Medford Memorial Middle School, NJ
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# No Correlation Between Precipitation Amounts (Rain Gauge) and Brightness Temperature (GOES-16 ABI)

**Abstract**

When researching GOES-16, there were a lot of readily available resources. One, in particular, was a fact sheet from the Cooperative Institute for Meteorological Satellite Studies (CIMSS) (http://cimss.ssec.wisc.edu/goes/OCLOFactSheetPDFs/). Based on review of this fact sheet, the research team decided to compare Brightness Temperature (BT) with amount of precipitation collected in a 24-hr period. The research question developed was, "What is the correlation between GOES-16 ABI Band 13 data and the amount of precipitation collected using a metric rain gauge?" The rain gauge data was collected in Medford, NJ 08055 over a four-week period. ABI Band 13 data was retrieved from the RAMMB Slider site. About ¾ of the way through the research window, the team realized there was no correlation between amount of precipitation and BT. The team asked for help from Dr. Tim Schmit, CIMSS, NOAA and Dr. Dan Lindsey, NOAA. It was suggested that instead of looking at amount of precipitation, it would better to check BT as the rain was occurring. This required the team to go back and use archived precipitation data for Medford **(https://www.wunderground.com)** to get the approximate times when rain occurred. This information was then checked against GOES-16 ABI Band 13 data. Three GOES images were saved for each day: one at 1300 UTC, 1800 UTC, and one at 2300 UTC, unless it rained. If it was actively raining, the images used were three hours before the rain, in the beginning of the rain, the middle of the rain, at the end, and three hours after. There seems to be a correlation between Band 13 data and the timing of precipitation events. A recommendation to future CSEP junior scientists is to redo the research with the new research question and check Brightness Temperature as the rain is occurring.

**Keywords: Brightness Temperature, GOES-16, Precipitation, Rain gauge, ABI Band 13**

## Research Question

"What is the correlation between GOES-16 ABI Band 13 data and the amount of precipitation collected using a metric rain gauge?"

The GOES-R series represents the best of the best weather satellites. There is an instrument on the satellites called the Advanced Baseline Imager (ABI) that has amazing capabilities. This satellite is very different from previous geostationary weather satellites as it is five times as fast temporal coverage, has four times the spatial resolution and provides three times more spectral information[1].

More reliable weather forecasts affect everyone because people look at the weather channels to plan ahead. People use forecasts and current weather conditions to plan family parties, as well as protect those same families during a tornado. By not being aware of future weather, people can find themselves heavily unprepared. Weather catastrophes, such as flash floods can put New Jersey residents in danger, but also can put animals in danger. To add to that, very few people understand about satellites. A lot of people don't believe NASA should be funded as much as they are. These people don't know that a large part of NASA's mission is to look at the Earth from space. The GOES-16 ABI Band 13 data used in this research represents Brightness Temperature (BT) to detect the clouds, and water vapor. BT is the estimated temperature of the cloud tops.

## Introduction

GOES-16 is part of the GOES-R Series which is made up of GOES-16, GOES-17, GOES-T, and GOES-U[2]. The satellites are assigned a number once put into orbit[3]. GOES stands for Geostationary Operational Environmental Satellites. GOES-16 is in orbit 22,300 miles up above Earth[2].

[1] https://www.goes-r.gov/spacesegment/abi.html

[2] https://Goes-r.gov

[3] https://www.nesdis.noaa.gov/GOES-R-Series-Satellites

An advanced piece of technology it holds is the ABI instrument which is the primary instrument that monitors Earth's weather, environment, and oceans. ABI stands for the Advanced Baseline Imager[1]. The ABI is far advanced over the instruments that came before it. It has five times faster temporal (time) coverage, has four times greater spatial resolution and provides three times more spectral information[4].

The ABI has 16 spectral bands. It is a passive instrument, which means it reads the amount of radiation coming off of things like trees, water, clouds, water vapor and aerosols. Band 13 measures at 10.3 μm. This helps in identifying clouds and types of clouds, cloud top brightness temperature and cloud top particle size [5]. The greatest application of Band 13 data is to identify convective severe weather (like thunderstorms and tornadoes) and hurricane strength.

The research team in this report thought there might be a correlation between Band 13 data and rain amounts. If the Band 13 products involve clouds and types of clouds, the research team thought there might be a link between rain clouds and the amount of precipitation produced. This correlation was not found.


