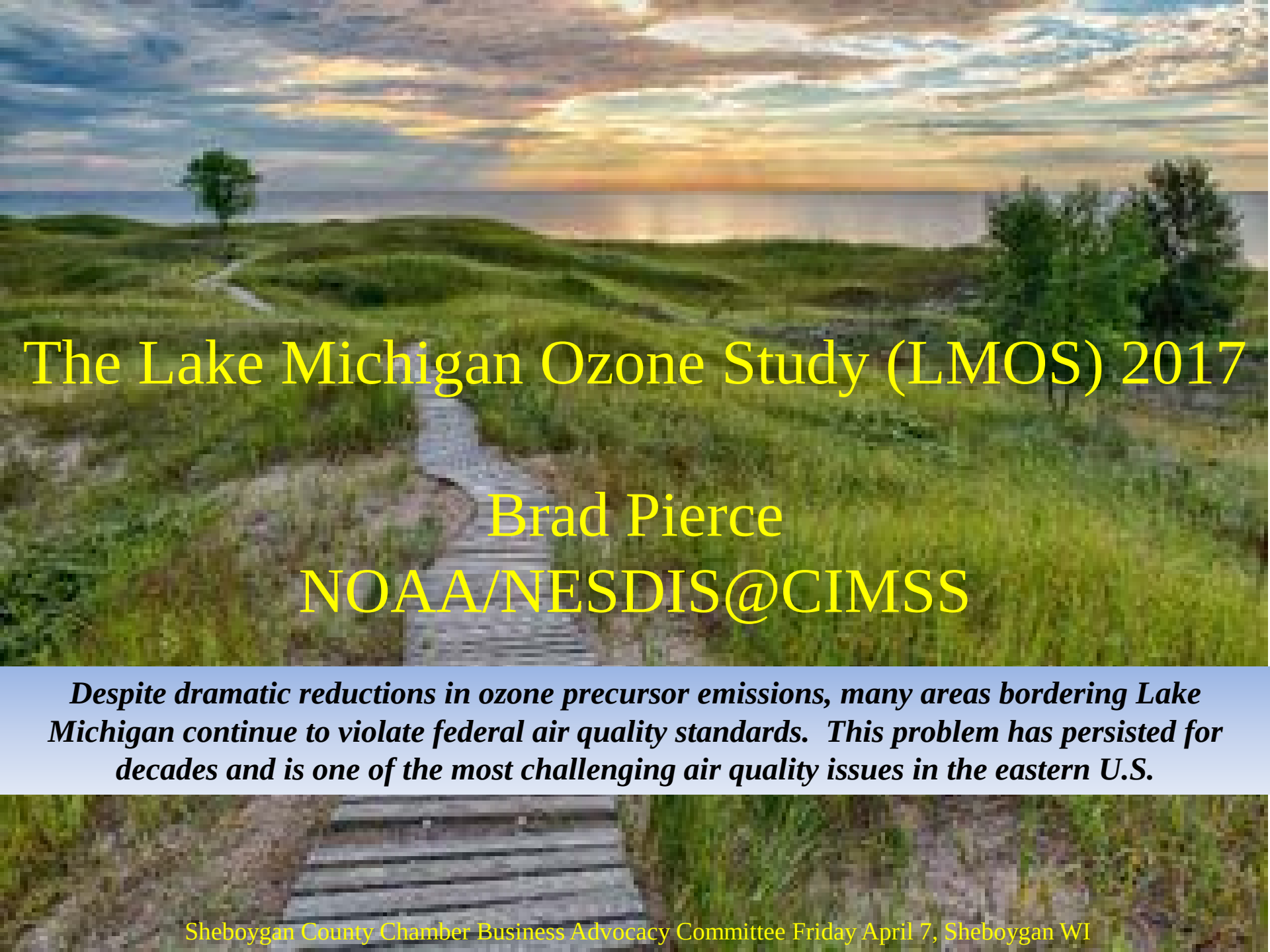
The Lake Michigan Ozone Study (LMOS) 2017

Brad Pierce
NOAA/NESDIS@CIMSS

Kohler-Andrae State Park, Sheboygan WI

Sheboygan County Chamber Business Advocacy Committee Friday April 7, Sheboygan WI



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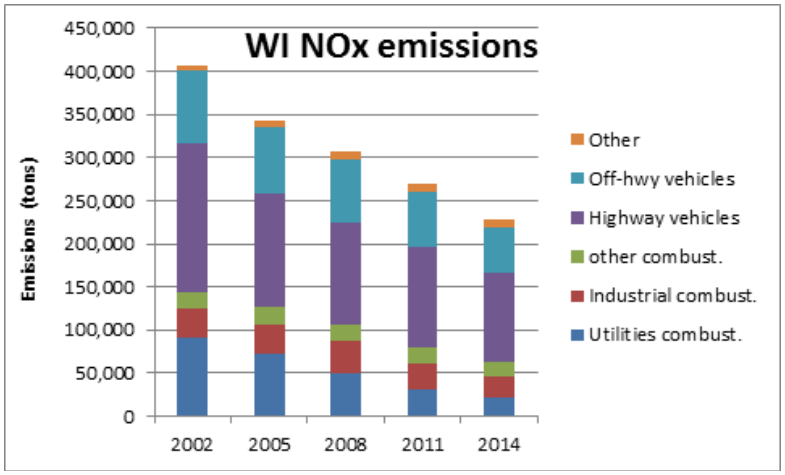
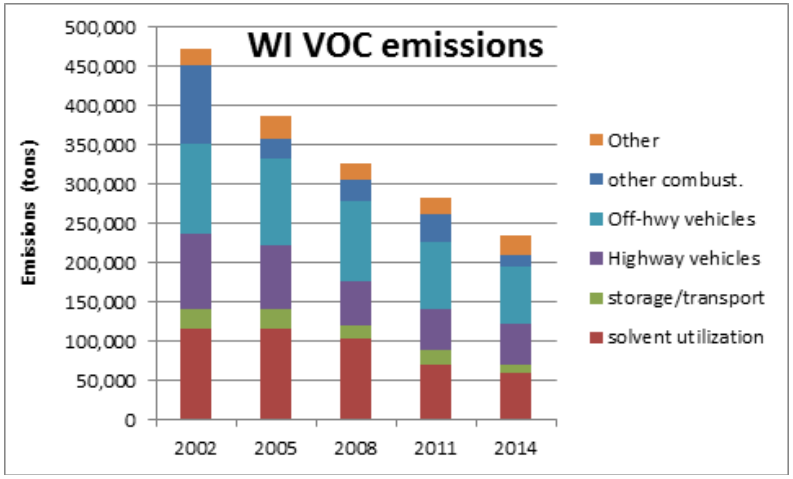
Despite dramatic reductions in ozone precursor emissions, many areas bordering Lake Michigan continue to violate federal air quality standards. This problem has persisted for decades and is one of the most challenging air quality issues in the eastern U.S.

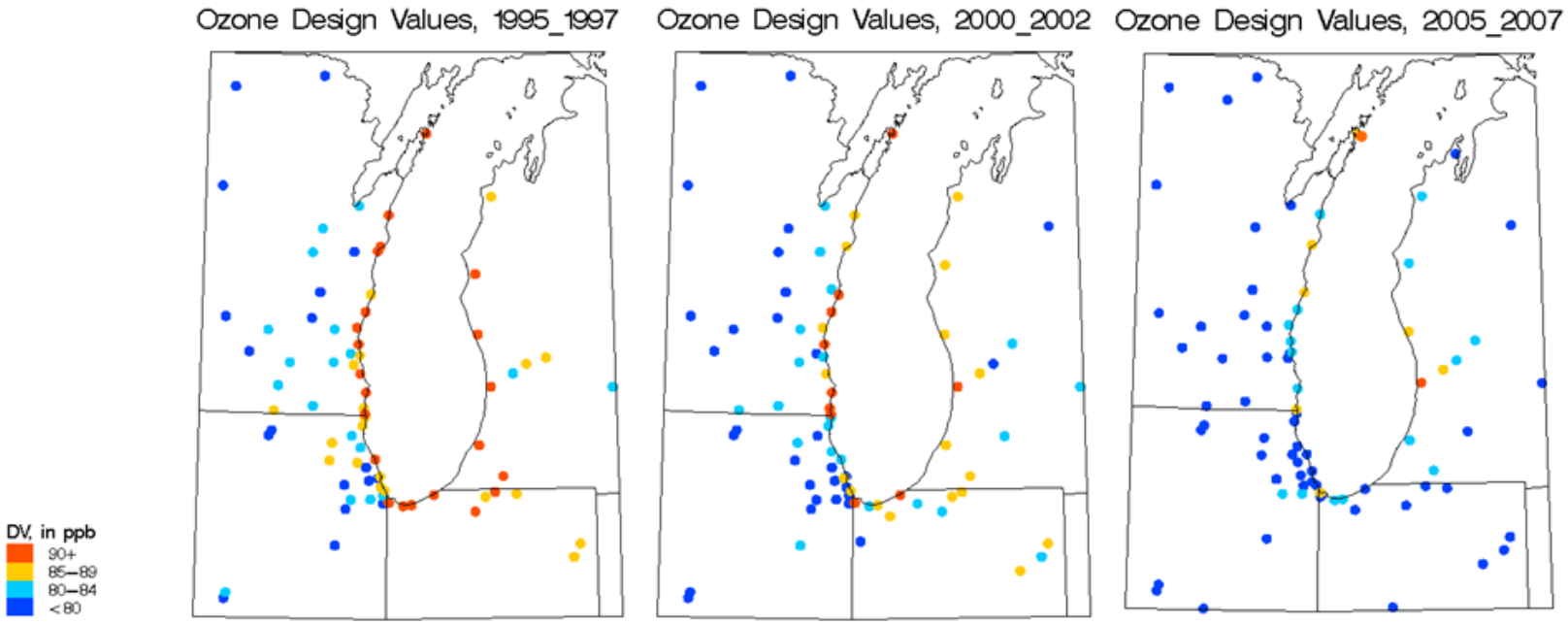
Sheboygan County Chamber Business Advocacy Committee Friday April 7, Sheboygan WI

