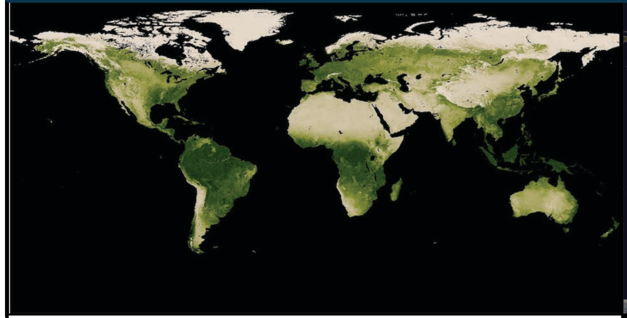
Part 6: Satellites and Sensors for Vegetation-Based Wildfire Applications (Post-Fire)

Zach Bengtsson, Juan L. Torres-Pérez, and Amber Jean McCullum

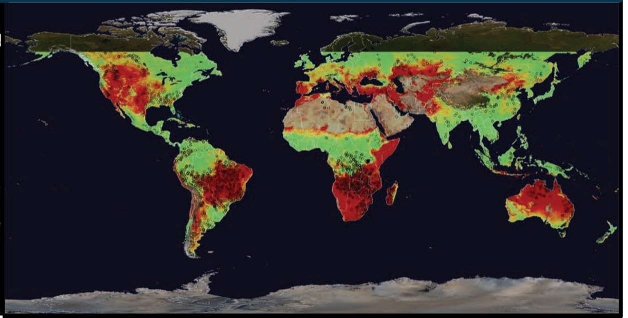
May 27, 2021

Webinar Agenda

Pre-Fire

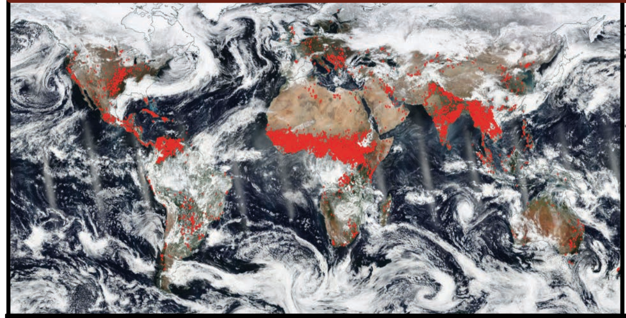


Session 1:
Climate and Hydrology

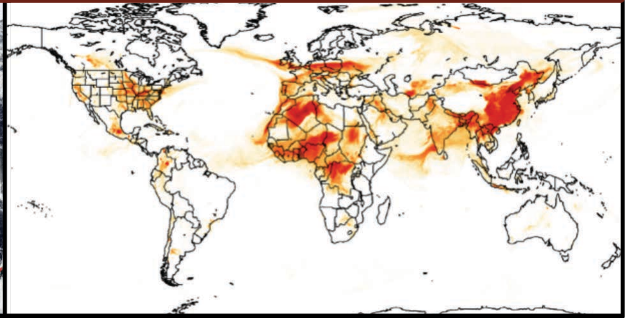


Session 2:
Vegetation

During Fire

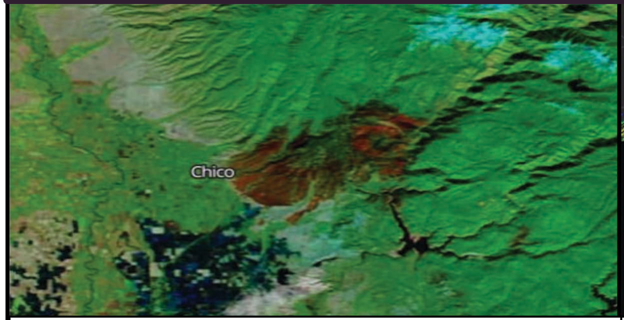


Session 3:
Active Fires and Smoke

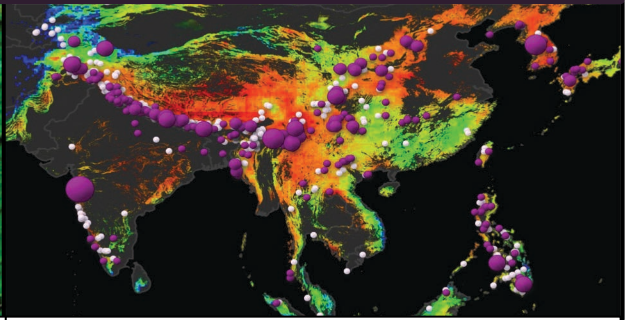


Session 4:
Smoke Forecasting

Post-Fire



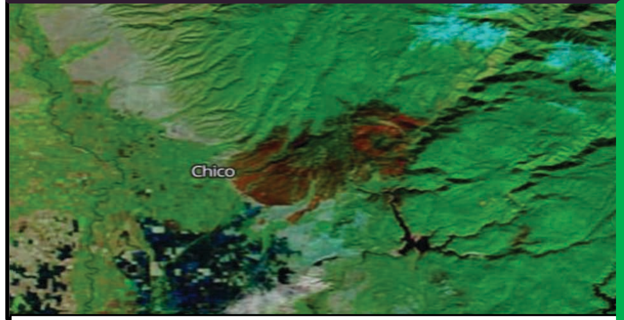
Session 5:
Climate & Hydrology

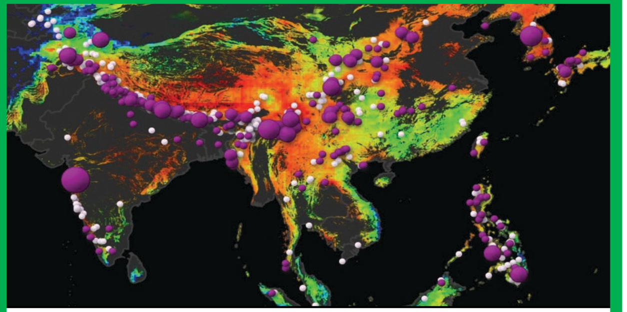


Session 6:
Vegetation

Webinar Agenda

Post-Fire





Session 5:
Climate & Hydrology

Session 6:
Vegetation

Juan Torres-Pérez

Zach Bengtsson

Amber McCullum

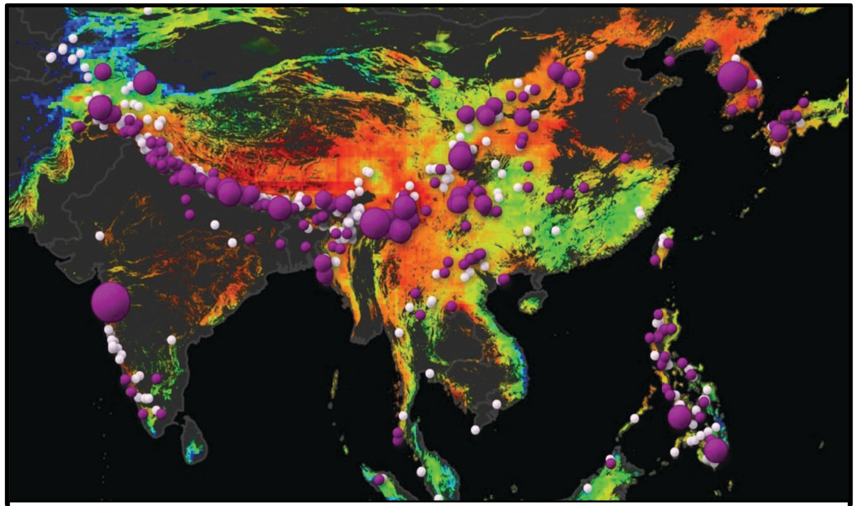
Blanca Rios
Guest Speaker

Course Structure and Materials

- 6, 2-hour sessions on May 11, 13, 18, 20, 25, & 27
- The same content is presented twice in English and Spanish
- Webinar recordings, PowerPoint presentations, and the homework assignment can be found after each session at:
  - https://appliedsciences.nasa.gov/join-mission/training/english/arset-satellite-observations-and-tools-fire-risk-detection-and
  - Q&A following each lecture and/or by email at:
    - juan.l.torresperez@nasa.gov or
    - bengtsson@baeri.org

Session Outline

- Review of the fire lifecycle and dynamics
  - Fire regimes
  - Burn severity
  - Post-fire vegetation regrowth
- Burned area and burn severity mapping
- Mapping post-fire vegetation regrowth
- Tools for post-fire mapping
- Case study review
- Summary
- Q&A Session

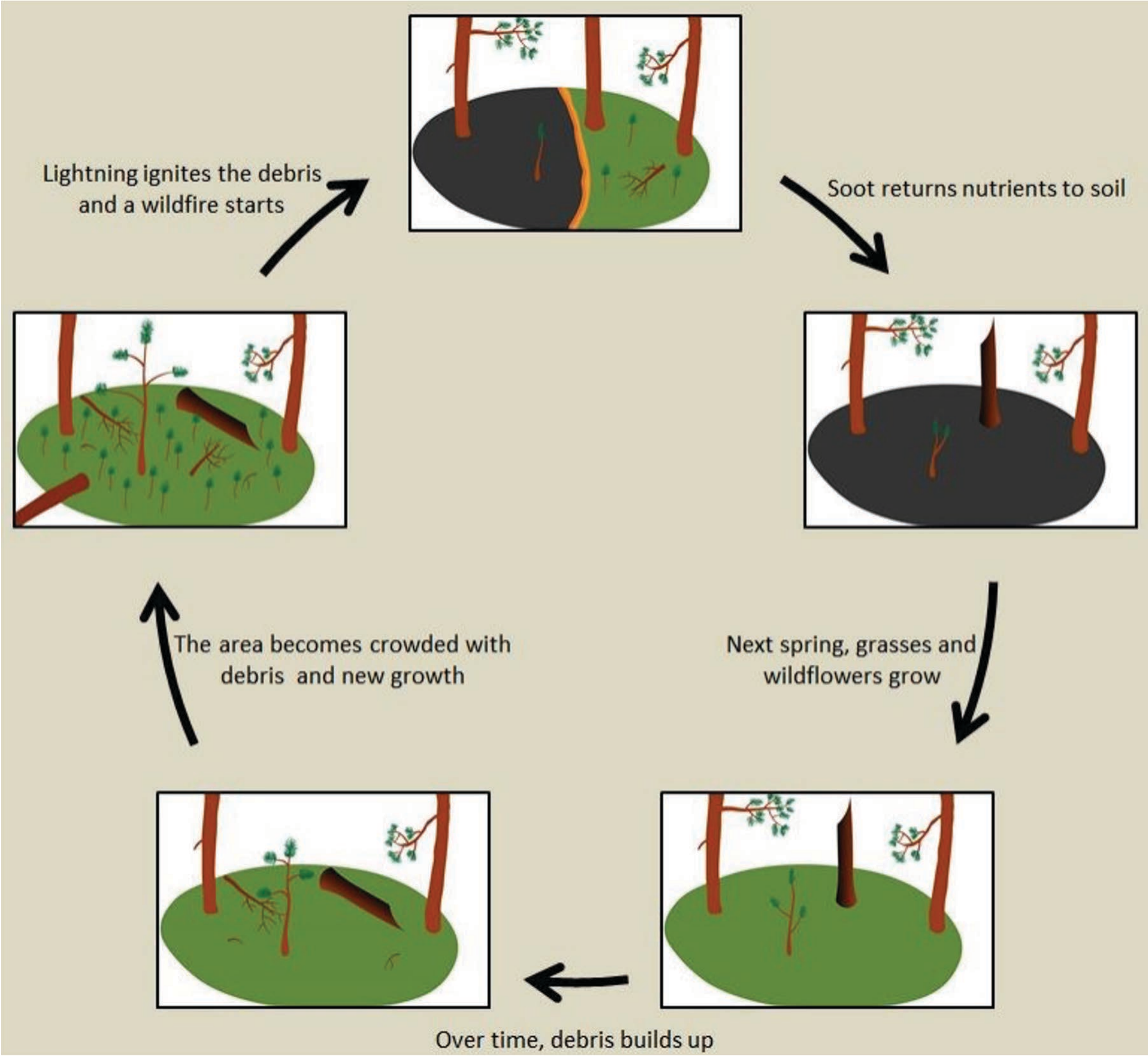


Session 6:
Vegetation (Post-Fire)

Fire Lifecycle and Dynamics

The Role of Fire in the Life Cycle of Vegetated Landscapes

- Naturally occurring fires are an important step in the life cycle of vegetated areas.
- Burning occurs at different intervals, depending on the regime of the ecosystem you are studying.
- Fire patterns vary with vegetation, vegetation type, and landscape cover.
  - For example, fires may burn more often in the shrubland type landscapes than the forest type.



Simplistic figure of the fire life cycle in vegetated lands. Image Credit: NPS

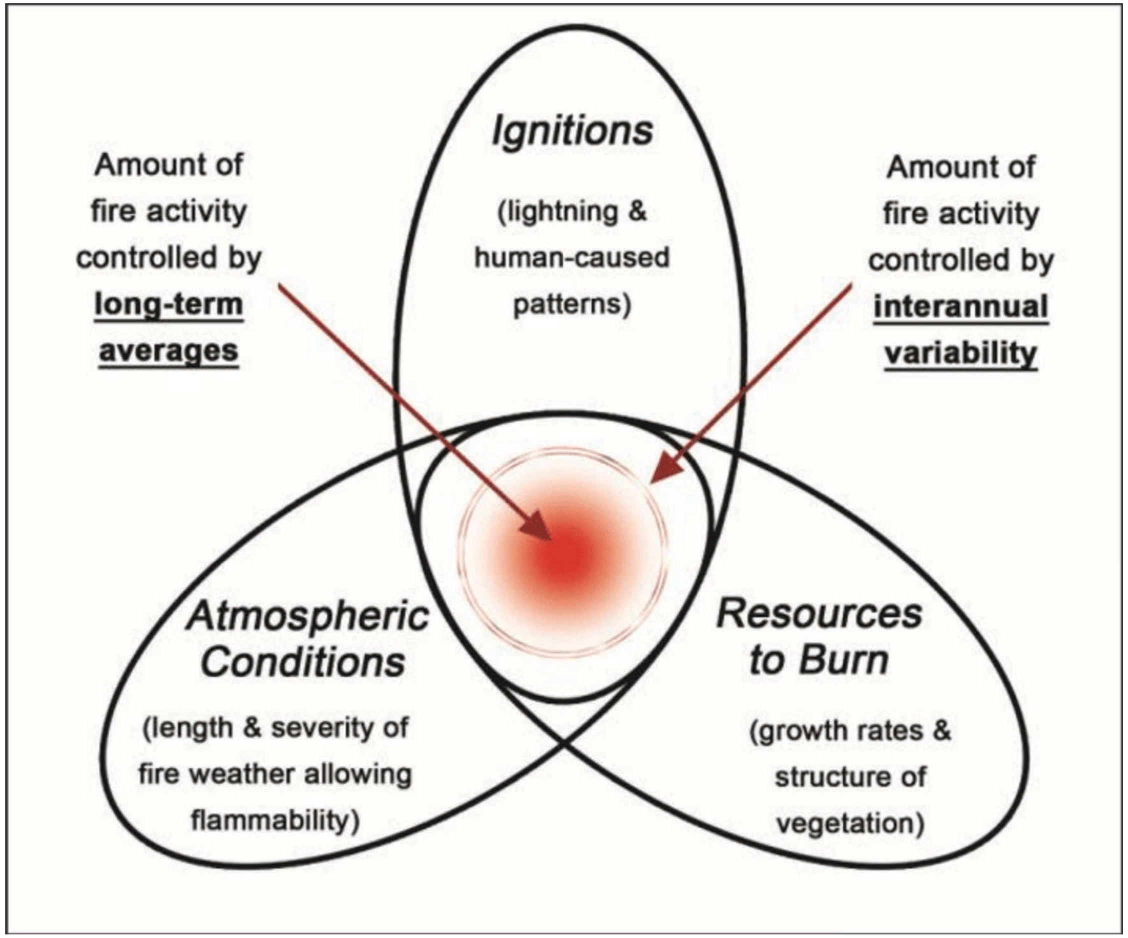
Impact of Climate Change on Fire Frequency and Intensity

- Over the past several decades, as the world has increasingly warmed, so has its potential to burn. (Gray, 2019)
- High temperatures and low humidity are two essential factors behind the rise in fire risk and activity. (Gray, 2019)
- Climate change impacts can increase the frequency and intensity of fires, disrupting fire regimes, lengthening fire seasons, and contributing to higher burn severity.

Image from the 2013 Rim fire in and near Yosemite National Park, California. Image Credit: Mike McMillan/USFS

Fire Regimes

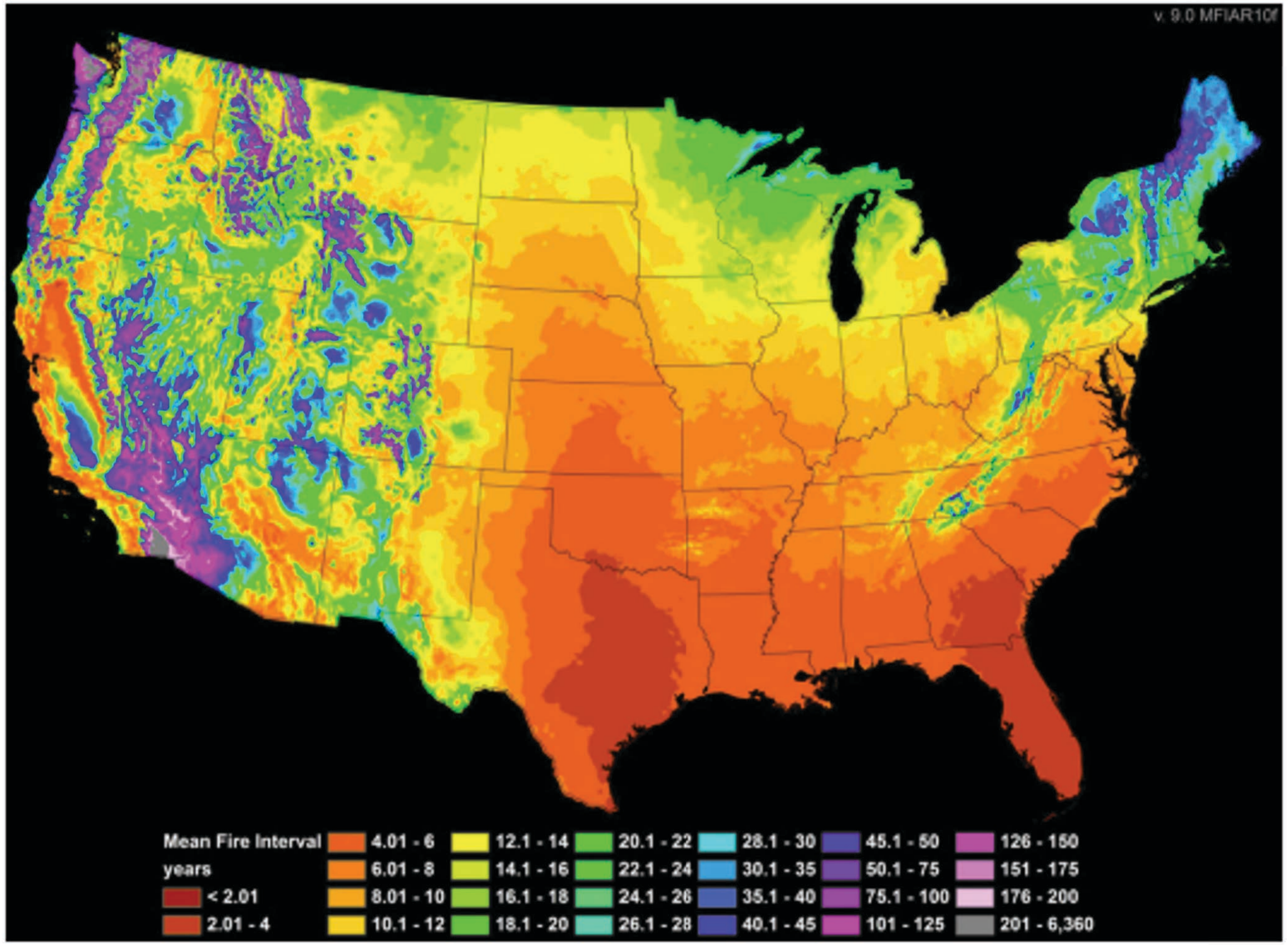
- **Fire regimes** describe and categorize patterns of fire ignition, seasonality, frequency, type (crown, surface, or ground fire), severity, intensity, and spatial continuity (pattern and size) that occur in a particular area or ecosystem.
- Fire dynamics depend on:
  - Climate and weather patterns
  - Vegetation composition and fuel structure
  - Past management
  - Landscape characteristics
  - Timing and severity of fire
  - Vegetation regrowth and current/future landscape management
- Local variability in fire regime classifications



Conceptual figure of fire regimes. Image Credit: Laris, 2013

Fire Return Interval

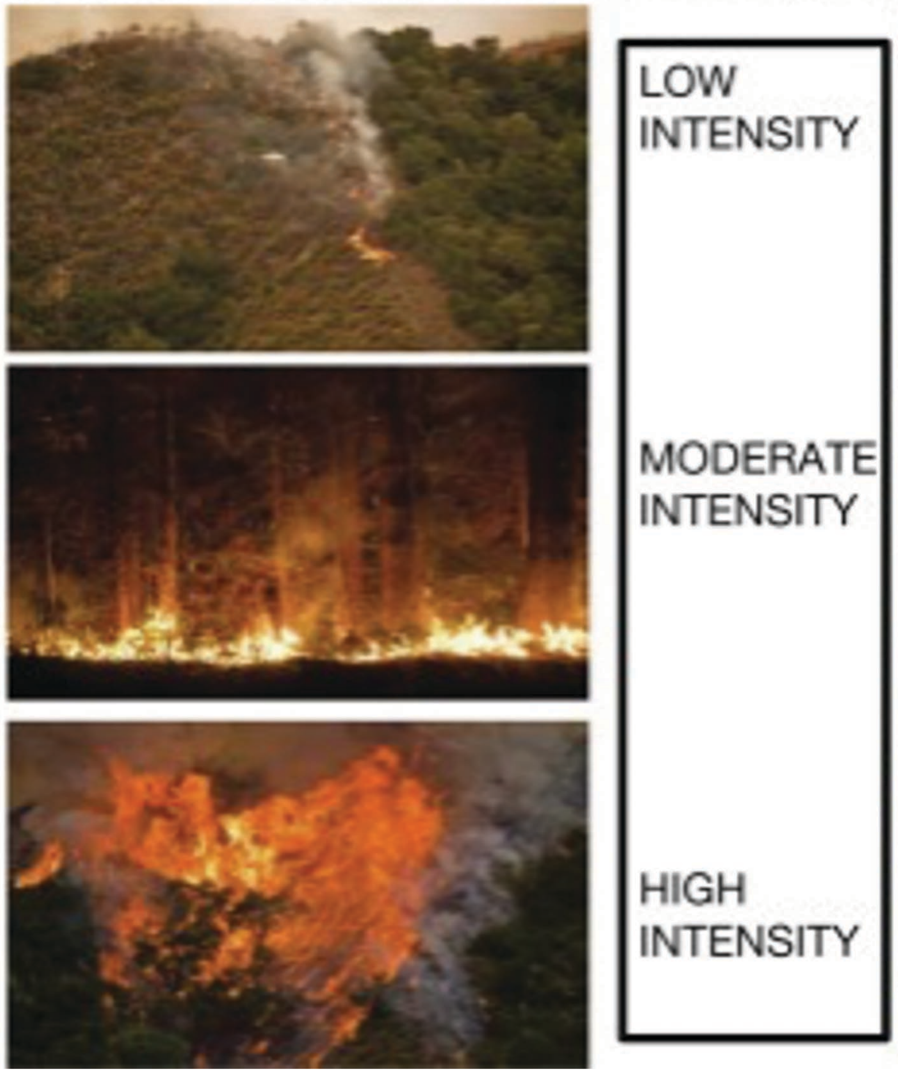
- **The average period between fires under the presumed historical fire regime**
  - Provides temporal metric about the expected occurrence of fire events over a number of years
  - Depends on ecosystem, landscape, and vegetation composition of distinct areas



