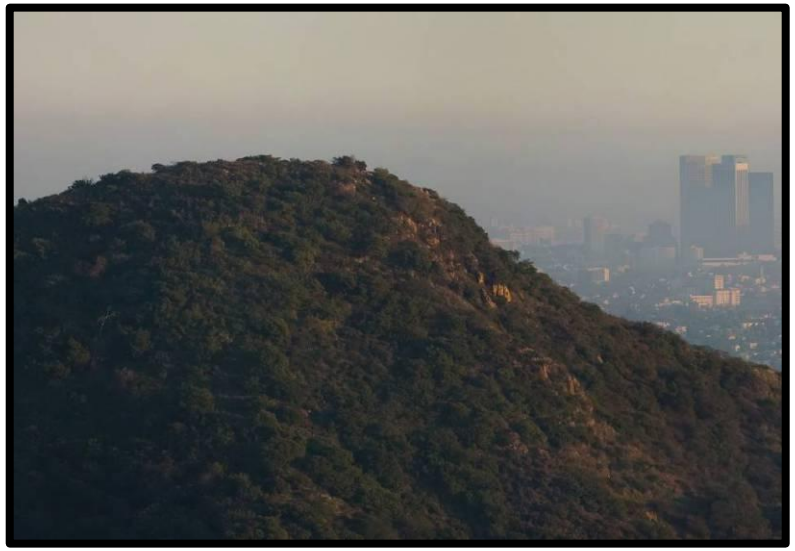
Evolving Urban Air Quality



NOAA CHEMICAL SCIENCES LABORATORY

Brian C. McDonald, Ph.D.

