An Analysis of Various Atmospheric Conditions during a LaNina Winter in Southeastern Michigan

Student Researchers:

Elissa Hadla, Renee Harp, Lana Ibrahim, Mariam Nasser

School:

Crestwood High School Dearborn Heights, MI 48127

Teacher:

Ms. Lina Abbas

January 23, 2026

Table of Contents

Abstract

In this research, researchers examined the relationship between **surface temperature**, **snow depth, cloud coverage**, **sky visibility**, and other atmospheric parameters in Dearborn Heights, Michigan. Researchers collected daily **surface temperature** and **snow depth** measurements at a school campus using an **infrared thermometer** and **meter stick.** In addition, **sky visibility** was recorded at an intersection, taking a picture of the Detroit skyline. Furthermore, parameters such as **air temperature**, **barometric air pressure**, and **humidity** were obtained using the

WeatherBug app associated with our school's Weather Networks weather station. In addition, PM was recorded using our school's PurpleAir device. Over 20 days, trends indicated a steady decrease followed by an upward trend in **surface** and **air temperatures** in the winter. A strong relationship was also found between **surface temperature** and **ambient air temperature. PM** values are typically higher during low pressure conditions and lower during high pressure conditions, which may also influence the observed trends shown. **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. **Barometric pressure** and **sky visibility had** an inverse relationship. As **visibility** increased, **pressure** decreased. Potential errors in data collection included environmental variability, 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 adding more parameters such as dew point to fully capture the capacity of the changing environment.

Key Words: Surface temperature, Cloud coverage, Humidity, Sky visibility, Barometric Pressure, PM, Snow Depth, Infrared Thermometer, and Meter Stick.

Research Questions:

1. What relationship exists between barometric pressure and air temperatures during a late December winter in Southeastern Michigan?

2. What relationship exists between temperature and sky visibility during a late December winter in Southeastern Michigan?

3. What relationship exists between cloud cover and relative humidity during a late December winter in Southeastern Michigan?

Null Hypotheses:

1. There is no correlation between barometric pressure and air temperature in the winter.
2. There is no correlation between temperature and sky visibility in the winter.
3. There is no correlation between cloud cover and relative humidity with sky visibility in the winter.

Introduction and Review of Literature:

Southeastern Michigan has been experiencing more variable winter weather in recent years, with winters generally becoming shorter but with more severe weather extremes. Human influence leading to Arctic warming has been implicated as a possible reason for this - "human influence on the Antarctic circulation is detectable in the strengthening of the stratospheric polar vortex and the poleward shift of the tropospheric westerly winds" (Screen et al., 2018), which has contributed to bitter cold winter conditions shifting south more frequently. Frequent LaNina episodes have also contributed to winters that are wetter, contributing to increased snowfall (NOAA, 2024).

As the region continues to urbanize, the effects of climate change are amplified by urban heat islands, where natural land is replaced with concrete and buildings, causing local temperatures to rise, exacerbating climate change in the area. Michigan has also been experiencing an increase in extratropical cyclones, which are large storm systems that form outside of the tropics. These cyclones bring intense weather, including cold-air outbreaks, heavy snowfall, and milder temperatures, all of which vary widely from year to year in the Great Lakes Region, despite overall warming trends (Hutson et al., 2024). Additionally, an "increase in jet stream waviness has, controversially, been linked to unusually rapid warming in the Arctic and has been thought to foreshadow a rise in extreme weather as climate change progresses" (Chalif et al., 2025).

These shifts affect both local ecosystems and public health. Shorter, harsher winters disrupt wildlife habitats, alter animal migration patterns, and affect food sources. Warmer temperatures are also creating conditions favorable for the spread of diseases and protective conditions for invasive species to thrive (Kiefer et al., 2024). This research is particularly important as it looks at what variability might exist within a larger regional area. As Michigan's climate becomes more unpredictable, understanding these changes may affect what local adaptation strategies cities will need to develop and implement to minimize damage from extreme winter weather events.

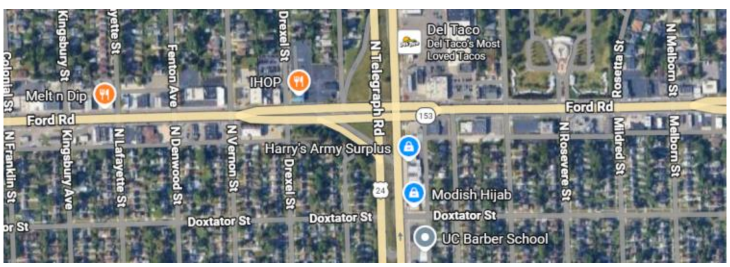
Materials and Methods

Over the course of about three weeks, researchers used GLOBE protocols to collect surface temperature, snowfall depth, air temperature, barometric pressure, relative humidity, wind speed, visibility, and cloud cover on the Crestwood High School campus. A PurpleAir device permanently mounted at school was used to record levels of particulate matter. Surface temperature was recorded at the GLOBE designated site in front of the school. On the site, nine random locations were used to record measurements of surface temperature (in Celsius) using the Raytech Infrared Thermometer. Those same nine locations were also used to measure the snow depth (in millimeters) using a meter stick and determined if the site's condition was either dry, wet, or snowy. Other weather parameters that were collected include the following: sky cloud coverage (%), ambient air temperature (C°), humidity (%), wind speed (mph), 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 of the school. Then, the researchers visited the PurpleAir website to collect the amount of PM2.5 (AQI) and PM1.0 (AQI) recorded at the same site in front of the school. Next, because the school site is flat and heavily built up, the researchers drove down a close main road to measure the visibility of Detroit skyline. Data collection occurred daily, after an hour of solar noon, ranging from 1:30-2:00pm between December 19, 2025, to January 9, 2026. A total of 20 days (about 3 weeks) of data were collected. The data was then uploaded to the GLOBE database to share the findings with others conducting similar research. All data was input into an Excel spreadsheet, where graphs were created to visually represent the data.


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. Meter Stick. Figure 3 (left) is a close-up picture of the meter stick. Figure 4 (right) is a student researcher demonstrating how they are properly collecting snow depth measurements, in millimeters, with the meter stick.

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.