Wisconsin emissions are declining and ozone is improving





NOx= NO+NO2 (nitrogen oxides) VOC=Volatile Organic Compounds, both are ozone precursors



But there are still coastal sites which are still above the new ozone standard (70ppbv)

- Anticipated new non-attainment areas with new, lower ozone standard and persistent exceedances of the old (2008) ozone standard.
- Impact of high ozone on public health in high density urban areas (Chicago, Milwaukee, Detroit, Windsor). Also, these areas serve as large emissions sources.

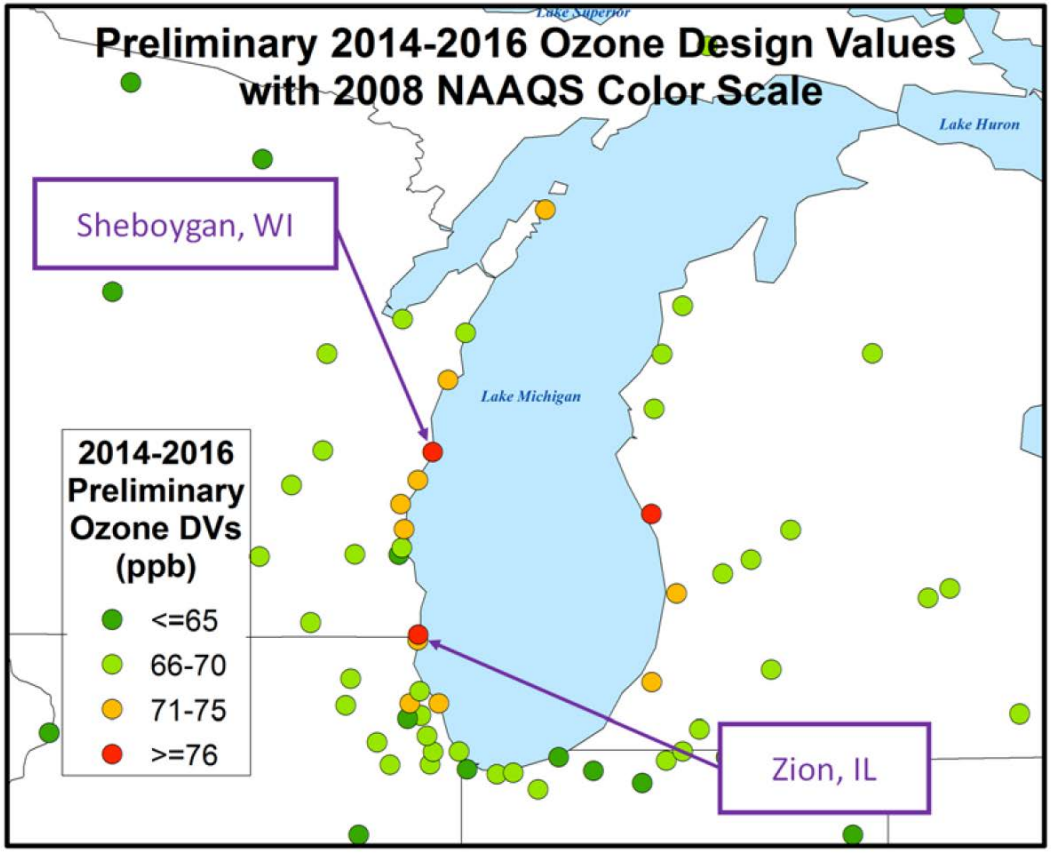
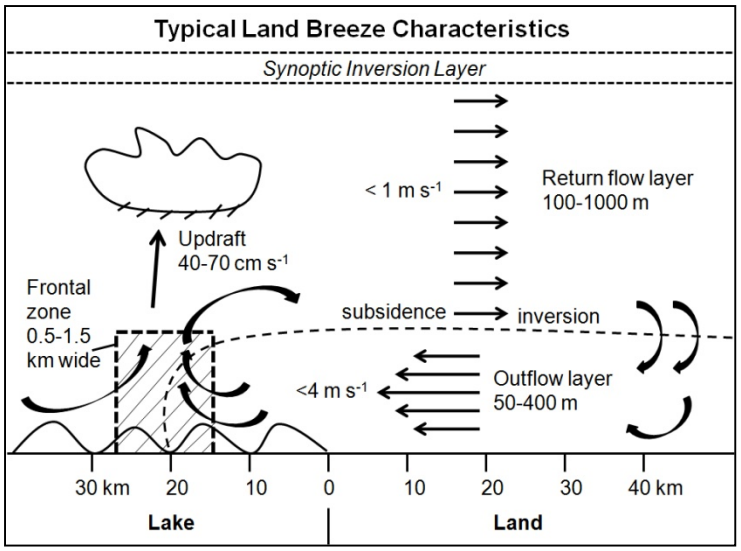


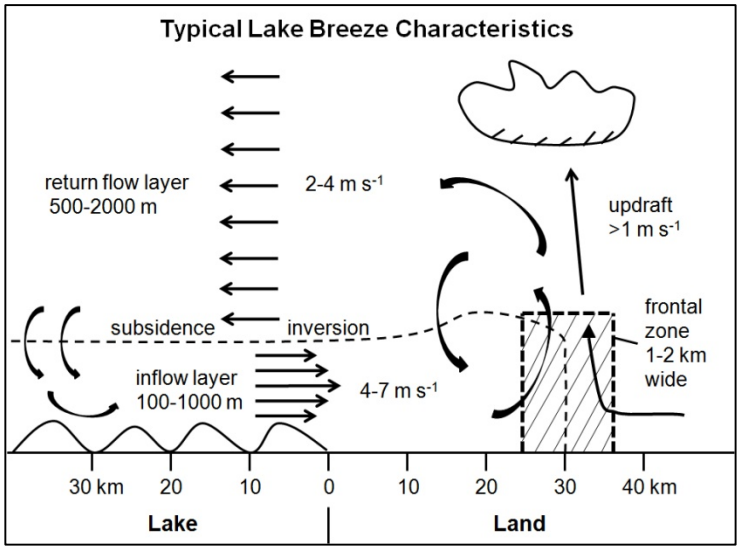
Figure 1. Ground sites hosting measurements for LMOS 2017

White Paper: http://www.ladco.org/

Lake Michigan and Ozone Formation

- ***Land breeze*** blows ozone precursor compounds from rush hour over lake.
- The boundary layer height is low due to cold water chilling the air above.
- The pollutants are concentrated near the surface where ozone forms.
- An afternoon ***lake breeze*** transports the ozone back onto land.