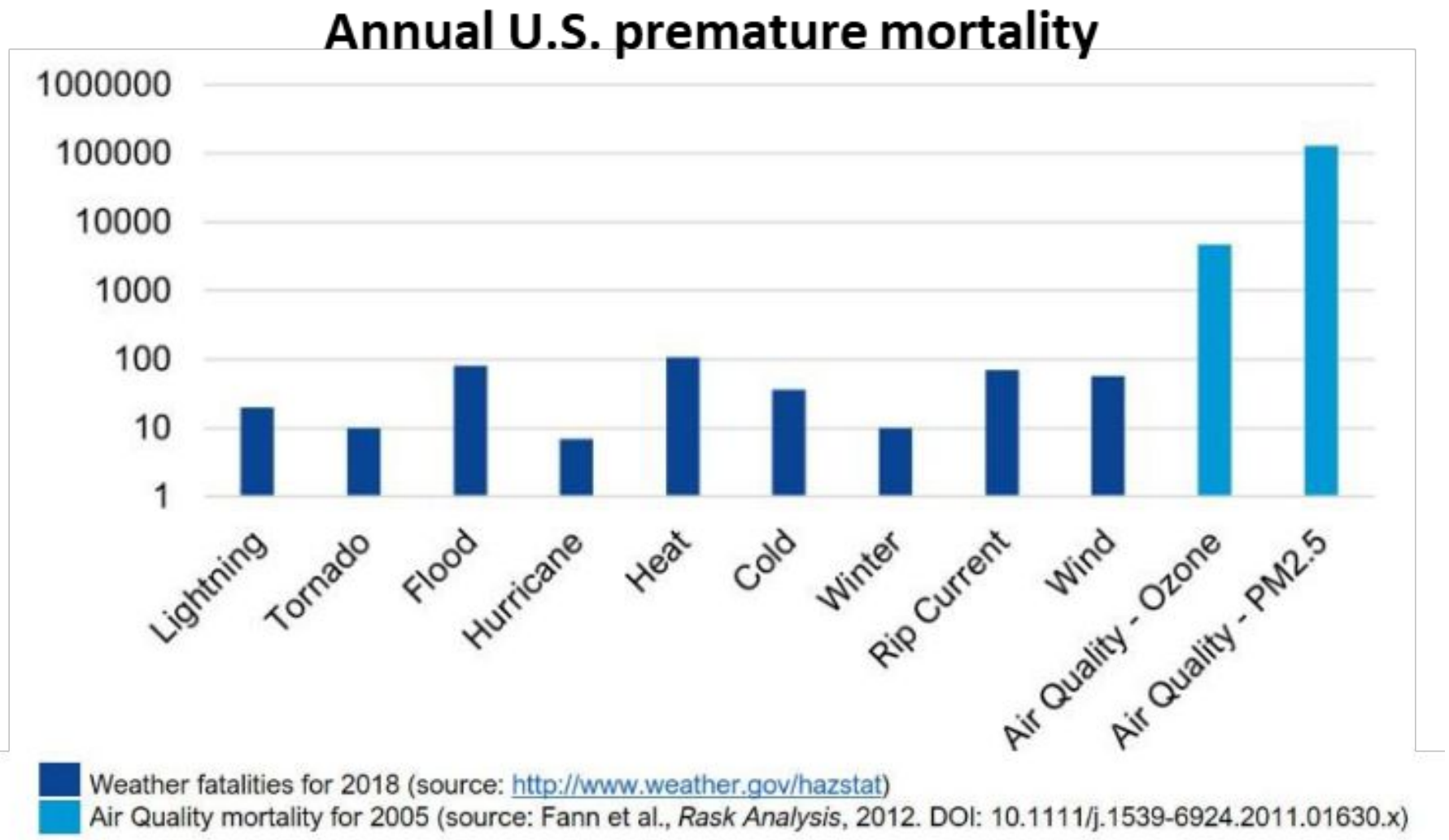
CIRES

University of Colorado Boulder

NOAA

48th Annual Climate Diagnostics and Prediction Workshop,
21st Annual Climate Prediction Applications Science Workshop (March 26, 2024)

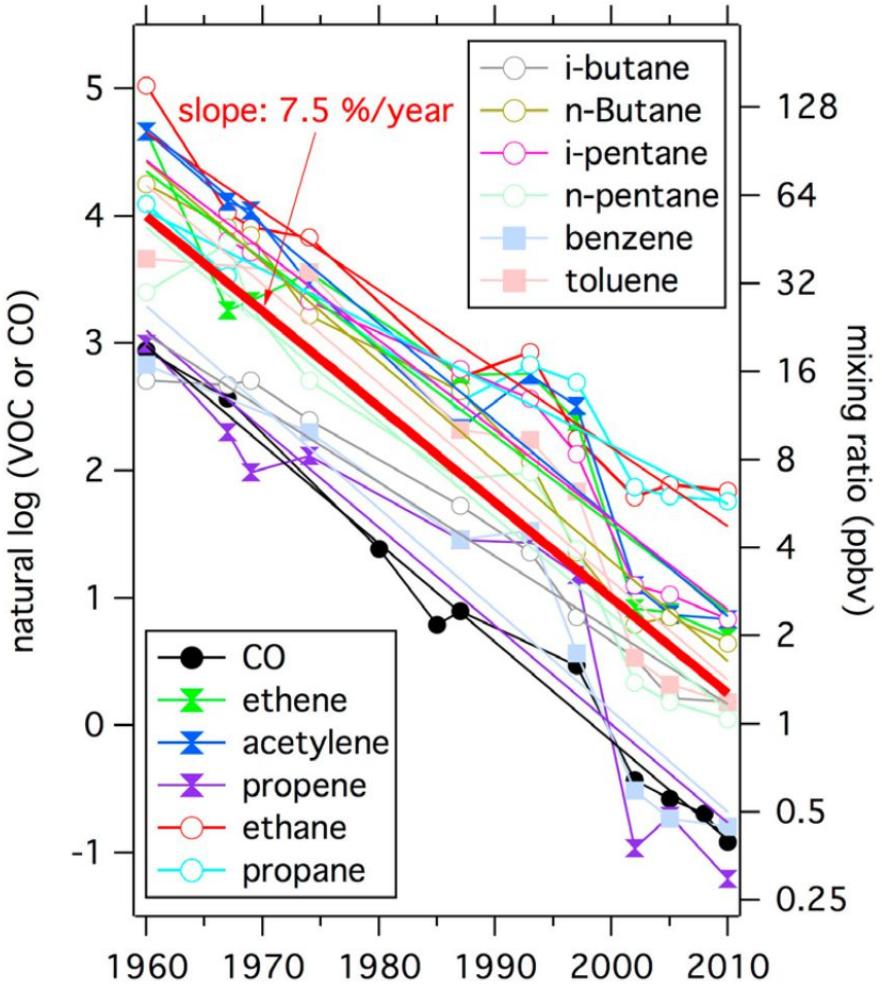
Air Pollution Results in Significant Damages to US Public



Poor air quality results in **~100,000 premature deaths** and nearly **$1T in damages** in the U.S. annually, many times greater than damages from extreme weather events.

