GOES-16 ABI Bands 2 and 13 Useful in Analyzing Tornadoes & Supercells

"CIMSS Blog, March 25, 2021, Severe Weather across the Deep South and Mid - South"

Kirk Kessler, Winny Lin, and Kaden Arthur

7th grade, Team 7-3 Medford Memorial Middle School, Medford, NJ, USA

ABSTRACT

The purpose of this current study was to investigate how images produced with energy data at certain wavelengths help to identify severe weather. The weather satellite used in this research was a Geostationary Operational Environmental Satellite (GOES). The specific GOES-R series satellite used was GOES - 16, the first in the series. The main instrument used on GOES - 16 is the Advanced Baseline Imager (ABI). The ABI measures the energy that is naturally given off of objects and substances, or solar energy that is reflected off of objects and substances in 16 different spectral bands; each band looks at different wavelengths of energy. The ABI is an instrument with lots of improvements compared to other instruments on older GOES series. The first step of the research was finding a case on the Cooperative Institute for Meteorological Satellite Studies (CIMSS) website. Severe Weather across the Deep South and Mid - South was picked because we wanted something that involved storms. Storms were the main focus of this research because they are very interesting when looking at the cloud growth with different bands used in the blog, which were bands 2 and 13. Bands 2 and 13 help with analyzing the phenomena of tornadoes and supercells because they are useful for measuring cloud-top size, and temperature. With the information on the cloud tops, it is then easier to find the severity of the storms and the probability of tornadoes. The third step taken was analyzing the images and clicking on the different links. After having a better understanding of the images, we started to research our phenomena. Some of the major findings include when cloud tops grow cooler through time, it is likely a growing cumulonimbus cloud, which will produce severe thunderstorms. These severe thunderstorms will also likely spawn destructive tornadoes due to the strong updrafts and moist conditions. It was concluded that the ABI is an amazing instrument that really helps in understanding supercells and tornadoes.

RESEARCH QUESTION

How does GOES - 16 imagery created using ABI bands 2 and 13 help to analyze the phenomena, tornadoes and supercells.

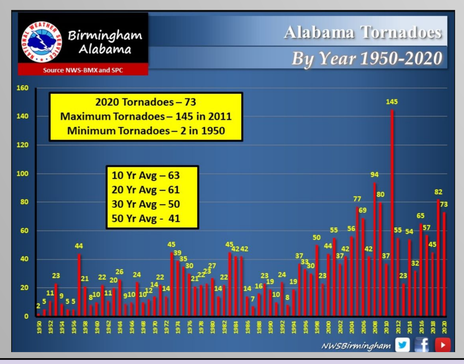

Figure 1: Alabama Tornadoes from 1950 - 2020 (above). As of April 2, 2021, Alabama had a total of 64 tornado reports, and we're only about ⅓ of our way through the year. In addition, 2021 already has more tornadoes than most years put on this graph.

METHODS AND RESULTS

When first looking at the satellite images given on the CIMSS blog, we looked at the date and time of the images, and converted the time into local time. Then we analyzed the basic direction the cloud was moving, and its location. Once that was taken care of, we started taking bits and pieces of the images and tried to find out what they meant, like the colors, bands used, etc. Next, research of the bands took place. We found that band 2 uses visible satellite imagery, which measures the amount of energy reflected from an object. And band 13 measures the amount of heat given off by the given object, and that depends on the average kinetic energy of the object. We then found out the size and type of cloud by looking at the shades of gray on the band 2 image, and the colors on band 13. Analyzing the red and cyan letters was the next step. When looking at the blog, we noticed a link to the Storm Prediction Center (SPC) reports. We then decided to correlate the information on the blog with the information on the SPC reports to see if they have any connections. With a closer look, we noticed that the time of the tornado events on the satellite image matched with the time on the SPC reports. Then, we decided to use two of the satellite images with the tornadoes (T) plotted on it as our images. In addition, we looked for some on-ground images of the tornadoes shown on the satellite image. With this information, we found out what our images meant.

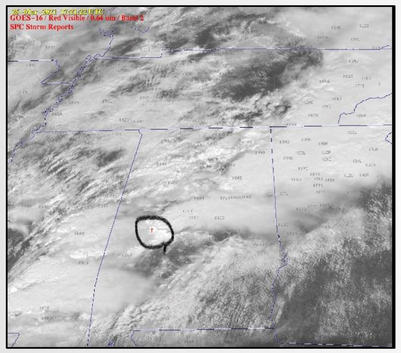

Image 1: Satellite Imagery Using Band 2 (above). An EF-3 tornado spawned (labeled with red "T") near Centreville, Alabama due to severe thunderstorms occurring all week. This image was taken by Band 2, which uses visible satellite imagery. Visible satellite imagery detects reflected radiation from the sun. If the cloud's albedo (proportion of radiation reflected) is very high, then the cloud will appear bright white. If it has a low albedo, it appears dark gray. Since the cloud shown in this image is bright white, that means this is a thick cloud, which is most likely a cumulonimbus.

