

NASA's Land, Atmosphere Near Real-time Capability for EOS (LANCE): Delivering Data and Imagery to Meet the Needs of Near Real-Time Applications.

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LANCE's Roots: Rapid Response

Terra Launched in 1999

Following the large wildfires in Montana in 2000, the US Forest Service reached out to NASA and the University of Maryland to request near real-time data and imagery to support wildfire suppression and response.

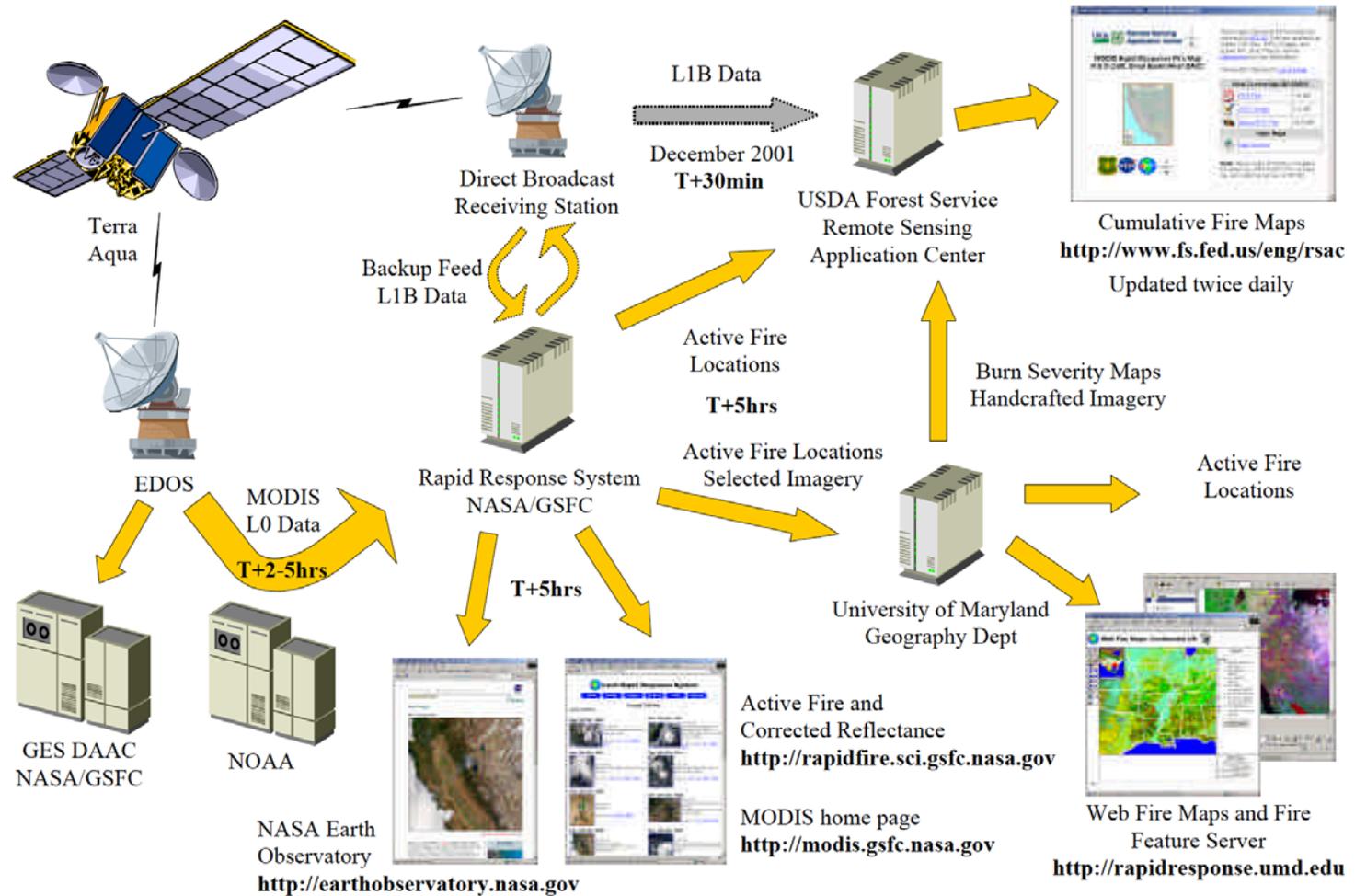
This led to the development of the Moderate Resolution Imaging Spectroradiometer (MODIS) Land Rapid Response System.



*Photo by John McColgan, Bureau of Land Management, Alaska Fire Service.
Source https://commons.wikimedia.org/wiki/File:Deerfire_high_res.jpg
Bitterroot River on the Sula Complex in the Bitterroot National
Forest in Montana, United States*

LANCE's Roots: Rapid Response (cont)

MODIS Rapid Response Project: Design



The MODIS Rapid Response Project – J. Desclotres – 07/24/02

Initial Focus:
North America
Wildfires

Later
expanded to
serve low
bandwidth
users imagery
from selected
areas of the
Globe

LANCE's Roots: Near Real-Time Processing Effort (NRTPE)

Prior 9/11/01, no capability existed to provide global observations from MODIS to operational facilities in near real-time. It was the sudden need for improved observational capabilities to support the responding forces in the Middle East that spurred the creation of the NRTPE using the NOAA "bent-pipe"

Example of Active Fire / Corrected Reflectance Product
Siberia (05/22/01)



Example of 250m Corrected Reflectance Product
Hurricane Erin (09/11/01)

