A Study of Variations in the Difference between Air and Surface Temperature

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Abstract

My research is about surface temperature and air temperature and the difference between them. My research question was, "How does the difference between surface temperature and air temperature vary with cloud cover and season changes?" I used the GLOBE surface temperature, air temperature, and cloud protocols to collect data. The limited number of cloudy days in the study prevented me from making some conclusions about clouds. My data shows that over a few weeks, the difference between surface and air temperature can change a lot, and that surface temperature has a better relationship to this difference. I suspect that wind plays a big role in this difference.

Question/Hypothesis

How does the difference between surface temperature and air temperature vary with cloud cover and season changes? I asked myself this question while looking at my surface temperature data. As I researched this topic I found that this temperature difference varied quite a bit. One day the surface temperature and air temperature could be as close together as 0.4 ℃ or as far apart as 29.3 ℃.

My hypothesis was that the amount of cloud cover affects the surface temperature therefore affecting the air temperature, changing the difference between them. I made my hypothesis with some knowledge that I learned in science class. The amount of concrete, building materials, glass, metal and more affect the surface temperature (and therefore air temperature). Trees or grass help to reduce surface temperatures. That is also the reason why we have Urban Heat Islands which are hotspot where a developed city puts heat into the air. My research question can be answered with GLOBE data because I collected surface temperature and air temperature data using GLOBE protocols.

Introduction

It is important to understand surface and air temperature because these values can help track climate change. Studies have shown that surface temperature is a major predictor variable to air temperature (Kawashima et al. 2000). Prior to beginning this research, I knew that the albedo (the amount of light/radiation reflected off a surface) of concrete, glass, building materials, and many other things will cause the surface temperature to rise. The sun heats the ground and then the ground heats the air. Whether it is sunny or cloudy can affect the amount of the sun's radiation reaching Earth's surface, which can affect surface temperature and air temperature (Manikin, n.d.).

In my research I learned that we can get cooler temperatures when it is windier because wind velocity decouples the surface and air temperature (Stoll and Brazel 1992). That means that when it is windy the air temperature and surface temperature won't be as close. Spring in New Mexico is often called "wind season". It was wind season when I took my measurements. In Fig 1 my hair is blowing in the wind.

For my research I used the GLOBE Protocols for surface temperature, air temperature, and clouds. My measuring techniques are important because if I were to take them wrong they would be incorrect and throw off my whole study. For example, I had to measure surface temperature three times and find the mean of my measurements in order to make sure my measurement is representative ("Surface Temperature Protocol", 2014). These protocols allowed me to collect data to answer my question about the difference between surface and air temperature.

Fig. 1

Fig. 2

Research Methods – Data Sources

The initial data that inspired this project was the data we took as a class over a span of three weeks. As I looked at the data it sparked my curiosity. From there I asked why there was so much variation in the data collected. As I looked at the data I got the idea to study it more closely, which inspired this research. I had a problem with the class data. Most of the data was incomplete, students either had not collected cloud data or all three surface temperature measurements.

In order to answer my questions, I collected a new set of consistent and complete surface and air temperature data. The parameters I collected were the date, the time, latitude, longitude, where I was outside my house (my backyard), the surface I took the measurements on (concrete), three surface temperature readings, an air temperature reading, and cloud notes. I collected data from my backyard right where the pink heart is in Fig. 3.

The GLOBE protocols that I used were air temperature, surface temperature, and clouds. I collected data at different times everyday to be sure I got a good variance of times. I took most of my measurements in the evening because of my schedule. Every day twice a day at different times I would go outside, type the date and time, and then I would take three surface temperature measurements and type them (Figure 2). Next I would take an air temperature reading and enter it into my log. Finally, I would look at the clouds and write cloud notes.

Data Used

While I collected data on latitude, longitude, surface temperature, air temperature, surface type, surface conditions, and clouds, not all of this data was used to answer my research question. All of the data was collected and recorded by myself. My teacher helped me upload my data to the GLOBE website.