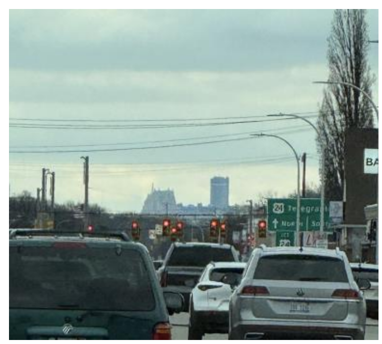
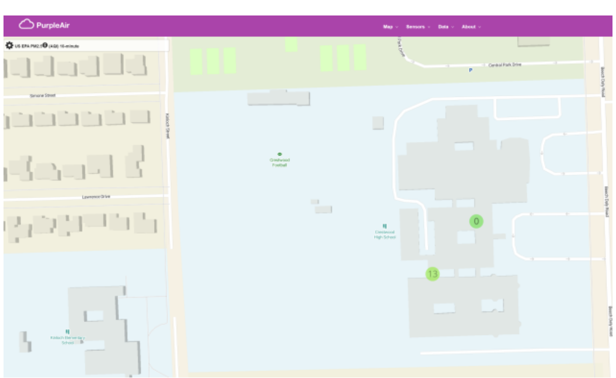


Figure 7 and 8. Additional Research Site. Figure 7 shows site #2 of the research sites, an overview of where the researchers photographed their data at the intersection of Ford Rd. and Telegraph Rd., Dearborn Heights, Michigan, USA. Latitude 42.3167, Longitude -83.2965, elevation 191 meters. The red square shows where the researchers took a picture from their phone and inserted it into the GLOBE database. The figure to the right (8) displays the area where the researchers took a photo at the surface level.



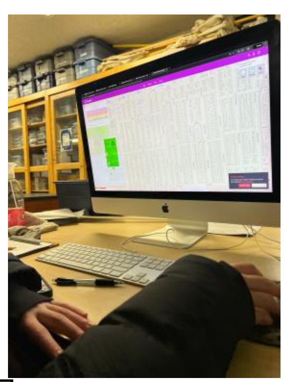


Figure 9 and 10. Website Data Collection. Figure 9 shows the PurpleAir Map on the site in front of the school, using Crestwood's satellite, to accurately collect measurements of PM2.5 and PM1.0. Figure 10 shows a student researcher analyzing the map to accurately gather the measurements.

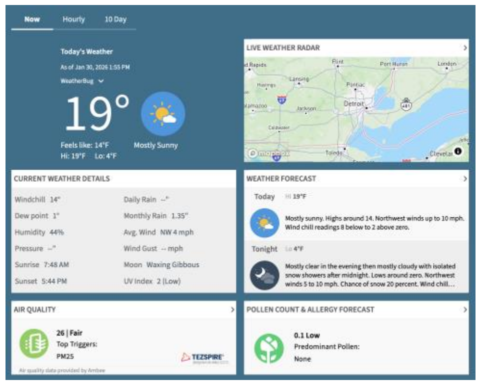
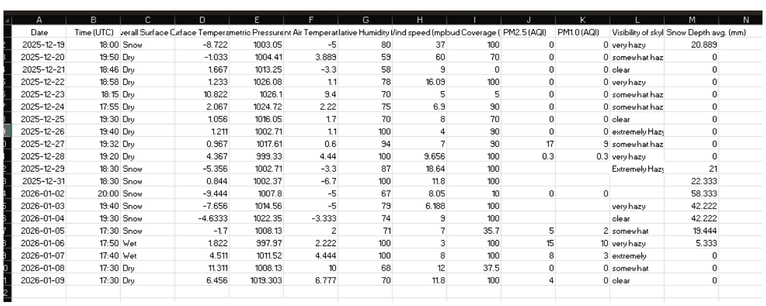


Figure 11. Weather Network Collection. Figure 11 shows the WeatherBug open to show how the researchers extracted data for their sky cloud coverage (%), ambient air temperature (C°), humidity (%), wind speed (mph), and barometric air pressure (mb) measurements.



Date	Time (UTC)	verall Surface C	urface Tempera	metric Pressure	nt Air Temperat	lative Humidity	Vind speed (mp	oud Coverage (	PM2.5 (AQI)	PM1.0 (AQI)	Visibility of sky	Snow Depth avg. (mm)
2025-12-19	18:00	Snow	-8.722	1003.05	-5	80	37	100	0	0	very hazy	20.889
2025-12-20	19:50	Dry	-1.033	1004.41	3.889	59	60	70	0	0	somewhat haz	0
2025-12-21	18:46	Dry	1.667	1013.25	-3.3	58	9	0	0	0	clear	0
2025-12-22	18:58	Dry	1.233	1026.08	1.1	78	16.09	100	0	0	very hazy	0
2025-12-23	18:15	Dry	10.822	1026.1	9.4	70	5	5	0	0	somewhat haz	0
2025-12-24	17:55	Dry	2.067	1024.72	2.22	75	6.9	90	0	0	somewhat haz	0
2025-12-25	19:30	Dry	1.056	1016.05	1.7	70	8	70	0	0	clear	0
2025-12-26	19:40	Dry	1.211	1002.71	1.1	100	4	90	0	0	extremely Hazy	0
2025-12-27	19:32	Dry	0.967	1017.61	0.6	94	7	90	17	9	somewhat haz	0
2025-12-28	19:20	Dry	4.367	999.33	4.44	100	9.656	100	0.3	0.3	very hazy	0
2025-12-29	18:30	Snow	-5.356	1002.71	-3.3	87	18.64	100			Extremely Hazy	21
2025-12-31	18:30	Snow	0.844	1002.37	-6.7	100	11.8	100				22.333
2026-01-02	20:00	Snow	-9.444	1007.8	-5	67	8.05	10	0	0		58.333
2026-01-03	19:40	Snow	-7.656	1014.56	-5	79	6.188	100			very hazy	42.222
2026-01-04	19:30	Snow	-4.6333	1022.35	-3.333	74	9	100			clear	42.222
2026-01-05	17:30	Snow	-1.7	1008.13	2	71	7	35.7	5	2	somewhat	19.444
2026-01-06	17:50	Wet	1.822	997.97	2.222	100	3	100	15	10	very hazy	5.333
2026-01-07	17:40	Wet	4.511	1011.52	4.444	100	8	100	8	3	extremely	0
2026-01-08	17:30	Dry	11.311	1008.13	10	68	12	37.5	0	0	somewhat	0
2026-01-09	17:30	Dry	6.456	1019.303	6.777	70	11.8	100	4	0	clear	0

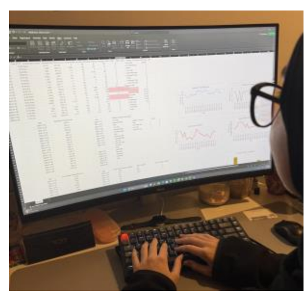


Figure 12 and 13. Microsoft Excel Data Input. Figure 12 displays 20 days of research data points, parameters, and measurements. Figure 13 shows a student researcher filling in the spreadsheet with data filled with data.

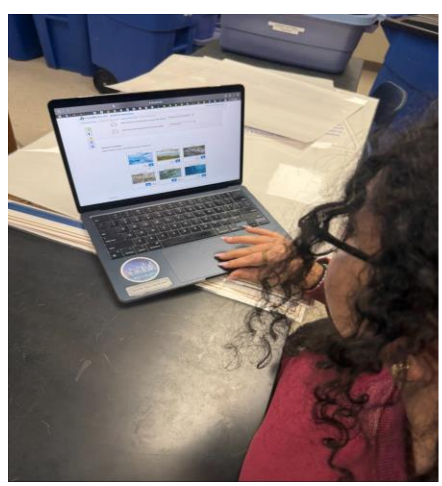


Figure 14 and 15. Data Entry. The researchers input their parameters into the GLOBE website, under the "SCIENCE Data Entry" area. These parameters include air temperature, surface temperature, wind speed, barometric pressure, relative humidity, cloud coverage, snow depth, and the site's overall condition. This data was then analyzed thoroughly to determine correlations between certain parameters.

