

Connecting wildfire dynamics to air quality: a case study of the 2020 Northern California wildfire season.

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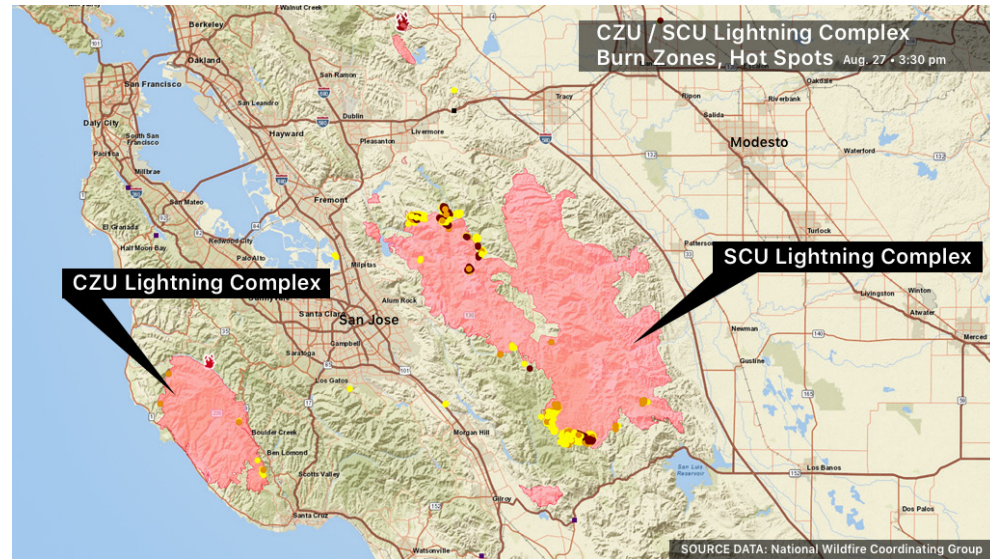
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*Presenting author (me)

March 22, 2022



The 2020 wildfire season in SF, some memories through photos.

- On August 16th 2020, an anomalous summertime **lightning storm** rolled through the SF Bay area.
- Lightning strikes ignited numerous fires which merged into wildfire complexes, creating a logistical nightmare for CalFire
- SCU Lightning Complex Fire burned **very close** to Livermore, with numerous evacuations in surrounding communities.



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A photo from CalFire, posted Aug. 31, 2020 by Henry W. Coe State Park, shows a dramatic view of control burns set on the west side of a dozer line. <https://morganhilltimes.com/scu-complex-fully-controlled-after-record-setting-wildfire-season/>

The 2020 wildfire season in SF, some memories through photos.

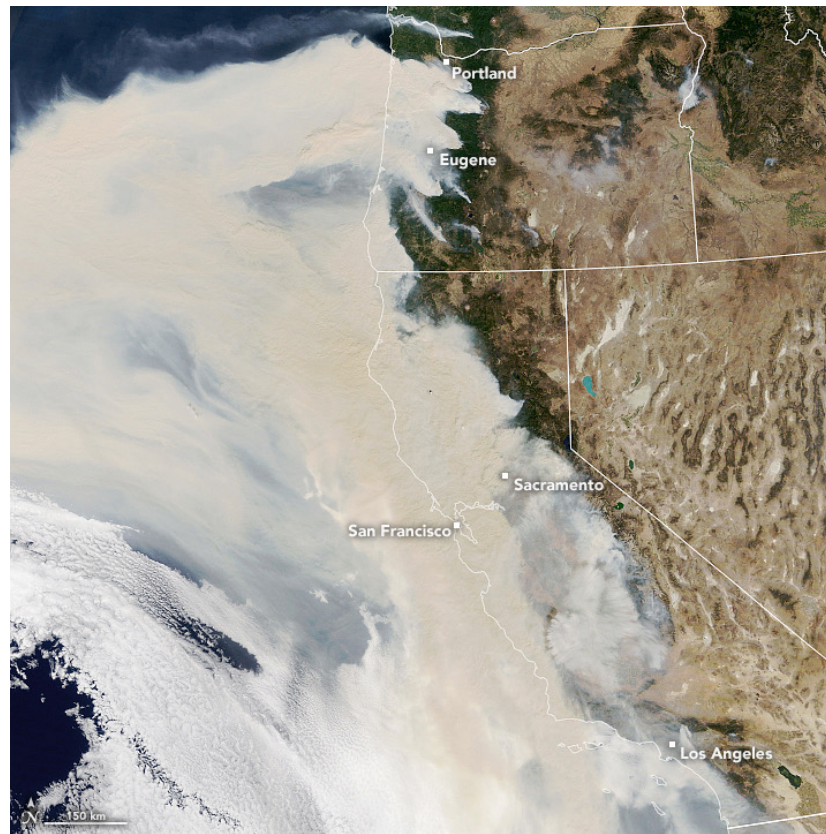
- On September 4th 2020, the Creek Fire started east of Fresno, cause is unknown
- The fire produced a pyrocumulonimbus cloud that reached 55,000 feet ASL, the highest ever observed smoke plume



On Friday September 4, 2020 the Creek Fire began. The fire is burning in the Big Creek area between Shaver Lake, Big Creek and Huntington Lake. The cause of the fire is under investigation. (Courtesy of Sierra National Forest) <https://www.kqed.org/news/11836899/creek-fire-traps-campers-in-the-sierra-national-forest>

The 2020 wildfire season in SF, some memories through photos.

- From September 8th – 15th, long range transport of smoke from fires near Portland, OR blanked most of the CA coast in a thick layer of smoke.



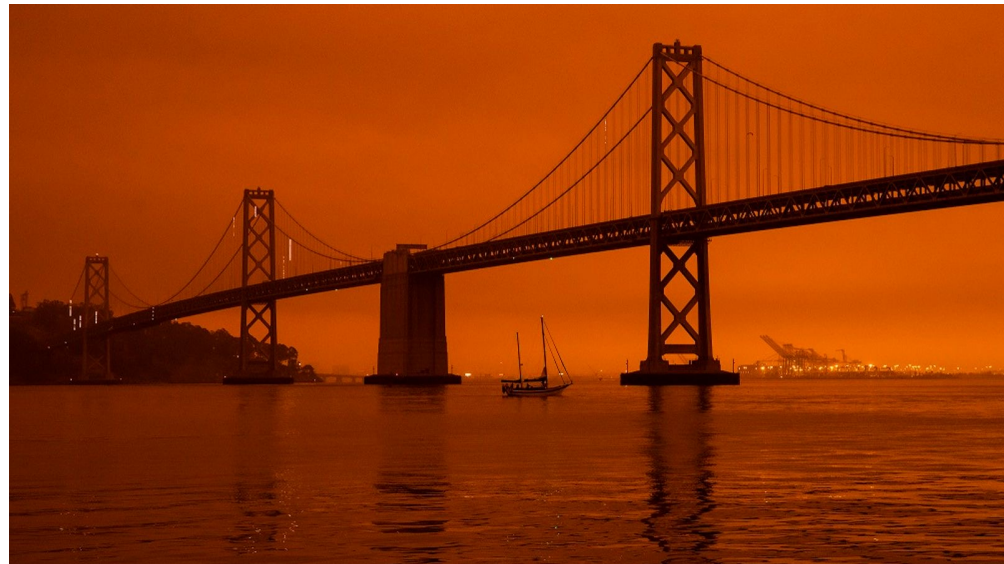
MODIS Truecolor image from Terra Satellite, September 9th, 2020.
<https://earthobservatory.nasa.gov/images/147261/a-wall-of-smoke-on-the-us-west-coast>

The 2020 wildfire season in SF, some memories through photos.

- From September 8th – 15th, long range transport of smoke from fires near Portland, OR blanked most of the CA coast in a thick layer of smoke.
- This caused the SF skies to turn an eerie orange color; photos went viral on social media and made national news.

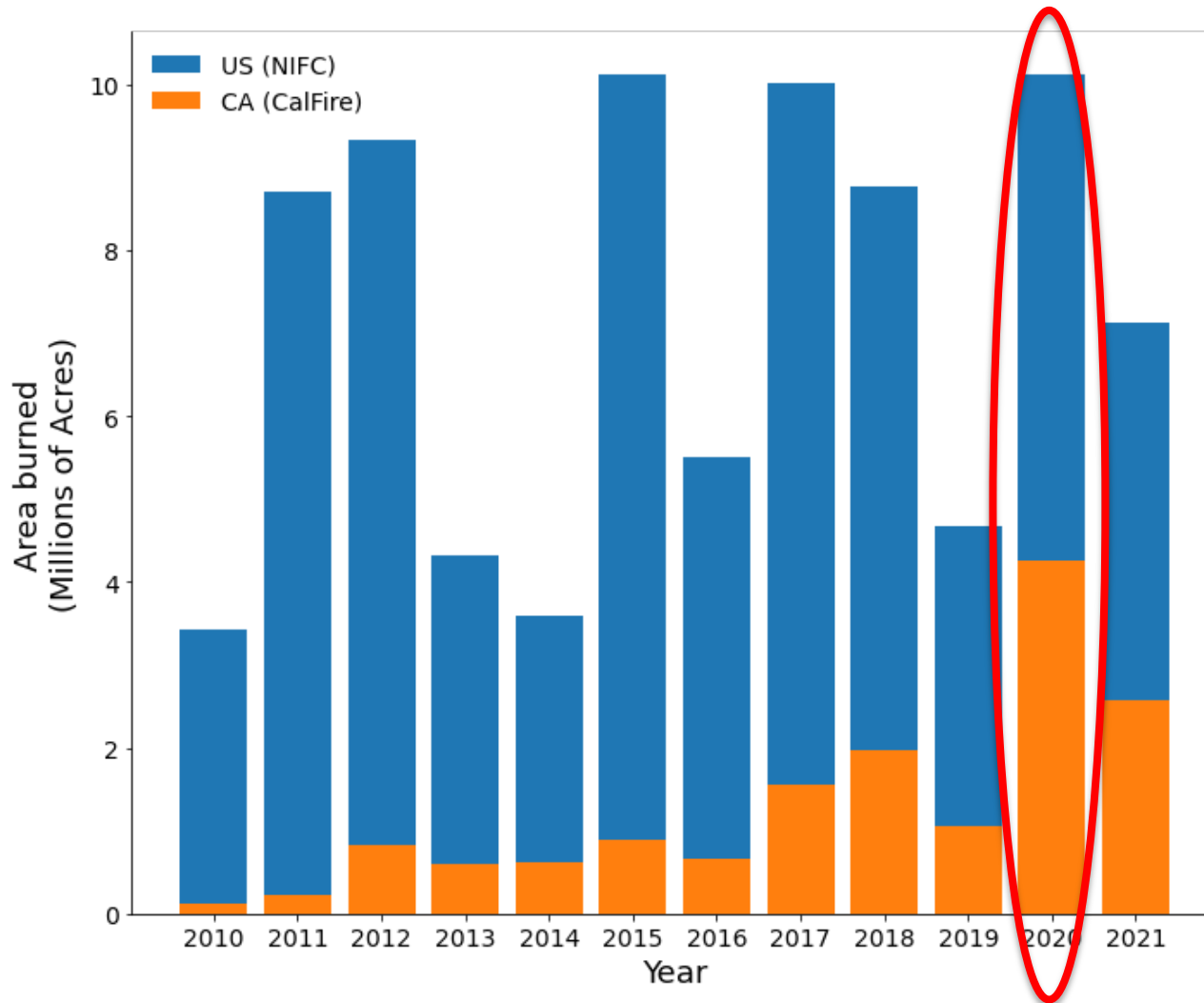


Photograph: Jessica Christian/San Francisco Chronicle/Getty Images
<https://www.wired.com/story/bay-area-just-turned-orange-all-eyes-on-purpleair/>

