



Part 4: During-Fire Fire Emissions and Smoke Forecasting

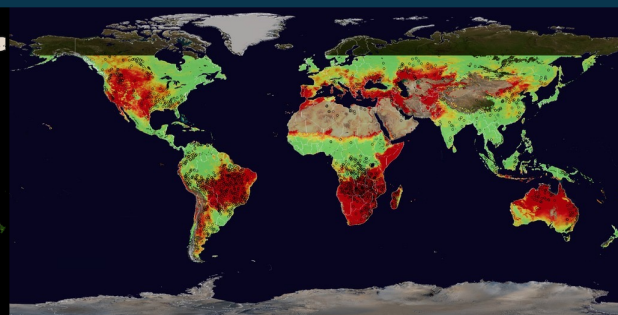
Melanie Follette-Cook, Pawan Gupta, and Ana Prados

May 20, 2021



Webinar Agenda

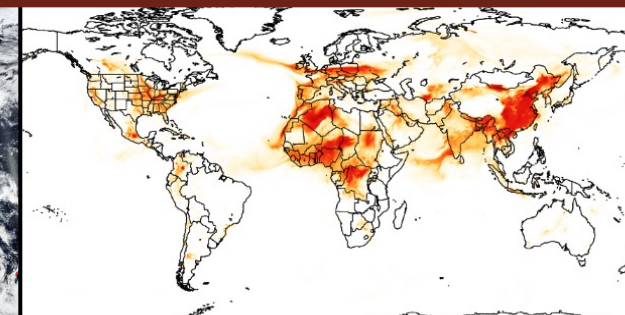
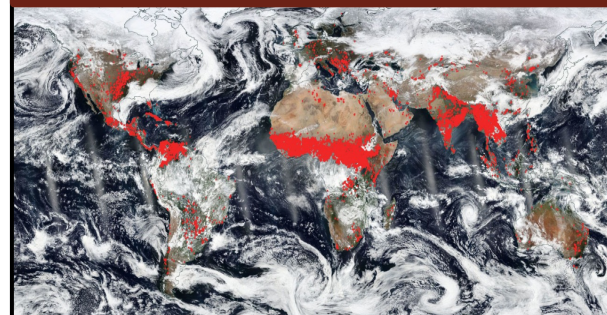
Pre-Fire



Session 1:
Climate and Hydrology

Session 2:
Vegetation

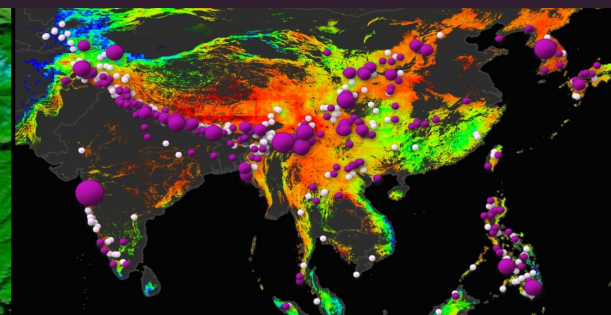
During Fire



Session 3:
Active Fires and Smoke

Session 4:
Smoke Forecasting

Post-Fire





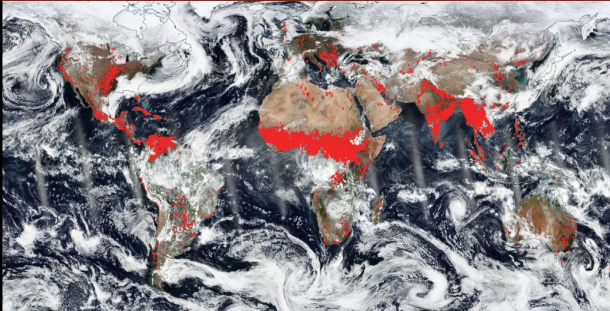
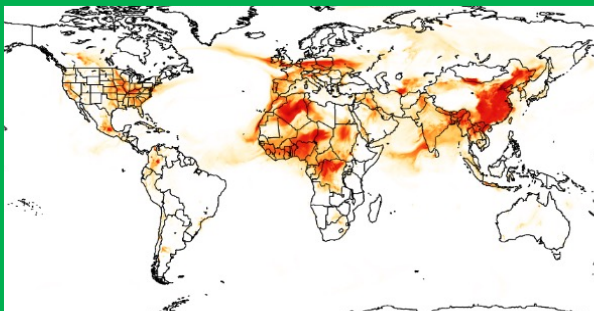
Session 5:
Climate & Hydrology

Session 6:
Vegetation



Webinar Agenda

During Fire  

	
Session 3: Active Fires and Smoke	Session 4: Smoke Forecasting



**Melanie
Follette-Cook**



Pawan Gupta



Ana Prados



Learning Objectives

- Understand the different ways fire emissions can be estimated using satellite observations
- Identify several different fire emissions datasets available
- Locate several global and US air quality forecasts




Questions

- Please enter your questions in the Q&A box. We will answer them in the order they were received at the end of today's presentation.
- We will post the Q&A to the training website following the conclusion of the webinar.



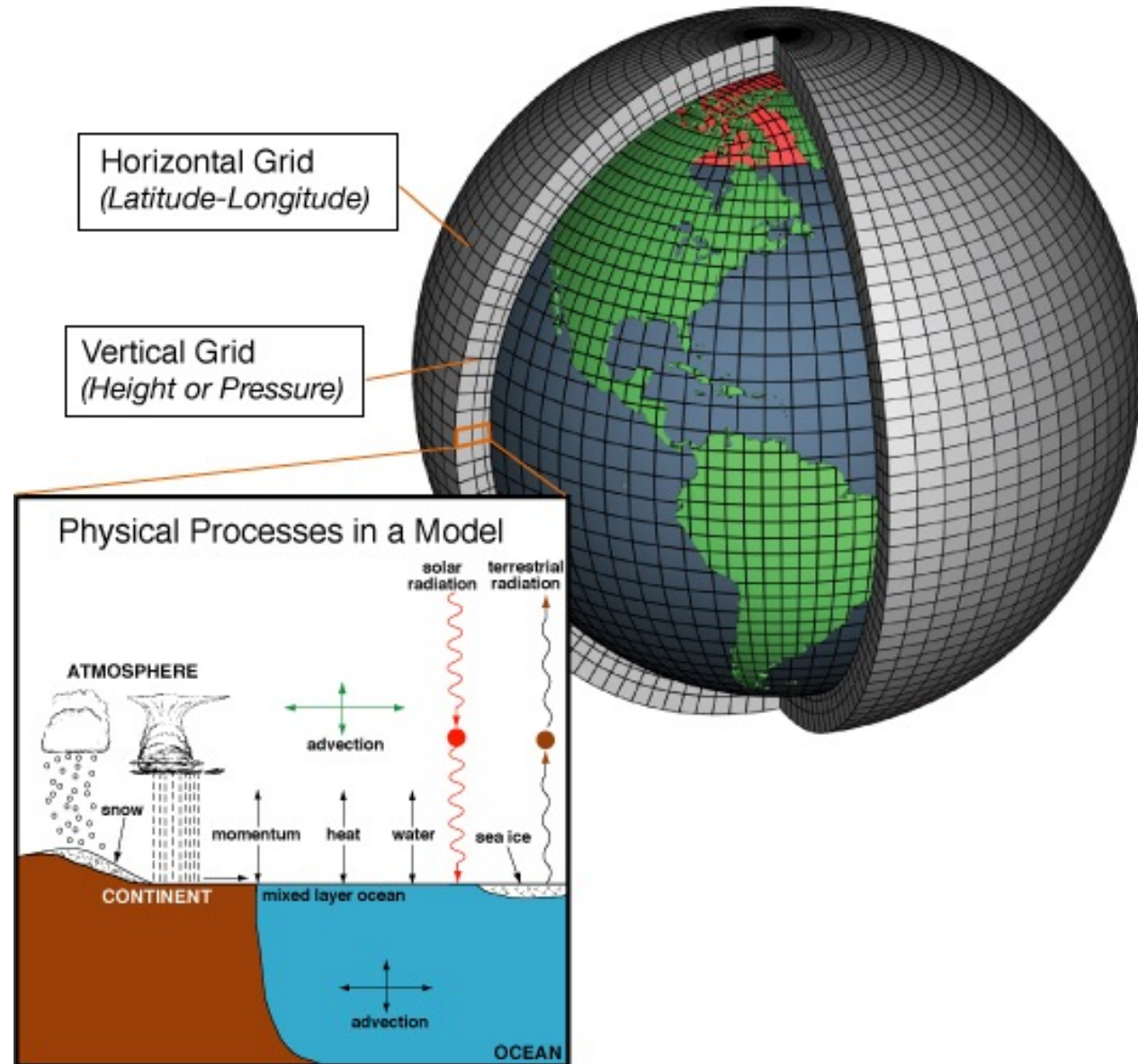
Why do we want to model smoke from fires?

- Cloud Physics and Chemistry
 - Radiative Budget
 - Greenhouses Gases
 - Air Quality and Health
- 
- Smoke from fires is an important source of trace gases and aerosols, or particulate matter (PM)
 - 50% of global CO emissions
 - 20% NOx emissions
 - ~40% Black Carbon emissions
 - ~74% Organic Carbon emissions
 - Smoke also...
 - Reduces visibility
 - Contributes to O3 formation
 - Causes negative health impacts from increased PM

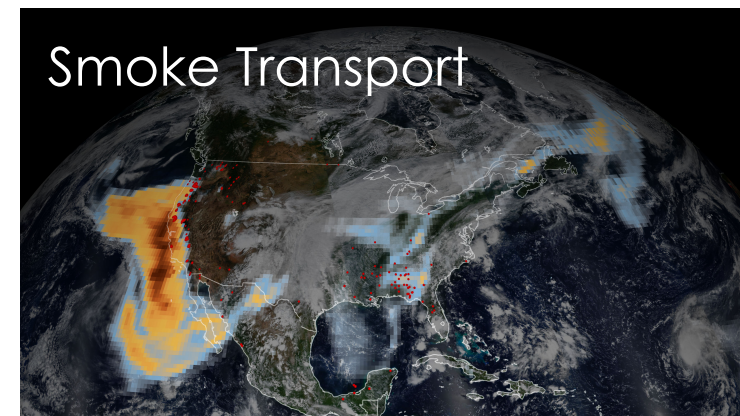


Modeling Smoke in the Atmosphere

- Meteorology
- Chemistry
- Emissions



How do models simulate fires and smoke?



