

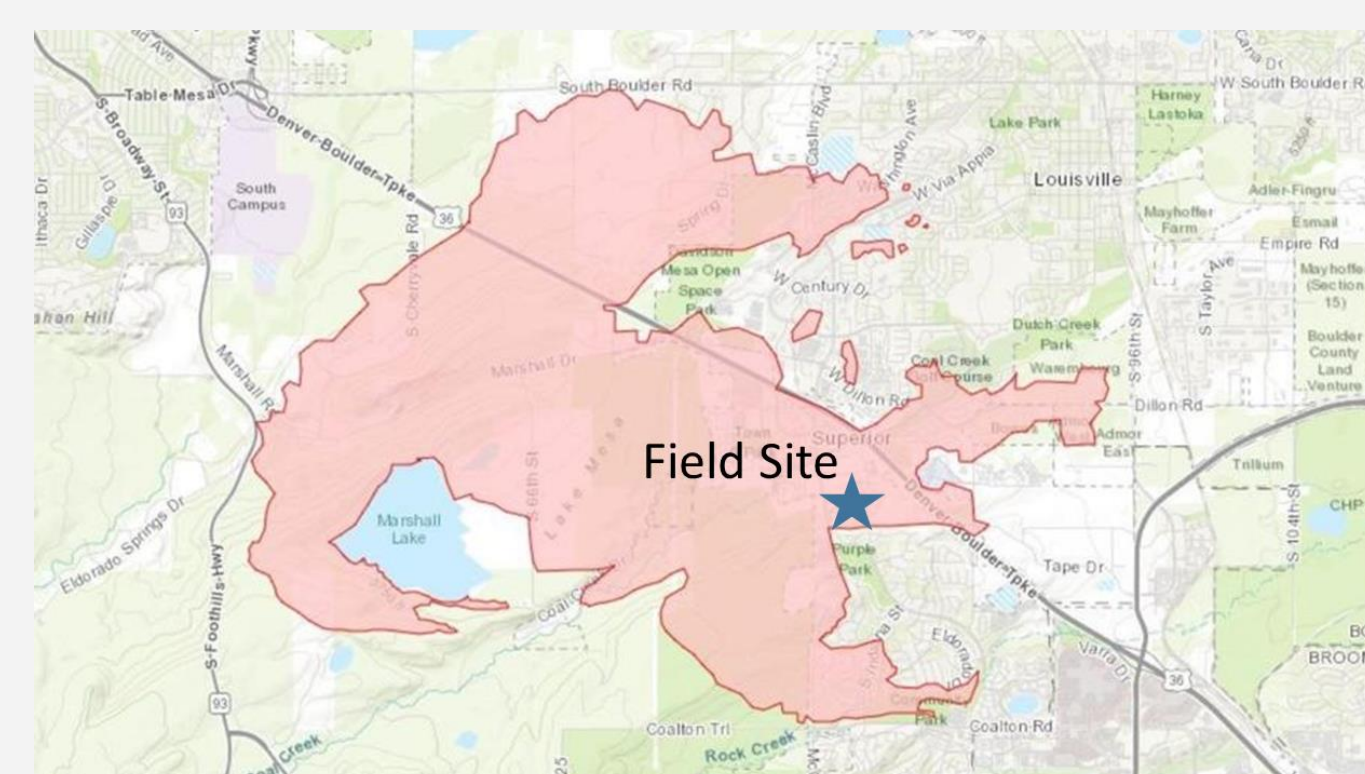
Background/Motivation

Marshall Fire

- Fire burned on December 30, 2021
- The most destructive fire in Colorado history in terms of structural damage.¹
- Extreme dry conditions in the preceding months and intense winds the day of contributed to the fire spread and impact.
- Multi-group deployment occurred roughly nine days after the fire investigating air quality impacts.
- Deployed for roughly 1 month.

