Unprecedented Health Tolls of the 2020 Western United States Wildfires

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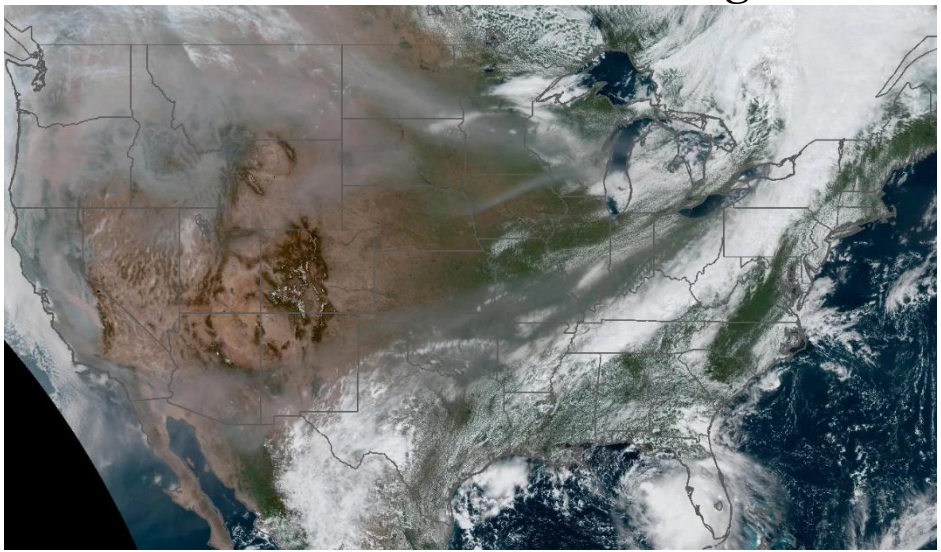
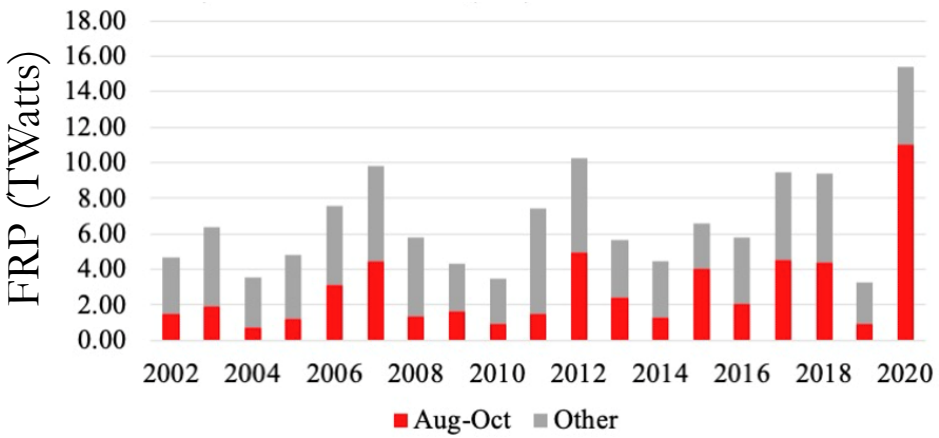
Satellite Monitoring of 2020 Western US Wildfires

Smoke Plume of First US "Gigafire"



(GOES-16 @ AerosolWatch)

MODIS Fire Radiative Power (FRP)