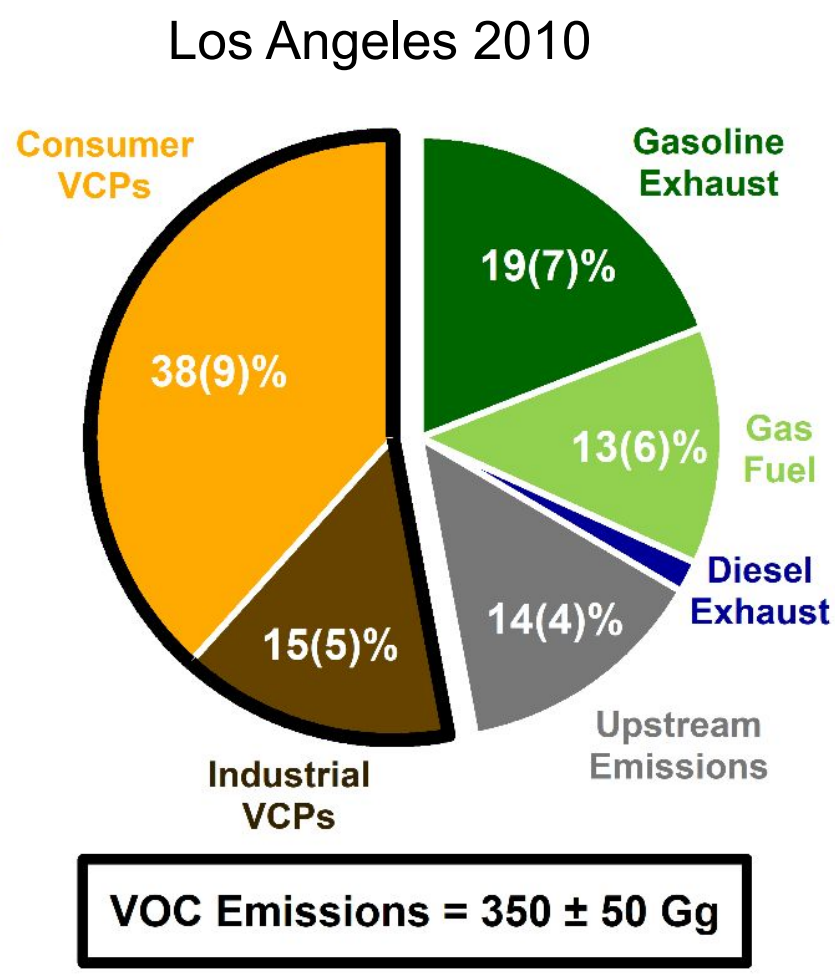
Evolution in Sources of Anthropogenic Volatile Organic Compounds

Gasoline VOCs Decreasing Rapidly

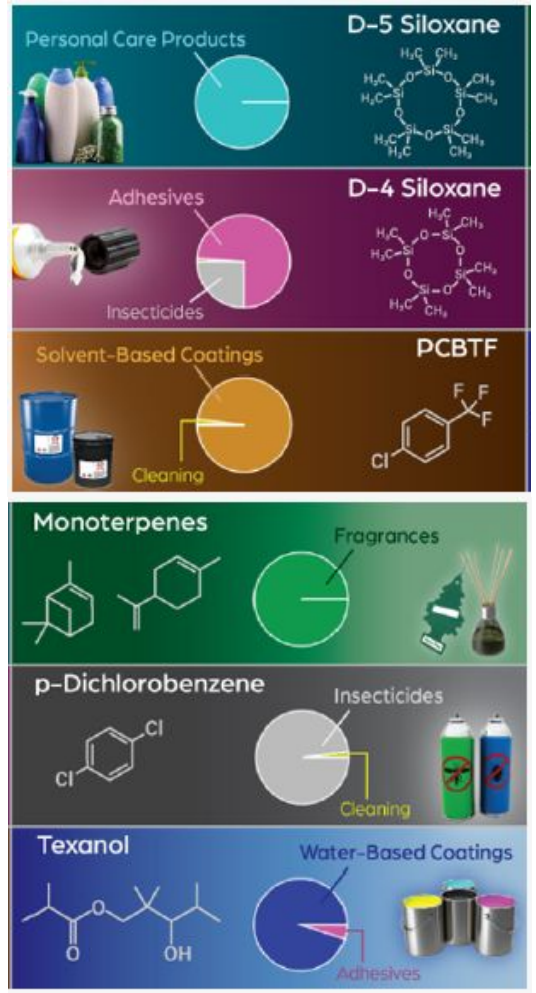


Warneke et al. (*J. Geophys. Res.* 2012)

