NOAA ROSES Semi-Annual Report

Reporting Period: March 2021 – August 2021 (FY20 / Year 1 - 2nd half)

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Project Title: Advanced Concepts Enabling Situational and Hazards Awareness
                    via Imagery (ACES-HAI)

Executive Summary

Scientists at CIRA have pioneered the exploitation of the GOES-R series Advance Baseline Imager (ABI) for value-added imagery applications. From design of a 'missing' green band that enables true color imagery, to novel fire temperature products credited with saving lives, to fusion with the GOES Lightning Mapper (GLM) in ways that are now widely emulated, to advanced techniques in Dynamic Enhancement Background Reduction (*DEBRA*) for lofted dust, and the multi-dimensional blending technique that enables *GeoColor* imagery, CIRA's award-winning imagery that is used in circles of research, operational forecasting, and the news media. The objective of this project is to look for the vast array of additional and unexploited capabilities in the realm of imagery/product fusion. This project focuses on the development of novel and innovative approaches that tap into this potential, via a paradigm shift to the *GeoColor* application that pursues the following key, central objectives:

1) Signal encoding of lofted dust and a new short/mid-wave infrared ABI fire product
2) Propagating composite daytime snow cover information into the night
3) Integrating Proxy Vis to enable an advanced low-cloud description at night
4) Incorporating satellite-derived Level-2 products for imagery/product synergy
5) Enabling a 0.5 km, 1-min "mesobox-anywhere, on-demand" via spatial and temporal sharpening
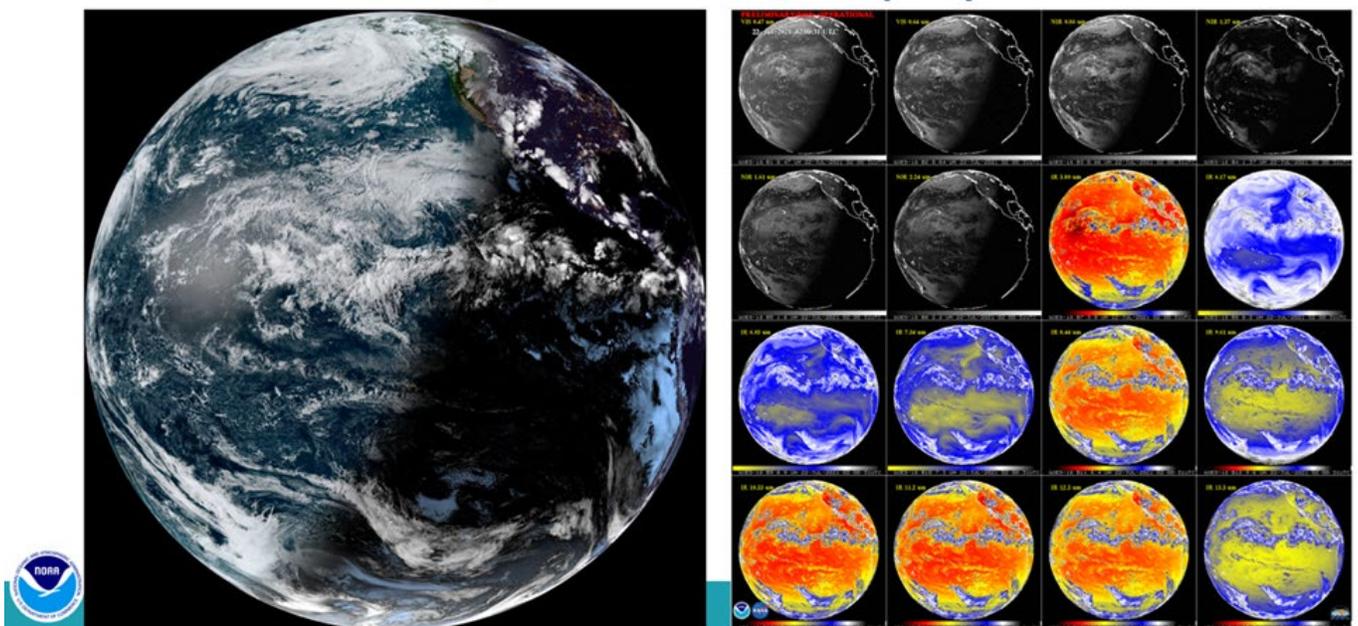
Special Achievements:

➢ On 17 May 2021, Pam Sullivan announced that **CIRA's GOES-R Imagery Specialist Dakota Smith won the "GOES-R Communications Award for the 2nd quarter of FY21"**
Pam Sullivan added the announcement to the slides she was presenting on May 17th.

Special Achievement Figure 1*: Slide presented by Pam Sullivan as part of a GOES-R presentation announcing that Dakota Smith won the "Outstanding Communications Award" for the 2nd Quarter FY21.*

➢ **8 July 2021: GeoColor created On-the-Fly in AWIPS:** B. Line and D. Molenar worked with the TOWR-S team to install a new process for CIRA GeoColor creation and display in CIRA AWIPS. The new method reduces internet bandwidth, creates the full resolution GeoColor product, and allows for viewing of GeoColor in all GOES sectors. The process is being tested at CIRA, and feedback provided back to the TOWR-S team. This new AWIPS GeoColor method will soon be applied to NWS AWIPS.

➢ **21 July 2021:** NASA's Earth Observing System Data and Information System (EOSDIS) announced "**the addition of Geostationary Operational Environmental Satellites (GOES) GeoColor imagery into Worldview**."

➢ **Early August 2021: Preparation of "first light" imagery from GOES-T:**
In early August, the Product Readiness and Operations Team and others produced a dataset of GOES-18 ABI radiances using observed GOES-17 radiances as input. The "GOES-18" ABI radiances were part of the Data Operations Exercise (DOE)-2. The radiances that were processed as GOES-18 were then successfully displayed by the AWG Imagery Team in a number of software systems for a given day and time. This effort was made to better prepare for GOES-T/18 first light imagery. The *GeoColor* image provided by the CIRA team included in the Figure below was produced using Rayleigh correction look-up-tables (LUTs) adapted for GOES-18 using pre-launch spectral response functions that were previously acquired by the AWG Imagery Team. Images of the individual ABI bands were provided by CIMSS members of the AWG Imagery Team.

Special Achievement Figure 2: A GOES-17 Full Disk image, processed as GOES-18, of GeoColor (by CIRA) and a multi-panel image of all ABI spectral bands (by UW/CIMSS).

