Monitoring Data Analyses for Wildfire Smoke Exceptional Events Demonstrations:

Lessons Learned and Future Approaches from Far Downwind Sites in the Great Lakes Region

Amy Robinson, Michigan Department of Environment, Great Lakes, and Energy
Angie Dickens, Lake Michigan Air Directors Consortium (LADCO)

EGLE
MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

LADCO

NAAMC 2024 Presentation

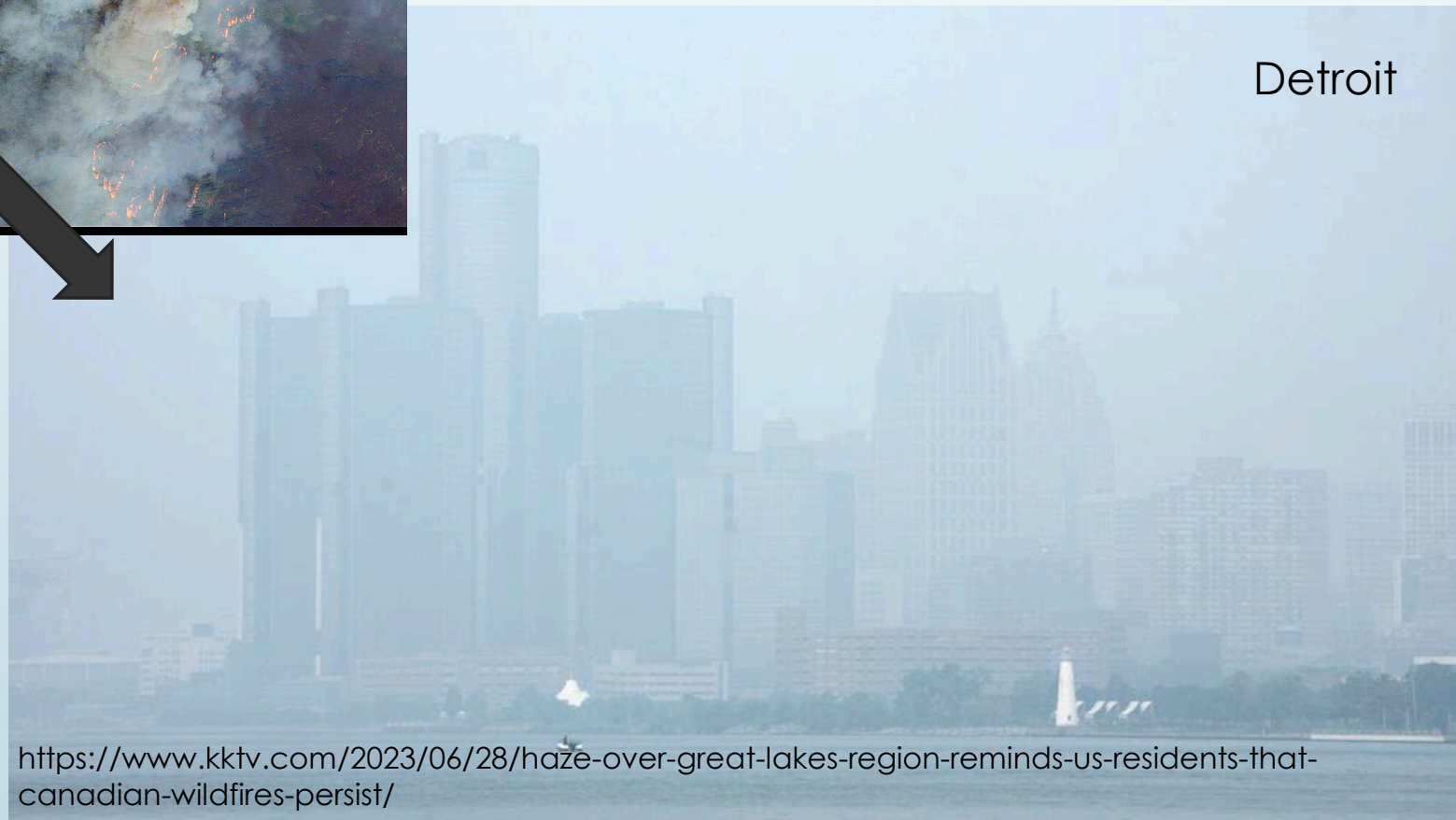
https://www.kktv.com/2023/06/28/haze-over-great-lakes-region-reminds-us-residents-that-canadian-wildfires-persist/

Outline

- Introduction
- Quantity of smoke
- Composition of smoke
- Application to EE demos

Summer 2023: Canadian wildfires

https://en.wikipedia.org/wiki/2023_Canadian_wildfires



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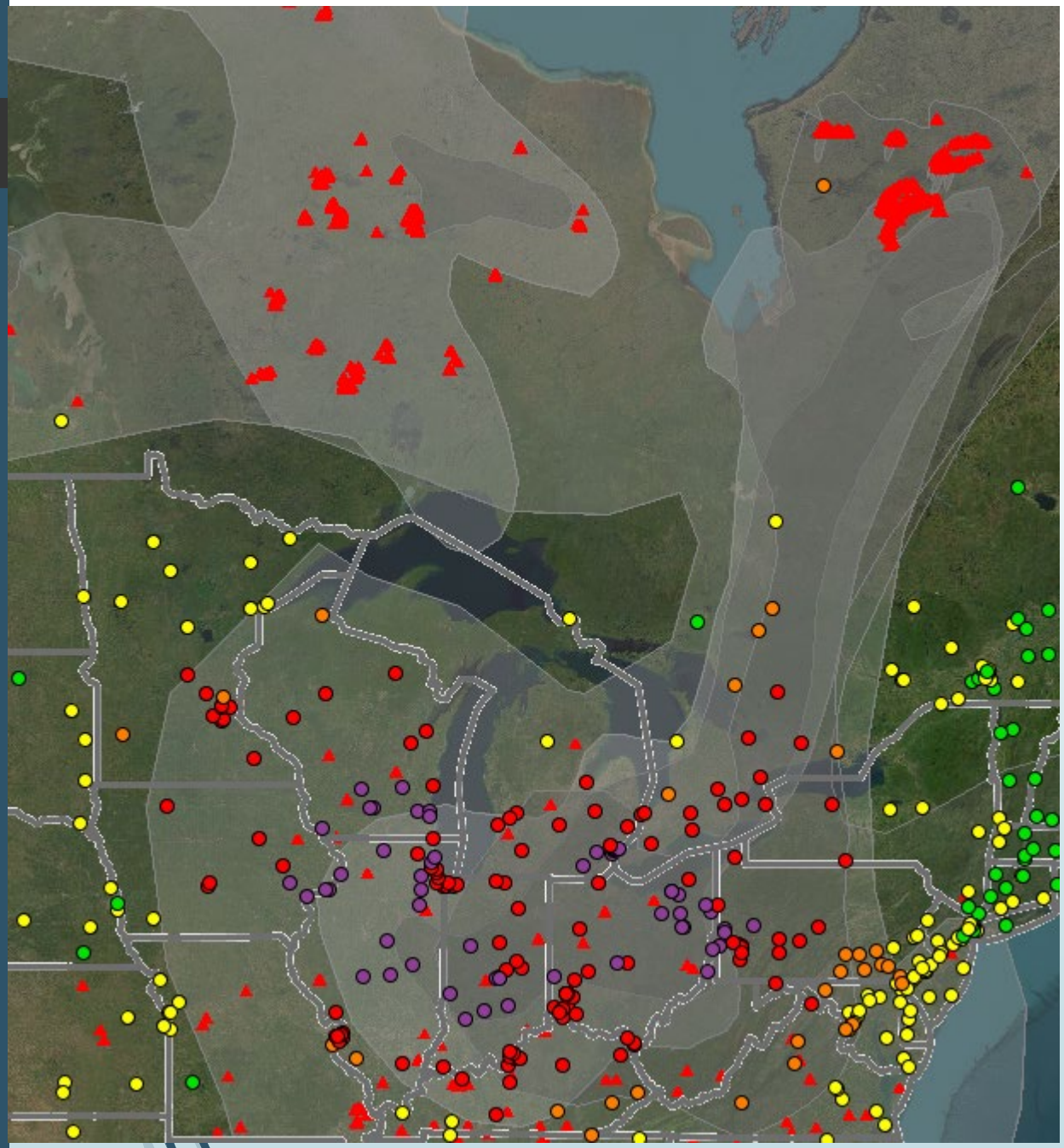