Volatile Chemical Products now Major Urban Source



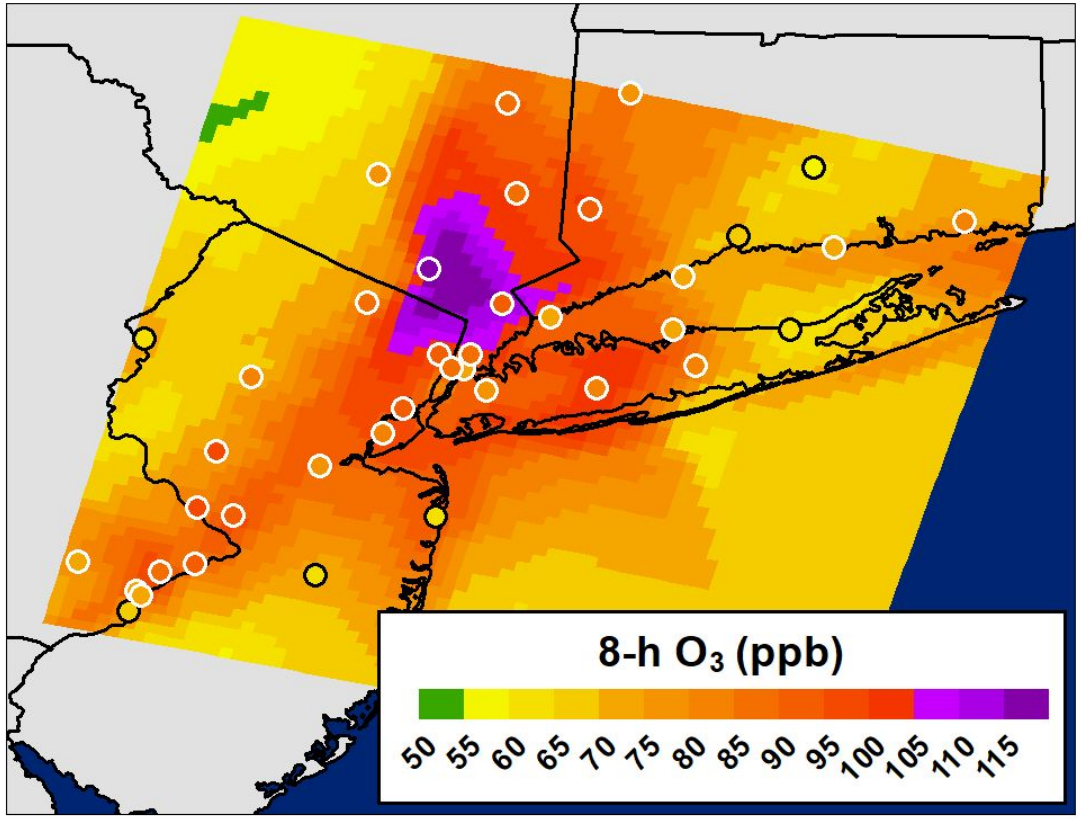
McDonald et al. (*Science* 2018)



Gkatzelis et al. (*ES&T* 2021)

Highest Ozone Observed In NYC in Decades during Large Heatwave

WRF-Chem Model



Obs Max = 118 ppb
Model Max = 119 ppb

AQI

0 - 50 Good	9,200 people
51 - 100 Moderate	1.8 million people
101 - 150 Unhealthy for Sensitive Groups	5.1 million people
151 - 200 Unhealthy	19 million people
201 - 300 Very Unhealthy	1.9 million people

∑(Unhealthy) ~ 26 million people

Coggon et al. (*PNAS 2021*)

Research Objectives

- Quantify emerging urban source of VOCs
- Model impacts on ground-level ozone formation
- Assess the implications for vehicle electrification on reducing ozone

