

GOES-R Risk Reduction Bi-Annual Report

Reporting Period: July 2018 – December 2018 (1st half of FY18 / Year 2 funding cycle)

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Project Title: Developing an Environmental Awareness Repertoire of ABI Imagery ('DEAR-ABII') to Advise the Operational Weather Forecaster

Project Number: 476

Executive Summary

The Himawari-8 Advanced Himawari Imagery (AHI) provided a golden opportunity to develop multispectral and data-fusion imagery products tailored to an assortment of operational forecaster situational awareness needs in advance of GOES-R Advanced Baseline Imager (ABI). Value-added applications such as Rayleigh-corrected true color, GeoColor (a data fusion product), fire temperature, 'blue-light' and background-reduced dust, snow/ice, and other enhancements have been crafted to provide context and a sanity check for the suite of quantitative (Level-2) products supported by the GOES-16 and GOES-17 ABI. Several of these applications have followed the natural progression from polar-orbiting platforms (based on the MODerate-resolution Imaging Spectroradiometer (MODIS) leading into the Visible/Infrared Imaging Radiometer Suite (VIIRS).

This DEAR ABII project aims to transition, further refine, and demonstrate through established Satellite Proving Ground channels these AHI-based imagery applications to first-light ABI data. The products are made available to operational centers and National Weather Service (NWS) forecasters in the AWIPS-II display environment.

Special Achievements:

1. **President Trump re-tweets a NOAA GOES-16 GeoColor image** for his tweet on 11 October 2018, warning the public that Hurricane Michael is a very dangerous storm and requesting that people follow the directions of State and Local Officials (**Figure 1**).
2. **GOES-17 imagery made available in SLIDER:** On 30 August 2018, within four minutes of the first GOES-17 imagery being available from the GRB (GOES

Rebroadcast) satellite feed, CIRA was making every pixel of it available to both the scientific community and the general public.

3. A version of **DEBRA started running on the public SLIDER** on 1 November 2018.
4. CIRA's **Snow/Cloud Discriminator** and the **Snow/Cloud Layer products** have both been successfully **transitioned to GOES-17**.
5. **GLM overlays** are now available for GOES-16 and for GOES-17 GeoColor Imagery for the CONUS and full disk domains.
6. A brand new research application for GOES-R ABI products is being explored by the DEAR-ABII Team: "**Optical Flow in GOESR ABI GeoColor.**"
7. New progress was made in the development and analysis of **Cloud-Cleared Background** products, enlisting the help of a NOAA Hollings Scholar, Angela Burke.
8. **NWS WFO Offices frequently used CIRA's GeoColor** to publish special weather events
9. **GOES-16 and GOES-17 GeoColor imagery was heavily used in the GOES-R Program Office GOES-R Quarterly Newsletter**, including on the cover pages.
10. **GOES-16 and GOES-17 GeoColor imagery regularly tweeted by @NOAASatellites.**
11. **GOES-16 GeoColor image on the new webpage banner of NOAA CLASS.**
12. **GOES-16 and GOES-17 GeoColor Imagery continued to be used extensively by the media.**
13. **Australian Bureau of Meteorology (BoM) uses Himawari-8 AHI RGB Fire Temperature and GeoColor imagery.**

Progress toward FY18 Milestones

FY18 (Year 2) Milestones (1 July 2018 – 30 June 2019)

1. Begin conducting near real-time demonstrations of core products, distributed on AWIPS/NAWIPS and on the web working with liaisons to monitor performance.
(1 July 2018 – 30 June 2019)

2. Begin development of augmented DEBRA algorithm with 1.38 μm + blue band. *(1 July 2018 – 30 June 2019)*
3. Begin development of augmented GeoColor with new layers (lightning, dust, fog, fire). *(1 July 2018 – 30 June 2019)*
4. Begin development of custom products as defined via Liaison/forecaster interactions. *(1 July 2018 – 30 June 2019)*
5. Begin preparing and supplying materials (product descriptions, representative case studies) to training partners. *(1 January 2019 – 30 June 2019)*
6. Prepare/submit a publication on GOES-R synthetic true color. *(1 March – 30 June 2019)*

PROJECT ACCOMPLISHMENTS

(during this reporting period of July 2018 – December 2018)

Milestone 1: Begin conducting near real-time demonstrations of core products, distributed on AWIPS/NAWIPS and on the web working with liaisons to monitor performance.

We reported in our previous quarterly report that the synthetic, hybrid, atmospherically corrected (SHAC) true color product for ABI was used by the GOES-R Program Office for the “first light” imagery of GOES-16 as well as for GOES-17 (31 May 2018). The GOES-R Program Office continues to use GeoColor imagery very frequently in all of its Newsletters and other promotional materials.

During this reporting period, work continued on **refining the LUTs** to improve the characterization of specific true color scenes that are not well represented within the AHI/ABI domains. Daily GOES-16 and GOES-17 GeoColor and other RGB ABI loops are being closely examined for any problems. GOES-16/17 Loops of the Day are available to operational forecasters as well as the public at:

http://rammb.cira.colostate.edu/ramsdisk/online/loop_of_the_day/

Since GOES-17 has moved to its permanent GOES-West location at 137.2 W, GOES-17 GeoColor Imagery has joined GOES-16 GeoColor Imagery in its importance to highlight many different types of hazard weather events, now reaching from the western coast of Africa to eastern coast of Australia. During this reporting period, **CIRA’s Snow/Cloud Discriminator and the Snow/Cloud Layer products** have both been successfully transitioned to GOES-17 (**Figure 2**). The GOES-17 products were also introduced to CIRA’s SLIDER web display application page at <http://rammb-slider.cira.colostate.edu/>

During this reporting period the GOESR DEAR ABII Team transitioned many more GOESR-ABI RGB products to GOES-17. The full list of multispectral imagery products available on SLIDER for GOES-16/17 include: GeoColor, Natural Color (aka Day Land Cloud RGB), Natural Color-Fire (aka Day Land Cloud Fire RGB), Fire Temperature RGB, Airmass RGB, Dust RGB, Volcanic Ash RGB, SO₂ RGB, Day Cloud Phase Distinction RGB, Nighttime Microphysics RGB, Day Snow/Fog RGB, Snow/Cloud Discriminator and Snow/Cloud Layer products. The **SO₂**, **Nighttime Microphysics** and **Day/Snow Fog** RGBs were new additions to SLIDER during this reporting period. The Shortwave Albedo product was added for GOES-17, and a “split window difference” product was added for GOES-16 during this period, as well.

CIRA’s **Fire Temperature RGB** was first developed at CIRA for VIIRS and has since been applied to ABI with much positive feedback from the user community. GOES-16 RGB Fire Temperature product has been frequently used by NWS forecasters to highlight the extreme wildfire smoke events in the western United States during Spring, Summer, and early Fall of 2018. Both, **CIRA’s GOES-16 Fire Temperature and CIRA’s GOES-16 Natural Color-Fire products have been transitioned to GOES-17**. These products have been standardized for use in AWIPS and are easily displayed through the “on-the-fly” RGB capability available to all AWIPS users.

The fire RGBs have been utilized by the NWS to detect and monitor fires. The Fire Temperature RGB was used by the NWS WFO in Monterey, CA, to detect the “Gulch Fire”, a small fire in rural Monterey County, California (**Figure 3**). An example of the Natural Color-Fire RGB (which appears as “Day Land Cloud Fire RGB” in AWIPS), as used by the NWS WFO in Elko, NV, is shown in **Figure 4**.

Operational Forecasters frequently used the GOES-16 GeoColor product to monitor many of the extreme fire events which hit California in 2018. **Figure 5** depicts California’s deadly Camp and Woolsey fires on 11 November 2018 at 18:45 UTC. A GOES-16 GeoColor “Loop-of-the-Day” composed for this event covers the fire and strong smoke development for November 11th from 15:00 UTC to 23:45 UTC. To display the loop [click here](#).

See also comments below in the section: Additional Information – Interaction with Operational Partners.

GOESR GLM overlays were made available for GOES-16 and for GOES-17 GeoColor Imagery. The GLM overlay products are “CIRA’s Group Energy Density” and “CIRA’s Group Flash Count Density”. An example of a GLM Group Flash Count overlay over GeoColor at night during a severe weather outbreak over the South-Eastern United States from 6 November 2018 can be seen in **Figure 6**.

Another new product developed during the reporting period is an overlay product of **GeoColor with radar products, specifically with Multi-Radar/Multi-Sensor (MRMS)** fields. An example of GeoColor with an overlay of MRMS Merged Base Reflectivity can be seen in **Figure 7**.

A new research application for GOES-R ABI products is being explored by the DEAR-ABII Team: “**Optical Flow in GOESR ABI GeoColor**”. The Atmospheric Motion Vectors (AMV) necessary for the Optical Flow are being derived from a sequence of (typically 3) GOES-R Images. Preliminary tests have been performed on GeoColor Imagery depicting gust fronts/dust storms, supercells, and multiple high-impact hurricanes. Different types of algorithms are being tested (LK, Affine LK, 8-Parameter LK, and Fanreback). CIRA Postdoc Jason Apke is leading this effort for the DEAR-ABII project.

Milestone 2: Begin development of augmented DEBRA algorithm with 1.38 μm + blue band.

On 1 November 2018, a version of DEBRA began to run on CIRA’s public-facing SLIDER. This allows now for the forecasters to observe fall/spring dust storms which are often kicked up by the descending storm track.

New progress was made in the development and analysis of **cloud-cleared background products**. Cloud-cleared backgrounds are currently produced by taking the warmest 10.35 μm brightness temperature for a given pixel during a 21-day period, and then using the date/time index of the warmest pixel location as an index to provide the likeliest cloud-free location for all other ABI channels. An analysis performed, which located areas of large standard deviation in the monthly-mean cloud-cleared background surface brightness temperatures and reflectance values, suggested improvements to the product by incorporating 10.35 μm -3.9 μm information into the cloud-clearing index method described above. Continuing work on developing the best method to incorporate the band difference is ongoing. Application of the current cloud-cleared background to low-cloud retrievals at night show improved rejection of false-positive cloud retrievals using the cloud-cleared backgrounds; continued development and quality control of the cloud-cleared product should yield further improvements for dynamic background-based retrieval algorithms. Cloud-Cleared product information is an essential part for the improved performance of the DEBRA cloud mask.