➢ **July/August/September 2021**: First GeoProxy (integrating Proxy Visible imagery into GeoColor at nighttime) was produced for a case study of an Atlantic storm system which developed during 21-23 March 2021 (see Milestone 3 below).

➢ **Incorporating satellite-derived Level-2 products for imagery/product synergy:** Two specific new blending techniques were explored during this reporting period which utilize Dense Optical Flow (DOF) Level-2 processing.

➢ ***Washington Post***, 22 April 2021: *The Washington Post's Capital Weather Gang* published an article titled: "Biden taps ocean scientist Rick Spinrad to run NOAA". The article came with a large GOES-17 GeoColor image.
https://www.washingtonpost.com/weather/2021/04/22/biden-noaa-administrator-rick-spinrad/

Progress toward FY20 Milestones and Relevant Findings

Significant Milestone Accomplishments during this reporting period are listed below:

1) **Cloud-free background for use in the fire detection algorithm**

   Work started on the "DEBRA-like approach" to identify hot spots vs. the background. **Figure 1** shows the first attempt at creating a cloud-free background for use in the fire detection algorithm. This "cloud-free" background was created assuming the warmest longwave IR pixel over a two-week period is cloud-free. The fact that hot spots from fires are already present in this background image indicates that more work is necessary to create a proper cloud-free background that does not contain fires. The goal is to add a fire layer into GeoColor, and to improve fire detection using the cloud-cleared backgrounds.

   Figure 1*: Initial attempt at developing a cloud-free background indicates that hot spots from fires are not properly excluded yet. This would inhibit fire detection in locations where hot spots are already present in the background. More work is needed to create an improved cloud- and fire-free background.*

2) **Carrying daytime-observed snow fields into the night-side imagery as a layer of information in *GeoColor***

   We started during the previous half-year to develop a pseudo code for carrying daytime-observed snow field into the night-side imagery as a layer of information in *GeoColor*. The goal is to aggregate snow-layers from daytime NDDI information over an allowable range of solar zenith angles. The next step is to insert the snow layer on the nighttime-side imagery between the surface and city lights layer (and below the low- and high- cloud layers) in the multi-dimensional blend. We will also explore the usage of the CLAVR-x cloud mask as part of the filtering for the snow mask.

The proposed approach for the snow layer is as follows:

- An array of same dimension as the ABI CONUS grid is initialized to floating point zero values. This array will accumulate detection "energy" for the mask → MASK_ACCUM
- Another array of same dimension is initialized to zero, to be used as a spatially-resolved counter → MASK_COUNT
- The binary cloud/snow enhancement (which demarcates snow as white and cloud as yellow) is run if the at-pixel solar zenith angle is below a critical threshold.
- Use the normalized-difference snow index (NDSI), normalized to NDSI_norm, as the energy term, summed up over the course of the mask compilation period.
- This NDSI is suppressed by an ABI 1.38 µm high cloud (e.g., cirrus or optically thick cloud), to reduce contributions to the energy term from large particle ice clouds.
- The number of times a pixel is incremented with NDSI_norm values, a counter is incremented.
- Upon completion of the mask window, MASK = MASK_ACCUM / MASK_COUNT (i.e., an average) for MASK_COUNT > threshold.

Initial development will be done within the existing cloud/snow RGB product, and upon successful demonstration this layer will be ported to GeoColor for nighttime blending. We will focus on implementing this during the second year of ACES-HAI.

3) Integrating Proxy Vis to enable an advanced low-cloud description at night

Significant progress was made with initial work on integrating Proxy Vis with *GeoColor* to enable an advanced low-cloud description at night. The GeoColor and the ProxyVis product are both available in real-time for GOES-16, GOES-17, Himawari, and MSG. They are being displayed in CIRA's SLIDER (https://rammb-slider.cira.colostate.edu/), AWIPS2, and NAWIPS. We have successfully developed a first algorithm for a combined ProxyVis and GeoColor product, called "*GeoProxy*". The goal is to use ProxyVisible as a nighttime layer to CIRA GeoColor, forming a blended *GeoProxy* application.

Step 1 of this integration was the reading and converting the proxy-visible layer into the *GeoColor* processing code. Step 2 focused on the necessary scaling to optimize its display as an intermediate layer above the city lights and below the high-cloud layer. Step 3 handled the transition zones from nighttime to daytime and from daytime to nighttime. These are critical transition zones for the GeoProxy imagery development as ProxyVis will only be integrated during the nighttime.
See **Figures 3-1, 3-2, and 3-3** below.

Short description of the GeoColor/ProxyVis synthesis: *GeoProxy*
- CIRA GeoColor Imagery combines daytime visible color image (estimates green from Vis, SW/IR channels), 11-3.9 µm IR channel brightness temp difference (BTD) at night, static city lights image background
- The simple 11-3.9 µm IR is limited in its depiction of low cloud field, it can miss features
- Use ProxyVisible as a nighttime layer to CIRA GeoColor, forming a blended "*GeoProxy*" application
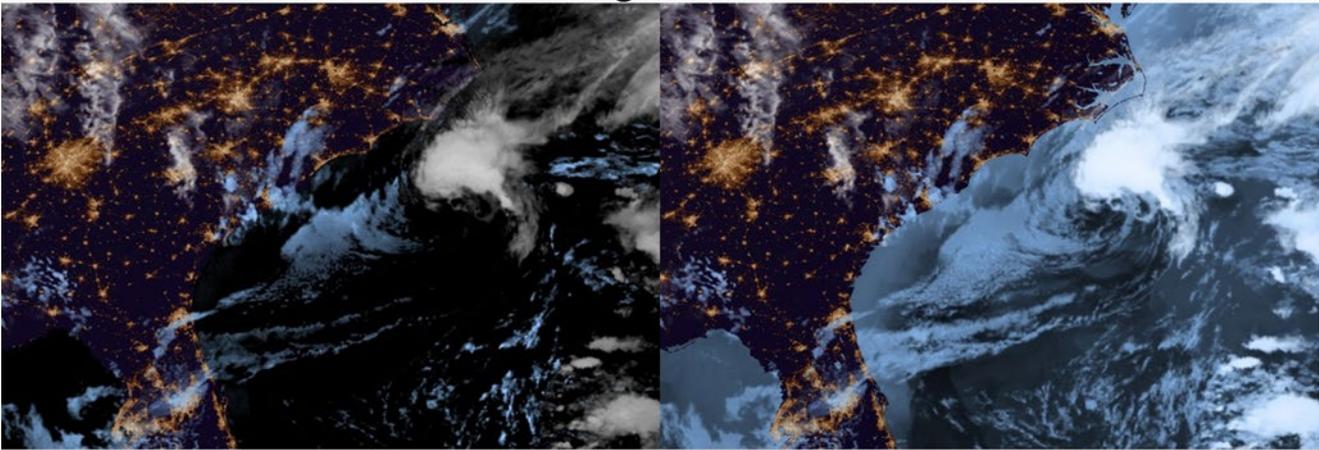- Our first GeoProxy imagery test case is depicting an Atlantic storm system which developed during 21-23 March 2021