Summer 2023: Canadian wildfires

June 28, 2023

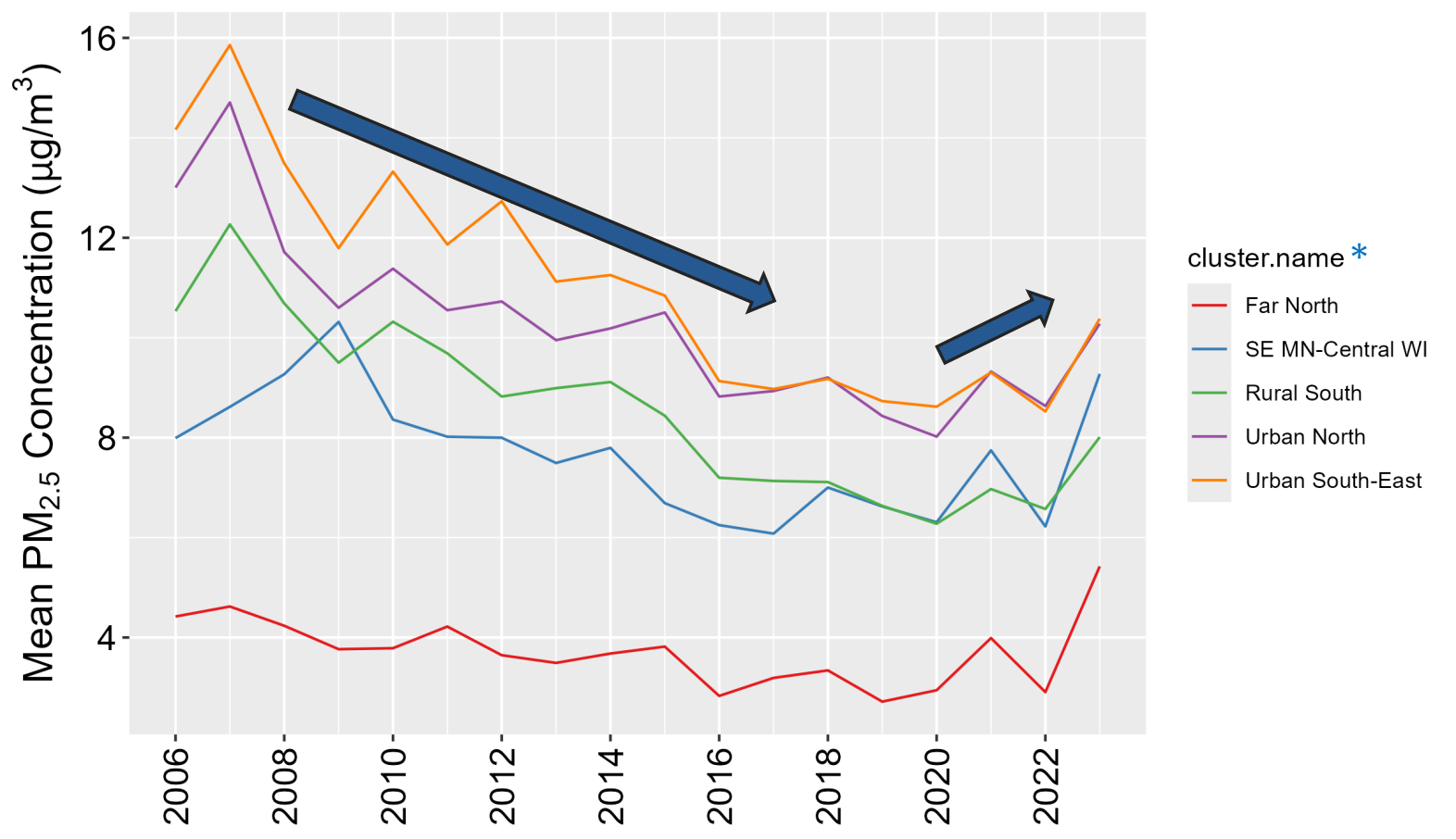
- Smoke from wildfires in Quebec spread over the region
- 24-hour averages up to 214 $\mu g/m^3$ in central Illinois (over 1000 miles away)

Smoke impacts over the whole summer

- Heaviest impacts in June
- Urban areas had up to 18 “Tier 1” days with smoke and up to 88 “Tier 2” days with smoke

- Many states are working on exceptional events demonstrations for summer of 2023