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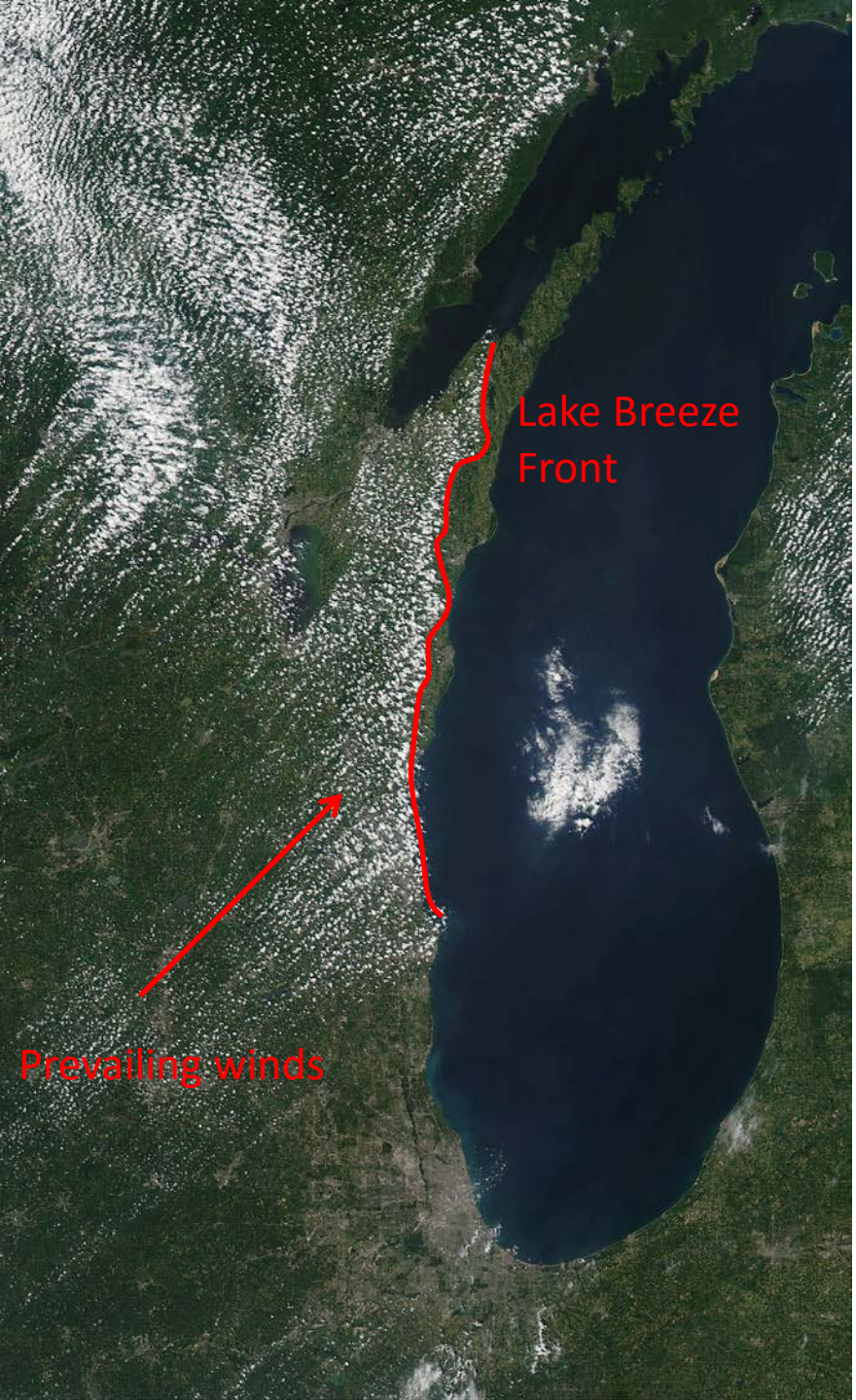
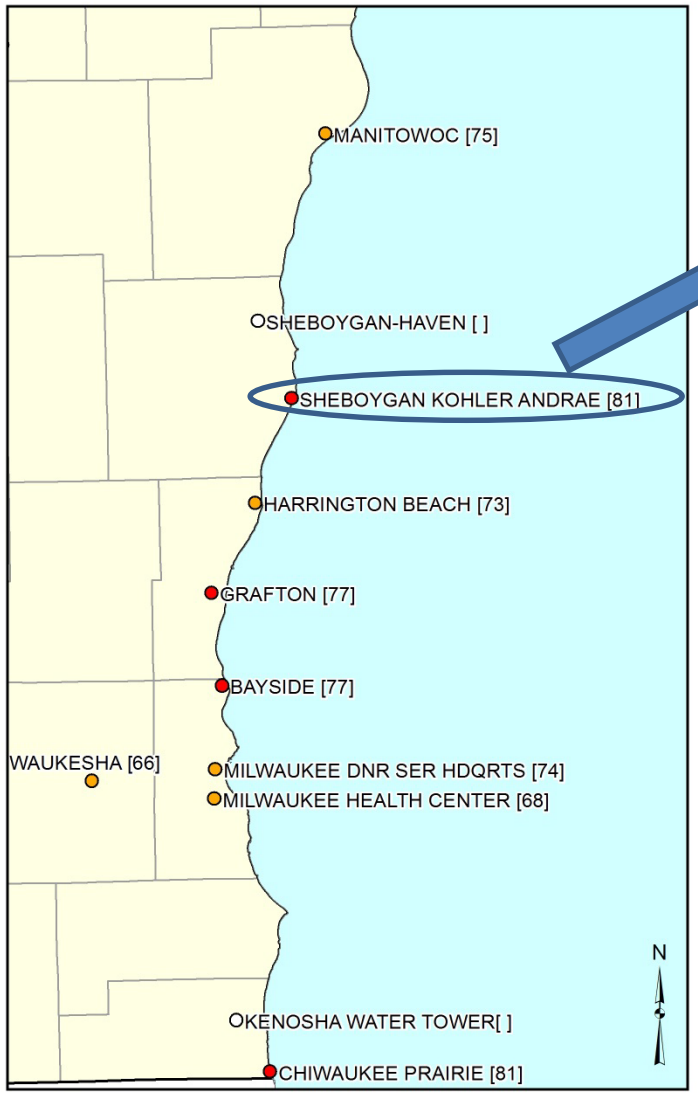
MODIS Image July 17, 2011



Satellite image of Lake Michigan showing Lake Breeze Front

From Mike Majewski, WDNR

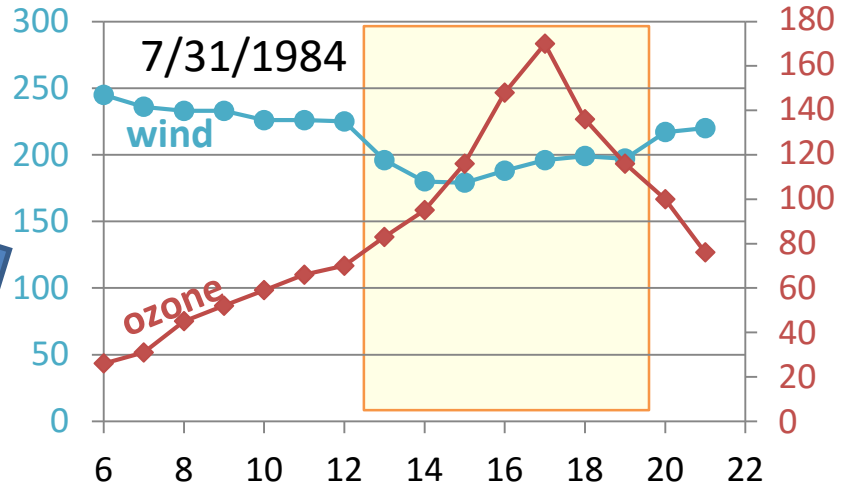
Effects of the lake breeze on ozone concentrations

