How Does Aerosol Optical Thickness (AOT) Vary Within 50 Kilometers of Lake Erie?

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Abstract

This research study was conducted by Shumate Middle School students: Charlotte Clavet (8th Grade), Lilyannah Dunigan (7th Grade), and Joselyn Zieleck (6th Grade), at Shumate Middle School (Gibraltar School District) located in Gibraltar, Michigan (United States of America). Our research team was tasked with measuring the Aerosol Optical Thickness in our atmosphere. All measurements were taken between October 1, 2019 through February 3rd, 2020. Our research question is, “What is the aerosol optical thickness (AOT) found in Gibraltar, Michigan (United States of America)?” With this question in mind, we organized research about aerosols, and we formulated our hypothesis that “the aerosol optimal thickness would range between 0.0 and 0.1 nm.” We also compared our findings to three other study sites located within 50 kilometers of Lake Erie. After the data was collected and analyzed, we found our hypothesis was incorrect. However, the data collected was incredibly close to the stated range in our hypothesis.

Keywords: aerosol, aerosol optical thickness, variation

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International Virtual Science Symposium (IVSS) Badges

Our research team would like to apply for the following IVSS badges:

- **I Am a Collaborator** - Our team is applying for the “I Am a Collaborator” digital badge. As we had to work together as a team to create this environmental study. We share all of our data with students and scientists from around the world.
- **I Make An Impact** - Secondly, our team is applying for the “I Make an Impact” badge, as our research can be utilized to better understand aerosols within 50 kilometers of Lake Erie.
- **I Am a Data Scientist** - Finally, our team is applying for the “I Am a Data Scientist” badge, as we collected and sorted through a significant amount of data to better understand aerosol optical thickness.

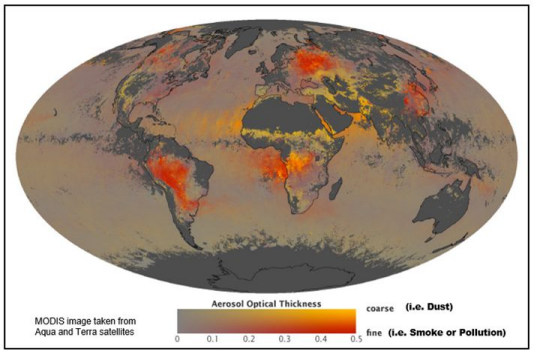
Introduction

Research Questions:

Over the past five school years of GLOBE, Shumate Middle School Citizen Scientists have submitted thousands of environmental measurements to the Global Learning and Observations to Benefit the Environment (GLOBE) Program. However, Shumate Citizen Scientists have yet to examine aerosols in our atmosphere. As a research team, we joined forces with Dr. Margaret Pippin (NASA Langley Research Center) to try and better understand our local environment. According to NASA Earth Observations (NEO), inhalation of aerosols can cause asthma or cancer, along with other serious health problems. However, scientists do not fully understand all of the ways that aerosols affect Earth's environment. With this in mind, our team is motivated to help scientists better understand the aerosols in our local environment. The research question our team decided to explore is, “What is the aerosol optical thickness (AOT) found in Gibraltar, Michigan (United States of America)?” Additionally, we explored the question, “How does AOT vary within 50 kilometers of Lake Erie?”

Our research team obtained a MODIS image (see Image 1 below) from the GLOBE Program’s Aerosols training module, and we noticed that the image indicated that the AOT for our area ranges between 0.0 nm and 0.1 nm. With this in mind, we set out to test the image’s accuracy.

Image 1 - MODIS Aerosol Optical Thickness



Hypothesis:

We believe that our average AOT will range between 0.0 nm and 0.1 nm.

Materials and Methods

GLOBE Protocols Utilized in this Study:

- Atmosphere - Aerosols
- Study and Comparison Sites: (See Below)
    - Study Site:
        - Shumate Middle School - Gibraltar, MI (United States of America)
    - Comparison Sites:
        - Stoney Creek High School - Rochester Hills, MI (United States of America)
        - Holland Central Schools - Holland, NY (United States of America)
        - Snyder Memorial Aerosols Site - Toledo, OH (United States of America)

Materials:

- Calitoo Sun Photometer
- Pencil
- GLOBE Aerosol Data Sheet
- Clipboard
- Chromebook for Data Entry
- Google Sheets for Data Storage and Quick Analysis

Methods:

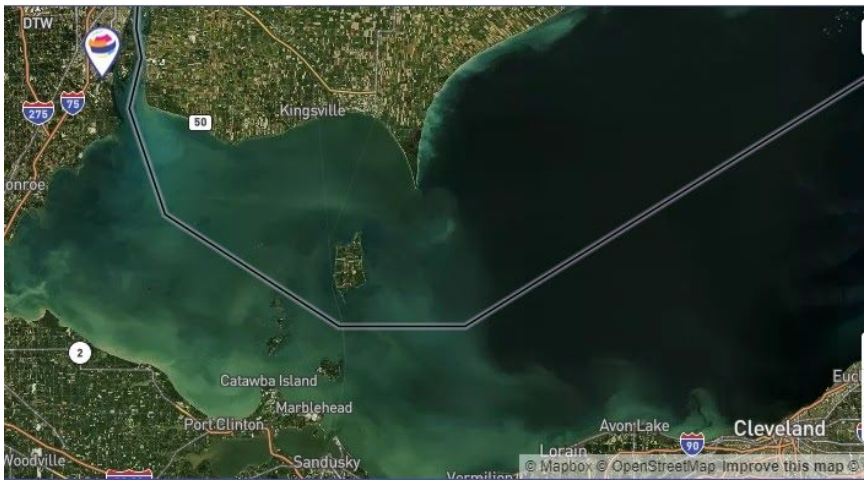
- Travel outside to a designated area to take your aerosols measurement.
- Position the photometer so that the sun is resting inside of the black dot on the top of the device.
- Next, switch the Calitoo to measuring mode.
- Hold down the red button and wait until the numbers on the screen reach 1,000.
- Follow a series of prompts on the device to collect atmospheric data.
- Repeat this process two more times (for a total of three measurements).

- Record all of the data on the GLOBE data sheet.
- Return to the classroom once the measurements have been taken.
- Submit the data to the GLOBE website.
- Add the data to the team's Google Sheet.
- Put the Calitoo and clipboard away.

Study Site:

Aerial Image 1 - Shumate Middle School

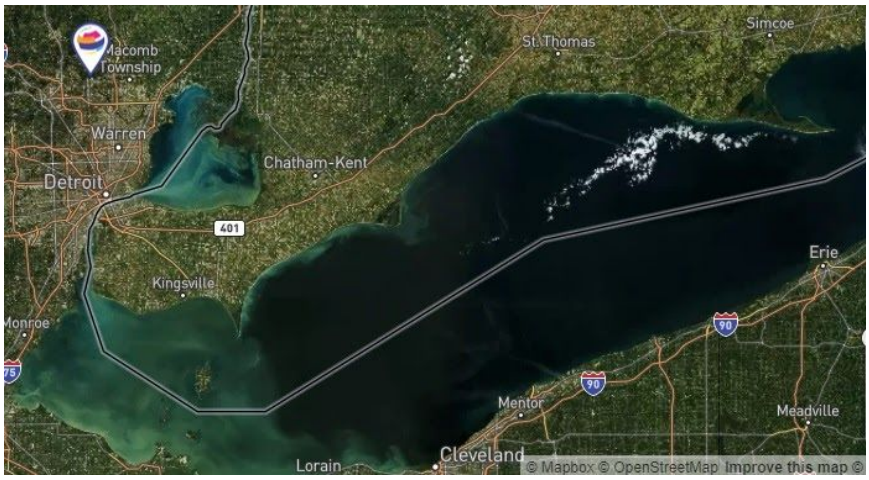
Latitude 42.0862, Longitude -83.21017, Elevation 176.7m



Comparison Sites: (Within 50 Kilometers of Lake Erie)

Aerial Image 2 - Stoney Creek High School

Latitude 42.70468, Longitude -83.12, Elevation 238.0M



Aerial Image 3 - Holland Central Schools
Latitude 42.64568, Longitude -78.5413, Elevation 340.3M

Aerial Image 4 - Snyder Memorial Aerosols Site
Latitude 41.66123, Longitude -83.6127, Elevation 216.0M