Measurement Goals

- Our measurements focused on gas phase Volatile Organic Compounds (VOCs).
- In general, VOCs have been tied to negative health impacts and that is the case as well with Wildfire emissions.²
- Indoor measurements in smoke impacted homes potentially looking for long term enhancement of VOCs as they are “trapped” in indoor spaces.³



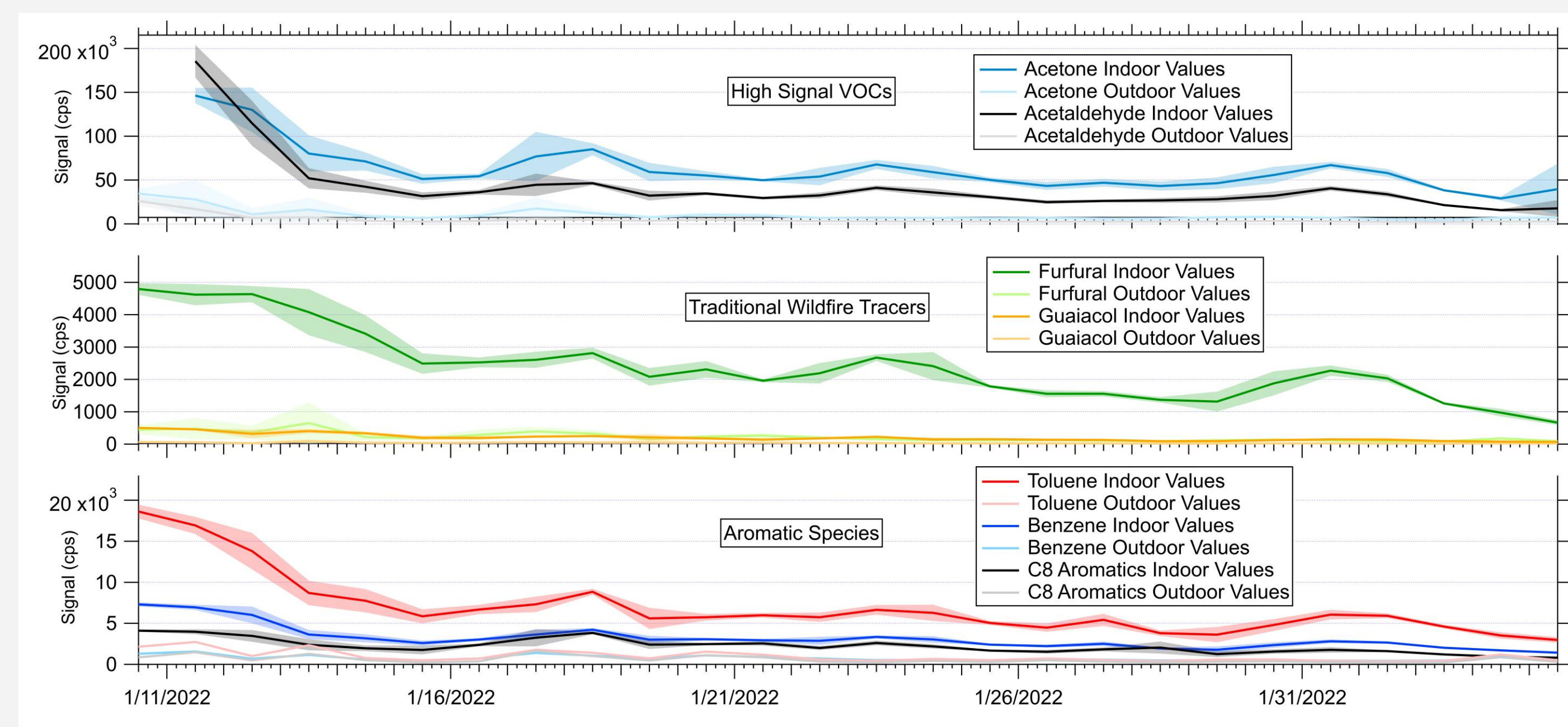
Area of effect from the Marshall Fire with site marked



