

# Wildfire smoke exposure along Colorado's Front Range during summer 2020: Untangling local and regional fire contributions with observations and models

Brandon McGuire  
[brandon.mcguire@colostate.edu](mailto:brandon.mcguire@colostate.edu)



Photo: Mike Natoli  
Fort Collins 8/18/2020



EPA Award #:  
84036301

# Colorado State University Team

## **Department of Atmospheric Science**

Brandon McGuire, Milena Guajardo, Jeffrey Pierce, Emily Fischer

## **Department of Journalism & Media Communication**

Ashley Anderson, Katie Abrams, Channing Bice, Lucy Chalgren

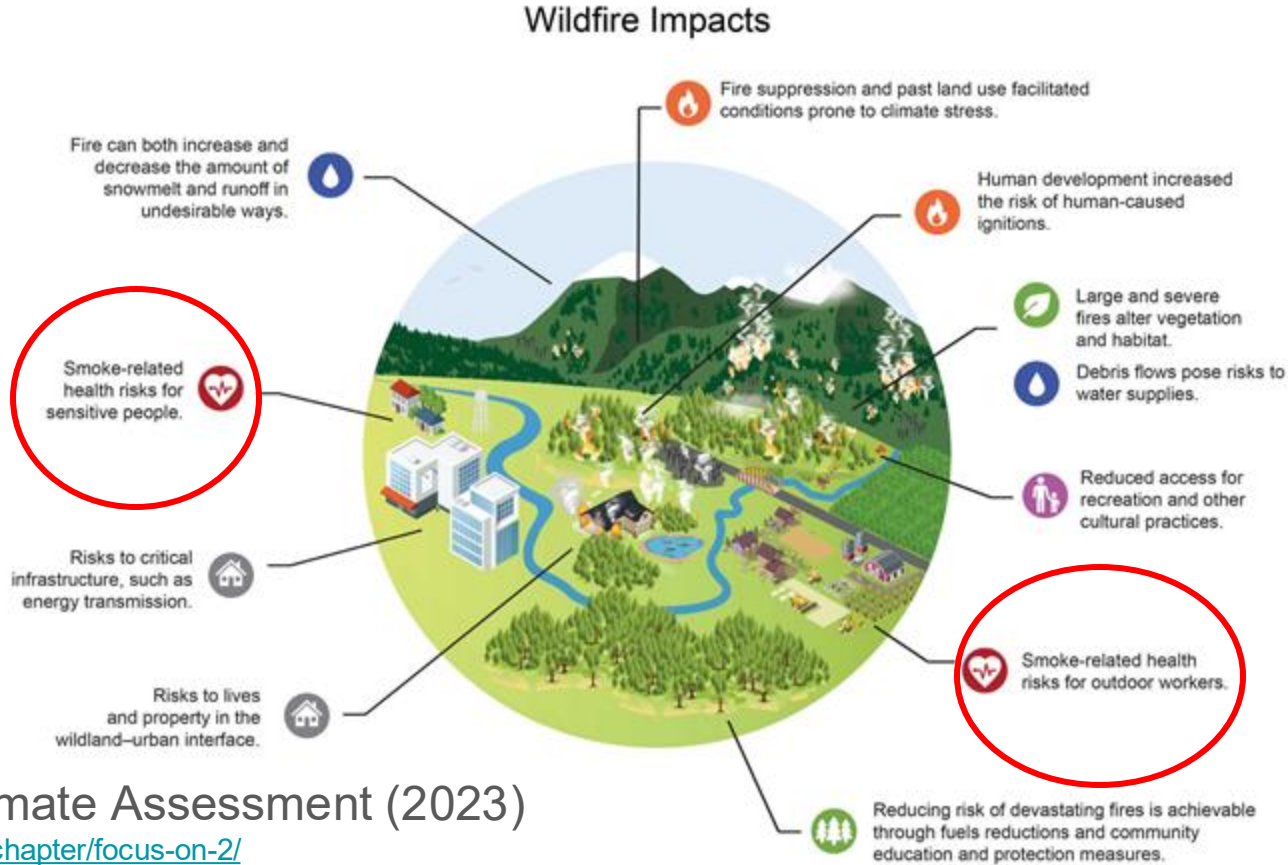
## **Department of Environmental & Radiological Health Sciences**

Sheryl Magzamen

## **Cooperative Institute for Research in the Atmosphere**

Bonne Ford

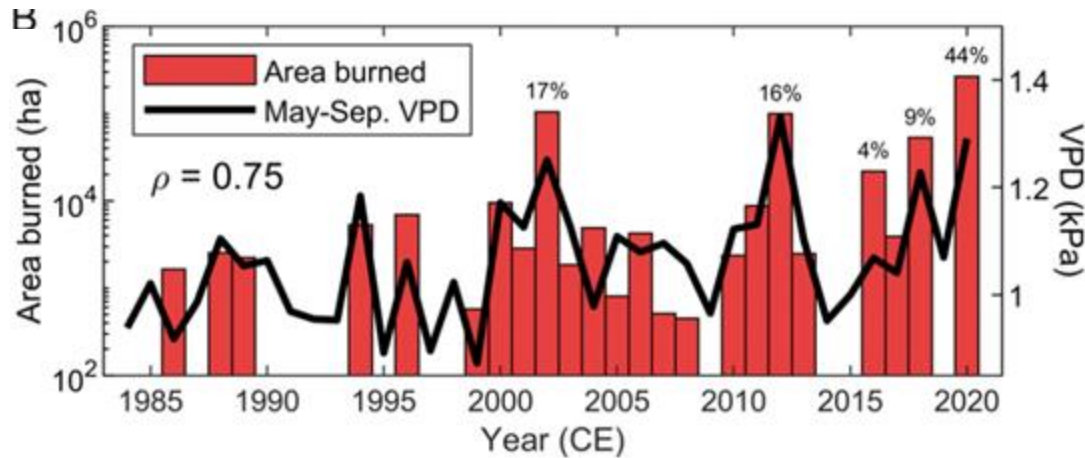
# Climate-driven increases in wildfire smoke are a growing concern for health, particularly for sensitive individuals and outdoor workers.



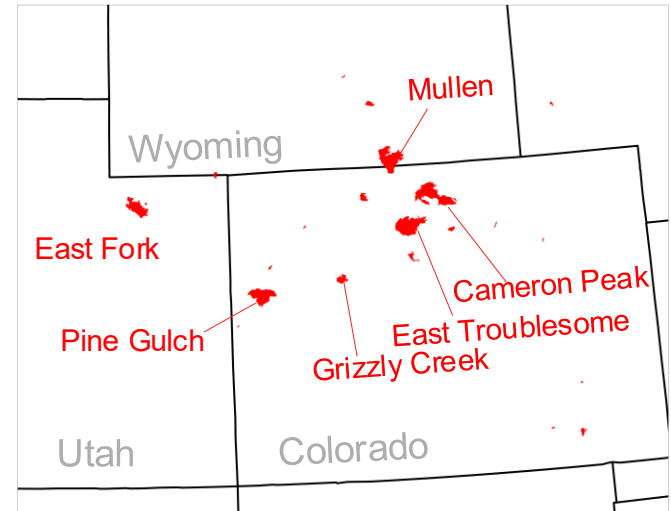
The Fifth National Climate Assessment (2023)