Annual $PM_{2.5}$ Trends in the Great Lakes region

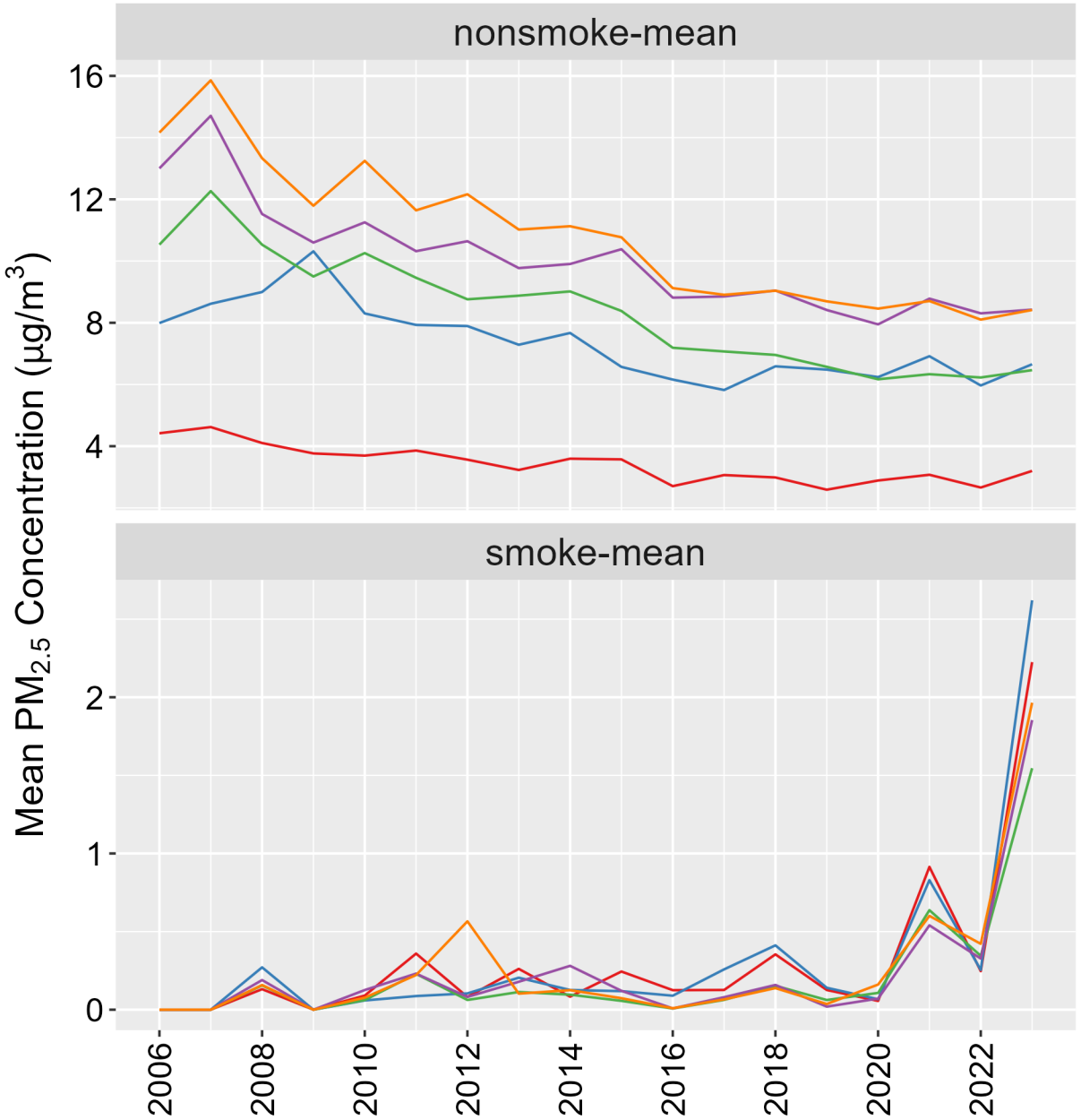


*Monitors grouped using k-means cluster analysis

Question: Emissions are still decreasing, so why is $PM_{2.5}$ increasing?

→ *Smoke???*

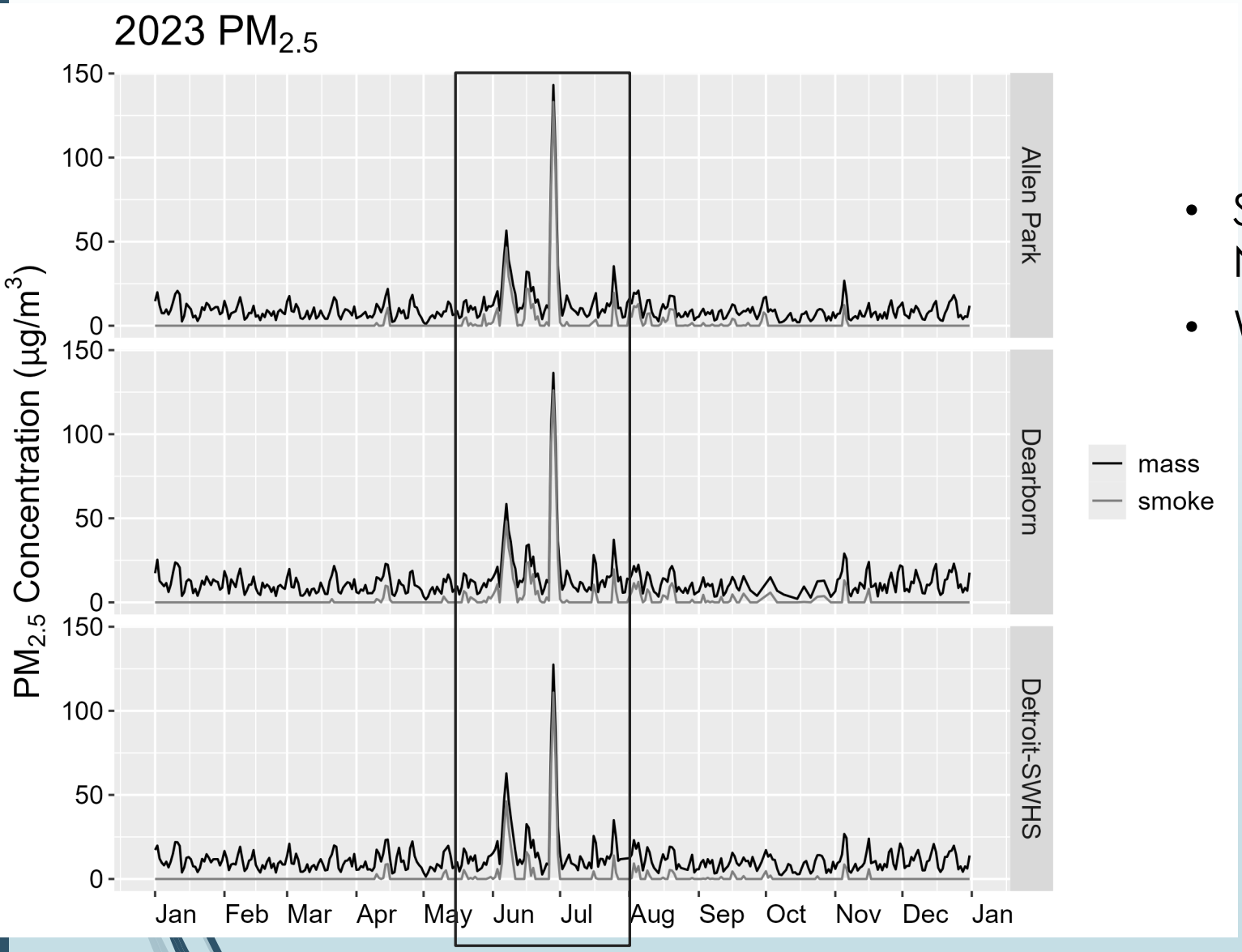
Separating Smoke and Non-smoke $PM_{2.5}$



