An Analysis of Autumn Cloud, Land, and Water Measurements at a Campus in Southeastern Michigan

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Abstract:

In this research, the researchers examined the relationship between **surface temperature**, **water temperature**, **cloud coverage**, and other atmospheric parameters in Dearborn Heights, Michigan. Researchers collected daily **surface temperature** measurements at two school

campus sites using an **infrared thermometer.** In addition, **water temperature** was recorded in a courtyard pond using a **Vernier temperature probe**. Furthermore, parameters such as air temperature, barometric air pressure, and humidity were gathered using the WeatherBug app. Over 74 days, trends indicated a steady decrease in surface and water temperatures as the season shifted from late summer to winter. **Surface temperature** and **water temperature** showed a direct correlation with water cooling at a slower rate due to its higher heat capacity. A strong relationship was also found between **surface temperature** and ambient air temperature. However, no significant correlation was observed between **cloud coverage** and **surface temperature**, suggesting other environmental factors play a more dominant role in comparing these parameters. Humidity and **cloud coverage** demonstrated a complex relationship, with high **cloud coverage** generally corresponding to increased humidity, but varying patterns when **cloud coverage** was low. Potential errors in data collection included environmental variability, sensor placement, and occasional gaps in daily measurements. This data leads to understanding seasonal climate variations on a local scale and highlights the need for further research to refine methods and expand study periods. The researchers suggest to add more parameters such as UV, particulate matter, or wind speed in order to fully capture the capacity of the changing environment.

Key Words: Surface temperature, water temperature, cloud coverage, infrared thermometer, Vernier temperature probe

Research Questions:

1. How do land surface and water temperature data vary from late summer to late fall?
2. How does cloud coverage affect surface temperatures in the fall?
3. How does surface temperature relate to ambient air temperature throughout the fall?

Null Hypotheses:

1. There is no correlation between the surface and water temperature.
2. There is no correlation between the cloud coverage and the humidity.
3. There is no correlation between surface temperature and ambient air temperature throughout the fall.

Introduction and Review of Literature:

Michigan has experienced a noticeable climate shift over the past 60 years. Even as seasons overall are warming, there is still considerable variation from year to year (Thomson and Stanberry, 2024). One of the most evident shifts is the lengthening of summers and the shortening of winters. These seasonal changes have mixed effects on insect populations as some species benefit from the extended warm season, while others face challenges as their reproductive cycles are disrupted.

Beyond ecological impacts, these shifts also pose health concerns, particularly due to insect-borne diseases. Warmer temperatures and increased humidity can create favorable conditions for vectors such as mosquitoes and ticks, raising the risk of disease transmission (Thomson and Stanberry, 2024). Additionally, "variations in LST influence atmospheric temperature and moisture at a local scale—while affecting the convective environment and precipitation processes over a much larger spatial scale" (Wang et al., 2022). This means that warming lake surface temperatures do not just impact Michigan's lakes directly but also contribute to broader atmospheric instability. However, studying these changes on a smaller scale is essential to understanding their localized effects on organisms. Unlike broad climate assessments, small-scale studies provide detailed insights into how specific populations are adapting or struggling with these environmental changes. Notably, most research tends to focus on spring and summer, leaving a gap in understanding the effects of climate change during the fall.

As Michigan's climate continues to change, balancing urban growth with environmental preservation is more important than ever. Michigan is among the leading U.S. States in land conversion from natural to urbanized uses and also in overweight prevalence (Vojnovic et al. ,2005). Rising temperatures, shifting precipitation, and habitat loss are already disrupting ecosystems and affecting both wildlife and human health. Protecting natural landscapes like forests and farmland helps regulate temperatures, maintain water cycles, and support biodiversity, but without action, these benefits will decline (Mumtaz, 2023). This research is especially urgent because it focuses on the understudied fall season, a critical period when many species either adapt to changing conditions or struggle to survive. Understanding these local impacts allows us to track changes, predict future challenges, and develop strategies to protect ecosystems and public health before the effects become irreversible.

Materials and Methods

Surface temperature data was collected daily at two sites on a school campus using GLOBE Program protocol. This data was transferred from the field data sheet to the GLOBE database. Other weather parameters that were collected include the following: sky coverage (%), ambient air temperature (C°), humidity (%), and barometric air pressure (mb). These were recorded using the WeatherBug app that collects data in real time directly from the researcher's Earth Network weather station that is mounted on the roof the school. Surface temperature (C°) was collected using a Raytech infrared thermometer. Nine random locations were used to collect these measurements daily. A Vernier temperature probe (C°) was used to collect hydrology measurements in the school's courtyard pond daily.