Figure 3-1: Nigh-time satellite imagery (22 March 2021 at 2330 UTC) with GeoColor to the left and GeoProxy on the right

Figure 3-2: Night-to-Day transition (23 March 2021 at 1200 UTC) with GeoColor to the left and GeoProxy on the right. The ProxyVisible layer is not optimized for over-land, and thus is applied only over water surfaces, as determined by a land/water mask.

Figure 3-3: Daytime imagery (23 March 2021 at 1300 UTC) with GeoColor to the left and GeoProxy on the right. The two forms of imagery are identical during the day by design.

Current Status:
1. The ProxyVisible layer is included only over *water bodies* (not optimized for over-land)
2. Overall, the addition of ProxyVisible improves the depiction of the low cloud field
   a. The current version of proxy visible is too bright if we are interpreting the values as an equivalent visible light reflectance…with cloud free ocean producing values in the 0.20 to 0.30 range.
   b. Used scaling to adjust
3. The ProxyVisible layer becomes "bright" near the limb
   a. Likely the result its use of the thermal bands and the effects of limb darkening
   b. Might need to apply correction depending on satellite zenith angle
4. Might need to adjust the IR (top) layer at night
   a. There are cases ProxyVisible bleeds-through, since the IR layer is too transparent
   b. This should be an easy change.
5. There are some places where the original 10.35 – 3.9 BTD provides better structural information in the low cloud field than ProxyVisible.
   a. Might try a version of *GeoProxy* with the 10.35-3.9 BTD laid atop the ProxyVisible layer, to recapture some of those structures

Initial Results:
- The addition of ProxyVisible to GeoColor (for a GeoProxy product) improves the depiction of the low cloud field at night.
- This new product will potentially improve the night-time forecasting of storms over the ocean.

4) Incorporating satellite-derived Level-2 products for imagery/product synergy – using Dense Optical Flow

Two specific new blending techniques were explored during this reporting period which utilize Dense Optical Flow (DOF) Level-2 processing. The first is the so-called "Speed Sandwich," where the DOF wind speeds derived from visible imagery sequences are combined with the texture from the red-band (0.64 µm) channel (**Fig. 4.1**). Unlike traditional DOF RGBs, which convey speed and direction of the flow by changing saturation and hue respectively, the Speed Sandwich conveys only speed through the hue, and the visible reflectance through the value (or brightness), thus the direction can then be inferred visually through the motion of the brightness features. A couple notable advantages with this RGB are 1) A forecaster can readily identify cloud-types and features in this RGB as the output very closely resembles typical visible imagery which they are accustomed to and 2) Feature speed is simple to identify where it may be more ambiguous with a speed/direction combination RGB. The Speed Sandwich highlights different cloud layers in sheared scenes, and developing convection changes to hotter colors if it resides in strong speed shear as it grows (e.g. **Figs. 4.1. c, d**), offering unique context over traditional convection initiation (CI) RGBs (e.g. the Day-Cloud Phase Distinction RGB).