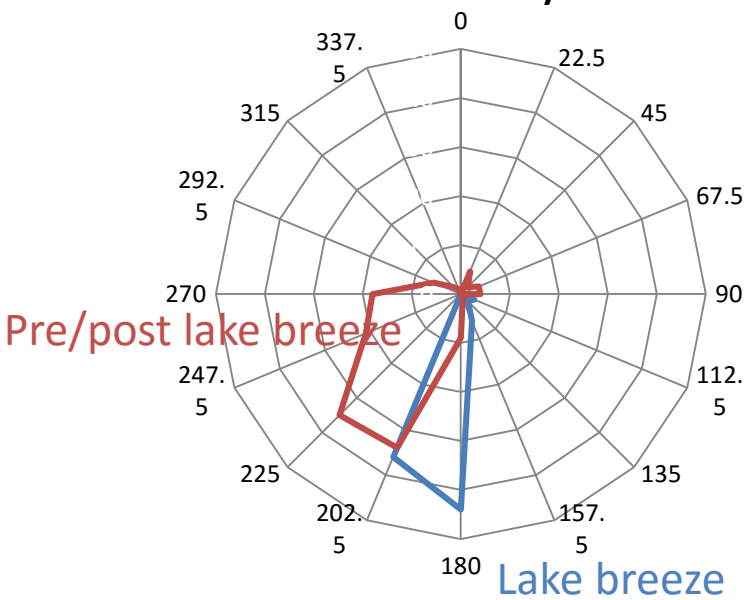


8-Hour Ozone DVs in ppb

- Data Incomplete
- ⩽ 65
- 66 - 75
- 76 - 84
- ⩾ 85

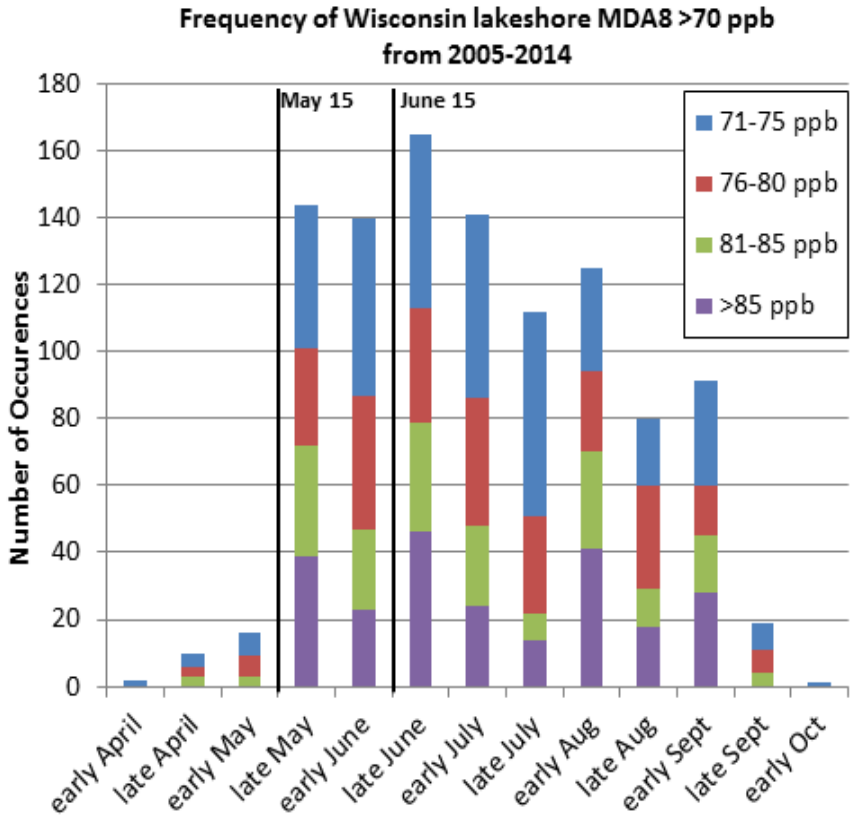
Ozone Standards
1997 NAAQS: 84 ppb
2008 NAAQS: 75 ppb

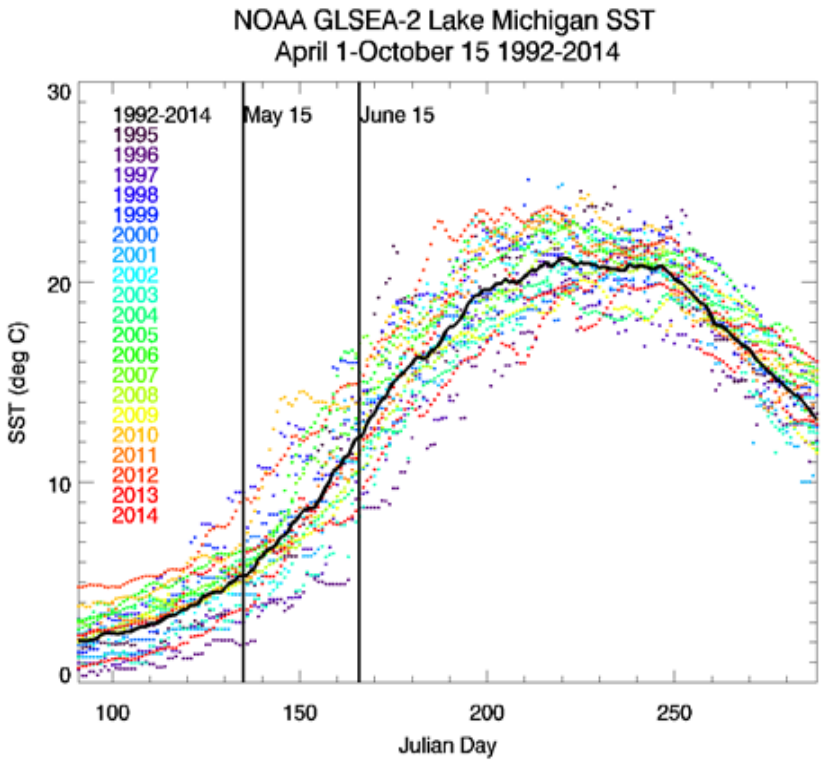




Lake Michigan Ozone Study (LMOS) 2017

Campaign Study Period May 22- June 22, 2017





Primary science objectives focusing on characterizing the recirculation, aging, and mixing of the Chicago and Milwaukee urban plumes as they move over Lake Michigan and their impact on surface ozone.

White Paper: http://www.ladco.org/

LMOS Measurement Suite

SSEC SPARC Trailer
(HALO Wind Lidar, AERI T/Q profiles, HSRL aerosol extinction, CIMEL aerosol optical depth),

EPA Pandora (Column NO2, HCHO), insitu (O3, NOx, HCHO)

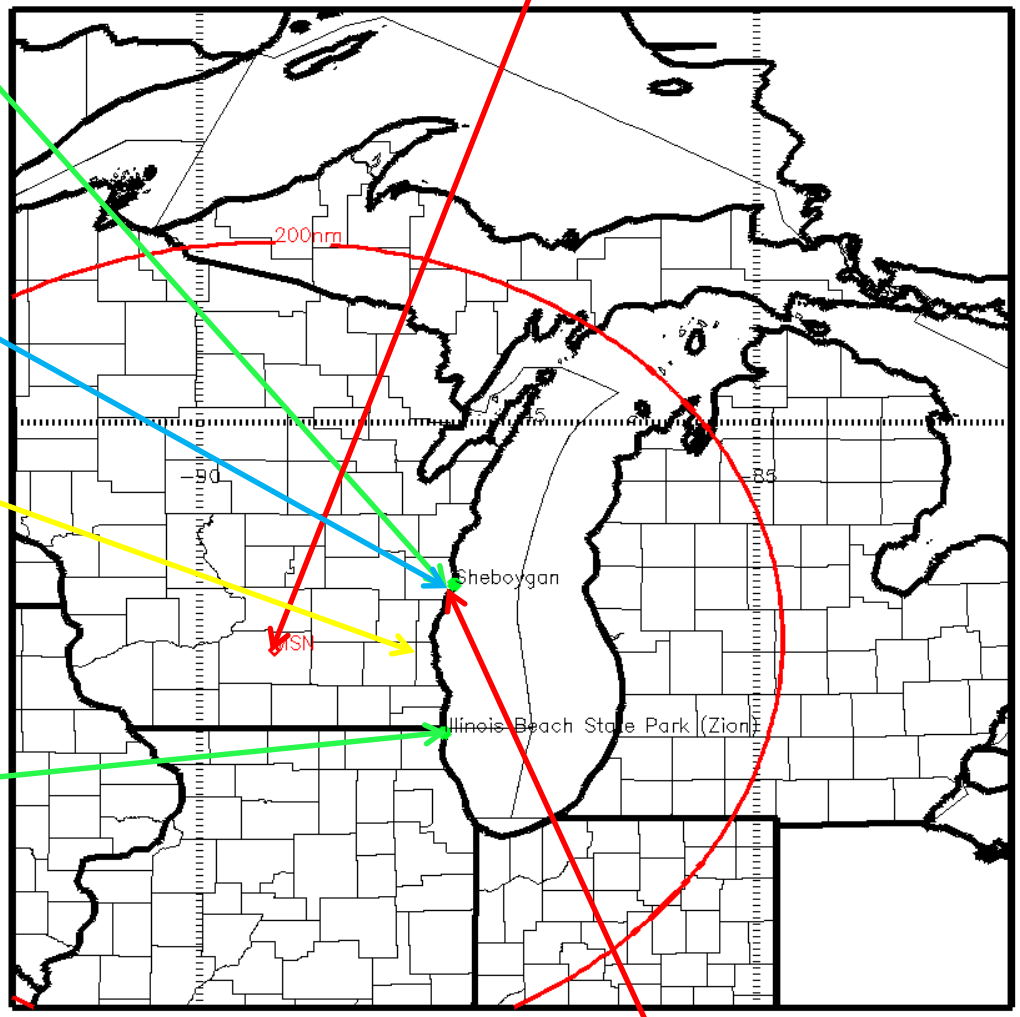
NOAA Ship (EPA Pandora, ceilometer, insitu O3, (tethered Kite and shipboard),

EPA Geospatial Measurement of Air Pollution (GMAP) mobile van (O3)

UNI Microwave Radiometer T/Q profiles, SoDAR winds, Pandora (Column NO2, O3)