Data collection occurred daily at 2:30pm between September 30, 2024 to December 20, 24. A total of 74 days of data were collected. The research results were compiled into an Excel spreadsheet, where graphs were created to visually represent the data. The data was then uploaded to the GLOBE database to share the findings with others conducting similar research.

Figure 1 and 2. Infrared Thermometer. Figure 1 (left) is a close-up image of the Elekcity Infrared Thermometer Laser Temperature Gun 774. Figure 2 (right) shows a student researcher using the infrared thermometer to record surface temperature measurements.

Figure 3 and 4. Water Thermometer. Figure 3 (left) is a close-up picture of the Vernier Temperature Probe. Figure 4 (right) is a student researcher demonstrating how they are collecting water temperature measurements with the water thermometer.

Figure 5 and 6. Research Site. Figure 5 shows site #1 of the research sites, an overview of where the researchers recorded their data at Crestwood High School, Dearborn Heights, Michigan, USA. Latitude 42.19, Longitude -83.17, elevation 216.3 meters. The red square shows where all nine spots of surface temperature were recorded at. The figure on the right (6), displays the area where the researchers recorded surface temperature measurements, viewed from the ground.


Figure 7 and 8. Additional Research Site. Figure 7 shows site #2 of the research sites, it is the researcher's school's courtyard pond at Crestwood High School, Dearborn Heights, Michigan. Latitude 42.19, Longitude -83.17, elevation 216.3 meters. The red marker shows where all three spots of water temperature were recorded. The image on the right displays the area where the researchers recorded water temperature measurements, viewed from the ground.

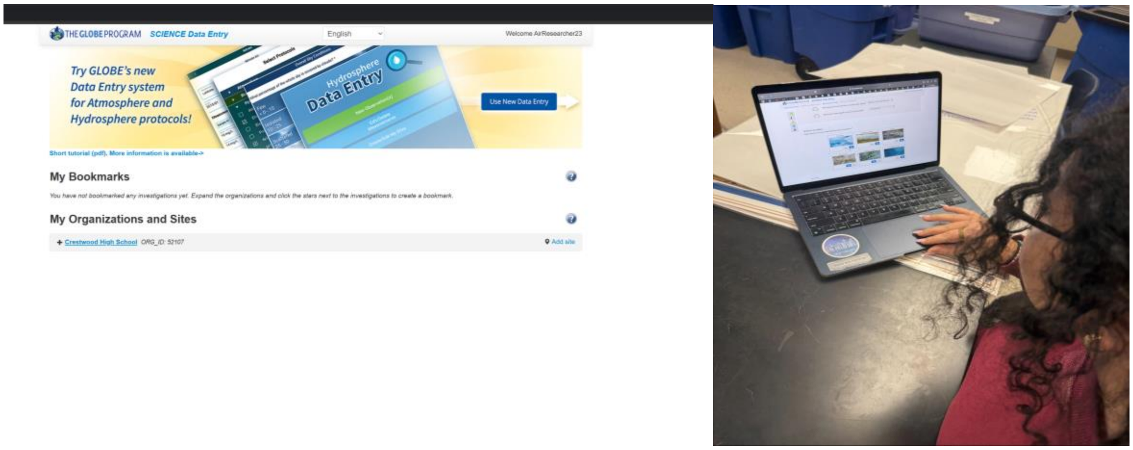

Figure 9 and 10. Data Entry. The researchers input their parameters into the GLOBE website, under the "SCIENCE Data Entry" area. These parameters include air temperature, surface temperature, water temperature, barometric pressure, relative humidity, cloud coverage, and the site's overall condition. This data was then analyzed thoroughly to determine correlations between certain parameters.

