



Earth Observations for Informing Disaster Risk and Response to Drought, Wildfire, and Flooding in Mexico

Active Fire Conditions

May 10, 2023

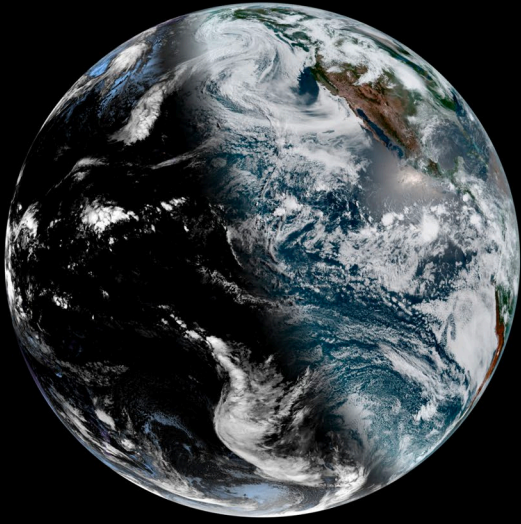


Several Satellite Instruments Observe Fire Detections

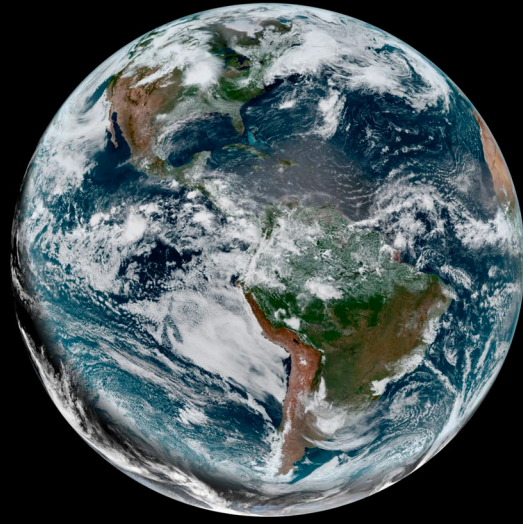
	MODIS	VIIRS	ABI
Platform	Terra , Aqua	Suomi NPP, NOAA-20, NOAA-21	GOES 16, 17, 18
Launched	Dec 1999, May 2002	Oct 2011, Nov 2017, Nov 2022	Nov 2016, Mar 2018, Mar 2022
Swath	2,330 km	3,040 km	---
Equator Crossing Time	10:30 am (des), 1:30 pm (asc)	1:30 pm (asc), 1:30 pm (asc)	Geostationary
Spatial Resolution	250 m, 500 m, 1 km	375 m, 750 m	500 m, 1km, 2km
Temporal Resolution	Global Coverage: 1-2 days	Global Coverage: Daily	Full Disk: 15 min CONUS: 5 min
Spectral Coverage	36 bands (VIS, IR, NIR, MIR) Band 1-2: 250 m Band 3-7: 500 m Band 8-36: 1 km	22 bands (VIS, IR, NIR, MIR) I-Bands (1-4): 375 m M-Bands (1-16): 750 m Day/Night Band: 750 m	16 bands (VIS, IR, NIR, MIR) 500 m – 2 km



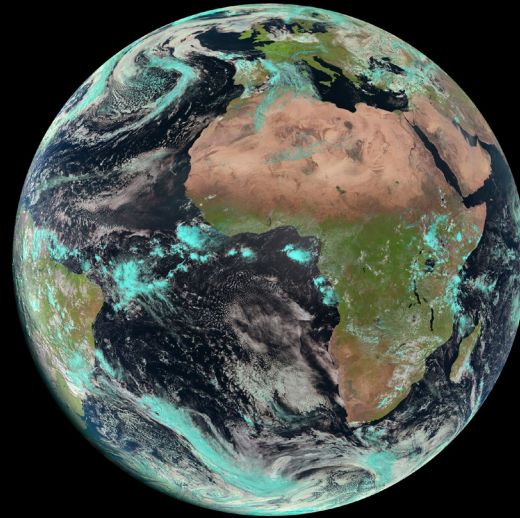
Geostationary Observations of Active Fires



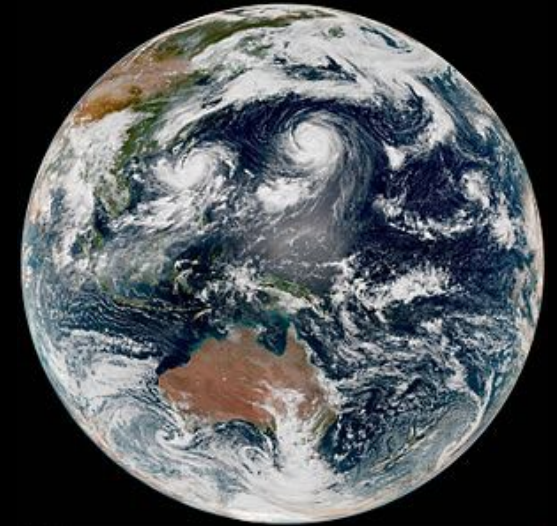
GOES-West/ABI



GOES-East/ABI



MSG/SEVIRI



Himawari/AHI



Active Fire Products

- The Thermal Anomalies/Active Fire products deliver actively burning locations in NRT at 2 km (ABI), 1 km (MODIS), or 375 m (VIIRS) resolution.
- Provides snapshots of active burning fires

Fire Detections NOAA-20 VIIRS

9/1/2022 – 9/31/2022



Sensors and Product Names

MODIS	MOD04A1 (Terra) MYD04A1 (Aqua)
VIIRS	VNP14IMGTDL_NRT (SNPP) VJ114IMGTDL_NRT (N20)
ABI	FDC



What are Thermal Anomalies?

- Significant increase in absolute radiance at $\sim 4 \mu\text{m}$ and $\sim 11 \mu\text{m}$
 - Measured as Brightness Temperature (BT) (K)
- All algorithms are similar.
 - Cloud masks applied
 - Use other wavelength bands to filter out sun glint and coastal regions



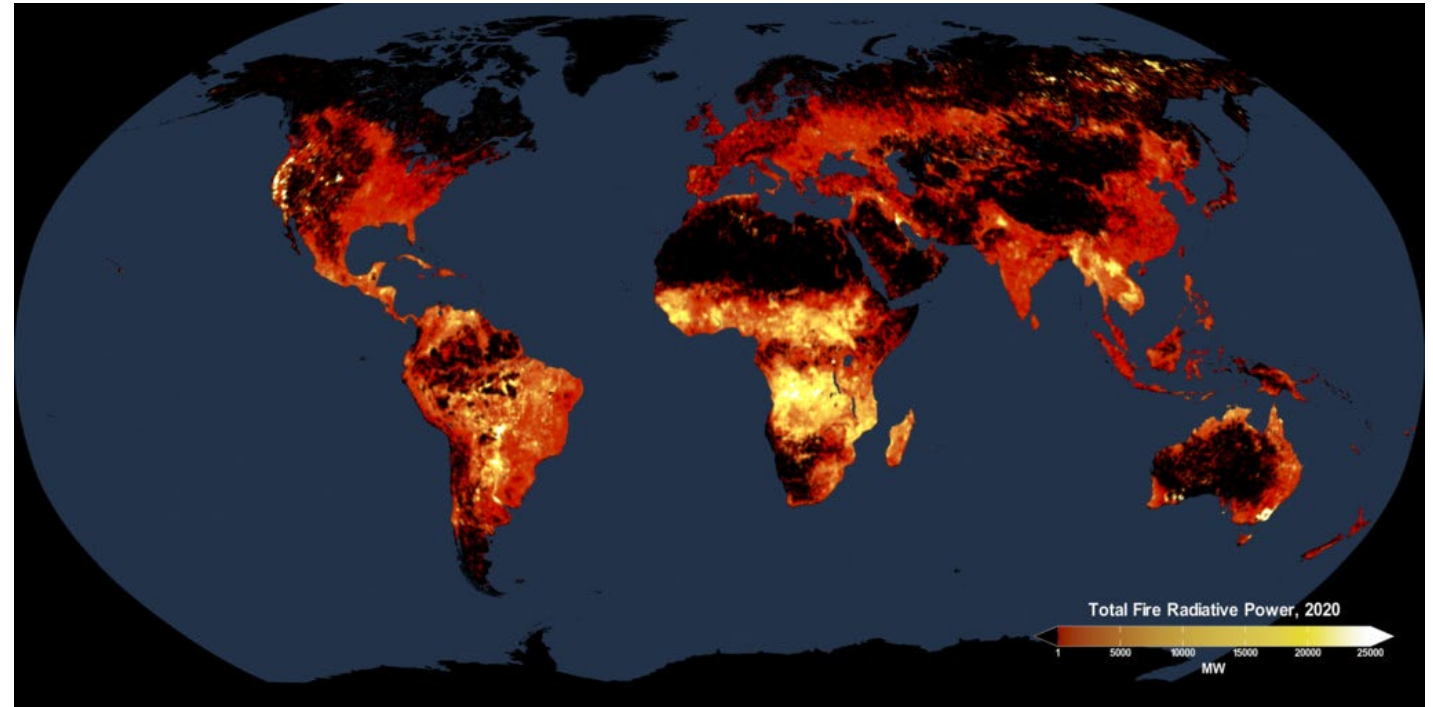
VIIRS Fire Detections, NASA Worldview



Fire Radiative Power (FRP)

- Rate of emitted radiative energy by a fire
 - Usually expressed in units of power (W, MW, or J/s)
- Fire Radiative Energy (FRE)
 - Time integrated FRP, usually expressed as (J)
 - Correlation between FRE and fire emissions

VIIRS 375m Cumulative FRP for 2020



<https://svs.gsfc.nasa.gov/4899>



VIIRS Active Fires, Jan-Sep 2021



<https://svs.gsfc.nasa.gov/4945>

Active Fire Detection Algorithm

Classify Cloud and Water Pixels

- Use thresholds in brightness temperature (BT) and reflectance in particular bands
- Different thresholds for day and night

Active Fire Detection

- Use fixed or dynamic (moving window) thresholds to identify potential fire pixels
- Use complementary data from other channels

Are you sure it's a fire?

- Characterize background
- Check for bright fire-free targets (glint, coastal regions, deserts, cleared forests)



VIIRS Algorithm

Band	Wavelength Range	
I4	3.55 – 3.93 μm	Fire Detection
I5	10.5 – 12.4 μm	Compared with I4 to separate active fire from background
I1	0.6 – 0.68 μm	Cloud
I2	0.846 – 0.885 μm	Sun glint
I3	1.58 – 1.64 μm	Water Discrimination

Data Artifacts:

Pixel Saturation

South Atlantic Magnetic Anomaly (SAMA)

Candidate Fire Pixel Identification

- $BT_4 > BT_{4S}$ OR $\Delta BT_{45} > 25K$ (daytime)
- $BT_4 > 295K$ OR $\Delta BT_{45} > 10K$ (nighttime)

$BT_{4S} = 501 \times 501$ background BT window

$$BT_{45} = BT_4 - BT_5$$

Validation

- Error rate: 0 – 1.2% (China)



VIIRS – File Contents

<https://www.earthdata.nasa.gov/learn/find-data/near-real-time/firms/viirs-i-band-375-m-active-fire-data>

Attribute	Description	
Latitude	Latitude	Center of nominal 375 m fire pixel
Longitude	Longitude	Center of nominal 375 m fire pixel
Bright_ti4	Brightness Temperature I-4	VIIRS I-4 channel brightness temperature of the fire pixel (K)
Scan	Along Scan Pixel Size	Actual pixel size
Track	Along Track Pixel Size	Actual pixel size
Acq_Date	Acquisition Date	Date of VIIRS acquisition
Acq_Time	Acquisition Time	Time of acquisition/overpass of the satellite (in UTC)
Satellite	Satellite	N= Suomi NPP, 1=NOAA-20
Confidence	Confidence	Low - Areas of sun glint and lower relative temperature anomaly Nominal - Free of potential sun glint contamination during the day and strong temperature anomaly in either day or nighttime data High - Day or nighttime saturated pixels
Version	Version (Collection and Source)	"1.0NRT" - Collection 1 NRT processing "1.0" - Collection 1 Standard processing
Bright_ti5	Brightness Temperature I-5	I-5 Channel brightness temperature of the fire pixel measured in Kelvin
FRP	Fire Radiative Power	FRP depicts the pixel-integrated fire radiative power in MW (megawatts).
DayNight	Day or Night	D= Daytime Fire, N= Nighttime Fire

MODIS Algorithm

Channel	Central Wavelength	
21,22	4 μm	Active fire detection
31	11 μm	Active fire detection, cloud masking, forest clearing rejection
32	12 μm	Cloud masking
1	0.65 μm	Sun glint and coastal false alarm rejection; cloud masking
2	0.86 μm	Bright surface, sun glint, and coastal false alarm rejection; cloud masking
7	2.1 μm	Sun glint and coastal false alarm rejection

Potential Fire Pixel Identification

- 0.86 Reflectance < 0.35 (daytime only)
- $BT4 > BT4^*$
- $BT4 - BT11 > \Delta BT^*$

$BT4^*$ and ΔBT^* are dynamic thresholds calculated using a $\sim 301 \times 30$ moving window centered on the pixel of interest.

Validation

- Global Commission Error (false alarms) 1.2%

Giglio et al., 2016

<https://www.sciencedirect.com/science/article/pii/S0034425716300827>

NASA's Applied Remote Sensing Training Program



MODIS – File Contents

<https://www.earthdata.nasa.gov/learn/find-data/near-real-time/firms/mcd14dl-nrt>

Attribute	Description	
Latitude, Longitude	Latitude, Longitude	Center of 1 km fire pixel
Brightness	Brightness Temperature 21 (K)	Channel 21/22 brightness temperature of the fire pixel (K)
Scan	Along Scan Pixel Size	Actual pixel size
Track	Along Track Pixel Size	Actual pixel size
Acq_Date	Acquisition Date	Data of MODIS acquisition
Acq_Time	Acquisition Time	Time of acquisition/overpass of the satellite (in UTC)
Satellite	Satellite	A = Aqua and T = Terra
Confidence	Confidence (0-100%)	Confidence estimates range between 0 and 100% and are assigned one of the three fire classes (low-confidence fire, nominal-confidence fire, or high-confidence fire).
Version	Version (Collection and Source)	Version identifies the collection and source of data processing, for example: "6.1URT" - Collection 6.1 Ultra Real-Time processing. "6.1NRT" - Collection 61 Near Real-Time processing. "6.1" - Collection 61 Standard processing.
Bright_T31	Brightness Temperature 31 (K)	Channel 31 brightness temperature of the fire pixel (K)
FRP	Fire Radiative Power	Pixel-integrated FRP in MW (megawatts)
Type*	Inferred Hot Spot Type	0 = Presumed Vegetation Fire, 1 = Active Volcano, 2 = Other Static Land Source, 3 = Offshore
DayNight	Day or Night	D= Daytime fire, N= Nighttime fire

ABI Algorithm

Channel	Central Wavelength	
2	0.64 μm	Cloud screening, surface albedo
7	3.9 μm	Hot spot location and characterization
14	11.2 μm	Hot spot location and characterization
15	12.3 μm	Cloud identification

Validation

- High false alarm rate

Fire Pixel Identification

- Part I
 - Loop over all pixels to identify all possible fire pixels
- Part II
 - Threshold tests to refine fire pixel identification and Fire Classification

The GOES algorithm uses spectral, contextual, and temporal tests, the thresholds for which are dynamically determined.



