

Case Studies: Effects of Location on Surface Temperatures



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Abstract

The Urban Heat Island Effect suggests that cities are warmer than rural areas because cities contain more infrastructures (e.g. buildings and roads) and lack vegetation (e.g. trees and grass) compared to rural areas. This research focuses on determining whether the location of a school really makes a difference regarding surface temperatures. The research question is "How is surface temperature affected based on the area?" In order to investigate the research question, we measured the surface temperature of the grass in the baseball field at Freeport High School in New York. We used the GLOBE Visualization System to research different schools, which collected surface temperatures of a grassy field and that were located at a similar latitude compared to Freeport High School. In Case Study #1, we compared data from Freeport High School (Residential Urban Area) vs. Mountain View Middle School (Suburban Residential Area). In Case Study #2, we compared data from Waite High School (Residential Urban Area) vs. Perkins High School (Rural Area). Data was collected between October 2017 and March 2019. The results show that the Urban Heat Island Effect generally occurs in Case #1. However, Case #2 shows the opposite with Waite High School (urban area) being overall colder than Perkins High School (rural area). An explanation to this discrepancy could be general climate patterns: Freeport High School is also located along the North Atlantic coast whereas Mountain View School is more inland. In Case #2, both schools are along Lake Erie; however, Perkins High School is on the eastern side of the lake and Waite High school on the western side of the lake. General planetary wind patterns indicate that the wind blows toward the east/northeast at this latitude. Therefore, Perkins High School receives warmer temperature from Lake Erie but not Waite High School. Water has a higher specific heat than land and has a moderating effect on temperatures. The data shows that Freeport High School and Perkins High Schools receive this moderating effect compared to the other two schools.

Research Question

The purpose of this investigation is to see how different the surface temperature would be depending on the area (i.e. rural, suburban residential, and urban residential). The research question is "How is surface temperature affected based on the area?"

What is surface temperature? Surface temperature is the heat or infrared energy absorbed by the surface of the Earth and radiated back into the atmosphere. The Sun emits radiation in the form of electromagnetic waves. Some of this heat is absorbed by the atmosphere before it hits Earth's surface, the rest is absorbed by the oceans, and various land cover such as concrete or grass at the surface.

