Emissions from Fires at the Wildland-Urban Interface

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Outline:

1. US fires at the wildland-urban interface
2. Laboratory study of emissions
3. Importance of fire temperature

CIRES

#ForeverBuffs

Recent U.S. Fires at the Wildland-Urban Interface (WUI)

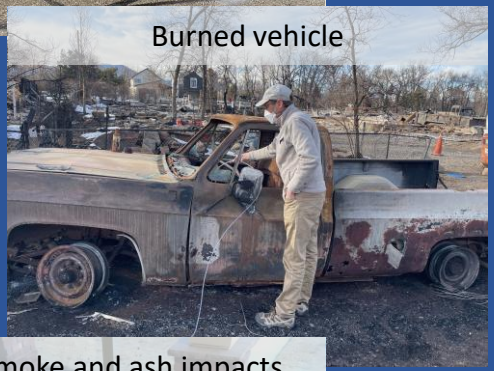
Recent U.S. Fires at the Wildland-Urban Interface (WUI)

Some similarities:

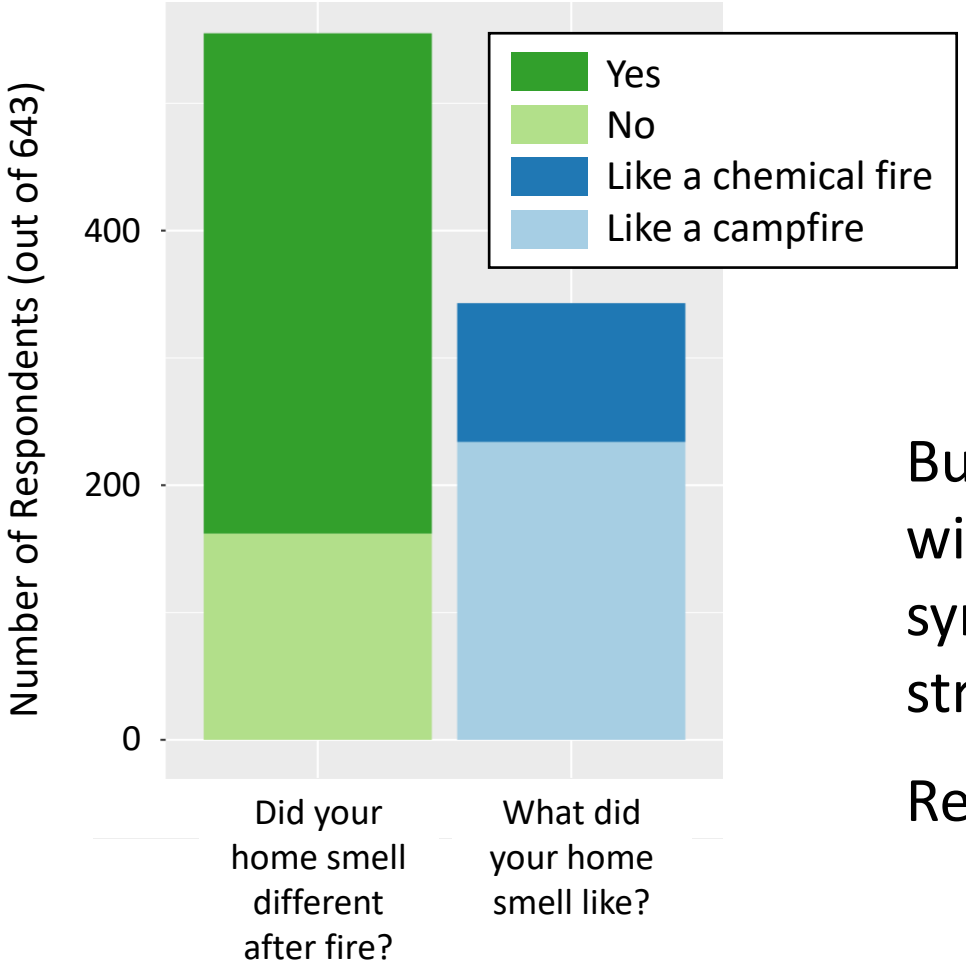
- Started and propagated by high winds
- Many were not in the “standard” fire season
- Grass fires that become urban conflagrations
- Majority of the fuel is contained in structures

Many questions:

- What are the emissions from burning structures, vehicles, electronics, etc.?
- What are the longer-lasting impacts?
- How do you clean up homes, soils, etc.



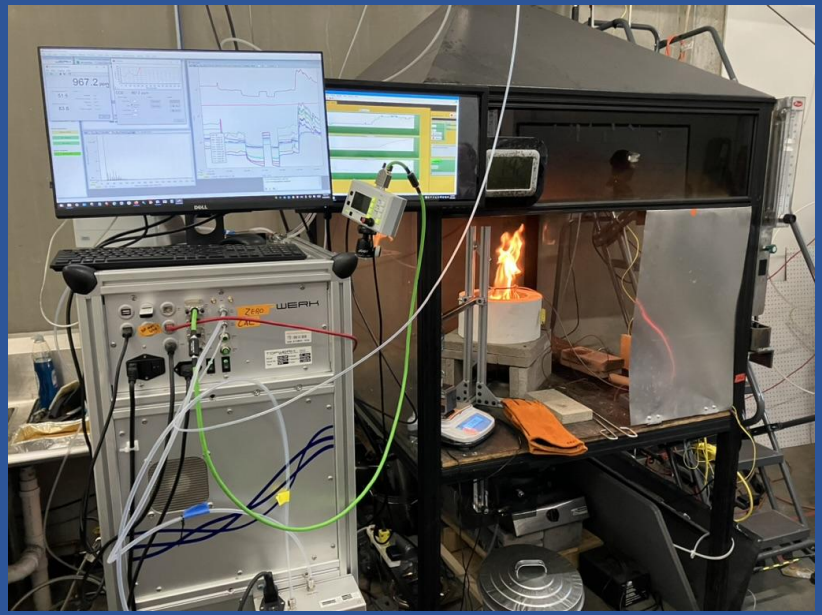
Health Impacts after Marshall Fire



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

Reid et al. [ES&T Air 2025]

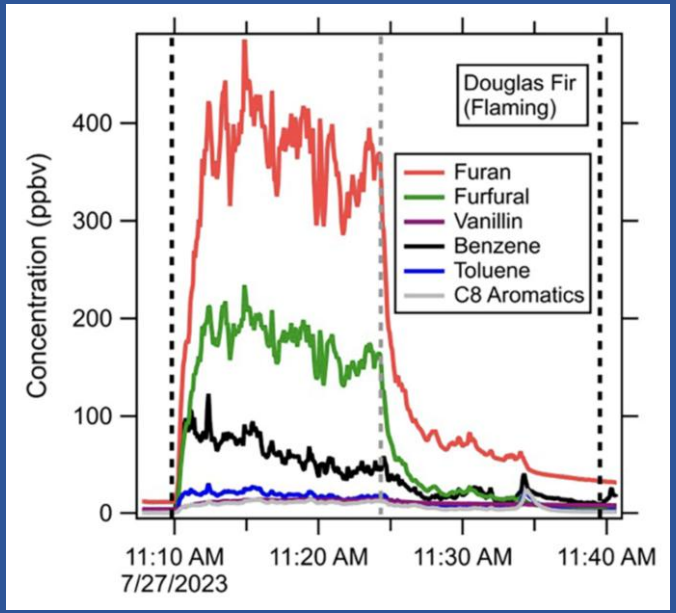
BHASMA Study: VOCs from Burning and Pyrolysis of Building Materials



July – August 2023 at Colorado State U.