The application of blue and 1.38 μm band reflectance information for daytime, over-water enhancement of dust will be evaluated in the coming months.

Milestone 3: Begin development of augmented GeoColor with new layers

Two versions of the existing daytime **VIIRS Cloud/Snow Discriminator** algorithm have now – for the first time - **been successfully developed for GOES-17 ABI**: a “binary” discriminator that highlights all clouds in yellow and snow and ice in white, and a “high/low” discriminator that colors clouds by height, with yellow low clouds, orange mid-level clouds, and magenta high clouds. Since the ABI lacks a Day/Night Band, the utility of the GOES-16 and GOES-17 products is limited to daytime scenes. Full disk, CONUS and mesoscale products for GOES-16 and GOES-17 are now being produced in real time, and are also available on the RAMMB SLIDER website. We are currently working on development of a methodology to convert the images produced for SLIDER into files that may be easily ingested into AWIPS. This is necessary to make these products available to NWS forecasters, as the Snow/Cloud products are not reproducible using the “on-the-fly” RGB capability within AWIPS.

Milestone 4: Begin development of custom products as defined via Liaison/forecaster interactions.

On 13 July 2017, GOES-16 GeoColor imagery started to be provided to forecasters in AWIPS/NAWIPS. By now, GOES-16 GeoColor is heavily used by NWS WFOs and National Centers. The Fire Temperature RGB was added to AWIPS through the “on-the-fly” RGB module developed at NASA SPoRT, and all NWS WFOs throughout CONUS have access to it. This “simple” RGB is created from the operational GOES data feed and, as such, is not delivered through the LDM. We also successfully adapted the Cloud/Snow Discriminator and the DEBRA products to AWIPS/NAWIPS. They are now about to be tested on AWIPS.

Milestone 5: Begin preparing and supplying materials (product descriptions, representative case studies) to training partners.

1. GOES-16 **and** GOES-17 GeoColor, RGB Fire Temperature, Snow/Cloud Discrimination, and a suite of other RGB composites (including recipes from EUMETSAT, JMA, NASA SPoRT, and CIRA) are now all available in real-time on the CIRA RAMMB SLIDER website (<http://rammb-slider.cira.colostate.edu>). This web application has been provided to NOAA/NESDIS/StAR where SLIDER is now running in realtime.
2. *The CIRA/RAMMB real-time **SLIDER** website is the principal public-facing demonstration utility for DEAR-ABII products.* GOES-17 has been added to SLIDER, the interactive web viewer for displaying static and looping images from **GOES-16 and GOES17** ABI and Himawari-8 AHI. All 16 bands from **both** ABIs and AHI are available for all sectors in real time: Full Disk, CONUS [ABI], Japan [AHI], and the rapid scan

mesoscale domains. CIRA's GeoColor product is the default product for the GOES-16/17 views. GeoColor blends the Synthetic, Hybrid, Atmospherically Corrected (SHAC) True Color imagery during the day with a low cloud and fog discrimination product at night.

During this quarter we successfully **transitioned several standard EUMETSAT RGB recipes for GOES-17 ABI and added those to SLIDER** as well.

These are: Natural Color, Airmass, Day Cloud Phase Distinction, Nighttime Microphysics, Day Snow/Fog, Dust, Volcanic Ash Microphysics, and the Japanese SO₂ – Sulfur Dioxide product (JMA). The Day Snow/Fog, Nighttime Microphysics and SO₂ RGBs are new to SLIDER during this reporting period, and are available for GOES-16 as well.

The following GOES-17 ABI CIRA products are also available in SLIDER: Snow/Cloud Discrimination, Snow/Cloud Layers, Short Wave Albedo, Fire Temperature RGB, Natural Color-Fire RGB. CIRA's GLM Group Energy Density and GLM Group Flash Count Density products are also available. They also turn out to be very useful when displayed as overlay over GeoColor.

The CIRA/RAMMB SLIDER web display tool continues to be very successful. This website has become the go-to source for ABI imagery for a wide variety of users, operational forecasters, public, and the media.

Plans for Next Reporting Period

Work will continue on all listed milestones for the second half of Year 2.

Additional Information

I. Interaction with operational partners

- National Center requests for CIRA GeoColor imagery were received from: The **Aviation Weather Center, Ocean Prediction Center, Weather Prediction Center, the Anchorage Volcanic Ash Advisory Center.**
- CIRA continued to work closely with **NWS partners** to make sure the GOES-16 imagery is displaying properly in their **AWIPS and NAWIPS** systems. GeoColor

Imagery is now flowing to numerous NWS offices (via LDM) to be viewed in AWIPS (for evaluation).

- As mentioned above, under the Project Accomplishment section Milestone 1, GOES-16/17 **GeoColor imagery is very frequently used by NWS forecasters** to visualize wildfire smoke events, dust, severe storms, low cloud/fog at night, and other hazardous events.
- Mike Stavish, SOO, **WFO Medford, Oregon**, sent an email to CIRA informing us that his WFO forecasters use CIRA's GeoColor product for their forecasts all the time

From: Michael Stavish - NOAA Federal <michael.stavish@noaa.gov>

Date: Thu, Jul 19, 2018 at 12:45 PM

Thought I'd shoot this your way. Forecaster Brett Lutz shown. Fyi, we are always watching the Geocolor. Great for smoke. Always getting questions from forecasters - "Why isn't this a baseline product in AWIPS???"

- By now all NWS/WFOs are receiving the **GOES-16 and the GOES-17 Fire Temperature** and Natural Color-Fire (aka **Day Land Cloud Fire RGB**) product. These products are easily displayed using the “on-the-fly” RGB capability within AWIPS. The RGB Fire Temperature Quick Guide was posted on-line at:
http://rammb.cira.colostate.edu/training/visit/quick_guides/Fire_Temperature_RGB.pdf

The Day Land Cloud Fire RGB Quick Guide is available here:

http://rammb.cira.colostate.edu/training/visit/quick_guides/QuickGuide_GOESR_DayLandCloudFireRGB_final.pdf

- **Idaho Department of Environmental Quality use of Smoke Imagery from CIRA:** Sara Strachan of the Idaho Department of Environmental Quality updated the Idaho Satellite Smoke Analysis on 23 August 2018 to include a GOES-16 Geocolor image from CIRA's SLIDER display tool. See <https://idahodeq.maps.arcgis.com/apps/MapSeries/index.html?appid=caa25aa20f754286a73eeb61dcd9fb9d>
- **Australian Bureau of Meteorology (BoM) uses Himawari-8 AHI RGB Fire Temperature imagery:** Mika Peace, who works for the Bureau of Meteorology, Australia, is providing fire forecasting support for the Queensland, Australia, wildfires. He informed CIRA/RAMMB on 29 November 2018, that “*his office is using SLIDER for real-time monitoring and operational decision support*”. Himawari-8 AHI RGB Fire Temperature imagery on SLIDER from 30 November 2018 highlighted the large number of fires burning in Queensland (**Figure 8**). An example image is shown in the figure below. A loop of this event has been made available on the CIRA “Himawari Loop of Interest” webpage:

http://rammb.cira.colostate.edu/ramsd/online/loop_of_the_day/himawari.asp

This loop shows a sea-breeze front passing over a region of fires, with the increase in wind causing a temporary intensification of the fires. These sea breeze fronts have also been linked with the development of “morning glory” clouds over the Gulf of Carpentaria.

- The **Japan Meteorological Agency (JMA)** has adopted CIRA’s AHI true-color algorithm to display their version of GeoColor.
- The **South Korean Air Force** sent one of their Lead Air Force Aviation Weather Forecasters to CIRA with the goal to learn as much as possible about Satellite Meteorology applicable to Aviation Hazards and Aviation Weather Forecasting. Major Hyekyong Kim visited CIRA from 1 August 2018 – 30 January 2019. The CIRA Meteorological Satellite Application Team worked closely with Major Kim during her visit. Training of Major Kim on GOESR DEAR ABII aviation-related products was one of the highest priorities during her time at CIRA.

Support of true color real-time production at NOAA and NESDIS for Outreach and Communication

- GOES-16 GeoColor image now on the new webpage banner of NOAA CLASS at <https://www.bou.class.noaa.gov/saa/products/welcome;jsessionid=50E06D5A0319104DEB13BA14A3E44EFE> (see **Figure 9**).
- CIRA GOES-16 and GOES-17 GeoColor imagery is used regularly by NESDIS News <https://www.nesdis.noaa.gov/news-articles-archive?page=1>
- NOAA Satellites (@NOAASatellites) regularly tweets CIRA’s GOES16/17 ABI GeoColor imagery to highlight special weather events (**Figures 10 and 11**).
- GOES-16 and GOES-17 True Color/GeoColor imagery is heavily used in the GOES-R Program Office GOES-R Quarterly Newsletter, including on the cover pages. (see **Figure 12**).
- NWS WFO Offices frequently use CIRA’s GeoColor to publish special weather events (**Figure 13**).
- Daily ABI loops are being posted on CIRA’s webserver and are frequently downloaded by NESDIS for their use.