Data Summary

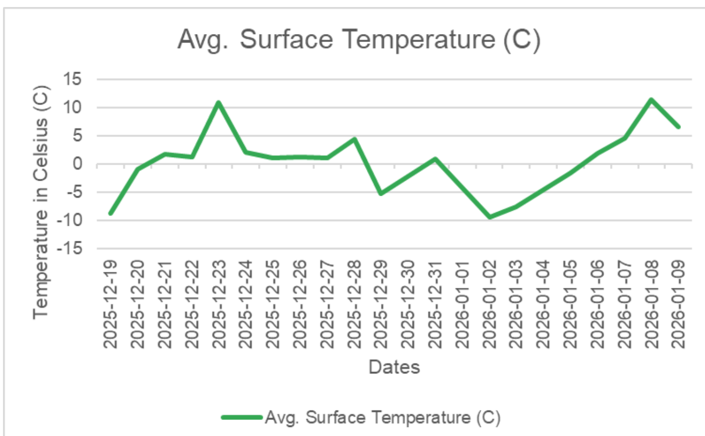


Figure 16. Average Surface Temperature (C°) Over Time. The line graph above shows the average surface temperature with an upward trend over time. The researchers concluded that the surface temperature steadily increases, with little peaks and downward fluctuations.

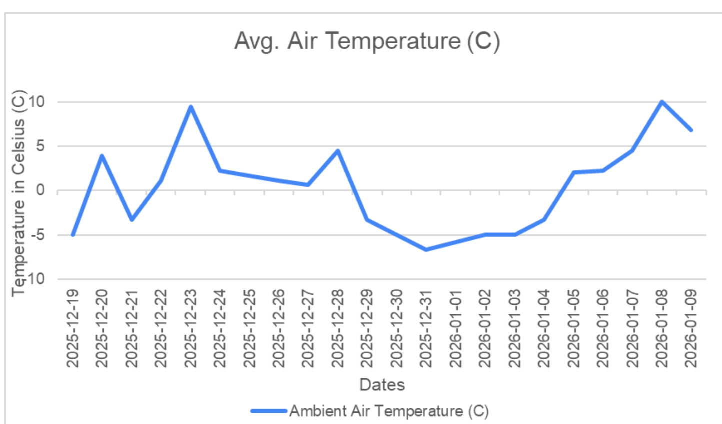


Figure 17. Average Air Temperature (C°) Over Time. The line graph above indicates that air temperature experiences noticeable fluctuations, with a general decrease followed by an upward trend toward the end of the observed period.

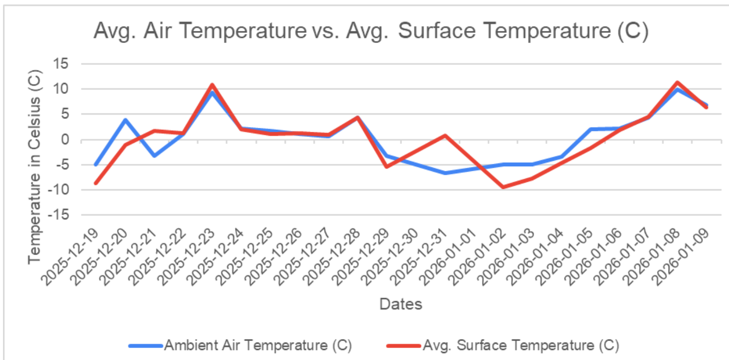


Figure 18. Surface Temperature (C°) vs. Air Temperature (C°). The graph shows a direct relationship between surface temperature and ambient air temperature over time. When the air temperature is high, the surface temperature is also high, and both are following a similar decreasing trend. There are some fluctuations, but it is seen that the two variables are closely correlated.

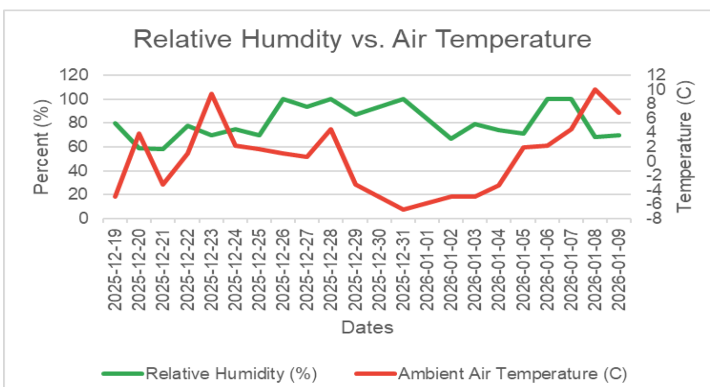


Figure 19. Relative Humidity (%) vs. Air Temperature (C°). The graph shows an inverse relationship overtime. As air temperature increases, relative humidity generally decreases, with some short-term fluctuations observed.

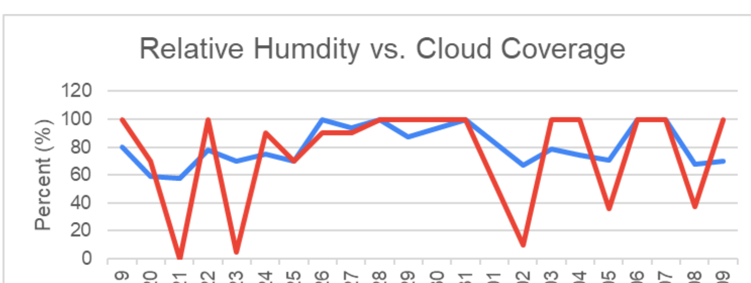


Figure 20. Relative Humidity (%) vs. Cloud Coverage (%). This graph illustrates a positive relationship between the two parameters. High cloud coverage tends to coincide with higher relative humidity, although some variability is present.