Figure 1.
This is an artist's image of GOES-16. One of the primary instruments on GOES-16 is the Advanced Baseline Imager (ABI). It collects data using 16 different spectral bands. The GOES-16 CSEP group used the ABI Band 13 during research.

[4] https://www.goes-r.gov/spacesegment/abi.html

[5] http://cimss.ssec.wisc.edu/goes/OCLOFactSheetPDFs/ABIQuickGuide_Band13.pdf

## Research Methods

Precipitation was collected at the same time every day in a metric rain gauge. An exception was over weekends and holidays when there were multiple days' worth of accumulation. Brightness Temperature images from GOES-16 ABI Band 13 satellite images, using the Regional and Mesoscale Meteorology Branch (RAMMB) slider, on the Colorado State website, were recorded daily and multiple times during the day.

The metric rain gauge was set in one of the courtyards of Medford Memorial Middle School. In the courtyard, there is a rain gauge stand, which is mounted in gravel. The pathway is gravel, and grass outlines it. In the grass, there are several trees scattered throughout the area (*see figures 3 and 4)*. Each day (except on weekends or holidays), at solar noon, millimeter measurements were taken. If the water inside the rain gauge was frozen, then a new gauge was put on the stand and the frozen water was brought inside to thaw. The GLOBE Precipitation protocol was used to enter the precipitation data into the GLOBE website. There were 22 entries of data on GLOBE.gov over a span of 30 days.

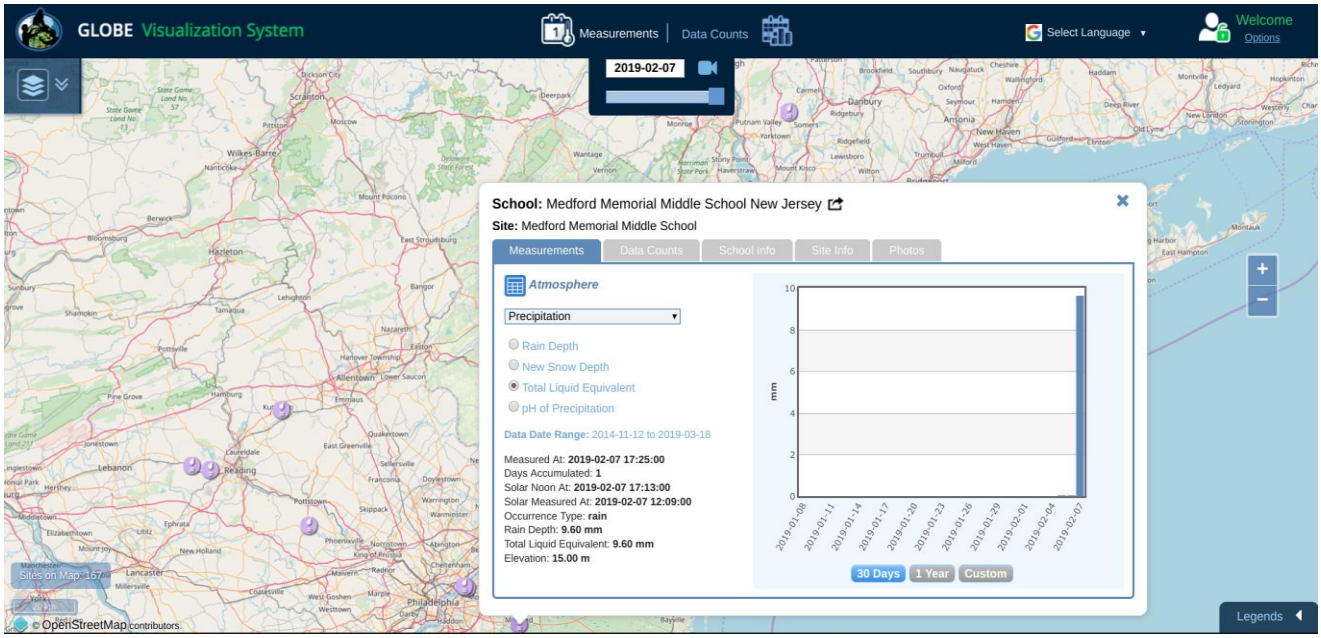
A scientist who was reached out to was Dr. Tim Schmit, NOAA, CIMSS. Dr. Schmit provided initial information and then suggested the research team contact Dr. Dan Lindsey, NOAA. Dr. Lindsey recommended the team use Band 13 as that is the band that measure clouds. Dr. Lindsey also provided brightness temperature images for February 5th to February 19th because access to images on those days was limited on the RAMMB slider. Both Dr. Schmit and Dr. Lindsey were very instrumental when it came to helping the CSEP GOES-16 research team.