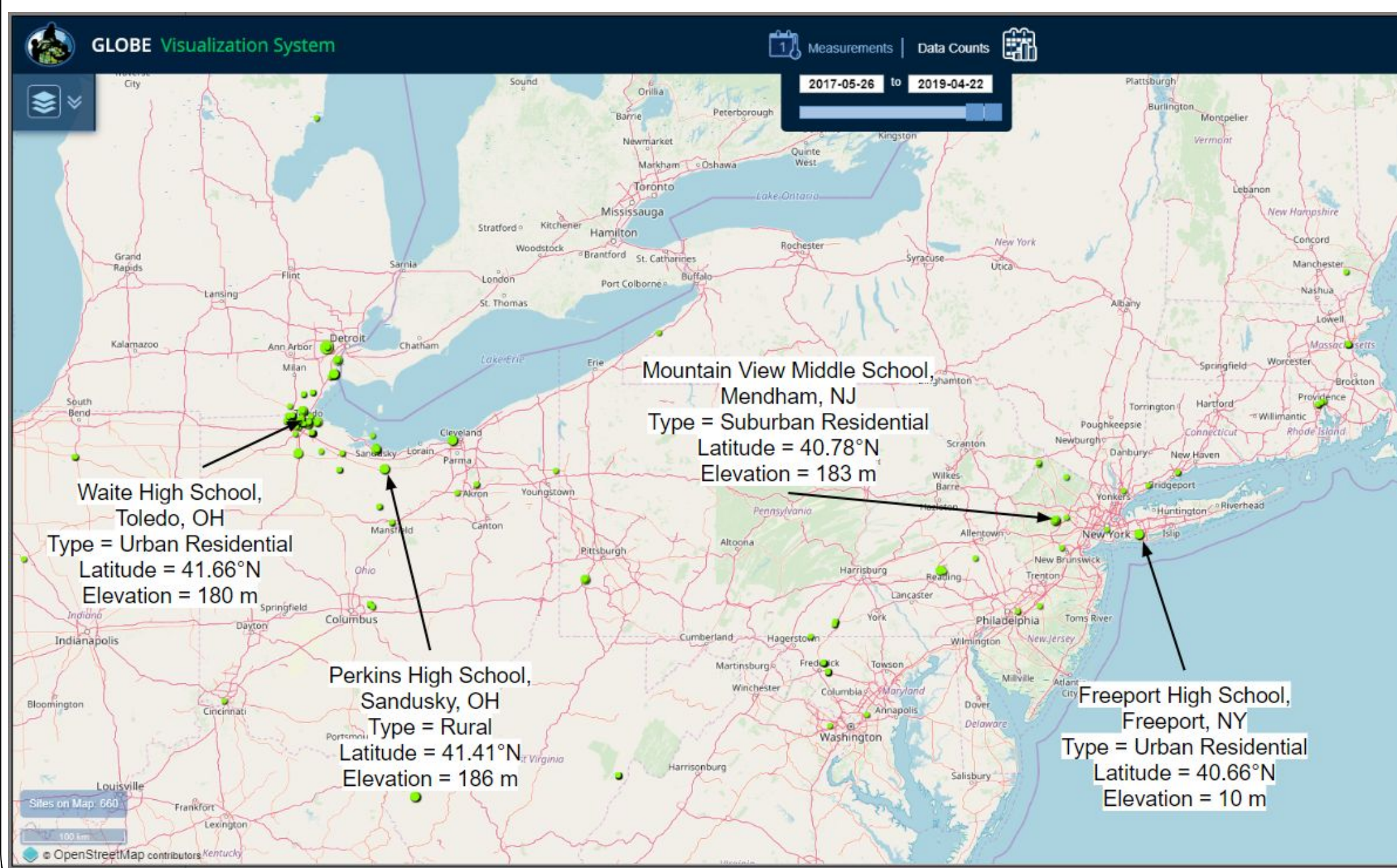
The goal of this research is to show that areas with more buildings have higher surface temperatures. According to The New York Reference Tables for Physical Setting/EARTH SCIENCE (ESRT), concrete (i.e. rocks) making up the buildings and other urban infrastructures has a lower specific heat compared to the water vapor coming from vegetation during the process of transpiration. Rural areas contain more vegetation, and therefore, should have a lower surface temperature than urban or suburban areas.

Hypothesis

The hypothesis is that if there are a lot of trees and plants, then the surface temperature will be lower compared to an urban area containing