The majority of the “ABI Loop-of-the-Day” which are posted almost daily, are GeoColor loops, which can be viewed by the public.

http://rammb.cira.colostate.edu/ramsdisk/online/loop_of_the_day/

Examples of “ABI Loop-of-the-Day” GeoColor imagery posted during the reporting period:

[2018-12-17 - Fog fills the valleys of the Southeast U.S. at night, then burns off during the day - GeoColor - HTML5 Loop](#)

[2018-12-14 - Smog stagnates in the San Joaquin Valley of California - GeoColor - HTML5 Loop](#)

[2018-12-10 - Low clouds and fog advance south from the Great Lakes to the Ohio River Valley - Geocolor - HTML5 Loop](#)

[2018-11-30 - The storm that brought heavy rain to California yesterday kicked up a dust storm in West Texas today - GeoColor - HTML5 Loop](#)

[2018-11-15 - GOES-17 has arrived at its new home \(137.2 °W longitude\) - GeoColor - HTML5 Loop](#)

[2018-11-12 - Smoke from the California wildfires makes its way over the Pacific Ocean - GeoColor - HTML5 Loop](#)

[2018-11-06 - A nighttime severe weather outbreak in the Southeast U.S. - GeoColor with GLM overlay - HTML5 Loop](#)

[2018-11-01 - Dust advects over the Gulf of California - GeoColor - HTML5 Loop](#)

[2018-10-22 - Wave clouds blanket the Northeast U.S. - GeoColor - HTML5 Loop](#)

[2018-10-19 - Tropical Storm Vicente forms off the coast of Guatemala - GeoColor - HTML5 Loop](#)

[2018-10-16 - "Popcorn cumulus" cloud streets in Venezuela - GeoColor - HTML5 Loop](#)

[2018-09-19 - Polluted floodwaters from the Carolinas are entering the Gulf Stream \(Pamlico Sound is particularly dirty\) - GeoColor - HTML5 Loop](#)

[2018-09-12 - Today is your last chance to prepare for Major Hurricane Florence - GeoColor - HTML5 Loop](#)

[2018-08-22 - "Popcorn cumulus" cloud streets in the Southeast U.S. - GeoColor - HTML5 Loop](#)

[2018-08-03 - Hurricane Hector in the East Pacific - GeoColor - HTML5 Loop](#)

[2018-07-30 - Wave clouds produced by the Lesser Antilles - GeoColor - HTML5 Loop](#)

II. Conference / Workshops / Presentations

Miller, S. D., C. J. Seaman, J. Solbrig, J. Apke, K. Hilburn, S. Longmore, Y.-J. Noh, 2018: Developing an Environmental Awareness Repertoire of ABI Imagery ('*DEAR-ABII*') to Advise the Operational Weather Forecaster. *FY18 GOES-R Risk Reduction – Science Project Review*, CIRA, Fort Collins, 19 December 2018

Miller, S. D., C. J. Seaman, J. Solbrig, J. Apke, K. Hilburn, J. M. Forsythe, J. Haynes, Y.-J. Noh, S. Longmore, 2018: Overview of aviation-forecast relevant CIRA satellite algorithm developments.
US Air Force Major Kerrin Caldwell – visit to CIRA, Fort Collins, 18 December 2018.

Lindsey, D. T.: GOES-R ABI: A New Tool for Observing Convection. Poster presentation including CIRA imagery. *2018 AGU Annual Fall Meeting*, Washington, DC, 10-14 December 2018.

Lindsey, D. T.: Advancing Satellites Through Observations. NOAA Booth presentation (included CIRA-produced imagery). *2018 AGU Annual Fall Meeting*, Washington, DC, 10-14 December 2018.

Miller, S. D., J. M. Forsythe, L. Grasso, J. Haynes, Y.-J. Noh, M. Zupanski, R. Brummer, J. Solbrig, D. T. Lindsey, 2018: New GOES-R Risk Reduction Activities at CIRA. *CIRA Connect Workshop* at NOAA/ESRL, 5 October 2018, Boulder, CO

Miller, S. D., 2018: Advanced Imagery Applications for the GOES-16/17 Advanced Baseline Imager. *NOAA/ESRL CSD Seminar*, 26 September 2018.
(<https://www.esrl.noaa.gov/csd/seminars/>)

Miller, S. D., W. C. Straka III, C. J. Seaman, and J. R. Torres, 2018: NOAA-20/Suomi-NPP Pairing Offers a Practical "Encore" for the VIIRS Day/Night Band. *Current and Future Meteorological Satellite Systems and Data Access Conference Session, EUMETSAT Meteorological Satellite Conference*, 17-21 September, Tallinn, Estonia.

Miller, S. D., C. J. Seaman, Y.-J. Noh, D. T. Lindsey, J. M. Forsythe, J. F. Dostalek, J. R. Torres, and K. P. Micke, 2018: CIRA Development of Alaska-Relevant Satellite Applications from

Suomi-NPP, JPSS-1 and GOES-R. *ACCAP Virtual Alaska Weather Symposium*, 22 August. *Remote presentation*.

Miller, S. D., Y.-J. Noh, D. T. Lindsey, C. J. Seaman, J. M. Forsythe, J. M. Haynes, and L. D. Grasso, 2018: Aviation-Relevant Satellite Research and Algorithm Development at CIRA. *FAA Aviation Weather Research Program (AWRP) Review Meeting*, 10-11 July 2018, Boulder, CO.

III. Outside Project Publicity / GeoColor in the Media

Note: For this section figures are embedded in the text

CIRA GeoColor Imagery now being displayed at the Harvard University Museums of Science and Culture: Alex Griswold, a video producer who works for the exhibits department at the Harvard University Museum of Science and Culture, contacted CIRA and asked for GOES-16 full disk high-resolution GeoColor images, covering the time period of 25 August 2017 through 4 October 2017 at a temporal resolution of 15 minutes. CIRA mailed him the large requested dataset on November 15th. A GeoColor imagery animation with a focus on two Atlantic category 5 Hurricanes Irma and Maria, became part of a new public exhibit at the Harvard University Museum of Science and Culture, which started on December 9th.

Alex Griswold added a very positive comment about the GeoColor imagery he requested: “*While I’m writing I should take a few minutes to express my appreciation for this imagery. These high resolution full disk images are phenomenal to see in full color and with such detail. If nothing else, it’s an amazing way to communicate to the public the fragility and finiteness of our beautiful planet, and in movies, the storms and frontal systems are a fantastic tool for teaching and understanding meteorology*”.

Below is an excerpt of media who used CIRA GOES-16/17 ABI GeoColor Imagery for covering weather and hazard events during the reporting period. Figures are embedded into this section.

GOES-16/17 products, mainly the GOES16 GeoColor, continued to be used by many different media outlets. Most media outlets access the CIRA products via CIRA’s Web application SLIDER (<http://rammb-slider.cira.colostate.edu>). Below is a non-comprehensive list of some of the postings/broadcasts that used CIRA’s GOES-16/17 GeoColor imagery.

Himawari-8 True Color Imagery used by BBC: 30 July 2018: Himawari-8 AHI True Color imagery using the CIRA Hybrid, Atmospherically Corrected (HAC) true color algorithm has been provided to the *BBC* for an upcoming TV series, “Earth From Space”. The imagery is being provided by JMA, with credit to NOAA/NESDIS and CIRA.

GeoColor imagery shown on CNN’s The Situation Room: On 12 September 2018, CNN’s Wolf Blitzer interviewed Dr. Louis Uccellini (NOAA/NWS) as part of CNN’s afternoon broadcast “The Situation Room”. The broadcast included also several CIRA/RAMMB GOES16 products, like the GOES16 GeoColor imagery.

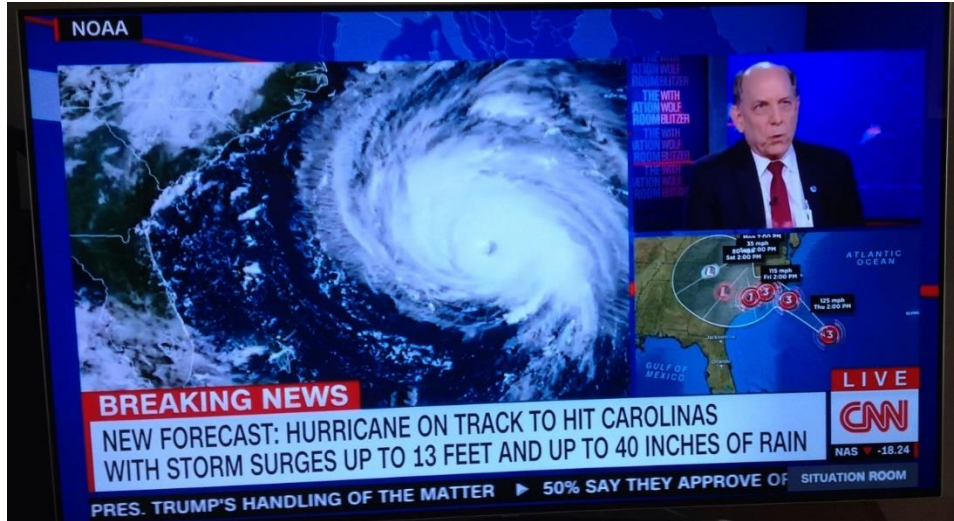


Figure 14: Dr. Louis Uccellini (NOAA/NWS) is being interviewed during CNN’s afternoon broadcast “The Situation Room” (12 September 2018 at 5 pm ET). The broadcast included several CIRA/RAMMB GOES16 products, like the GOES16 GeoColor imagery.

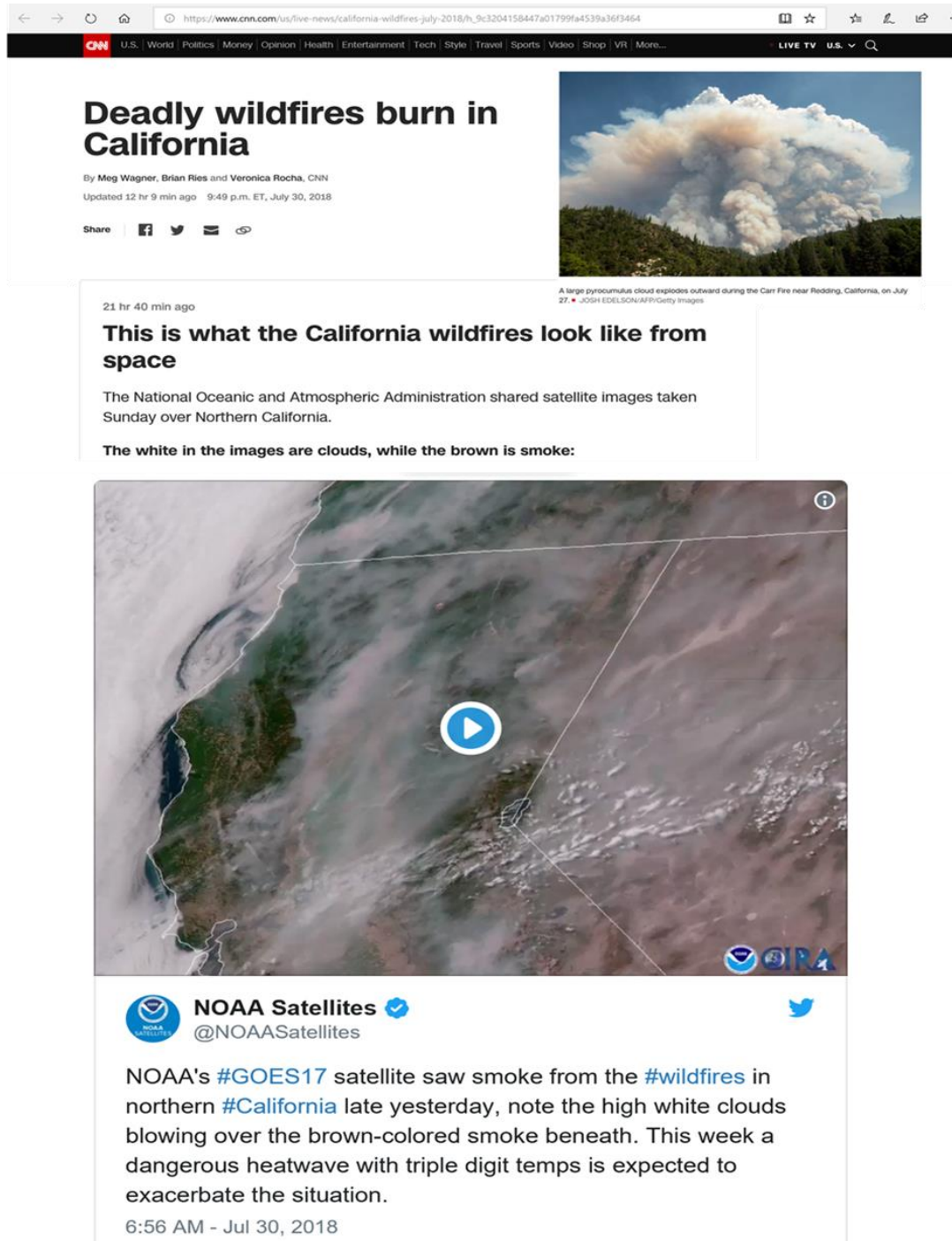
CNN Homepage <https://www.cnn.com> on 10 September 2018 with a report on the intensification of Hurricane Florence: “Category 4 hurricane is expected to get stronger”. (See **Figure 15**).