ABI – File Contents

<https://www.star.nesdis.noaa.gov/goesr/docs/ATBD/Fire.pdf>

Attribute	Dimension	
Fire Mask Codes	Grid (xsize, ysize)	Codes indicating final disposition of pixels (including fire flags if so determined)
Subpixel Fire Size	Grid (xsize, ysize)	Subpixel fire size for processed fires (codes 10 and 30) (km ²) This is set to -9 if the subpixel fire temperature is less than 400 K at the end of the algorithm.
Subpixel Fire Temp	Grid (xsize, ysize)	Subpixel fire temperature for processed fires (codes 10 and 30) (K) This is set to -9 if the subpixel fire temperature is less than 400 K at the end of the algorithm.
Subpixel FRP	Grid (xsize, ysize)	Subpixel fire radiative power for processed fires (codes 10, 13, 14, 30, 33, and 34) (MW)
Previous Fire Mask	ABI Full Disk Grid	ABI full disk mask of seconds since 1 January 2001 when a fire was last detected in that fixed grid pixel.
QA Flags	Grid (xsize, ysize)	QA flags where 0 indicates a fire and nonzero indicates non-fire pixels (see table)
Metadata	27 values, 12 strings	<ul style="list-style-type: none"> a. Number of fire categories b. Definition of each fire category c. Percent of pixels for each fire category d. Number of QA flag values e. Definition of each QA flag value f. Percent of retrievals with each QA flag value g. Total number of fires

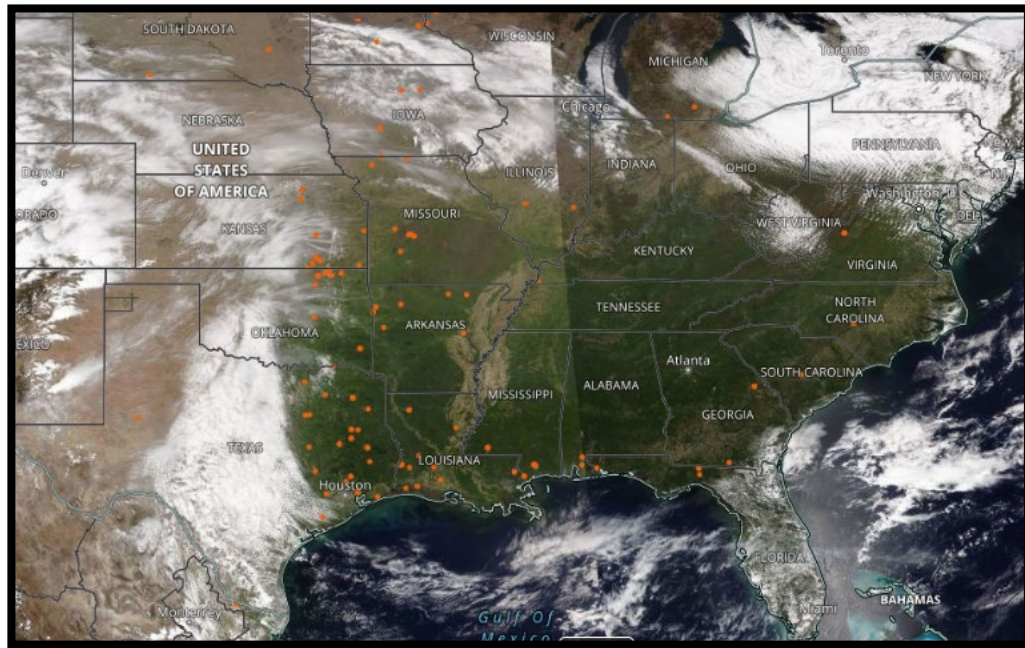
GOES-R ABI WF_ABBA FDCA QA Flags	
QA Code	Fire Mask Code(s) and Definition
0	10-15, 20-25, 30-35 [20-25 not used for ABI currently]: These are the codes for fires, all are considered valid algorithm output.
1	100: Fire-free land pixel that was not otherwise screened out.
2	200, 205, 210, 215, 220, 225, 230, 240, 245: The pixel failed opaque cloud tests.
3	0, 40, 50, 60, 130, 150-153, 155: Pixel unusable due to unusable surface type, sunglint, or being off the disk. Also includes reserved mask values not including 20-25.
4	120-127, 160: Bad input data.
5	170, 180, 182, 185-188: A calculation in the algorithm failed.

VIIRS Detects 3–4x More Fires Than MODIS

Daytime Active Fire Detections – 4/27/2022

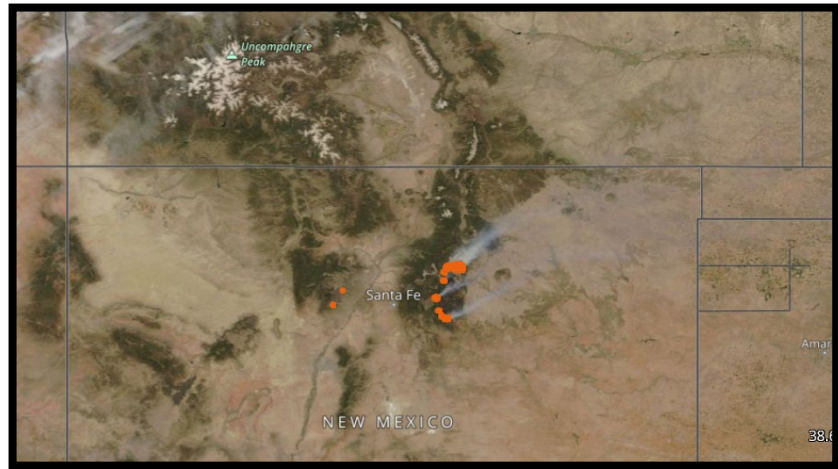
MODIS - Aqua

VIIRS

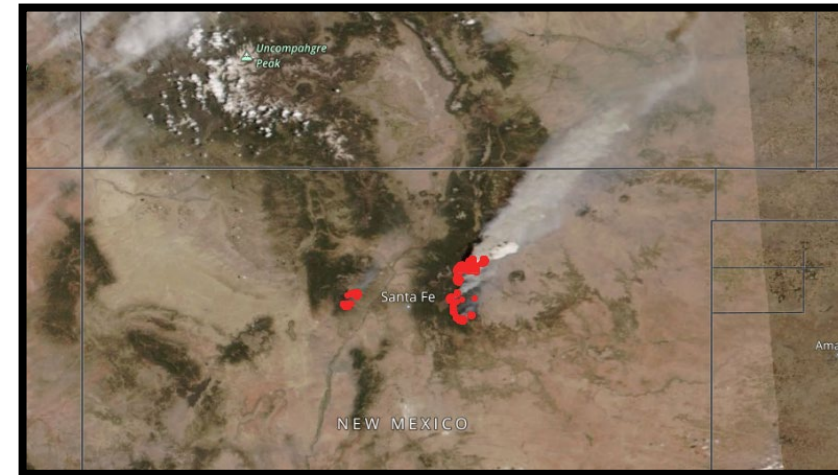


One Fire, Multiple Views – May 10, 2022

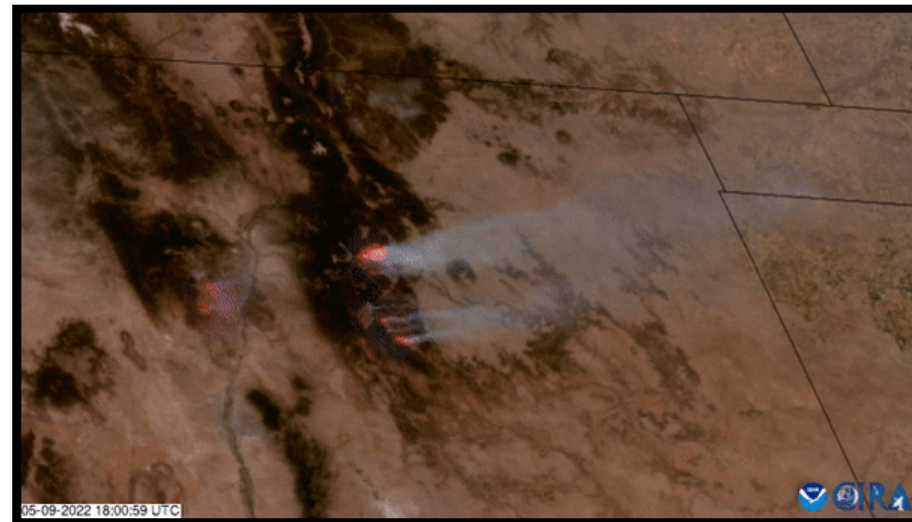
MODIS - Terra



VIIRS



ABI



Thermal Anomalies Algorithms

- Limitations:
 - False positives: small forest clearings (bare soil)
 - Large fire omissions due to thick smoke
 - Larger pixel size of MODIS and ABI can miss small fires
- MODIS Collection 6 (most recent) improves upon these errors.
 - Global commission error of 1.2%
 - Similar error for VIIRS



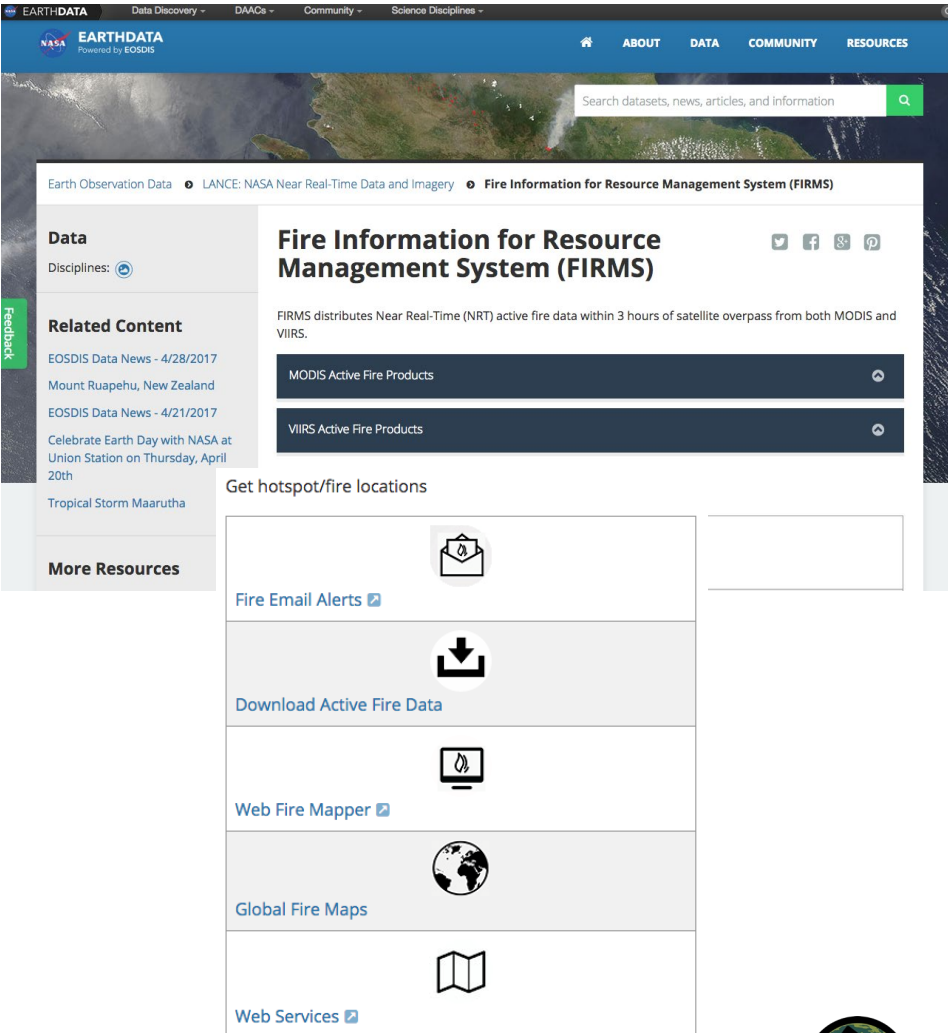
MODIS Fire Detections, NASA Worldview



Fire Information for Resource Management System (FIRMS)

<https://earthdata.nasa.gov/earth-observation-data/near-real-time/firms>

- Near real-time (NRT) active fire data within 3 hours of satellite overpass
 - Shorter latency for CONUS (~30 min)
- Global MODIS and VIIRS fire locations, and provisional geostationary observations
- Historical data available
- Available In:
 - Email alerts
 - Download shapefile, WMS, KML, or TXT
 - Visualization in **Web Fire Mapper** or **Worldview**
- Video Tutorial: [How to Use NASA's Fire Information for Resource Management System \(FIRMS\)](#)



The screenshot shows the NASA Earth Data website interface for the Fire Information for Resource Management System (FIRMS). The page features a search bar at the top, a navigation menu with links for ABOUT, DATA, COMMUNITY, and RESOURCES, and a main content area. The main content area includes a title for "Fire Information for Resource Management System (FIRMS)", a description stating "FIRMS distributes Near Real-Time (NRT) active fire data within 3 hours of satellite overpass from both MODIS and VIIRS.", and a list of related content and resources. The related content includes "MODIS Active Fire Products" and "VIIRS Active Fire Products". The resources section includes "Fire Email Alerts", "Download Active Fire Data", "Web Fire Mapper", "Global Fire Maps", and "Web Services".



Where to Obtain MODIS Fire Products

Archived Data



Land Process Distributed Active Archive (LPDAAC):
<http://lpdaac.usgs.gov/>



NASA Earthdata: <https://earthdata.nasa.gov/>

Near Real Time (NRT)



Worldview: <http://worldview.earthdata.nasa.gov>



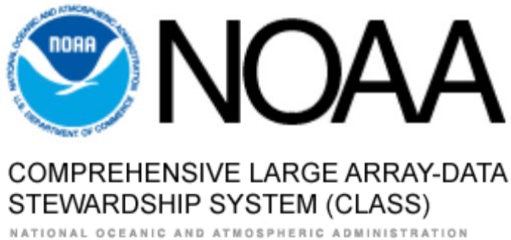
Where to Obtain VIIRS Products



Worldview: <http://worldview.earthdata.nasa.gov>

VIIRS Active Fire

VIIRS Active Fire: <http://viirsfire.geog.umd.edu>



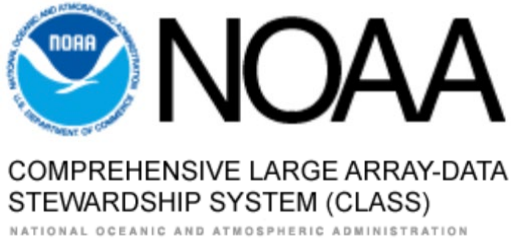
NOAA Comprehensive Large Array-Data Stewardship System (CLASS): <https://www.avl.class.noaa.gov/saa/products/welcome>

LAADS DAAC

Level-1 and Atmosphere Archive & Distribution System: <https://ladsweb.modaps.eosdis.nasa.gov/>



Where to Obtain ABI Products



NOAA Comprehensive Large Array-Data Stewardship System (CLASS): <https://www.avl.class.noaa.gov/saa/products/welcome>



University of Wisconsin GOES Page:
<http://cimss.ssec.wisc.edu/goes/goesdata.html>