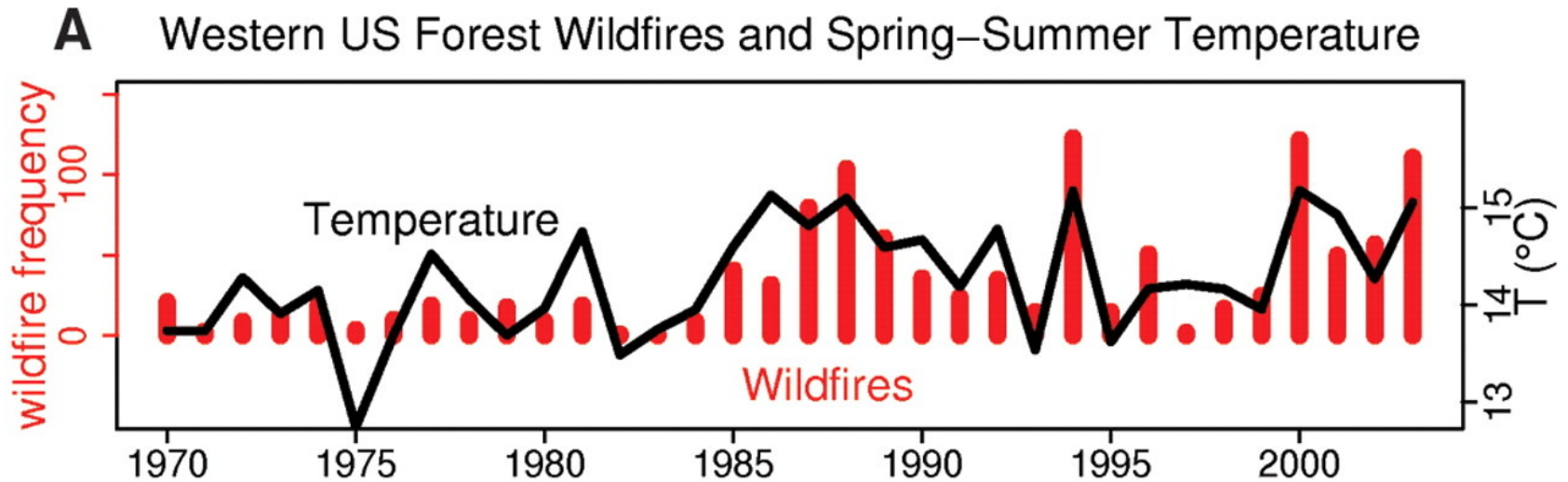


<https://news.sky.com/video/sky-turns-orange-in-san-francisco-12068529>

Exacerbated by severe drought, the 2020 wildfire season was the worst in CA history.

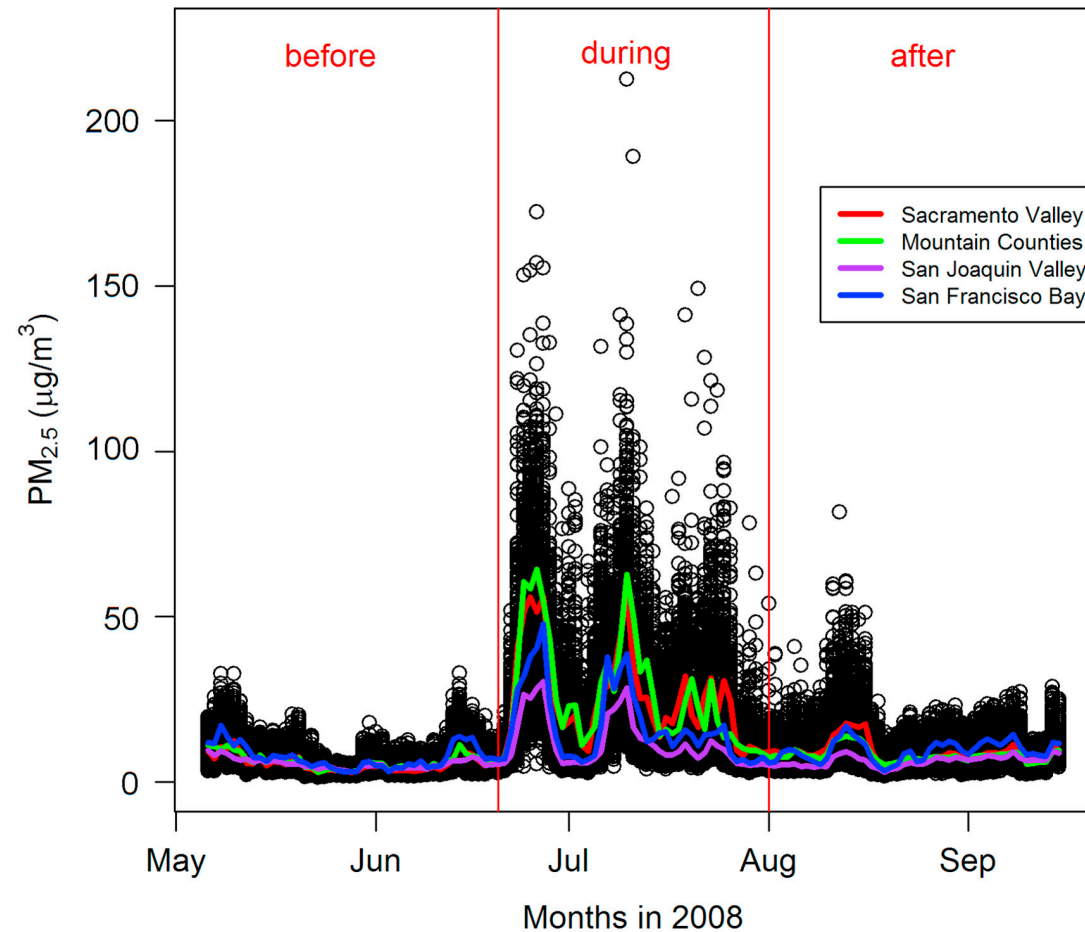
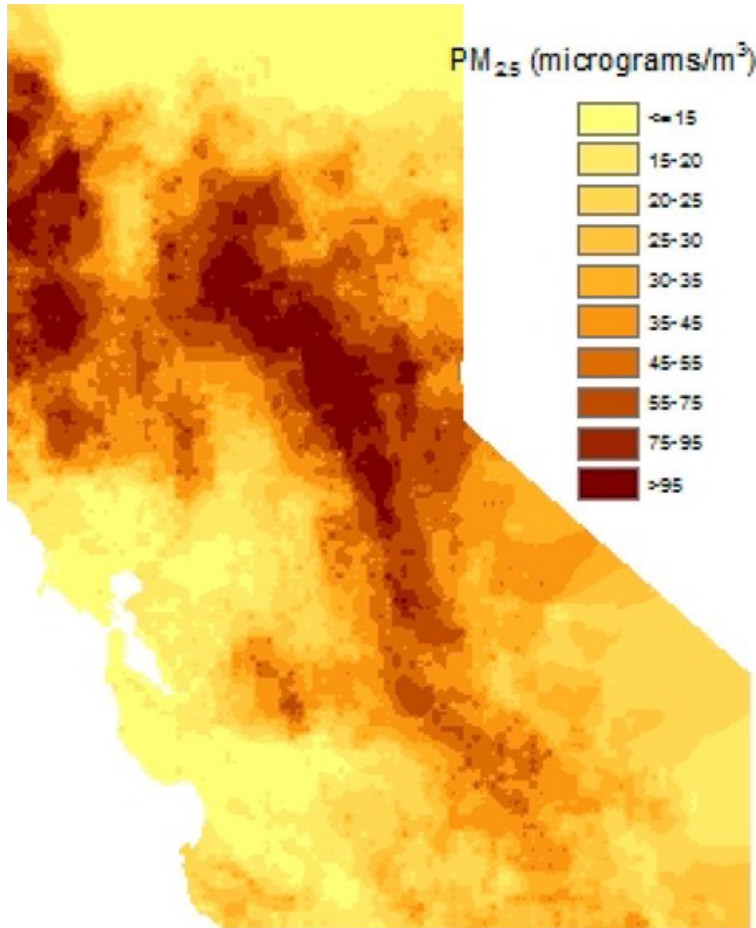


This is consistent with trends over the western US, showing a strong correlation between wildfire activity and spring/summer temperature.



Westerling et al., 2006

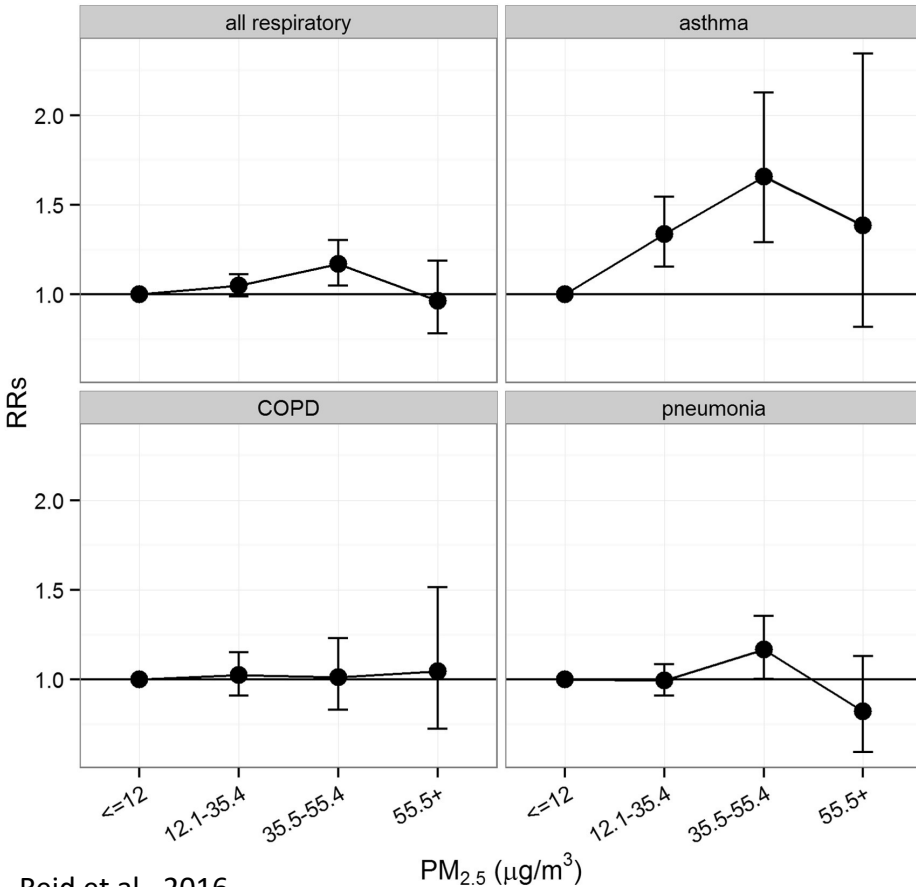
Wildfire smoke represents a major threat to public health, but we don't always know how much smoke people are breathing.