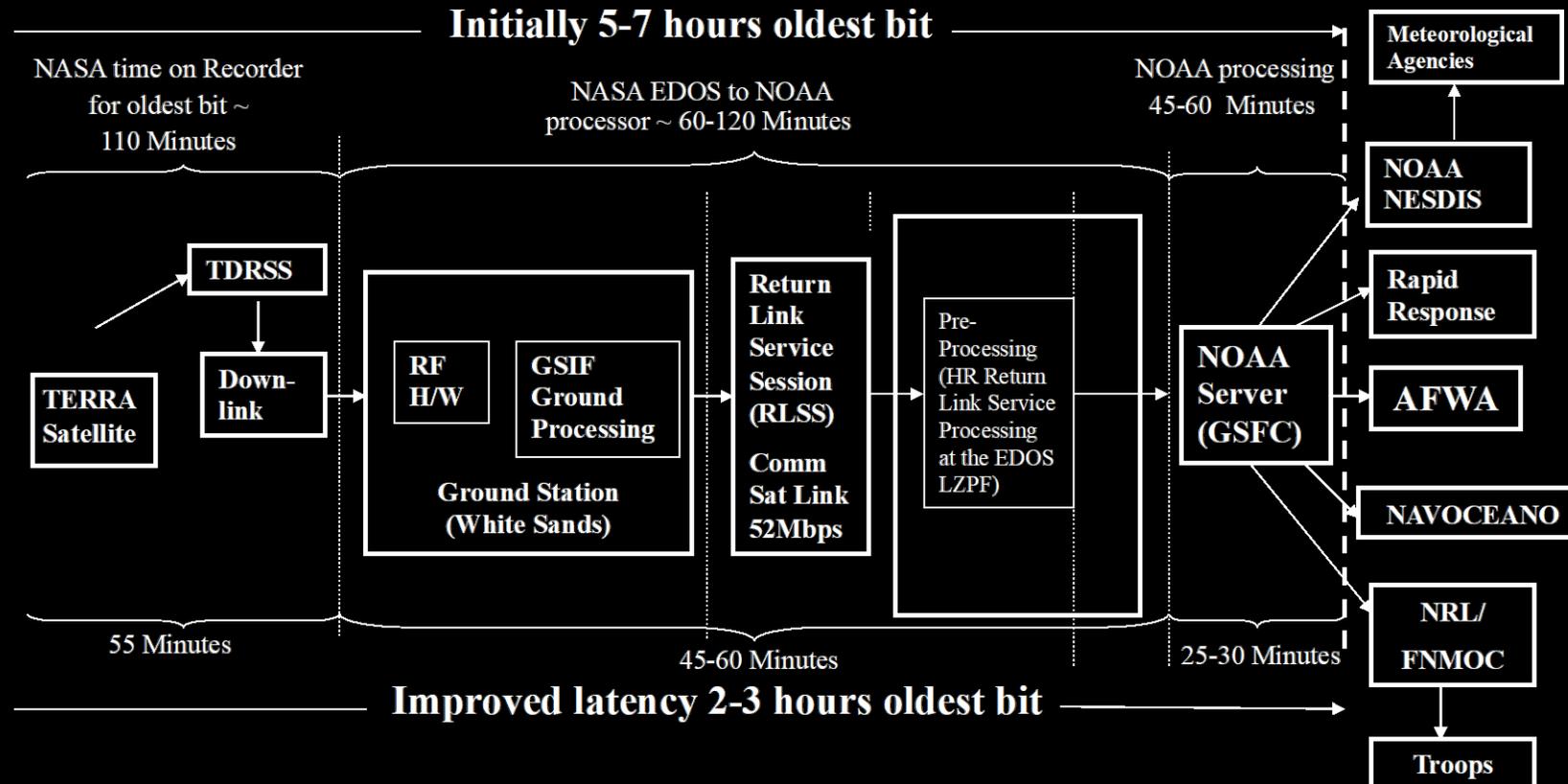


Example of Corrected Reflectance Product
Dust Storm in Western Africa (05/08/01)



Initially the near real-time data was used for wildfire management but it soon became clear that there were many other applications such as monitoring hurricanes, convective cloud top height, aircraft contrails, dust storms as well as floods, ash plumes and oil spills.

LANCE's Roots: NRTPE (cont)



NRTPE system Located at NASA GSFC

Aqua MODIS & AIRS NRT Processing added following 2002 launch

Goal: <3 hours from satellite observation

In late 2001 the National Polar-Orbiting Operational Environmental Satellite System (NPOES - NASA/NOAA/Department of Defense) established the Near Real-Time Processing Effort (NRTPE) to provide military, weather agencies and first responders with timely data from NASA's Earth Observing Satellites. It was a risk reduction to aid and familiarize future applications users through observations of dust storms, fires, and severe weather.

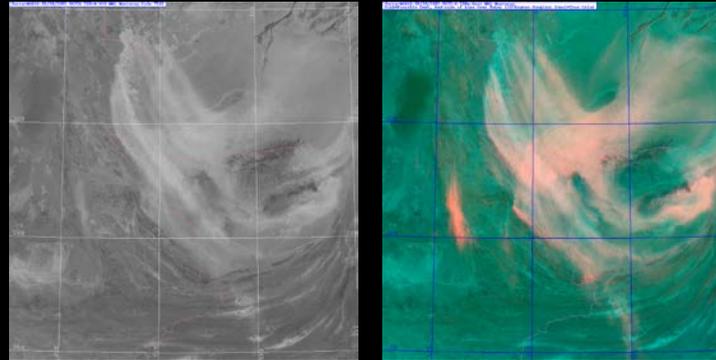
NRTPE: A Model for Transition-Oriented R&D



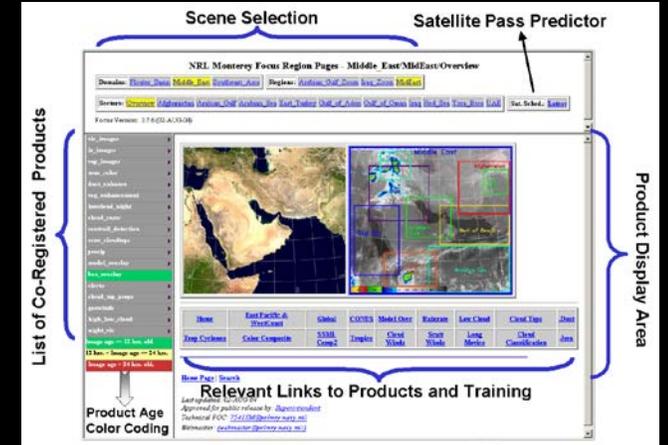
Fall 2001: Following 9/11, NRL endorses a New Start with focus on next-generation (e.g., EOS) satellite technology exploitation.



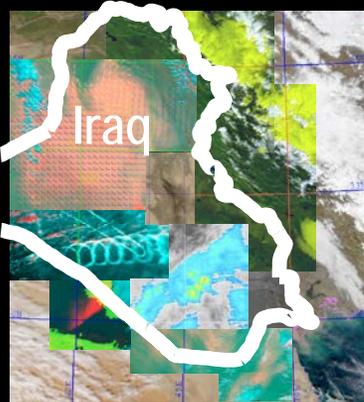
Winter 2001-2002: NRTPE effort supports Coalition Forces during Operation Enduring Freedom (OEF) in Afghanistan.



Summer 2002: A new 'blue light absorption' technique for enhancing lofted mineral dust storms begins development, enabled by NRTPE MODIS data. It is used extensively by Coalition Forces.



Winter 2002-2003: A large suite of value-added satellite imagery applications populates the NRL/FNMOC SIPRNET Satellite Focus web page, accessible by DoD users worldwide.



March-May 2003: NRTPE data leveraged for extensive support of Operation Iraqi Freedom.



"Navy ships are taking over all operations in support of ground troops and bomb runs. All ships are receiving aircraft from others as well. We are currently using the (convection and dust) products to determine the Abe's track to safely support the mission."

—USS Abraham Lincoln

2003: Feedback from operational users afloat indicate myriad positive impacts of NRTPE data in terms of mission planning, execution, weapons selection, etc.

2004: NRL Monterey Satellite Group is recognized by NASA for collaborations in the NRTPE for operational DoD support.

Proven success of a badge-less team with a common goal

Slide provided by Steve Miller
<https://www.tandfonline.com/doi/full/10.1080/01431160500383772>
 Miller, S. D. 2003. A consolidated technique for enhancing desert dust storms with MODIS

