Pre-Fire Risk Assessment

Amita Mehta

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Objective

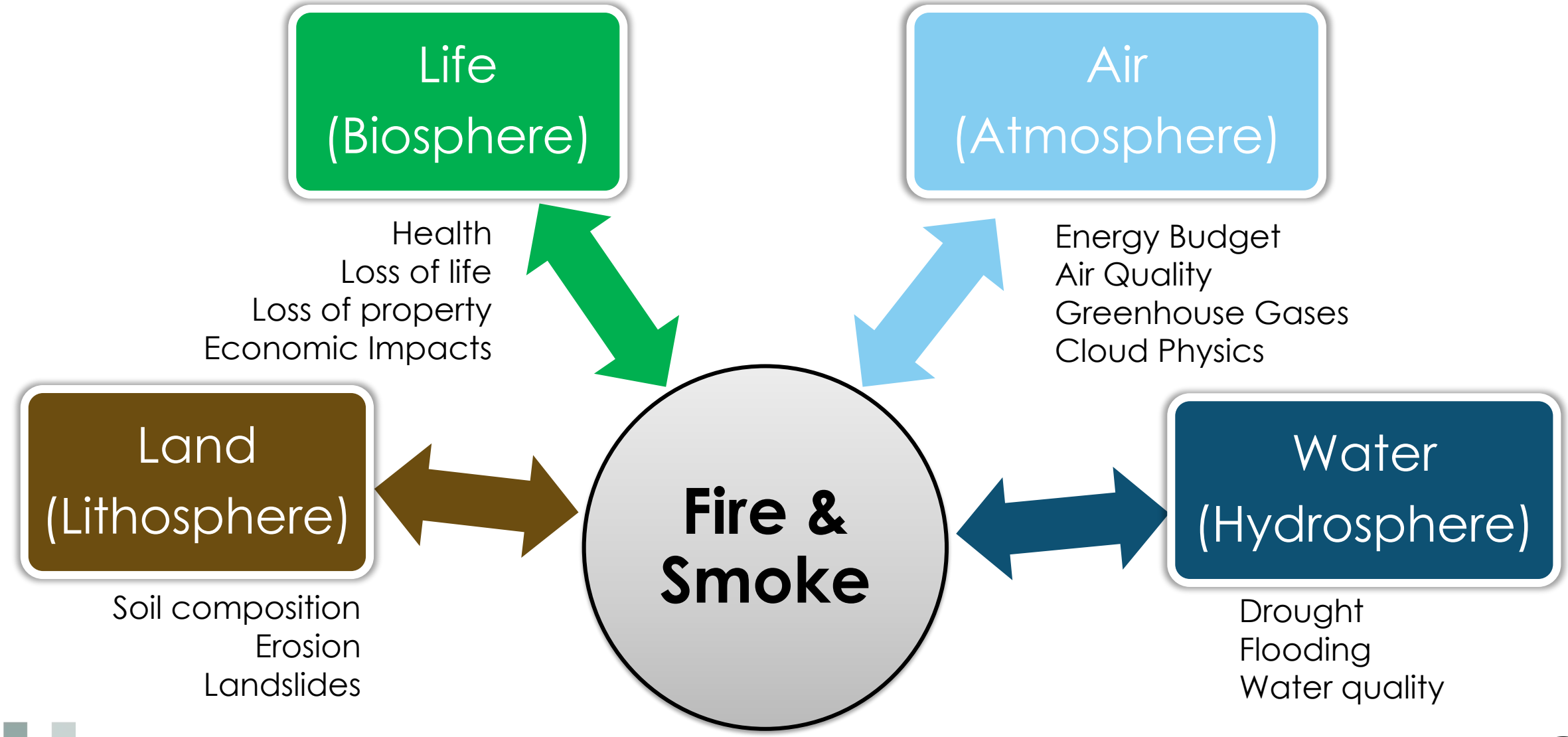
By the end of this presentation, you will be able to identify data products relevant for assessing pre-fire environmental conditions.

Outline

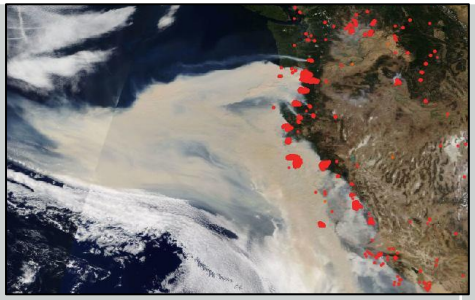
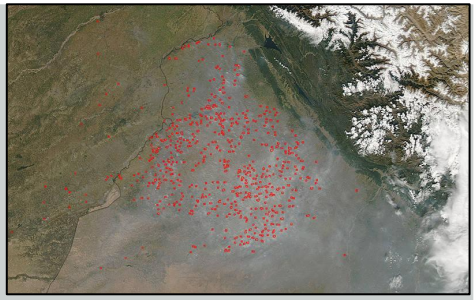
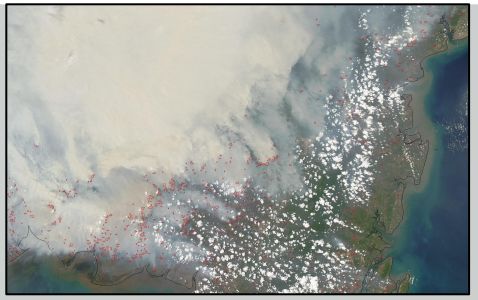
- Types of fires
- Data products relevant for pre-fire conditions risk assessment
- Case study: pre-fire conditions for California fires
- Demonstration: Pre-fire conditions for March 2022 fire in Sierra de Santiago, Nuevo León