<https://nca2023.globalchange.gov/chapter/focus-on-2/>

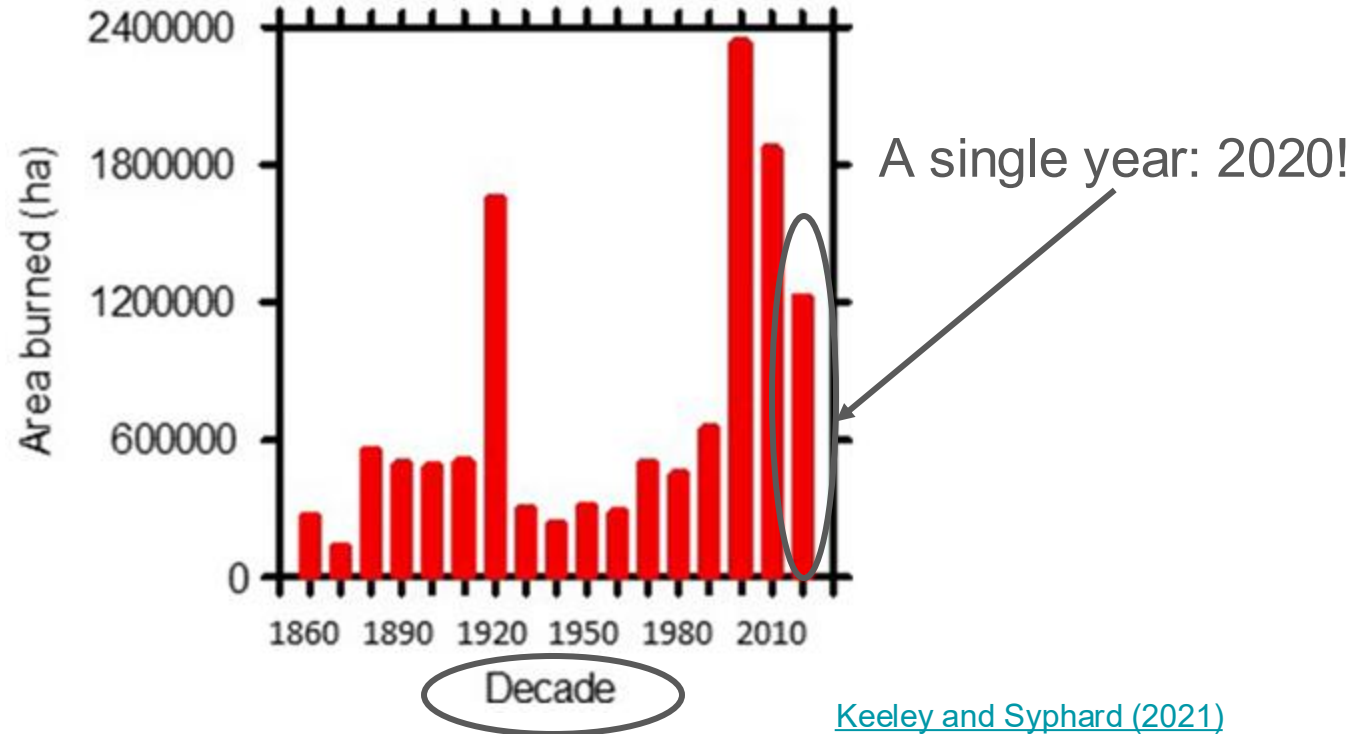
95% of the **area burned** in the central Rockies since 1984 occurred in the 21<sup>st</sup> century. 2020 accounted for 44% of the **area burned**!



[Higuera et al. \(2021\)](#)

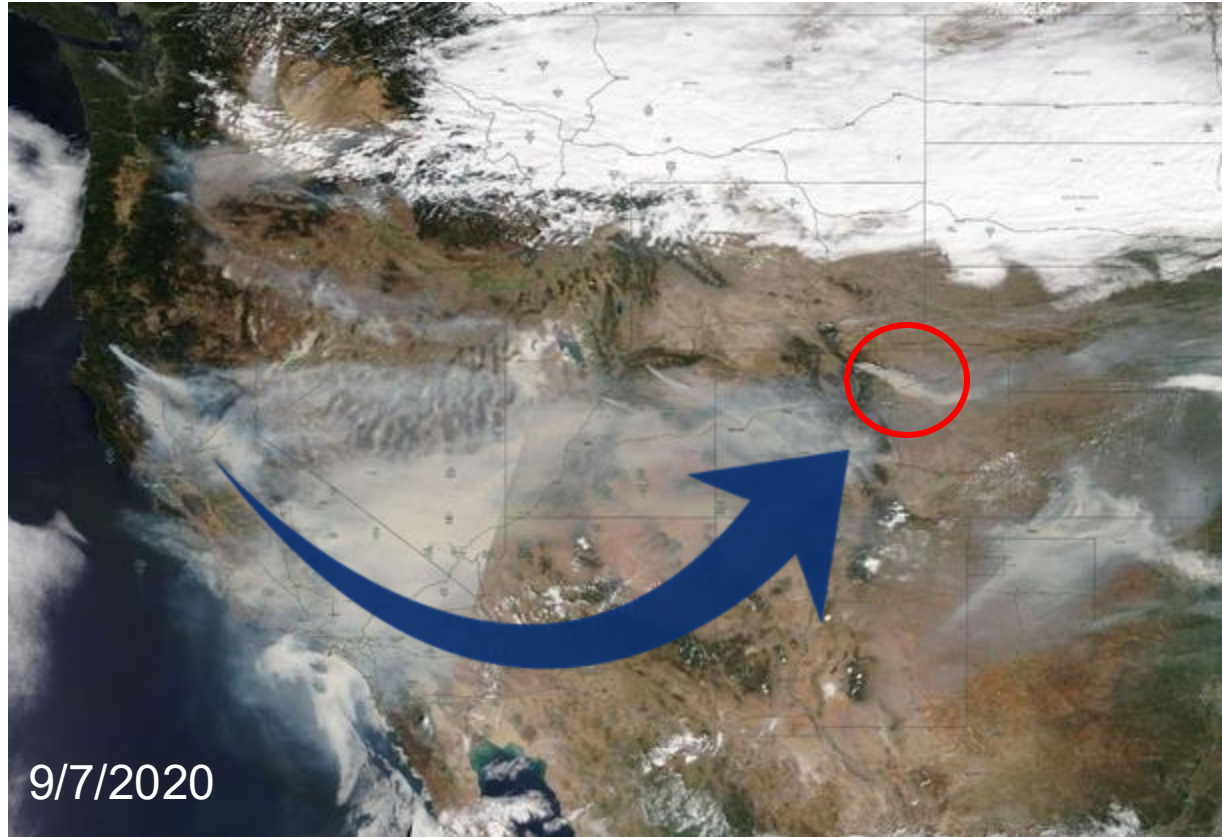


Broadly, 2020 was an extraordinary fire year. In California, historical data shows a significant **area burned** in 2020 alone.

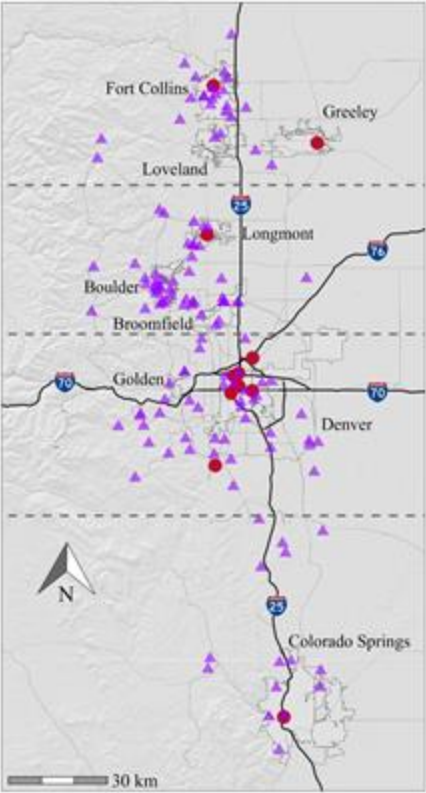


[Keeley and Syphard \(2021\)](#)

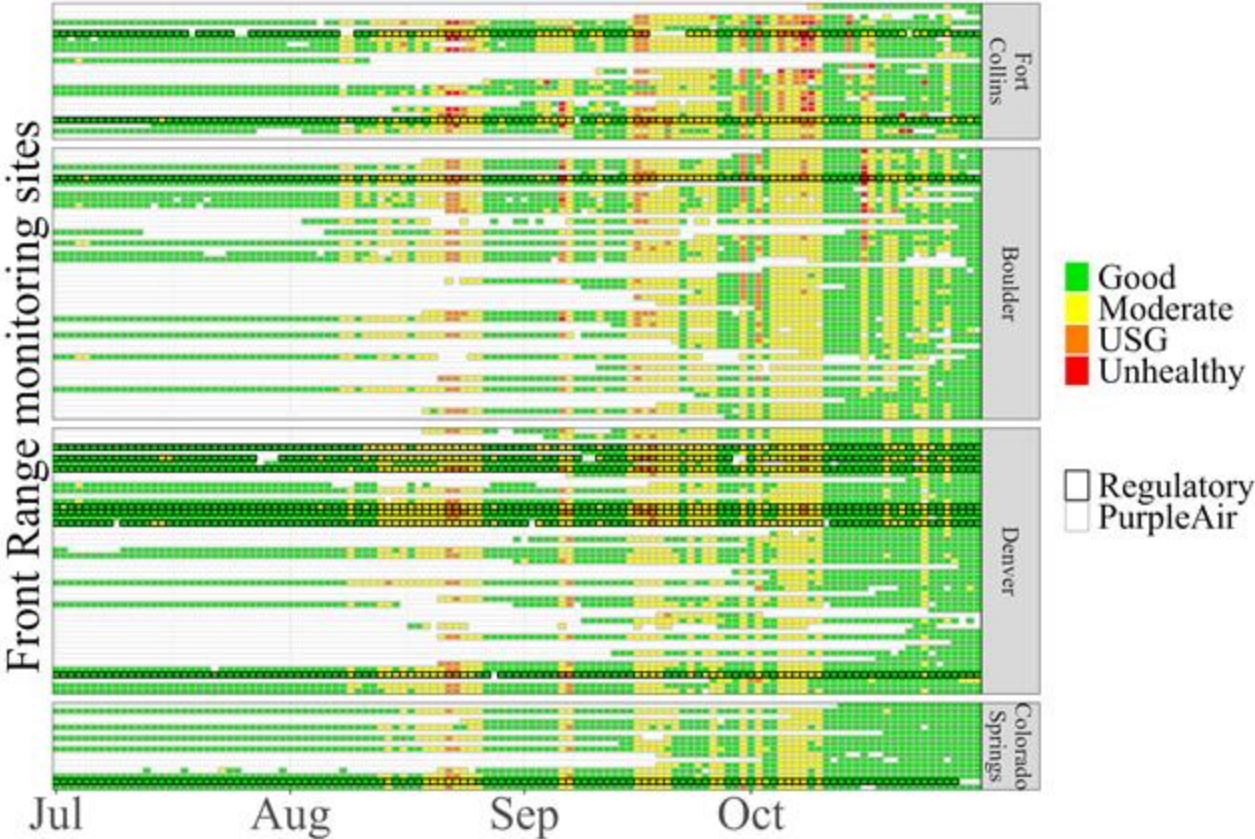
Both **local** and **long-range transported** smoke affected the Front Range in 2020.



