Using Aeropod Technology to Interpret Select Microscale Weather Parameters Using Vertical Profiling

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Abstract

Microclimates are largely unassessed when looking at the threat of climate change and environmental threats. Our research is about how various weather parameters on a microscale level such as **dew point**, air temperature, and **relative humidity**, affect **cloud formation**. We used the GLOBE Cloud Protocols and the GLOBE AREN Protocols when retrieving the data. Our research compared these weather parameters at ground level to 122 meters in the air. A Kestrel 5500 Weather Meter, mounted on a tripod 1.2 meters high, took data on various weather parameters for 7 days. The Kestrel was then attached to an Aeropod, which it flew on an "Into The Wind" Levitation 7 ft Delta Kite 122 meters high to collect data. We found that as altitude increased, dew point and relative humidity increased, whilst air temperature decreased. Furthermore, we found, the higher humidity and dew point were, the lower clouds formed which were overcast, like stratocumulus clouds. Some recommendations we and Mr. David Bydlowski of NASA had to move forward are measuring particulate matter to compare the results with Princess Chulabhorn, a school in **Thailand**. We have been communicating weekly with them, and plan to complete this investigation in the imminent future.

Introduction

While weather is typically forecasted as averages across different regions, microclimates in local areas often go largely unassessed. Yet, many of these microclimates are where all of us live, go to school, recreate outdoors, etc. Currently, most local weather conditions are predicted based on larger regional models of weather and climate. Although this usually proves fairly precise and accurate, it is only when one truly understands more microscale weather conditions that truly accurate decisions can be made about safety and other smaller scale decisions that need to be made by school administration. Climate change begins locally and is felt globally. Local datasets can contribute to a better regional and global model of how our planet operates. The effective management of microclimates can either help or hinder the larger threat of climate change and help the local geographical regions adapt to climate change (Sriraj). Microclimates and the collection of data on various weather phenomena can help contribute much needed missing data and help assess the role that clouds play in climate change. The effect of clouds on climate change is just beginning to be more clearly understood. Dew point is the temperature at which water vapor condenses and is useful in estimating conditions such as snow, rain, near-surface humidity, and other meteorological parameters.

We can also use projections of dew point temperature to help in predicting the formation of dew or fog. It may also give us a starting point for approximating low temperatures the next day, as the lowest temperature will end up relatively close to the dew point at the time of maximum temperature the day before (Ukhurebor). Dewpoint and relative humidity are two important weather parameters in the formation of clouds. Clouds and cloud types can either contribute to climate change or reflect heat back to space (Identify Cumulus Clouds 2).

Research Questions

- Do near surface weather parameters such as air temperature, humidity, and dew point predict the altitude and the types of clouds that form during the winter?
- How do select surface weather parameters measured at ground level compare with the same weather parameters at an altitude of approximately 122 meters or 400 feet above the surface during the winter?
- How does vertical weather profiling using AREN/NASA technology compare at northern latitudes as compared with warmer latitudes like those found in Thailand in the future?

Null Hypotheses

- Select surface weather parameters cannot be used to predict the types of clouds that form and the altitude at which they form.
- There is no correlation between air temperature, humidity, and dew point measured at 1.2 meters from the surface of the ground as compared with the same measured parameters at a height of 122 meters.
- Vertical weather profiling using AREN/NASA technology used to collect select atmospheric data at a northern latitude will be the same as compared with a warmer latitude found in Thailand.

Methods

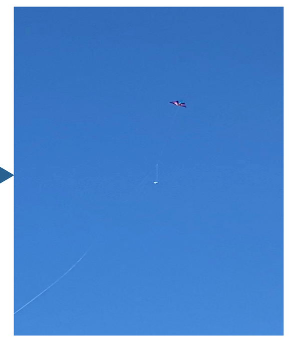
Crestwood High School Practice Field Site. This photo is 304.8 m high

Kestrel 5500 Weather Meter used to take atmospheric data

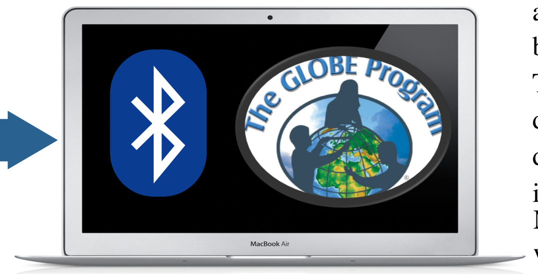
Kestrel 5500 Weather Meter mounted on tripod

