ABSTRACT

AOT is Blowing With The Wind

A study conducted using GLOBE protocols to analyze wind speed, air temperature, AOT & sunlight of the atmosphere during the morning, mid-day, and afternoon.

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What is the relationship between temperature and wind speed and the relationship between Aerosol Optical Thickness "AOT" of the atmosphere, during the day at morning, mid-day, and afternoon? It was predicted that the temperature would rise during the day, causing the winds to become stronger. It was also predicted that aerosols in the atmosphere would increase during the day, resulting in a thicker aerosol optical thickness (AOT) measurement letting less sunlight reach the Earth's surface.

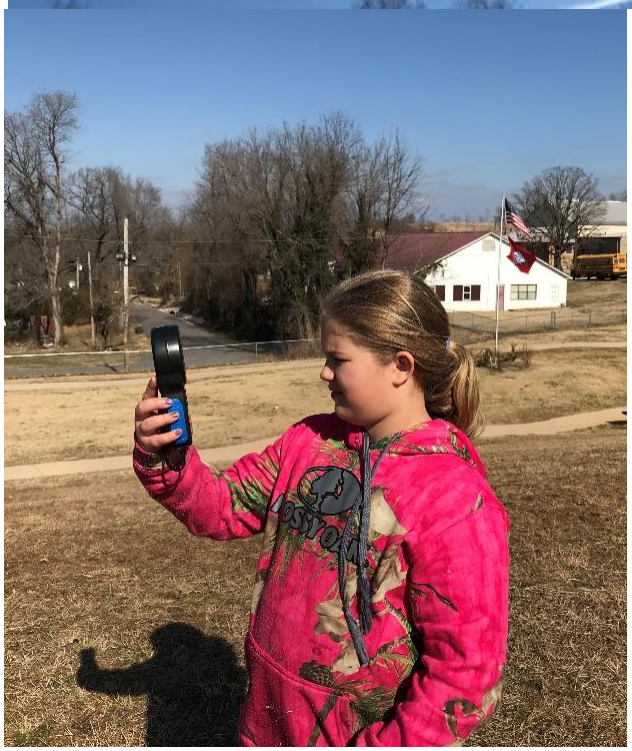
Following the GLOBE protocols, the researchers collected and recorded the temperature and wind speed for 15 days using a digital anemometer and thermometer for 15 days and they also used a digital sun photometer to measure the AOT on 10 days when clouds were not blocking the sun. Approximate data collection times: 9:30am, 12:00 noon, & 2:30pm. The researchers followed the GLOBE protocols for weather data collection. Once the data was collected, the information was uploaded into the GLOBE atmospheric data base.

Morning averages: wind speed 3.46Km/H, temperature 13.78˚C, AOT reading 0.667, 62.66% of sunlight. **Mid-Day averages:** wind speed 4.49Km/H, temperature 15.01˚C, AOT reading 0.923, 50.86% of sunlight. **Afternoon averages:** wind speed 3.64Km/H, temperature 15.17˚C, AOT reading 0.586, and 63.97% of sunlight.

The hypothesis for wind speed and temperature was partially supported by the data. As the day went on, the temperature and wind increased over the morning, however the afternoon winds averaged 0.85Km/H less than the Mid-Day average. **The hypothesis for AOT readings was also only partially supported by the data.**

AOT is Blowing With The Wind

A study conducted using GLOBE protocols to analyze wind speed, air temperature, AOT & sunlight of the atmosphere during the morning, mid-day, and afternoon.