Image 2: On-Ground Image of Image 1 Tornado (above). Video taken by Michael Mugrage shows the funnel cloud starting to take form in Centreville, Alabama (shown by the red circle). Seconds after this image was taken, the tornado took form. There are also surrounding rain/thunder clouds, which is part of the cumulonimbus cloud shown in Image 1.

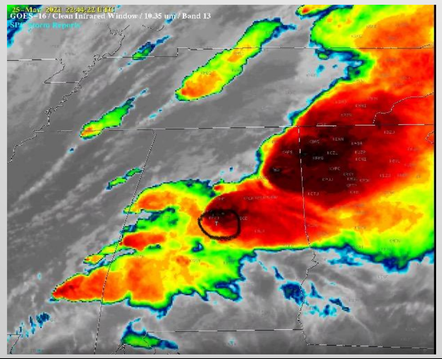

Image 3: Satellite Imagery Using Band 13 (above). On the same day, another EF-3 tornado (labeled with a cyan "T") spawned in Calera, AL. There were multiple tornadoes forming around this area throughout the day. This image is captured by band 13, which uses infrared imagery. The cloud top appears to be at a pretty high altitude, since parts of the cloud get up to around -60℃ (red / orange). The black also indicates an overshooting top, so this is another way to see the cumulonimbus cloud.

Image 4: On-Ground Image of Image 3 Tornado (above). Circled in red, you can see the tornado in Calera Alabama, which had just formed moments ago before this photo was taken. It is kind of difficult to see the cloud, but you can see rain surrounding the tornado.

RESULTS

Image 5: Warm Front Moving East/Northeast (left). Shown in this image, a warm front is moving across Alabama. This is bringing warm, moist air into the area. This creates a problem when cold, dry air collides with the warm air. The warmer air is violently pushed up by the colder air and creates serious updrafts. If the updrafts are strong enough, the clouds get really tall and this produces a severe storm. If the storm becomes a supercell, it can create a tornado.

DISCUSSION AND CONCLUSIONS

Bands 2 and 13 were very useful when looking at the phenomenon, supercells and tornadoes. These two bands helped when analyzing the size of the given cloud. Through time, band 13 can see the temperature change of cloud tops. If the cloud top's temperature gradually gets colder, that means that it is likely a cumulonimbus cloud growing vertically due to its strong updrafts. Using band 2, you can interpret if it is a thick or thin cloud based on the amount of energy they reflect (albedo); if the cloud is brighter on the image, it has a higher albedo. If it appears darker that means it absorbs more energy rather than reflecting energy, having a lower albedo. Some examples of this are water sources, cirrus clouds, and fog. Band 13 was perfect for this blog because it is less sensitive to picking up water vapor absorption, so the water vapor temperatures won't interfere with measuring the temperature of the cloud tops. That's why band 14 was not chosen for this observation; it is more sensitive to water vapor absorption with its 11.2 µm wavelength range. With band 13, it is easier to identify the true elevation of the cloud and the temperature of the cloud. Band 2 also played a big part in analyzing the images for this research. Band 6 could have been somewhat useful, since it can detect early cloud development with its 2.2 µm wavelength , but that's all it has to offer for this project. So in conclusion, band 2 and band 13 were the most useful bands for this topic of study, providing the best information on the phenomenon, supercells and tornadoes.

REFERENCES

How a Tornado is Formed

[1] Staff, National Geographic. "Tornado Facts and Information." *Environment*, National Geographic, 3 May 2021, www.nationalgeographic.com/environment/article/tornadoes.

CIMSS Satellite Blog

[2] "University of Wisconsin-Madison Space Science and Engineering Center." *CIMSS Satellite Blog*, cimss.ssec.wisc.edu/satellite-blog/archives/category/severe-convection/page/2.

SPC Storm Reports

[3] *SPC Severe Weather Event Review for Thursday March 25, 2021*, www.spc.noaa.gov/exper/archive/event.php?date=20210325.

Sawyerville/Centreville/Columbiana Tornado-March 25, 2021

[4] US Department of Commerce, NOAA. "Sawyerville/Centreville/Columbiana Tornado - March 25, 2021." *National Weather Service*, NOAA's National Weather Service, 6 Apr. 2021, www.weather.gov/bmx/event_03252021centreville.

Alabama Tornadoes in 2021 Information

[5] Sebree, Tyler. "Alabama's 2021 Tornado Numbers Are Striking; Most Active Month Now Underway." *Https://Www.wsfa.com*, 2 Apr. 2021, www.wsfa.com/2021/04/02/alabamas-tornado-numbers-are-striking-most-active-month-now-underway/#:~:text=No%20state%20is%20close%20to%20Alabama's%2064%20tornado%20reports%20so%20far%20in%202021&text=MONTGOMERY%2C%20Ala.

ABI Quick Guides

[6] "ABI BANDS QUICK INFORMATION GUIDES." *ABI Bands Quick Information Guides*, www.goes-r.gov/mission/ABI-bands-quick-info.html.