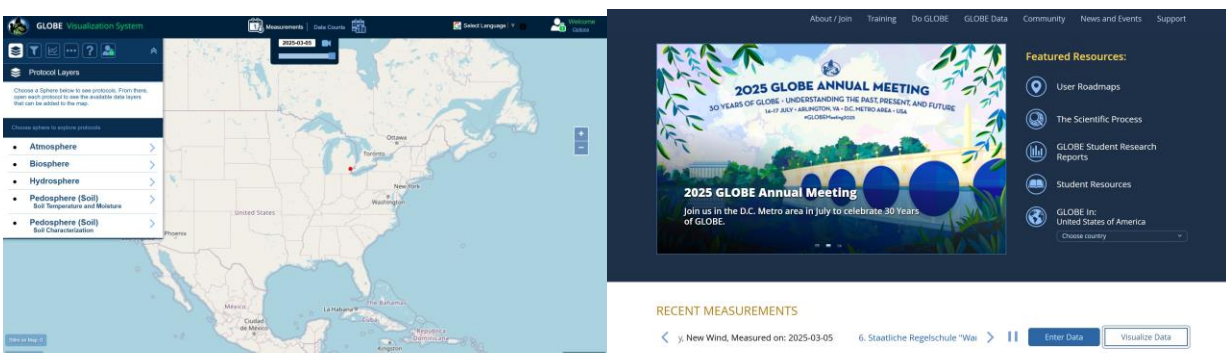

Figure 11 and 12. Globe Visualization Page. The image above shows the researchers' data points using the GLOBE Visualization Page.

Data Summary:

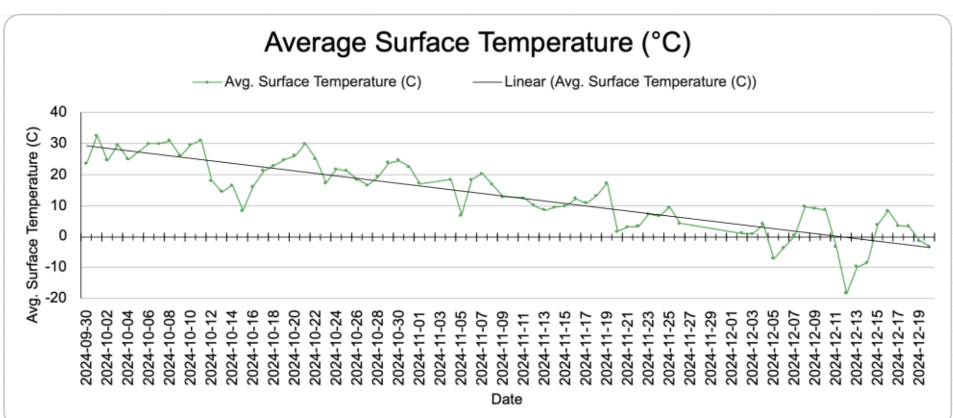

Figure 13. Average Surface Temperature (C°) Over Time. The line graph above shows the average surface temperature with a downward trend over time. The R-value of about –0.86 indicates a strong negative correlation. With this, the researchers concluded that the surface temperature steadily decreases, with little fluctuations.

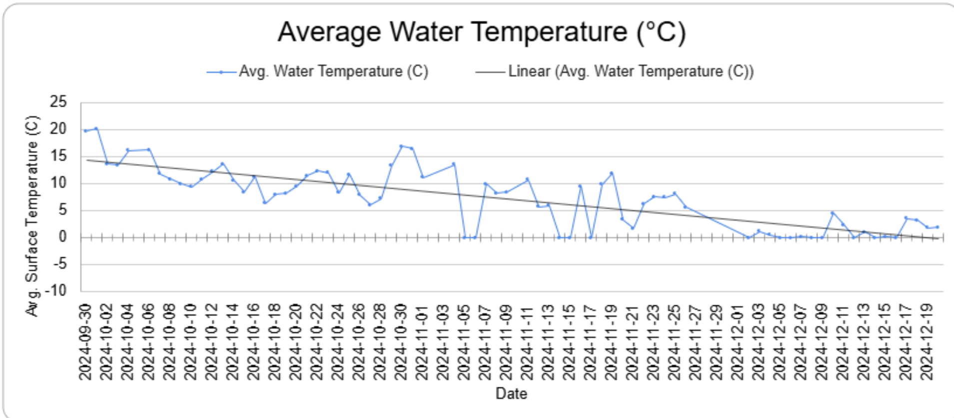

Figure 14. Water Temperature (C°) Over Time. The line graph above shows the line of best fit which shows the overall trend of average water temperature over time. It decreases steadily as the colder days appear, however there are some minor fluctuations.