Figure 15: CNN Homepage on 10 September 2018 – reporting on Hurricane Florence.

GOES-17 GeoColor product used by CNN: On July 30th, CNN depicted a CIRA GOES-17 GeoColor imagery loop as part of their online article on “Deadly Wildfires burn in California” to highlight what “the California wildfires look like from space” (see **Figure 16** below).

https://www.cnn.com/us/live-news/california-wildfires-july-2018/h_9c3204158447a01799fa4539a36f3464



The image is a screenshot of a web browser displaying a CNN news article and a tweet. The article, titled "Deadly wildfires burn in California", is dated July 30, 2018. It features a photograph of a large, billowing white and brown smoke plume rising from a forested area. Below the article is a tweet from NOAA Satellites (@NOAASatellites) dated July 30, 2018, at 6:56 AM. The tweet includes a video player showing a satellite image of California with a play button in the center. The video player also displays the NOAA and CIRA logos. The tweet text describes the satellite imagery, noting high white clouds and brown smoke, and mentions an expected heatwave.

Deadly wildfires burn in California

By Meg Wagner, Brian Ries and Veronica Rocha, CNN
Updated 12 hr 9 min ago 9:49 p.m. ET, July 30, 2018

Share | Facebook | Twitter | Email | Print

21 hr 40 min ago

This is what the California wildfires look like from space

The National Oceanic and Atmospheric Administration shared satellite images taken Sunday over Northern California.

The white in the images are clouds, while the brown is smoke:

A large pyrocumulus cloud explodes outward during the Carr Fire near Redding, California, on July 27. © JOSH EDELL/CONA/AFIP/Getty Images

NOAA Satellites @NOAASatellites

NOAA's #GOES17 satellite saw smoke from the #wildfires in northern #California late yesterday, note the high white clouds blowing over the brown-colored smoke beneath. This week a dangerous heatwave with triple digit temps is expected to exacerbate the situation.

6:56 AM - Jul 30, 2018

Figure 16: CNN reporting on California fires on 30 July 2018.

CNN online on 10 September 2018: “Hurricane Florence upgraded, on track to hit East Coast as major storm this week”.

<https://www.cnn.com/2018/09/09/us/florence-tropical-storm-hurricane-forecast-wxc/index.html>

The Guardian (US Edition) on-line on 8 September 2018: “Tropical storm Florence likely to become a hurricane, forecasters say”. <https://www.theguardian.com/world/2018/sep/08/tropical-storm-florence-latest-hurricane-north-south-carolina>

USA Today on 13 September 2018: “Hurricane Florence path: Where the monster storm is now, where it's going.” <https://www.usatoday.com/story/news/nation/2018/09/13/hurricane-florence-where-where-its-going/1289101002/>

National Public Radio on 13 September 2018: “Hurricane Florence Starts To Hit The Carolina Coast With High Winds And Rushing Seas”.

<https://www.npr.org/2018/09/13/647358237/hurricane-florence-weakens-a-bit-as-it-closes-in-on-north-carolina-coast>

National Public Radio on 12 September 2018: “ 'Disaster Is At The Doorstep,' N.C. Governor Says As Hurricane Florence Zeroes In”. <https://www.npr.org/2018/09/12/647005403/hurricane-florence-zeroes-in-on-carolinas-bringing-130-mph-winds>

9news Denver on 10 September 2018: “Hurricane Florence: U.S. airlines begin waiving change fees”. <https://www.9news.com/article/news/nation-now/hurricane-florence-us-airlines-begin-waiving-change-fees/465-803d227a-f539-4bf6-81c6-48e20fa0f96f>

The Denver Post on 11 September 2018 interviewed CIRA’s Outreach Expert Matt Rogers: “Predicting the eye of Hurricane Florence from the Colorado mountains”.

<https://www.denverpost.com/2018/09/11/hurricane-florence-predictions-from-colorado-mountains/> . See Figure 17 below.

NEWS > WEATHER

Predicting the eye of Hurricane Florence from the Colorado mountains

From NOAA's research lab in Boulder to CSU's hurricane predictors, Colorado plays a vital role in tracking Mother Nature



1 of 11

This GOES East satellite image taken Tuesday, Sept. 11, 2018, at 10:30 a.m. EDT, and provided by NOAA shows Hurricane Florence in the Atlantic Ocean as it threatens the U.S. East Coast, including Florida, Georgia, South and North Carolina. Millions of Americans are preparing for what could be one of the most catastrophic hurricanes to hit the Eastern Seaboard in decades. Mandatory evacuations begin at noon Tuesday, for parts of the Carolinas and Virginia (NOAA via AP)

By DAVID MIGOYA | dmigoya@denverpost.com | The Denver Post
 PUBLISHED: September 11, 2018 at 6:36 pm | UPDATED: September 11, 2018 at 6:40 pm

SIGN UP FOR NEWSLETTERS AND ALERTS

Figure 17: Denver Post article on 11 September 2018.

AXIOS Newsletter on 10 September 2018: Featured article on homepage: “Hurricane Florence on track for direct, dangerous strike”.

<https://www.axios.com/>

Earther on 10 September 2018: “Why Hurricane Florence Could Gerate Historic Rainfall”.

<https://earther.gizmodo.com/oh-my-god-look-at-the-atlantic-ocean-right-now-1828936191>

Earther on 11 September 2018: “Oh My God Look at the Atlantic Ocean Right Now”.

<https://earther.gizmodo.com/why-hurricane-florence-could-generate-historic-rainfall-1828971346>

Vox on 12 September 2018: “Hurricane Florence: what we know about the powerful storm heading for the Carolinas”.

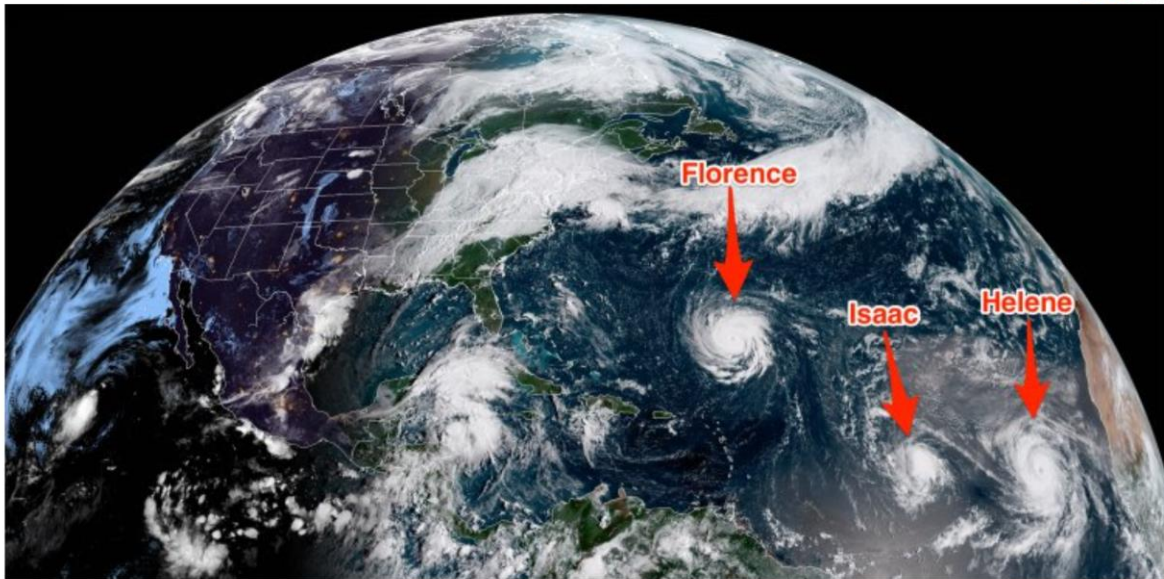
<https://www.vox.com/2018/9/10/17840874/hurricane-florence-forecast-south-carolina-north-outer-banks-evacuations>

Business Insider on 10 September 2018: “Astronauts in space just saw all 3 threatening hurricanes lurking in the Atlantic Ocean”.

<https://www.businessinsider.com/hurricane-florence-isaac-helene-space-pictures-2018-9?r=UK&IR=T> (Figure18).

Astronauts in space just saw all 3 threatening hurricanes lurking in the Atlantic Ocean

Dave Mosher Sep. 10, 2018, 12:00 PM



Satellite imagery shows hurricanes Florence, Isaac, and Helene from space on September 10, 2018. CIRA/RAMMB; GOES-16/NOAA

Figure 18: Business Insider on 10 September 2018.