The Second DOF-RGB explored is the "CTC Sandwich," a similar blend of visible imagery and derived 10.3 µm brightness temperature cooling over 5-min. DOF enables the tracking of features in visible and, by extension, the retrieval of temporal properties over moving features like cloud-top cooling (CTC). Again, this RGB allows the user to intuitively identify cloud-features which the help of the red-band brightness and assess how strong pre-convective updrafts are by identifying cumulus with larger cooling magnitudes (**Fig. 4.2**). Using information from both the Speed Sandwich and CTC RGBs in combination allows a forecaster to identify the stronger convection within this example scene over South Dakota which developed in an environment with more instability and wind shear. Efforts are underway to produce these RGBs in real-time on SLIDER and explore techniques to use and blend GeoColor to enhance product quality. The Speed and CTC Sandwich products use DOF tools that were highlighted in a recent publication for exploring cloud-top rotation signatures over deep convection (Apke and Mecikalski 2021). These products were also demonstrated at the EUMETSAT Satellite Users 2021 conference and locally at the CSU-CIRA Jamboree.
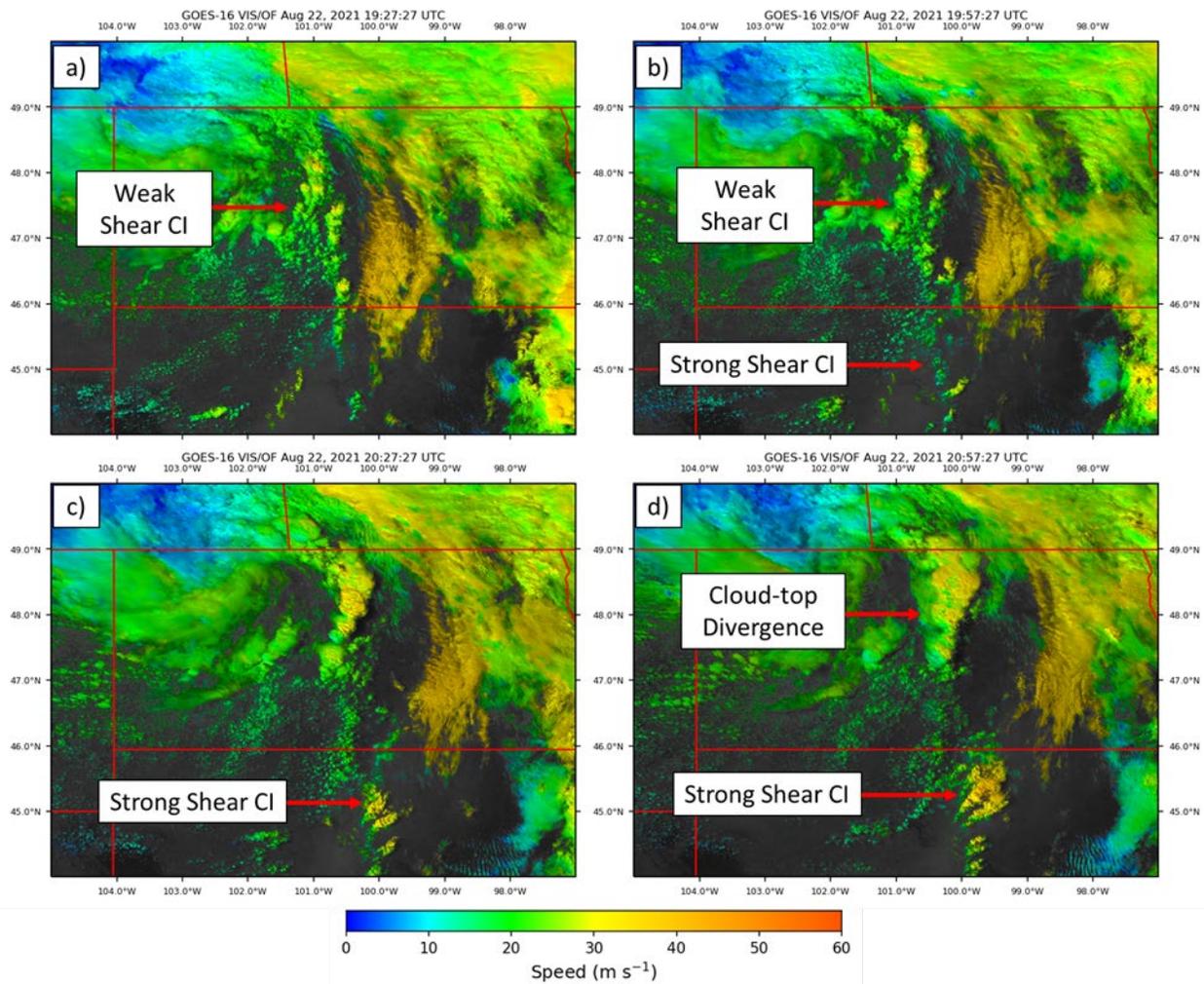
Figure 4.1. *Example Speed-Sandwich RGB over North Dakota on 22 Aug 2021 at a) 1927 UTC, b) 1957 UTC, c) 2027 UTC and d) 2057 UTC, where speed derived from DOF (color shading) is combined with the texture from the 0.64 µm imagery reflectance factor (brightness). Highlighted are developing severe thunderstorms over South Dakota which produced significantly severe hail compared with weaker storms over central North Dakota.*
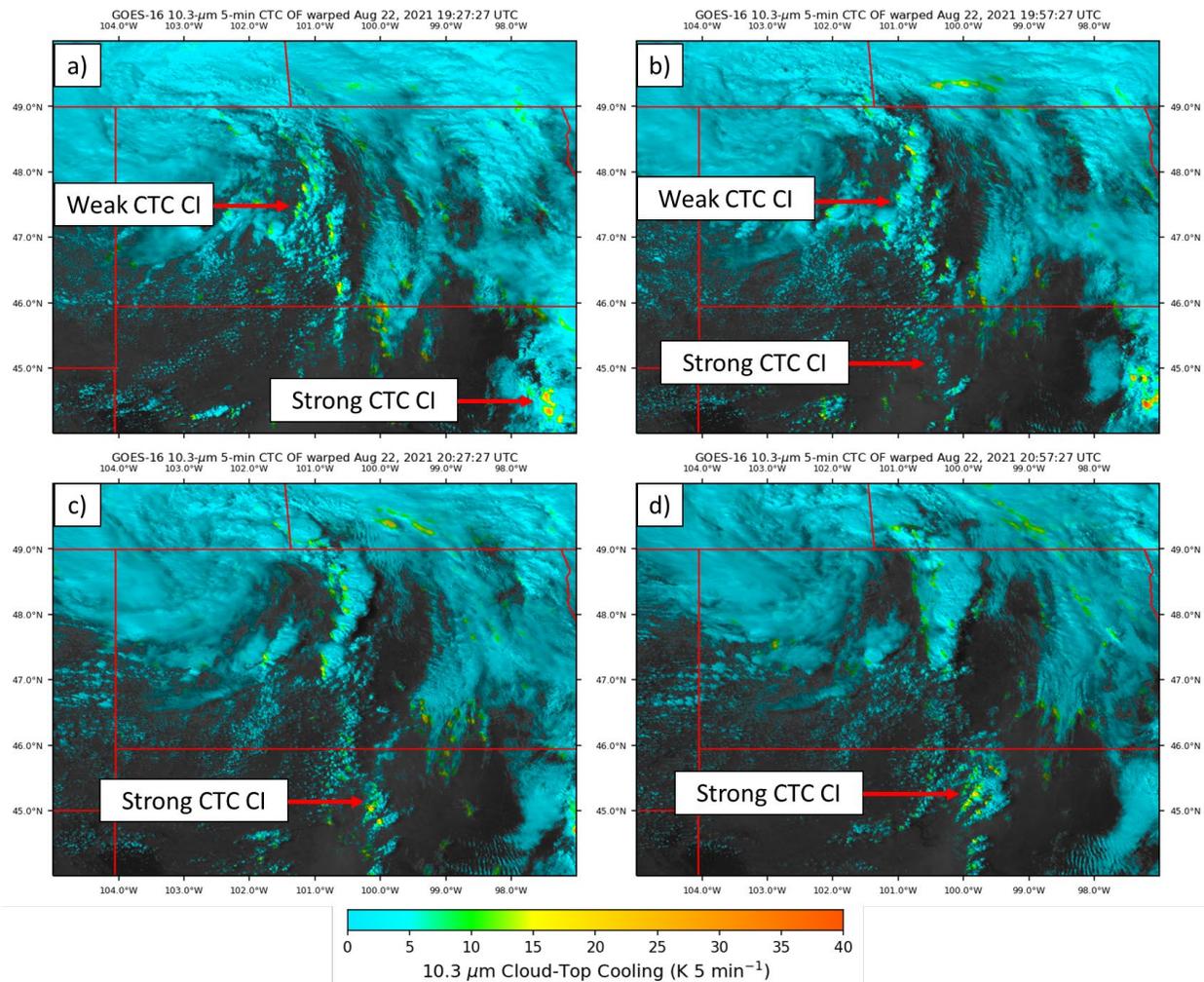
Figure 4.2. *Same as* **Fig. 4.1**, *now shown with cloud-top cooling shading. Highlighted are developing severe thunderstorms over South Dakota which produced significantly severe hail compared with weaker storms over central North Dakota.*

5) Enabling a 0.5 km, 1-min "mesobox-anywhere, on-demand" via spatial and temporal sharpening

During the first half of this project year, a full-bit depth DOF interpolation algorithm was developed and explored for both creating temporally sharpened imagery and validation of DOF motions through comparisons to real imagery. This period, the interpolation algorithm was expanded to full RGBs, including imagery sharpening to get 0.5 km resolution, and tested at typical CONUS 5-min resolution.