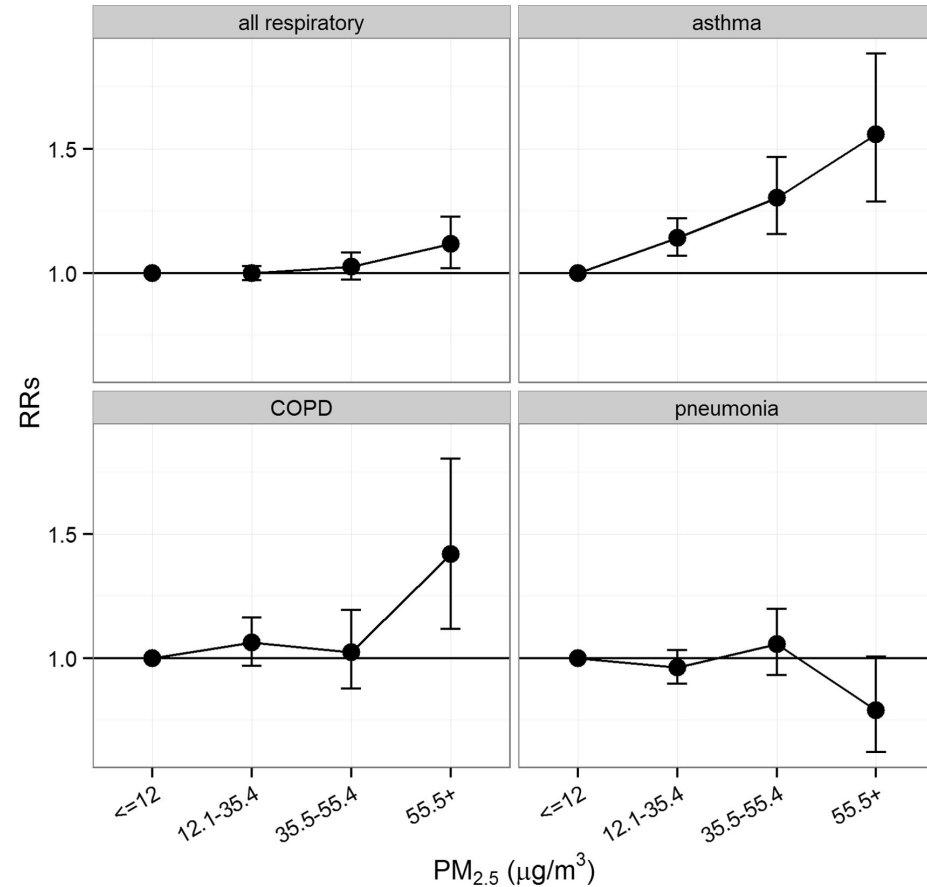
Reid et al., 2015; Reid et al., 2016

Health effects are large, but also uncertain.

Respiratory Hospitalizations



Respiratory Emergency Department Admissions.

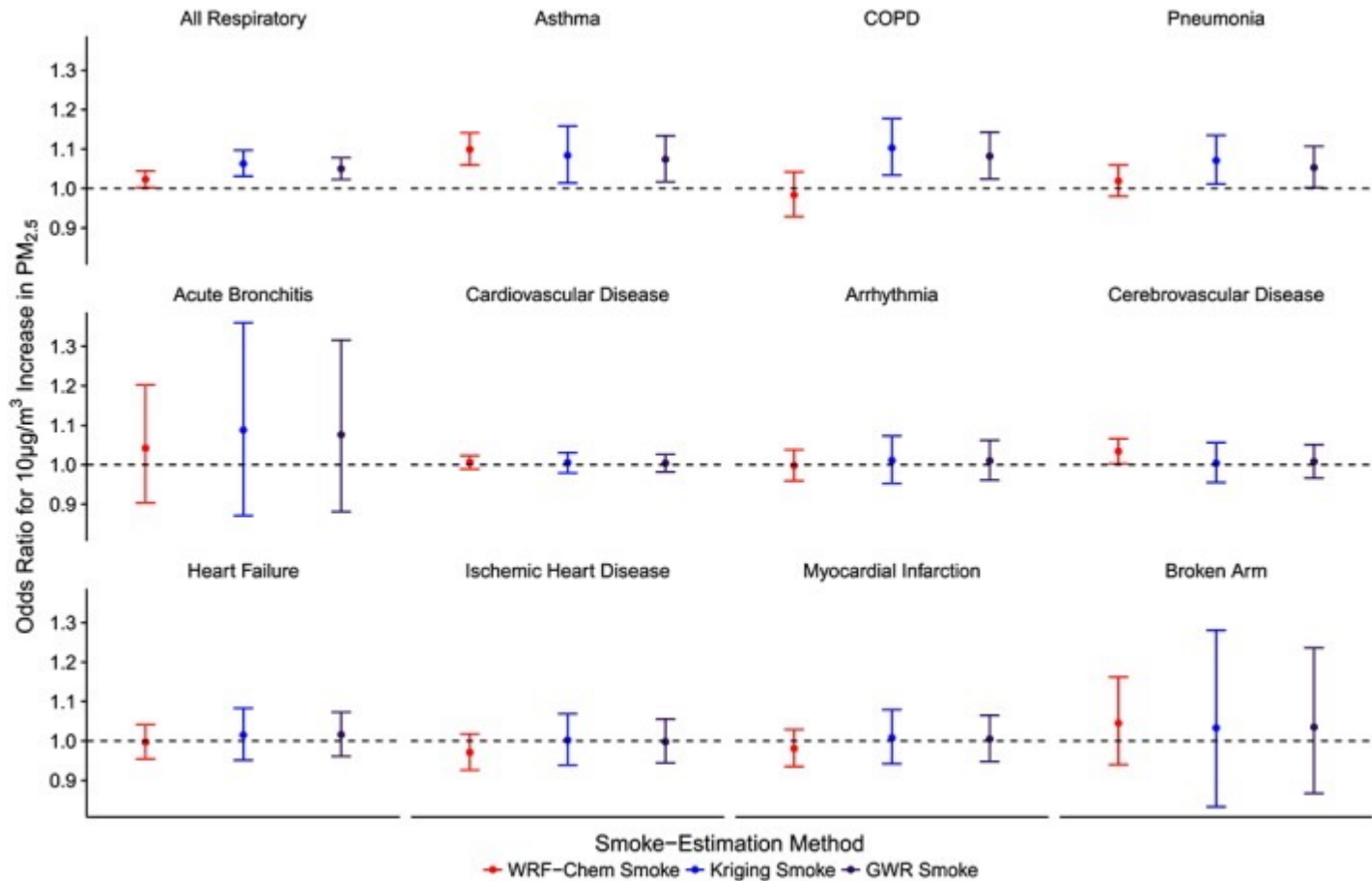


Reid et al., 2016

PM_{2.5} (μg/m³)

PM_{2.5} (μg/m³)

Not-pictured; uncertainty due to *exposure misclassification*



Gan et al., 2017

We can use high-fidelity physics and chemistry with numerical weather prediction to simulate smoke from wildfires.

Weather and atmospheric processes:

- Wind speed and direction
- Solar irradiance and surface heat fluxes
- Atmospheric stability
- Complex marine and topographic effects on all the above

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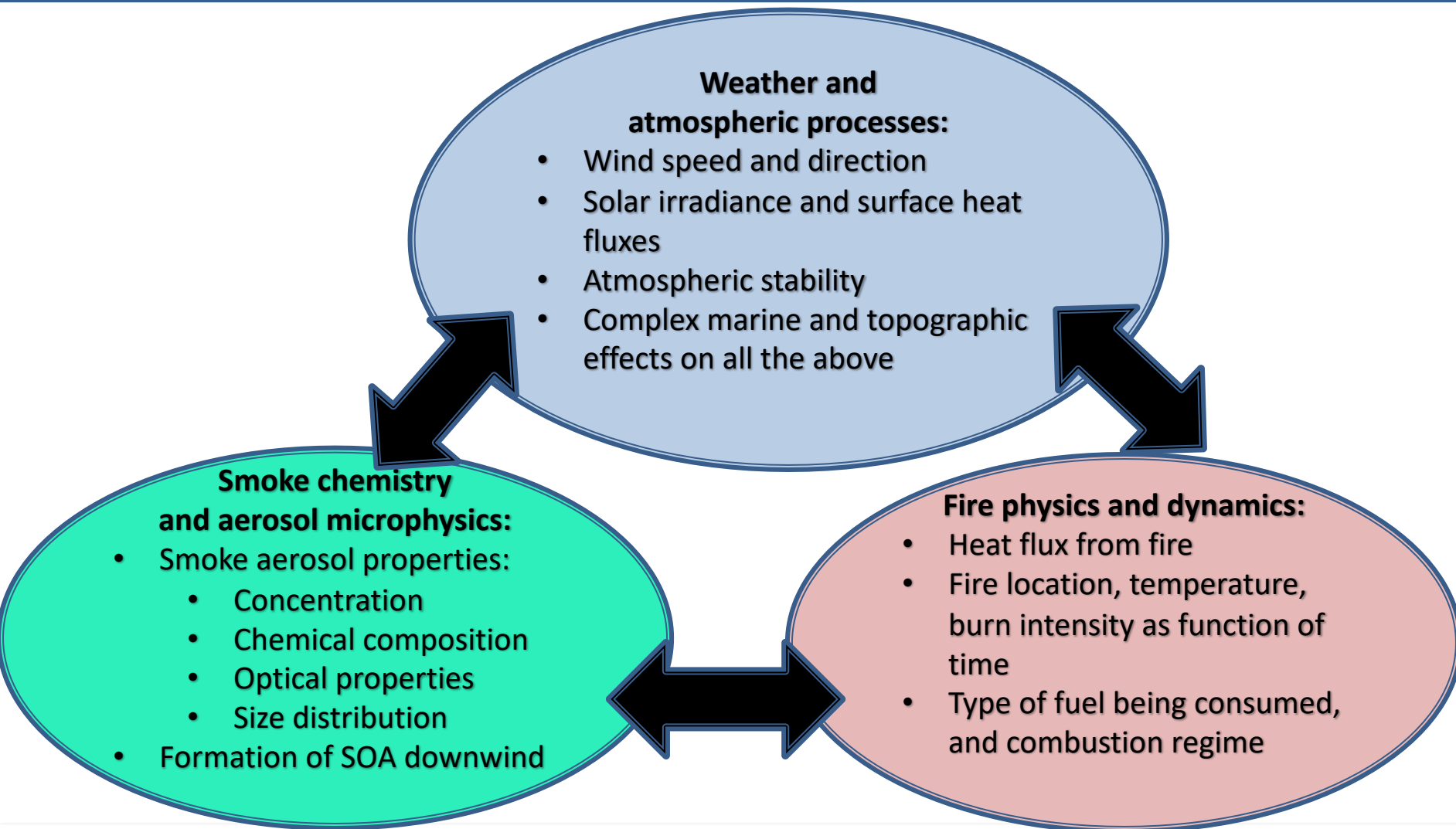
Smoke chemistry and aerosol microphysics:

- Smoke aerosol properties:
 - Concentration
 - Chemical composition
 - Optical properties
 - Size distribution
- Formation of SOA downwind