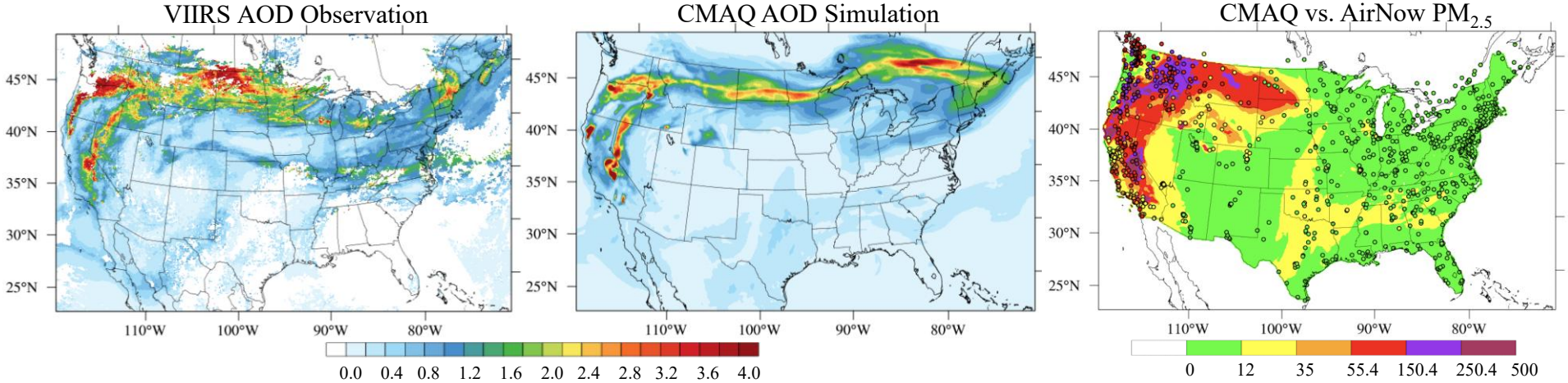


(Source: NASA FIRMS)

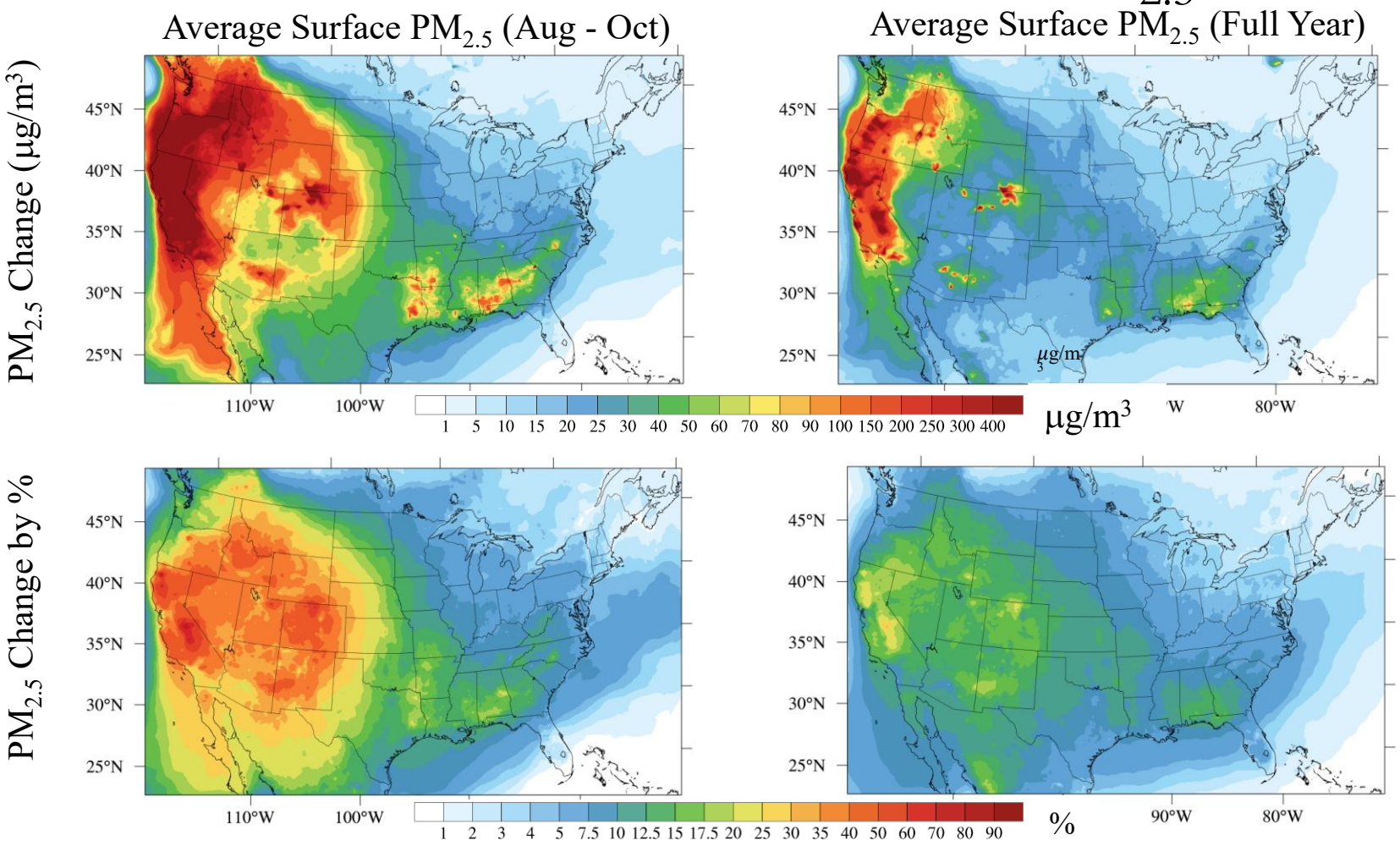
- What are the air quality effects (exceedances)?
- **What are the health consequences of the widespread smoke pollution?**