A demonstration on the Day-Cloud Phase Distinction RGB (**Figs. 5.1 b, d**) highlights how accurate this interpolation algorithm is, as differences from the real imagery (**Figs. 5.1 a, c**) are difficult to spot. Closer inspection shows that the algorithm struggles in non-linear development between frames (i.e. bubbling deep convection or cloud condensation), highlighted by the red circles in **Fig. 5.1**. Typically, we find that these non-linear motions are either blurred across frames or unnaturally warped in the cases of condensation and evaporation when the motion is not handled properly. As the 5-min interpolation frames are computed using the 1-min meso-sectors, the real data continue to be used here to identify tuning parameters and best practices for producing the most accurate sharpening results which can then be applied to actual CONUS imagery.
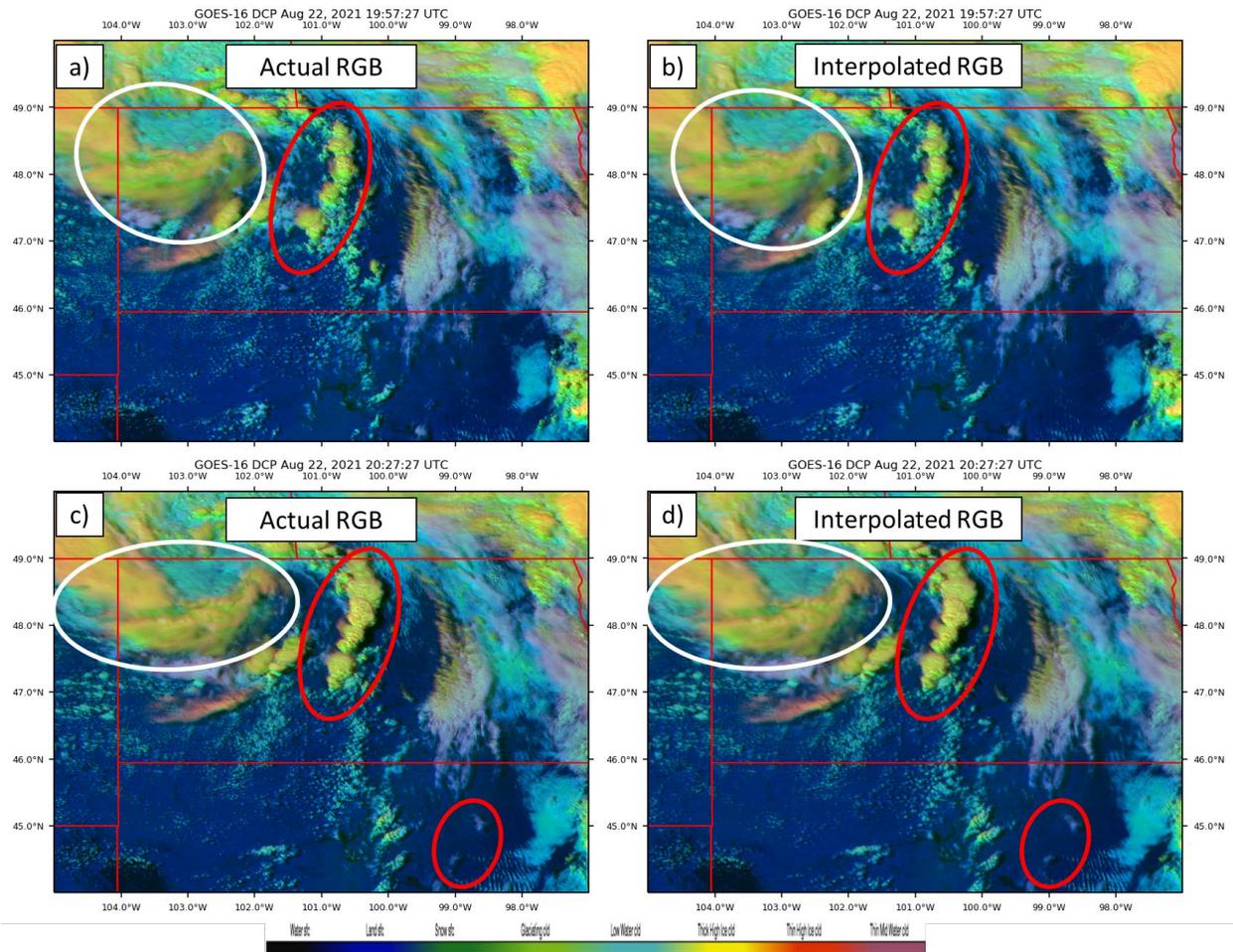
Figure 5.1. *Example Day Cloud Phase RGB over North Dakota on 22 Aug 2021 at a) 1927 UTC and c) 2027 UTC, shown with DOF 5-min imagery interpolated to the same times in b) and d). Highlighted in the red circles are where the interpolation had decreased accuracy (within bubbling convection and rapidly condensing/evaporating cloud scenes), and highlighted in the white circles are where the interpolation performs well.*
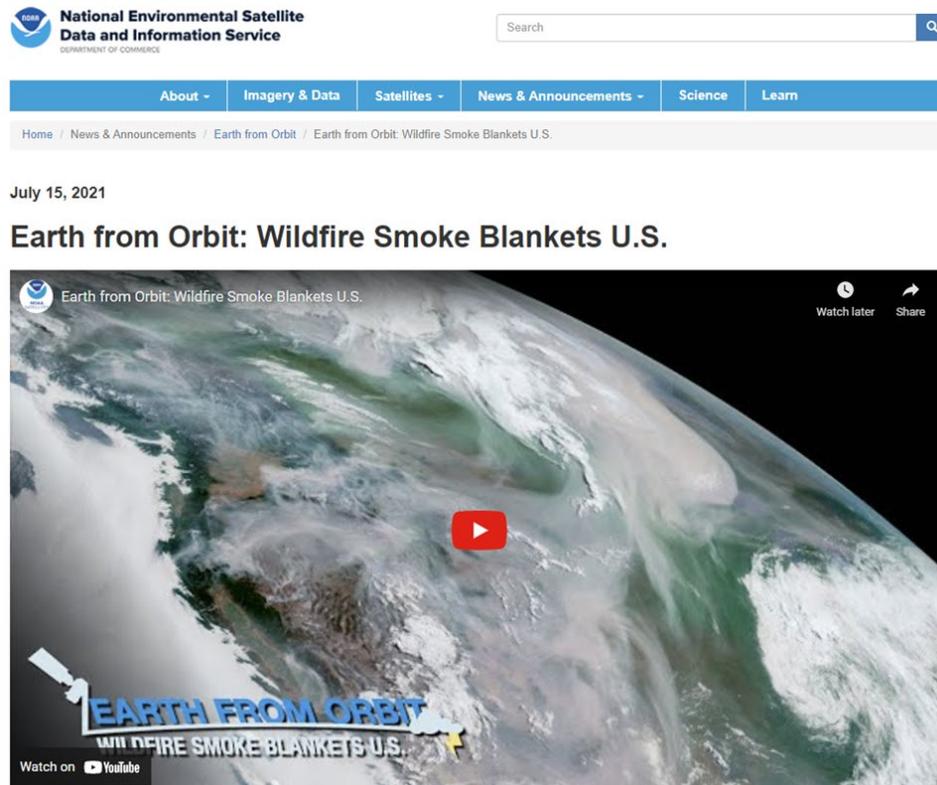
Additional Noteworthy Achievements