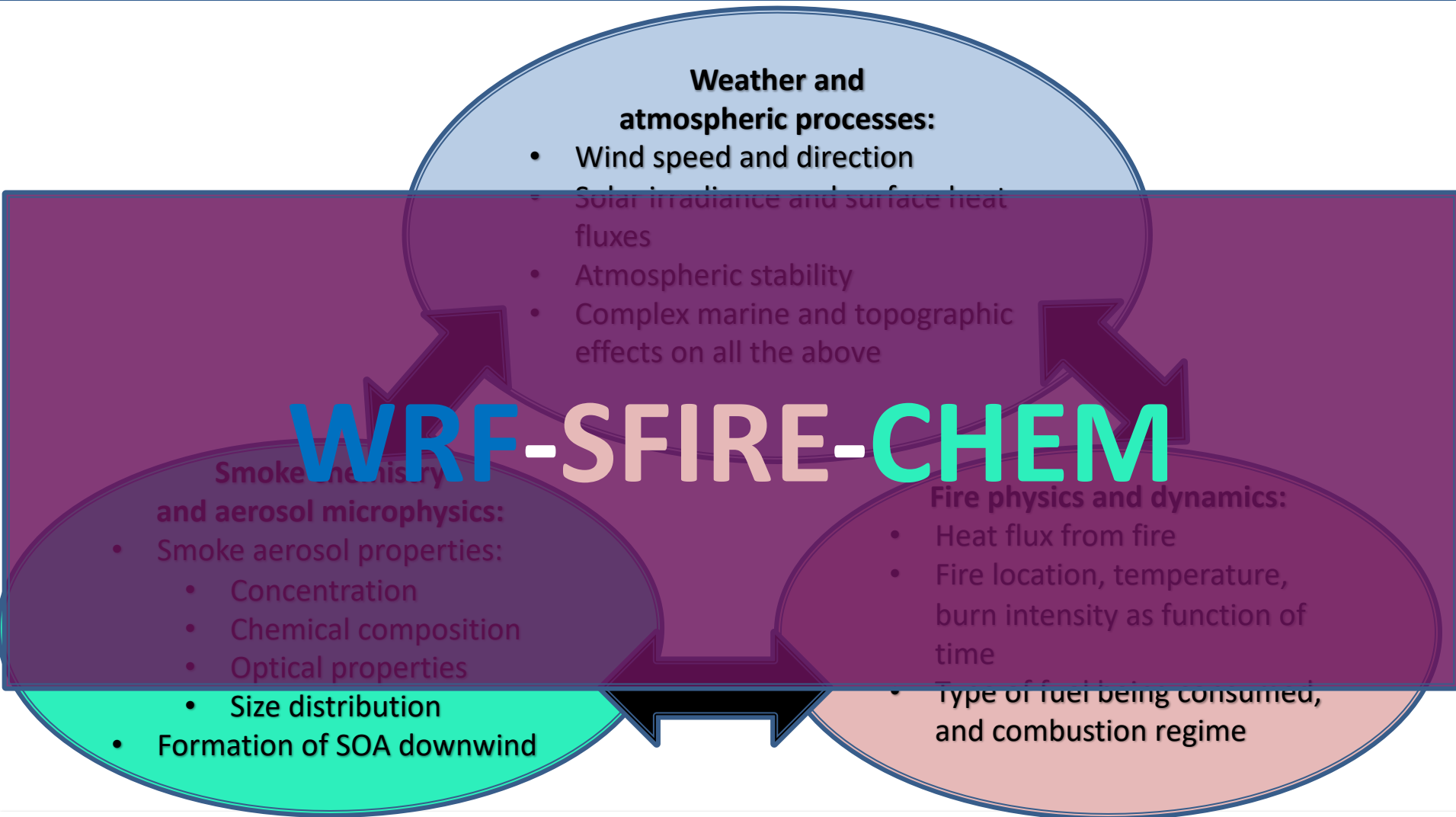
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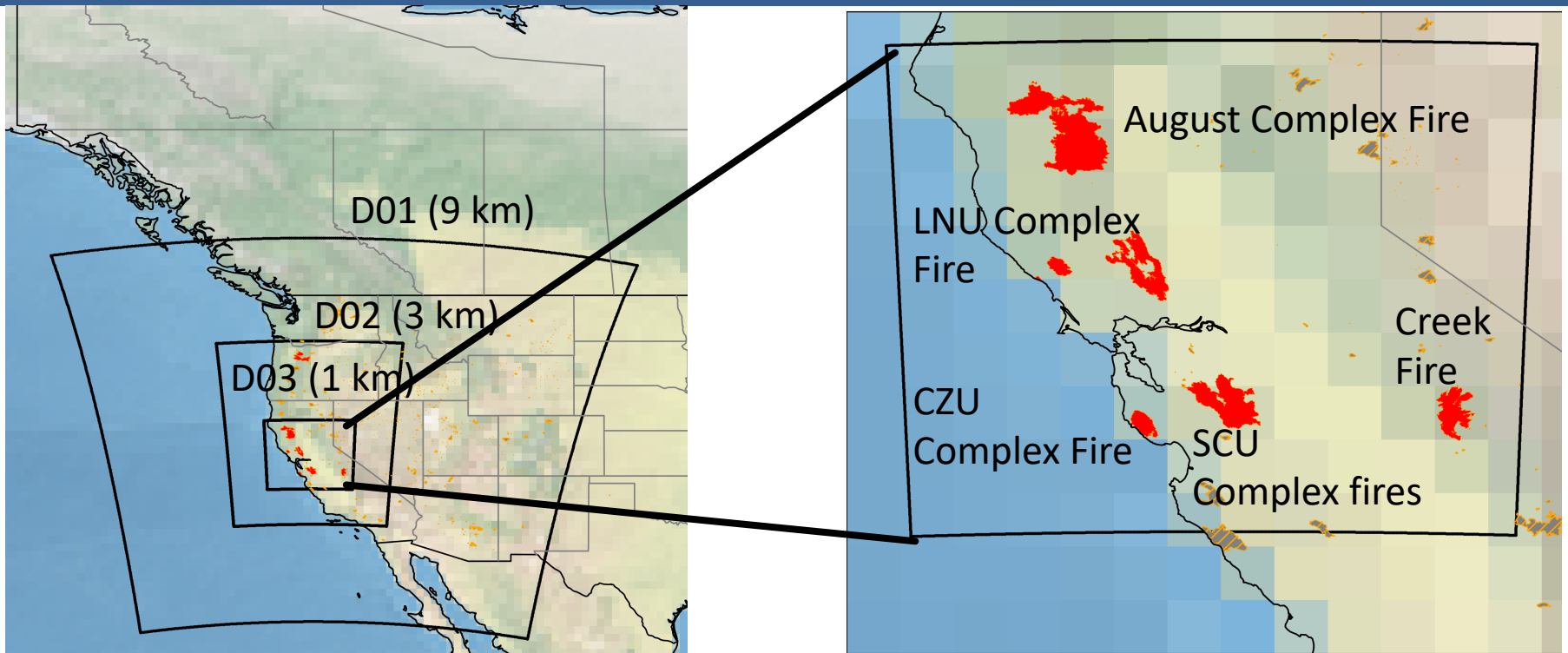
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Simulation setup for 2020 Case Study

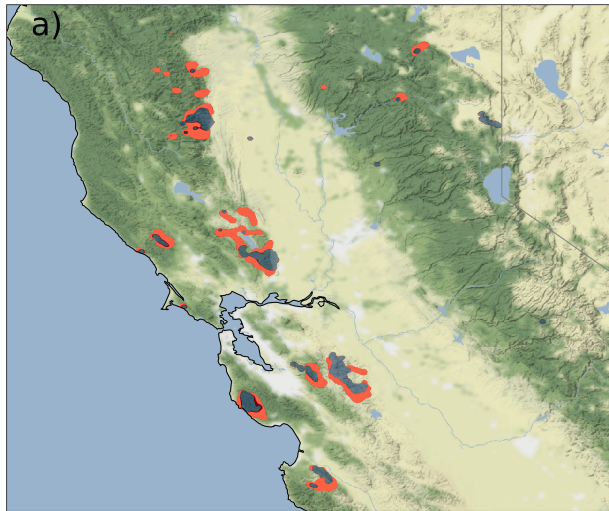


- Multiscale simulation setup in the WRF framework using:
 - 1) WRF meteorology-only simulation
 - 2) **WRF-Chem, FINN for biomass burning emissions**
 - 3) **SFIRE fire spread model with FINN-derived emission factors**
- Simulate period between August 16th and September 15th, 2020

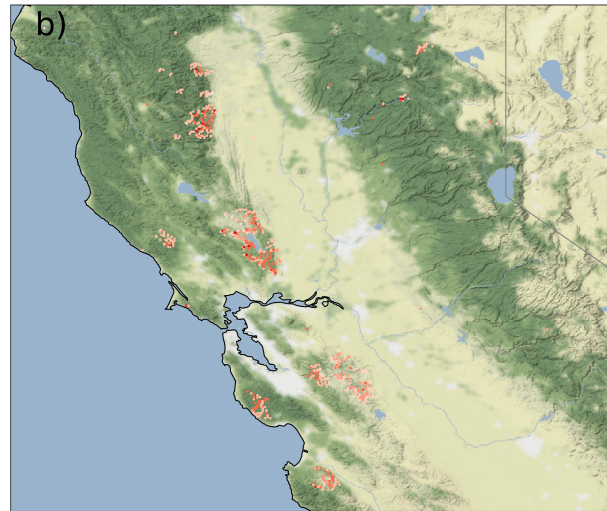
SFIRE (Dynamic fire spread) vs FINN (satellite-based emissions inventory); how does burn area compare?

2020-08-19 08:00:00

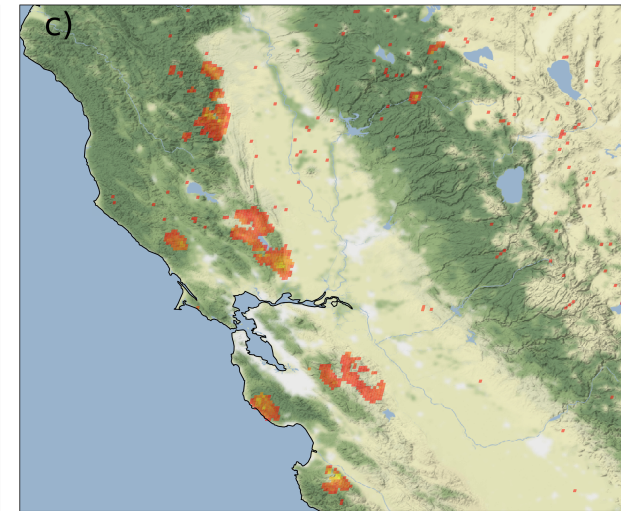
SFIRE Emission Area



FINN Emission Area

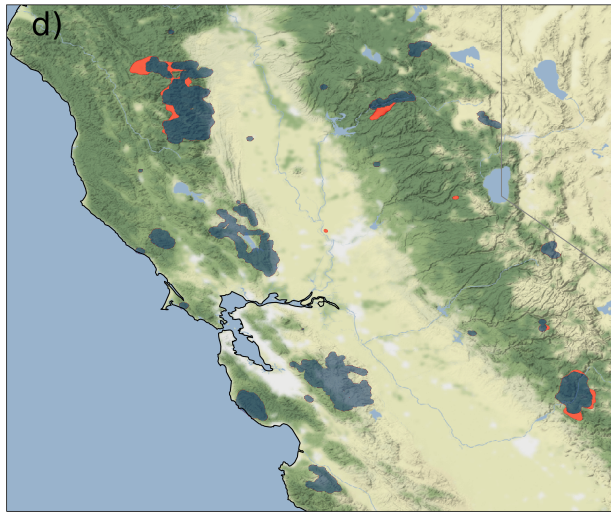


GOES-R FDC Fire Area



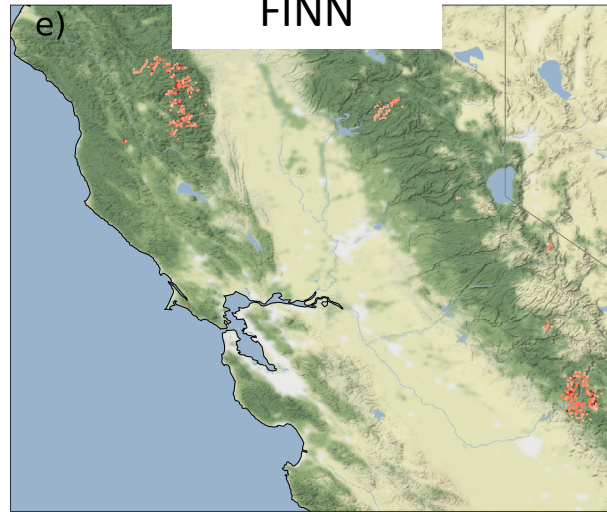
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SFIRE