Quantifying Air Quality Effects of Wildfire Emissions

- Wildfire emissions: blended MODIS and VIIRS fire detection with NASA QFED emission algorithm (Zhang et al., 2015);
- Two runs using the Community Multiscale Air Quality (CMAQ) model: With and Without fire emissions;
- Study period (August – October, 2020);
- Full chemistry with detailed anthropogenic and natural emissions;



Wildfire Effects on Surface $PM_{2.5}$



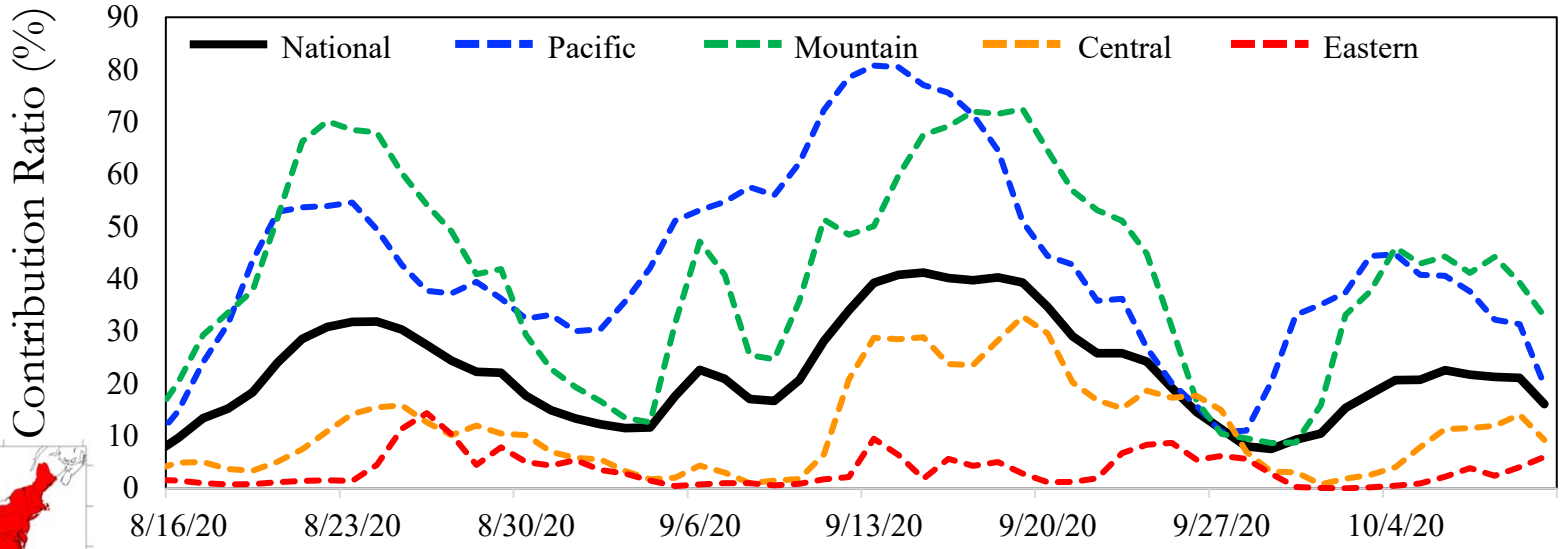
Wildfire Contribution to Surface $PM_{2.5}$