Types of Fires

Fire in the Earth System

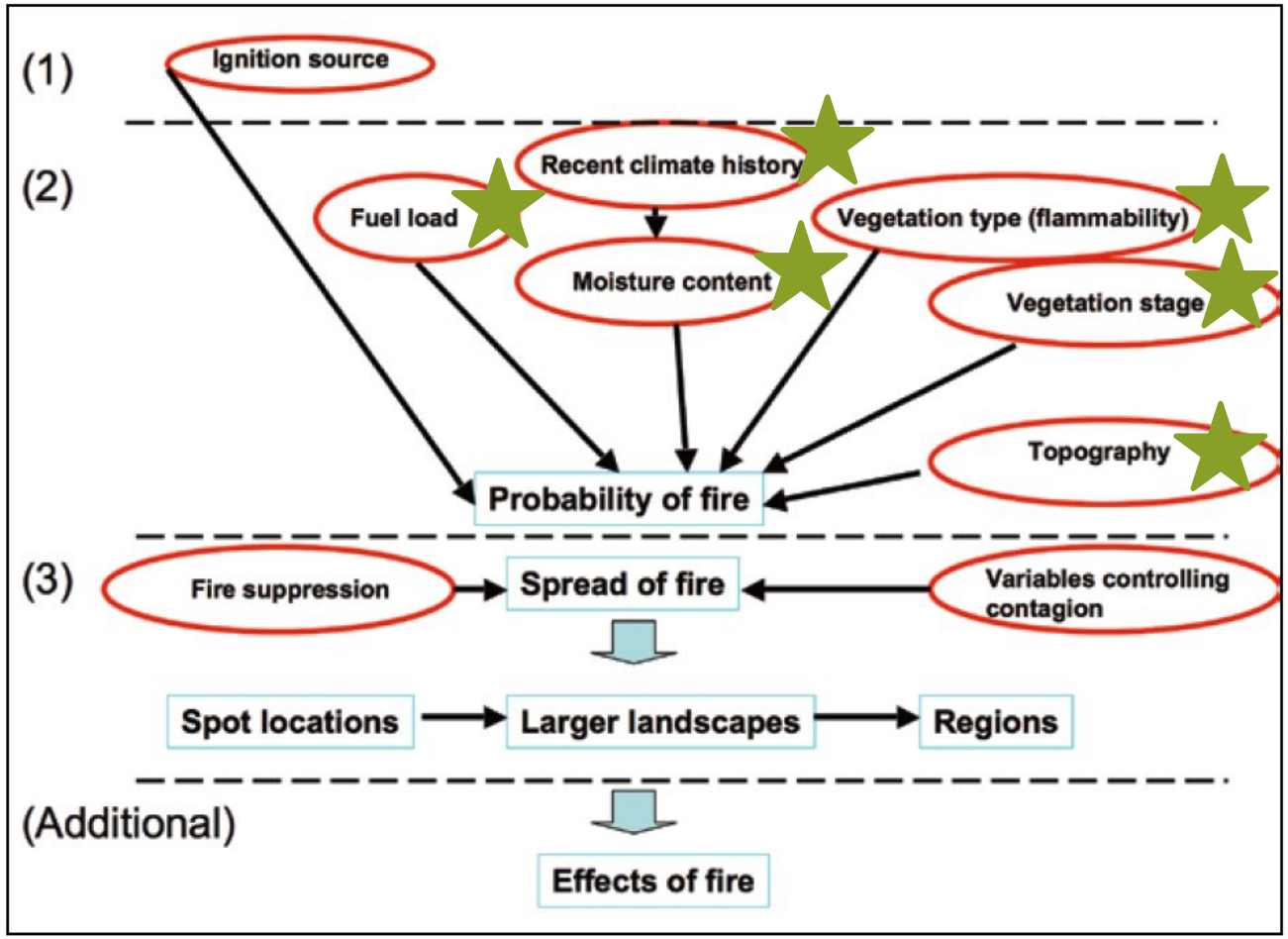


Types of Fire

	Wildfire or Wildland	Deforestation	Agricultural	Peat
				
What does it burn?	Forests, shrub, grass	Forests	Crops, grasses, shrubs	Peat (soil-like material)
When does it burn?	Dry seasons, variable from year to year	Seasonal	Seasonal	Seasonal, variable from year to year
Why did it burn?	Natural (lightning), or humans (prescribed burns, accidental, arson)	Humans (forest clearing for livestock and crops)	Humans (burn prior to or after a growing season to clear fields for crops)	Natural (permafrost thaw), humans (clear land for crops and animal grazing)
How did it burn?	Higher intensity, can burn millions of acres if not controlled	High intensity	Lower intensity	Very low intensity, burns underground, difficult to put out

Fire Risk Mapping Framework

Where remotely sensed data can be used independently or with ground-based observations



Calculation of fire risk: There are three aspects to predicting fire: (1) the probability of ignition; (2) the biophysical influences on fire, such as fuel load, moisture content, flammability of the vegetation, and topography; and (3) the spread of fire once it gets established.

Image Credit: Weinstein and Woodbury, USFS

Comprehensive fire risk maps are challenging to produce due to the many factors that impact the probability of fire.

National Aeronautics and Space Administration

Data Product Relevant for Pre-fire Risk Assessment

Monitoring Weather, Climate, and Hydrology Conditions

- Precipitation
- Soil Moisture
- Temperature
- Humidity
- Winds
- Vegetation
- Topography

NASA remote sensing and Earth system models provide weather, climate, and hydrology data for pre-fire, during-fire, and post-fire conditions.

Monitoring Weather, Climate, and Hydrology Conditions

- Precipitation (GPM-IMERG)
- Soil Moisture (SMAP)
- Temperature (Landsat, MODIS)
- Humidity (MERRA-2*)
- Winds (MERRA-2)
- Vegetation (MODIS NDVI)
- Topography (SRTM, TanDEM-X)

NASA remote sensing and Earth system models provide weather, climate, and hydrology data for pre-fire, during-fire, and post-fire conditions.

*MERRA-2:Modern-Era Retrospective analysis for Research and Applications, Version 2
https://gmao.gsfc.nasa.gov/reanalysis/MERRA-2/index.php

Weather, Climate, and Hydrology Data from Models

Parameter	Model	Spatial/Temporal Resolutions and Coverage
Precipitation, Temperature, Relative Humidity, Winds	MERRA-2	0.5° x 0.667°, Hourly, Monthly 1980 to Present
Precipitation, Temperature, Relative Humidity, Winds	GEOS_5 FP	5/16° x 1/4 ° Hourly, Near-real Time and **5-day Forecast**
Soil Moisture	NLDAS GLDAS v2.1	0.25° x 0.25°, Hourly, Monthly 1979 to Present 1° x 1°, 3-hourly, Monthly 2000 to Present

MERRA-2:Modern-Era Retrospective analysis for Research and Applications, Version 2
https://gmao.gsfc.nasa.gov/reanalysis/MERRA-2/index.php
GOES-5 FP: Goddard Earth Observing System, Version 5 (GEOS-5) Forward Processing
https://gmao.gsfc.nasa.gov/weather_prediction/
NLDAS: North American Land Data Assimilation System https://ldas.gsfc.nasa.gov/nldas
GLDAS: Global Land Data Assimilation System https://ldas.gsfc.nasa.gov/gldas

NASA Earth System Model Forecast (GEOS-5)

https://gmao.gsfc.nasa.gov/GEOS_systems/

- Goddard Earth Observing System (GEOS)-5 provides near real time data and forecast data.
- Data are available at 5/16 x 1/4-degree lon-lat grid, 42 vertical level.
- Surface data available every hour
- Atmospheric (A), Oceanic (O) and Coupled A-O General Circulation Model configuration options
- Chemistry-Climate and Chemistry-Transport models available