Vox on 12 September 2018 interviewed Chris Slocum “Hurricane Florence will slow down. That’s a bad thing”. <https://www.vox.com/energy-and-environment/2018/9/12/17851214/hurricane-florence-path-forecast-slow-down-stall-rain>

Yahoo Lifestyle on 12 September 2018: “Hurricane Katrina survivor post tips for people evacuating their homes as Hurricane Florence approaches”. <https://www.yahoo.com/lifestyle/hurricane-katrina-survivor-posts-tips-people-evacuating-homes-hurricane-florence-approaches-191352550.html>

PalmBeachPost on 10 September 2018: “UPDATE: Category 4 Florence lumbers toward Carolina coast, evacuations urged”. <http://weatherplus.blog.palmbeachpost.com/2018/09/10/florence-strengthens-expected-to-be-category-4-by-thursday/>

Japanese TV Company TV-Asahi (week of 10 Sep 2018): CIRA/RAMMB GeoColor imagery of Himawari-8 showing Super Typhoon Ompong/Mangkhut, (approaching the Philippines) and GOES-16 imagery of Hurricane Florence was being utilized by Japanese network TV-Asahi as part of a story on the impact of these storms on the affected countries.

The Guardian on-line depicted a GOES-16 GeoColor Image of Hurricane Michael on its title page on 11 October 2018 (Figure 19).

<https://www.theguardian.com/us-news/live/2018/oct/10/hurricane-michael-latest-live-news-updates-florida-evacuations-storm->

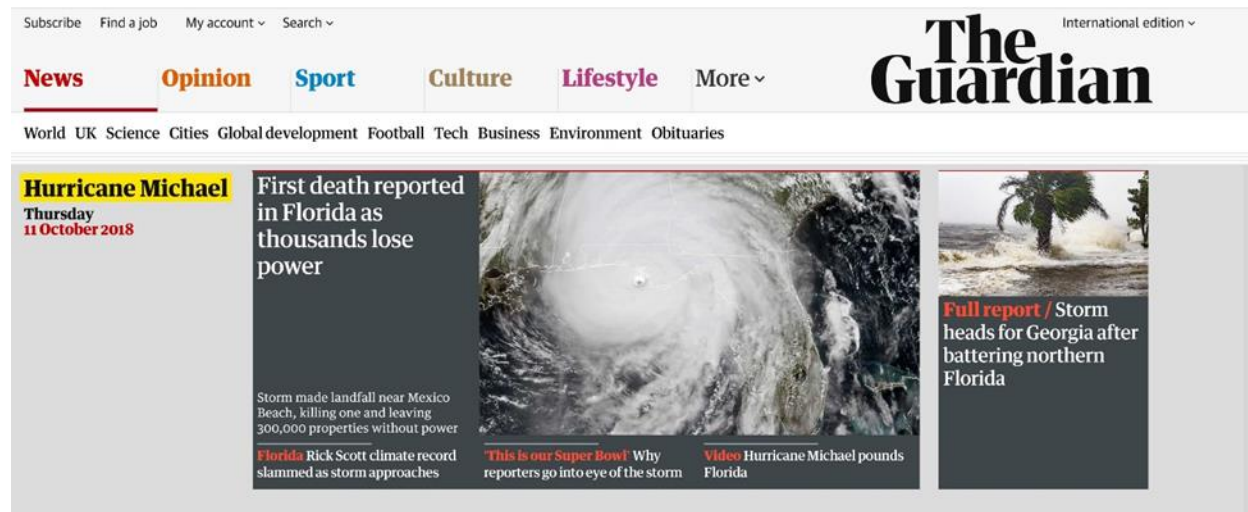


Figure 19: Front page of The Guardian on-line (11 October 2018) depicting Hurricane Michael approaching the Florida coastline.

PBS NOVA using CIRA's GOES-16 GeoColor Imagery: Alex Hoon, Senior Meteorologist and IMET with the Fire Weather Program Manager (NWS, Reno, NV) was working the Camp Fire in early November 2018. He expressed his appreciation for Dan Lindsey sending him a GOES-East GeoColor imagery loop with RGB Fire Temperature overlay while he was fighting the fire. When Mr. Hoon was interviewed by PBS NOVA team, while on the Camp Fire, he shared the GeoColor/RGB Fire Temperature imagery with the PBS. The PBS NOVA Team liked the imagery and is planning to use CIRA's GeoColor loop for the Camp Fire on Nov 8th as well as for the Carr Fire, when it burned through Redding, CA on July 26th.

On Thu, Nov 29, 2018 at 5:28 AM Alex Hoon - NOAA/NWS Federal <alexander.hoon@noaa.gov> wrote:

"Awesome, thank you! I am going to send NOVA what I have for now, and we can send them additional items in the coming days. I'll cc you guys on the e-mail so you remain in the loop."

BBC Request CIRA's GeoColor Imagery for Documentary About Florida: On 6 December 2018, CIRA/RAMMB was contacted by Harry Lawrence, a Researcher for Natural World at the BBC. They were working on a documentary about Florida, and found CIRA's SLIDER GOES-16 GeoColor imagery from last year's hurricane season. Lawrence asked if they could get some of the original, high-resolution imagery to use in the documentary. CIRA provided them with

GOES-16 GeoColor imagery showing Hurricane Florence from 2018, and Hurricanes Irma, Katia, and Jose from 2017.

Use of CIRA GeoColor Imagery in Jardine Lloyd Thompson Insurance Publication:

CIRA GeoColor imagery depicting the strong Nor'easter storm (“Superbomb”) from 3-6 January 2018 (Figure 8) has been utilized in a December 2018 publication by Chicago-based Jardine Lloyd Thompson, a financial services company serving the insurance industry (**Figure 20**). Many insurance companies are increasingly concerned about increasing weather volatility resulting in more frequent or severe catastrophes. The publication leverages current weather and climate data in its attempt to quantify the increased impact of winter storms.

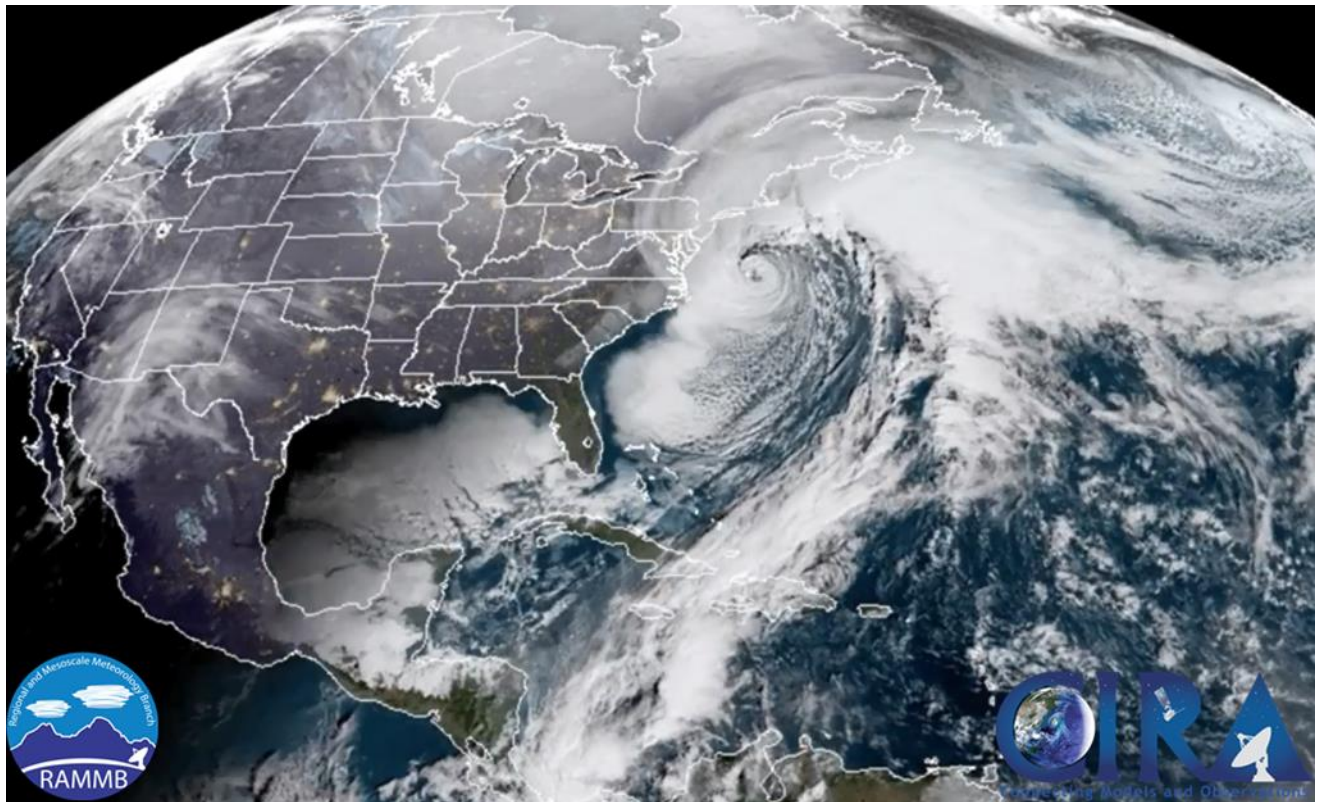


Figure 20: GOES-16 GeoColor imagery from the 3-6 January 2018 nor'easter, utilized in a December 2018 publication by Chicago-based Jardine Lloyd Thompson, a financial services company serving the insurance industry.

IV. Relevant Journal Publications

New publication!

Broomhall, M., L. Majewski, V. Villani, I. Grant, and S. D. Miller, 2019: Correcting Himawari-8 Advanced Himawari Imager data for the production of vivid true colour imagery. *J. Atmospheric Ocean. Technol.* In Press.

Lindsey, D. T., S. Nam, and S. D. Miller, 2018: Tracking oceanic nonlinear internal waves in the Indonesian seas from geostationary orbit. *Rem. Sens. Environ.*, **208**, 202-209, <https://doi.org/10.1016/j.rse.2018.02.018>.

Miller, S. D., R. L. Bankert, J. E. Solbrig, J. M. Forsythe, and Y.-J. Noh, 2017: A Dynamic Enhancement with Background Reduction Algorithm: Overview and Application to Satellite-Based Dust Storm Detection. *JGR-Atmospheres*, **122**(23), 12,938–12,959, doi.org/10.1002/2017JD027365.