- Observations
 - Satellite
 - Aircraft
 - Ground
- Predictive
 - Use an ignition and fire spread model to predict fires

- Trace gases
- Aerosols

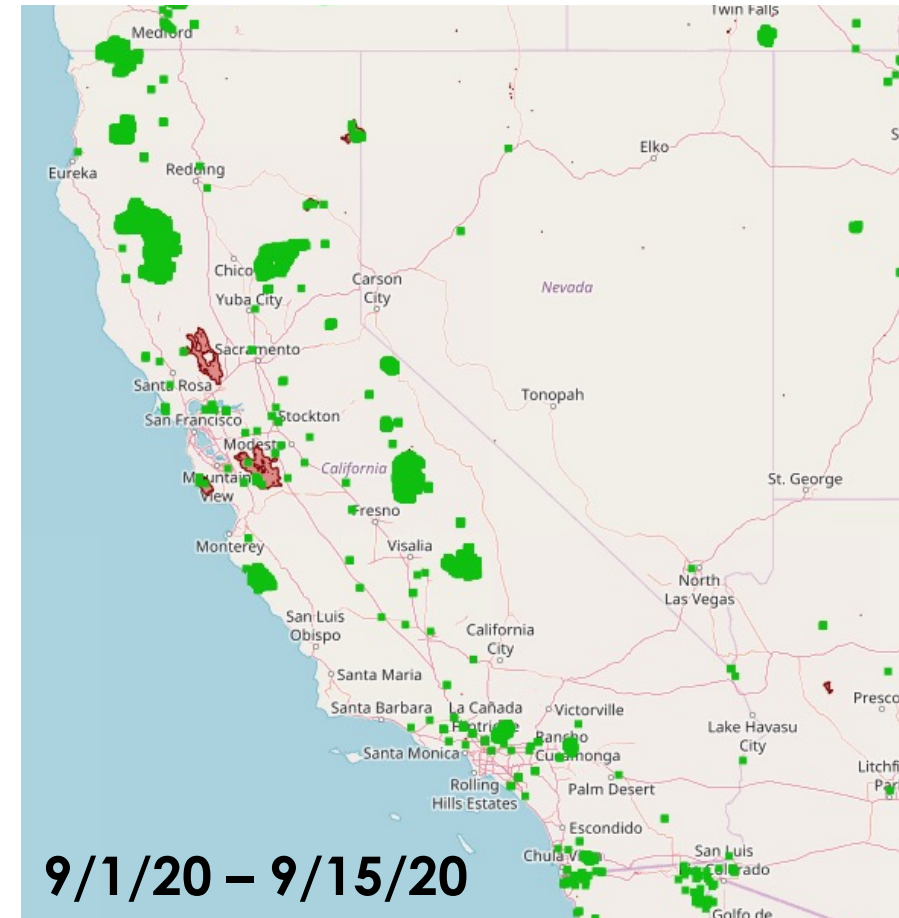
- Injection Height
How high is the smoke?
- Persistence
How long does the fire last?
- Timing
Are the emissions always the same, or do they change by the hour?



Satellite Observations used to Calculate Fire Emissions

- Burned Area
 - Spatial extent of recent fires
 - Not available in near real time (NRT)
 - More details in Part 6
- Thermal Anomalies
 - Detects thermal anomalies from active fires
 - Used to report fire locations and Fire Radiative Power (FRP)
 - Available in near real time (NRT)
 - More details in Part 3

MODIS Burned Area + VIIRS Active Fire Detections



Created using the [GWIS](#) tool



Fire Emissions – What is in smoke?

- Smoke contains both trace gases and aerosols...
- Greenhouse Gases (CO_2 , CH_4)
- Trace Gases (NO_2 , CO , O_3)
- Aerosols ($\text{PM}_{2.5}$, BC, OC)
- NMOC (non-methane organic compounds)
 - e.g., aldehydes, alcohols, alkenes, alkanes, etc.
 - HCHO, and other ozone and aerosol precursors
- Actual composition of emissions will be a function of:

Fuel Source
(What is burning?)

Environmental Conditions
(e.g., is the fuel very dry?)



Calculating Fire Emissions

The amount, or mass, of a species emitted is related to the amount of dry fuel burned, through an *emission factor*. These emission factors usually vary by species and by biome and vegetation type.

$$M_s = EF_s * M_{dry}$$

Mass of Species, s Emission Factor of Species, s Mass of Dry Fuel

Emission factors carry a lot of uncertainty. Most are the result of controlled experiments in a laboratory or have been calculated through in-situ measurements.



Satellite Observations to Estimate the Amount of Fuel Burned

There are two common ways to estimate the amount of fuel burned:

Burned Area Approach

- Burned area sources:
 - MODIS burned area product
 - Calculated using fire pixel counts
- Emissions Datasets:
 - GFED (uses burned area, fire counts)
 - FINN (uses fire counts)

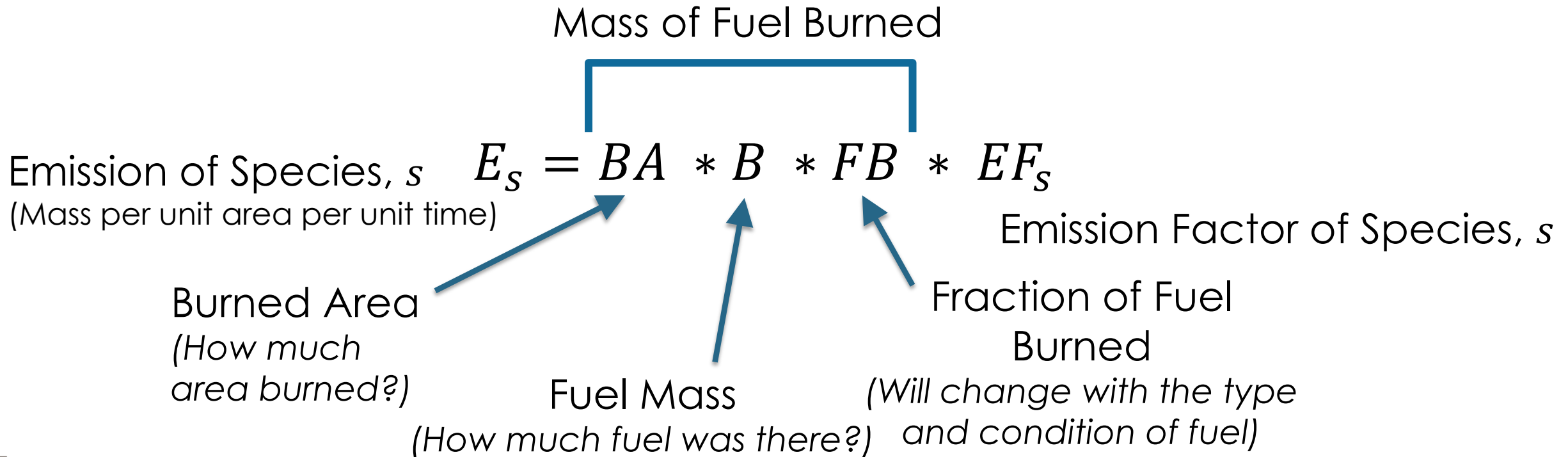
Fire Radiative Power Approach

- Use Fire Radiative Power (FRP)
- Emissions Datasets:
 - QFED
 - GFAS
 - FEER



Burned Area Approach - Theory

The mass of fuel burned can be calculated with additional information about the mass of available fuel, as well as combustion completeness.



[Wiedinmyer et al., 2011](#)



FRP Approach: Theory

The energy emitted by a fire is directly related to the brightness temperature at $\sim 4 \mu\text{m}$.

$$FRP = 4.34 \times 10^{19} (T_4 - T_{4b})$$

FRP (Units = MW) is the rate of radiative energy emitted by a fire.

↑
Fire pixel brightness temperature in the $\sim 4 \mu\text{m}$ channel

↑
 $4 \mu\text{m}$ brightness temperature of the background around the fire pixel



FRP Approach: Theory

Studies have shown that burning dry vegetation yields a similar amount of energy, regardless of vegetation type. So:

Emission of Species, s $E_s = \alpha * FRP$ ← Fire Radiative Power

Emission coefficient relating FRP to emission of a given species

Example:
FEER





Global Fire Emissions Datasets

Fire Emissions: Quick Guide

	GFED4s	FINN	QFED	GFAS	FEER
Product	Burned Area, Active Fire Counts	Active Fire Counts	FRP	FRP	FRP
Time Period	1997 - Present	2002 - Present	2000 - Present	2003 - Present	2003 - Present
Resolution	0.25°	1 km	0.1°	0.1°	0.1°
Reference	Giglio et al. (2013) ; Randerson et al. (2012) ; Van der werf et al. (2017)	Wiedinmyer et al. (2011)	Darmenov and Da Silva (2015)	Kaiser et al. (2012)	Ichoku and Ellison (2014)
Website	https://www.globalfiredata.org/	https://www2.acom.ucar.edu/modeling/finn-fire-inventory-ncar	https://portal.nccs.nasa.gov/datashare/isa/aerosol/emissions/QFED/v2.5r1/	https://atmosphere.copernicus.eu/global-fire-emissions	https://feer.gsfc.nasa.gov/

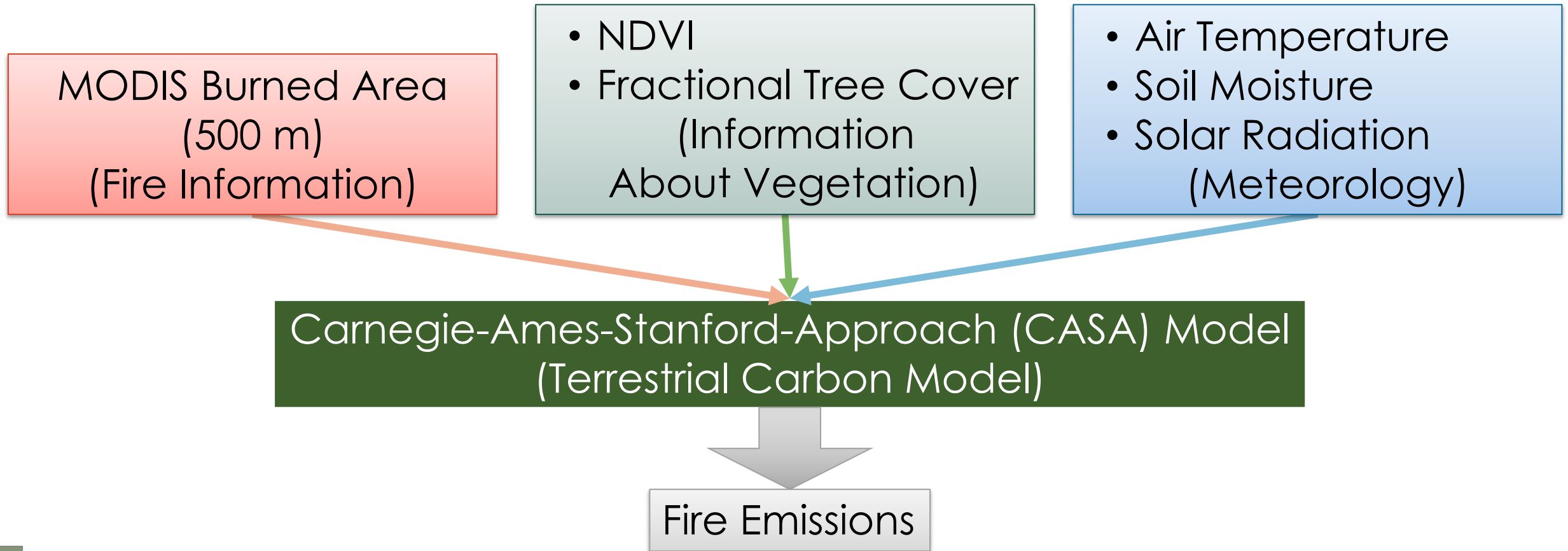




GFED

Global Fire Emissions Database (GFED)

GFED is probably the most well-known and widely used fire emissions dataset.



