Comparing Select Atmospheric Parameters Between Disparate Geographic Locations Using Collaboration Between Two GLOBE Schools

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Abstract:

During the 2022-2023 school year, a group of researchers from Crestwood High School in Dearborn Heights, Michigan and the ACS International School in Doha, **Qatar** collected data on select **GLOBE atmospheric protocols** in their two different geographic locations using portable, consumer-grade Vernier Weather Stations. Using the device, a variety of data was collected on each of the two schools' soccer fields. The **Vernier Weather Device** was fitted with a wind attachment and held at an elevation of one (1) meter from the ground to collect data. Following the data collection with that device, **surface temperature** was measured using GLOBE protocols with an infrared thermometer. Additionally, for Dearborn Heights only, the data from the portable weather station was compared to the data collected by our permanent, research-grade WeatherBug station located on the corner of the roof of our new science classrooms. Atmospheric protocols, including wind speed, wind direction, wind chill, temperature, heat index, dew point, relative humidity, absolute humidity, station pressure, altitude, and barometric pressure collected in both Michigan and Qatar. Since all data was taken by both schools on the same day and close to solar noon, it was possible to analyze the data and make some comparisons between the two sites. Furthermore, noting the differences in the measurements from the portable and stationary weather station allowed us to test the accuracy of the portable Vernier weather station. Additionally, testing the accuracy of the relatively inexpensive, portable weather station may allow for the collection of data by numerous other students around the globe, transcending geographical boundaries and drawing scientific conclusions that would have not been made otherwise. Moving forward, the researchers recommend the Vernier Weather Station be considered for use by other schools and citizen scientists to facilitate greater collaboration and scientific data in microclimates across the globe.

Key words: Atmospheric protocols, GLOBE, Vernier Weather Device, Qatar, surface temperature

Research Questions:

The following research questions are relevant not only to our local area, but to the global community as well. Through these questions, researchers were able to use GLOBE atmospheric protocols to investigate the atmospheric trends of two schools eight time zones apart. Being able to inexpensively and quickly obtain and share GLOBE atmospheric data between distant locations is useful in helping to understand the geographic and atmospheric differences between different locations on the planet.

1. How do atmospheric protocols at ground level (1 meter from the ground surface) vary from atmospheric protocols at ground level (1 meter from the ground) at an entirely different geographical location and climate (Qatar)?

2. How does atmospheric protocol data collected from the Vernier Go Direct Weather Station compare with atmospheric protocol data reported from a WeatherBug Station?

3. Can atmospheric protocol measurements from portable weather devices like the Vernier Weather Station be utilized effectively by students across the world to create an inexpensive way to collect, share, and compare their atmospheric data?

Null Hypotheses:

1. There is no significant difference in atmospheric measurements taken at ground level in Dearborn Heights, Michigan as compared to data collected at ground level in Doha, Qatar.

2. There is no difference in atmospheric data collected by either the Vernier Go Direct Weather Station(s) or WeatherBug device(s).

3. Vernier Go Direct atmospheric measurements can be utilized effectively by students across the world as an inexpensive medium to collect weather related data.

Introduction and Review of Literature:

Atmospheric data including wind parameters, temperature, heat index, dew point, relative and absolute humidity, station pressure, altitude, and barometric pressure can all be used to predict weather and climate trends, relating to larger global issues such as climate change (Klausen et al., 2021). For example, data regarding wind parameters can affect rates of evaporation, the mixing of surface waters, and the development of storm surges (Fondriest staff, 2010). Additionally, the atmospheric and ground surface temperatures collected can indicate a progression of global climate change. Likewise, measuring humidity, both absolute and relative, can indicate the weather conditions, such as dew, fog, or precipitation. Lastly, barometric pressure is a significant indicator of weather patterns. Low-pressure systems lead to cloudiness, wind, and precipitation, while high-pressure systems indicate calmer weather as we watch on the weather news each evening. Observing and collecting data on such parameters in different microclimates can aid in analyzing the issue of climate change on both a local and global scale.

Furthermore, the usage of the inexpensive, portable Vernier Weather Station supports citizen science participation across the globe, which can aid in mitigating meteorological observational disparities (Caluwaerts et al., 2021). To explain, the Vernier weather station provided relatively accurate atmospheric data when compared to the WeatherBug station if altitude differences are taken into consideration. Importantly, the Vernier weather station costs less than 1% of the cost of the WeatherBug station- a roughly $100 value for the former compared to about $12,000 value for the latter. The portability and inexpensiveness of the Vernier Weather Station coupled with its relative accuracy can allow it to be a reliable source of atmospheric data for GLOBE citizen scientists.