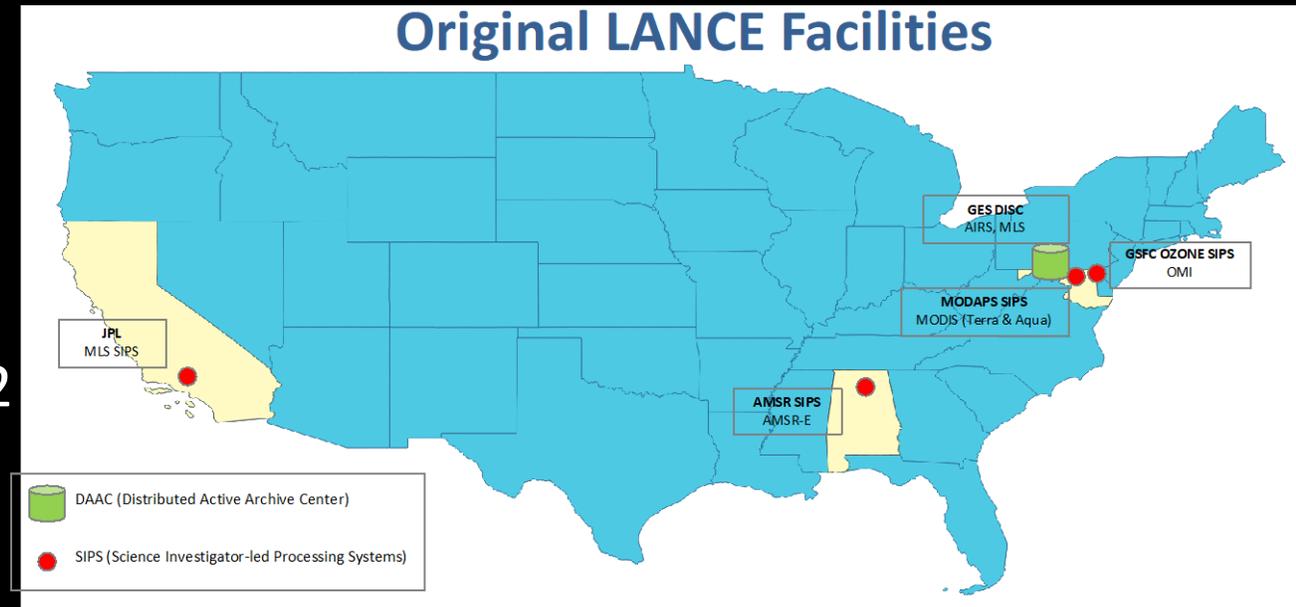


Establishment of LANCE

The growing demand for Rapid Response global data and near real-time products (including media demand for imagery) and an aging NRTPE system spurred NASA Headquarters to fund a new, more robust system leveraging existing EOSDIS standard product processing facilities.

LANCE was formally established in September 2009 and began serving NRT data from:

- MODIS (Terra and Aqua)
- AIRS (Aqua)
- AMSR-E (Aqua) later replaced by AMSR2
- MLS (Aura)
- OMI (Aura)





LANCE Approach:

- Leverage existing science processing expertise to create high quality NRT products
- Provide data and imagery within 3-hours of satellite observation:
 - To achieve the 3-hour latency requirement, all aspects of data processing, from geo-location (attitude and ephemeris) data to ground systems and inputs to science algorithms, had to be modified.
- Provide data products with high reliability using redundant systems
- Establish an “umbrella environment” with uniform high-level requirements to ensure consistency and foster coordination and cooperation between the individual elements
- New requirements and enhancements are reviewed and recommended by the LANCE User Working Group

Continued expansion of LANCE

7 Spacecraft/10 instruments

In addition to MODIS, AIRS, MLS, OMI, AMSR2 The following instruments were added to LANCE between 2015 - 2019

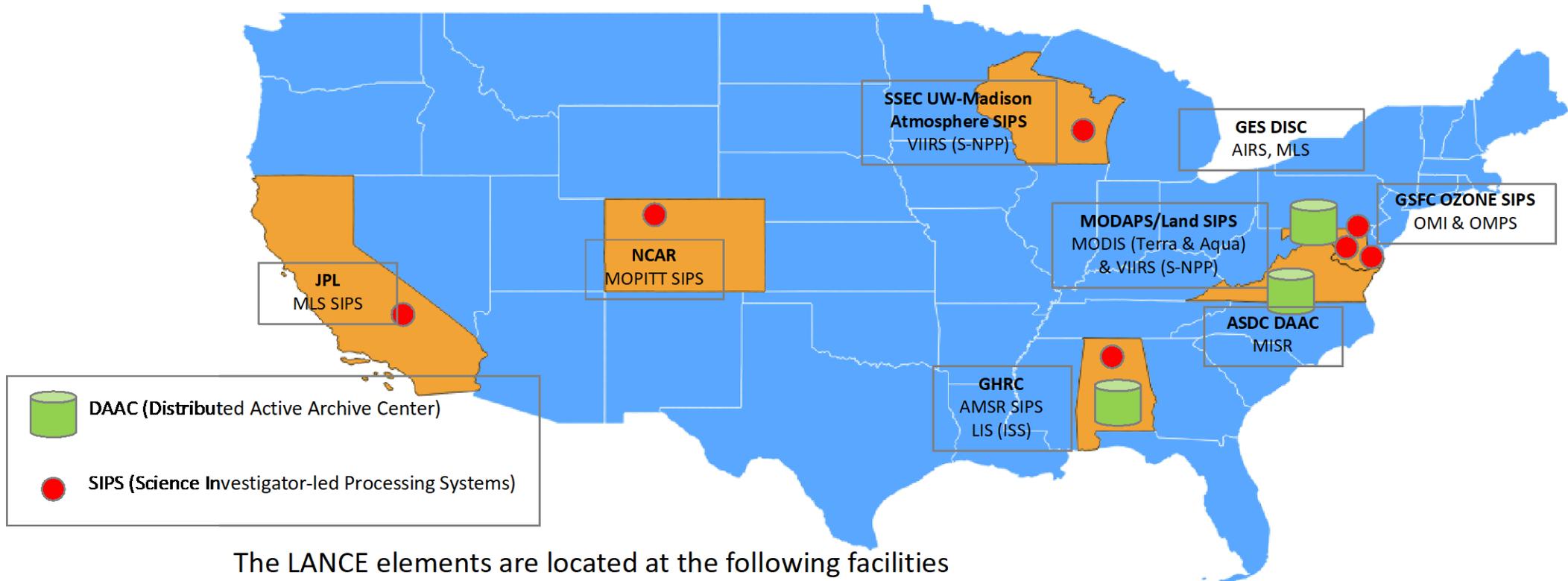
Instrument	Product Categories	Data added to LANCE
LIS ISS	Lightning, Atmospheric Electricity, Weather Events	Mar 2018
MISR	Cloud motion vectors (Winds), Radiances	Jun 2016
MOPITT	Total column carbon monoxide (CO) retrieved from thermal infrared radiances	Oct 2017
OMPS	Total Column Ozone and Aerosol Index, SO ₂ , Ozone Profile	S-NPP: Dec 2017 NOAA 20: Dec 2019
VIIRS	375 m Active Fire, Corrected Reflectance Imagery, Land Surface Reflectance, Land Surface Temperature, Snow Cover, Sea Ice, Ice Surface Temperature	S-NPP: Oct 2017 NOAA 20: Aug 2019

The following products were recently added to LANCE

- VIIRS Nighttime Imagery product; January 2017
- OMPS Pyrocumulonimbus product (PyroCb); October 2018
- MODIS Thermal Alert System (MODVOLC); produced in 2018 by LANCE from MODIS data to serve the volcano monitoring community and distributed primarily through the University of Hawaii
- MODIS Multi-Angle Implementation of Atmospheric Correction (MAIAC); produced in 2019 by LANCE to support the air quality and climate/atmospheric modeling communities
- MODIS Global Near Real-Time Flood Product (in progress)