Mean fire interval map from Guyette et al. 2012. Fire intervals are vulnerable to alteration due to climate change. Image Credit: Guyette et al. 2012

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

Soil Burn Severity

- The **fire-induced changes** in physical, chemical, and biological **soil properties** that impact hydrological and biological soil functions

Image Credit: Stefan Doerr

Low

Moderate

High

Image Credit: co-co.org

Effects of Fire on Land Surface

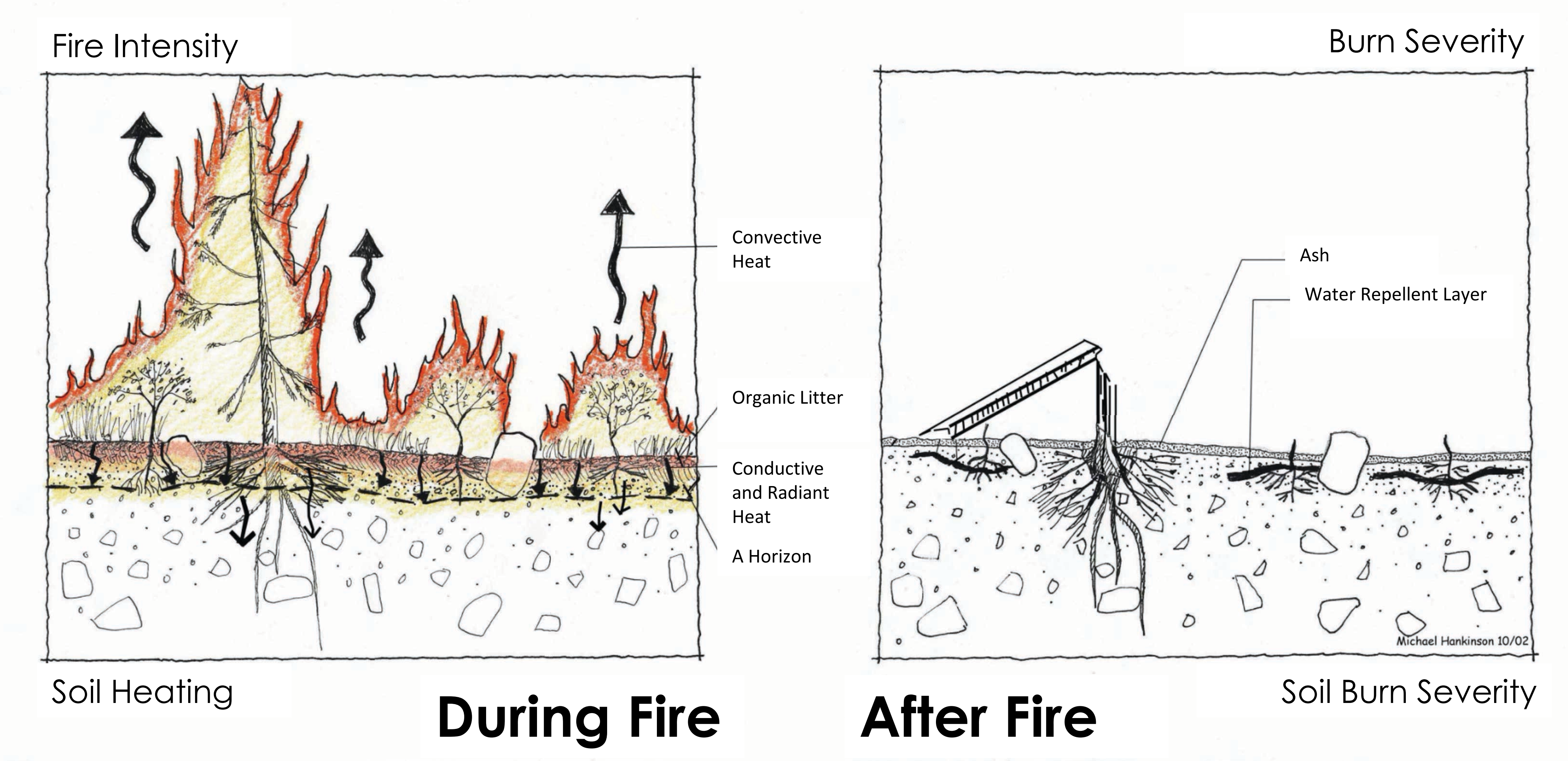


Image Credit: USDA Forest Service Gen. Tech. Rep. RMRS-GTR-243. 2010

Field Perspective

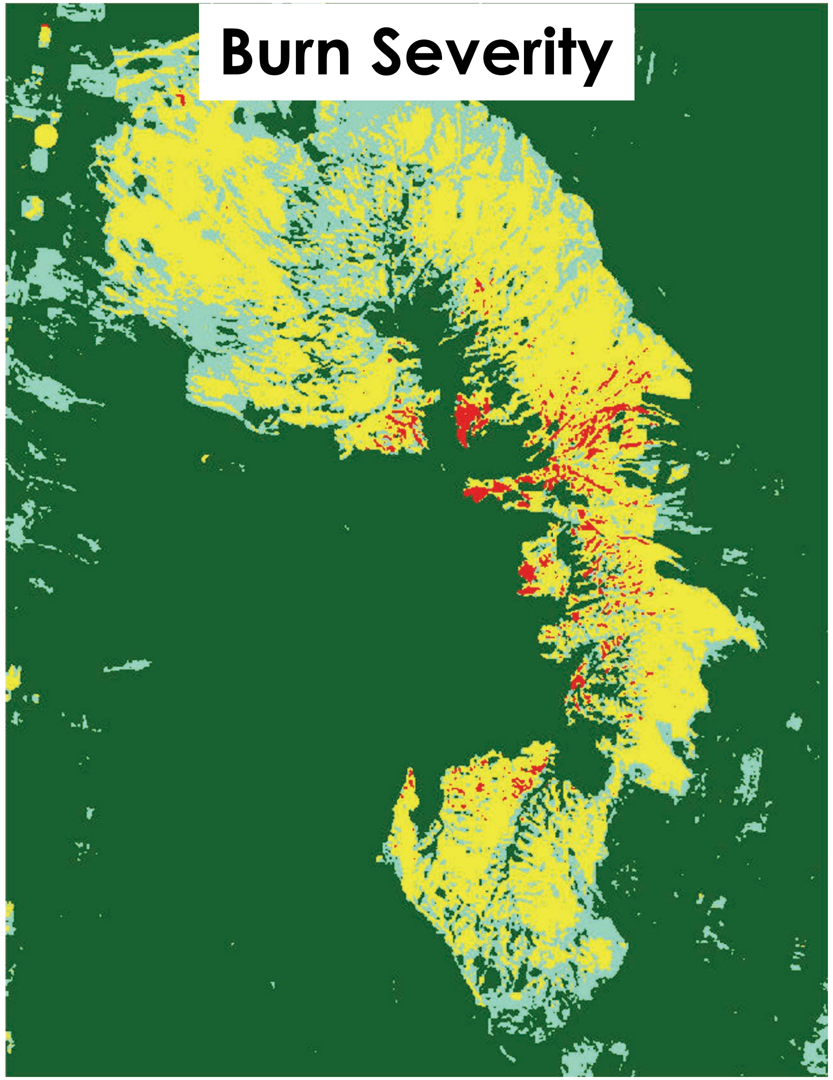
- Ground-based severity assessments post-fire:
  - Composite Burn Index (CBI)
  - Field observing of the burn scar mosaic
  - Water repellency tests
- Ground-based regrowth assessments post-fire:
  - Tree injury assessment
  - Determination of tree mortality
  - Field monitoring of vegetation regeneration



Images: USDA Forest Service Gen. Tech. Rep. RMRS-GTR-243. 2010

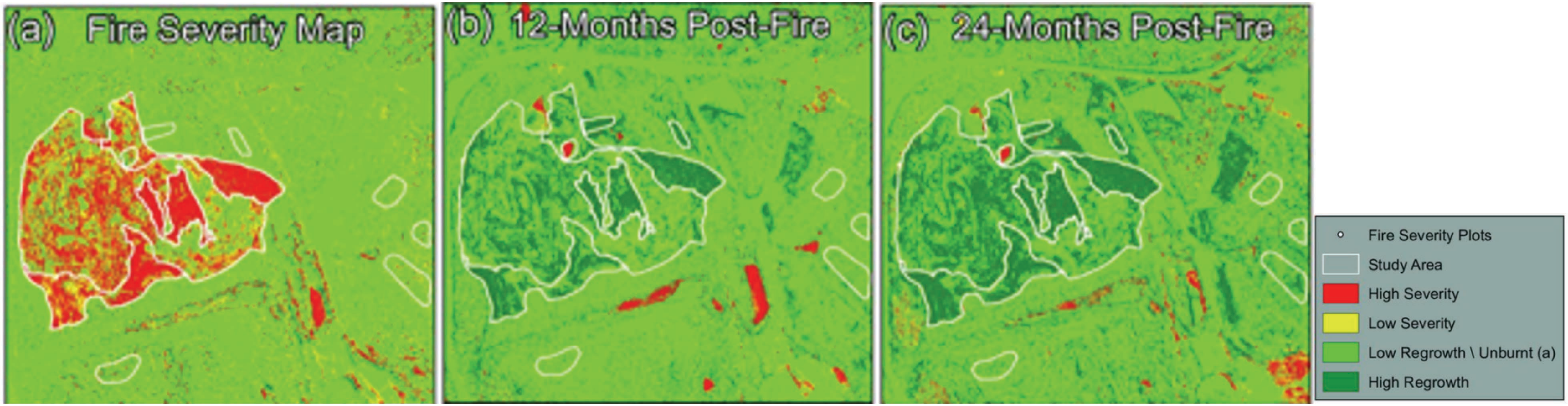
Remote Sensing Perspective: Burned Area and Burn Severity

- 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.



Remote Sensing Perspective: Vegetation Regrowth

- Vegetation indices and land classifications use imagery to assess vegetation regeneration and condition at various post-fire intervals.

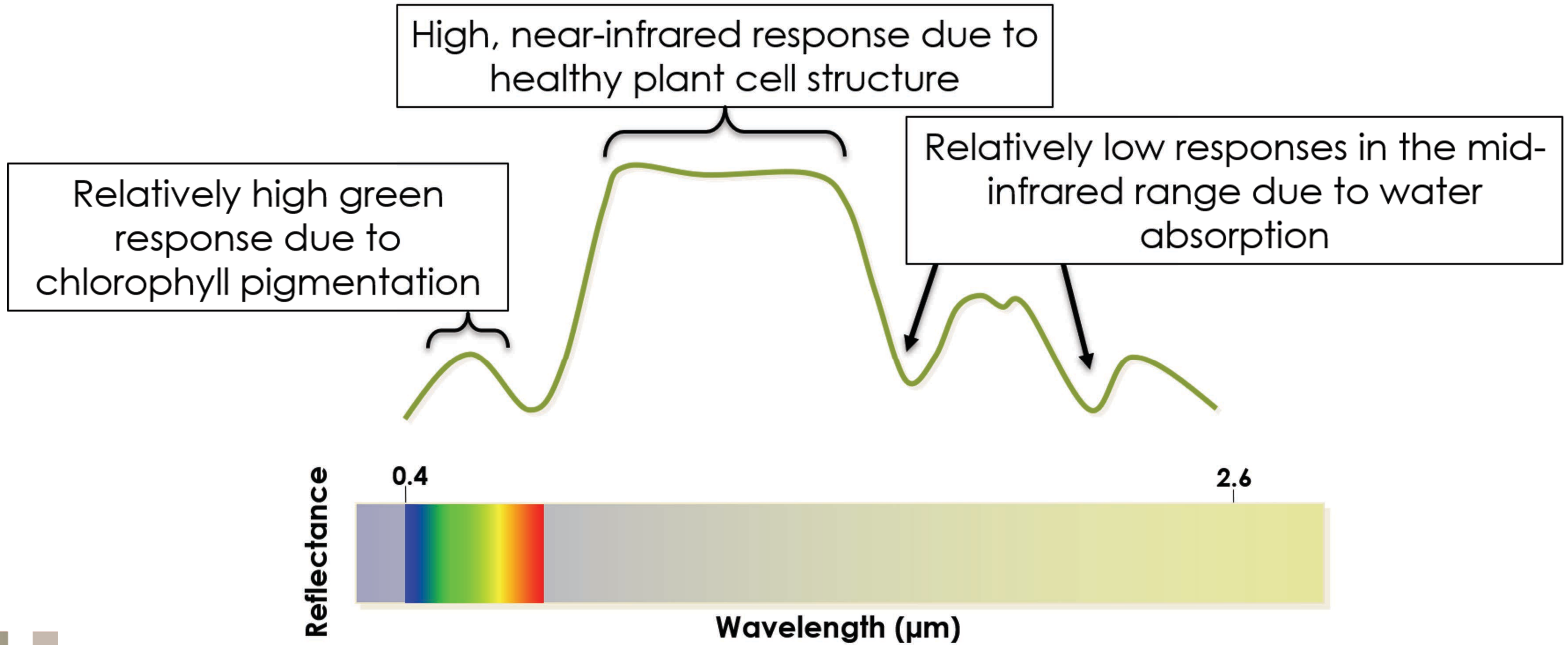


Differenced Normalized Difference Vegetation Index (dNDVI) analysis of WorldView-3 images showing: (a) fire severity map; (b) fire recovery 12-months post-fire; and (c) fire recovery 24-months post-fire at a coal mine rehabilitation in semi-arid Central Queensland, Australia. Credit: McKenna, Phinn, & Erskine, 2018

Burned Area and Burn Severity Mapping

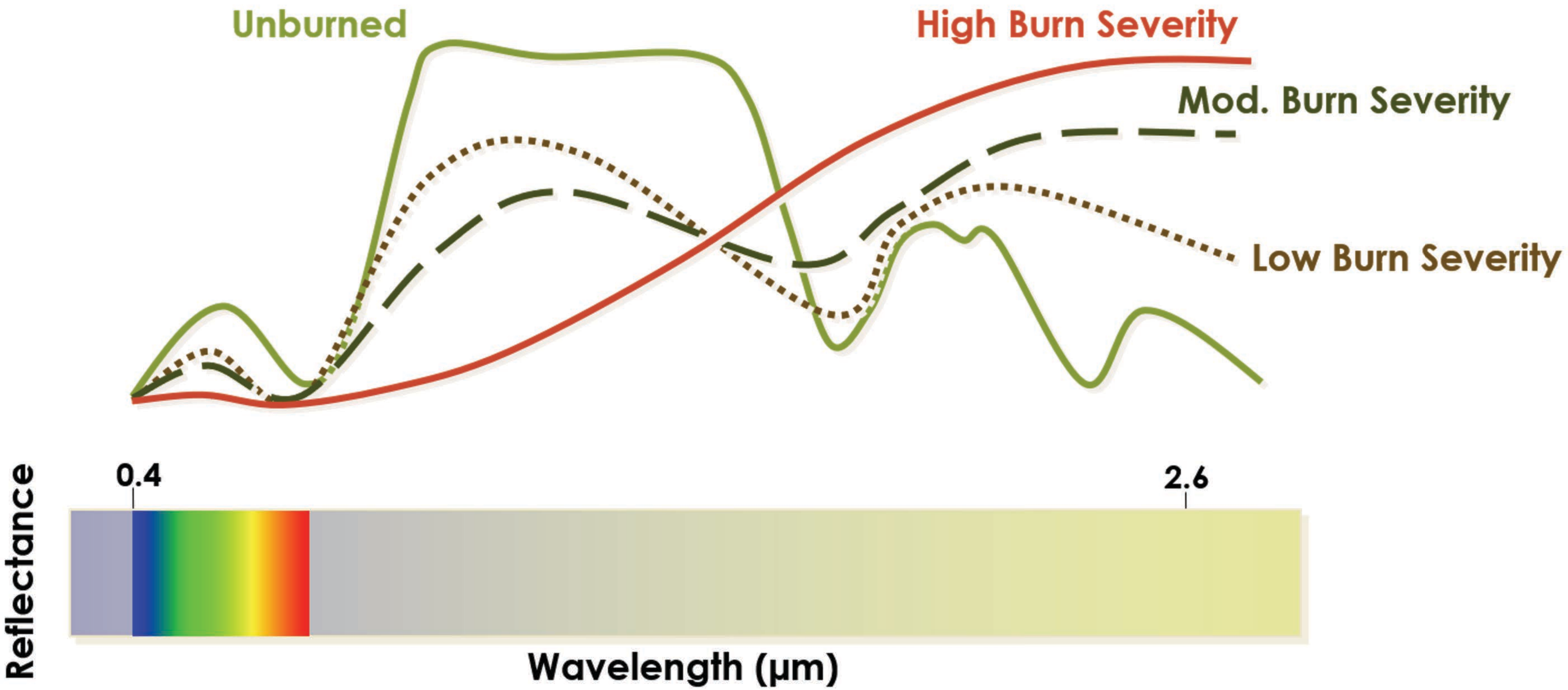
Typical Vegetation Spectral Response

Spectral Response Curve of Typical Vegetation from 0.4 to 2.6 µm



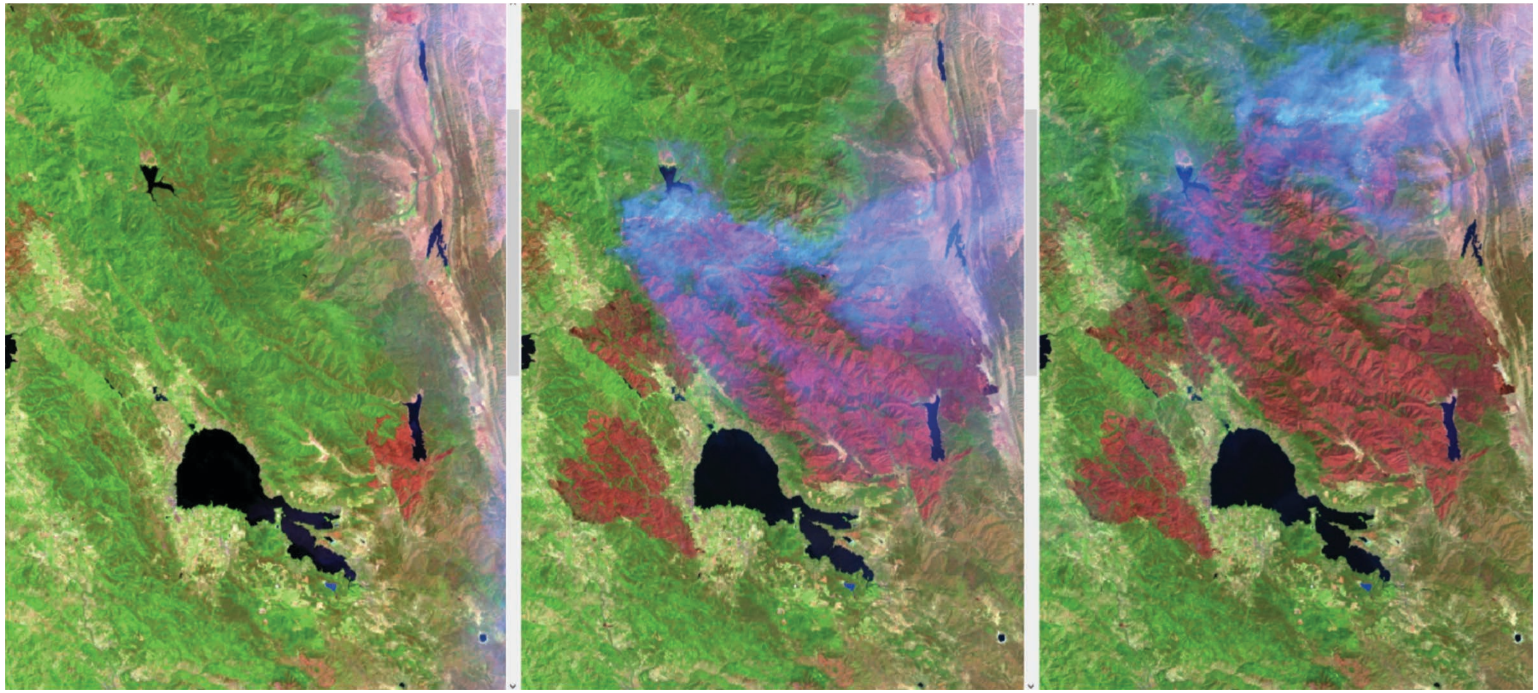
Healthy Vegetation vs. Burned Areas

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)

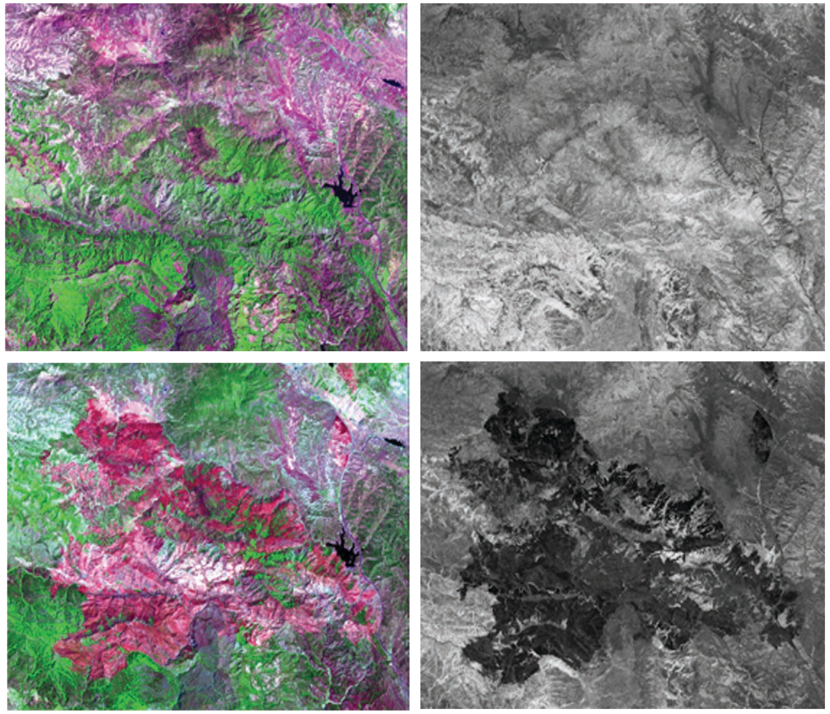
- **Normalized Burn Ratio (NBR)**
- Establishes extent of burned area before and after fire event