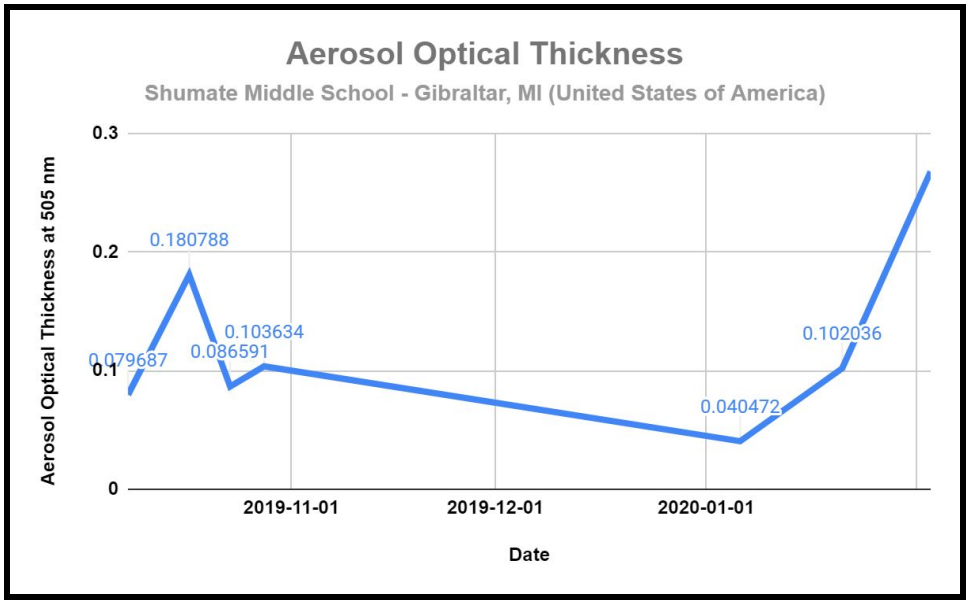
Data Summary

Data Table 1 - Optical Thickness and Transmission Percent

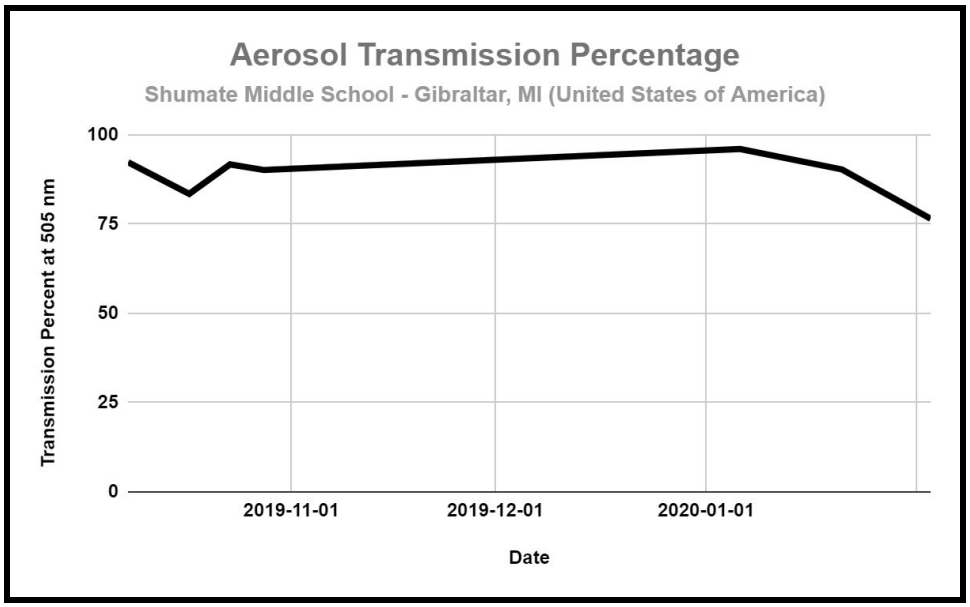
Date	Aerosol Optical Thickness at 505 nm	Transmission Percent at 505 nm
2019-10-08	0.079687	92.340540
2019-10-17	0.180788	83.461240
2019-10-23	0.086591	91.705220
2019-10-28	0.103634	90.155530
2020-01-06	0.040472	96.033590
2020-01-21	0.102036	90.299750

2020-02-03	0.267736	76.510990
Average	0.122992	88.643837
Maximum	0.267736	96.033590
Minimum	0.040472	76.510990