Cloud Data taken through Globe Observer App

Kestrel attached to Aeropod



Aeropod attached to kite at 122 meters collecting data



Data imported to laptop via Bluetooth then uploaded to Globe Database

Results

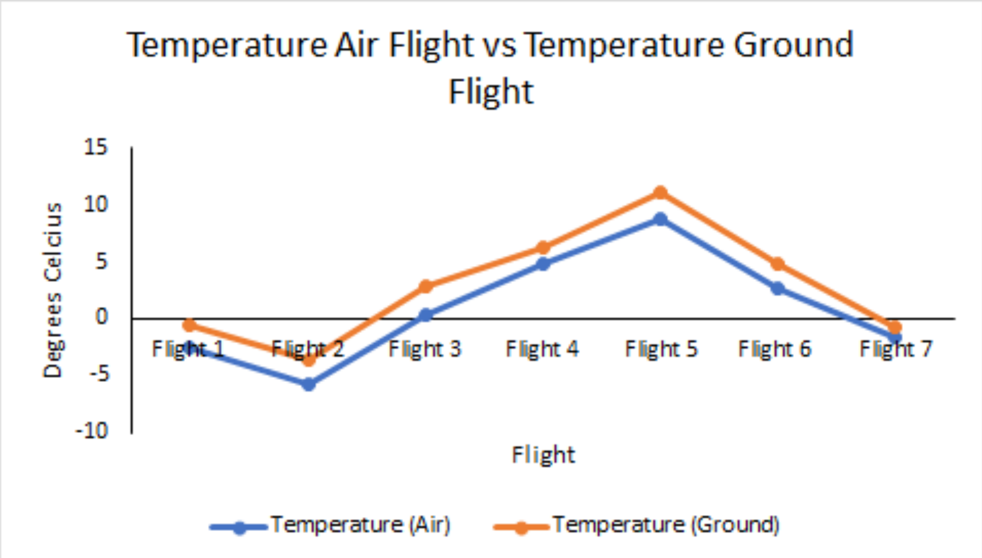


Figure 1: Air Temperature 1.2 Meters High vs 122 Meters High at Crestwood High School's Practice Field (°C). Air temperature is one of the most commonly recorded weather parameters. The air temperature indicates how fast the gas particles in the air are moving. Air temperature 1.2 meters high and 122 meters high seems to be very correlated. As altitude increases, air temperature decreases. This is clearly shown here; there seems to be a 2°C differential all the way through. As altitude increases about 120 meters, the air temperature decreases by about 2°C constantly.

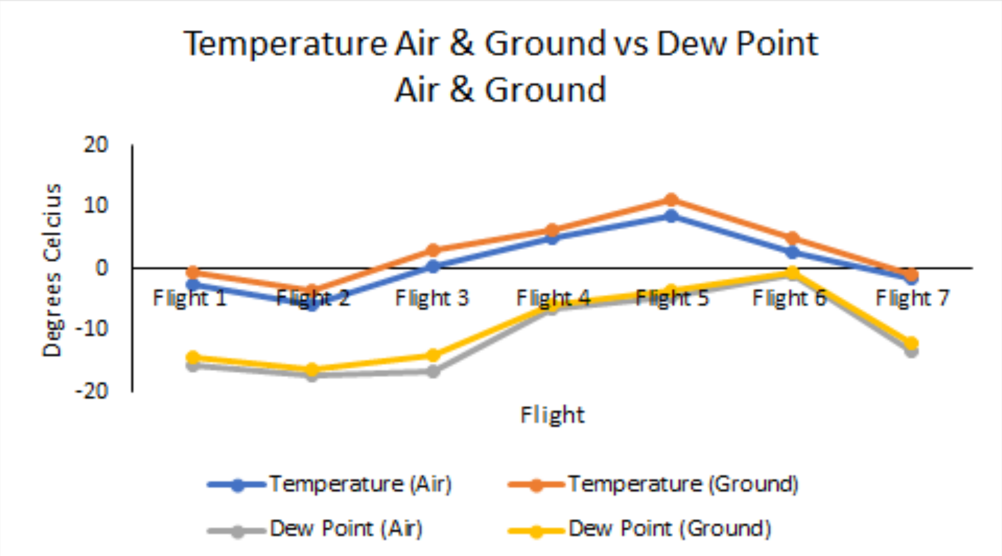


Figure 4: Air Temperature and Dew point 1.2 Meters vs 122 Meters High at Crestwood High School's Practice Field (°C). Temperature, as previously said, is one of the most commonly recorded weather parameters. The air temperature indicates how fast the gas particles in the air are moving. The dew point is also the point where air can't hold any more water vapor, and some of the water vapor has to condense. This is where cloud formation starts. The graph shows how air temperature on the ground and air, and the dew point on the ground and air are correlated. This showed how dew point is always a lower temperature than air, except when they are the same and condensation occurs. It seems that throughout the flights, the dew point was usually 15°C lower than the air temperature. With more investigation and conduction of flights, the researchers can try and support their claims with more data.