# Regulatory and PurpleAir monitors measured week-long periods with moderate to unhealthy PM<sub>2.5</sub> levels in 2020.



● Regulatory ▲ PurpleAir



# How well is western wildfire smoke:

## Captured by regulatory monitoring?

Doesn't capture smoke **variability when fires are local**

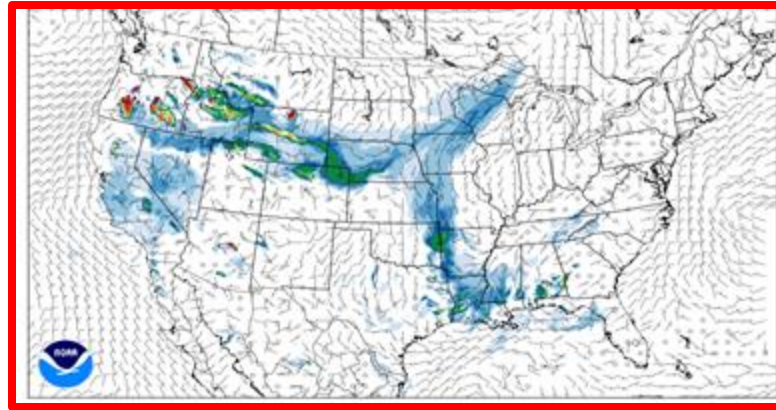
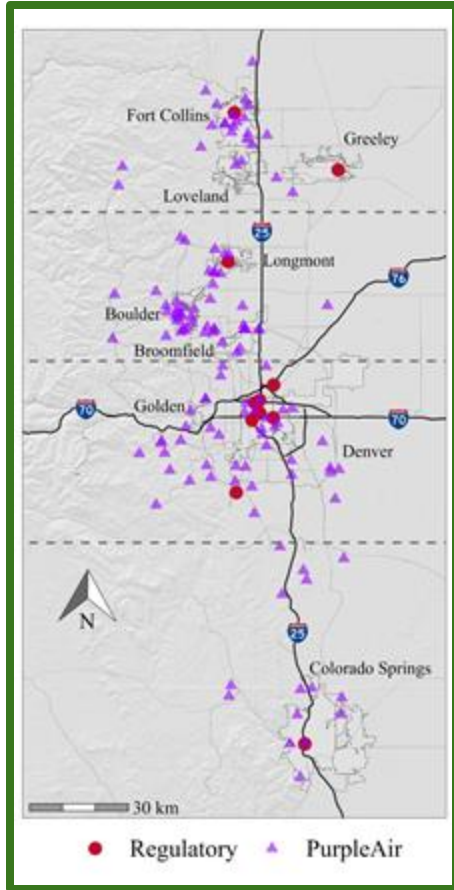
**Best suited for large plumes** evenly impacting populated areas

## Predicted by forecasts?

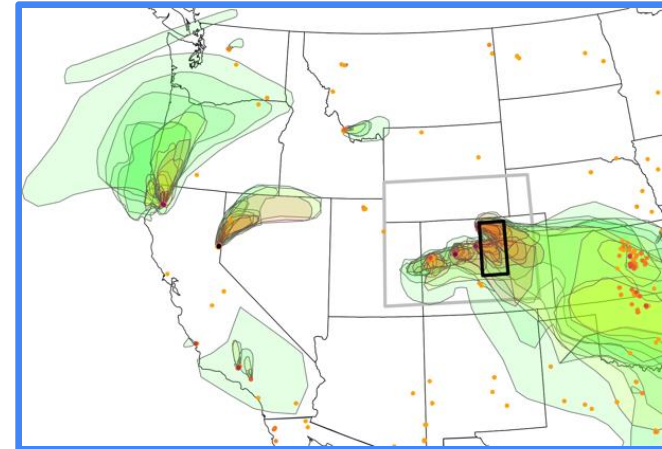
Best predictions associated with **long-range transported smoke**

Forecasts still challenged by **local fires**

We compared state and local (SLAMS) and PurpleAir monitors with HRRR-smoke modeled forecasts on HMS smoke days.

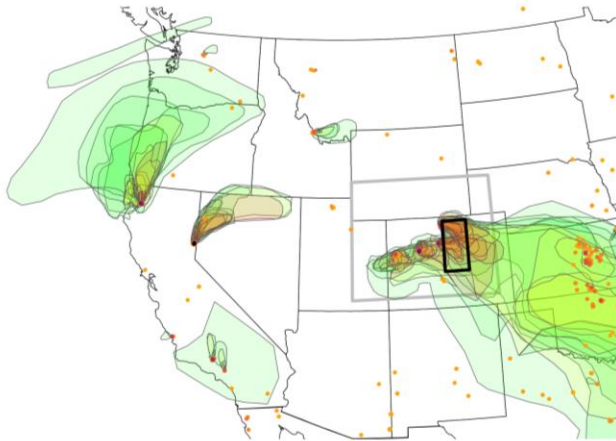


131 outdoor PurpleAir monitors and 11 EPA AQS SLAMS monitors in 2020.



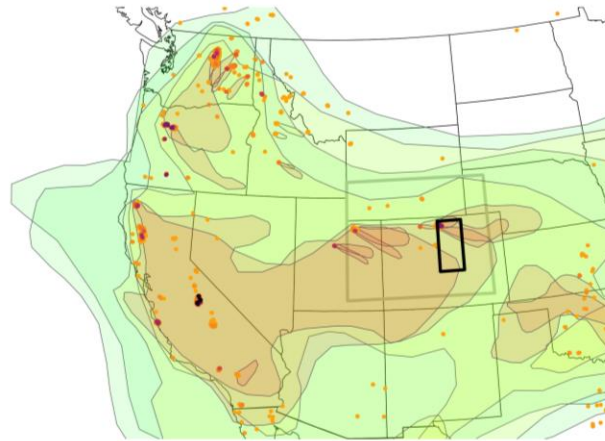
We used HMS to classify smoke plume type daily over the course of the 2020 wildfire season.