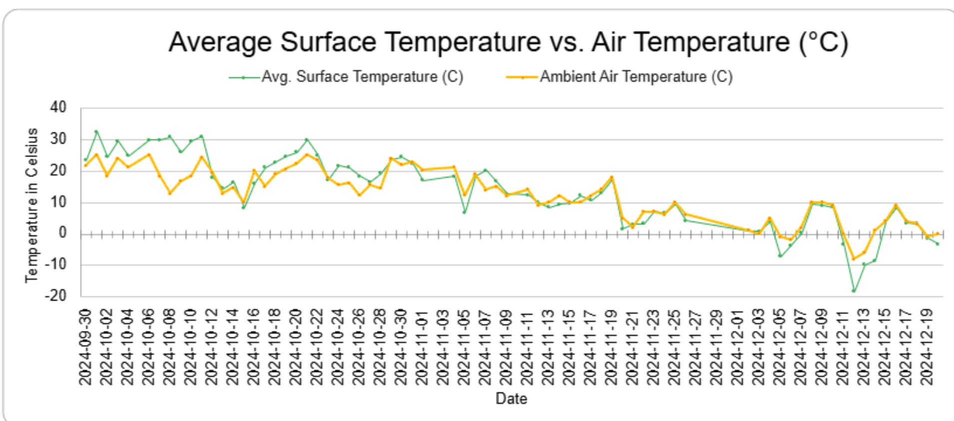

Figure 15. Surface Temperature (C°) vs. Ambient Air Temperature (C°). The graph shows a direct relationship between surface temperature and ambient air temperature over time. When the air temperature is high, the surface temperature is also high, and both are following a similar decreasing trend. There are some fluctuations, but it is seen that the two variables are closely correlated.

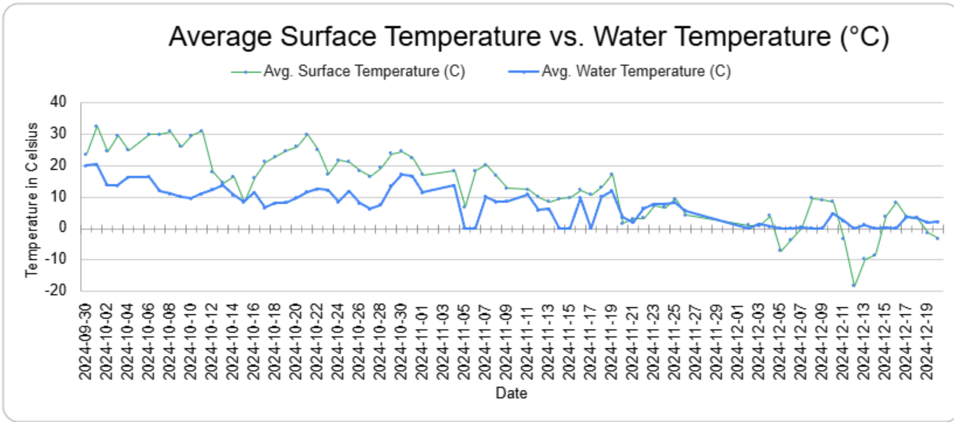

Figure 16. Surface Temperature (C°) vs. Water Temperature (C°). The graph shows a direct relationship between surface temperature and water temperature over time. When the surface temperature is high, the water temperature is relatively high, though it remains consistently lower than the surface temperature. On colder days, there were lower fluctuations.

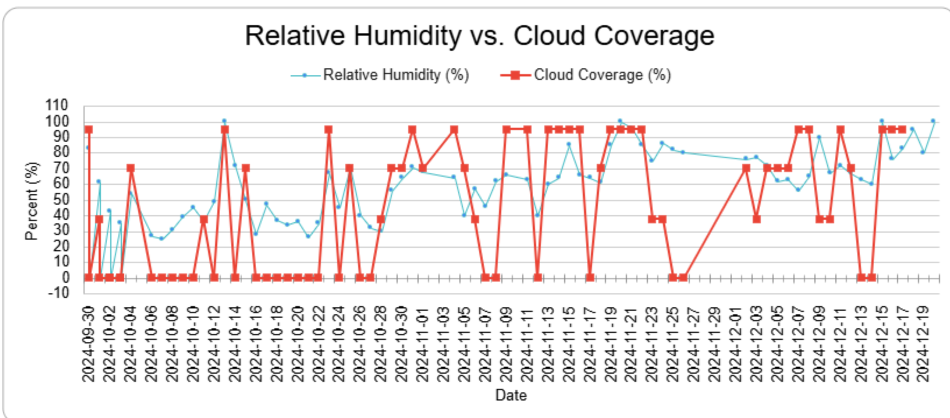

Figure 17. Relative Humidity vs Cloud Coverage. The line graph above shows the percentage of cloud coverage and percentage of relative humidity, having a direct proportion when cloud coverage is high. However, there is an inverse proportion present when the cloud coverage is low.