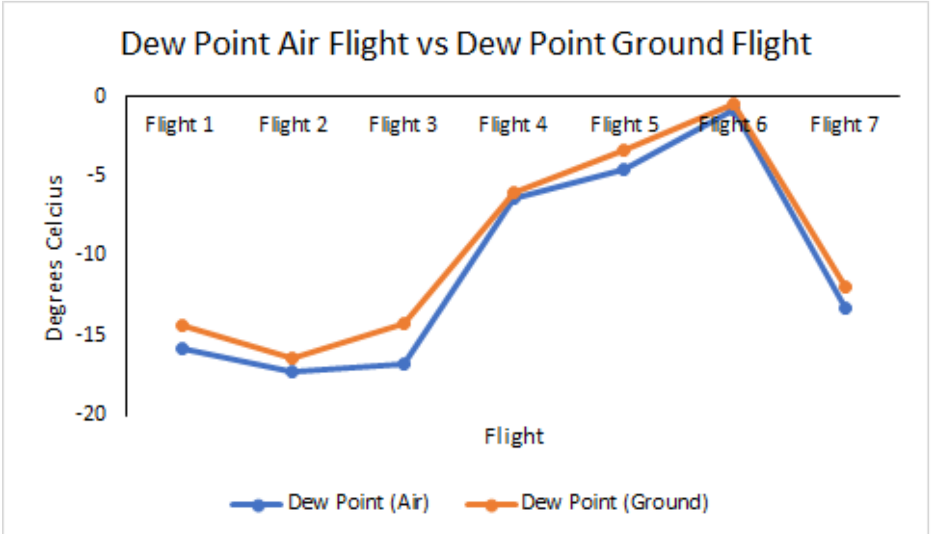


Figure 2: Dew Point 1.2 Meters High vs 122 Meters High at Crestwood High School's Practice Field (°C). Dew point is the temperature is the temperature the air must be cooled to in order to reach saturation. When dew point is reached, the air can't hold any more water vapor, so a portion of the water vapor has to condense and become a liquid. This is where the process of condensation begins, and a cloud begins to form. This means that dew point is directly correlated with cloud formation. Dew point at 1.2 meters high and 122 meters high seems to be directly correlated. Dew point in the air seems to always be lower than on the ground. If the dew point in the air and dew point on the ground became very similar, fog would begin to form.

	Type of Cloud	Temperature (°C)	Dew Point (°C)	Relative Humidity (%)	Cloud Pictures
Flight 1 2/19 at 21:04:00	Cirrus (10-25%)	Ground: -0.6 Air: -2.6	Ground: -14.3 Air: -15.8	Ground: 35 Air 35.4	
Flight 2 2/20 at 21:09:00	Cirrus (1-10%)	Ground: -3.7 Air: -5.7	Ground: -16.4 Air: -17.3	Ground: 36.7 Air: 39.4	
Flight 3 2/21 at 20:42:00	No Clouds (2 Contrails)	Ground: 2.9 Air: 0.4	Ground:-14.2 Air: -16.8	Ground 27.2 Air: 26.1	
Flight 4 2/22 at 19:30:00	No Clouds	Ground: 6.3 Air: 4.8	Ground: -6 Air: -6.4	Ground: 40.9 Air: 44	
Flight 5 2/23 at 18:20:00	No Clouds	Ground: 11.1 Air: 8.7	Ground: -3.4 Air: -4.6	Ground: 36.3 Air: 38.8	
Flight 6 2/25 at 20:26:00	Stratocumulus (90-100%)	Ground:4.9 Air: 2.6	Ground:-0.5 Air: -0.8	Ground: 68.1 Air: 78.2	
Flight 7 2/29 at 18:25:00	Cumulus (1-10%)	Ground: -0.8 Air: -1.7	Ground: -12 Air: -13.3	Ground: 42.3 Air: 40.8	

Table 1: Effects of Air Temperature, Dew Point, and Relative Humidity on Cloud Formation. This table shows the effect that air temperature, dew point, and relative humidity had on cloud formation. Dew point is the point where the air cannot hold any more water vapor, so water vapor has to condense. The higher the dew point, the more clouds form. Clouds associated with high dew point include stratocumulus, as shown in Flight 6, stratus clouds, nimbostratus clouds, etc. Relative humidity is the amount of water vapor in the air. The higher the relative humidity, the more clouds form. Types of clouds associated with high percentages of relative humidity include stratocumulus, nimbostratus, and stratus clouds. As shown in Flight 6, the relative humidity was significantly higher than the rest of the flights. The dew point was also significantly higher than the rest of the flights. This led to stratocumulus clouds that day. However, the other flights had much lower percentages of relative humidity and dew point, which lead to higher clouds such as cirrus, cirrocumulus, etc. The temperature however in this experiment did not show a direct correlation to cloud formation.