Photo of street where measurements were taken

Long Term Trends

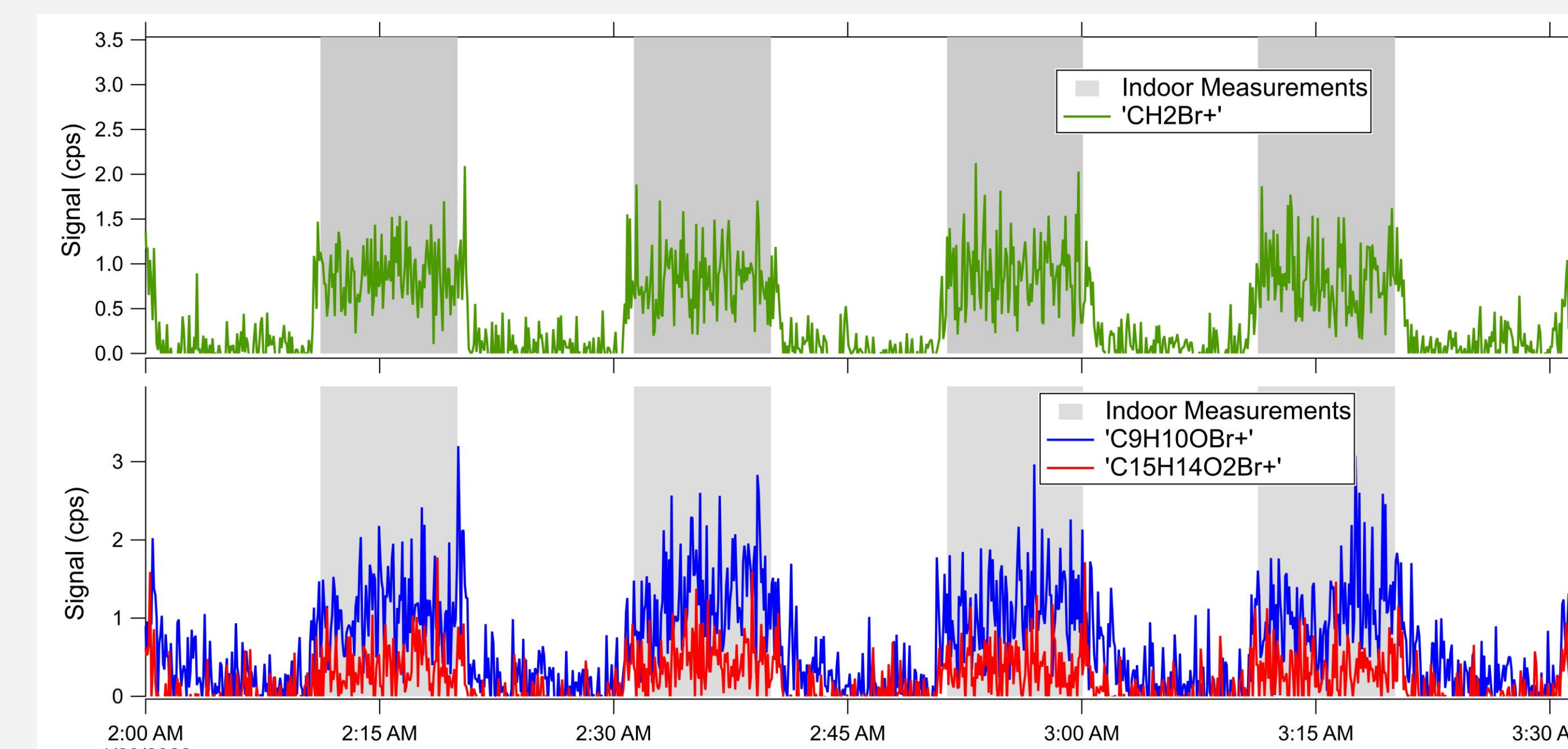
- Measurements of wildfire emissions have been well studied, though the Marshall fire is a unique case in that the main fuel was structural as opposed to biomass.
- Initial outlook shows these species to be elevated in the indoor environment, particularly over the first few days of our study, with the relative enhancement decreasing over time.
- Opportunity to observe short term smoke impacts as opposed to impacts months after the fire.⁵
- Wider range of species, including structural species, will be looked at for trends and exposure concerns.



Trends for daily averages of several VOCs for both indoor and outdoor values preliminarily broken into different types: aromatics, high signal, and traditional wildfire tracers.