Significantly, the majority of meteorological data is collected in open, rural environments, which can neglect atmospheric disparities caused by human-induced factors, such as in urban-heat islands (Caluwaerts et al., 2021). The fact that citizen scientists across the globe can use this technology in recording atmospheric data can compensate for the lack of atmospheric data in regions like cities, forests, and lakes (Caluwaerts et al., 2021). Therefore, the usage of portable weather stations in unique locations across the globe can assist in global weather forecasting and trend monitoring, especially in areas neglected by professional researchers.

Monitoring atmospheric data is of utmost importance in our world today as data provided by atmospheric research indicates the progression of global climate change and greenhouse gas concentrations which can be threatening to human health, ecosystems, agricultural production, etc. (Klausen et al., 2021). For example, as surface temperature increases, the soil's ability to sequester carbon decreases, an issue pertinent to ecosystems including that of the Michigan researchers. Additionally, the increase in surface temperature and decrease in humidity can decrease the amount of moisture held in the soil in both regions and the amount of precipitation, respectively, which is especially significant to dry geographical regions like Doha and agricultural regions like Michigan. Therefore, analyzing atmospheric measurements can help to make important observations and conclusions regarding larger issues such as global climate change.

Research Methods:

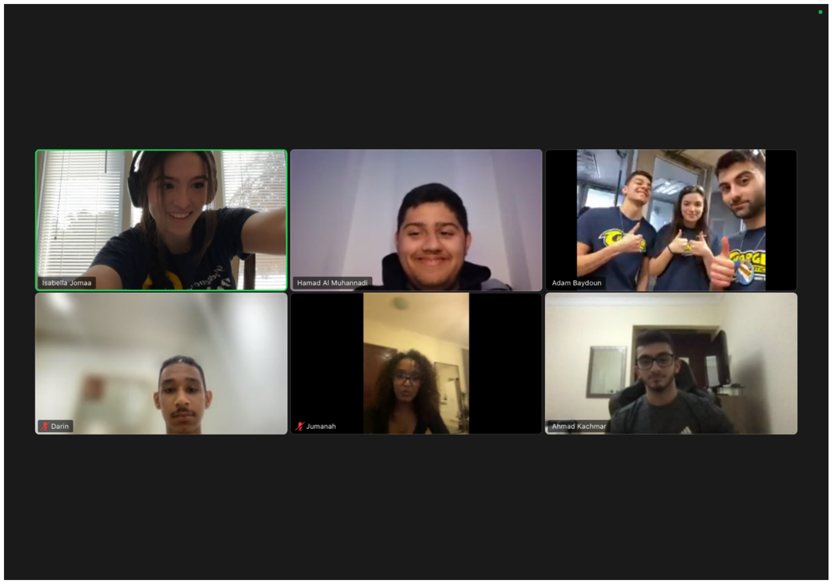

Figure 1. Collaboration. The figure above shows the Dearborn Heights, Michigan researchers and the Doha, Qatar researchers collaborating virtually over a ZOOM meeting.

Figure 2 and Figure 3. Research Sites. Image on the left is a satellite view of a research site at Crestwood High School (latitude 42°19’ 15” N and longitude - 83°17’ 39” W). Image on the right is a satellite view of a research site at ACS International School of Doha (latitude 25° 25’ 20” N and longitude of 51° 26’ 02” E).

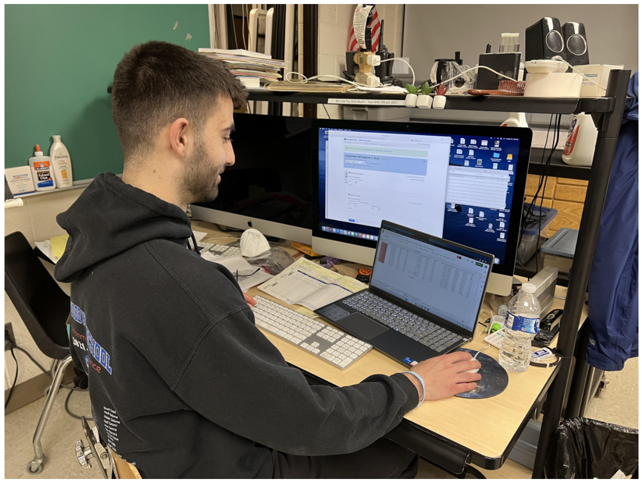

Figure 4. Data Entry. The image above shows Dearborn Heights researcher inputting the data into the GLOBE database.