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Roger G. Rose

May 5, 2019

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INTRODUCTION

Have you ever watched a brilliant orange sunrise or sunset? Have you ever noticed that as you look across the landscape, hills far away may appear hazy one day but clear on another day? Small solid and liquid particles suspended in the air, called aerosols are most likely the cause. When some people think of aerosols, they think about smoke and dust stirred up from people going about their day. Chemicals given off from the burning of fossil fuels in automobiles are another significant contributor of aerosols into the atmosphere. The study of aerosols in the atmosphere has become an area of interest by the GLOBE program. The international network called GLOBE "Global Learning and Observations to Benefit the Environment" is a science and education program that is made up of scientist, teachers, and students from more than 110 countries. The GLOBE program offers participants the opportunity to collect data that can be used by scientist to study and better understand the interactions between earth's systems. According to information retrieved from the GLOBE website, *"Aerosols influence our weather and climate because they affect the amount of sunlight reaching Earth's surface. Aerosol concentrations vary significantly with location and time. Aerosol optical thickness (AOT, also called aerosol optical depth) is a measure of the extent to which aerosols affect the passage of sunlight through the atmosphere. The larger the optical thickness at a particular wavelength, the less light of that wavelength reaches Earth's surface. This information is needed for climate studies, for comparison with satellite data and to understand the global distribution and variability of aerosols".*

RESEARCH QUESTIONS

There are two research questions being addressed for this project: What is the relationship between temperature and wind speed during the day from morning, mid-day, and afternoon? What is the relationship between the Aerosol Optical Thickness "AOT" of the atmosphere, during the day from morning, mid-day, and afternoon?

HYPOTHESES

It was predicted that the temperature would rise during the day as the Earth heated up, causing the winds to become stronger. It was also predicted that aerosols in the atmosphere would increase during the day, resulting in a thicker aerosol optical thickness (AOT) measurement letting less sunlight reach the Earth's surface.

METHODS & MATERIALS:

PROCEDURES

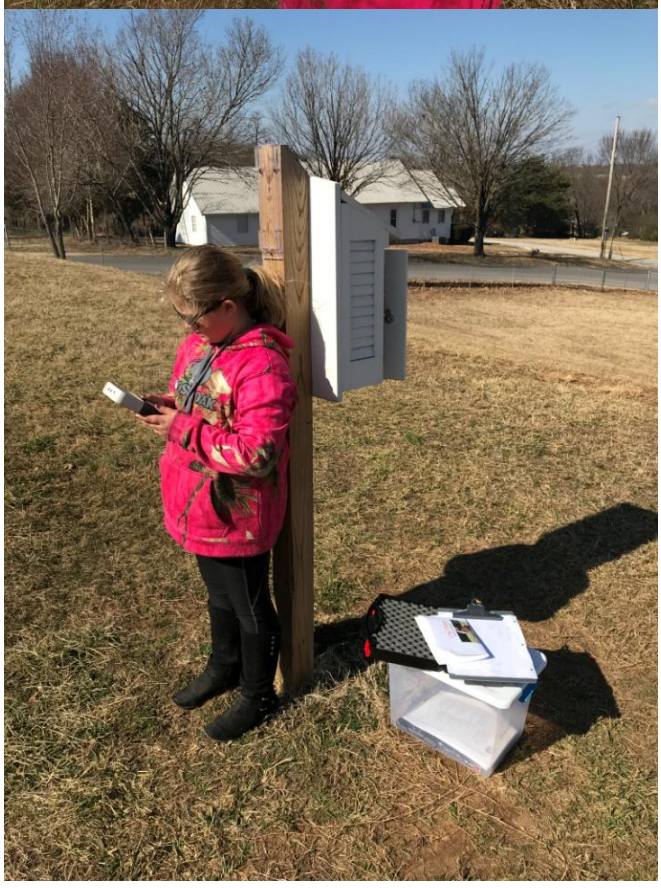
In order to prepare for this project, the researchers talked with their science teacher to learn about the GLOBE program and collecting weather data. Using the GLOBE weather station at the Alpena School campus, the science teacher instructed the researchers in the proper procedures for setting up and collecting data from a GLOBE weather station using a digital anemometer and thermometer. The researchers were also instructed in the use of collecting data on Aerosol Optical Thickness of the atmosphere using a digital sun photometer. Then, the researchers collected and record the temperature and wind speed during the morning, mid-day, and afternoon for 15 days. (Approximate weather data collection times were at 9:30, 12:00, & 2:30). The AOT data could only be collected on days when the sun was not blocked by cloud cover. The researchers collected AOT data for 10 days during the morning, mid-day, and afternoon. The researchers followed the GLOBE protocols for weather data collection. Once the data was collected, the information was uploaded into the GLOBE atmospheric weather data base.