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

Reflectance NBR

Pre-Fire

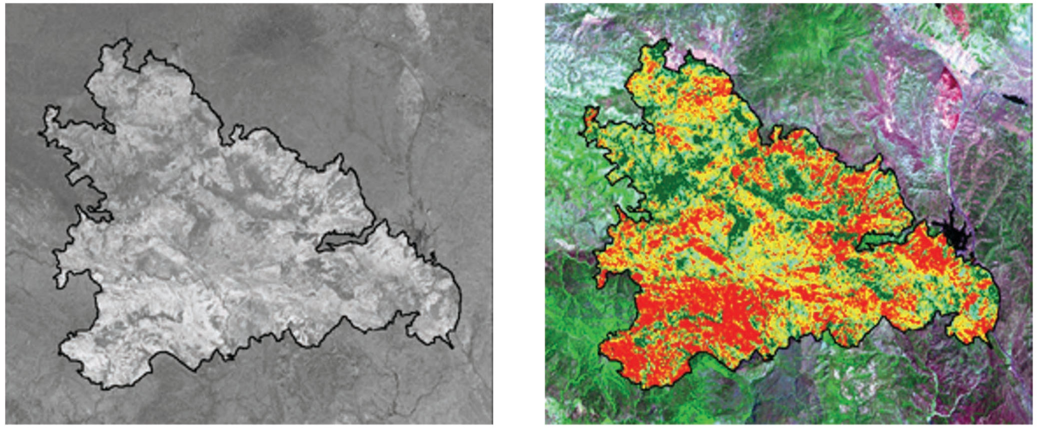
Post-Fire



dNBR

Thresholded Severity Product

Difference



Burn Severity: Relativized Differenced Normalized Burn Ratio (RdNBR)

- Variant of dNBR; removes bias associated with pre-fire vegetation condition
  - Developed by [Miller and Thode, 2007]
  - Example: Low density vegetation in pre-fire image experiences complete burn
    - i.e., a stand-replacing fire
  - RdNBR measures relative change of vegetation within the pixel:
    - 100% change in vegetation: RdNBR is high

dNBR & RdNBR

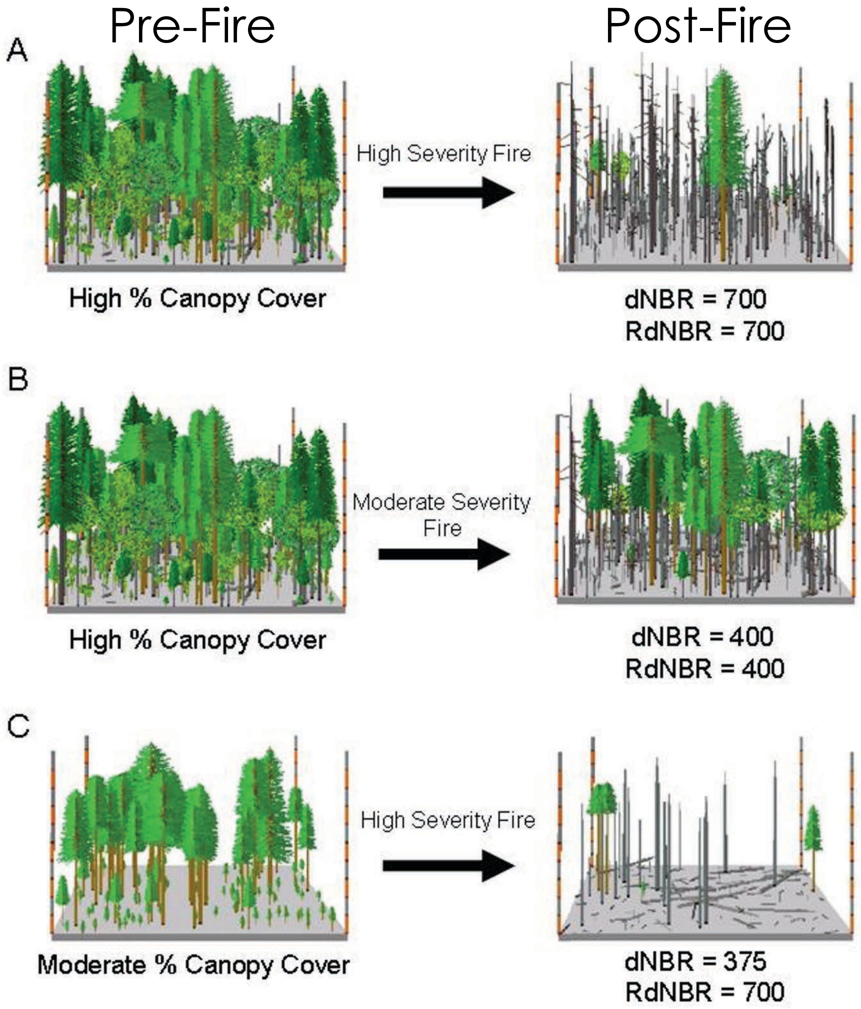
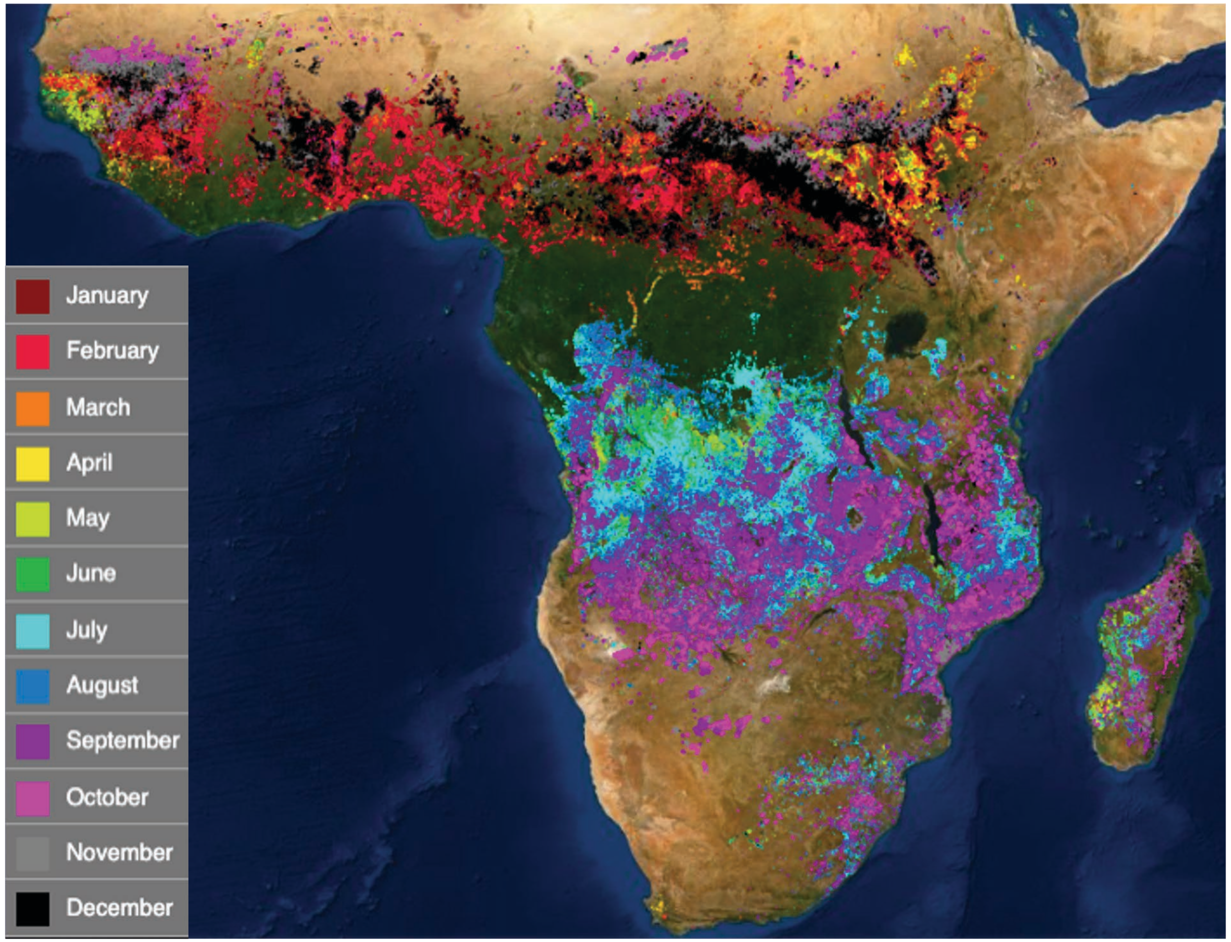


Image Credit: Remote Sensing of the Environment; 109, 66-80 (July 12, 2007)

Burned Area: MODIS

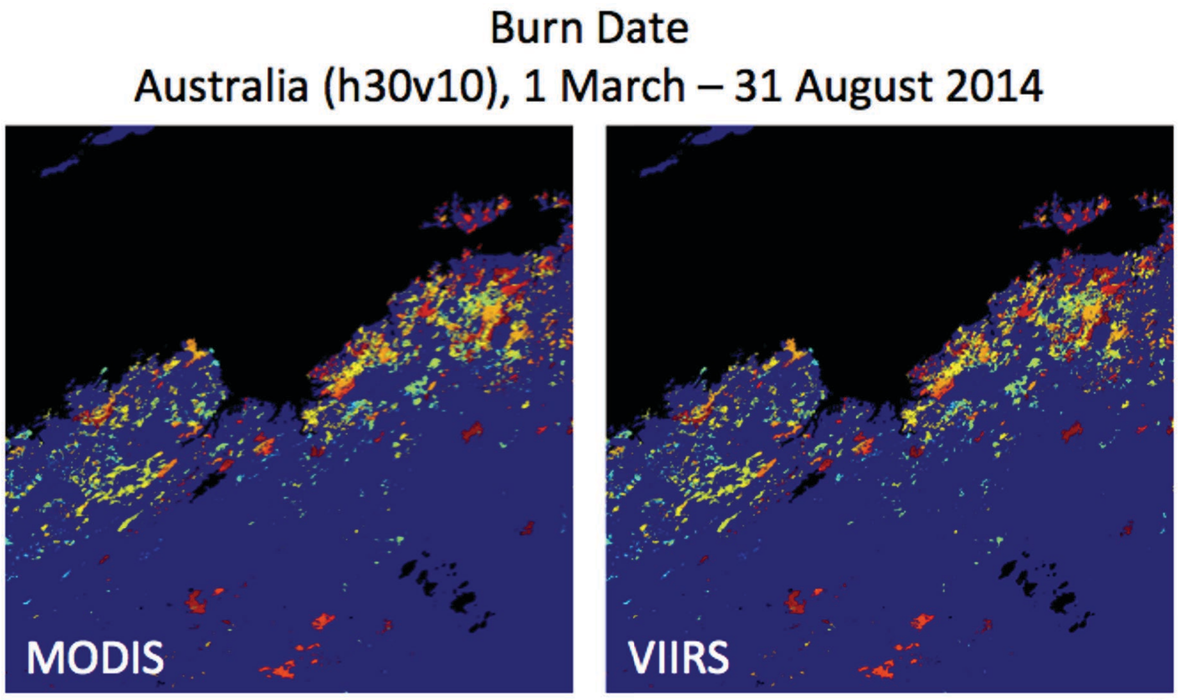
- Takes advantage of fire related changes to the landscape, like deposits of charcoal and ash, removal of vegetation, and alteration of the vegetation structure.
- The high temporal resolution of MODIS means it can detect occurrence of rapid changes in daily surface reflectance time series data and map the spatial extent of burned area for recent and previous fires.
- Terra and Aqua combined MCD64A1 Version 6 Burned Area data product is a monthly, global gridded 500 m product containing per-pixel burned area.



MODIS burned area mapped for 2020 by month in sub-Saharan Africa.
Image Credit: NASA FIRMS

Burned Area: VIIRS

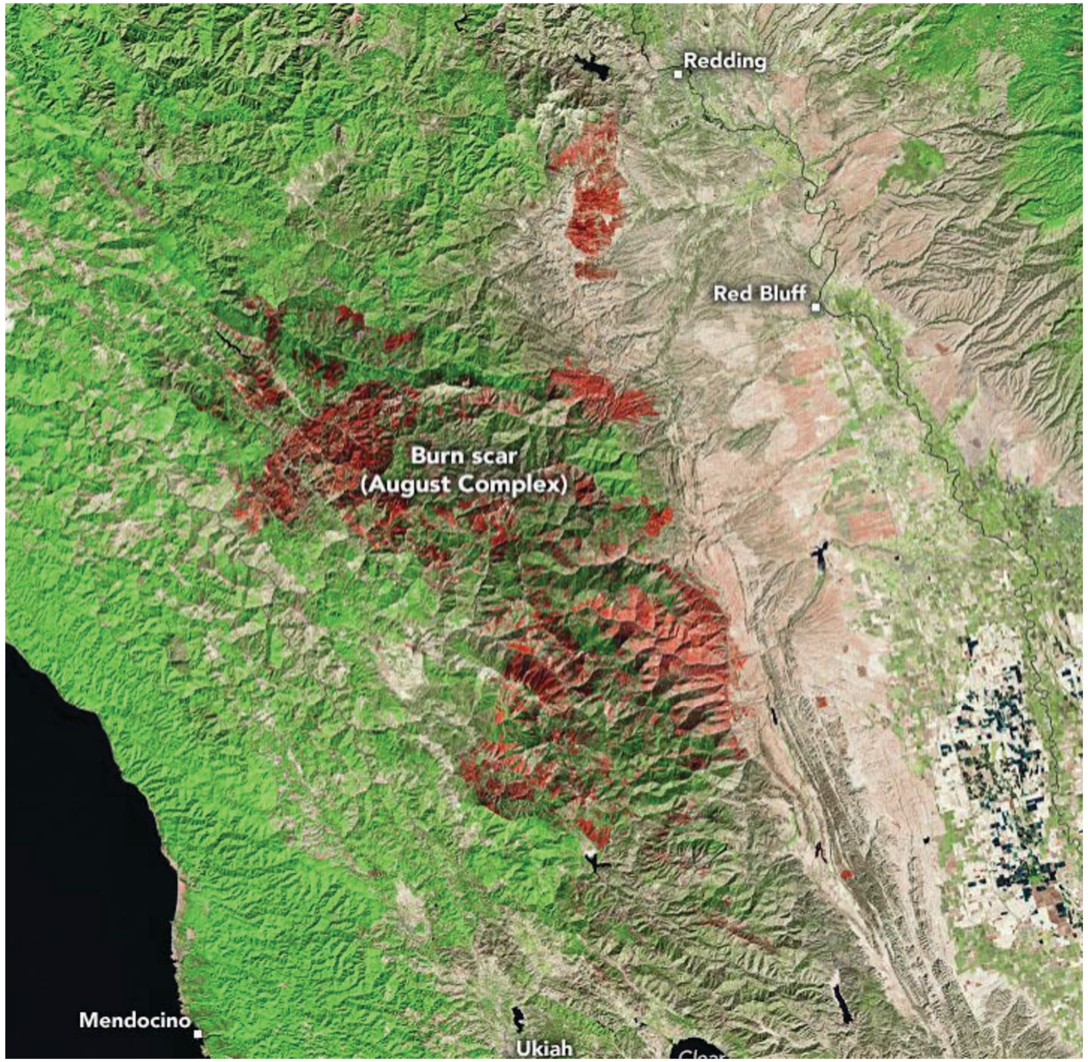
- The VNP64A1 data product is designed similarly to the MODIS burned area product to promote the continuity of the Earth Observation System (EOS) mission.
- Provisional data is released on a limited basis due to issues identifying burned area at the edges of inland water bodies and at high latitudes. Version 2 of this data product will address these issues.
- Monthly, global, gridded, 500 m product containing per-pixel burned area and quality information.



VIIRS burned area products will provide continuity with MODIS burned area products. Image Credit: NASA

Burned Area Assessment: Landsat 8

- The August Complex Fire was ignited by lightning storms in mid-August 2020.
- Fires in this area had consumed 1,032,264 acres by the morning of October 21 and were still burning (though 91% contained).
- Imagery captured by Landsat 8 on October 19 was processed using the Landsat Burned Area Algorithm to identify the burned area.
- Link: Landsat Burned Area Product



Burn scar of the 2020 August Complex Fire in Northern California using Landsat 8 OLI imagery acquired on October 19, 2020.
Image Credit: NASA

Normalized Burn Ratio: Landsat

- Derived from surface reflectance of the Landsat series (4-5 TM, 7 ETM+, and 8 OLI)
- 30 m resolution NBR data product ordered from:
  - https://espa.cr.usgs.gov/
- Landsat 4-7, NBR = (Band 4 – Band 7) / (Band 4 + Band 7)
- Landsat 8, NBR = (Band 5 – Band 7) / (Band 5 + Band 7)
- Data Specifications:
  - https://www.usgs.gov/core-science-systems/nli/landsat/landsat-normalized-burn-ratio

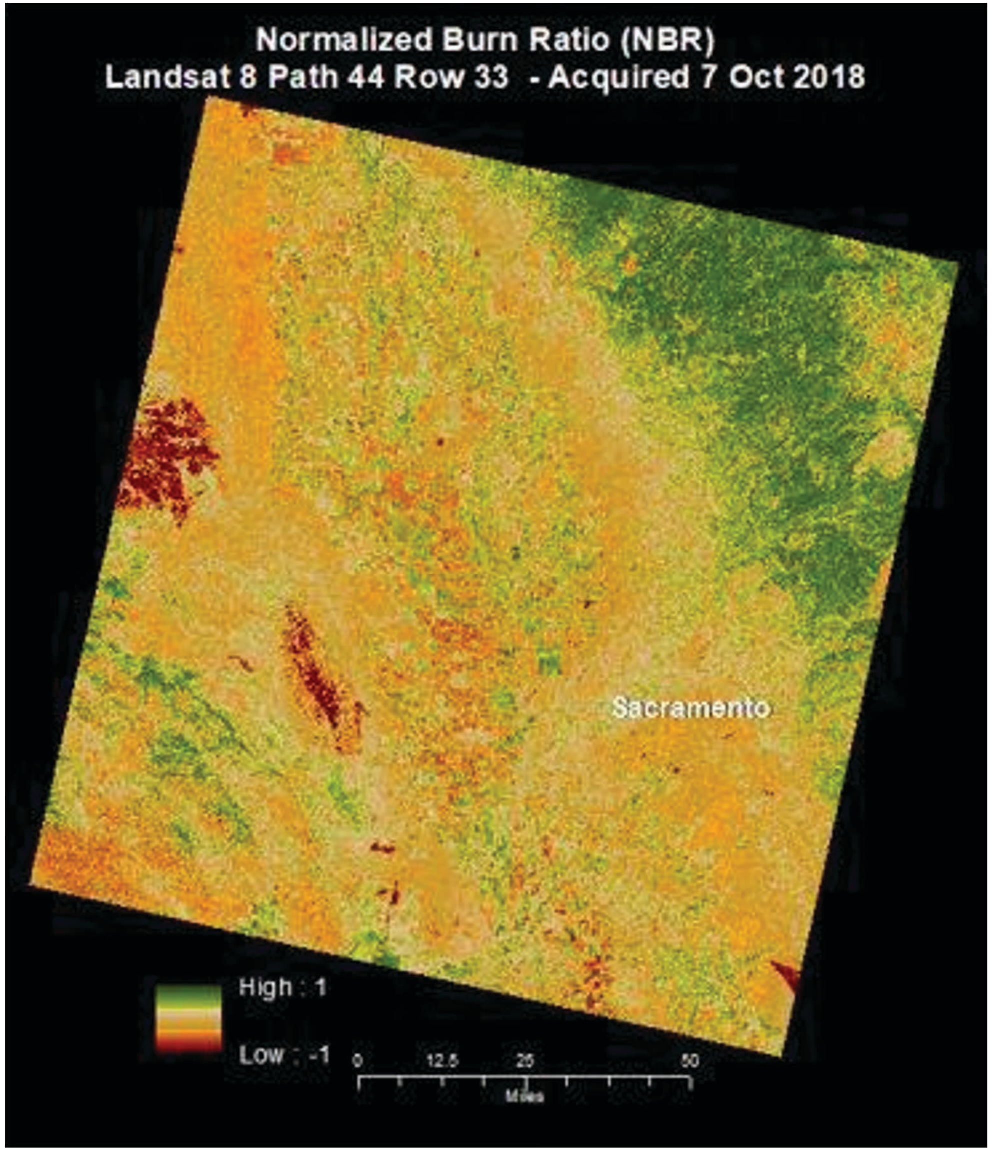
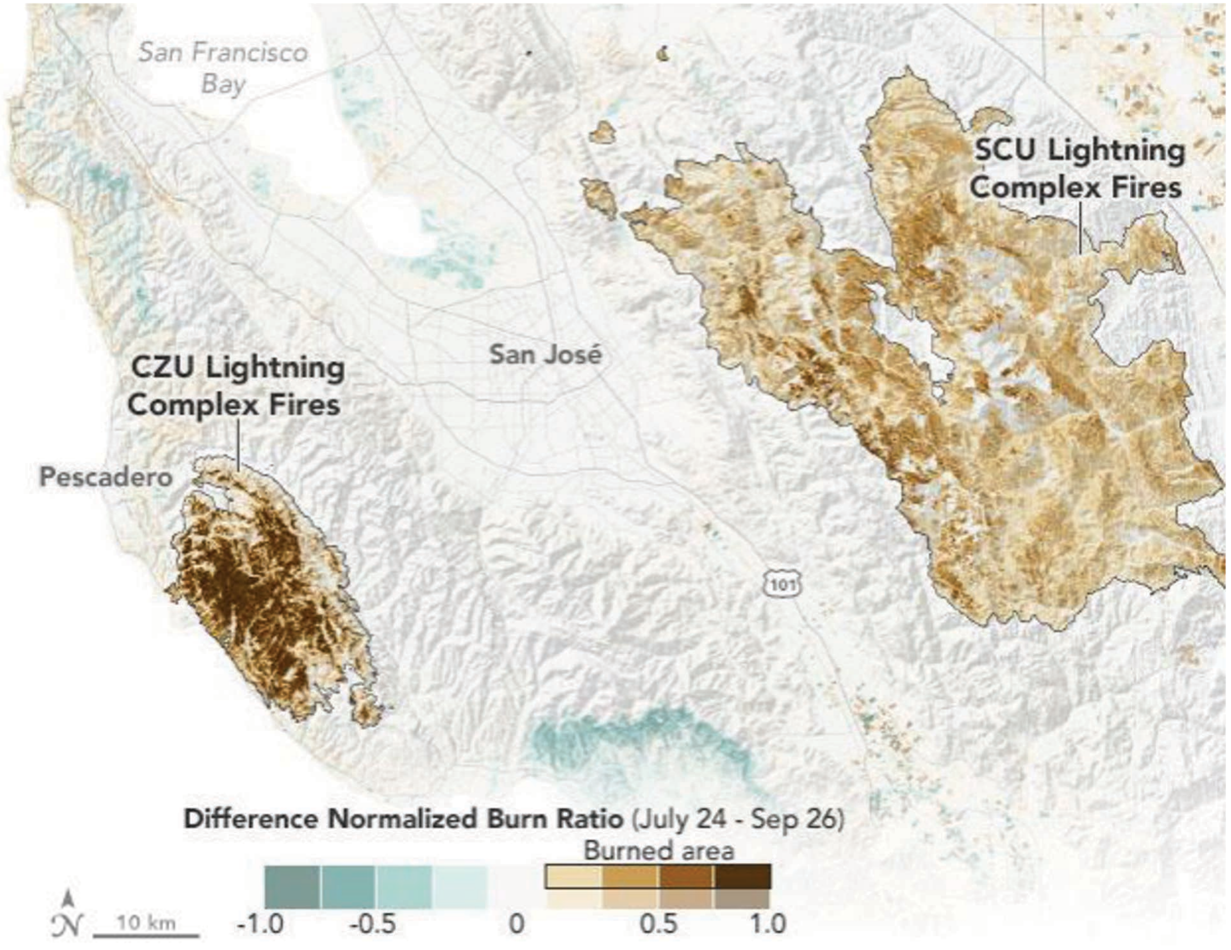


