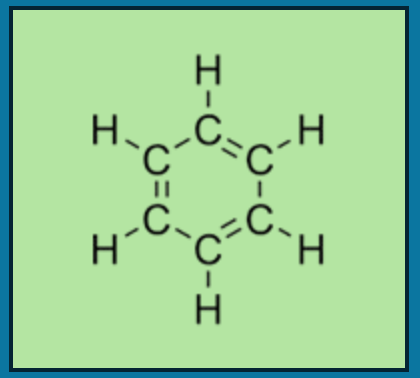
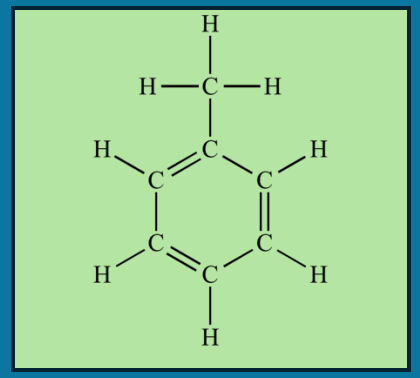
VOCs

Volatile **O**rganic **C**ompounds

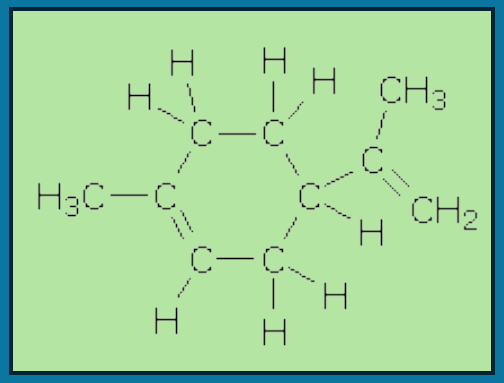
- Evaporates at or near room temperature
- Contains carbon atoms
- Contains a mix of different atoms



Benzene



Toluene



Limonene

PM 10 or 2.5

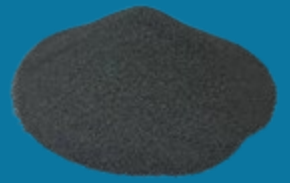
particulate matter less than 10 microns

particulate matter less than 2.5 microns

- Solid and/or liquid particles suspended in the air
- Dust that is visible is about 25 microns in size

Black Carbon

Nitrate



Trace Metals

Polycyclic Aromatic Hydrocarbons

Eaton Fire

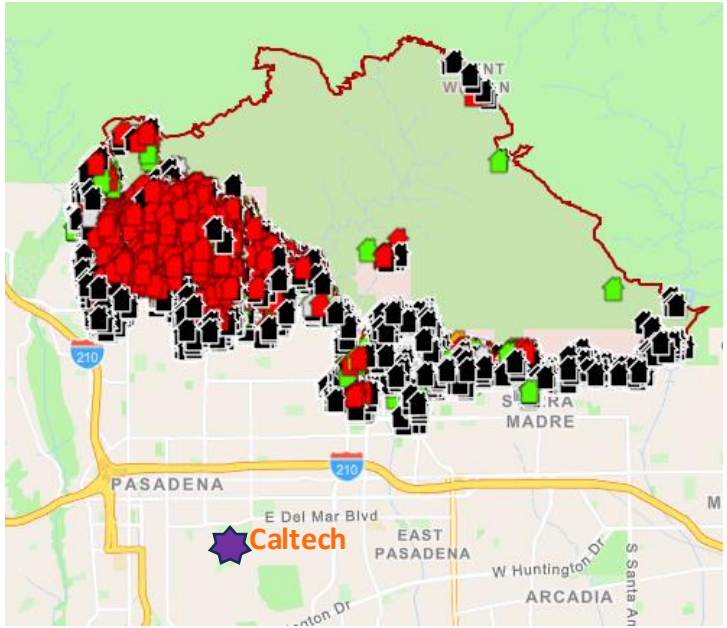
Fire started on January 7th 2025, around 6:10 pm, in Eaton Canyon.

Windstorm with gust at 100 mph all through the night

January 12th 30% containment

- +14,000 acres
- 9,418 structures destroyed
- 1,073 structures damaged

January 27th 95% containment



https://recovery.lacounty.gov/eaton-fire

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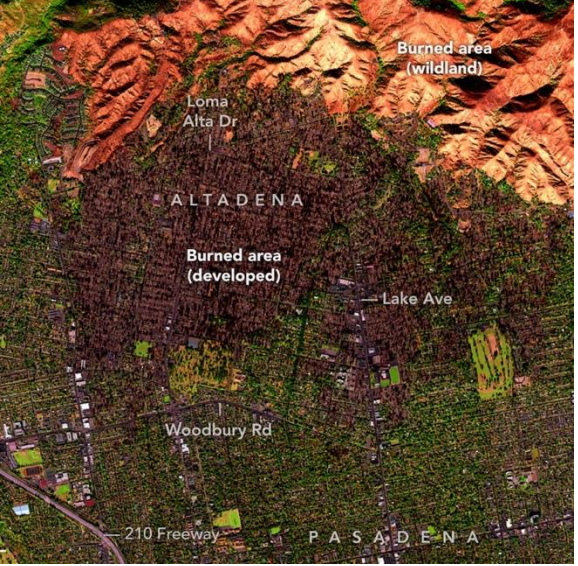
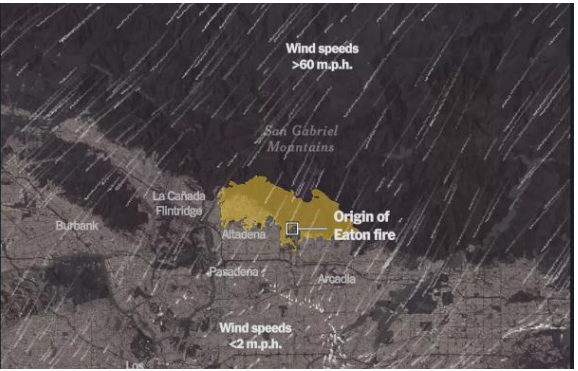


NASA Earth Observatory images annotated by Lauren Dauphin using data from Airborne Visible / Infrared Imaging Spectrometer-3 (AVIRIS-3) instrument, via NASA Earthdata Search.



Sources: Cal Fire, NOAA's National Centers for Environmental Prediction - January 8th 2025

Risk Assessment

*"A risk assessment is a process that **identifies potential hazards** and analyzes the **likelihood and severity of harm** they may cause"*

1 - Hazard Identification

- Wildfire smoke, ash and dust
- Urban fire smoke, ash and dust
  - Likely to contain toxic material – lead, asbestos, volatile organic compounds (VOC), other.

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Risk Assessment:

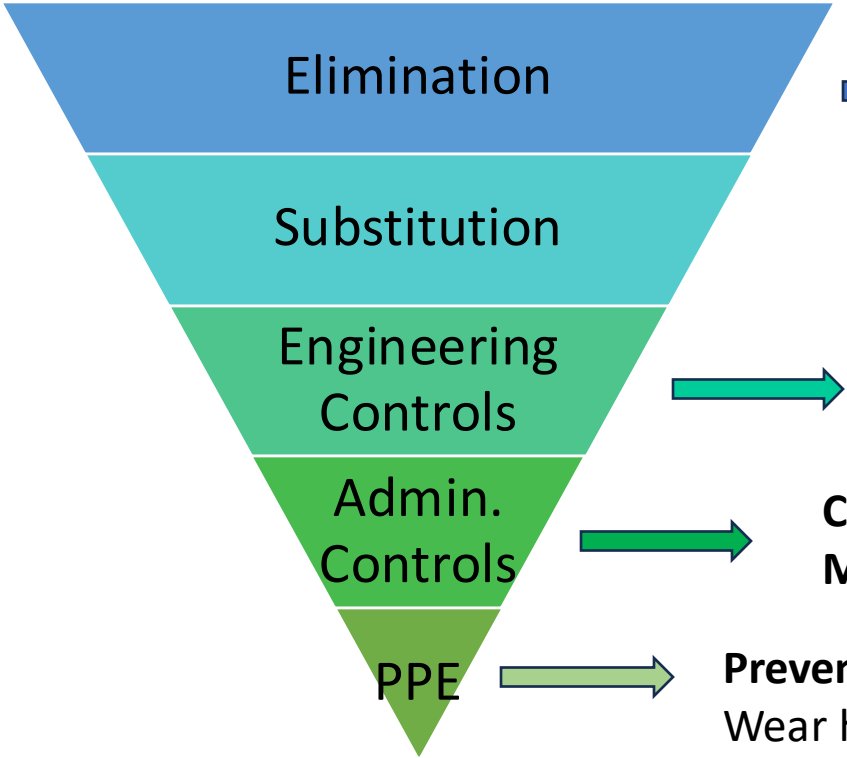
2-Potential for harm Likelihood x consequence (exposure dose & time)

- **Short Term:**
  - Higher dose of smoke and air contaminants
  - 1-4 days
  - **Route of exposure**
    - **Direct inhalation of smoke**
    - **Direct contact**

- **Long Term:**
  - Lower dose
  - Settled source
  - **Route of exposure:**
    - **Inhalation of disturbed ash and dust**
    - Skin/eye contact
    - Ingestion (young children)

<u>Individual circumstances also impact risk assessment</u>

Risk mitigation – Hierarchy of controls



Leave the area
Remove, clean-up dust and ash using wet methods (prevent disruption of dust/ash)

Filtration = capture/block hazard
HVAC systems
Individual rooms

Control entry points: windows/doors opening
Monitor hazard: AQI levels outdoor and indoor