Risk and Safety Concerns to be addressed: The only risk involved were looking directly at the sun while collecting the AOT data with a sun photometer. The researchers wore eye protection while collecting the AOT data and also did not look directly at the sun, as directed in the GLOBE protocols for AOT data collection.

Data Analysis: Once the data was collected it was analyzed by creating charts and graphs in order to identify patterns that might exist associated with wind speed, temperature, AOT, and the percent of sunlight reaching the earth's surface, all associated with the time of day for which the data was collected. A statistics t-Test was conducted comparing the data from different times of day to analyze the significance of difference.

MATERIALS

Digital Anemometer
Digital Thermometer
Calitoo Digital Sun Photometer
GLOBE Weather Station
Sun Glasses



DATA SUMMARY

Wind & Temperature Test Results						
	Wind Speed (Km/H)			Temperature °C		
Date	9:30am	12:00pm	2:30pm	9:30am	12:00pm	2:30pm
12-11-2018	4.6	9.7	8.6	18.8	18.8	20.4
12-12-2018	8.2	6.8	8.2	18.9	19.7	19.3
12-13-2018	2.1	2.6	3.2	16.7	17.5	18.3
12-14-2018	7.9	6.8	5.0	16.5	16.4	14.1
12-17-2018	0.7	5.0	3.6	14.5	17.4	18.1
12-18-2018	1.0	4.6	2.5	17.1	18.9	18.7
12-19-2018	1.0	5.7	4.6	8.2	13.1	14.1
12-20-2018	7.2	5.8	5.0	14.2	17.4	18.4
12-22-2018	2.1	3.9	1.4	19.4	16.5	17.6
12-29-2018	3.2	1.4	1.8	20.2	19.0	19.5
12-30-2018	2.4	1.8	1.9	9.4	11.2	11.4
12-31-2018	5.4	2.8	1.8	10.2	11.1	12.1
01-01-2019	0.7	1.0	2.1	9.7	9.8	9.7
01-02-2019	0.0	0.3	2.1	6.4	9.5	9.1
01-03-2019	5.4	6.4	2.8	6.5	8.8	6.8
Total	**51.9**	**67.3**	**54.6**	**206.7**	**225.1**	**227.6**
Mean	**3.46Km/H**	**4.49Km/H**	**3.64Km/H**	**13.78°C**	**15.01°C**	**15.17°C**

Average Aerosol Optical Thickness (AOT) (Percent % of light transmitted was calculated using *GLOBE Aerosols Table AT-AE-1*)						
	Morning		Mid-Day		Afternoon	
Test #	AOT	Average % of Light Transmitted	AOT	Average % of Light Transmitted	AOT	Average % of Light Transmitted
(12-11-18)	1.036	39.62	1.248	34.28	1.225	34.99
(12-12-18)	0.073	90.50	0.116	90.50	0.179	87.63
(12-17-18)	0.753	50.41	1.571	25.58	0.663	52.55
(12-22-18)	0.033	90.50	0.433	67.76	0.493	63.87
(1-5-19)	1.006	40.52	0.936	34.10	0.920	43.08
(1-9-19)	0.036	90.50	0.036	90.50	0.025	90.50
(1-15-19)	1.837	21.32	1.988	17.41	1.739	22.30
(1-18-19)	0.086	90.50	0.942	37.43	0.505	63.80
(1-20-19)	0.134	90.50	0.061	90.50	0.027	90.50
(1-21-19)	1.676	22.30	1.902	20.56	0.086	90.50
Total	**6.670**	**626.67**	**9.233**	**508.62**	**5.862**	**639.72**
Mean	**0.667**	**62.66%**	**0.923**	**50.86%**	**0.586**	**63.97%**

