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

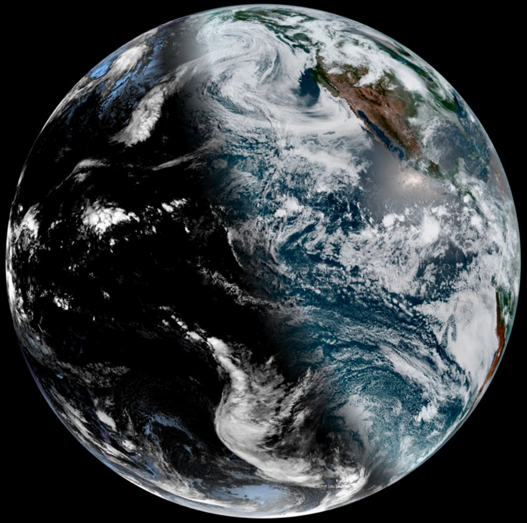
Active Fire Conditions

May 10, 2023

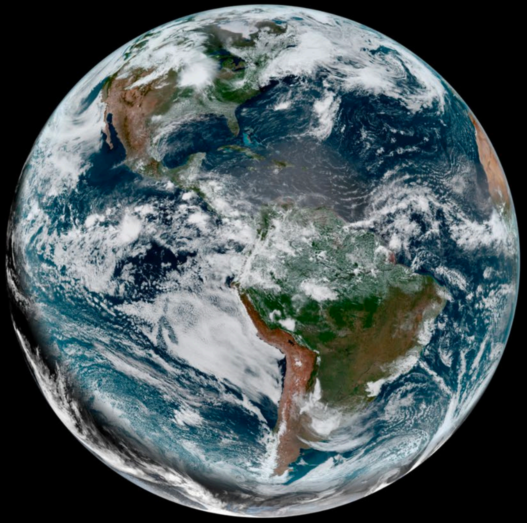
Several Satellite Instruments Observe Fire Detections

	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

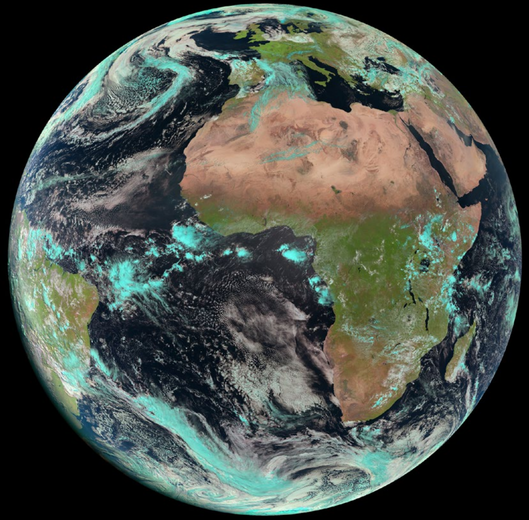
Geostationary Observations of Active Fires



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

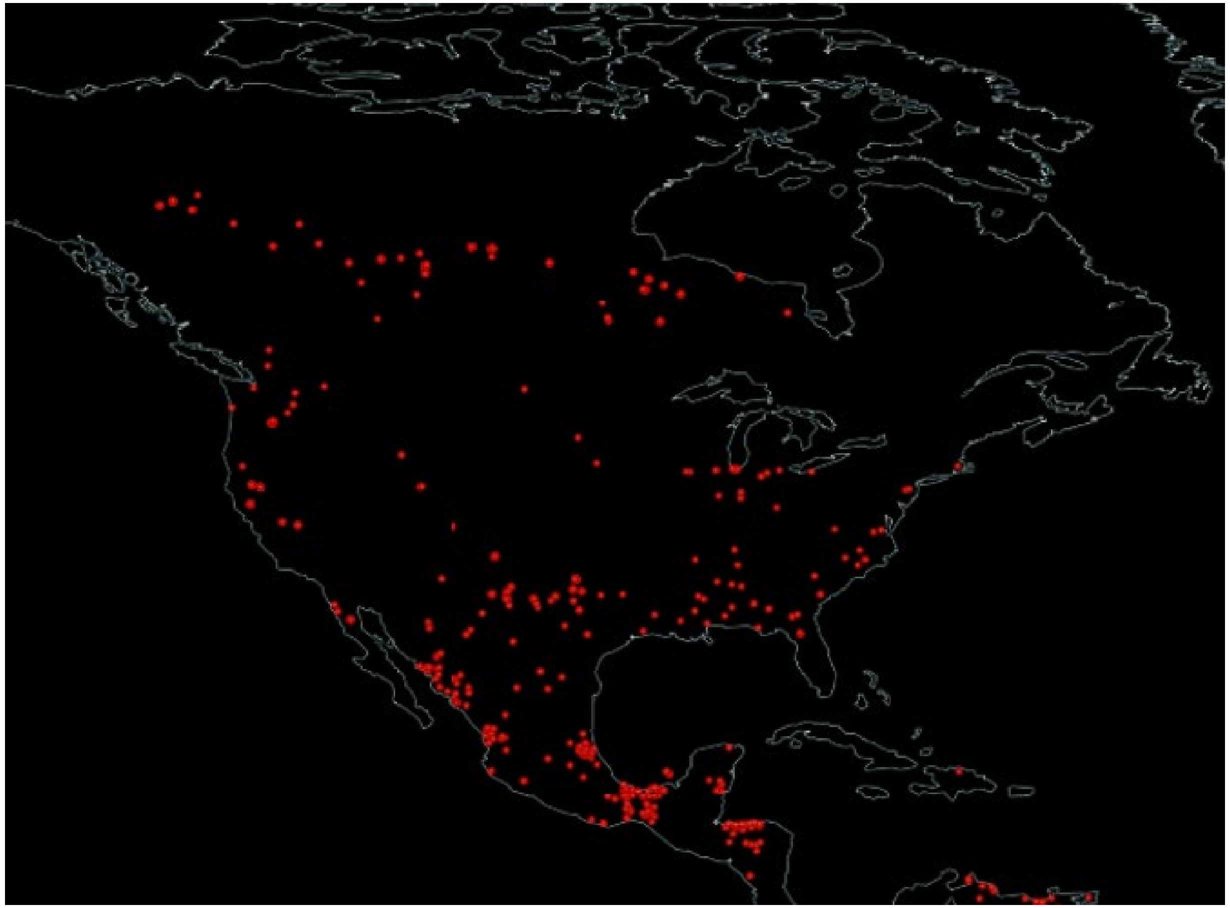
Fire Detections
NOAA-20 VIIRS
9/1/2022 – 9/31/2022

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 ~4 μm and ~11 μm
  - 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

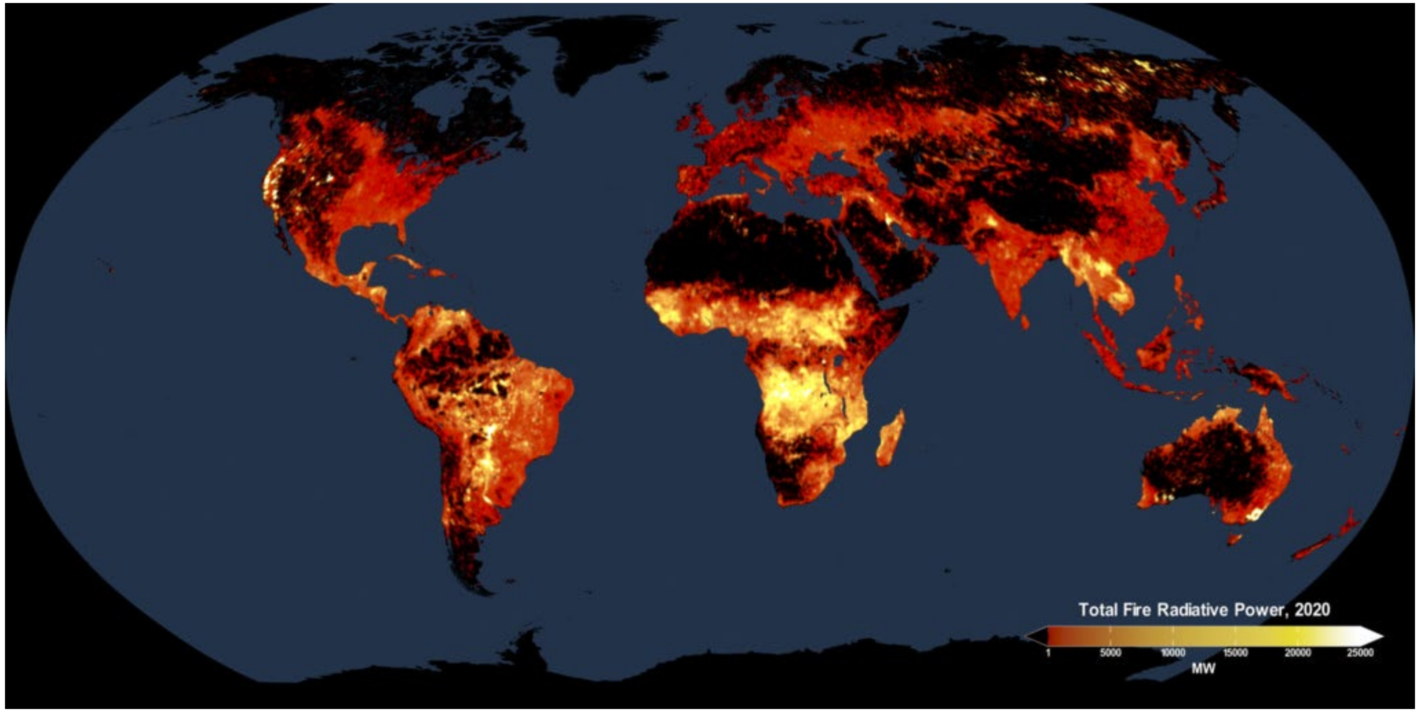


VIIRS Fire Detections, NASA Worldview

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 Sun glint Water Discrimination
I2	0.846 – 0.885 μm	
I3	1.58 – 1.64 μm	

Candidate Fire Pixel Identification

- $BT_4 > BT_{4S}$ OR $\Delta BT_{45} > 25K$ (daytime)
- $BT4 > 295K$ OR $\Delta BT45 > 10K$ (nighttime)

BT_{4S} = 501 x 501 background BT window

$BT_{45} = BT_4 - BT_5$

Data Artifacts:
Pixel Saturation
South Atlantic Magnetic Anomaly (SAMA)

Validation

- Error rate: 0 – 1.2% (China)

Schroeder et al., 2014
https://www.sciencedirect.com/science/article/pii/S0034425713004483

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 > ΔBT*

BT4* and ΔBT* are dynamic thresholds calculated using a ~301x30 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

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.

Schmidt et al., 2012 (ATBD)
https://www.star.nesdis.noaa.gov/goesr/docs/ATBD/Fire.pdf

ABI – File Contents

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

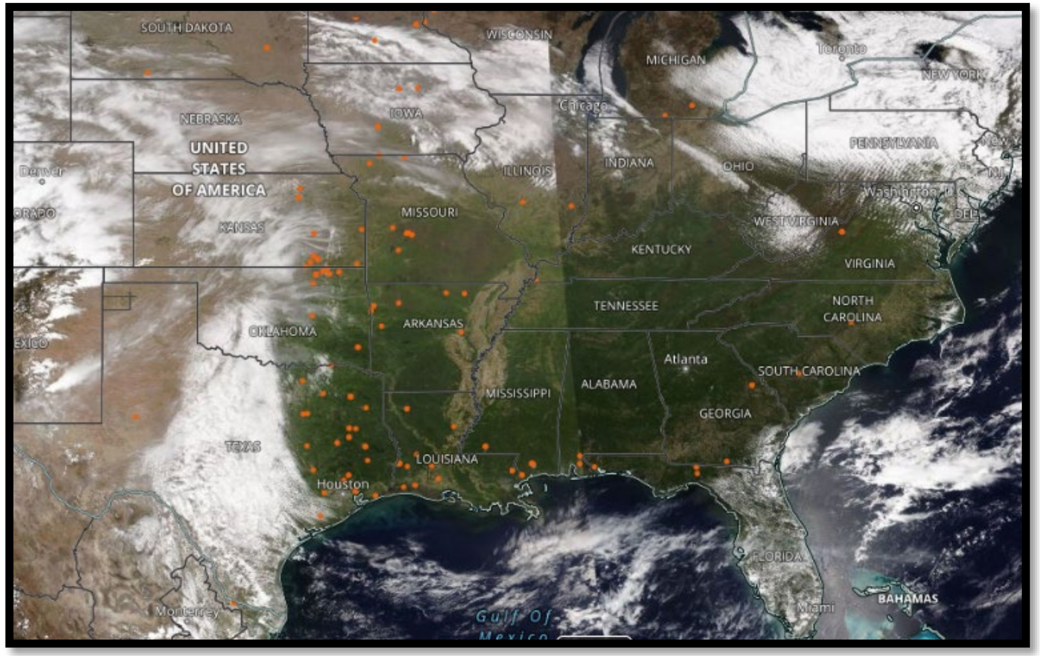
Attribute	Dimension	
Fire Mask Codes	Grid (xsize, ysize)	Codes indicating final disposition of pixels (including fire flags if so determined)
Subpixel Fire Size	Grid (xsize, ysize)	Subpixel fire size for processed fires (codes 10 and 30) (km^2) This is set to -9 if the subpixel fire temperature is less 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	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 h. Total number of fires

GOES-R ABI WF_ABBA FDCA QA Flages	
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.

