

Hourly RAVE Emissions for Air Quality Forecast

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Science Team

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Wildfire Smoke Impacts Human Health

- Wildfires emit massive amounts of trace gases and aerosol emissions
- Smoke pollutants degrade downwind air quality
- Exposure to wildfire smoke causes health issues

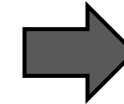
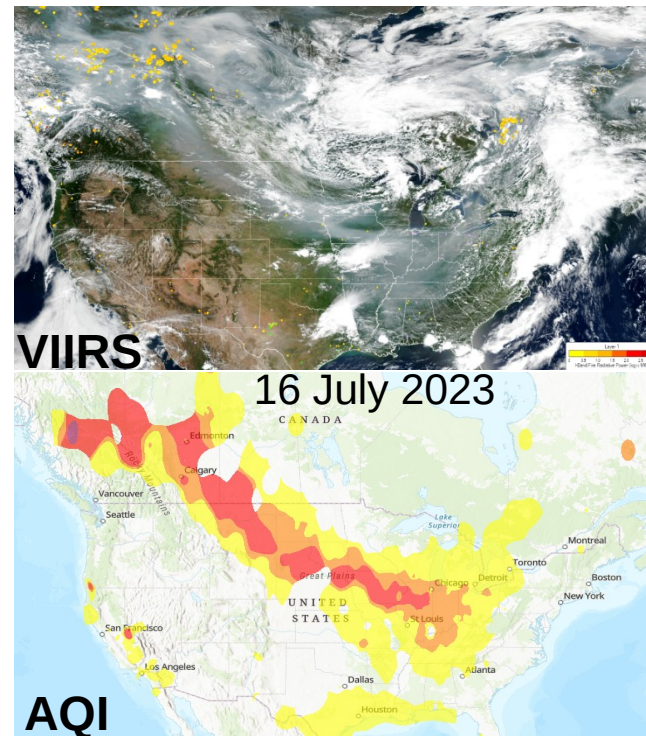
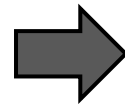
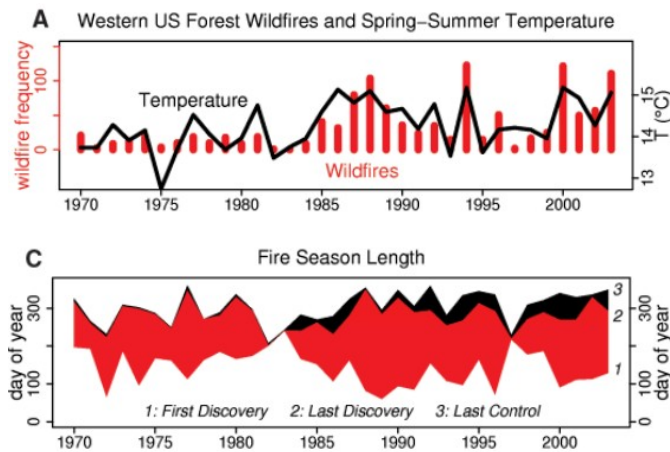


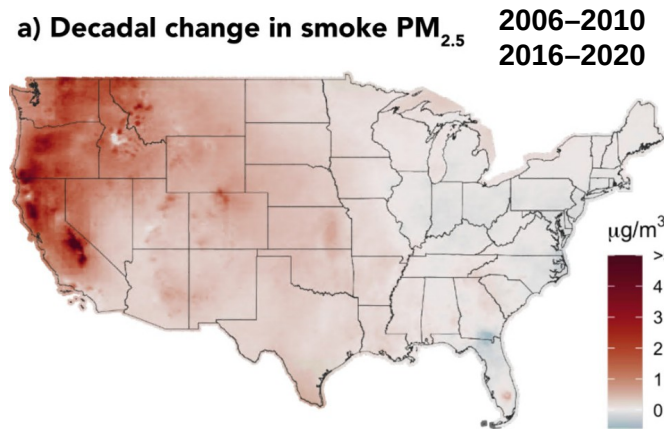
Image credit: the New York Times

Increasing Fire Activities in the United States

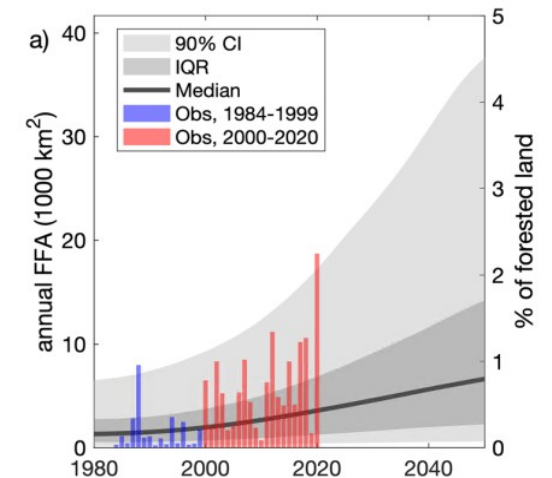
- Fire activity has increased in the past few decades
 - *fire area, fire season length, and frequency*
- Smoke contributions to $PM_{2.5}$ has increased since 2016
- Fire activity is projected to increase in the next few decades



Westerling et al. 2006



Childs et al. 2022



Abatzoglou et al. 2021

Fire Emissions for Air Quality Forecasting

- **Fire emissions are essential inputs for air quality models**
 - hourly fire emissions (for aerosol species)
 - hourly fire intensity (FRP) for modeling plume injection height

Inventory	Approach	Resolution	Parameters	Forecast Applications
GFED5	Conventional	0.25° monthly	<ul style="list-style-type: none"> • MODIS burned area and MODIS/VIIRS fire detections; modeled fuel 	
FINN2.5	Conventional	fire point daily	<ul style="list-style-type: none"> • MODIS/VIIRS fire detections; fuel compiled from published literature 	CMAQ
FLAMBE	Conventional	fire point daily	<ul style="list-style-type: none"> • MODIS & GEO satellites fire detections 	NAAPS
GFAS1.4	FRP-based	0.1° daily/hourly	<ul style="list-style-type: none"> • MODIS FRP 	ECMWF CAMS
FEER1.0	FRP-based	0.1° daily	<ul style="list-style-type: none"> • MODIS FRP 	
QFED2.5	FRP-based	0.1° & 0.25° daily	<ul style="list-style-type: none"> • MODIS FRP 	NASA GEOS-5
GBBEPx4/5	FRP-based	0.1° & 0.25° & FV3 daily	<ul style="list-style-type: none"> • VIIRS FRP 	NWS global aerosol models
RAVE1.2/2.0	FRP-based	3km & 13km, hourly	<ul style="list-style-type: none"> • ABI and VIIRS FRP 	NOAA EMC AQM/CMAQ NOAA RRFS