To begin, researchers in Dearborn Heights, Michigan, the United States, and Doha, Qatar, collaborated over ZOOM meetings to decide the exact protocols for taking measurements. For example both groups decided measurements were to be recorded every day at solar noon for 14 days in a row. Further, each collection of data from the Vernier was collected over a span of 60 seconds and a height of approximately 1 meter. The surface temperature readings were taken from 9 spots around the reading site in a 10-meter radius with the sensor also 1 meter off the ground, with effort to ensure no shadows were interfering with the measurement.

Researchers in Dearborn Heights and Doha simultaneously recorded atmospheric data using the Vernier Go Direct Weather Device over a two week period in February of 2023. The Vernier Go Direct Device was connected to a wind attachment to monitor wind direction and speed. The aforementioned data collected included wind speed, wind direction, wind chill, temperature, heat index, dew point, relative humidity, absolute humidity, station pressure, altitude, and barometric pressure readings. Additionally, an Etekcity Lasergrip 1080 was used by both groups of researchers to take surface temperature readings. Also, low level cloud and surface types were recorded, for reference. The data collected using the Vernier device in both Michigan and Qatar were compared to attempt to answer Research Question (1), regarding whether a difference in atmospheric parameters was present between the two geographic locations of Michigan and Qatar.

The sites used for this investigation was the Crestwood High School soccer/football practice field lot– exact location of latitude 42°19’ 15” N and longitude - 83°17’ 39” W and the ACS International School Doha’s soccer field– exact latitude of 25° 25’ 20” N and longitude of 51° 26’ 02” E. Furthermore, for the Michigan location, the data collected using the Vernier device was compared to the data collected by the stationary WeatherBug Station in order to determine the level of accuracy of the Vernier device. The data collected by the Vernier and WeatherBug devices in Michigan were analyzed and compared in order to answer Research Questions (2) and (3), regarding the accuracy of the inexpensive, portable Vernier device in comparison to the expensive, stationary, research-grade WeatherBug device.

Results:

Figure 4 and Figure 5. Vernier Go Direct Weather Device. Image on the left shows the Vernier Go Direct Weather Device that we used to take most of our data. Image on the right shows a Dearborn Heights researcher taking data using the device.

Figure 6 and Figure 7. Etekcity Lasergrip 1080. Image on the left shows the Etekcity Lasergrip 1080 that we used to measure surface temperature. Image on the right shows a Dearborn Heights researcher taking surface temperature readings.

Figure 7. Location of WeatherBug Station Relative to Ground Level. The figure above shows the research-grade WeatherBug Station located on top of the school building in Dearborn Heights, Michigan.

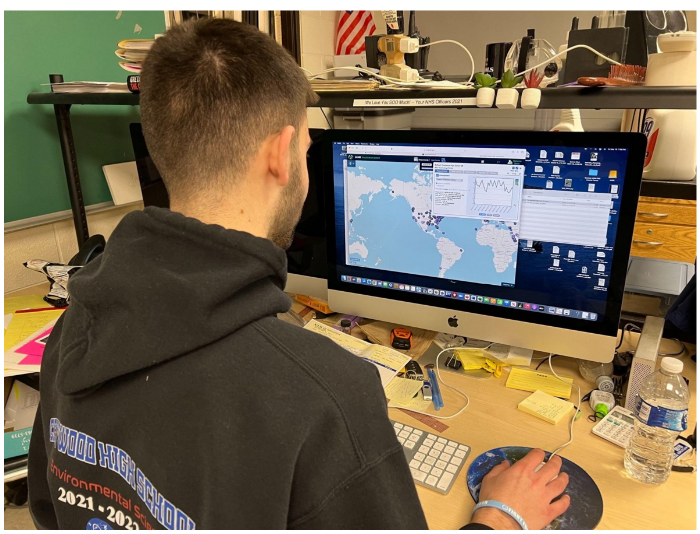

Figure 8. GLOBE Visualization page. The figure above shows Michigan researcher Adam Baydoun using the GLOBE Visualization page with collected data.