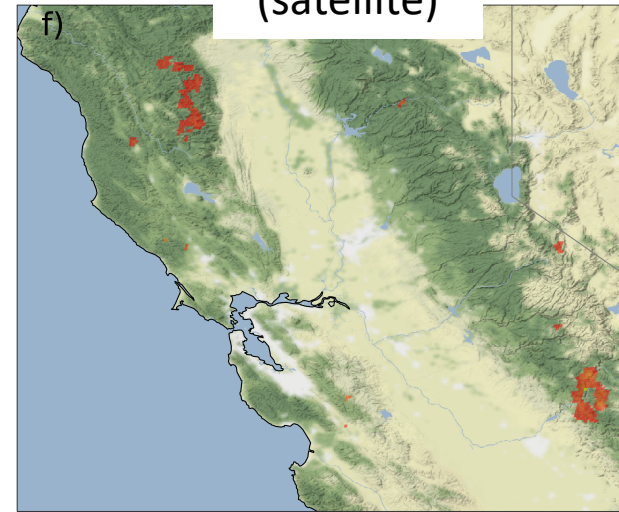


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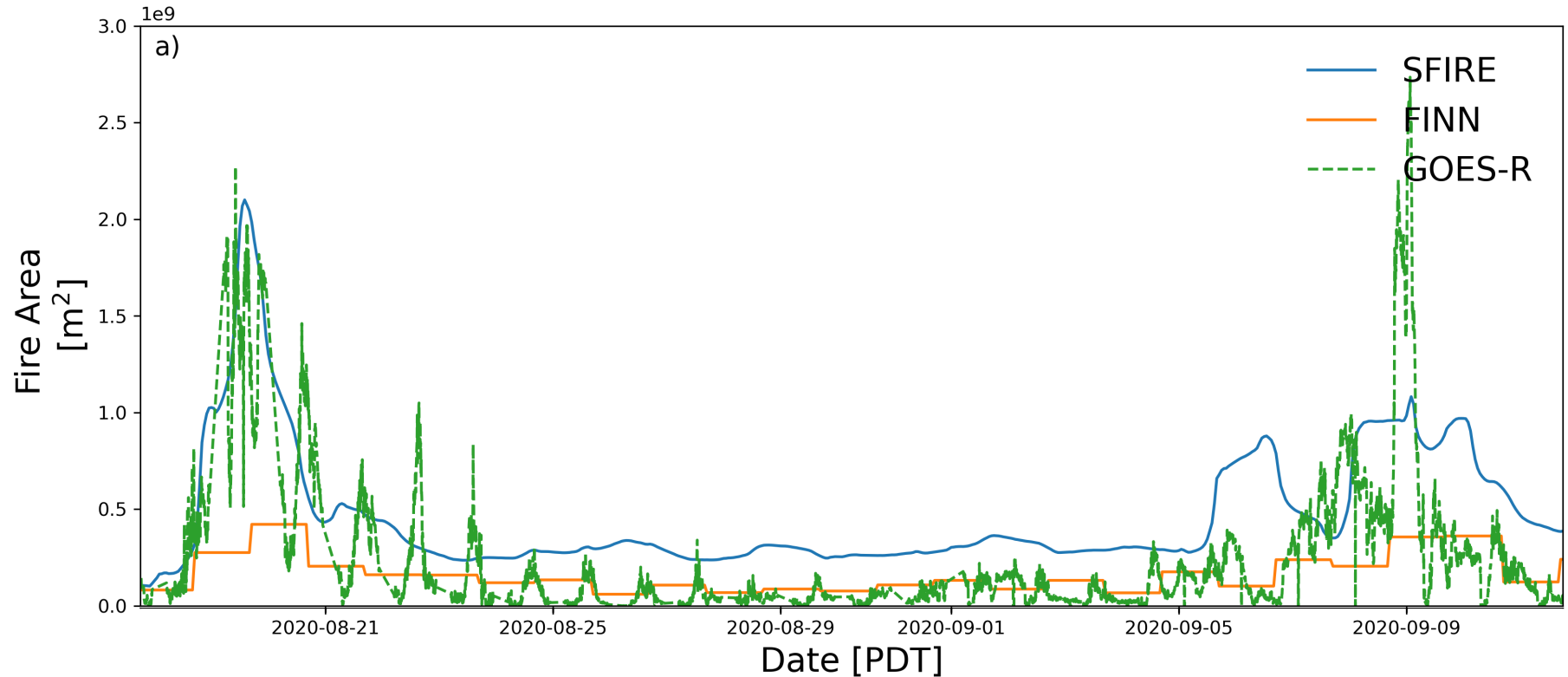
FINN



GOES-R
(satellite)

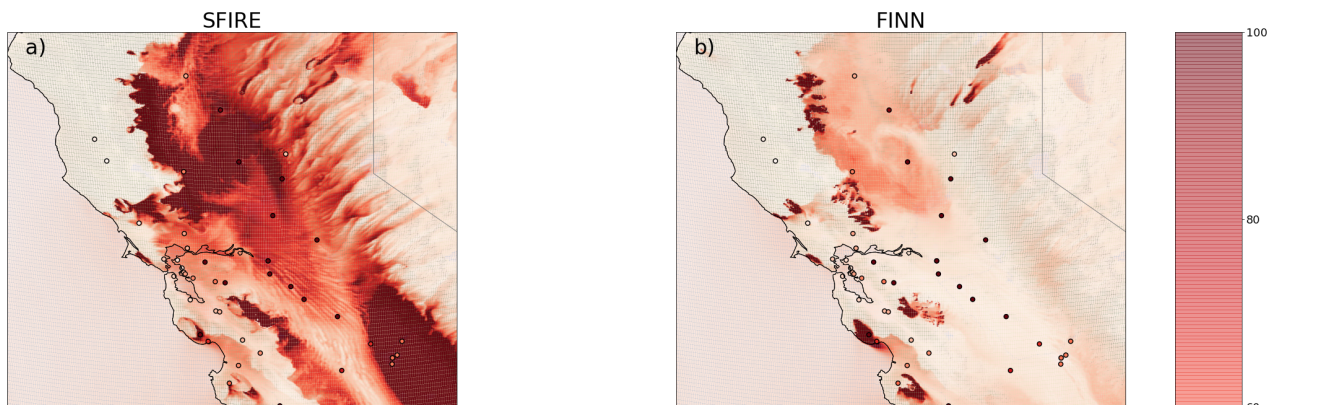


Dynamic fire spread (SFIRE) simulations have greater area burn than emissions inventory (FINN).

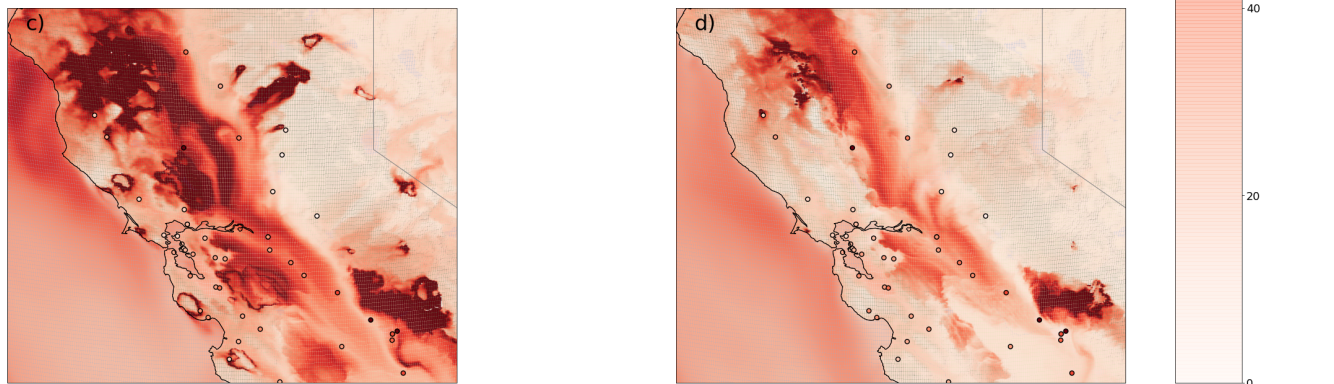


WRF-SFIRE simulations produce greater smoke concentrations at the surface.