GFED Fire Emissions Data

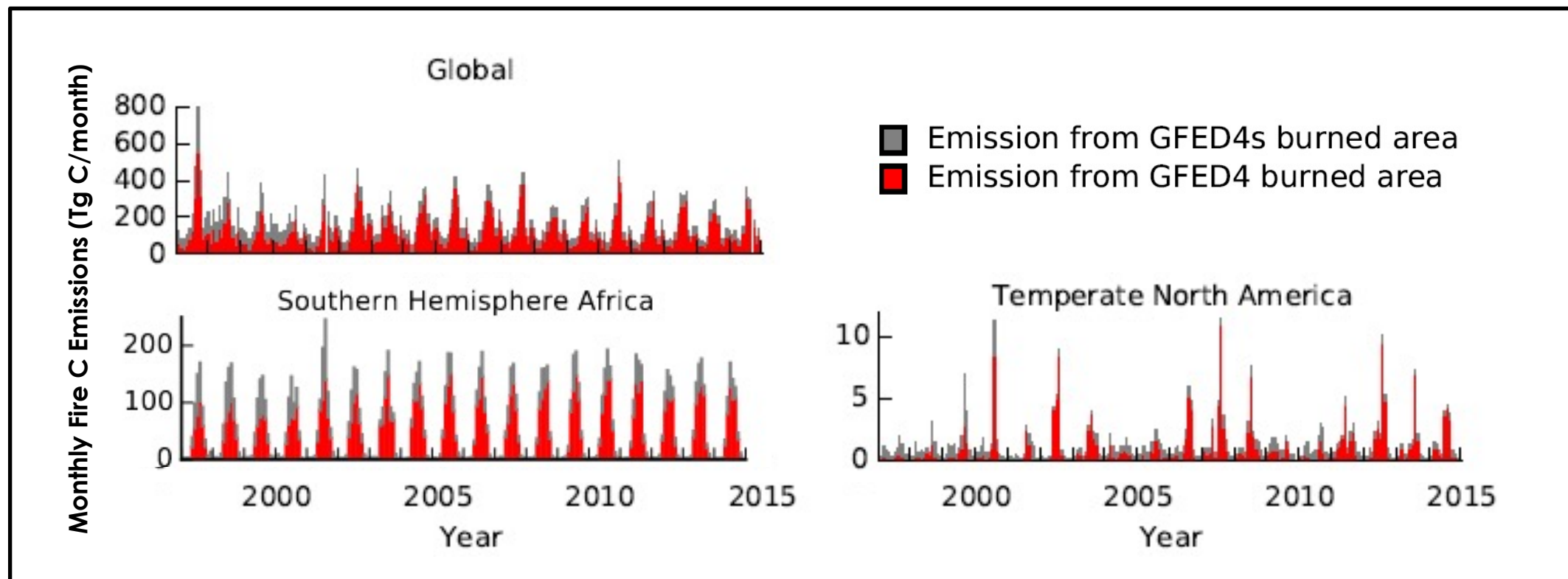
	GFED4	GFED 4s (GFED 4 + small fires)	GFED NRT
Satellite Observations	MODIS burned area Active fire data from VIIRS and ATSR (Pre-MODIS era)	MODIS burned area, surface reflectance MODIS thermal anomalies	VIIRS thermal anomalies
Spatial Resolution	0.25° x 0.25°	0.25° x 0.25°	~550 m x 550 m
Time Period	1997 – 2016	1997 – 2016 (2017-2020 beta files available)	2019 – Present
Temporal Resolution	Monthly, Daily, 3-Hourly (2000 - Present)	Monthly, Daily, 3-Hourly	Daily
File Format	HDF	HDF5	

Python and Matlab readers available for hdf5 on the GFED website.



How much do small fires matter?

GFED4 vs. GFED4s



Not including small fires results in an underestimation of emissions.



GFED Website

<https://www.globalfiredata.org/>

- Download GFED Emissions
- Amazon Dashboard
- Fire Atlas Data
- Analysis Tool
 - Subset and download emissions

GFED UPDATES DATA AR6 HISTORIC AMAZON DASHBOARD FIRE ATLAS ANALYSIS TOOL REGIONAL HIGHLIGHTS CONTACT

Amazon fire activity in 2020 surpasses 2019 September 22, 2020
In September, 2020 surpassed 2019 to become the most active fire year in the southern Amazon since 2012, the year...
Read more...

Leaflet | GFED Burned Area (2014)

Global Fire Emissions Database

Fires are an important source of atmospheric trace gases and aerosols and they are the most important disturbance agent on a global scale. In addition, deforestation and tropical peatland fires and areas that see an increase in the frequency of fires add to the build-up of atmospheric CO₂.

We have combined satellite information on fire activity and vegetation productivity to estimate gridded monthly burned area and fire emissions, as well as scalars that can be used to calculate higher temporal resolution emissions. Most of the resulting datasets are downloadable from this website for use in large-scale atmospheric and biogeochemical studies. The core datasets are:

- Burned area from [Giglio et al. \(2013\)](#)
- Burned area from "small" fires based on active fire detections outside the burned area maps detailed in [Randerson et al.](#)

Contact:

For questions regarding burned area (not small fire burned area), please contact [Louis Giglio](#).

For questions regarding small fire burned area or the conversion of monthly to daily / 3-hourly emissions, please contact [James Randerson](#).

For questions regarding emissions, please contact [Guido van der Werf](#).

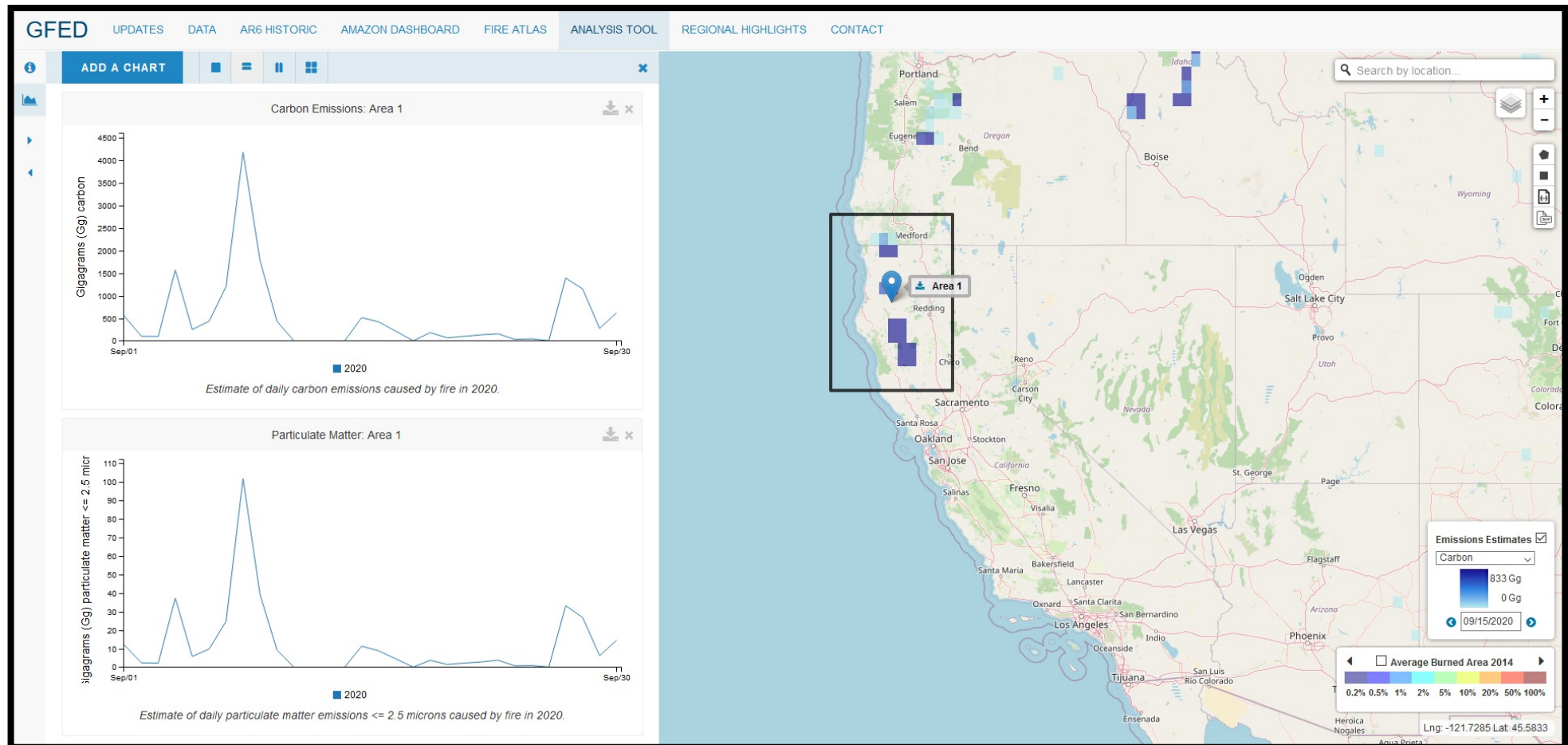
For questions regarding the fire atlas or VIIRS near real time emissions estimates, please contact [Niels](#)



GFED Website Demo

<https://www.globalfiredata.org/>

- We will recreate this figure.

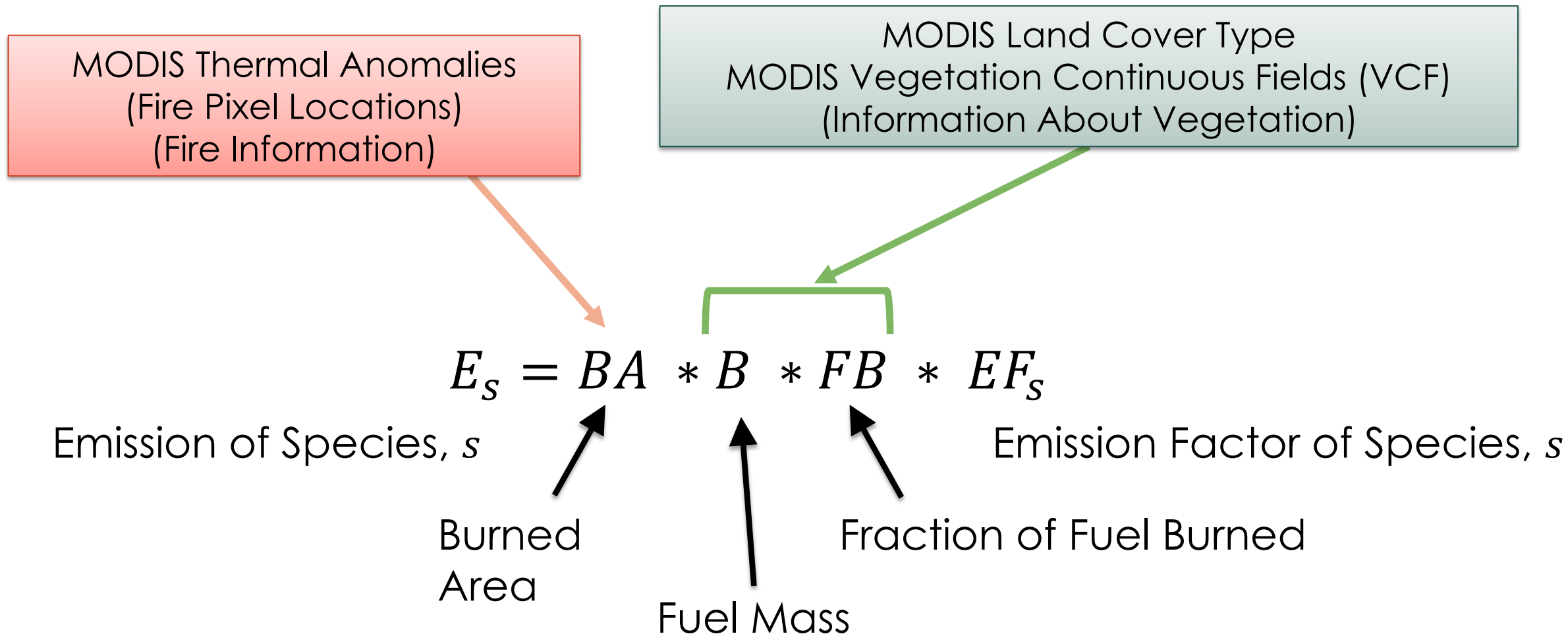




FINN

Fire Inventory from NCAR (FINN)

FINN is a global, high-resolution (1 km²) fire emissions dataset.