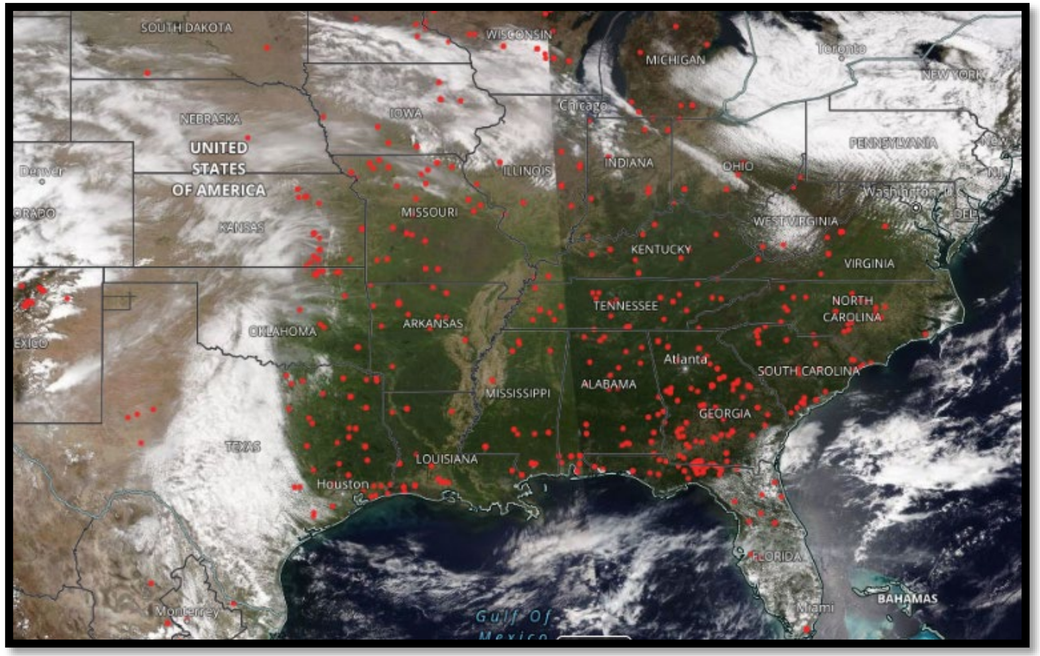
VIIRS Detects 3–4x More Fires Than MODIS

Daytime Active Fire Detections – 4/27/2022

MODIS - Aqua

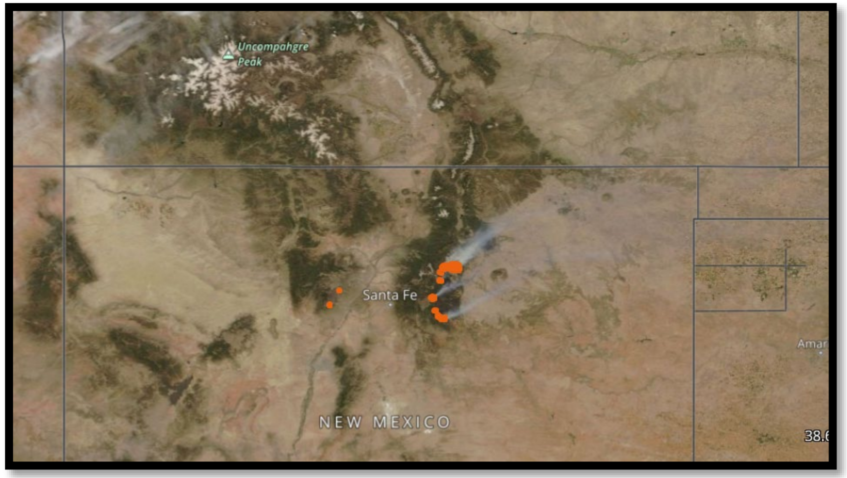


VIIRS

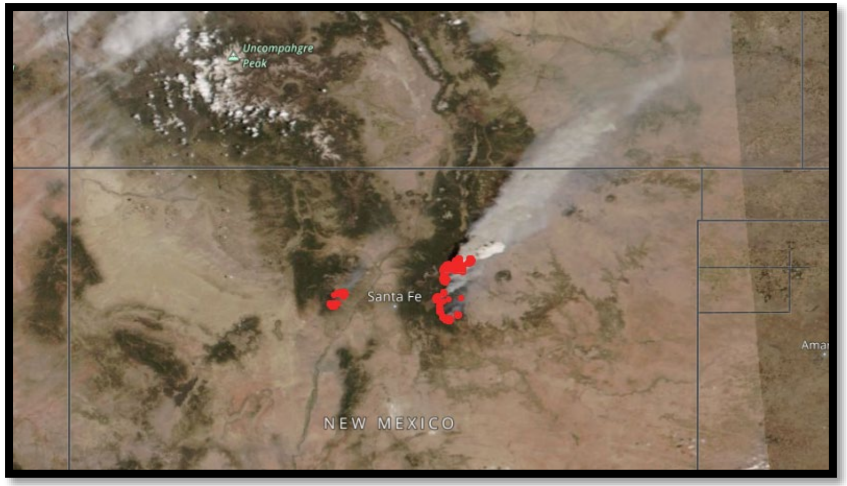


One Fire, Multiple Views – May 10, 2022

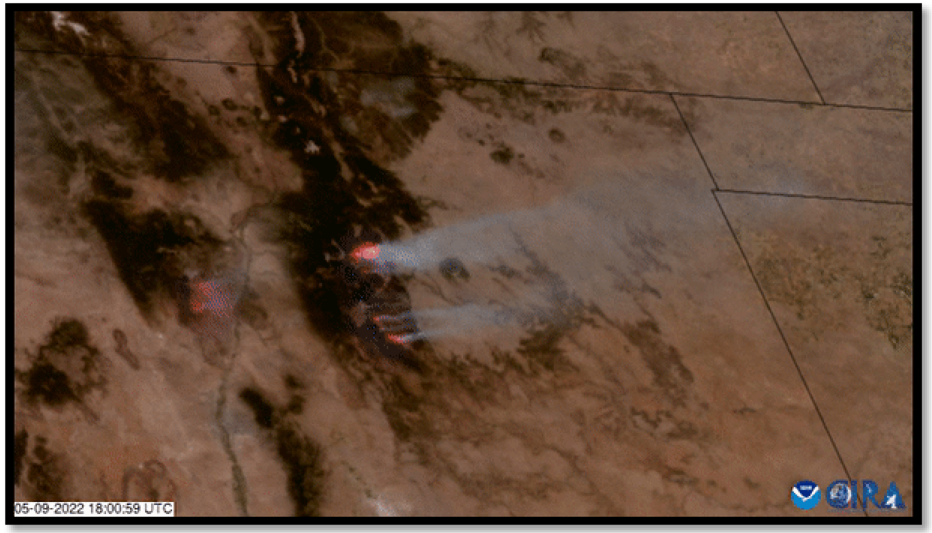
MODIS - Terra



VIIRS



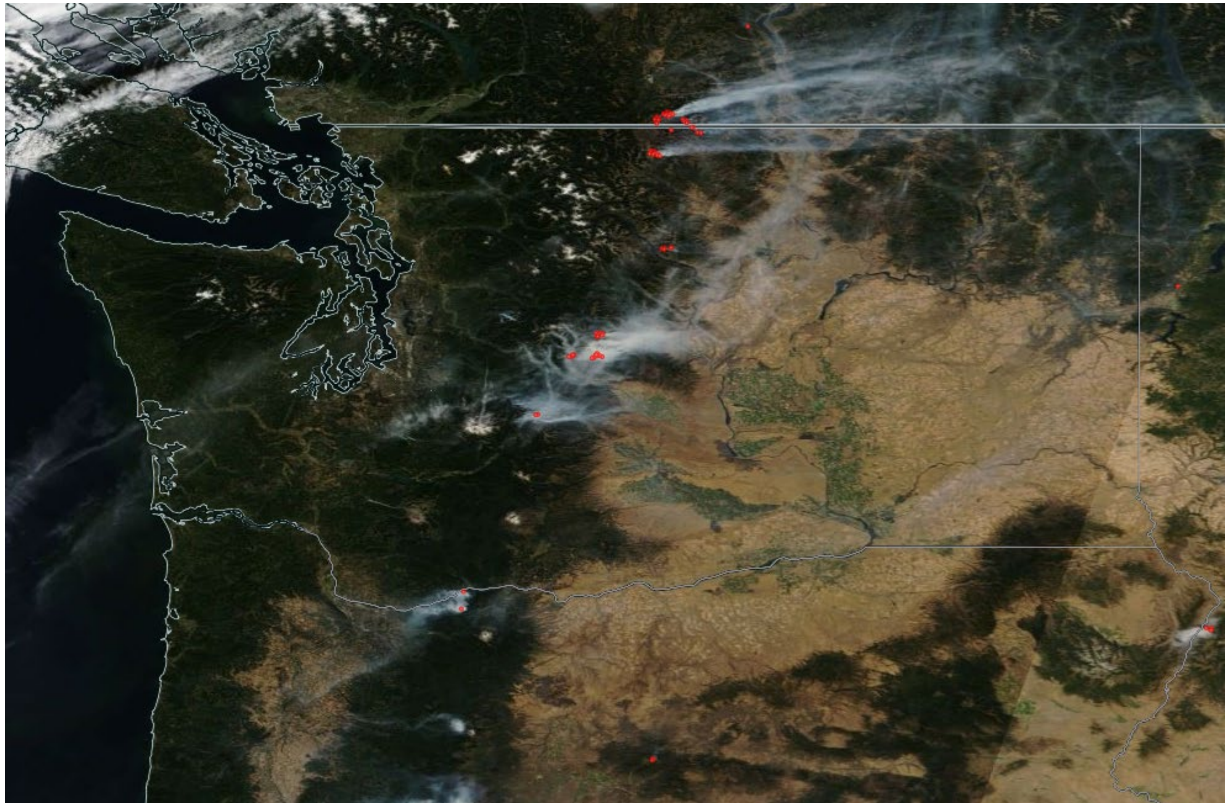
ABI



https://rammb.cira.colostate.edu/ramsdis/online/loop.asp?data_folder=loop_of_the_day/goes-16/20220510000000&number_of_images_to_display=400&loop_speed_ms=50

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

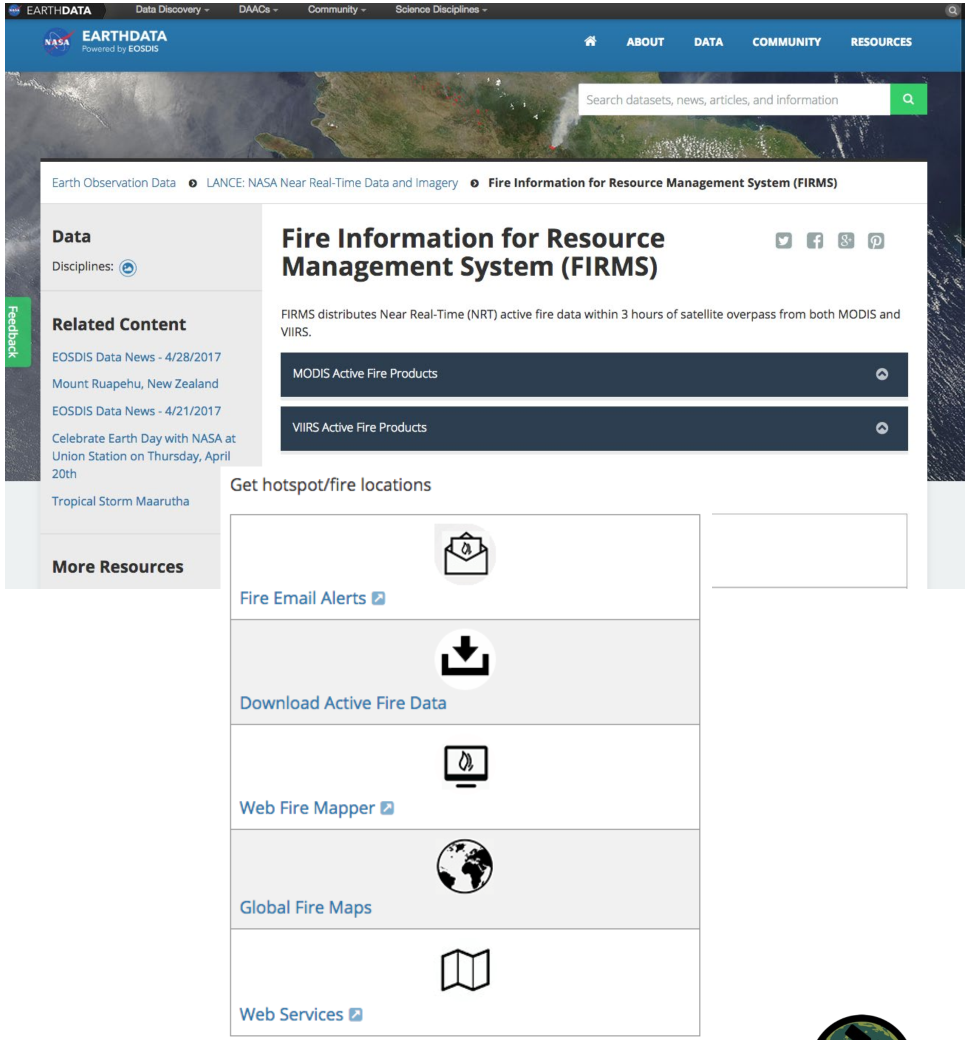


MODIS Fire Detections, NASA Worldview

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)]



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: http://viirsfire.geog.umd.edu

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

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

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Post-Fire Assessment

May 10, 2023

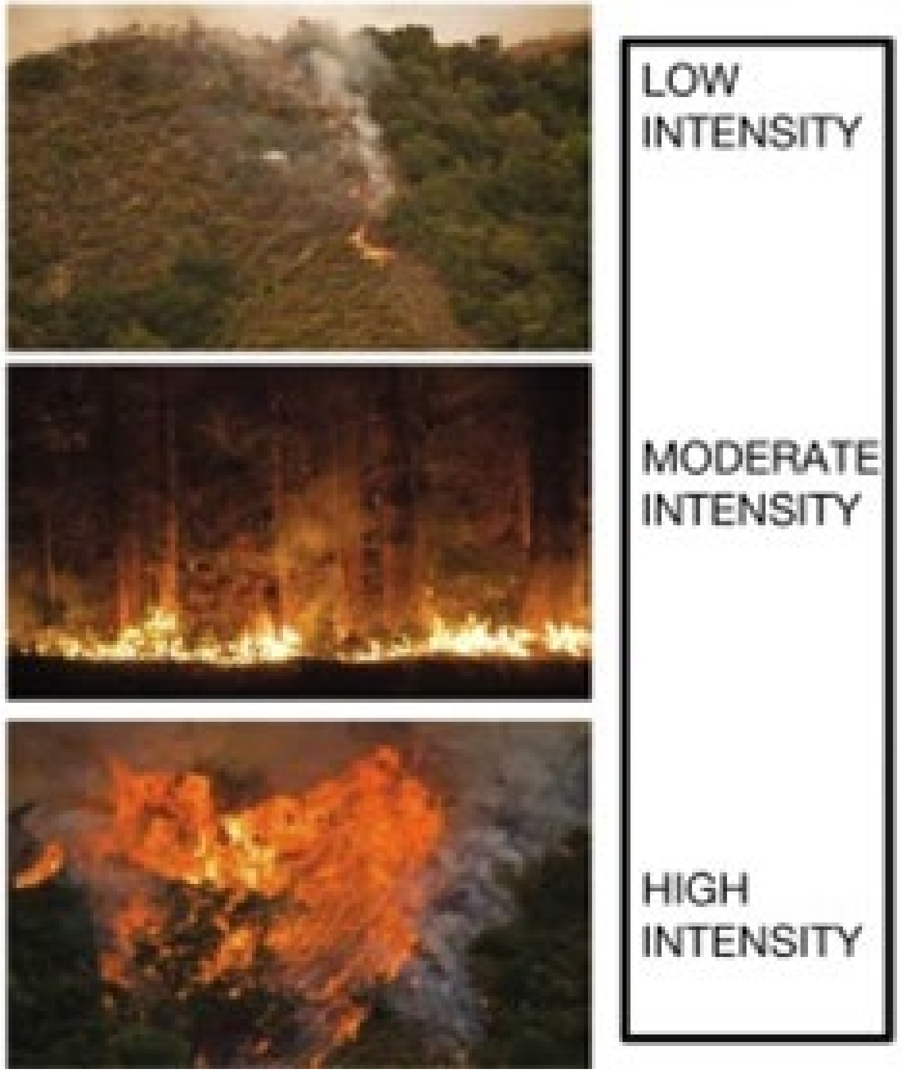
Post-Fire Impacts

- 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.