Unique Emission Concerns

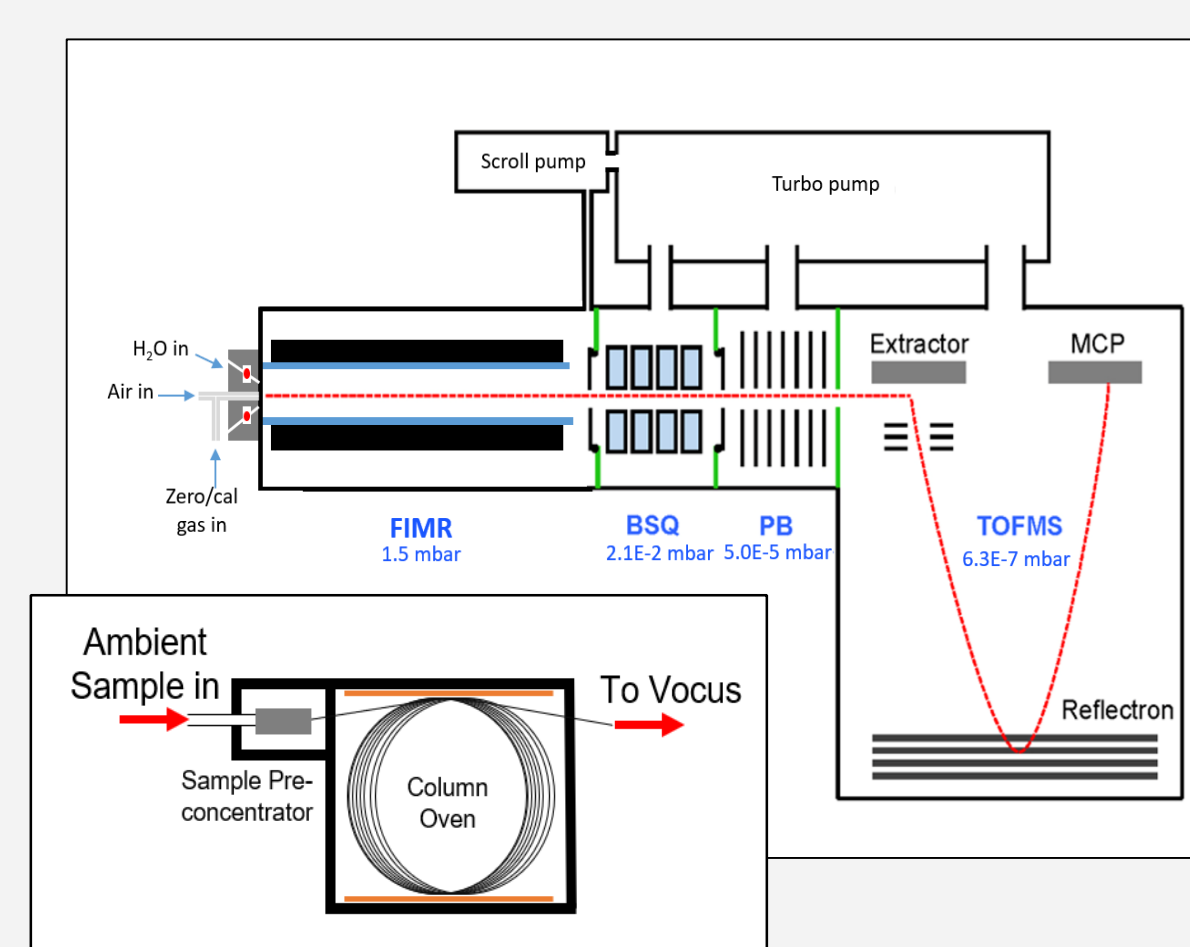
- The fact that structures made up the bulk of the fuel for the fire raises the prospect of unique/structural emissions being part of the profile.
- These emissions could be derived from building materials, tires, etc.
- One type of species that could be of concern are brominated flame retardants which are seen in older furniture and have been investigated in lab pyrolysis (burning) studies.⁸
- Several species appear to be enhanced in indoor environments several weeks after the fire (low signal).



