events in this area (Zhang et al., 2024).**

(10) Table 2: Please include the calculation methods for the statistical metrics, such as MB, FE, and FB.

Response: Thank you for your suggestion. The formulas corresponding to these parameters have been added (Lines 275 – 282):

The calculation formula for the parameters is as follows:

$$\mathrm{RMSE} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(F_i - O_i)^2}, (3)$$

$$\mathrm{MB} = \frac{1}{N}\sum_{i=1}^{N}(F_i - O_i)^2, (4)$$

$$\text{FB} = \frac{\overline{F} - \overline{O}}{0.5 \times (\overline{F} + \overline{O})}, (5)$$

$$\text{FE} = \frac{\sum_{i=1}^{N} (F_i - \overline{F})^2}{\sum_{i=1}^{N} (O_i - \overline{O})^2} - 1, (6)$$

$$\text{IOA} = 1 - \frac{\frac{1}{N}\sum_{i=1}^{N} (F_i - O_i)^2}{\frac{1}{N}\sum_{i=1}^{N} (|F_i - \overline{O}| + |O_i - \overline{O}|)^2}, (7)$$

Note: F: Simulated value; $\overline{F}$: Mean of simulated values; O: Observed value; $\overline{O}$: Mean of observed values; N: Sample size.

(11) Page 8, Line 201: Please clarify the standard used to define "O3 pollution day" and cite related references, for example: doi:10.1016/j.rse.2024.114482

Response: Thank you for your suggestion. Based on the MDA8 standard explained above, we define days exceeding this threshold as ozone pollution days.

(12) Page 9, Lines 220–221: Please provide possible explanations for the observed results.

Response: Thank you for your suggestion. Higher latitude regions generally provide photochemical environments that are more conducive to ozone formation, especially during summer, while complex topography in these areas further facilitates ozone accumulation. We have added relevant explanations in the revised manuscript (Lines 312 – 315):

Cities located at higher latitudes, often with mountainous landscapes, ge nerally exhibited higher O_3 concentrations, a pattern that may be attributed to photochemical environments more conducive to ozone formation as well as terr ain features favoring ozone accumulation. In contrast, lower-latitude cities tende d to have lower ozone levels.

(13) Figure 3: Some regions in the figure appear to lack data. Please clarify.

Response: Thank you for your comment. This discrepancy arises from gaps in the ground-based ozone observations, which do not affect the validity of the conclusions drawn in our study.

(14) Page 13, Line 239: It appears that subfigure (d) is missing from the figure.

Response: Thank you for your suggestion. This reference should correspond to Figure 2b, and the correction has been made in the manuscript.

(15) Figure 10: The units of O3 in the text are μg/m3, but they are given in ppmv here.

Please maintain consistency in the units.

Response: Thank you for your suggestion. The figure has been redrawn after unit conversion to ensure consistency.

(16) Figure 12: Why do the VWS grids differ in size among the three station regions?

Please clarify this discrepancy.

Response: Thank you for your question. This discrepancy arises from variations in the observational data resolution among different wind profile radars, which results in the differences in resolution shown in the figure.