When the original research plan was constructed, it was decided to measure Brightness Temperature three times a day, every day. When it was realized that there couldn't really be a correlation between amount of precipitation and BT, the research team decided to experiment with a new research question (BT and timing of the rain) so future junior scientists might pick up on the new research and continue with it. This new question meant going back into archived data on Wunderground (https://www.wunderground.com) to see when it was raining in Medford, not

how much it was raining. The data was put into a bar graph, with one X-axis, and two Y-axes which is shown in the results portion of the report.

To double check that the precipitation observations actually made it into the GLOBE program database, The GLOBE Visualization Page was checked.

**Figure 2. GLOBE Visualization Page**




This is where precipitation was visualized for the group on the GLOBE website.

**Figure 3. Citizen Science Education Program (CSEP) Research Team**

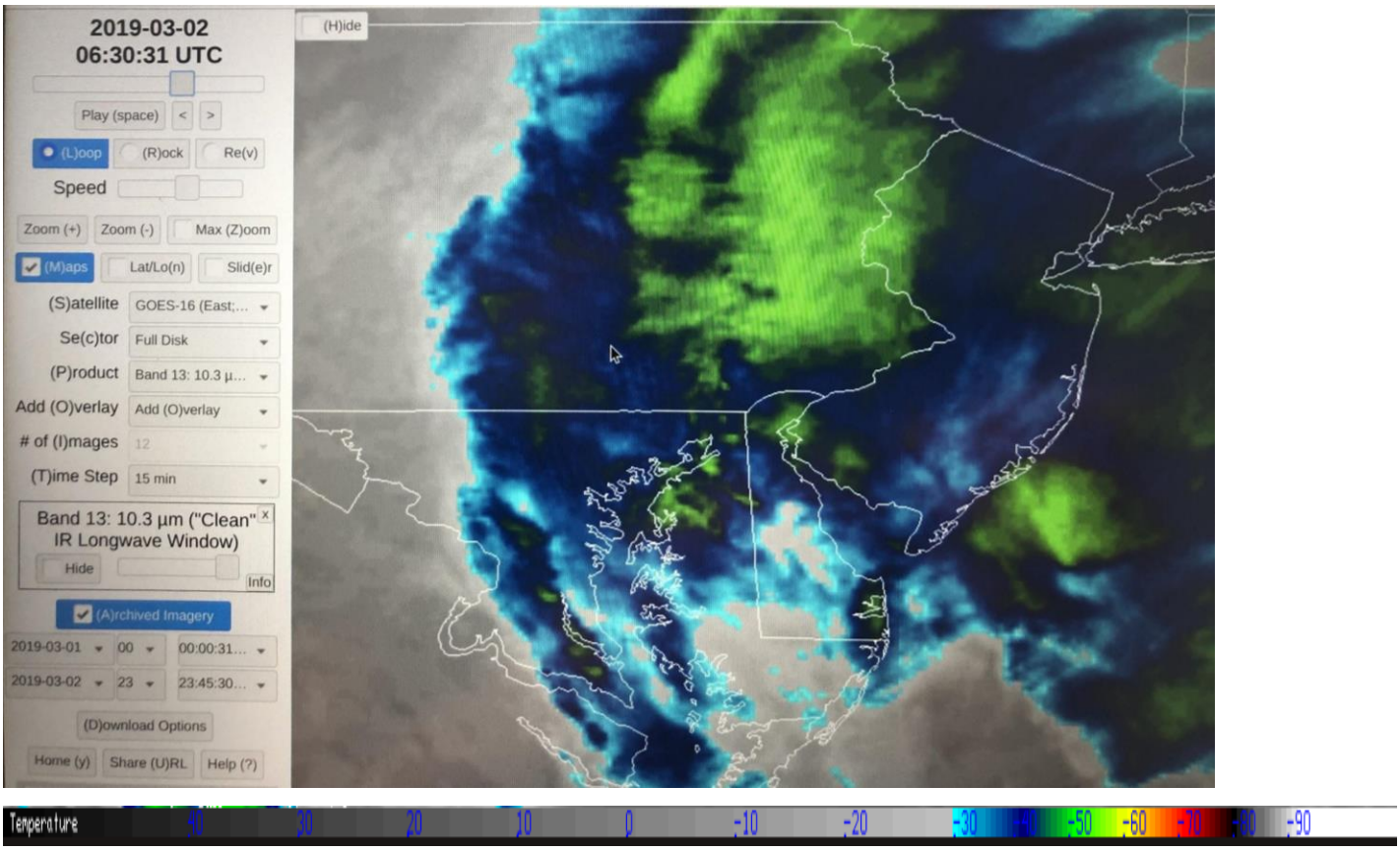
Here is the CSEP GOES-16 research team comprised of Mason Doshi (far left), Andrew Fricke (left middle), Elena Garistina (right middle) and Logan Michaels (far right) with the rain gauge. Precipitation measurements were taken from the 5th of February to the 12th of March.