LANCE Facilities in 2019



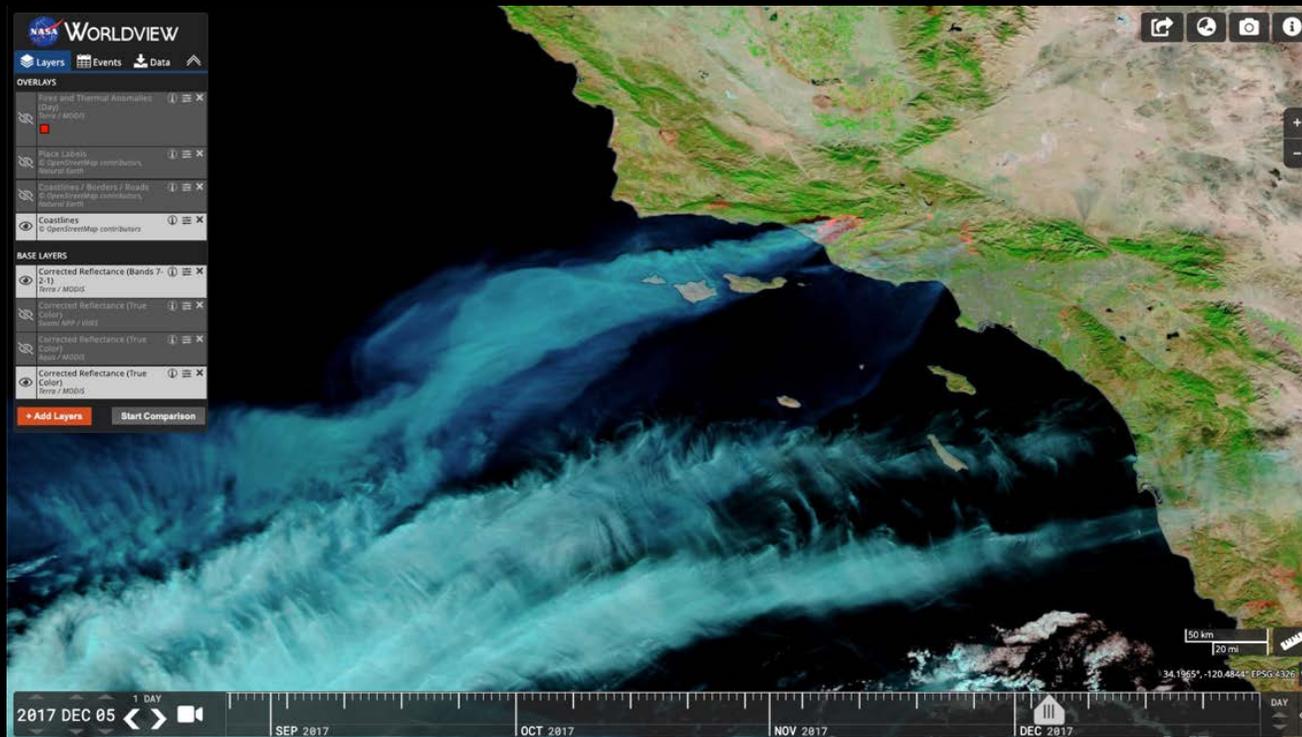
The LANCE elements are located at the following facilities

- **GSFC Earth Sciences Data and Information Services Center (GES DISC)** is providing AIRS data with support from the AIRS Science Computing Facility (SCF) at JPL , and MLS data via the MLS SIPS at JPL
- **Atmospheric Science Data Center (ASDC) DAAC** is providing MISR data with support from the MISR SCF at JPL
- **AMSR Science Investigator-led Processing System (SIPS)** is providing AMSR2 and **Global Hydrology Resource Center (GHRC) DAAC** is providing LIS data
- **MODIS Adaptive Processing System (MODAPS) and Land SIPS** are providing MODIS and VIIRS Land data
- **OZONE Science Investigator-led Processing System (SIPS)** is providing OMI and OMPS data
- **MOPITT SIPS (National Center for Atmospheric Research (NCAR))** is providing MOPITT data
- **Atmosphere SIPS (Space Science and Engineering Center (SSEC) University of Wisconsin)** is providing VIIRS Atmosphere data

NASA GIBS and Worldview were born out of LANCE

NASA EOSDIS developed the LANCE-powered Global Imagery Browse Services (GIBS) and the Worldview web application in 2011

- GIBS openly provides 900+ satellite imagery layers as web services, many available in NRT
- Worldview is a web-based mapping application using GIBS which allows users to easily download NRT imagery, interactively explore this imagery, and download the underlying data
- Built with the LANCE user community in mind



Left: Screenshot of Worldview showing Corrected Reflectance Imagery (Bands 7,2,1) from MODIS Terra. The image shows thick smoke streaming from several fires in southern California

<https://worldview.earthdata.nasa.gov>

NASA WORLDVIEW

Layers Events Data

OVERLAYS

- Place Labels
© OpenStreetMap contributors, Natural Earth
- Coastlines / Borders / Roads
© OpenStreetMap contributors, Natural Earth
- Coastlines
© OpenStreetMap contributors

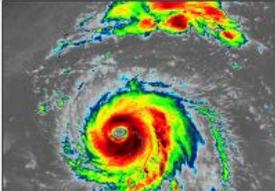
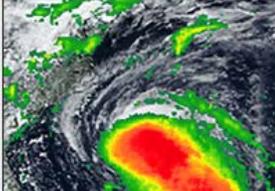
BASE LAYERS

- Corrected Reflectance (True Color)
Suomi NPP / VIIRS
- Corrected Reflectance (True Color)
Aqua / MODIS
- Corrected Reflectance (True Color)
Terra / MODIS

+ Add Layers Start Comparison

Welcome to Worldview!

Visually explore the past and the present of this dynamic planet from a satellite's perspective. Select from an array of stories below to learn more about Worldview, the satellite imagery we provide and events occurring around the world. [Start using Worldview](#) →

 View dust storms from a satellite's perspective. Dust Storms	 Hurricane Dorian (September 2019)	 Satellite Detections of Fire
 Sunglint	 Tropical Cyclone Idai (March 2019)	 Earth at Night
 Pine Island Glacier/Iceberg B-46, Nov 2018	 Camp Fire (November 2018)	 Hurricane Florence (September 2018)

Do not show until a new story has been added.

Check out our new geostationary layers!



