# Clouds and Their Effect On Surface Temperature

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**Abstract**

The purpose of this project was to explore the relationship between different types of clouds and their effects on the surface temperature of our planet. The project explored low, mid, and high level clouds specifically, and observed their own respective differences. It analyzed multiple surfaces so that we can be sure of trends found on given days in relativity to our Earth. Our project works to answer the question:  How does the amount of high, middle and low level clouds present in the sky affect the surface temperature measured? We predicted that if there are lower level clouds present then the surface temperature will be colder because lower level clouds reflect heat from the sun and prevent its rays from getting to the ground. Based on the data shown later in our presentation, we were correct. We performed our experiment using the GLOBE Atmosphere Investigation Cloud Protocol Data Sheet, a thermometer, and a computer to record the data. We can conclude because of our research that low level clouds work to create a colder surface temperature, while high level clouds do the opposite, making a warmer one.

**Introduction**

Rain, snow, hail, sunny, and cold days. Where does weather influence come from? When we were asked to explore one of the biomes, one specifically stood out to us: the atmosphere. The atmosphere plays a huge role in human life, influencing all biotic factors on earth. When diving deeper, clouds and their influence on surface temperature became our main focus. So the question remains: How does the amount of high, middle and low level clouds present in the sky affect the surface temperature measured? If there are lower level clouds present then the surface temperature will be colder because lower level clouds reflect heat from the sun and prevent its rays from getting to the ground.

The clouds in our atmosphere form at many levels, and high level clouds play a very important role in surface temperature. High level clouds can be found in the form of contrails. Contrails are formed from aircraft exhaust when water vapor condenses and freezes around small particles of aerosols. The three main high-level tropospheric clouds are cirrus, cirrocumulus, and cirrostratus. Cirrus clouds are short- detached and almost hair-like clouds. Cirrocumulus are short-lived and appear as little round puffs in long rows of the sky. Cirrostratus clouds appear as wide, thin sheets that allow the sun's shine to pass through. National Geographic's (2023) Cloud Cover article expands into cirrus clouds, saying that their presence in high-level ecosystems usually calls for low-pressure systems, and therefore storms. However cirrus clouds in high level systems, creating warming for our Earth. They absorb the Earth's radiation and make sure that more is cycled back to our Earth than into space. Nasa's Earth Observatory states, (1999) "The overall effect of the high thin cirrus clouds is to enhance atmospheric greenhouse warming." As a result of their transparency and heating-radiation properties, the higher the presence of high-level clouds, the warmer the surface temperature.

Low clouds however, do not have the same effect on the surface temperature that high-level clouds do. Low level clouds can be found in the form of fog, a water vapor that changes in the air. However, the primary low level clouds are nimbostratus, cumulonimbus, stratus, cumulus, and stratocumulus. Stratus clouds are low-level that appear as grey or white and are long lasting. Nimbostratus specifically appear as grey, thick layers of cloud. These are often the scenes of overcast. Furthermore, cumulonimbus clouds, commonly known as thunderclouds, appear as a flat dark wall. These clouds are the only cloud type that can produce hail, thunder, and lightning. They are associated with cold fronts and disappoint many when spotted. Cumulus clouds are detached white tufts. Cumulus clouds are often correlated with fair weather conditions, although a dark cloud base can be present. Stratocumulus clouds are thicker types of cumulus clouds that appear dark grey and conjoined, typically producing rain or snow pellets. Low level clouds, based on Nasa's Earth Exorbitory data have the opposite warming effect of high-level clouds. Rather than emitting radiation, these thicker clouds do not let as much energy from the sun reach the surface. Based on this information, low-level clouds can be associated with a cooling effect. The higher presence of low-level clouds, the cooler the surface temperature.

The final type of clouds, mid-level clouds, play the smallest role in surface temperature. There are two types of mid-level clouds, altostratus and altocumulus. Altostratus clouds are large-thin sheets. These are usually full of water droplets as well as ice crystals. These clouds' arrival tends to form ahead of a warm or occluded front. Altocumulus clouds are flat puffy clouds that are separated into clumps, sometimes throughout the whole sky. Altocumulus clouds are associated with settled weather and show a rising heat into the atmosphere. Mid-level clouds have the least impact on weather and surface temperature. But, their presence still has a small effect on the surface temperature. Mid-level clouds do not trap as much heat radiation from Earth like high-level clouds do, and they do not reflect as much light from the sun like low-level clouds do. However, due to the moderate altitude, they tend to block some sunlight. Therefore the more mid-level clouds present, the cooler the surface temperature.