Image Credit: USGS

Burn Severity Assessment: Landsat 8

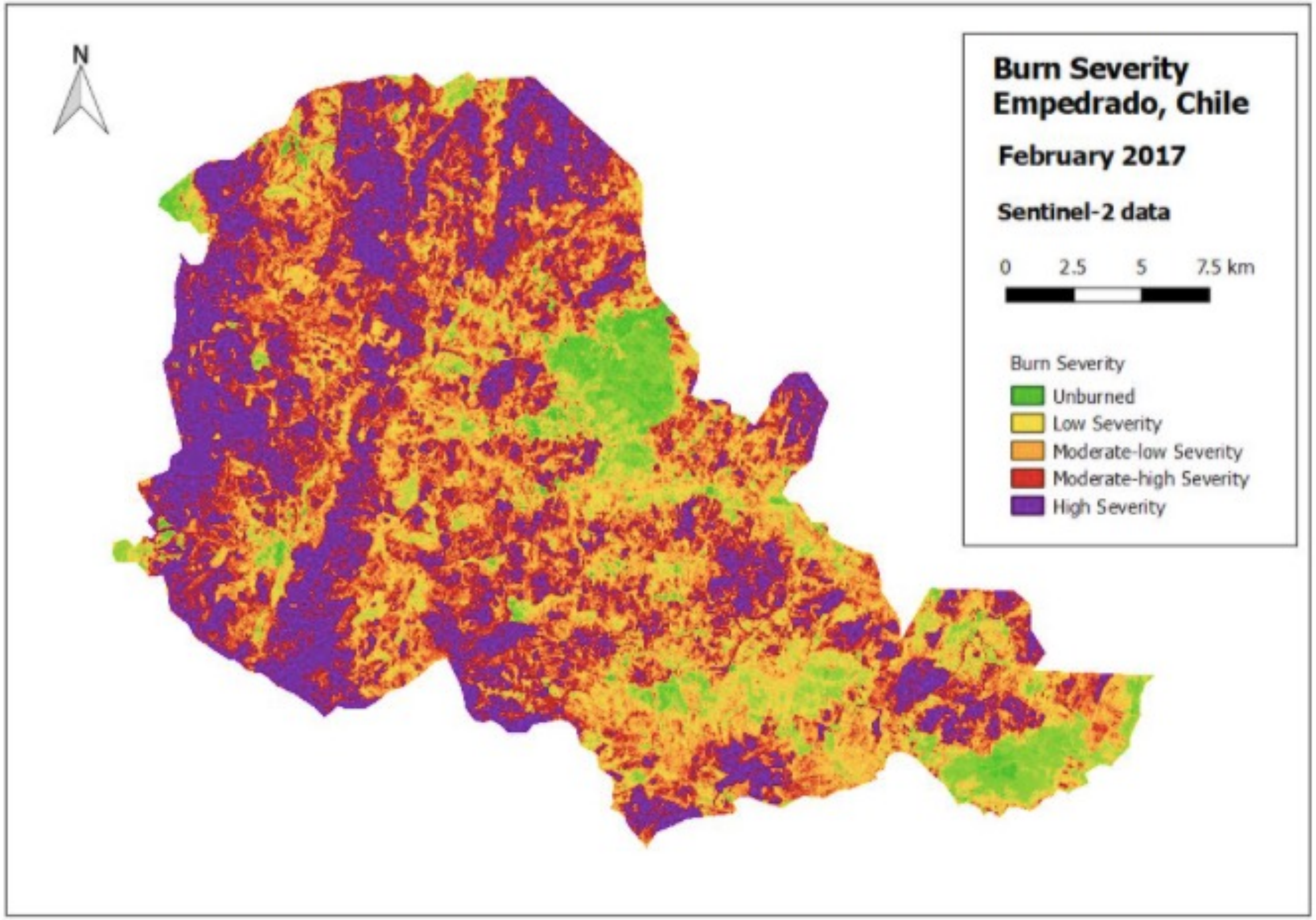
- The CZU and SCU Lightning Complex Fires of August and September 2020 burned 86,500 acres and 396,000 acres, respectively.
- Landsat 8 data from July 24 (pre-fire) and September 26 (post-fire) were used to calculate NBR and then dNBR, and values were thresholded to map severity.
- Shades of tan and brown reveal the severity of the burns from each fire, with the darkest shades revealing the greatest damage to the landscape.



Burn severity of the CZU and SCU Lightning Complex Fires in California. Note that higher burn severity does not equate to more burned area, as evidenced by comparison of these two complex fires.
Image Credit: NASA

Burn Severity Assessment: Sentinel-2

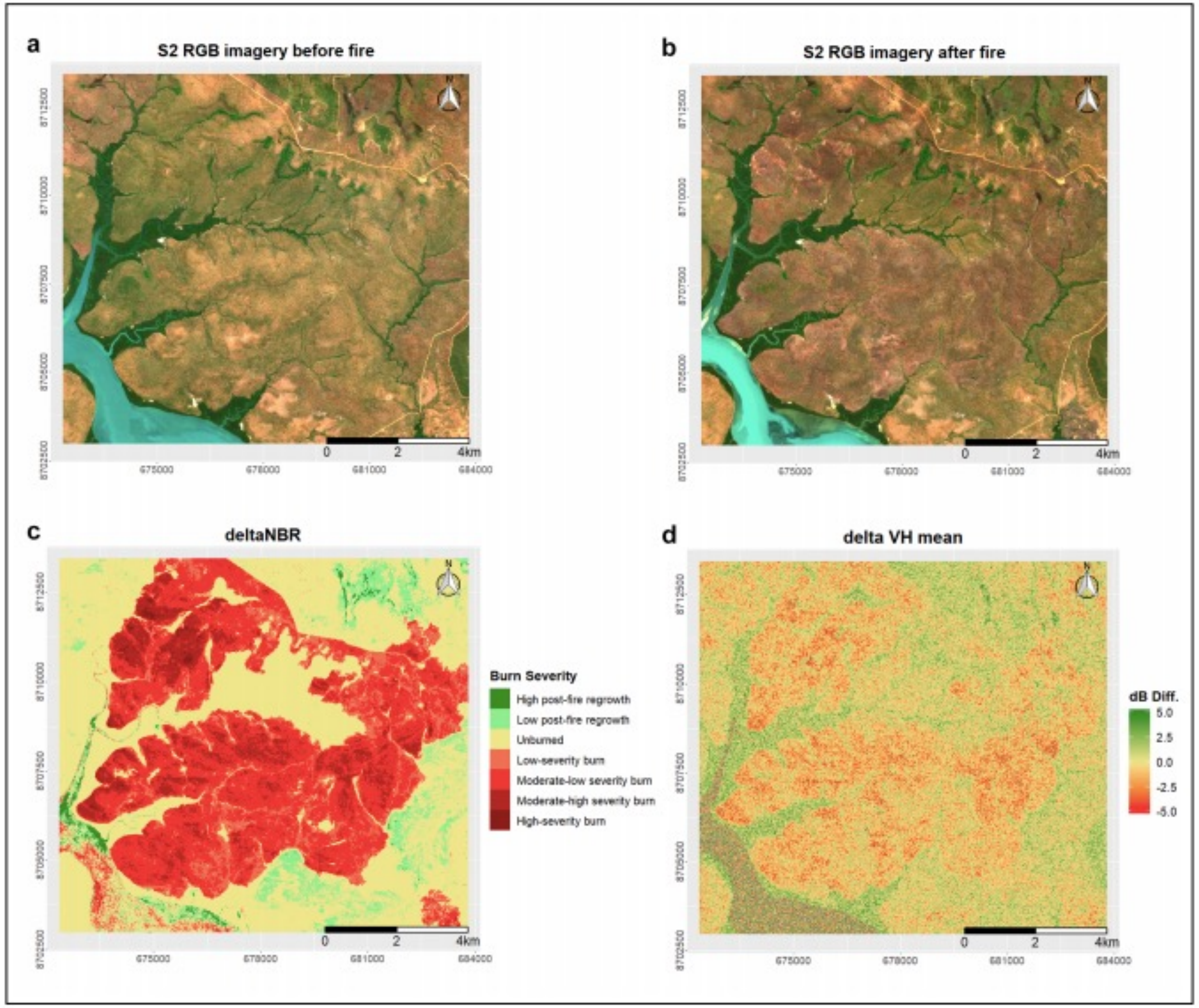
- Sentinel-2 data is also useful for burn severity mapping.
- The methodology for completing burn severity assessment is similar to Landsat, with differences in exact bands for calculations.
- UN-SPIDER is a great resource for burn severity methodologies for Sentinel-2 and Landsat 8:
  - https://github.com/UN-SPIDER/burn-severity-mapping-EO



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

Sentinel-1 SAR Burned Area and Severity Applications

- Philipp & Levick (2019) examined the utility of Sentinel-1 C-Band SAR data examined for estimating burn severity in savanna ecosystems
- Sentinel-1 C-band backscatter (VH) proved sensitive to the structural changes imparted by fire and was correlated with the Normalized Burn Ratio (NBR) derived from Sentinel-2 optical data.
- Large-scale detection of savanna burn on Australia's Tiwi Islands (shown in the figure on the right)



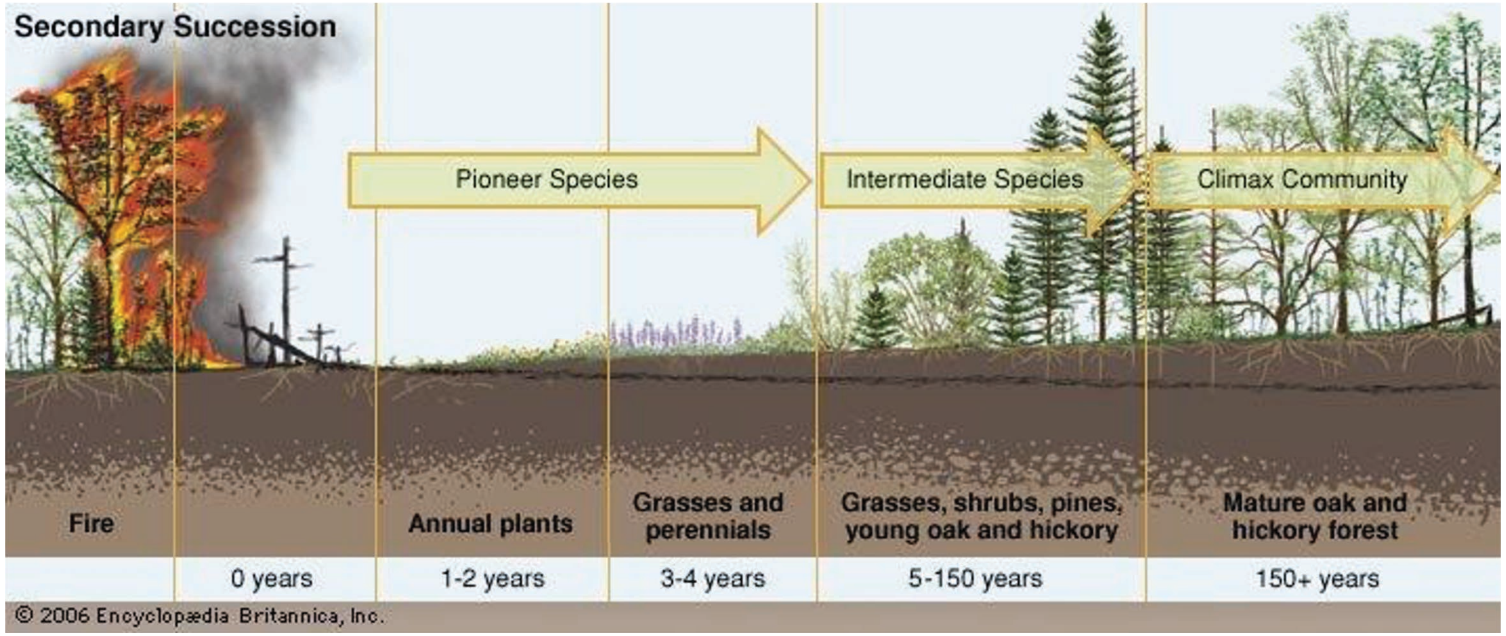
Optical images before (a) and after (b) the fire are visualized. High burn severities as classified by "deltaNBR" (c) also stand out in the mean delta VH SAR image (d).
Image Credit: Philipp & Levick, 2019

National Aeronautics and Space Administration

Mapping Post-Fire Vegetation Regrowth

Post-Fire Secondary Succession

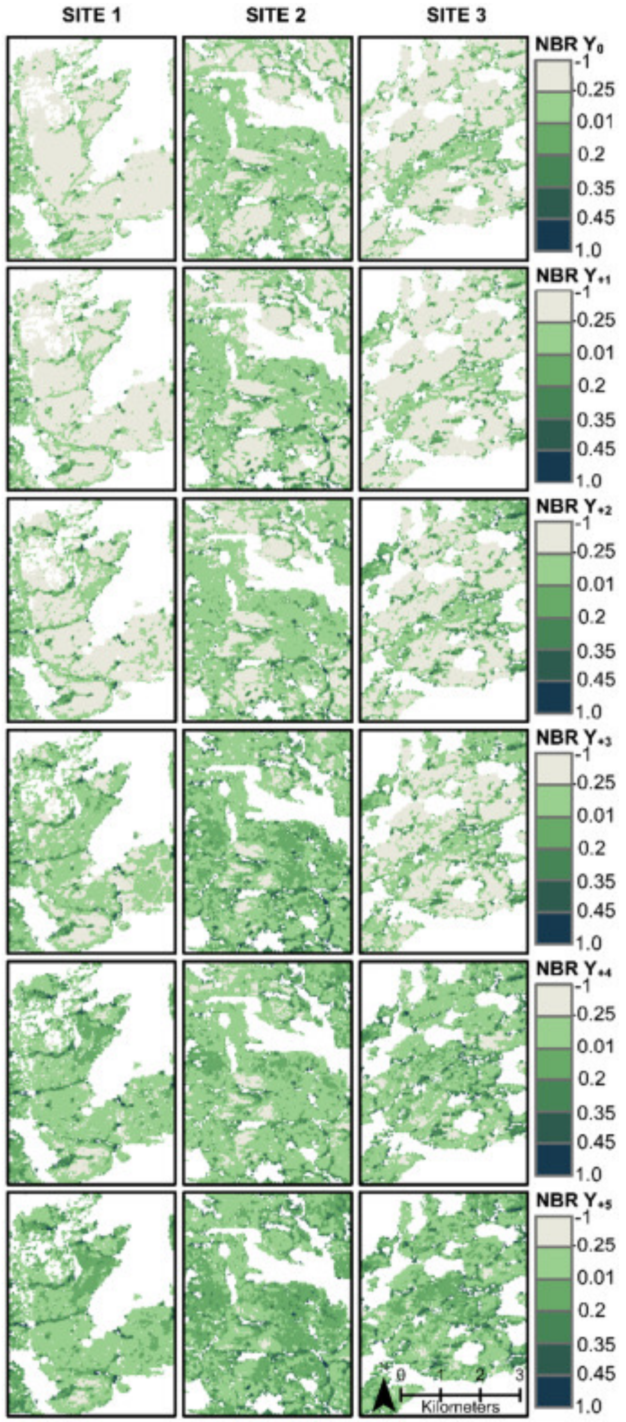
- After fire disturbance, vegetation regrowth follows a pattern of succession.
- Timelines and plant species vary across different forest types, shrublands, etc.
- Mapping vegetation regrowth includes characterizing vegetation as dominant successional vegetation type changes over time.



Example of secondary succession due to fire. Image Credit: Britannica

Vegetation Regrowth: NBR

- High NBR values (closer to 1) indicate vegetation presence and detect regrowth.
- Mapping NDVI at regular intervals post-fire provides a metric for vegetation recovery.
- [Frazier et al. (2018)](#) mapped NBR in Canadian boreal forest site where fires occurred at 5 year intervals post-fire.
- Vegetation regrowth is observable throughout the time series.



NBR time series from the year of disturbance to five years after are shown for 3 Canadian boreal forest sites, with time since disturbance increasing from the top row to the bottom of the rows. Generally, NBR increases with time since disturbance. Image Credit: Frazier et al. (2018)

Vegetated Landscape Measurement Parameters from Part 2

Vegetation Type and Extent
- Land Cover Classification
- Fractional Cover (FC)

Vegetation Stage and Health
- Vegetation Health Indices

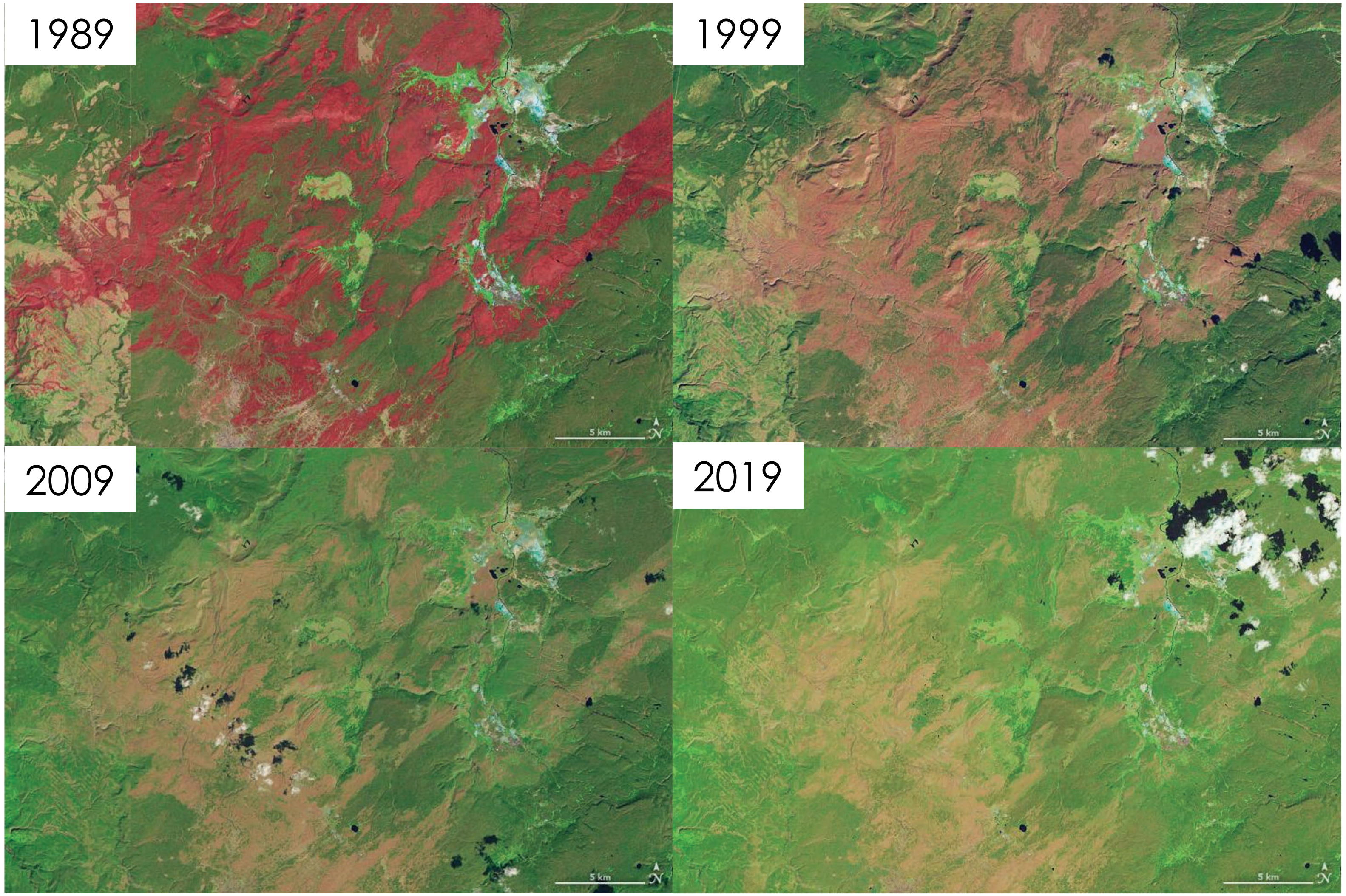
Vegetation Moisture Content
- Moisture Indices
- Radar Measurements

Vegetation Structure
- Density
- Height

***Refer back to part 2 of this training series for a more detailed explanation of how to map these parameters and for tips on pre-processed data products:**
https://appliedsciences.nasa.gov/join-mission/training/english/arset-satellite-observations-and-tools-fire-risk-detection-and

Post-Fire Vegetation Regrowth: NDVI

- In the summer of 1988, lightning- and human-ignited fires consumed vast stretches of Yellowstone National Park.
- 793,000 of the park's 2,221,800 acres burned.
- Landsat 5 and 8 Normalized Difference Vegetation Index (NDVI) estimates show the slow recovery of vegetation over the burn scar.