Prevent exposure at the individual level:
Wear high-quality mask – N95
Glove and Tyvek suit when cleaning-up ash

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Containment Measures

Preventing the outdoor contaminants to reach people inside laboratories, offices and homes

Wet clean dust and ash
Use HEPA vacuum interior/carpets

Improve HVAC air recirculation and filtration:
2100 MERV-13/charcoal filter ordered and being deployed
21 x 48”x100ft rolls of charcoal filter
Individual air purifiers

- 1500 units in Student Housing
- 900 units in Campus Buildings

Addition of sticky mats at building entry
Assessment of windows and door seal quality.
Remove shoes before entering

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Monitoring Air Quality

Monitoring outdoor air quality (PM2.5)

(Caltech AQI or AirNow.gov)

Indoor Air Quality (PM2.5)

- Spot check throughout Campus
- Continuous monitoring – building assessment
  - 10 monitors deployed around campus – 1/13 to 1/30
  - Understand building behavior for indoor *versus* outdoor air quality
    - +/- air purifier
  - Assess efficiency of mitigation practices

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Air Quality Assessment During January 2025 Los Angeles Fires

Sina Hasheminassab (JPL)
Haroula Baliaka (Caltech)

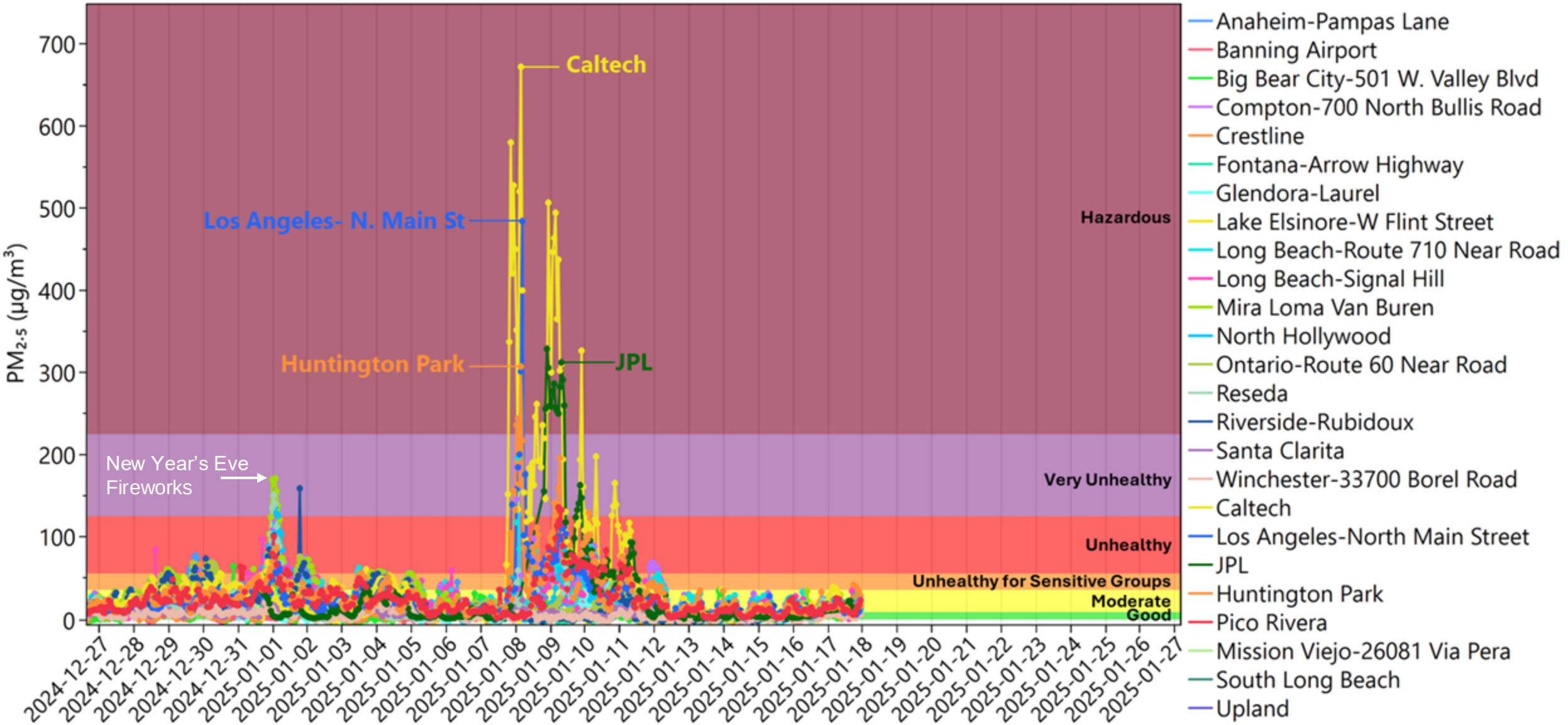
31 January 2025

Satellite imagery from Copernicus Sentinel-3, acquired on January 9, 2025

Spread of Wildfires Smoke Seen from Space

Data Source: GOES East Advanced Baseline Imager; Animation created using NASA Worldview tool

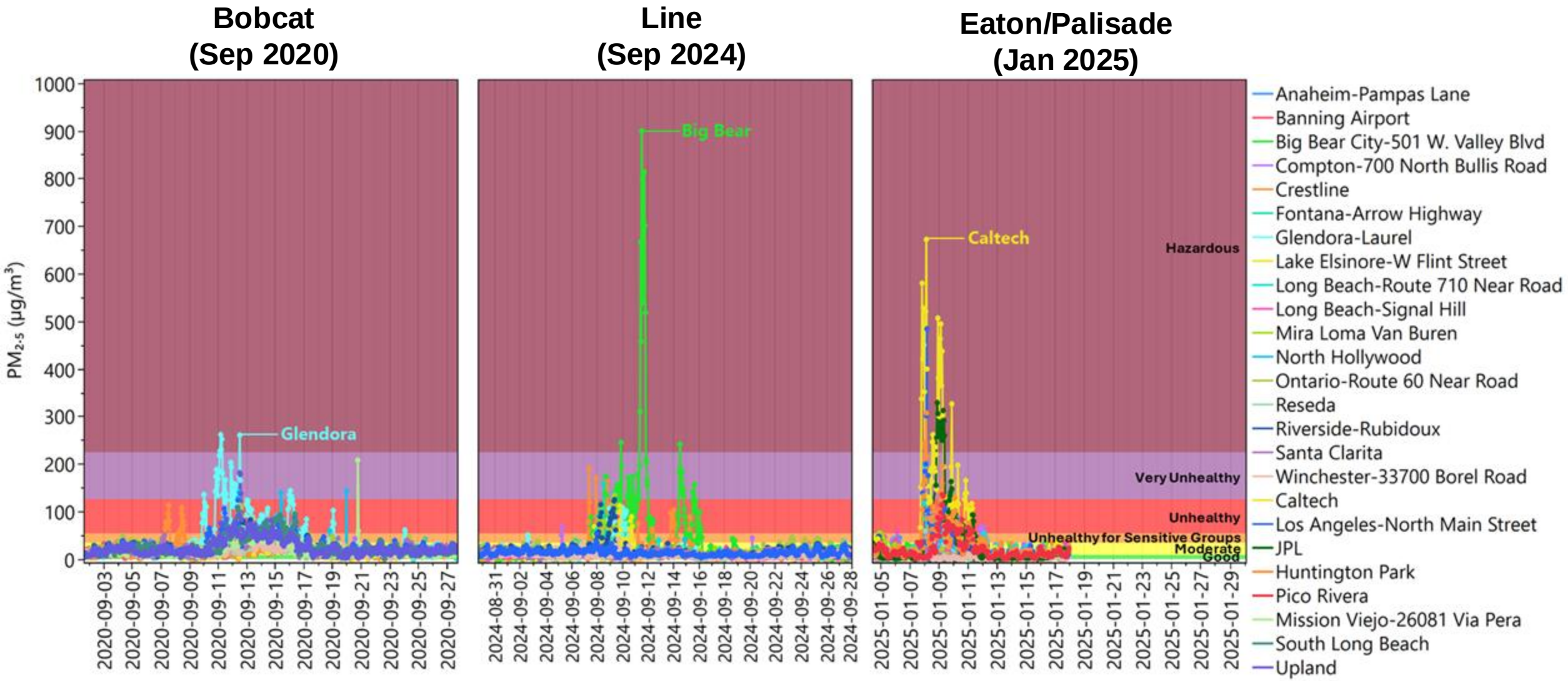
Hourly Outdoor $PM_{2.5}$ Levels Across the Los Angeles Basin During Eaton/Palisade Wildfires



Note: PM2.5 at JPL and Pico Rivera was measured using research-grade instruments (i.e., non-EPA-approved methods).