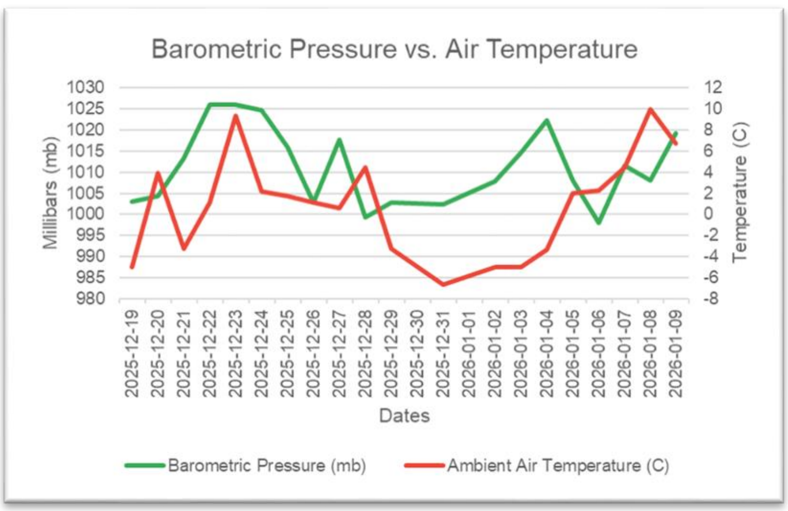


Figure 21. Barometric Pressure (mb) vs. Air Temperature (C°). The graph shows an overall inverse relationship between barometric pressure and air temperature. Periods of higher air temperature often correspond with lower barometric pressure, with moderate fluctuations.

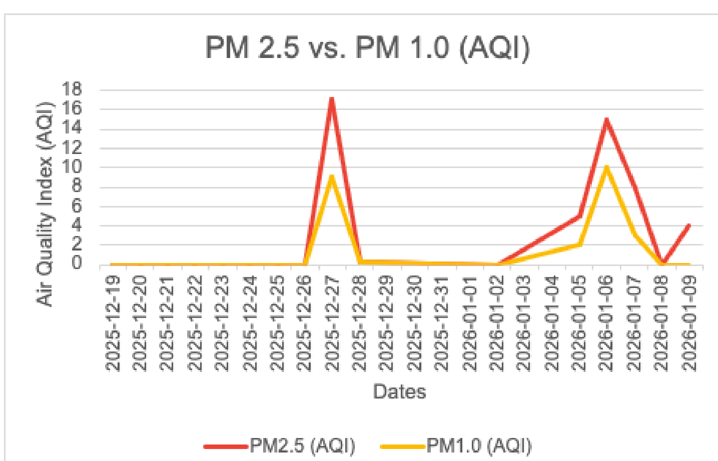


Figure 22. PM 2.5 (AQI) vs. PM 1.0 (AQI). This graph demonstrates a strong positive correlation between the two levels. Peaks and declines occur simultaneously, indicating that increase in particulate matter affects both measurements similarly.

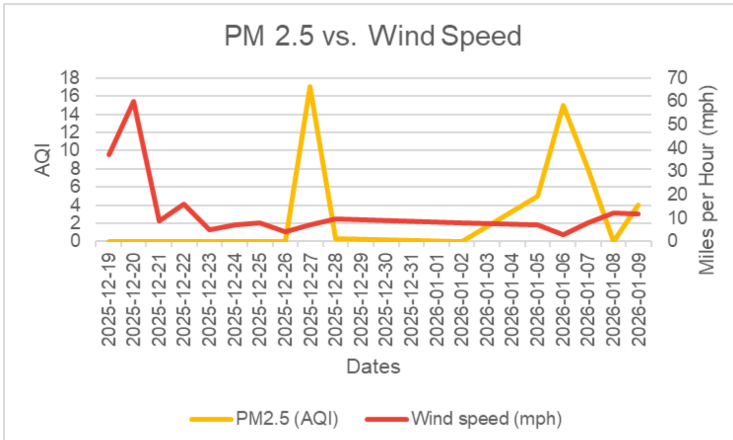


Figure 23. PM 2.5 (AQI) vs. Wind Speed (mph). The graph indicates that higher wind speeds are generally associated with lower PM 2.5 concentrations, suggesting that increase wind may help disperse PM. However, some spikes in PM 2.5 are still observed, suggesting that wind speed does not fully explain variations in air quality alone. Because the PurpleAir sensor is located inside the school's courtyard and data was collected during winter conditions, its measurements may be affected and be interpreted with caution. Also, PM values are typically higher during low pressure conditions and lower during high pressure conditions, which may also influence the observed trends shown.

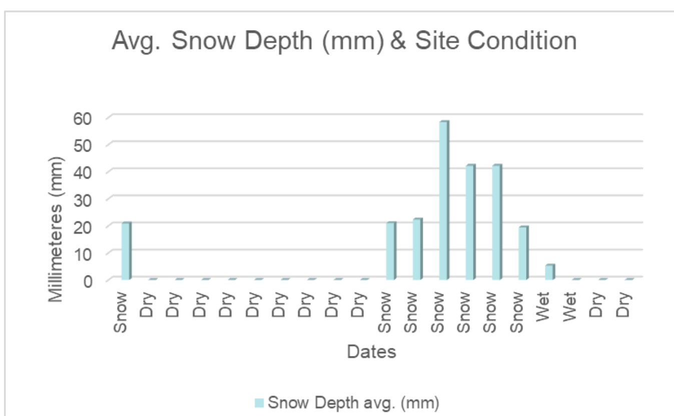


Figure 24. Average Snow Depth (mm) & Site's Overall Condition. This bar graph displays variations in average snow depths across different site conditions. Snow-covered conditions correspond to higher snow depth values, while dry and wet conditions show minimal or no snow accumulation.

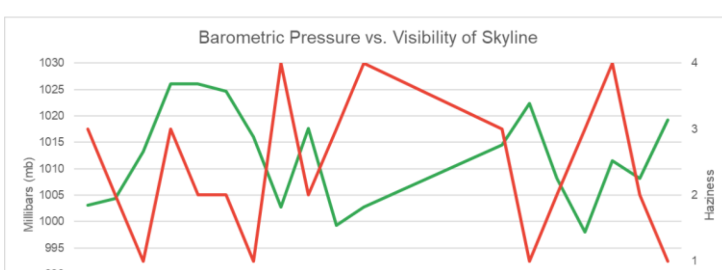


Figure 25. Barometric Pressure vs. Visibility of Detroit's Skyline (Haze Level). The graph shows changes in skyline visibility over time using a haze scale, where 1 represents clear conditions, 2 represents somewhat hazy conditions, 3 represents very hazy conditions, and 4 represents extremely hazy conditions. The data indicate fluctuations in visibility, with periods of increased haze likely influenced by atmospheric conditions such as particulate matter and humidity. This visibility was compared to barometric pressure as shown by the graph. The researchers concluded that these variables were inversely proportional. As visibility increases, the pressure decreases respectfully.