- Determined amount of smoke on a given day
  - = $PM_{2.5\text{-daily}}$ – (Mean $PM_{2.5}$ + 1 stdev)$_{\text{nonsmoke-days-month}}$
  - When smoke in satellite column (HMS smoke)
  - Method adapted from Childs et al. (2022) *ES&T* and Burke et al. (2023) *Nature*

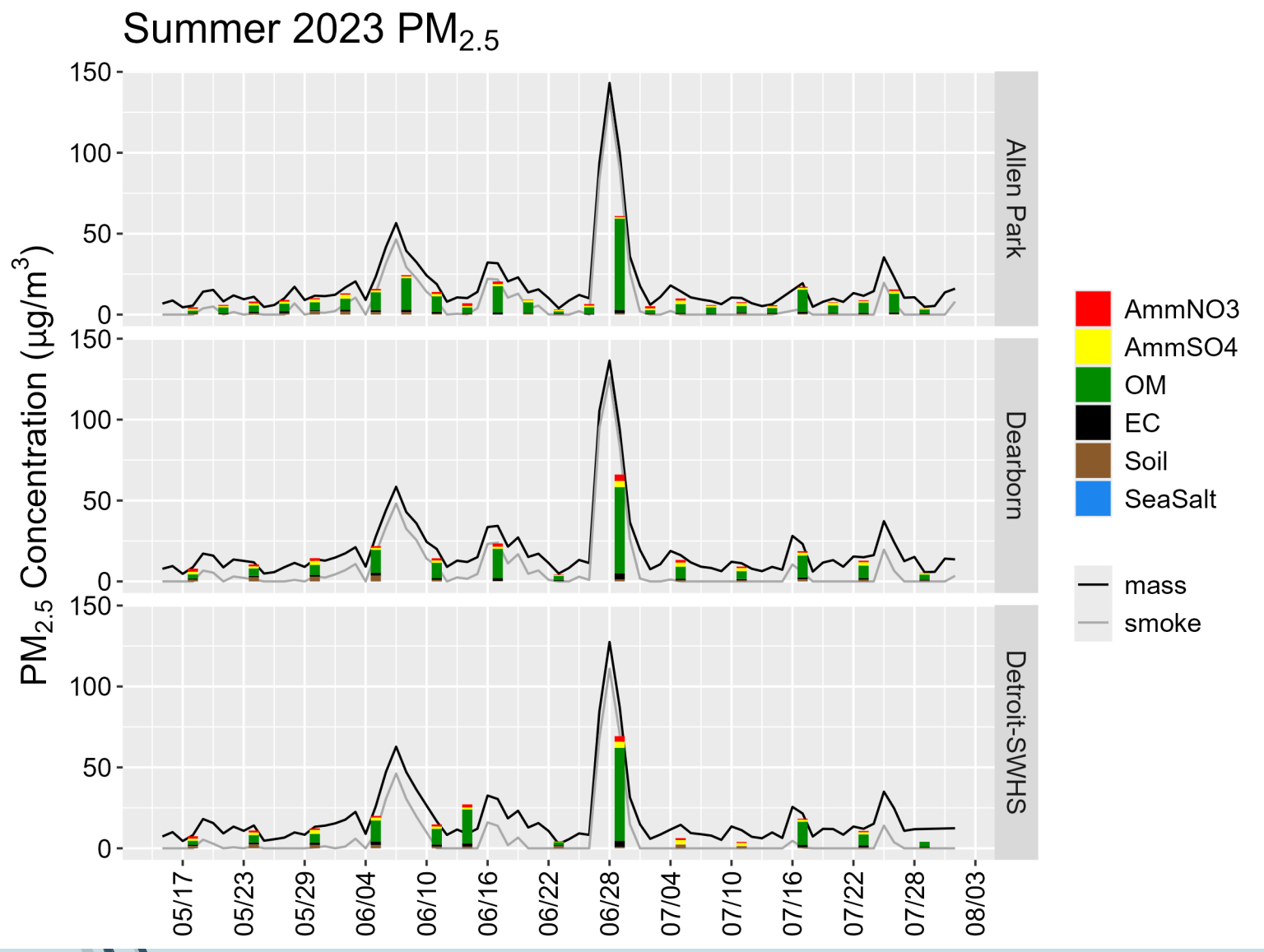
- Large increase in smoke $PM_{2.5}$ in 2021 & 2023
- Smoke accounts for observed increase in $PM_{2.5}$
  - Non-smoke $PM_{2.5}$ trends have been roughly flat in recent years

Smoke in 2023 – Focus on Detroit



- Smoke episodes from April through November
- Worst in June

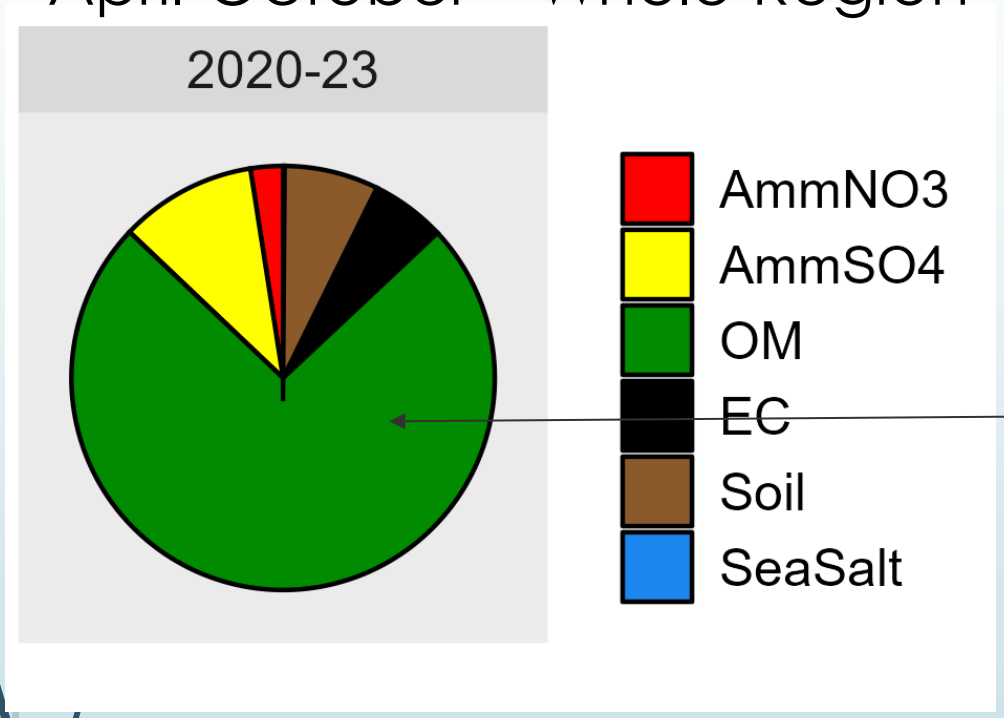
Composition of Smoke: $PM_{2.5}$ Speciation - Detroit