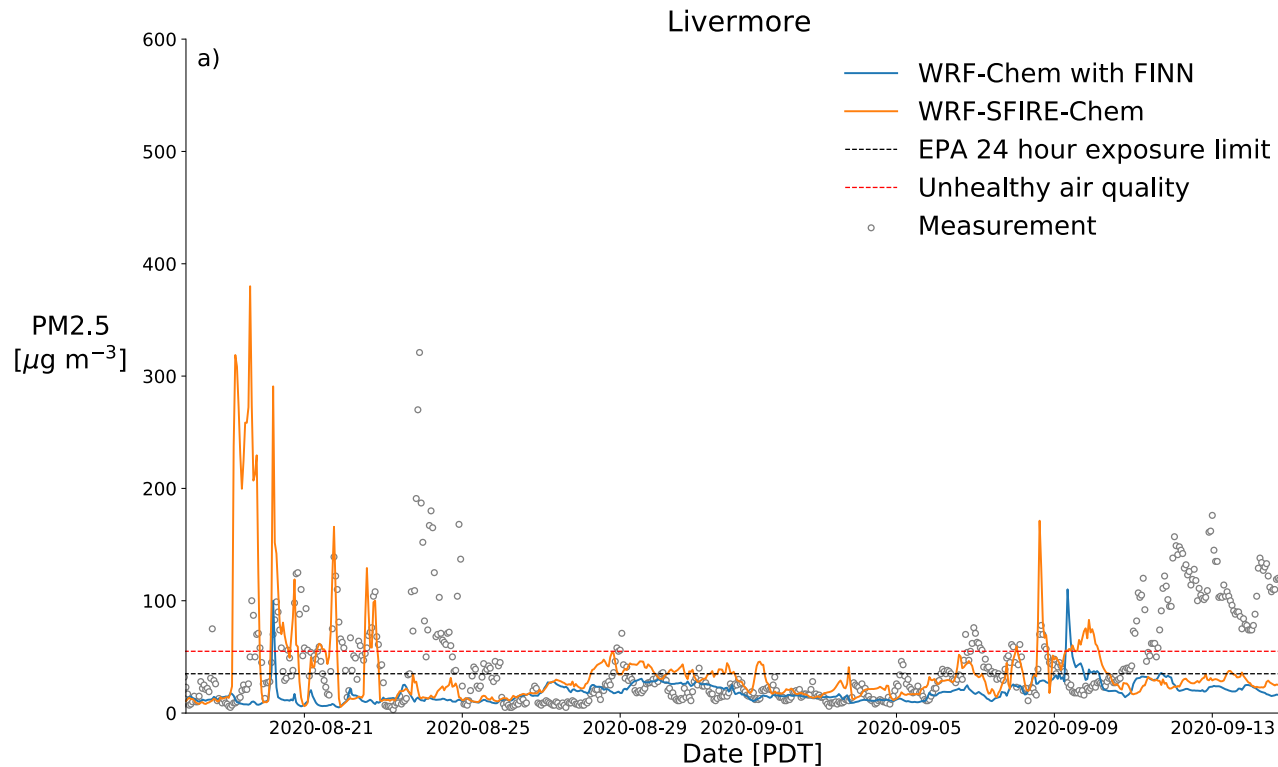
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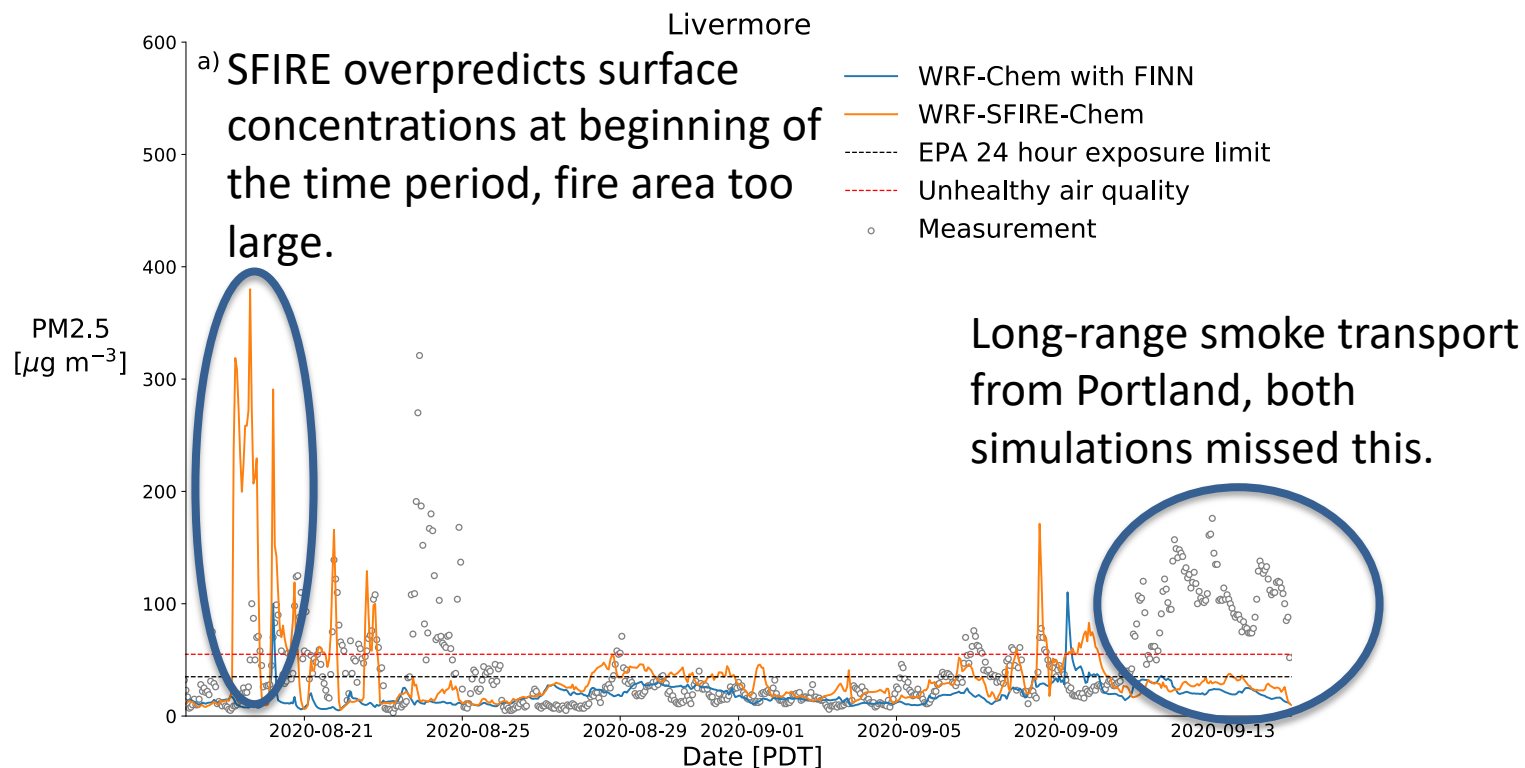
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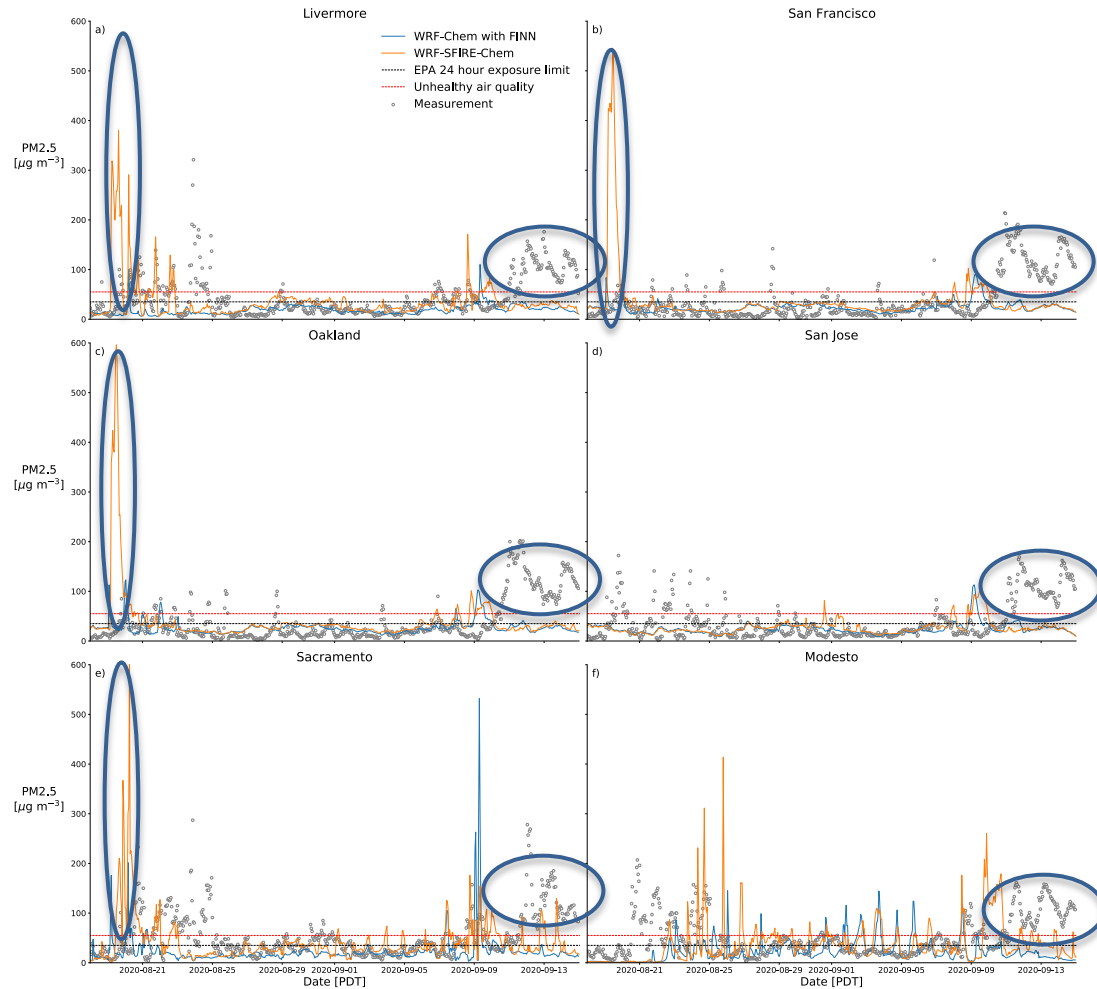
Comparisons to observations show WRF-SFIRE overpredicts smoke early in the simulation.