Fire Emissions for Air Quality Forecasting

- **Data gap - lack of hourly fire emissions**

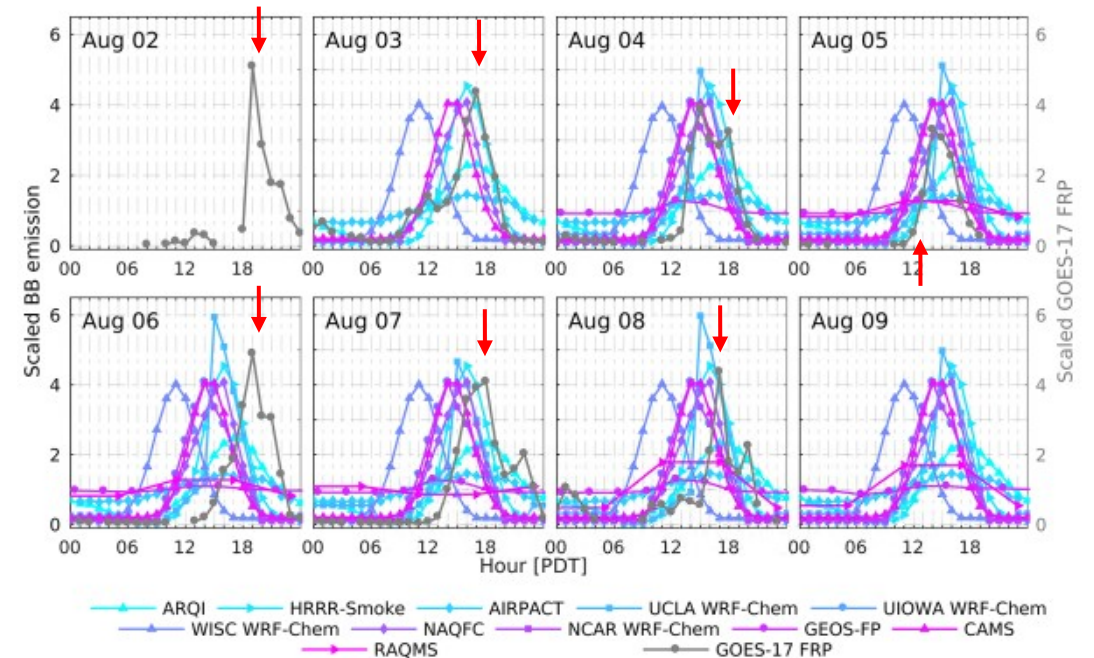
- Two common strategies

1. persistent emissions
2. redistribute daily emissions using a shape-fixed climatology

- **Challenges**

- Misrepresent diurnal patterns of fire emissions.
- Result in underprediction or overprediction

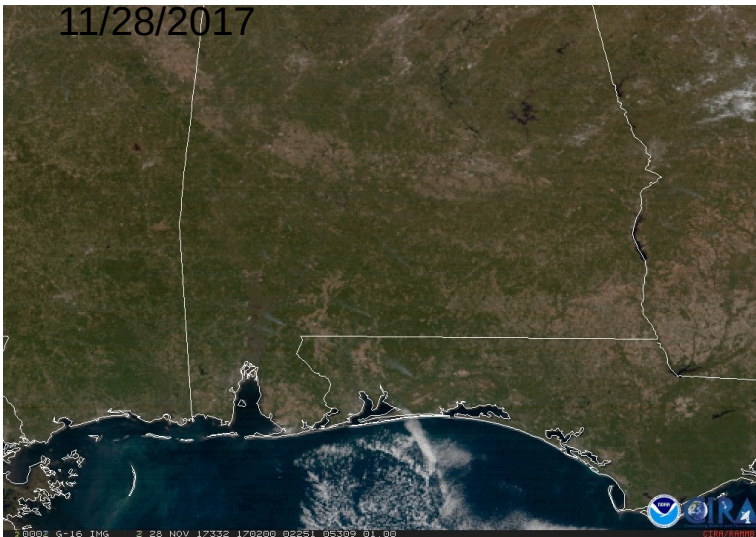
Williams Flat Fire 2019



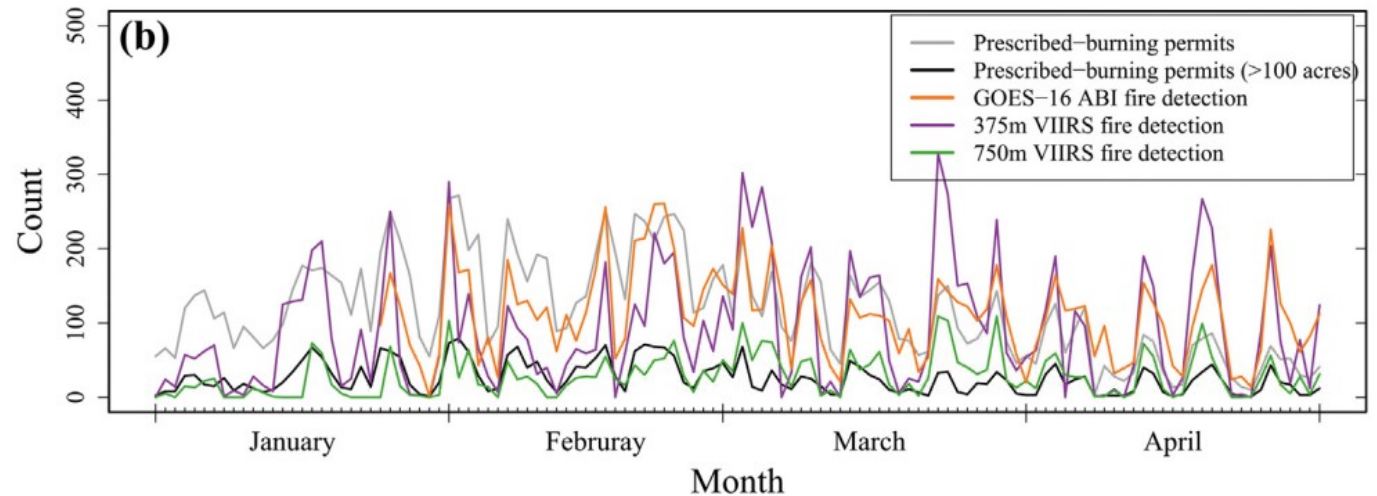
ABI and VIIRS Sensors Provide New Opportunities

Sensor	Footprint Size	Frequency	Detection Capability
ABI	2 km (nadir)	<ul style="list-style-type: none"> CONUS: 5 min Full-disk: 10 min 	detect fires \geq 34 MW
VIIRS	0.375 km	<ul style="list-style-type: none"> twice daily 	detect fires \geq 1 MW

GOES-16 ABI, Southeast US,
11/28/2017



Prescribed burn permits and satellite detections during Jan - Apr 2018 in Florida