- Limited to sampling days (1/3, 1/6, or 1/12)
- See large OC peaks during smoke peaks
- Also have peaks in EC and K

Composition of Smoke: $PM_{2.5}$ Speciation

April-October – Whole Region



Smoke is ~ 74% organic matter (OM)

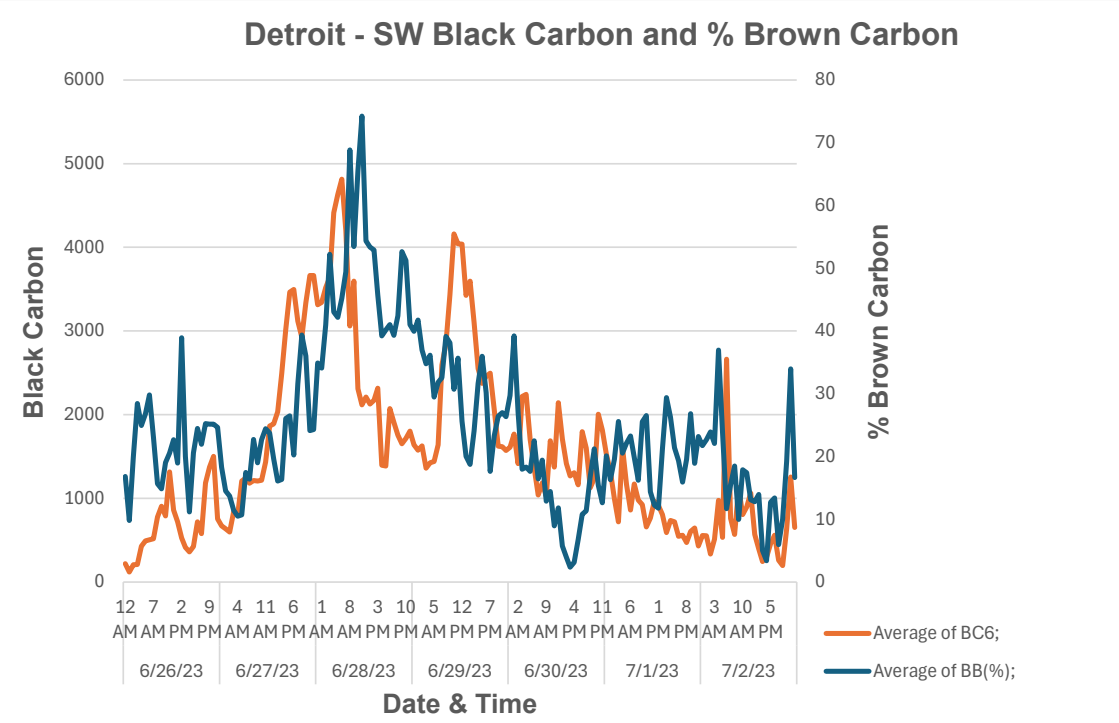
- Smoke composition mostly consistent across clusters & over time
- Useful tracers of smoke: OC, EC, potassium (K)
  - Made up a fairly consistent fraction of the smoke
  - OC/EC wasn't consistent in data

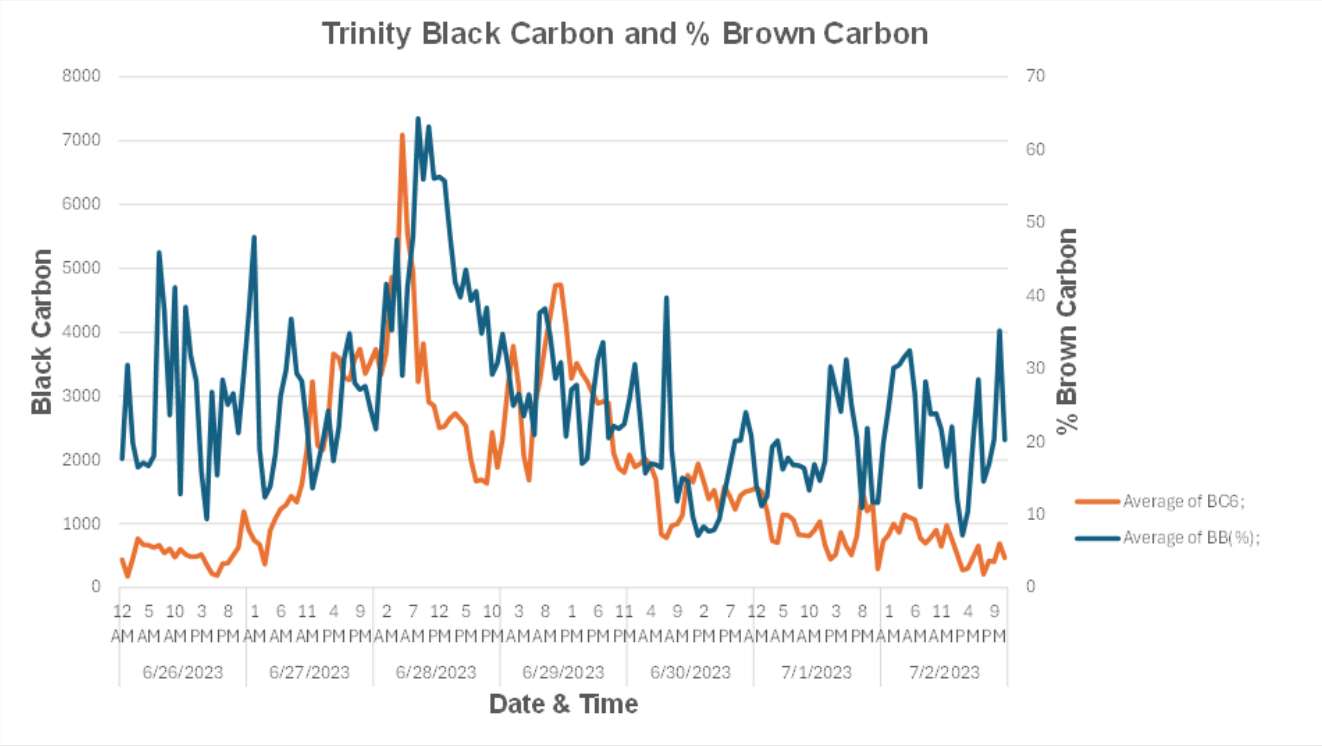
Also useful to estimate composition of non-smoke $PM_{2.5}$

- This is the more controllable portion states will need to target in attainment plans