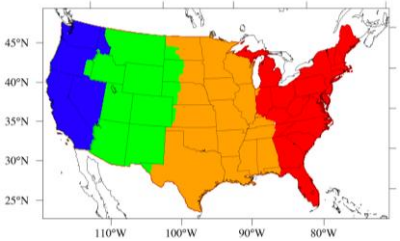
- The Contribution Ratio (CR) to assess wildfire contribution to $PM_{2.5}$

$$CR = \frac{M_{WDF} - M_{NOF}}{M_{WDF}} \times 100\%$$

M_{WDF} – Model prediction with wildland fire;

M_{NOF} – Model prediction with no fire;

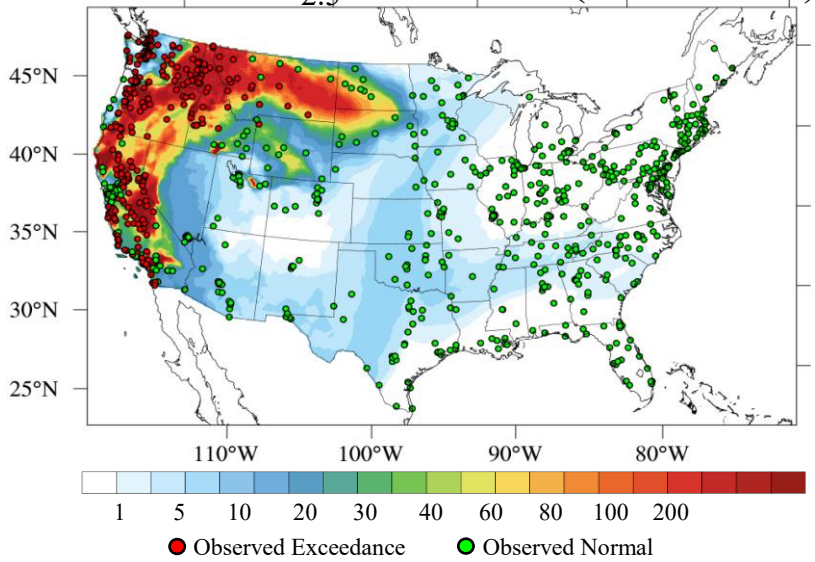




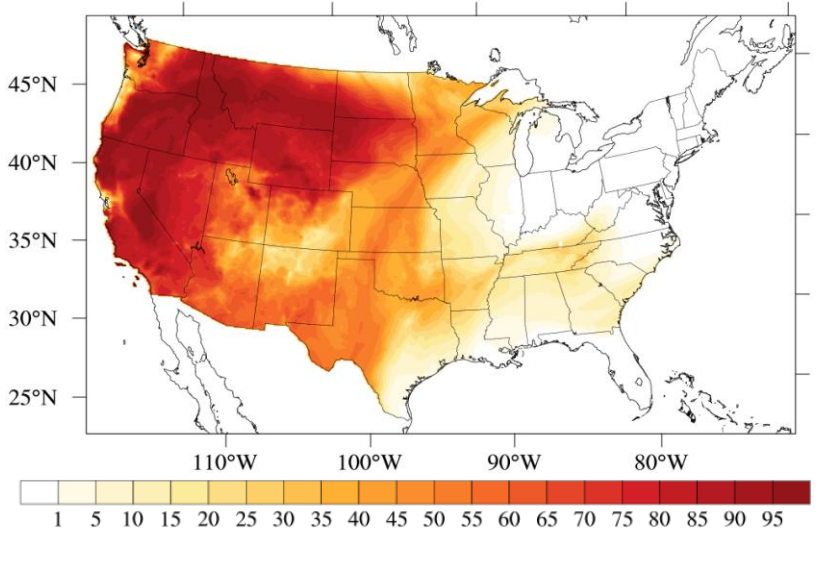
Wildfire Effect on $PM_{2.5}$ Exceedances