5-9 April 2021: New Meteosat products (Natural Color-Fire and DEBRA) are now live on SLIDER.

ACES-HAI Product Dissemination:

- **GeoColor implementation at NESDIS**
  - GOES-16 and GOES-17 ABI GeoColor products are running in real-time at NESDIS
  - GOES-16 and GOES-17 ABI GeoColor imagery is available on the NESDIS GOES-East and on the NESDIS GOES-West Viewer websites:
    https://www.star.nesdis.noaa.gov/GOES/conus.php?sat=G16
    and
    https://www.star.nesdis.noaa.gov/GOES/conus.php?sat=G17

- **NOAA-NASA Earth from Orbit Animations**

  o 15 April 2021**: Earth from Orbit: Eruption of La Soufrière on St. Vincent**
    https://www.nesdis.noaa.gov/la-soufriere-erupts

  o 15 July 2021: **Earth from Orbit: Wildfire Smoke Blankets U.S.**
    https://www.nesdis.noaa.gov/content/earth-orbit-wildfire-smoke-blankets-us

  o 19 August 2021: **Earth from Orbit: Hurricane Season Heats Up.**
    GeoColor and visible (band 2) imagery were used to show several tropical storms and
    hurricanes. https://www.nesdis.noaa.gov/news/earth-orbit-hurricane-season-heats

- **NASA's Earth Observing System Data and Information System (EOSDIS) adds GeoColor
  Imagery**
    On 21 July 2021, NASA's Earth Observing System Data and Information System (EOSDIS)
    announced "the addition of Geostationary Operational Environmental Satellites (GOES)
    GeoColor imagery into Worldview." In a superb example of Decadal Survey recommendations
    for increased interagency collaboration, NOAA and NASA have coordinated to enable the
    display of NOAA produced GeoColor on NASA's Worldview website, complementing their
    demonstration of near real time NASA sensor data. The announcement was posted on NASA's
    EARTHDATA homepage https://earthdata.nasa.gov/ and came with a detailed description of
    the GeoColor product and the history of its development led by CIRA's Dr. Steve Miller. The
    full article can be found here: https://earthdata.nasa.gov/learn/articles/goes-geocolor-
    worldview

- **GOES-16 and GOES-17 ABI GeoColor products are running at NWS WFOs** (through the
  AWIPS LDM) and are also being used by the **National Centers (OPC, WPC, SPC, AWC, NHC).**

- ACES-HAI baseline products, especially **GeoColor** imagery, are regularly being used by the **GOES-R Program Office**

Additional Methods of Dissemination:

- **Training Sessions**
- Presentation at **scientific conferences** and **workshops (as listed below)**
- Posting on **twitter accounts** (especially on @CIRA_CSU, @NOAASatellites, @NWS)
- **Satellite blogs** using SLIDER imagery (https://satelliteliaisonblog.com/)
- **NOAA and CIRA Facebook pages** using SLIDER imagery (https://www.facebook.com/CIRACSU, https://www.facebook.com/NOAASatellites/)
- Use of **SLIDER imagery / imagery loops** by **NOAA Management** (https://rammb-slider.cira.colostate.edu/)
- **Publications (as listed below)**

CIRA/RAMMB Satellite Blogs:

https://satelliteliaisonblog.com/
https://rammb2.cira.colostate.edu/research/goes-r/proving_ground/blog/

Relevant Publications:

Apke, J. M., and J. R. Mecikalski, 2021: On the Origin of Rotation Derived from Super Rapid Scan Satellite Imagery at the Cloud-Tops of Severe Deep Convection. *Mon. Weather Rev.*, **149**, 1827–1851, https://doi.org/10.1175/mwr-d-20-0209.1

Grasso, L. D., D. Bikos, J. Torres, J. F. Dostalek, T.-C. Wu, J. Forsythe, H. Q. Cronk, C. J. Seaman, S. D. Miller, E. Berndt, H. G. Weinman, and K. B. Kasper, 2021: Satellite Imagery and Products of the 16-17 February 2020 Saharan Air Layer Dust Event over the Eastern Atlantic: Impacts of Water Vapor on Dust Detection and Morphology. *Atmos. Meas. Tech.*, **14**, 1615–1634, 2021 https://doi.org/10.5194/amt-14-1615-2021

Miller, S. D., D. T. Lindsey, C. J. Seaman, and J. E. Solbrig, 2020: *GeoColor*: A Blending Technique for Satellite Imagery. *J. Atmos. Ocean. Tech.*, **37**(3), 429-448, https://doi.org/10.1175/JTECH-D-19-0134.1

Presentations:

Apke, J. M., S. Miller and M. Rogers, 2021: Dense Optical Flow Research at CIRA. *CIRA Jamboree 2021,* Fort Collins, CO. 9 Sep 2021.