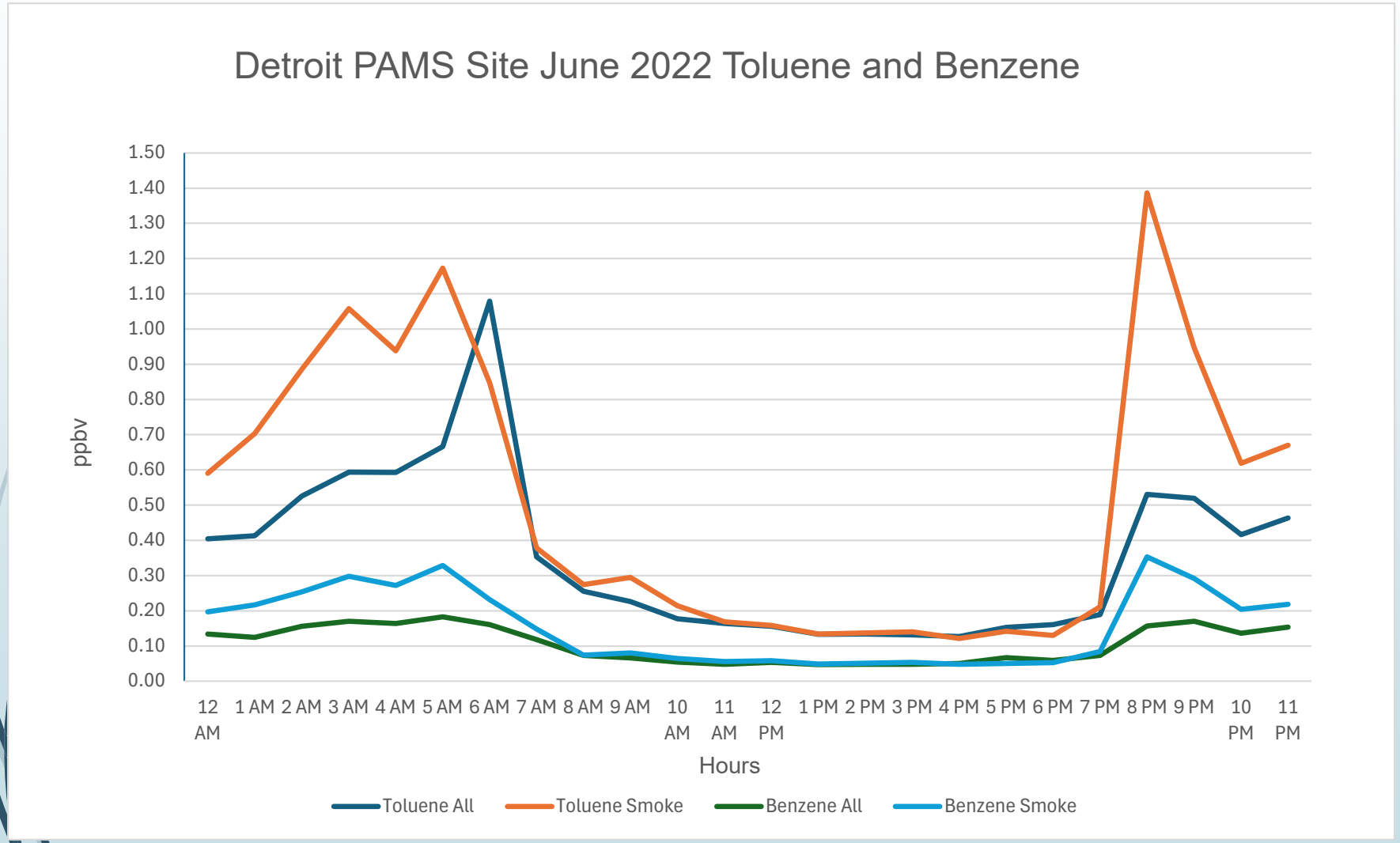
Composition of Smoke: Black and Brown Carbon – Detroit June

Data from Magee AE 33 Aethalometers





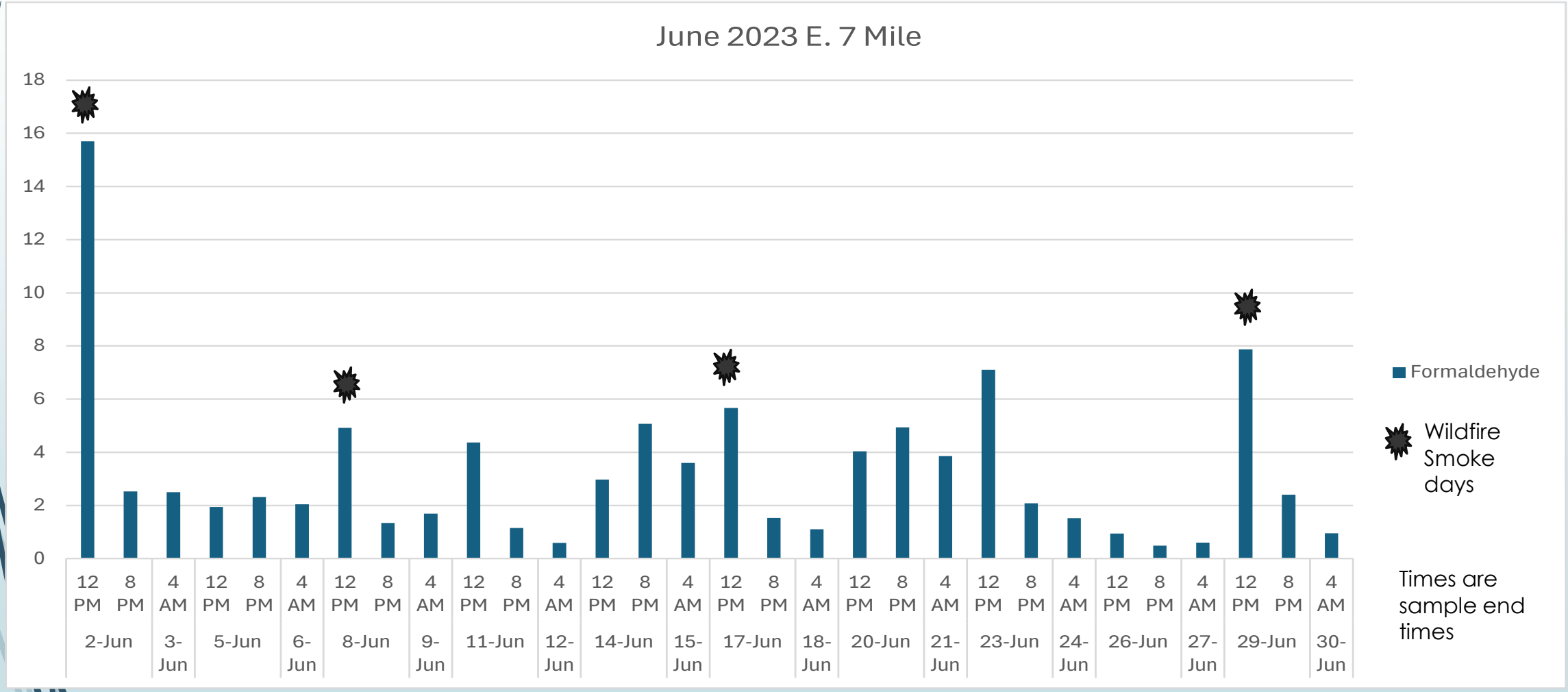
Composition of Smoke: Benzene and Toluene – Detroit