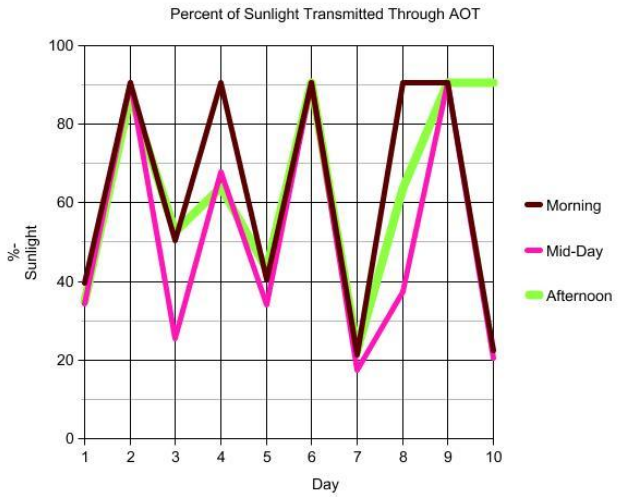
RESULTS

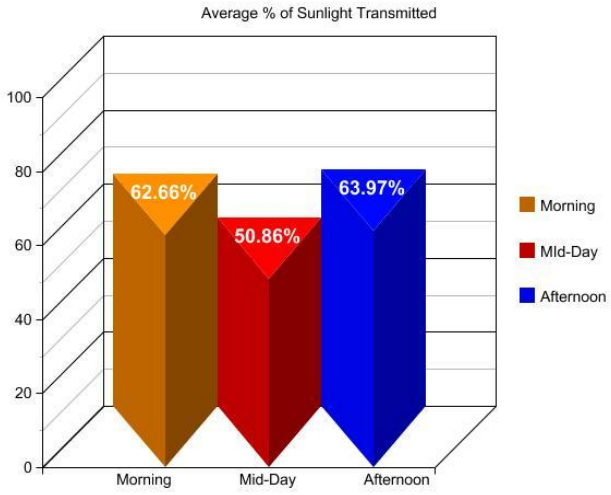
RESULTS

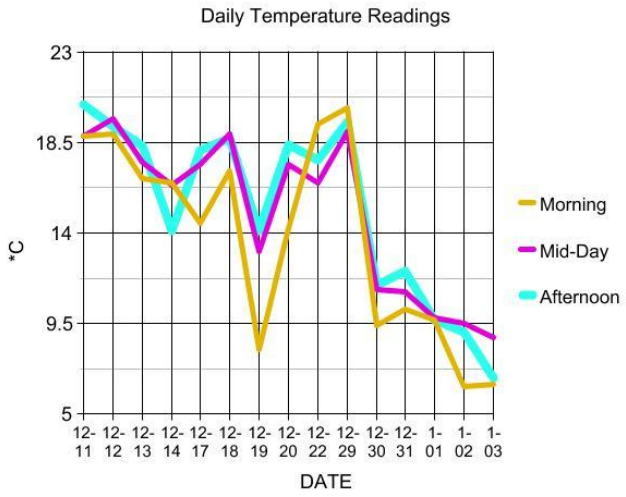
Morning Data Collection: Average wind speed was 3.46Km/H. The average temperature was 13.78˚C. The average AOT reading was 0.667. The average percentage of sunlight that came through the atmosphere reaching the surface of the earth was 62.66%.

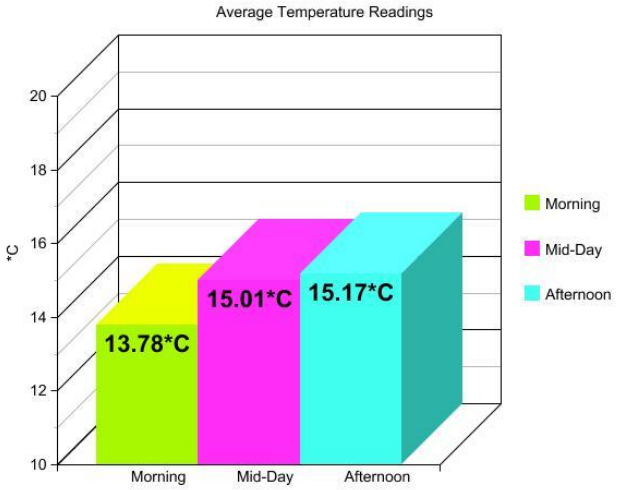
Mid-Day Data Collections: Average wind speed was 4.49Km/H. The average temperature was 15.01˚C. The average AOT reading was 0.923. The average percentage of sunlight that came through the atmosphere reaching the surface of the earth was 50.86%.