Data Sources: CARB's Air Quality and Meteorological Information System; Caltech (Dr. John Crounse); ASCENT Network (Haroula Baliaka; Dr. Sally Ng)

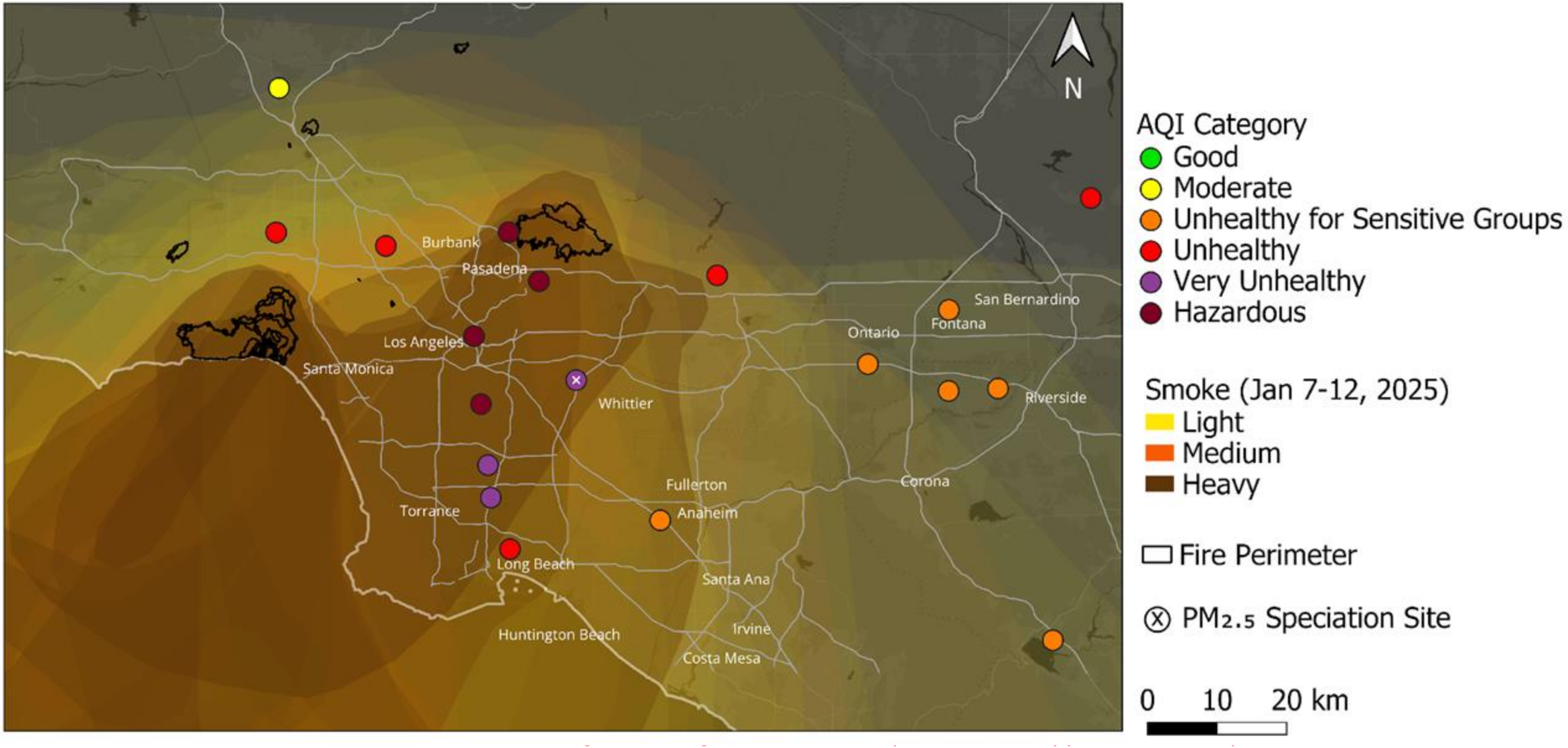
Hourly Outdoor $PM_{2.5}$ Levels Across the Los Angeles Basin During Recent Wildfires



Note: PM2.5 at JPL and Pico Rivera was measured using research-grade instruments (i.e., non-EPA-approved methods).

Data Sources: CARB's Air Quality and Meteorological Information System; Caltech (Dr. John Crounse); ASCENT Network (Haroula Baliaka; Dr. Sally Ng)

Maximum Hourly Air Quality Index (AQI) Between Jan 7-12, 2025, Across the Los Angeles Basin



Data Sources: CARB's Air Quality and Meteorological Information System; Caltech (Dr. John Crounse); ASCENT Network (Haroula Baliaka; Dr. Sally Ng); NOAA HMS; CA FIRIS

Takeaways & Next Steps

- Smoke from the Eaton and Palisades fires degraded air quality across the Los Angeles Basin, with impacts observed over 100 miles away, reaching Catalina and San Clemente Islands.

- Communities downwind of the fires experienced higher PM2.5 levels, with the largest impact near the fire and lower levels farther away.

- Since the fires, air quality has returned to typical levels in monitored areas. Recent rain events further improved air quality in the region, but localized variations may persist.

- ASCENT's monitoring site in Pico Rivera (~14 miles south of Altadena) detected notable increases in black carbon and select elements between Jan 8-11 but they returned to typical levels after Jan 12th.

- **Next Steps**: Many research institutions, including JPL and universities, plan to assess air quality impacts, study ash composition, and analyze long-term air pollution trends in fire-impacted communities. Efforts are underway to secure funding and resources to initiate monitoring and support public health agencies. As these projects progress, findings will be shared with communities and local officials to support effective decision-making.

Heavy metals in fire dust

Francois Tissot

Professor of Geochemistry

31 January 2025

Caltech

Smoke and dust

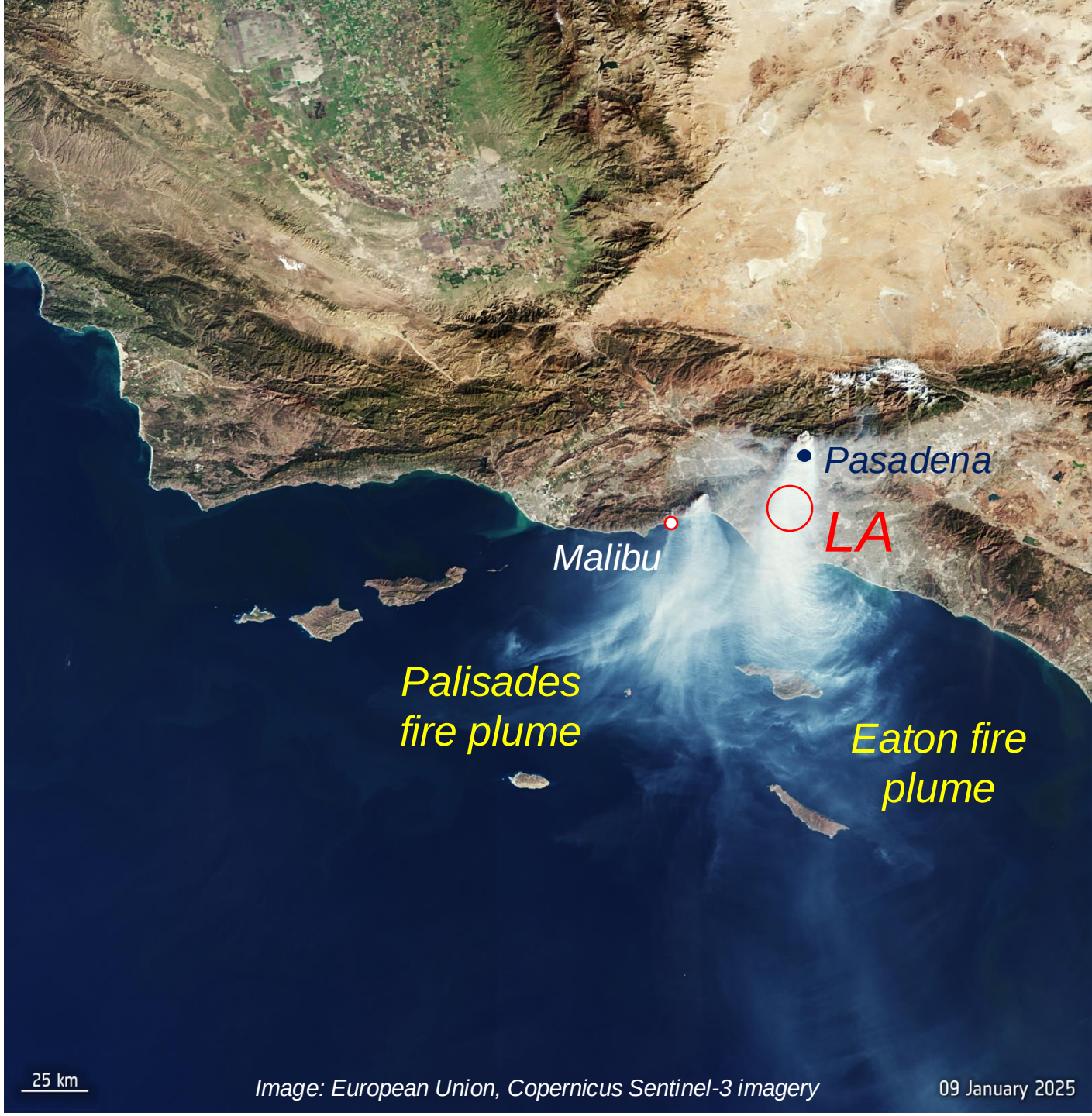
- Urban fires can release heavy metals (e.g., lead, cadmium) as vapors and fine particles,
- which can be transported by winds,
- before deposition along the fire plume trajectory.

Were heavy metals released by the Eaton fire?

How much heavy metals were deposited in indoor spaces a few miles south of the fire?

How does this compare with EPA clearance levels?

How effective is a basic surface cleaning (with water)?