**LOCAL**



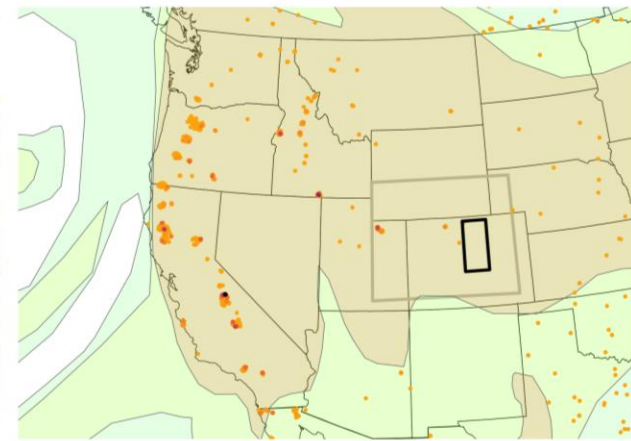
narrow plumes

**MIXED**



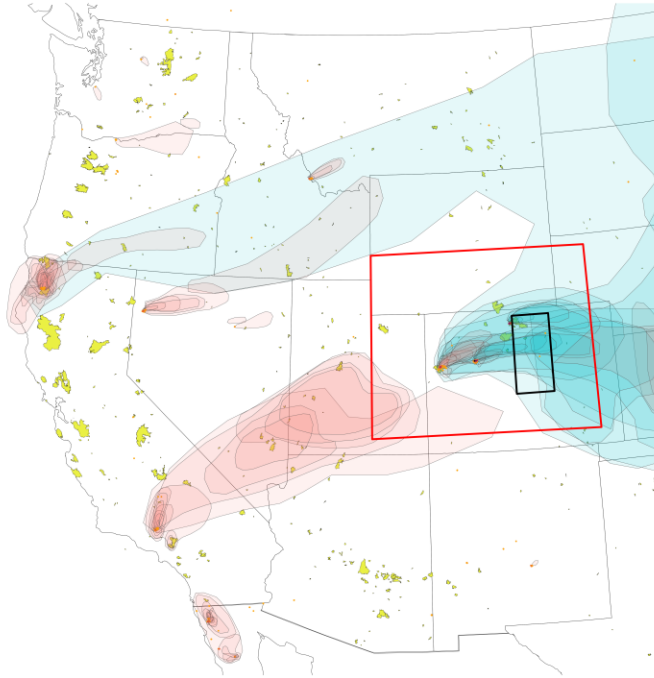
multi-scale plumes

**Long Range Transport (LRT)**

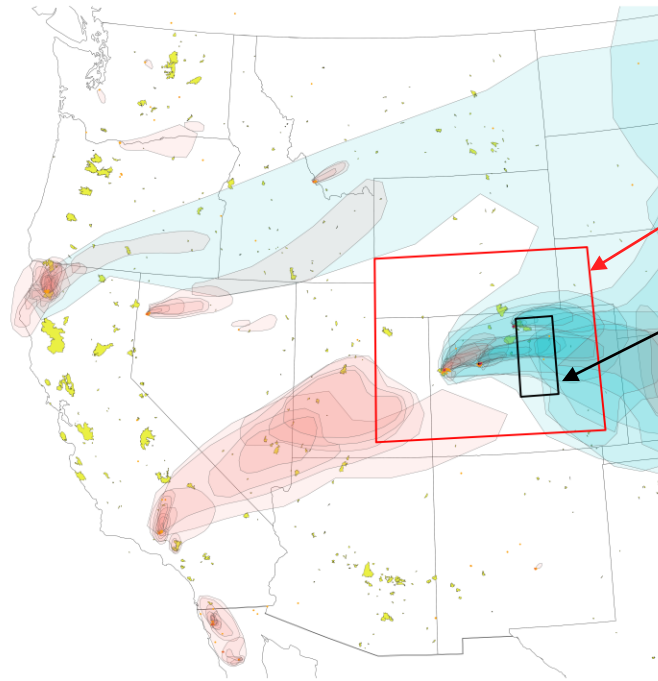


large multi-state plumes

We use the plume intersection polygons to automatically assign each day to a category.



We use the plume intersection polygons to automatically assign each day to a category.

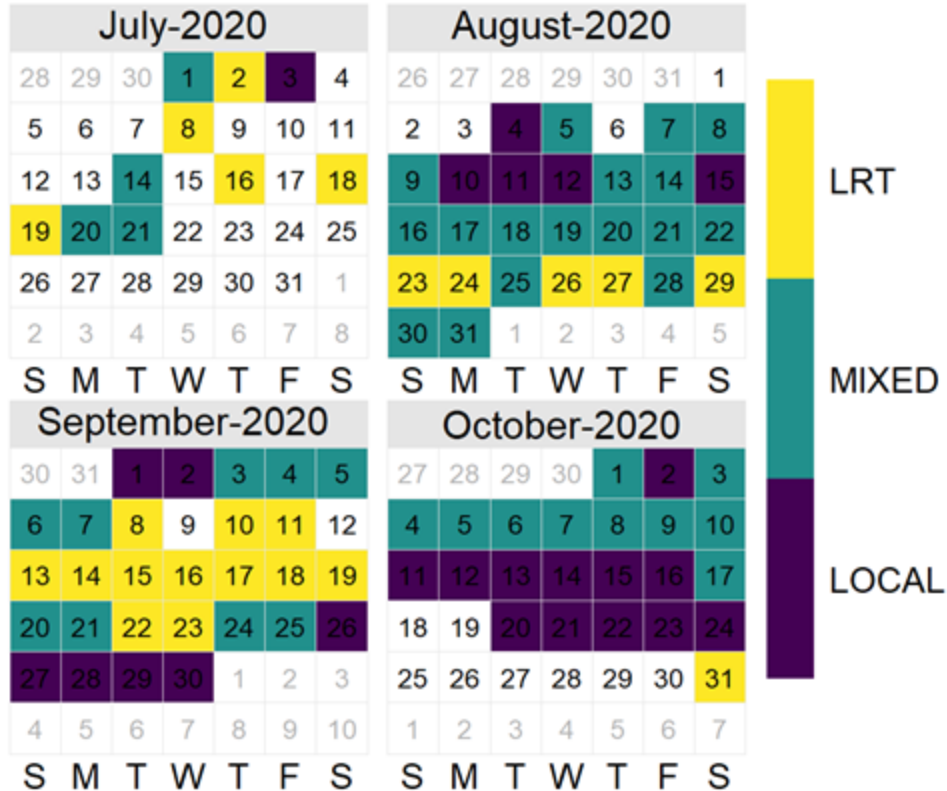


Local fire box

Study area

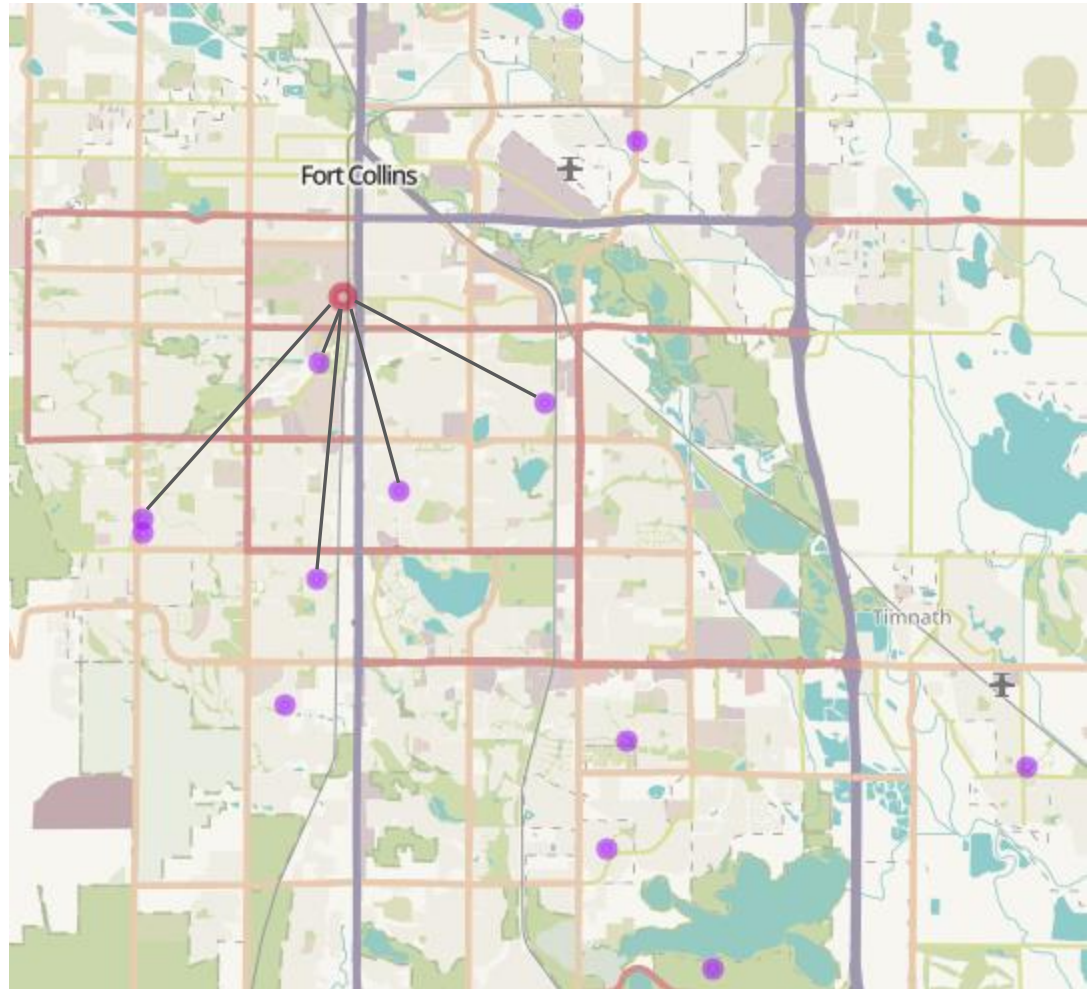
The intersecting plumes (blue) originating within the red box are considered LOCAL smoke and the plumes from outside the red box are long range transport (LRT) smoke. MIXED smoke days contain contributions from both.