Weather Maps

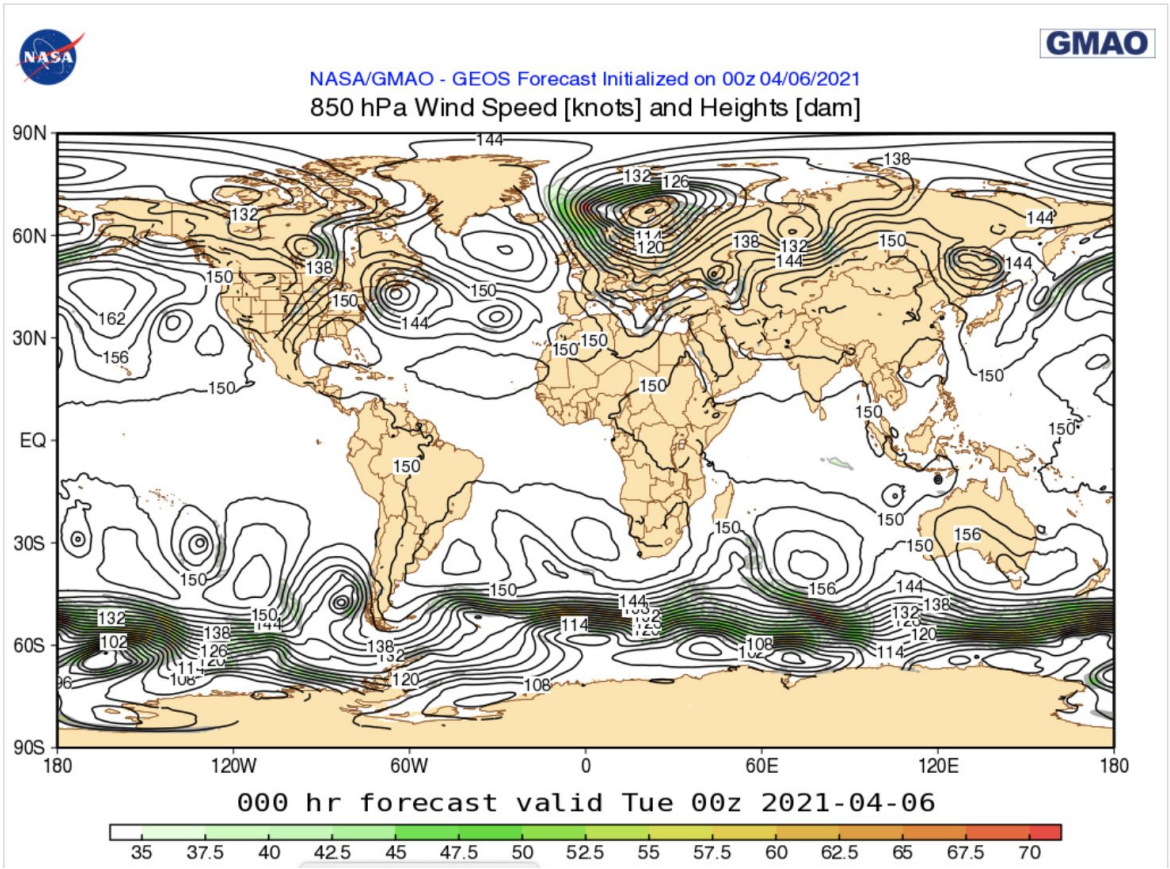
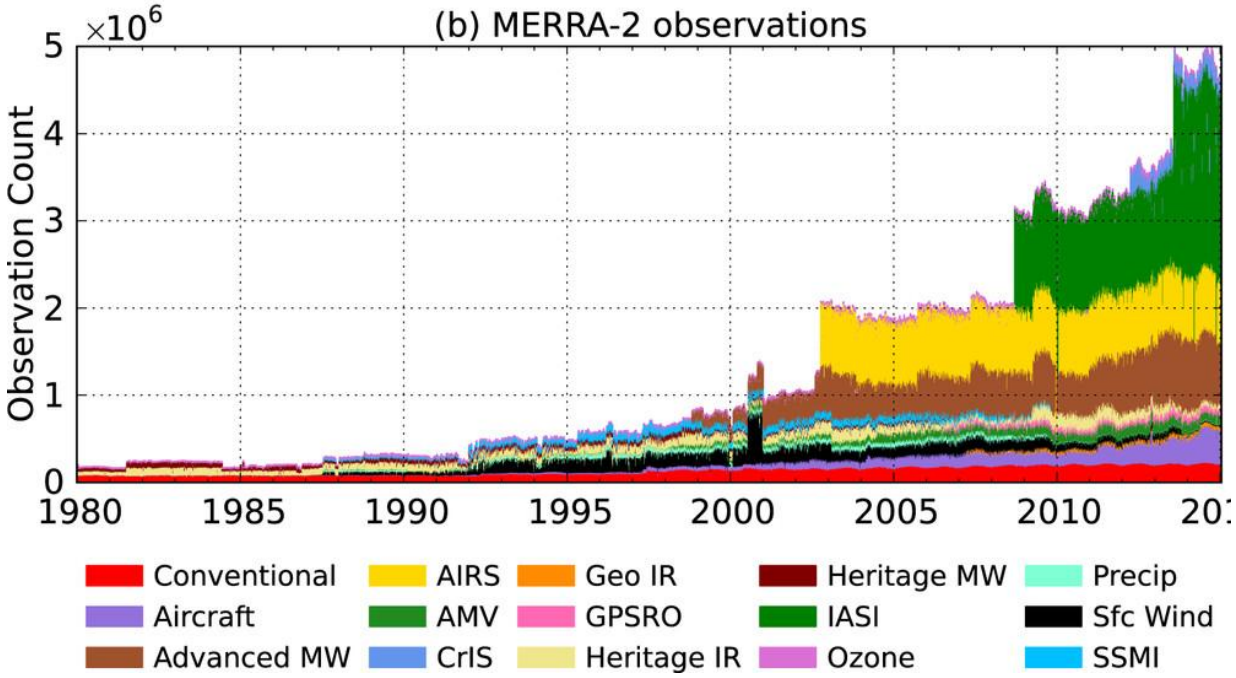


Image Credit: NASA GMAO

MERRA-2

https://gmao.gsfc.nasa.gov/reanalysis/MERRA-2/

- Blends the vast quantities of observational data with output data of the Goddard Earth Observing System (GEOS) model (1980 – present)
- Provides state-of-the-art global analyses on weather to climate time scales
- Focuses on improvement in the hydrological cycle



