Volatile Organic Compounds inside Homes Impacted by Smoke from the Marshall Fire

Outline:
• Causes of the Marshall Fire
• Impacts on indoor air
• Decline of VOCs with time
• Effectiveness of remediation

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2021 Had a Wet Spring and a Dry Fall in Boulder

2021 precipitation – 19-yr average

2021 RH – 19-yr average

Wet spring allows grasses to grow more than usual
Dry fall grasses dry out and 1-hr fuels build up

CO Div. of Fire Prevention & Control
December 30 Had Very Strong Winds

NWS Forecast Office Boulder, CO

**HIGHEST WIND REPORTS...**

<table>
<thead>
<tr>
<th>Location</th>
<th>Speed</th>
<th>Time/Date</th>
<th>Lat/Lon</th>
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<tbody>
<tr>
<td>0.7 Mi S Of Northwest Pkwy</td>
<td>56 MPH</td>
<td>1235 PM 12/30</td>
<td>39.97N/104.99W</td>
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<td>: Colorado...</td>
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<tr>
<td>: Adams County...</td>
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<tr>
<td>03 SSW Boulder</td>
<td>108 MPH</td>
<td>0225 PM 12/30</td>
<td>39.99N/105.27W</td>
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<tr>
<td>01 NE Crisman</td>
<td>102 MPH</td>
<td>1120 AM 12/30</td>
<td>40.05N/105.35W</td>
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<tr>
<td>03 NW Marshall</td>
<td>80 MPH</td>
<td>0125 PM 12/30</td>
<td>39.98N/105.28W</td>
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<td>: Boulder County...</td>
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<tr>
<td>03e03750rwsarlpl At Baseline</td>
<td>73 MPH</td>
<td>1123 AM 12/30</td>
<td>40.00N/105.26W</td>
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<tr>
<td>Wondervu</td>
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<td>0956 AM 12/30</td>
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<tr>
<td>Atoc - Univ. Colorado Campus</td>
<td>71 MPH</td>
<td>1050 AM 12/30</td>
<td>40.01N/105.27W</td>
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</tbody>
</table>
2 Lives lost
1084 Buildings burned
149 Damaged
Many unburnt homes were exposed to heavy smoke during the fire.
Smoke Impacts Inside Homes

- Ash and soot were deposited indoors
- Strong burn smell indoors
- Many people did not return for weeks if not months
Detailed Measurements in one Home in Superior

- Newer home next to old town Superior
- January 8 – February 9
- Home was cleaned on February 7-8
- Collaboration with Mike Hannigan, Nina Vance, Colleen Reid and TOFWERK
- Funding: CIRES, NSF RAPID
Most VOCs were Enhanced Indoors Relative to Ambient
Aromatic VOCs were Enhanced Indoors and Decreased Gradually

- Decreases took longer than anticipated
- There must be large reservoirs of VOCs indoors after the fire
- Looking for dependence on volatility or solubility
Similar Decreases in Known Wildfire Tracers

- Decreases took longer than anticipated
- There must be large reservoirs of VOCs indoors after the fire
- Looking for dependence on volatility or solubility
Early February: VOCs are similar in homes near the burnt area and elsewhere in Boulder County.
Are there VOCs from non-Biomass Fuels?

Example: what happens to brominated flame retardants in a fire?

- Some evidence for break-down products from flame retardants
- Much more work is required on this and other fuels!
Mediation – Air Cleaners

- Activated carbon filters can be very effective at reducing indoor VOCs
- After use, VOCs quickly return to previous values
- Significant VOC reservoirs must exist
Professional Smoke Remediation

• Many homes were professionally cleaned within weeks to months after the fire
• Costs per home: $10,000s
Measurements in Multiple Homes in Boulder County

These homes had not been touched since fire

These homes had been professionally cleaned

Furfural

Photo: Steve Brown
Indoor VOCs During Remediation

Day 1: limonene up to 1 ppmv from cleaners used to wipe down surfaces

Hydroxyl cleaners are used at night and, later in the week, during the day.
Indoor SOA Formation During Cleaning

- As used, OH only reacts with monoterpenes from cleaning products
- Products include SOA and many gas-phase products
- Unlikely for any radicals to reach the walls

Data and analysis: Hannigan group
Indoor VOCs Before and After Remediation

“Before”
Average of 6 hours

“After”
Average of 6 hours

Mass spectra were compared between these two periods
Indoor VOCs Before and After Remediation

No discernable reductions in all the measured VOCs!
Conclusions

• Emissions from fires at the wildland-urban interface are severely understudied

• Air quality effects can linger for weeks in indoor environments
  • What are the reservoirs?
  • Does this happen for other types of pollutants?

• Strong need for testing and remediation standards
  • Carbon filters provide temporary relieve
  • Hydroxyl generators are ineffective for cleaning indoor VOCs
Meet the Home SOS Team

Will Dresser  Alex Bradley  Bart Croes  Trupti Das  Abby Koss
Mike Hannigan  Nina Vance  Colleen Reid  Christine Wiedinmyer  Evan Coffey
Avery Hatch  Caroline Frischmon  Jon Silberstein

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• CIRES
• NSF RAPID