Days were classified through the season: **25 LOCAL** days, **23 LRT** days, and **40 days** with **MIXED** smoke.

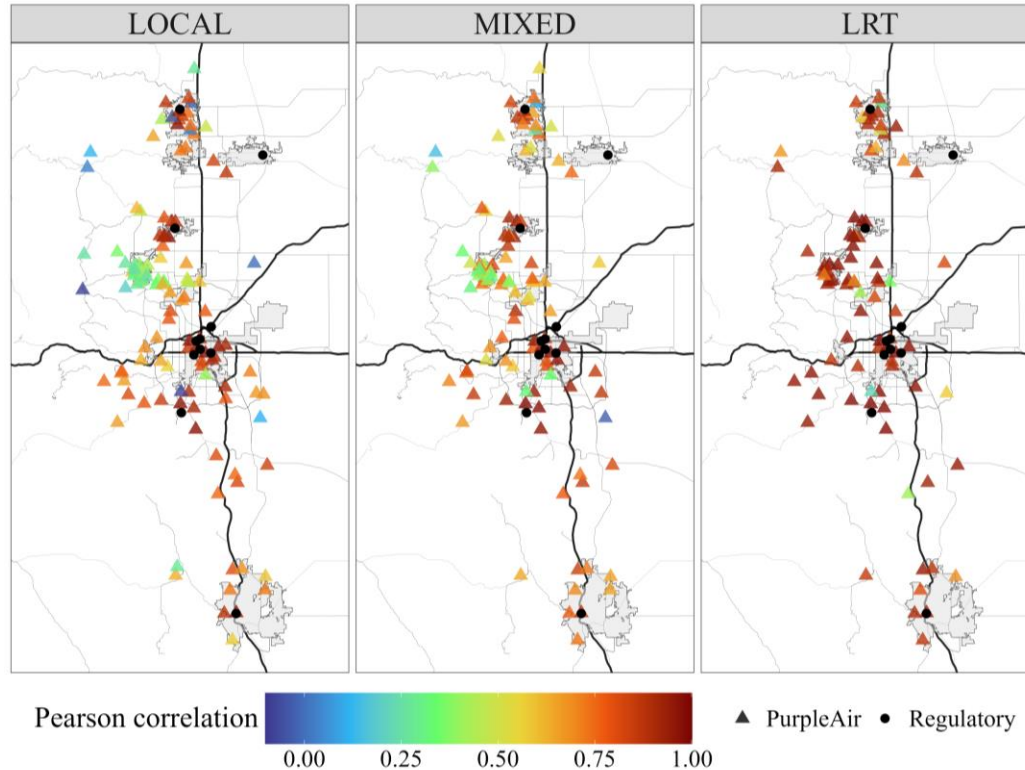


# Monitoring

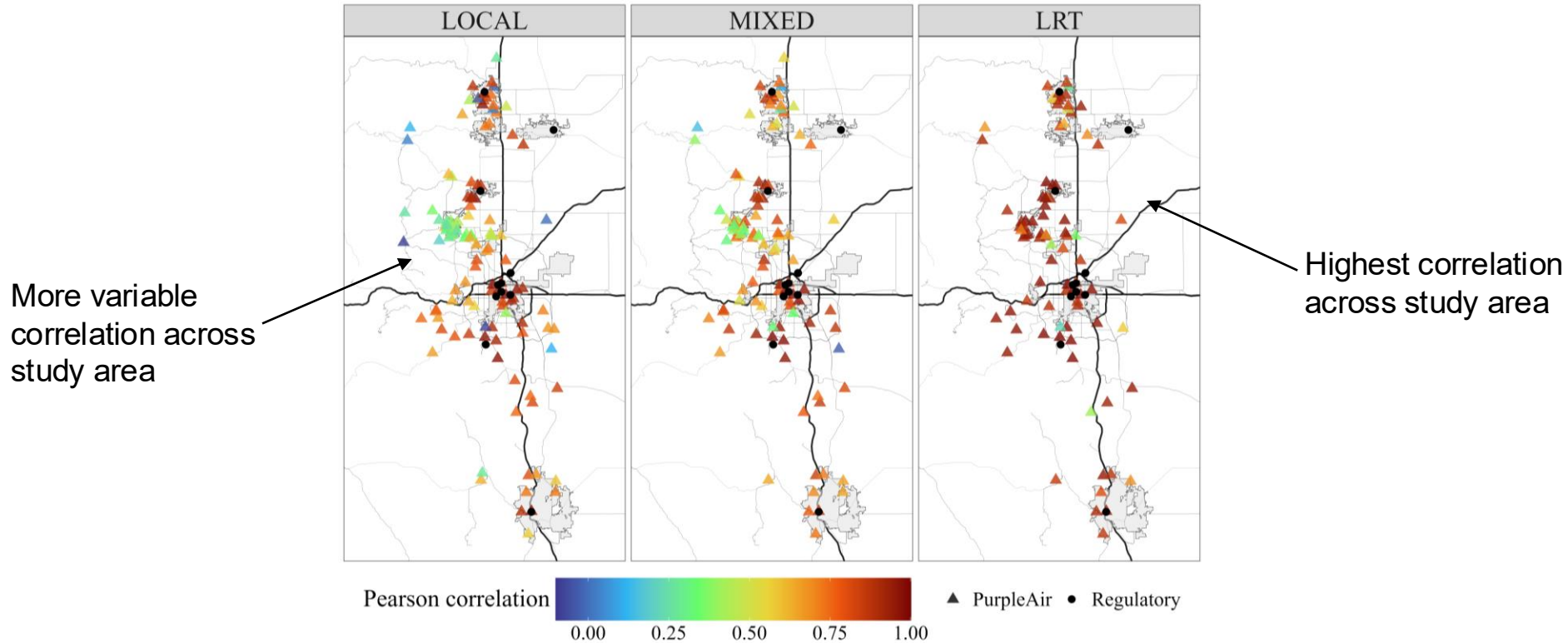
We quantify relationships between the **PurpleAirs** and **SLAMS** monitor by looking at every PurpleAir and its nearest regulatory neighbor.



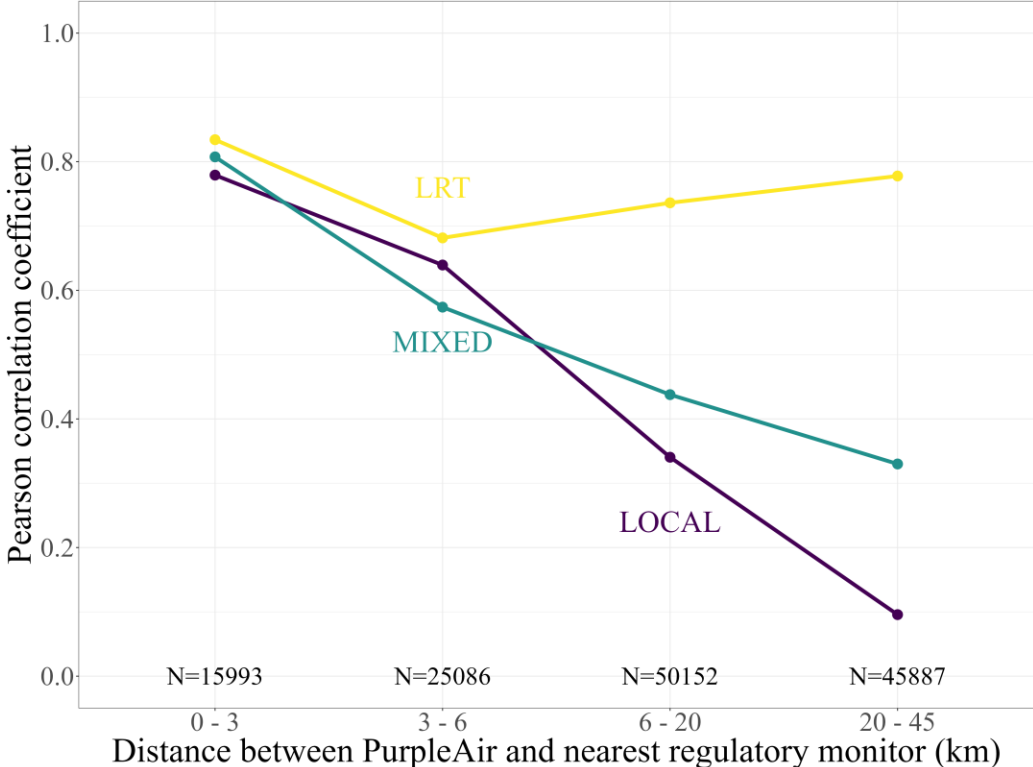
We determine the correlation between each PurpleAir and the nearest regulatory monitor, by smoke category.