7 Smoke Days

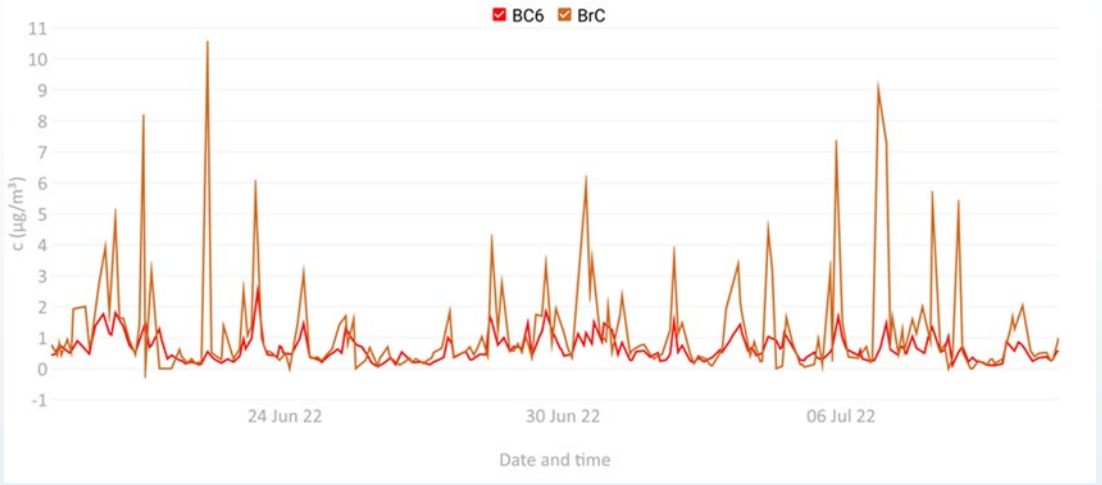
Dickinson, G. N., et al. (2022). *GeoHealth*, 6, e2021GH000546. https://doi.org/10.1029/2021GH000546

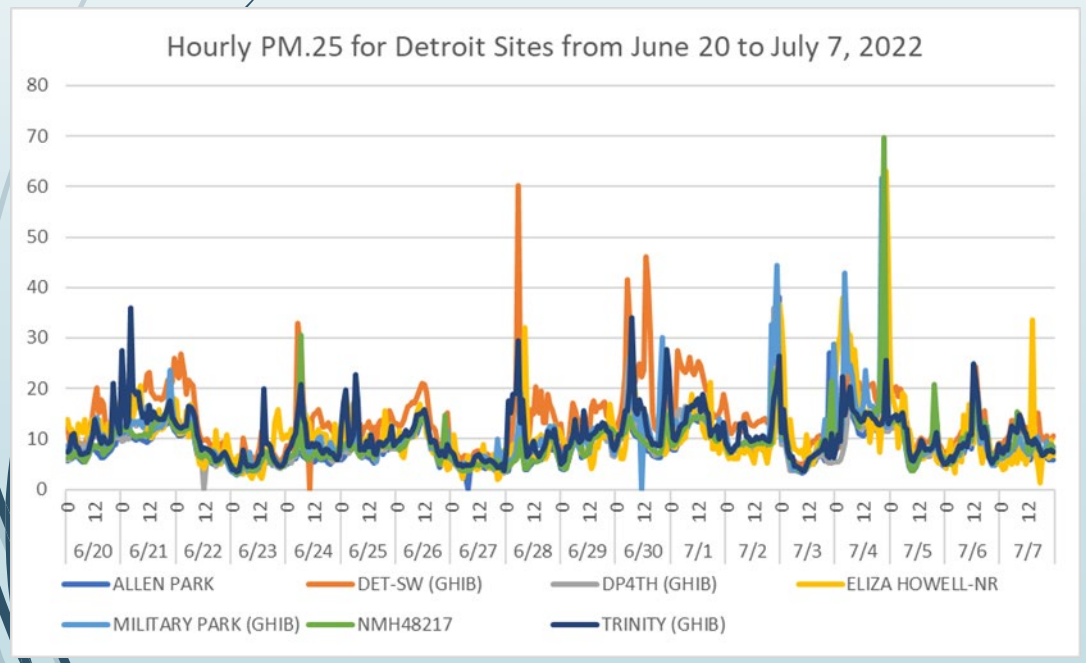
Composition of Smoke: Formaldehyde – Detroit

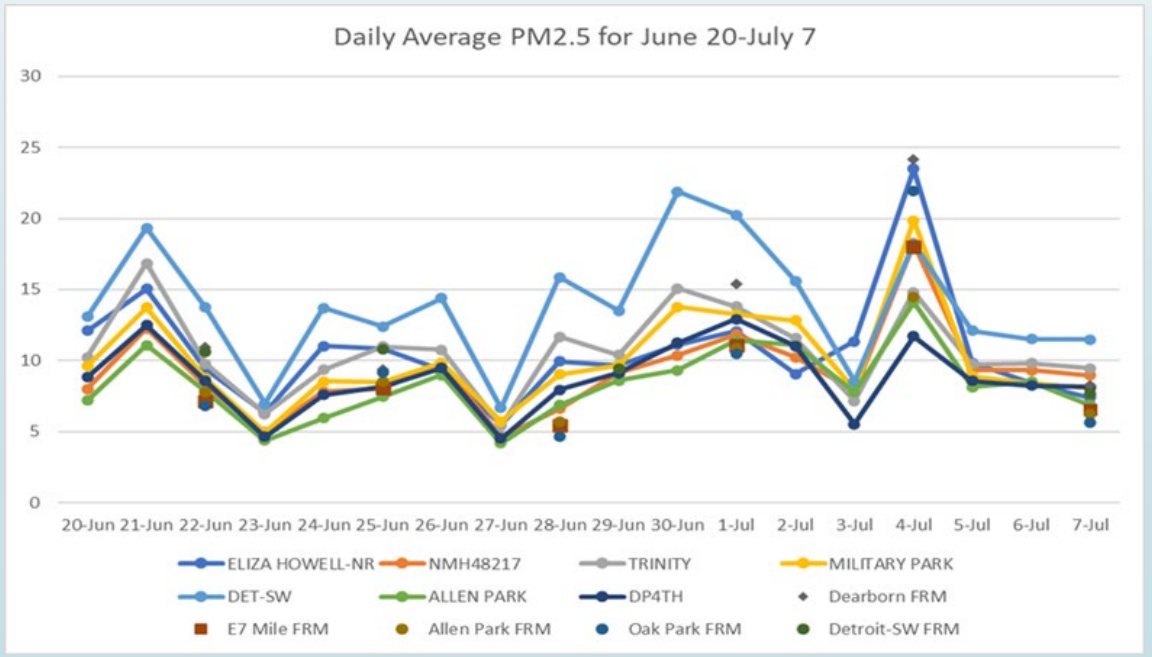


Liao, Jin et al. (2021). Formaldehyde evolution in U.S. wildfire plumes during the Fire Influence on Regional to Global Environments and Air Quality experiment (FIREX-AQ). 21(24). https://doi.org/10.5194/acp-21-18319-2021