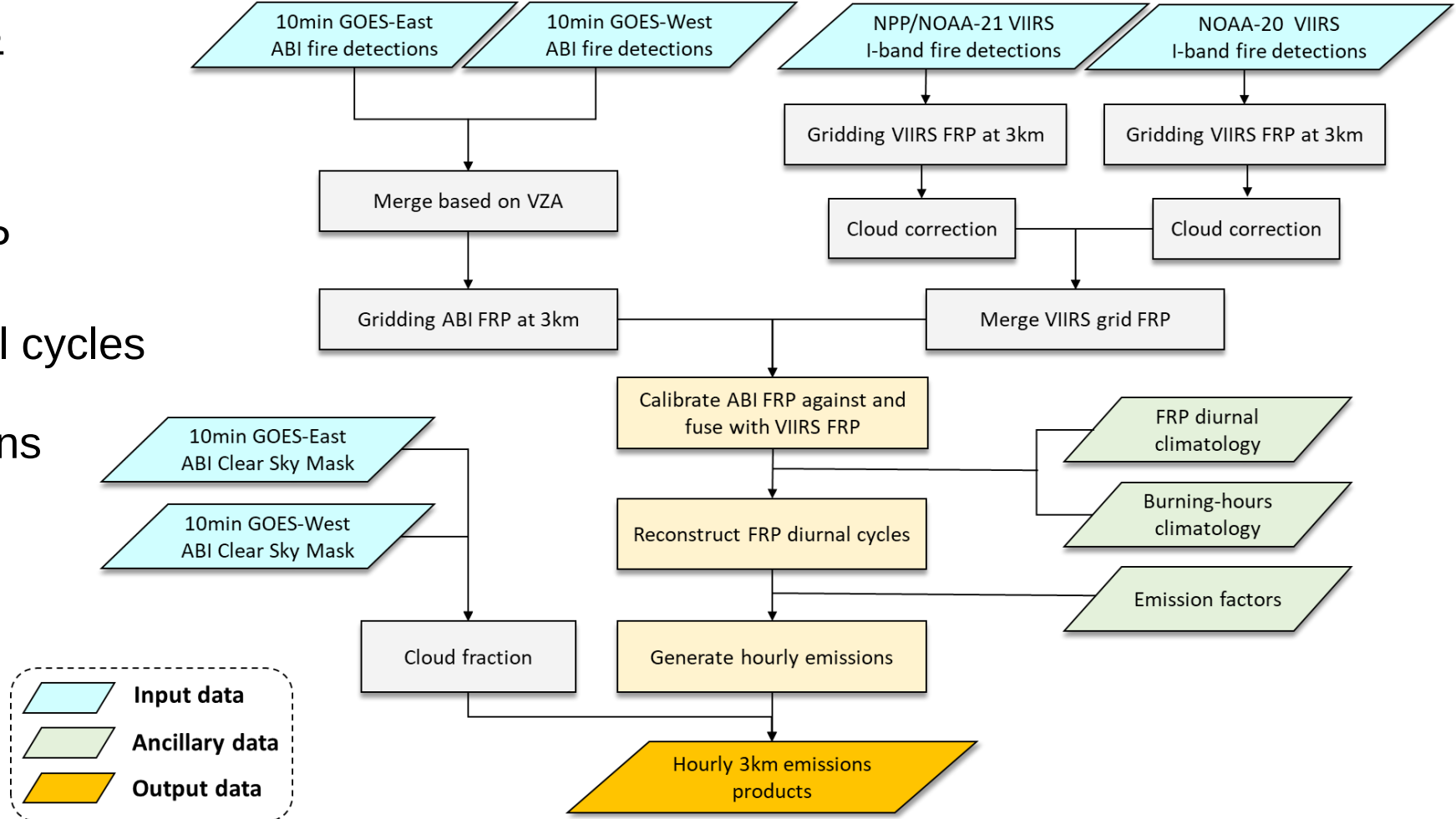


Li et al. 2020

RAVE Algorithm

Processing steps

- ① Grid FRP at 3km
- ② Fusing ABI & VIIRS FRP
- ③ Reconstruct FRP diurnal cycles
- ④ Estimate hourly emissions

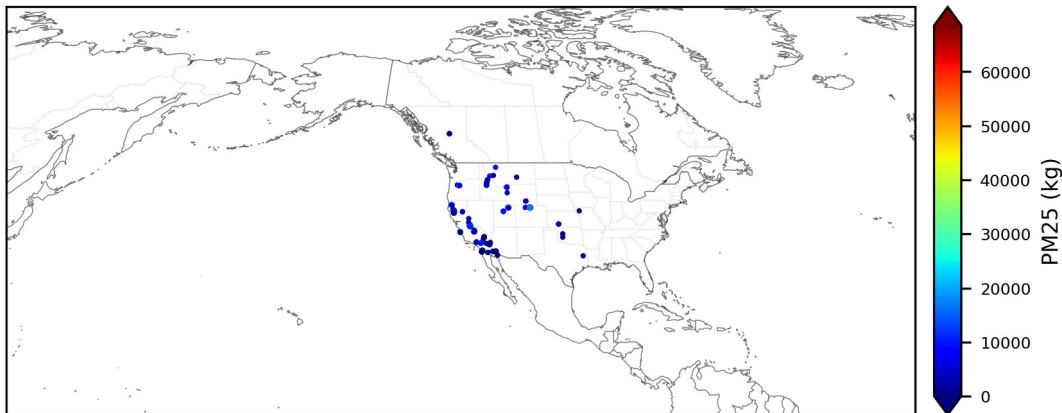


RAVE Product (3km & 13km)

- Hourly estimates

- Emission mass for 11 chemical species (CO₂, CO, PM_{2.5}, BC, OC, NO_x, CH₄, NH₃, SO₂, TPM, and VOCs)
- Scaled emission mass for aerosol species
- FRP (Mean & SD) and FRE
- FRP prediction flag
- Cloud fraction
- QA

PM_{2.5} Emissions (2020-09-07T00:00:00Z)



Name	Long Name	Type
RAVE-HrlyEmiss-3km_v2r0_blend_s202207052300000_e202207...	RAVE_HrlyEmiss_3km	Local File
area	cell area	Geo2D
BC	BC Biomass Emissions	Geo2D
BC_scaled	Scaled BC Biomass Emi...	Geo2D
CH4	CH4 Biomass Emissions	Geo2D
CH4_scaled	Scaled CH4 Biomass E...	Geo2D
Cloud_Fraction	Cloud Fraction	Geo2D
CO	CO Biomass Emissions	Geo2D
CO2	CO2 Biomass Emissions	Geo2D
CO2_scaled	Scaled CO2 Biomass E...	Geo2D
CO_scaled	Scaled CO Biomass Em...	Geo2D
FRE	Fire Radiative Energy	Geo2D
FRP_MEAN	Mean Fire Radiative P...	Geo2D
FRP_SD	Standard Deviation of ...	Geo2D
grid_lat	latitude	Geo2D
grid_latt	latitude	Geo2D
grid_lon	longitude	Geo2D
grid_lont	longitude	Geo2D
grid_x	cell corner longitude	1D
grid_xt	T-cell longitude	1D
grid_y	cell corner latitude	1D
grid_yt	T-cell latitude	1D
land_cover	land cover type	Geo2D
Metadata	maximum emission ma...	-
NH3	NH3 Biomass Emissions	Geo2D
NH3_scaled	Scaled NH3 Biomass E...	Geo2D
NOx	NOx Biomass Emissions	Geo2D
NOx_scaled	Scaled NOx Biomass E...	Geo2D
OC	OC Biomass Emissions	Geo2D
OC_scaled	Scaled OC Biomass Em...	Geo2D
PM25	PM2.5 Biomass Emissions	Geo2D

File

"RAVE-HrlyEmiss-3km_v2r0_blend_s202207052300000_e20220705"

File type: Hierarchical Data Format, version 5

```
netcdf file:/D:/program/RAVE/RAVE_v2/v2_for_NOAA/checkIs...
dimensions:
  grid_x = 6241;
  grid_y = 2611;
  time = 1;
  grid_xt = 6240;
  grid_yt = 2610;
variables:
  float grid_x(grid_x=6241);
    :long_name = "cell corner longitude";
    :units = "1";
    :axis = "X";
    :valid_range = 1.0f, 6241.0f; // float

  float grid_y(grid_y=2611);
    :long_name = "cell corner latitude";
    :units = "1";
    :axis = "Y";
    :valid_range = 1.0f, 2611.0f; // float

  short time(time=1);
    :long_name = "time";
    :units = "hours since 2022-07-05 23:00:00";
    :calendar = "gregorian";
    :axis = "T";
    :time_increment = "010000";
    :begin_date = "20220705";
```


Upgrade from V1 to V2

Updates in V2

- Use NOAA's new VIIRS active fire products – NOAA-20 and NOAA-21 EFIRE
- Correct terrain-caused parallax errors in the ABI fire pixel locations
- Update the FRP time series fitting algorithm to avoid negative predictions and overpredictions