Note: the DEBRA publication (Miller et al. 2017, listed above) was designated as a “Journal Highlight” by JGR:Atmospheres handling Editor Zhanqing Li. JGR Highlight Title: “Addition by Subtraction: Raising the Bar for Satellite Imagery”. Full JGR highlight text: <https://eos.org/editor-highlights/addition-by-subtraction-raising-the-bar-for-satellite-imagery>

Miller, S. D., T. L. Schmit, C. J. Seaman, D. T. Lindsey, M. M. Gunshor, R. A. Kors, Y. Sumida, and D. W. Hillger, 2016: A Sight for Sore Eyes: The Return of True Color Imagery to Geostationary Satellites. *Bull. Amer. Meteor. Soc.*, **97**(10), 1803-1816, doi:10.1175/BAMS-D-15-00154.1.

NOTE: *BAMS* Cover Article

Key Graphics

- See next page -



Figure 1: President Trump using a GOES-16 GeoColor image for his tweet on 11 October 2018.

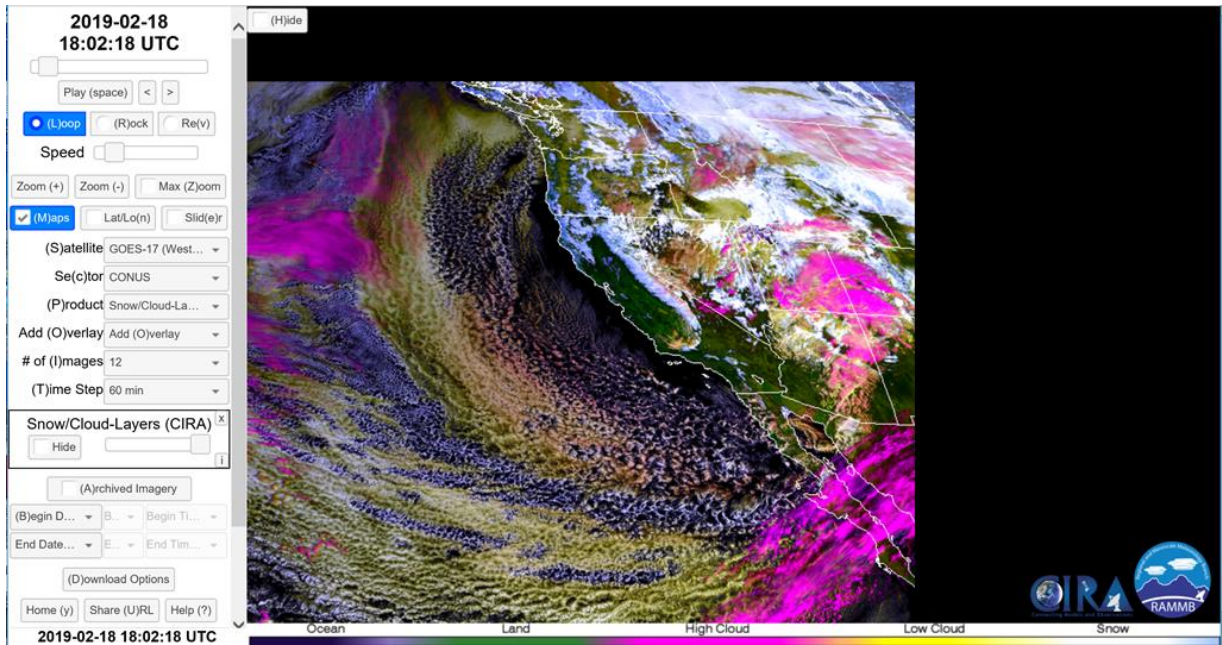


Figure 2: Snow/Cloud Layer product from 18 February 2019 displaying large amount of snow on the ground (white) over the western United States.

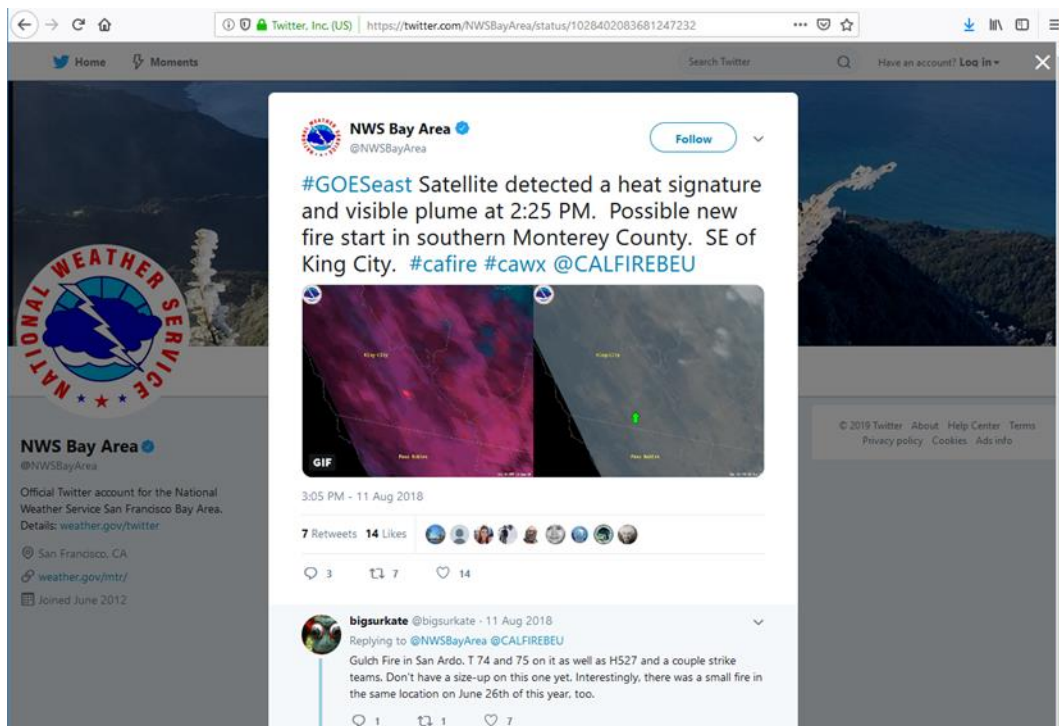


Figure 3: Social media post by the NWS WFO in Monterey, CA (@NWSBayArea on Twitter) showing the utility of the Fire Temperature RGB in detecting a small fire on 11 August 2018.

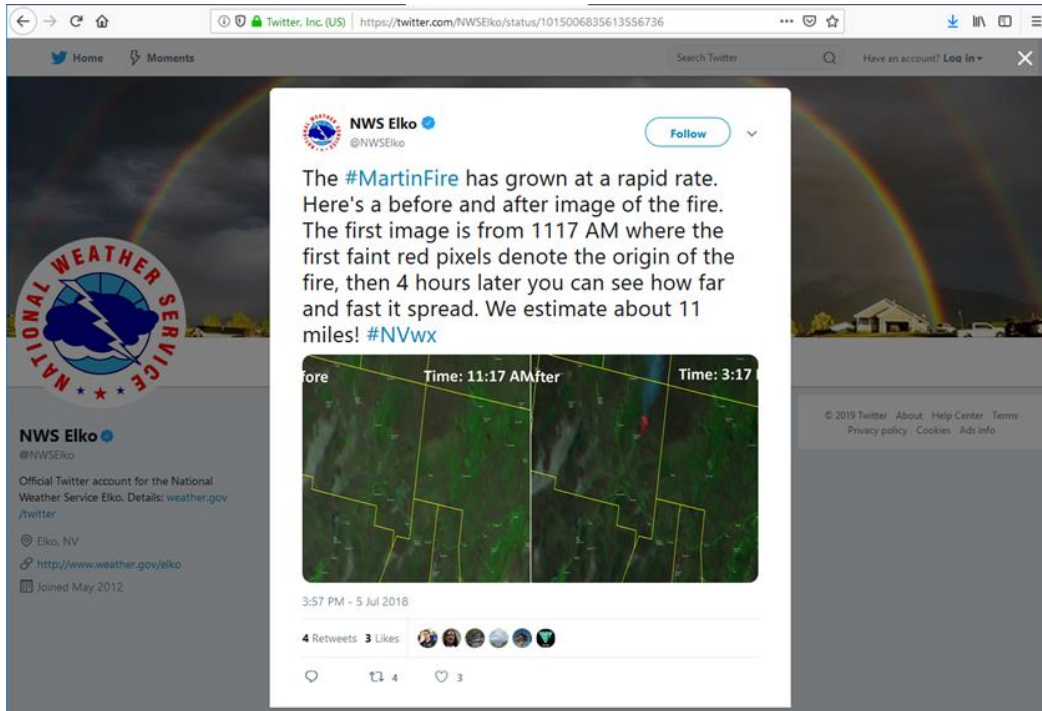


Figure 4: Social media post by the NWS WFO in Elko, NV, showing the Natural Color-Fire RGB (aka Day Land Cloud Fire RGB) was used to detect the Martin Fire in central Nevada, 5 July 2018.

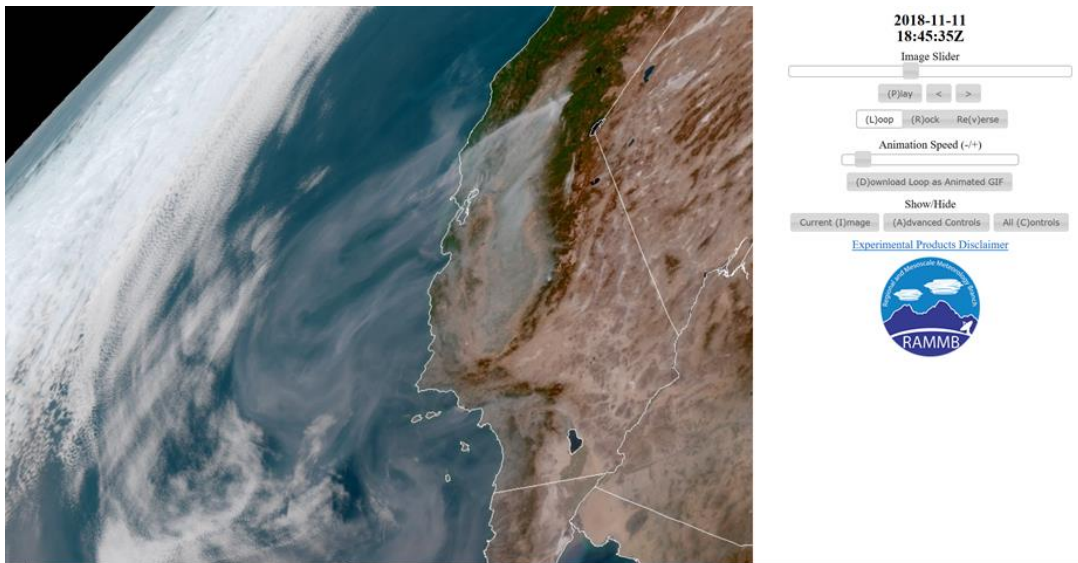


Figure 5: GOES-16 GeoColor smoke from California's Camp and Woodley fire on 11 November 2018 at 18:45 UTC. For a 9-hour loop (15 minute interval) [click here](#).