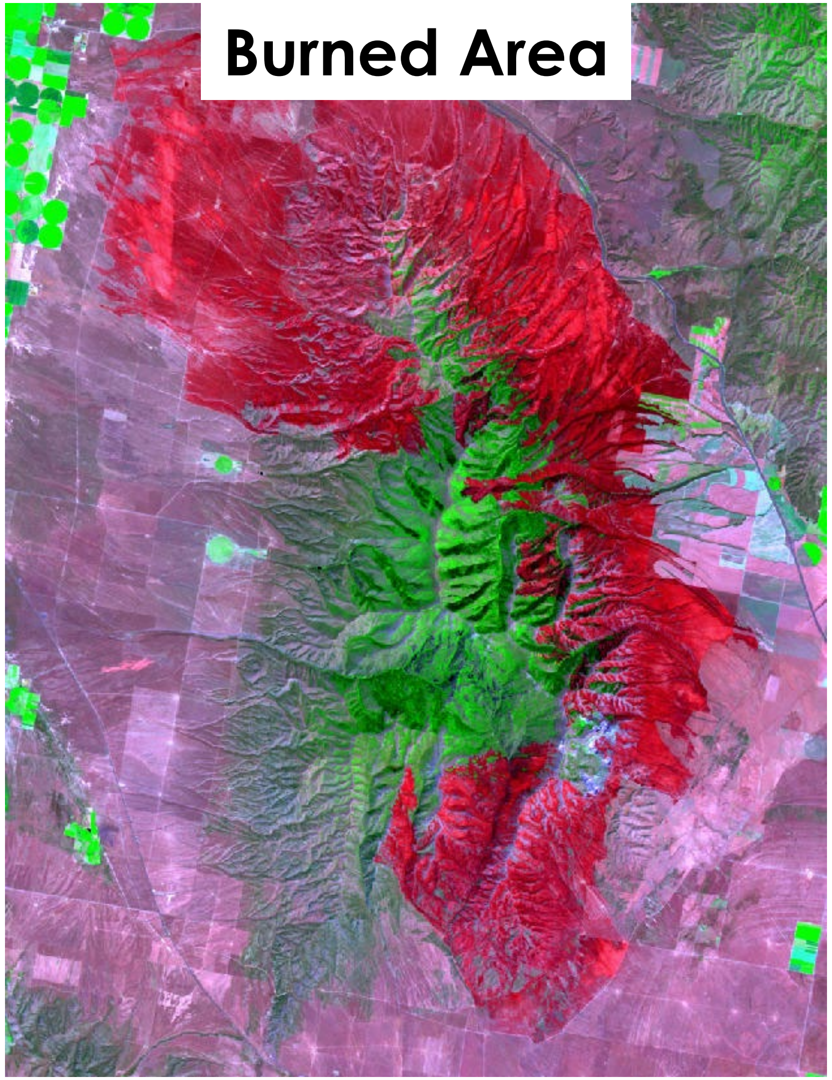
Example scale of fire intensity.
Image Credit: NPS.gov, NIFC.gov, K. Crocker, D. A. DellaSala

Burn Severity

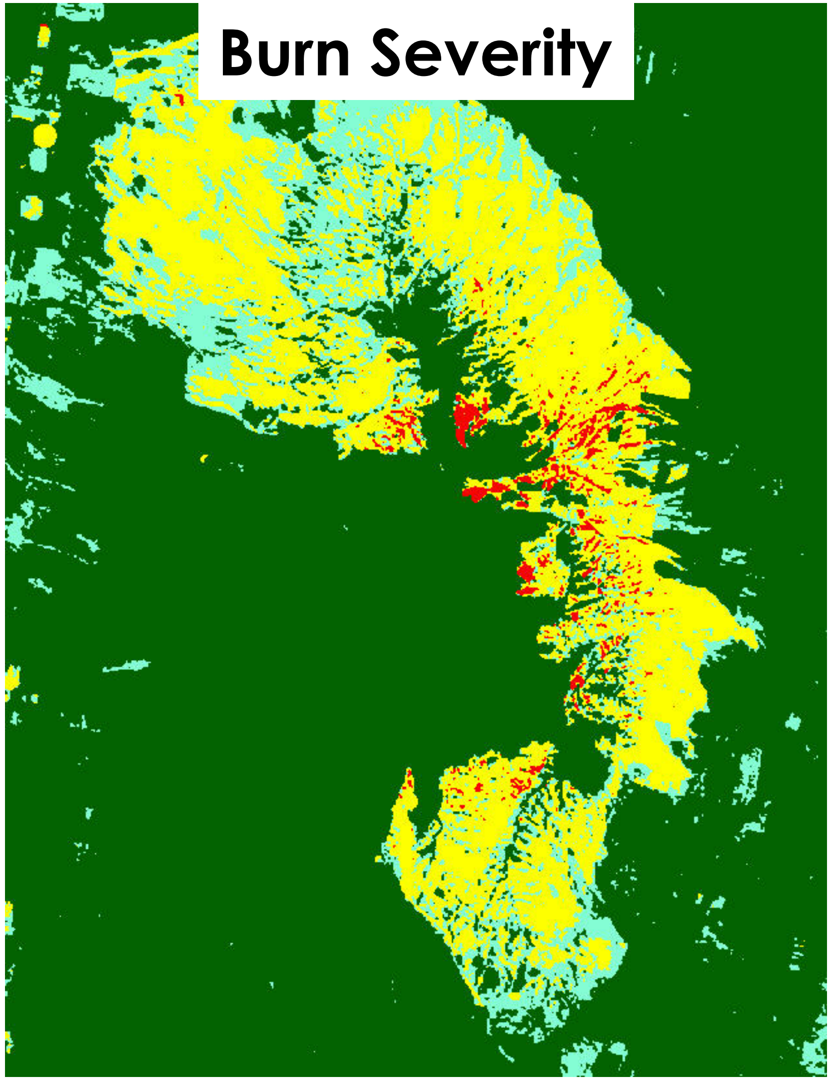
- The **effect of a fire on ecosystem properties**, often defined by the degree of mortality of vegetation
- Degree to which a site has been altered or disrupted by fire; loosely, a product of fire intensity and residence time

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

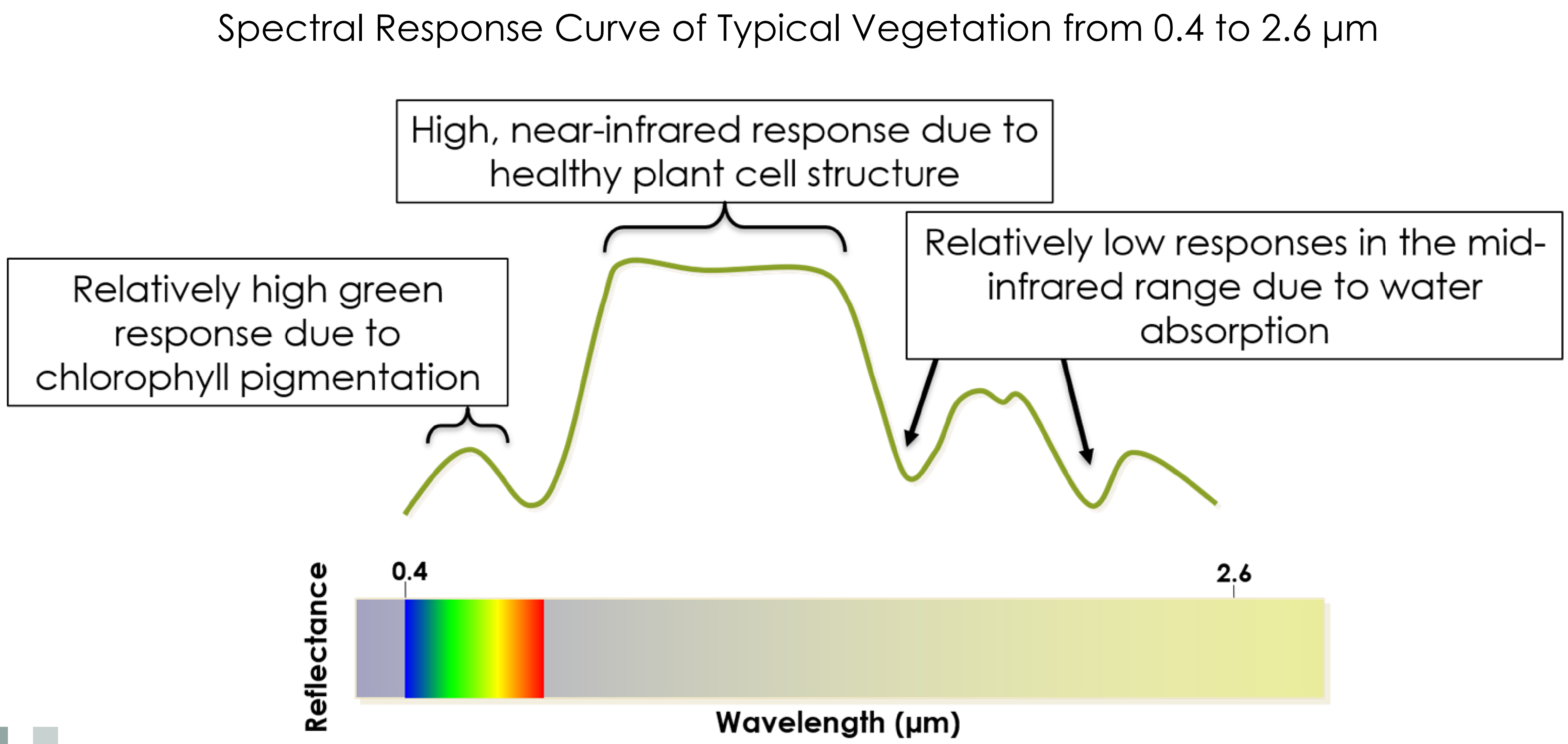
Remote Sensing Perspective: Burned Area and Burn Severity



- 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.