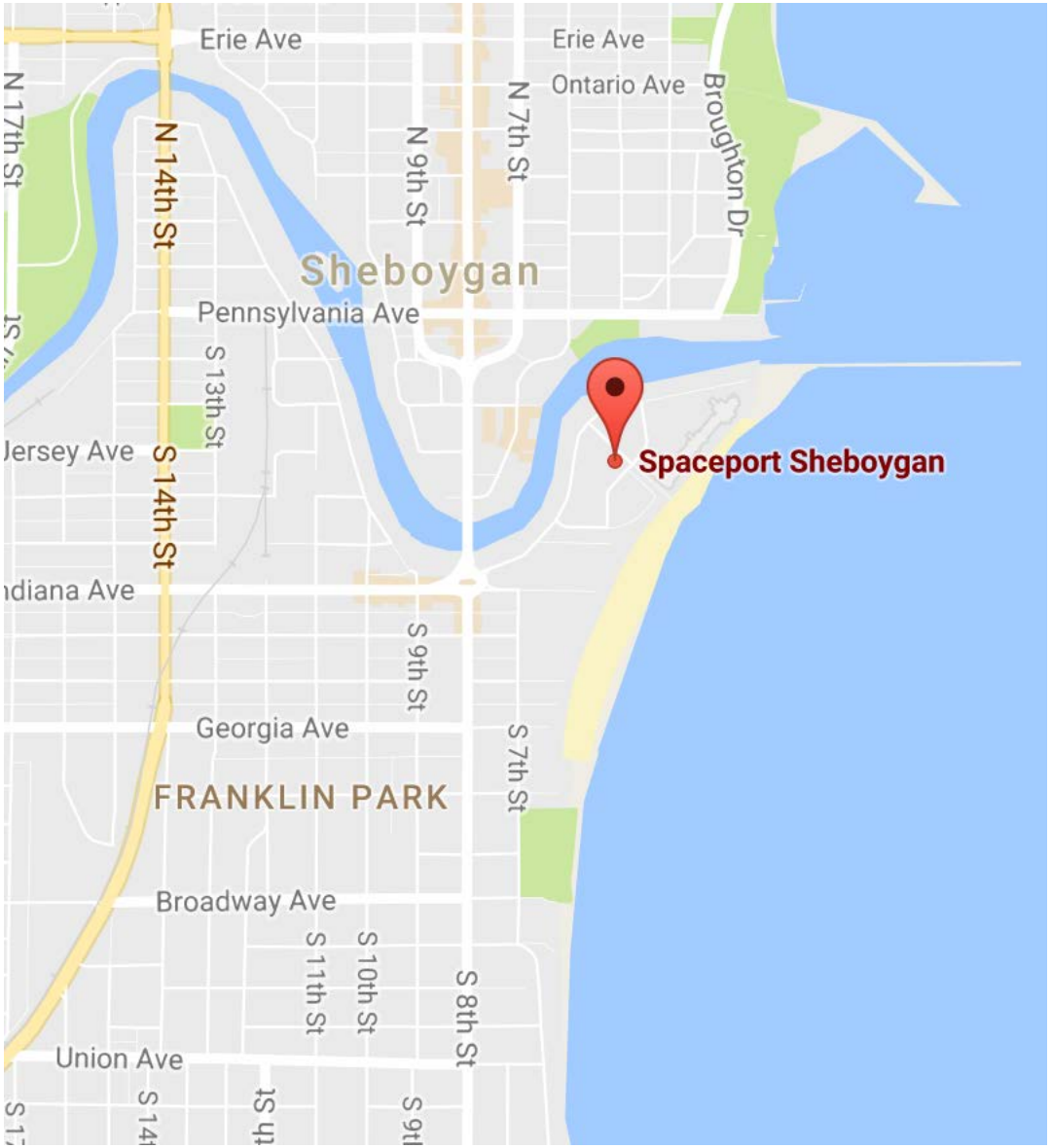
Insitu super site (UW-Madison/UofM NOy/VOC U-Iowa Aerosol)

NASA airborne column NO2, HCHO, O3, and aerosols (GEOTASO Airborne UV-VIS Spectrometer, AirHARP Polarimeter)



Scientific Aviation insitu O3, NO, NO2

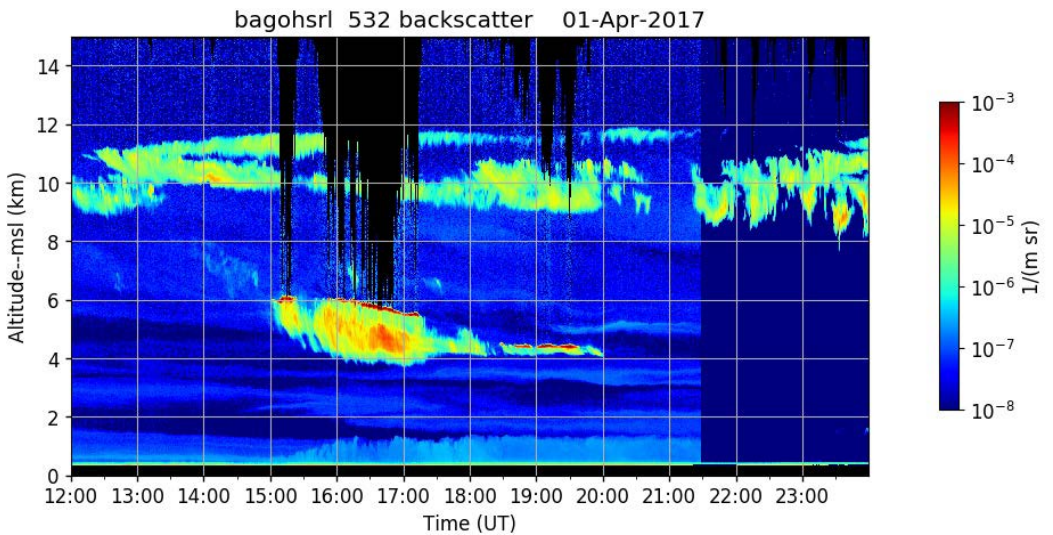
Sheboygan Ground Site: Spaceport Sheboygan



Sheboygan Ground Site: Spaceport Sheboygan UW-Madison SPARC Trailer

- **Boundary Layer Meteorology/Surface Meteorology** Tim Wagner, Univ. of Wisconsin. SPARC: the SSEC Portable Atmospheric Research Center. funded by NOAA
  - *Profiles:* Atmospheric Emitted Radiance Interferometer (AERI), HSRL Lidar, Doppler lidar wind profiler.
  - *In situ meteorology:* Vaisala T, RH, pressure, wind speed, wind direction, precipitation.

- **O3 Profiles** by Tethered Kite (ozone and meteorology), in conjunction with Dept. of Atmospheric Science, Univ. Wisconsin.



Sheboygan Research Site: Spaceport Sheboygan EPA Research Trailer

U.S. EPA Federal Reference Methods for Trace Gases along with Formaldehyde (O3 precursor):

- **NOx/NOy methods:**
  - Teledyne T500U Cavity attenuated phase shift spectroscopy (CAPS)
  - Teledyne 200EUP Photolytic converter – O_3 chemiluminescence
- **O_3 method:**
  - 2B Technologies M211 Scrubberless UV
- **HCHO**
  - Aerodyne QCL

Ship measurements: NOAA -GLERL Lake Michigan Field Station Research Vessel R5503

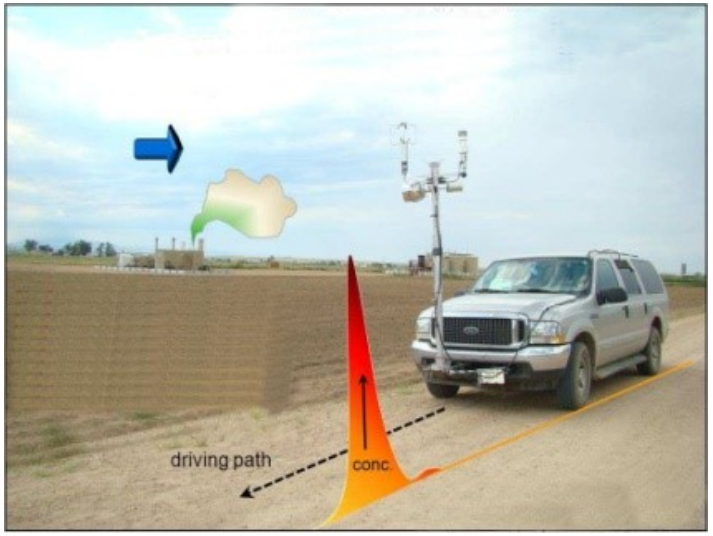
The NOAA Great Lakes Environmental Research Laboratory (GLERL) will be providing the RV R5503 during June 2-22

- EPA Pandora, ceilometer, insitu O3 measurements using tethered Kite and shipboard
- Based out of Sheboygan, WI during deployment

Mobile Van Measurements: EPA Region Geospatial Measurement of Air Pollution (GMAP)

Coastal/inland ozone gradients

GMAP has an integrated Differential Ultra Violet Absorption Spectroscopy (DUVAS) that can provide high frequency (1 second) measurements while moving or parked.