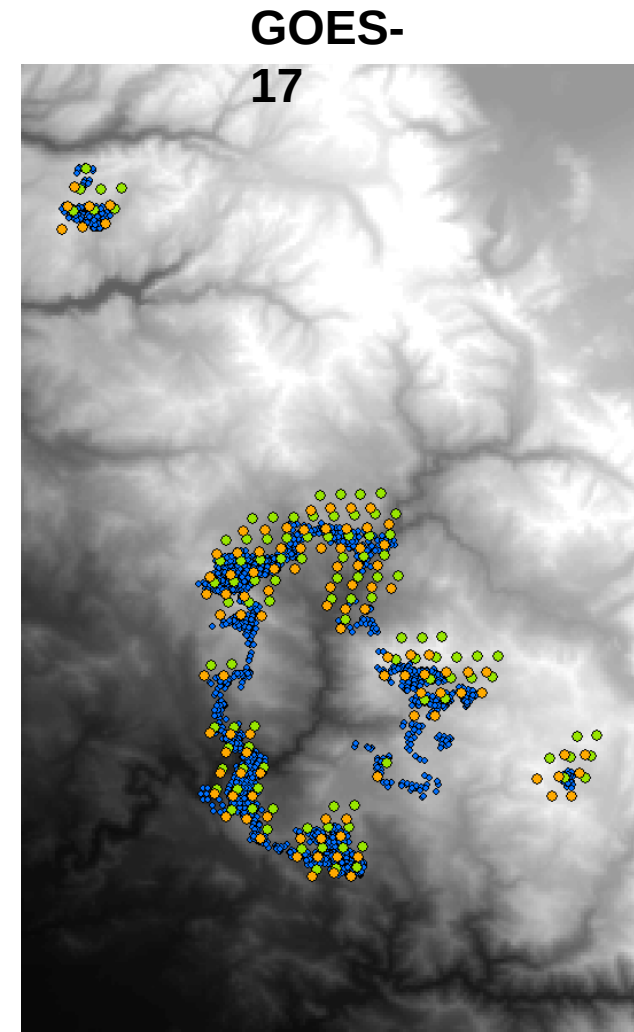
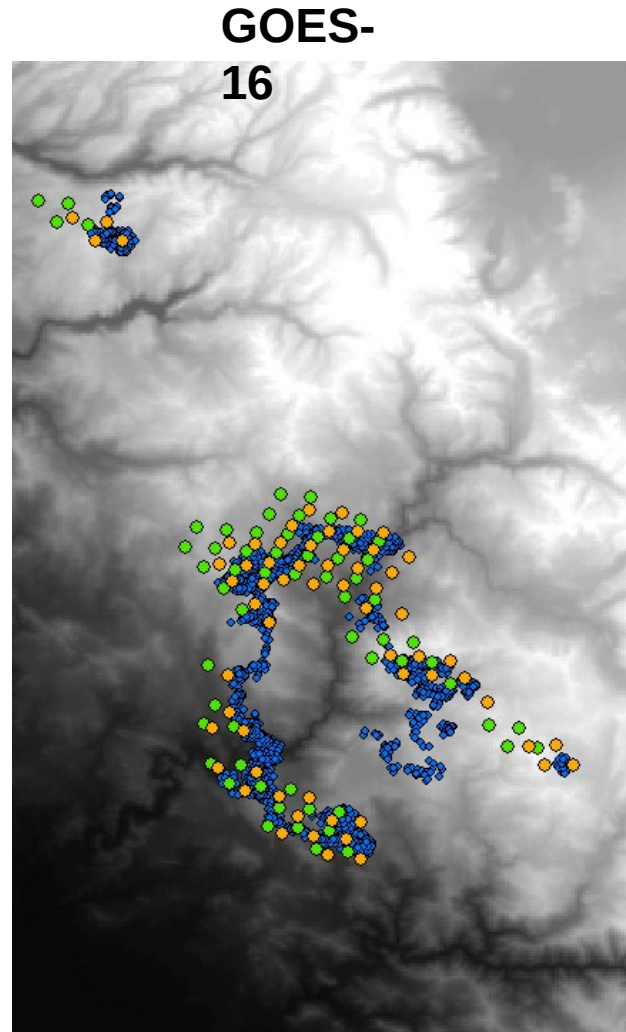
Parallax Correction - Examples (California)

Fire Pixels

VIIRS

ABI (before correction)

ABI (after correction)



DEM (Altitude) low  high

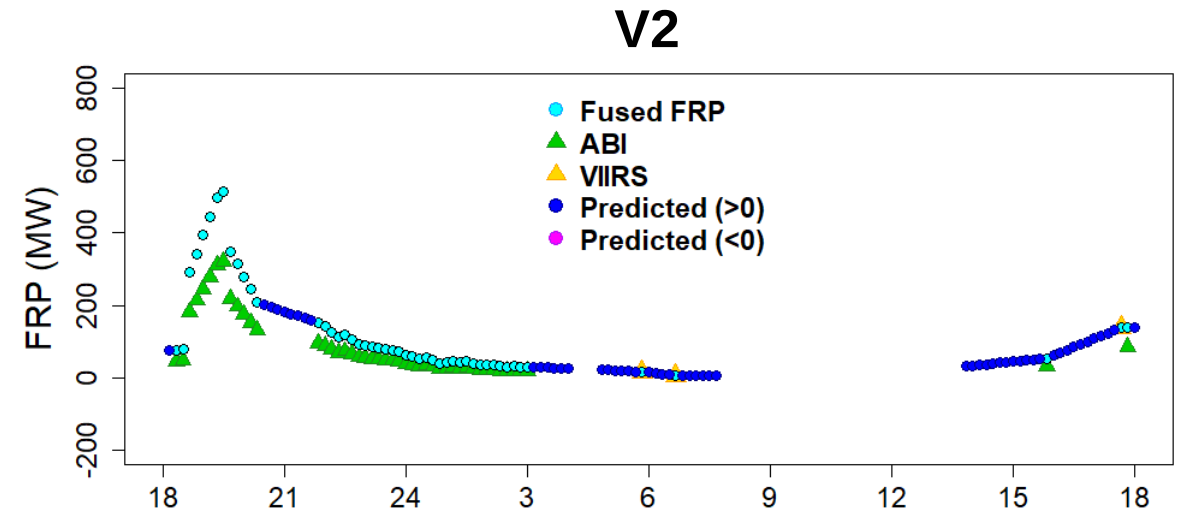
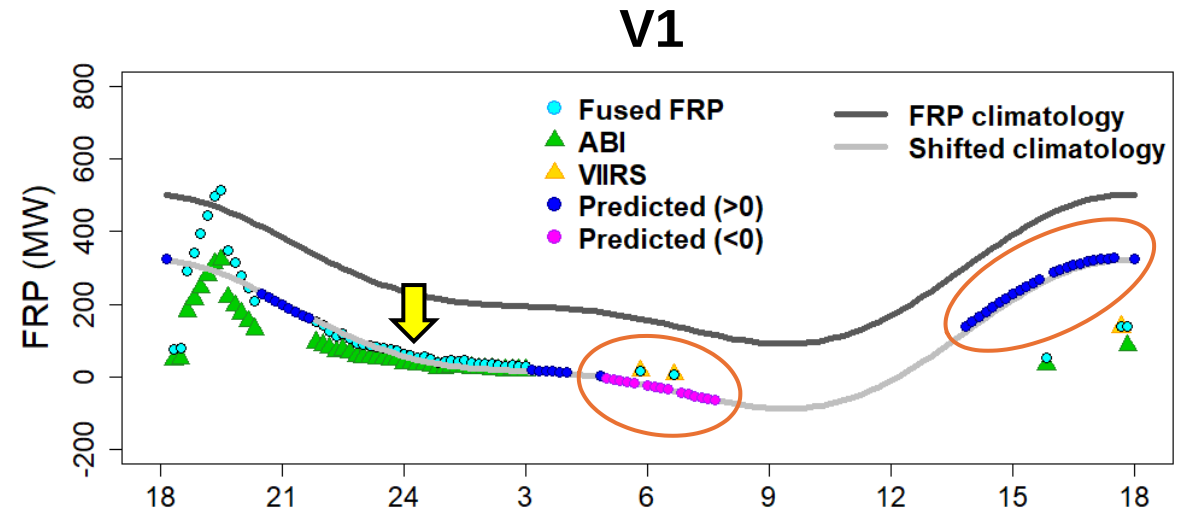
Update FRP Fitting Algorithm