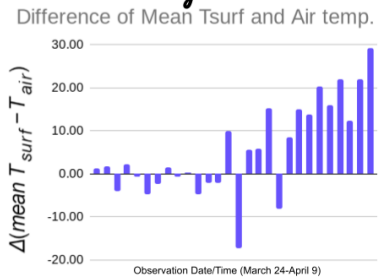
Data collection went smoothly, unless my dog wanted to help or if it was super windy and cold. I collected a total of 84 data points for surface temperature. This number is high because I collected three measurements each time I collected data. I found the mean of these three measurements to use in my data analysis. I collected a total of 28 data points for air temperature, clouds, and the other parameters I measured over the 15 days that I collected data. I did not end up using my cloud data because during the time I was collecting data, we did not have many days with consistent cloud cover. I did not have enough data to form a conclusion about clouds. This data helped me answer my research question because I was able to examine what factors affect surface and air temperature.

Fig. 3

Results – Data Visualization

In this project 28 data points were collected and entered into the GLOBE Database. My initial results showed that between March 24, 2021 and April 9, 2021, the difference in surface temperature and air temperature continued to increase (Figure 4). This result inspired me to ask why the change increased so much over the time I was taking measurements.

Fig. 4



Several factors affect surface temperature, including the sun and the presence of clouds. My research showed that surface temperature affects air temperature, but what factors affect the difference between those two? Figures 5 and 6 show the relationship between $\Delta(mean\ T_{surf} - T_{air})$ and air temperature and surface temperature, respectively.

Fig. 5

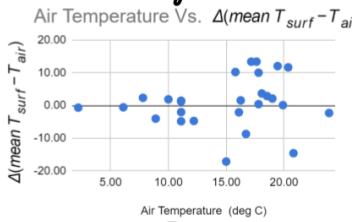
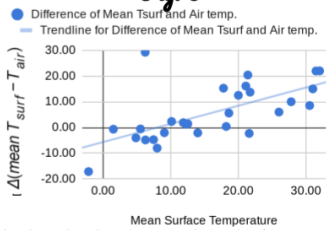


Fig. 6



These graphs show that there is not a relationship between air temperature and $\Delta(mean\ T_{surf} - T_{air})$ but there is a relationship between surface temperature and $\Delta(mean\ T_{surf} - T_{air})$. Surface temperature affects the difference more than air temperature.

Discussion – Data Analysis

While my hypothesis was that cloud cover affects the difference in surface temperature and air temperature, my data did not allow me to make a conclusion about this. My results did show that the difference in surface temperature and air temperature varies a great deal over a short period of time. My research and data suggest that the constant varying of $\Delta(mean\ T_{surf} - T_{air})$ could be caused by wind and changing seasons. As I said in my introduction I took my measurements in the beginning of spring when it was wind season. Stoll and Brazel (1992), demonstrate that wind can uncouple air and surface temperatures. My results seem to confirm their findings. My qualitative observations from the period of time of this study were that the wind was really awful. Almost every time I went out to take measurements there was a strong bone chilling wind.

While I could not state the effect of clouds on $\Delta(mean\ T_{surf} - T_{air})$, my data shows that surface temperature is more closely related to $\Delta(mean\ T_{surf} - T_{air})$ than air temperature.

The greatest uncertainties in my research came from the sensors that I used. My teacher was not able to calibrate my infrared thermometer. This means that my temperature measurements may not be as accurate as they could be.

If I could continue this project, I would want to find a pyranometer so that I could compare the radiation reaching Earth's surface to the difference between air and surface temperature.

Conclusions – Data Interpretation

In conclusion, the difference between surface and air temperature varies with cloud cover, weather, and season. My specific results demonstrate that surface temperature is more closely related to the difference between these parameters than air temperature. Over the course of this project, I was not able to gather enough data points with different cloud types to support or refute my hypothesis, but I did demonstrate that factors like wind may be more important to the difference between air and surface temperature in places like New Mexico that are windy but frequently do not have clouds.

I appreciated doing this research for GLOBE and NASA because it was a long term project that gave me something to do. While completing this project, I learned that surface temperature affects air temperature, and that wind affects both. This project gave me a better appreciation and understanding of the scientific process.

Bibliography

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