

# Ozone and air quality over Lake Michigan

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## Background

It is estimated that 7 million people die each year due to air pollution, according to the World Health Organization.<sup>1</sup> Ozone and air quality levels are measured and recorded in many cities throughout the United States, but the models of air quality over Lake Michigan are not validated by any measurements. The purpose of this study is to find out what the air quality is like over the lake and to determine how air pollutants travel in the transition environment between the coast and the lake. The transition environment referenced here is labeled as 'frontal zone' in the upper figure and is more commonly known as the lake breeze front. When the cold air over the lake moves over the warm land during the day, it rises, creating the lake front. That warm air can cycle back over the lake causing an inversion layer with warm air above cold air. An inversion layer prevents atmospheric mixing, which leads to build up of pollutants such as ozone. This could lead to a large pocket of pollutants trapped over Lake Michigan. We hope to discover the accuracy of that hypothesis.

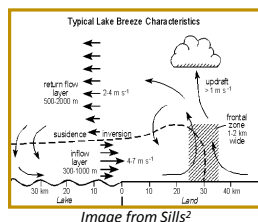


Image from Google maps

## Methods

To further understand how and where the pollutants move, we looked for a way to evaluate shoreline measurements with the Community Multi-scale Air Quality Model (CMAQ). We compared the CMAQ model to hourly ozone measurements at five shoreline sites to evaluate the model and then calculate the bias between the model and measurements.

### Ozone Bias = Observed – Predicted Ozone

Knowing the bias lets us quantify the accuracy of the model. The hourly ozone measurements were taken from the National Oceanic and Atmospheric Administration's (NOAA) website. Calculations were done using MatLab and Origin to find the average ozone mixing ratios at the shoreline sites to determine north-south gradients.

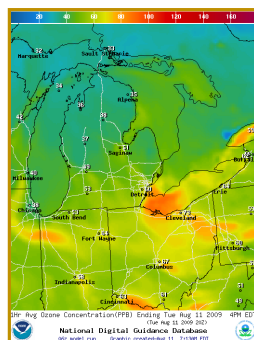


Image from www.noaa.gov

## Citations

- <sup>1</sup> www.who.int
- <sup>2</sup> www.yorku.ca
- <sup>3</sup> Cleary, P. A. et al. ACP 2015: Print

## Acknowledgements

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## Results

The figure to the right represents the ozone bias around and over Lake Michigan. The observed ozone over the lake is roughly 15ppb greater on average than what was predicted using the CMAQ model. It can be seen from the graph below that the measured ozone levels on the shoreline are repeatedly higher than the predicted ozone levels, often significantly so, with the exception of Milwaukee. Milwaukee tends to have the highest monthly average ozone levels due to its urban environment. The other counties in this study are all suburban or rural counties. Therefore, we can conclude that the model is fairly accurate in urban environments, but is inadequate when predicting ozone in suburban/rural environments and above the lake.

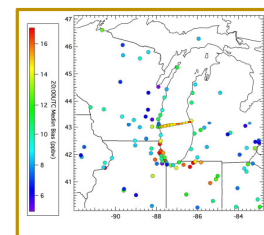
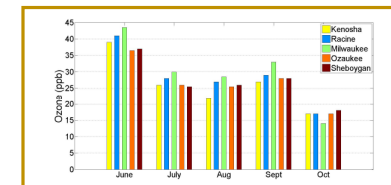
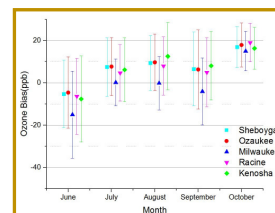


Image from Cleary et al. <sup>3</sup>



Hourly ozone measurements were taken from one site per county. Due to this, the regional distribution is not well represented. Sheboygan county and parts of Kenosha county are actually in marginal non-attainment of federal ozone standards.

## Further Study

We are currently developing an experiment to continue studying pollutants in the transition environment at the shoreline with a UAV. The UAV will allow us to discover what the atmospheric distribution of pollutants is across the lake front boundary. From these measurements, we hope to determine the role of the lake in the cycling of pollutants in the transition environment.



UAV with POM inside



Personal Ozone Monitor

A personal ozone monitor (POM) will be used in the UAV to measure ozone levels. We tested the accuracy of the POM at varying wind speed and directions by driving with its inlet collecting samples out the window of the car. The precision of the POM's sampling and GPS were determined by walking around Eau Claire while sampling. The graph on the left was constructed from the data of one of the three walks. An ozone generator was used to calibrate the POM as well as to determine its response time.