Graph 1 - Aerosol Optical Thickness



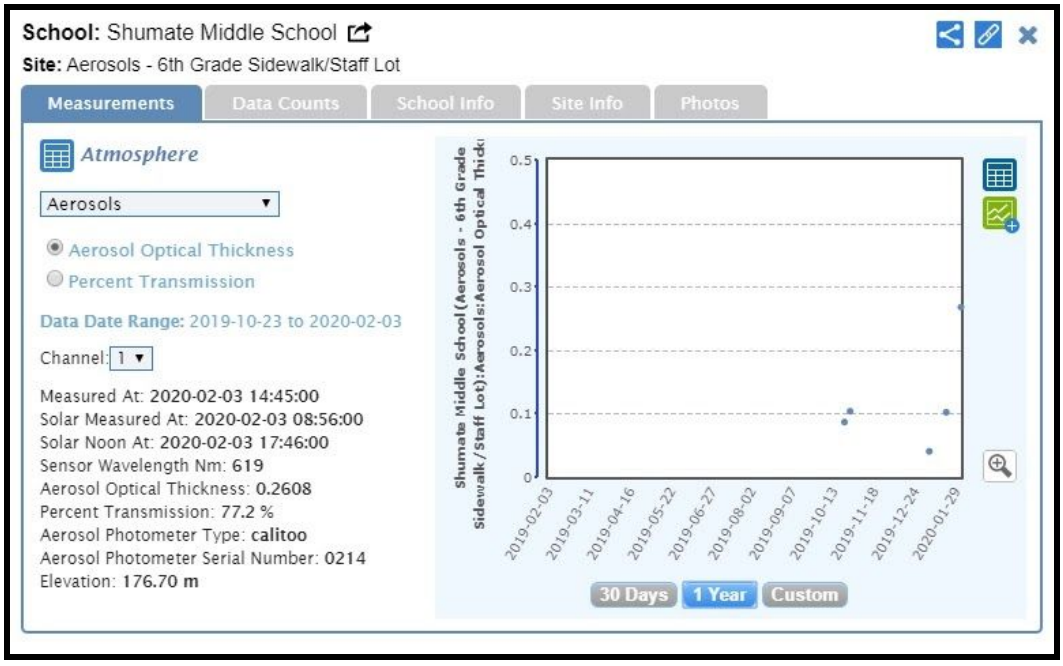
Graph 2 - Aerosol Transmission Percentage



Data Table 2 - Comparison Data

Comparison Study Sites within 50 Kilometers of Lake Erie				
Site Name	State	Measured On	Aerosol Optical Thickness at 505 nm	Transmission Percent at 505 nm
Stoney Creek High School	Michigan	10/9/2019	0.099906	90.492256
Stoney Creek High School	Michigan	10/10/2019	0.105077	90.025552
Stoney Creek High School	Michigan	10/28/2019	0.108946	89.677878
		Average	0.104643	90.065229
Holland Central Schools	New York	9/6/2019	0.053203	94.818718
Holland Central Schools	New York	10/21/2019	0.082896	92.044696
Holland Central Schools	New York	12/11/2019	0.110847	89.507556
Holland Central Schools	New York	12/13/2019	0.686952	50.310704
		Average	0.233475	81.670418
Snyder Memorial Aerosols Site	Ohio	9/9/2019	0.136231	87.264106
Snyder Memorial Aerosols Site	Ohio	10/9/2019	0.087475	91.624207
Snyder Memorial Aerosols Site	Ohio	10/28/2019	0.096466	90.804077
Snyder Memorial Aerosols Site	Ohio	11/19/2019	0.213279	80.793086
Snyder Memorial Aerosols Site	Ohio	2/11/2020	0.168149	84.522797
		Average	0.140320	87.001654

GLOBE Visualization 1 - Study Site



Analysis and Results

The average AOT value collected at Shumate Middle School (Gibraltar, Michigan) was 0.122992 nm. To serve as a comparison, our team selected Stoney Creek High School (Rochester Hills, Michigan), Holland Central Schools (Holland, New York), and Snyder Memorial Aerosols Site (Toledo, Ohio) from GLOBE's Advanced Data Access Tool (ADAT). We downloaded the AOT data from each site, and we created a data table to average the collected AOT data. Stoney Creek High School collected three measurements and had an average AOT of 0.104643 nm. Holland Central Schools collected four measurements and had an average of 0.233475 nm. Lastly, Snyder Memorial Aerosols Site collected five measurements and had an average AOT of 0.140320 nm. The highest AOT was collected at Holland Central Schools (0.686952 nm). The lowest AOT was also collected at Holland Central Schools (0.053203 nm).

Conclusions

Overall, our hypothesis was incorrect. However, we were really close. As stated above, we believed the average AOT would range between between 0.0 and 0.1 nm. The average AOT at Shumate Middle School was 0.122992 nm. This value is slightly higher than our hypothesis. Additionally, the comparison site's numbers were yet again a little larger than our hypothesis. Stoney Creek High School had an average AOT of 0.104643 nm, Snyder Memorial Aerosols Site had an average AOT of 0.140320 nm, and Holland Central Schools had an average AOT of 0.233475 nm. All of these study sites are all slightly higher than our hypothesis. After looking through the data the highest AOT was collected Holland Central Schools. As a comparison, Stoney Creek High School was the closest to 0.1 nm.