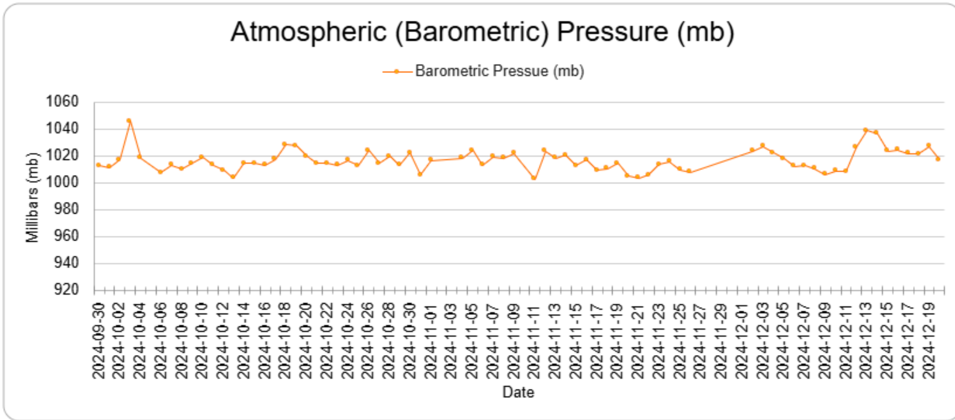

Figure 18. Barometric Air Pressure (mb) with Dates. The line graph shows atmospheric (barometric) pressure over time, with relatively stable values and minor variations/fluctuations. As you can see, it averaged at around 1015 mb, as the pressure remains constant throughout the researchers' measurements.

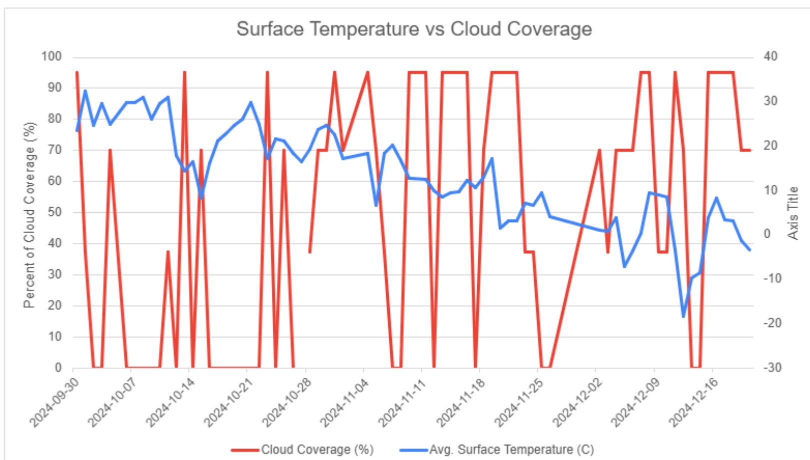

Figure 19. Surface Temperature vs Cloud Coverage. The line graph shows surface temperature steadily decreasing as the days get colder. However, cloud coverage fluctuates throughout the whole research recordings of 74 days. As you can see, there seems to be no correlation between these two parameters.

Analysis and Results:

Surface temperature directly correlates with two of the parameters the researchers measured. One of these parameters, include water temperature. As shown in Figure 16, surface temperature and water temperature have a direct relationship. The researchers found that as surface temperature decreases during the fall, the average water temperature also decreases. This is a result of reduced solar radiation and increased heat loss to the atmosphere. This pattern suggests that heat from the air and water interact causing water temperature to change, in response to surface conditions. Water temperature stays lower than surface temperature but still follows the same trend, making them directly proportional. This leads to the rejection of the first null hypothesis, which stated that there is no correlation between surface temperature and water temperature, as the findings indicate otherwise.

The other parameter that was also had a direct relationship with surface temperature, was ambient air temperature. As shown in Figure 15, ambient air temperature follows a similar pattern to surface temperature, meaning that as air temperature decreases, surface temperature also decreases. The researchers can conclude that air temperature plays a major role in influencing surface condition, with cooling air leading to steady loss of heat. This led the researchers to reject the third null hypothesis.

Humidity levels have an inverse relationship with surface temperature. As temperature gets colder, humidity levels tend to rise and stabilize. Cold air has a lower capacity to retain water vapor, leading to the higher relative humidity. As a result, there was more weather variations like fog or precipitation.

As the researchers compared Figure 13 and 18, barometric air pressure and surface temperature show no correlation between each other. Surface temperature has a strong downward pattern with fluctuations, while barometric pressure has a relatively stable pattern with little fluctuations. The lack of a consistent relationship between these two parameters, suggests that changes in surface temperature do not directly influence barometric air pressure. This tells the researchers that other environmental factors likely affect each variable independently.