NDVI estimates over the course of 30 years show increase in greenness, indicating vegetation regrowth across the burn scar. Image Credit: NASA

Post-Fire Vegetation Assessment: Land Cover

- NASA DEVELOP team working with partners at the Colorado State Forest Service and Trinchera Ranch in Southern Colorado
- Spring Creek Fire burned a total of 108,045 acres
  - 9,100 acres of Trinchera Ranch
- Pre- and post-fire detection of Aspen stands

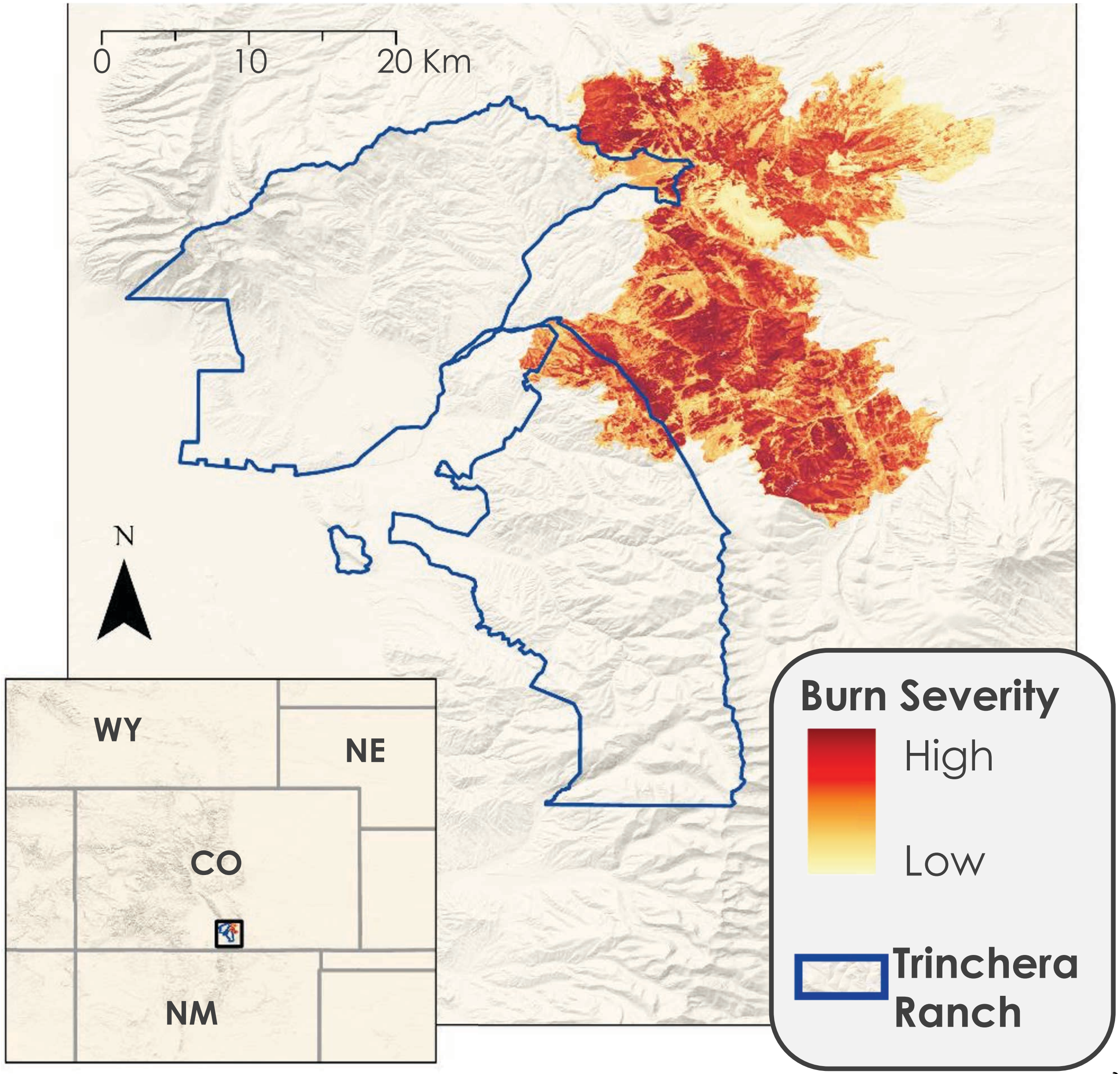


Image Credit: NASA DEVELOP

Post-Fire Vegetation Assessment: Land Cover

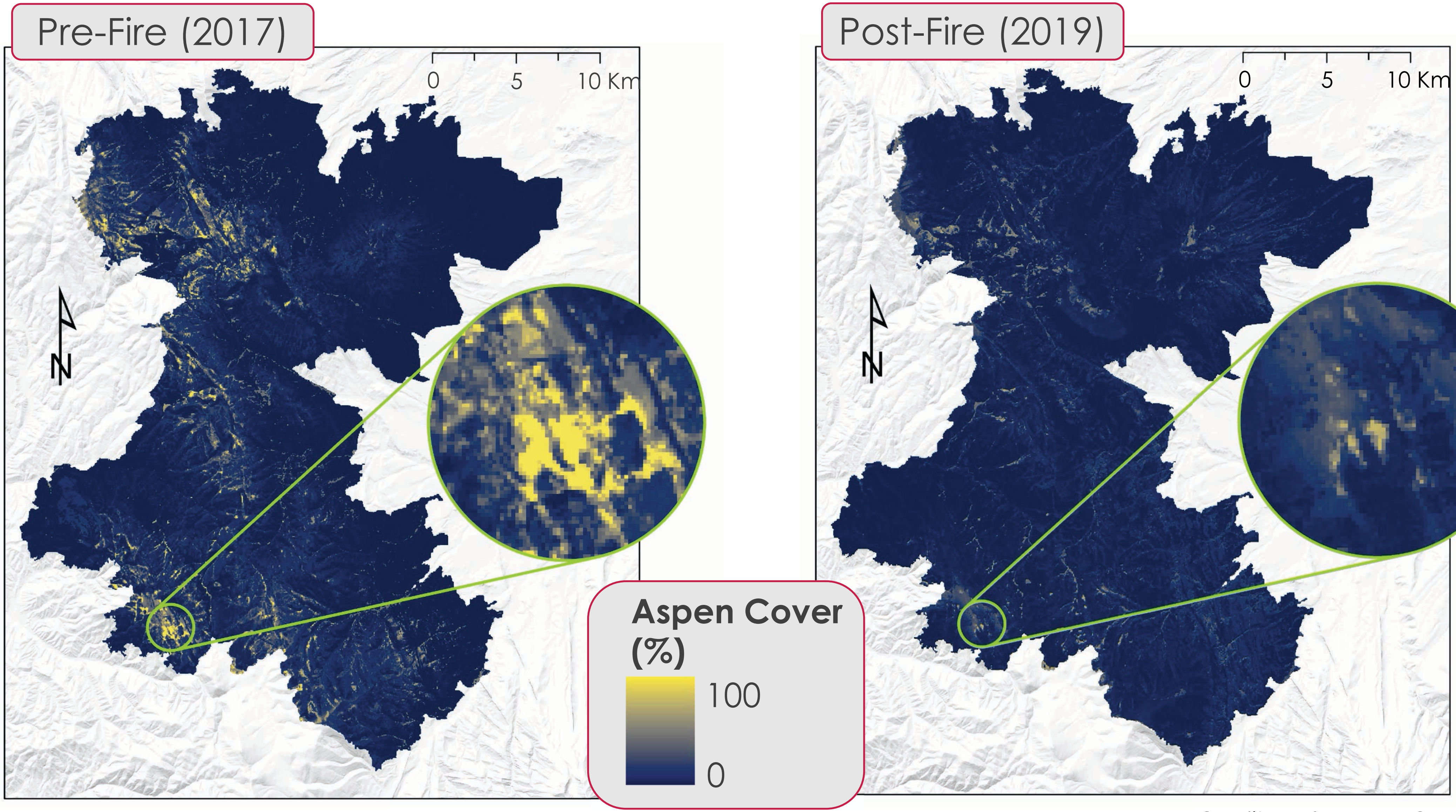
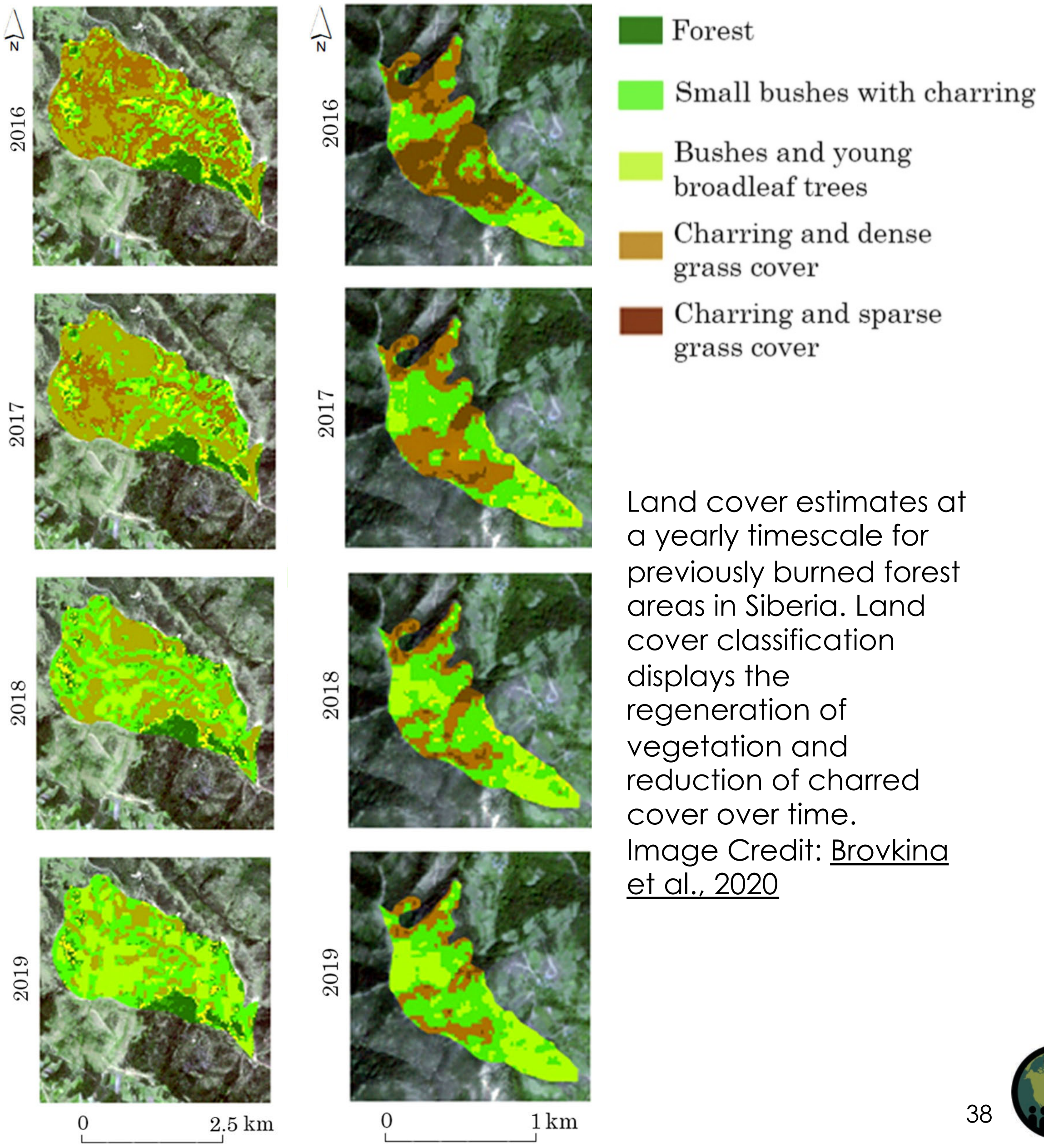


Image Credit: NASA DEVELOP

Post-Fire Vegetation Regrowth: Land Cover

- Land cover classification can map vegetation regrowth over time and provide vegetation type information useful in determining successional stage.
- Brovkina et al. (2020) used Sentinel-2 data to classify previously burned forested areas from 2016-2019 to assess change in vegetation type and reduction of burned cover.

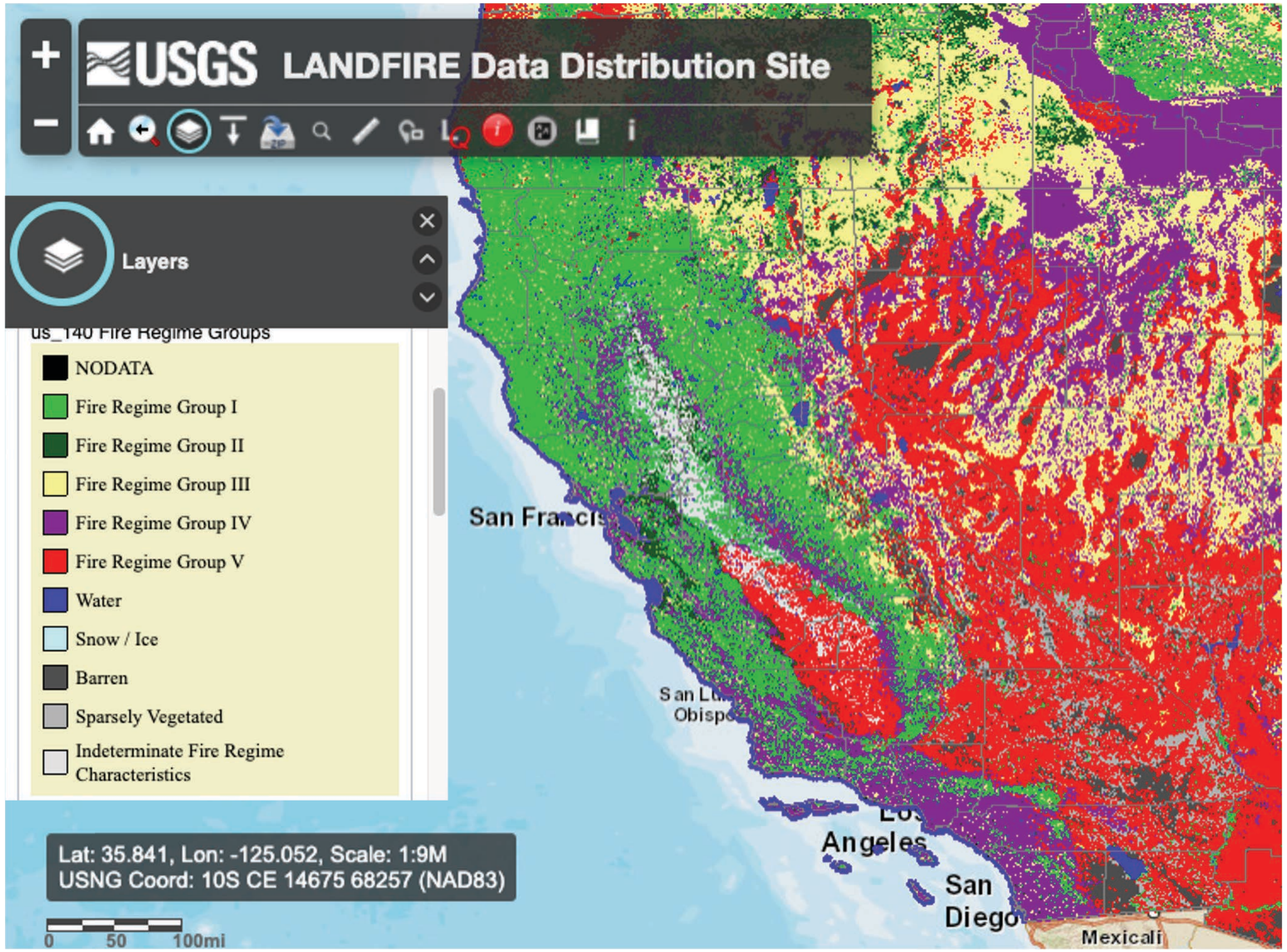


Land cover estimates at a yearly timescale for previously burned forest areas in Siberia. Land cover classification displays the regeneration of vegetation and reduction of charred cover over time. Image Credit: Brovkina et al., 2020

Tools for Post-Fire Mapping

LANDFIRE: Fire Regime Products

- **For the U.S. via LANDFIRE:**
  - https://landfire.gov/viewer/viewer.html
- **Fire Frequency and Severity Products:**
  - Fire regime groups
  - Fire return interval
  - Percent low-severity, mixed-severity, and replacement-severity fire
- **Vegetation Departure Products:**
  - Vegetation condition class
  - Vegetation departure
  - Succession class



LANDFIRE fire regime class for California.
Image Credit: LANDFIRE

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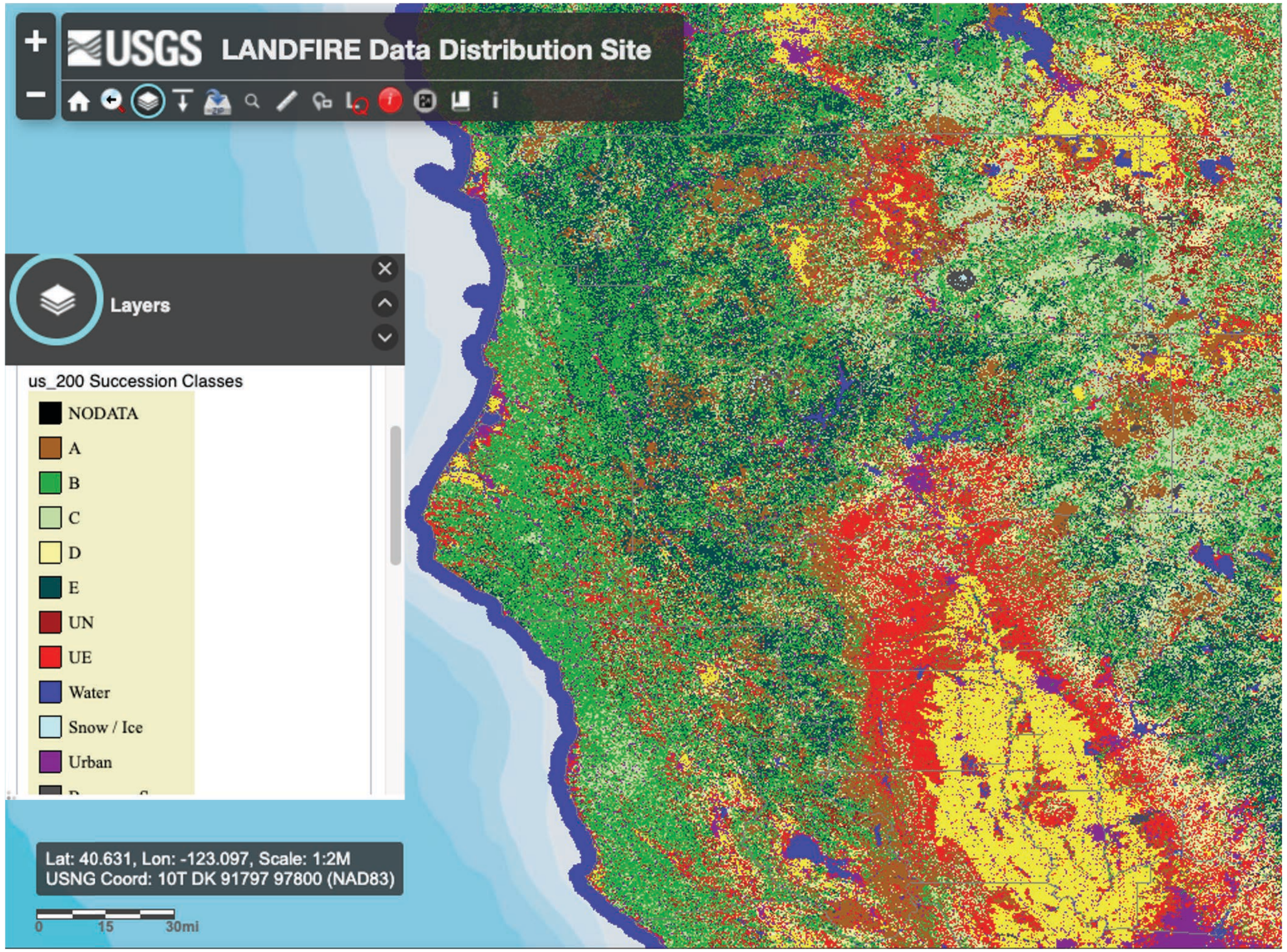
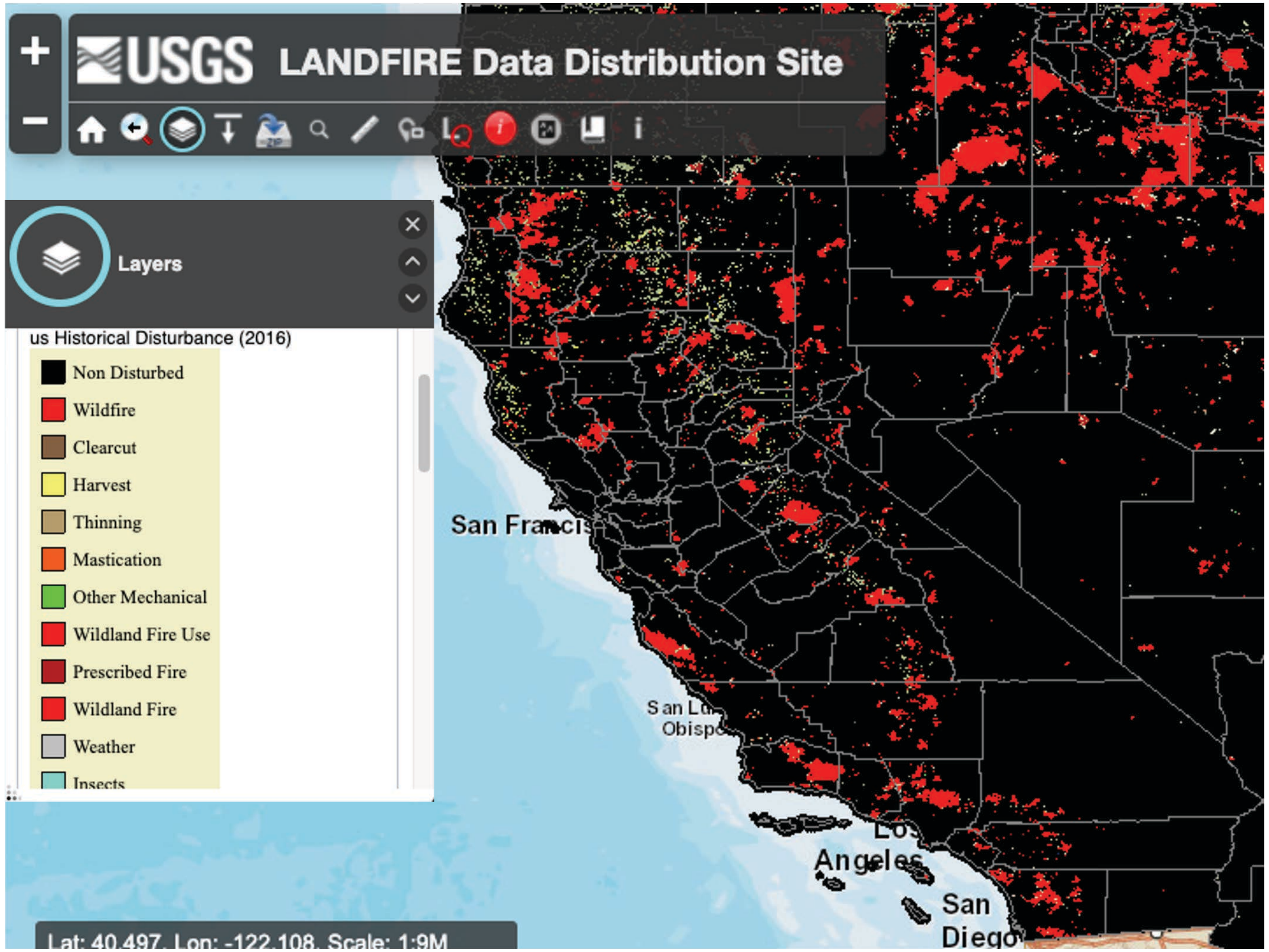


LANDFIRE succession class for Northern California.
Image Credit: LANDFIRE

LANDFIRE: Disturbance Data

- **For the U.S. via LANDFIRE:**
  - https://landfire.gov/viewer/viewer.html
- **Disturbance Data:**
  - Annual
  - Vegetation
  - Fuel
  - Historical
- **Vegetation Disturbance:**
  - Transition magnitude
  - Forest vegetation transitions
  - Non-forest vegetation transitions
  - Forest vegetation simulator
- **Data Specifications for All Layers:**
  - https://landfire.gov/index.php