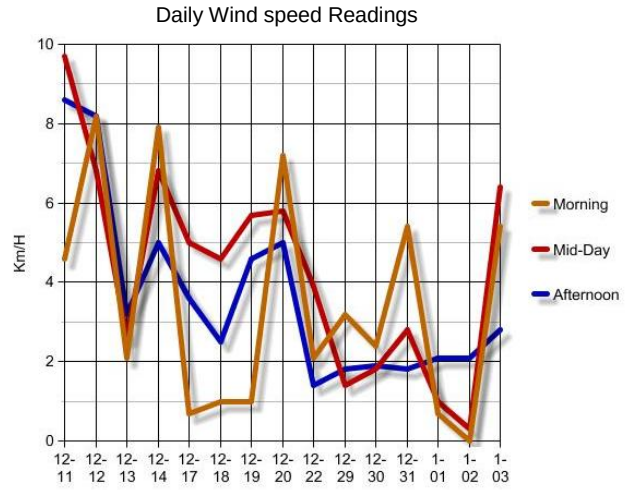
Afternoon Data Collection: Average wind speed was 3.64Km/H. The average temperature was 15.17˚C. The average AOT reading was 0.586. The average percentage of sunlight that came through the atmosphere reaching the surface of the earth was 63.97%.

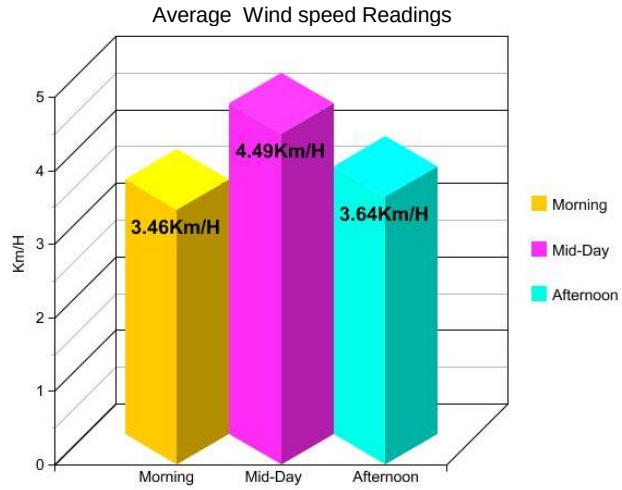


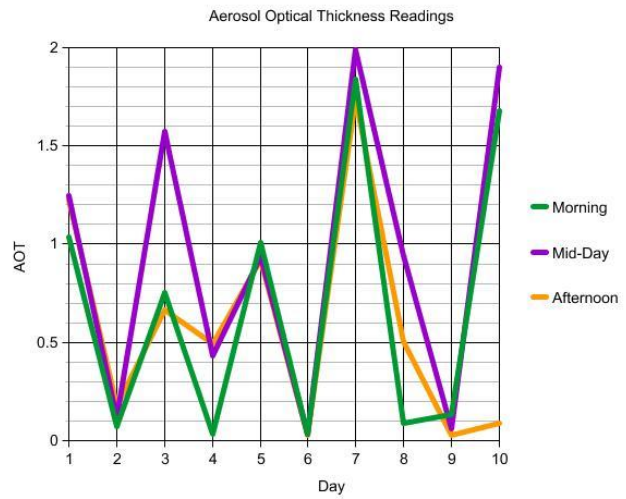


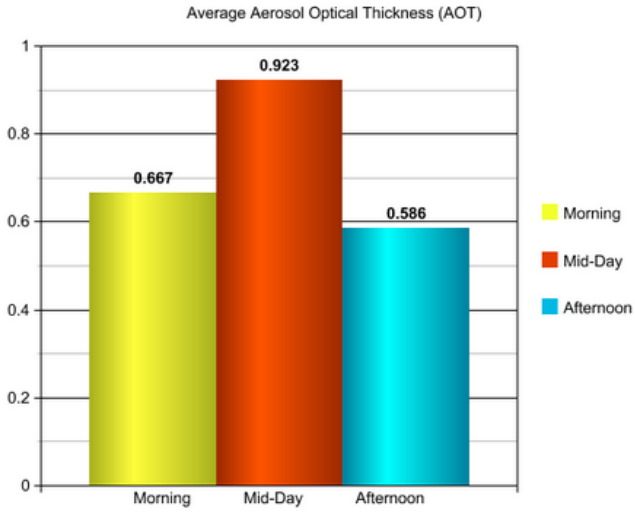

Daily Temperature Readings
23
18.5
14
9.5
5
*C
12-11 12-12 12-13 12-14 12-17 12-18 12-19 12-20 12-22 12-29 12-30 12-31 1-01 1-02 1-03
DATE
Morning
Mid-Day
Afternoon


Average Temperature Readings
20
18
16
14
12
10
*C
13.78*C
15.01*C
15.17*C
Morning
Mid-Day
Afternoon
Morning
Mid-Day
Afternoon


Daily Wind speed Readings
10
8
6
4
2
0
Km/H
12-11 12-12 12-13 12-14 12-17 12-18 12-19 12-20 12-22 12-29 12-30 12-31 1-01 1-02 1-03
Morning
Mid-Day
Afternoon


Average Wind speed Readings
5
4
3
2
1
0
Km/H
3.46Km/H
4.49Km/H
3.64Km/H
Morning
Mid-Day
Afternoon
Morning
Mid-Day
Afternoon


Aerosol Optical Thickness Readings
2
1.5
1
0.5
0
AOT
1 2 3 4 5 6 7 8 9 10
Day
Morning
Mid-Day
Afternoon


Average Aerosol Optical Thickness (AOT)
1
0.8
0.6
0.4
0.2
0
0.667
0.923