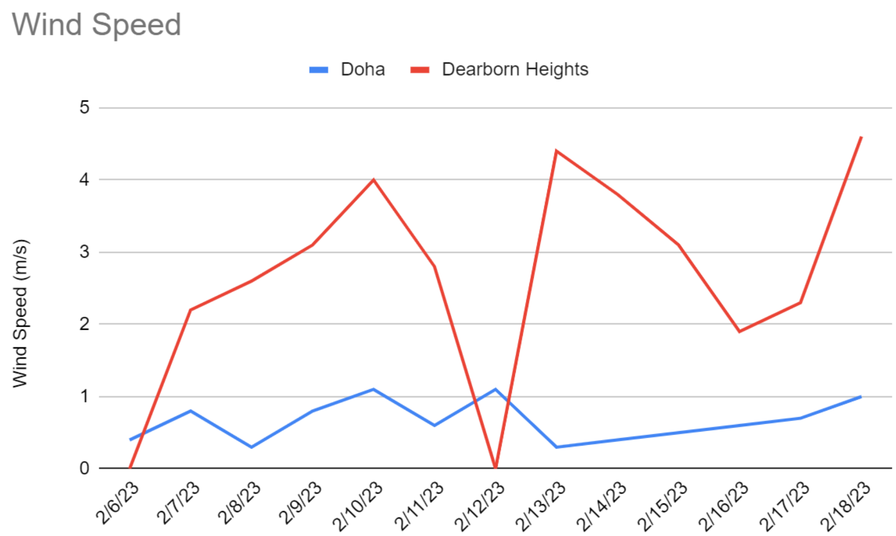

Figure 9. Wind Speed Comparison. The line graph shows the comparison of wind speed between the site in Doha and the site in Dearborn Heights. For the entirety of the two weeks, the wind speed in Doha is significantly less than that of Dearborn Heights, with the exception of 12 February 2023, averaging around or below 1 m/s. Further, the wind speed in Doha is less variable as it remains around or below 1 m/s is more consistent and averages around below 1m/s while the wind speed in Dearborn Heights fluctuates between a low of 0 m/s and a high of around 4.5 m/s.

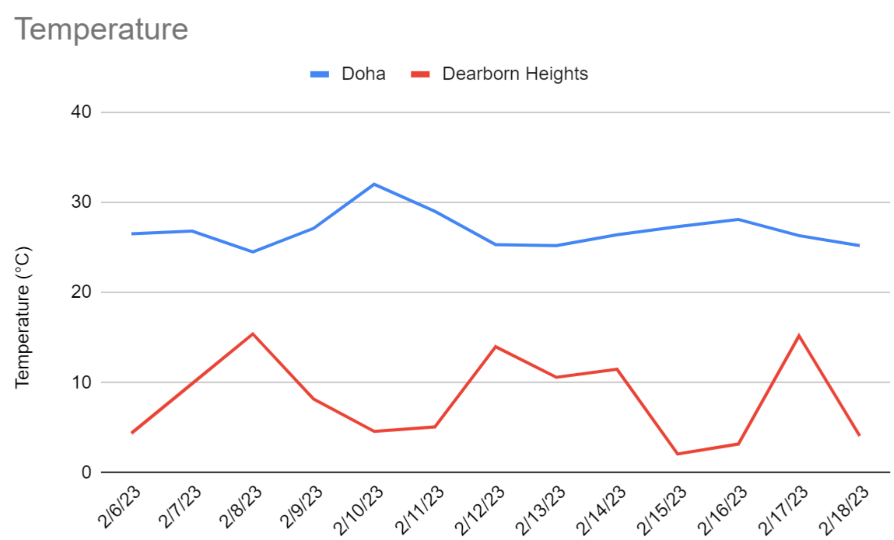

Figure 10. Temperature Comparison. The line graph shows the comparison of temperature between the site in Doha and the site in Dearborn Heights. The temperature in Dearborn Heights averages around 8.3 °C in the 2 week period and fluctuates much more than the temperature in Doha which had a much higher average of around 26.9 °C.