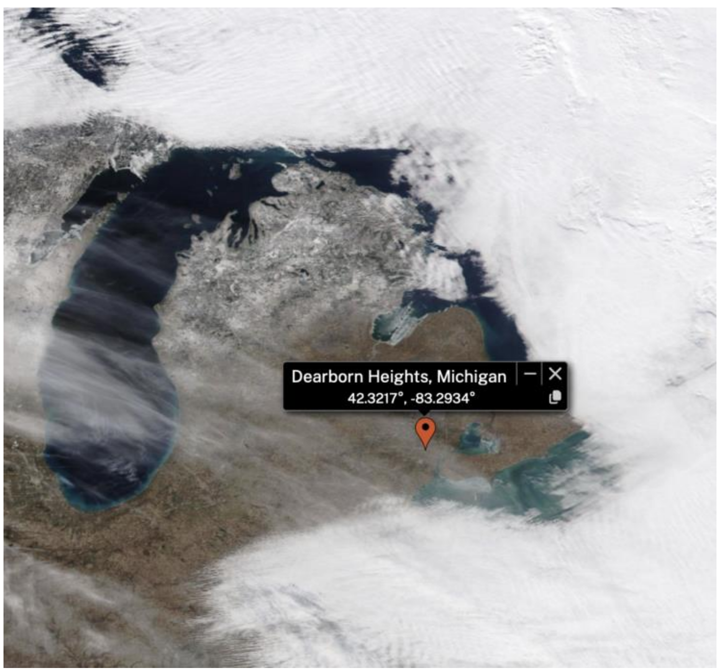


Figure 26. Satellite image from the NOAA-22/VIIRS instrument displayed on NASA Worldview showing cloud conditions near Dearborn Heights, Michigan at approximately 5:30 PM UTC on December 23, 2025. The satellite image shows limited high cloud cover over the study area. This observation matches the ground data collected by researchers, which recorded less than 10% cloud coverage.

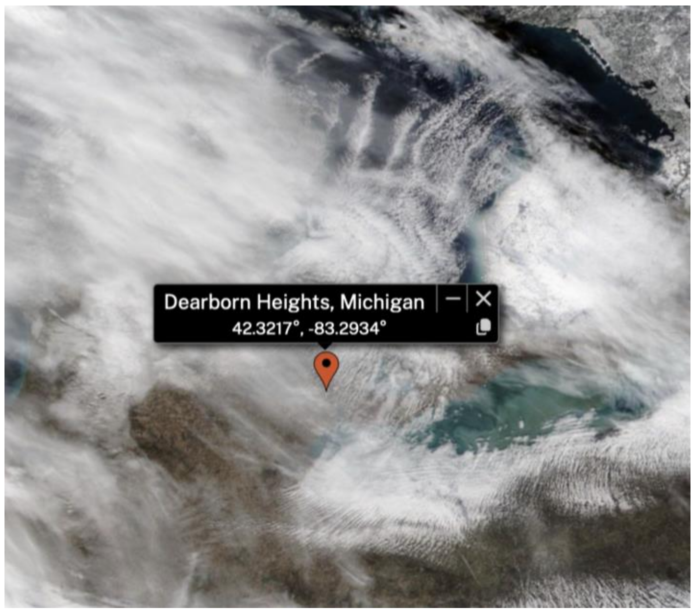


Figure 27. Satellite image from the NOAA-22/VIIRS instrument displayed on NASA Worldview showing cloud conditions near Dearborn Heights, Michigan at approximately 5:30 PM UTC on December 26, 2025. The satellite image shows widespread cloud cover over the study area near Dearborn Heights, Michigan. This observation matches the ground data collected by researchers, which recorded 90% cloud coverage.

Figure 28 & 29. Satellite image from the NOAA-22/VIIRS instrument displayed on NASA Worldview showing cloud conditions near Dearborn Heights, Michigan at approximately 5:30 PM UTC on December 28, 2025. The satellite image shows widespread cloud cover over the study area near Dearborn Heights, Michigan. This observation matches the ground data collected by researchers, which recorded 100% cloud coverage and the bomb cyclone covering the area, causing the blizzards and strong wind speeds shown in **Figure 29.**

Analysis and Results

Variables of barometric pressure and air temperature during a late December early January winter in Southeastern Michigan suggest an inversely proportional relationship. Overall, barometric pressure fluctuates across the span of data. As seen in Figure 21, periods of higher air temperature generally correlate with lower barometer pressure, except for a few fluctuations. This is a result of warm air having molecules which are further apart, causing it to be less dense and rise, leading to less pressure on the surface. Cold air has molecules which are closer apart, so it is denser and sinks, leading to more pressure on the surface. This leads to the rejection of the second null hypothesis, which states that there is no correlation between barometric pressure and air temperature in the winter, as the findings indicate otherwise.

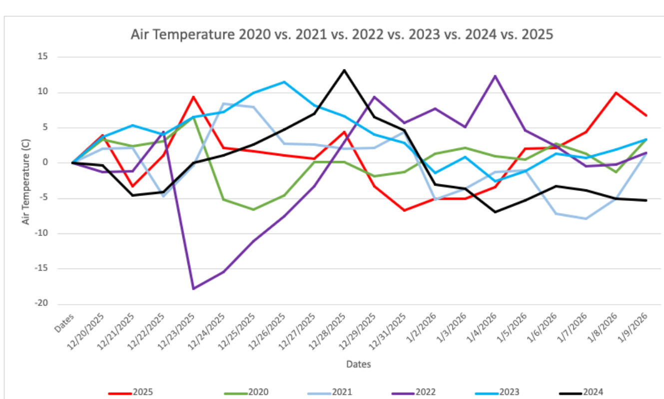
As the researchers compared Figure 20 and Figure 25, ambient air temperature and sky visibility in the winter show no correlation with each other during this time period. In each figure, haziness and air temperature can be observed to constantly fluctuate. Although there are some instances throughout the graph in which ambient air temperature and sky visibility are directly proportional, there is no consistent pattern between the two variables, leading the researchers to accept the third null hypothesis. This research was short term in nature, meaning that extended data collection would be necessary to confirm the relationship observed between air temperature and sky visibility. This also tells the researchers that other environmental factors likely affect each variable independently. In contrast, Figure 18 depicts a clear direct relationship between surface temperature and air temperature. They follow a similar decreasing trend when air temperature decreases, and so does surface temperature.

Relative humidity and Detroit skyline visibility in the winter are also inversely related. According to Figure 19, relative humidity fluctuates but overall, it remains consistent between about 60% to 100%. As compared between Figure 19 and Figure 25, periods of increasing humidity percentages are correlated with increasing haziness, leading to decreased visibility of the Detroit skyline. This is a result of higher water vapor in the atmosphere condensing onto suspended particles. This condensation causes the particles to grow larger and contributes to increased haziness. As haziness increases, visibility of the Detroit skyline decreases. Cloud coverage is also directly proportional to sky visibility because periods of low haziness correlate with low cloud coverage. An additional possible anomaly in the visibility data was the heavy use of salt on local roads during this time period. The turbulence of heavy traffic on roads covered with salt can push particles up in the air. The researchers concluded rejecting the fourth null hypothesis as there is a clear positive correlation between relative humility and cloud coverage with visibility of the Detroit skyline in the winter.