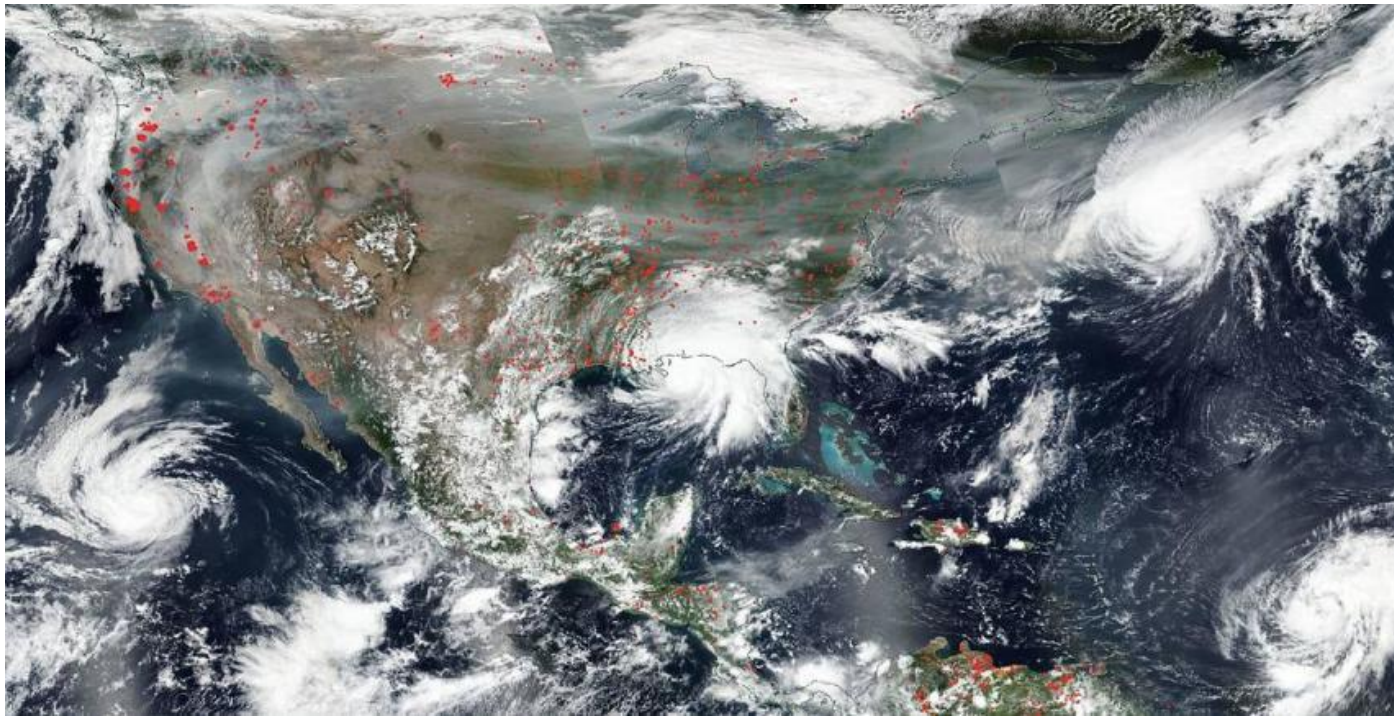
Available from Google Earth Engine

MERRA-2 Overview: The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2), Ronald Gelaro, et al., 2017, J. Clim., doi: 10.1175/JCLI-D-16-0758.1

Case study: Pre-fire Conditions for California Fires

California 2020 Fires

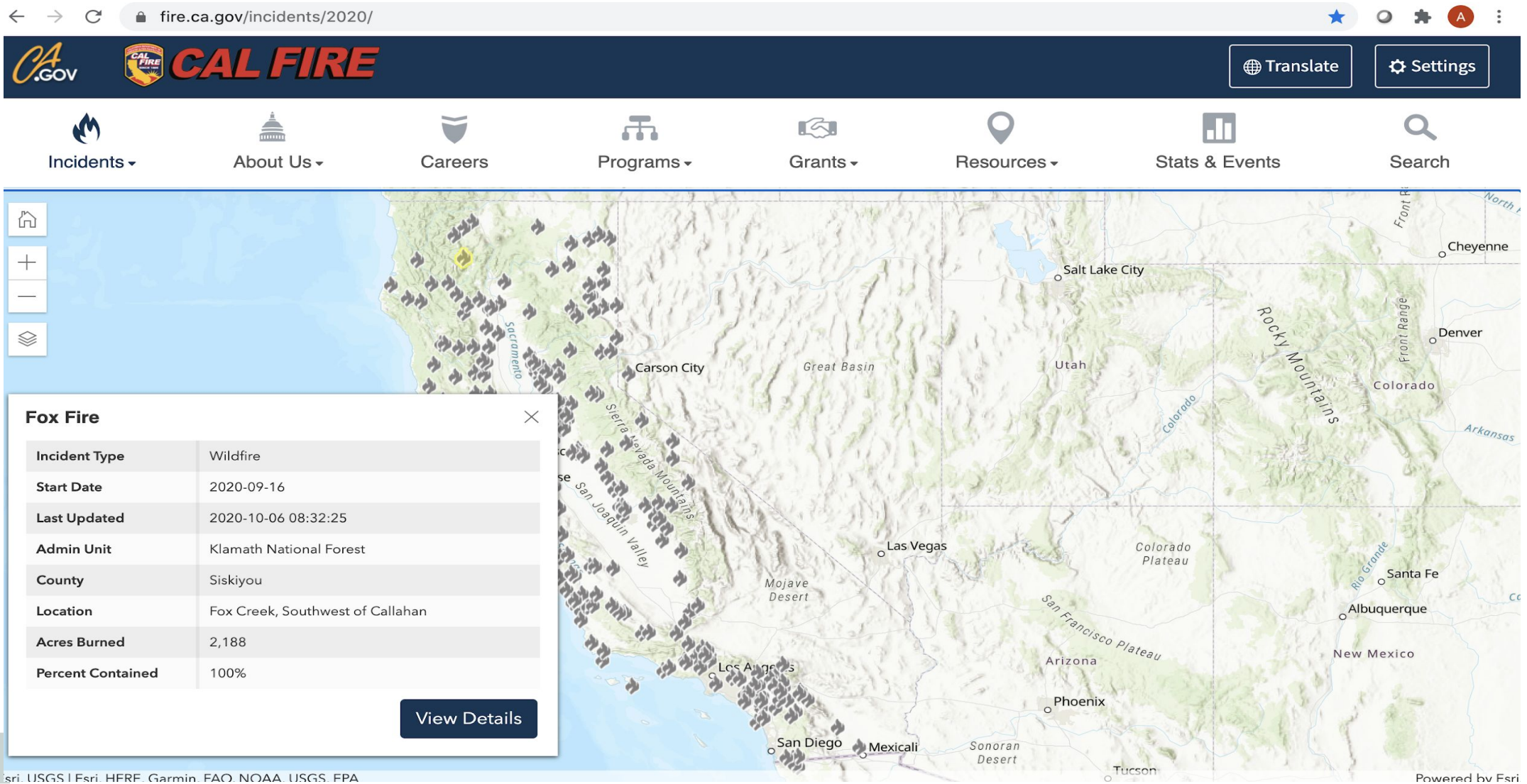
- **Six of the top 20 largest fires in California occurred in 2020.**
  - Over 3 million acres burned, 2 dozen deaths, 4,000 homes destroyed, hundreds of thousands evacuated
- **Pre-Fire Conditions:**
  - Warmer and drier climate patterns, extensive build-up of fuels
  - Record-breaking air temperatures with high winds; many events were lightning triggered