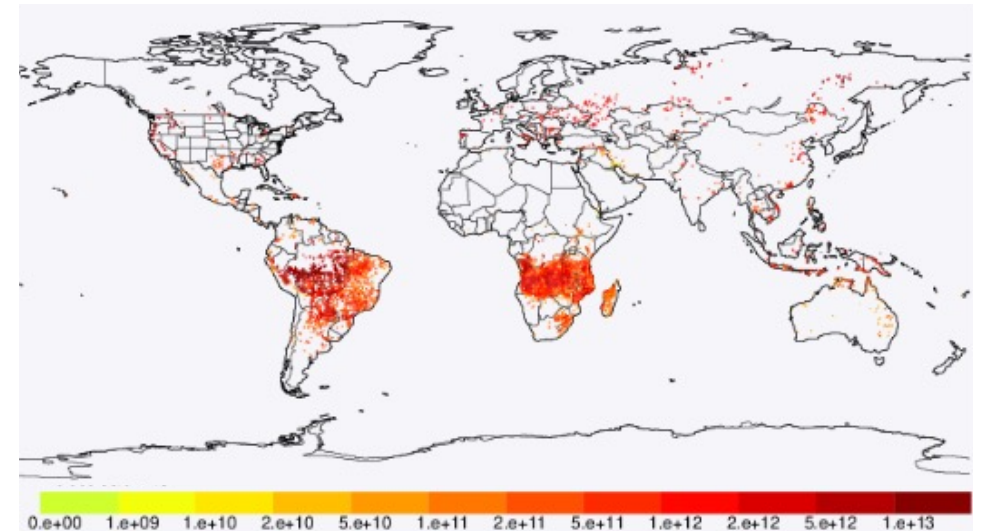


FINN v2.2

<https://www2.acom.ucar.edu/modeling/finn-fire-inventory-ncar>

- Global
- 2002 – Present
 - (MODIS + VIIRS available 2012-2019)
- ~1 km² Spatial Resolution
- Daily
- ASCII (text) files
- Trace gas and aerosol speciation for three chemical mechanisms (.csv files):
 - MOZART4
 - SAPRC99
 - GEOS-Chem
- Utilities to grid FINN emissions to NetCDF for use in WRFChem or global models

FINN CO Emissions: Sep 12, 2020



Fire Emissions of CO [molecules/cm²/s]

*binned to 0.5 deg

<https://www.acom.ucar.edu/acresp/forecast/fire-emissions.shtml>

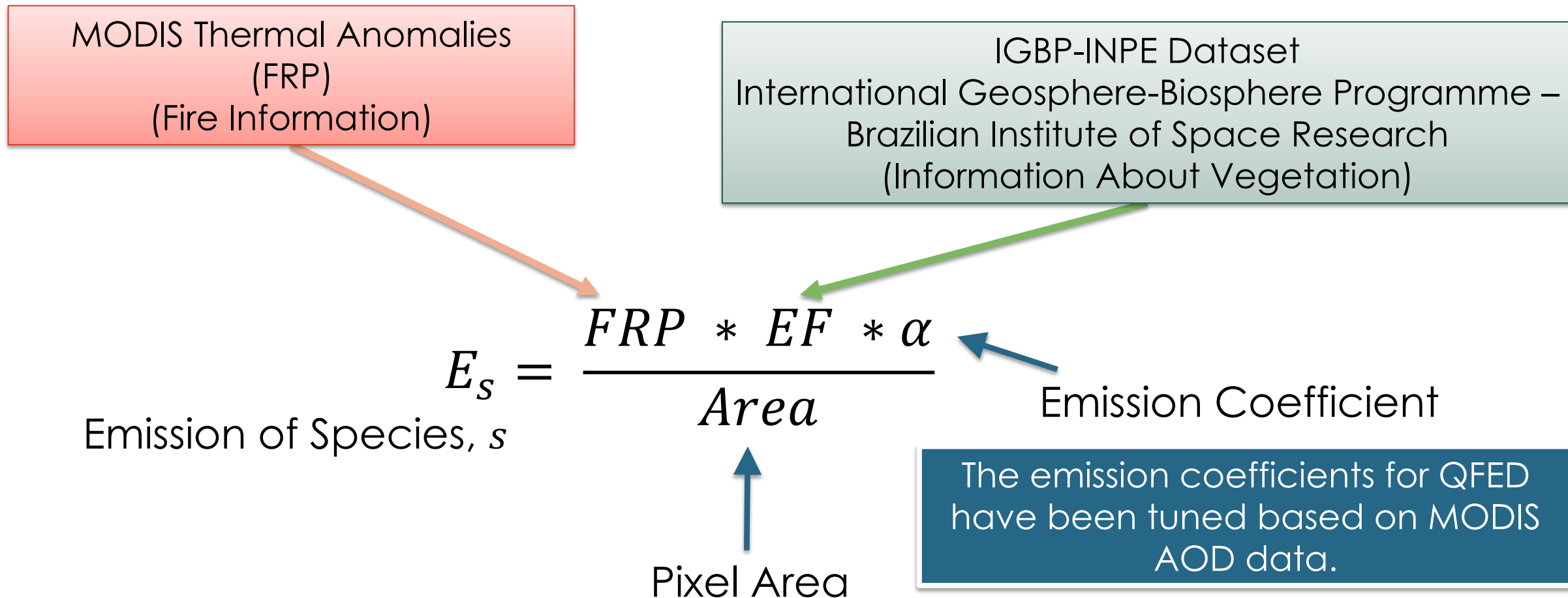




QFED

Quick Fire Emissions Database (QFED)

QFED emissions are used in the NASA GEOS forecast model.



Quick Fire Emissions Database (QFED)

<https://portal.nccs.nasa.gov/datashare/iesa/aerosol/emissions/QFED/v2.5r1/>

- Global
- 2000 - Present
- $0.1^\circ \times 0.1^\circ$, $0.25^\circ \times 0.25^\circ$ Spatial Resolution
- Daily Emissions, NRT
- NetCDF4
- Two Gridded Products:
 - FRP
 - Trace gas and aerosol emissions
- Caution should be used in using these emissions in other models besides GEOS.





GFAS

Global Fire Assimilation System (GFAS)

GFAS emissions are used in ECMWF Copernicus Atmosphere Monitoring Service (CAMS) forecasts.

MODIS Thermal Anomalies
(FRP)
(Fire Information)

Land Classification from GFED v 3.1
(Information About Vegetation)

$$E_s = \frac{FRP * EF * \alpha}{Area}$$

Conversion Factor

Derived using GFED v3.1



GFAS

<https://atmosphere.copernicus.eu/global-fire-emissions>

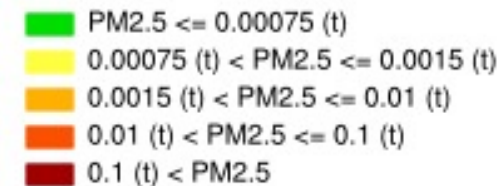
- Global
- 2003 – Present
- $0.1^\circ \times 0.1^\circ$ Spatial Resolution
- Daily, NRT
- GRIB file format
- Includes information on:
 - Injection height (from a plume rise model)
 - FRP
 - Emissions of trace gases and aerosols

GFAS PM Emissions Sep 2020



Created using the [GWIS](#) tool.

Particulate Matter (PM2.5)



Global Wildfire Information System (GWIS)

<https://gwis.jrc.ec.europa.eu/>

- Visualize Current Observations
 - Fire Danger and Lightning Forecast
 - MODIS and VIIRS Active Fire Detections
 - MODIS and VIIRS Burned Area
 - GFAS Emissions
 - Fuel Classes
- Historical Overviews
 - Continent/Country/Sub-Country
 - Number of fires, burned area, fire size, seasonality
 - Single or multi-year images and data
- Download Data



The screenshot shows the homepage of the Global Wildfire Information System (GWIS). At the top, there is a navigation bar with the JRC logo and contact information. Below the navigation bar, there are logos for GEO, NASA, and Copernicus. The main content area features a world map with various colored overlays representing wildfire data. The text 'Global Wildfire Information System GWIS' is prominently displayed over the map. Below the map, there is a 'Welcome to GWIS' section with a paragraph of introductory text. To the right of this text, there are two buttons: 'Visit the brand-new Country Profile' and 'GWIS Applications'. Under 'GWIS Applications', there are three sub-sections: 'Current Situation Viewer', 'Country Profile', and 'Data & Services', each with a brief description and a 'Read more' link. At the bottom of the page, there is a footer with links for 'JRC Mission', 'Cookies', 'Legal notice', and 'Privacy Statement'.

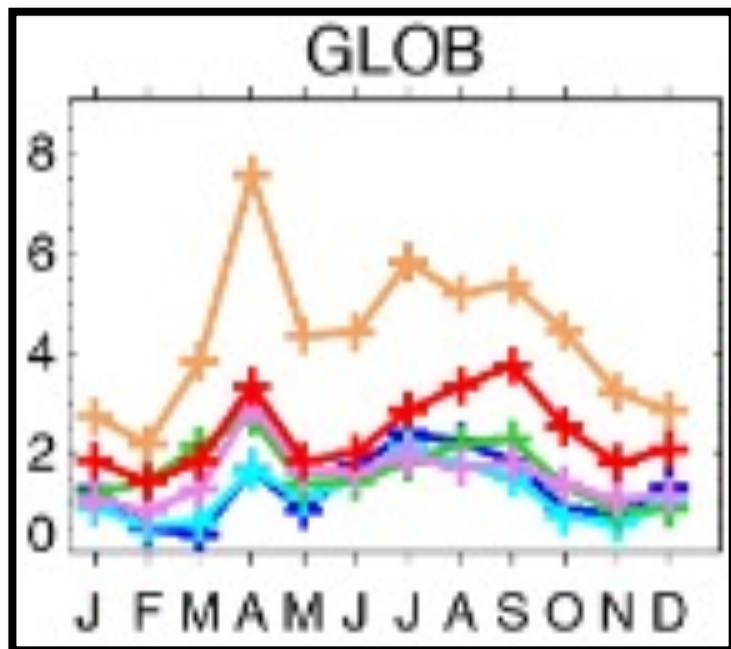


Burned Area vs. Thermal Energy: Sources of Uncertainty

Burned Area	Thermal Energy (FRP)
Omission of small fires (MODIS limit is fires > 100 m ²)	Omission of small fires (MODIS limit is fires > 100 m ²) VIIRS detects 3-4x more fires than MODIS
Omission of fires obscured by clouds	Omission of fires obscured by clouds
Misidentification of land cover type	Omission of fire with weak thermal signatures (e.g., smoldering fires)
Inaccurate fuel estimates, combustion completeness	Conversion factor estimation
Emission factors	Emission factors



How do these datasets compare?



Adapted from Figure 4
[Pan et al., 2020](#)

Emissions Dataset	Total Organic Carbon Emissions from Fire – 2008 (Tg)
GFED v3.1	15.65
GFED v4s	13.76
FINN v1.5	19.48
GFAS v 1.2	18.22
FEER v1.0	28.48
QFED v 2.4	51.93

QFED and FEER tend to show the highest emissions as a result of tuning the emissions to match MODIS AOD.