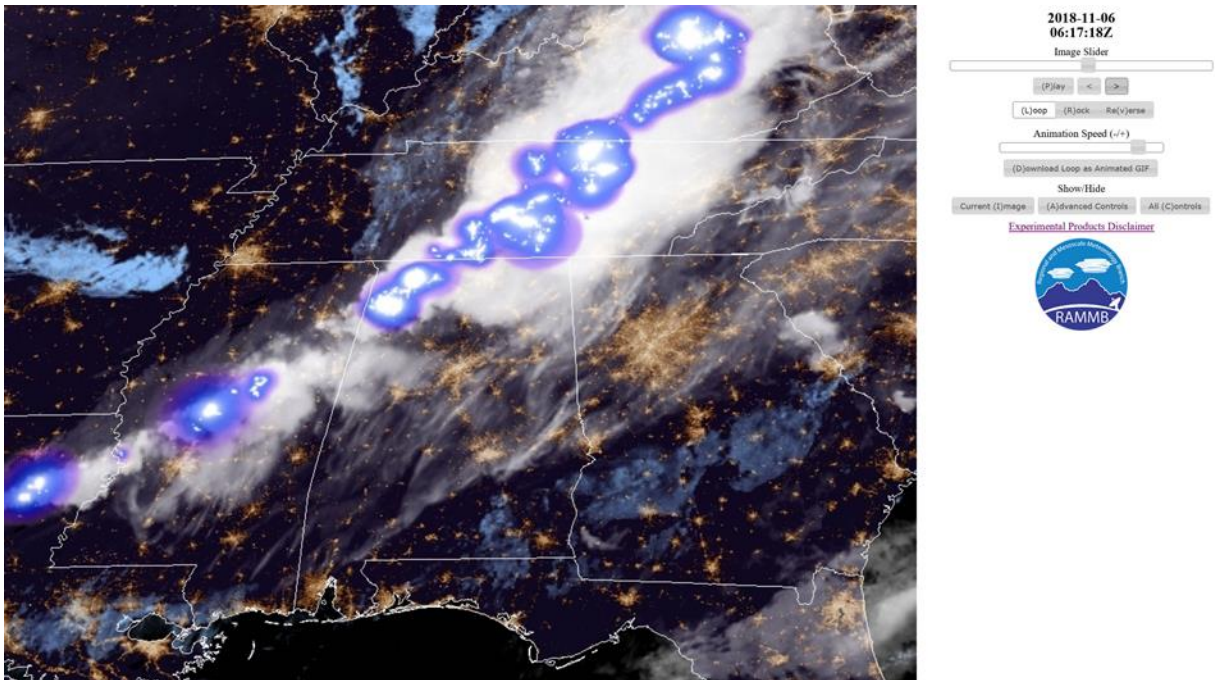


Figure 6: GLM Group Flash Count overlay over GeoColor at night (SLIDER display) during a severe weather outbreak over the South-Eastern United States from 6 November 2018 at 6:17 UTC.

rammb-slider.cira.colostate.edu

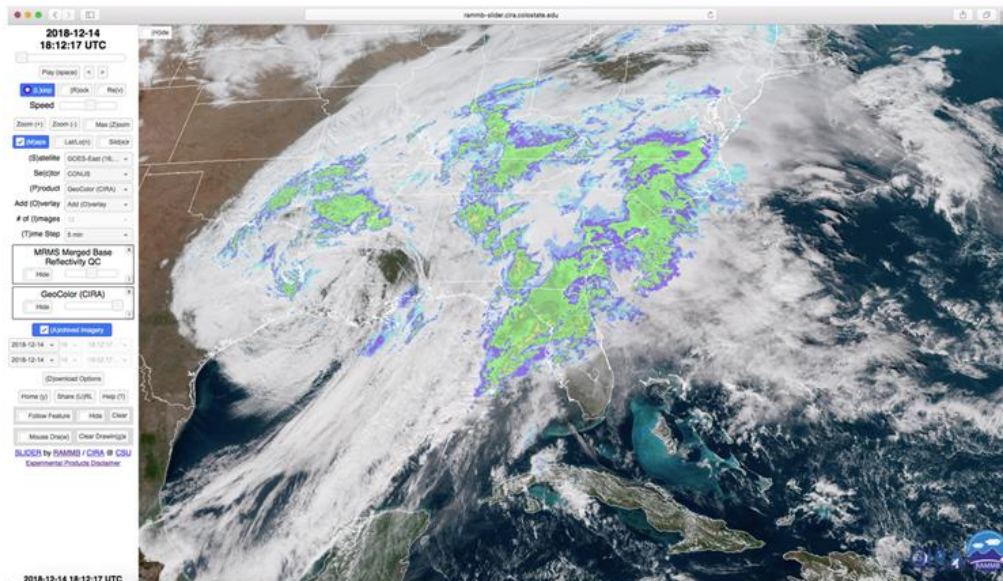


Figure 7: GOES-16 GeoColor from 14 December 2018 at 18:12 UTC with an overlay of MRMS Merged Base Reflectivity.

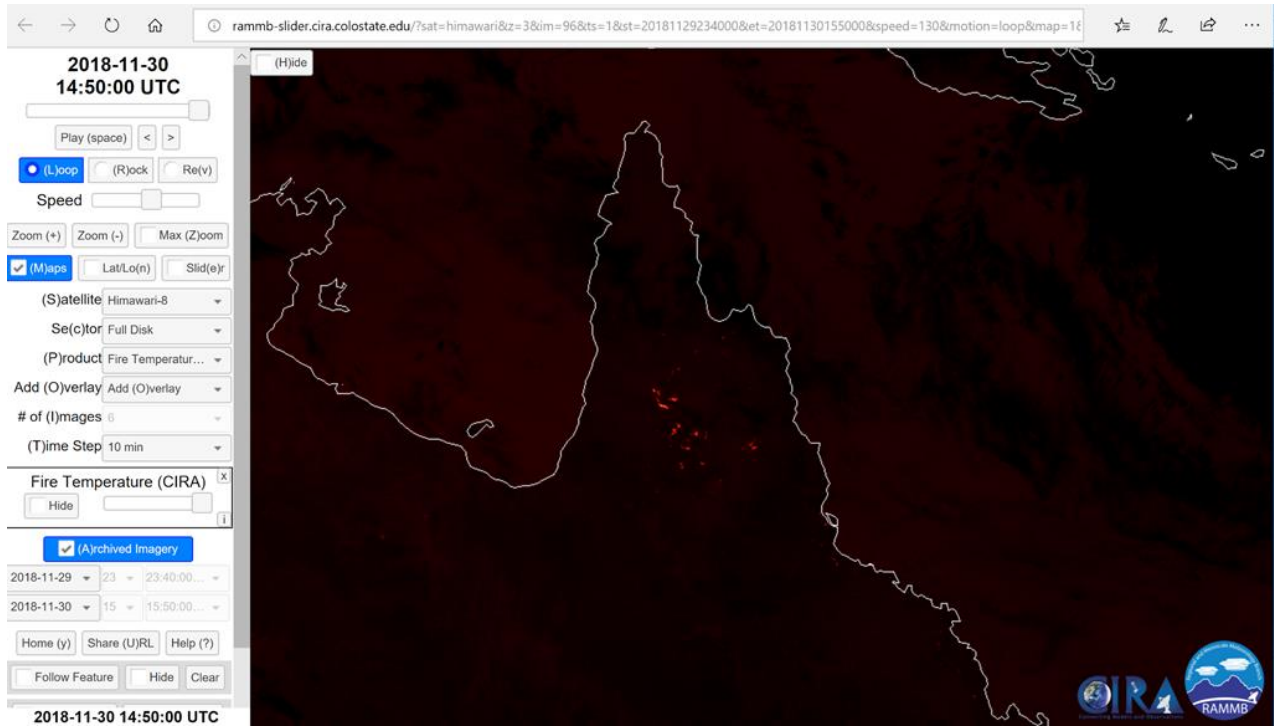


Figure 8: Fire Temperature RGB image from Himawari-8 AHI showing a large number of fires at night in Queensland, Australia (14:50 UTC, 30 November 2018).

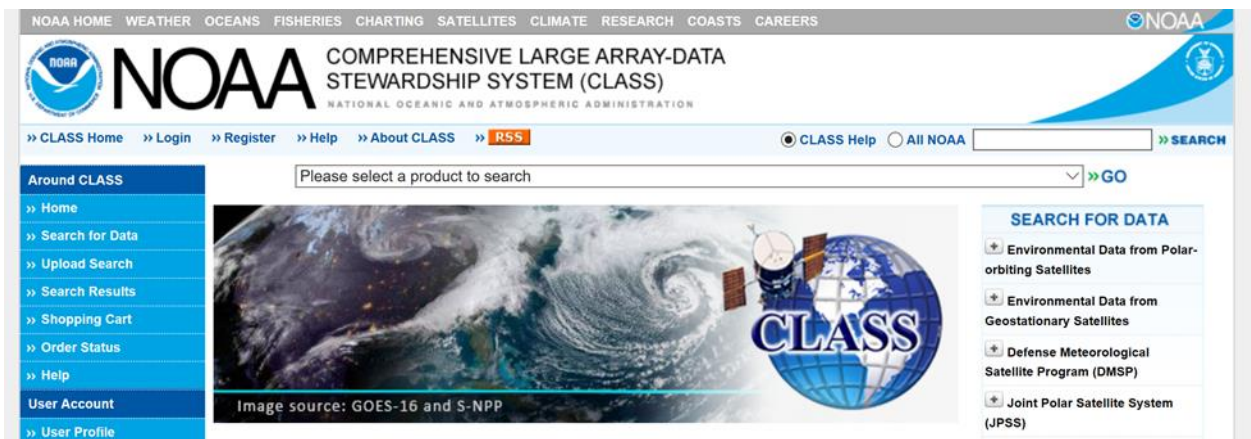


Figure 9: NOAA CLASS webpage banner with GeoColor Imagery (July 2018 – present).