LANDFIRE historical disturbance data for California.
Image Credit: LANDFIRE

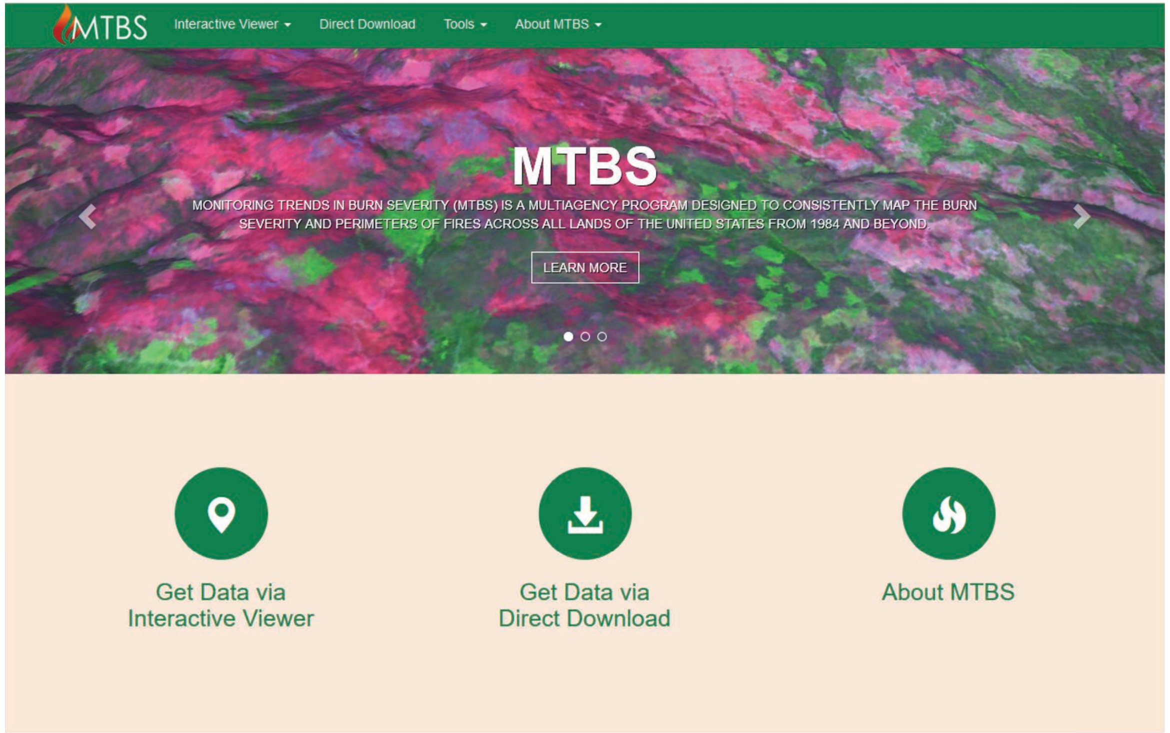
Fire Information for Resource Management System (FIRMS)

- 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

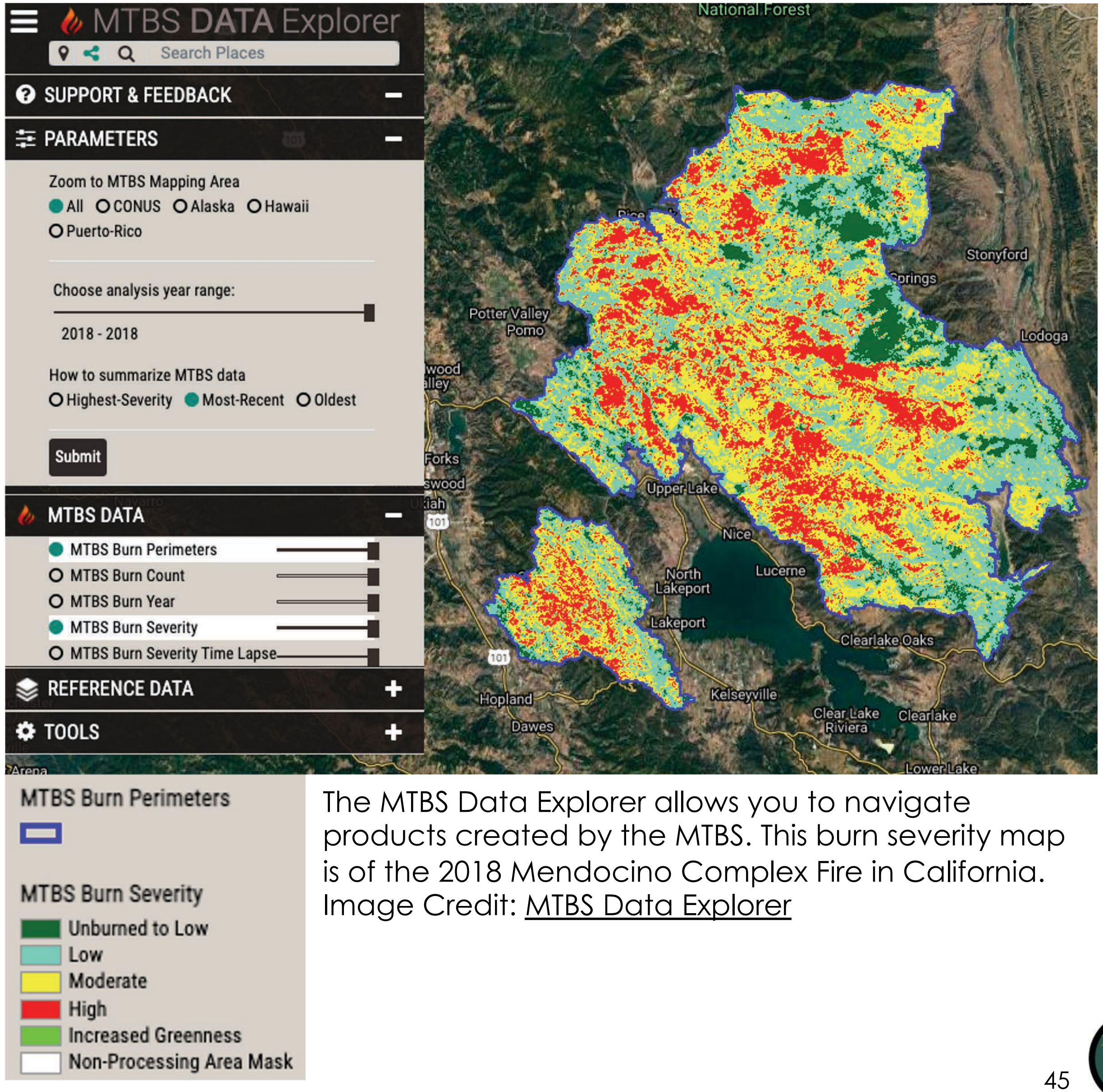
Monitoring Trends in Burn Severity (MTBS)

- MTBS Link:
  - http://www.mtbs.gov/
- Project designed to consistently map burn severity and fire perimeters across the U.S.
  - Partnership between USGS & USDA Forest Service
  - For the U.S. only
- Remote sensing and ground-based assessments
- Outputs:
  - NBR from Landsat (pre- and post-fire)
  - Differenced NBR (dNBR)
  - Classification of burn severity
    - Based on pre- and post-fire imagery, plot data, & analyst's experience with fire behavior
  - Fire Perimeter
  - Geospatial Metadata



MTBS Data Explorer

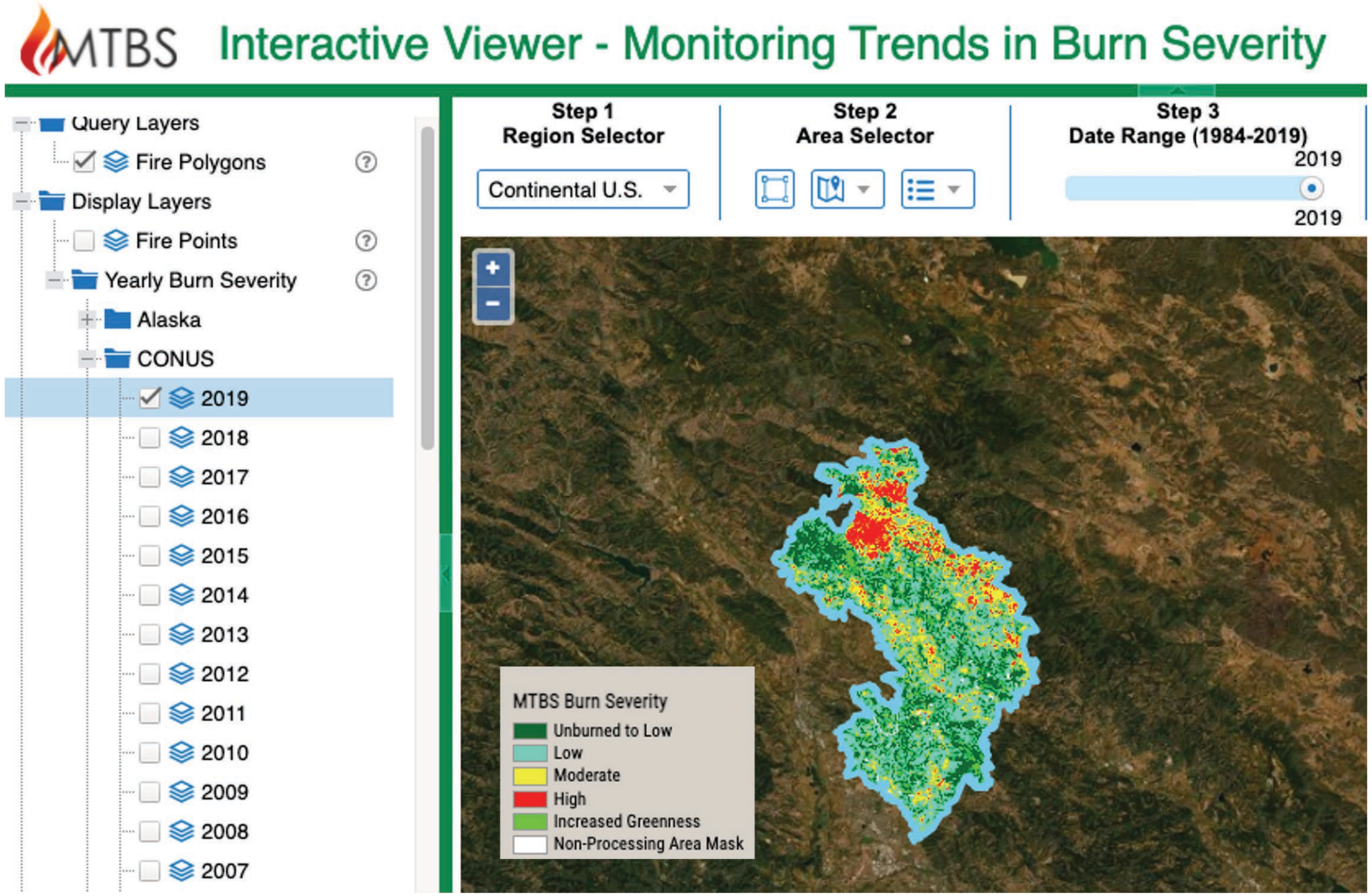
- Data Explorer Link:
  - https://www.mtbs.gov/data-explorer
- Developed within Google Earth Engine
- Explore the entire MTBS burn severity archive
- Calculate statistical summaries over a user-defined area of interest
- Analyze single point (30 x 30m) data
- Download data as CSV and PNG



The MTBS Data Explorer allows you to navigate products created by the MTBS. This burn severity map is of the 2018 Mendocino Complex Fire in California. Image Credit: MTBS Data Explorer

MTBS Interactive Viewer

- Data Explorer Link:
  - [https://www.mtbs.gov/viewer/index.html Web map interface](https://www.mtbs.gov/viewer/index.html)
- Explore the entire MTBS burn severity archive
- Currently has more up-to-date data than the MTBS Data Explorer (this will likely change)
- Download data for a single fire or bulk download many



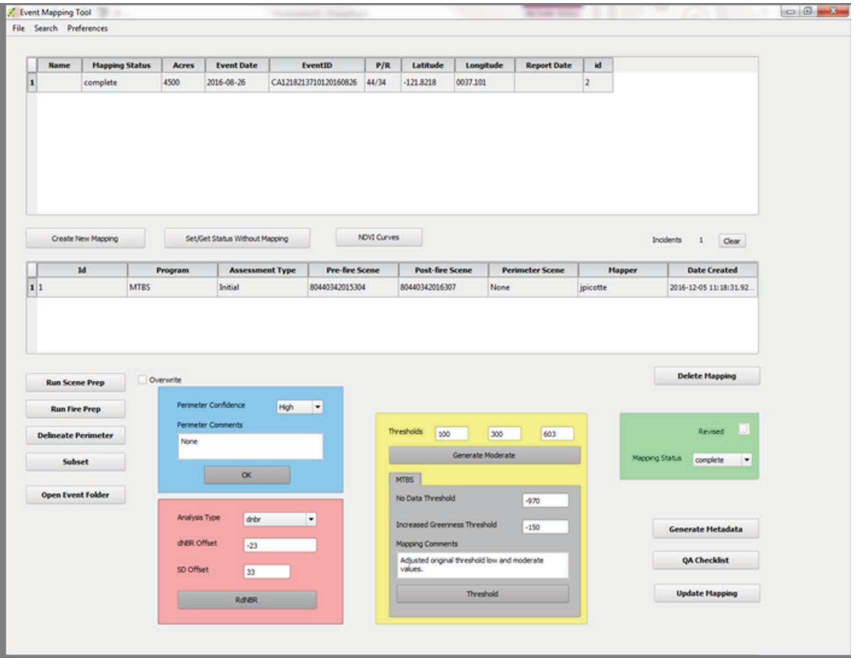
The MTBS Data interactive viewer allows you to navigate products created by the MTBS. This burn severity map is of the 2019 Kincade Fire in California.
Image Credit: MTBS Interactive Viewer

Fire Mapping Tool (FMT)

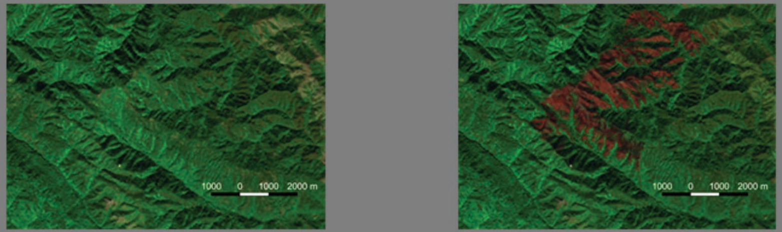
- The QGIS-based FMT was developed to address the needs of users who either need to determine the effects of small fires that are below the MTBS burned area threshold, or who cannot wait for an MTBS assessment to be published.
- Resources:
  - Tool and Instructions: https://mtbs.gov/qgis-fire-mapping-tool
  - ARSET Techniques for Wildfire Detection and Monitoring: https://appliedsciences.nasa.gov/join-mission/training/english/arset-techniques-wildfire-detection-and-monitoring
- FMT Process:
  - Landsat Imagery ordered from https://espa.cr.usgs.gov/
  - Creates dNBR images
  - Builds fire perimeter and masking vector files (i.e., shapefiles)
  - Calculates RdNBR offset and subsequently outputs a RdNBR image
  - Suggests potential low, moderate, and high burn severity thresholds
  - Creates thresholded burn severity product
  - Outputs metadata

FMT Process for Fire Perimeter and Burn Severity Assessment

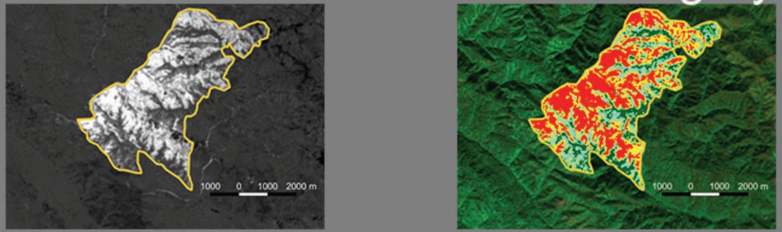
Step 1: Identify a fire using sensor detections or another data source



Step 2: Use QGIS tool to enter fire information and order imagery

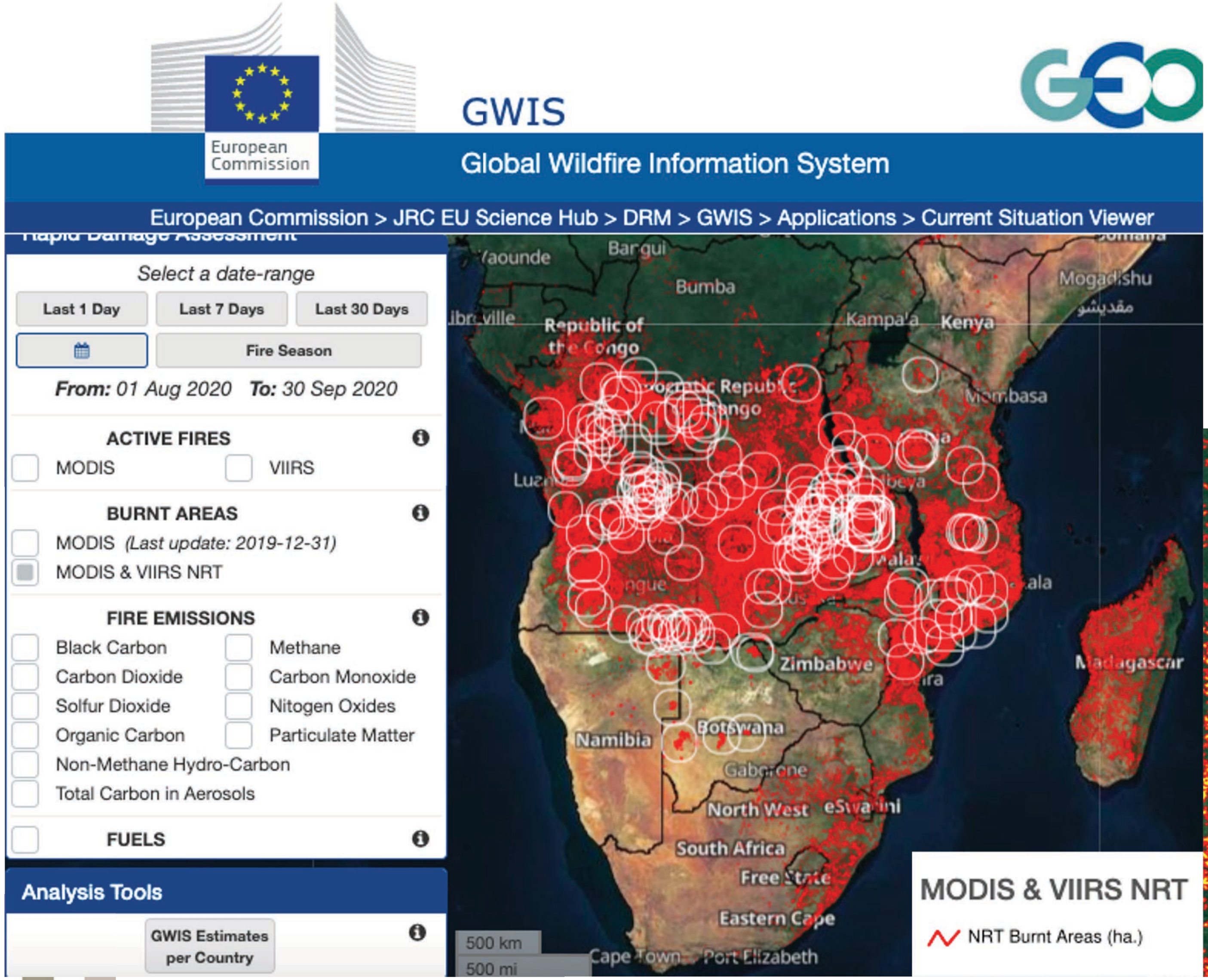


Step 3: Identify pre- (left) and post- (right) fire Landsat Scenes

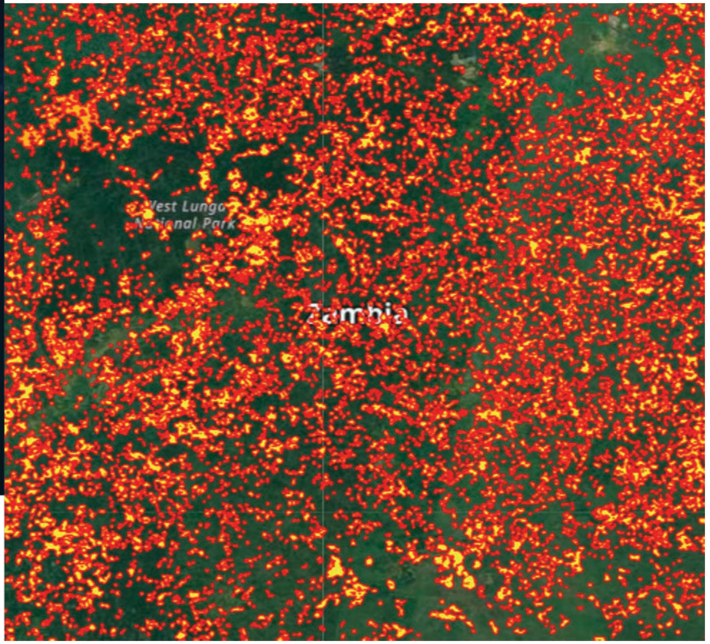


Step 4: Map fire perimeter and burn severity

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.