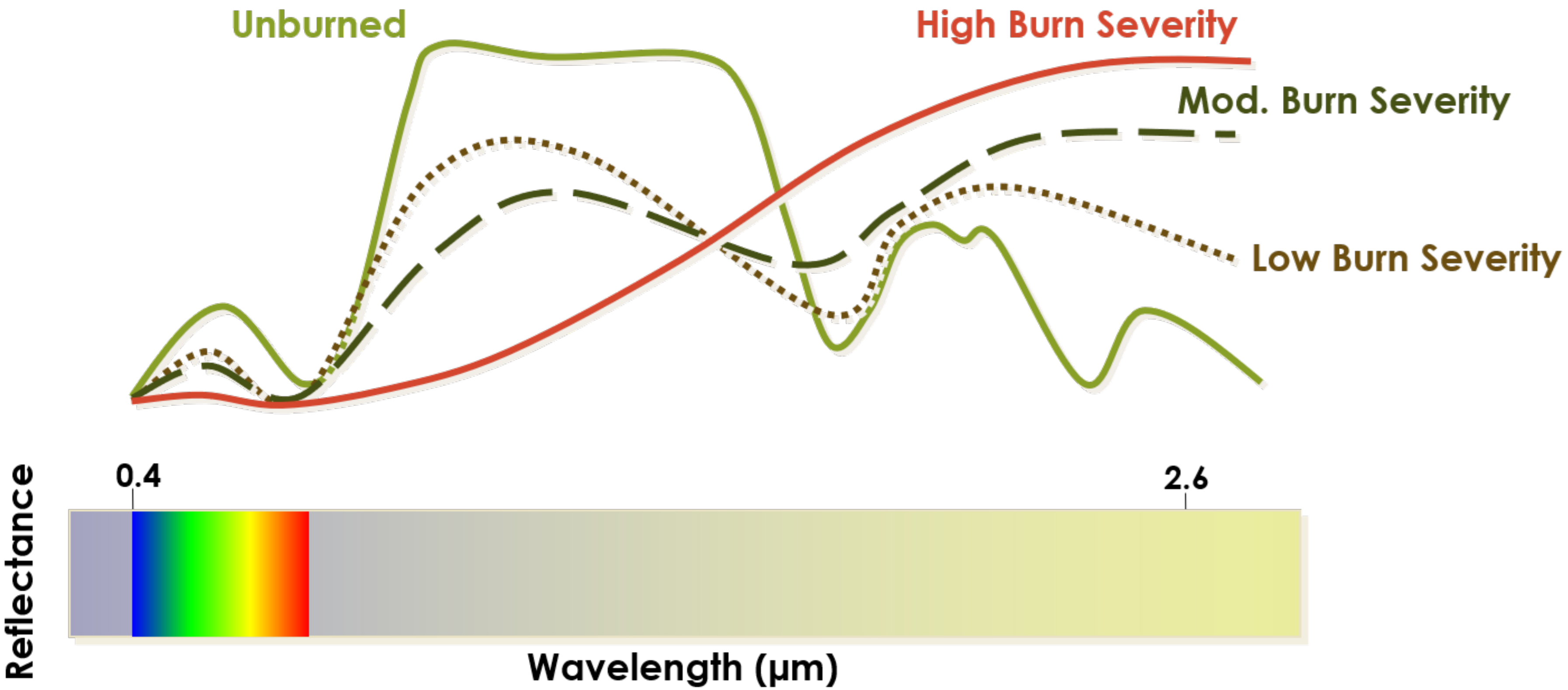


Typical Vegetation Spectral Response



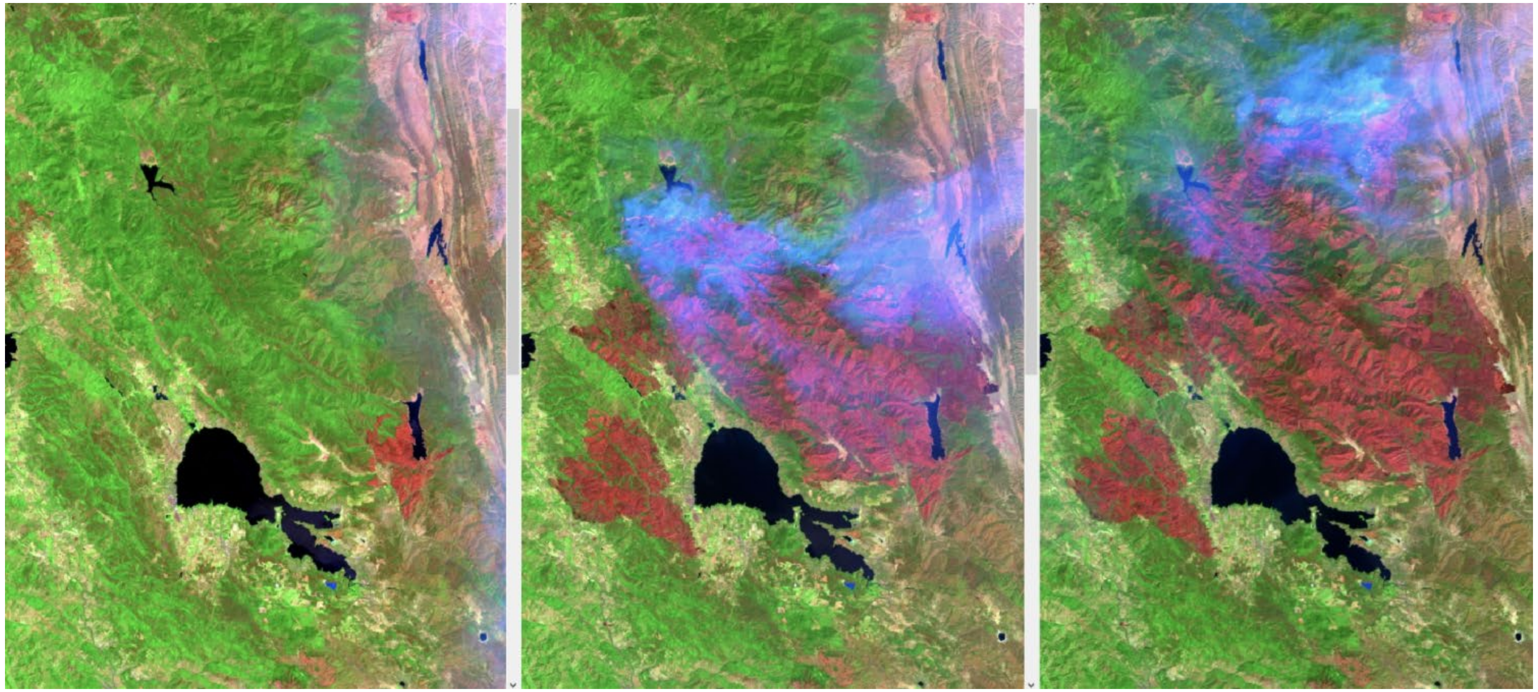
Healthy Vegetation vs. Burned Areas

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)

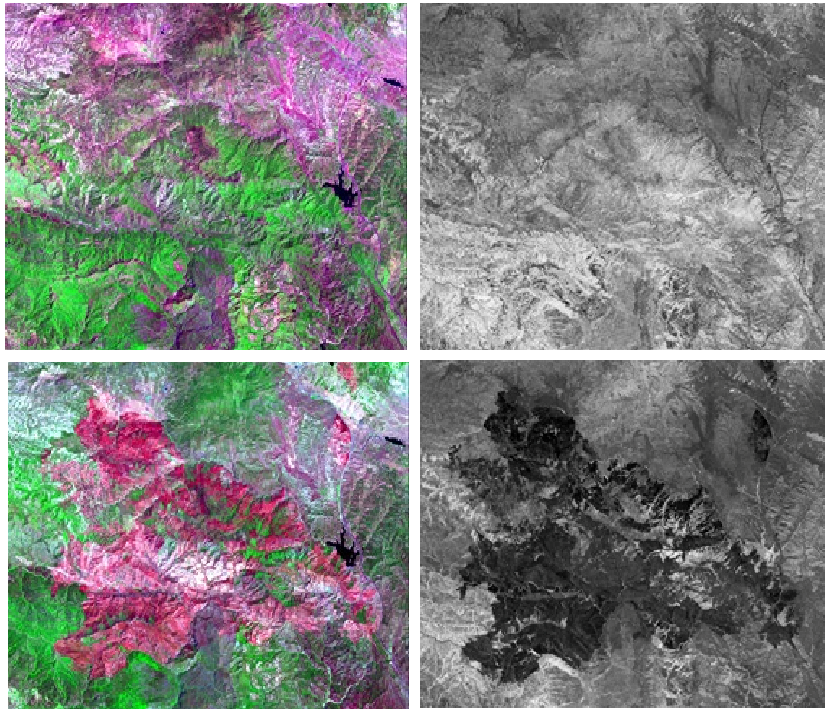
- **Normalized Burn Ratio (NBR)**
- Establishes extent of burned area before and after fire event

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

Reflectance | NBR

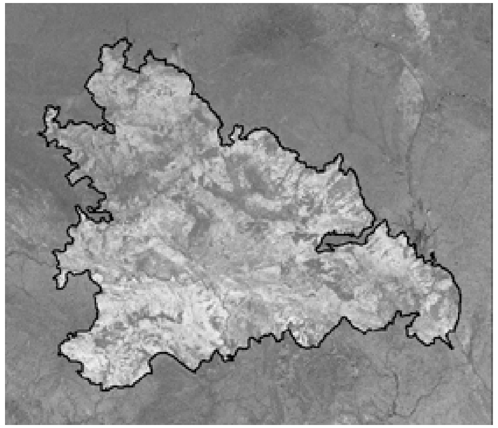
Pre-Fire

Post-Fire

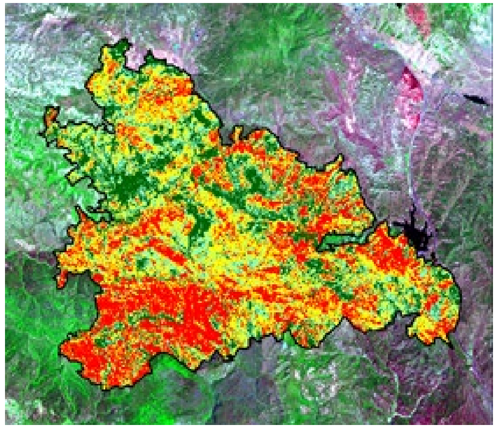


Difference

dNBR



Thresholded Severity Product



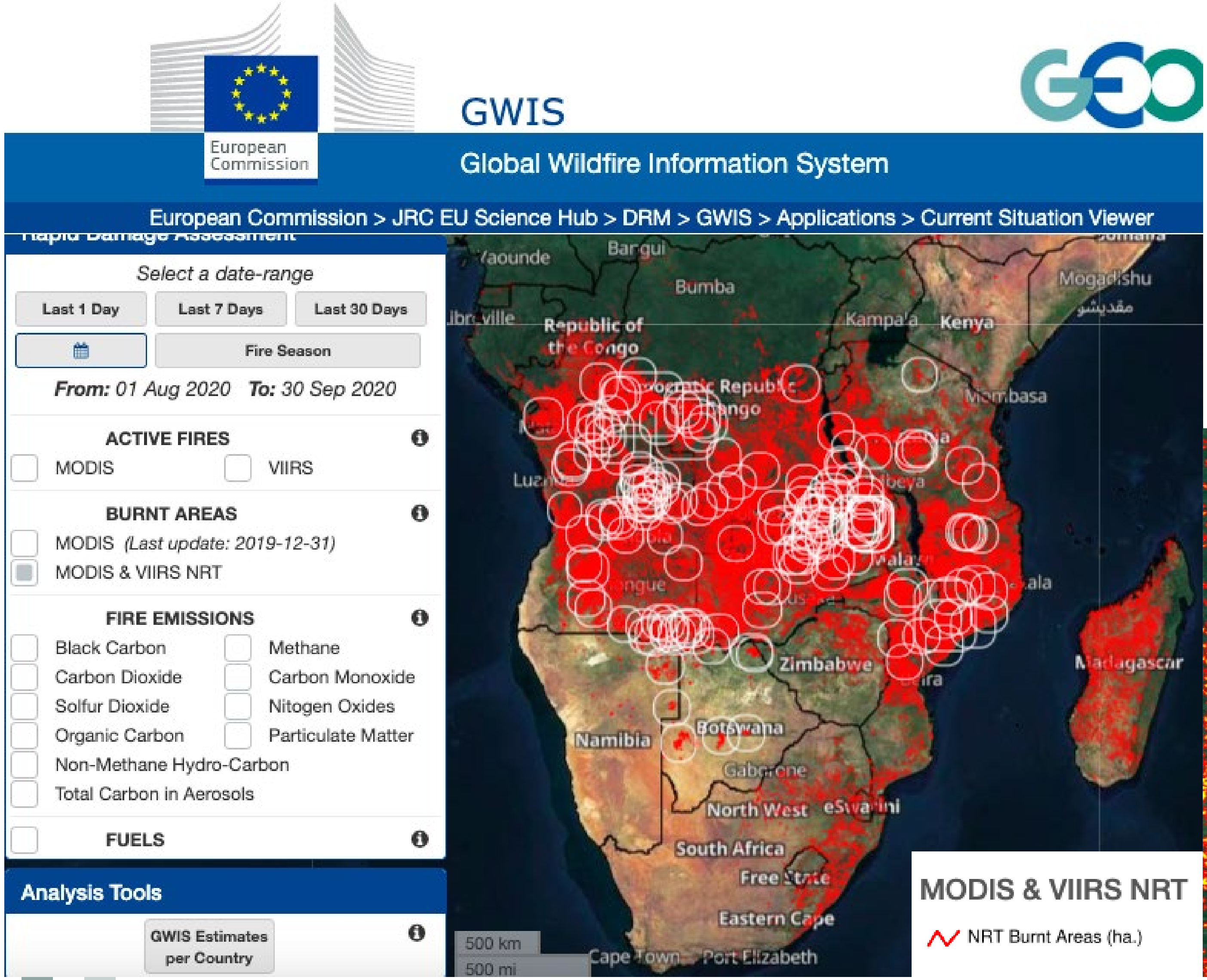
Tools for Post-Fire Mapping

Fire Information for Resource Management System (FIRMS)

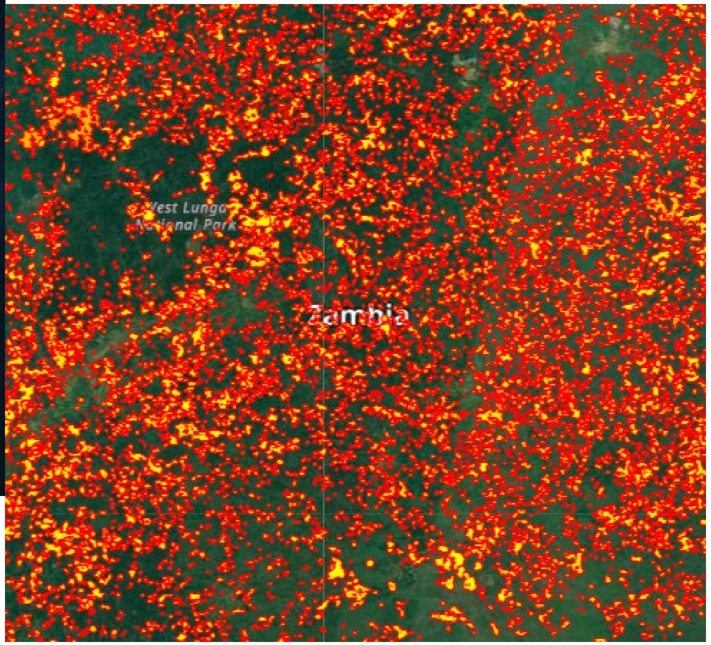
- NASA FIRMS:
  - https://firms2.modaps.eosdis.nasa.gov/
- Data available globally
- MODIS Burned Area Product
- Also includes VIIRS and MODIS fire detection and active fire data
- Near Real-Time (NRT) data replaced with standard science-quality data as they become available (usually with a 2-3-month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



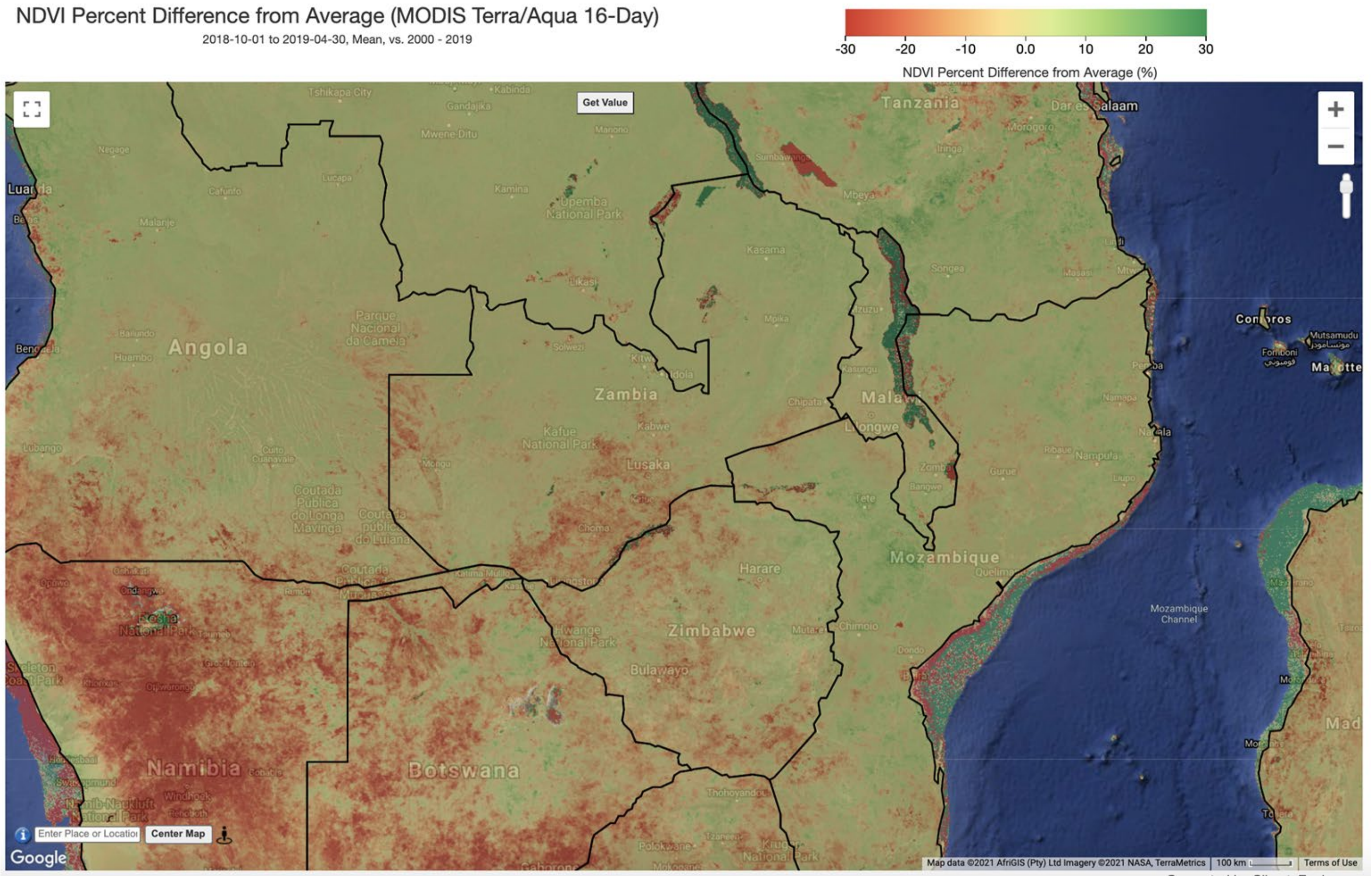
A zoomed view over Zambia displaying MODIS & VIIRS NRT Burned Area.