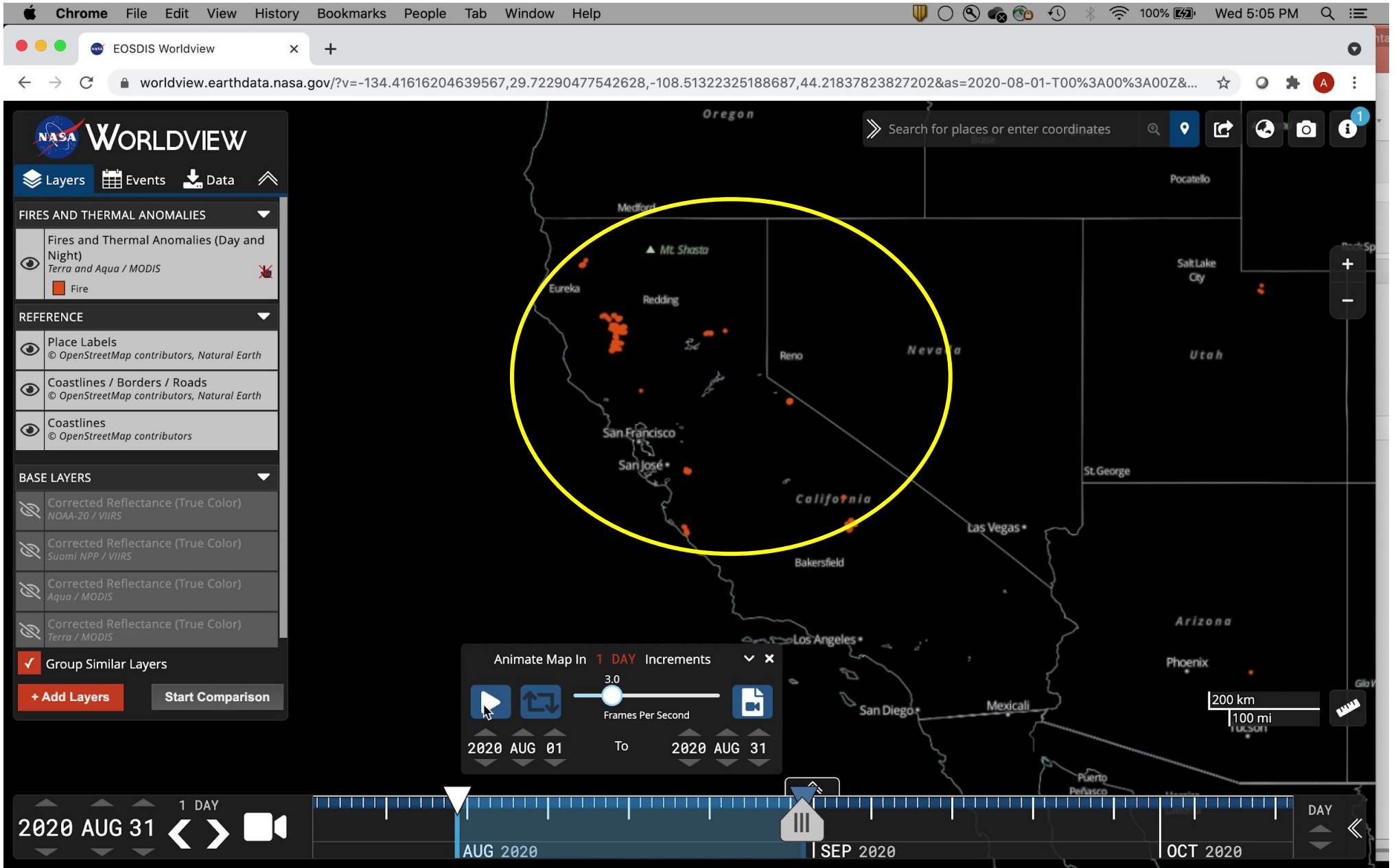
NASA's Aqua satellite captured this true-color image of the United States on Sep. 15, 2020, showing the fires in the West, the smoke from those fires drifting over the country, several hurricanes converging from different angles, and Hurricane Sally making landfall.
Image Credit: NASA

California Fires: 2020

https://www.fire.ca.gov/incidents/2020/



California Fires August 2020

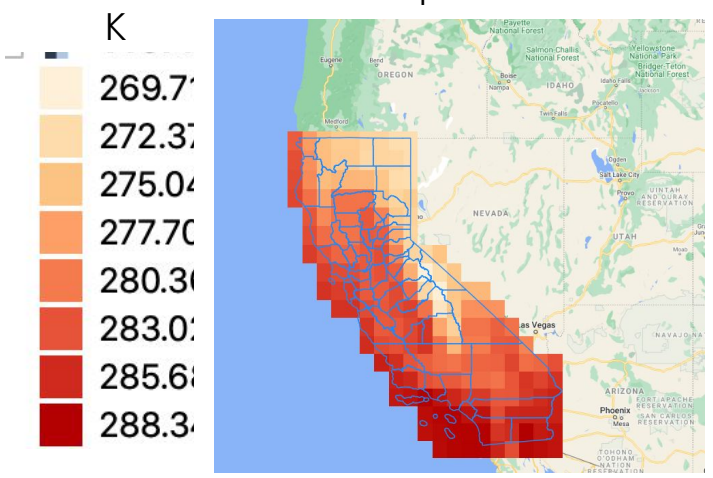


Pre-Fire Season Climatology of Temperature, Precipitation, Soil Moisture

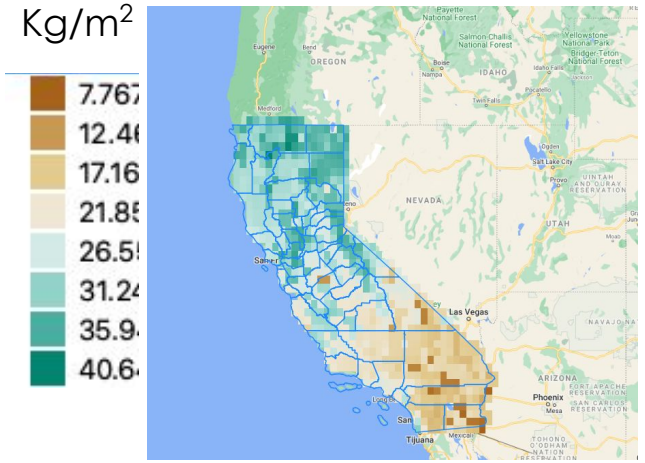
- Using Giovanni seasonal mean maps (averaged over 2001 to 2020) for California are calculated for **December-January-February (DJF)** from:

  - MERRA-2, 10-m air temperature
  - IMERG precipitation
  - GLDAS soil moisture (0 to 10 cm)

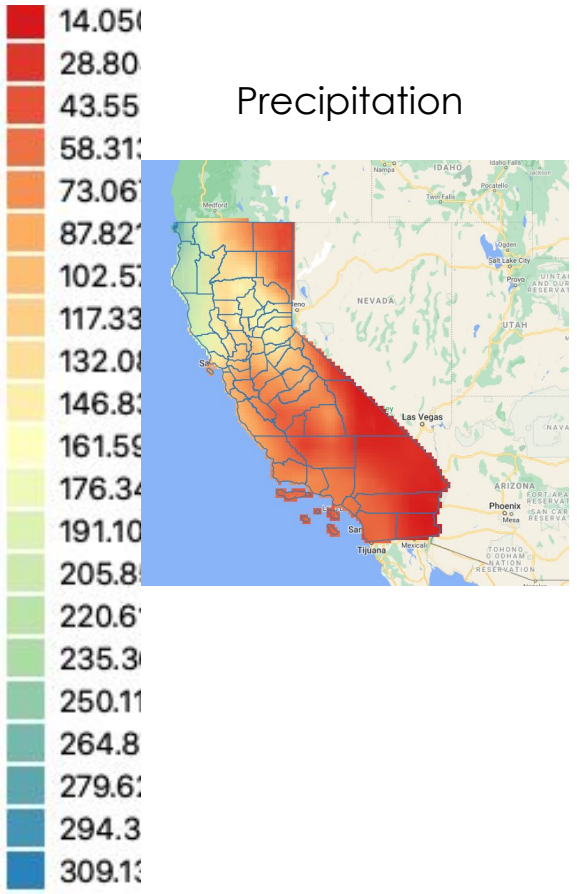
Temperature



Soil Moisture



Precipitation



Pre-Fire Season Anomalies of Temperature, Precipitation, Soil Moisture

- Using Giovanni, seasonal mean maps for 2020 are calculated and anomaly maps (departure from 20-year mean) are calculated using QGIS