- **V1 - Shifting FRP diurnal Climatology**

- Negative FRP predictions
- FRP overpredictions

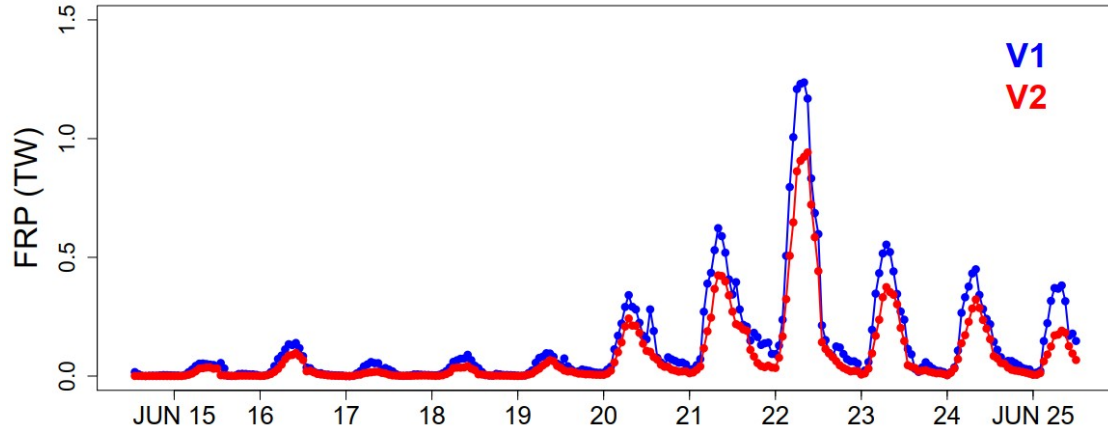
- **V2 - Fitting with normalized FRP diurnal climatology**

- Fix negative predictions and overpredictions

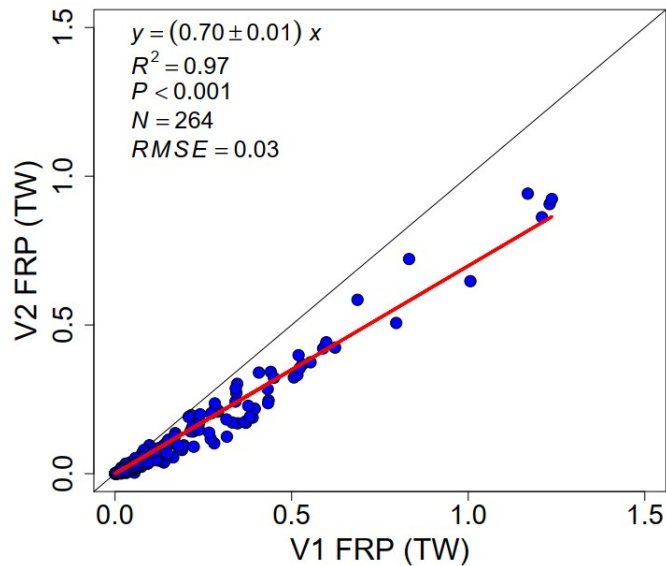
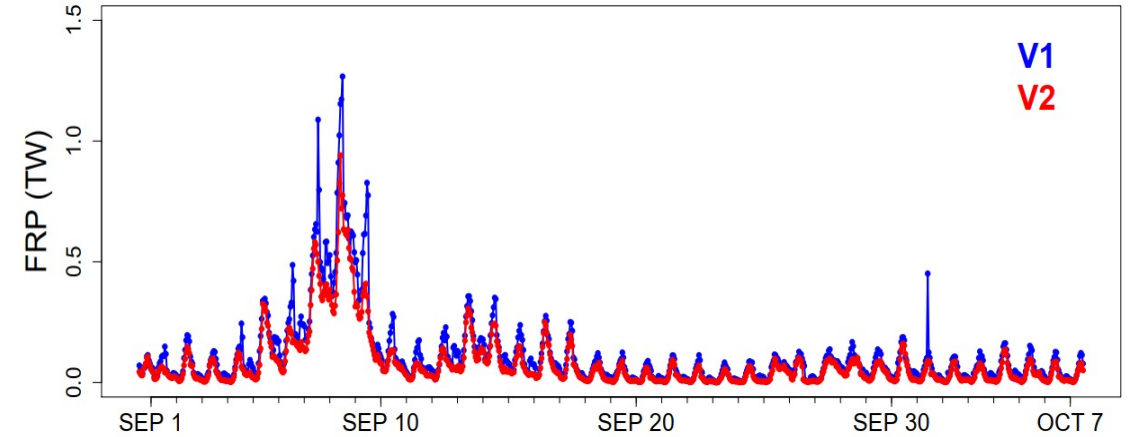