1000 km
1000 mi

3.8056°, -87.6635° EPSG:4326

2020 JAN 06 1 DAY

NOV 2019 DEC 2019 JAN 2020 DAY

 **WORLDVIEW**

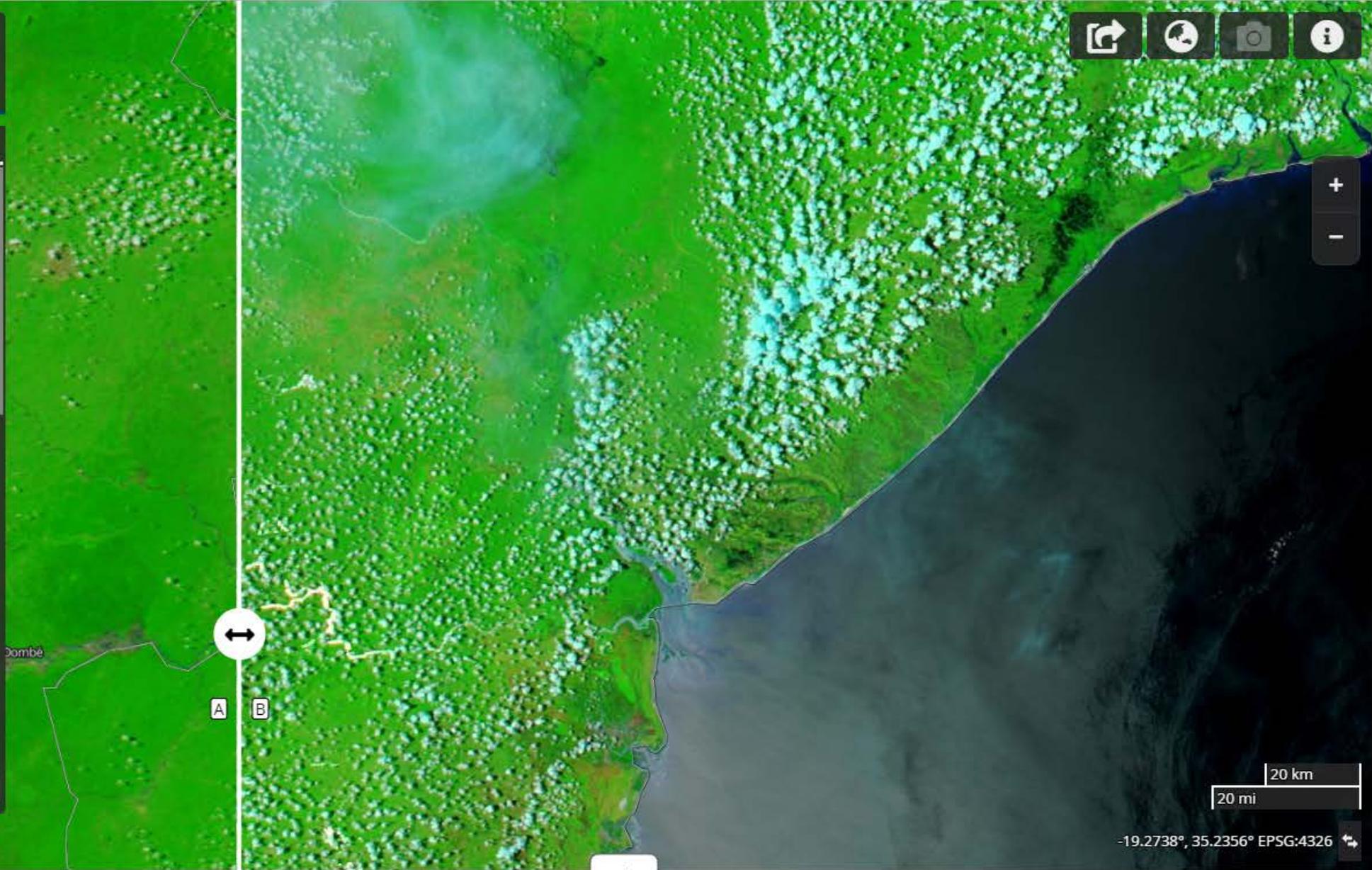
 Layers  Events  Data 

 A: 2019-03-25  B: 2019-01-11

- OVERLAYS
-  Fires and Thermal Anomalies (Day and Night) Terra / MODIS   
 -  Fires and Thermal Anomalies (Night, 375m) Suomi NPP / VIIRS   
 -  Fires and Thermal Anomalies (Day, 375m) Suomi NPP / VIIRS   
 -  Fires and Thermal Anomalies (Day and Night) Terra and Aqua / MODIS   
 -  Fires and Thermal Anomalies (Day and Night) Aqua / MODIS   
 -  Place Labels   

COMPARE MODE: **Swipe** Opacity Spy

 + Add Layers  Exit Comparison



2019 MAR 25   

MAR 2019 APR 2019 MAY 2019

NASA WORLDVIEW

Layers Events Data

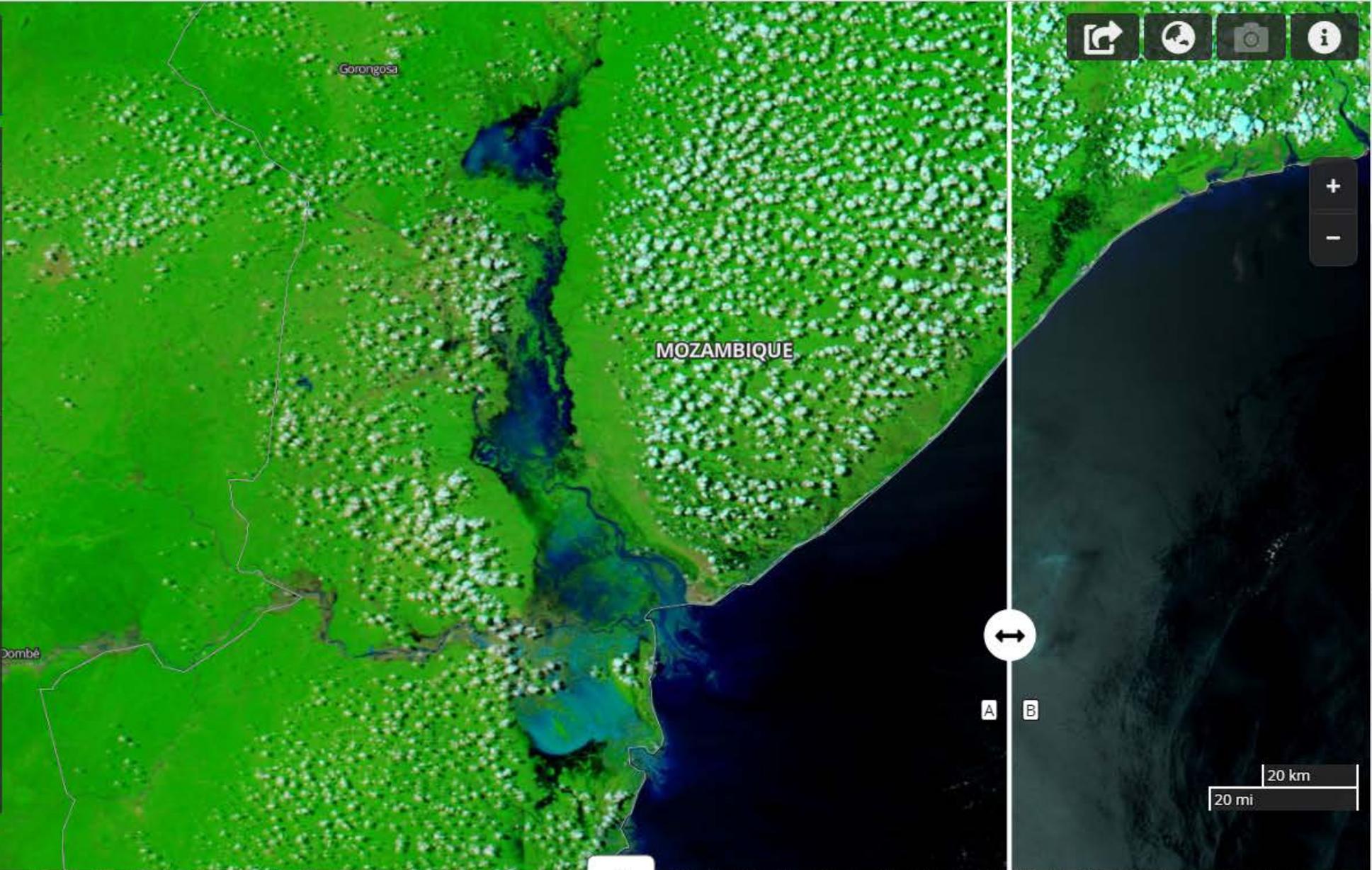
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- Fires and Thermal Anomalies (Day and Night) Aqua / MODIS
- Place Labels © OpenStreetMap contributors