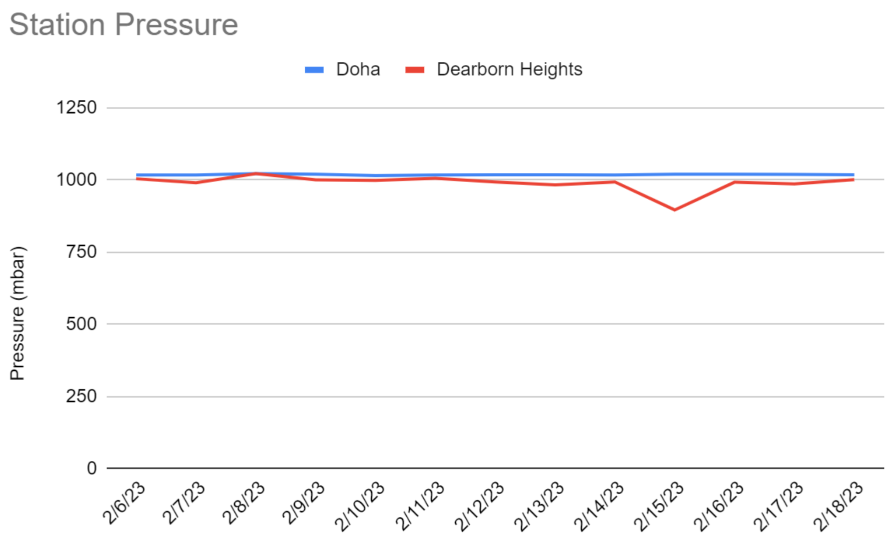

Figure 11. Station Pressure. The line graph above shows the comparison of weatherbug station pressure between Doha and Dearborn Heights. Station pressures for Dearborn Heights and Doha in the 2-week period remained mostly constant with little fluctuations, with the exception of 15 February 2023 where it was substantially lower in Dearborn Heights than Doha. Dearborn Heights pressure was also slightly lower throughout the 2-week research period.

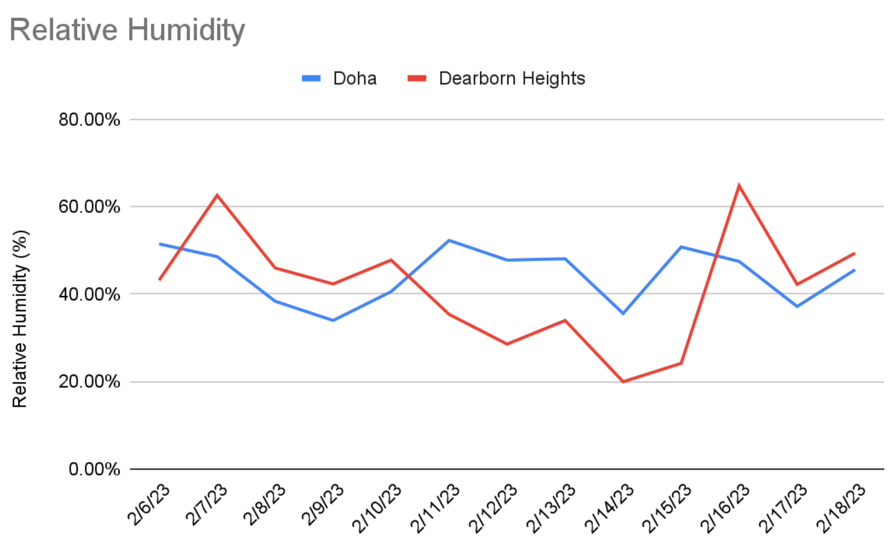

Figure 12. Relative Humidity. The line graph above shows the comparison of relative humidity between Doha and Dearborn Heights. Dearborn Heights starts off with a higher humidity than Doha and then gradually falls to an absolute minimum of 20% humidity while Doha has an absolute minimum of 34%. While both sets of data fluctuate, the Dearborn Heights data is more variable in comparison to the Doha data.