V2 vs. V1

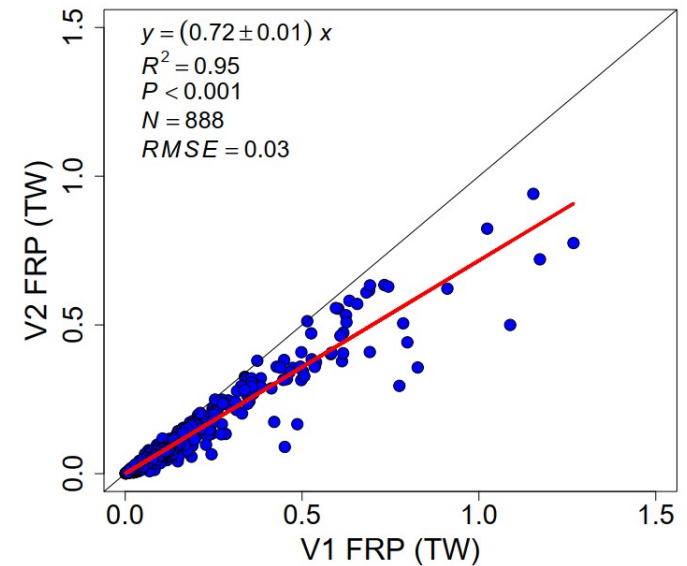
Quebec Fires 2023



Western US 2020

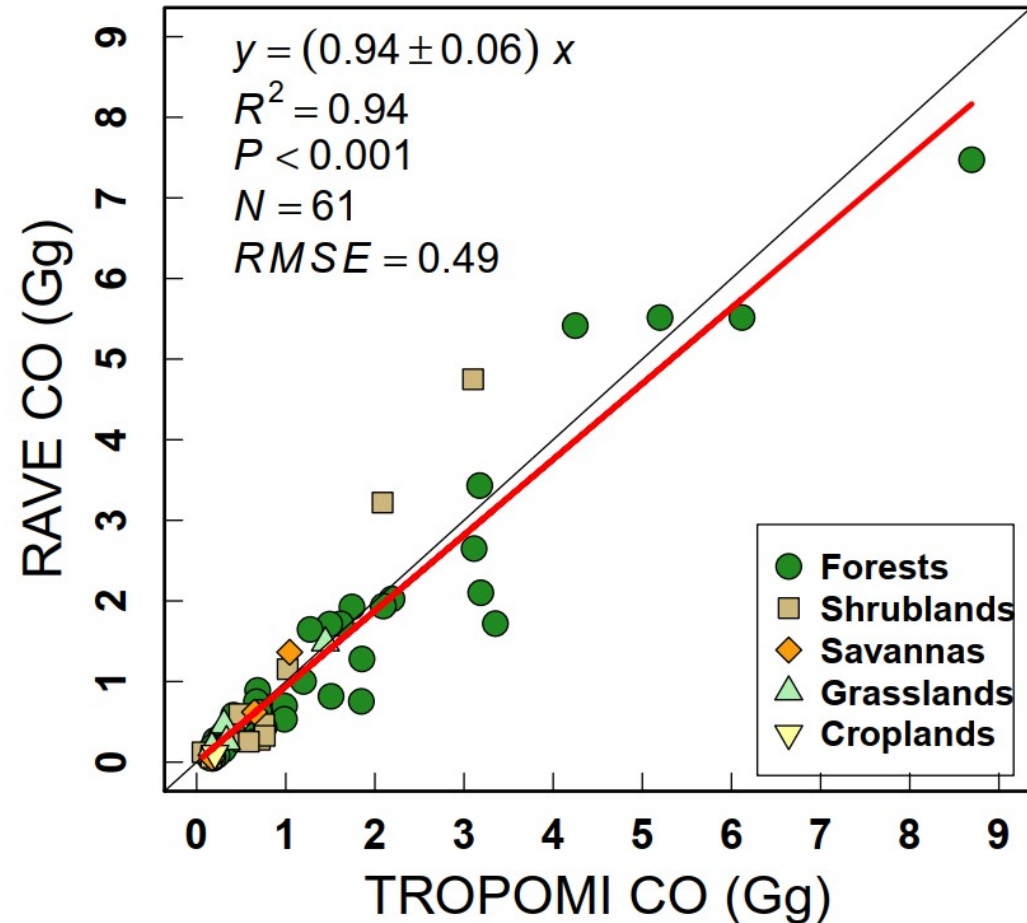
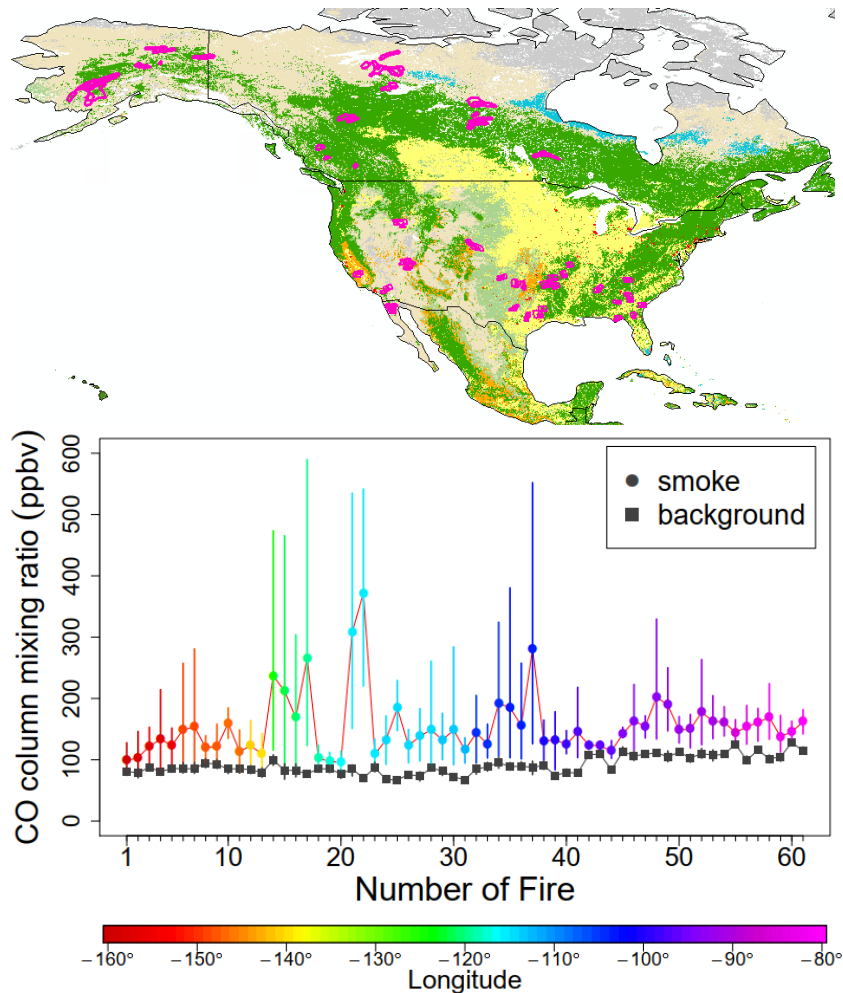


