Investigating Gradients in Ozone and Temperature with Respect to Lake Breeze Onsets During the 2017 Lake Michigan Ozone Study

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Abstract

The 2017 Lake Michigan Ozone Study (LMOS) was a collaborative, multi-agency field campaign that ran May 22, 2017, through June 22, 2017, in eastern Wisconsin and northeastern Illinois. The UW-Eau Claire mobile platform operated in between Sheboygan, WI and Grafton WI. We drove an automobile and measured ozone via Personal Ozone Monitor, temperature and relative humidity via Kestral sensor in order to investigate ozone gradients between ground monitoring stations at coastal and inland locations north of Milwaukee. The mobile platform deployed on targeted event days to coincide with other LMOS measurements on June 2, 3, 12, 13 and 17th. On June 2nd, a large lake breeze extended inland and ozone observations varied little across the study's sites; however, on June 3rd there was a shallow lake breeze that formed and large temperature and ozone gradients were observed. The mobile data will be used to discern local ozone gradients in comparison to ground-based WI-DNR and Illinois EPA sites. Investigations using ozone, wind speed and direction, and temperature data collected from WI-DNR and Illinois EPA ground stations will construct an understanding into the onset of lake breezes at different sites will also be presented.

UWEC Mobile Platform

Throughout the month-long campaign, there were 5 measurement trips conducted to the shoreline of Lake Michigan to collect data. Data were taken from sites from Grafton, WI to Sheboygan, WI with momentary stops (approx. 5 minutes) placing a 2B Technologies Personal Ozone Monitor (POM) 3 meters high along with a Kestrel Wind Meter. The POM recorded ozone in units of ppb and the Kestrel Wind Meter collected wind speed in mph. The data collected connect the stationary WI DNR Ground Monitoring Sites and the Illinois Environmental Protection Agency.

Lake Breezes

With the measurements taken from the WIDNR, Illinois EPA, and the UWEC Mobile Platform, we are able to conclude that there was a deep lake breeze on June 2nd, which was identified by large drop in temperatures, high ozone, and the abrupt change in wind direction. June 3rd did not have a lake breeze, however it did have visible ozone and temperature gradients.

Temperature Gradients

A signifier of a lake breeze onset is the decrease in temperature during the morning of the breeze day. In contrast, without a lake breeze, the temperature will increase throughout the morning, reaching its peak later in the day.

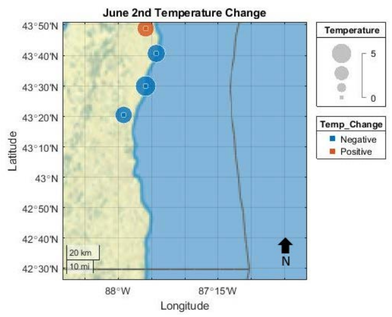

Fig. 1-Temperature Gradients on June 2nd

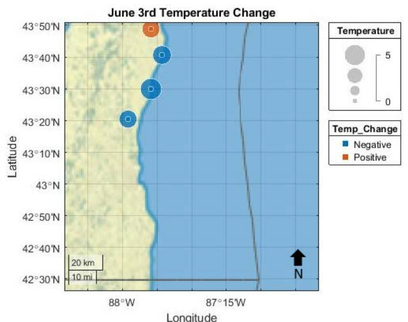

Fig. 2-Temperature Gradients on June 3rd

Ozone Gradients

On days with a lake breeze onset, ozone reaches a high consistently across the land covered by the breeze front. These highs reach above the EPA standards for ozone requirements. In contrast, days without lake breezes do not see the same amount of ozone and instead form gradients of ozone, where different shoreline and inland sites have different amounts of ozone.

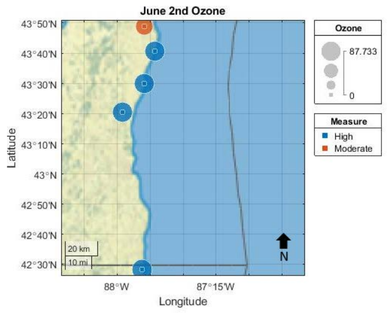

Fig. 3-Data from WIDNR and IEPA. Moderate ozone is 35-70 ppb, high ozone is >70 ppb.

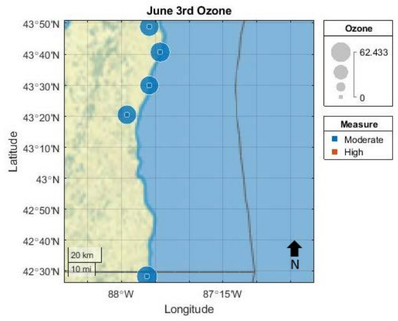

Fig. 4-Data from WIDNR and IEPA. Moderate ozone is 35-70 ppb, high ozone is >70 ppb.

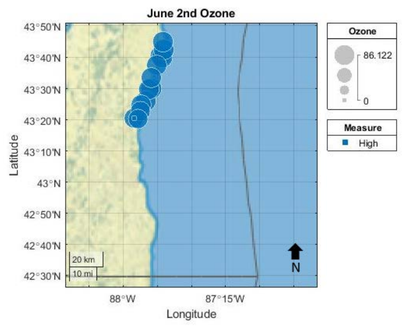

Fig. 5-Data from UWEC Mobile Platform. High ozone is >70 ppb.