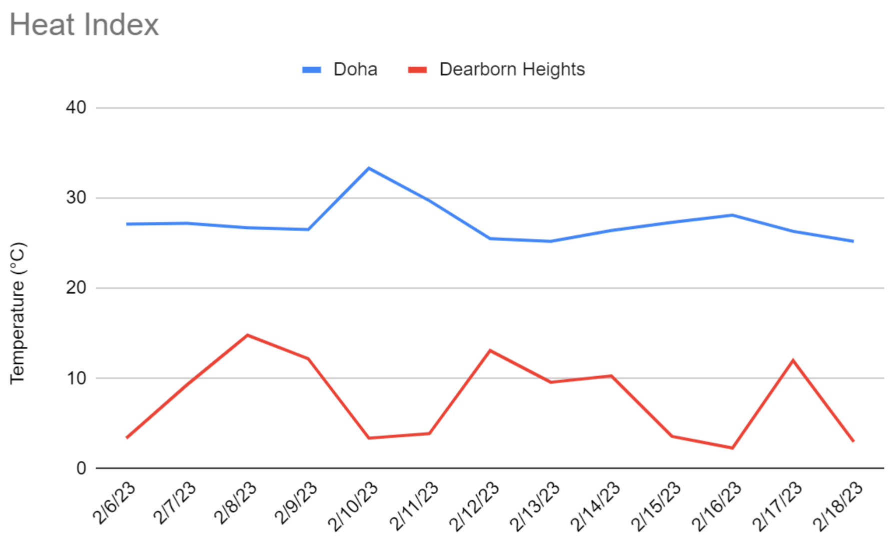

Figure 13. Heat Index. The line graph above shows the comparison of heat indexes between Doha and Dearborn Heights. Heat index is how hot it actually feels and is a mix of temperature and humidity. Doha has a higher heat index than Dearborn Heights that has an average around 7.8 C while Doha has an average 27.3 C. Also, the Dearborn Heights data is inversely related to the Doha graph.

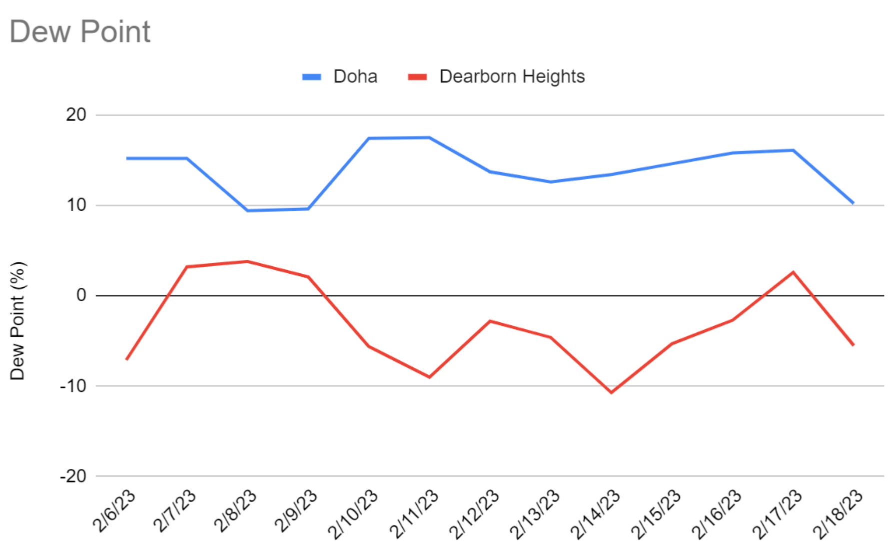

Figure 14. Dew Point. The line graph above shows the comparison of dew points between Doha and Dearborn Heights. The dew point of Doha remains significantly higher than that of Dearborn Heights for the entirety of the two-week period. Further, the graphs are inversely related.

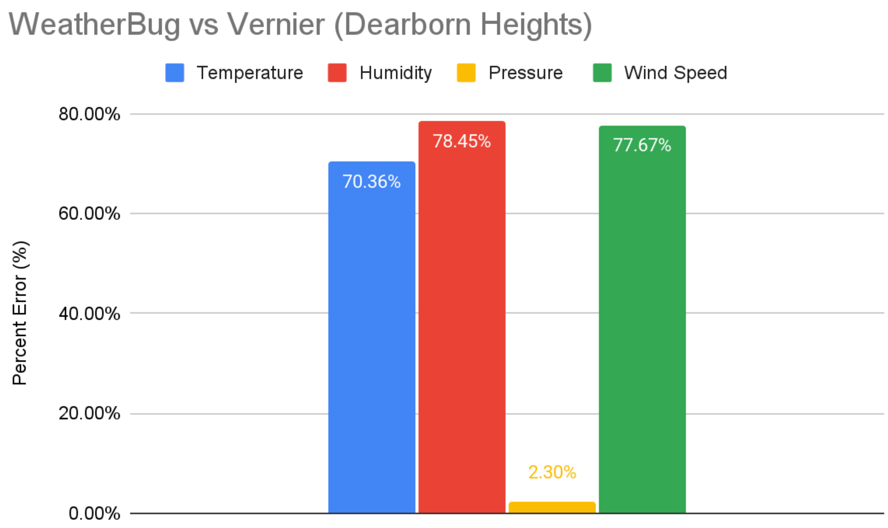

Figure 15. Weather Bug vs Vernier (Dearborn Heights). The graph above shows the percent error of temperature, humidity, pressure and wind speed between the WeatherBug Station and Vernier Go Direct Weather Device in Dearborn Heights, Michigan. Temperature, humidity and wind speed have a relatively high percent error of around 70-80%. On the contrary, pressure had a negligible percent error of around 2.3%.