~30% difference

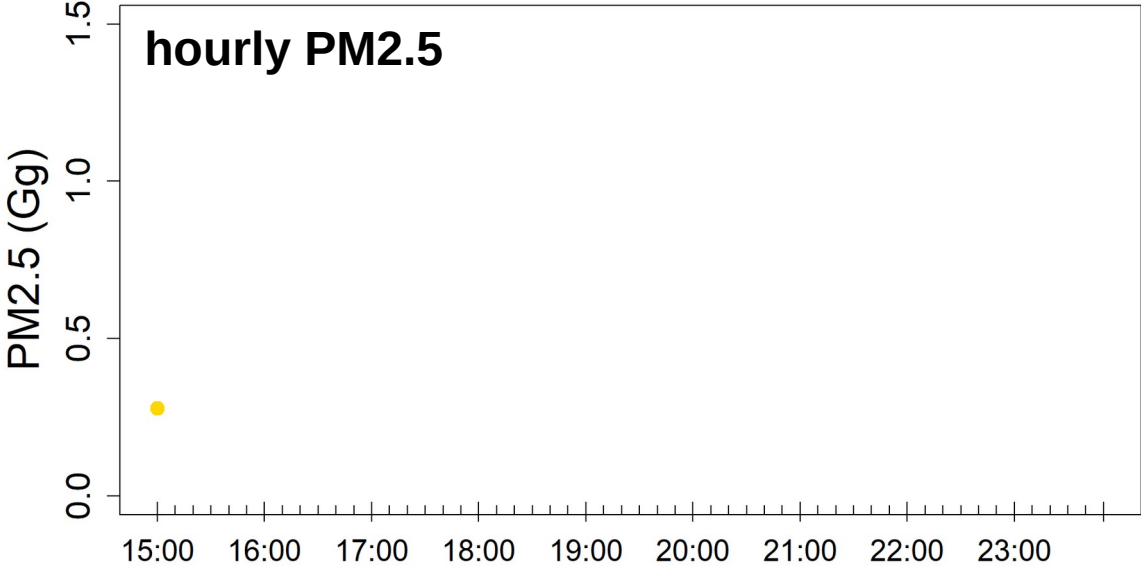
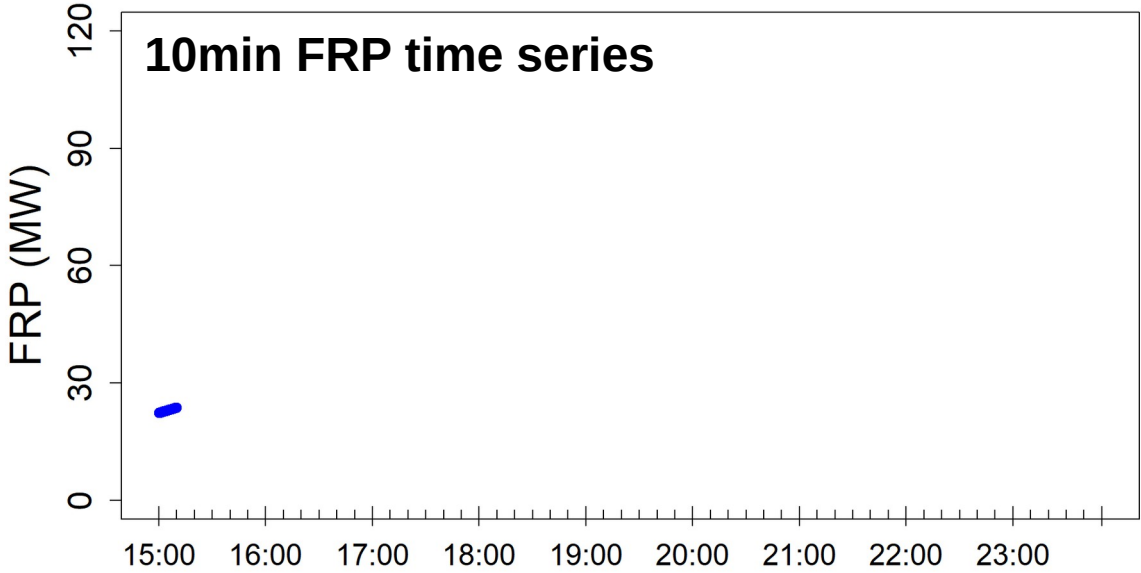
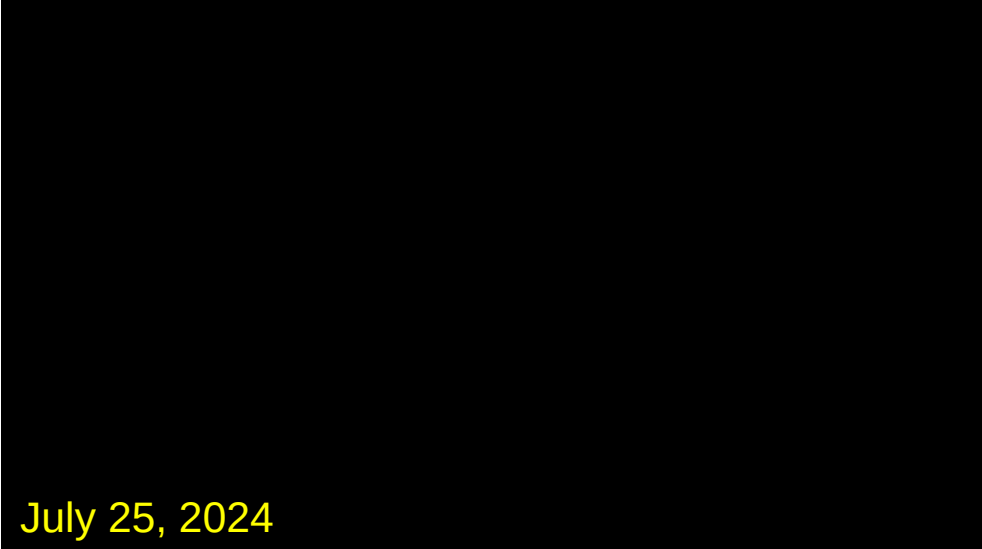


Evaluation of RAVE Emission with TROPOMI CO

- RAVE CO and TROPOMI CO are generally comparable over a total of 61 fresh smoke plumes



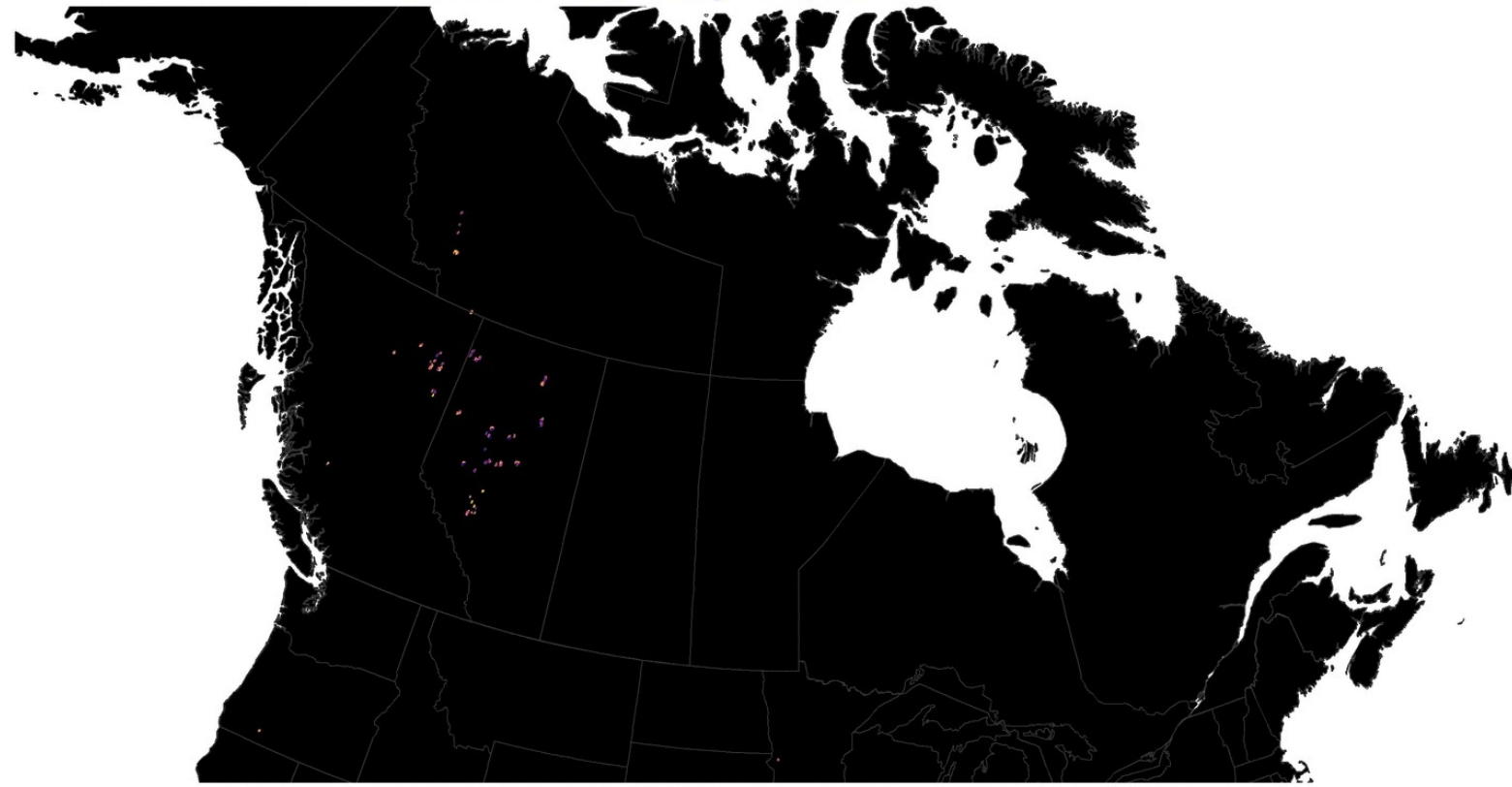
RAVE Examples: Park Fire, California 2024