References

- VIIRS Algorithm
 - Schroeder et al., 2014, Remote Sensing of Environment
<https://www.sciencedirect.com/science/article/pii/S0034425713004483>
- VIIRS User Guide
 - https://viirsland.gsfc.nasa.gov/PDF/VIIRS_activefire_User_Guide.pdf
- VIIRS Algorithm Theoretical Basis Document (ATBD)
 - https://viirsland.gsfc.nasa.gov/PDF/VIIRS_activefire_375m_ATBD.pdf
- MODIS Collection 6 Algorithm
 - Giglio et al., 2016, Remote Sensing of Environment
<https://www.sciencedirect.com/science/article/pii/S0034425716300827>
- MODIS User Guide
 - https://modis-fire.umd.edu/files/MODIS_C6_C6.1_Fire_User_Guide_1.0.pdf
- ABI ATBD
 - <https://www.star.nesdis.noaa.gov/goesr/docs/ATBD/Fire.pdf>
- ABI Fire Detection Fact Sheet (with links)
 - https://www.goes-r.gov/education/docs/fs_fire.pdf
- ABI and VIIRS ADP and AOD Documents
 - <https://www.star.nesdis.noaa.gov/smcd/spb/aq/AerosolWatch/documents.php>





Earth Observations for Informing Disaster Risk and Response to Drought, Wildfire, and Flooding in Mexico

Post-Fire Assessment

May 10, 2023

Post-Fire Impacts

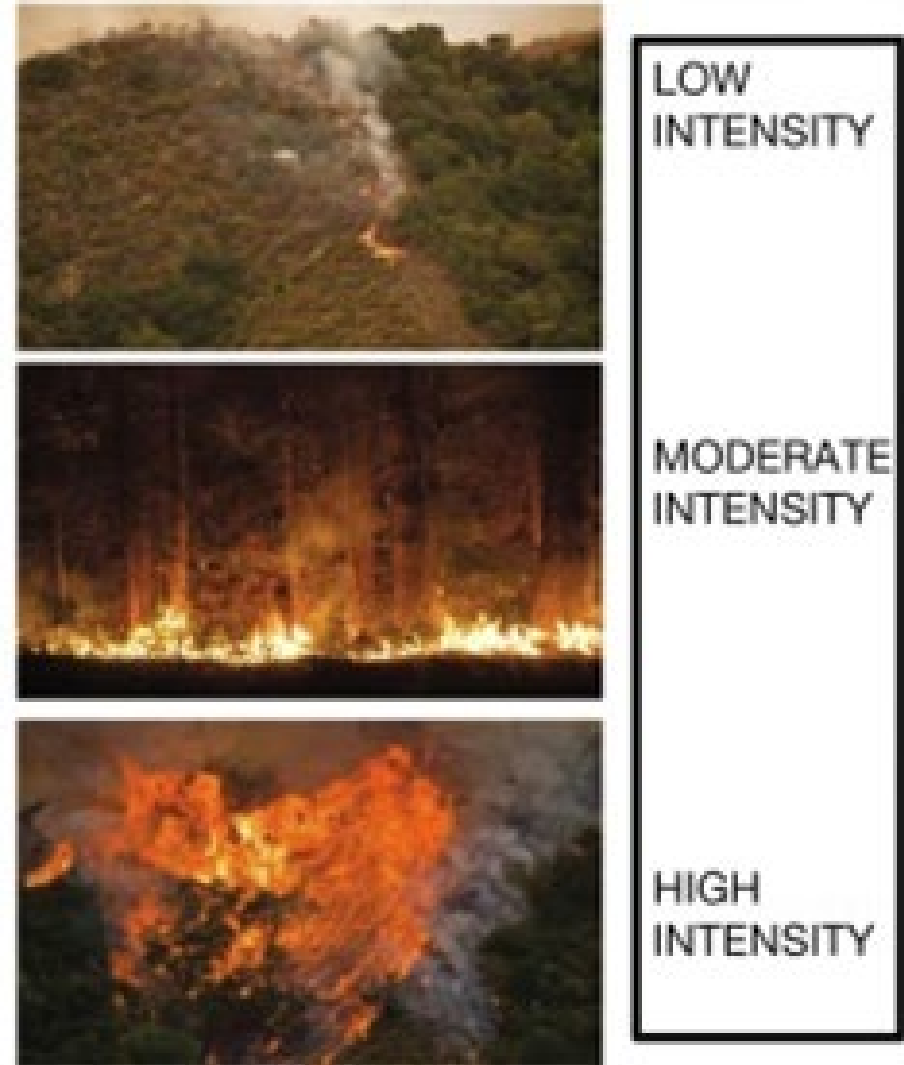
- Fires are a part of the natural forest, grassland, and tundra environment.
- Fires have long-lasting impacts to surrounding human lives and infrastructure.
- Some of the major post-fire impacts on environment are:
 - Release of carbon dioxide and soot particles in the atmosphere, thereby influencing climate
 - Change in soil chemistry and reduction in soil fertility
 - Destruction of vegetation leading to increased runoff and soil erosion
 - Influence on nutrient cycling and flow
 - Destruction of ecosystems and wildlife

<http://www.geog.leeds.ac.uk/courses/level3/geog3320/studentwork/groupd/positiveandnegative.html>



Fire Intensity

- The **amount of energy or heat release per unit time or area** and encompasses several specific types of fire intensity measures.
- Byram (1959): “The rate of energy or heat release per unit time, per unit length of fire front, regardless of its depth.”
- Fire intensity dictates burn severity.



Example scale of fire intensity.

Image Credit: [NPS.gov](https://www.nps.gov), [NIFC.gov](https://www.nifc.gov), K. Crocker, D. A. DellaSala



Burn Severity

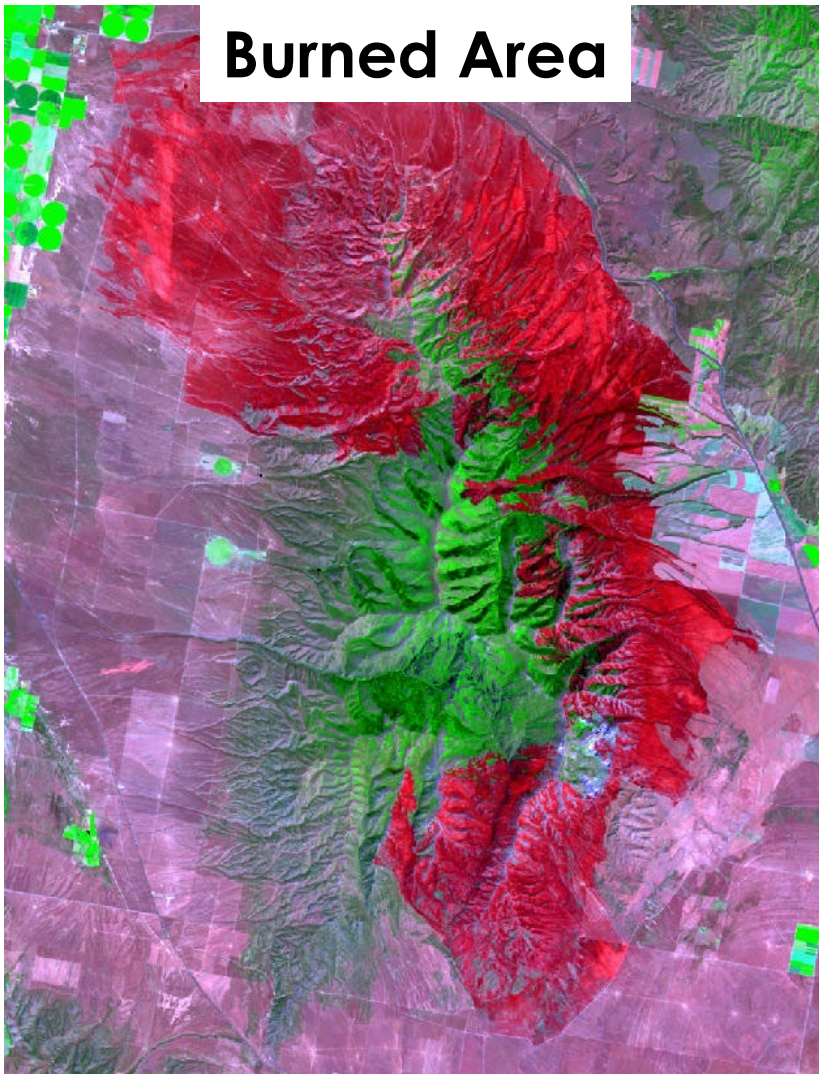
- The **effect of a fire on ecosystem properties**, often defined by the degree of mortality of vegetation
- Degree to which a site has been altered or disrupted by fire; loosely, a product of fire intensity and residence time



Example of high severity burned area.
Image Credit: USDA Forest Service Gen. Tech. Rep. RMRS-GTR-243. 2010



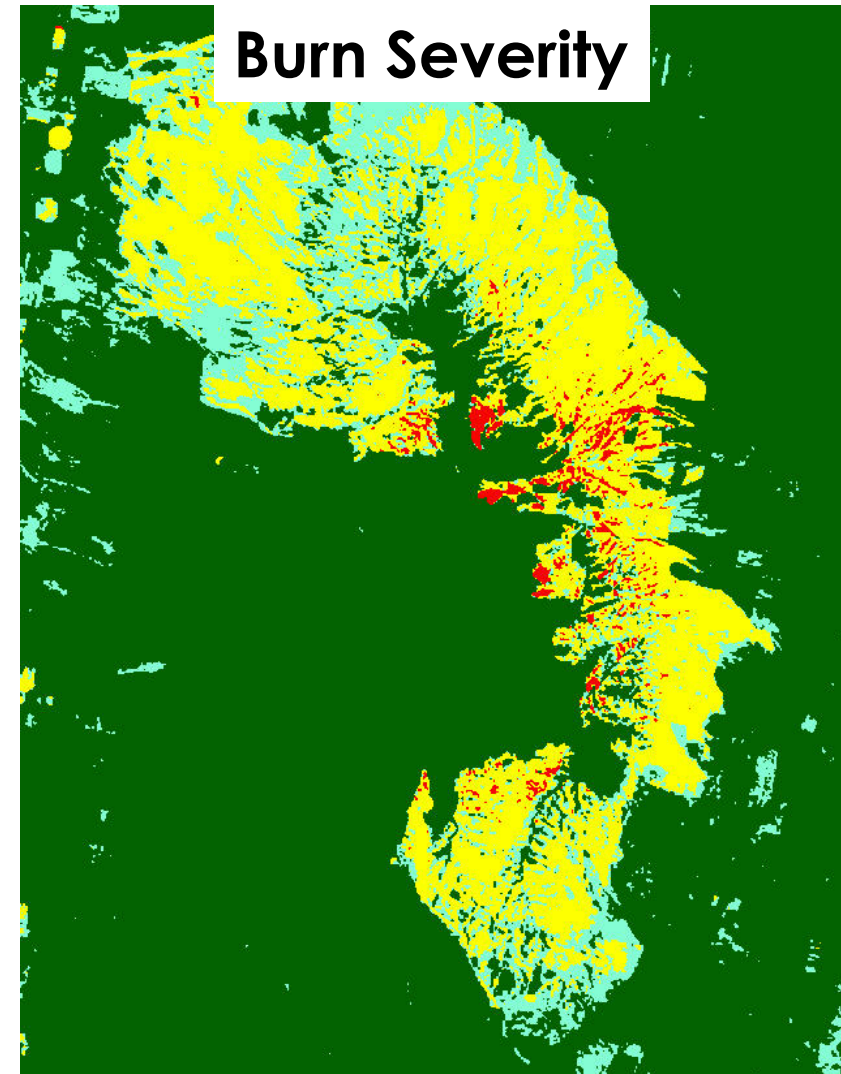
Remote Sensing Perspective: Burned Area and Burn Severity



- Burned area uses imagery to assess the extent of impacts on vegetation for a particular fire event.

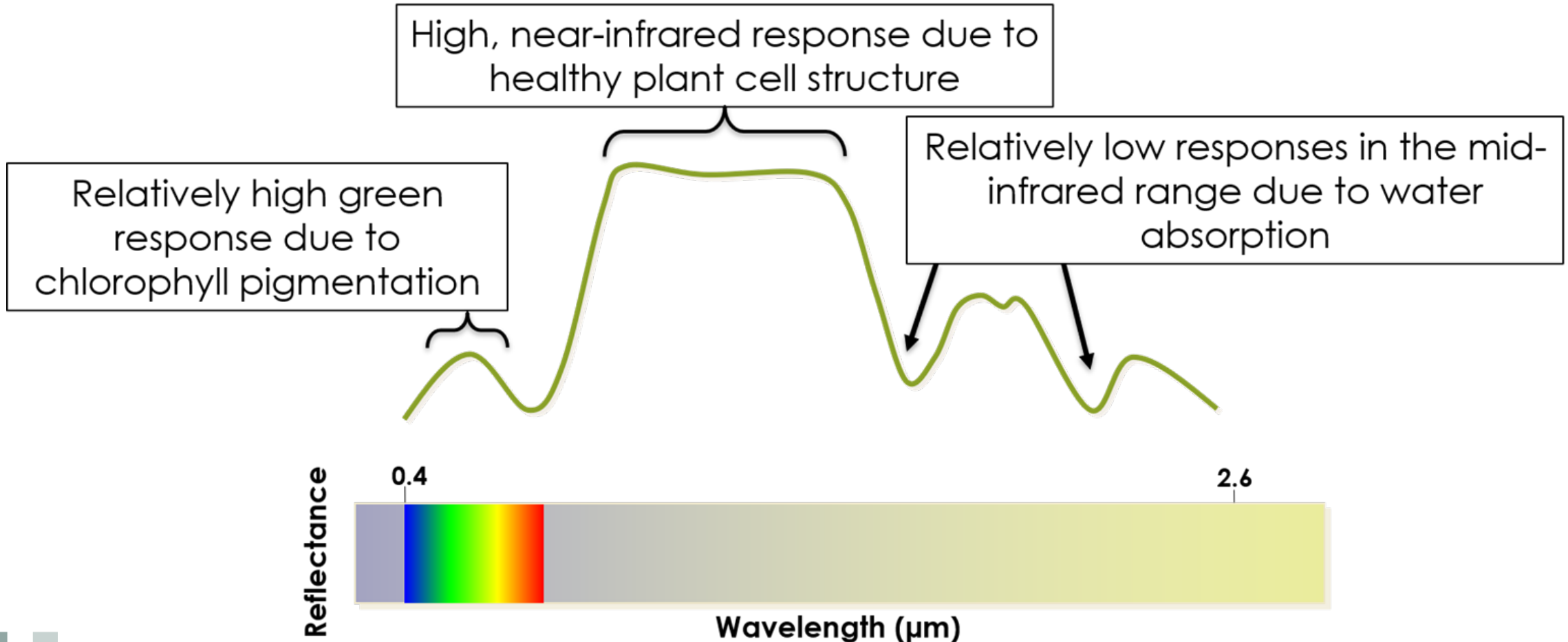


- Burn severity compares burned area information to pre-fire imagery to assess relative magnitude of burn impacts.