PI: Shantanu Jathar

Others involved: Laskin, Nizkorodov, Goldstein groups

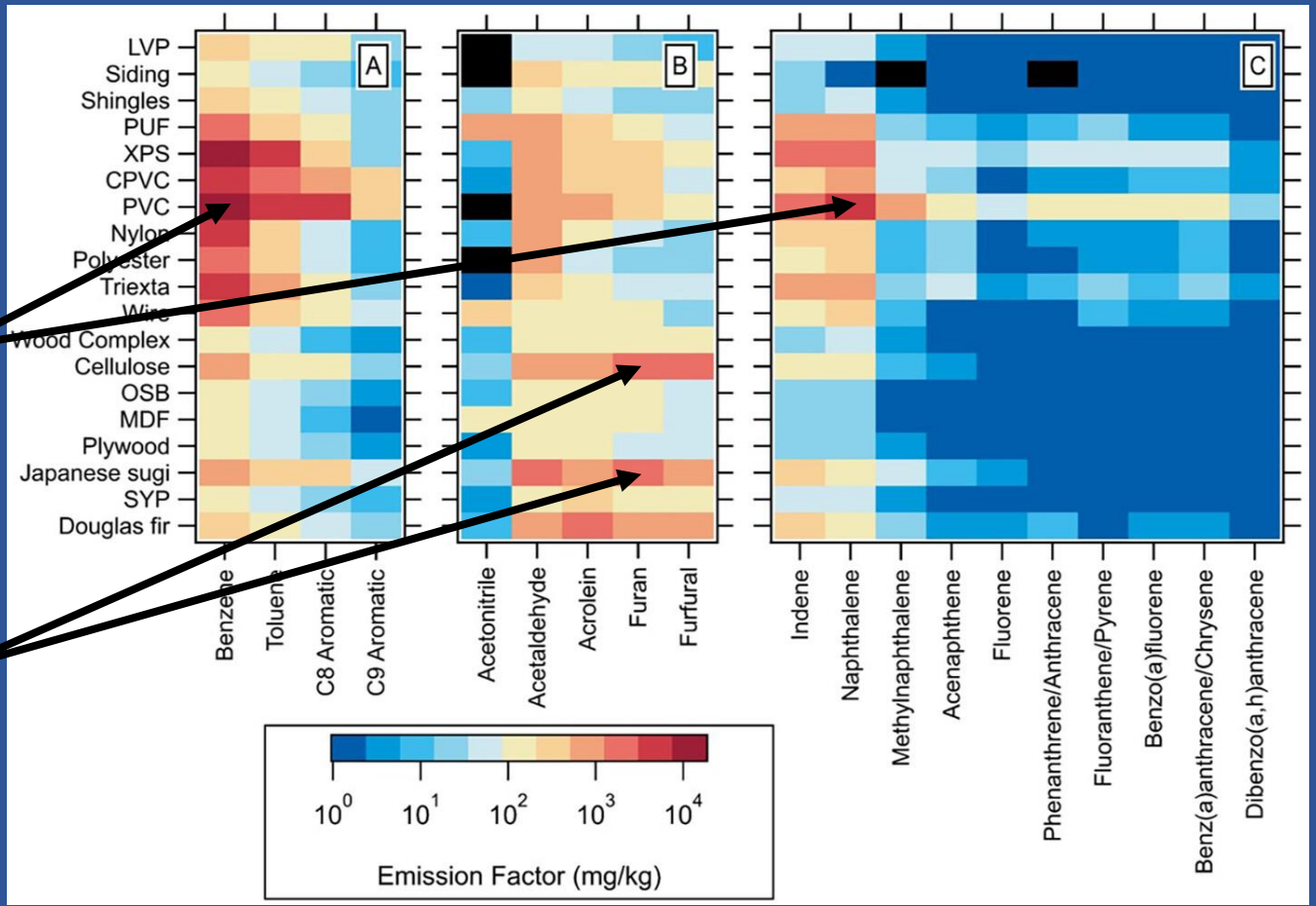


VOCs measured by mass spectrometry

Integrated amount → emission factors (mg VOC / kg fuel)

VOC Emission Factors for Building Materials

- Aromatics and PAHs are highest from the burning of plastics
- Furanoids are higher from woody products

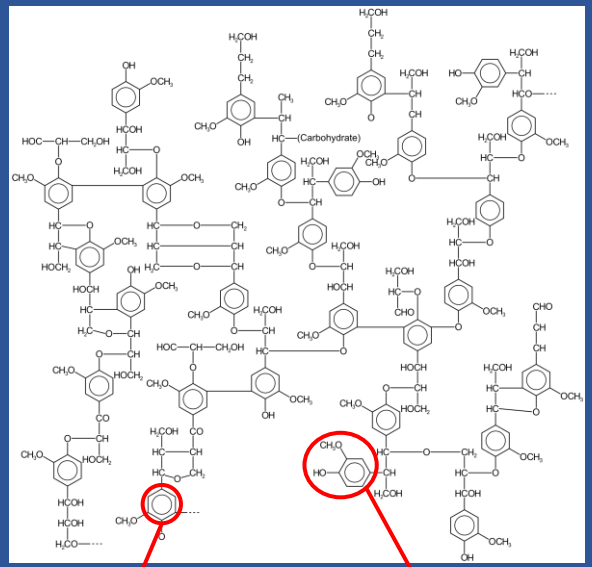


Dresser … and de Gouw [ES&T 2026]

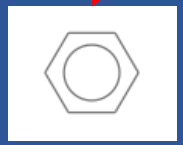
How are VOCs Produced in Vegetation Fires?