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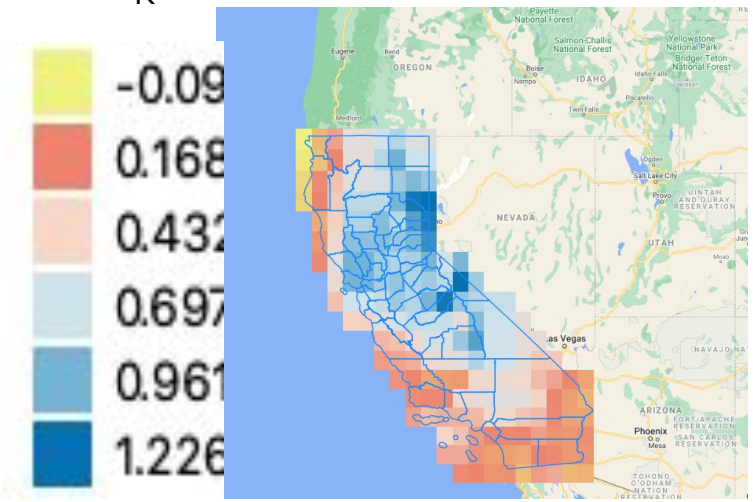
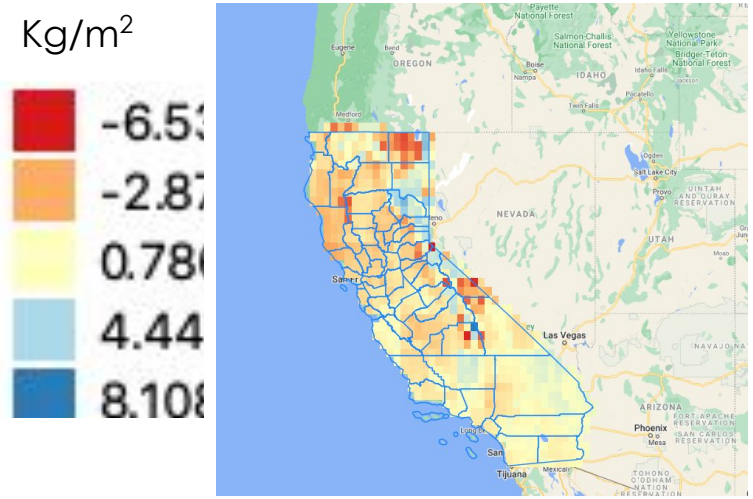
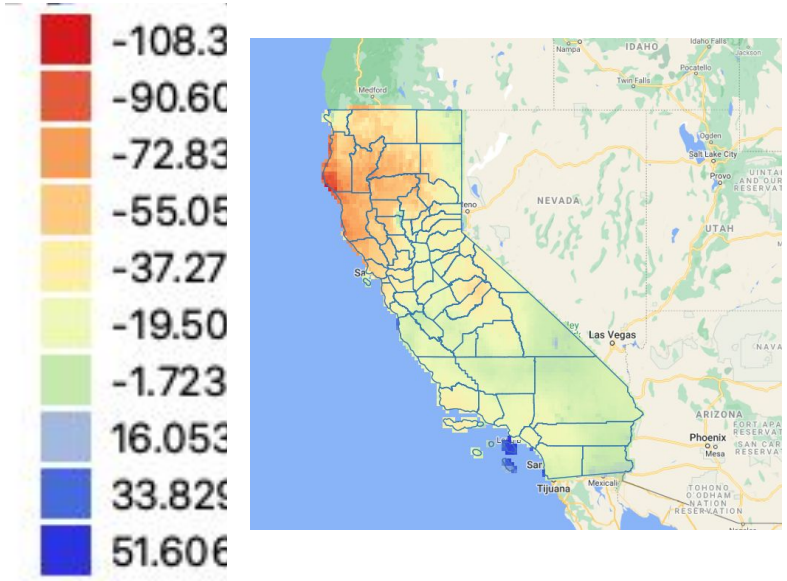


