Atmos. Chem. Phys. Discuss., 14, C12468–C12472, 2015
www.atmos-chem-phys-discuss.net/14/C12468/2015/

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.

P. A. Cleary et al.

clearypa@uwec.edu

Received and published: 28 February 2015

We thank the reviewer for the thoughtful comments to this manuscript. Because of the common concern brought up by both referees 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 questions 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. Non-attainment of Federal Ozone Standards are still of concern. Kenosha remains in marginal non-attainment of federal ozone standards (as of 2012) and Sheboygan County, north of Milwaukee, remains in non-attainment. The proposed rule as of Nov. 26th, 2014 is to reduce the 8-hour primary standard to between 65 and 70 ppb ozone, which has the possibility of maintaining the non-attainment status for these counties in the future. These counties in non-attainment in Wisconsin are unique in that they are both suburban, Lake Michigan shoreline counties as opposed to urban or rural counties. The relationship between Chicago emissions, and meteorology of Lake Michigan in air quality in Wisconsin is being evaluated by this.

Other papers have been addressing the role of Lake Breeze in air quality near the Great Lakes of North America (Levy, Makar, Sills, Pugliese), with a whole campaign (BASQ-MET) dedicated to the evaluation of the influences of lake breezes on shoreline air quality. This paper is a first step in associating Lake Michigan ground level ozone mixing ratios off-shore with those on-shore, but a full assessment of lake breezes as they cross different land-based stations is beyond the scope and focus of this paper. We don't doubt that our experiment will be meaningful to contextualize the research being done near/over the Great Lakes, but we are not interested in generating a different analysis for assessing the presence of lake breeze at this time as it is outside the scope of this paper. We have included more language on pages 2-3 of the revised manuscript to describe how this study fits in with modern studies on the role of the Great Lakes on shoreline air quality.

2. The DOAS instrument is accurate to within 4% of calibration slope per year. For the observations made in this study, the measurements for ozone were made within 1 year of calibration. The DOAS instrument and TECO instrument were not co-located but each instrument was calibrated in 2009. The TECO instrument was calibrated against an ozone standard instrument at NOAA before and after the 2009 campaign.

ACPD

14, C12468–C12472, 2015

The DOAS instrument was evaluated with an in-beam absorption cell as outlined in the text. We assume all forecast ozone mixing ratios to be significant to ± 1 ppb, and the text has been modified to address this. We also stated that the two instruments were never intercompared on p 12 and estimated an uncertainty because of this.

3. The text of the paper has been changed to respond to the questions outlined here. The national air quality forecast model is made up of the North American Mesoscale (NAM) meteorological model and the EPA's Community Multiscale Air Quality modeling system. The NAM produces meteorological parameters which are used within the CMAQ model to simulate gas-phase chemistry. The output of the CMAQ experimental model (using the developmental model: Carbon Bond Mechanism 05) was obtained in order to minimize uncertainties in model comparison with measurement. The emissions inventory is based on the EPA's 2005 National Emissions Inventory (Pan et al 2014). The meteorology forecasts are run every 12 hours to input into the CMAQ and may not adequately capture changes in lake breeze circulation due to its smaller temporal resolution than the forecast model. The section on model comparison has been changed to reflect a comparison using the CMAQ experimental model. We intend to include 3 new authors (Stu McKeen, Jeff McQueen, and Youhua Tang) in this paper who aided in acquiring the CMAQ experimental model output in 2009 and provided additional analysis of these new model ozone forecasts.

Minor comments: 1. P23206: The text has been modified to address the reviewer's comments. The DOAS instrument is a multi-species monitor and so is a strategy to obtain multiple, relevant, measurements with one device.

2. P23204: The text has been modified to address this point. We also added points to the map in Figure 1 to depict coal-fired power plants in the map, which are sources of NOx and SO2.

3. 23210: text was modified and power plants were added to Figure 1.

4. 23210: Text has been modified.

ACPD
14, C12468–C12472, 2015

5. 23207: Text has been modified to address reviewer's comments. 6. 23211 Details were added to the manuscript to answer these questions. No filter was used for the meteorological measurements.

The ferry path in Figure 1 is the line across the lake. The path of the light for the DOAS measurement is given in the inset. This was clarified in the caption. Discussion of Figure 2 was modified to include larger mixing ratios being observed from the south.

Mixing ratios is used instead of concentration throughout the revised manuscript.

23204. A reference was added. Also, Figure 9 shows all of the data which depicts the overprediction.

23209. We added CMAQ analysis of measurements conducted at that site, so we do feel that it is relevant to the discussion.

23210: We addressed this question in the revised manuscript. The sources of NO2 are expected to also be highest during the day (mobile sources and powerplants, all primarily land-based) but the losses from photolysis and reaction with OH bring the diurnal profile of NO2 to a minimum mid-day consistently over this experiment. Based on our observations, either there is a consistent large source of NO2 offshore (which is unlikely – this would require a lot of shipping exhaust only at night offshore) or land-based sources of NO2 produce local NO2 which is lost mid-day. We note that formation of NO3 and N2O5 at night can be a considerable loss of NOx, as outlined in the paper Brown, et al., 2004, for a marine boundary layer experiment. Because we only measure NO2, we do not have a fully comprehensive constraint on all NOx but the fact that NO2 is photolyzed in the day and has losses with OH which can lead to a minimum mid-day adequately describes the diurnal observations of NO2. If losses of NO2 at night were high, we would also require a high emissions rate from off-shore at night to compensate for these high losses to describe the observations (as a function of wind direction and time of day). Because we do not expect there to be regular high emission sources of NOx at night offshore that are higher than daytime, land-based source emissions, we

ACPD

14, C12468–C12472, 2015

believe the most reasonable explanation for high NO2 at night from offshore being a reduction in losses at night. The revised manuscript has included more discussion of this issue.

Figures 11, 12 and 14 have been modified based on our new evaluation of the model.

P 23214 line 10-13. The sentence has been modified.

Figure 13 has been modified.

Reference of Makar 2010 has been added.

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