Pyrolysis and Flame Chemistry

Lignin: wood and bark

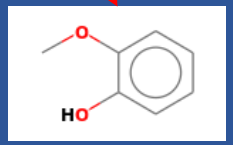


Higher temp



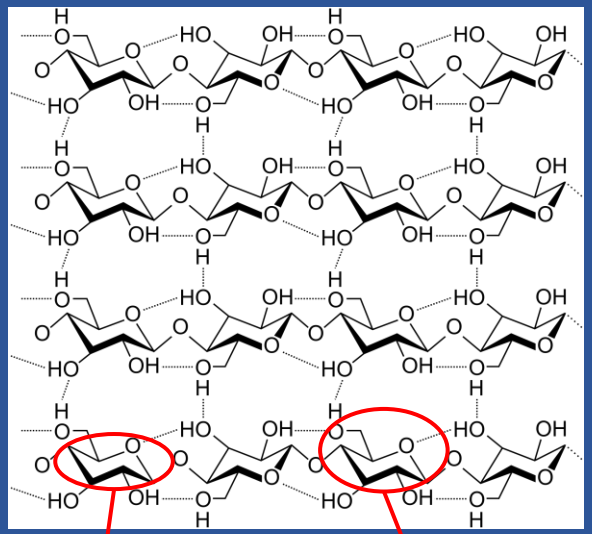
Benzene

Lower temp

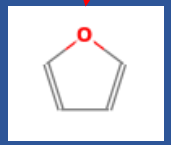


Guaiacol

Cellulose: leaves and fibers

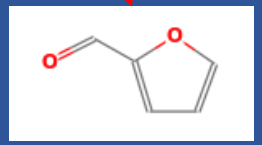


Higher temp



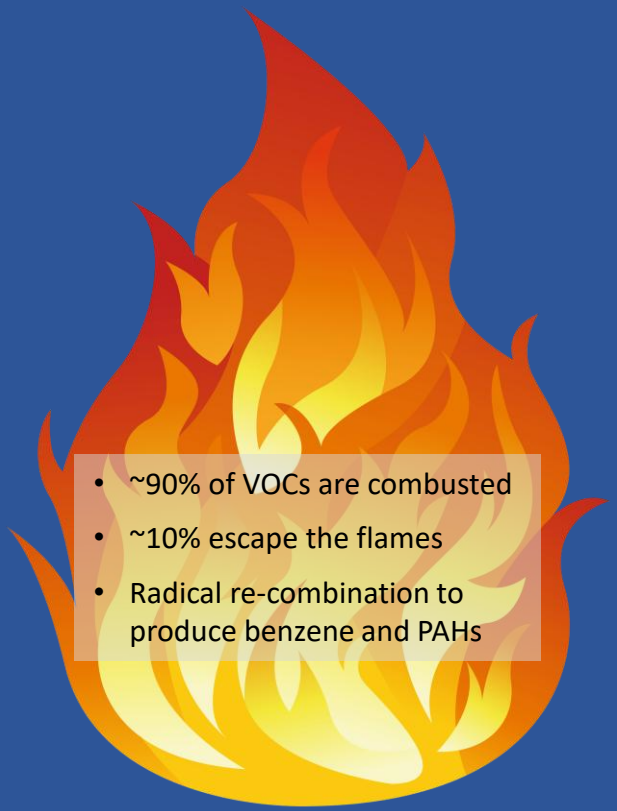
Furan

Lower temp



Furfural

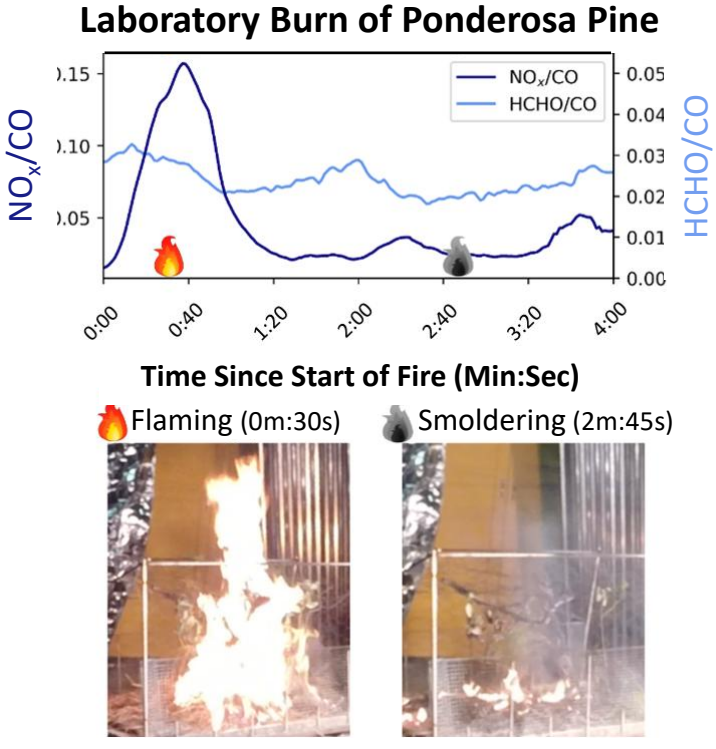
Flame Chemistry



- ~90% of VOCs are combusted
- ~10% escape the flames
- Radical re-combination to produce benzene and PAHs

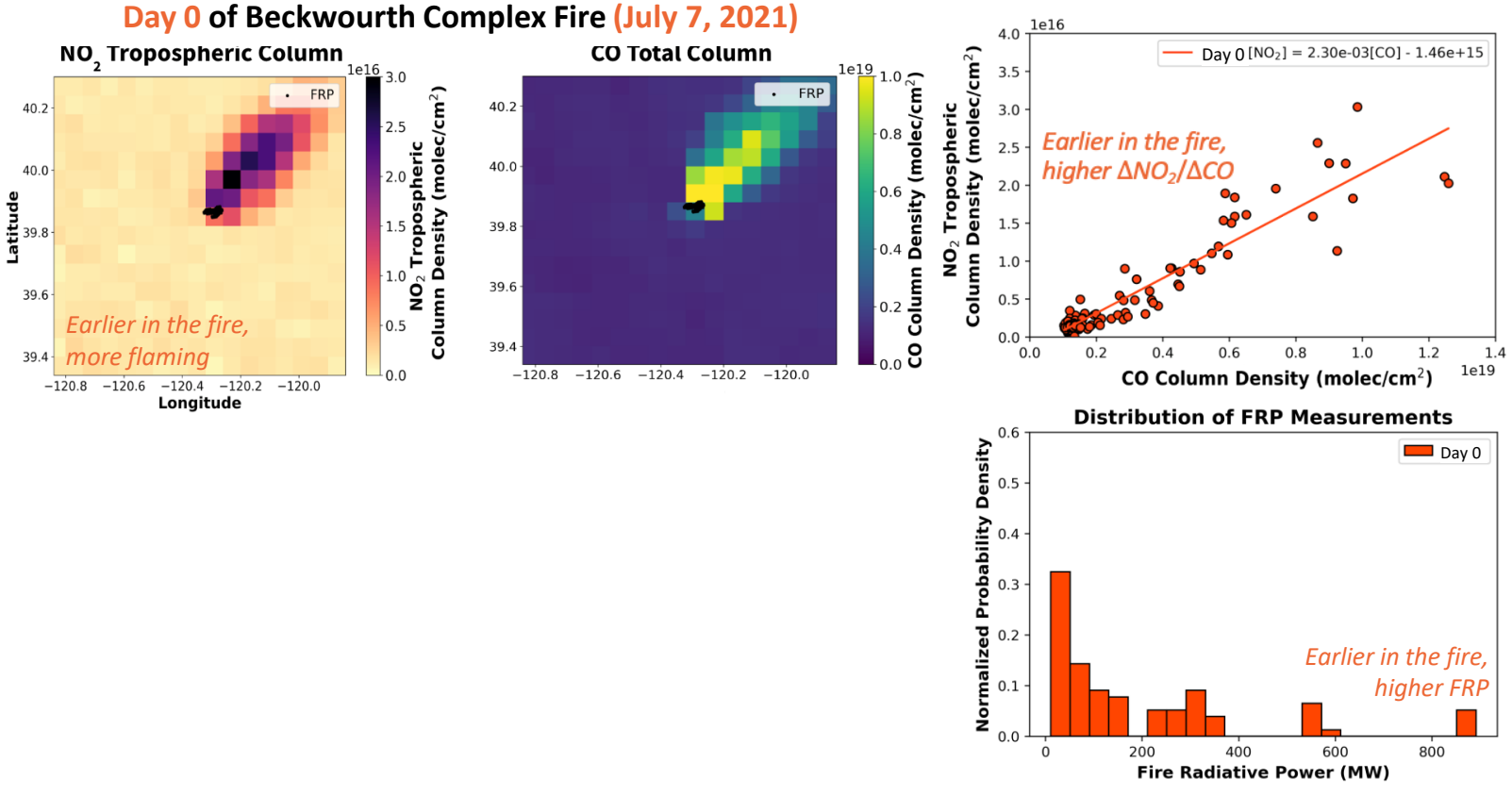
Emissions Change over the Course of a Burn