**Figure 4. CSEP Research Team**

Here the team is taking rain gauge measurements. The rain gauge is in both millimeters and inches. Millimeters were used as units. If the rain overflowed past 25.4 millimeters (the capacity of the small cylinder), then the overflow was poured into the small cylinder and added together.

**Figure 5. RAMMB-Slider Data**

http://rammb-slider.cira.colostate.edu




This is the website that was used to collect Brightness Temperature data. On the bottom is the legend which shows which colors correspond to the temperature of the cloud tops in degrees Celsius. On the left is a menu that changes the satellite. It also shows the start and end dates as well as the start and end times. There are more options to customize but those were the ones that were used to collect Brightness Temperature data. For example, this image is 2019-03-02 at 06:30 UTC. This image shows a Brightness Temperature about -37°C for Medford, New Jersey.

## Results

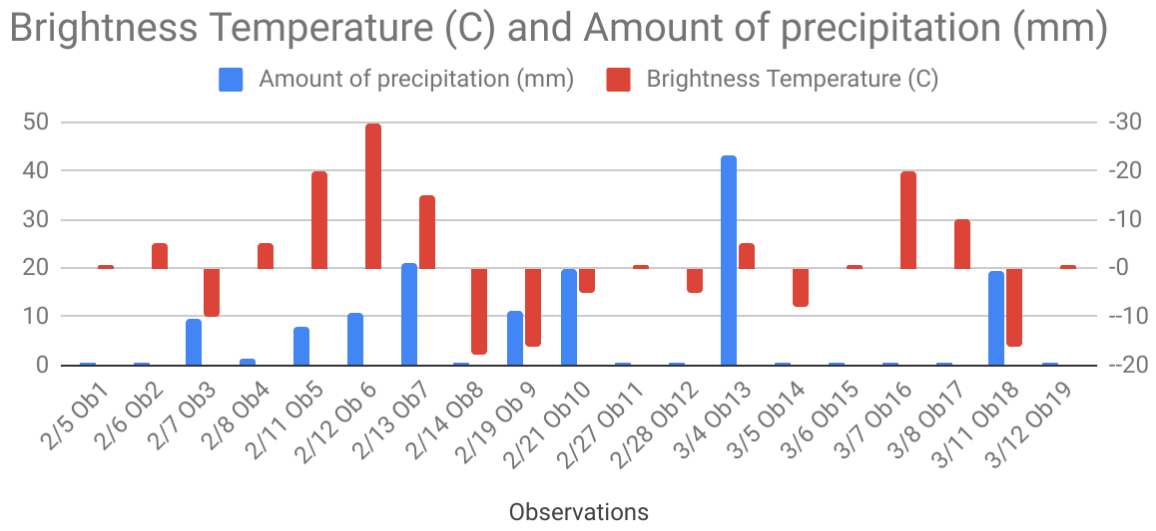



Figure 6.

This is the graph that was used to find a correlation between the amount of precipitation and brightness temperature. When you see (--) before a number on the right vertical axis, that means positive. There was no correlation found. This was because the Team had not taken into consideration when the rain was falling.

Technically, the above graph shows the data for the entire research project. However, the research team wanted to add more data for proof of concept, so other CSEP teams, next year, could continue the research of BT correlation with the timing of precipitation. Below are the graphs for the new approach.