Summer 2021 Field Work to Investigate Urban Air Quality

CSL NOAA CHEMICAL SCIENCES LABORATORY

Caltech

DES DEPARTMENT OF ENVIRONMENT AND SUSTAINABILITY

CALIFORNIA AIR RESOURCES BOARD

Mobile Laboratory contains:

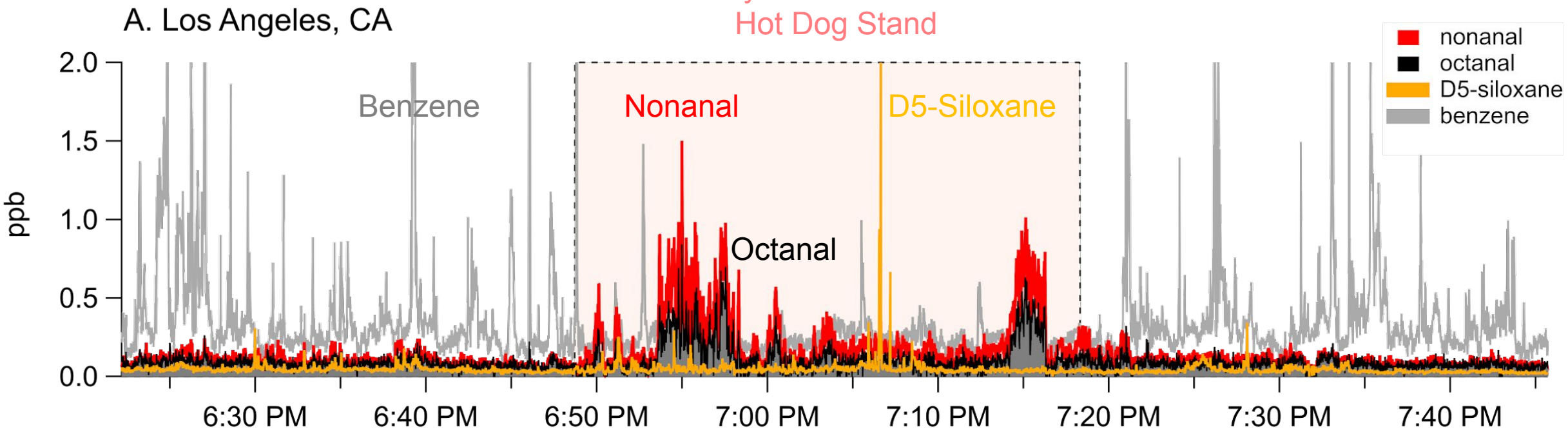
(1) PTR-ToF-MS for VOCs
(2) NOxCRDS for NO, NO2, O3, and NOy
(3) Picarro for GHGs
(4) Cannister system for sampling VOCs

GOALS

Drive through LA and Las Vegas to measure the spatial distribution of emissions in heavily urban areas.