- NO_x, HONO, black carbon, benzene and PAHs are especially high at high-temperature combustion
- Other trace gases like HCHO and CO stay relatively constant throughout the fire
- Can we see these same trends from space?



Results from the 2016 NOAA FireLab Study

NOx Emissions are Higher in First Days after a Wildfire Erupts



Anderson … and de Gouw [GRL 2023]

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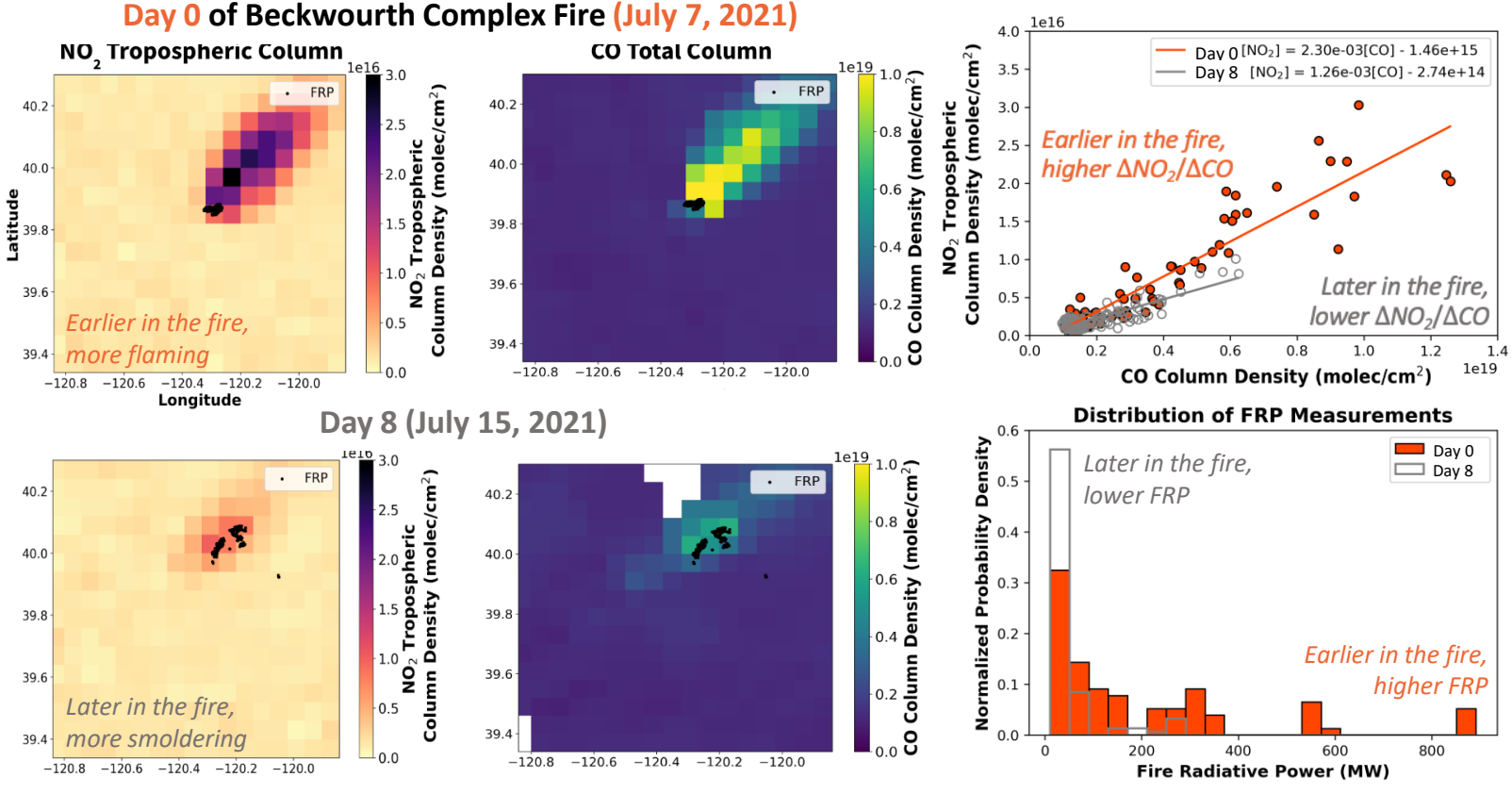