Several potential brominated fire retardant emissions showing enhancement in indoor environments

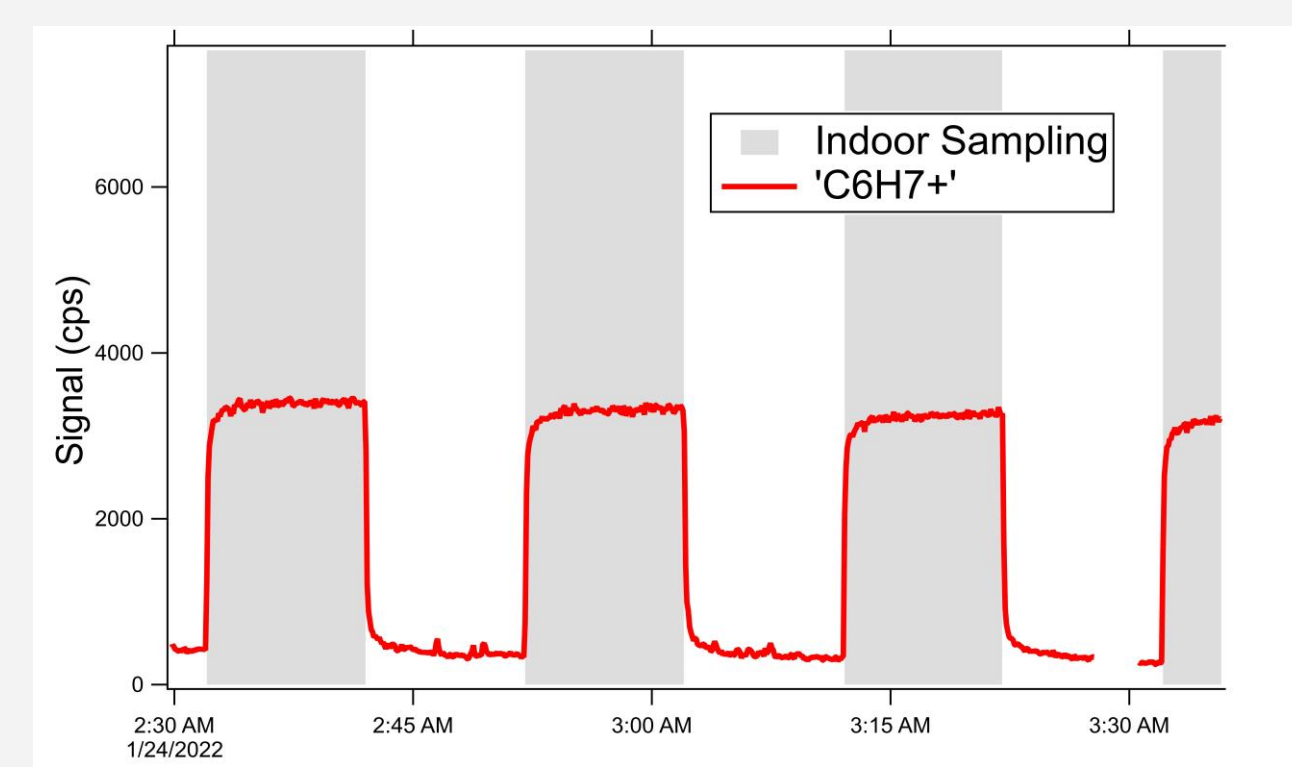
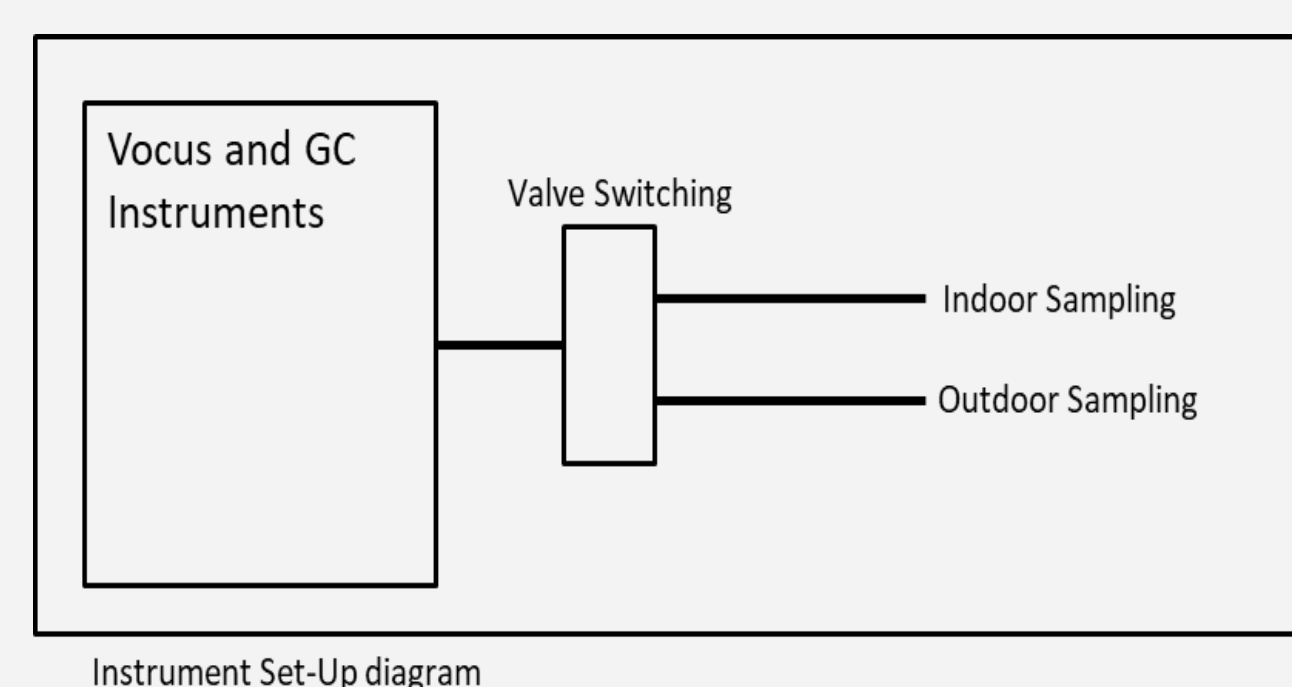
Instrumentation