Air Quality and Smoke Forecasting

Air Quality (AQ) Forecasting

- Provide the public with health alerts
- Provide visibility/haze advisories
- Inform emergency response
- Help environmental regulators decide if temporary emissions reductions are needed



Air Quality Forecasts vs. Smoke Forecasts

AQ Forecast

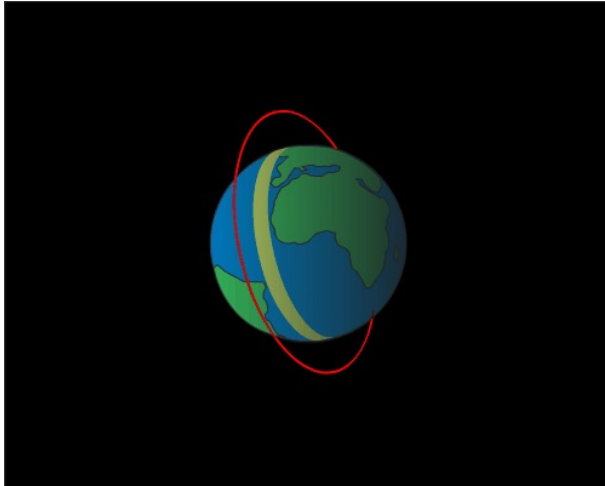
- Forecasts pollutants that are important for AQ
- Includes emissions/pollutant sources other than fire
- Aerosol forecasts (e.g., GEOS-FP) forecast aerosols only
- Composition forecasts (e.g., GEOS-CF, CAMS) forecast trace gases and aerosols

Smoke Forecast

- Forecasts the transport of smoke from fires (e.g., the estimated $PM_{2.5}$ emitted from a fire)
- Component of AQ forecast or standalone forecast



Forecasting Smoke – Limitations and Considerations



Frequency of Fire Observations

Forecast models can only transport emissions from fires that are viewed by satellite.



Fire Persistence

A satellite might see a fire one day, and not the next. Models make assumptions about how long fires last.

[Image source](#)

Smoke Injection Height

The altitude of smoke injection is critical to transporting the smoke accurately.



[Image source](#)



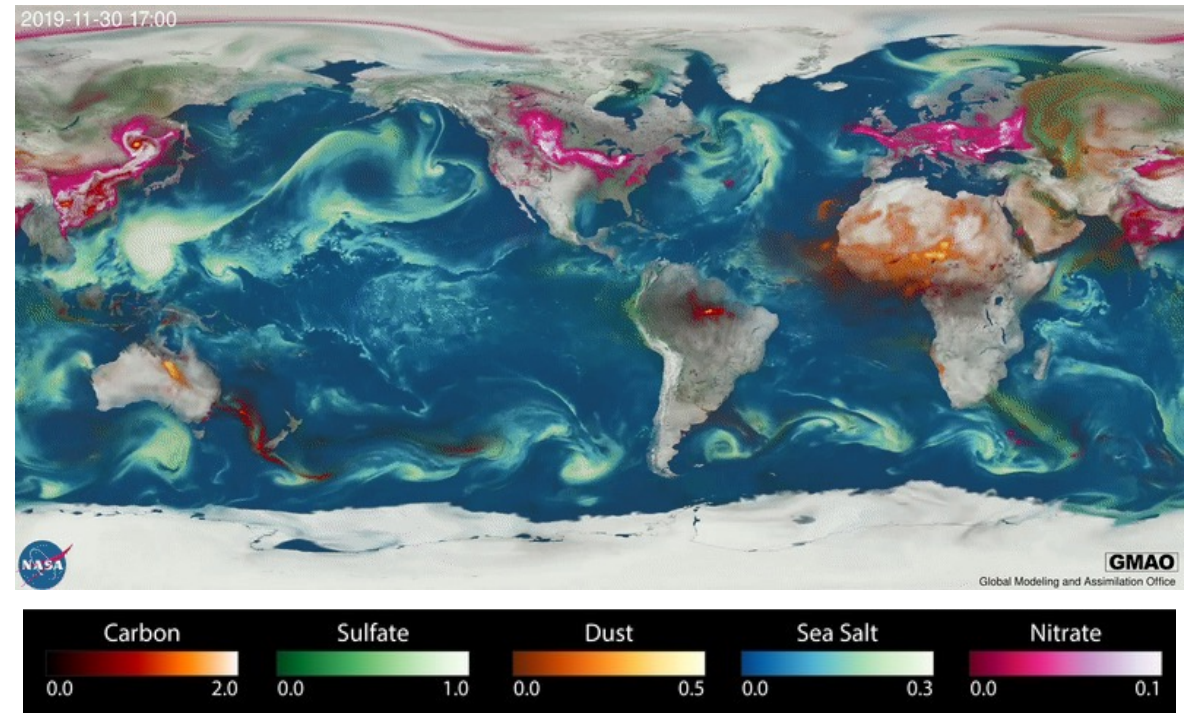


Global Air Quality Forecasts

NASA Goddard Earth Observing System (GEOS) Model

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

- Developed and maintained by the Global Modeling and Assimilation Office (GMAO)
- GEOS provides NRT weather and composition forecasts
- ~25 km Spatial Resolution
 - Weather forecast (Forward Processing (FP)) includes aerosols and CO
 - Composition forecast (CF) includes trace gases like ozone and NO₂, as well as PM_{2.5}



AOD (550 nm)

<https://svs.gsfc.nasa.gov/31100>



Available GEOS Forecasts

<https://portal.nccs.nasa.gov/datashare/gmao/>

Forward Processing (FP)	Composition Forecast (CF)
10-day forecast of meteorology and aerosols	1 day Analysis + 5-day forecast of meteorology, aerosols, and trace gases
Data assimilation (including AOD)	No data assimilation
Initialized daily at 00Z and 12Z	Initialized daily at 12Z
~25 km spatial resolution	~25 km spatial resolution
QFED fire emissions	QFED fire emissions



GEOS-FP: Data Access and Aerosol Forecast Maps

<https://fluid.nccs.nasa.gov/weather/>

Datagrams

Aerosol Maps
(2D and 3D)

Download
the
forecast
output

The screenshot shows the NASA Global Modeling and Assimilation Office (GMAO) website. The header includes the NASA logo and the text "Global Modeling and Assimilation Office GMAO". Below the header is a navigation bar with links for "Weather", "Mission Support", "CF", "Reanalysis", and "Carbon". The main content area is titled "Weather Analyses and Forecasts" and features four panels: "Datagrams", "WxMaps", "Chem Maps", and "3D Chem Maps". The "Datagrams" panel displays a vertical cross-section plot of relative humidity and wind speed. The "WxMaps" panel shows a 3-hour accumulation forecast map for precipitation, SLP, and 1000-500mb thickness. The "Chem Maps" panel shows a 2D map of dust aerosol optical thickness. The "3D Chem Maps" panel shows a 3D visualization of aerosol distribution. A sidebar on the left contains "Navigation" and "Data Access" sections with various links.

Navigation

- » Datagrams
- » WxMaps
- » Chem Maps
- » 3D Chem Maps
- » Observing System Stats
- » Radiances Monitoring
- » Observation Impacts
- » WMS Viewer: GEOS Aerosols

Data Access

- » HTTPS
Assimilation | Forecast
- » OPeNDAP
Assimilation | Forecast
- » Data Download Tool
Assimilation | Forecast

Weather Analyses and Forecasts

Datagrams

WxMaps

Chem Maps

3D Chem Maps



GEOS-FP: Maps

Chem Maps

The screenshot shows the 'Atmospheric Composition (2D) Maps' interface. On the left, there are several configuration panels: 'FIELDS' with 'Aerosols' selected and 'OC Sfc Mass' chosen; 'CO' with various regional options; 'Other Gases' with 'NO3 Sfc Mass' and 'SO2 Col Mass' selected; 'REGIONS' set to 'North America'; 'FORECAST INITIAL TIME' set to '30Apr2021 00z'; and 'FORECAST LEAD HOUR' set to '000h 30Apr2021 00z'. The main map area displays a color-coded map of 'OC Surface Mass [$\mu\text{g}/\text{m}^3$]' over North America, with a color scale from 0.1 to 5. Below the map are 'ANIMATE' and 'DOWNLOAD MOVIE' buttons.

Select a variable

Select a map region

Select a forecast

Animate the map

3D Chem Maps

The screenshot shows the 'Atmospheric Composition (3D) Maps' interface. The left configuration panels are similar to the 2D view but include 'LEVELS' set to '850' hPa. The main map area displays a 3D visualization of '850 hPa PM2.5 [$\mu\text{g}/\text{m}^3$]' over North America, with a color scale from 2 to 408.6. Below the map are 'ANIMATE' and 'DOWNLOAD MOVIE' buttons.

Select a variable

Select a region

Select a pressure level

Animate the map

Select a forecast

<https://fluid.nccs.nasa.gov/wxmaps/chem2d/>

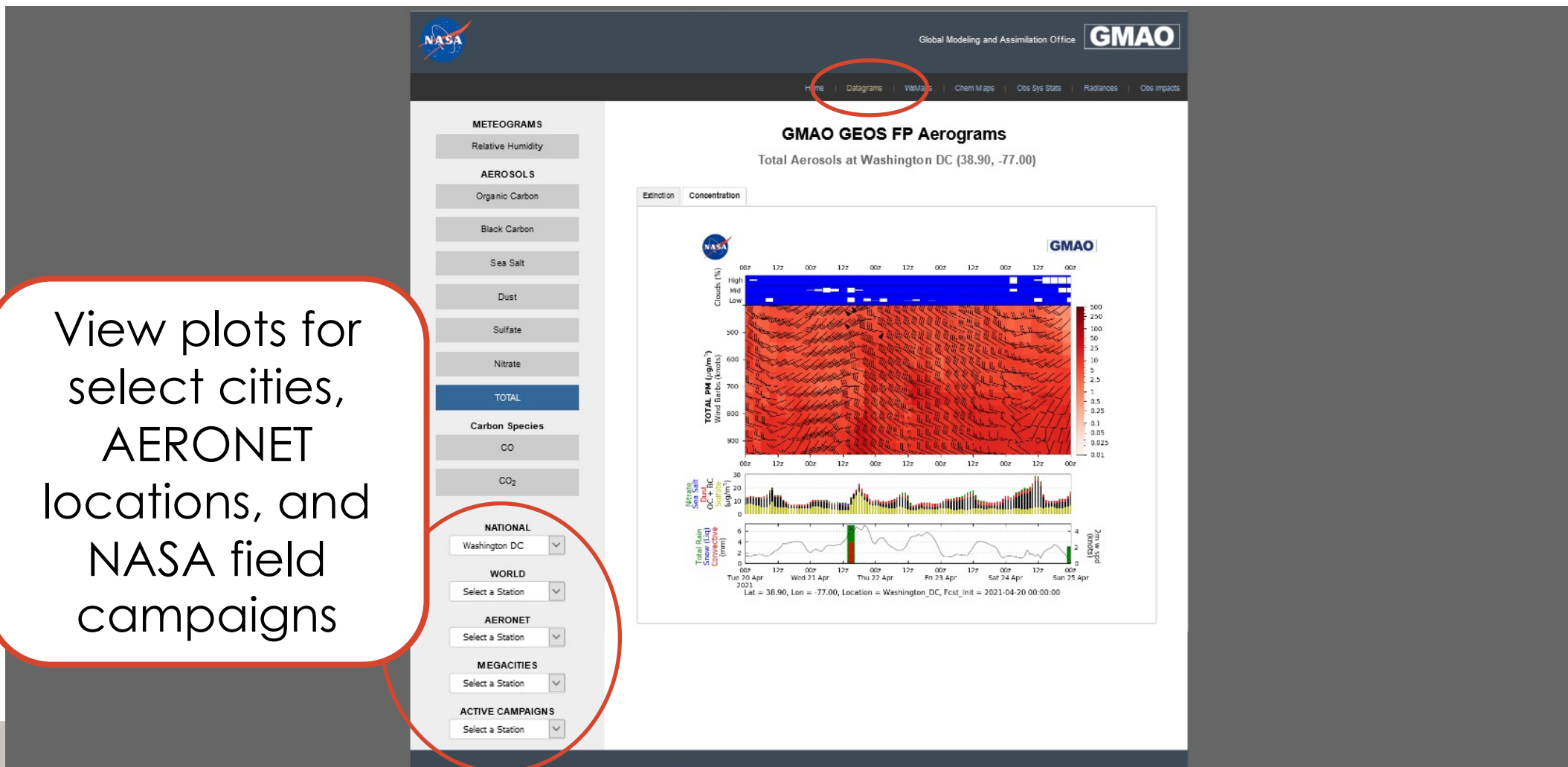
<https://fluid.nccs.nasa.gov/wxmaps/chem3d/>



GEOS-FP: Datagrams

Datagrams show the vertical profile of the aerosol forecast at a given location, along with information about aerosol types.