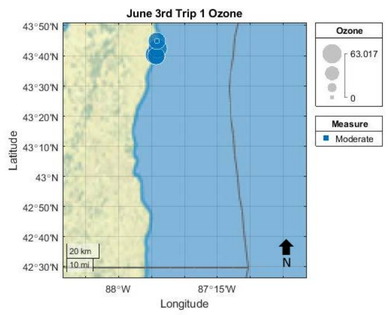

Fig. 6-Data from UWEC Mobile Platform; 1st trip of June 3rd. Moderate ozone is 35-70 ppb.

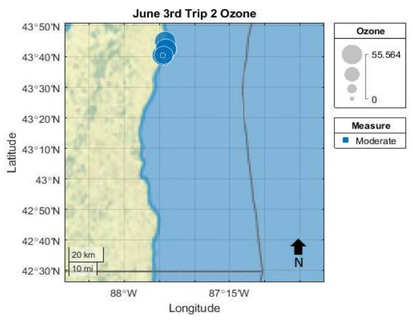

Fig. 7-Data from UWEC Mobile Platform; 2nd trip of June 3rd. Moderate ozone is 35-70 ppb.

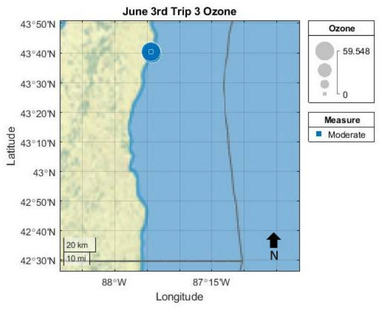

Fig. 8-Data from UWEC Mobile Platform; 3rd trip of June 3rd. Moderate ozone is 35-70 ppb.

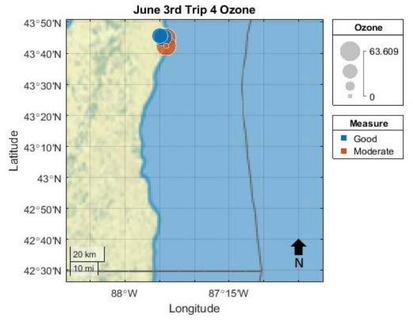

Fig. 9-Data from UWEC Mobile Platform; 4th trip of June 3rd. Good ozone is < 35 ppb, moderate ozone is 35-70 ppb.

Wind Direction

A lake breeze front shifts the prevailing winds from blowing offshore (from the land to the lake) to blowing onshore. This shift in prevailing winds marks the movement of the lake breeze front as it travels across the shoreline and further inland. For this study, onshore winds are westerly winds.

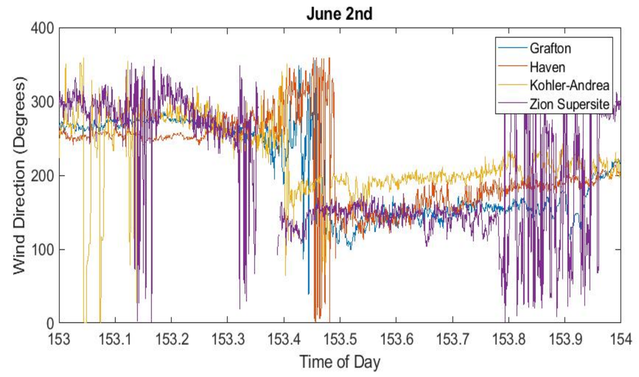

Fig. 10-Data from the WIDNR and Illinois EPA on June 2nd

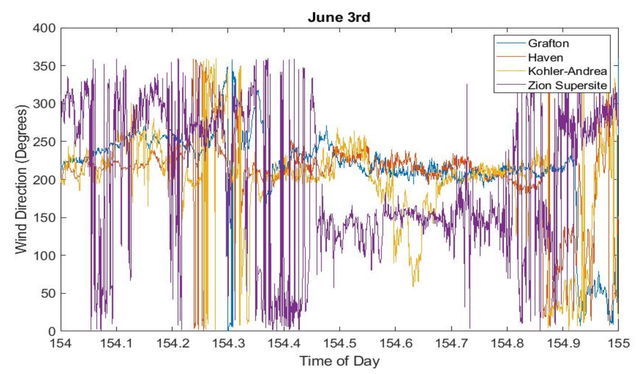

Fig. 11-Data from the WIDNR and Illinois EPA on June 3rd

Conclusions

With the measurements taken from the WIDNR, Illinois EPA, and the UWEC Mobile Platform, we are able to conclude that there was a deep lake breeze on June 2nd, which was identified by large drop in temperatures, high ozone, and the abrupt change in wind direction. June 3rd did not have a lake breeze, however it did have visible ozone and temperature gradients.

Future Research

This project will use a fixed-wing drone with sensor integration to further expand the original LMOS study. Data collection will be conducted over the summer of 2019 along the western shoreline of Lake Michigan to identify and classify further lake breezes.

Acknowledgements

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