Vocus PTR-TOF-MS/ARI GC



Schematic diagrams of the Vocus PTR-TOF-MS and the gas chromatograph.

Measurement Set-up



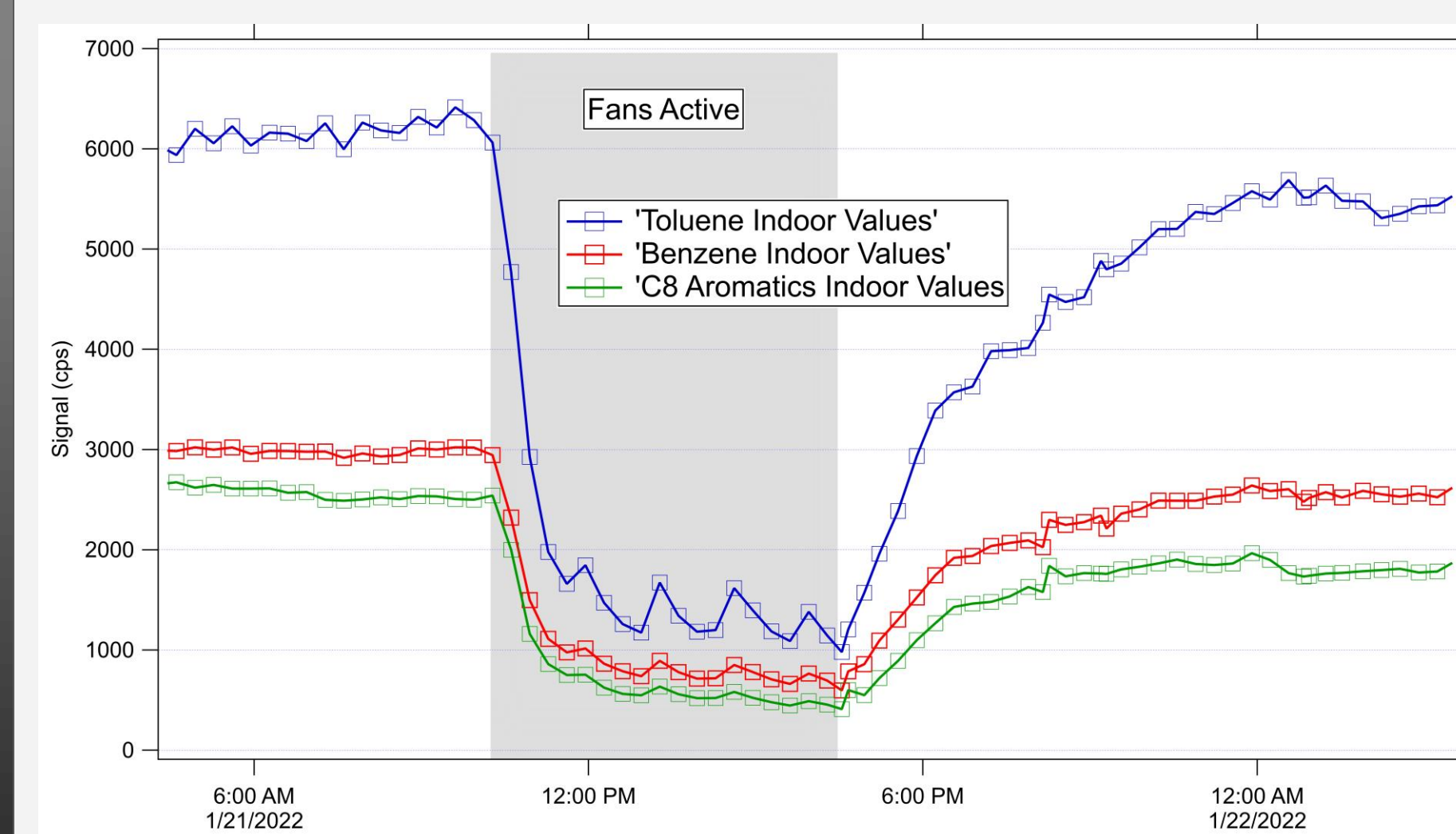
Small data segment for indoor vs outdoor measurements