As seen in Figure 22, PM 2.5 and PM 1.0 are directly correlated. As PM 2.5 increases, PM 1.0 also increases. In Figure 23, there is no observed correlation between PM 2.5 and wind speed. Wind speed was relatively fast during the first three days of data collection, and following that, it remained steady and fluctuating at 25mph and under. In Figure 24, average snow depth and site conditions vary. The graph depicts that snow-covered conditions generally correlate with higher snow depth values, and dry and wet conditions show no significant correlation to snow accumulation.

Possible errors in our data can possibly be related to outside environmental factors. This includes wind, precipitation, or sensor placement, which could have introduced inconsistencies in surface temperature readings. The researchers may have made errors in interpreting data, analyzing types of cloud and cloud coverage, incorrect sensor placement, or gaps in the data set of days missed. Specifically, measurements may not have been obtained exactly at solar noon and rather at a later point in time, potentially causing variation over time. In addition, the researchers could have expanded their data collection by driving to further locations to observe visibility of the Detroit skyline. By only observing visibility at the same location each day, the researchers are limited in drawing connections to visibility in other locations.

Globe Data Analysis



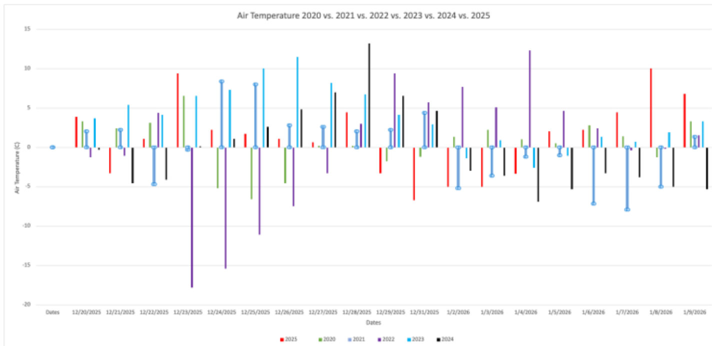


Figure 26 (top) and Figure 27 (bottom). Crestwood High School Air Temperature Data from the GLOBE Database from 2020 to 2025. The researchers compared their research to previous GLOBE data conducted on the Crestwood High School Campus between 2020-2025 to observe how temperature patterns have changed over time. The graph shows variations in daily noon temperature trends, including differences in temperature peaks and periods of colder temperatures between the two years.

Several environmental factors could have contributed to these differences. Changes in cloud cover, snow depth, wind patterns, and overall weather conditions can all influence air temperature. For example, increased cloud cover can reduce solar heating during the day and trap heat at night, while snow cover can reflect sunlight and keep surface temperatures lower. Differences in large-scale weather patterns between the two could also impact local temperature readings.

These results suggest that local air temperatures can vary significantly from year to year based on atmospheric conditions. The comparison also highlights the importance of long-term data collection when studying climate patterns. While short term changes may reflect weather variability, repeated data collection over multiple years can help identify larger climate trends and environmental changes.

Discussion

This research provides evidence regarding how air temperature, surface temperature, wind speed, barometric pressure, particulate matter, relative humidity, snow depth, visibility, and cloud coverage interact during winter conditions in southeastern Michigan. By examining these variables together, the researchers developed a clearer understanding of how winter atmospheric conditions influence air quality and visibility on a local scale.

To improve data accuracy and reliability, several adjustments could be made. Collecting measurements multiple times throughout the day, rather than at a uniform time during solar noon, could better represent daily changes in temperature, wind speed, and air quality. Gathering data from additional locations would allow for comparisons between different surrounding environments and surface conditions. For example, using a research-grade instrument for surface temperature data collection could provide more precise data for later analysis. Including nighttime observations would also offer insight into how cloud coverage affects heat retention and air quality after sunset.

The findings of this study have several applications beyond the general interest. Winter air quality is an important public health issue because fine particles such as PM2.5 can increase respiratory irritation and worsen symptoms for people with asthma. This risk is especially high during calm weather conditions, when pollutants are less likely to disperse and can build up near the ground. This research helps explain why some winter days may appear hazier even when there is no obvious smoke source. Higher humidity and increased cloud coverage can reduce visibility by interacting with particles already present in the air. This information also connects to everyday decision-making, such as when schools or communities may want to pay attention to air quality alerts for outdoor activities. Visibility findings have significance as well, since haze and low cloud conditions can affect air quality, driving conditions, and general outdoor safety during winter.

Future research could expand these findings in many ways that are specific to winter conditions and urban air behavior. One direction would be to examine how different “types” of winter days relate to particulate matter and visibility (for example, calm high-pressure days versus windier storm system days), since pressure and wind are often tied to how well the atmosphere mixes near the surface. Another direction would be to focus more directly on dew points to better understand how atmospheric moisture contributes to reduced visibility.

It is often difficult for high school students to directly collect winter data in Michigan because enhanced school safety makes it difficult to leave the building during the day. Taking yearly measurements throughout late December and early January during winter break each winter would lead to having data on consistent GLOBE protocols that could be used long-term to monitor and track weather similarities and differences over time. Eventually, if data is taken over 30 years or more, student researchers could help to create an understanding of how climate change is impacting the winter our school district and city experiences in Southeastern Michigan.

Overall, this study effectively demonstrates the relationship between winter atmospheric conditions, air quality, and visibility. While the results highlight consistent patterns among temperature, wind, pressure, and particulate matter, refining measurement approaches and interpreting data could strengthen future work. Continued yearly research can further improve an understanding of how winter atmospheric conditions influence local environmental conditions.

Conclusion

Using an Infrared Thermometer and meter stick, the researchers were able to gather land surface temperature and snow depth data. With the data collected, researchers were able to observe consistent fluctuations in surface and atmospheric conditions throughout the winter season. After gathering data, researchers concluded that winter surface temperature, air temperature, barometric pressure, relative humidity, and visibility are interrelated and vary in response to changing atmospheric conditions.

These changes in temperature come from reduced solar altitude during winter, as the sun is lower in the sky and daylight hours are shorter, resulting in decreased insolation reaching the earth's surface. As a result, land surface temperatures remain lower and more responsive to atmospheric conditions. Snow covered surfaces showed lower surface temperatures due to increased reflectivity, which limits surface warming during daylight hours. This pattern supports the observation that surface temperature closely follows air temperature during winter conditions.

Barometric pressure and air temperature displayed an inverse relationship, with higher air temperatures corresponding to lower barometric pressure. This occurs because warmer air is less dense and rises, while colder air is denser and sinks, increasing surface pressure. Relative humidity and cloud coverage were observed to increase together, which contributed to greater atmospheric haziness and reduced skyline visibility. Increased humidity allows more obituaries and particles to stay suspended in the air, limiting visibility.

Particulate matter concentrations (PM2.5 and PM1.0) were strongly correlated, increasing and decreasing simultaneously. Higher wind speeds were associated with lower particulate matter concentrations, suggesting that wind aids in dispersing airborne particles. This observation is supported by the following: “General patterns for each variable were clear:... the higher wind speed is, the lower PM2.5 concentration is in all seasons... and the higher relative humidity is, the higher concentration is (in winter)" (Zhang, 2023).