- USA EPA National Ambient Air Quality Standards (NAAQS): 35 μg/m^3 for 24h average; 12 μg/m^3 annual average.
- Wildfires major contributor to 3,720 observed $PM_{2.5}$ exceedances during Aug-Sep 2020.

20200915 $PM_{2.5}$ Difference (WDF-NOF)



20200915 $PM_{2.5}$ Contribution Ratio



>4.6M people exposed to smoke $PM_{2.5}$ levels exceeding annual NAAQS in 2020.

Quantifying Health Impacts of the 2020 Wildfires

(Unpublished data, do not quote/post online)

$$\Delta y_i = y_{0,i} * \left(e^{\beta * Q_i}\right) * Pop_i$$

Δy – Excess mortality

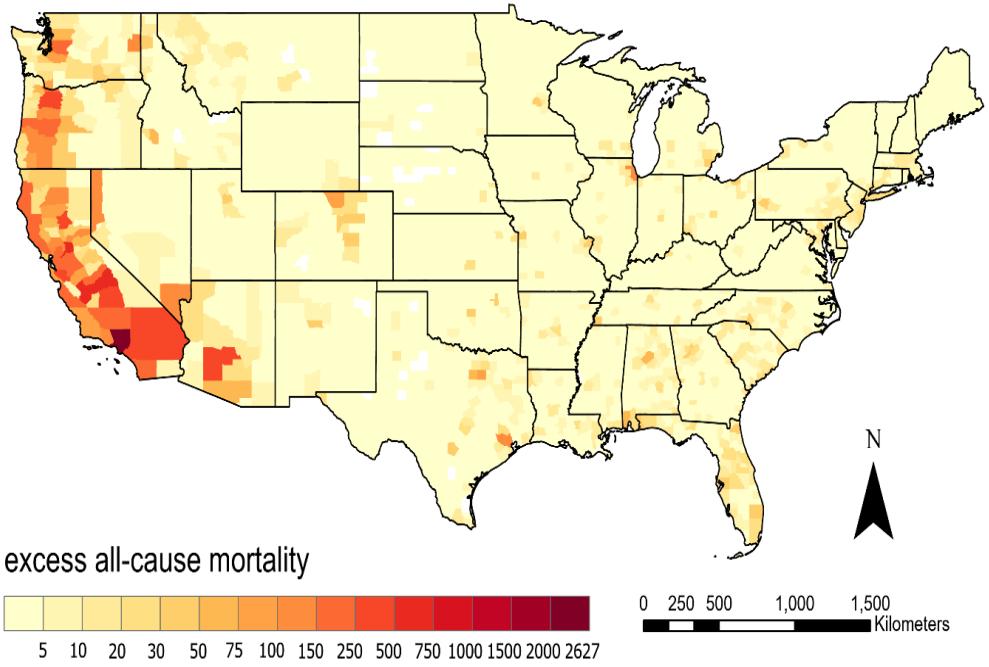
i – County i

$y_{0,i}$ - baseline mortality rate

β -- the effect coefficient reported in Krewski et al. (2009)