0.586
Morning
Mid-Day
Afternoon
Morning
Mid-Day
Afternoon

Data Analysis for Wind Speed

t-Test: Paired Two Sample for Means

wind speed Km/h	*9:30am*	*12:00pm*
Mean	3.46	4.306666667
Variance	7.799714286	6.979238095
Observations	15	15
Pearson Correlation	0.570938324	
Hypothesized Mean Difference	0	
df	14	
t Stat	-1.300862012	
P(T<=t) one-tail	0.107155171	
t Critical one-tail	1.761310136	
P(T<=t) two-tail	0.214310343	
t Critical two-tail	2.144786688	

t-Test: Paired Two Sample for Means

wind speed Km/h	*9:30am*	*2:30pm*
Mean	3.46	3.64
Variance	7.799714286	5.126857143
Observations	15	15
Pearson Correlation	0.556802363	
Hypothesized Mean Difference	0	
df	14	
t Stat	-0.287382763	
P(T<=t) one-tail	0.38901459	
t Critical one-tail	1.761310136	
P(T<=t) two-tail	0.77802918	
t Critical two-tail	2.144786688	

t-Test: Paired Two Sample for Means

wind speed Km/h	*12:00pm*	*2:30pm*
Mean	4.306666667	3.64
Variance	6.979238095	5.126857143
Observations	15	15
Pearson Correlation	0.8139733	
Hypothesized Mean Difference	0	
df	14	
t Stat	1.677856398	
P(T<=t) one-tail	0.057774547	
t Critical one-tail	1.761310136	
P(T<=t) two-tail	0.115549094	
t Critical two-tail	2.144786688	