Apke, J. M., S. Miller, B. Line, J. Forsythe, and K. Bedka, 2021: Demonstrations in Satellite Product-Infused Dense Optical Flow Winds and Motions for Earth and Atmospheric Sciences. *EUMETSAT 2021 Conference,* Virtual. 27 Aug 2021.

Seaman, C. J., 2021: CIRA's SLIDER: A website for displaying realtime, global satellite data at full resolution. 2021 AMS GOES-R/JPSS Short Course. Virtual. 17-18 March 2021

Social Media:

Products developed under this ACES-HAI project are regularly being used by social media, twitter accounts, and by national and international news organizations.

Some noteworthy examples are listed below:

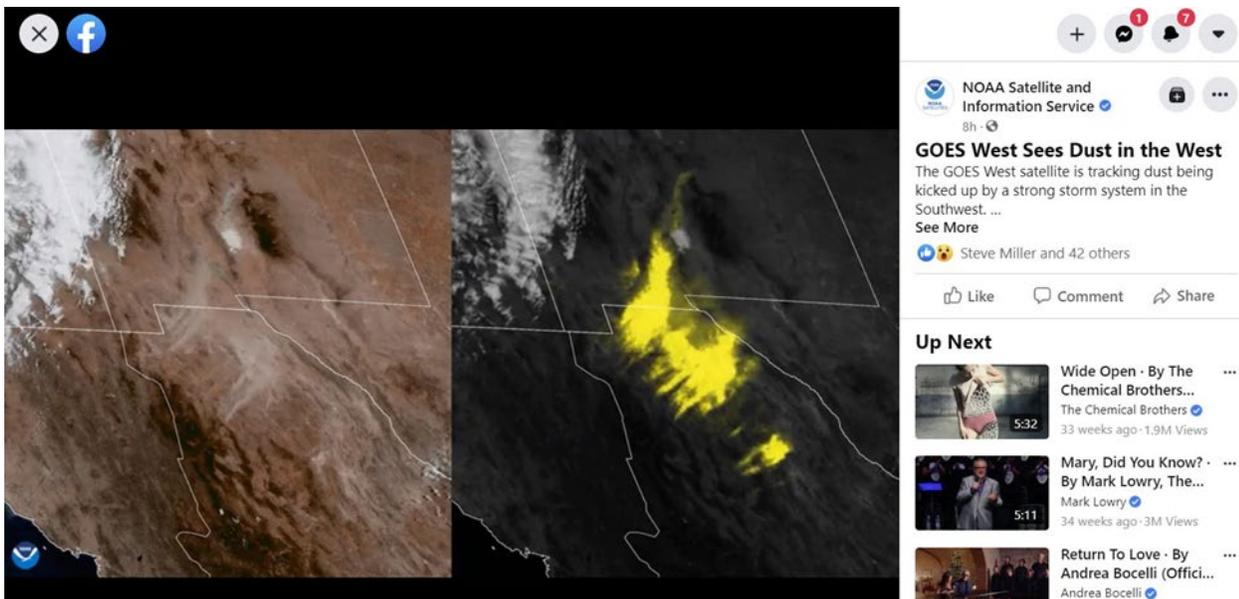NWS Seattle tweets with GeoColor imagery loops:
https://twitter.com/NWSSeattle/status/1383879461016199169
https://twitter.com/NWSSeattle/status/1380636819767709698
https://twitter.com/NWSSeattle/status/1380552006561976324
https://twitter.com/NWSNewYorkNY/status/1422570610677338117

16 March 2021
NOAA Satellites facebook and **twitter pages** captured GOES-17 GeoColor and DEBRA showing a dust event with the dust sweeping into New Mexico and West Texas. GOES-17 GeoColor product (left) and the DEBRA Dust product (right).
https://twitter.com/NOAASatellites/status/1371911804977303553
https://www.facebook.com/NOAASatellites/videos/998960164355477

20 March 2021
@NWS tweeted FullDisk GOES16 GeoColor imagery loop to highlight Equinox/beginning of spring!
https://twitter.com/NWS/status/1373275281897701379

Noteworthy newspaper publication with GeoColor imagery:

9 April 2021:
A *Washington Post Capital Weather Gang* article written by Jason Samenow on 9 April 2021 titled "Biden administration proposes record $6.9 billion budget for NOAA" depicted a GeoColor image of Hurricane Delta (October 2020).

Capital Weather Gang

Biden administration proposes record $6.9 billion budget for NOAA

It's a 50 percent increase above the budget proposed by the Trump administration

NOAA satellite image of Hurricane Delta in October. (NOAA)

By **Jason Samenow**
April 9, 2021 at 12:16 p.m. MDT

12 April 2021:
GeoColor and GLM in the news: An *NPR* article on a recent meteor sighting in Florida (12 April 2021) included GeoColor imagery provided by the NWS Tampa Bay office. This image, with GLM overlay, showed the location of GLM's detection of the meteor off the east coast of Florida. Numerous reports of the meteor sighting were shared on social media, and several examples were included in the article.
URL:
https://www.npr.org/2021/04/13/986664216/what-is-that-in-the-sky-floridians-catch-meteors-close-brush-with-earth

'What Is That In The Sky?' Floridians Catch Meteor's Close Brush With Earth

April 13, 2021 · 3:55 AM ET

JACLYN DIAZ

The National Weather Service Tampa Bay said its Geostationary Lightning Mapper captured the bright meteor that shocked Floridians late Monday as it burned up off the coast.