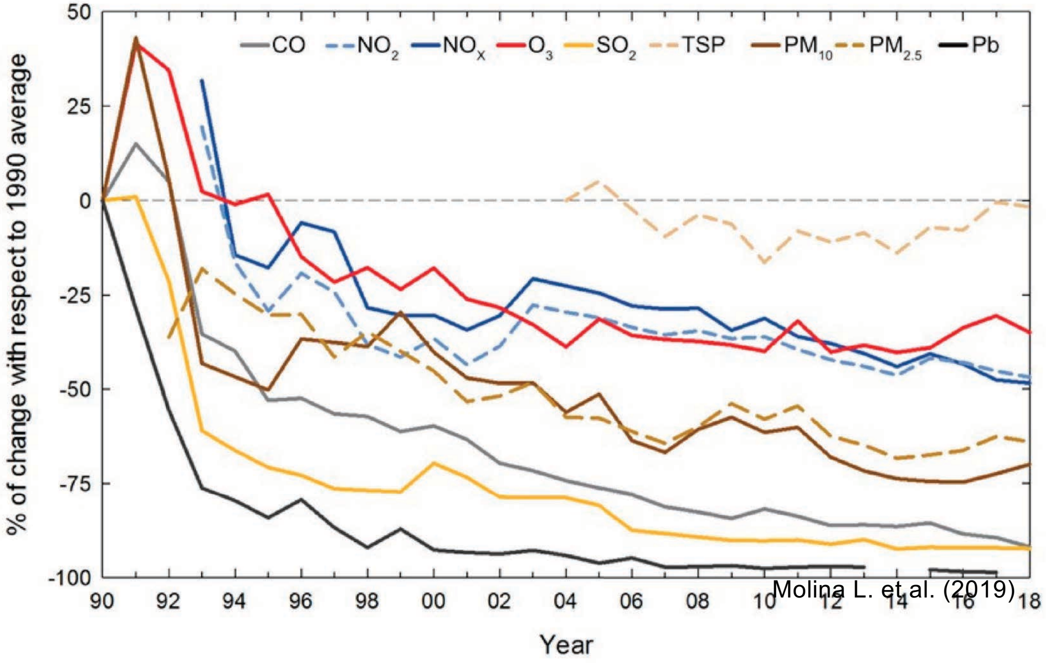
Image Credits: GWIS

Smoke Emissions from Biomass Burning in Central Mexico and its Impact on Air Quality in Mexico City

Blanca Rios, Bradford S. Barrett, Graciela B. Raga

May 2019 Case Study

Poor Air Quality Episodes in Mexico City: The Role of Meteorological Conditions



Molina L. et al. (2019)

Variability of winter and summer surface ozone in Mexico City on the intraseasonal timescale

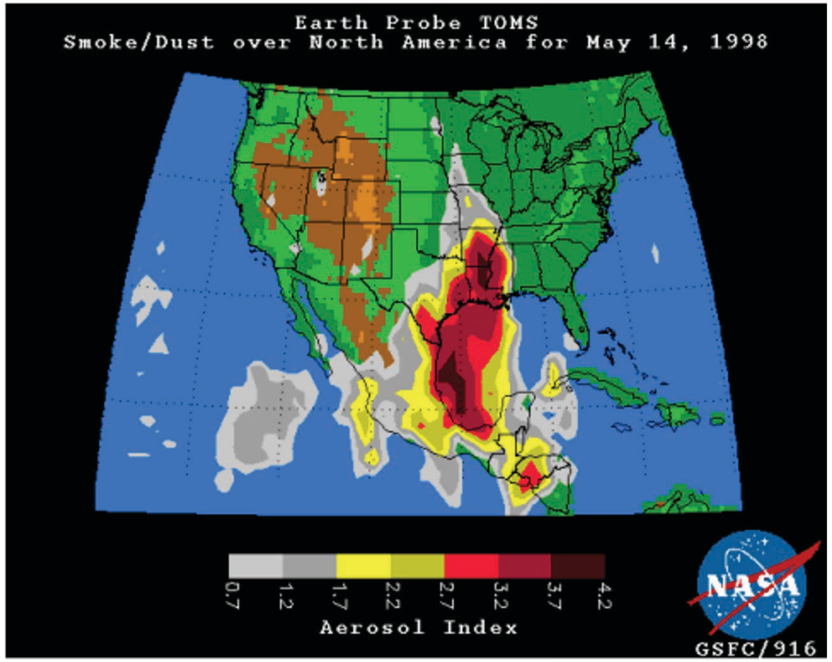
Bradford S. Barrett[1,2] and Graciela B. Raga[1]

Atmospheric blockages as trigger of environmental contingencies in Mexico City ☆

Rafael Silva-Quiroz[a,b,*], Ana Leonor Rivera[b,c], Paulina Ordoñez[d], Carlos Gay-Garcia[a,d], Alejandro Frank[b,c,1]

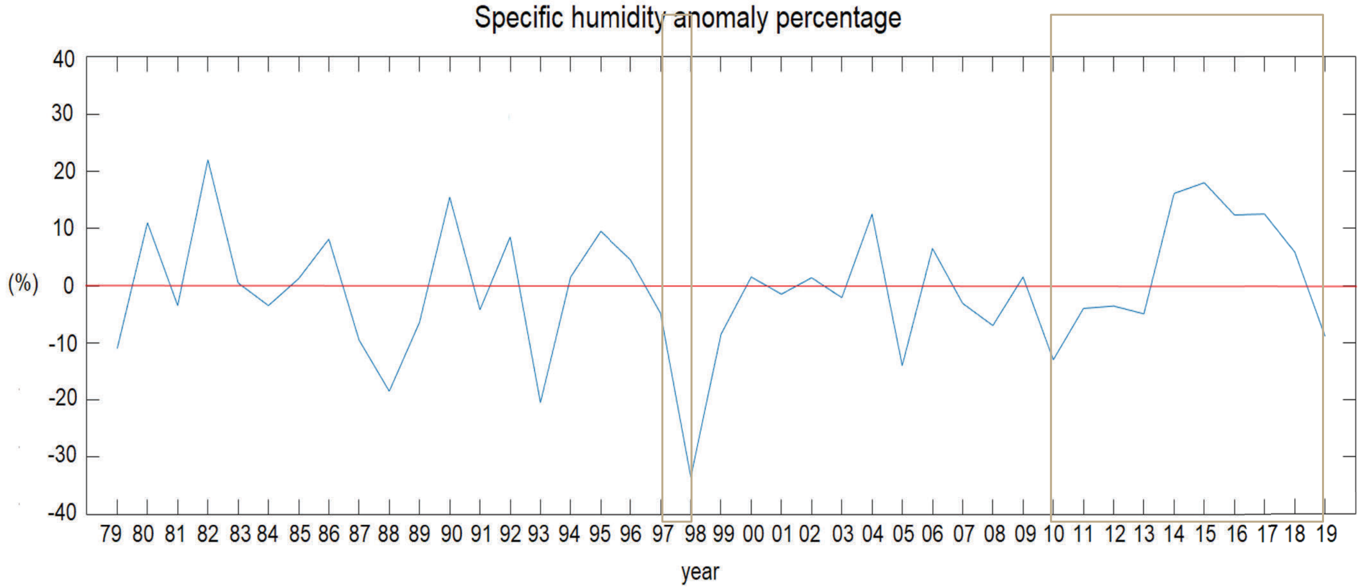
- In the last 30 years, the atmospheric concentrations of Pb, SO_2, and CO have been significantly reduced.
- Although the concentrations of O_3, PM_{10}, and $PM_{2.5}$ have also decreased, they are still above the air quality standards.
- In Mexico City, specific meteorological conditions can cause a rapid deterioration of the already poor air quality.

The Impact of Regional Fires on Air Quality in Mexico City

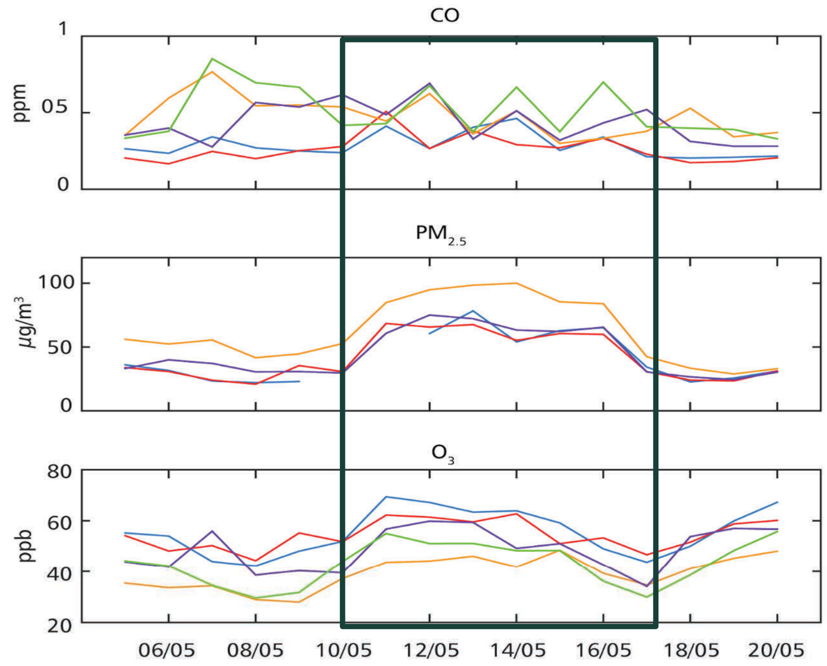


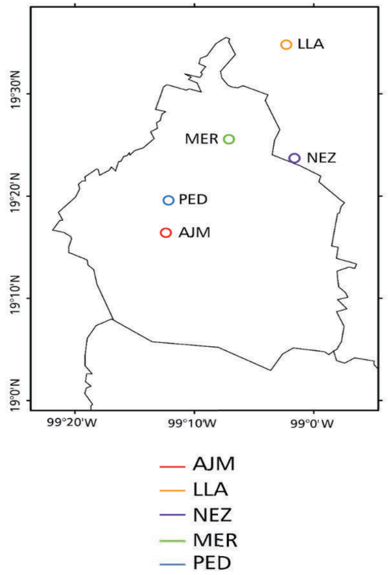
- In 1998, fires in Mexico and Central America not only reached Mexico City, but also affected the Central Plains of the United States.
- Several studies carried out in the MILAGRO campaign showed that the composition of fine particles in the city indicated the presence of chemical markers emitted by local fires.

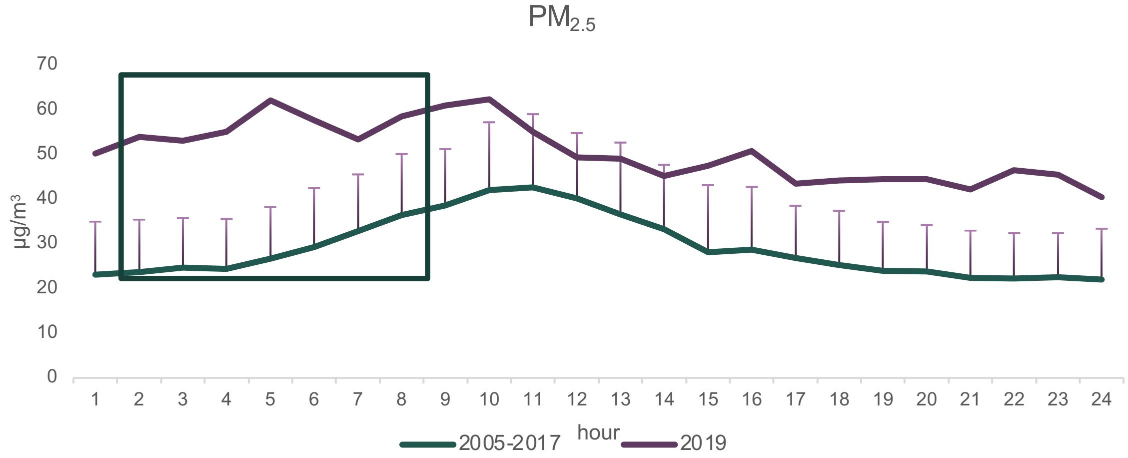
- Specific humidity anomalies were calculated with ERA5 data for the last 40 years and it was detected that 1998 was the driest year.
- While 2019 was the driest year in the last 10 years, although only 10%.



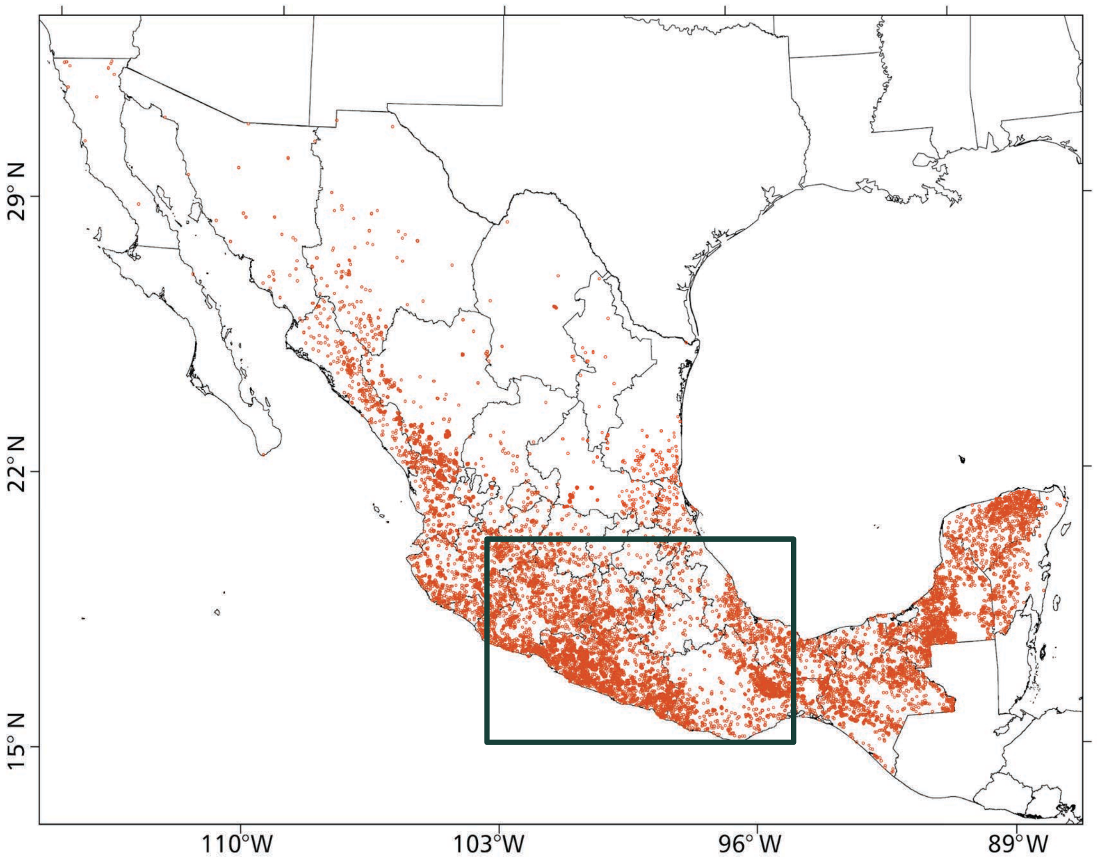
Air Quality in Mexico City During May 2019







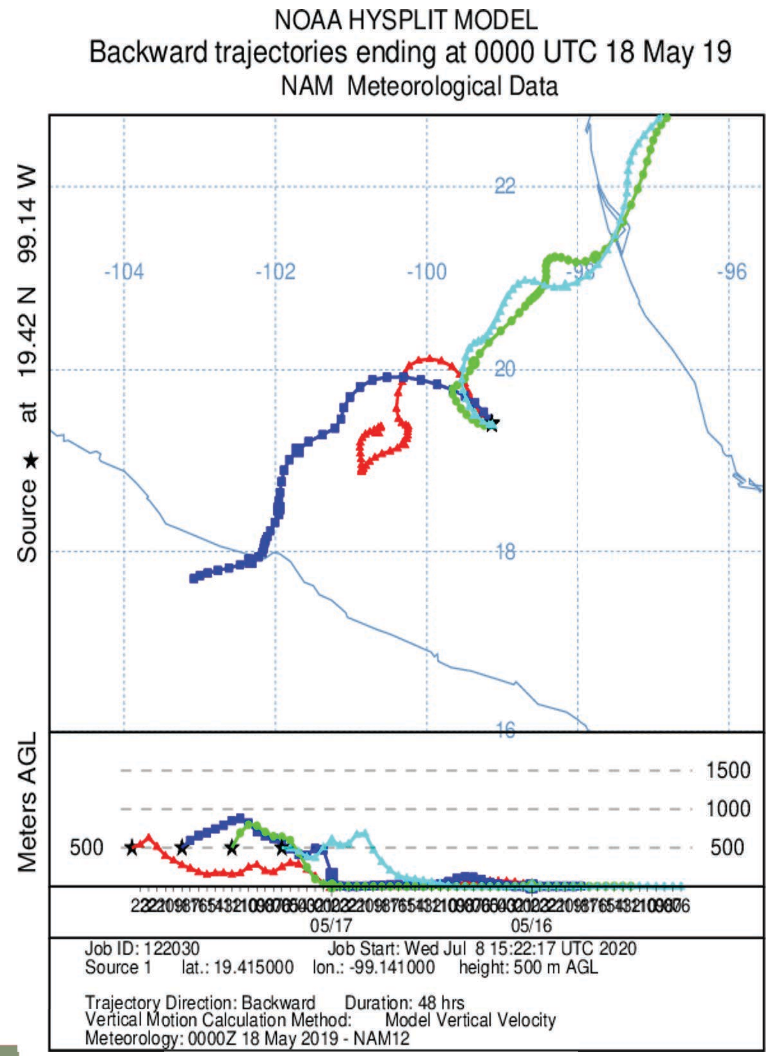
- From May 10 to 17, Mexico City experienced a very serious air quality episode, which can be seen in these graphs showing average daily concentrations of CO, $PM_{2.5}$, and O_3 in five RAMA stations.
- An increase in the concentrations of $PM_{2.5}$ and O_3 is observed during those days.
- Fine particulate concentrations rose throughout the city and throughout the night, which is not the case in normal urban conditions.

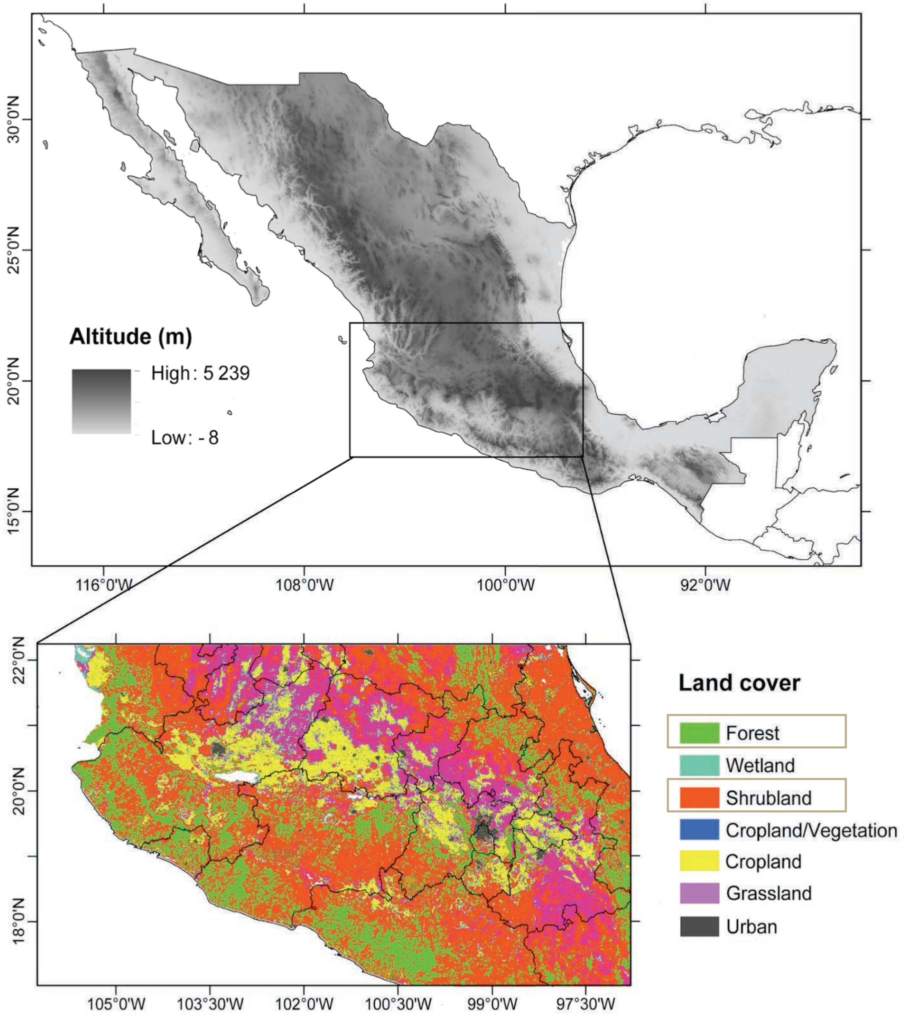


- The fires of May 10-17 are featured on this map. The data was obtained from the VIIRS I-Band 375 m Active Fire product.
- Many fires are observed in the central-western states of Mexico, whose emissions could be advected towards Mexico City and worsen air quality.

"The motivation for this study is to learn more about the meteorological conditions and emissions of pollutants that combined to result in the extremely poor air quality episode experienced in Mexico City in May 2019. In particular, the goal is to identify the sources of the regional pollution, the type of fuel burned in the fires, and the predominant transport patterns."

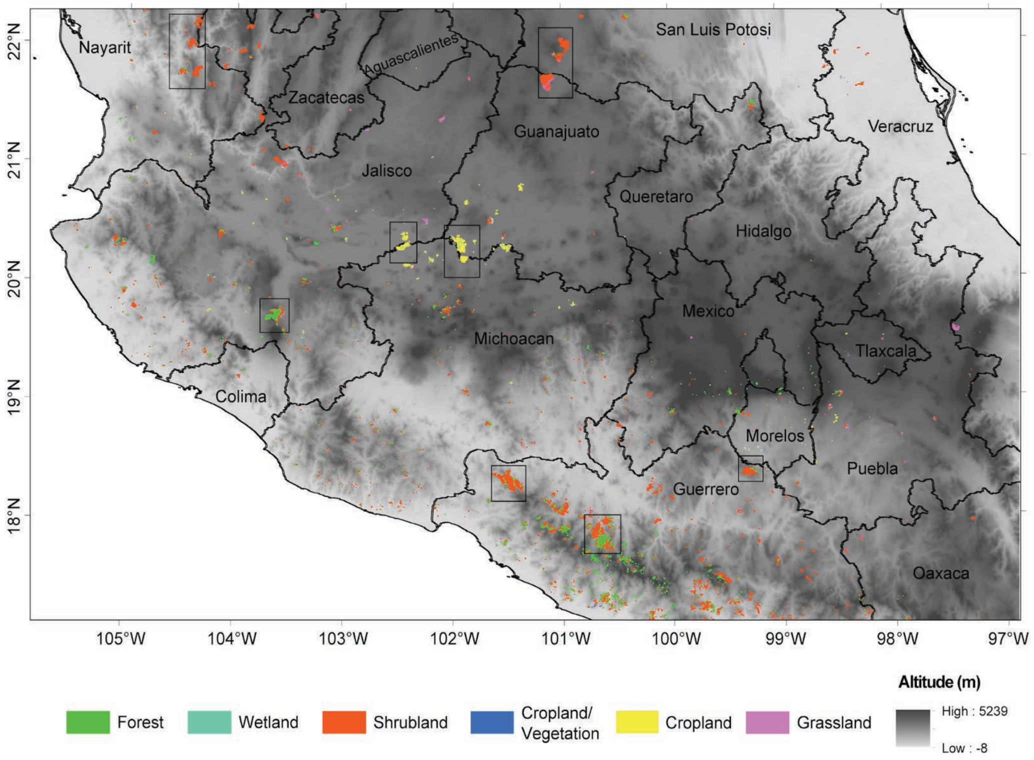
Study Region

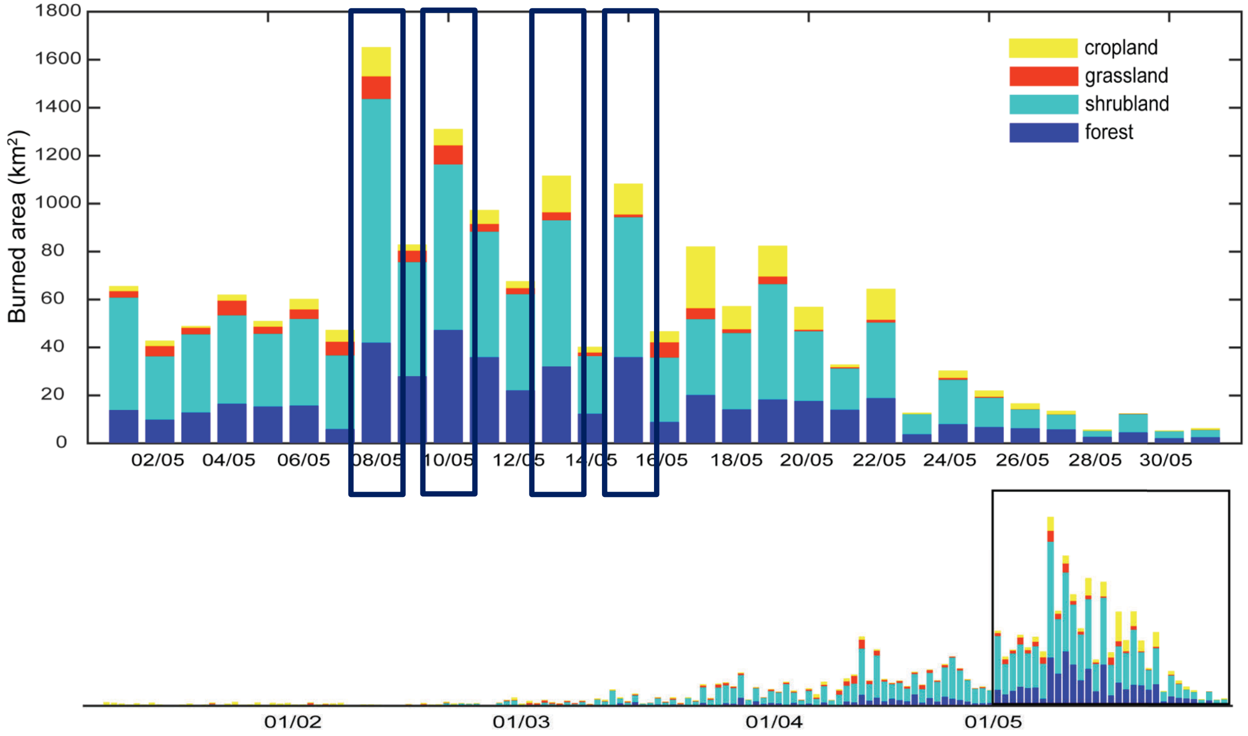




- The study region was selected through the analysis of 48-hour retro-trajectories with HYSPLIT from May 10 to 18 at 4 different times.
- According to the MODIS vegetation map of 2018 (MCD12Q1), the main land cover in the study region is scrub, followed by forest.