Data Analysis for Temperature

t-Test: Paired Two Sample for Means

*Temperture *C*	*9:30am*	*12:00pm*
Mean	13.78	15.00666667
Variance	24.22171429	15.62209524
Observations	15	15
Pearson Correlation	0.926043081	
Hypothesized Mean Difference	0	
df	14	
t Stat	-2.431903477	
P(T<=t) one-tail	0.014518298	
t Critical one-tail	1.761310136	
P(T<=t) two-tail	0.029036595	
t Critical two-tail	2.144786688	

t-Test: Paired Two Sample for Means

*Temperture *C*	*9:30am*	*2:30pm*
Mean	13.78	15.17333333
Variance	24.22171429	19.50638095
Observations	15	15
Pearson Correlation	0.893136513	
Hypothesized Mean Difference	0	
df	14	
t Stat	-2.437659684	
P(T<=t) one-tail	0.014358616	
t Critical one-tail	1.761310136	
P(T<=t) two-tail	0.028717231	
t Critical two-tail	2.144786688	

t-Test: Paired Two Sample for Means

*Temperature *C*	12:00pm	2:30pm
Mean	15.00666667	15.17333333
Variance	15.62209524	19.50638095
Observations	15	15
Pearson Correlation	0.970503086	
Hypothesized Mean Difference	0	
df	14	
t Stat	-0.578453136	
P(T<=t) one-tail	0.286073464	
t Critical one-tail	1.761310136	
P(T<=t) two-tail	0.572146927	
t Critical two-tail	2.144786688	

Data Analysis for Aerosol Optical Thickness (AOT)

t-Test: Paired Two Sample for Means

	morning AOT	*mid-day AOT*
Mean	0.667	0.9233
Variance	0.491118	0.559987344
Observations	10	10
Pearson Correlation	0.892417863	
Hypothesized Mean Difference	0	
df	9	
t Stat	-2.389015069	
P(T<=t) one-tail	0.020311463	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.040622927	
t Critical two-tail	2.262157163	

t-Test: Paired Two Sample for Means

	morning AOT	*afternoon AOT*
Mean	0.667	0.5862
Variance	0.491118	0.323697289
Observations	10	10
Pearson Correlation	0.613044014	
Hypothesized Mean Difference	0	
df	9	
t Stat	0.447540197	
P(T<=t) one-tail	0.332531297	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.665062594	
t Critical two-tail	2.262157163	

t-Test: Paired Two Sample for Means

	mid-day AOT	*afternoon AOT*
Mean	0.9233	0.5862
Variance	0.559987344	0.323697289
Observations	10	10
Pearson Correlation	0.613892044	
Hypothesized Mean Difference	0	
df	9	
t Stat	1.774331522	
P(T<=t) one-tail	0.054876962	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.109753924	
t Critical two-tail	2.262157163	

Data Analysis for % of Sunlight Transmitted

t-Test: Paired Two Sample for Means

Average % of Light Transmitted	*morning*	*mid-day*
Mean	62.667	50.862
Variance	931.5929344	934.6476178
Observations	10	10
Pearson Correlation	0.842552755	
Hypothesized Mean Difference	0	
df	9	
t Stat	2.177775419	
P(T<=t) one-tail	0.028691044	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.057382088	
t Critical two-tail	2.262157163	

t-Test: Paired Two Sample for Means

Average % of Light Transmitted	*morning*	*afternoon*
Mean	62.667	63.972
Variance	931.5929344	646.0438844
Observations	10	10
Pearson Correlation	0.580104632	
Hypothesized Mean Difference	0	
df	9	
t Stat	-0.158539396	
P(T<=t) one-tail	0.438766091	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.877532183	
t Critical two-tail	2.262157163	

t-Test: Paired Two Sample for Means

Average % of Light Transmitted	*mid-day*	*afternoon*
Mean	50.862	63.972
Variance	934.6476178	646.0438844
Observations	10	10
Pearson Correlation	0.679351845	
Hypothesized Mean Difference	0	
df	9	
t Stat	-1.809530752	
P(T<=t) one-tail	0.051906001	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.103812003	
t Critical two-tail	2.262157163	