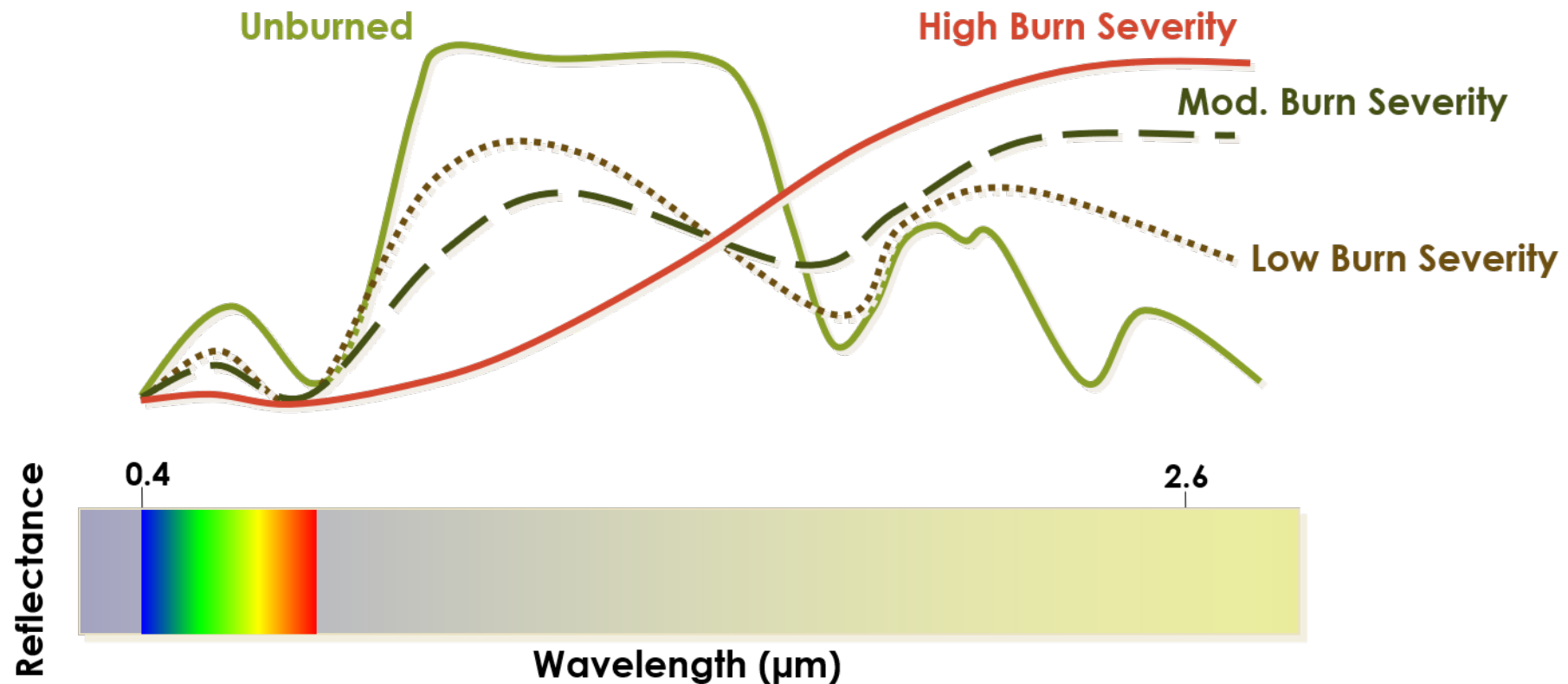
Typical Vegetation Spectral Response

Spectral Response Curve of Typical Vegetation from 0.4 to 2.6 μm



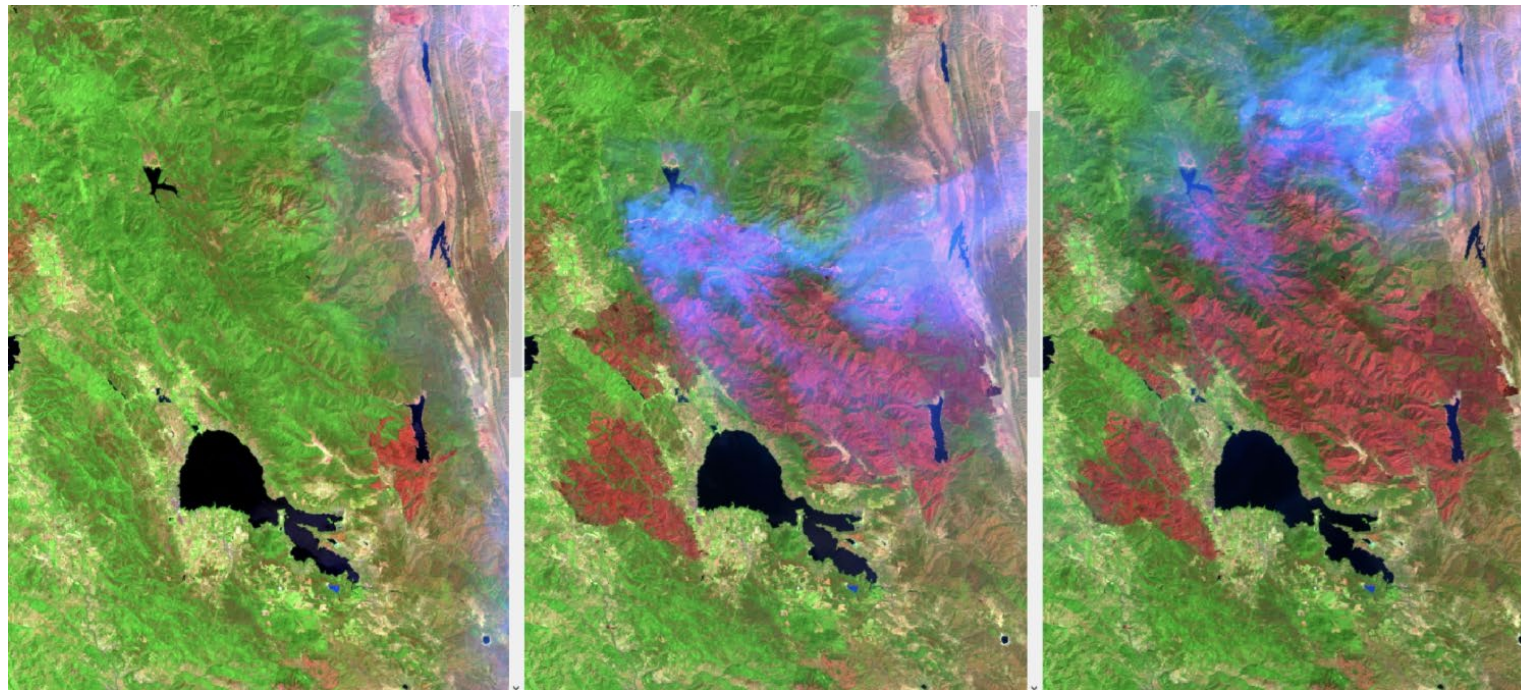
Healthy Vegetation vs. Burned Areas

Exploiting Spectral Response Curves



Burned Area: Normalized Burn Ratio (NBR)

- Used to identify burned areas
- Compare pre- and post-burn to identify burn extent and severity



July 26

Aug 11

Aug 27

Mendocino Complex Fires, 2018

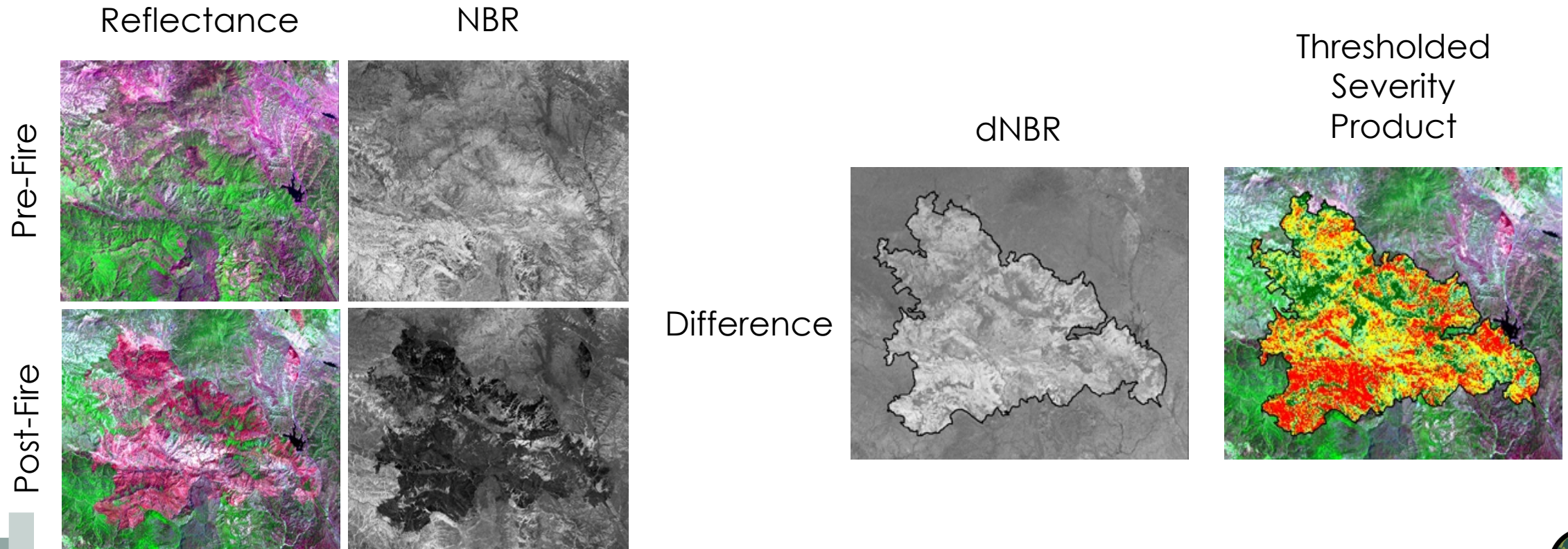
$$NBR = \frac{(NIR - SWIR)}{NIR + SWIR}$$



Burn Severity: Differenced Normalized Burn Ratio (dNBR)

- **Normalized Burn Ratio (NBR)**
- Establishes extent of burned area before and after fire event

- **Differenced Normalized Burn Ratio (dNBR)**
- Provides a comparison of pre- and post-fire conditions to determine severity
- $dNBR = \text{Pre-Fire NBR} - \text{Post-Fire NBR}$





07-20-2015



07-07-2022



Tools for Post-Fire Mapping

Fire Information for Resource Management System (FIRMS)

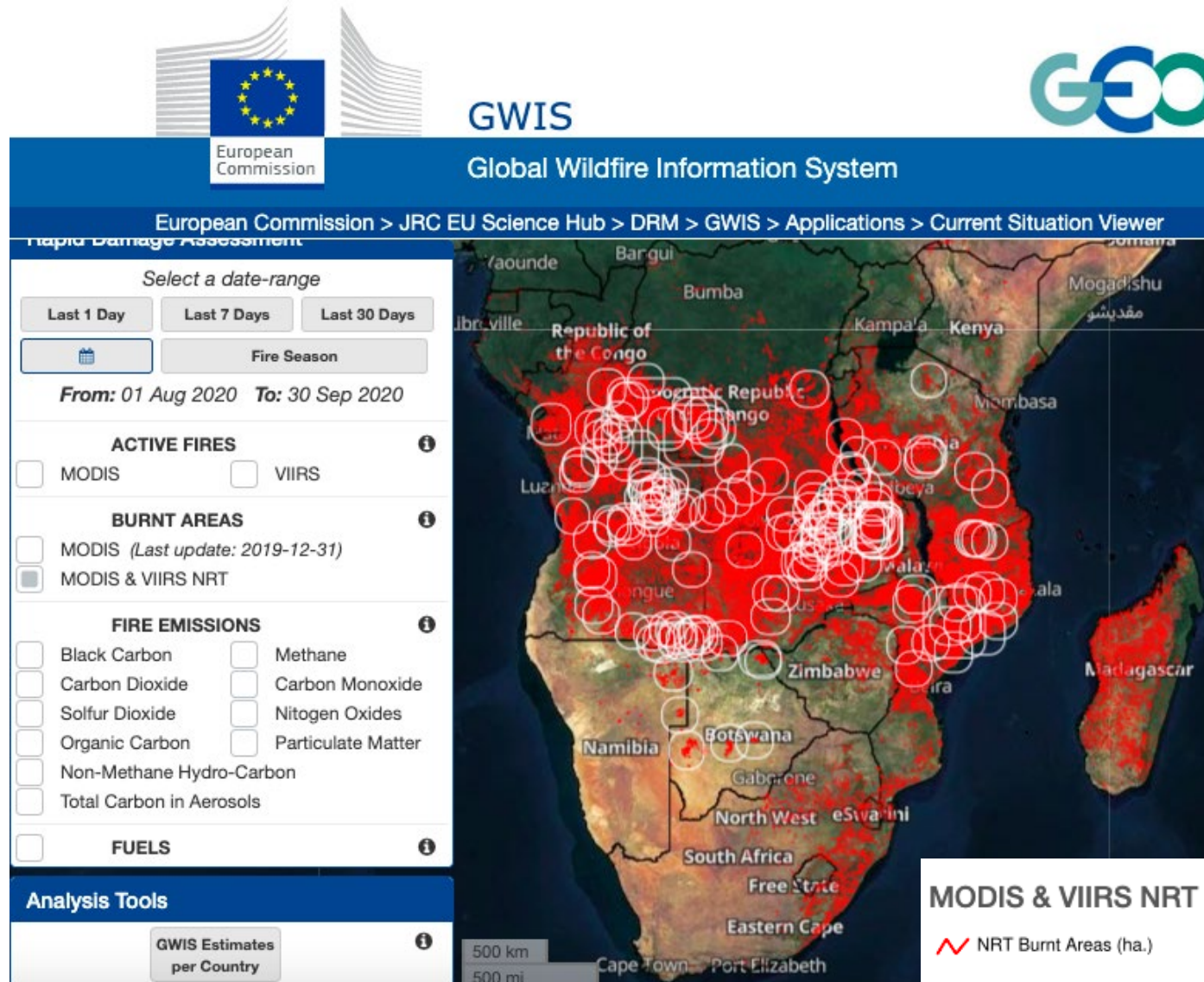
- NASA FIRMS:
 - <https://firms2.modaps.eosdis.nasa.gov/>
- Data available globally
- MODIS Burned Area Product
- Also includes VIIRS and MODIS fire detection and active fire data
- Near Real-Time (NRT) data replaced with standard science-quality data as they become available (usually with a 2-3-month lag)
- Data Download:
 - <https://firms2.modaps.eosdis.nasa.gov/download/>



MODIS burned area displayed for Northern California displaying burned areas in August and September 2020. Image Credit: [FIRMS](#)



Global Wildfire Information System (GWIS): Burnt Area



- GWIS has a variety of fire metrics available, including MODIS burnt area products and the MODIS & VIIRS Near Real-Time burnt area product (shown here).
- GWIS: https://gwis.jrc.ec.europa.eu/apps/gwis_current_situation/index.html



A zoomed view over Zambia displaying MODIS & VIIRS NRT Burned Area.