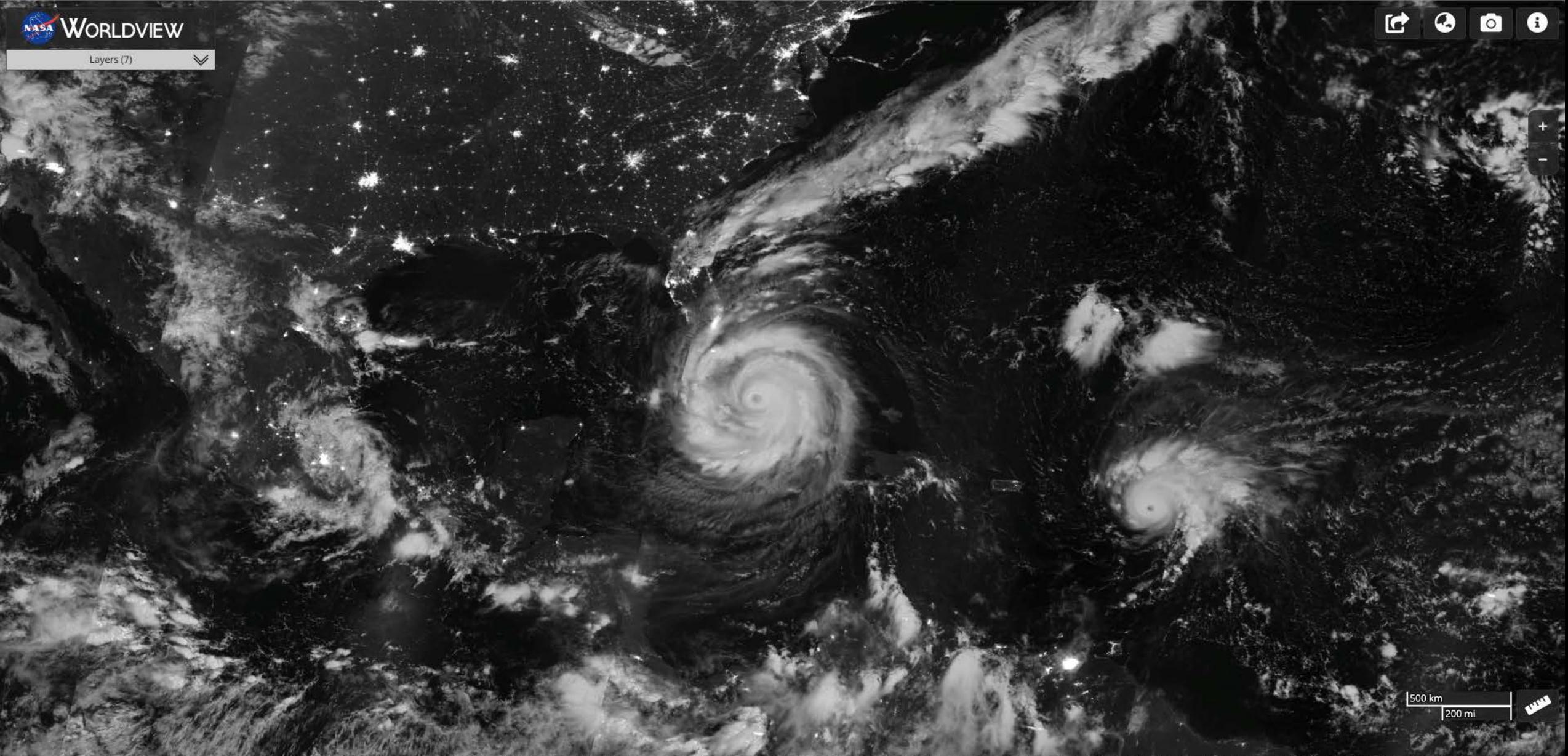
COMPARE MODE: **Swipe** Opacity Spy

+ Add Layers Exit Comparison



2019 MAR 25 DAYS < > [Video Icon]

MAR 2019 APR 2019 MAY 2019



2017 SEP 09      

JUL 2017 | AUG 2017 | SEP 2017 | OCT 2017 | NOV 2017

NASA Worldview screenshot of Nighttime imagery from 9 September 2017 produced VIIRS data and showing Hurricane Irma .

NRT Geostationary Imagery Now Available in Worldview

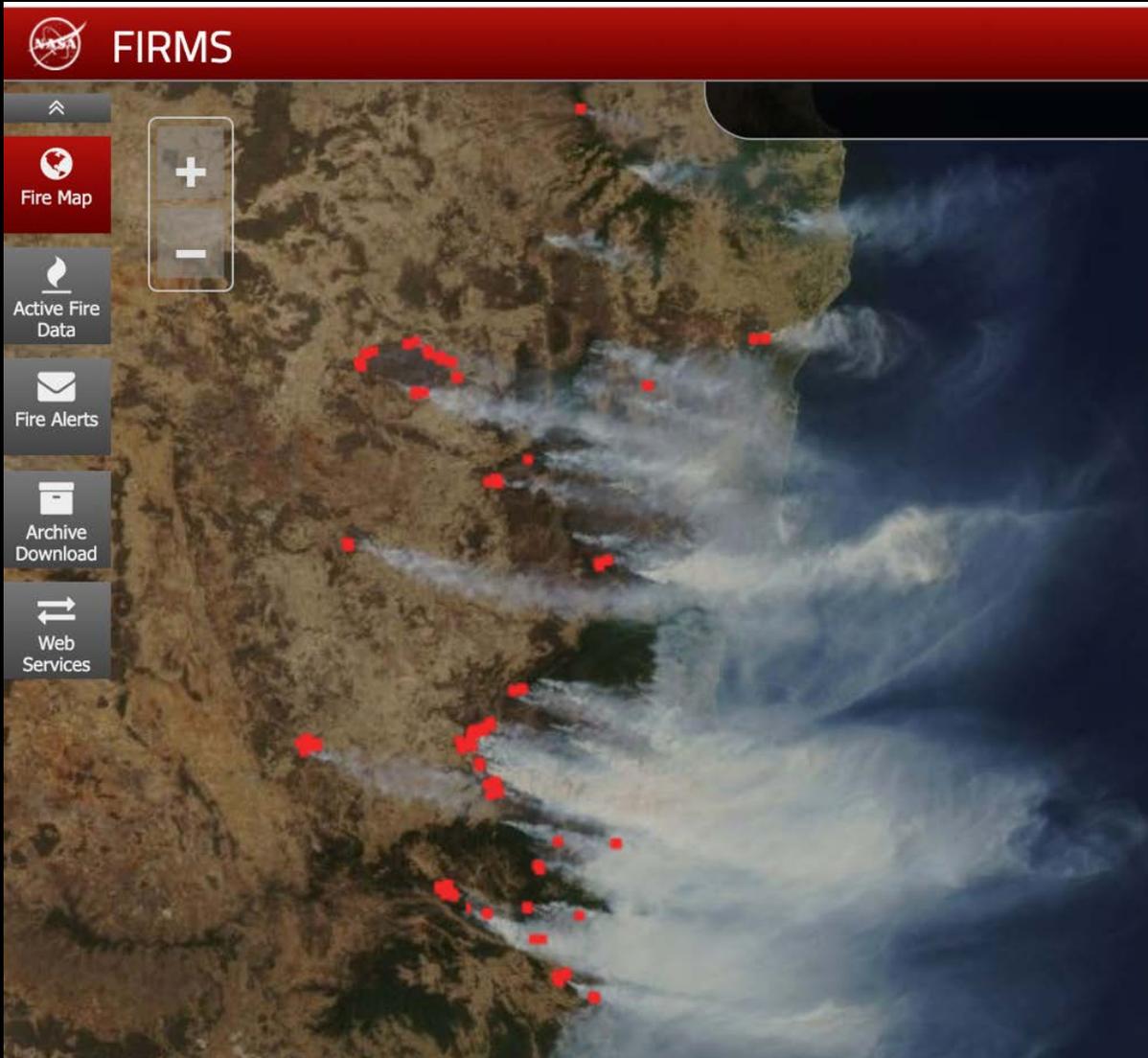
Data provided by MSFC Short-term Prediction Research and Transition Center (SPoRT)