many buildings. On the opposite, if an area contains a lot of buildings then the surface temperature will be higher.

Research Methods

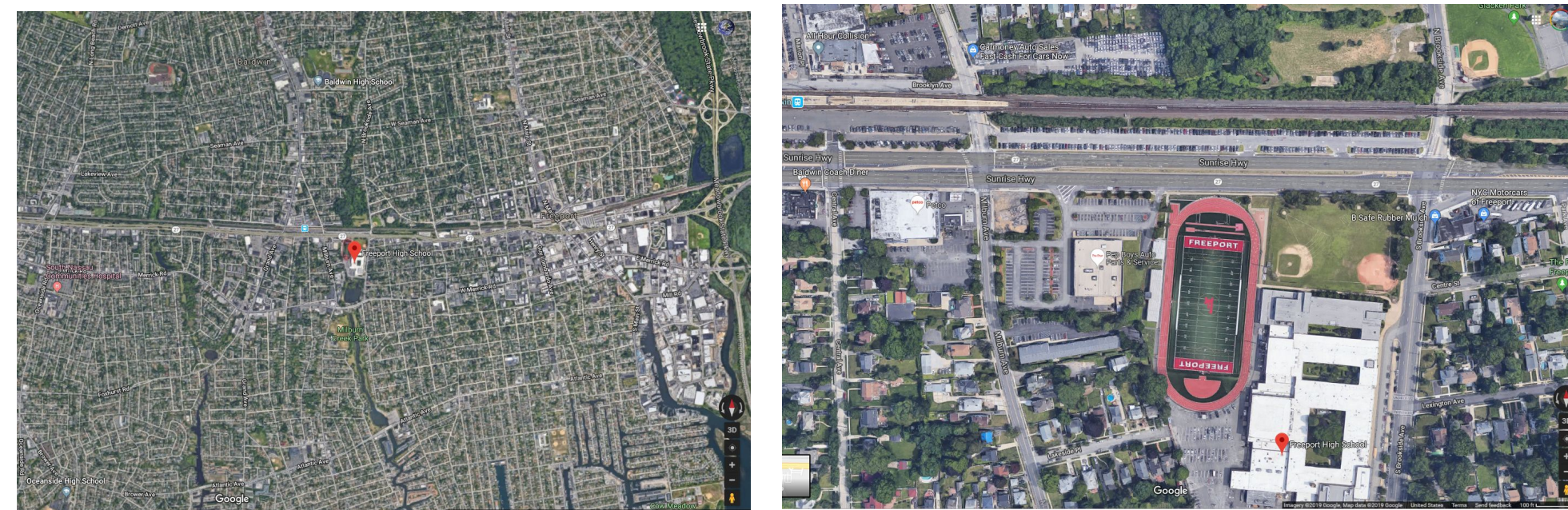
- Surface temperature observations were completed between October 19, 2017 and March 21, 2019, by following the GLOBE Surface Temperature Protocol for collecting atmospheric data at each Site.
- The sites were selected based on their amount of data, dates of data collection, latitude, and elevation that had to be similar to Freeport, NY. The sites were also selected based on their population density (i.e. rural, suburban residential, and urban residential).
- Only the surface temperature of the grass is being used.