Eaton fire - Sampling

> 7000 houses destroyed in Altadena

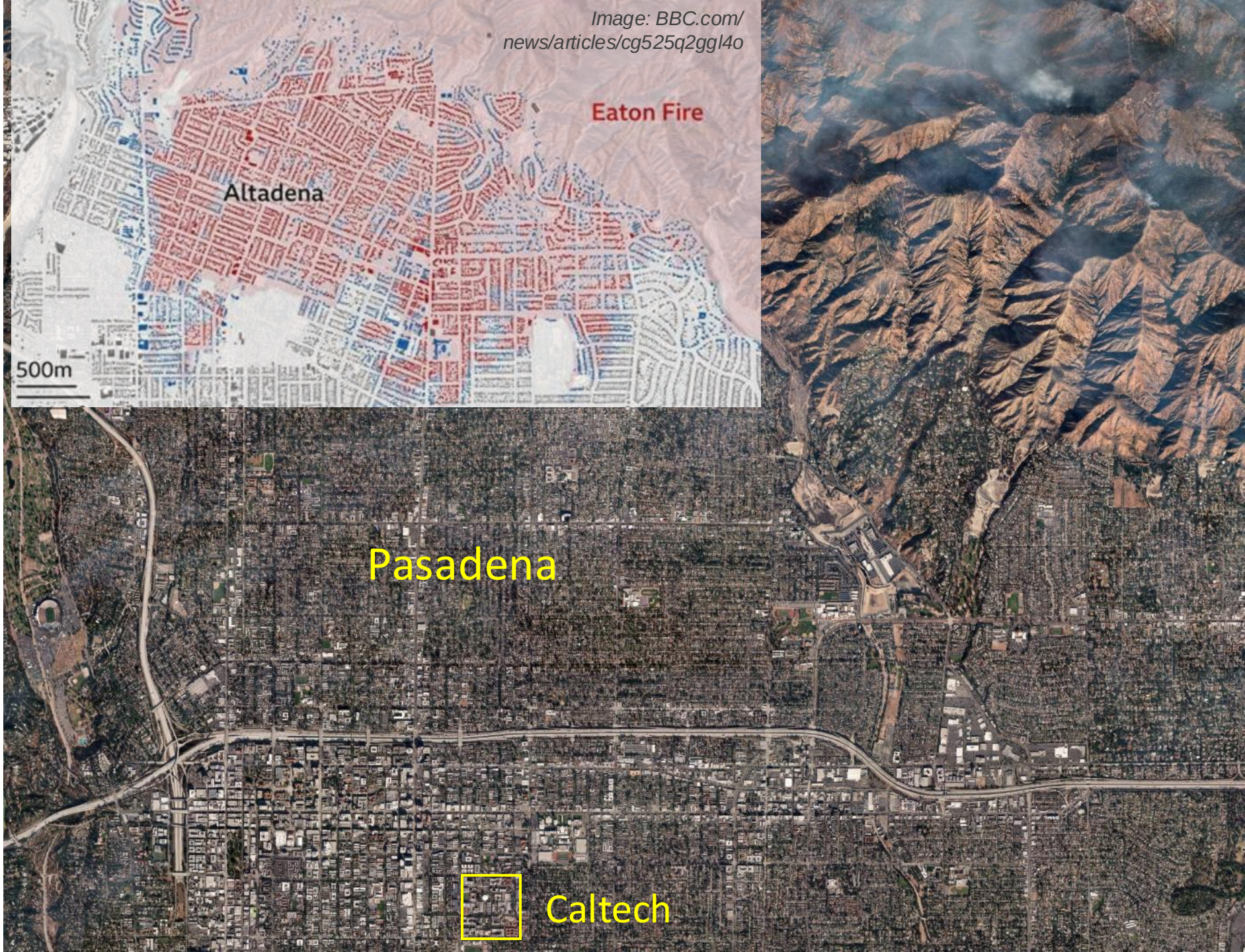
90% houses built before 1975
→ Lead-based paint likely

~10 ash samples in Pasadena
+
~100 dust samples inside 4 Caltech buildings

Measured heavy metals.

Here, focus on :
Lead (Pb)
Cadmium (Cd)
Arsenic (As)
Chromium (Cr)

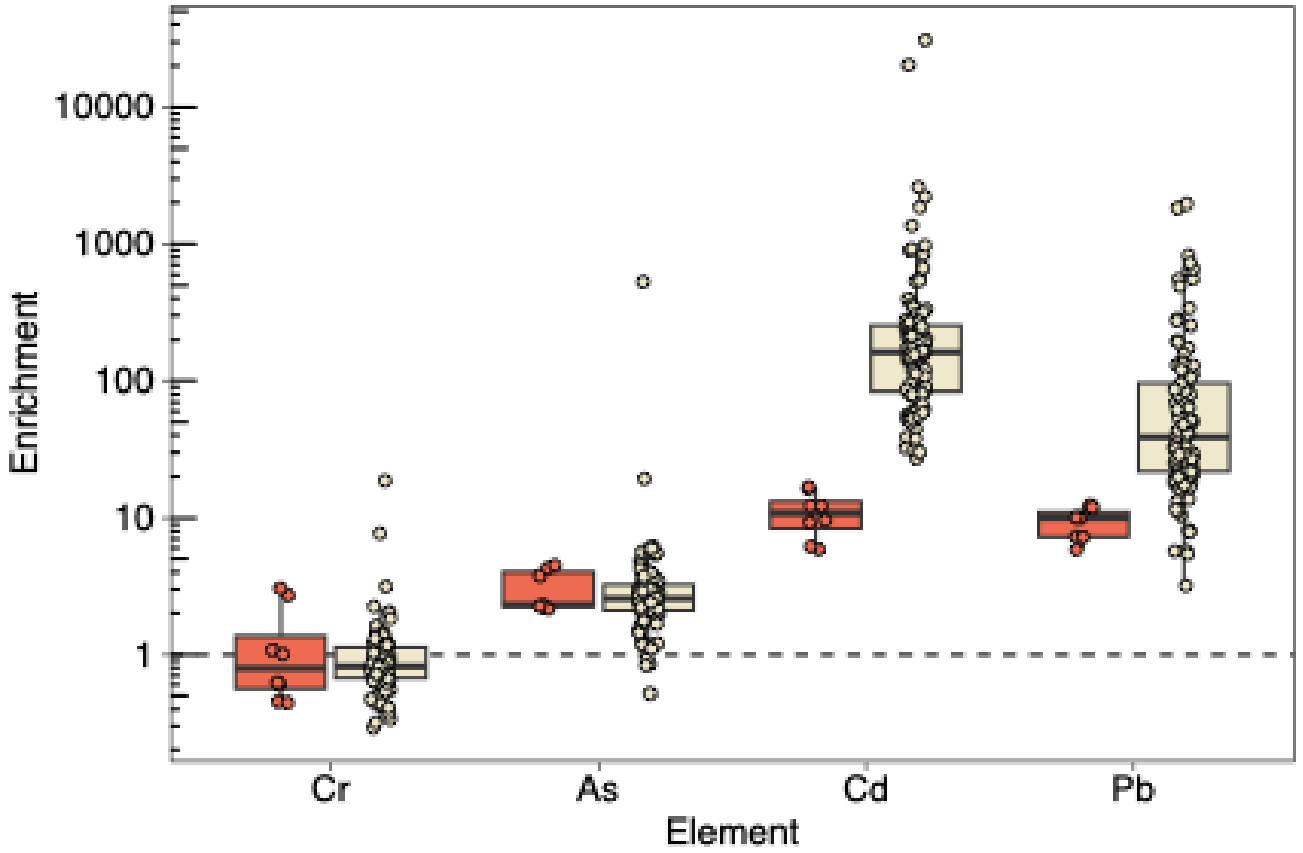
Image: https://wilg.github.io/la-fire-maps/images/1050010040277300.html



Sampling surfaces

(~1 week after fire started)

Metal enrichment (relative to soil)



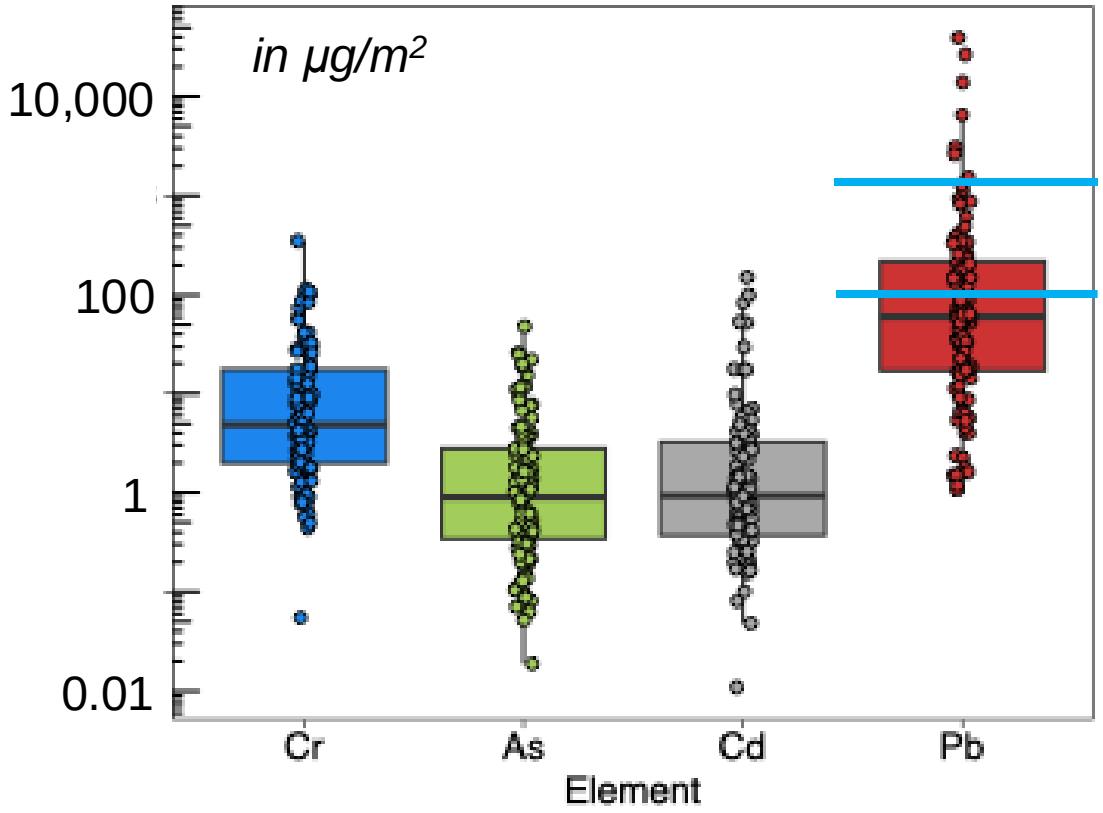
Dust

Ashes

→ **Lead and cadmium are ~10-100x more abundant in dust (i.e., fine particles) than ashes.**