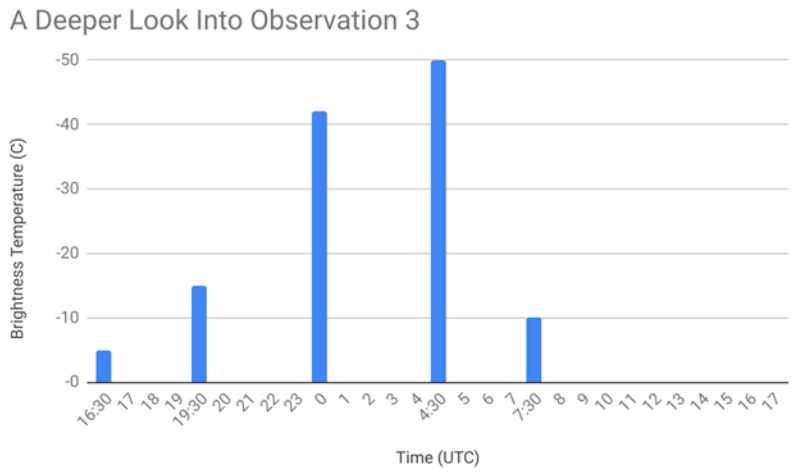



Figure 7.

Above is a mini, in-depth graph of observation 3. Instead of doing the amount of precipitation, the time of the rain was graphed. Times 3 hours before (-5 C), when it started raining (-15 C), in the middle of when it was raining (-42 C), the end of the rain (-50 C), and finally 3 hours after (-10 C), were used.

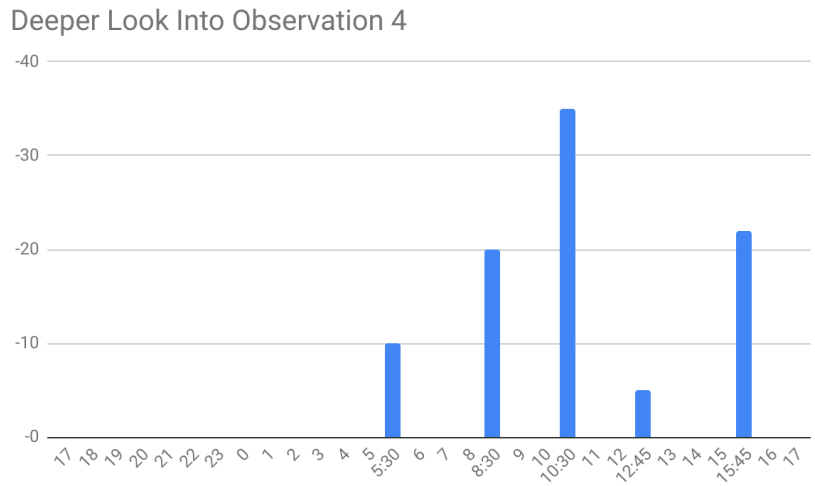



Figure 8.

This is a mini graph of observation 4. The same thing as in figure 2 was used. 3 hours before (-10 C), when it started raining (-20 C), in the middle of when it was raining (-35 C), the end of the rain (-5 C), and finally 3 hours after (-22 C).

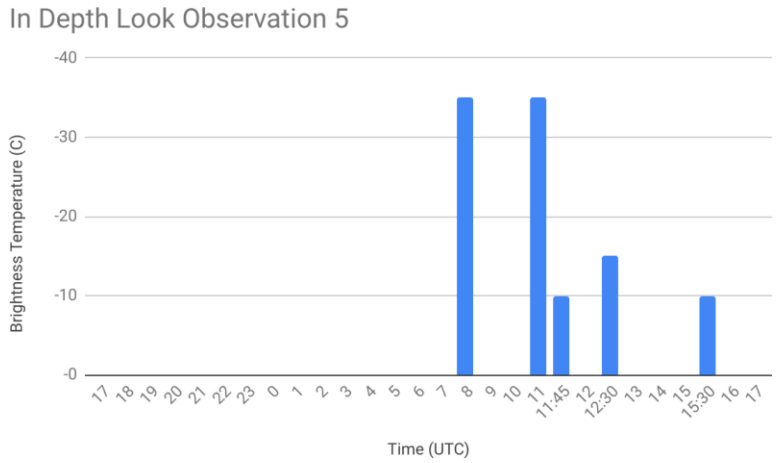



Figure 9.

This is a mini graph of observation 5. 3 hours before (-35 C), when it started raining (-35 C), in the middle of when it was raining (-10 C), the end of the rain (-15 C), and finally 3 hours after (-10 C).