- GOES-East, GOES-West, and Himawari-8 full disk imagery available every 10 minutes
- Imagery can be animated over time and exported as a movie
- Red Visible, Clean Infrared, and Air Mass products currently available; more products on the way

The screenshot displays the NASA Worldview interface. On the left, a sidebar contains a 'Layers' panel with 'OVERLAYS' and 'BASE LAYERS' sections. The 'OVERLAYS' section includes 'Coastlines / Borders / Roads', 'Place Labels', 'Coastlines', and three 'Red Visible' layers from Himawari-8, GOES-West, and GOES-East. The 'BASE LAYERS' section has '+ Add Layers' and 'Start Comparison' buttons. The main area shows a world map with a large satellite image of Earth. At the bottom, a timeline interface allows for animation, with 'Animate Map In' set to 10 MINUTE increments and a 'Frames Per Second' slider at 3.0. The timeline shows a range from 2020 JAN 01 11:00 Z to 2020 JAN 02 14:10 Z. A scale bar indicates 5000 km and 2000 mi.



Fire Information for Resource Management System (FIRMS) merges with LANCE in 2012



FIRMS provides global NRT active fire/thermal anomaly data from MODIS and VIIRS.

Originally developed at the University of Maryland in 2007 in partnership with the United Nations (UN) Food and Agriculture Organization (FAO), in 2012 FIRMS became part of LANCE

Users can:

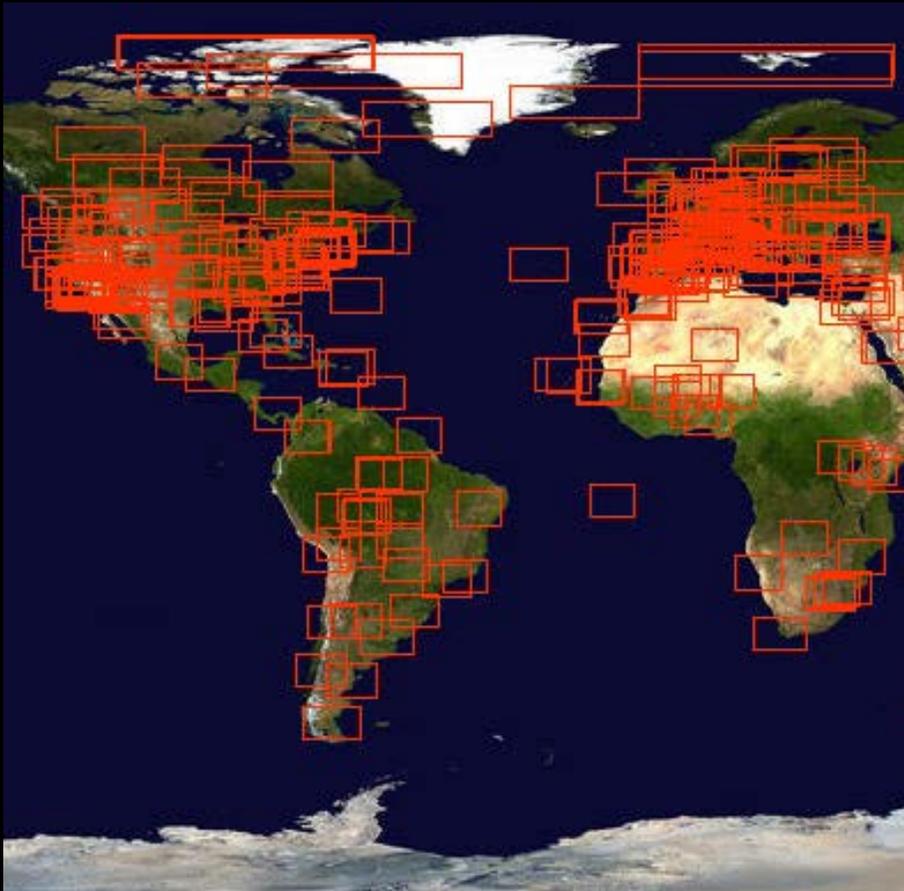
- view data and imagery in FIRMS Fire Map
- receive email Fire Alerts
- download data in easy to use formats

Approximately 240,000 FIRMS alerts (including daily, rapid and weekly alerts) are sent to users in more than 160 countries.

Left: FIRMS Fire Map showing active fires in New South Wales, Australia. The fires, overlaid in red, are on a corrected reflectance true color image from VIIRS SNPP from 11/13/ 19

MODIS Rapid Response merges with LANCE

In 2011 Rapid Response became part of LANCE and in 2019 it was replaced with Worldview Snapshots



NASA Worldview Snapshots

Map Projection: Geographic
Base Layer: Terra, MODIS, True Color, Corrected Reflectance
Layer Date (UTC): 01/06/2020
Overlay Layers: Fires Coastlines Coastlines, Borders & Roads

Bottom Left: min Latitude: -90.000000, min Longitude: -180.000000
Top Right: max Latitude: 90.000000, max Longitude: 180.000000
Resolution: 10km
File Format: JPEG
Auto Scale: Yes



NASA Disasters Program and Mapping Portal



The Disasters program, within Applied Sciences, supports NASA Earth Science within the Science Mission Directorate .

NASA Disasters team coordinated the analysis and use of near real-time satellite observations including LANCE near real-time products to support active disasters events. These information and products have been made available on the NASA Disasters Mapping Portal to help stakeholders and end users in their decision-making processes.

NASA Disasters Mapping Portal:

<https://maps.disasters.nasa.gov>

NASA Disasters Web Page:

<http://disasters.nasa.gov>



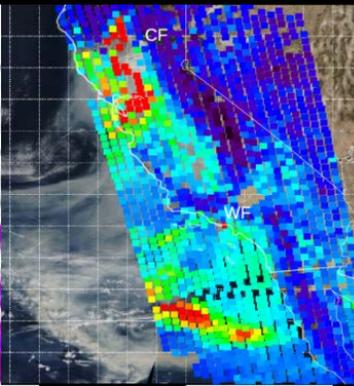
NASA Disasters Program Promotes the Use of LANCE NRT Products for Disaster Risk Reduction



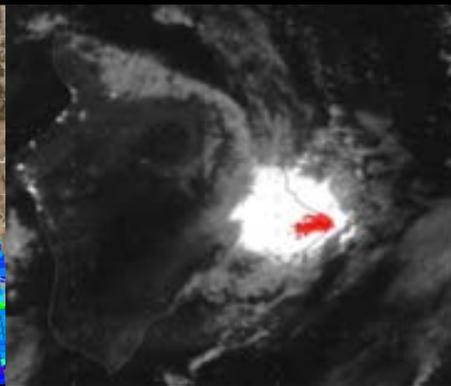
LANCE provides near real-time (NRT) products and supports disaster risk reduction activities before, during and after a disaster including volcano eruptions, landslides, wildfire, flood, hurricane, earthquake and etc..