CONCLUSION

The hypothesis for wind speed and temperature was partially supported by the data. As the day went on, the temperature and wind increased over the morning, however the afternoon winds averaged 0.85Km/H less than the Mid-Day average. **The hypothesis for AOT readings was also only partially supported by the data.** As the day went on, the AOT readings increased from the morning to the Mid-Day average, but the AOT decreased in the afternoon, resulting in a higher percentage of sunlight in the afternoon than in either the morning or mid-day.

DISCUSSION

The researchers learned that there are more factors which affect wind speed and temperature than just aerosol optical thickness and sunlight. Barometric pressure, the amount of humidity in the atmosphere, and the temperature of the different layers of the atmosphere also play a large role in determining what the overall weather is in any given area at a particular time. In the future, the researchers would like to conduct a more extensive data collection study using GLOBE protocols over different seasons to gain a better understanding of the world they live in.

ACKNOWLEDGEMENT

The researchers were assisted in their project by their teacher, Mr. Rose. He trained them how to use the *CALITOO* sun photometer, the digital anemometer and digital thermometer. They were also instructed in the how to collect the data according to the GLOBE protocols. Mr. Rose also showed the researchers how to use the computer program to conduct a statistics t-Test to help analyze their data.

REFERENCES/BIBLIOGRAPHY:

Boucher, Olivier, et al. "Clouds and Aerosols." *Climate change 2013: the physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, 2013. 571-657.

Brooks, David R., and Forrest M. Mims. "Development of an inexpensive handheld LED-based Sun photometer for the GLOBE program." *Journal of Geophysical Research: Atmospheres* 106.D5 (2001): 4733-4740.

Brooks, David R. "Scientist-Teacher-Student Partnerships for Aerosol Optical Thickness Measurements in Support of Ground Validation Programs for Remote Sensing Spacecraft." *54th International Astronautical Congress of the International Astronautical Federation, the International Academy of Astronautics, and the International Institute of Space Law*. 2003.

Butler, Dixon M., and Ian D. MacGregor. "GLOBE: Science and education." *Journal of Geoscience Education* 51.1 (2003): 9-20.

Calitoo, Oct 3, 2016 - *CALITOO*. SunPhotometer. *User Manual*. October 2016. 21, avenue de Fondeyre - 31200 TOULOUSE CEDEX - FRANCE. Tél. : 05 62 24 48 92 ...
retrieved from the Internet on 10/21/2018 at
www.calitoo.fr/uploads/documents/en/usermanual_2016_en.pdf

Justus, C. G., et al. "Methods for estimating wind speed frequency distributions." *Journal of applied meteorology* 17.3 (1978): 350-353.

King, Michael D., et al. "Cloud and aerosol properties, precipitable water, and profiles of temperature and water vapor from MODIS." *IEEE Transactions on Geoscience and Remote Sensing* 41.2 (2003): 442-458.

Kolb, C. E., et al. "An overview of current issues in the uptake of atmospheric trace gases by aerosols and clouds." *Atmospheric Chemistry and Physics* 10.21 (2010): 10561-10605.

McClatchey, Robert A., et al. *Optical properties of the atmosphere*. No. AFCRL-72-0497. AIR FORCE CAMBRIDGE RESEARCH LABS HANSCOM AFB MA, 1972.

Paulson, Ca A. "The mathematical representation of wind speed and temperature profiles in the unstable atmospheric surface layer." *Journal of Applied Meteorology* 9.6 (1970): 857-861.

Rodgers, Clive D. "Retrieval of atmospheric temperature and composition from remote measurements of thermal radiation." *Reviews of Geophysics* 14.4 (1976): 609-624.

Toledo, F., et al. "AOT Retrieval Procedure for Distributed Measurements With Low-Cost Sun Photometers." *Journal of Geophysical Research: Atmospheres* 123.2 (2018): 1113-1131.