Discussion:

The researchers reject the null hypothesis that there is no significant difference in atmospheric measurements taken at ground level in Dearborn Heights, Michigan as compared to data collected at ground level in Doha, Qatar in terms of the atmospheric parameters of wind speed, temperature, station pressure, relative humidity, heat index, and dew point. The wind speed average taken by the Michigan researchers was significantly higher and varied greatly as the respective lower temperature and higher pressure in Michigan. In terms of temperature, Doha had a higher, more consistent temperature compared to the temperature taken in Dearborn Heights which is likely due to the seasonal differences. Station pressure remained predominantly consistent between the two areas with the Michigan data being slightly lower. Similarly, the relative humidity fluctuates at a similar rate in both Doha and Dearborn Heights with the exception of Dearborn Heights fluctuating at a more extreme degree. This is likely due to precipitation differences, such as snow in Dearborn Heights. With respect to heat index, Doha likely has a greater heat index as their geographical location is closer to the equator thus allowing for a higher temperature and humidity from the Persian Gulf. Last, in terms of dew point, there is a relatively inverse relationship between the data collected in Doha and Dearborn Heights as the sea breeze from Persian Gulf creates greater moisture in Doha's atmosphere while cooling off the land increasing Doha's dew point. While there was significant difference in atmospheric data collected between the Vernier Go Direct Weather Station(s) and the WeatherBug device(s), the significant difference between the technology was likely due to the differences in altitude of the devices as the Vernier Go Direct Weather Device was help one meter from the ground while the WeatherBug Device is at a significantly greater height. Therefore, we reject the null hypothesis that there was no significant difference between the Vernier Go Direct Weather Device and the WeatherBug Device. Additionally, the researchers accept the null hypothesis that the Vernier Go Direct atmospheric measurements can be utilized effectively by students across the world as an inexpensive medium to collect weather related data as the accuracy of the device is comparable to research grade equipment that it can help provide and better track weather patterns in both a macro and micro scale. This device will move beyond physical country boundaries, religions, cultures, and language barriers and provide a suitable device for student scientists to compare and track correlations between data across the globe.

Notably, there were many possible sources of error with the data collected, primarily due to the great distance between the Michigan researchers and the Doha researchers, who were only able to collaborate virtually. For example, the measurements taken by both groups of researchers could be slightly skewed due to inconsistencies between the placement of the Vernier and surface temperature devices. Additionally, the Michigan researchers took surface temperature readings on natural grass, while the Doha researchers did so on artificial turf, which could account for inaccuracies within the surface temperature measurements. Further, the possible inaccuracies present in the data are not limited to the above; more inaccuracies may be present due to the physical and language barriers between the Michigan and Doha researchers. Significantly, the data involved in this report was taken during a limited period of time, in the winter of Michigan and Doha, which is significantly colder for the former. For future research, it would be significant to compare the atmospheric data collected in both geographic regions during a different season, or perhaps, a longer period of time, spanning several seasons. Importantly, the original intention of the Michigan researchers was to write this paper as a collaboration with the researchers from Doha, with both groups contributing to the actual composition of the report. However, this was unable to occur as the Doha researchers did not attend physical school for roughly two months due to the 2022 World Cup, which was held in Doha. Thus, the Michigan researchers are the sole authors of this report, which could account for any biases presented in the report toward Michigan.

Additionally, though there appears to be a large margin of error between the Vernier device and the WeatherBug station in the graphs, this margin of error can be explained by numerous factors. Temperature has a percent error of 70.36% while humidity has a percent error of 78.45%. While this may appear to be high, one must take into consideration the altitude differences between the Vernier device and the WeatherBug station. To explain, the Vernier device was used at an altitude of about 1 meter off the ground while the WeatherBug station is located on top of the school building, quite a few feet off the ground. Temperature and humidity both decrease as altitude increases, possibly accounting for the disparities present between the two devices.