In Figure 17, the researchers suggested that there is a relationship between relative humidity and cloud coverage, where high cloud coverage generally corresponds to high humidity, showing a direct proportion. However, when cloud coverage is low, humidity doesn't have the same pattern, sometimes increasing or remaining stable, suggesting an inverse proportion. This tells us that while cloud coverage and humidity are somewhat correlated, other atmospheric factors may influence their relationship. The researchers concluded to reject the second null hypothesis. As in Figure 19, there is no clear correlation between cloud coverage and surface temperature. While clouds can block sunlight and trap heat at night, other factors like seasonal changes, wind, and humidity also have a huge influence. The fluctuations in both variables suggest surface temperature does not consistently respond to cloud coverage.

Possible errors in our data can be connected to outside environmental factors. This includes wind, precipitation, or sensor placement, which could have introduced inconsistencies in surface temperature and water temperature readings. The researchers could have made errors in interpretation data, analyzing types of cloud and cloud coverage, incorrect sensor placement, or gaps in data set of days missed. In addition, the researchers could have expanded their data collection by taking temperatures at night. By only taking temperature readings at 2:30pm, the researchers are limited in drawing connections to temperature affects during other periods of the day, including night time readings.

GLOBE Data Analysis:

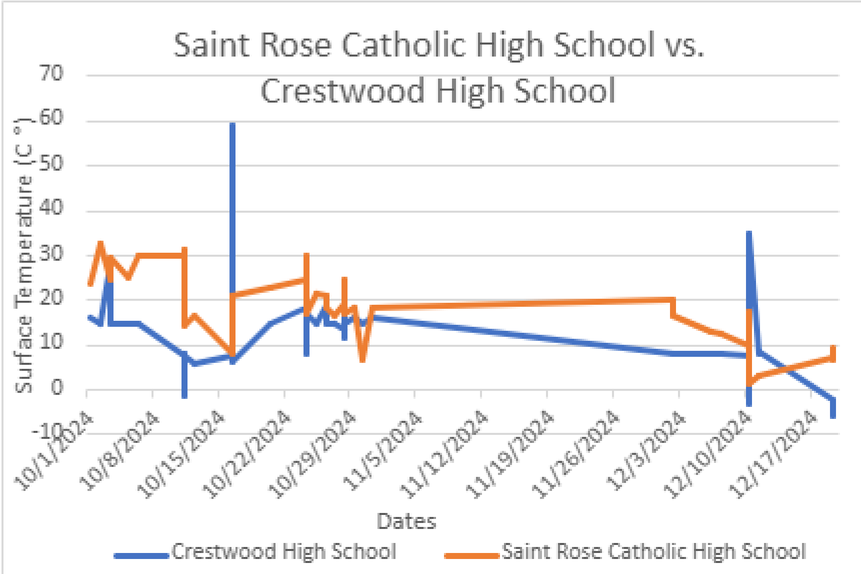

Figure 20. Saint Rosa Catholic High School vs. Crestwood High School. The line graph compares both schools in surface temperature, indicating a steady direct relationship. This direct relationship shows a decrease in surface temperature as the days appear.

The researchers compared their surface temperature data from Saint Rose Catholic High School in Girard, Ohio, and Crestwood High School in Dearborn Heights, Michigan. Both locations experienced cooling temperatures from late summer to early winter. There was a strong correlation between the surface temperature findings at both sites, suggesting that temperature patterns were consistent despite being in different regions. Analyzing these patterns helps determine whether temperature changes are consistent across regions or influenced by local factors such as humidity and precipitation.

A key difference between the two locations is the influence of Great Lakes weather patterns. Dearborn Heights is more affected by lake-effect precipitation, which can increase cloud coverage and humidity. If temperature trends remain similar despite these differences, it suggests a broader seasonal pattern.

Both measurements were taken on a grassy field site, minimizing variability caused by differences in land cover, ensuring that temperature changes are primarily influenced by atmospheric conditions rather than surface type. The findings suggest that while large-scale seasonal temperature shifts follow a predictable pattern, short-term variations are influenced by local factors such as humidity, wind patterns, and precipitation.