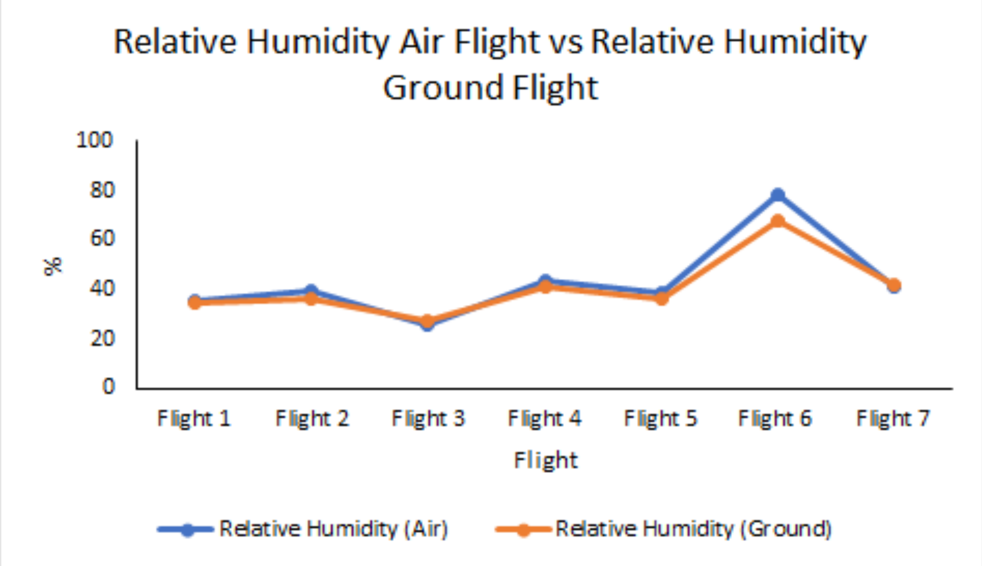


Figure 3: Relative Humidity 1.2 Meters High vs 122 Meters High at Crestwood High School's Practice Field (%). Relative humidity is the amount of water vapor present in the air. This number is expressed as a %. When relative humidity is 100%, water vapor condenses and begins to form clouds. The relative humidity seems to be relatively the same on the ground vs in the air. In the air, the relative humidity increases by a very miniscule amount.