Additionally, wind speed has a percent error 77.67%. This may be explained due to the fact that the WeatherBug station is located on top of the school building, with very few obstructions is to be expected as wind speed also varies with altitude and the buildings, trees or even our own bodies could have affected the air flow to the Vernier while the weather bug isn't affected because it's on the roof of Crestwood High School. Pressure, however, has a very low percent error of 2.3%, due to the fact that for pressure, specifically, the altitude difference is small enough to be negligible.

Conclusion:

Using the relatively inexpensive, portable Vernier Go Direct Weather Station, researchers in Dearborn Heights, Michigan and Doha, Qatar found a significant difference in atmospheric measurements taken at ground level in both geographic locations. Further, the measurements in the Michigan location using the Vernier Go Direct were compared to measurements taken by the research-grade WeatherBug Weather Station. As a result, the Vernier device was concluded to be an appropriate educational-grade device to predict and monitor weather and climate trends. Therefore, the Vernier Go Direct atmospheric measurements can in fact be utilized effectively by students across the world as an inexpensive medium to collect weather related data as the data collected by this device is extremely accurate at a level that is on par to research grade devices like the aforementioned WeatherBug.

The usage of the Vernier device will allow students and other citizen scientists across the globe to take relatively accurate atmospheric measurements for their geographic location, helping to mitigate the meteorological gaps present in current data. Additionally, this device will open greater collaborative efforts between student scientists across the globe, allowing for an accurate microscale collection of data and corresponding global weather patterns. The use of this device could transcend country boundaries, religions, cultures, and language barriers to unite student researchers in a collective effort to better understand atmospheric phenomena and patterns on a micro and global scale.

In the future, this research may be expanded to other geographic locations across the globe. For future reference, similar data should be collected over longer periods of time, spanning more than one season. Also, ground-level data should be taken simultaneously with reports from the WeatherBug station, so as to have the highest accuracy of comparison between the two data sets. Finally, working with collaborators across the globe, as well as a mentor, provided a unique experience for all researchers. Collaborating with students in an entirely different geographic location allowed researchers to expand their knowledge and perspectives on the topic, formulating a truly memorable experience in which all participants were able to grow as citizen scientists. A project like this under the design of a NASA scientist would make a great GLOBE Measurement Campaign or intense observation period.

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Badges:

I Am A Collaborator:

The researchers hope to receive the “I Am A Collaborator” badge for their collaboration with Darin Chebib, Ahmad Kachmar, Hamad Almuhannadi, and Jumanah El Hassan from the ACS International School of Doha, Qatar. Transcending religions, cultures, country boundaries, and time zones, the researchers collaborated with their international peers to formulate conclusions about global weather patterns and the accuracy of the GLOBE approved Vernier Weather Go Direct Device. By collaborating with our international student counterparts, the researchers make a personal connection to achieve the goals of their research while involving students from other nations and biome-types. This allowed for a greater understanding of the data collected as well as a better appreciation of cultural and climate differences. By sharing experiences and working together to achieve a common goal, relationships were strengthened across the globe.

I Make An Impact:

The researchers hope to receive the “I Make an Impact” badge for their global collaboration with students across the world, working together to research atmospheric trends. The goal of their research was to make an impact on global student collaborations by making a personal connection with other students in face to face conversations via Zoom. Instead of simply relying on the Internet to compare and validate the data from the Vernier Go Direct Device, making personal connections with others truly makes a *global* impact with our research.

I Am A Data Scientist:

The researchers hope to receive the “I Am A Data Scientist” badge for their data collection, inferences/analysis of the data, and organization of the data. The researchers collected data from two geological locations, organized into graphs and analyzed it for any correlations in the data. Consecutively over the course of fourteen days, the researchers had to collect and organize data using Google Sheets. Additionally, information was shared to Qatar Collaborators via Gmail and Google Sheets. A significant amount of the results revealed that the Vernier Go Direct Weather Station is a suitable device for research and comparisons in countries across the world. The researchers hope to use their findings to make inferences regarding future global atmospheric protocol measures. Considering the relatively inexpensive device used for collection, by broadening this research matter across countries, worldwide data on atmospheric measures will help students and people across the globe research and compile data in an efficient and inexpensive manner. Some limitations of the data include issues with the device, connection between the Vernier Go Direct and technological application on laptop. Additionally, the time differences between the two data locations are limitations of the data.