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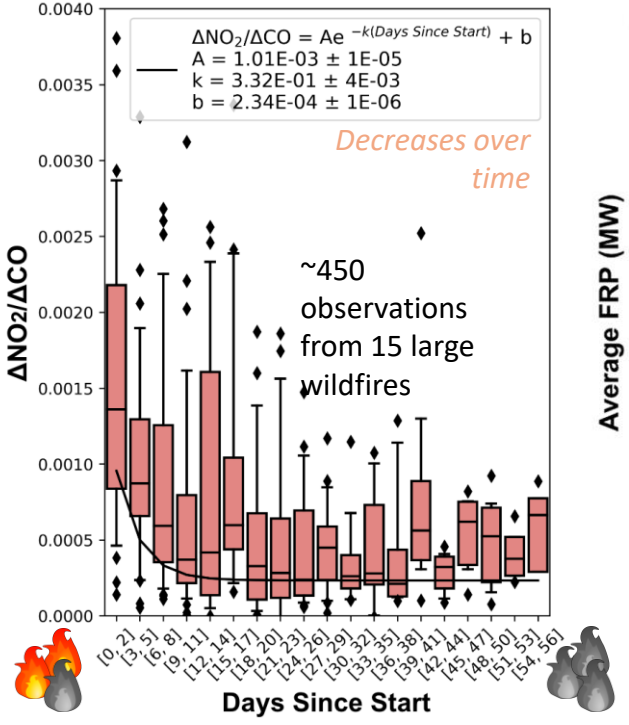
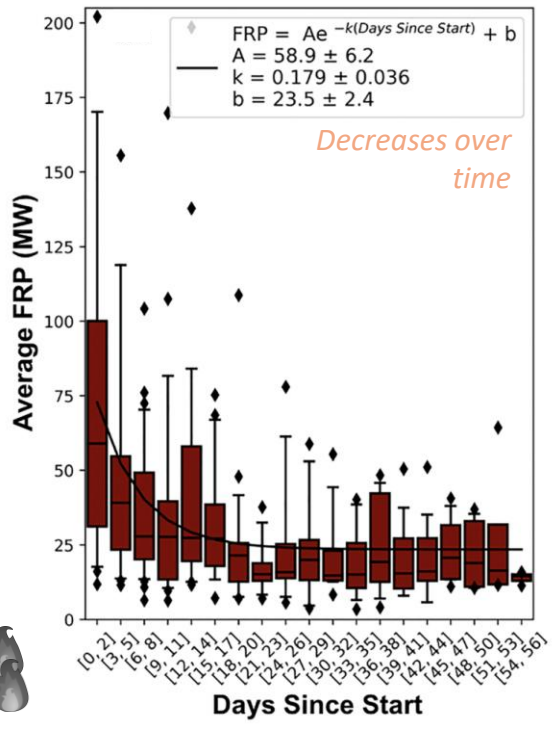
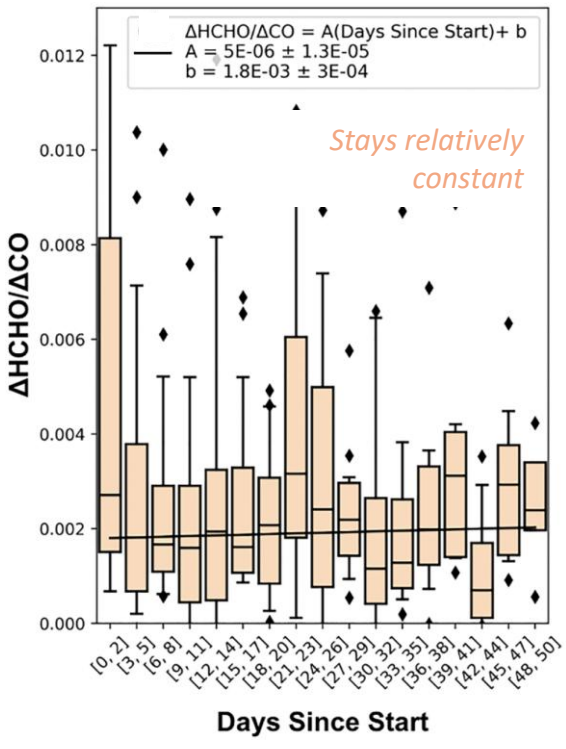






Anderson … and de Gouw [GRL 2023]

Conclusions

- WUI fires are increasingly common
- Emissions from the burning of building materials contain more air toxics such as benzene and PAHs
- Hotter fires emit more air toxics (benzene, PAHs, black carbon) and reactive species (HONO, NOx)

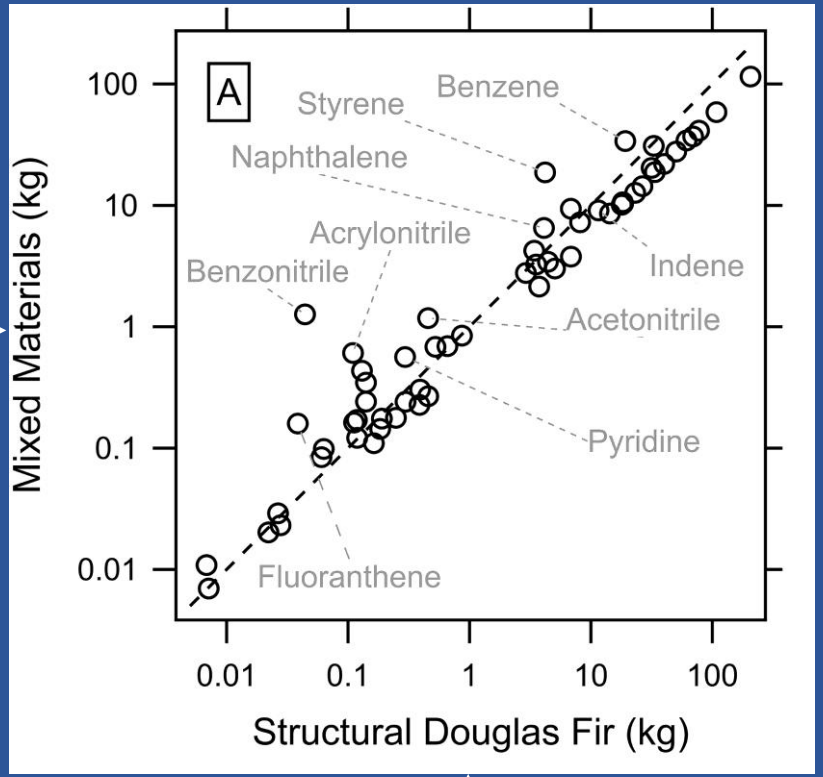
Acknowledgements

- NSF RAPID, NOAA AC4, NSF GRFP, Sloan Foundation, CIRES

Which VOCs Stand Out During an Urban Fire?