- Proton-Transfer-Reaction Mass Spectrometry (PTR-MS) allows VOCs to be measured with a high sensitivity (parts-per-trillion) and fast time response (seconds).⁴
- Time-of-Flight (TOF) provides high mass resolution ($m/\Delta m \sim 12,000$).
- Gas Chromatography pre-separation of VOCs allows for improved identification and quantification.

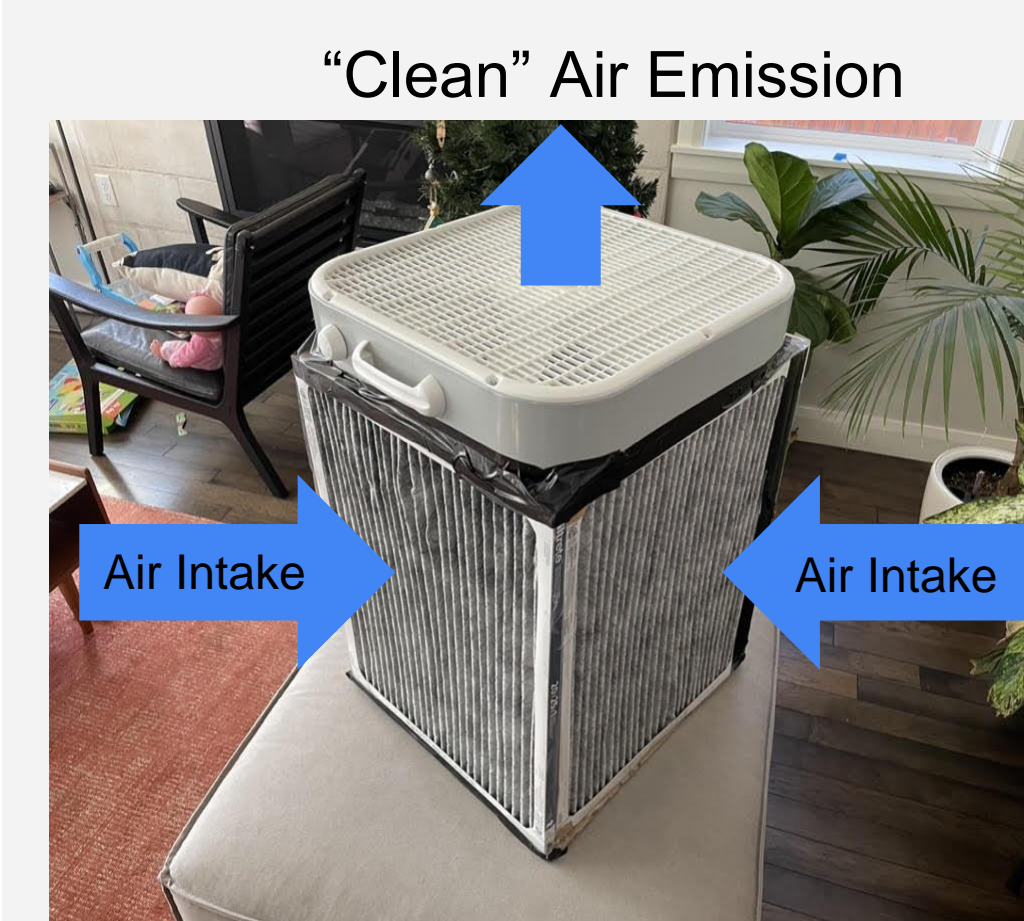
- Sampling set up to alternate between indoor and outdoor measurements in order to measure indoor enhancement and relative trends over time.