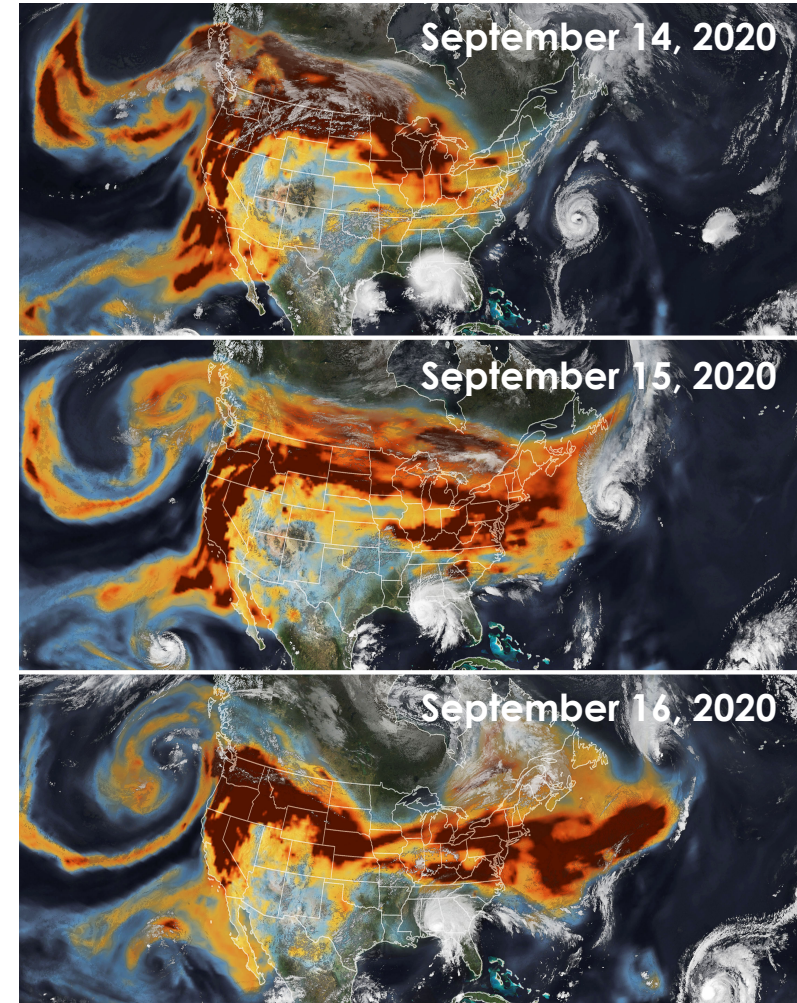
View plots for select cities, AERONET locations, and NASA field campaigns



GEOS-FP + QFED Emissions: CA Fires, Sep 2020

- QFED emissions in the NASA GEOS-FP forecast show the transport of smoke from fires along the west coast of the United States across the country and beyond.

<https://earthobservatory.nasa.gov/images/147293/a-meeting-of-smoke-and-storms>



Black Carbon Column Mass Density (mg/m²)

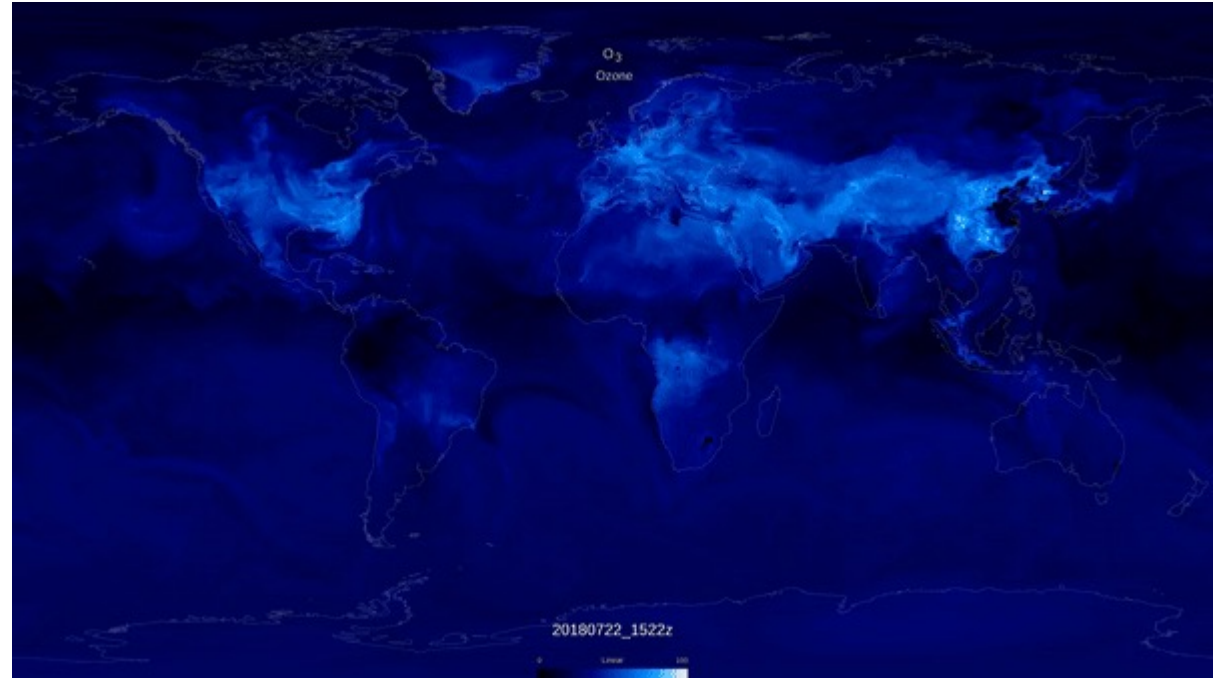
0 5 ≥10



NASA Composition Forecasts (GEOS-CF)

https://gmao.gsfc.nasa.gov/weather_prediction/GEOS-CF/

- The GEOS-Composition Forecast (CF) system forecasts trace gas and aerosol fields using constrained meteorology from the GEOS-FP system and the GEOS-Chem chemical mechanism.
- GEOS-Chem is a community-developed global 3-D model of atmospheric chemistry.
 - 250+ chemical species
 - 700+ chemical reactions
- One 5-day forecast per day
- O₃, NO₂, PM_{2.5} ...
- 15 min output for the surface
- Available since Jan 2018
- Uses QFED fire emissions



<https://svs.gsfc.nasa.gov/4754>



GEOS-CF

<https://fluid.nccs.nasa.gov/cf/>



NASA Global Modeling and Assimilation Office **GMAO**

Weather | Mission Support | CF | Reanalysis | Seasonal

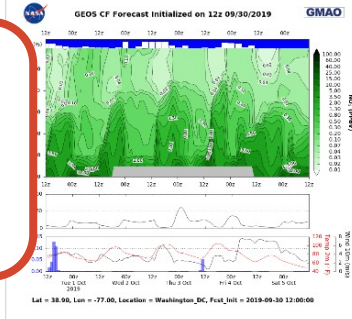
NASA Global Modeling and Assimilation Office **GMAO**

Home | Datagrams | Surface Concentrations | Total Column

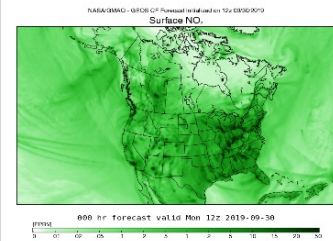
- Navigation
- » Datagrams
 - » Surface Concentrations
 - » Total Column

GMAO Composition Forecast Products

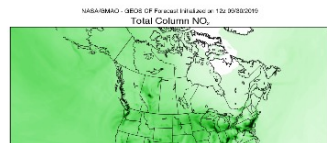
Datagrams



Surface Concentrations



Total Column



Datagrams
Surface Maps
Total Column Maps

FIELDS

Surface

O3	NO2
CO	SO2
PM2.5	

REGIONS

North America

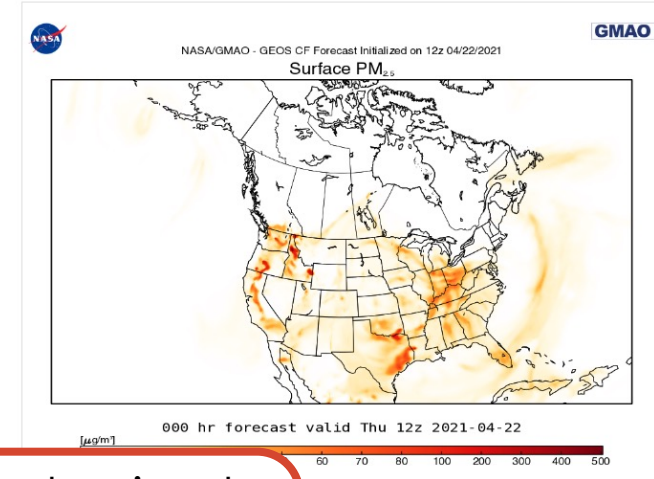
FORECAST INITIAL TIME

22Apr2021 12z

FORECAST LEAD HOUR

000h 22Apr2021 12z

Composition Forecast Maps



View and animate forecasts of surface O3, PM2.5, and other pollutants



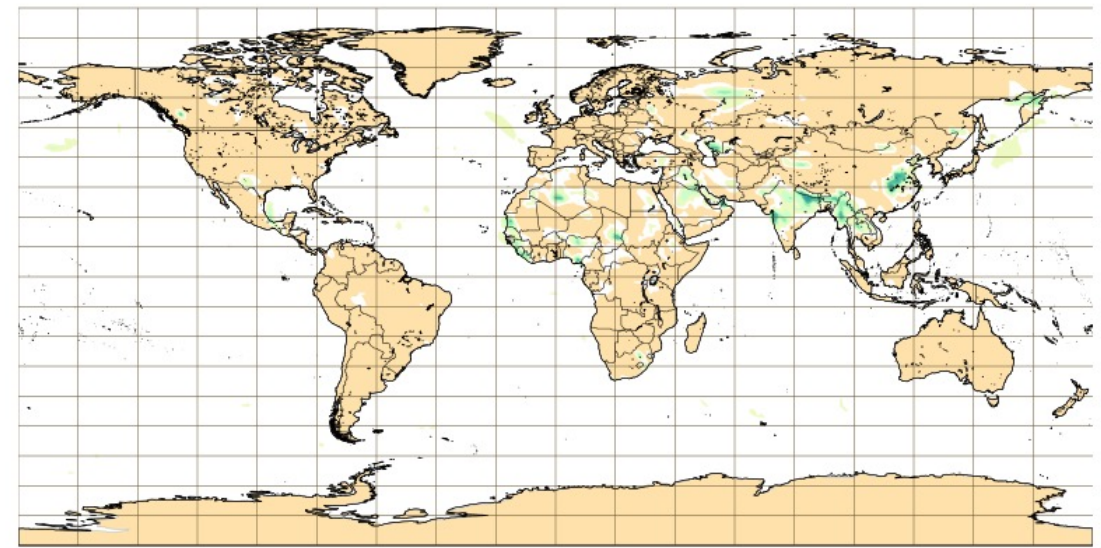
ECMWF Copernicus Atmosphere Monitoring Service (CAMS)