Emissions from a home containing:

Douglas Fir	50%
SYP	10%
Plywood	10%
MDF	10%
OSB	10%
Wire	1%
Triexta	1%
Polyester	2%
Nylon	1%
PVC	1%
CPVC	1%
XPS	1%
PUF	1%
Shingles	1%

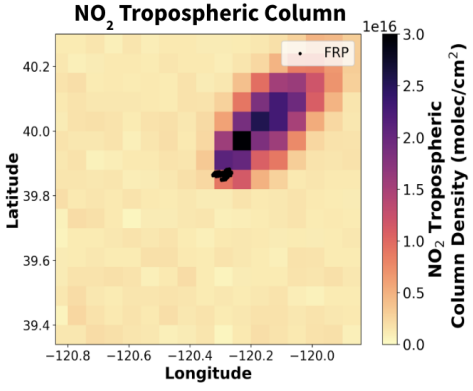


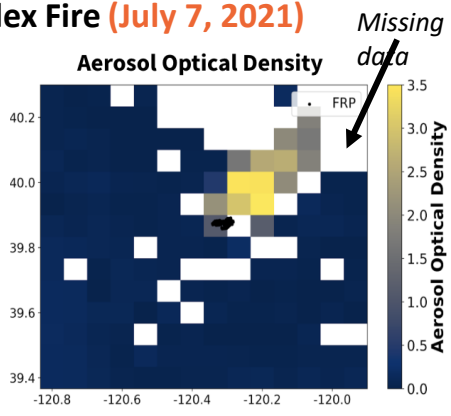
Nitriles and styrene are especially high during WUI fires and may be good markers

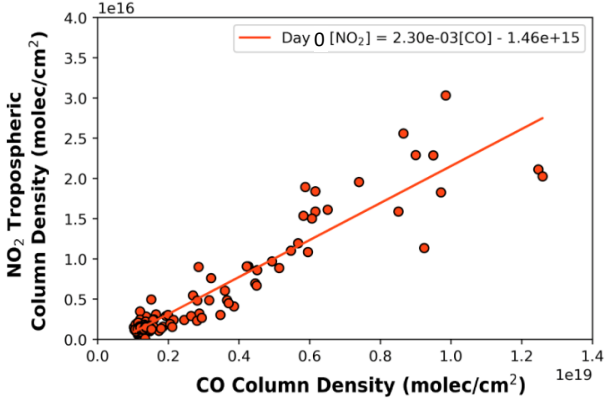
Emissions from a home containing 100% Douglas Fir

Trends in $\Delta NO_2/\Delta CO$ are Robust Despite Aerosol Shielding

Day 0 of Beckwourth Complex Fire (July 7, 2021)







Anderson et al. 2023

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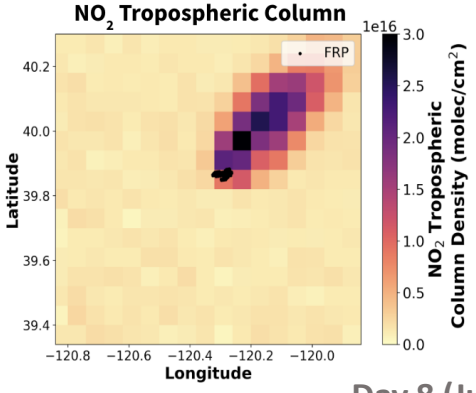
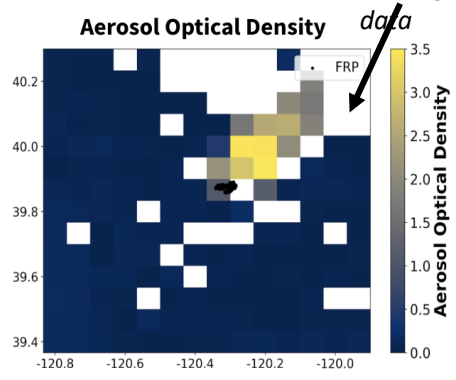
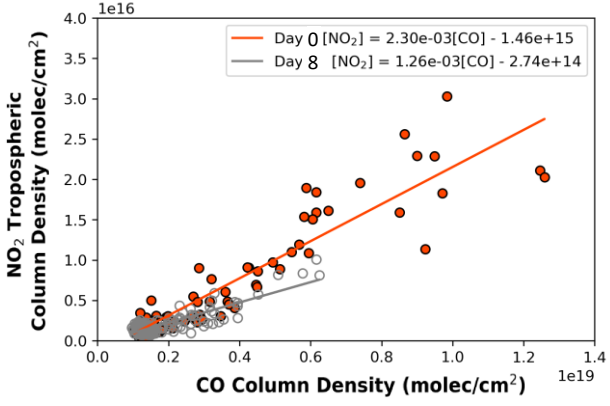
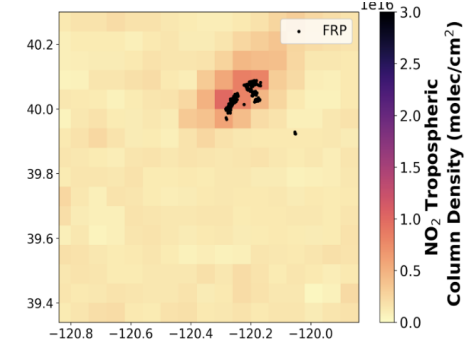
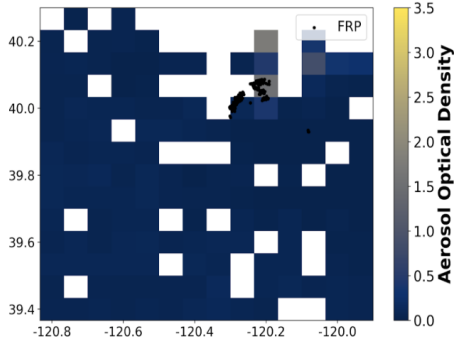






Day 8 (July 15, 2021)