Mitigation Tests

- Tests were conducted on the mitigation options presented to home owners for improving indoor air quality: ventilation/filtration.⁶
- Ventilation events were conducted with immediate impact, though species would recover their initial concentration several hours after the event.
- Filter boxes (“Corsi-Rosenfeld”) boxes were used as filtration devices for indoor air with both particle and activated carbon filters.⁶
- Particle filters showed no impact on the VOC profile while activated carbon filter boxes helped to dramatically reduce the VOC profile while they were active.
- These events can be used to give insight into the indoor “reservoirs” of VOCs based on measurements of the response time for a given VOC.⁷



Trends for indoor values of several aromatic species during an activated carbon filter event at the home



“Corsi-Rosenfeld” box at the site with activated carbon filter

Conclusions/Looking Forward

- This study presented a unique opportunity to study smoke impacts in the immediate aftermath of the fire and from a fire that differed from traditional wildfires.
- We have made inroads into observable VOC trends in the indoor environment and will continue to work on wider exposure estimates as well as source apportionment
- Mitigation strategies using ventilation and filtration were utilized to decrease VOC concentrations and may also help to better understand indoor reservoirs/sources of VOCs
- Remediation cleanings, which are not an area that has been studied extensively, were observed and results will give insight not only to how it changes the VOC profile but exposure levels during the cleaning.
- Other data streams from the study such as particle data, GC data, and other MS measurements will be used as this work continues to inform/strengthen our results.

Acknowledgments

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- Thanks to Christine Wiedinmyer, members of the Hannigan group (Caroline Frischmon, Jonathan Silberstein, Evan Coffey) and Vance group (Avery Hatch).
- Also special thanks to the home owners for allowing us to conduct these measurements in their homes.

References

1. Vo, Thy, Gilbert, David, Prentzel Olivia. Marshall fire officially becomes Colorado's most destructive, with 991 homes and businesses burned, officials confirm. *The Colorado Sun*. Jan 1, 2022
2. Reid, C., Brauer, M., Johnston, F. et al. Critical Review of Health Impacts of Wildfire Smoke. *Environmental Health Perspectives* **124**, 9 (2016).
3. Wang, Chen, et al. Surface reservoirs dominate dynamic gas-surface partitioning of many indoor air constituents. *Science Advances*. **6**, 8 (2020)
4. Krechmer, Jordan, et al. Evaluation of a New Reagent-Ion Source and Focusing Ion-Molecule Reactor for Use in Proton-Transfer-Reaction Mass Spectrometry. *Anal. Chem.* **90**, 20 (2018)
5. Kohl, Lukas, et al. Limited Retention of Wildfire-Derived PAHs and Trace Elements in Indoor Environments. *Geophysical Research Letters*. **46**, 1 (2018)
6. Wildfires and Indoor Air Quality (IAQ). EPA. <https://www.epa.gov/indoor-air-quality-iaq/wildfires-and-indoor-air-quality-iaq>
7. Wang, Chen, et al. Surface reservoirs dominate dynamic gas-surface partitioning of many indoor air constituents. *Science Advances*. **8**, 6 (2020)
8. Ortuna, Nuria, Moltó Julia, Conesa, Juan, et al. Formation of brominated pollutants during the pyrolysis and combustion of tetrabromobisphenol A at different temperatures. *Environmental Pollution*. **191**, 31-37 (2014)