We determine the correlation between each PurpleAir and the nearest regulatory monitor, by smoke category.

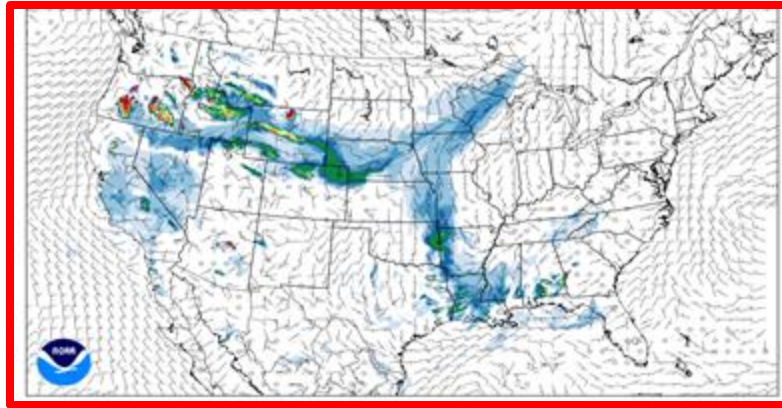


For LRT periods, monitors spaced < 20 km is sufficient.  
For local plumes, ~6 km spacing likely needed

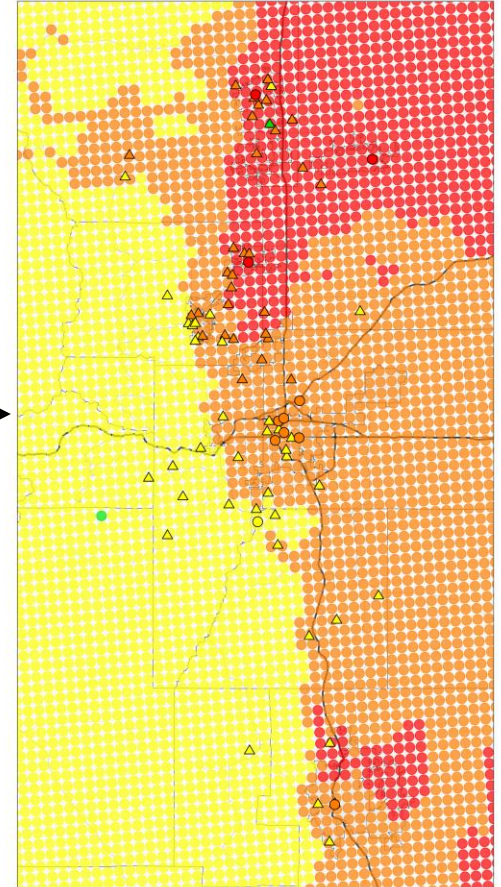


# Forecasts

HRRR-smoke hourly forecast data was compared to measured concentrations.



09/17/2020 04:00



Example day that shows  
good hourly AQI agreement.

10/02/2020 00:00

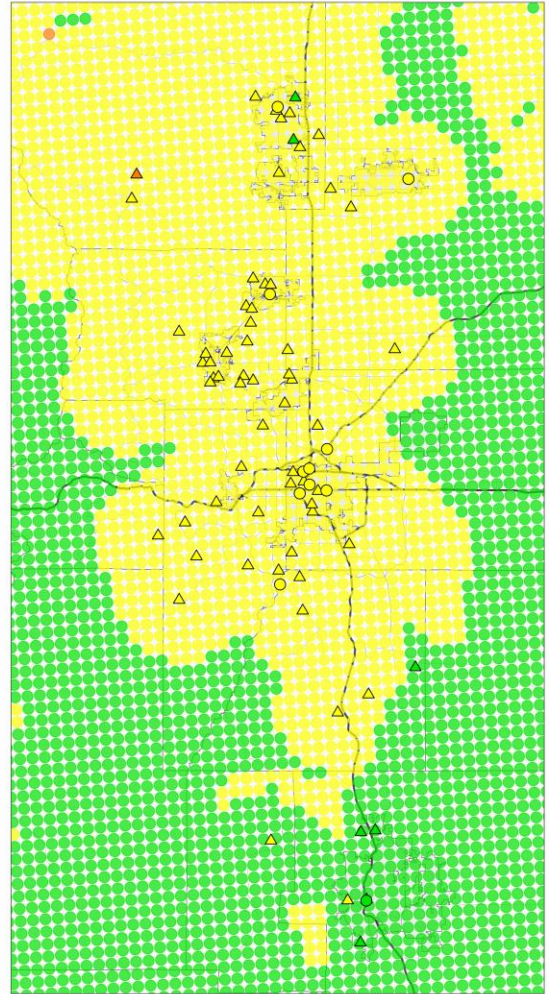


Smoke category: LOCAL

Example day that shows  
good hourly AQI agreement.

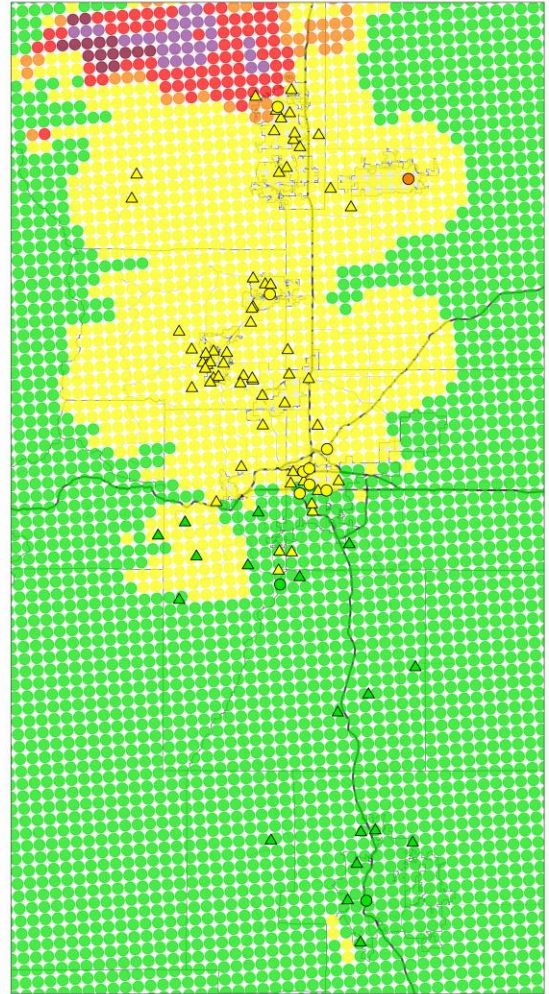
Smoke category: LRT

09/16/2020 00:00



Example day that shows the forecasted plume to be a few hours behind the observations.

09/26/2020 00:00



Smoke category: LOCAL

Example day which shows a forecasted overprediction of the plume compared to observations.