Enrichment = (X/U) sple / (X/U) crust

Metal deposition on indoor surfaces



EPA dust-lead clearance:*

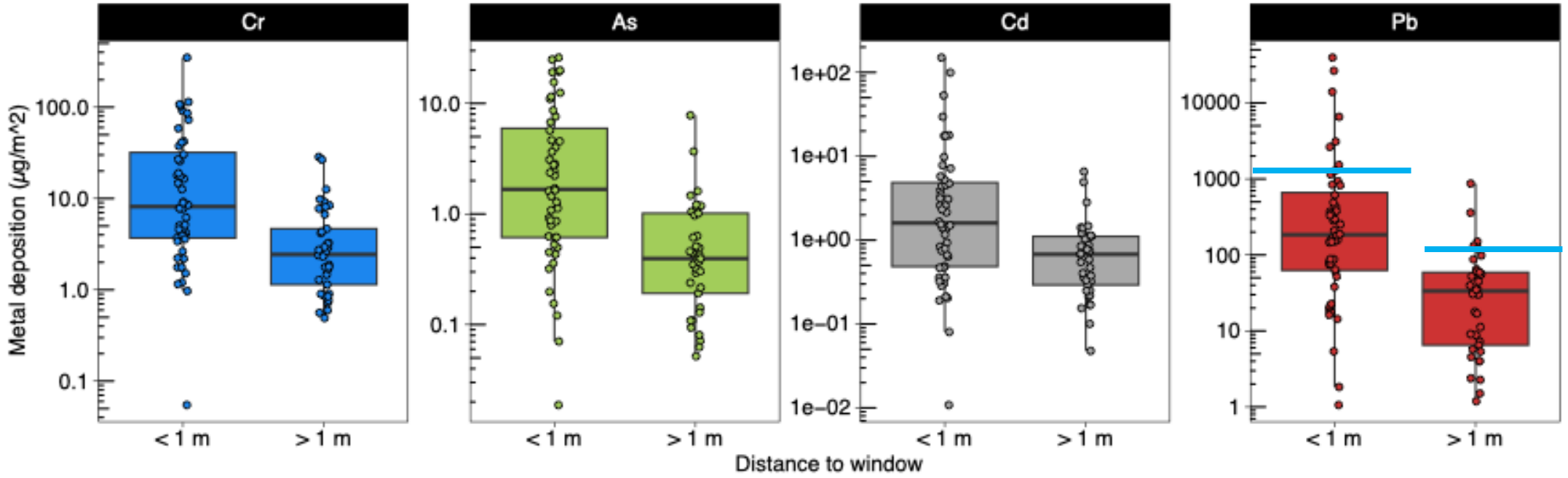
← 1,100 µg/m² on window sills

← 110 µg/m² on floors

Large variations for each element.
On average ~100x more Pb than Cd or As.

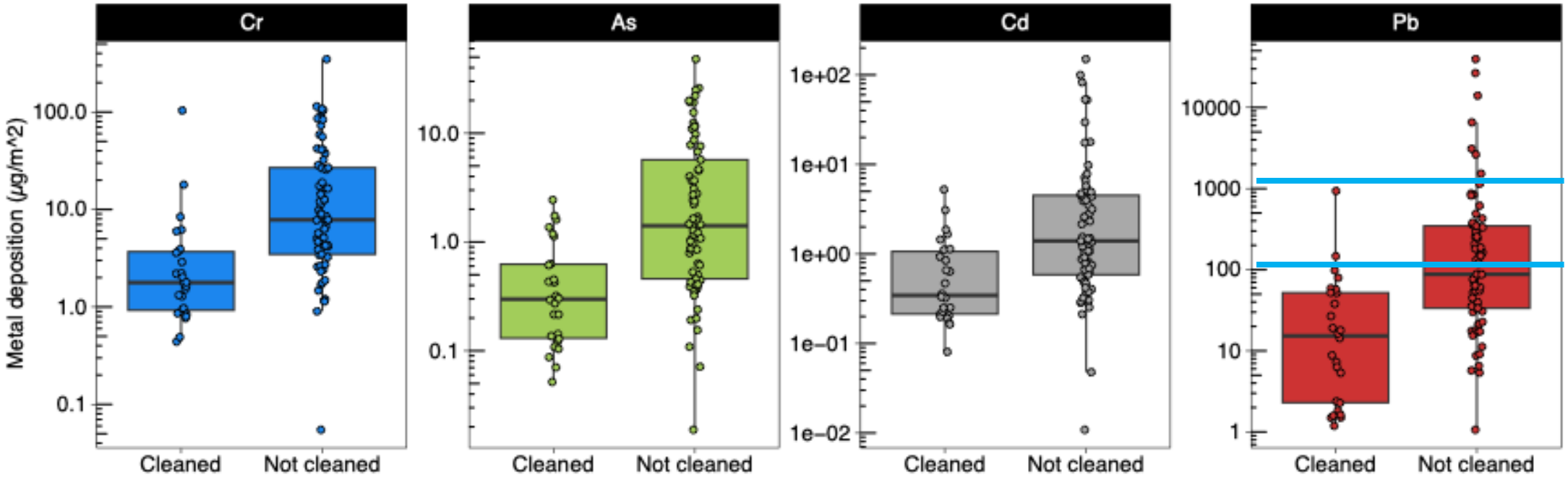
**Hazard Standards and Clearance Levels for Lead in Paint, Dust and Soil (TSCA Sections 402 and 403)*

Metal deposition: distance to windows



Heavy metal deposition decreases with distance from window
→ ~ 10x less Pb if > 1 m away from window.

Impact of basic cleaning (i.e., wet wiping)



Basic cleaning is efficient: removes 90 % of heavy metal deposition (Pb, Cd, Cr, As)

→ Here, after 1x cleaning, below the EPA dust-lead clearance levels.

Heavy metals in fire dust & smoke

Lead levels in ashes are only slightly higher than in soil/dirt.

Lead is enriched in fine dust/particles.

In 4 Caltech buildings, data shows **heavy metal deposition on indoor surfaces.**

Highest deposition within 1 m of the window.

Wet-cleaning removed ~90% of deposited metals, bringing values below the EPA recommended thresholds.

→ Wet-cleaning is necessary but efficient.

(Ideally, wear PPE while cleaning surfaces: gloves, goggles and N95 mask).

Use HEPA vacuum to minimize fine dust exposure.

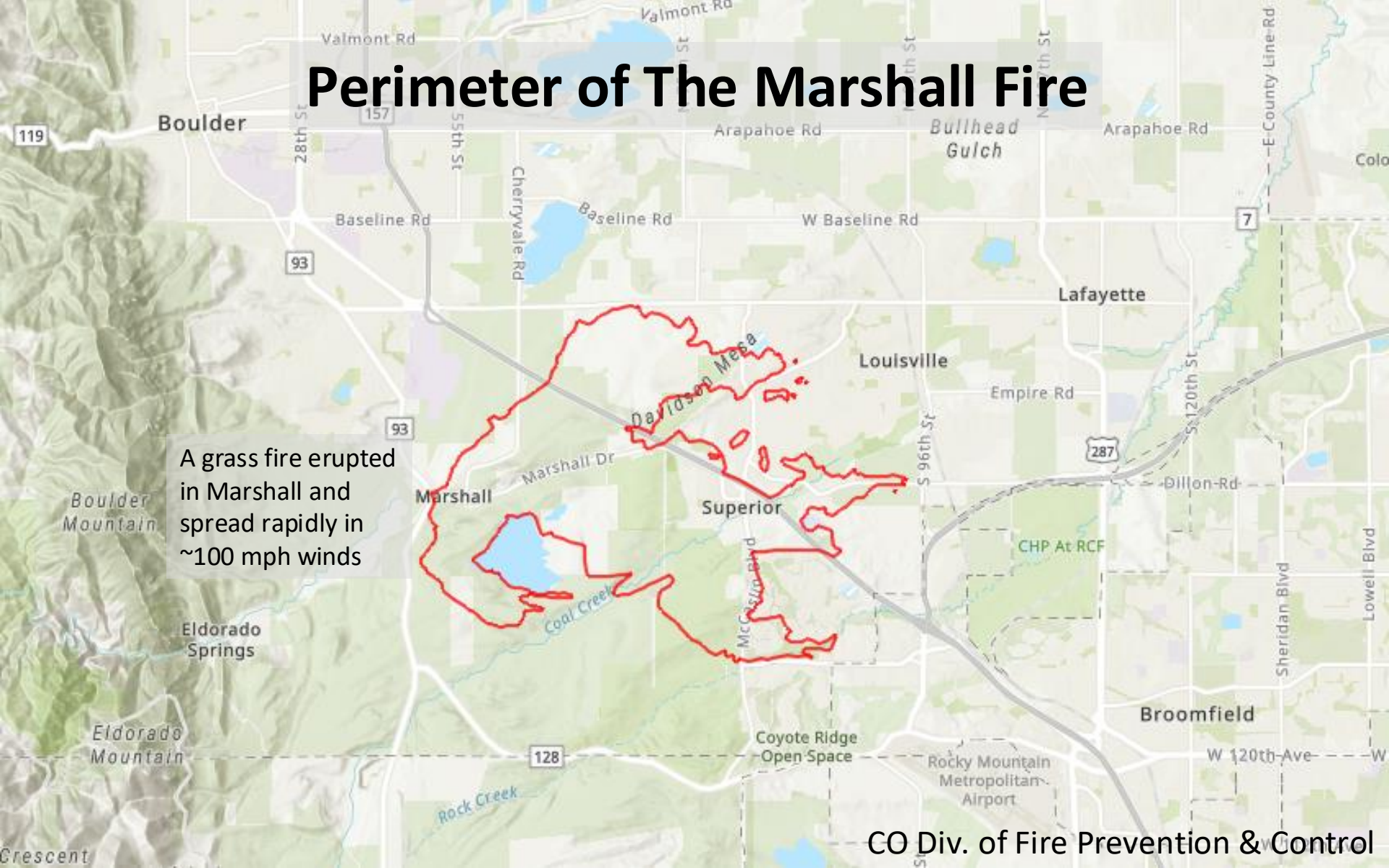
Environmental Impacts of the Marshall Fire