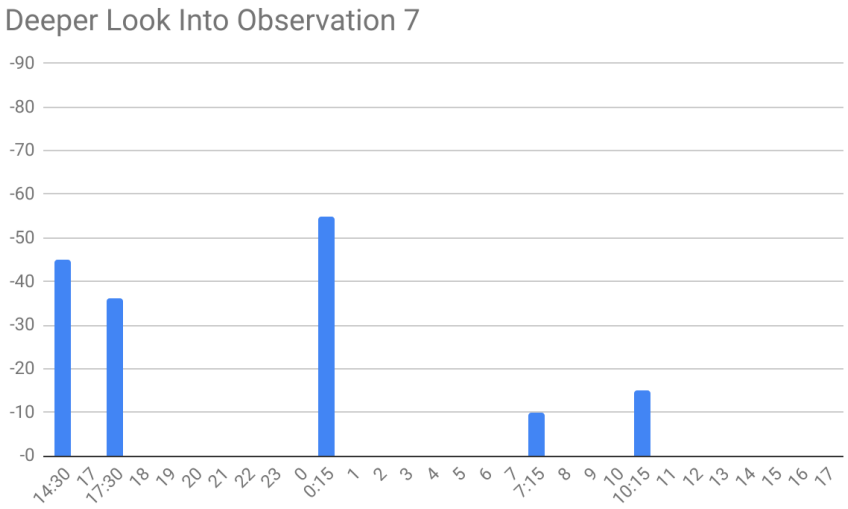



Figure 10.

This is a mini graph of observation 7. 3 hours before (-45 C), when it started raining (-37 C), in the middle of when it was raining (-55 C), the end of the rain (-10 C), and finally 3 hours after (-15 C).

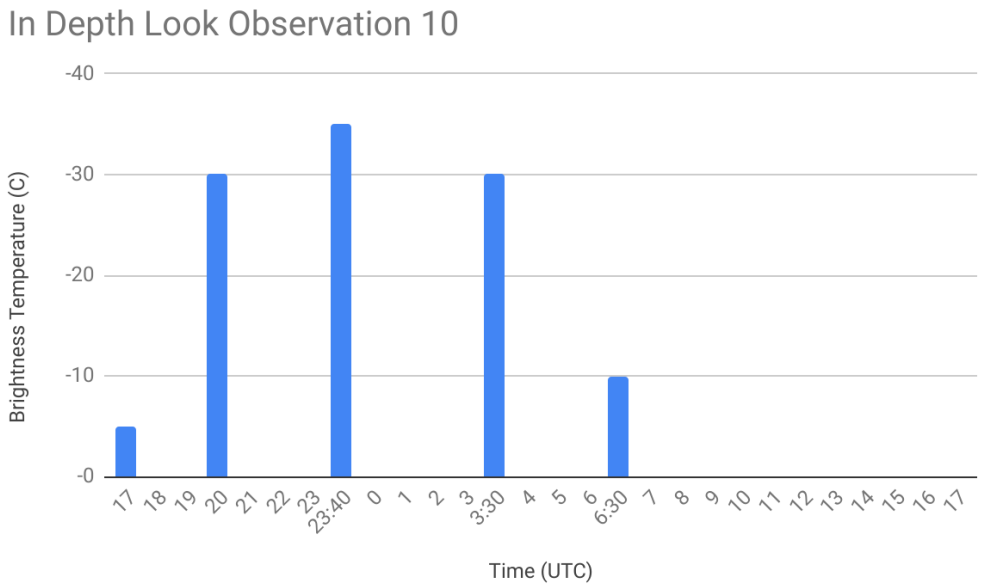



Figure 11.

This is a mini graph of observation 10. 3 hours before (-5 C), when it started raining (-30 C), in the middle of when it was raining (35 C), the end of the rain (-30 C), and finally 3 hours after (-10 C).

