Every Pixel of *GOES-17* Imagery at Your Fingertips

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Over the past several years, the United States has seen devastating wildfires across the West, mudslides in California, and one of the costliest hurricane seasons on record. In the face of such catastrophes, data from the new *GOES-16*—operational as GOES-East— and *GOES-17* satellites are essential to the National Weather Service's (NWS) mission of protecting life and property. However, because these datasets are so large, users are not able to access them in real time with conventional ways of viewing satellite imagery over the web. To address this problem, a new web application, Satellite Loop Interactive Data Explorer in Real-Time (SLIDER; http://rammb-slider.cira.colostate.edu/), was recently developed. SLIDER provides access to every pixel from the imagers aboard the *GOES-16*, *GOES-17*, and *Himawari-8* satellites in real time. This allows users such as forecasters at NWS offices, incident meteorologists (IMETs) supporting wildfire operations in the field, academic researchers, and even the general public to improve their situational awareness during extreme weather events.

The experimental version of SLIDER was unveiled for public use in June 2017 by the Cooperative Institute for Research in the Atmosphere (CIRA) in partnership with NOAA's Regional and Mesoscale Meteorology Branch, collocated at Colorado State University. SLIDER was created to make these extremely high-resolution satellite imagery loops useful and easily accessible online to a diverse set of users.

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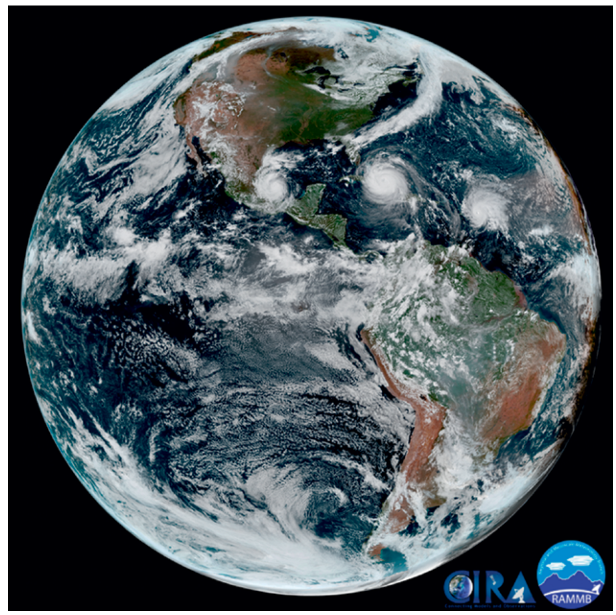

Fig. 1. SLIDER displaying CIRA's GeoColor product from *GOES-16* showing Hurricanes Katia, Irma, and Jose all in the Atlantic basin on 8 Sep 2017. While this view shows the imagery at 16-km resolution, users are able to easily zoom in and view any part of the imagery at full resolution, up to 0.5 km (http://col.st/AnrVg). Please note that this imagery from *GOES-16* was taken when its data were considered preliminary and nonoperational.

Much of the value of these datasets would be lost if they were hard for users to access or could only be viewed at coarser spatial or temporal resolutions. SLIDER gives users a fast, intuitive interface with which to view this imagery, even from the browsers on most smartphones.

SLIDER provides full-resolution imagery from all spectral bands, for all sectors, from *GOES-16*'s and *GOES-17*'s Advanced Baseline Imagers (ABI) and *Himawari-8*'s Advanced Himawari Imager (AHI). Compared to the previous generation of GOES satellites, the data volume coming from the ABI instruments has increased dramatically. In addition