12 April 2021:
The Weather Channel: Satellite Images Show the Explosive Eruptions at St. Vincent's La Soufrière Volcano; https://weather.com/news/news/2021-04-12-la-soufriere-volcano-satellite-imagery

14 April 2021:
The Washington Post: Satellite images show St. Vincent blanketed with volcanic ash as eruptions continue; https://www.washingtonpost.com/world/2021/04/14/st-vincent-volcano-eruption-images/
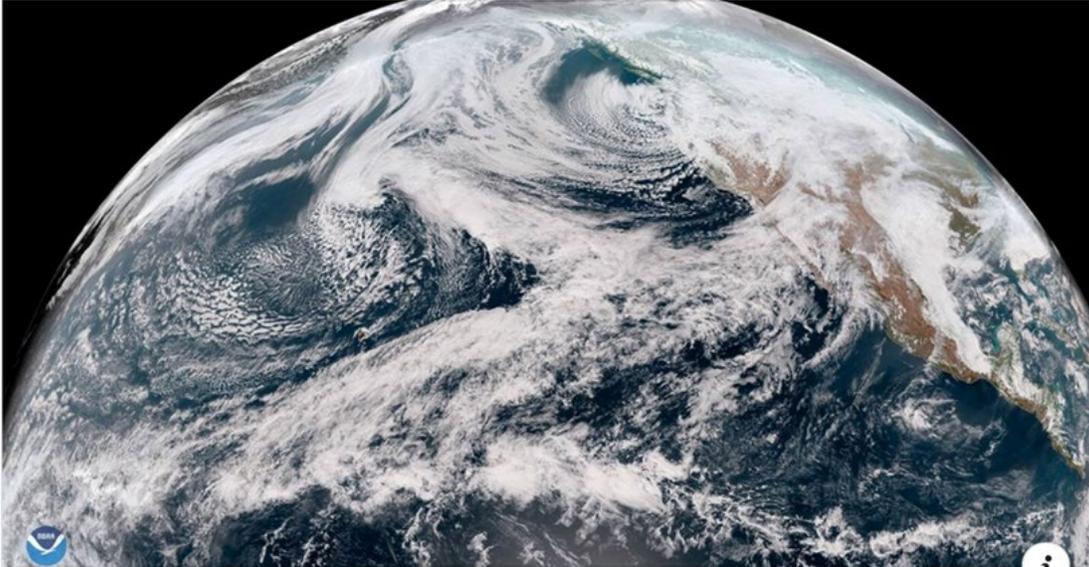
22 April 2021:
Washington Post, 22 April 2021: *The Washington Post's Capital Weather Gang* published an article titled: "Biden taps ocean scientist Rick Spinrad to run NOAA". The article came with a large GOES-17 GeoColor image.
https://www.washingtonpost.com/weather/2021/04/22/biden-noaa-administrator-rick-spinrad/

Capital Weather Gang ✔
3h · 🌐

JUST IN: Rick Spinrad, an experienced ocean scientist who previously served as the agency's chief scientist and ran its research arm and ocean service, chosen to lead NOAA. He continues the long-standing tradition of scientists selected to run the agency: https://wapo.st/3vqavQv

WASHINGTONPOST.COM
Biden taps ocean scientist Rick Spinrad to run NOAA
He's an oceanographer with decades of science and policy experience and previously serv...

1 – 15 July 2021:
News media posting Western U.S. wildfire imagery of GeoColor and Fire Temp

Wildfires out west: Over the last two weeks, large wildfires have burned across the western U.S. and parts of Canada. In particular, the Bootleg Fire has grown to over 200,000 acres with multiple episodes of pyrocumulus plumes and extreme wildfire behavior. Numerous news organizations used GeoColor and Fire Temperature imagery online and on-air. Details and URLs for these articles are included below.

NBC: Nightly News with Lestor Holt; 07/14/21, https://www.youtube.com/watch?v=DIRHPm7BTiU&t=307s

CBS: Evening News with Norah O'Donnell; 07/13/21, https://www.youtube.com/watch?v=kxMHf-4lQa0&t=141s

CBS News: Oregon wildfire becomes biggest in the nation, burning over 200,000 acres; 07/14/21, https://www.cbsnews.com/news/bootleg-fire-oregon-update/

The Hill: 16k firefighters now battling wildfires ripping through the West; 07/15/21, https://thehill.com/changing-america/resilience/natural-disasters/563164-16000-firefighters-now-battling-wildfires

New York Times: Heat Wave Updates: Temperatures Ease but Fires Grow Across the West; 07/12/21, https://www.nytimes.com/live/2021/07/12/us/us-heat-wave

Washington Post: Wildfire smoke is clogging skies in the Western U.S., Canada; 07/13/21, https://www.washingtonpost.com/weather/2021/07/13/wildfire-smoke-western-states-canada/

CNN: Here's what the massive Oregon wildfires look like from space; 07/14/21,

Yahoo News: Bootleg Fire's smoke captured on satellite video; 07/14/21, https://news.yahoo.com/bootleg-fires-smoke-captured-satellite-185108896.html

Axios: Heat wave roasts the West wildfires explode in size; 07/12/21, https://www.axios.com/heat-wave-continues-west-wildfires-grow-7285bff3-8637-414b-b5bd-03efa73625f0.html

Discover Magazine: The West's Worsening Infernos as Seen from Space; 07/14/21, https://www.discovermagazine.com/environment/the-wests-worsening-infernos-as-seen-from-space

The Guardian: American west stuck in cycle of 'heat, drought and fire', experts warn; 07/13/21, https://www.theguardian.com/us-news/2021/jul/12/wildfires-california-oregon-drought-heat-fire-cycle

19 July 2021:
New York Times homepage depicts a CIRA GeoColor-FireTemp loop (yes a loop!) of the huge Bootleg Fire in Oregon. The full article can be found here:
https://www.nytimes.com/2021/07/19/climate/bootleg-wildfire-weather.html?action=click&module=Spotlight&pgtype=Homepage

A satellite view of the Bootleg Fire burning in Oregon last week. NOAA, NASA Goddard Space Flight Center, CIRA

27-30 August 2021:
Media covering Hurricane Ida using CIRA GeoColor imagery.
Hurricane Ida made landfall on the Louisiana coastline, bringing powerful winds and devastating storm surge. The remnants of Ida moved inland bringing destructive flash floods and tornadoes across the Mid-Atlantic and Northeast. Numerous news organizations used **GeoColor** of Hurricane Ida, online and on-air. Details and URLs for these articles are included below.

The Guardian: Hurricane Ida's rampage through Louisiana - in pictures ; 08/30/21, https://www.theguardian.com/us-news/gallery/2021/aug/30/hurricane-ida-new-orleans-louisiana-damage

Fox News: As Hurricane Ida moves rapidly toward Gulf Coast, Nora could impact Southwest; 08/28/21, https://www.foxnews.com/us/hurricane-ida-moves-rapidly-toward-gulf-coast-nora-could-impact-southwest

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Plans for Next Reporting Period

Work on all project milestones will continue during the first half of project year 2.

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