Detroit 2022 Ozone EE Demonstration







Future EE Demonstrations

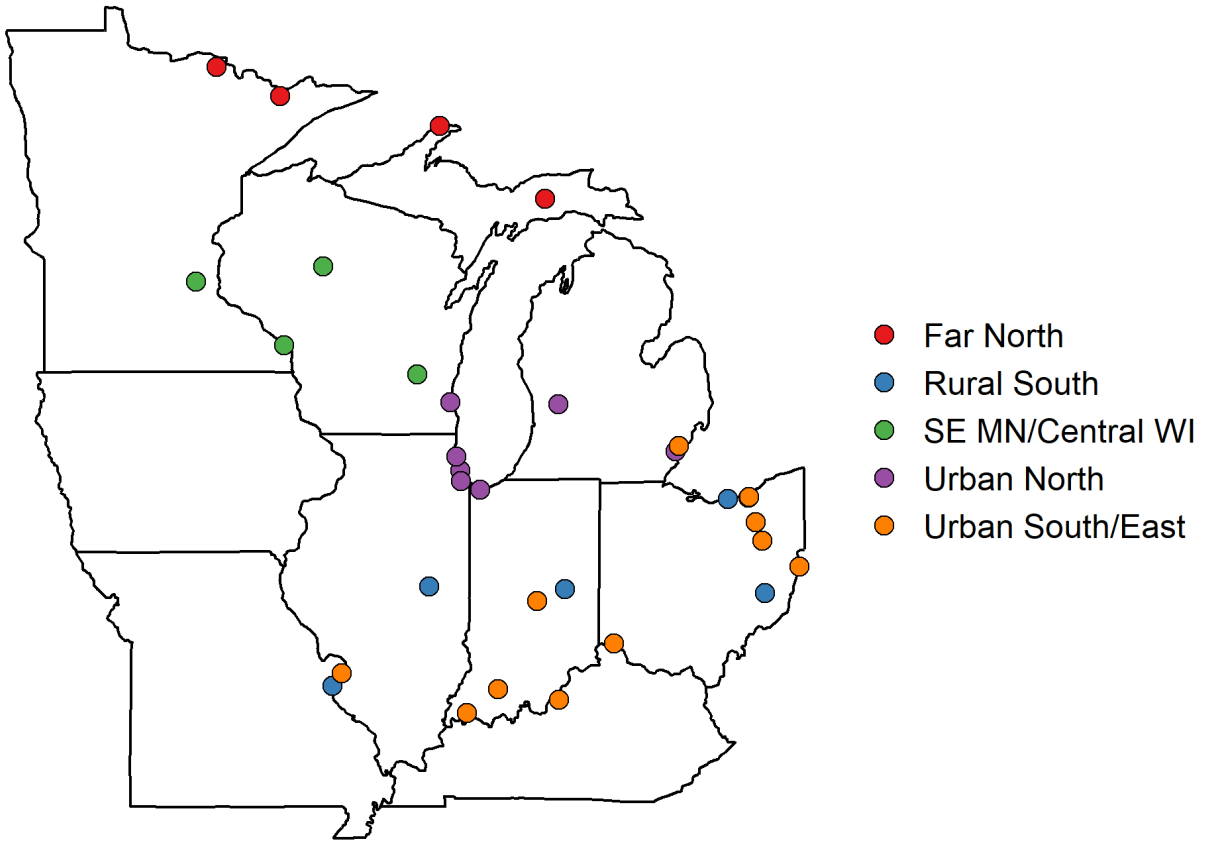
- Additional support not needed for Tier 1 $PM_{2.5}$ demos
- Tier 2 $PM_{2.5}$ demos and Ozone demos could benefit from:
  - Estimates of quantity of smoke
    - Should consider both the presence of smoke in satellite column and at ground level
  - Chemical evidence for presence of smoke at ground level
    - $PM_{2.5}$ speciation data → high OC, EC, K
    - Aethalometer data → high % brown carbon
    - VOC data → high benzene & toluene
    - Carbonyl data → high formaldehyde

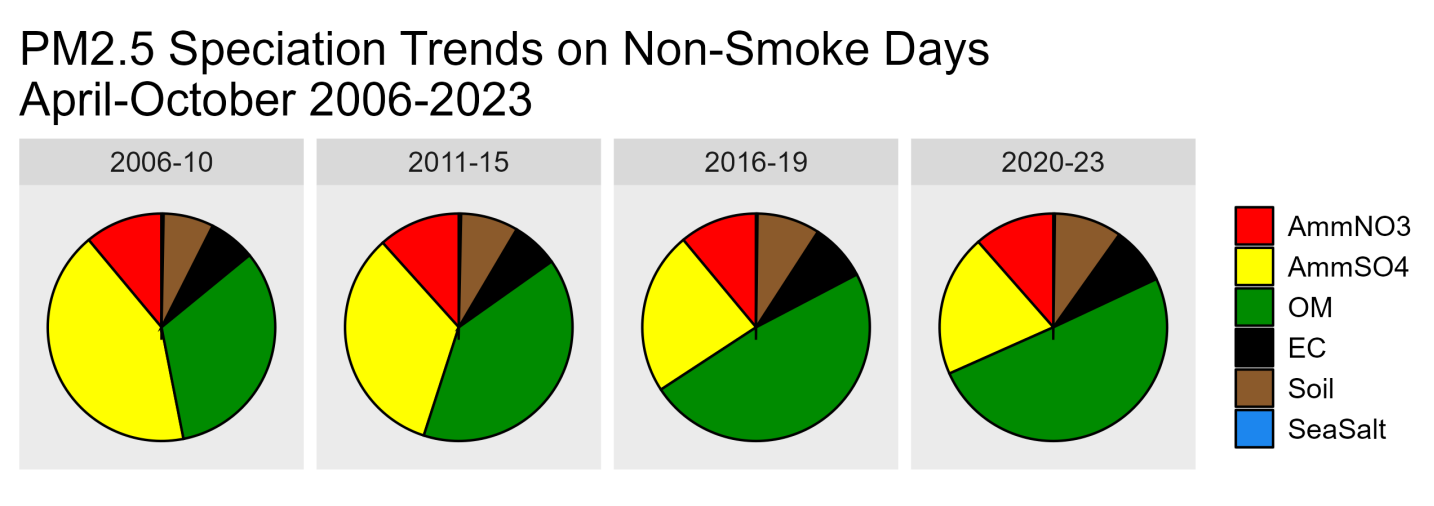
Thank you!

Questions?

Amy: ROBINSONA1@michigan.gov
Angie: dickens@ladco.org

$PM_{2.5}$ Speciation Clusters




PM2.5 Speciation Trends on Non-Smoke Days
April-October 2006-2023
2006-10
2011-15
2016-19
2020-23
AmmNO3
AmmSO4
OM
EC
Soil
SeaSalt