Conclusion:

Using an Infrared Thermometer and a Vernier Temperature Probe, the researchers were able to collect land surface and water surface temperatures. With the data collected researchers were able to observe the gradual decrease in temperatures from the fall to winter seasons. After gathering data, researchers concluded that from late summer to late fall, land surface and water temperature both experience a decline in temperature. These declines in temperature, originate from a decrease in altitude of the sun due to the sun rising further south of east as autumn progresses, resulting in gradual decrease in angle of insolation Michigan receives. As we enter the fall, the decrease in direct sunlight causes a significant decrease in surface temperatures due to longer nights and shorter daylight, resulting in longer cooling periods. Water temperatures start to show a decrease slower than surface temperature due to waters higher heat holding capacity. This data is supported by the following: “As water bodies have a greater specific heat capacity compared to other physical objects, its warming-up rate is slower than other materials, resulting in the cool island effects during the daytime” (Wu and Zhang, 2019). In addition, the researchers found that as the season changed from late summer to fall, surface temperatures began to decrease. This observation is supported by the following: “The ongoing changes in the Earth’s climate have been associated with changes in the timing and duration of the seasons, and many ecological and physical systems have been disrupted” (Alghamdi, 2023). Increased cloud coverage affects surface temperature in the fall by limiting the intensity of sunlight reaching Earth’s surface during the day. Over time, surface temperature and ambient air temperature vary daily throughout the fall. Gradually over time cooler temperatures result in an overall decline in temperature. Surface temperatures are generally affected more than ambient air temperatures throughout the fall due to the primary source of surface temperature coming from solar radiation. Ambient air temperatures are changed more drastically by weather conditions than by the amount of sunlight Earth is receiving. Further research should be conducted to more fully understand the impact changes in seasons have on surface and water temperatures. This research could be improved by expanding our study period and taking data multiple times throughout the day rather than one specific time.

Discussion

This research provides evidence regarding how surface temperature, water temperature, cloud coverage, and atmospheric conditions interact during the change from late summer to winter in southeastern Michigan. By analyzing these parameters, the researchers developed a better understanding of seasonal changes on a local micro level scale.

To improve data accuracy and validity, several adjustments should be made. Extending data collection through winter and spring would provide a more complete view of seasonal trends, for example, when does fall begin each year and when does it end (in terms of weather conditions?). Collecting data at multiple times during the day, other than only at 2:30 PM local time, could document temperature fluctuations in greater detail. Expanding data collection beyond the school campus to other local could allow for comparisons between varying environments. Multiple recording sites could highlight how different land might impacts temperature changes. More unique measuring tools, such as pyranometers for solar radiation and anemometers for wind speed, could provide additional data to explain temperature and cloud variations more thoroughly. Observing night temperature patterns would also provide insights into how clouds influence heat retention.

The findings of this study have some applications beyond the classroom. Understanding local climate variations can help communities prepare for seasonal changes and address climate-related challenges such as the flooding some cities experience during intense rainfall events. These results may help urban planners develop strategies to address urban heat island effects by planting more vegetation and install more permeable surfaces. Insights on how water bodies regulate temperature could aid environmental management, especially for aquatic ecosystems.

Future research could expand on these findings in several ways. Studying how snow affects surface and water temperatures would provide more seasonal insights. A multi-year study could reveal long-term climate trends in Michigan. Comparing areas with different vegetation levels could show how plants regulate temperature. This could then connect to insects and animal species living in or around these areas. Expanding the study to other regions and climates would determine if these patterns are unique to Michigan. Researching how air pollution affects cloud coverage and temperature trends could offer insight into urban environmental factors. Lastly, examining land use and industrial activity could help identify human-driven climate impacts.

This study effectively demonstrated the relationships between land and water temperatures, cloud coverage, and atmospheric conditions throughout autumn. However, refining data collection methods and expanding research areas could overall enhance the research data. By expanding the study's view and adding other techniques, future research can deepen our understanding of local and global climate patterns.

Acknowledgments:

The researchers collaborated with their AP Environmental Science teacher, GLOBE Advisor, and Science Club Advisor, Mrs. Diana Johns. Throughout the research, Mrs. Johns provided guidance on climate patterns and data collection methods. Mrs. Abbas, NHS co-advisor and co-adviser of science club, has also supported this research in guidance for writing the research project. With support from their mentors, the researchers gained a deeper understanding of the long-term significance and potential impact of their study. Dr. Czyjkowski and Mr. David Bydlowski from GLOBE NASA Mission Earth and the GLOBE NASA AREN Program were also instrumental in providing us with much needed equipment to complete this research.