These findings are also consistent with broader winter climate patterns in the Great Lakes region. This data is supported by the following: "During La Niña events, below-normal temperatures and shifts in winter precipitation patterns are favored across the southern Great Lakes region" (NOAA, 2024).

This study incorporated five years of previous air temperature data to better understand long term temperature trends and seasonal changes. However, the researchers hope to encourage future Crestwood High School student researchers to continue this work conducted to fully understand how winter atmospheric conditions influence surface temperature, air quality, and visibility.

Acknowledgments

The researchers collaborated with their former AP Environmental Science teacher and Science Club Advisor, Mrs. Diana Johns, who has continued to provide guidance throughout the research process. Mrs. Johns offered support on climate patterns and data collection methods. Mrs. Abbas currently serves as the AP Environmental Science teacher and GLOBE Advisor, and who provides ongoing guidance in data analysis and research writing. With mentorship from both advisors, the researchers developed a deeper understanding of the long-term significance and potential impact of their study. Thanks also to Mission Earth and the AREN Project for providing some of the instruments and grants to purchase materials necessary to collect data using GLOBE protocols.

Bibliography

Chalif, J. I., Osterberg, E. C., & Partridge, T. F. (2025). A Wavier Polar Jet Stream Contributed to the Mid-20th Century Winter Warming Hole in the United States. *AGU Advances.* https://doi.org/10.1029/2024AV001399

Hutson, A., Fujisaki-Manome, A., & Glassman, R. (2024). Historical Trends in Cold-Season Mid-Latitude Cyclones in the Great Lakes Region. *Geophysical Research Letters, 51*, e2024GL109890. https://doi.org/10.1029/2024GL109890

Kiefer, M. T., Andresen, J. A., McCullough, D. G., Wieferich, J. B., Keyzer, J., & Marquie, S. A. (2023).Microclimatic Variability of Cold-Season Minimum Temperatures in Michigan, United States: A Study with Implications for Insect Mortality. *Journal of Applied Meteorology and Climatology, 62*(9), 1187–1203. https://doi.org/10.1175/jamc-d-23-0067.1

National Oceanic and Atmospheric Administration (NOAA). (2024, November 8). La Niña Impacts and Outlook: Great Lakes Region. https://www.drought.gov/sites/default/files/2024-11/ENSO%20Great%20Lakes%20November%202024.pdf

Screen, J. A., Bracegirdle, T. J., & Simmonds, I. (2018). Polar Climate Change as Manifest in Atmospheric Circulation. *Current Climate Change Reports, 4*(4), 383–395. https://doi.org/10.1007/s40641-018-0111-4

Zhang, L. (2023, July). Conceptual Models of $PM_{2.5}$ in Great Lakes Region. Lake Michigan Air Directors Consortium (LADCO). https://www.ladco.org/wp-content/uploads/Training/Interns/LADCO_2023_Internship_Final-Report.pdf

Appendix

2020-12-20T11:59:00	2020-12-20T17:30:30	3.3
2020-12-21T11:58:00	2020-12-21T17:30:59	2.4
2020-12-22T11:58:00	2020-12-22T17:31:29	3.1
2020-12-23T11:56:00	2020-12-23T17:31:59	6.5
2020-12-24T11:57:00	2020-12-24T17:32:29	-5.2
2020-12-25T11:56:00	2020-12-25T17:32:58	-6.6
2020-12-26T11:56:00	2020-12-26T17:33:28	-4.6
2020-12-27T11:55:00	2020-12-27T17:33:57	0.2
2020-12-28T11:55:00	2020-12-28T17:34:26	0.2
2020-12-29T11:54:00	2020-12-29T17:34:55	-1.8
2020-12-30T11:54:00	2020-12-30T17:35:24	4.8
2020-12-31T11:53:00	2020-12-31T17:35:53	-1.2
2021-01-01T11:53:00	2021-01-01T17:36:21	-0.6
2021-01-02T11:52:00	2021-01-02T17:36:49	1.3
2021-01-03T12:07:00	2021-01-03T17:37:16	2.2
2021-01-04T12:06:00	2021-01-04T17:37:44	1.0
2021-01-05T12:07:00	2021-01-05T17:38:10	0.5
2021-01-06T12:08:00	2021-01-06T17:38:37	2.8
2021-01-07T12:07:00	2021-01-07T17:39:03	1.4
2021-01-08T12:05:00	2021-01-08T17:39:28	-1.3
2021-01-09T12:05:00	2021-01-09T17:39:53	3.3

Figure 28. Crestwo[...] collected by student researchers at Crestv[...] study analyzed this data to evaluate how[...]

2021-12-20T11:59:00	2021-12-20T17:30:22	2.0
2021-12-21T11:59:00	2021-12-21T17:30:52	2.2
2021-12-22T11:58:00	2021-12-22T17:31:22	-4.7
2021-12-23T11:58:00	2021-12-23T17:31:51	-0.3
2021-12-24T11:57:00	2021-12-24T17:32:21	8.4
2021-12-25T11:57:00	2021-12-25T17:32:51	8.0
2021-12-26T11:56:00	2021-12-26T17:33:20	2.8
2021-12-27T11:56:00	2021-12-27T17:33:50	2.6
2021-12-28T11:57:00	2021-12-28T17:34:19	2.0
2021-12-29T11:57:00	2021-12-29T17:34:48	2.2
2021-12-30T11:58:00	2021-12-30T17:35:17	1.1
2021-12-31T11:58:00	2021-12-31T17:35:46	4.4
2022-01-01T11:55:00	2022-01-01T17:36:14	1.9
2022-01-02T11:56:00	2022-01-02T17:36:42	-5.2
2022-01-03T11:53:00	2022-01-03T17:37:10	-3.6
2022-01-04T11:56:00	2022-01-04T17:37:37	-1.2
2022-01-05T11:51:00	2022-01-05T17:38:04	-1.0
2022-01-06T12:06:00	2022-01-06T17:38:30	-7.2
2022-01-07T12:05:00	2022-01-07T17:38:56	-7.9
2022-01-08T12:08:00	2022-01-08T17:39:22	-5.0
2022-01-09T12:06:00	2022-01-09T17:39:47	1.3

Figure 29. Crestwood High School Air Temperature Data. This data was collected by student researchers at Crestwood High School in 2021-2022. The researchers in this study analyzed this data to evaluate how air temperature trends changed between time periods.