<https://atmosphere.copernicus.eu/>

- CAMS provides five-day global composition forecasts of aerosols and other pollutants
- Data assimilation (including AOD)
- Initialized daily at 00Z and 12Z
- ~40 km Spatial Resolution
 - ~10 km for Europe-only
- GFAS fire emissions
- 2012-Present

Base time: Wed 14... Area: Global Parameter: PM2.5

PM2.5 - fine particulate matter [ug / m3] (provided by CAMS)
Wednesday 14 Apr, 00 UTC T+3 Valid: Wednesday 14 Apr, 03 UTC



< > VT: Thu 15 Fri 16 Sat 17 Sun 18



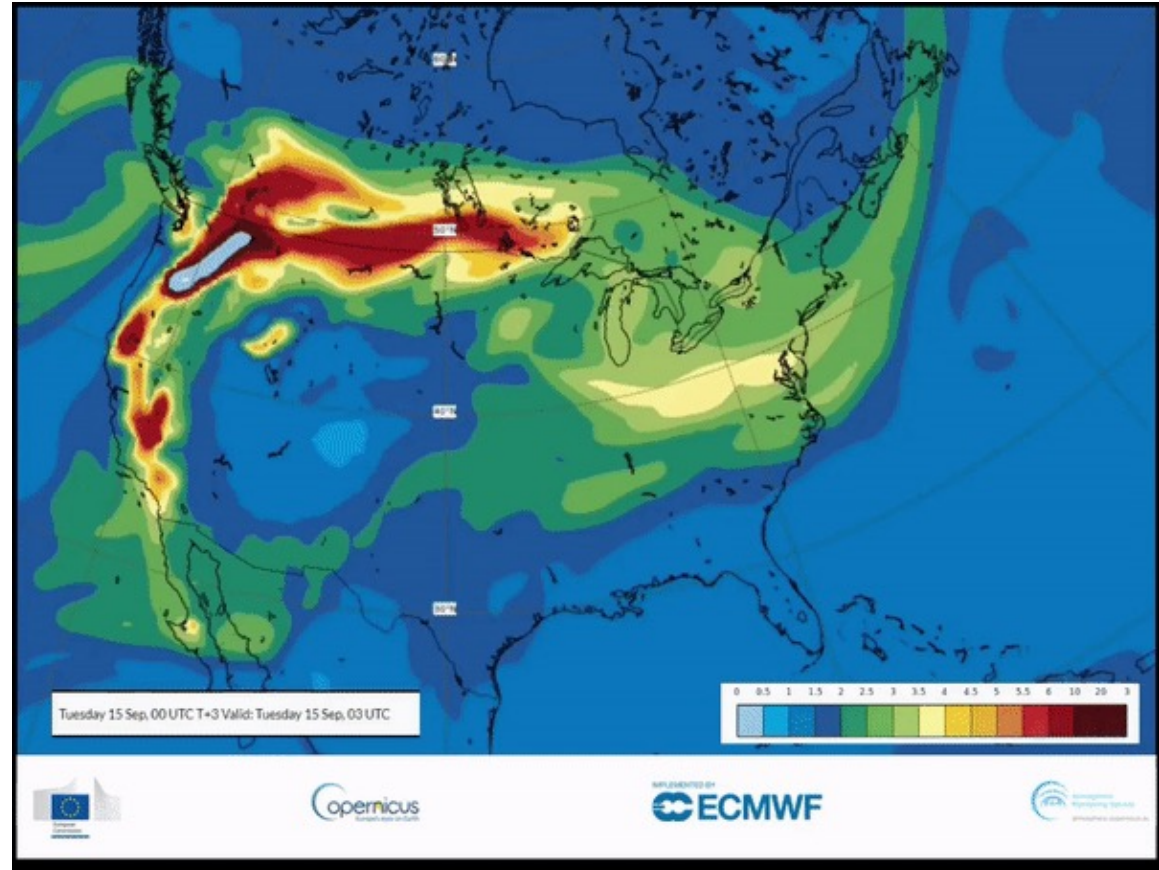
CAMS particulate matter forecasts

<https://atmosphere.copernicus.eu/charts/cams/>



CAMS Forecast + GFAS Emissions: CA Fires, Sep 2020

- GFAS emissions in the CAMS forecast show the transport of smoke from fires across the US and forecasted to reach Europe days later.



Total column of carbon monoxide [10^{18} molecules / cm^2]

Source: [Twitter](#)

NASA's Applied Remote Sensing Training Program





US Smoke Forecasts

NOAA Weather Models for Smoke Forecasts

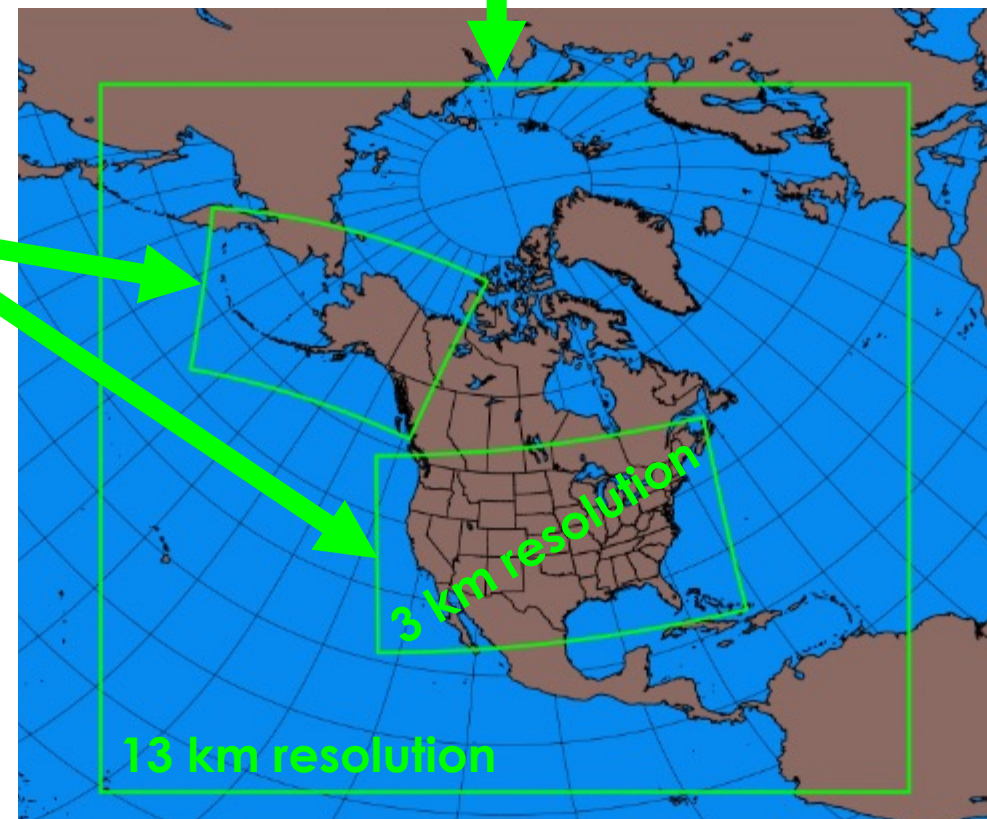
<https://rapidrefresh.noaa.gov/>

<https://rapidrefresh.noaa.gov/hrrr/>

- The NOAA Rapid Refresh (RAP) is a continental-scale hourly weather forecast and data assimilation system.
- The NOAA High-Resolution Rapid Refresh (HRRR) model, is also updated hourly and covers a smaller geographic domain.
 - Assimilates radar data every 15 min

High
Resolution
Rapid Refresh
(HRRR)

Rapid Refresh
(RAP)



https://rapidrefresh.noaa.gov/pdf/Alexander_AMS_NWP_2020.pdf



NOAA Smoke Forecasts

	RAP-Smoke	HRRR-Smoke
Spatial Resolution	13 km	3 km
Initialized	Hourly	Hourly
Domain	North America	CONUS/Alaska
Boundary Conditions	NOAA GFS	RAP-Smoke
Fire detections	MODIS + VIIRS	MODIS + VIIRS
Forecast	21 h	18 h
Website	https://rapidrefresh.noaa.gov/RAPsmoke/	https://rapidrefresh.noaa.gov/hrrr/HRRRsmoke/

RAP-Smoke and RAP-HRRR use fire emissions of PM_{2.5} calculated using a method very similar to QFED, but not tuned to AOD.