RAVE Examples: Canadian Wildfires 2023

- Hourly RAVE PM2.5 emissions on 18 May 2023

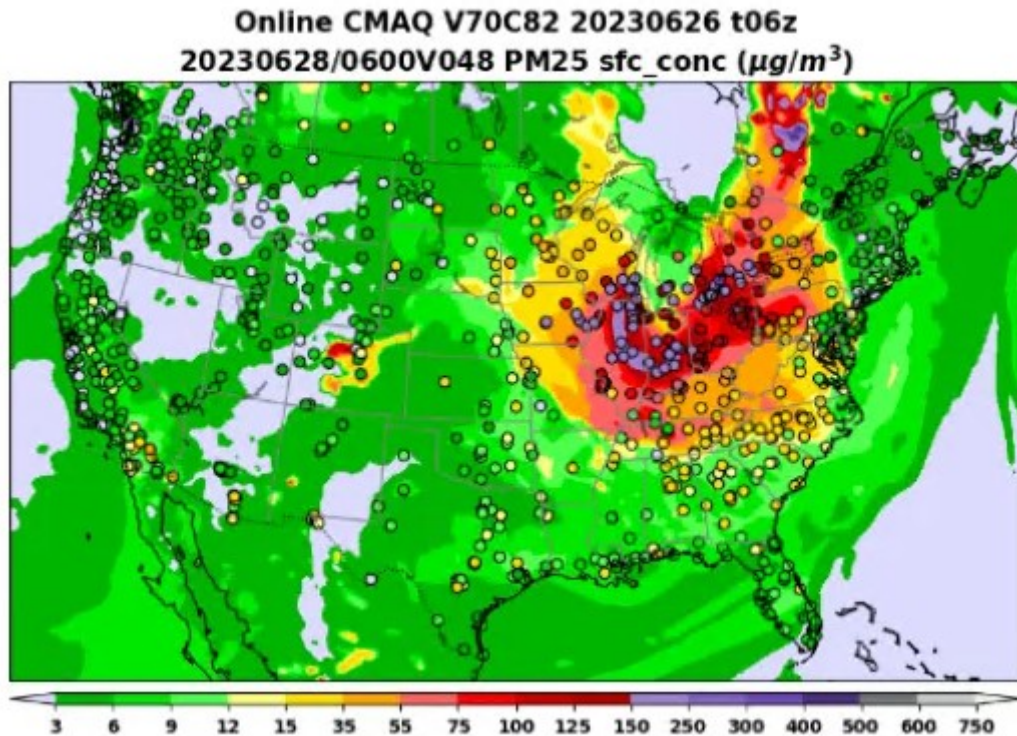
00:00 UTC, May 18, 2023



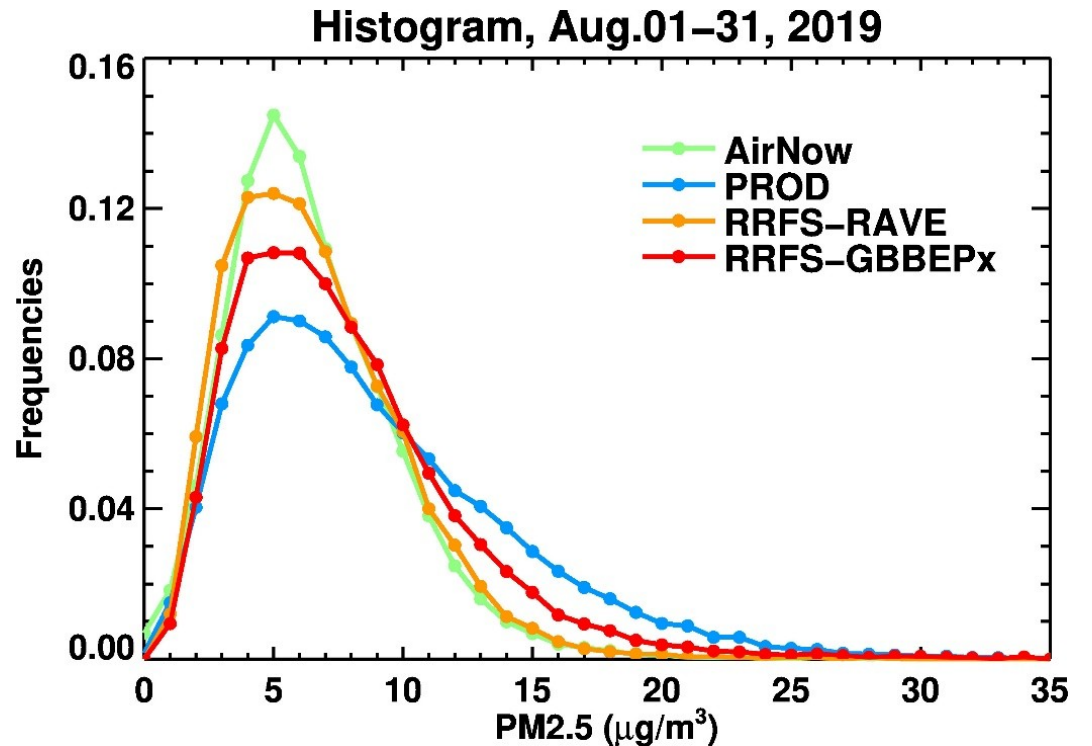
PM2.5 (kg) 10^0 10^1 10^2 10^3 10^4 10^5

RAVE Product Applications

- Testing RAVE product in NOAA's AQM-CMAQ and RRFS-CMAQ models



AQM-CMAQ



RRFS-CMAQ

Product Access

1. Near-real time product

- NOAA CLASS
- NOAA NESDIS/STAR
(shobha.kondragunta@noaa.gov)

2. Reprocessed data (2019-2023)

- RAVE Science Team

NOAA HOME WEATHER OCEANS & COASTS FISHERIES CHARTING SATELLITES CLIMATE RESEARCH CAREERS

NOAA COMPREHENSIVE LARGE ARRAY-DATA STEWARDSHIP SYSTEM (CLASS) NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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Enterprise Fire and Emissions Products (FIRES) » GO

Search - FIRES

Data Description

Enterprise Fire and Emissions Products (FIRES) - Enterprise Fire and Emissions Products (FIRES)

Temporal

(maximum range is 366 days)

Start Date (format: YYYY-MM-DD) 2024-09-03 [calendar icon]

Start Time (UTC) (format: HH:MM:SS) 00:00:00

End Date (format: YYYY-MM-DD) 2024-09-10 [calendar icon]

End Time (UTC) (format: HH:MM:SS) 23:59:59

Specify the range of the times for: Each Day Or The Entire Range Of Days

Advanced Search

Datatype

- All Species Emissions at 0.1 x 0.1 Degree Grid
- Global Daily Black Carbon (BC)
- Global Daily Carbon Monoxide (CO)
- Global Daily Carbon Dioxide (CO2)
- Global Daily Mean Fire Radiative Power (FRP)
- Global Hourly Emissions
- Global Daily Organic Carbon (OC)
- Global Daily Particulate Matter 2.5 microns (PM2.5)
- Global Daily Quality of Emissions
- Regional Daily Total Particulate Matter 2.5 microns (PM2.5)
- Global Daily Sulfur Dioxide (SO2)
- RAVE Product at 13km Resolution
- RAVE Product at 3km Resolution

Quick Search & Order to place large order without reviewing inventory or granule (file) metadata.

Search to place small order after reviewing inventory and granule metadata, including browse images when available.

Save Criteria Load Criteria Dataset Name View Reset

https://www.class.noaa.gov/saa/products/search?datatype_family=FIRES



Thank You!