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Appendix:

Date	Average surface temperature (degrees C)
10/1/2024	16
10/2/2024	15
10/3/2024	28.4
10/3/2024	15
10/5/2024	15
10/6/2024	15
10/11/2024	7.8
10/11/2024	7.2
10/11/2024	8.1
10/11/2024	5.7
10/11/2024	-1.3
10/11/2024	7.4
10/11/2024	7.7
10/12/2024	5.8
10/16/2024	7.7
10/16/2024	59
10/16/2024	6.4
10/20/2024	15
10/24/2024	18.5
10/24/2024	12.9
10/24/2024	8.3
10/24/2024	17.9
10/24/2024	17
10/25/2024	15
10/26/2024	19
10/26/2024	15
10/27/2024	15
10/28/2024	13.6
10/28/2024	16
10/28/2024	13.5
10/28/2024	11.8
10/28/2024	15
10/27/2024	15
10/28/2024	13.6
10/28/2024	16
10/28/2024	13.5
10/28/2024	11.8
10/28/2024	15
10/29/2024	16
10/30/2024	15
10/31/2024	16
12/2/2024	8.2
12/2/2024	8.2
12/6/2024	8.1
12/7/2024	8.2
12/10/2024	7.6
12/10/2024	-1.2
12/10/2024	4.4
12/10/2024	5.2
12/10/2024	8.3
12/10/2024	4.4
12/10/2024	6.4
12/10/2024	-3.2
12/10/2024	35.1
12/11/2024	8.1
12/11/2024	8.7
12/19/2024	-2.3
12/19/2024	-5.9
12/19/2024	-3

Figure 21. Saint Rosa Catholic High School Surface Temperature Data. This data was collected by student researchers at Saint Rosa Catholic High School in Girard, Ohio. The researchers in this study created graphs from this data to analyze comparisons between the two locations.

Badges:

I am a Data Scientist

The researchers hope to receive the "I am a Data Scientist" badge for their efforts in collecting and organizing data using the Infrared thermometer, Vernier water probe, and the Weather Bug app. The researchers collected 74 days of data, starting in the fall and ending in the mid-winter season. The data the researchers have gathered over this period of time was then put into an Excel sheet to create graphs. The researchers analyzed these graphs to determine the correlations they had with one another. After thorough analyzation, the researchers compared their results to St. Rosa Catholic School, noting correlations that existed. Although graphs were made and compared, there were some limitations in the two school's research. Firstly, all data was collected during daytime at the same time each day. Additionally, the censor placement interpretation of data by the researchers could have errors. Finally, there were gaps in the data set in the days the researchers missed. To further the research in the future, these errors should be avoided by staying consistent and precise with the measurements each day.

I Make an Impact

The researchers hope to receive the "I Make an Impact" badge as their research can make a beneficial difference for their school and community. By studying how surface temperature, water temperature, and atmospheric conditions interact during seasonal changes, this research provides valuable insights for urban planning and environmental management in Southeastern Michigan. Locally, the findings can help mitigate urban heat island effects by promoting increased vegetation and sustainable infrastructure. Understanding how water bodies regulate temperature is also crucial for protecting aquatic ecosystems and managing climate-related challenges in the region. The researchers plan on presenting their findings to the city's local watershed commission, which could help the commission strategize more sustainable plants for our city's rain gardens so they can last longer in order to minimize flooding. This research contributes to global climate studies by analyzing how land and water surfaces interact with atmospheric conditions. The findings can be applied to similar environments worldwide, helping scientists and policymakers develop strategies to address climate change. Through continued research and data collection, the project has the potential to influence environmental policies and inspire future scientific exploration.

I am a Problem Solver

The researchers hope to earn the "I am a Problem Solver" badge because of their efforts in identifying possible solutions to the problems in their community. By analyzing seasonal changes in surface and water temperatures, humidity, and cloud coverage, the researchers aim to enhance local understanding of climate patterns. The research highlights the need for improved urban planning strategies, such as increasing green spaces to militate temperature fluctuations and better flood management to address seasonal precipitation changes. Additionally, the researchers' findings on water temperature variations emphasize the importance of protecting aquatic ecosystems, as colder water holds more dissolved oxygen, benefiting fish populations.

Through this research, the researchers advocate for more comprehensive data collection methods to improve climate monitoring at the local level. They suggest expanding research to include night time temperature measurements and additional environmental parameters such as wind speed and solar radiation. These efforts can help communities make decisions about climate adaptation and sustainability. The researcher's work aligns with Earth system science principles by demonstrating how interconnected environmental factors influence local ecosystems, reinforcing the importance of continued research and action to support a better world.