Discussions

When selecting our GLOBE IVSS Project, the idea of taking aerosol measurements immediately sparked our interest. Dr. Pippin (NASA) sent our research team a Calitoo Sun Photometer to utilize during this project, and we greatly appreciate her support in this process. At first, our team thought it would be easy to take aerosol measurements. However, taking aerosol measurements can be a difficult task. Nobody else at Shumate Middle School had attempted a project like this before (including Mr. Bouwman). First, we had to teach ourselves how to correctly use the equipment, and had to research the GLOBE Aerosols Protocol. At first we relied on YouTube tutorials to learn how to use the Calitoo. We also read the directions numerous times. Eventually we figured it out and were ready to take measurements. Next, we ran into the biggest problem - weather. Often in Michigan, sunlight is abundant during late spring through early fall. We were trying to take aerosol measurements during late fall through winter. As expected we got a low count as we only had seven days where the photometer was able to take measurements. Obviously this is not what we had hoped for. Our team was very frustrated considering the other Shumate Citizen Science research teams were able to take measurements daily. We also wanted to collect a significant amount of data. During the middle of winter, our team started looking at aerosol data collected by other schools, and we realized that we were not behind on measurements. This made us feel better. Despite all of the hardships, we enjoyed our project and seeing the photometer work along with being able to use it.

Moving forward, our team plans on taking additional aerosols measurements. As we collected more measurements, we became even more curious about the aerosols phenomena. We look forward to taking both spring and early summer measurements. We will examine the data collected and compare it to the data collected for this report.

The outcome of our project has our group proud of our work, as no Citizen Scientist at Shumate Middle School has attempted to measure aerosols. We worked hard and invested in this project to (hopefully) make a difference and inspire others. As a team, we love science! In the words of Mae Jemison, “You have as much right as anyone else to be in this world, and to be in any profession you want. You don't have to wait for permission.” This project was meaningful for our group, and we hope this opens up many science doors for us in the future. In conclusion, we are happy with the results of our IVSS project.

Collaboration

Group Roles:

- **Charlotte Clavet** - Measurement taker, spreadsheet manager, data entry, and report author.
- **Lilyannah Dunigan** - Measurement taker, spreadsheet manager, data entry, and report author.
- **Joselyn Zieleck** - Measurement taker, spreadsheet manager, data entry, and report author.

Advantages of Collaboration:

In order to create this study, teamwork was a must. As a team, all members participated equally and collected, analyzed, and submitted measurements to the GLOBE Program. Our team collected aerosol data for Dr. Margaret Pippin (NASA). Additionally, we hope that our aerosol measurements can be utilized by students and scientists around the world. Our group would also like to thank the Citizen Scientists at Stoney Creek High School, Holland Central Schools, and the University of Toledo (Snyder Memorial Aerosols Site) that collected the data that we utilized for comparison in this study.

Acknowledgements

- **Charlotte Clavet (8th Grade - Shumate Middle School)** - I would like to thank my parents for their endless support and for allowing me to sign up for GLOBE Advisory. Thank you to my group for being great to work and take measurements with. Additionally, a big thanks to Mr. Bouwman for helping each and every one of us to complete these projects. Thanks for providing the resources needed to take measurements, and for being awesome.
- **Lily Dunigan (7th Grade - Shumate Middle School)** - I would like to thank my mom, my dad, Chris, and Megan for giving me the resources I need to be successful. I would also like to thank my best friends Mia, Raven, and Mia (there are two), for encouraging me to do my best and making me happy every day. Another thanks to Mr. Bouwman for being patient and kind every step of the way.
- **Joselyn Zieleck (6th Grade - Shumate Middle School)** - I would like to thank Mr. Bouwman for making this all happen. This is my first year in the GLOBE Advisory, and I already feel so accomplished. Mr. Bouwman has done a lot to help our group. Another thanks goes to my parents for helping me along the way, and for helping me succeed this far. My biggest dream that I hope to achieve is to work for NASA as an Astrophysicist.
- **Special Thank You** - We would like to thank Dr. Margaret Pippin (NASA) for lending us the Calitoo Sun Photometer and for her unconditional support.

References

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