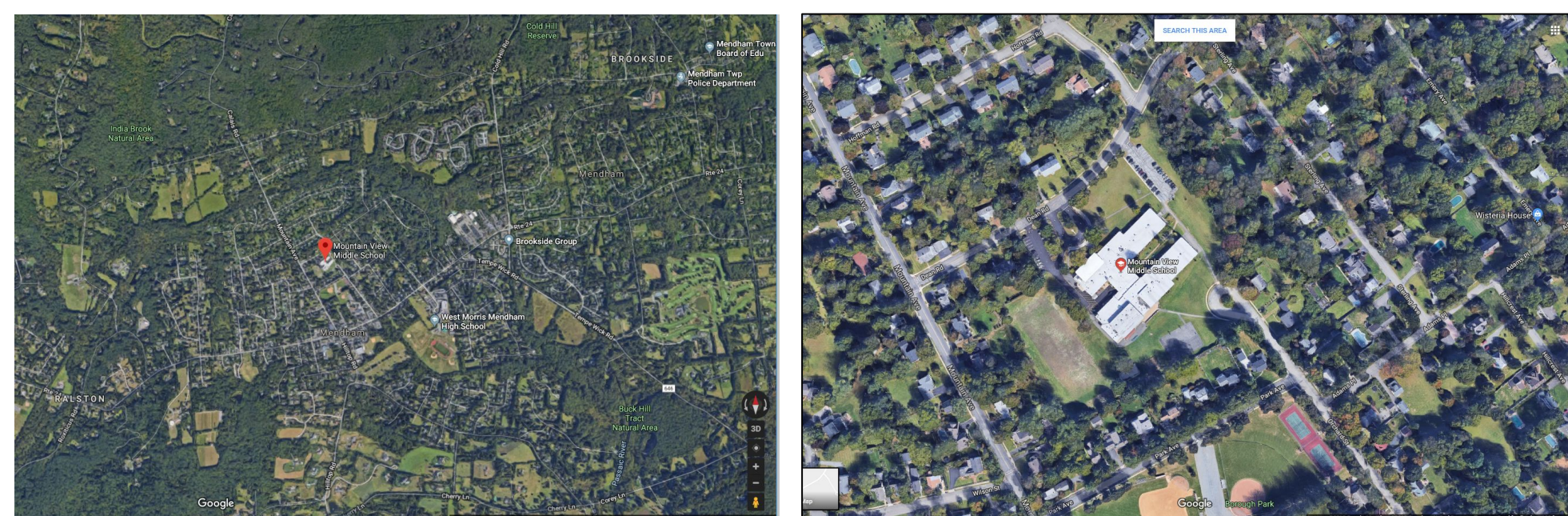
Sites

Case Study #1

Urban Residential Area #1 = Freeport High School



Suburban Residential Area = Mountain View Middle School



Case Study #2

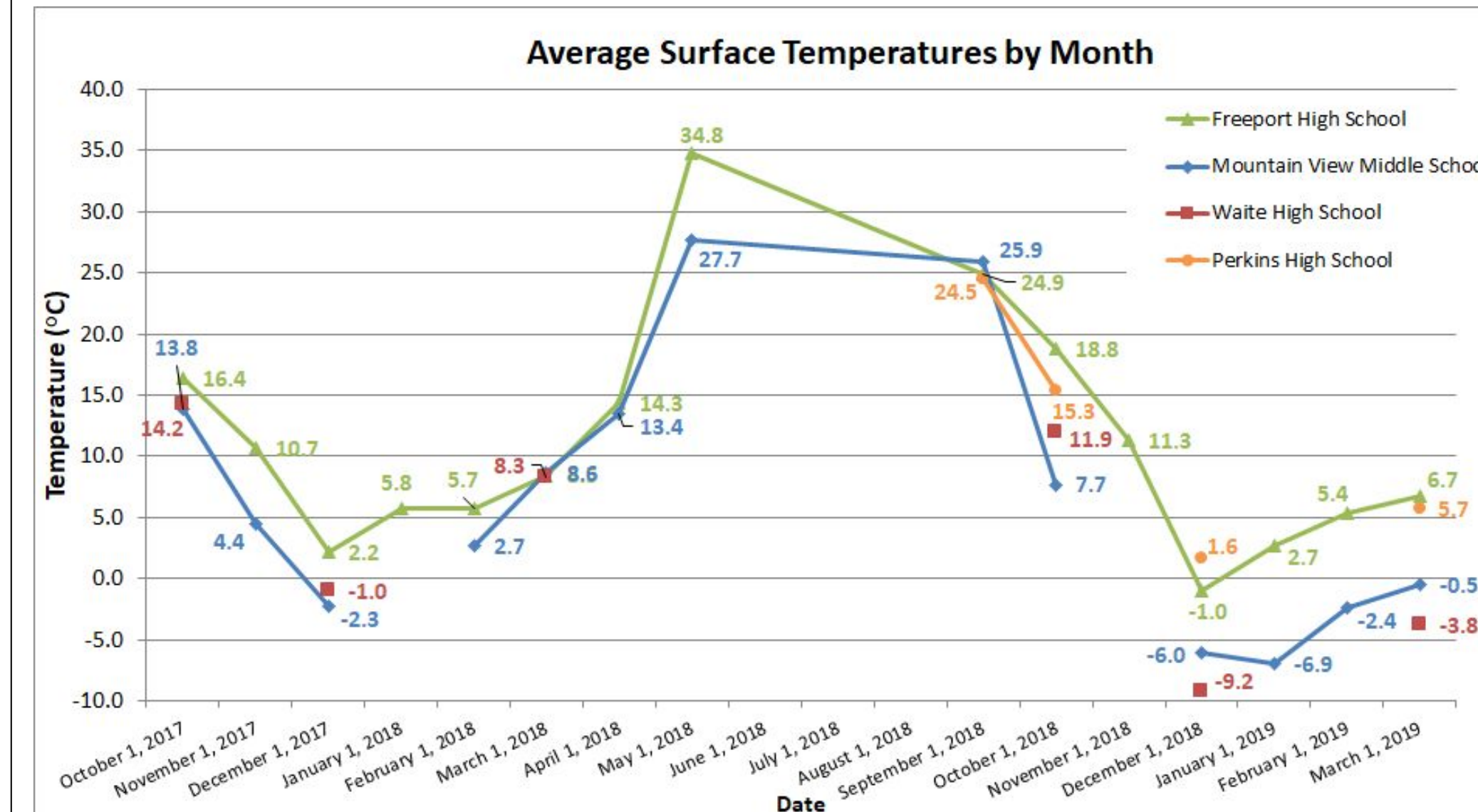
Urban Residential Area #2 = Waite High School