Kg/m^2

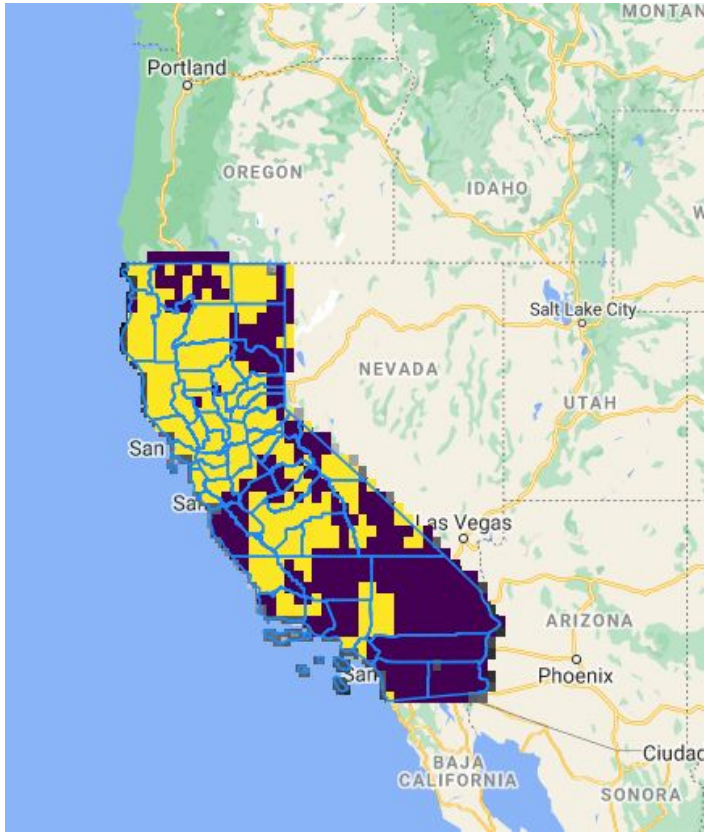


mm/month

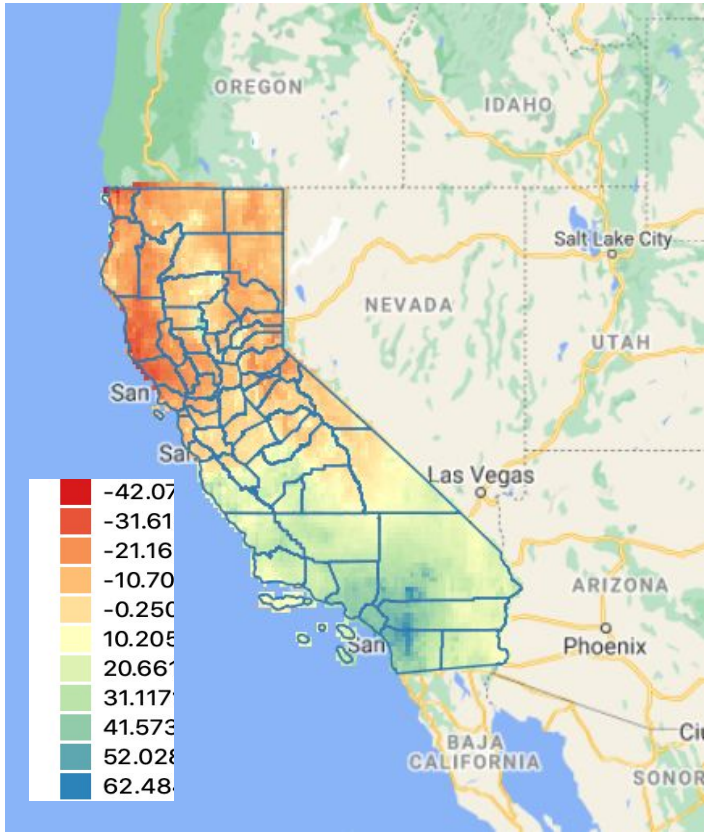


Seasonal Climate Indicator For Potential Fire Risk Areas

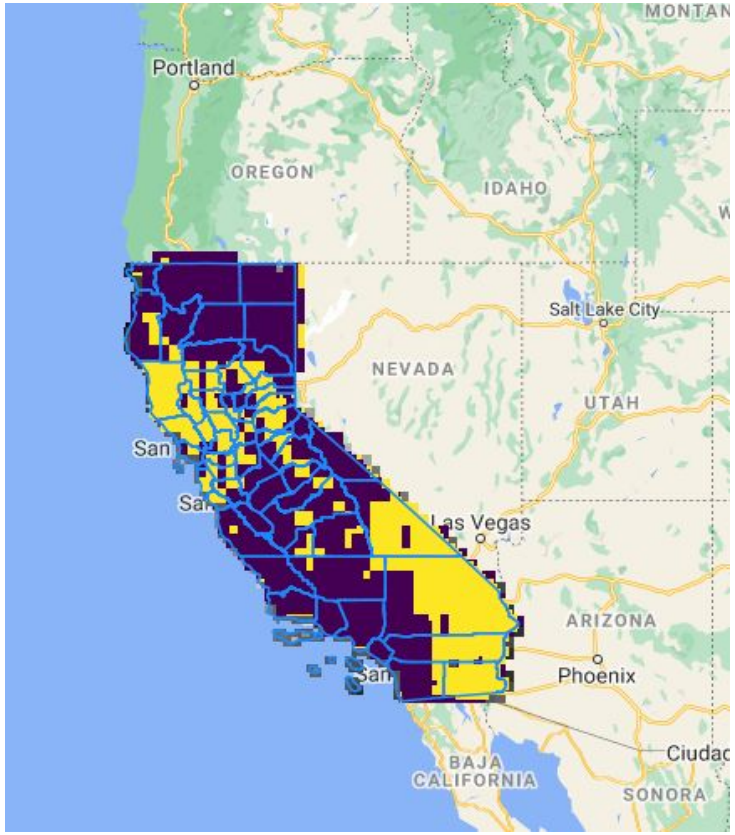
December-January-February 2020



March-April-May 2020



June-July-August 2020



Warmer than normal temperature and below normal precipitation and soil moisture

Vegetation Index Anomalies

- Anomalies can indicate changes in vegetation health (due to drought high temperatures, etc.).
- VIIRS NDVI anomaly product for July 3, 2020, shows negative anomalies in northern California prior to August fires, indicating potential impacts to vegetation from dryness and high temperature.

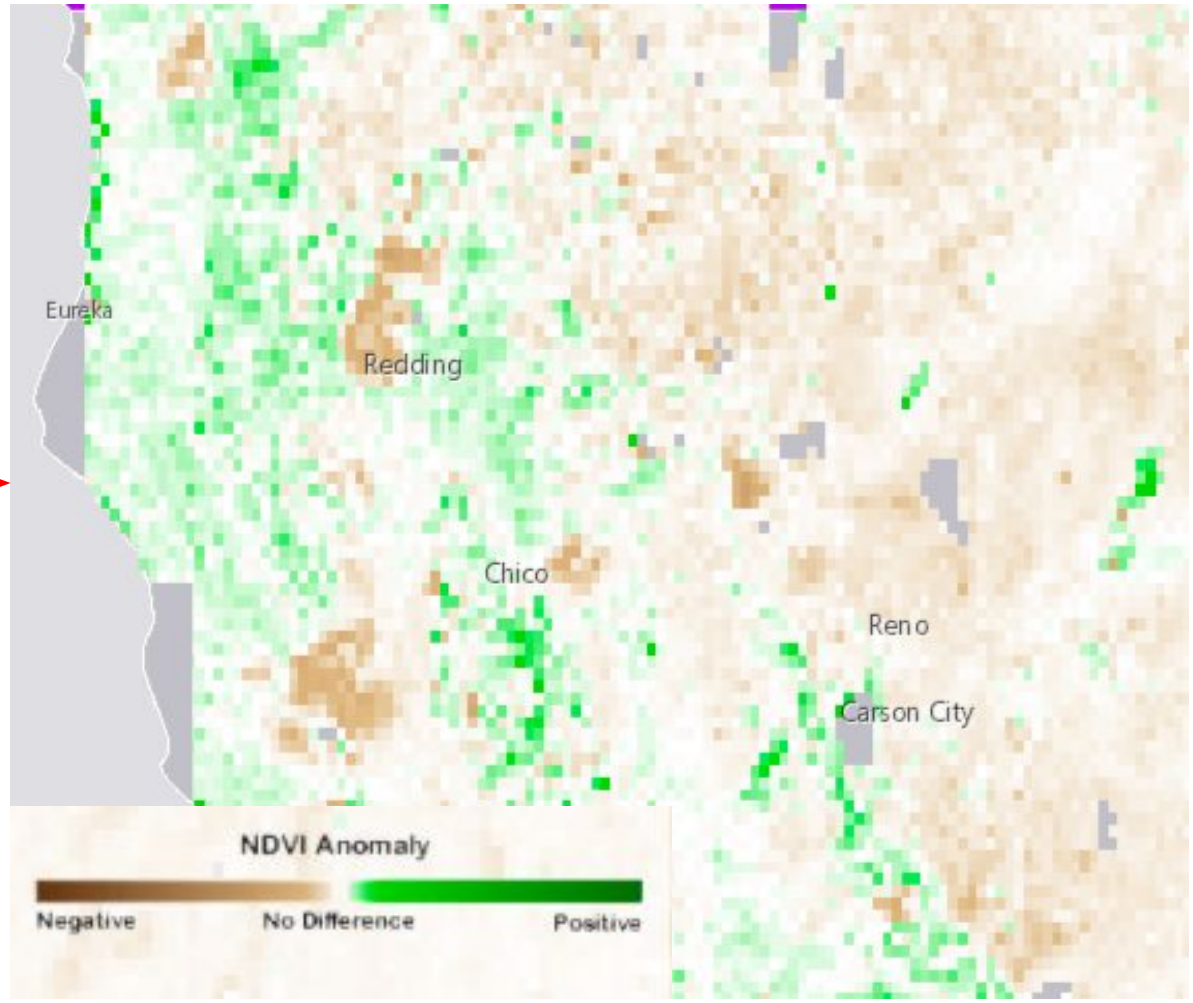


Image Credit: Crop Monitor

California 2020 Fires: Live Fuel Moisture Content

- Live Fuel Moisture Content (LFMC) – the mass of water per unit of dry biomass in vegetation – **exerts a direct control on fuel ignitability, fuel availability, and fire spread, and is thus an important parameter in assessing fire risk**.
- SAR data used to map dryness
- Data from National Fuel Moisture Database used in the model