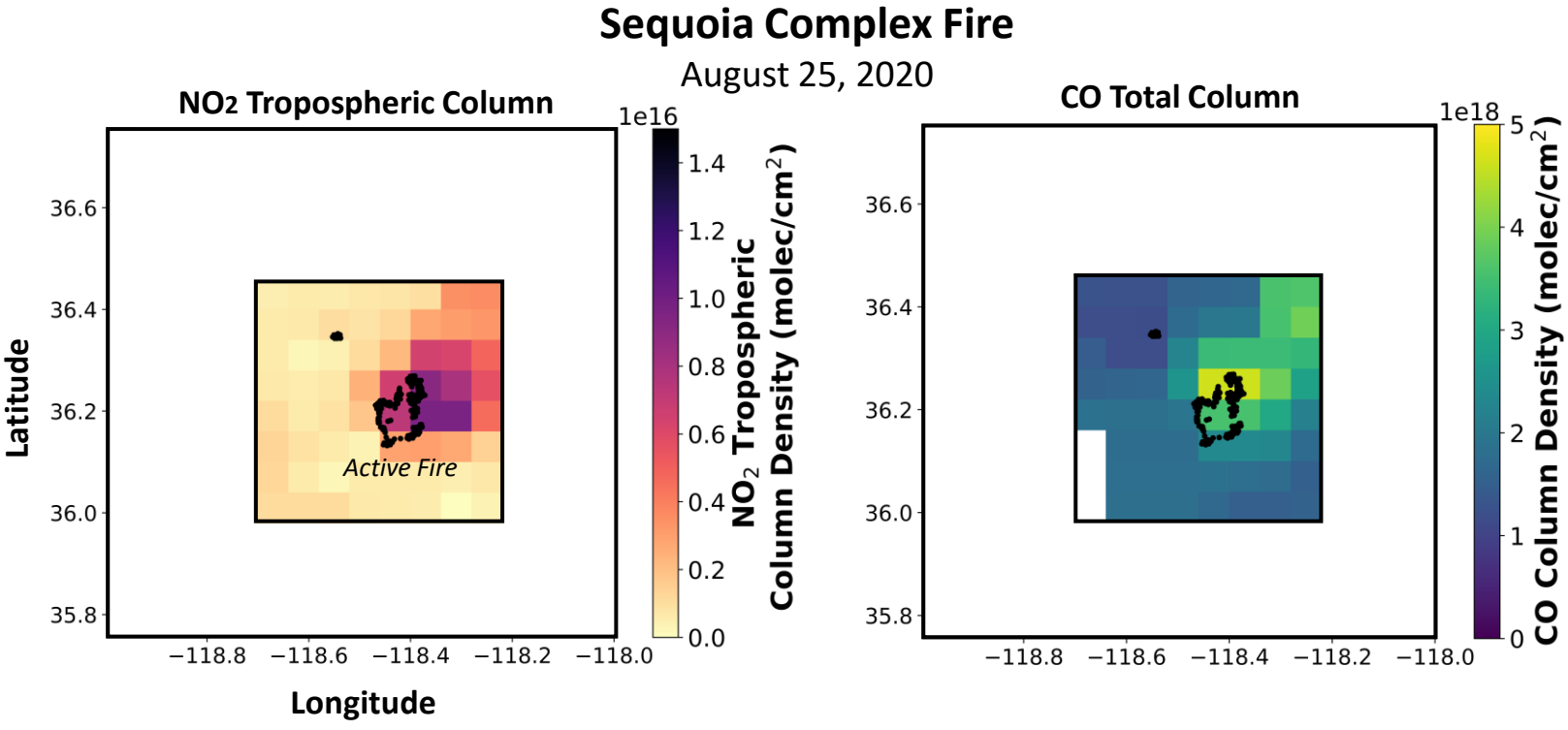


- Differences in aerosol optical density do not cause the decrease in $\Delta NO_2/\Delta CO$ over time
- Radiative transfer used to determine that the underestimation in TROPOMI $\Delta NO_2/\Delta CO$ was a factor of 2-3

Thank you to Barbara Dix and Jordan Schnell!

Anderson et al. 2023

Estimating the Impact of Chemistry by Comparing Emission Ratios of Fresh and Aged Smoke



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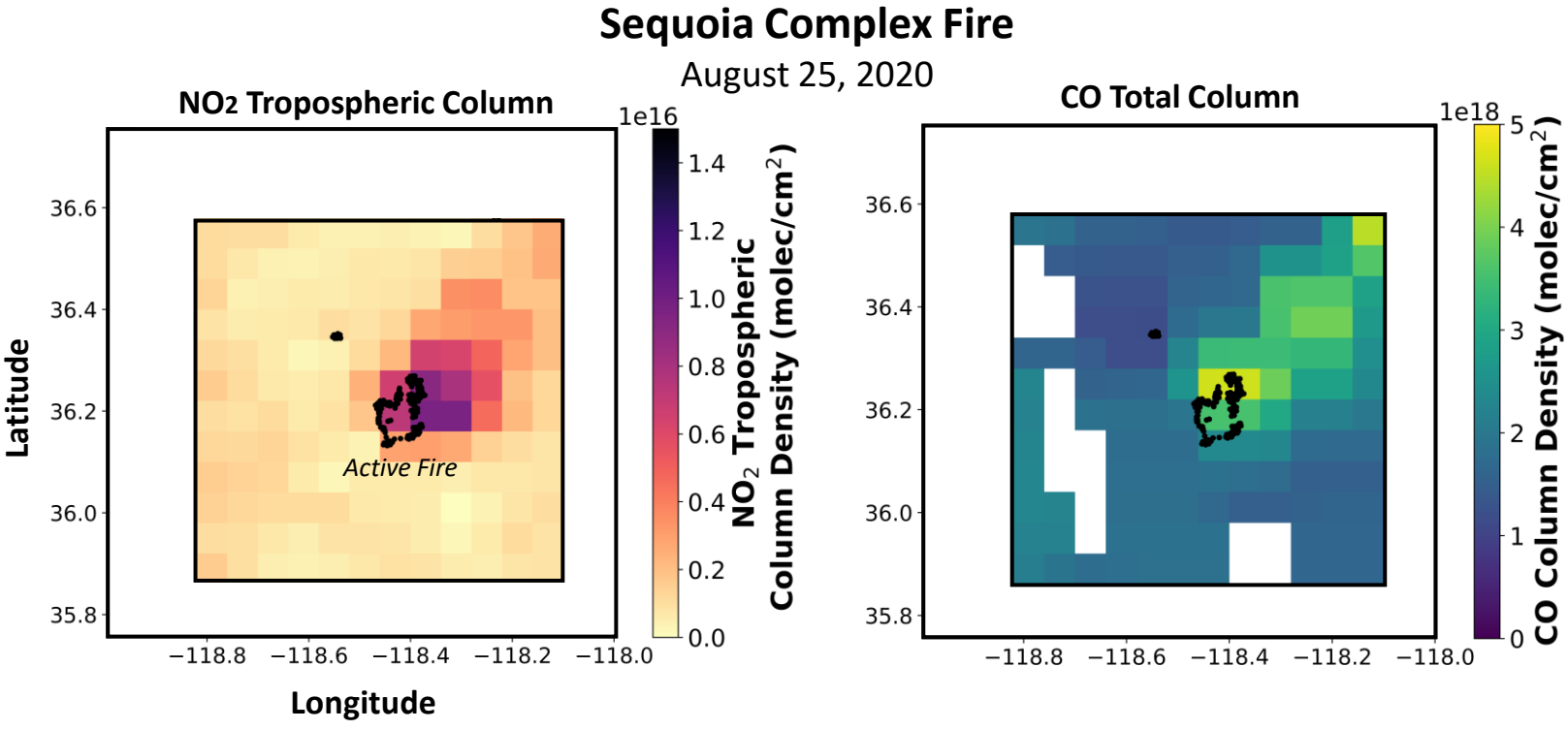