Rural Area = Perkins High School

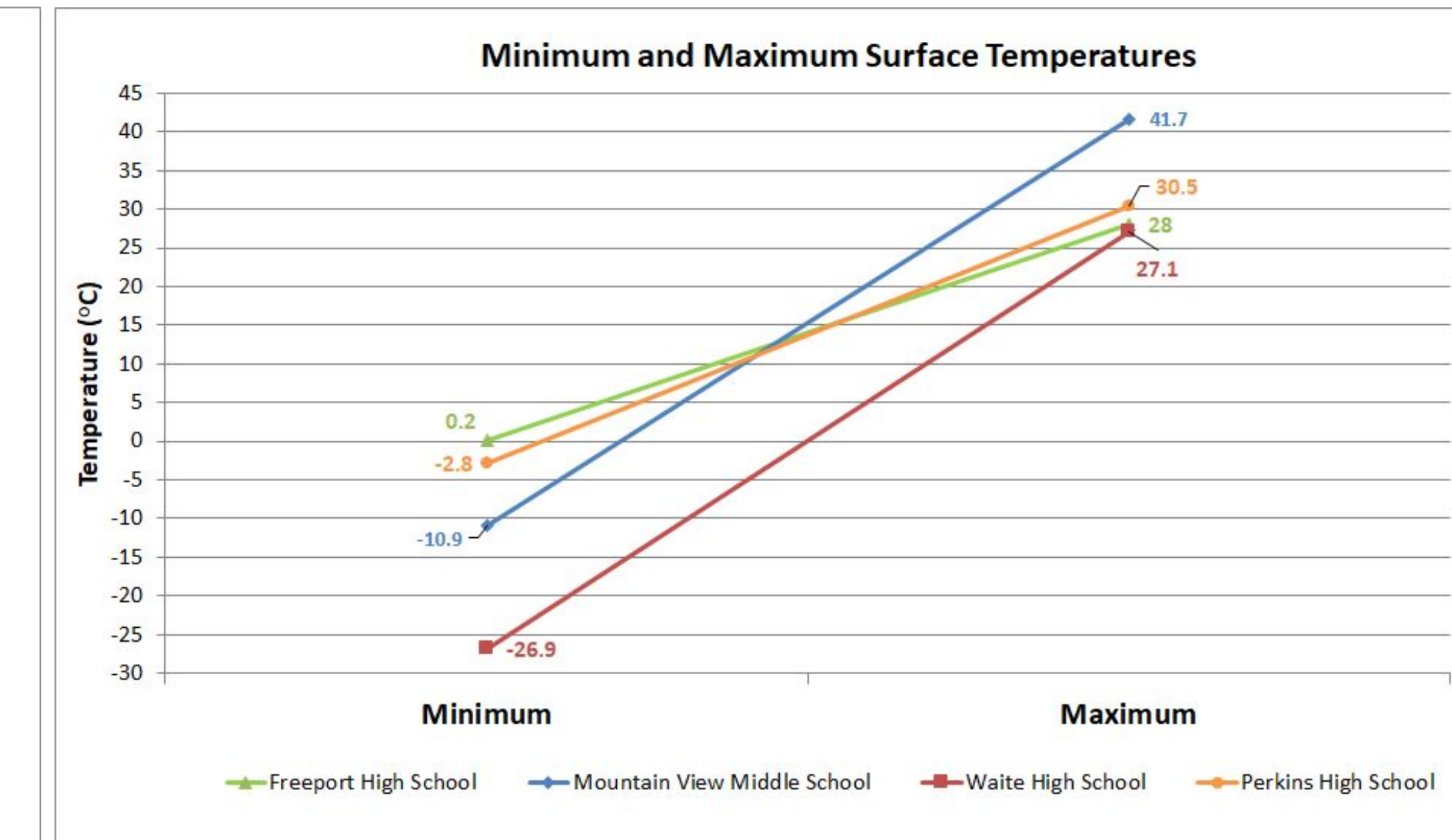


Results



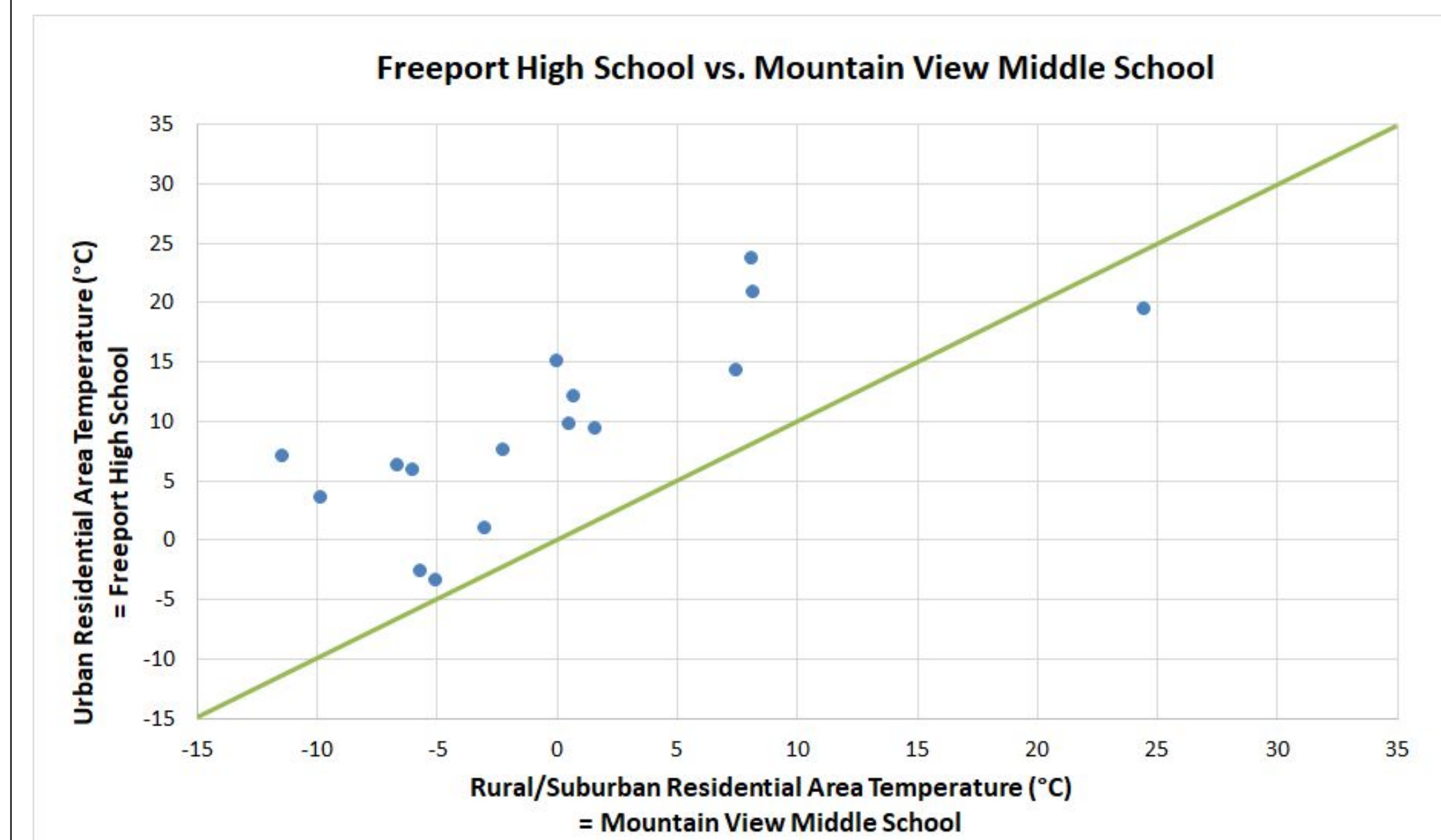
Graph #1 - Average Surface Temperatures by Month:

The average surface temperature for each school was calculated for each month between October 1, 2017 and March 31, 2019. No data was collected during the summer (June to August 2018).