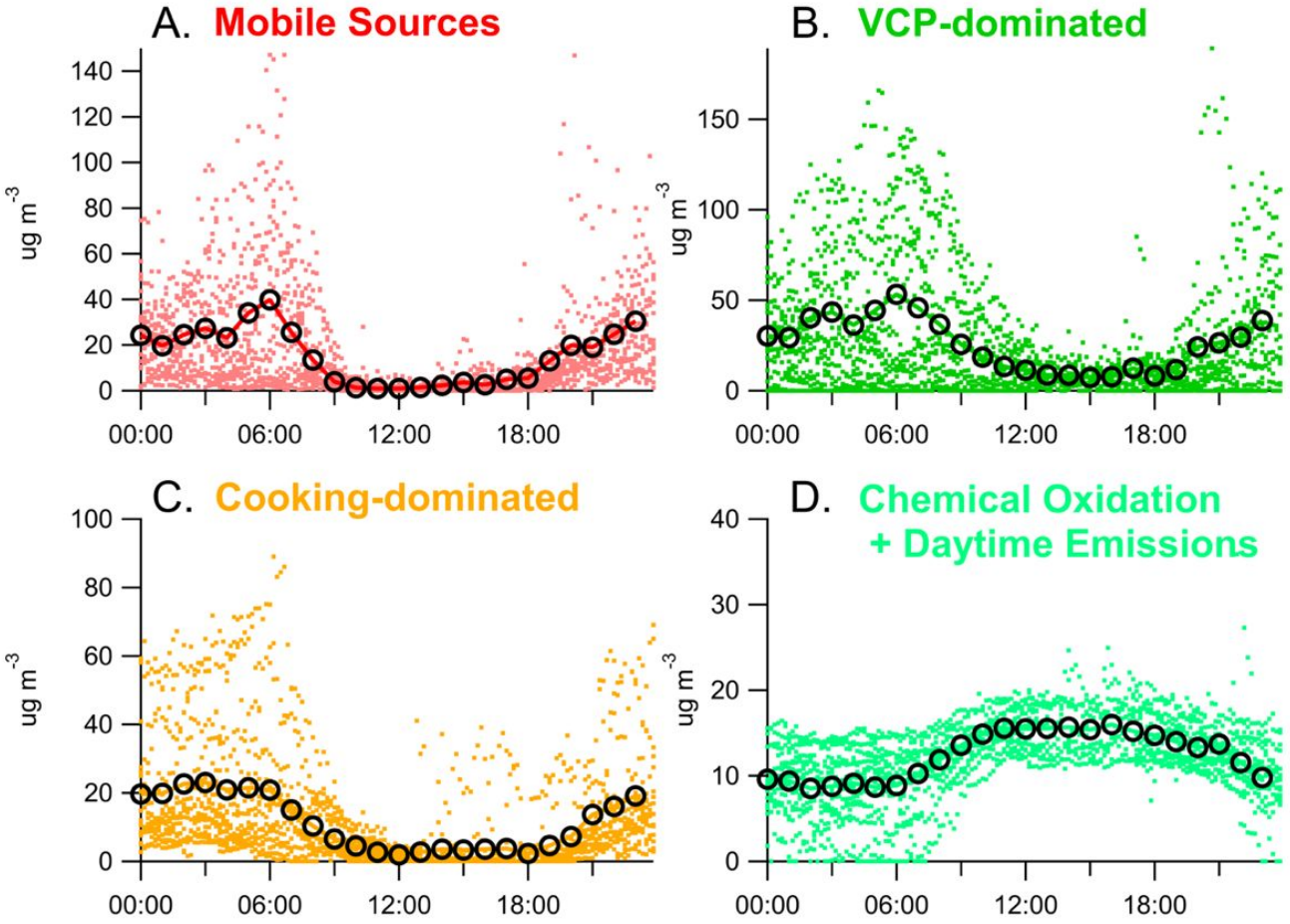
Identifying Chemical Markers for Urban Emission Sources

Drive by Al Roker's Favorite Hot Dog Stand

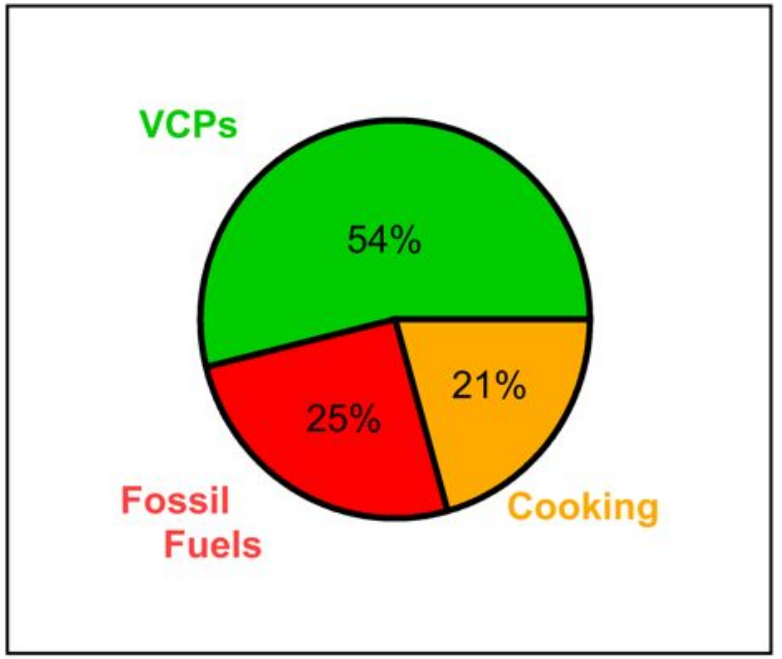


Coggon et al. (*Atmos. Chem. Phys.* accepted)