Image Credits: GWIS

Climate Engine

http://climateengine.org/

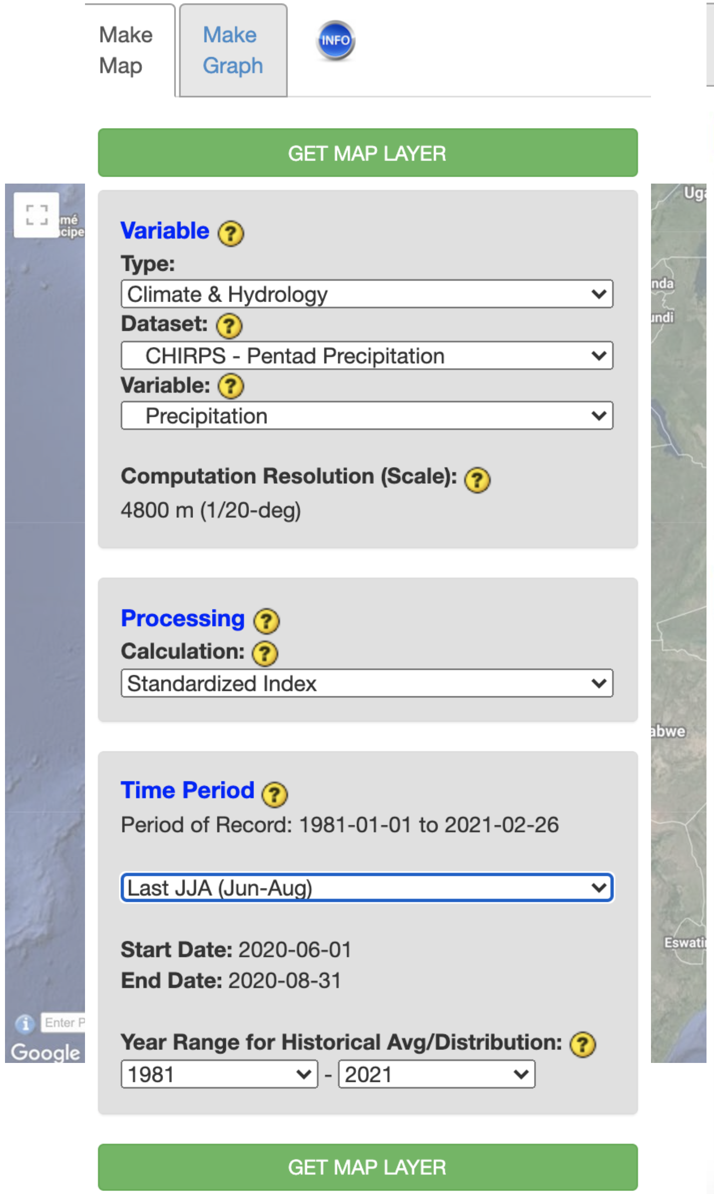
- Uses Google's Earth Engine for on-demand processing of satellite and climate data via web browser
- Time series and statistical summaries
- Downloadable results in GeoTIFF format and time series results as .csv or .xlsx format
- Share map or time series results with web URL links

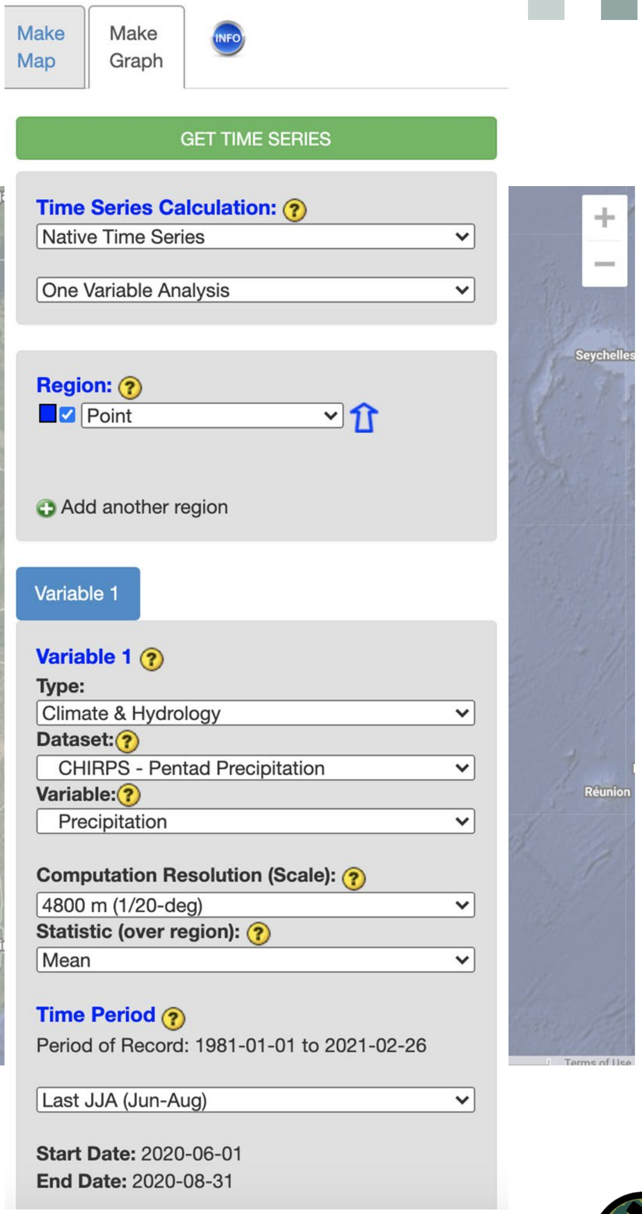


Climate Engine

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

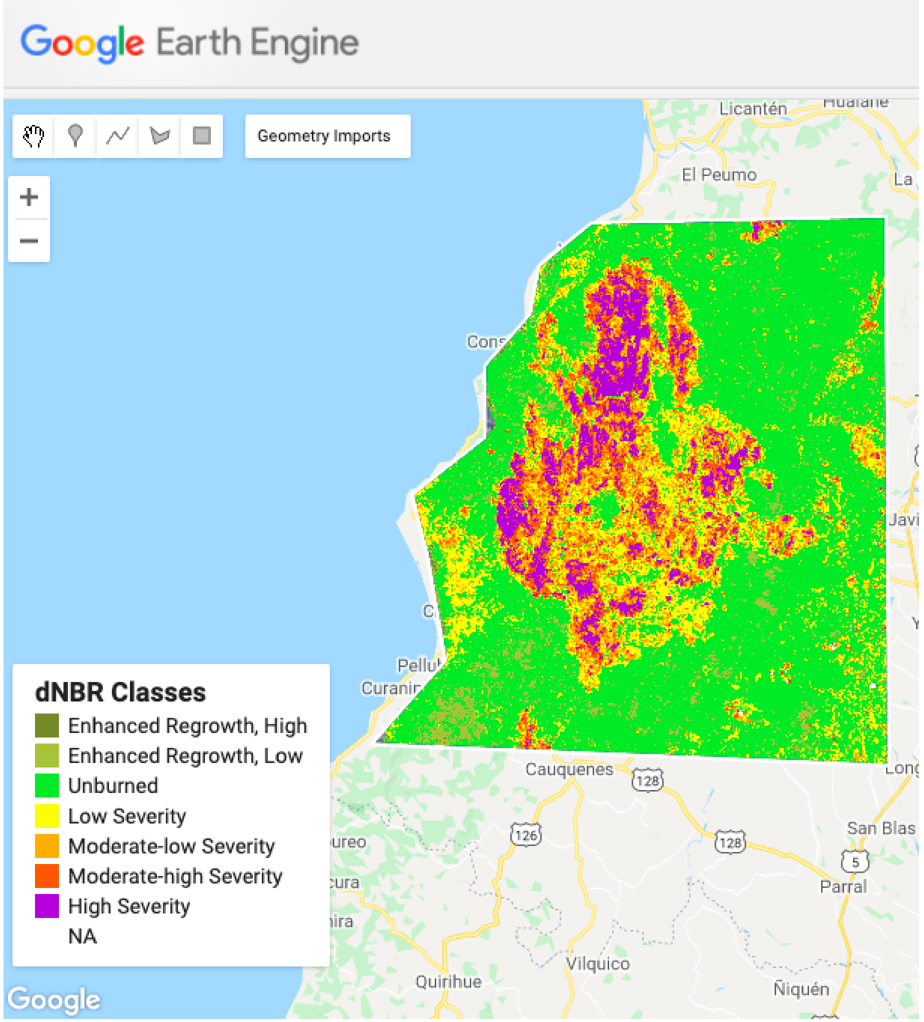




Google Earth Engine for Post-Fire Mapping

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]

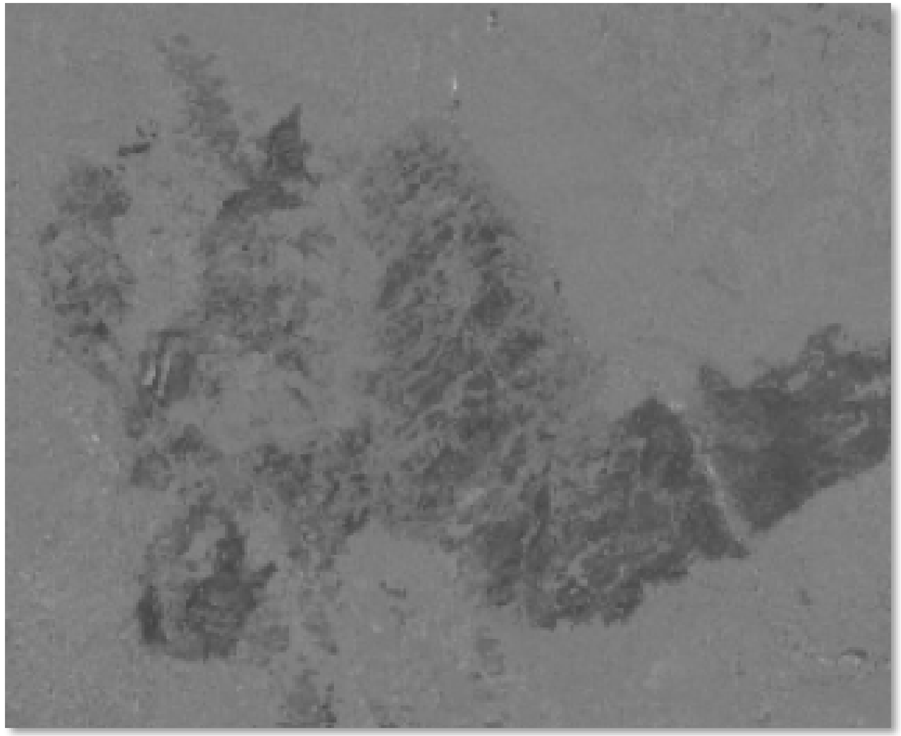


Example of burn severity mapping using Sentinel-2 data in Empedrado, Chile in February 2017. This map was produced using the UN-SPIDER Burn Severity with GEE script. Credit: UN-SPIDER

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

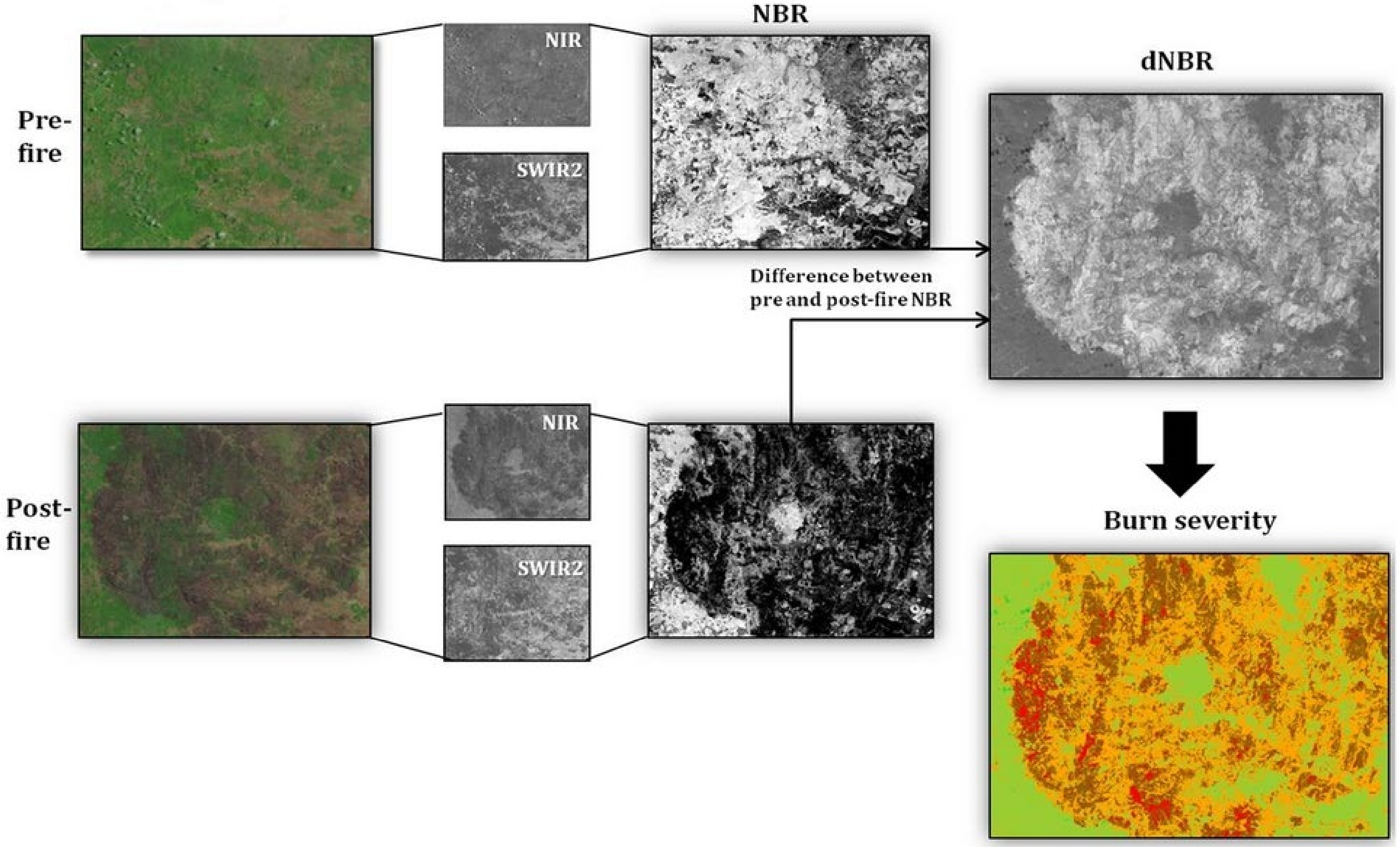


LYTTON CREEK FIRE CODE LINK:

https://code.earthengine.google.com/bf0e7325fd0c23ff828815adaa8f9eb0

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

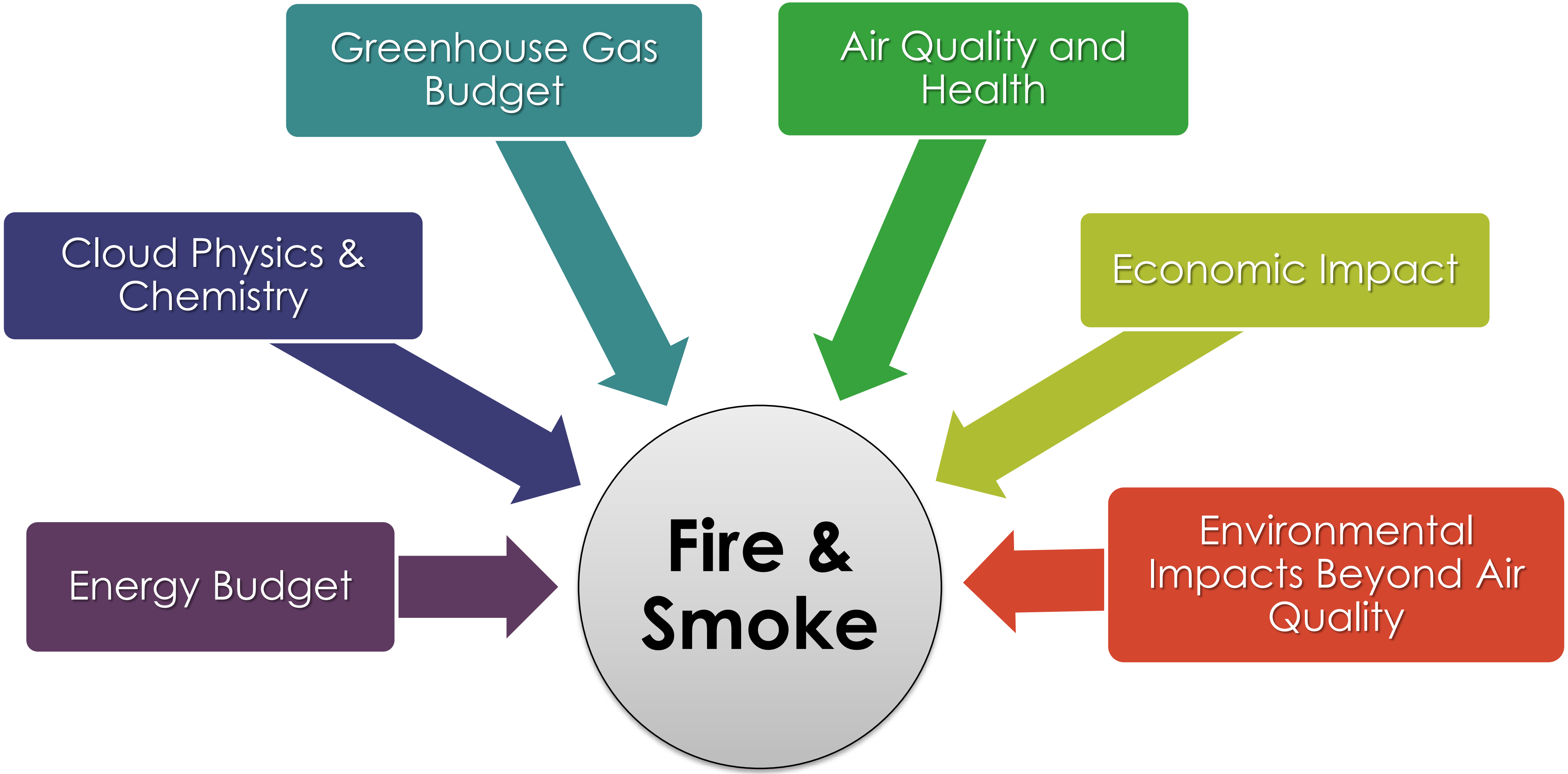
Resources

- 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


National Aeronautics and Space Administration
07-20-2015
07-07-2022

Appendix

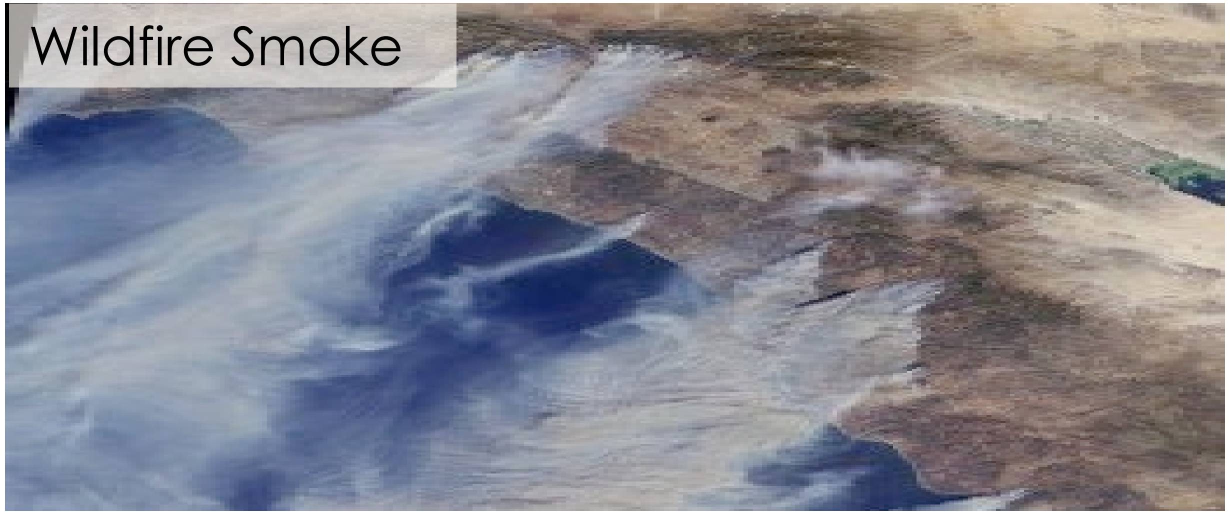
Smoke Monitoring from Space


Greenhouse Gas Budget
Air Quality and Health
Cloud Physics & Chemistry
Economic Impact
Energy Budget
Fire & Smoke
Environmental Impacts Beyond Air Quality