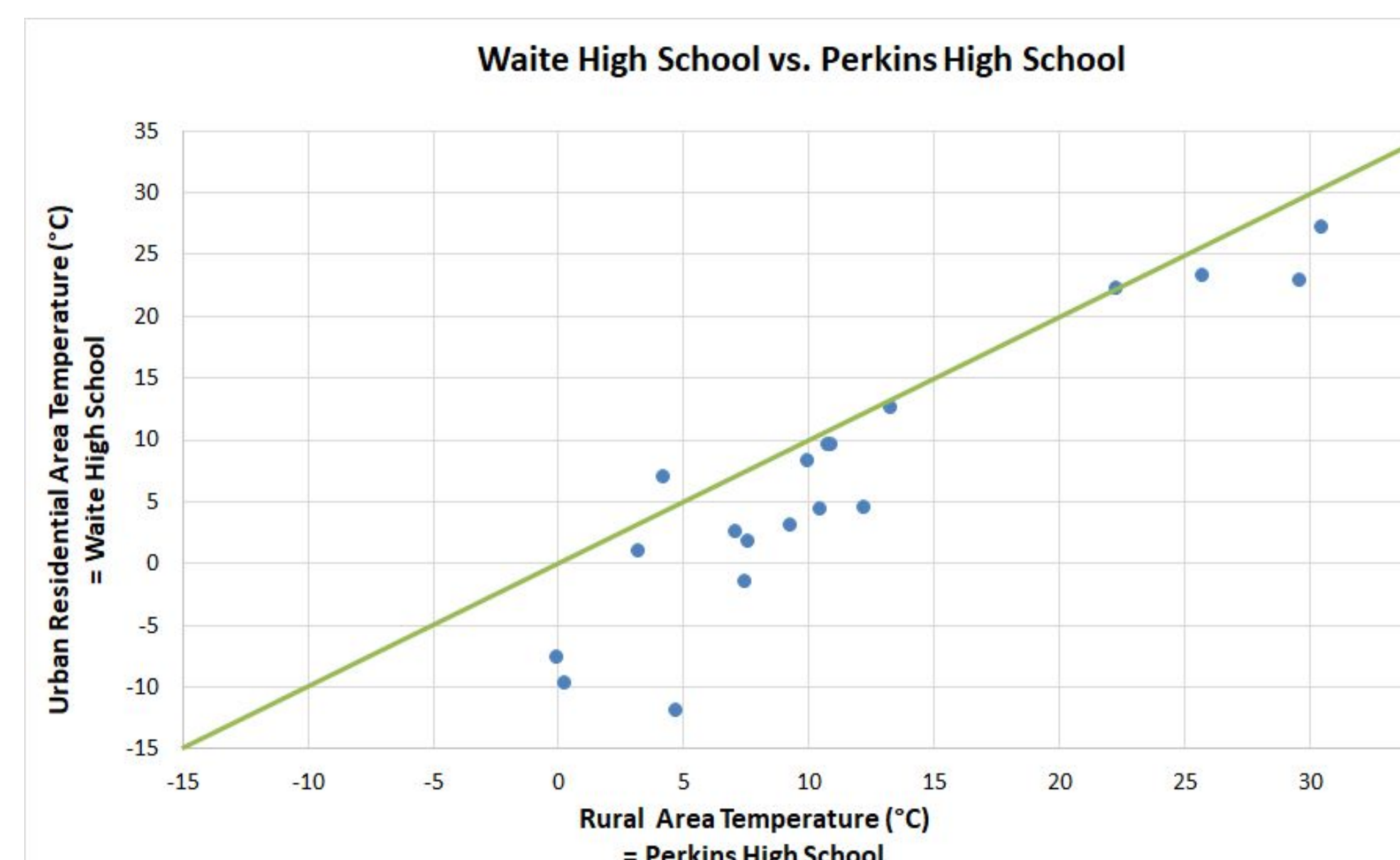
Graph #2 - Maximum and Minimum Surface Temperatures:

This graph displays the maximum and the minimum surface temperatures for each school for the data collected between October 1, 2017 and March 31, 2019. No data was collected during the summer (June to August 2018). Perkins High School only has data for the 2018-2019 school year. Waite High School only has data for the months of October, December, and March, which is during the GLOBE Surface Temperature Field Campaign.



Graph #3 - Surface Temperatures: Freeport High Schools vs. Mountain View Middle School:

The graphs shows surface temperatures collected on the same day at about the same time. There were 16 days when surface temperatures were collected at both schools. The green line represents the hypothetical surface temperatures if both school had the same surface temperature on the same day.



Graph #4 - Surface Temperatures: Waite High Schools vs. Perkins High School:

The graphs shows surface temperatures collected on the same day at about the same time. There were 18 days when surface temperatures were collected at both schools. The green line represents the hypothetical surface temperatures if both school had the same surface temperature on the same day.

Data Analysis

Graph # 1:

- The surface temperatures of Freeport High School and Mountain View Middle School decreased between October 2017 and December 2017 and between September 2018 and December 2018. The surface temperatures gradually increased between January 2018 and May 2018 and between January 2019 and May 2019.
- Case Study #1:** In general, the surface temperatures of Freeport High School were higher than those of Mountain View Middle School, except in September 2018, when Mountain View Middle School had a slightly higher temperature (25.9°C) than Freeport High School (24.5°C).
- Case Study #2:** In the graph #1" Average Surface Temperature by Month" is shown that Perkins High School has higher temperatures than Waite High School during surface temperature was taken in both schools.