[1]http://www.duvastechnologies.com/index.php?option=com_content&view=featured&Itemid=435

Airborne Measurements: NASA GeoTASO, Scientific Aviation insitu O3 and NOx

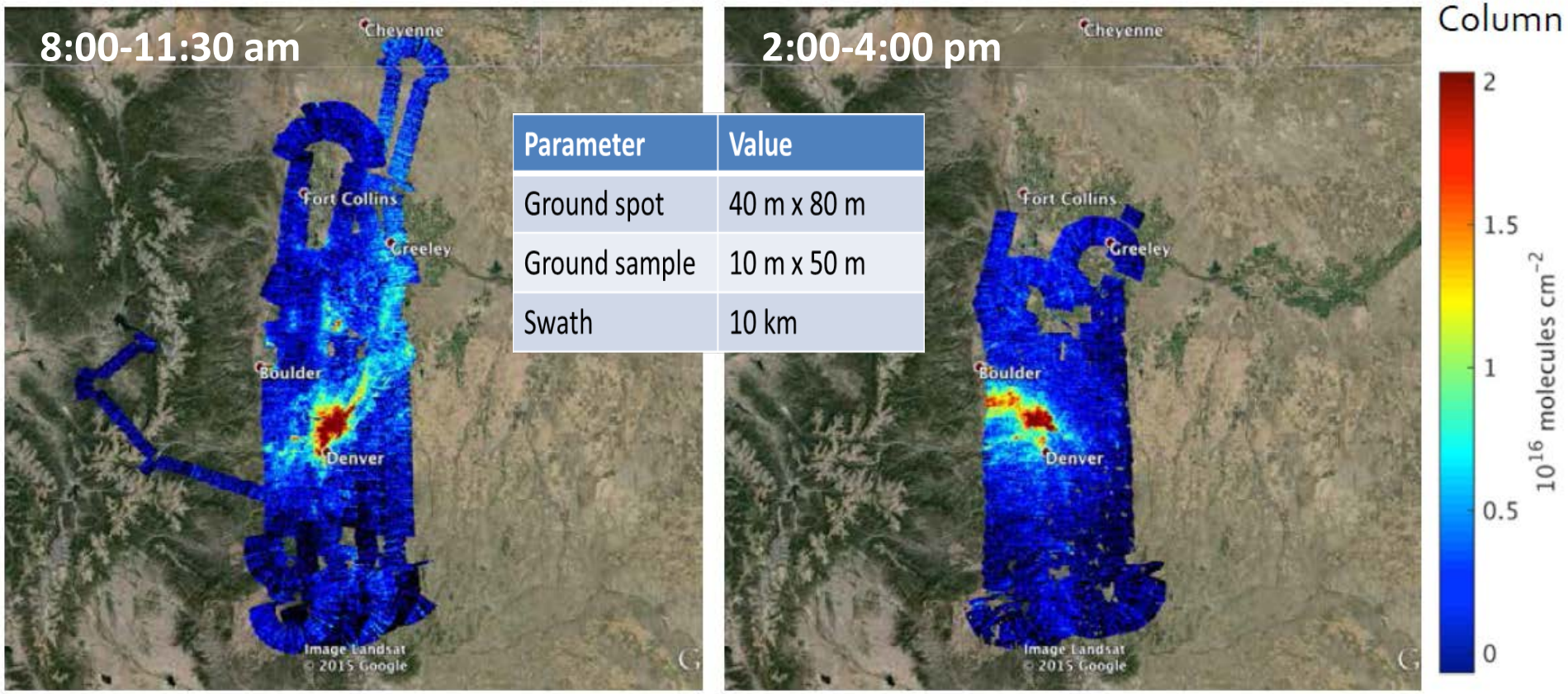
NASA Beechcraft UC-12 instrument Geostationary Trace gas and Aerosol Sensor Optimization (GeoTASO). GeoTASO is a UV-Vis Spectrometer that is an airborne simulator for the future Tropospheric Emissions: Monitoring of Pollution (TEMPO) mission and is used to retrieve column NO2, HCHO, and aerosols.

Scientific Aviation Mooney airplane equipped with meteorological, O3 and NOX measurements. Spirals over key ground sites and measurements within the boundary layer over land and water. ***Funded by Electric Power Research Institute (EPRI)***

NASA Airborne Remote Sensor
Geostationary Trace Gas and Aerosol Sensor Optimization (GeoTASO)

- Airborne platform
- Column retrievals of NO2, HCHO, O3, SO2, CHOCHO

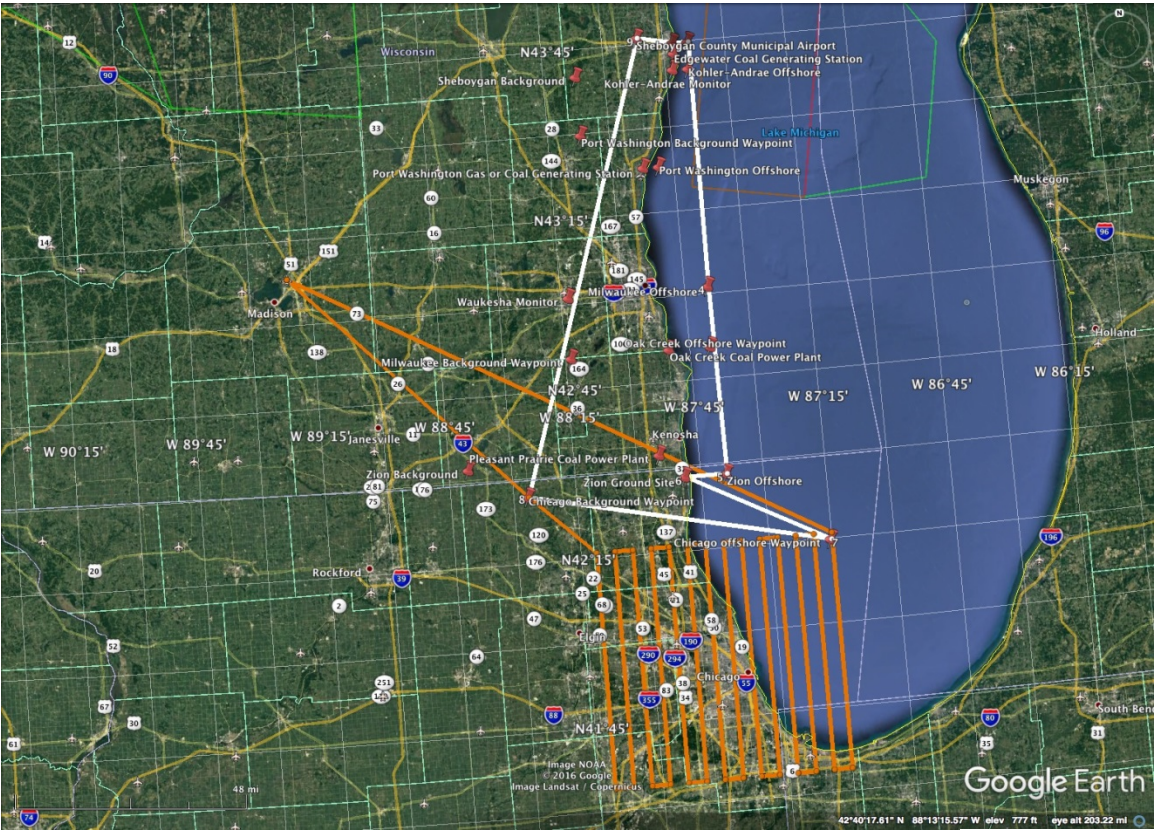
NO_2 over Denver, 2 August 2014



Parameter	Value
Ground spot	40 m x 80 m
Ground sample	10 m x 50 m
Swath	10 km

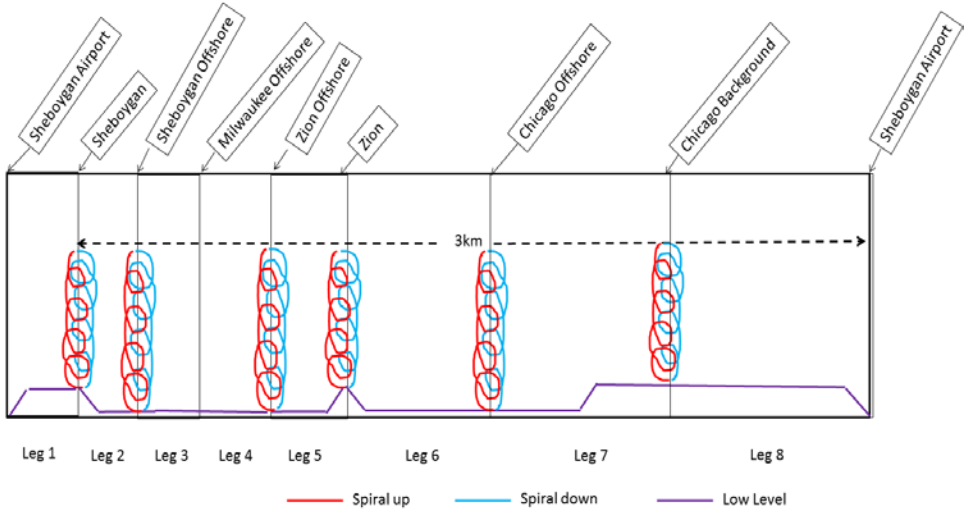
From Caroline Nowlan (Harvard-Smithsonian Center for Astrophysics, Cambridge, MA)