Boulder, Colorado
December 30, 2021

Joost de Gouw[1], Thomas Borch[2], Noah Fierer[1], Mike Hannigan[1], Eve Hinckley[1], Julie Korak[1], Cresten Mansfeldt[1], Diane McKnight[1], Colleen Reid[1], Marina Vance[1], Christine Wiedinmyer[1]
[1]Univ. of Colorado Boulder, [2]Colorado State Univ.

Photo: Leo Pelle

Perimeter of The Marshall Fire

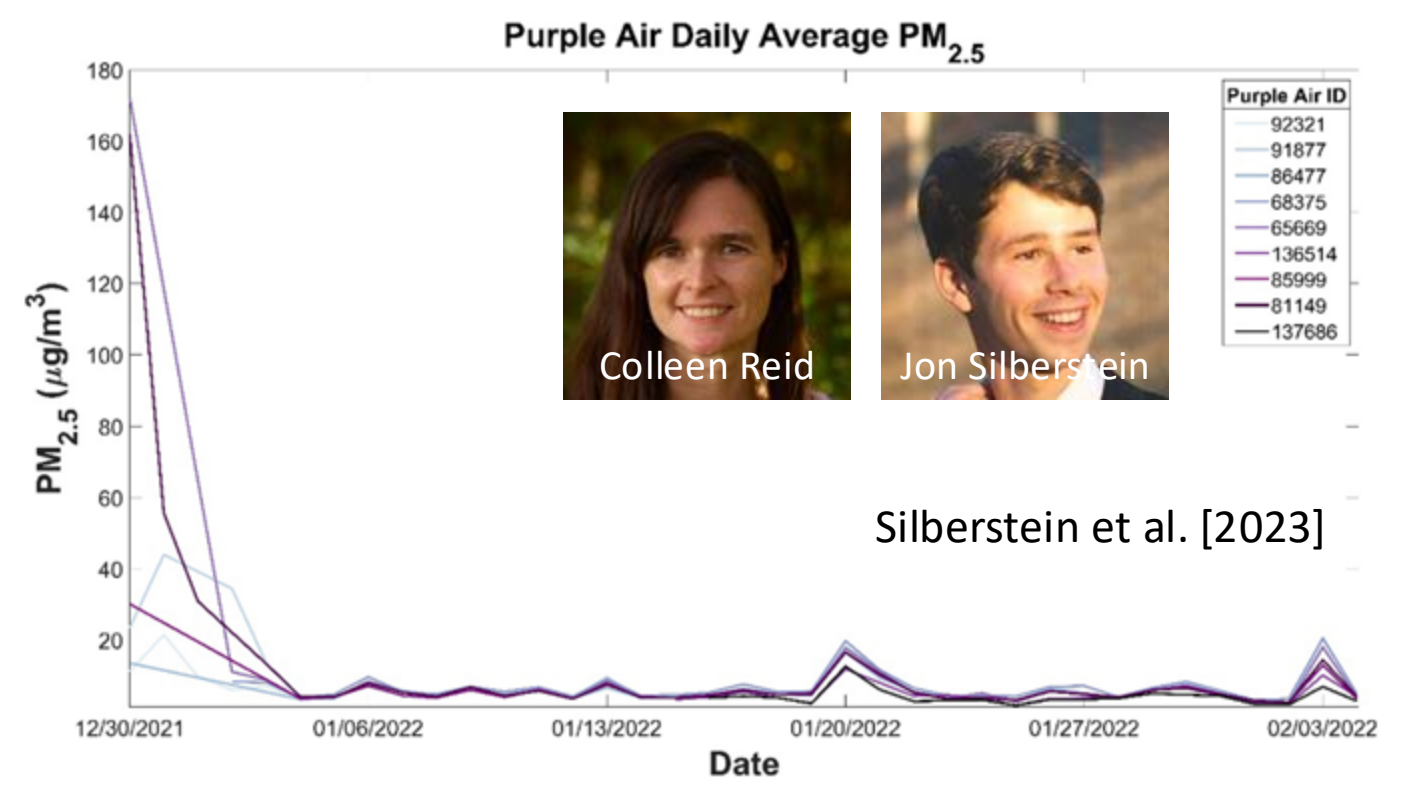


A grass fire erupted in Marshall and spread rapidly in ~100 mph winds

CO Div. of Fire Prevention & Control


2 Lives lost
1084 Buildings burned
149 Damaged
@bclemm

Ambient Air Quality was only Briefly Impacted



Caveat: many Purple Air monitors were destroyed or went off-line

But: Post-Fire Impacts Were Significant

- Ash and soot were deposited indoors
- Strong burn smell indoors
- Many people did not return for weeks if not months

Our Responses to the Community Concerns

What Did We Do?

Recently updated

Friday, January 17, 2025

How to mitigate post-fire smoke impacts in your home

CU Boulder scientists provide facts on wildfire-related indoor air quality and tips on how to mitigate