When further exploring this correlation between clouds and surface temperature, we came across urban heat islands. A heat island can form from many different factors. To quote EPA (2024), “Clear weather conditions result in more severe heat islands by maximizing the amount of solar energy reaching urban surfaces and minimizing the amount of heat that can be carried away. Conversely, strong winds and cloud cover suppress heat island formation.” This means fewer clouds allow heat to pool in one area and absorb into the surface. But these islands cannot just be blamed on the weather. The rise in temperature also comes from waste energy burned by people, such as from cars and factories. With all this absorption comes large problems.

We found health risks occur in heat islands when their temperature becomes too high. As a report from Springer Nature (2017) states, “The most direct effect on health from the UHI is due to heat risk, which is exacerbated in urban areas, particularly during heat waves.” Heat waves are detrimental to groups more susceptible to disease and sickness, such as the elderly. Heat waves also damage the environment and contribute to climate change. As a result, many people turn on air conditioners, burning fossil fuels and emitting greenhouse gases. UCAR Center for Science Education (2025) predicts, “By 2050, 70% of urban dwellers worldwide will be affected, so the problem of urban heat islands will continue to grow.” This problem will worsen if unchecked.

Thankfully, there are things we can do to prevent and suppress urban heat islands. Popular solutions include cool roofs, cool pavements, and planting more vegetation and trees. A cool roof has high solar reflectance that absorbs and transfers less heat, reducing temperatures in the surrounding area. Cool pavements are made from paving technologies like concrete or asphalt, or newer approaches such as coatings or grass paving. These pavements help with absorption and provide a more comfortable environment. Planting more vegetation and trees in urban areas lowers surface temperature by providing shade and cooling through evapotranspiration. As described by EPA (2024), this process “cools the air by using heat from the air to evaporate water. This cooling also occurs from the surrounding soil and when trees and vegetation catch rainfall on their leaves.” These solutions would help climate change and positively impact urban heat problems.

In conclusion, through our research about the relationship between surface temperature and cloud coverage, we hope to create a better understanding of urbanization and climate change by analyzing local weather patterns. This data will help create more adaptive strategies for our changing climate, encouraging sustainable cities to reduce heat islands and rising temperatures.

## <u>Methods and Materials</u>

### <u>Methods</u>:

First, we gather all needed materials (computer, ThermoWorks thermometer, GLOBE Atmosphere Investigation Cloud Protocol Data Sheet)

***Make sure that you are dressed appropriately for the weather that day as you will be outside for a while.**

Next, we head outside and start recording information on the type of clouds present in the sky using the GLOBE Atmosphere Investigation Cloud Protocol Data Sheet such as the types of high, medium and low level clouds. We then look at the number of contrails and if it is clear or foggy. Then we look at the color of the sky and see if it is dark blue, blue, light blue, or near white. Last on our chart, we look at how much of the sky is covered by clouds and what type of clouds are present.

Then, we walk around to our 3 different locations and take 3 temperatures from that area with the ThermoWorks infrared surface temperature thermometer.

***Make sure your arm is facing straight out with the thermometer pointed straight down at the ground and DO NOT point the thermometer at other people, especially towards the eyes.**

After that we record the temperatures we got in our data table on the computer

Finally we head inside.

We did 6 of these trials over about 1 month.