Graph # 2:

- This graph show the maximum and minimum surface temperatures of each school. Mountain View Middle School has the highest maximum surface temperature (41.7°C) and Waite High School has the lowest maximum (27.1°C). Waite High School also has the lowest minimum surface temperature (-26.9°C) and Freeport High School has the highest minimum (0.2°C).
- Case Study #1:** Freeport High School has more moderate temperatures (minimum = 0.2°C and maximum = 28°C) compared to Mountain View Middle School, which are more extreme (minimum = -10.9°C and maximum = 41.7°C).
- Case Study #2:** Perkins High School has more moderate temperatures (minimum = -2.8°C and maximum = 30.5°C) compared to Waite High School, which are more extreme (minimum = -26.9°C and maximum = 27.1°C).
- The lines representing Freeport High School and Perkins High School are very similar and the lines representing Mountain View Middle School and Waite High School are very similar.

Graph # 3 (Case Study #1):

- This graph shows that Freeport High School (residential urban area) had warmer surface temperatures compared to Mountain View Middle School (suburban residential area) 15 out of the 16 days. On one day only was the surface temperature of Mountain View Middle School warmer than that of Freeport High School.

Graph # 4 (Case Study #2):

- This graph shows the opposite of Graph #3. Perkins High School (rural area) had warmer surface temperatures compared to Waite High School (residential urban area) 16 out of the 18 days. On one day only was the surface temperature of Waite High School School warmer than that of Perkins High School. In addition, the surface temperatures of both schools were the same on one of the days (point on the green line).

Conclusions

- Case Study #1 - Freeport High School and Mountain View Middle School**

The surface temperature of the grass is generally warmer at Freeport High School throughout the year. This observation matches with our hypothesis and is probably because there are more buildings and other infrastructures than there is vegetation present in Freeport, NY. According to Graph #2 (Maximum and Minimum Surface Temperatures), Mountain View Middle School has more extreme surface temperatures (min = -10.9°C and max = 41.7°C) compared to Freeport High School (min = 2°C and max = 28°C). A possible explanation is that Freeport High School is located on the Atlantic Ocean coast, and therefore, the water of the ocean moderates the surface temperatures and the climate in Freeport compared to Mountain View Middle School, which is located inland, and therefore, has more extreme temperatures.

- Case Study #2 - Waite High School vs. Perkins High School**

The data collected Waite High School and Perkins High School doesn't match our hypothesis. In this case, the rural area (i.e. Perkins High School) is generally warmer than the residential urban area (i.e. Waite High School). One explanation could be that Waite High School is located on the West side of the Lake Erie, and as a result, doesn't receive the moderating effect of the water because the winds are blowing from the southwest to the east/northeast. In this case, it appears that general climate patterns are overruling the Urban Heat Island Effect.

The two case studies show that changes in surface temperature may be subjected to the location of the schools (i.e. rural, suburban residential, and urban residential); however, the Urban Heat Island Effect is also impacted by general climate patterns such as inland (i.e. Mountain View Middle School) vs. cities located closer to large bodies of water such as North Atlantic Ocean (Freeport High School) and Lake Erie (i.e. Waite and Perkins High Schools). In the latter case, geographic location and global wind patterns also affect the surface temperatures with Waite High School (urban area on the west side of Lake Erie) having generally lower surface temperatures than Perkins High Schools (rural but on the east side of Lake Erie).

Limitations

Some limitations of the the Freeport data set is that surfaces and air temperatures were not collected every single day. Also it was difficult to find schools with data from the same day In Long Island no schools collected surface temperatures, closest one with enough data was in New Jersey. It was difficult to find different types of schools (urban, rural, suburban, in land, island etc) with the same latitude. We did not took the surface temperature at the same time every time also we did not use the same instrument as the other schools to take the surface temperature.

Bibliography

- ESRT = Reference Tables for Physical Setting/EARTH SCIENCE from the University of the State of New York.
- Prentice Hall Brief Review for the New York Regents Exam, Earth Science: The Physical Setting, by Jeffrey C. Callister, Pearson 2010.