Solar Eclipse Affects Convective Clouds

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ABSTRACT

The research question for this investigation was " How does a solar eclipse affect weather?" After doing some research, it was evident that the question needed to be narrowed down. It was decided to look at convective clouds. The team constructed a hypothesis, which stated, "If cumulus or cumulonimbus clouds are viewed during an eclipse, then there would be a reduction in clouds, because of the drop in land surface temperatures."The research/data collected was mainly focused on the Geostationary Operational Environmental Satellite (GOES), specifically GOES-16. This satellite is used to provide imagery on atmospheric conditions and is a GLOBE partner satellite. The group found out that convective clouds were the most affected by solar eclipses due to the gradual drop in the land surface temperatures. Convective clouds form when warm air rises (because of its buoyancy) through cooler surrounding air in the atmosphere. Since convective clouds rely on warm land surface temperatures, a slight cooling is going to impact the vertical growth of cumulus clouds. The land surface temperatures slightly dropped because of the solar eclipse which decreased the solar radiation. Therefore, convective clouds that are dependent on warm surface temperatures cannot form and they start to be suppressed. The best data the team found was from the University of Wisconsin CIMSS (Cooperative Institute of Meteorological Satellite Studies) Blog from the 2017 total solar eclipse. After analyzing the data, it was concluded that cumulus/cumulonimbus clouds are affected by the lack of solar radiation, which decreases the land surface temperatures. In addition, it was seen that other types of clouds were forming normally and did not seem to be affected by the solar eclipse.

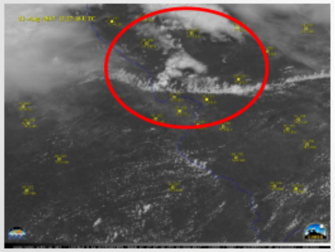
HYPOTHESIS

If cumulus or cumulonimbus clouds are viewed during an eclipse, then there will be a reduction in clouds, because of the drop in land surface temperatures.

Image 1: This is an image made up of multiple exposures, of the evolution during a solar eclipse. This picture was taken from the the beach of Mazarkan, Mexico.

METHODS AND RESULTS

From the recent solar eclipse that happened on April 8th, the program was interested in seeing how the eclipse affected weather parameters. The six parameters of weather include humidity, air temperature, air pressure, clouds, precipitation, and wind. Guessing a number between one and six, the group ended up with clouds. The team narrowed down the question to "How does the solar eclipse affect clouds?" The team first researched the possible impacts that the eclipse could have over clouds. However, it was decided we would narrow down our question even more and formulate a hypothesis from this. Wanting to use a type of cloud that was most affected by temperature, the team chose to use cumulus or cumulonimbus clouds since they were convective clouds. The team then briefly researched how clouds form to understand the procedure that goes into the creation of clouds, specifically vertically growing clouds. The hypothesis basically stated that cumulus clouds would decrease due to a drop in land surface temperatures. After that, the group started looking for any solid data that could help support the hypothesis. CloudSat and CALIPSO, both GLOBE satellites were decommissioned in 2023. The team moved on to the GOES-R series, and looked at the University of Wisconsin, CIMSS (Cooperative Institute of Meteorological Satellite Studies) Blog. Nothing definitive was found for the 2024 solar eclipse, but there was an interesting animation from the 2017 total solar eclipse. The team also looked at temperature data and satellite imagery to show that temperature did decrease during the eclipse process.



CIMSS Blog - https://cimss.ssec.wisc.edu/satellite-blog/archives/24751

Image 2: This image was captured using GOES-16 Red Visible Band over eastern Missouri and southern Illinois. The timestamp in this image is 17:27:18 UTC, before the eclipse shadow. The cumulus clouds are in the process of forming at this time. The three images that follow are part of the animation/satellite footage that GOES-16 had captured.

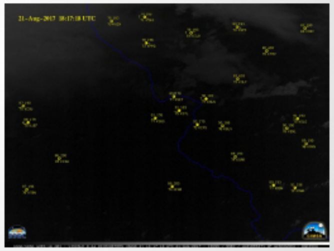


Image 3: This image showed the region during totality. As the image is using a visible band, it is difficult to see how the clouds are affected. The timestamp for this image is 18:17:18 UTC. It seems as if the cumulus clouds might be subdued. If the clouds increase after totality, we can infer this was the case.

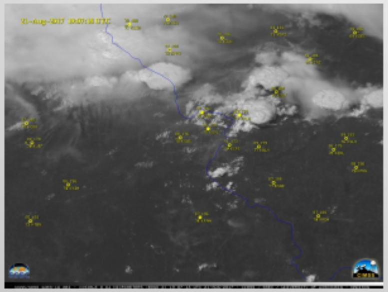


Image 4: The time stamp for this image is 19:07:18 UTC, a short time after the solar eclipse shadow passed. As you can see from this image, the paused development of the cumulus clouds that could be seen from the previous images is now growing again.

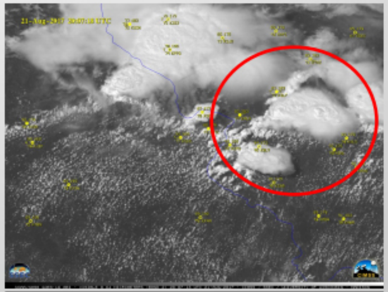
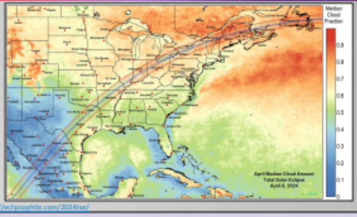


Image 5: The current time in this image is 20:07:18 UTC. Now that some time has passed since the eclipse shadow, the cumulus clouds are forming rapidly and are back into their development pattern. In the red circle, the growing cloud tops of the cumulonimbus clouds are more visible and voluminous, showing that the clouds have gained some height.

ADDITIONAL INFORMATION



Eclipsophile - https://eclipsophile.com/2024tse/

Figure 1: This figure shows the average cloud fraction in the United States during the total solar eclipse. The cloud fraction is a portion of each pixel that is covered by a cloud. The lowest on the scale, 0, means that there are no clouds. The highest on the scale, 0.9, indicates that the area is very cloudy. The red and blue lines represent the path of totality. In places over Mexico and Texas, the cloud fraction appears to be between 0.1 - 0.5. However, in places Northeast, such as Maine, that overlapped with the path of totality, there is an abundance of clouds seeing as the area there is shaded red.

DISCUSSION AND CONCLUSIONS

Using GOES-16, we gathered data on how cumulus clouds decrease as the land surface temperatures drop. We ended up using data from the August 21, 2017 total solar eclipse since this was the best evidence we could find. However, the solar eclipses from both dates are very similar, so the data could be used to determine how the eclipse affected clouds. The four images on the left are from the same satellite footage and show the fluctuation and decrease of the cumulative clouds. Convective clouds rely on warm land surface temperatures to form. The total solar eclipse may have lasted for only four minutes, but the eclipse as a whole lasted for a while. For example, in our location, the moon started to block the sun at about 1 PM and the sun was totally unblocked somewhere around 4:35 PM. In that time frame, the land surface temperatures were slowly dropping. In Image 3, the eclipse shadow that went over the region repressed the growing cumulus clouds that could be seen in Image 2. Once the shadow passed, the cumulus clouds began to form again. However, other clouds as a whole were not affected, it was just convective clouds which were impacted by temperature changes. Therefore, the evidence supports the hypothesis.

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