Image Credits: [GWIS](#)

NASA's Applied Remote Sensing Training Program

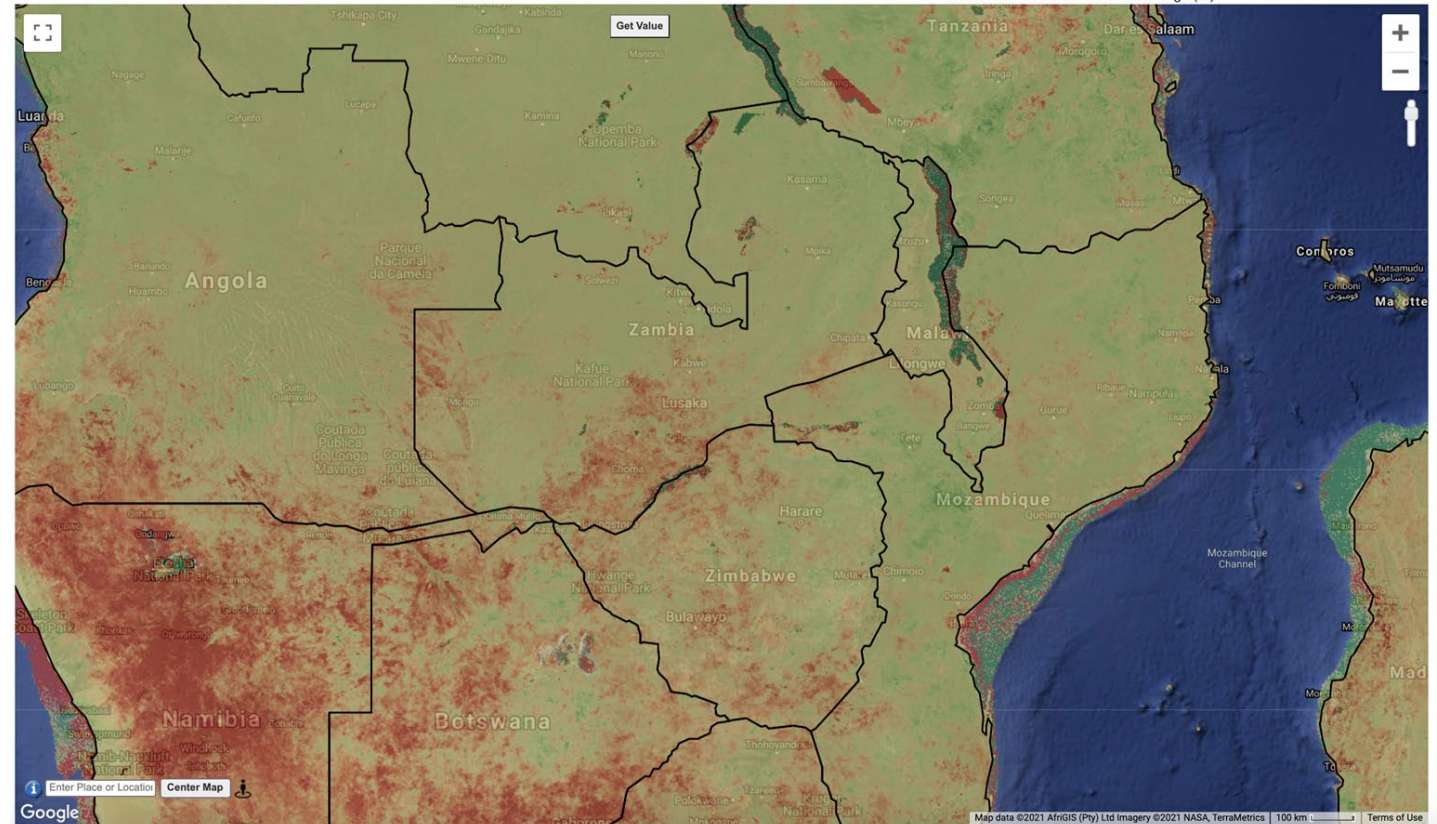
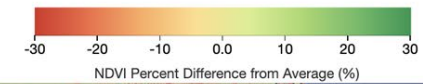


Climate Engine

<http://climateengine.org/>

- Uses Google's Earth Engine for on-demand processing of satellite and climate data via web browser
- Time series and statistical summaries
- Downloadable results in GeoTIFF format and time series results as .csv or .xlsx format
- Share map or time series results with web URL links

NDVI Percent Difference from Average (MODIS Terra/Aqua 16-Day)
2018-10-01 to 2019-04-30, Mean, vs. 2000 - 2019



Climate Engine

<http://climateengine.org/>

- Overcomes computational limitations of big data for use in real-time monitoring
- Fully customizable spatial and temporal analyses
- Comprehensive set of variables that provide early warning indicators of climate impacts such as drought, wildfire, and agricultural production

The image shows two side-by-side panels from the Climate Engine website. The left panel is titled 'Make Map' and the right panel is titled 'Make Graph'. Both panels have an 'INFO' icon in a blue circle.

Make Map Panel:

- GET MAP LAYER** (green button)
- Variable** (with help icon):
 - Type: Climate & Hydrology
 - Dataset: CHIRPS - Pentad Precipitation
 - Variable: Precipitation
- Computation Resolution (Scale)** (with help icon): 4800 m (1/20-deg)
- Processing** (with help icon):
 - Calculation: Standardized Index
- Time Period** (with help icon):
 - Period of Record: 1981-01-01 to 2021-02-26
 - Last JJA (Jun-Aug)
 - Start Date: 2020-06-01
 - End Date: 2020-08-31
 - Year Range for Historical Avg/Distribution: 1981 - 2021
- GET MAP LAYER** (green button)

Make Graph Panel:

- GET TIME SERIES** (green button)
- Time Series Calculation** (with help icon):
 - Native Time Series
 - One Variable Analysis
- Region** (with help icon):
 - Point (checked)
 - + Add another region
- Variable 1** (blue header):
 - Variable 1** (with help icon):
 - Type: Climate & Hydrology
 - Dataset: CHIRPS - Pentad Precipitation
 - Variable: Precipitation
 - Computation Resolution (Scale)** (with help icon): 4800 m (1/20-deg)
 - Statistic (over region)** (with help icon): Mean
 - Time Period** (with help icon):
 - Period of Record: 1981-01-01 to 2021-02-26
 - Last JJA (Jun-Aug)
 - Start Date: 2020-06-01
 - End Date: 2020-08-31





07-20-2015



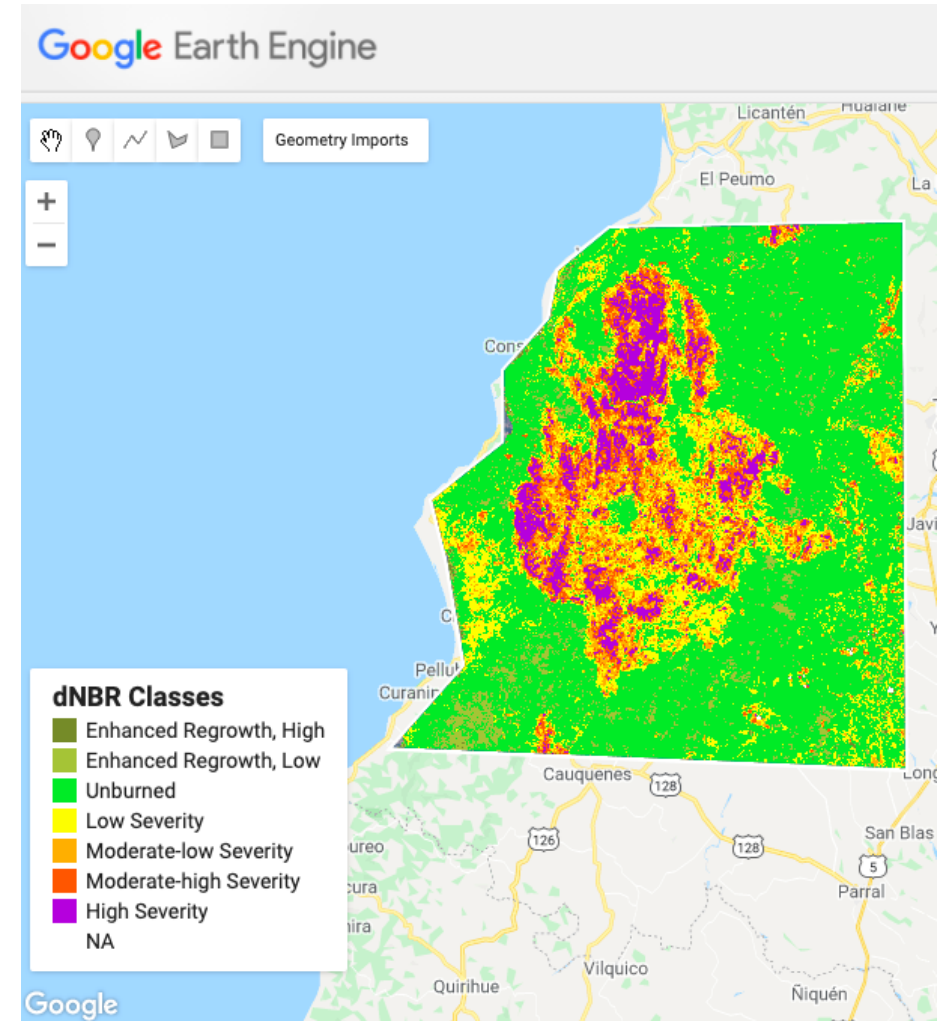
07-07-2022



Google Earth Engine for Post-Fire Mapping

Applications of GEE for Land Management: Burn Severity

- Burn severity mapping completed in GEE manipulates pre-loaded Sentinel-2 or Landsat 8 data and uses the GEE platform as a means to quality control and filter data.
- Normalized Burn Ratio (NBR) and differenced NBR (dNBR) are calculated.
- Thresholding rates the severity of wildfire burning to complete a full burn severity assessment.
- Refer to the step-by-step [UN-SPIDER burn severity in GEE training](#)



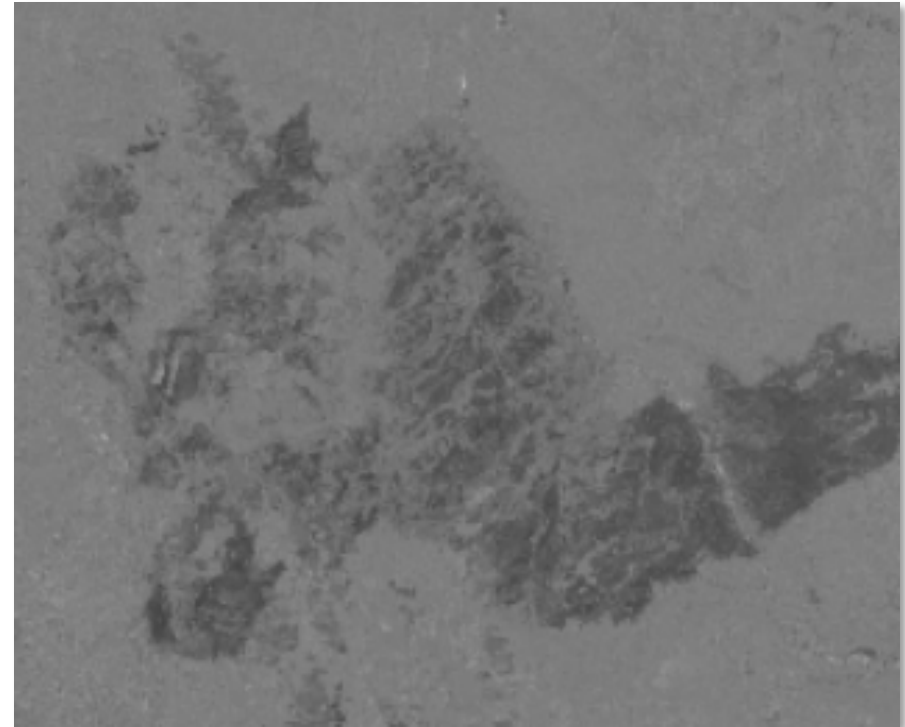
Example of burn severity mapping using Sentinel-2 data in Empeadrado, Chile in February 2017. This map was produced using the UN-SPIDER Burn Severity with GEE script. Credit: [UN-SPIDER](#)



Lytton Creek Fire In GEE

For this exercise, we will:

1. Load the pre- and post-fire Landsat images
2. Calculate the Normalized Burn Ratio (NBR) for the pre- and post-fire images
3. Calculate the differenced NBR (dNBR) for the pre- and post-fire images
4. Classify the burn severity and add a legend
5. Calculate the burned area
6. Export the burned area statistics as a .csv



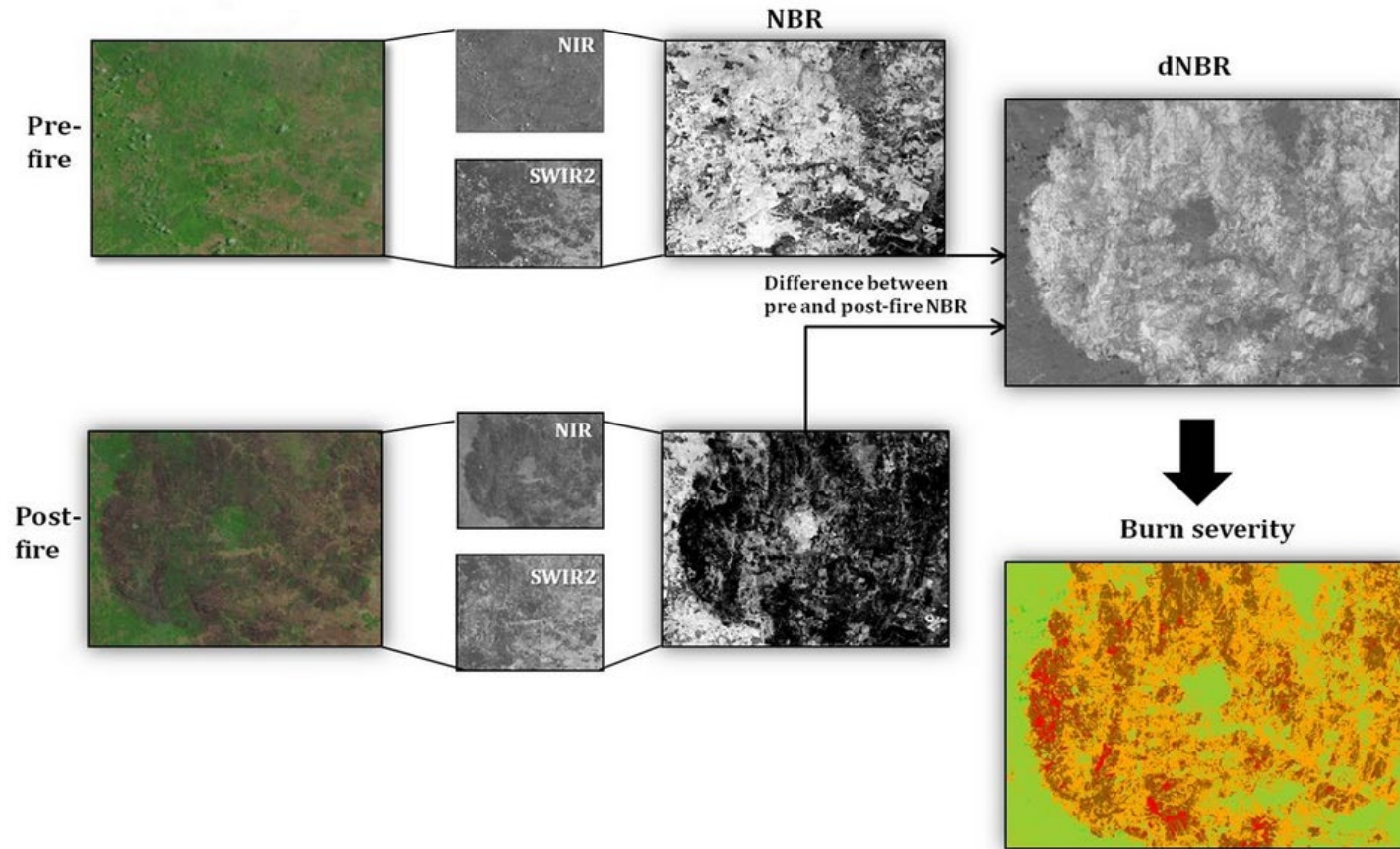
LYTTON CREEK FIRE CODE LINK:

<https://code.earthengine.google.com/bf0e7325fd0c23ff828815adada8f9eb0>



Bolivian Fires of 2020 In GEE

- Most of this code was generated via the United Nations Office for Outer Space Affairs, UN-SPIDER Knowledge Portal.
- Please refer to this website for more information: <https://un-spider.org/advisory-support/recommended-practices/recommended-practice-burn-severity>



Bolivian Fires of 2020 In GEE

For this exercise we will:

1. Select the study area
2. Select the date range
3. Select the satellite platform (Landsat 8 or Sentinel 2)
4. Identify what the user selected in steps 1-3
5. Apply a cloud and snow mask
6. Mosaic and clip images to the study area
7. Calculate the NBR for the pre- and post-fire images
8. Calculate the dNBR
9. Add all the image layers to the map
10. Calculate burned area
11. Add a legend to the map
12. Export the dNBR image
13. Export the burned area statistics as a .csv



BOLIVIAN FIRES CODE LINK:

<https://code.earthengine.google.com/25ade354b78d713f37ec8aa1b9c66952>



Summary

- Fire impacts soil chemistry, watershed dynamics, vegetation extent and type, and many other features of the landscape.
- Remote sensing can be used to assess the burned area extent, burn severity, and vegetation regrowth.
- There are multiple tools for assessing post-fire landscapes, including:
 - LANDFIRE
 - FIRMS
 - MTBS
 - GWIS
 - AppEEARS
 - And GEE, which we have featured in this session



Resources

- Google Earth Engine Beginners Cookbook: <https://developers.google.com/earth-engine/tutorials/community/beginners-cookbook>
- LANDFIRE: <https://landfire.gov/>
- Fire Information Resources Management System (FIRMS): <https://firms2.modaps.eosdis.nasa.gov/>
- Monitoring Trends in Burn Severity (MTBS): <http://www.mtbs.gov/>
- MTBS Fire Mapping Tool: <https://www.mtbs.gov/qgis-fire-mapping-tool>
- Global Wildfire Information System (GWIS): <https://gwis.jrc.ec.europa.eu/>
- Canada's Record-Breaking Heatwave: <https://airs.jpl.nasa.gov/resources/228/nasas-airs-tracks-record-breaking-heat-wave-in-pacific-northwest/>
- CNN Article about the Lytton Fire: <https://www.cnn.com/2021/07/08/americas/canada-lytton-wildfire-climate-change-indigenous-intl-cmd/index.html>
- Earth Observatory Article about the Bolivian Fire outbreak: <https://earthobservatory.nasa.gov/images/147408/fierce-fires-in-bolivia>





07-20-2015



07-07-2022



Appendix



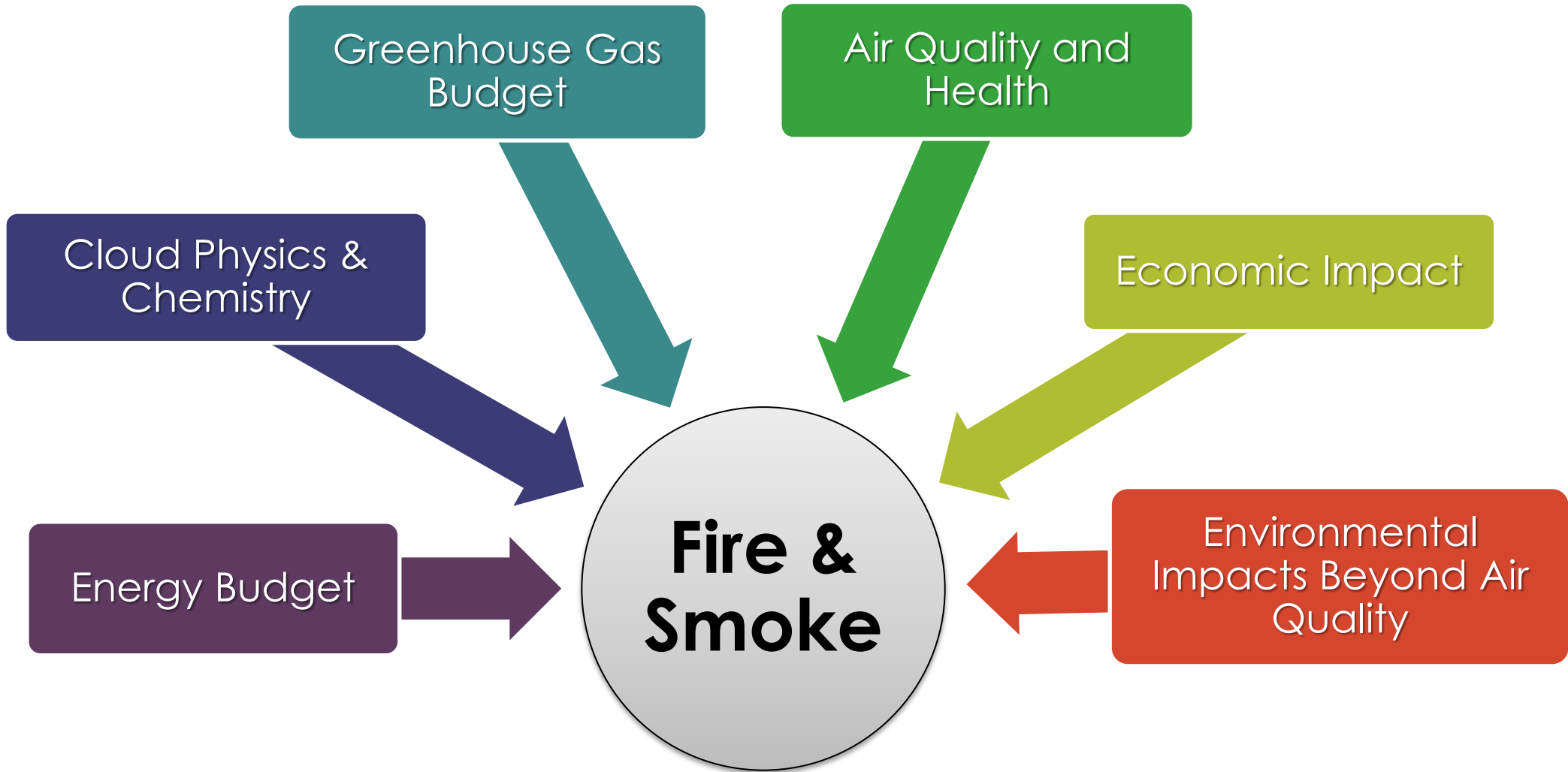
07-20-2015



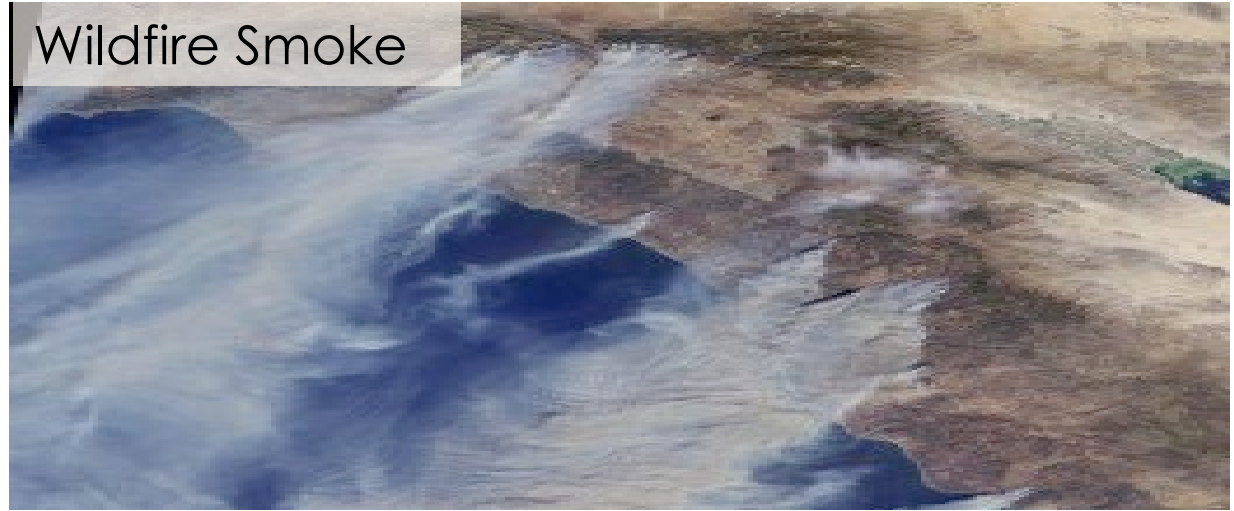
07-07-2022



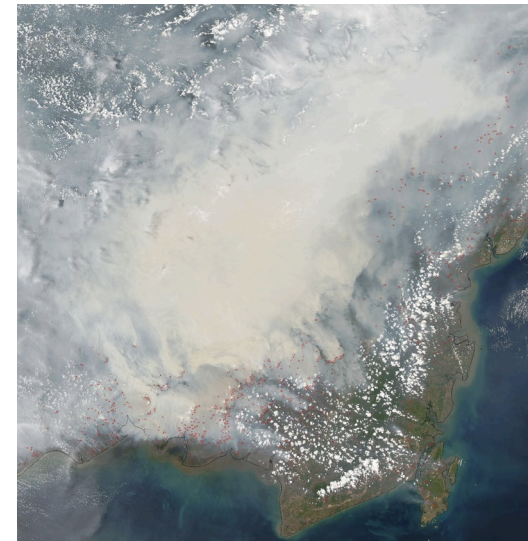
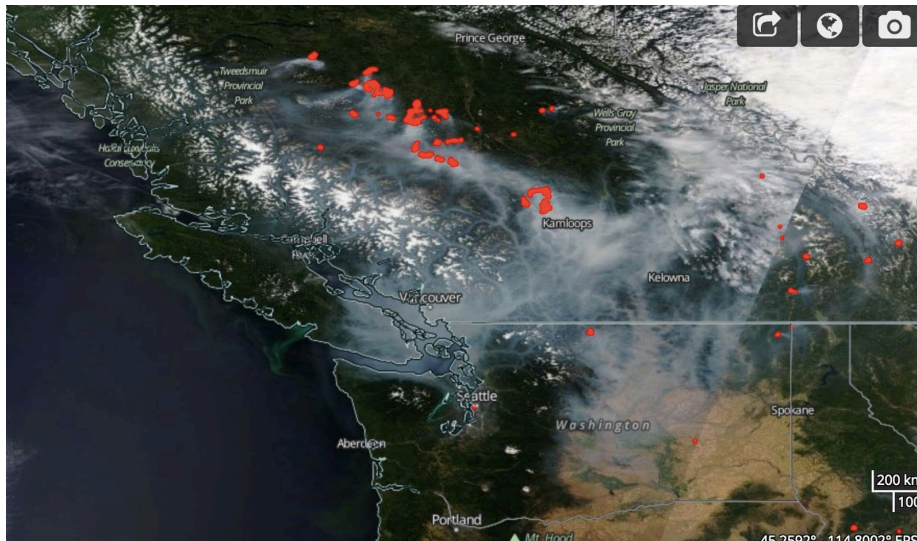
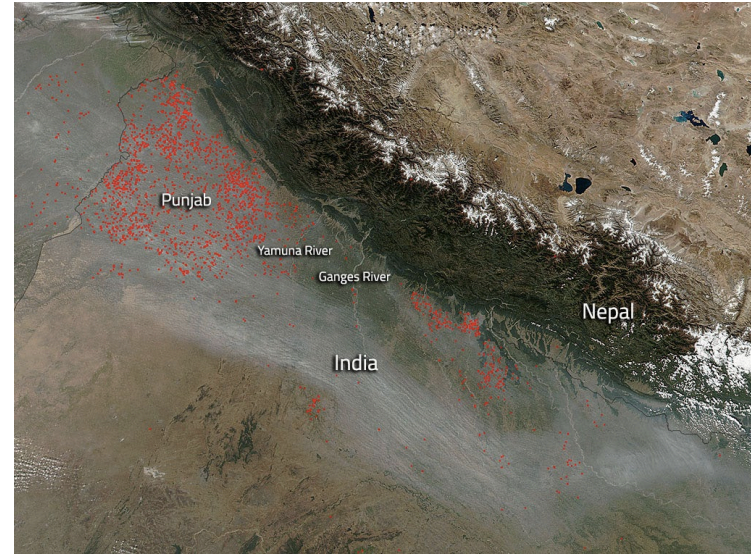
Smoke Monitoring from Space