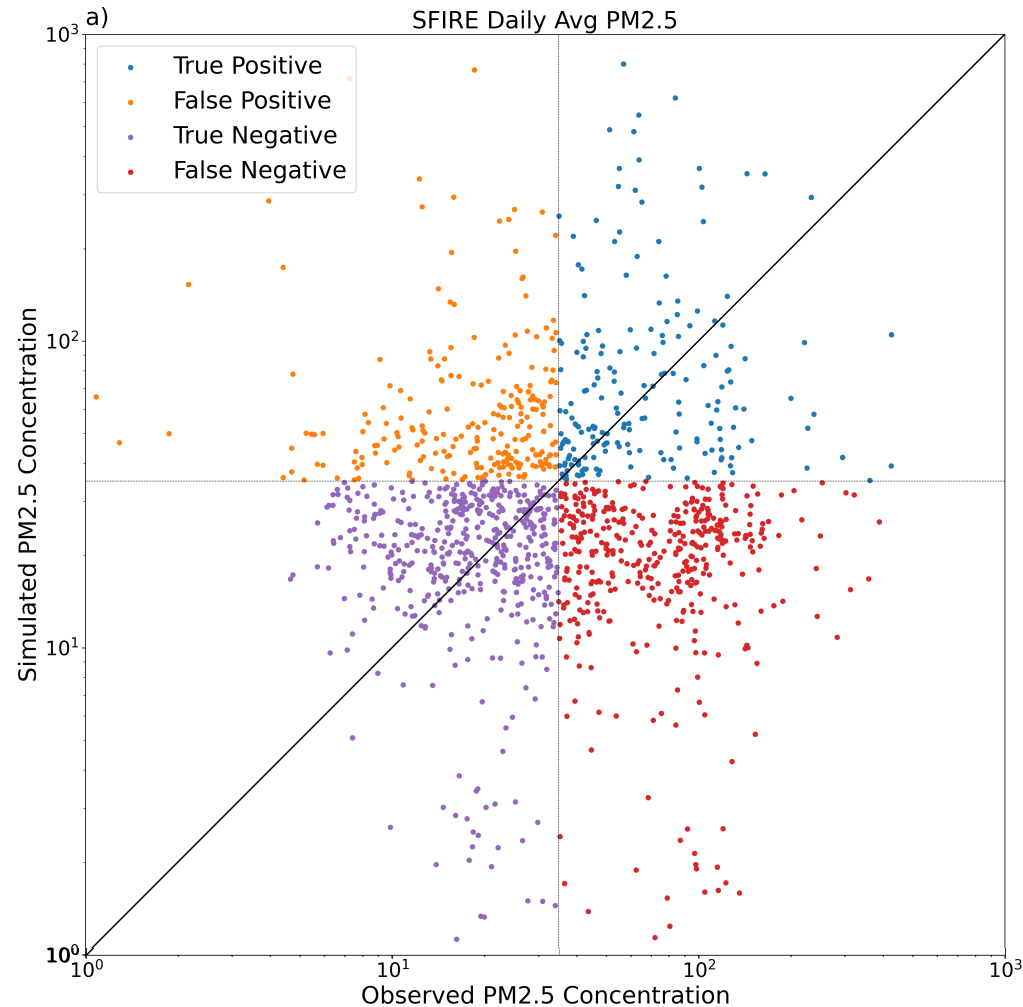
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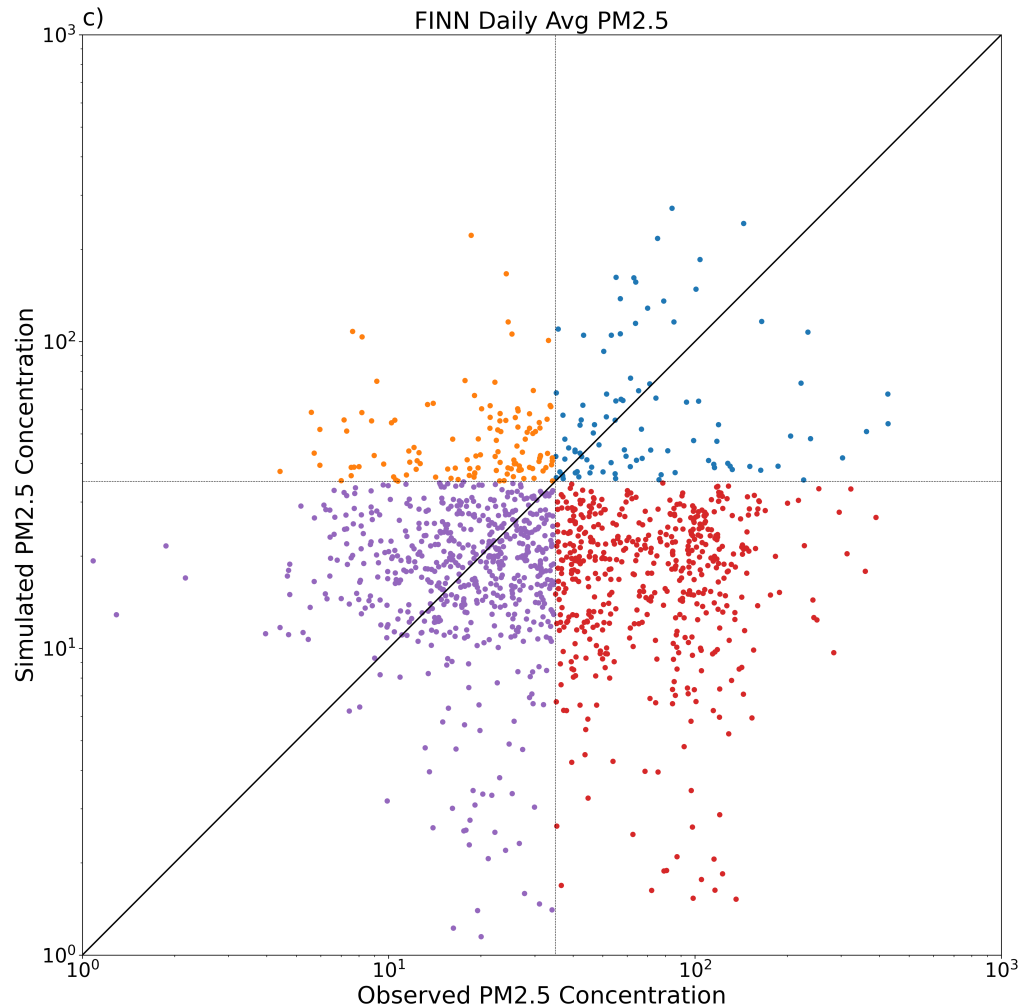
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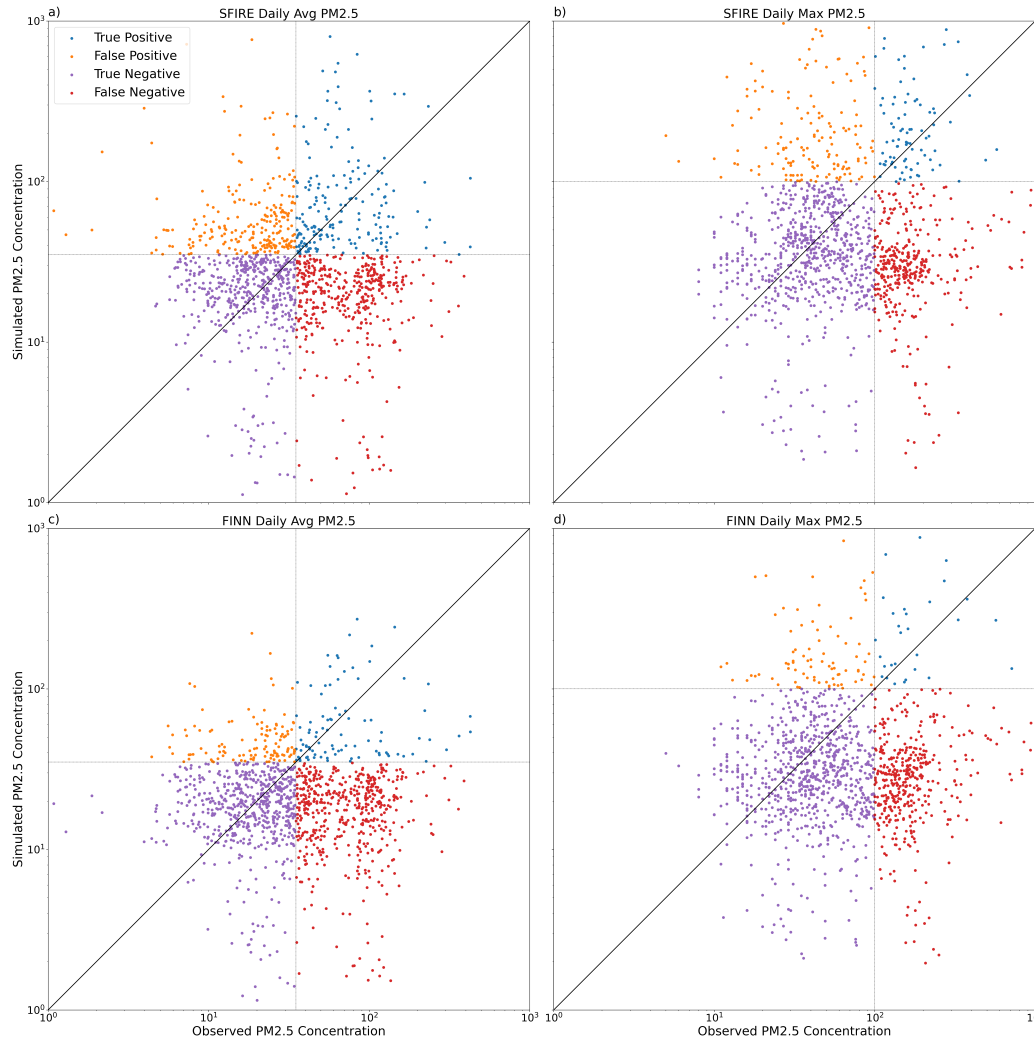
SFIRE vs FINN, actual predictive value is not so different.



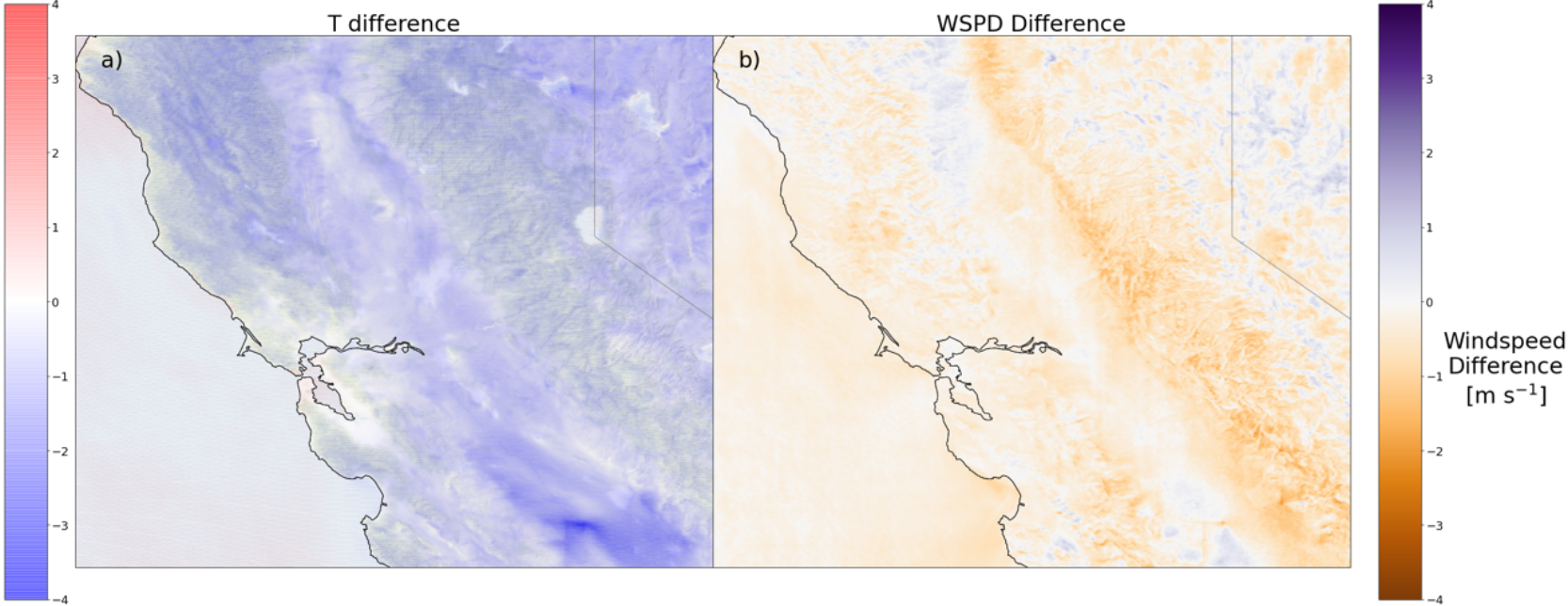
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Smoke blocks sunlight, leading to cooler temperatures. How big was this effect?