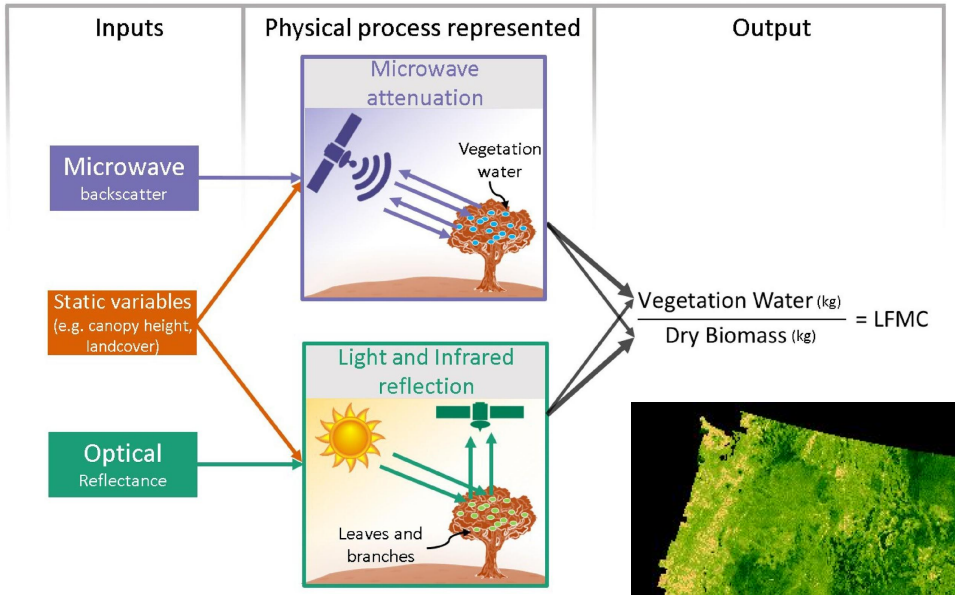
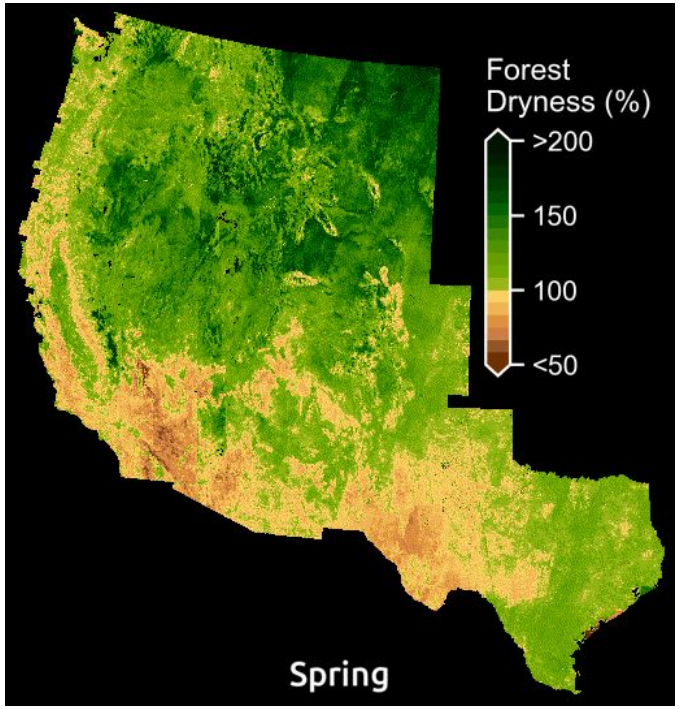
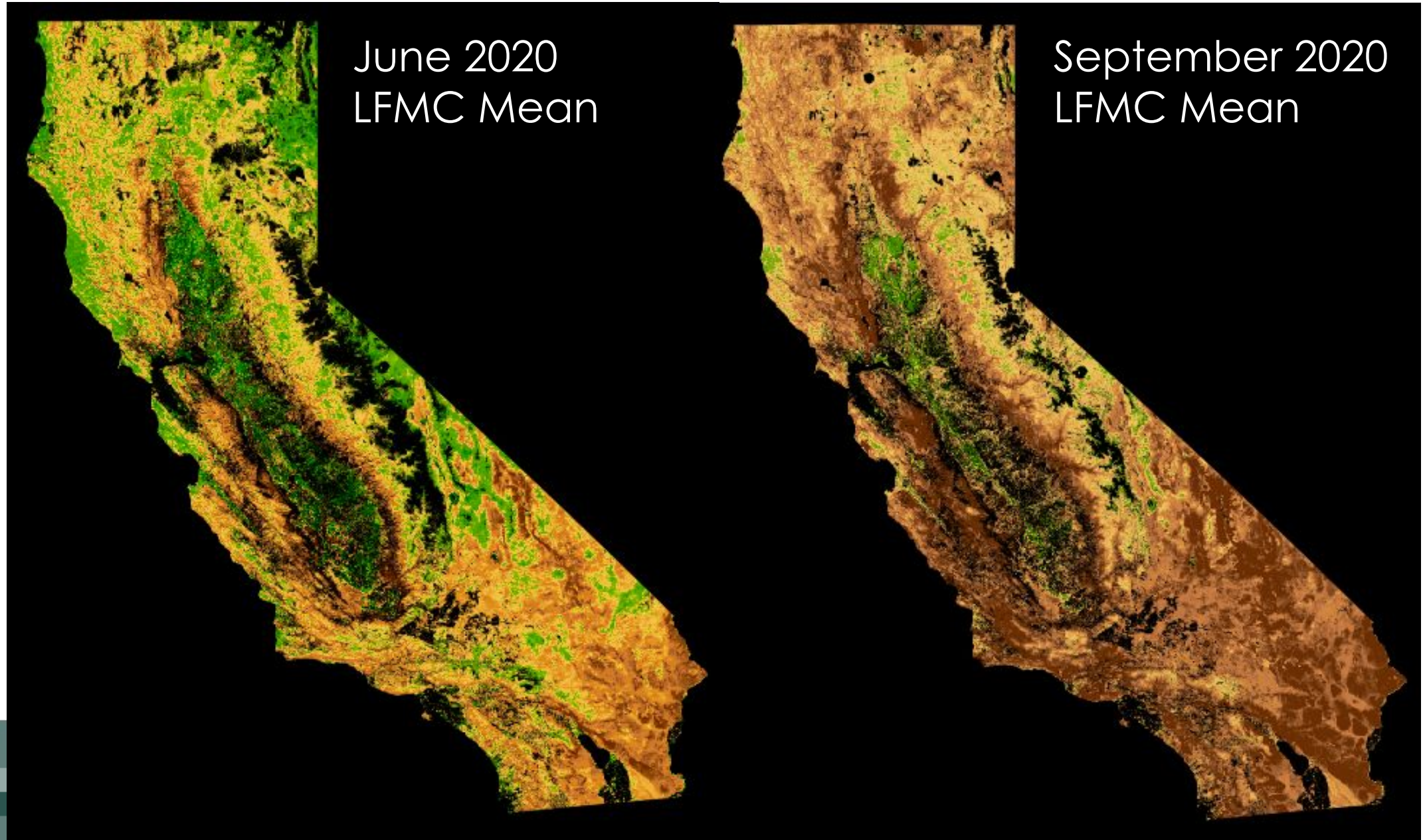


Image Credit: Rao et al 2020



California 2020 Wildfires: Live Fuel Moisture Content (LFMC)



- **Notable decrease in fuel moisture over the course of summer months.**

National Aeronautics and Space Administration

Demonstration: Pre-fire Conditions for March 2022 Fire in Sierra de Santiago, Nuevo León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Thank You!