Smoke Color and Texture in Satellite Images

Smoke from Small Fires

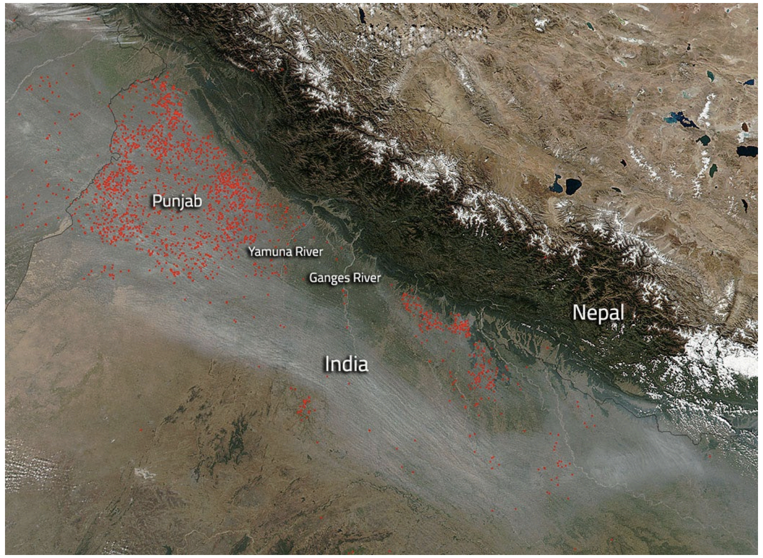
Wildfire Smoke

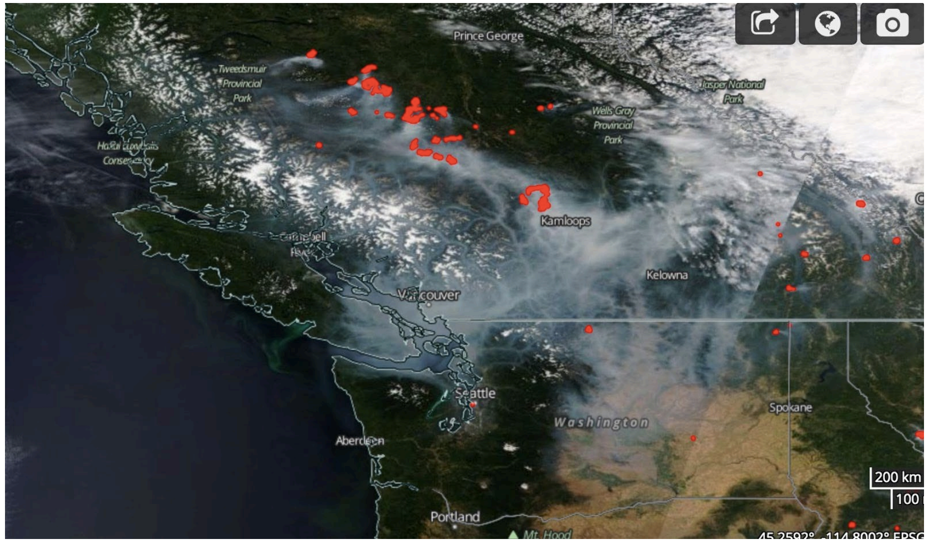


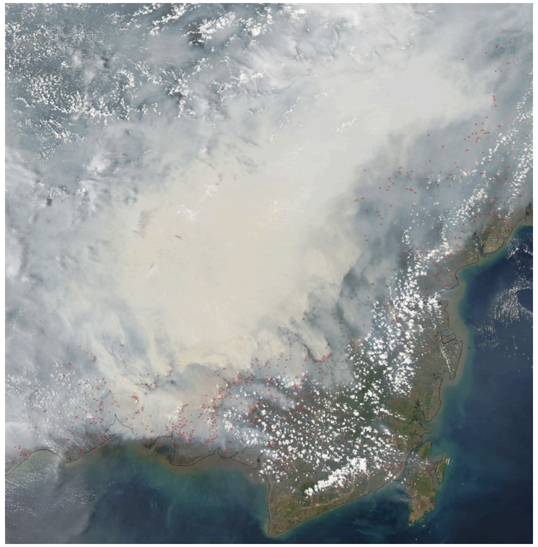
Oil Fires in Iraq

Urban-Industrial/Smoke Pollution

Visible Smoke from Fires

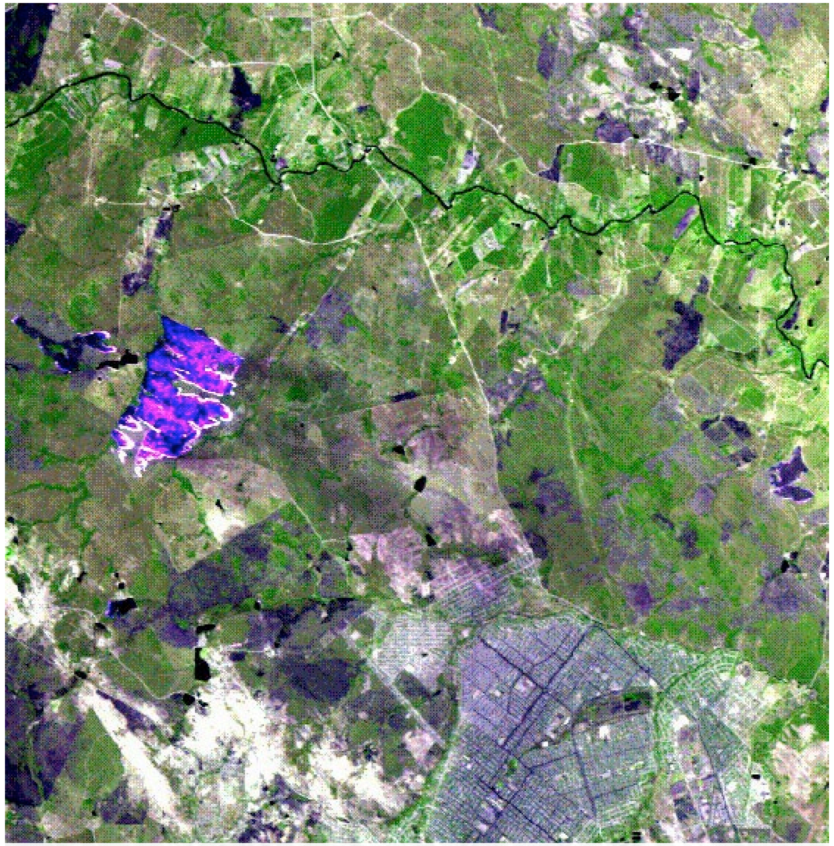






Selection of Spectral Bands for Smoke Detection

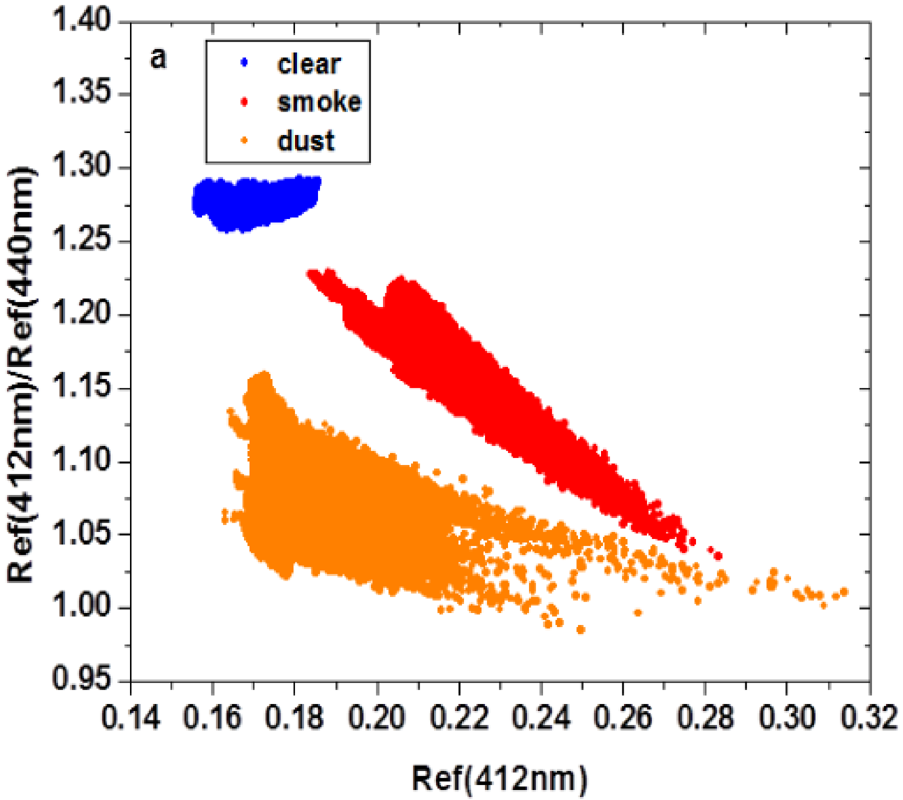
R = 0.66 µm
G = 0.55 µm
B = 0.47 µm

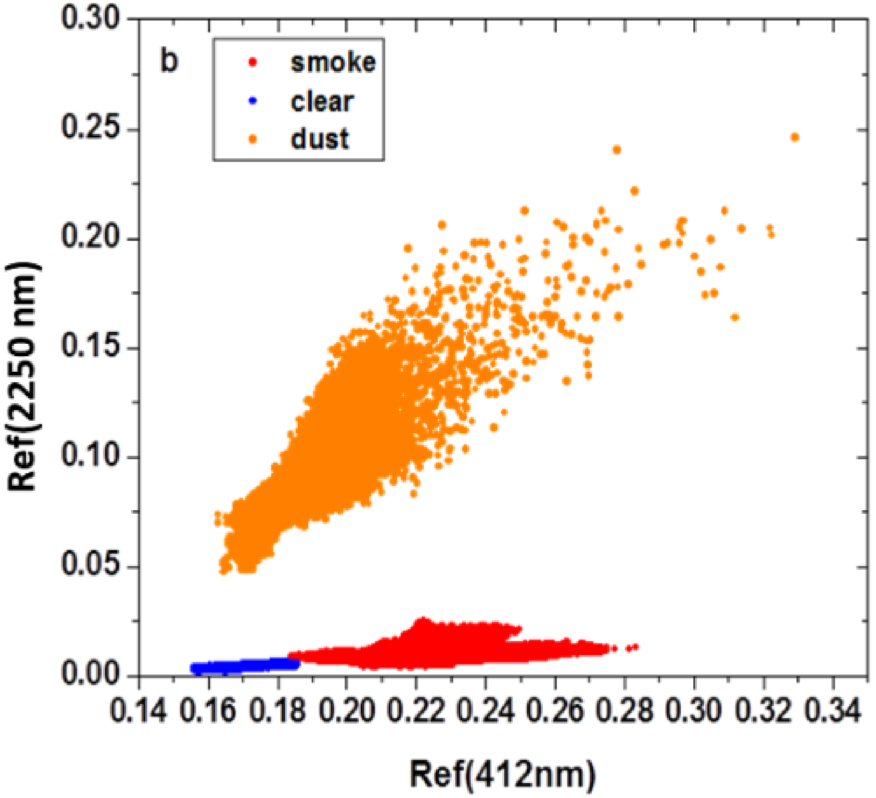


R = 1.6 µm
G = 1.2 µm
B = 2.1 µm

Smoke Detection – Spectral Signature

https://www.star.nesdis.noaa.gov/jpss/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.

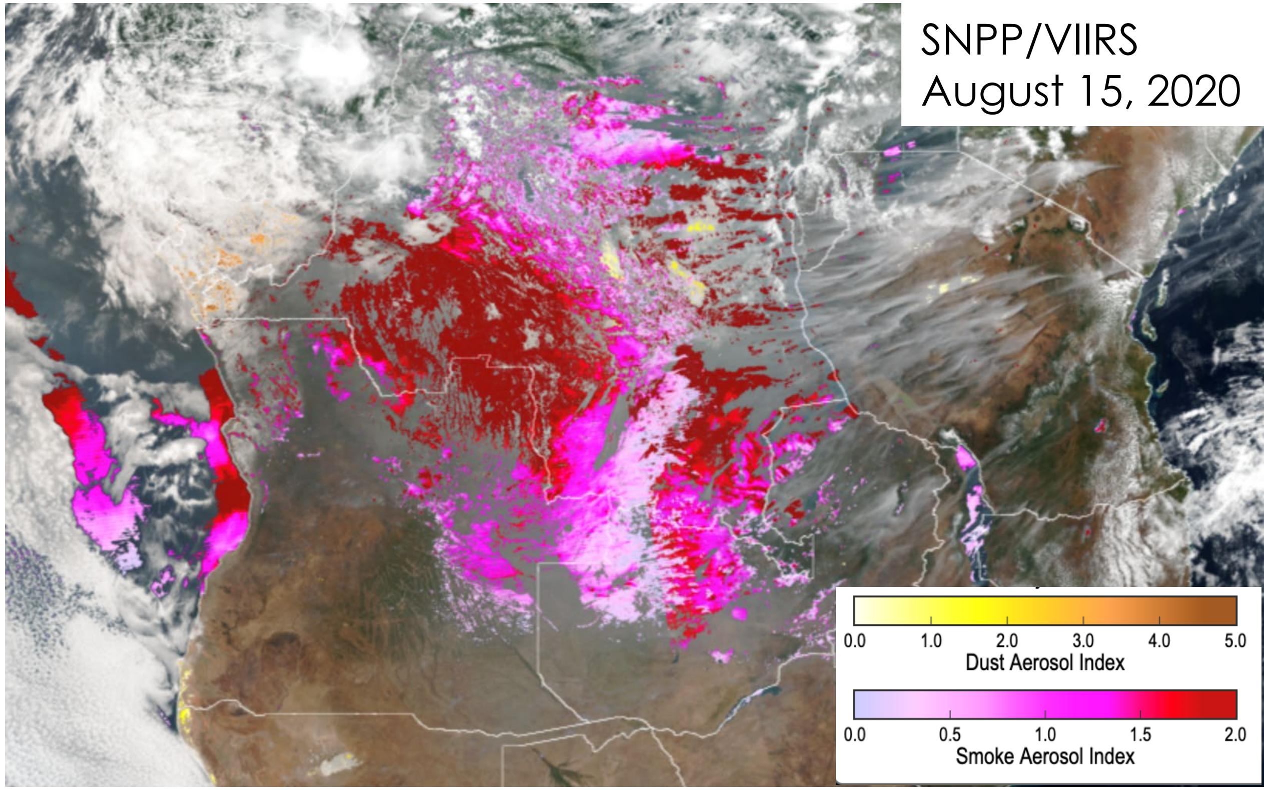
Absorbing Aerosol Index

AAI = -100[1og10(R412/R440) – log10(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

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



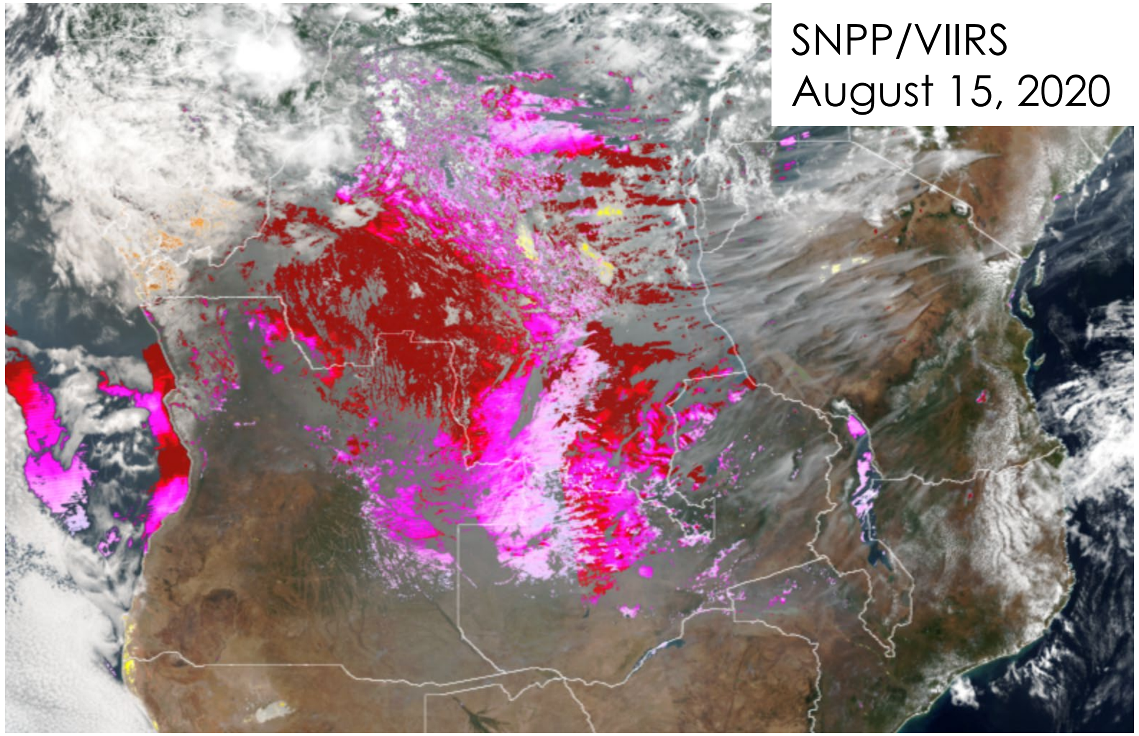
References:

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

Low, medium, and high confidence for each type



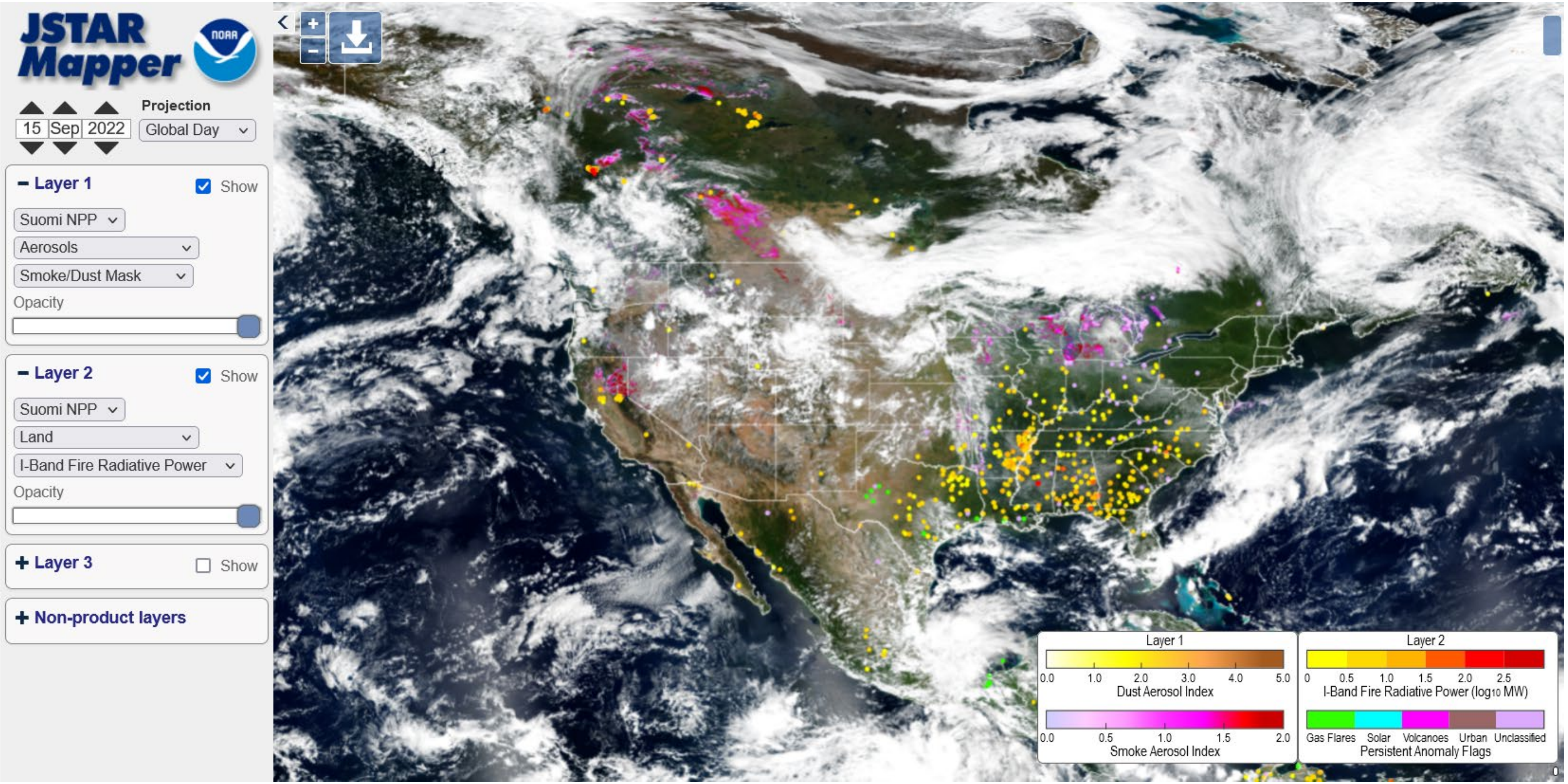
SNPP/VIIRS
August 15, 2020

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

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

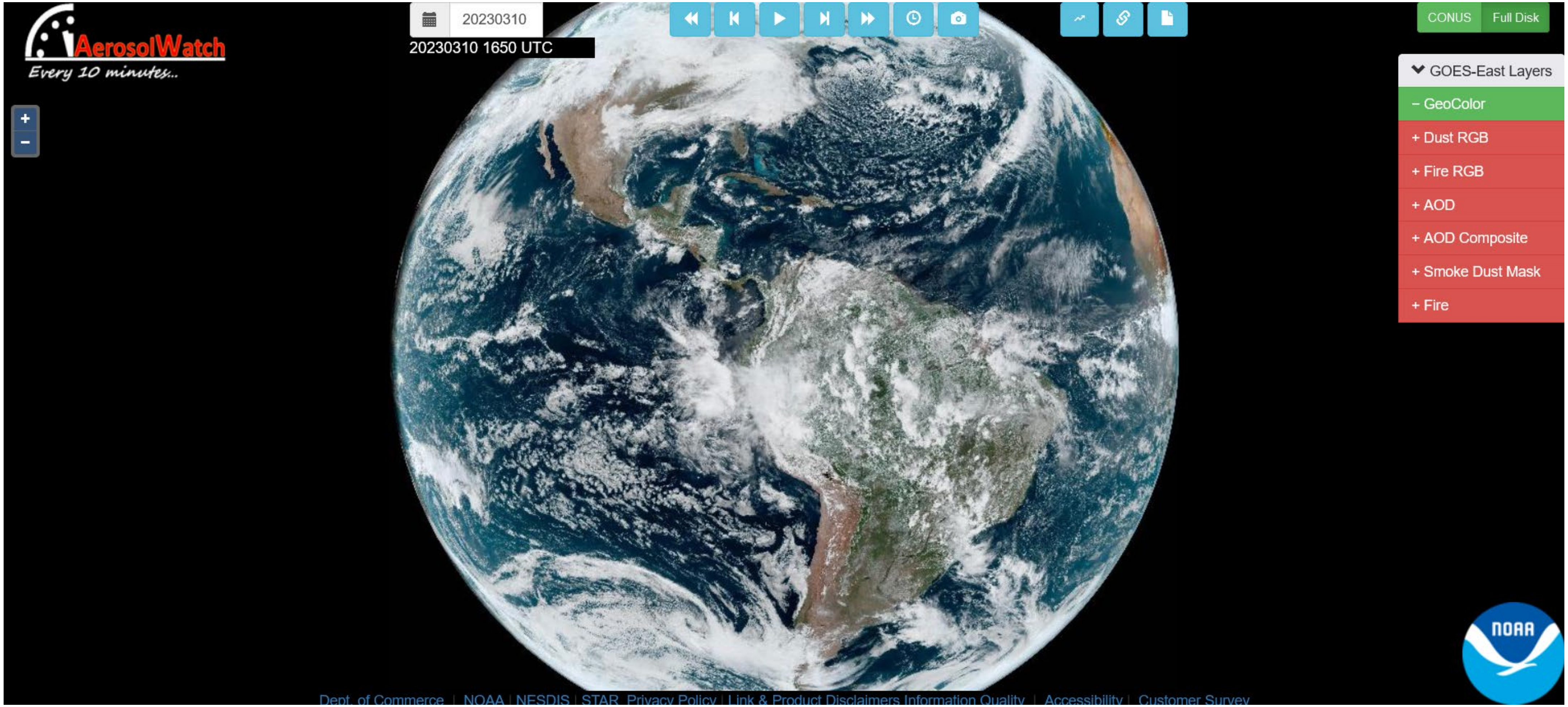
NOAA's Mapper - NPP, NOAA20, S5P

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



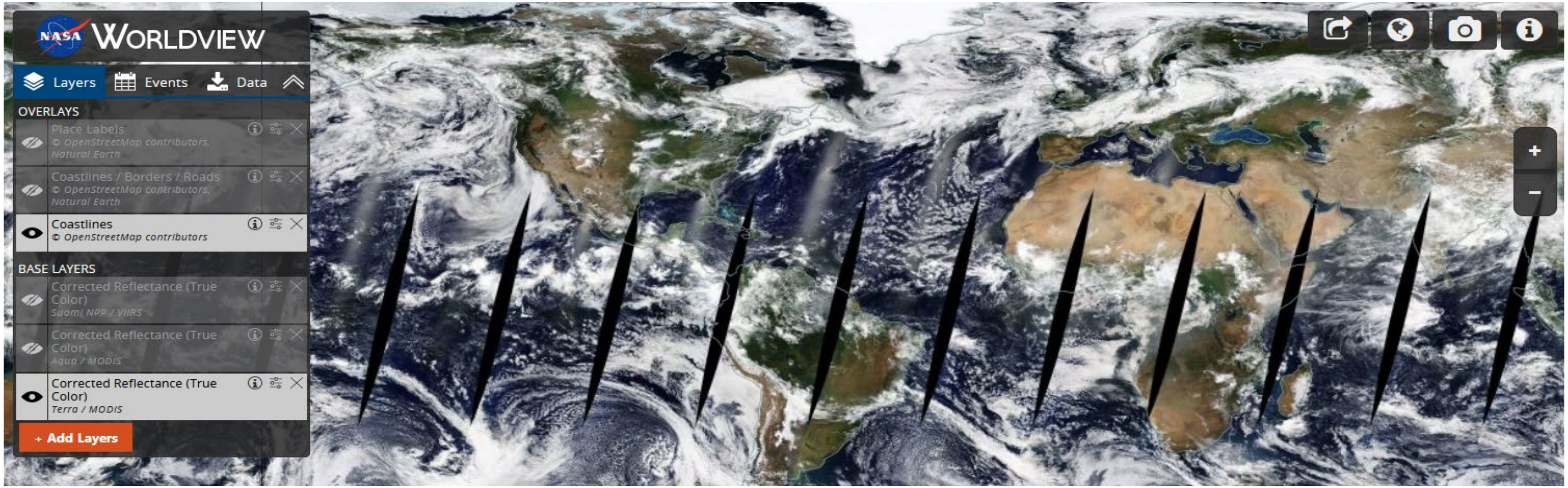
NOAA’s Aerosol Watch

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



Smoke Monitoring Tools – Worldview

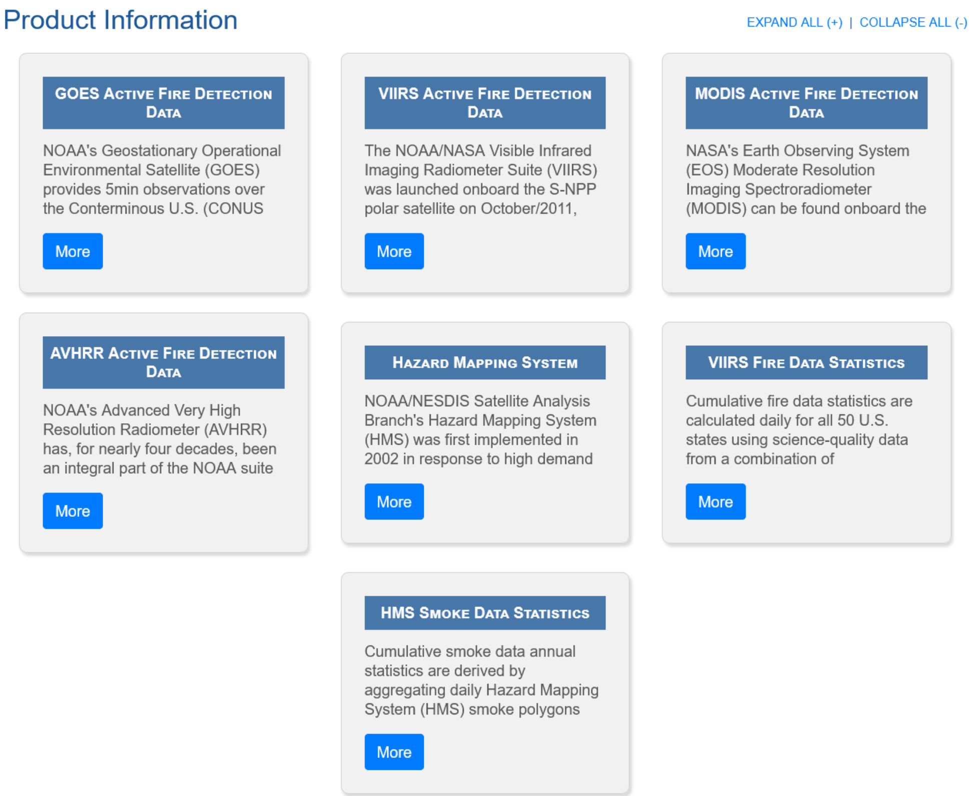
NRT Data & Image Access https://worldview.earthdata.nasa.gov/



- 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

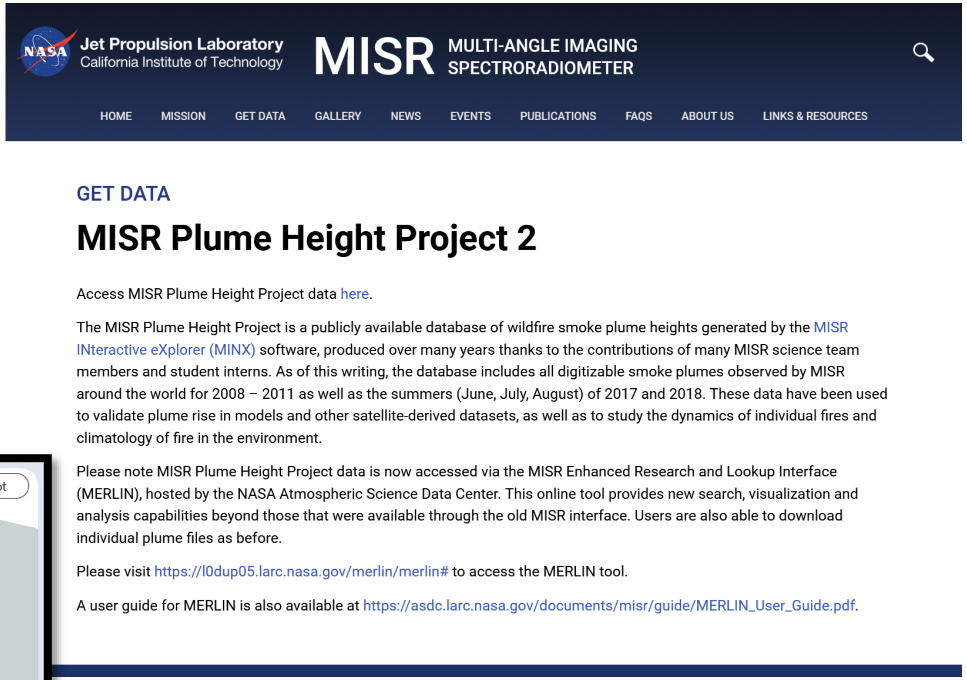


Aerosol Layer Altitude

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.



Jet Propulsion Laboratory
California Institute of Technology
MISR MULTI-ANGLE IMAGING SPECTRORADIOMETER

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GET DATA

MISR Plume Height Project 2

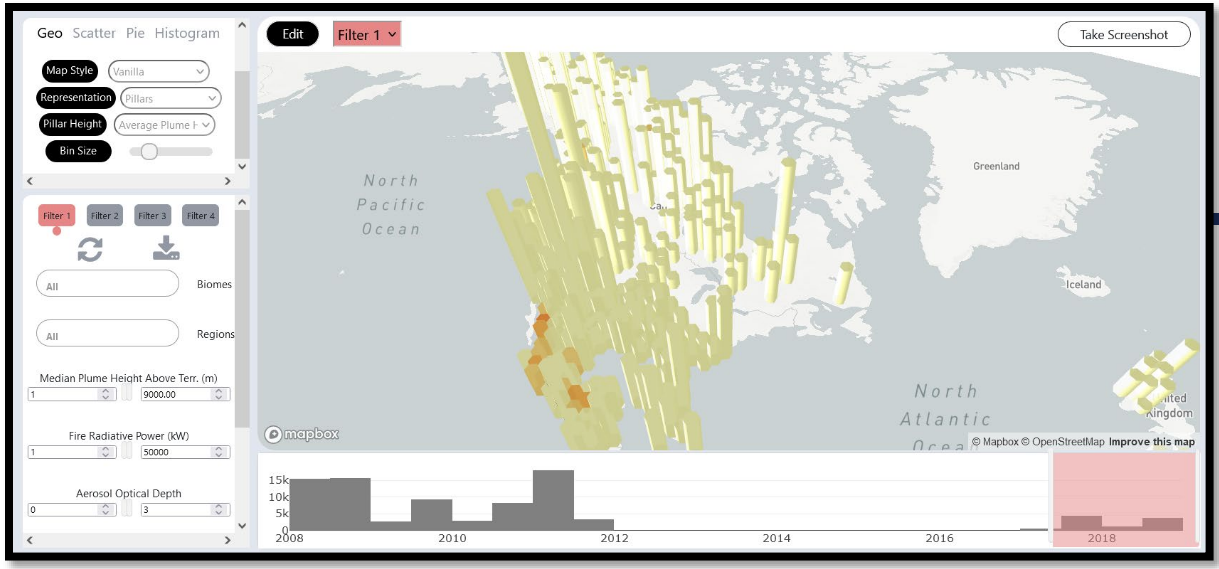
Access MISR Plume Height Project data here.

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

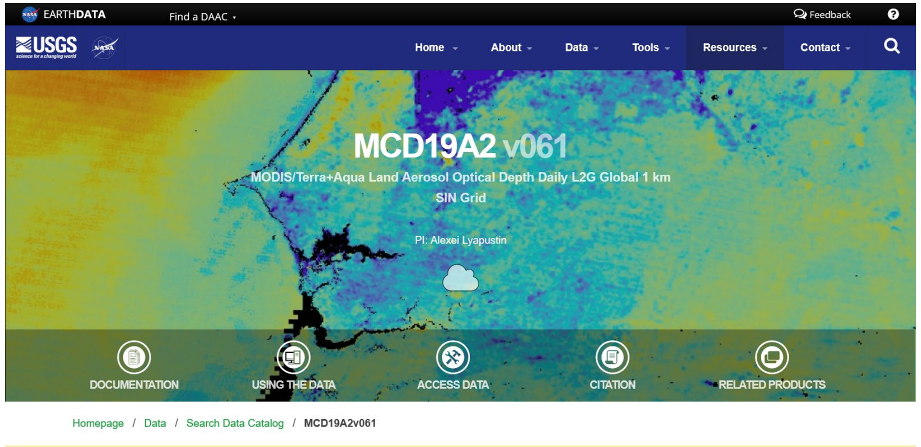
- Cloud-free conditions
  - Dust, smoke, volcanic ash
- Optimal Estimation algorithm assumes a single layer (50 hPa) with constant extinction and scattering properties
  - Assumption impacts AOD more than height retrieval
- Reports the height as the mid-pressure and mid-altitude of the layer at pixel 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

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



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

- Thermal technique represents an effective height
- Good agreement with MISR MINX, ~450m lower on average, ~200m low with respect to LiDAR (CALIOP)