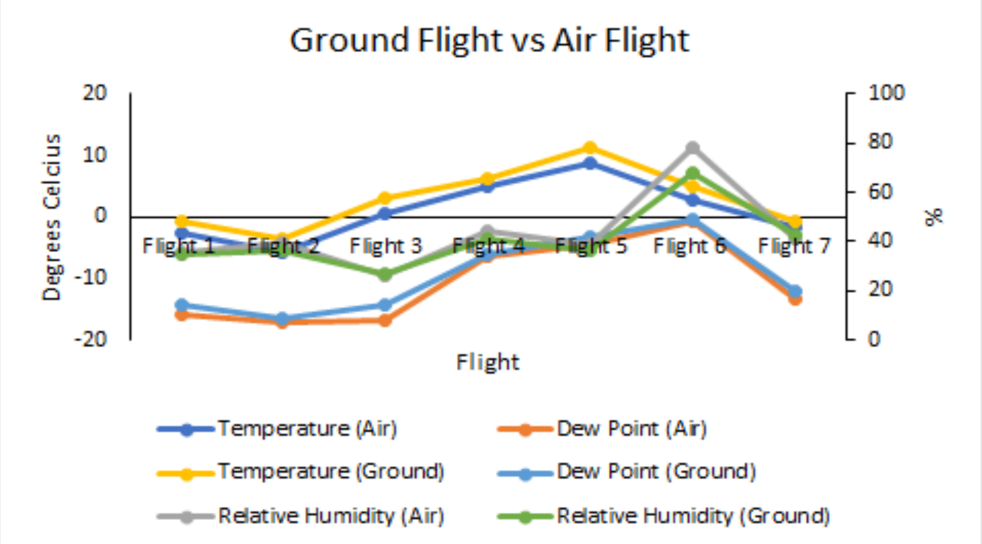


Figure 5: Air Temperature, Dew Point, and Relative Humidity 1.2 Meters vs 122 Meters High at Crestwood Highschool's Practice Field (°C) (%). This graphic shows the air temperature, dew point, and relative humidity on the ground vs the air throughout the 7 days. It also shows that each weather parameter had close correlations with each other. The dew point is always the lowest, the relative humidity higher, and temperature the highest. The temperature on the ground was always higher than in the air, the relative humidity percent was relatively the same, but the air's relative humidity percent was slightly higher. On the ground, the dew point seems to be slightly higher than in the air. This is a composite of all the data we took.

Conclusion

Overall, these weather parameters seem to be directly correlated as they increased in altitude. After carefully analyzing the data, and consulting with Mr. David Bydlowski of the NASA GLOBE AREN Project, the researchers affirmed direct correlations between these parameters. The impacts of working with Mr. David Bydlowski of NASA was very inspiring for the researchers. To work with a mentor involved with NASA was very beneficial and inspirational to the researchers. The researchers determined that as altitude increases, temperature and dew point decreases, while relative humidity increases. There is also a direct correlation between dewpoint, relative humidity and cloud formation. The higher the dew point and relative humidity, the increase in low level clouds that form, like stratocumulus or nimbostratus which overcast the whole sky.

Microclimate weather parameters are important to analyze because microclimates and their associated weather conditions are poorly understood and how they affect larger scale weather conditions is just beginning to be studied in greater detail. It is important to study the effects of microclimates on large scale, macroclimate trends. This project helped the researchers determine the effect of various weather parameters on cloud formation, and the overall effects on the macroclimate. A few improvements in methods next time the researchers aspire to reach are to get the kite higher in altitude, use different instruments, use a bigger kite, get the kite more vertical than slanted, and maybe next time, profile CO2 concentrations. Some globe protocols that can be added in the future are particulate matter added, as well as other air pollutant monitoring like nitrogen dioxide, sulfur dioxide, etc.

Discussion

After careful analysis, there were significant correlations found between select surface weather parameters measures at ground level like air temperature, dew point, and relative humidity compared with the same weather parameters at an altitude of approximately 122 meters above the surface during the winter.

•As altitude increased by approximately 100 meters, the air temperature was almost a constant 2°C lower than on the ground. Dew point was also relatively lower as altitude increased, by about 1-2°C lower than ground level dew point.

•Regarding relative humidity, as altitude increased by about 120 meters, relative humidity percent also increased on average by about 2-5°C.

•Additionally, the researcher's flights clearly showed the effects of higher relative humidity percentages and dew point in cloud formation.

The higher the relative humidity percent, and the higher the dew point, the lower, bigger clouds developed such as stratocumulus and stratus clouds This led to the rejection of the first two null hypotheses. However, the researchers had to accept the third null hypothesis because unfortunately the student researchers in Thailand are on a school break. When they are off break, which ends in May, the researchers plan to continue this research project and collect valuable data to compare. Some possible sources of errors include the Kestrel having the inability to be a barometer and an altimeter simultaneously, so there was no definitive way of obtaining the exact altitude. To add, the Kestrel may have not been acclimated to outside weather conditions long enough before flying.

Research Implications

While drones carrying weather instrumentation might seem like an easier method for measuring various weather parameters, this can often turn out to be a costly way of collecting data. More inexpensive drones cannot carry the weight of many weather sensors and because of strict FAA and licensing restrictions it simply isn't a good option for many schools in Michigan. In addition, drones work best in calm or no wind situations. The AREN Project uses NASA based Aeropod technology and a complete set-up to monitor weather relatively inexpensive (under $100) and can be used all over the world while still providing accurate results. Most importantly, as long as there is some wind, the kites carrying Aeropods can fly to collect weather data. Although large regional weather conditions are best recorded by remote-sensing satellites, many microclimates and their associated weather conditions are poorly understood and how they affect larger scale weather conditions is just beginning to be studied in greater detail. Our school campus is its own microclimate within a neighborhood of many homes and businesses. Information collected on how our microclimate compares with the larger community of Dearborn Heights can shed possible insight into phenomena such as fog formation, urban heat island effect and other small-scale weather events. This investigation also sought to collect winter weather data during some extremely cold months of the year. Because sports and many outdoor activities take place on our campus throughout the year, this research hopes to contribute to a local/school database to be used by individuals, teams, and local decision makers using our campus to make sound judgements about using our outdoor facilities throughout the year.

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