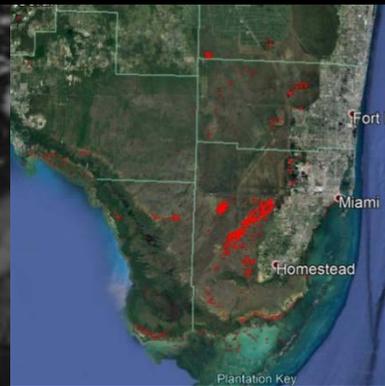
AMSR2 Surface Precipitation Rates product



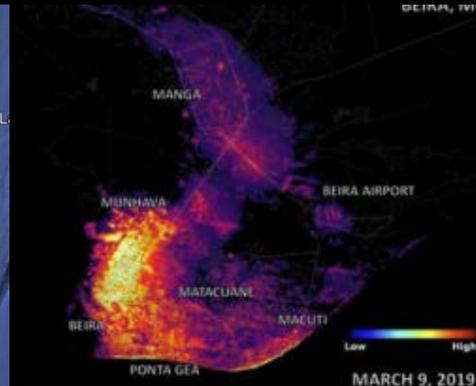
MOPITT CO product



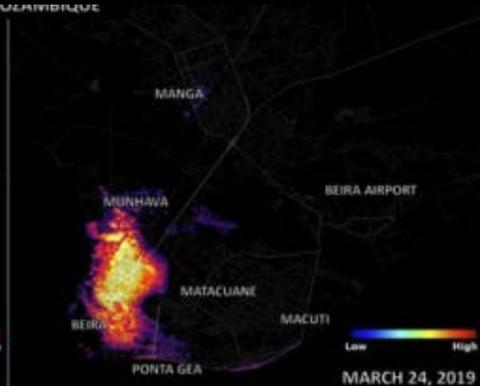
VIIRS Fire product



MODIS NRT Flood Mapping product



NASA's Black Marble Nighttime Light product



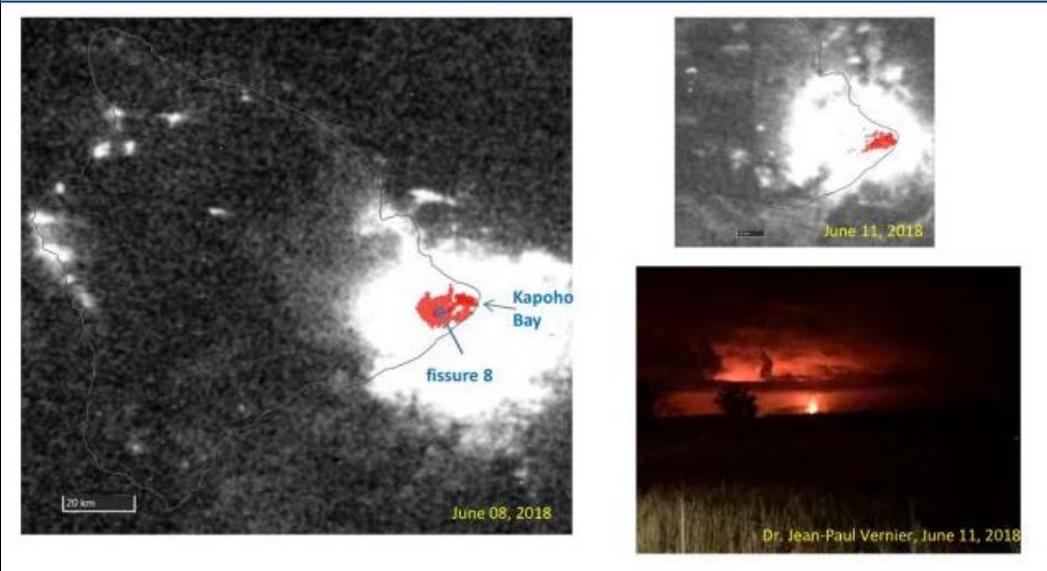
NASA's Black Marble Nighttime Light product



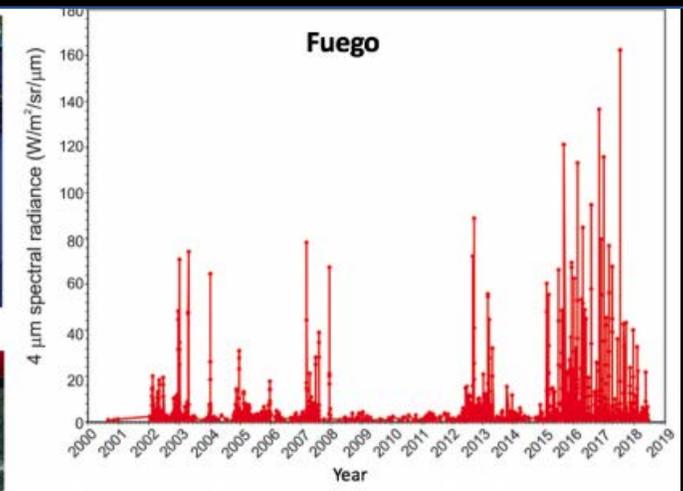
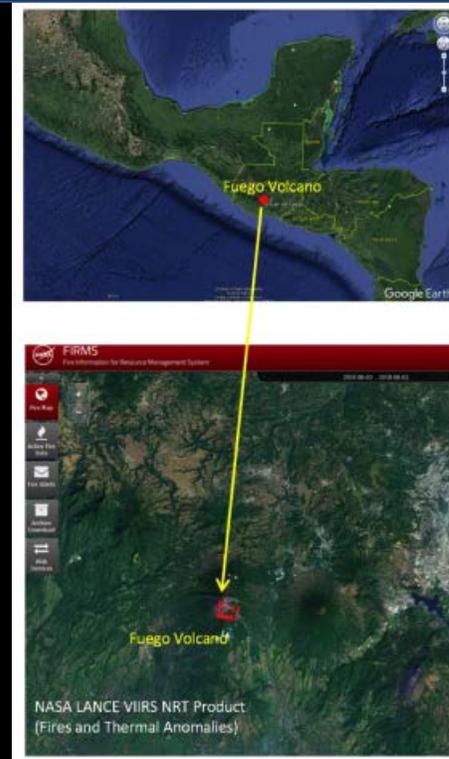
Example of NASA Disasters Program Use of LANCE



Examples of using LANCE NRT products for Volcano Eruptions:



The satellite images show that in Hawaii's Big Island, lava flows are located by LANCE VIIRS Fires NRT product, with the base map of VIIRS nighttime imagery in June, 2018.



The figure shows a plot of total emitted radiance (at 4 microns) from Fuego volcano observed by MODIS MODVOLC Volcano product from 2000 to present.



LANCE ... Where are we now?

- November 2019 was the 10th Anniversary of LANCE
- LANCE provides over 203 image and derived data products
- On an average day, over 16.2 TB of NRT products (data and imagery) are downloaded (excluding imagery from GIBS and Worldview)
- After 10 years Chris Justice (UMD) stepped down as chair of the LANCE UWG
 - New UWG Chair: Miguel Román (USRA)
- Recently approved to add NRT SMAP products
- The Project is considering adding experimental products and products from non-NASA instruments to serve the expanding user community



Thanks to my co-authors!

Diane Davies

David Green

Tian Yao

Ryan Boller