Scientific Aviation (white)/GeoTASO (orange): Chicago Raster Flight Plan

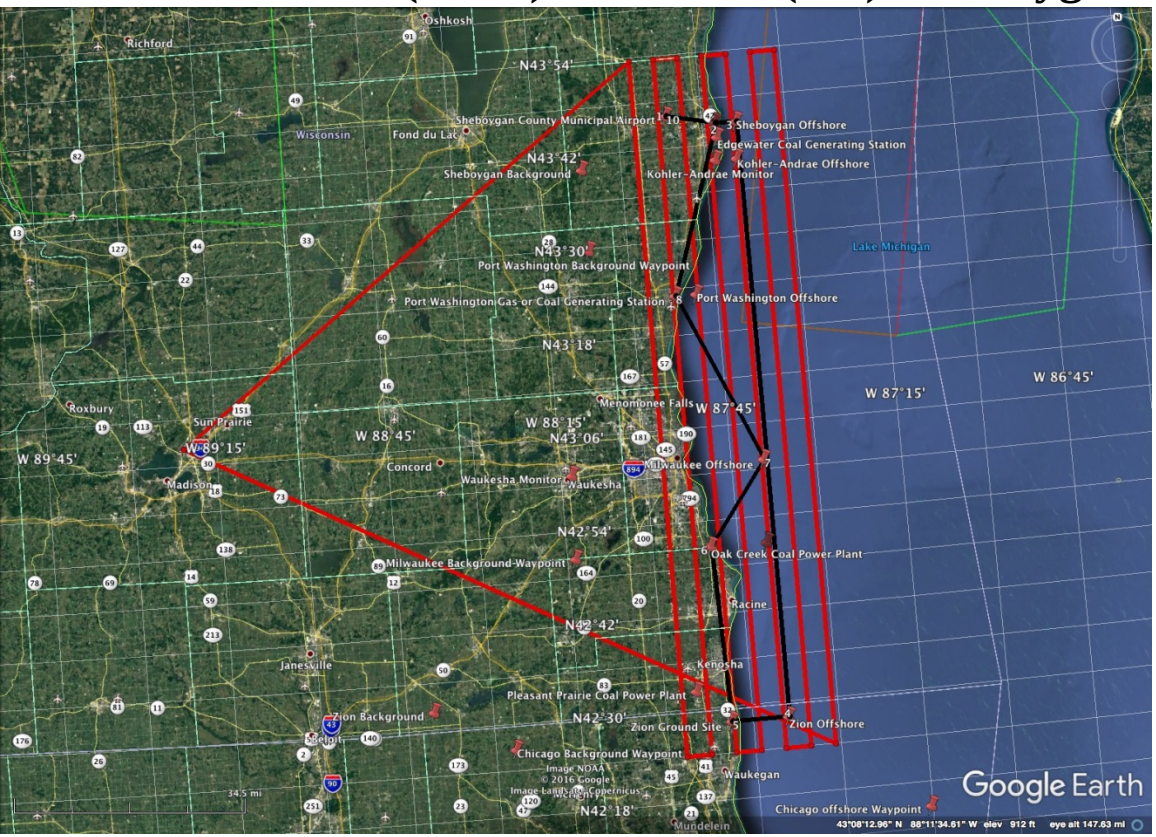


Chicago emissions with background and offshore profiling

Scientific Aviation Profiling

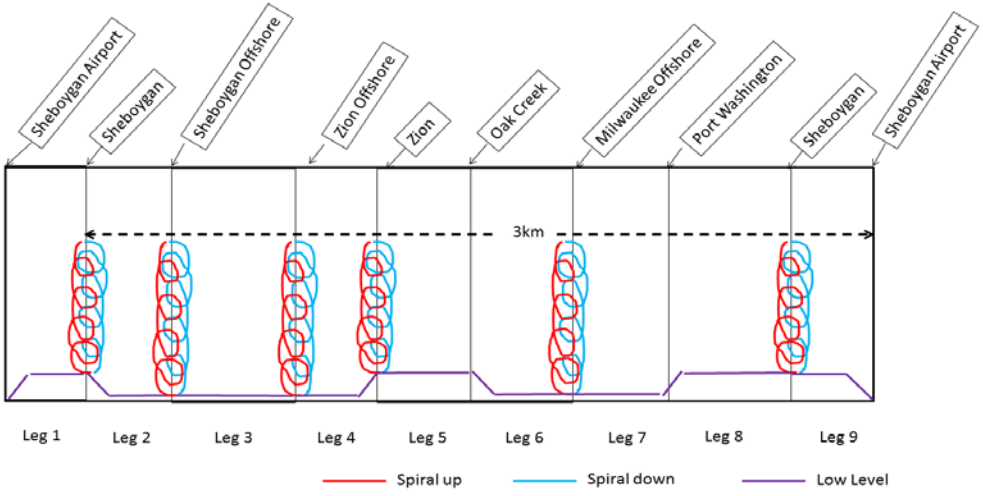


Scientific Aviation (black)/GeoTASO (red): Sheboygan to Zion Raster Flight Plan

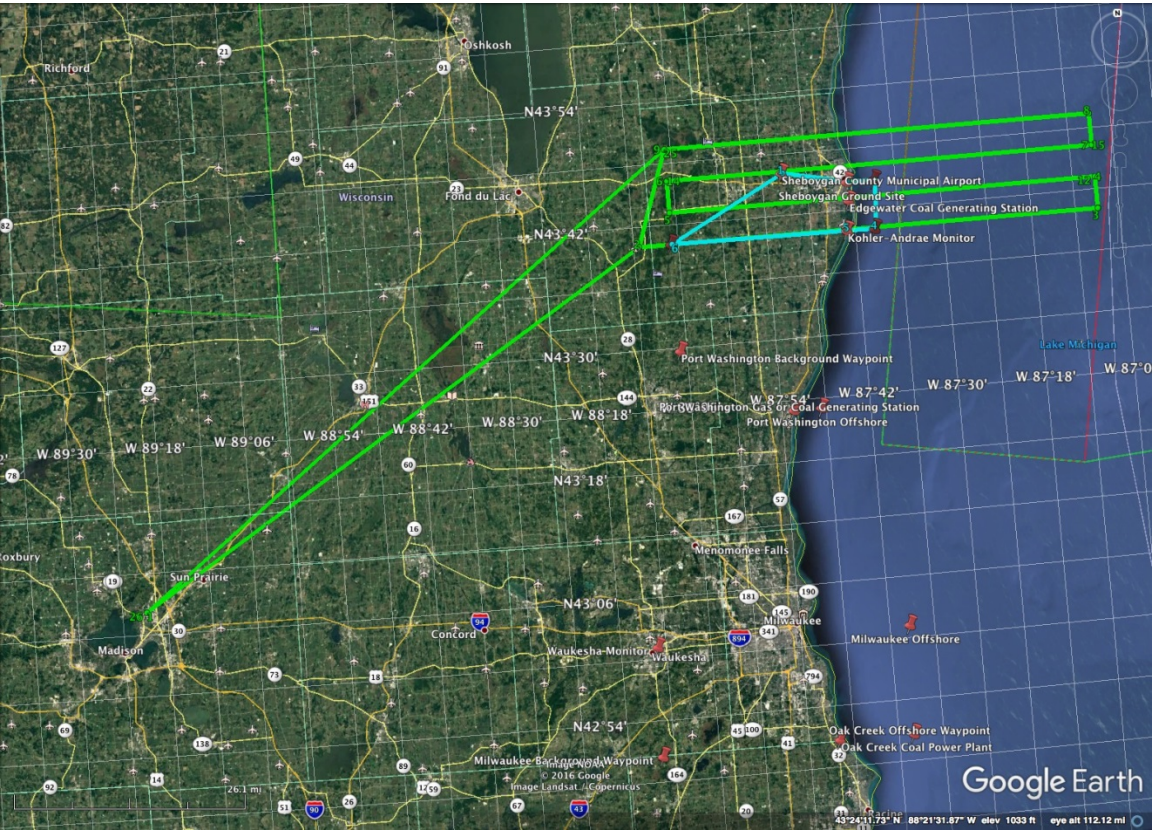


Scientific Aviation Profiling

Zion to Sheboygan coastal survey with onshore and offshore profiling

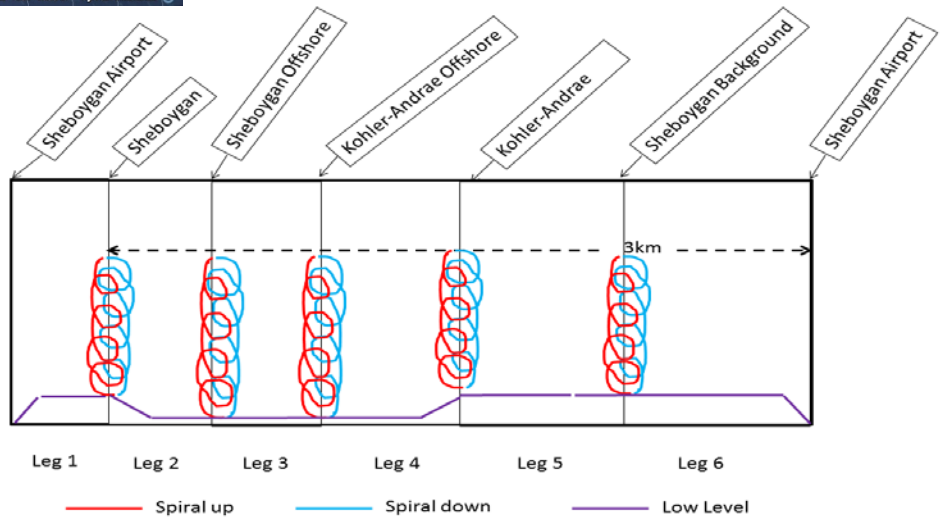


Scientific Aviation (blue)/GeoTASO (green): Sheboygan Raster (Three circuits) Flight Plan