ΔQ_i -- the change in $PM_{2.5}$ concentration

Pop_i - county-level population



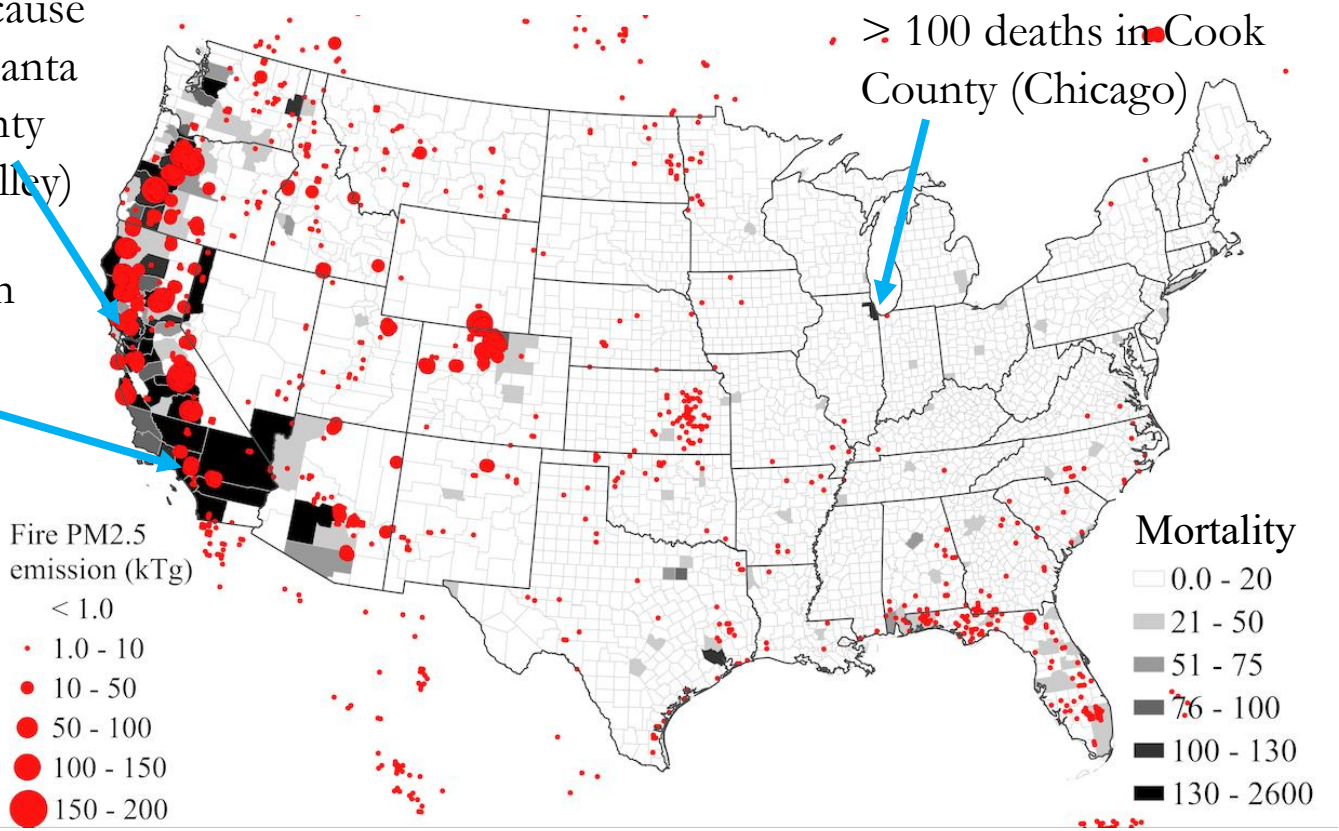
In 2020, wildfire $PM_{2.5}$ attributed to 22,494 (95% CI: 15,247 -29,602) excess deaths → ~0.79% of all-cause deaths in the contiguous United States.

Where were Wildfires? Who faced the Consequences?

34.6% all-cause deaths in Santa Clara County (Silicon Valley)

2,623 deaths in Los Angeles. #6 cause of death

> 100 deaths in Cook County (Chicago)



Health burden largely near sources, but consequences can be found faraway.