We Made Measurements of
PM and VOCs Inside Homes

And Surveyed ~15 More Homes

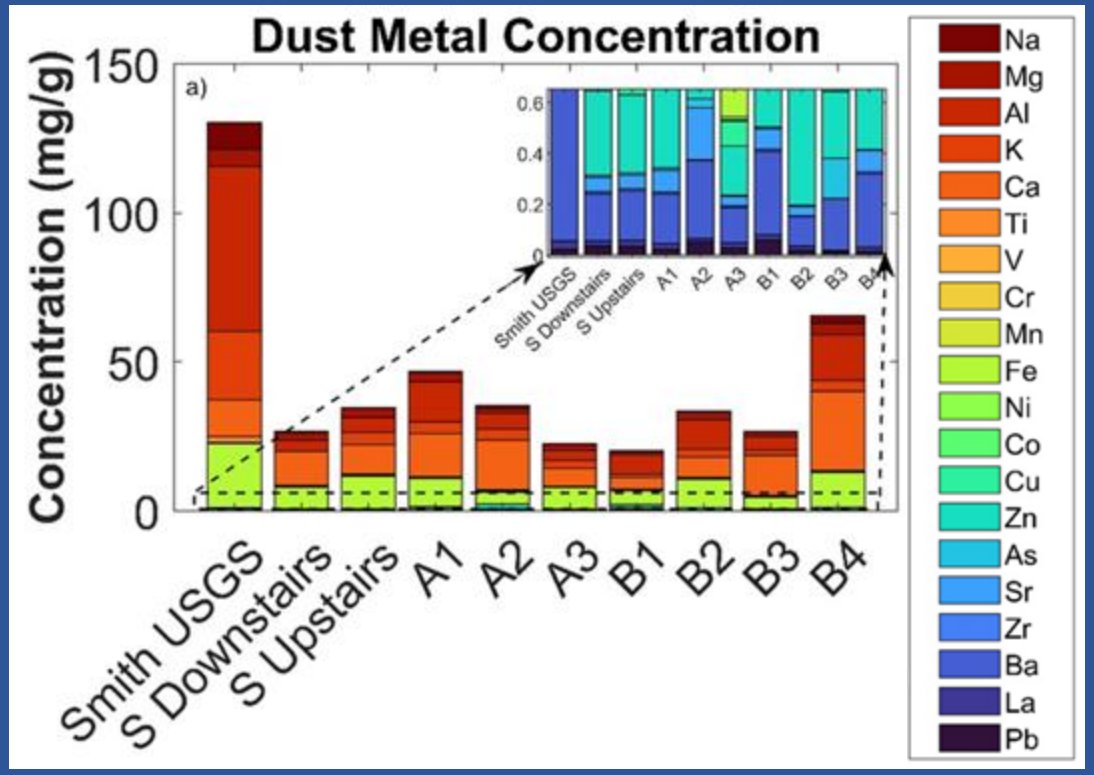
We Collected Soil and Water Samples

Thomas Borch, Eve Hinckley and Noah Fierer

Julie Korak and Cresten Mansfeldt

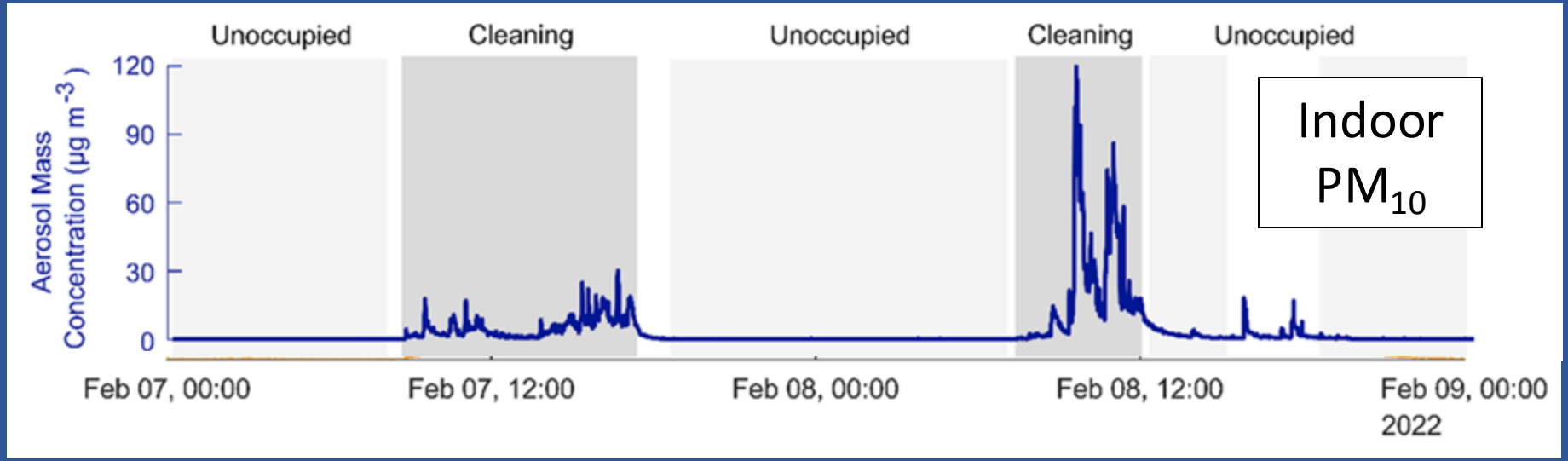
What Did We Find?

Chemical Composition of Indoor Ash and Soot



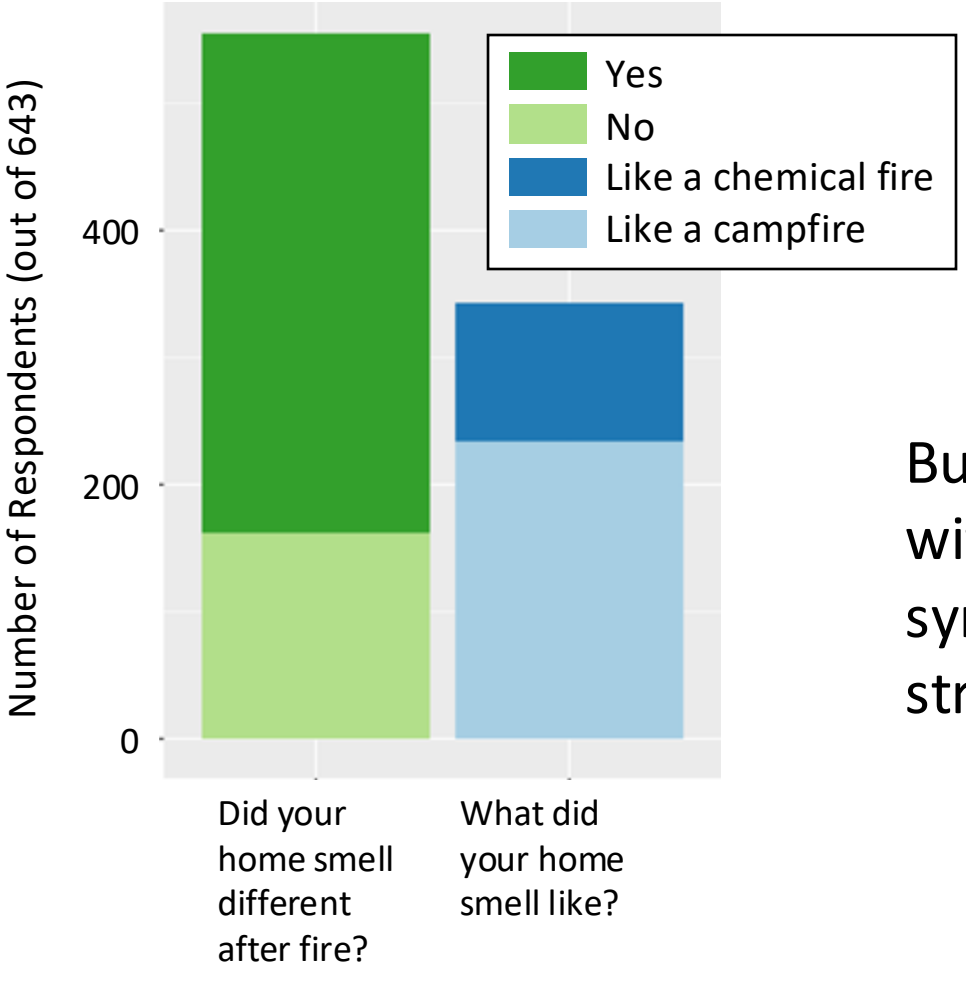
- Samples did contain compounds from wildfires
- But only small enhancements of heavy metals like lead

Ash and Soot were Resuspended during Home Cleaning



1. Indoor $PM_{2.5}$ was generally low after the fire
2. Cleaning caused indoor PM_{10} to spike: important to protect yourself!

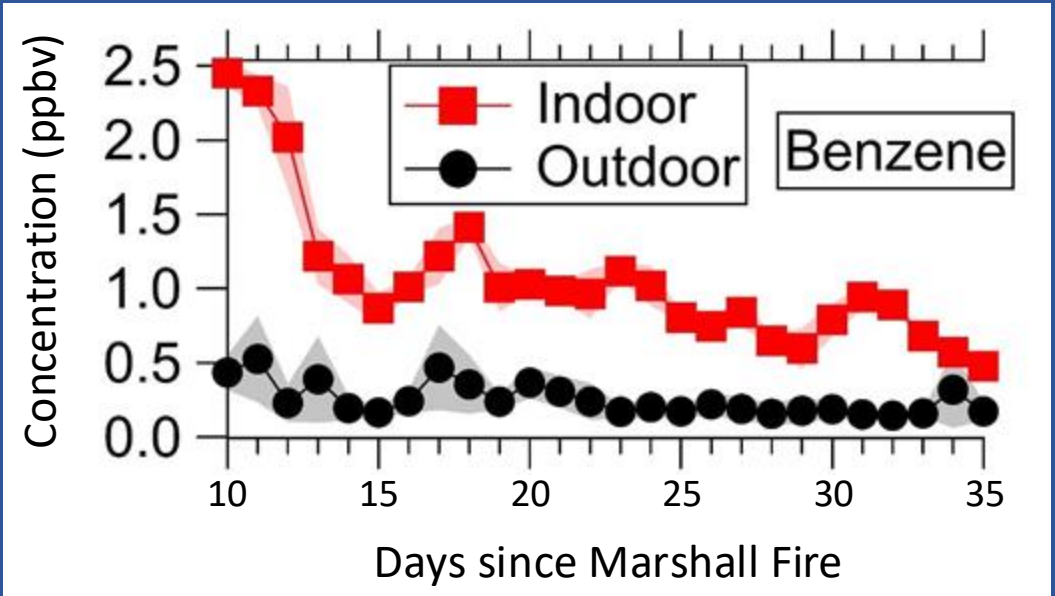
Most People Reported Indoor Burn Smells



Burn smells were associated with higher reporting of symptoms (headaches, strange taste in mouth)