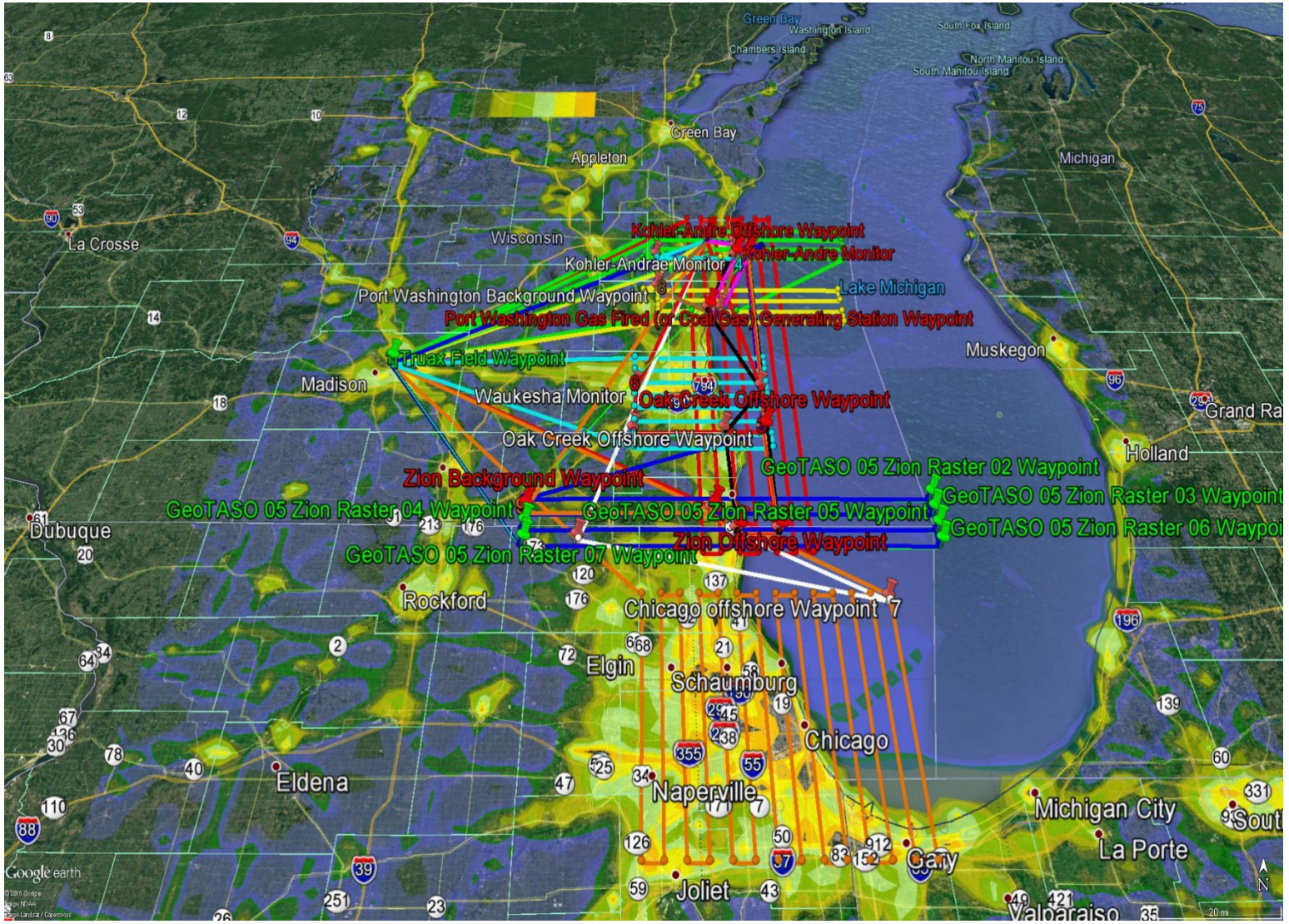


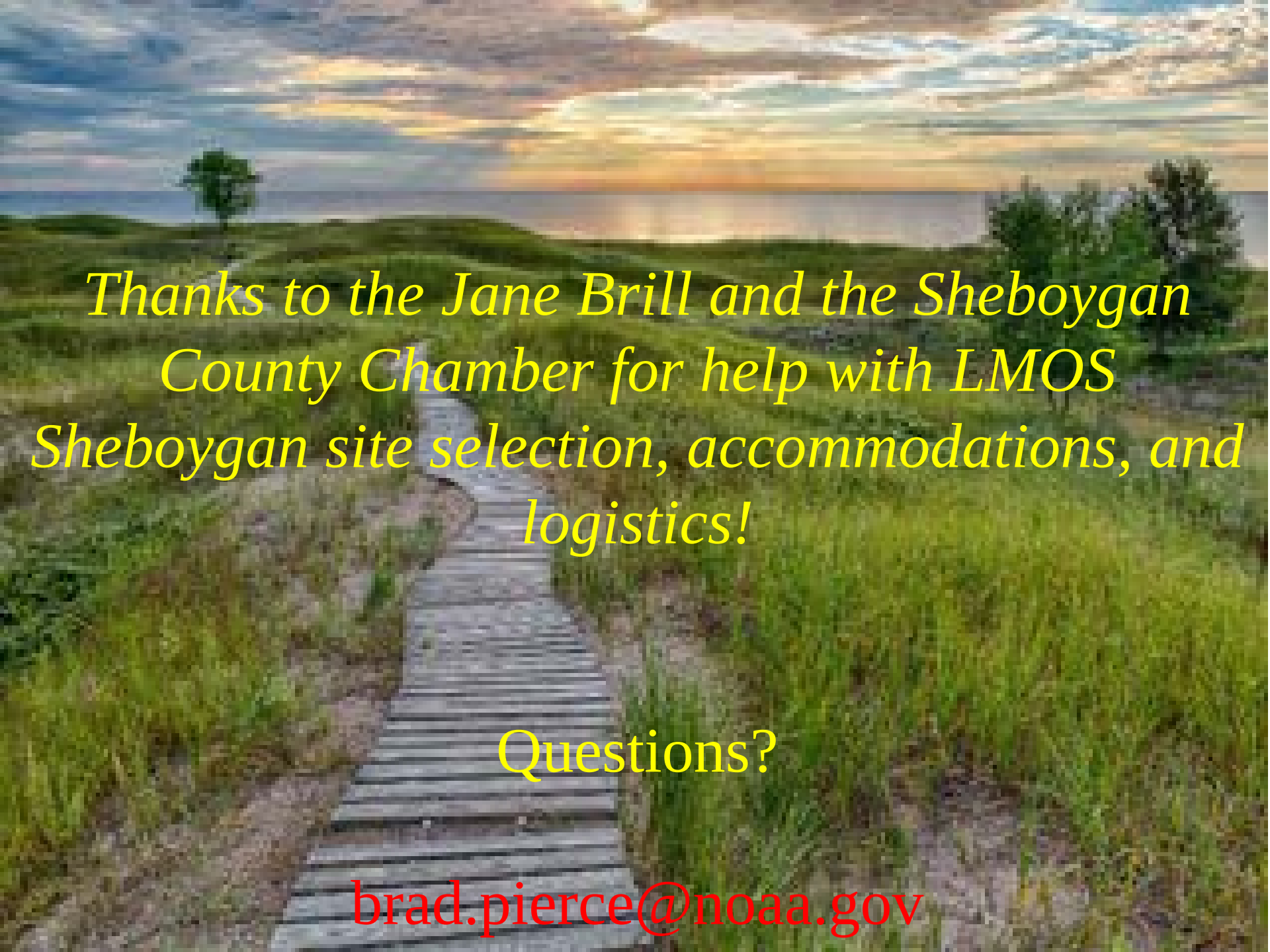
Sheboygan survey with background, onshore and offshore profiling

Scientific Aviation Profiling



All LMOS Flights with EPA National Emission Inventory 2011 NOx emissions




Thanks to the Jane Brill and the Sheboygan County Chamber for help with LMOS Sheboygan site selection, accommodations, and logistics!
Questions?
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