Using Chemical Fingerprints to Source Apportion VOCs



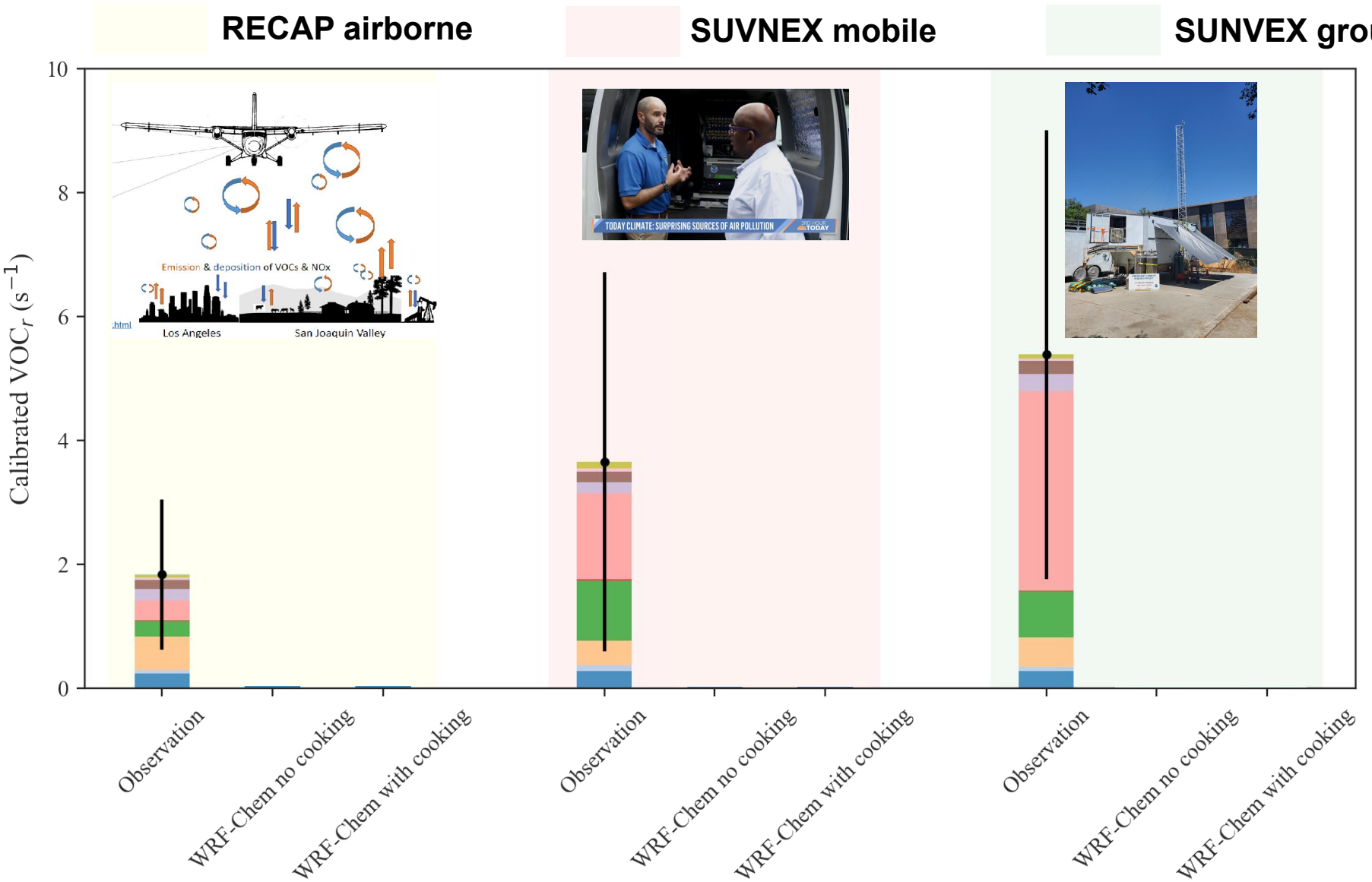
Las Vegas 2021

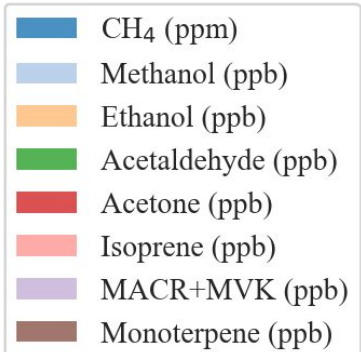


Matt Coggon
(NOAA CSL)