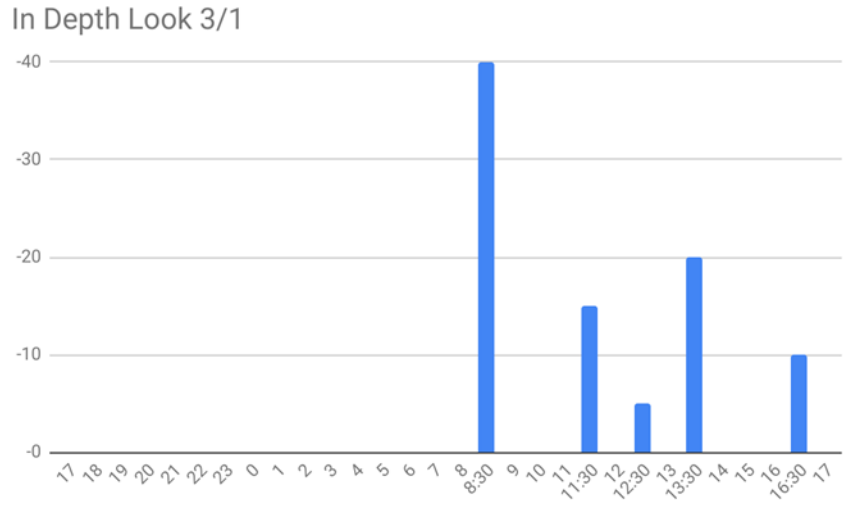



Figure 12. This is a mini graph of 3/1/19. The same thing as figures 2-6 was used, but this isn't one of the observations because this was a weekend day. 3 hours before (-40 C), when it started raining (-15 C), in the middle of when it was raining (-5 C), the end of the rain (-20 C), and finally 3 hours after (-10 C).

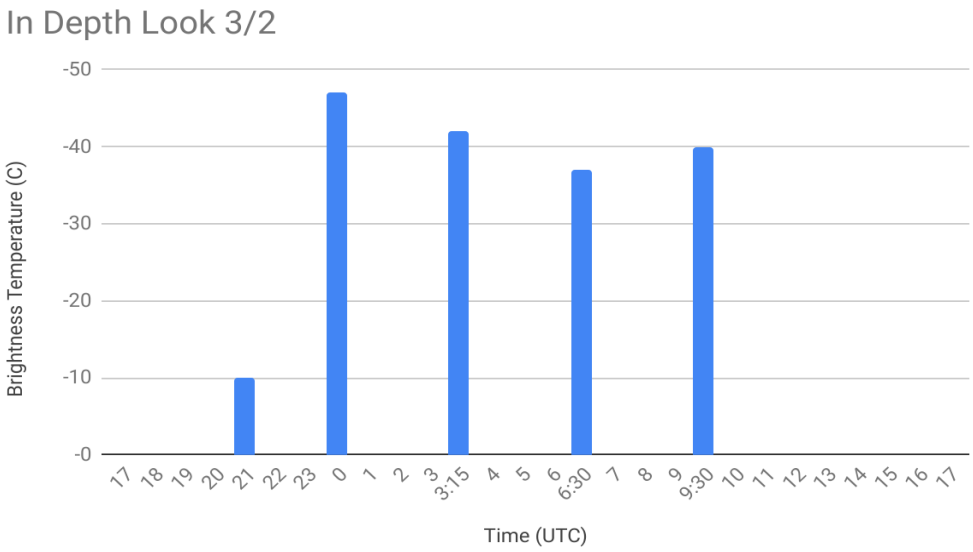



Figure 13.

This is a mini graph 3/2. The same thing as figures 2-7 were used, but this is also a weekend day and not one of the observations. 3 hours before (-10 C), when it started raining (-47 C), in the middle of when it was raining (-42 C), the end of the rain (-37), and finally 3 hours after (-40 C).

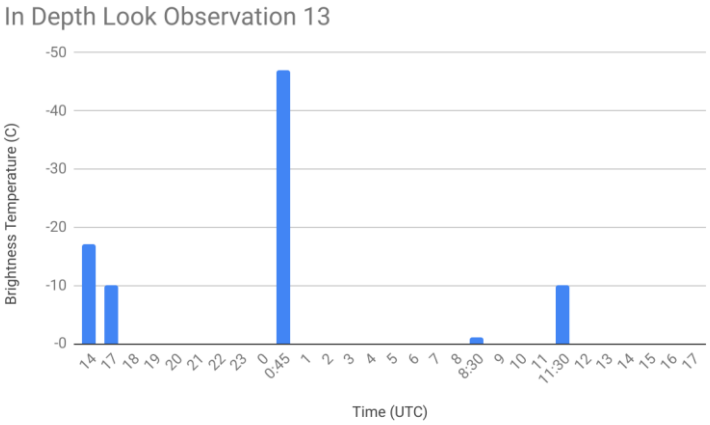



Figure 14.