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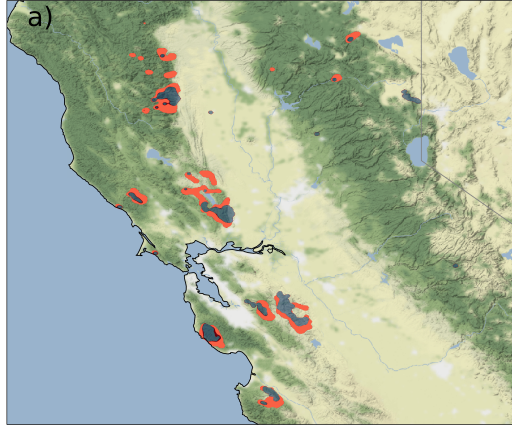
Extra slides



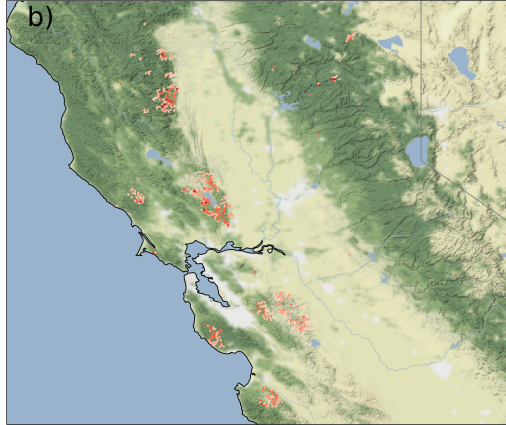
Panels, area burn

2020-08-19 08:00:00

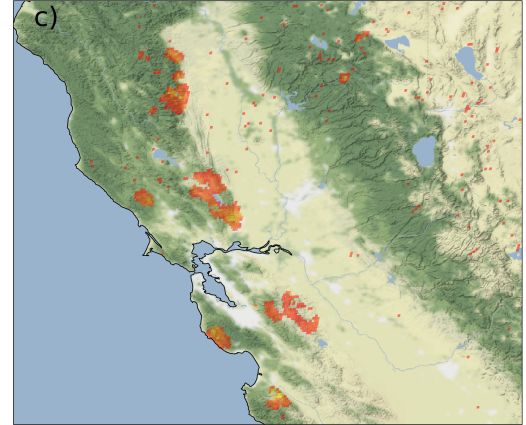
SFIRE Emission Area



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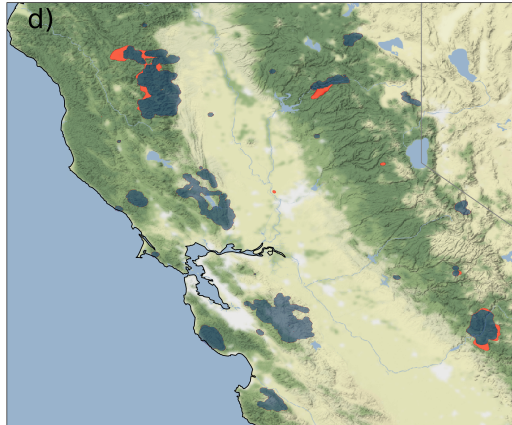


GOES-R FDC Fire Area

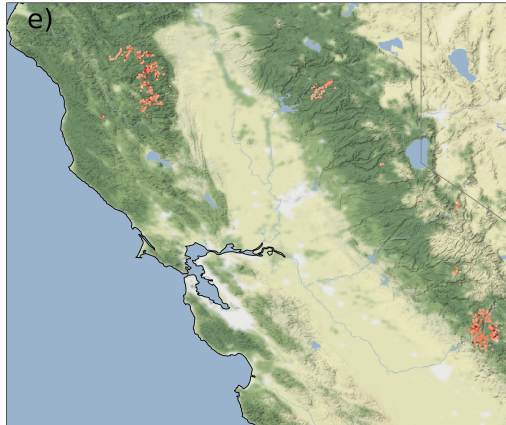


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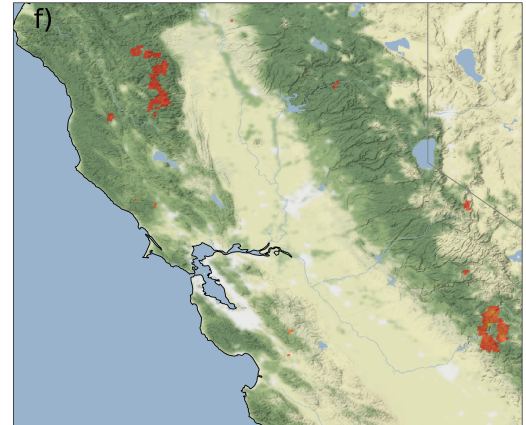
d)



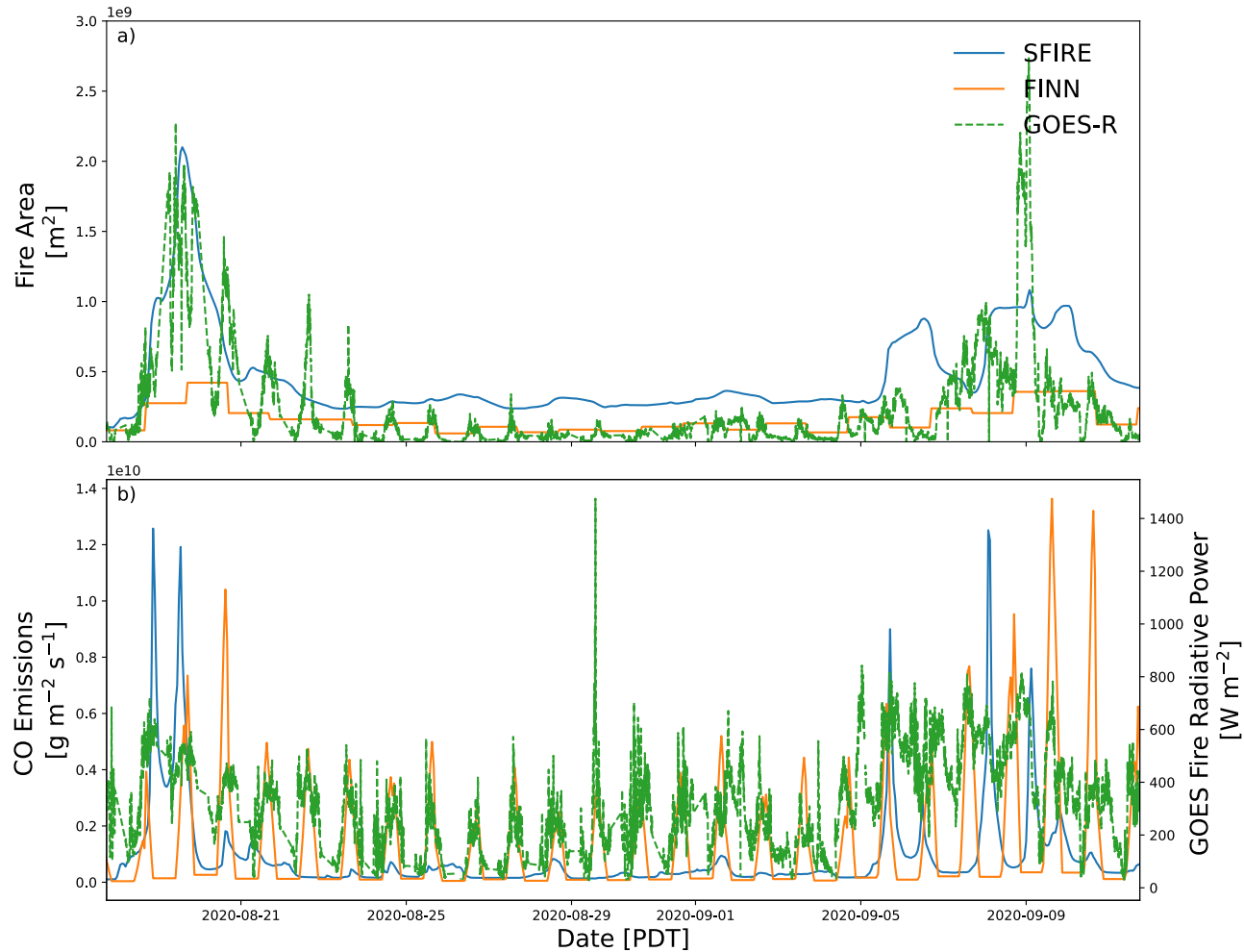
e)



f)



Area burn and CO Flux



Timeseries, no circles

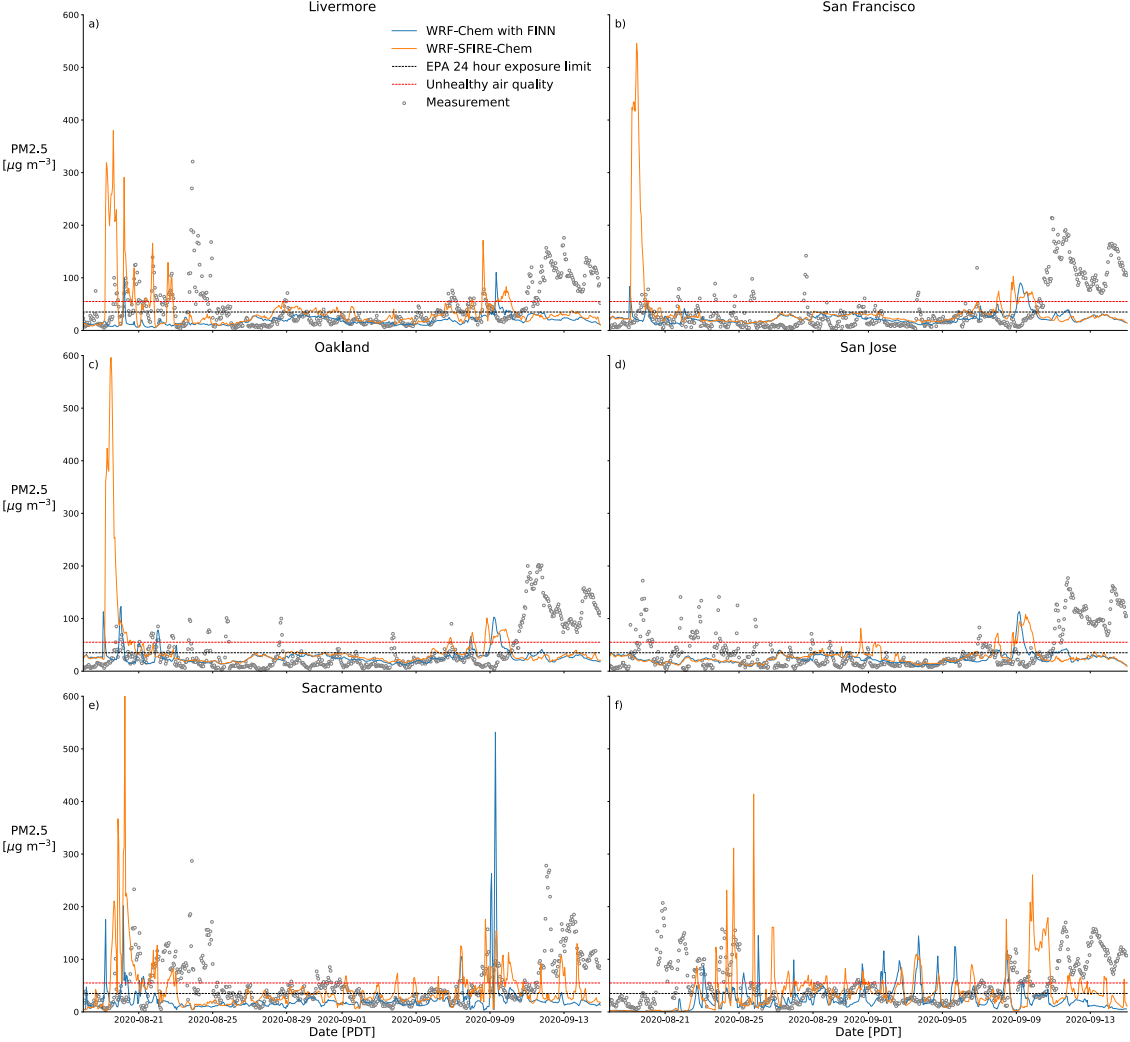


Figure 7

