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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Ozone distributions over southern Lake Michigan: comparisons between ferry-based observations, shoreline-based DOAS observations and air quality forecast models" *by* P. A. Cleary et al.

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Response to Reviewer 1 Comments: We thank the reviewer for the thoughtful comments to this manuscript. Because of the common concern brought up by both reviewers on the methodology we used for the model comparison, we revised the manuscript and analysis methods to conduct the model comparison using CMAQ model output grid values directly. This analysis will hopefully lay the referees' concerns to rest, although it has not changed the conclusions from our analysis. Responses to the reviewer ques-

tions are below, with the caveat that the model comparison section has been revised along with the figures in that section, to best reflect the changes in analysis.

1. We have added a statistical analysis (Kruskal-Wallis test, for non-parametric distributions) to the paper for figures 5, 6 and 7 to describe the significance in the differences in box plots given in the figures. The text has been modified to reflect these tests (p 14 lines 2-8 in revised manuscript). A Kruskal-Wallis test was used because we need to rank the observed distributions by median instead of by mean due to the fact that we cannot assume they are normal distributions. R-squared was also computed for agreement between model and measurement and included in the revised manuscript.

2. Statistical Comparisons are described above (using a Kruskal-Wallis test). The accuracy of the DOAS instrument was included on p6 line 24. The accuracy of the ozone monitor on the ferry was included in the methods section of the paper. The method for extracting the CMAQ output was changed but an estimate of the uncertainties in selecting a model grid point associated with the ferry position is in the revised manuscript. Quantification of the correlation in terms of R-squared was given in the text and in Figure 13. Added language to describe uncertainties was added to discussions in the intercomparison of ferry and shoreline DOAS observations.

3. The episode given in Figure 4 was chosen because concentrations of higher max ozone mixing ratios (70 ppb) in a short time period which also shows differences in max ozone as measured at the shoreline and over the lake. This week was chosen because of the range of ozone maxima depicted (with daily maxima ranging from 40-70ppb) and the example of a wind shift event that correlated to temperature and atmospheric composition changes at the shoreline on August 14th. This figure captures a particularly strong change in conditions on August 14th that depicts a strong temperature change, wind direction change and ozone mixing ratio change at the shoreline. This has been addressed in the revised manuscript.

4. A description of the model has been added to the manuscript. We changed the

method for model comparison and used the CMAQ experimental model output directly in this revision (which was obtained by the help of individuals we are including as co-authors in the revised manuscript). We are also including evaluation of the model meta-data at Kenosha, and forecast ozone with other air quality monitoring stations in the area.

Specific comments:

23209: Yes. The text was modified to state that 30-min average data was used

23210: We have included some more references in the introduction to describe trends in the area and trends near the Great Lakes (e.g. Pugliese, et al 2014) that are relevant to this study (p 3 of revised manuscript).

P 23210: This was addressed on p12 and assigned an uncertainty 23210 we used the metadata from the CMAQ experimental model to evaluate the shoreline observations.

23210 Daily max refers to the 30 minute averaged data and not 1 hour max.

23211: Median observations of offshore ozone peak in the region of 14-17 h CDT and that trend is very similar in the ozone observations. Comparisons of day-to-day peaks can be complicated by wind shifts at the shoreline (like on August 14th of Figure 5), therefore we don't believe there to be much difference in the peak ozone time of day offshore versus onshore. This has been addressed on (p 12 of the revised manuscript).

23212: "shoreline" has been added

23212: wind direction and temperature are not correlated over the whole campaign as the variations in temperature day-to-day are higher than that between the over-water air masses and over-land air masses. A wider range in temperatures are observed from air masses arriving at the shoreline site from land, and a smaller range in temperatures are observed from air masses arriving from offshore. Some correlations can be seen on smaller timescales (day-to-day variations). Also a higher median temperature can be observed from air masses arriving from on land than over water. This has been

addressed on p. 14 of the revised manuscript.

23212. No. Sometimes the ferry arrived in Milwaukee after midnight. A 2.5 hour trip starting at 22:00 CDT will get into port after midnight.

23214: There is a statistically significant difference in the distribution of differences (Kruskal-Wallis p=0.05) in ozone from summer (June, July, August) to fall (September, October) with median difference of 3.3ppb for summer and 1.6 ppb for all points. Instead of adding a figure this was included in the text on p. 12-13 of the revised manuscript.

23215: The section has been modified to include more details about the CMAQ model that was used.

23215: The model output has since been obtained directly and used for analysis. This has been updated in the revised manuscript.

23215 lines 22-23. No grid cells were averaged. The new figures represent the model comparison as the ferry transects each grid cell.

23216. Figures that depict daily maximum ozone have been modified. This is no longer relevant.

23216: There is no longer a discussion of 8-hour ozone in the model versus measurements.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 23201, 2014.