2022-12-20T11:59:00	2022-12-20T17:30:15	-1.3
2022-12-21T11:59:00	2022-12-21T17:30:45	-1.1
2022-12-22T11:58:00	2022-12-22T17:31:14	4.4
2022-12-23T11:58:00	2022-12-23T17:31:44	-17.8
2022-12-24T11:57:00	2022-12-24T17:32:14	-15.4
2022-12-25T11:57:00	2022-12-25T17:32:44	-11.1
2022-12-26T11:56:00	2022-12-26T17:33:13	-7.5
2022-12-27T11:56:00	2022-12-27T17:33:43	-3.3
2022-12-28T11:55:00	2022-12-28T17:34:12	3.0
2022-12-29T11:55:00	2022-12-29T17:34:41	9.4
2022-12-30T11:54:00	2022-12-30T17:35:10	11.9
2022-12-31T11:54:00	2022-12-31T17:35:39	5.7
2023-01-01T11:53:00	2023-01-01T17:36:07	4.3
2023-01-02T11:52:00	2023-01-02T17:36:35	7.7
2023-01-03T12:07:00	2023-01-03T17:37:03	5.1
2023-01-04T11:52:00	2023-01-04T17:37:30	12.3
2023-01-05T12:06:00	2023-01-05T17:37:57	4.6
2023-01-06T12:06:00	2023-01-06T17:38:24	2.4
2023-01-07T12:05:00	2023-01-07T17:38:50	-0.4
2023-01-08T12:05:00	2023-01-08T17:39:16	-0.2
2023-01-09T12:04:00	2023-01-09T17:39:41	1.5

Figure 30. Crestwood High School Air Temperature Data. This data was collected by student researchers at Crestwood High School in 2022-2023. The researchers in this study analyzed this data to evaluate how air temperature trends changed between time periods.

2023-12-20T11:59:00	2023-12-20T17:30:08	3.7
2023-12-21T11:59:00	2023-12-21T17:30:37	5.4
2023-12-22T11:58:00	2023-12-22T17:31:07	4.1
2023-12-23T11:58:00	2023-12-23T17:31:37	6.5
2023-12-24T11:57:00	2023-12-24T17:32:06	7.3
2023-12-25T11:57:00	2023-12-25T17:32:36	10.0
2023-12-26T11:56:00	2023-12-26T17:33:06	11.5
2023-12-27T11:56:00	2023-12-27T17:33:35	8.2
2023-12-28T11:56:00	2023-12-28T17:34:05	6.7
2023-12-29T11:55:00	2023-12-29T17:34:34	4.1
2023-12-30T11:55:00	2023-12-30T17:35:03	1.9
2023-12-31T11:55:00	2023-12-31T17:35:32	2.9
2024-01-01T11:54:00	2024-01-01T17:36:00	-0.4
2024-01-02T11:53:00	2024-01-02T17:36:28	-1.4
2024-01-03T11:53:00	2024-01-03T17:36:56	0.9
2024-01-04T12:07:00	2024-01-04T17:37:24	-2.6
2024-01-05T12:06:00	2024-01-05T17:37:51	-1.1
2024-01-06T12:06:00	2024-01-06T17:38:17	1.3
2024-01-07T12:06:00	2024-01-07T17:38:44	0.7
2024-01-08T12:05:00	2024-01-08T17:39:09	1.9
2024-01-09T12:05:00	2024-01-09T17:39:34	3.3

Figure 31. Crestwood High School Air Temperature Data. This data was collected by student researchers at Crestwood High School in 2023-2024. The researchers in this study analyzed this data to evaluate how air temperature trends changed between time periods.

2024-12-20T12:07:00	2024-12-20T17:30:30	-0.3
2024-12-21T11:59:00	2024-12-21T17:31:00	-4.6
2024-12-22T11:59:00	2024-12-22T17:31:29	-4.1
2024-12-23T11:59:00	2024-12-23T17:31:59	0.1
2024-12-24T11:57:00	2024-12-24T17:32:29	1.1
2024-12-25T11:57:00	2024-12-25T17:32:58	2.6
2024-12-26T11:56:00	2024-12-26T17:33:28	4.8
2024-12-27T11:56:00	2024-12-27T17:33:57	7.0
2024-12-28T11:55:00	2024-12-28T17:34:27	13.2
2024-12-29T11:55:00	2024-12-29T17:34:56	6.5
2024-12-30T11:54:00	2024-12-30T17:35:25	5.7
2024-12-31T11:54:00	2024-12-31T17:35:53	4.6
2025-01-01T11:53:00	2025-01-01T17:36:21	1.3
2025-01-02T12:07:00	2025-01-02T17:36:49	-3.0
2025-01-03T12:07:00	2025-01-03T17:37:17	-3.6
2025-01-04T12:07:00	2025-01-04T17:37:44	-6.9
2025-01-05T12:07:00	2025-01-05T17:38:11	-5.3
2025-01-06T12:06:00	2025-01-06T17:38:37	-3.3
2025-01-07T12:06:00	2025-01-07T17:39:03	-3.8
2025-01-08T12:07:00	2025-01-08T17:39:28	-5.0
2025-01-09T12:05:00	2025-01-09T17:39:53	-5.3

Figure 32. Crestwood High School Air Temperature Data. This data was collected by student researchers at Crestwood High School in 2024-2025. The researchers in this study analyzed this data to evaluate how air temperature trends changed between time periods.

Badges

I Am an Earth System Scientist

The researchers hope to earn the “I Am an Earth System Scientist” badge because their project investigates the interconnected nature of Earth’s systems by analyzing the interaction between atmospheric and surface conditions. The research question focuses on how variations in atmospheric factors influence surface temperature patterns. The researchers followed several GLOBE protocols to conduct their research including air temperature, barometric pressure, cloud coverage, relative humidity, and surface temperature.

By analyzing these variables together, the researchers demonstrated how atmospheric processes and seasonal conditions influence surface heating and cooling. This integrated approach highlights the dynamic interactions between Earth's spheres and reflects an Earth system science perspective that emphasizes interconnected processes rather than isolated environmental factors.

I Am a STEM Storyteller

The researchers hope to earn the "I Am a STEM Storyteller" badge because they shared the story of their research in a clear and engaging way that made complex scientific data understandable to others. The team communicated their findings using a platform on Instagram under the username "the_air_pioneers," allowing peers and community members to better understand how land, water, and atmospheric systems interact and influence local conditions. By making informational posts, the researchers emphasized how local environmental changes connect to broader climate processes. Through intentional storytelling and data visualization, the researchers demonstrated that scientific research can be communicated effectively, increasing awareness of environmental processes.

I Work with Satellite Data

The researchers hope to earn the "I Work with Satellite Data" badge because their research uses satellite mission data to investigate local atmospheric and climate conditions from a different observational perspective. The research incorporates satellite data from the NOAA-22 satellite using the VIIRS instrument, accessed through NASA Worldview, to analyze cloud coverage during the data collection period. This satellite data allowed researchers to observe environmental conditions from above, providing information that is not influenced by local surface level factors.

Satellite observations helped researchers determine whether local temperature and environmental measurements may have been influenced by nearby conditions such as buildings, snow cover, or localized weather effects. By comparing satellite data with ground observations, researchers were able to better understand how different environmental factors impact local climate measurements. This research demonstrates how satellite data can be used to strengthen climate investigations and improve understanding of environmental patterns.