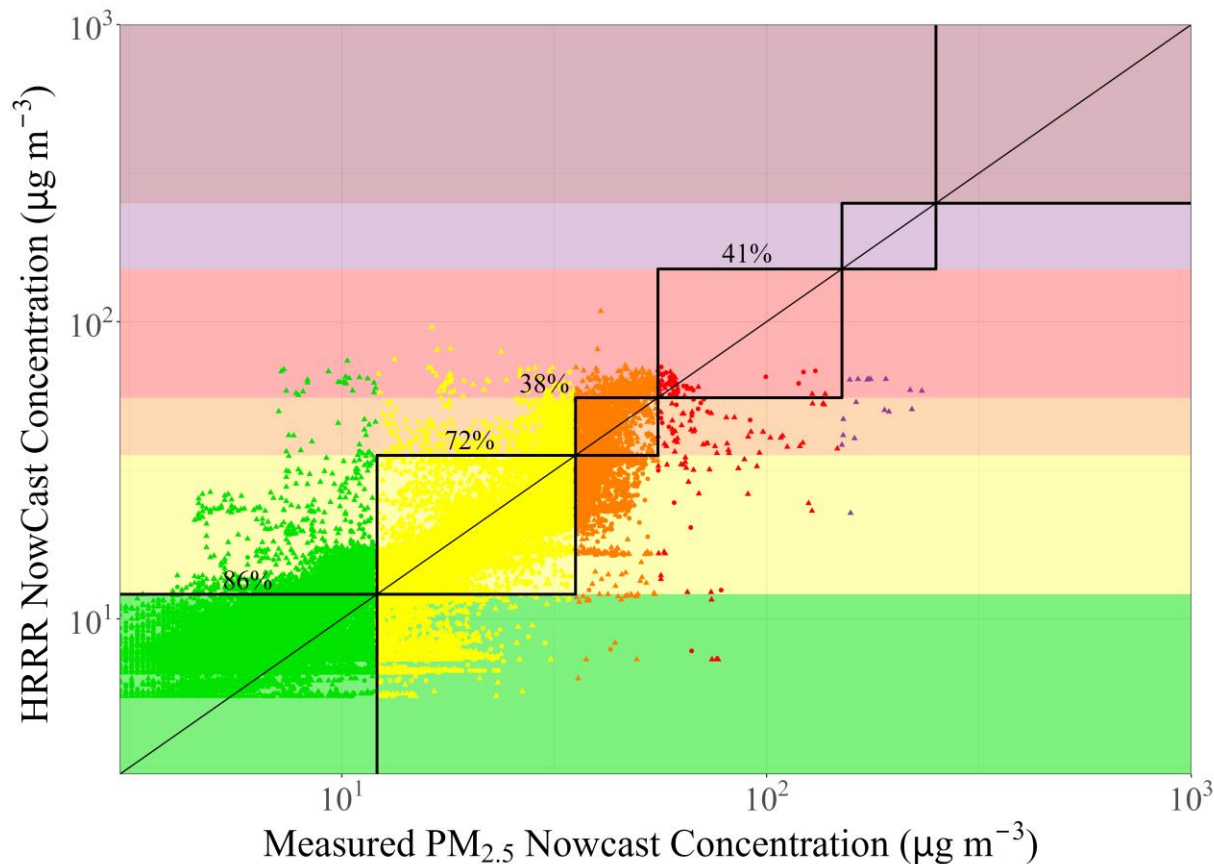
10/05/2020 00:00



Smoke category: MIXED

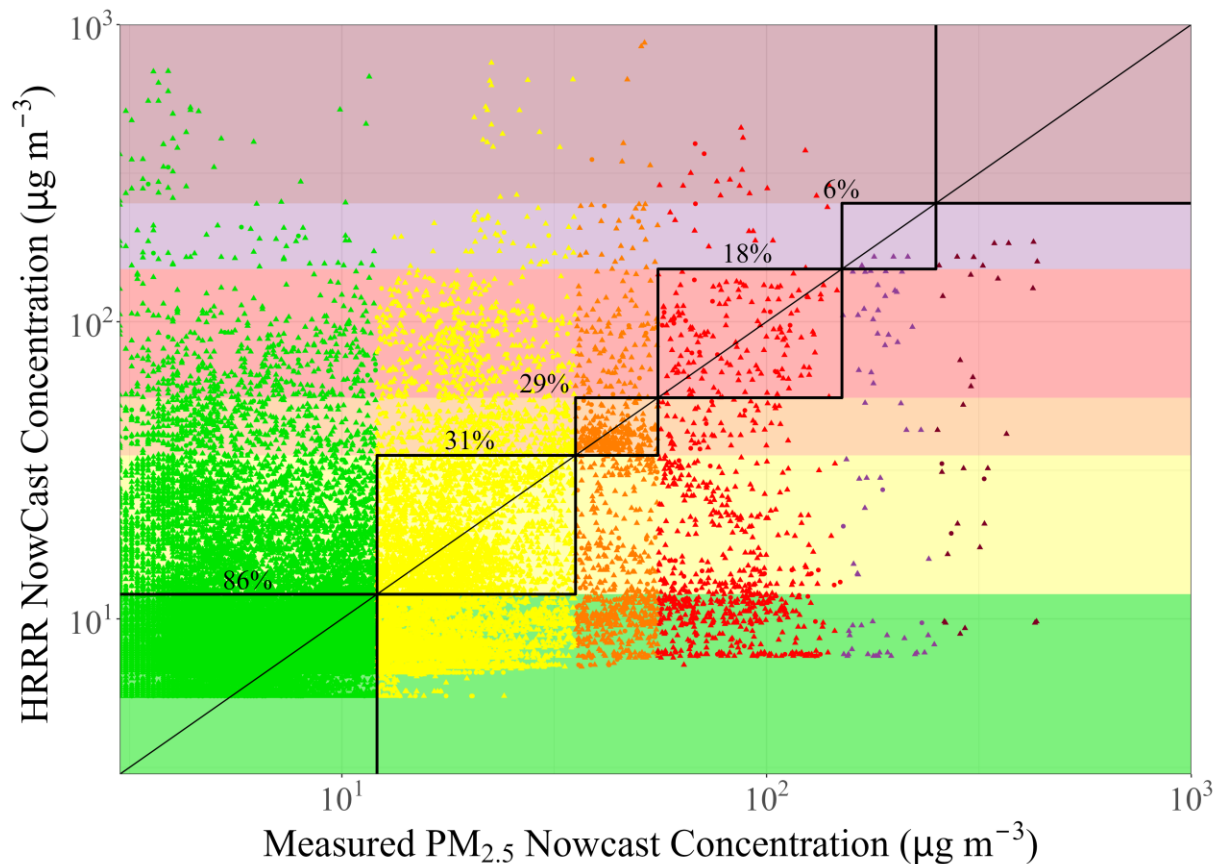
HRRR-smoke often predicts the correct hourly health effect category for LRT smoke.

*Points colored by measured HEC, boxes indicate HEC agreement. Percentages indicate HEC matches.*



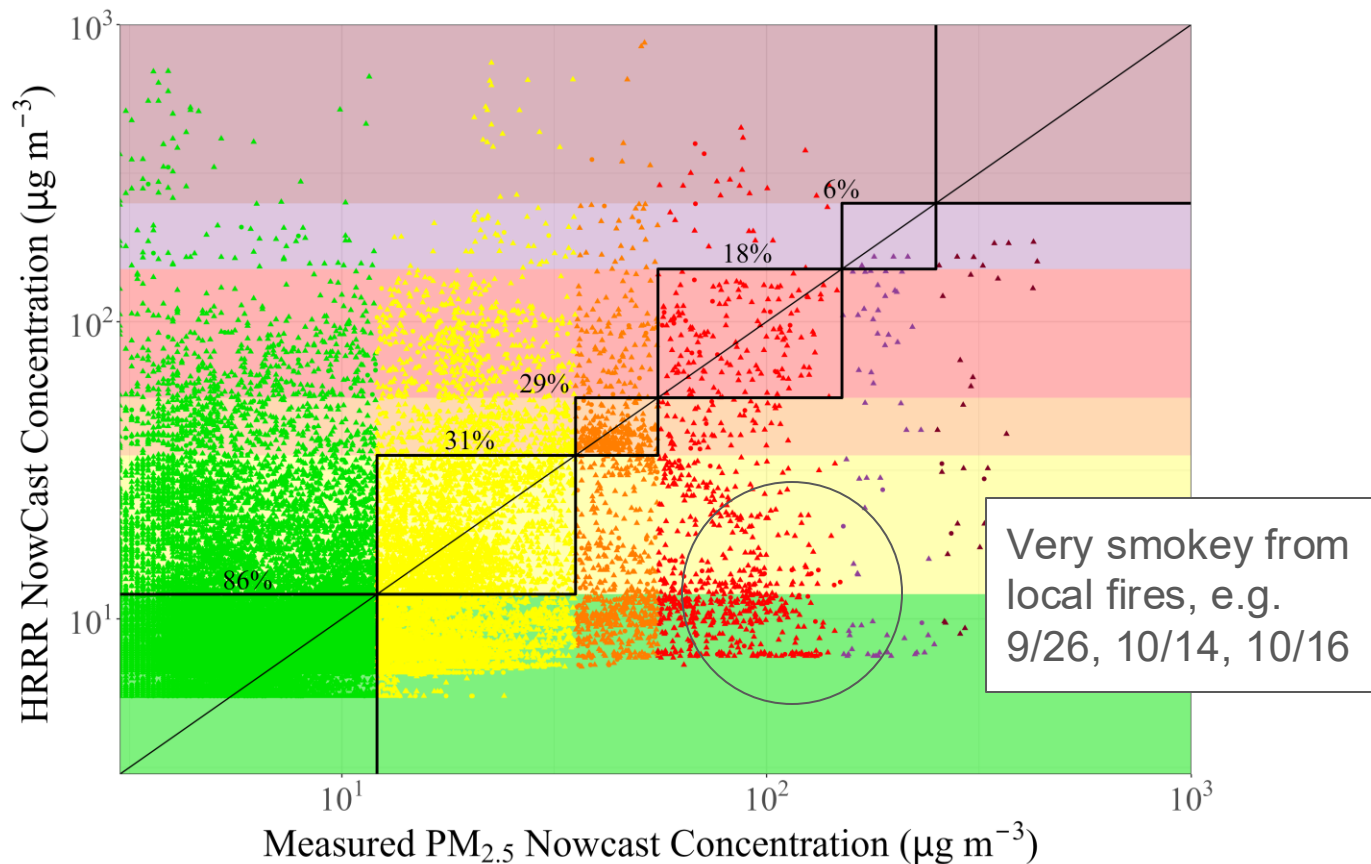
HRRR-smoke predictions are more variable under LOCAL smoke conditions.