Smoke Color and Texture in Satellite Images



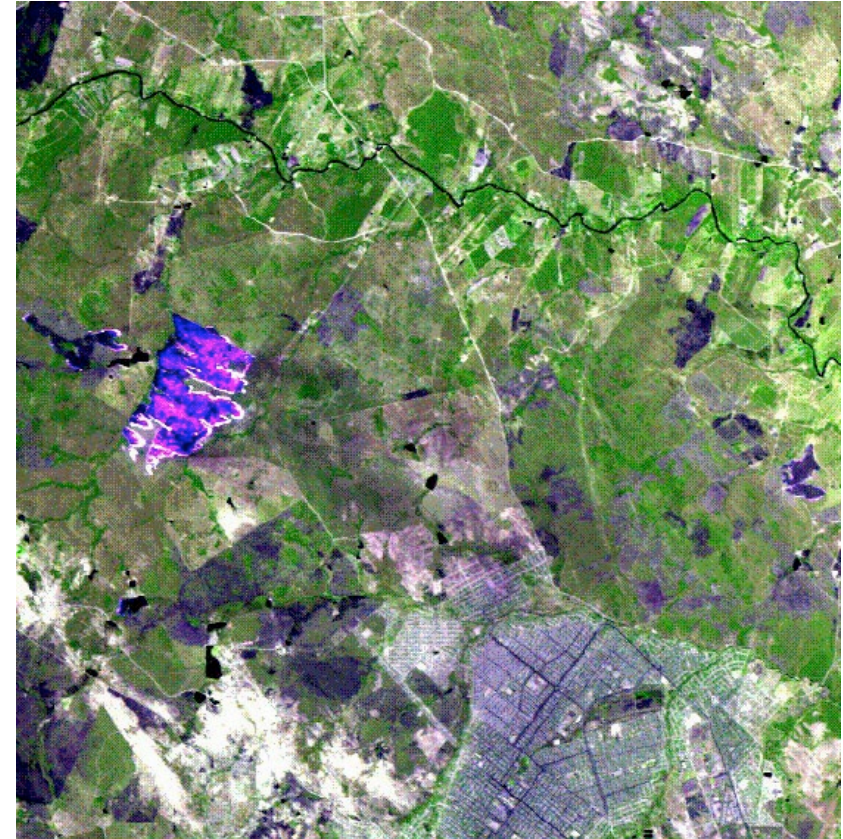
Visible Smoke from Fires



Selection of Spectral Bands for Smoke Detection



R = 0.66 μm
G = 0.55 μm
B = 0.47 μm

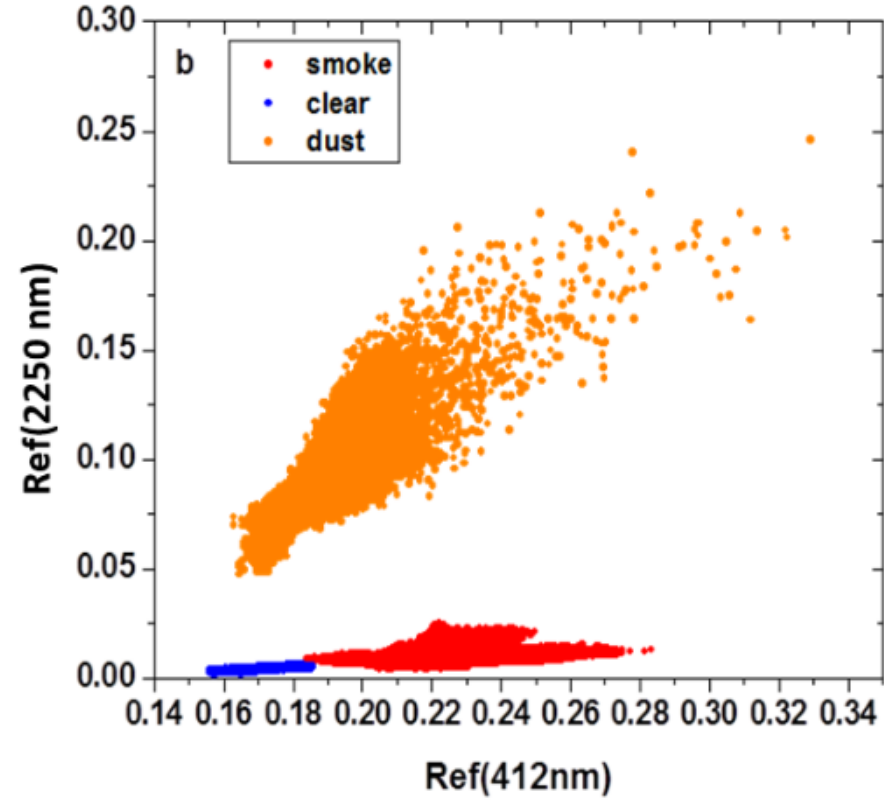
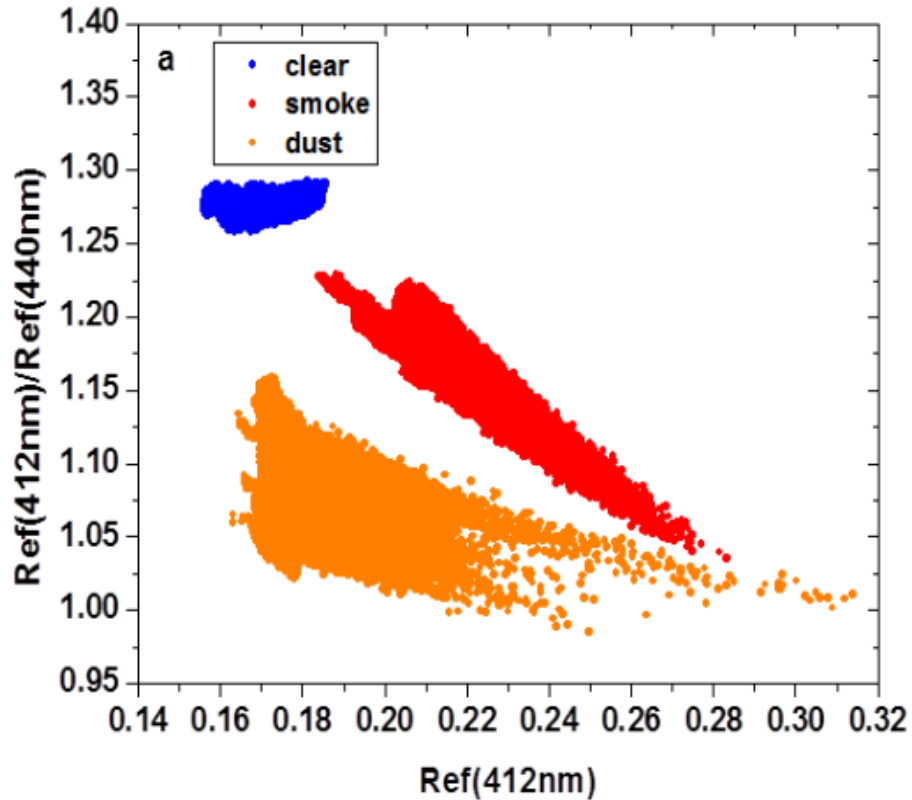


R = 1.6 μm
G = 1.2 μm
B = 2.1 μm



Smoke Detection – Spectral Signature

https://www.star.nesdis.noaa.gov/jps/documents/ATBD/ATBD_EPS_Aerosol_ADP_v1.5.pdf



Specific spectral responses of dust, smoke, clear, and cloudy parts of the atmosphere allow us to separate and classify different features in a satellite image.



How is Smoke/Dust Detected?

- Smoke/dust reduces the contrast between 412 nm and 440 nm as the absorption increases with the decreasing wavelength.

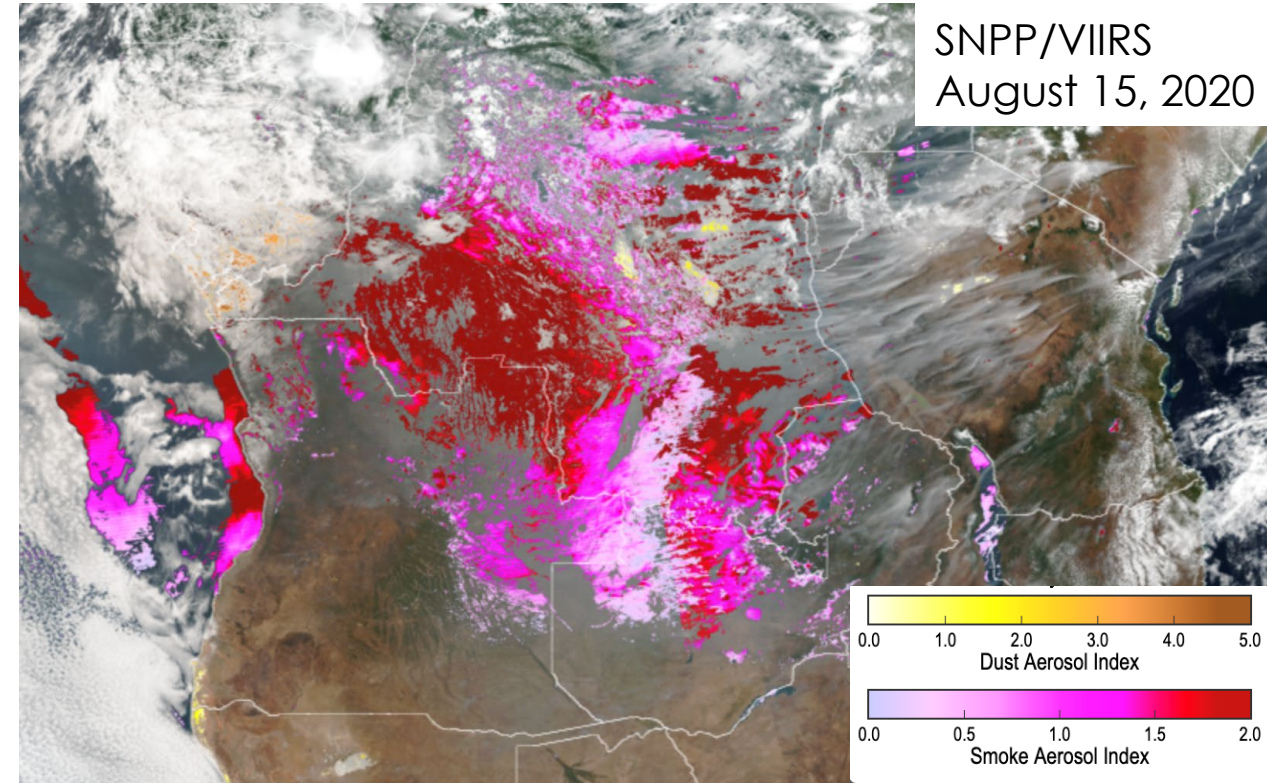
Absorbing Aerosol Index

$$AAI = -100[1 \log_{10}(R_{412}/R_{440}) - \log_{10}(R'_{412}/R'_{440})]$$

- Difference in particle size enables us to pick-out the smoke by introducing the short-wave IR channel (2.25 μm).

Dust, Smoke Discrimination Index

$$DSDI = -10[1 \log_{10}(R_{412}/R_{2250})]$$



References:

1. Algorithm Theoretical Basis Document
https://www.star.nesdis.noaa.gov/jpss/documents/ATBD/ATBD_EPS_Aerosol_ADP_v1.5.pdf
2. [Zhang et al., 2018, J. of Applied Remote Sensing](#)



NOAA's Aerosol Detection Product (ADP)

- Absorption Aerosol Index
- Dust, Smoke Discrimination Index
- 6 Type Flags: (1=Presence; 0=Absence)
 1. Volcanic Ash Flag
 2. Dust Flag
 3. Smoke Flag
 4. None/Unknown/Clear
 5. Cloud Flag
 6. Snow/Ice Flag
- Quality Flags

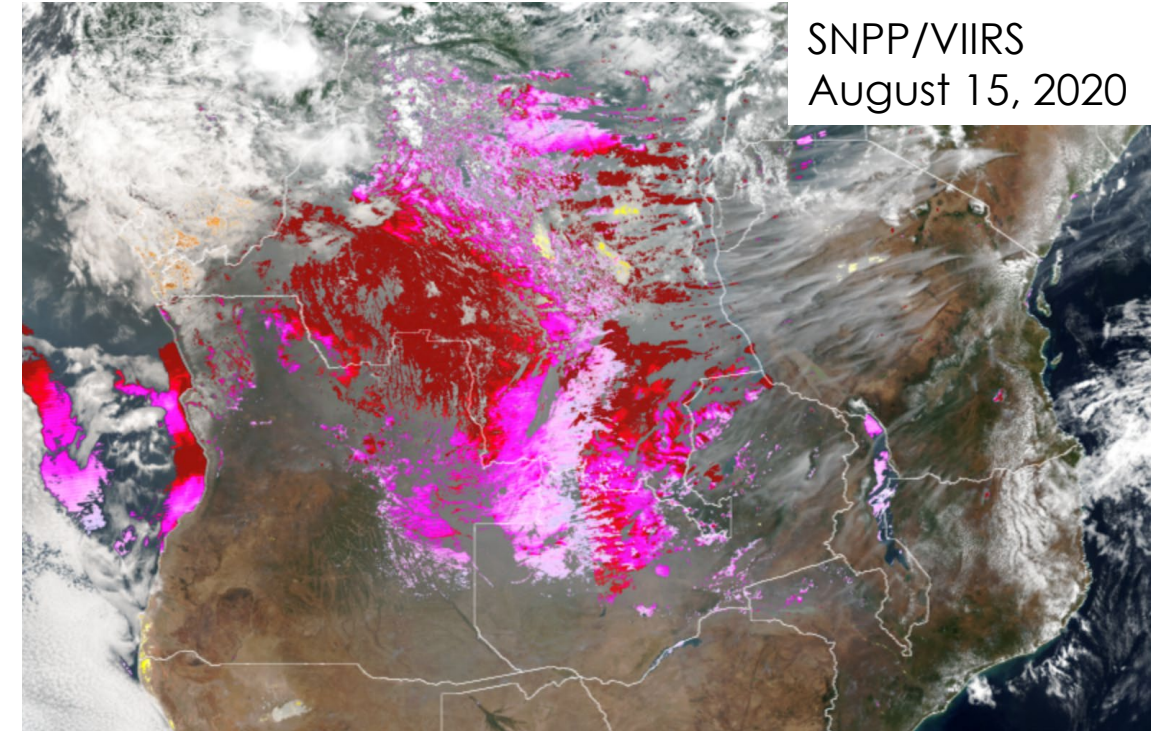


Image: <https://www.star.nesdis.noaa.gov/jpss/mapper>

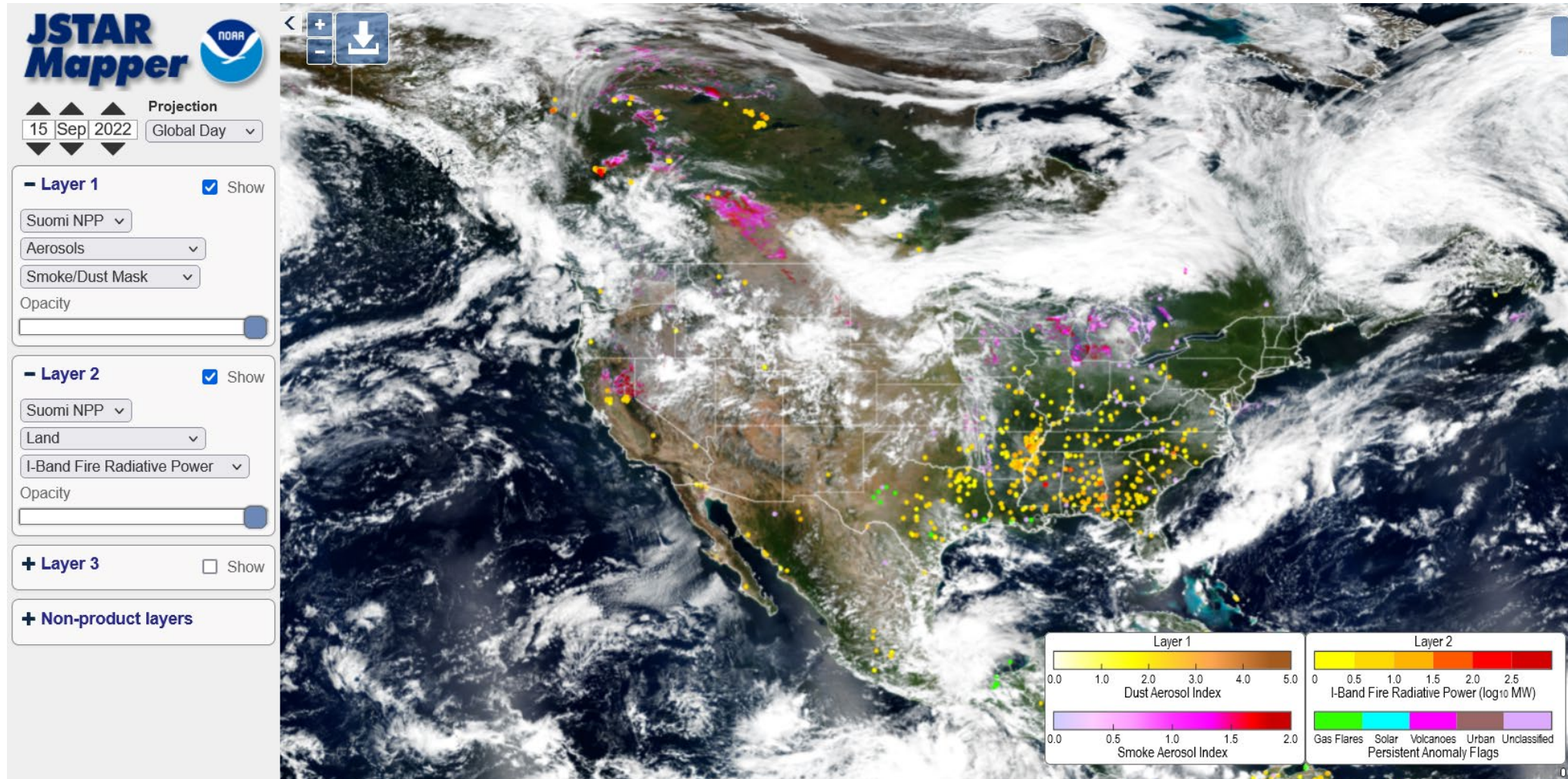
Low, medium, and high confidence for each type

File Example - **JRR-ADP_v2r1_npp_s201911010742162_e201911010743404_c201911010834210.nc**