Wildfire Health Effects and Economic Costs

(Unpublished data, do not quote/post online)

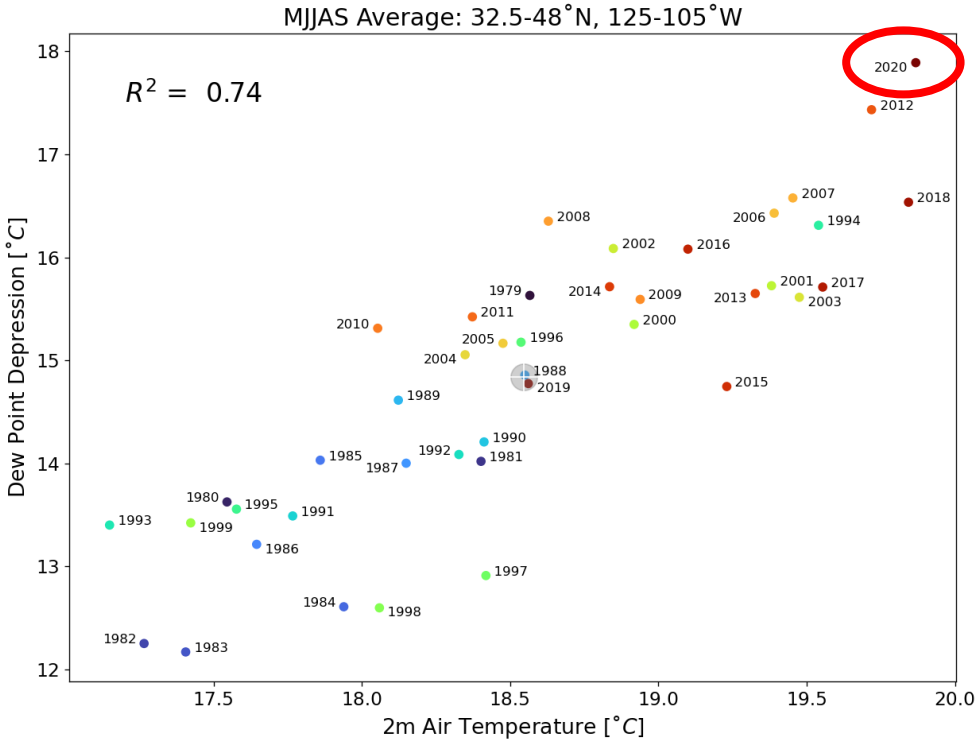
Wildfires	Year	Health End Points	Economic Loss (USD)	Reference
US Wildland Fires	2008 - 2012	1,500 - 2,500 deaths from short-term $PM_{2.5}$ exposure 8,700 – 14,000 deaths from long-term $PM_{2.5}$ exposure	$11B - $20B; $76B - $130B;	Fann et al, 2018
California Wildfires	2018	3,652 premature deaths; Medical costs and work time lost	$32B	Wang et al., 2020
Australian Megafires	2019	429 premature deaths; 4,853 hospital admissions;	$407M	Johnston et al., 2021
Washington Wildfires	2020	92 all-cause excess deaths from short-term exposure	N/A	Liu et al., 2021
2020 Western US Wildfires	2020	22,494 deaths from Long-term $PM_{2.5}$ exposure	$220B ($150B – $300B)	This study

Why So Many Wildfire in 2020?

- Anthropogenic climate change → ~55% of observed fuel aridity increases during 1979-2015 across western US forests (Abatzoglou and Williams, 2016);
- Fire-favorable weather fueled by declines in Arctic sea ice in preceding months → Artic-driven teleconnection (Zou et al., 2021).
- Three western Pacific typhoons strengthened NW US fire weather through an atmospheric wave train (Allen et al., 2020);

Dew Point Depression

(Mean Temperature - Mean Dew Point)



(Courtesy of Paul Dirmeyer)

Summary

- The 2020 Western Wildfires were the primary contributor to 3,700+ exceedances of the National Ambient Air Quality Standard for $PM_{2.5}$.
- In 2020, 22,494 excess deaths were attributed to exposure to wildfire smoke pollution in the Contiguous United States.
- Indirect cost of wildfires from health effects of smoke pollution ($220B in 2020) is much higher than direct losses (fire suppression, life/property losses).
- Climate and unique weather events are behind the 2020 western US wildfires.

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