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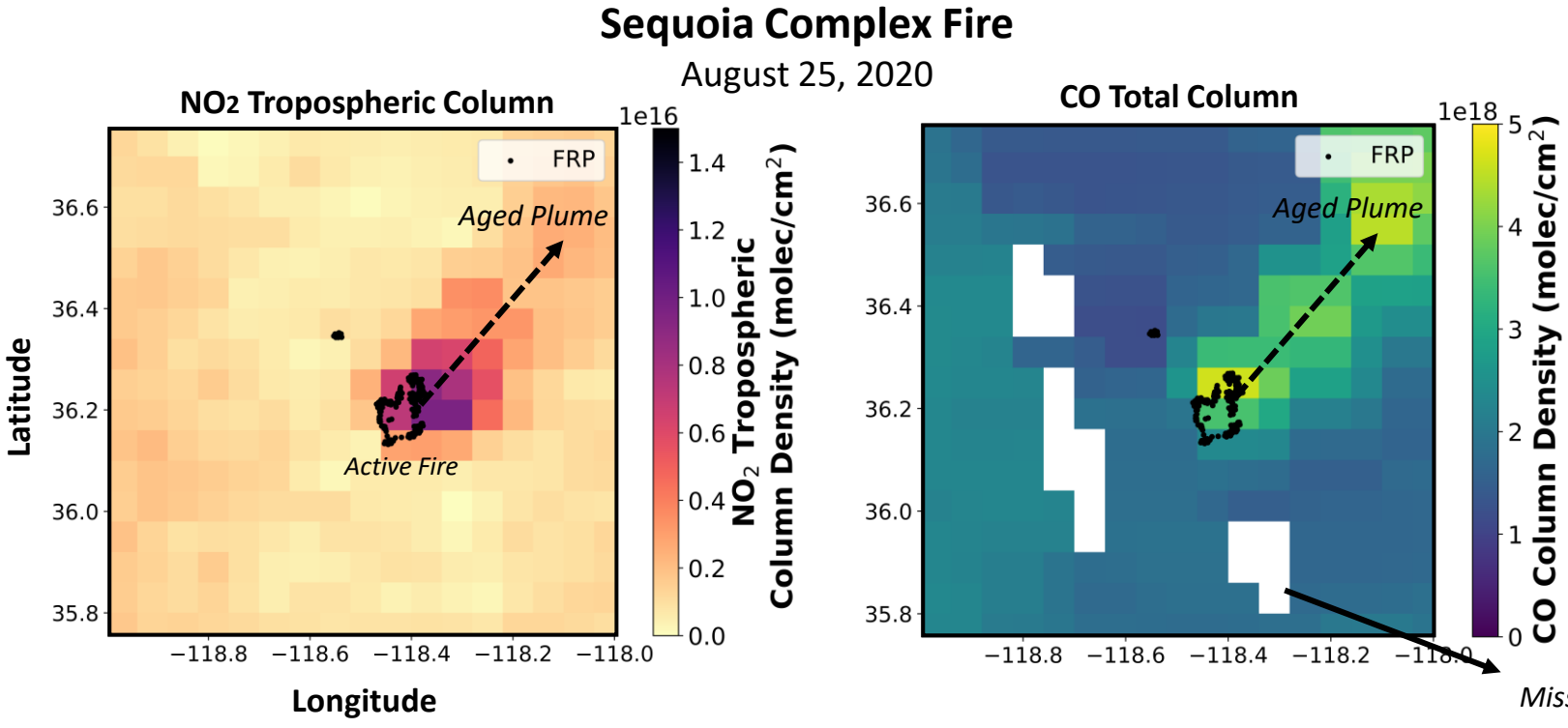

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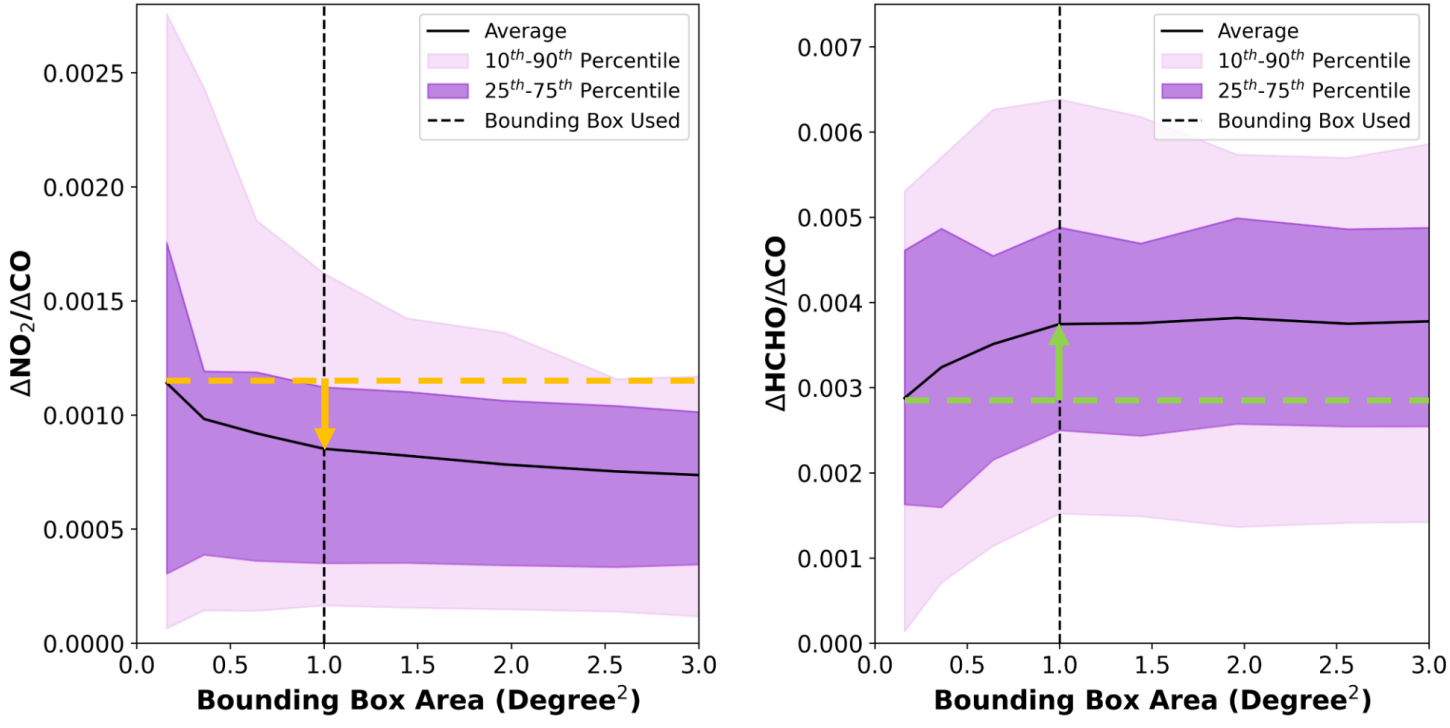
Chemistry Causes an Underestimation in $\Delta NO_2/\Delta CO$ and an Overestimation in $\Delta HCHO/\Delta CO$



- Chemistry causes a 25% underestimation in NO_2 and a 35% overestimation in HCHO

Anderson et al. 2023