NOAA's Mapper - NPP, NOAA20, S5P

<https://www.star.nesdis.noaa.gov/jpss/mapper>



NOAA's Aerosol Watch

<https://www.star.nesdis.noaa.gov/smcd/spb/aq/AerosolWatch/>

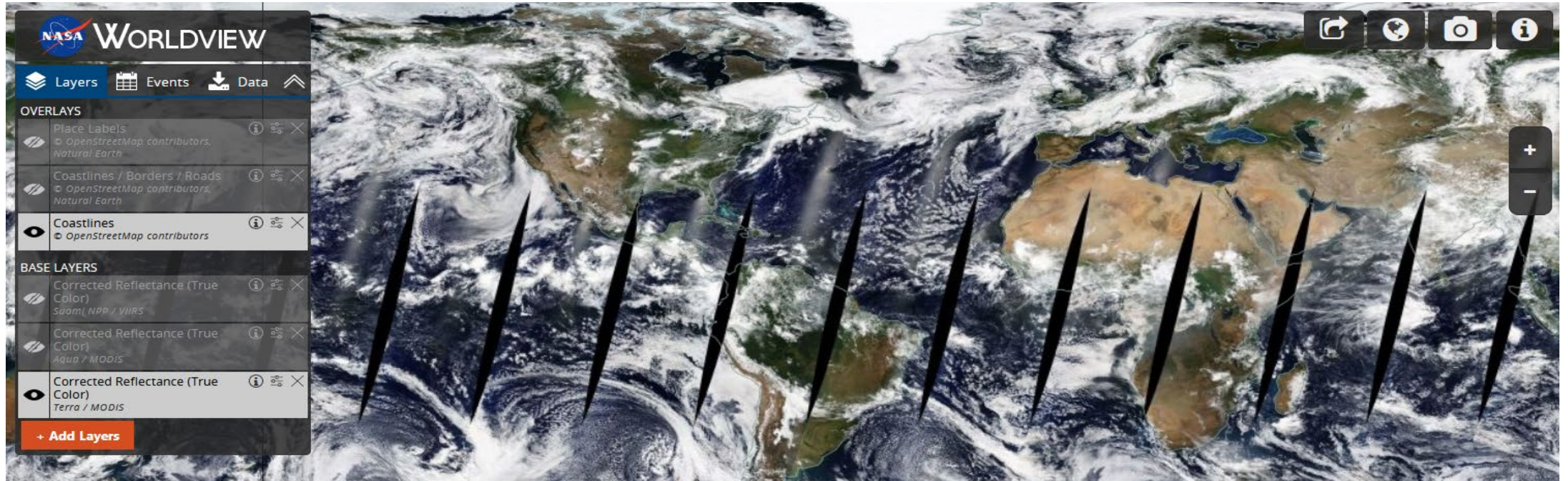
The screenshot displays the NOAA Aerosol Watch interface. At the top left, the logo reads "AerosolWatch" with the tagline "Every 10 minutes...". The main display is a satellite image of Earth, showing the Americas and surrounding oceans. A date and time selector at the top center shows "20230310" and "20230310 1650 UTC". Navigation controls (back, forward, play, stop, refresh, and share) are located above the image. On the right side, there is a "GOES-East Layers" menu with the following options: "GeoColor" (selected), "Dust RGB", "Fire RGB", "AOD", "AOD Composite", "Smoke Dust Mask", and "Fire". The "CONUS" and "Full Disk" buttons are visible at the top right. The NOAA logo is in the bottom right corner. At the bottom of the interface, there is a footer with links: "Dept. of Commerce | NOAA | NESDIS | STAR | Privacy Policy | Link & Product Disclaimers | Information Quality | Accessibility | Customer Survey".



Smoke Monitoring Tools – Worldview

NRT Data & Image Access

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



- Visible Imagery (MODIS, VIIRS)
- Fire Detection (MODIS, VIIRS)
- Aerosol Optical Depth (MODIS - 1, 3, 6, 10km, OMI, MISR)
- Aerosol Index (OMI)
- Day-Night Band (VIIRS)



NOAA's Hazard Mapping System

<https://www.ospo.noaa.gov/Products/land/hms.html#maps>

NOAA OFFICE OF SATELLITE AND PRODUCT OPERATIONS
NATIONAL ENVIRONMENTAL SATELLITE, DATA, AND INFORMATION SERVICE

Organization Services Products Operations

To go directly to the latest HMS analysis (map section), please bookmark:
<https://www.ospo.noaa.gov/Products/land/hms.html#maps>

Hazard Mapping System Fire and Smoke Product

Current Analysis

Analysis for day 03/12/2023 last updated Mar 12, 2023 15:49:15 GMT

Smoke:
Light
Medium
Heavy

Fire points:
<10 MW
10-49 MW
50-149 MW
150-349 MW
>=350 MW

Leaflet | Powered by Esri | Tiles © Esri — Source: Esri, DeLorme, NAVTEQ, USGS, Intermap, IPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2012

Disclaimer: The location of the fires displayed may be slightly offset from the actual fire location due to satellite resolution. [Read more](#)

[Fire KML](#) | [Smoke KML](#) | [Smoke Text Product](#) | [Archive](#)

WFS Data Formats:
[HMS Fire Detection](#) | [HMS Smoke Detection](#)

[Download Historical Fire/Smoke Data](#)

For questions or comments please contact SSDFireTeam@noaa.gov

Product Information

[EXPAND ALL \(+\)](#) | [COLLAPSE ALL \(-\)](#)

GOES ACTIVE FIRE DETECTION DATA

NOAA's Geostationary Operational Environmental Satellite (GOES) provides 5min observations over the Conterminous U.S. (CONUS)

[More](#)

VIIRS ACTIVE FIRE DETECTION DATA

The NOAA/NASA Visible Infrared Imaging Radiometer Suite (VIIRS) was launched onboard the S-NPP polar satellite on October/2011,

[More](#)

MODIS ACTIVE FIRE DETECTION DATA

NASA's Earth Observing System (EOS) Moderate Resolution Imaging Spectroradiometer (MODIS) can be found onboard the

[More](#)

AVHRR ACTIVE FIRE DETECTION DATA

NOAA's Advanced Very High Resolution Radiometer (AVHRR) has, for nearly four decades, been an integral part of the NOAA suite

[More](#)

HAZARD MAPPING SYSTEM

NOAA/NESDIS Satellite Analysis Branch's Hazard Mapping System (HMS) was first implemented in 2002 in response to high demand

[More](#)

VIIRS FIRE DATA STATISTICS

Cumulative fire data statistics are calculated daily for all 50 U.S. states using science-quality data from a combination of

[More](#)

HMS SMOKE DATA STATISTICS

Cumulative smoke data annual statistics are derived by aggregating daily Hazard Mapping System (HMS) smoke polygons

[More](#)



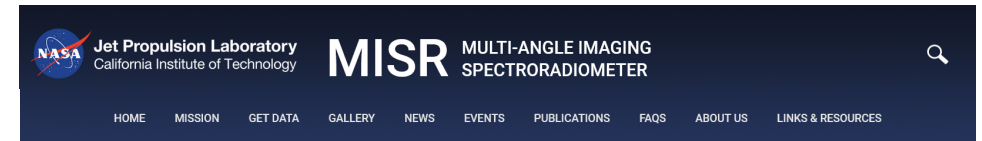
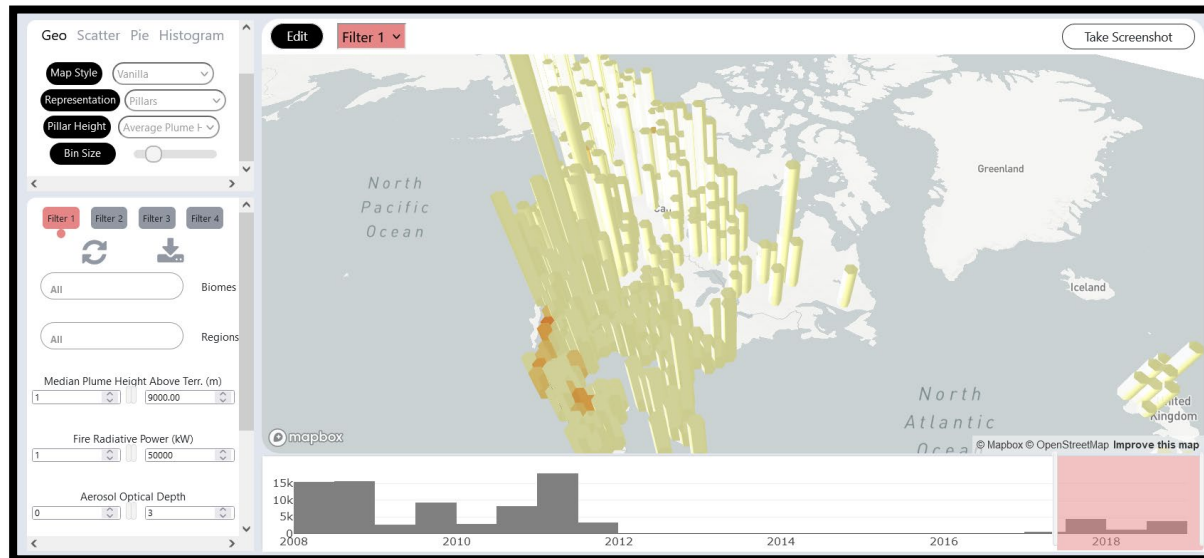


Aerosol Layer Altitude

Smoke Monitoring Tools – MISR Plume Height

<https://misr.jpl.nasa.gov/get-data/misr-plume-height-project-2/>

- Stereo height algorithm reports plume top heights and wind vectors.



GET DATA

MISR Plume Height Project 2

Access MISR Plume Height Project data [here](#).

The MISR Plume Height Project is a publicly available database of wildfire smoke plume heights generated by the [MISR Interactive Explorer \(MINX\)](#) software, produced over many years thanks to the contributions of many MISR science team members and student interns. As of this writing, the database includes all digitizable smoke plumes observed by MISR around the world for 2008 – 2011 as well as the summers (June, July, August) of 2017 and 2018. These data have been used to validate plume rise in models and other satellite-derived datasets, as well as to study the dynamics of individual fires and climatology of fire in the environment.

Please note MISR Plume Height Project data is now accessed via the MISR Enhanced Research and Lookup Interface (MERLIN), hosted by the NASA Atmospheric Science Data Center. This online tool provides new search, visualization and analysis capabilities beyond those that were available through the old MISR interface. Users are also able to download individual plume files as before.

Please visit <https://l0dup05.larc.nasa.gov/merlin/merlin#> to access the MERLIN tool.

A user guide for MERLIN is also available at https://asdc.larc.nasa.gov/documents/misr/guide/MERLIN_User_Guide.pdf.

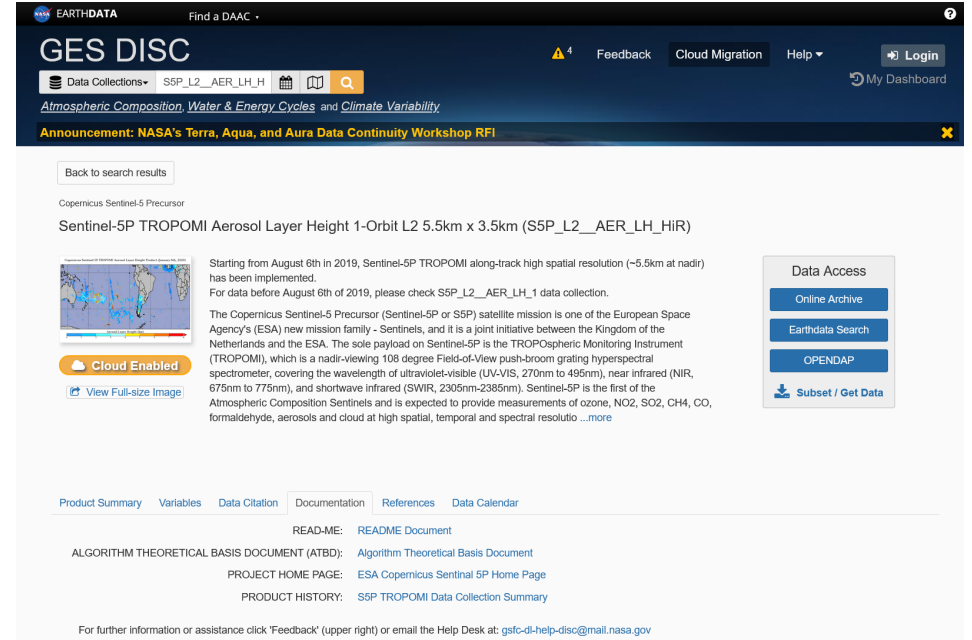
MERLIN visualization tool



TROPOMI Aerosol Layer Height

https://disc.gsfc.nasa.gov/datasets/S5P_L2_AER_LH_HiR_2/summary?keywords=S5P_L2_AER_LH_HiR_2

- Cloud-free conditions
 - Dust, smoke, volcanic ash
- Optimal Estimation algorithm assumes a single layer (50 hPa) with constant extinction and scattering properties
 - Assumption impacts AOD more than height retrieval
- Reports the height as the mid-pressure and mid-altitude of the layer at pixel resolution: 5.5 km x 3.5 km
- Also reports the AOD at 760 nm and error estimates
- Tends to be biased low over bright surfaces



GES DISC

Atmospheric Composition, Water & Energy Cycles and Climate Variability

Announcement: NASA's Terra, Aqua, and Aura Data Continuity Workshop RFI

Back to search results

Copernicus Sentinel-5 Precursor

Sentinel-5P TROPOMI Aerosol Layer Height 1-Orbit L2 5.5km x 3.5km (S5P_L2_AER_LH_HiR)

Starting from August 6th in 2019, Sentinel-5P TROPOMI along-track high spatial resolution (~5.5km at nadir) has been implemented. For data before August 6th of 2019, please check S5P_L2_AER_LH_1 data collection.

The Copernicus Sentinel-5 Precursor (Sentinel-5P or S5P) satellite mission is one of the European Space Agency's (ESA) new mission family - Sentinels, and it is a joint initiative between the Kingdom of the Netherlands and the ESA. The sole payload on Sentinel-5P is the TROPospheric Monitoring Instrument (TROPOMI), which is a nadir-viewing 108 degree Field-of-View push-broom grating hyperspectral spectrometer, covering the wavelength of ultraviolet-visible (UV-VIS, 270nm to 496nm), near infrared (NIR, 675nm to 775nm), and shortwave infrared (SWIR, 2305nm-2385nm). Sentinel-5P is the first of the Atmospheric Composition Sentinels and is expected to provide measurements of ozone, NO₂, SO₂, CH₄, CO, formaldehyde, aerosols and cloud at high spatial, temporal and spectral resolution ...more

Cloud Enabled

View Full-size Image

Data Access

Online Archive

Earthdata Search

OPENDAP

Subset / Get Data

Product Summary Variables Data Citation Documentation References Data Calendar

READ-ME: README Document

ALGORITHM THEORETICAL BASIS DOCUMENT (ATBD): Algorithm Theoretical Basis Document

PROJECT HOME PAGE: ESA Copernicus Sentinel 5P Home Page

PRODUCT HISTORY: S5P TROPOMI Data Collection Summary

For further information or assistance click 'Feedback' (upper right) or email the Help Desk at: gsfc-dl-help-disc@mail.nasa.gov

ATBD:

<https://sentinel.esa.int/documents/247904/2476257/Sentinel-5P-TROPOMI-ATBD-Aerosol-Height>



MAIAC Smoke Injection Height

<https://lpdaac.usgs.gov/products/mcd19a2v061/>

- Derive smoke plume heights using thermal contrast of smoke for pixels:
 - AOD at 470 nm must be > 0.8
 - Must have smoke-free ground brightness temperature
 - Brightness temperature difference between the ground and smoke must be > 0
- Limitations: Dissipating smoke, large areas of thick smoke where background can't be characterized, and small fires
- Thermal technique represents an effective height
- Good agreement with MISR MINX, $\sim 450\text{m}$ lower on average, $\sim 200\text{m}$ low with respect to LiDAR (CALIOP)



Lyapustin et al., 2020, IEEE

<https://ieeexplore.ieee.org/document/8834856>

MAIAC User Guide:

https://lpdaac.usgs.gov/documents/1500/MCD19_User_Guide_V61.pdf