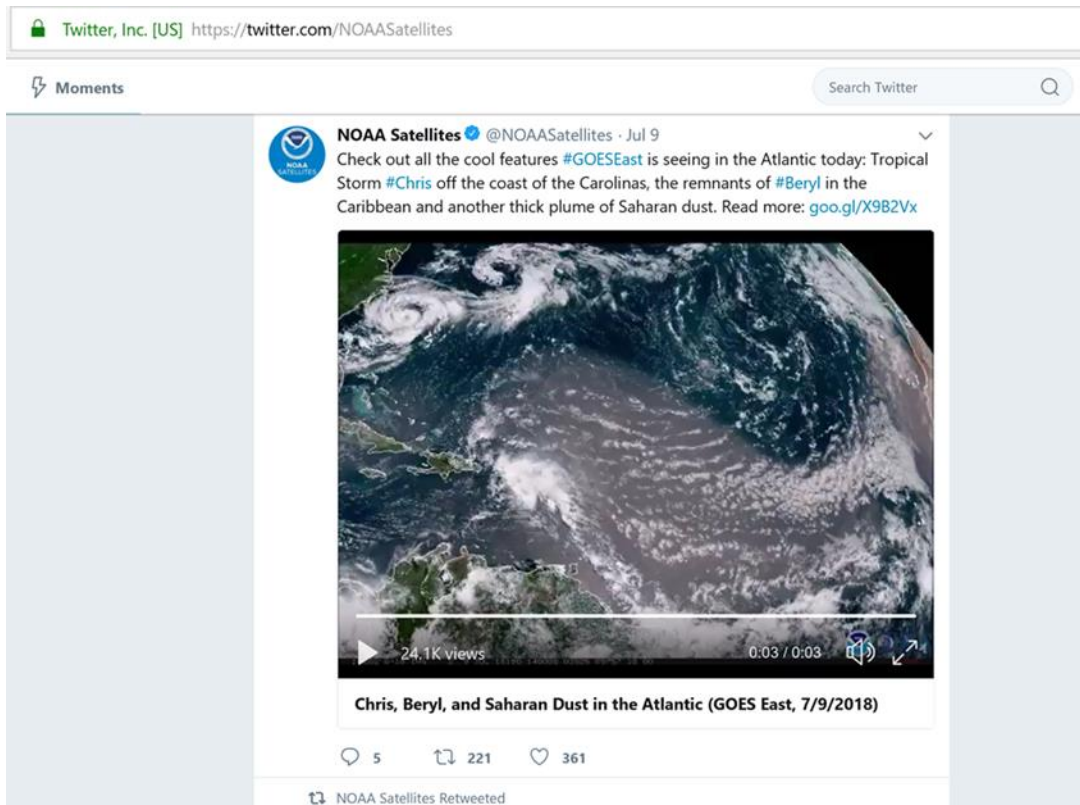


Figure 10: NOAA Satellites (@NOAASatellites) tweeting CIRA's GOES-16 GeoColor depicting a strong Atlantic dust event and Tropical Storm Chris off the coast of the Carolinas on 9 July 2018.

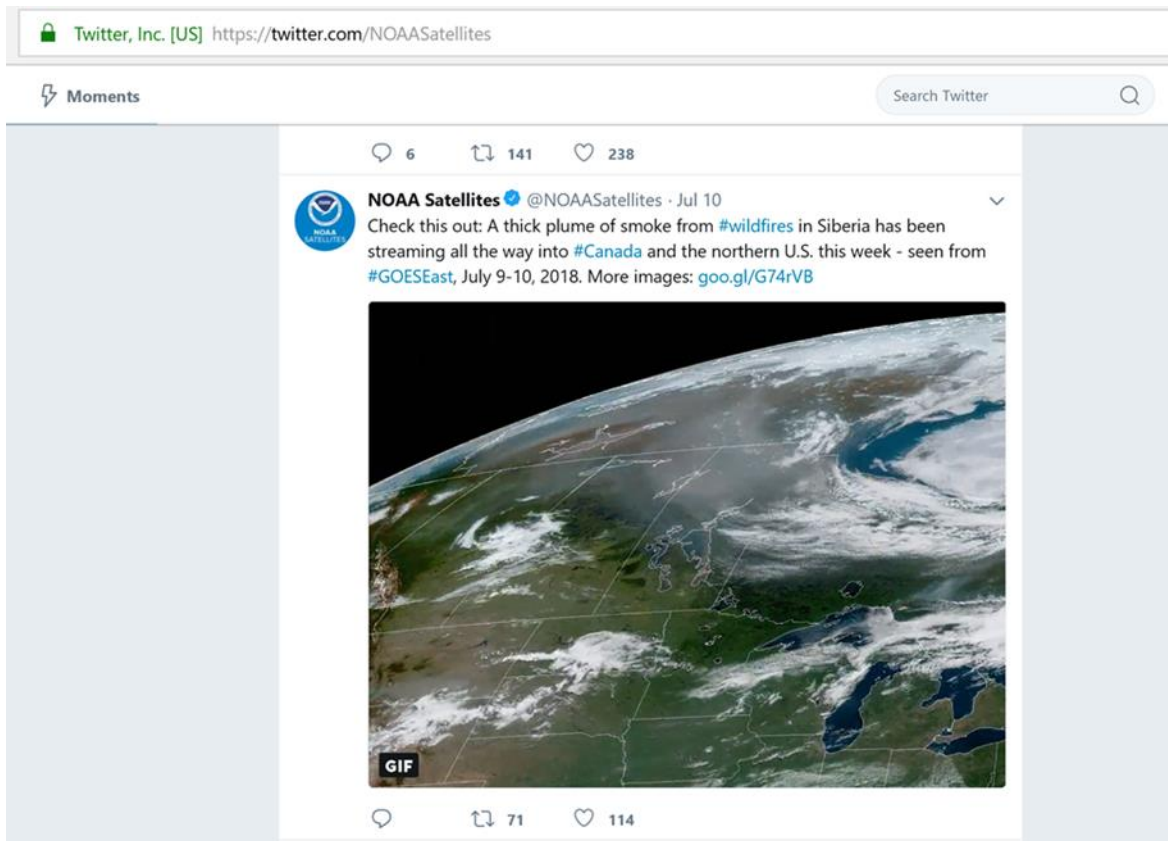


Figure 11: NOAA Satellites (@NOAASatellites) tweeting CIRA's GOES-16 GeoColor depicting thick plume of smoke from wildfires in Siberia streaming all the way into Canada and the northern U.S. on 10 July 2019.



**A Note from Pam Sullivan,
GOES-R System Program Director:**

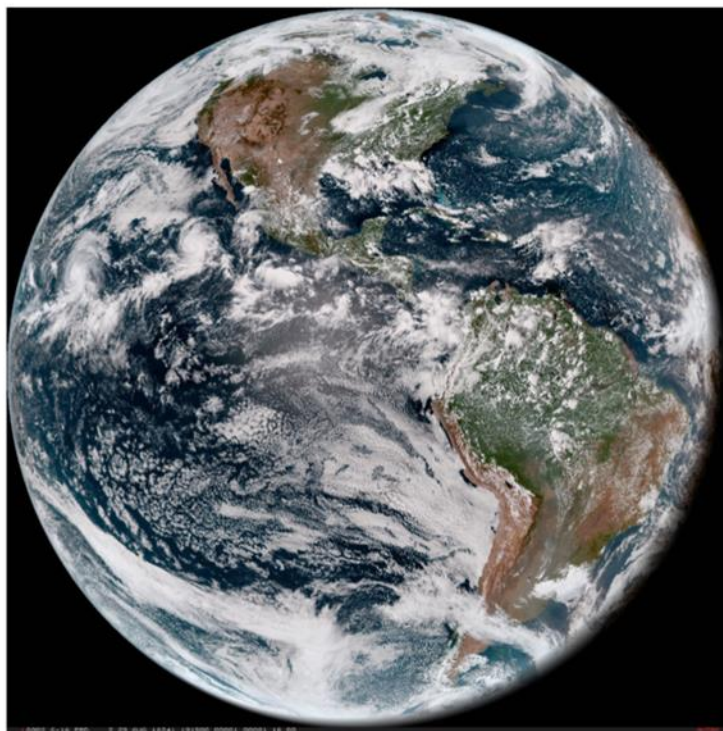


GOES-17 has nearly completed post-launch testing and preparations are underway for the Handover Readiness Review and transitioning

the satellite to operations as GOES West in December. The team of experts addressing the Advanced Baseline Imager (ABI) cooling system issue has made excellent progress. As a result of efforts to optimize its performance, the GOES-17 ABI is now projected to deliver >97% of the data it was designed to provide, a truly remarkable recovery. In parallel, the independent investigation team has isolated the likely root causes to help us understand the issue and how to avoid it. Redesign efforts are underway for the GOES-T and GOES-U ABI radiators based on their recommendations. I would like to commend the efforts of the many people involved in understanding and recovering from this issue. Our partners at the National Weather Service are amazed at the capability our scientists and engineers were able to recover from GOES-17 and I echo their praise for this great work.

GOES-17 HIGHLIGHTS

GOES-17 has nearly completed post-launch testing and is preparing for handover to NOAA. Data from all six instruments are now validated “beta” mature. The Magnetometer, Space Environment In-Situ Suite (SEISS), Solar Ultraviolet Imager (SUVI), and Advanced Baseline Imager (ABI) cloud and moisture imagery science products completed their beta Peer-Stakeholder Product Validation Reviews in August. Geostationary Lightning Mapper (GLM) data reached beta maturity in early October. Beta data is



GOES-17 full disk GeoColor imagery from the GOES-17 ABI on August 29, after the data started flowing through GRB. Credit: NOAA/NASA

Figure 12: CIRA’s GOES-17 ABI GeoColor full-disk imagery used on the title page of NESDIS’ GOESR Quarterly Newsletter Issue 23, which was posted on 11-October 2018.



Figure 13: NWS WFO Bay Area using GeoColor nighttime image to highlight the strong stratus along the Bay Area coast and inland on 21 July 2018.