*Points colored by measured HEC, boxes indicate HEC agreement. Percentages indicate HEC matches.*



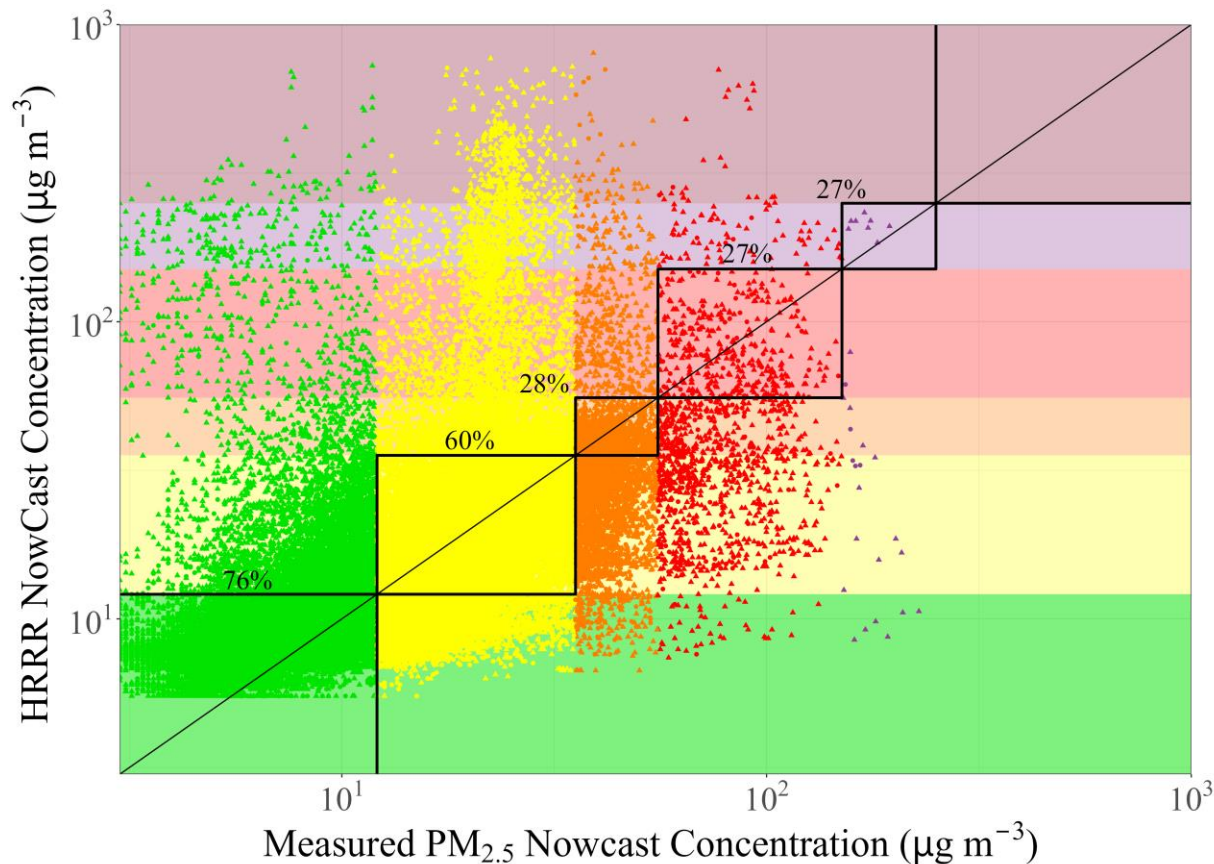
HRRR-smoke predictions are more variable under LOCAL smoke conditions.

*Points colored by measured HEC, boxes indicate HEC agreement. Percentages indicate HEC matches.*

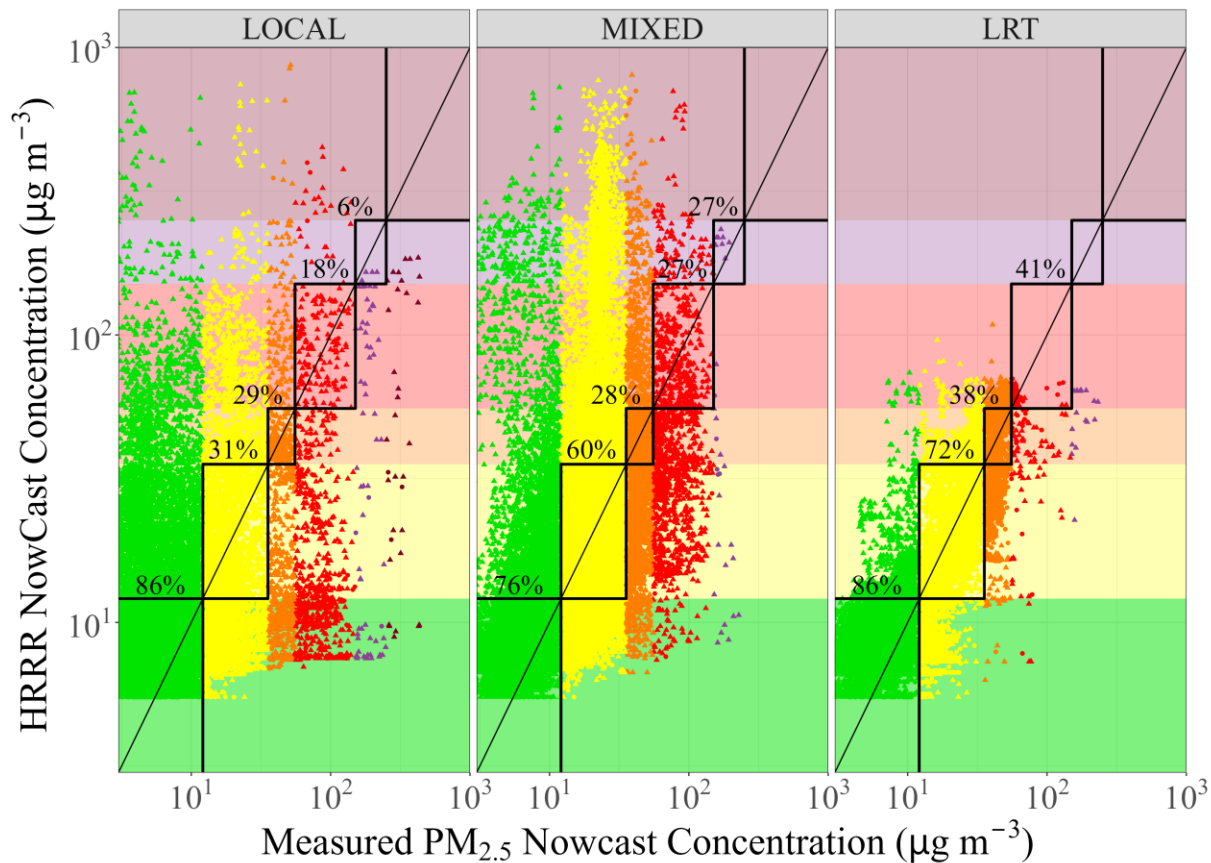


HRRR-smoke predictions are also variable for MIXED smoke days.

*Points colored by measured HEC, boxes indicate HEC agreement. Percentages indicate HEC matches.*



HRRR-smoke often predicts the correct hourly health effect category for LRT smoke.



# HRRR-smoke often predicts hourly concentrations to within one health effect category (HEC)

<b>Smoke Category</b>	<b>Observations</b>	<b>Same HEC (%)</b>	<b>Within one HEC (%)</b>
LOCAL	All Data	74.5	94.5
	Data in elevated HEC	29.3	84.1
MIXED	All Data	65	93.4
	Data in elevated HEC	54.3	90.1
LRT	All Data	76.8	99.5
	Data in elevated HEC	64	99.2

# Conclusion

- Based on this case study, we find a 6 km monitor spacing captures the nuances of wildfire smoke when the fires are nearby (less than ~ 600 km).
- HRRR-smoke does well capturing long-range transported smoke. Forecasts from local fires show more variable agreement with observations.
- Even so, we show that HRRR-smoke predicts > 84% of the hourly AQI to within one health effect category.
- Supplemental sensors and forecasting systems can be useful tools to more fully characterize wildfire smoke and communicate precautions to the public.