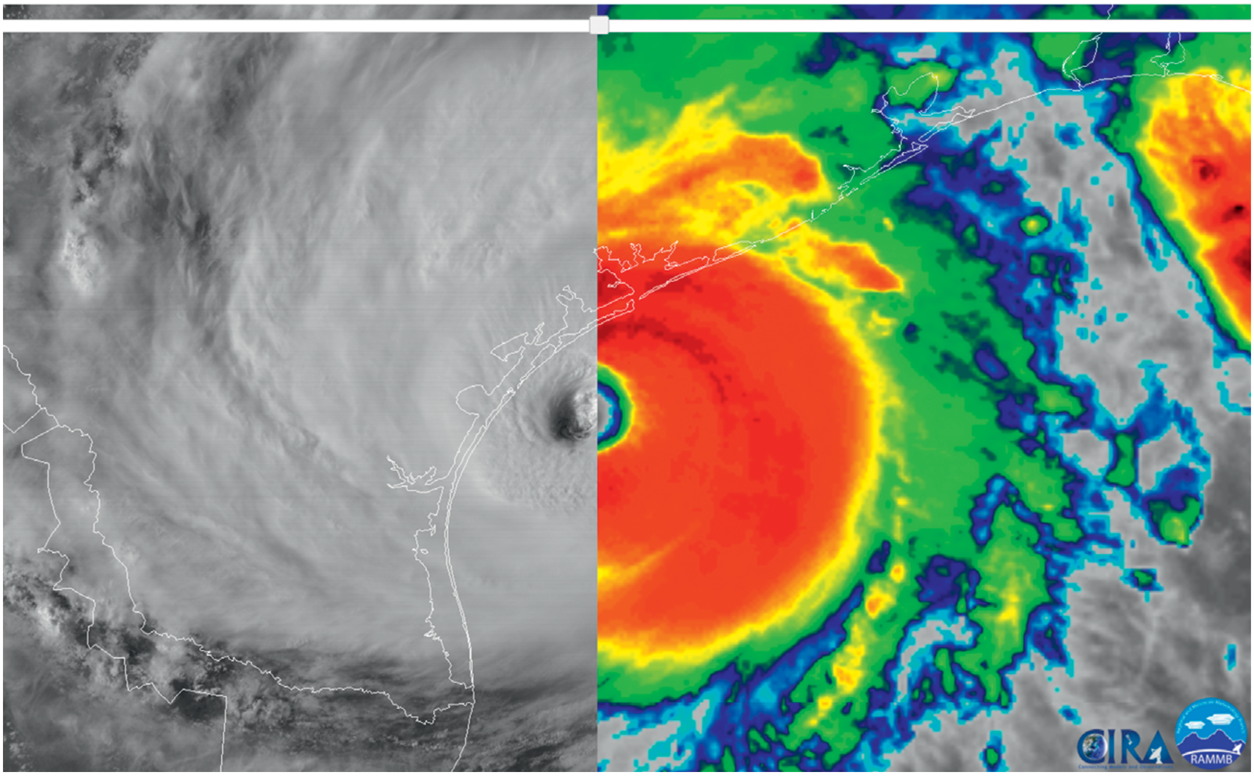

Fig. 2. SLIDER displaying *GOES-16* imagery of Hurricane Harvey making landfall on the Texas coast on 25 Aug 2017. Band 2 (0.64 μm) is displayed on the left at 0.5-km resolution, while band 13 (10.3 μm) is displayed on the right at 2-km resolution. The user is able to move the slider at the top of the imagery horizontally to see more or less of either product while the imagery loops (http://col.st/nki0t). Please note that this imagery from *GOES-16* was taken when its data were considered preliminary and nonoperational.

to three times the number of the spectral bands and four times the spatial resolution, the increased temporal resolution means that new imagery is available every 15 min for the full disk sector, every 5 min for the contiguous U.S. sector, and every minute for each of the two mesoscale domain sectors. SLIDER makes these spectral bands available alongside some of CIRA's value-added products created using the data from these satellites, such as GeoColor (see Fig. 1 and http://col.st/AnrVg) and Fire Temperature. This web application is able to provide this important service in a faster and more user-friendly way than other methods of accessing these datasets.

Other helpful web applications that are making this imagery available have each had to employ a strategy to handle the flood of imagery produced by these satellites. Some have chosen to make only lower-resolution imagery available for looping, such that full-resolution imagery can only be seen for single, static images. Others provide full-resolution loops, but only for certain bands or sectors. The web applications that do make all the imagery available tend to use web platforms like the Google Maps application programming interface, Google Earth, or Cesium to make this possible. These platforms create an "image pyramid" that chops the full-resolution imagery into many small "image tiles" at various resolutions. This allows a user to zoom in to see higher and higher resolution imagery without downloading the entire dataset. To display the imagery on a user's screen, these platforms have to make two round-trips to the server for each image tile: one to download a small text file that contains the URL for the image tile, followed by another to download the image tile itself. Depending on the length of the imagery loop and size of the user's screen, this can mean making these two round-trips for each tile hundreds of times to view a single loop. While SLIDER uses a similar image pyramid strategy for the imagery, what differentiates it from these other platforms is its ability to locally generate, in the user's browser, the URL for each image tile the user will need for any given view. By removing the need to download many small text files before it can start downloading the corresponding image tiles, it is able to provide a faster, smoother experience for the user.

In addition to its speed, the SLIDER interface has many helpful features such as the ability to zoom in on regions of interest, pan to see different parts of the imagery, and toggle map and latitude–longitude lines. Users also have options to change the time step and/or number of images to view, and the ability to view imagery from a multiweek archive.

Some of the advanced features include overlaying multiple image loops on top of one another, varying each loop's transparency, and showing or hiding each loop from view. True to its name, there is also a "slider" feature that allows users to directly compare loops side by side by moving a slider control back and forth horizontally (see Fig. 2 and http://col.st/nki0t). Extensive keyboard shortcuts make the use of a mouse optional, and all changes users make are immediately saved in the URL to facilitate sharing the exact same loop with colleagues and friends through e-mail and social media.

Since SLIDER publicly launched, CIRA has continued to get feedback that it is being used for a wide variety of purposes by users such as the science and operations officers working at NWS forecast offices, IMETs supporting wildfire operations, airline dispatchers, press outlets, and the general public. Archived examples of case studies that users have found particularly important include destructive fires in Northern California (http://col.st/s8WTS), the 2017 total solar eclipse (http://col.st/QcoF9), and Hurricane Irma making landfall on the Florida Keys (http://col.st/2fJMC).

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