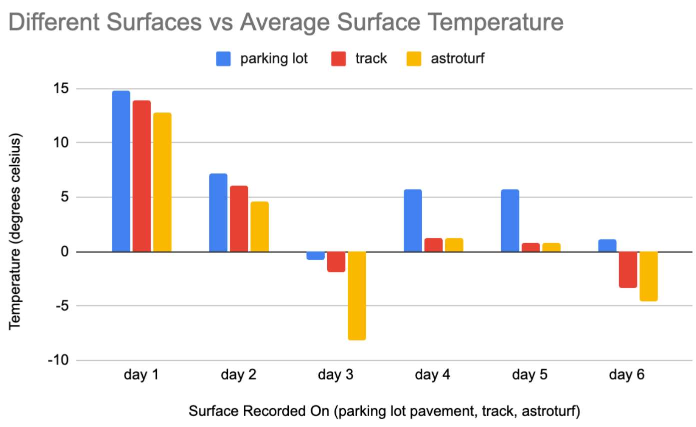
**<u>Materials</u>:**

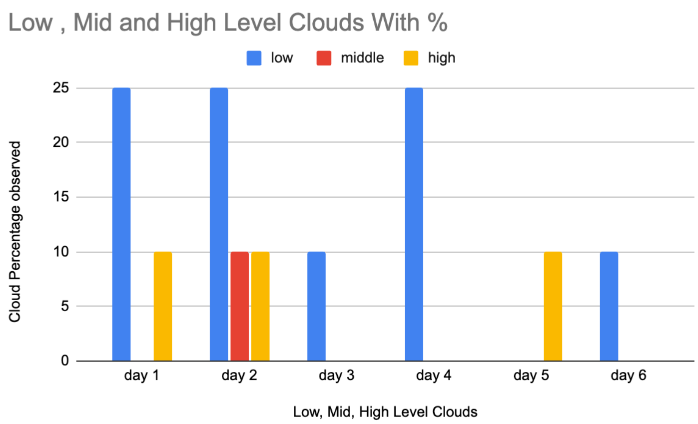
ThermoWorks Infrared surface temperature thermometer: was used the take the surface temp of 3 different areas

GLOBE Atmosphere Investigation Cloud Protocol Data Sheet: Told us the names of different types of clouds as well as helping us tell the fog level and amount of contrails present

Computer: Allowed us to accurately store the data we collected for the day

## Presentation of Data and Results




The correlation between surface temperature and types of clouds present on a certain day is very important in understanding the atmosphere. It shows how variations in temperature can affect cloud formation and structure. One trend we found with the temperatures was that the parking lot pavement was always the hottest surface of the day. We believe that this trend is due to the material of the parking lot being black asphalt. According to our data, on the days that mid and high level clouds were present with low level, there was a higher surface temperature. This was a trend we found that shows mid level and lower level clouds trapping heat as it rises. On the opposite side of the spectrum, when it is colder there are only low level clouds found as opposed to high or mid level in addition. Our data only had two colder days (days 3 and 6) and on those colder days we had only low level clouds, further proving our hypothesis. There was one outlier in our data set, day 4, where we expected a colder temperature than there was due to the fact there were only low level clouds. Overall our hypothesis was correct as our data showed low level clouds on colder days and high and mid level clouds being present on days when it was warmer.

## **Analysis and Results**

Our findings suggest that our initial hypothesis: If there are lower level clouds present then the surface temperature will be colder because lower level clouds reflect heat from the sun and prevent its rays from getting to the ground was consistent with our data. The clouds and temperatures lined up as we thought they would. When higher and mid level clouds were present the temperature tended to be higher, whereas with lower level clouds the temperature was colder. These patterns follow what we predicted to happen very accurately. We believe that we received these results because of how distinct cloud levels have different effects on temperature. Our research says that higher level clouds are thinner and trap the sun's heat as it bounces back off of the earth. This trapped heat warms up the surface temperature. However, low level clouds have the opposite effect as they are thicker and block rays of sun from hitting the surface in the first place. This effectively cools the surface temperature in that covered area. Our experiment was sound but we did have one outlier where higher level clouds were present and it was above 5. But we believe this is due to the difference in season, as when we started it was warmer fall weather but as we continued into winter there was a new “high temperature” for the colder weather. Our results very accurately tested our hypothesis and proved it with lots of evidence of trends/patterns.

**Conclusion**

Based on our data we can conclude that low, mid, and high levels of clouds do influence surface temperature. Other research from National Geographic has proved that high level clouds help to heat the Earth, allowing sunlight to penetrate the sky and prevent heat from escaping. Along with this, low level clouds have been found to reflect heat from the sun back into space, keeping Earth's surface temperatures cool. Our data showed this because on the days that only low-level clouds were present, colder surface temperatures were present. However on days that high and mid level clouds were present along with low level clouds, the temperature was warmer. It is commonly believed that all clouds cause colder temperatures, but based on our data and research this statement is false.

**Discussion**

If we were to do this experiment again we would gather data across more days to get more defined trends. Maybe spanning across a whole year (if we had the time) to see different cloud patterns and their effects on seasonal temperature. Our findings are consistent with other research we have found, matching the idea that low level clouds cool and high level warm the surface temperature. Our research is important because it can be used to help predict weather patterns. This is useful because it aids many people (meteorologists, researchers,etc.) in long term patterns, tracking any occurring changes, and making informed decisions based on these patterns. If we were to do a further study we might look at how these temperatures caused by cloud coverage affect people's health. As we have stated in our introduction, during our research we looked deeper into urban heat islands. If we were to further investigate we might do an experiment with our surrounding areas and see how our community is affected by this.

**Acknowledgments**

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