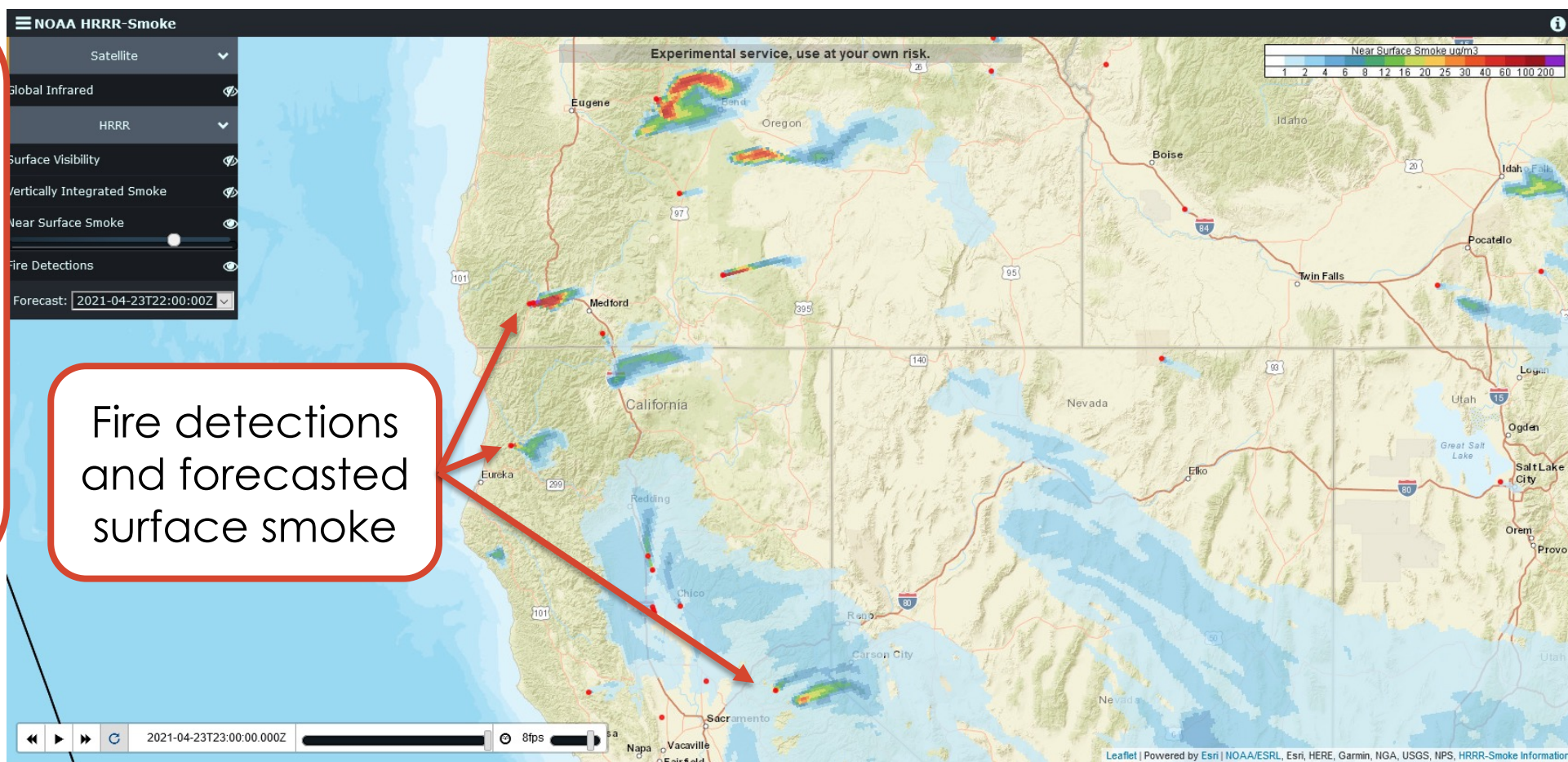


HRRR-Smoke Visualization

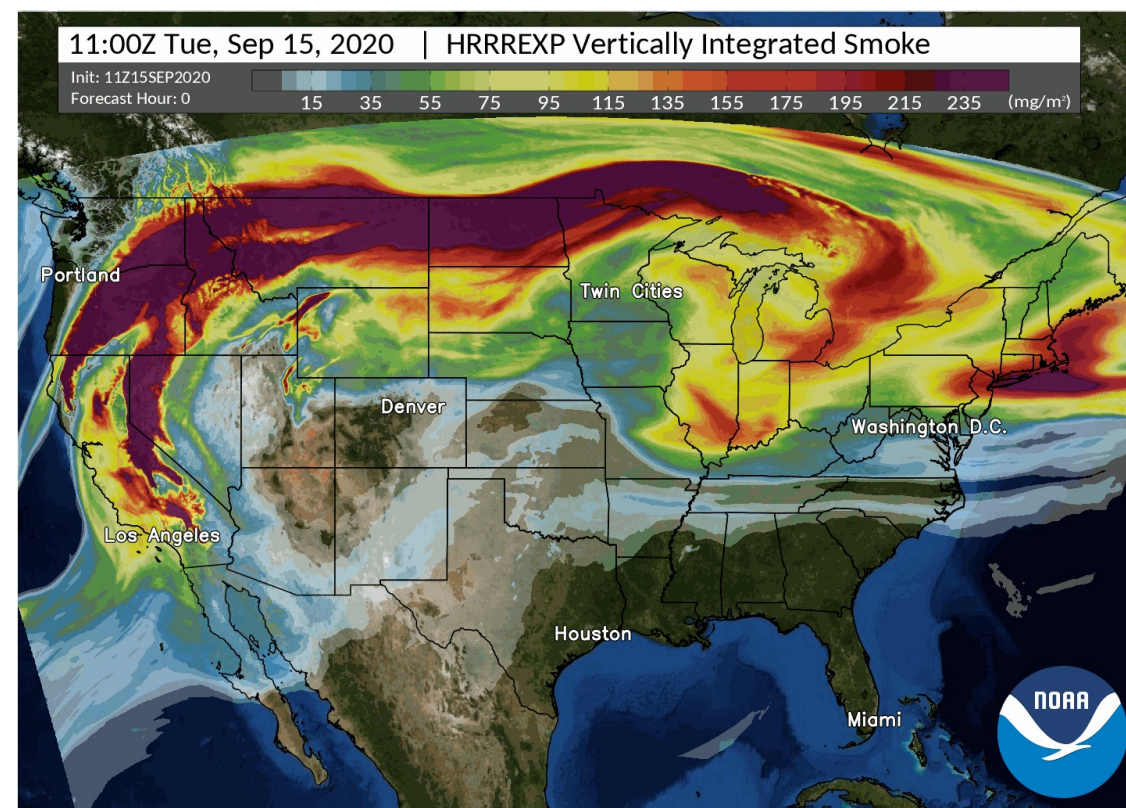
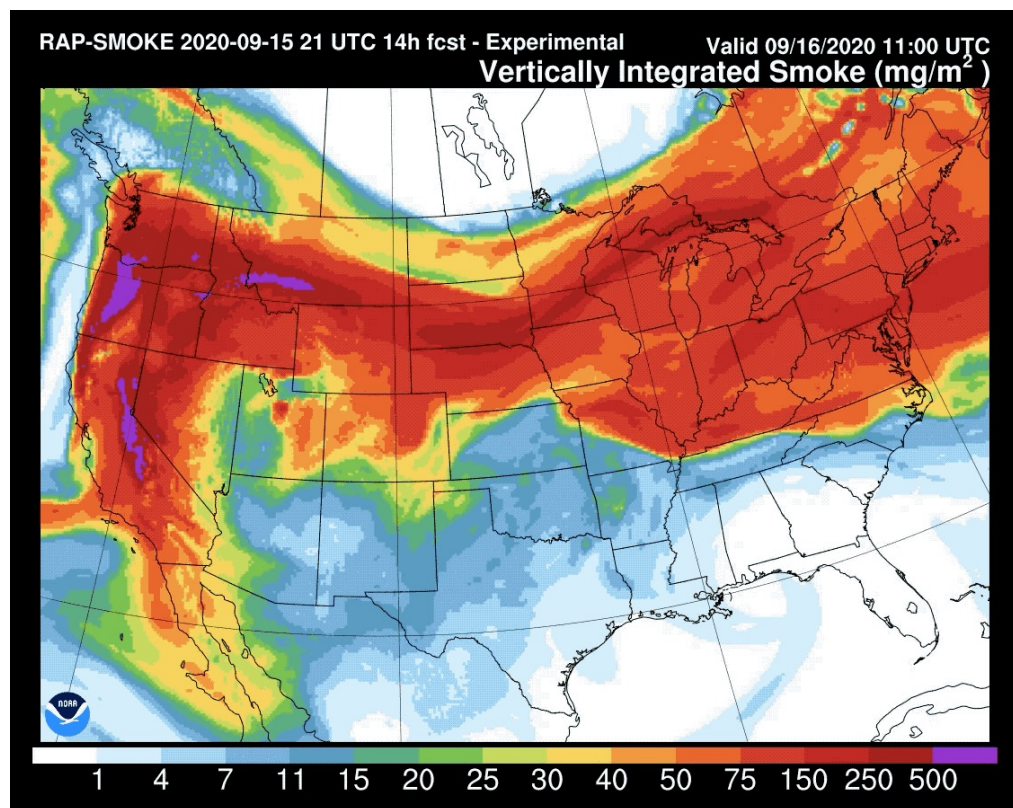
<https://hwp-viz.gsd.esrl.noaa.gov/smoke/index.html>

Layers include near-surface smoke ($\text{PM}_{2.5}$ [$\mu\text{g}/\text{m}^3$]), vertically integrated smoke (the amount of smoke in a 1 m^2 column of the atmosphere), and fire detections.

Fire detections and forecasted surface smoke



RAP-Smoke and HRRR-Smoke Forecasts – CA Fires, Sep 2020



RAP-Smoke and RAP-HRRR animations showing high resolution smoke transport. In the HRRR animation, individual plumes can be seen in Northern California.



Tool: U of Wisconsin RealEarth

<https://realearth.ssec.wisc.edu/>

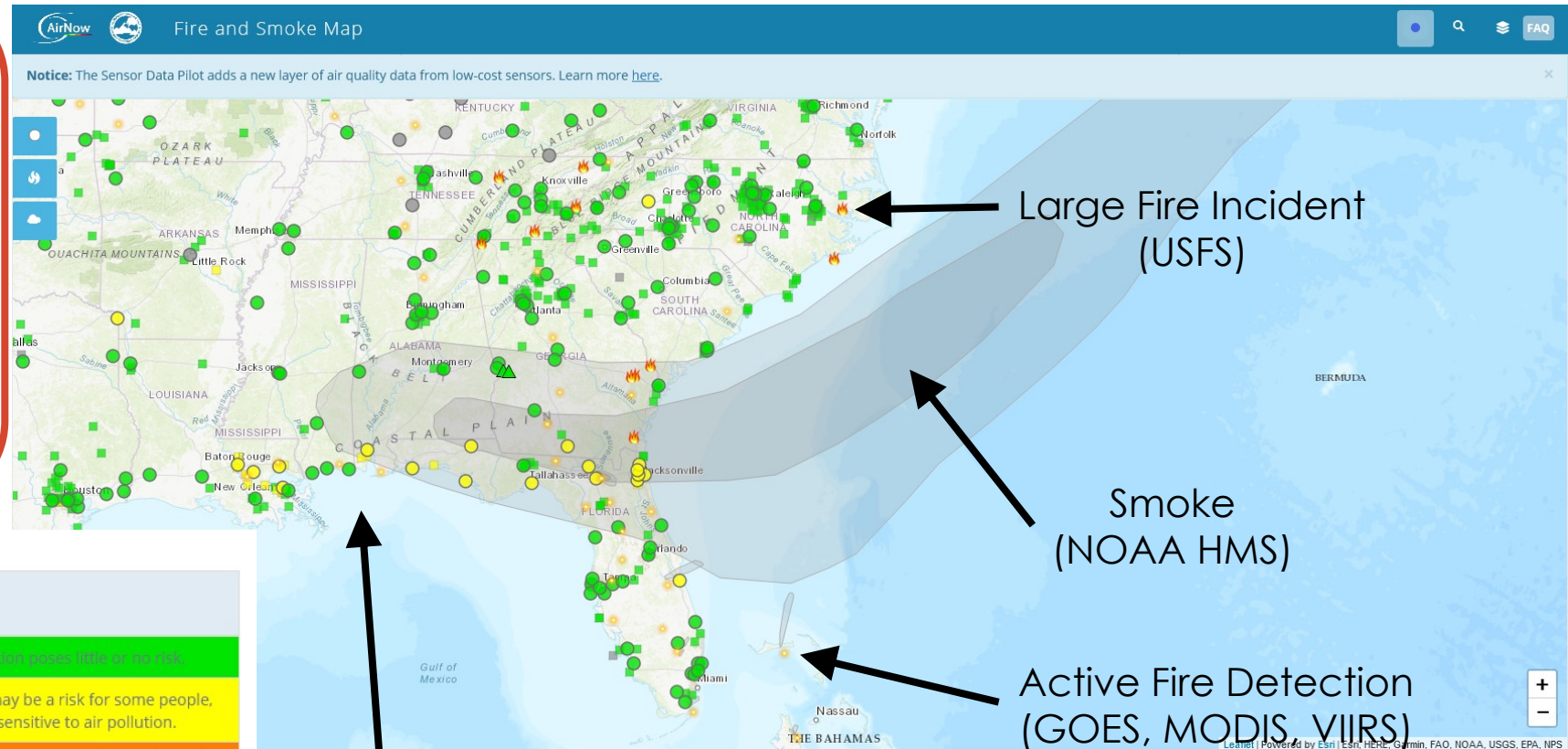
Real Earth is a visualization tool and app that animates fire-related model output, observations, and other Earth science data.



EPA AirNow Fire and Smoke Map

<https://fire.airnow.gov/>

Displays real-time information from ground monitors, fire detections and information, and smoke plume locations



AQI Basics for Ozone and Particle Pollution

Daily AQI Color	Levels of Concern	Values of Index	Description of Air Quality
Green	Good	0 to 50	Air quality is satisfactory, and air pollution poses little or no risk.
Yellow	Moderate	51 to 100	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.
Orange	Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is less likely to be affected.
Red	Unhealthy	151 to 200	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.
Purple	Very Unhealthy	201 to 300	Health alert: The risk of health effects is increased for everyone.
Maroon	Hazardous	301 and higher	Health warning of emergency conditions: everyone is more likely to be affected.

Air Quality Monitors – PM2.5
(Color = Air Quality Index)

- Permanent Monitor
- △ Temporary Monitor
- Low-Cost Sensor



Contacts

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- Training Webpage:
 - <https://appliedsciences.nasa.gov/join-mission/training/english/arset-satellite-observations-and-tools-fire-risk-detection-and>
- ARSET Website:
 - <https://appliedsciences.nasa.gov/what-we-do/capacity-building/arset>

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Homework and Certificate

- Three homework assignments:
 - Answers must be submitted via Google Form, accessed from the ARSET [website](#).
 - Due date for all homework: 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





Thank You!

