Referee Comment

Title: Ozone–NO_x–VOC Sensitivity of the Lake Michigan Region Inferred from TROPOMI Observations and Ground-Based Measurements

General comments

Acdan et al. use TROPOMI column density retrievals and PAMS surface concentration measurements of HCHO and NO_2 to study HCHO, NO_2, and ozone production sensitivities (indicated by FNRs) in the lake Michigan region. The authors carefully composite for typical ozone season days, ozone exceedance days, weekdays, and weekends. They identify a spatial heterogeneity in ozone chemistry sensitivity for Chicago metropolitan area and its surrounding region, where the metropolitan area remains VOC-sensitive. They find that changes in FNRs on ozone exceedance days indicate an increase in NOx-sensitivity in NOx-sensitive areas and an increase in VOC-sensitivity in VOC-sensitive areas. Connecting wind fields with lake breeze provides a nice illustration of a stronger lake breeze effect on higher-ozone days.

Overall, the paper provides important implications for ozone mitigation in the Lake Michigan Region. However, a few major issues should be addressed before I recommend publication.

(1) The uncertainties in using OMI threshold values to interpret TROPOMI FNRs are briefly mentioned. However, despite similar signal-to-noise ratios, TROPOMI still shows disagreement with OMI, and it would be good to see some discussion on how this difference, along with TROPOMI bias, may affect the study results.

(2) The unresolved biases and noises in FNR would be amplified as opposed to using HCHO and NO_2 columns individually. The equation for uncertainty propagation was not properly implemented for division in Appendix B. For division ($z = \frac{x}{y}$): $\delta_z = \sqrt{\left(\frac{\delta_{[x]}}{[x]}\right)^2 + \left(\frac{\delta_{[y]}}{[y]}\right)^2}\,|z|$. More discussion on retrieval errors can be found in Souri et al. 2022 (https://acp.copernicus.org/preprints/acp-2022-410/).

(3) For weekday/weekend analysis, there seem to be many more days selected for weekdays (327 days) than weekends (132 days). Would the result be impacted by averaging over more days? It may be necessary to test if the same number of days were selected.

(4) It would be interesting to see how different regions are similar/different in changes on higher-ozone days. Is there any broader implication of this study on similar urban environments? For example, Tao et al. 2022 (https://pubs.acs.org/doi/full/10.1021/acs.est.2c02972) compare TROPOMI HCHO, NO_2, and FNRs on ozone exceedance days versus non-exceedance days and weekdays versus weekends, for summer 2018 over New York City.

Specific comments

P3. Line 89. The definition of "typical O_3 season days" and "exceedance days" could be moved from P3. Line 104 to here (or briefly mentioned), as they appear for the first time.

P4. Line 116-122. It is controversial to conclude that the errors affecting HCHO and NO_2 retrievals can be canceled out rather than amplified by using their ratio. Please see more in the general comments.

P7. Section 2.2. What are the uncertainties in the PAMS surface measurements?

P9. Line 233-235. This sentence on diurnal cycles seems confusing. Not sure how having diurnal information would make a difference in the current observations. What time of the day were the 6-day interval HCHO measurements collected? Or is it daily mean?

P12. Line 309-311. May examine the mean temperatures for each composite and verify whether the higher-ozone days co-occur with hotter temperatures.

Technical comments

P2. Line 36. Could say "exceed the NAAQS" as O_3 is mentioned three times in this sentence.

P6. Line 164. 15 individual monthly composites?

P6. Line 166. "Next, we ~~next~~ created"