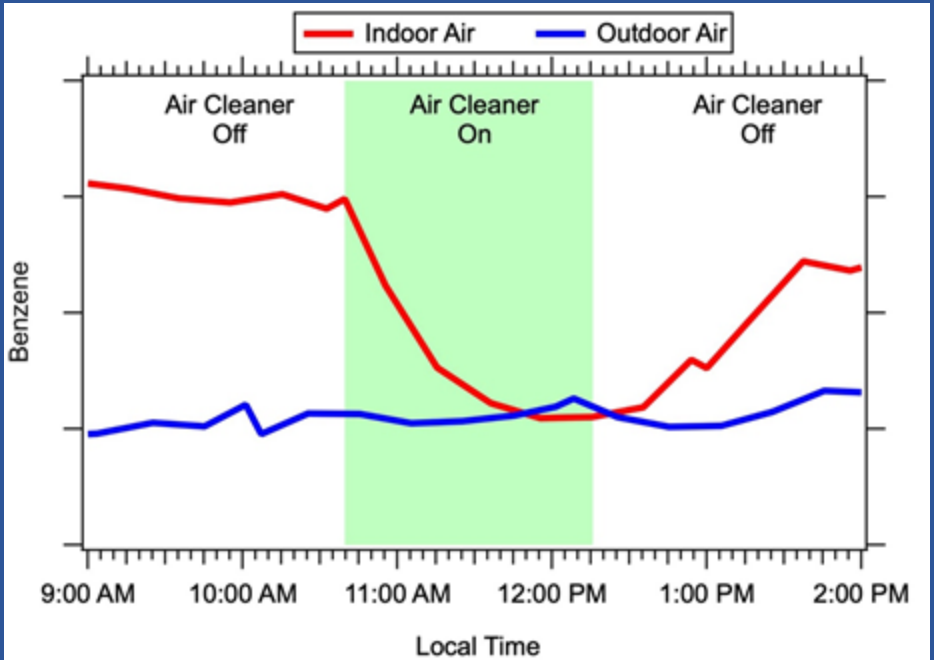
Many VOCs were Enhanced Indoors

One example: benzene - out of 100s measured



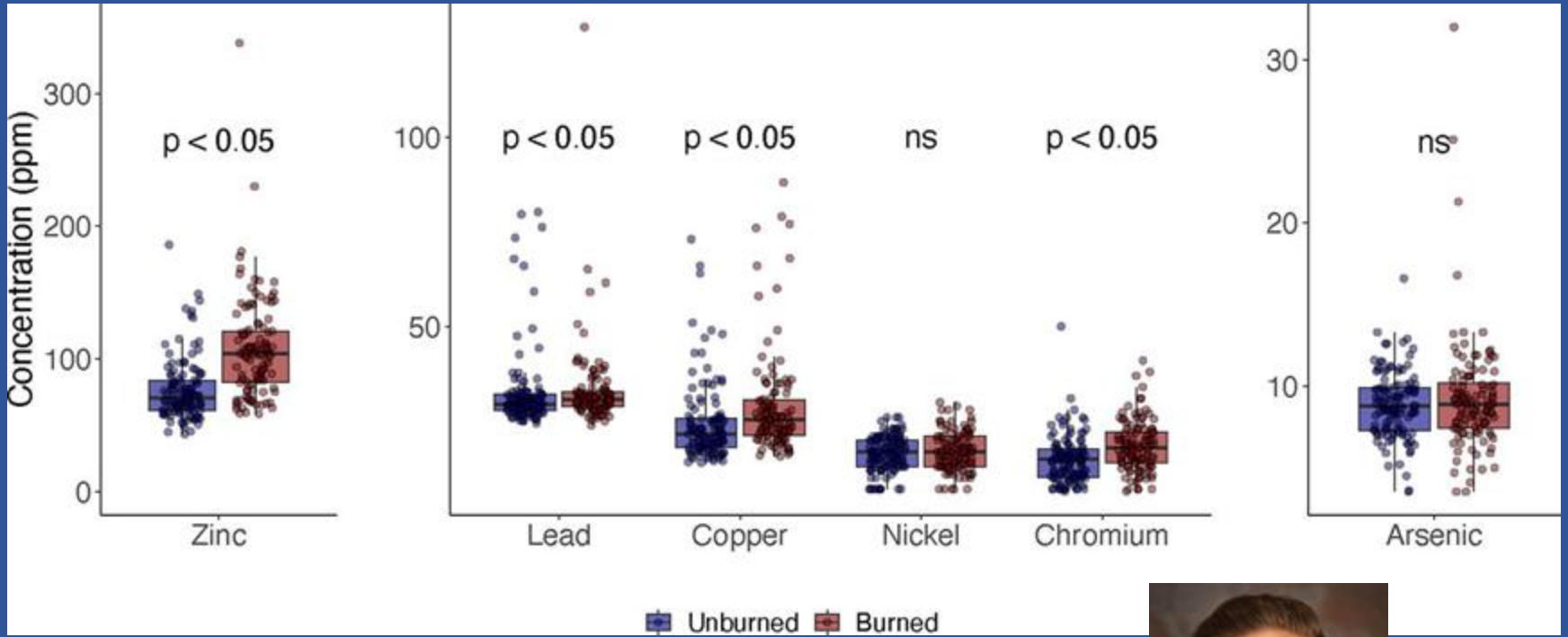
- VOC concentrations returned to normal after ~4-5 weeks
- Decreases took much longer than expected

Air Cleaners – How to Protect Yourself



- Air cleaners with activated carbon are very effective at removing indoor VOCs
- But: when you turn the cleaner off, the VOCs return

Analysis of Soil Samples

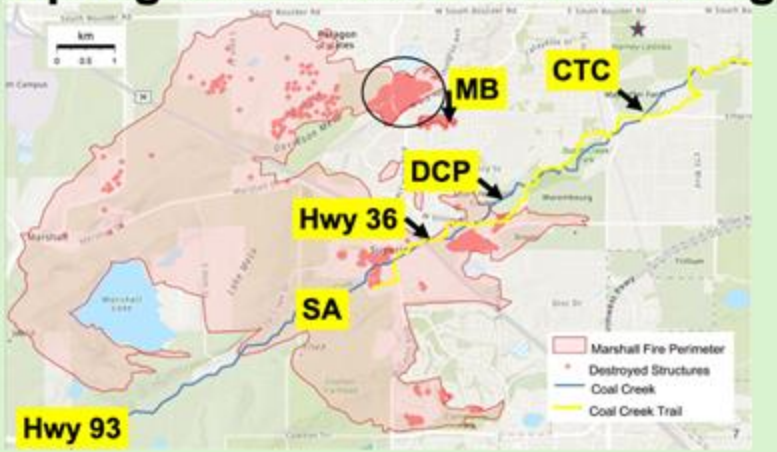


- No large enhancements in heavy metals
- Note: most homes were newer than Altadena

Sierra Jech

Analysis of Surface Water

Sampling within Coal Creek Drainage



Timeframe: 2 years (2022-2023)
Sampling Days: 58 (2-6 sites)
Samples Collected: 270
Water quality datapoints: >15,000
Benthic/Periphyton Surveys: 20

Data analysis is ongoing

Publications are forthcoming

For details about the study design

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

KEEP IT CLEAN PARTNERSHIP

City of Louisville
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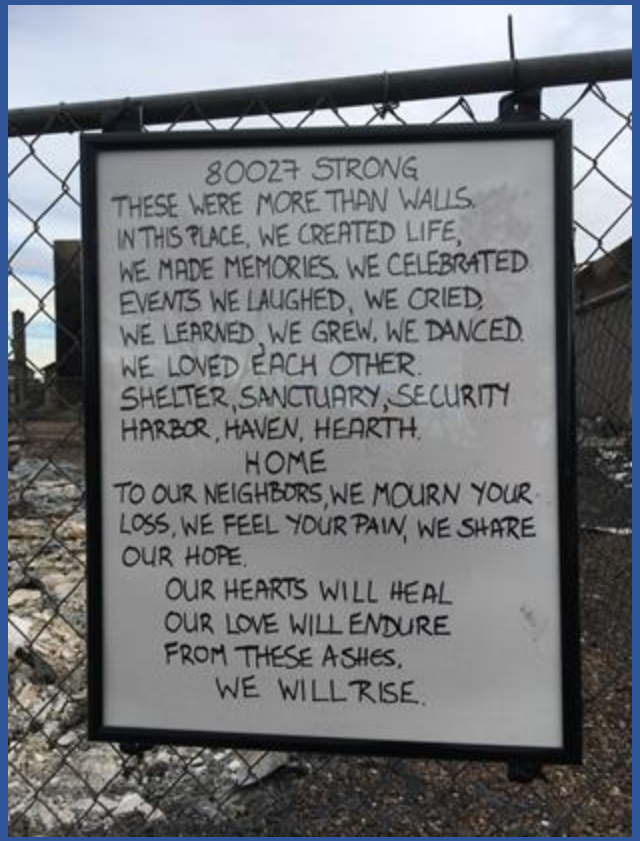
Boulder County

CITY OF BOULDER

NATURAL HAZARDS CENTER

Conclusions

- Indoor airborne dust was low in smoke-impacted homes except during cleaning
- VOCs can linger for weeks inside smoke-impacted homes
- Air cleaners are useful to temporarily reduce indoor VOCs
- Indoor dust, soils and water showed only weak enhancements in the concentrations of metals and other toxics



Acknowledgements

- Homeowners and residents
- Funding: CIRES RAPID, NSF RAPID, Sloan Foundation

Published Papers

- Silberstein, J. M., Mael, L. E., Frischmon, C. R., Rieves, E. S., Coffey, E. R., Das, T., Dresser, W., Hatch, A. C., Nath, J., Pliszka, H. O., Reid, C. E., Vance, M. E., Wiedinmyer, C., De Gouw, J. A., and Hannigan, M. P.: Residual impacts of a wildland urban interface fire on urban particulate matter and dust: a study from the Marshall Fire, *Air Qual Atmos Health*, 16, 1839–1850, doi.org/10.1007/s11869-023-01376-3, 2023.
- Jech, S., Adamchak, C., Stokes, S. C., Wiltse, M. E., Callen, J., VanderRoest, J., Kelly, E. F., Hinckley, E.-L. S., Stein, H. J., Borch, T., and Fierer, N.: Determination of Soil Contamination at the Wildland-Urban Interface after the 2021 Marshall Fire in Colorado, USA, *Environ. Sci. Technol.*, acs.est.3c08508, doi.org/10.1021/acs.est.3c08508, 2024.
- Dresser, W., Silberstein, J. M., Reid, C. E., Vance, M. E., Wiedinmyer, C., Hannigan, M., and de Gouw, J. A.: Volatile Organic Compounds inside Homes Impacted by Smoke from the Marshall Fire, *ES&T Air*, 2, 4–12, doi.org/10.1021/acsestair.4c00259, 2025.
- Reid, C. E., Finlay, J., Hannigan, M., Rieves, E. S., Walters, H., Welton-Mitchell, C., Wiedinmyer, C., de Gouw, J. A., and Dickinson, K.: Physical health symptoms and perceptions of air quality among residents of smoke-damaged homes from a Wildland Urban Interface (WUI) fire, *ES&T Air*, 2, 13–23, doi.org/10.1021/acsestair.4c00258, 2025.