This is a mini graph of observation 13. 3 hours before (-17 C), when it started raining (-10 C), in the middle of when it was raining (-47 C), the end of the rain (0 C), and finally 3 hours after (-10 C).

**Discussion:**

The results shown in Figure 6 demonstrate no correlation between ABI Band 13 data and the amount of precipitation in a given 24-hour period. As has already been mentioned several times, the original research question was not a good one. The research team understands that no correlation is its own result and furthers the knowledge about the topic. However, after seeing no correlation as the research progressed, the team decided to contact two professionals in the GOES field. The team learned that there could never be a correlation between BT and amount of precipitation with the research methods currently being used at that time. Therefore, the last part of the research window was spent backtracking, gathering archived data and checking to see if using timing of precipitation events would be more useful in future research. It was realized that the Brightness Temperature needed to be collected while it was raining, not when the precipitation was collected. Smaller graphs were made of the observations that showed what the Brightness Temperature was 3 hours before the rain, when the rain started, in the middle of the rain, when the rain ended, and finally 3 hours after the rain. There were enough possible correlations in this new data that another research group next year should continue the research. Future CSEPers should create separate graphs on days of precipitation with the brightness temperatures (like Figures 7-14). This advice should be taken because there might be a good correlation from when it rained to the Brightness Temperatures from Band 13. Also, future GOES Band 13 researchers might want to collaborate with teams that are looking at clouds.

**Conclusion**

The conclusion was reached by using Band 13 images, finding the BT's three times each day, and comparing it to the amount of rainfall by inserting both data into a graph. Though the research team did not find a valid correlation between the amount of rainfall and brightness temperature, a correlation can be found between the times that it actually rained and the brightness temperatures. Now knowing this information, future CSEPers should pursue this, and hopefully find more reliable and correct correlations. Another suggestion for future CSEPers is to use other bands on the ABI, not just Band 13. Working with a NOAA GOES scientist, like Dr. Lindsey, is a must for future research teams. Dr. Lindsey provided information not readily available to the public.

## Badges

### Badge #1- Be a Data Scientist

GLOBE was used to input precipitation data that was collected from the metric rain gauge. Plus, BT was collected and analyzed. Many graphs were made.

### Badge #2- Be a STEM Professional (Connect with a STEM professional)

Collaboration was between two scientists, Dr. Tim Schmit and Dr. Dan Lindsey. Dr. Tim Schmit led the team to Dr. Lindsey who became the team's mentor.

### Badge #3- Be a STEM Storyteller

The group created a song, titled "GOES – 16 Nation"

It is a rap. The lyrics are below. At the end, there is a link to a music video of the song.

***GOES-16 Nation***

***Songwriters: Elena Garistina, Mason Doshi, Andrew Fricke, Logan Michaels***

(Verse 1)
GOES, GOES-16;
Is the best satellite that you've even seen.
We monitor the BT (brightness temperature) using Band 13!
The time zone in the images is UTC
Measured using degrees Celsius
US uses Fahrenheit but don't you fuss

(Verse 2)
Finding correlations, what we do all day
Even when it is our... birthday
The relation that we tryin' to find
Is rainfall and BT (brightness temperature), yea we on this GOES grind

(Verse 3)
Ground precipitation and GOES 16 data
Using metric rain gauges don't be a hate-a'
Going to the courtyard, during lunch
Getting a lot of data, now that's a bunch!

(Chorus)
Comparin' ABI bands with precipitation
Workin' a lot with satellites, call it our creation
With this information,
We'll form a presentation,
We revolve around GOES-16, it's our nation

(Verse 4)
So when we doing research, what did we find?
There was no correlation, but we didn't mind
Maybe there will be with another band
Dr. Dan Lindsey givin' us a hand
Another mentor that we had
Was Dr. Schmit, yea he was pretty rad

(Chorus)
Comparin' ABI bands with precipitation
Workin' a lot with satellites, call it our creation
With this information,
We'll form a presentation,
We revolve around GOES-16, it's our nation

(Verse 5)
Have you ever heard of… CSEP?

It's the best organization, yep!

Turning students into junior scientists

Teaching the community 'bout science

But what's the main importance? you may ask,

BECOMING FUTURE SCIENTISTS IS THE MAIN TASK!

**Link to GOES 16 Nation music video. (Put on closed captions and time of video at 0:00.)**

https://www.youtube.com/watch?v=FiJs7zV8ekE&t=5s

**For more information about CSEP, go to www.csepcentral.org**

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