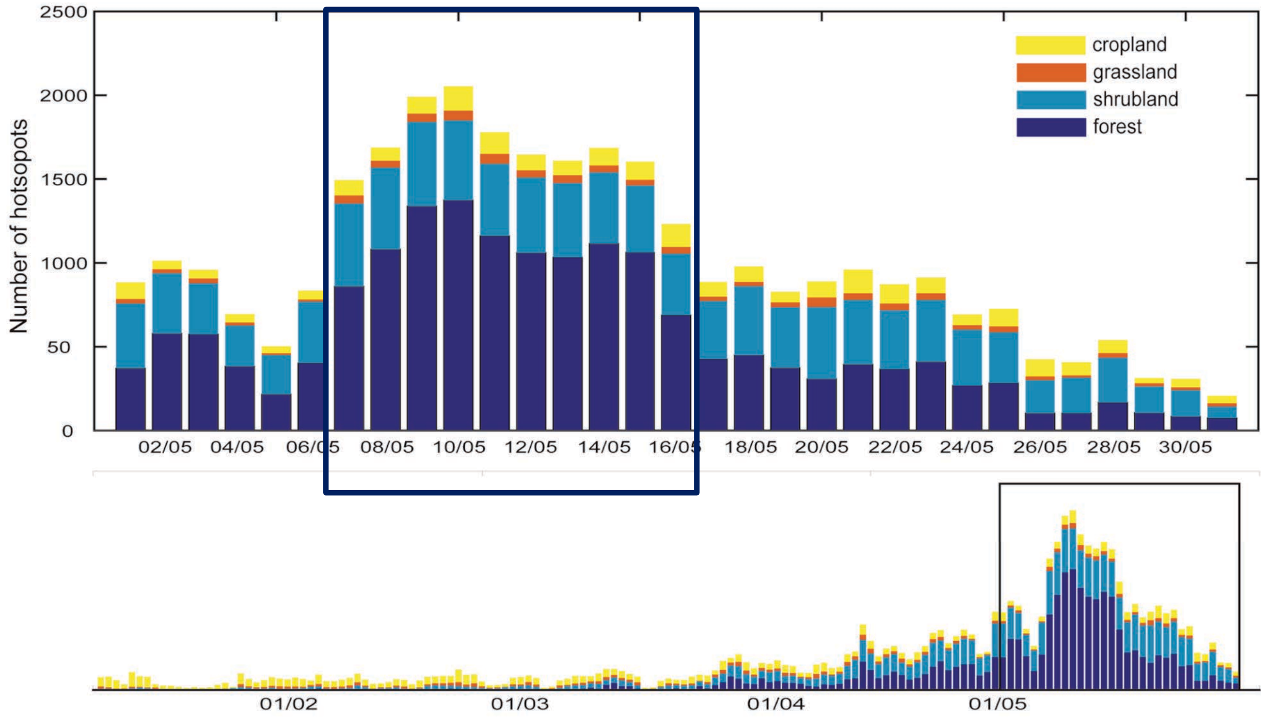
Results: Burned Area in Principal Land Covers

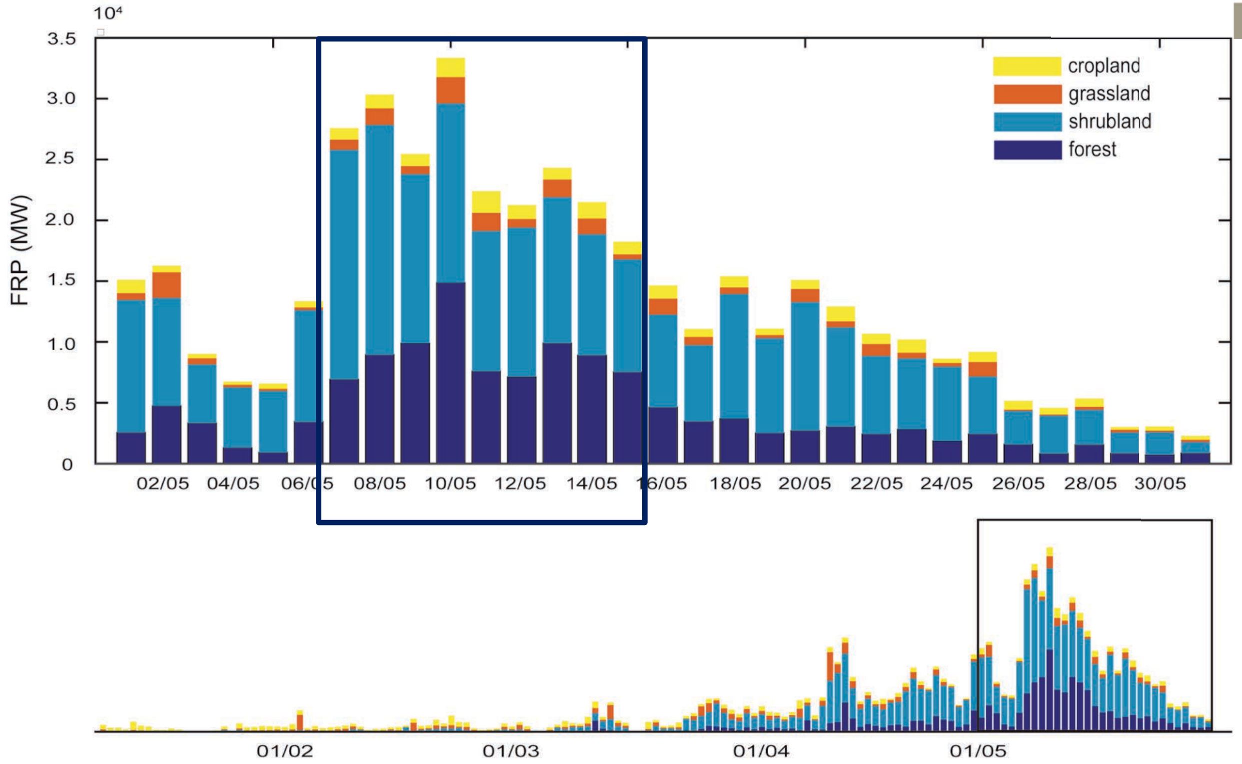




- This map illustrates the spatial distribution of burned area by land cover in the study region for May 2019. MODIS products MCD64A1 and MCD12Q1 were used.
- This graph shows the daily area burned by land cover within the study region from January to May, with a focus on May. The data were obtained from the MCD64A1 and MCD12Q1 products.

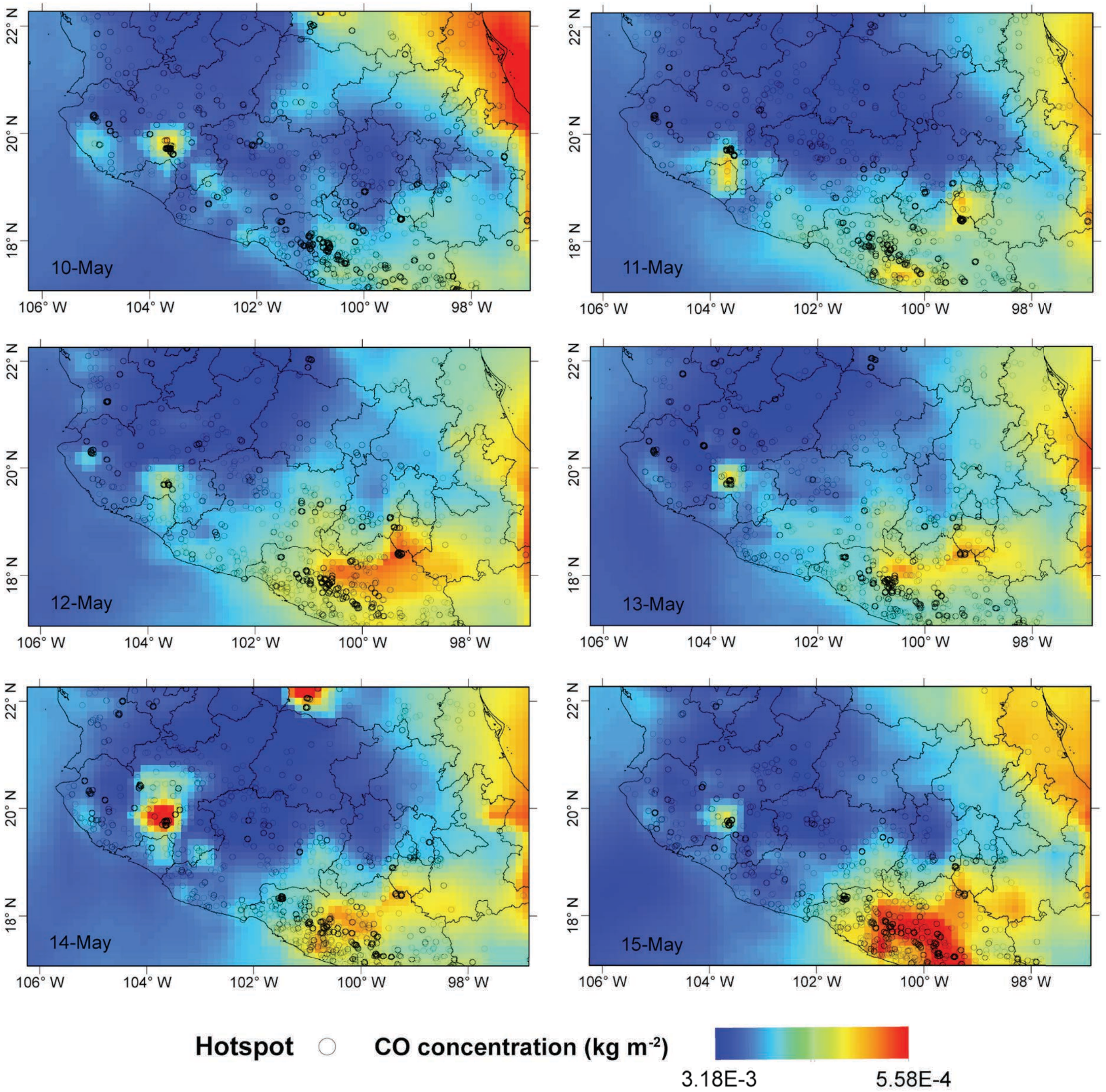
Hotspots and FRP in Principal Land Covers

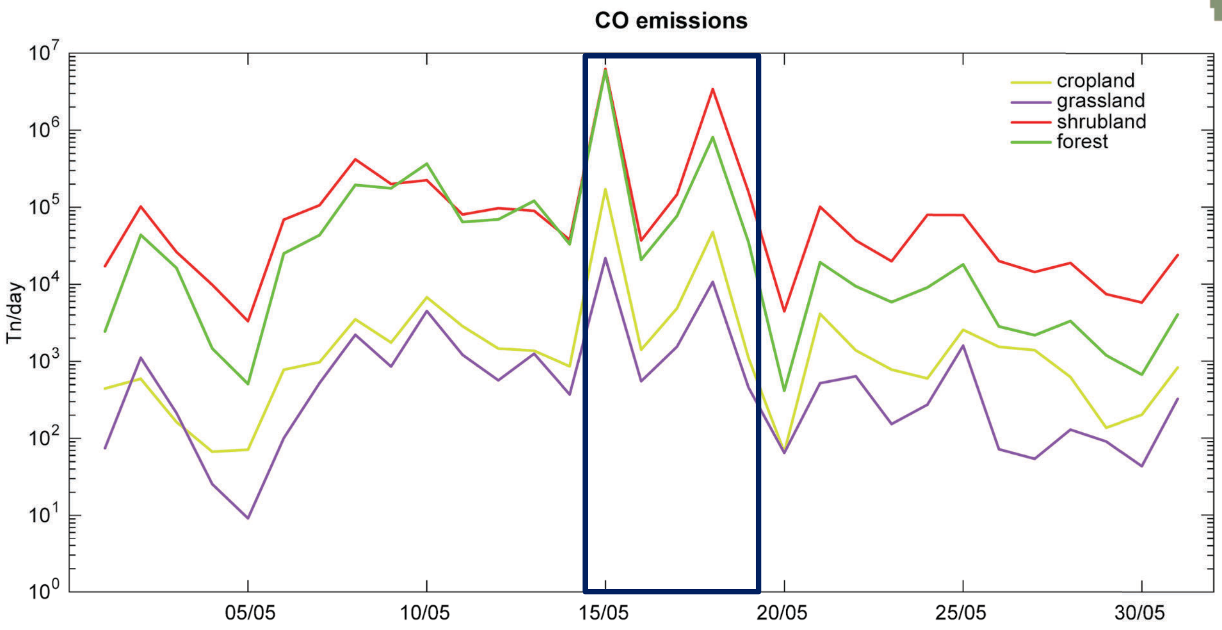




- These graphs show the number of hotspots and FRP detected by VIIRS I-Band 375m Active Fire from January to May 2019.
- 40% of the fires were detected within forests and 30% in bushes. However, the most intense burns were detected in bushes.

Fire Emissions





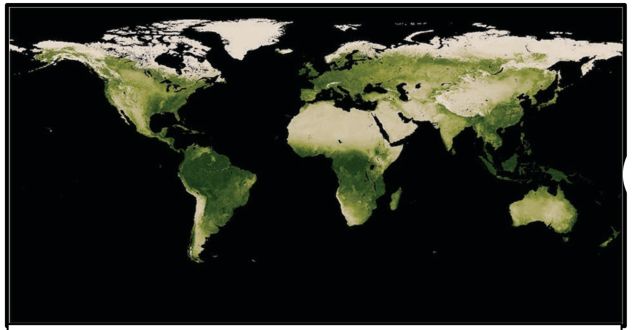
- The maps show the hotspots detected by VIIRS and the CO concentration estimated by CAMS.
- The graph represents the daily CO emissions from burns in May from the main land cover classes of the study region.

Preliminary Conclusions

- Although we still need to carry out other meteorological analyses, the evidence indicates that emissions from biomass burning in Guerrero, Michoacan, and the State of Mexico affected air quality in Mexico City during May of 2019. Back-trajectories highlight the potential for regional transport of smoke from neighboring states.

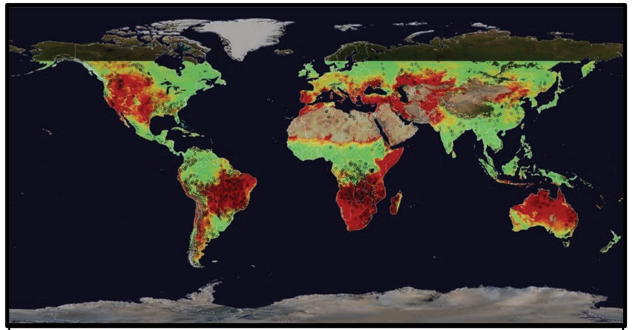
Thank You!

Webinar Review - Pre-Fire



Session 1:
Climate and Hydrology

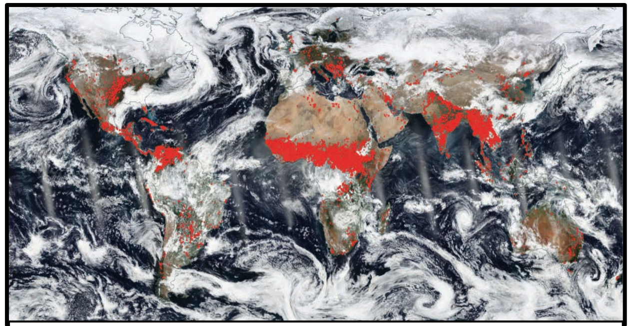
- Remote sensing and modeled data can be used for monitoring weather, climate, and hydrology conditions pre-fire.
- NASA provides tools to access and visualize climate and hydrology data on a global scale.
- Pre-fire season precipitation, soil moisture, and temperature anomalies indicate potential fire risk in the subsequent fire season.
- Fire Weather Index (FWI) is a system that tracks the moisture content of different fuel sizes and potential fire behavior.



Session 2:
Vegetation

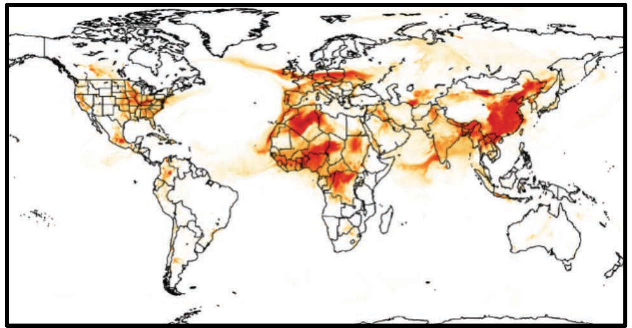
- Assessment of vegetation using remote sensing platforms provides the opportunity to characterize fire fuels for inclusion in pre-fire risk assessment.
- Indices and data analysis methods exist to assess topography and vegetation type, extent, stage, health, moisture, and structure using satellite and airborne imagery.
- A variety of online tools are available to display and download metrics that characterize vegetation fuels.

Webinar Review – During Fire



Session 3:
Active Fires and Smoke

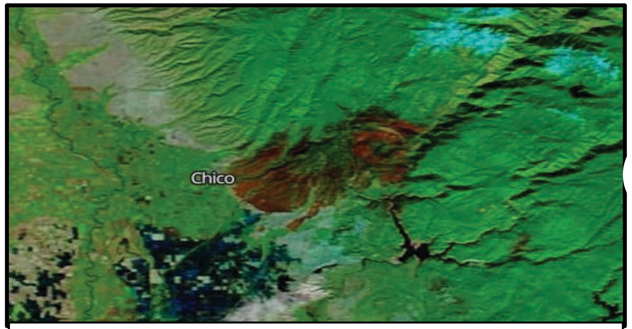
- Several satellites from LEO or GEO orbits provide fire detections worldwide on a daily basis and data are available for free in near-real time.
- MODIS has 20+ years of fire data records and VIIRS has been providing higher resolution fire data since 2012.
- Worldview and FIRMS are two online data visualization and data access tools to access active fire detection data.
- Smoke detection and AOD data are available from NASA and NOAA to monitor and track smoke in the atmosphere.
- NOAA provides satellite-derived daily $PM_{2.5}$ data over the US through the 'Aerosol Watch' online system.



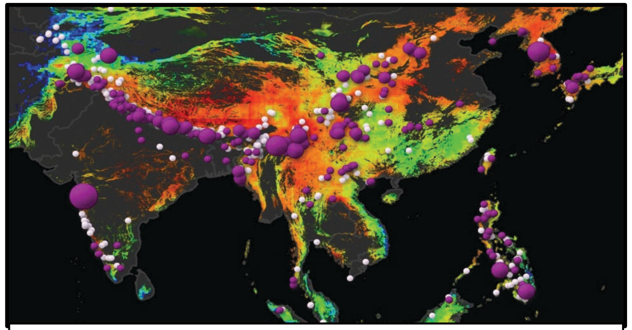
Session 4:
Smoke Forecasting

- Satellite observations of burned area, active fire detections, and fire radiative power (FRP) are used to estimate the emissions of trace gases and aerosols from fires.
- These emissions, along with information about plume height, fire duration, and variability in fire strength, are used by atmospheric chemistry models to simulate the transport of smoke.
- The GFED and GWIS websites offer tools to download and/or visualize GFED and GFAS fire emissions, respectively.
- NASA and ECMWF offer forecasts of atmospheric composition.

Webinar Review - Post-Fire



Session 5:
Climate & Hydrology



Session 6:
Vegetation

- Wildfires have short- and long-term impacts on water resources.
- Post-fire erosion and runoff transports sediments, debris, and chemicals to streams and reservoirs.
- Post-fire debris flow and water quality can be modeled and monitored using remotely-sensed data.

- Fires are an important method of dynamic change in ecosystems, occurring at average intervals depending on fire regime.
- Post-fire burned area and severity assessment can identify the extent and degree of vegetation loss over fire-impacted landscapes.
- Vegetation indices and land cover monitoring post-fire allows for the monitoring of regrowth.
- Many tools exist to assess burned area, burn severity, and fire regime information relevant to vegetation regrowth.

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Lead Instructor

Juan Torres-Pérez
Instructor

Robert Field
Guest Speaker

Eli Orland
Guest Speaker

Blanca Rios
Guest Speaker

Homework and Certificate

- Three homework assignments:
  - Answers must be submitted via Google Form, accessed from the ARSET website.
  - Due date for all three homeworks: **June 10, 2021**
- A certificate of completion will be awarded to those who:
  - Attend all live webinars
  - Complete the homework assignment by the deadline
  - You will receive a certificate approximately two months after the completion of the course from: marines.martins@ssaihq.com

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- ARSET Website:
  - https://appliedsciences.nasa.gov/what-we-do/capacity-building/arset

Thank you!