Coggon et al. (*Atmos. Chem. Phys.* accepted)

Input Cooking Emissions into WRF-Chem Model



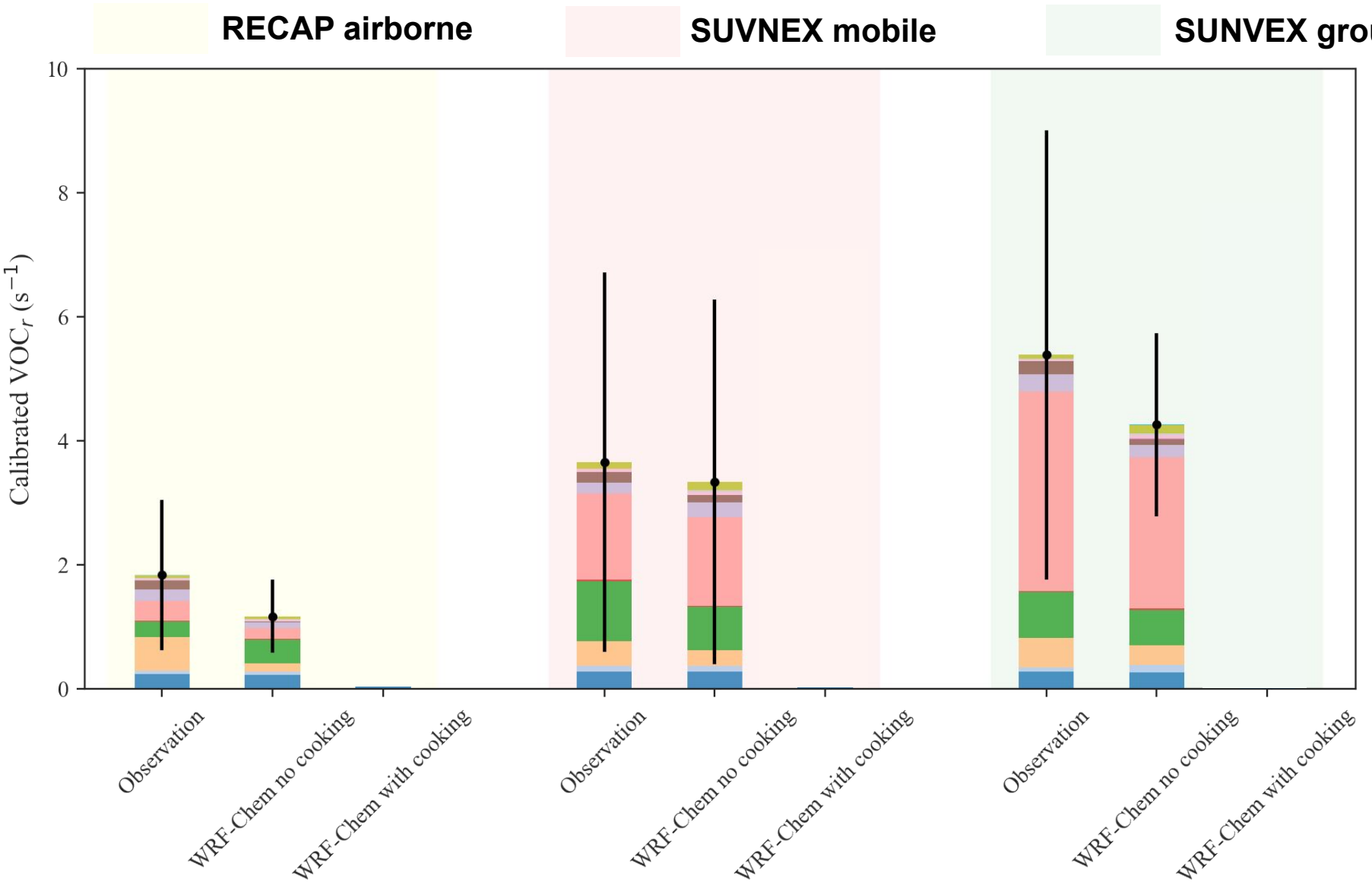


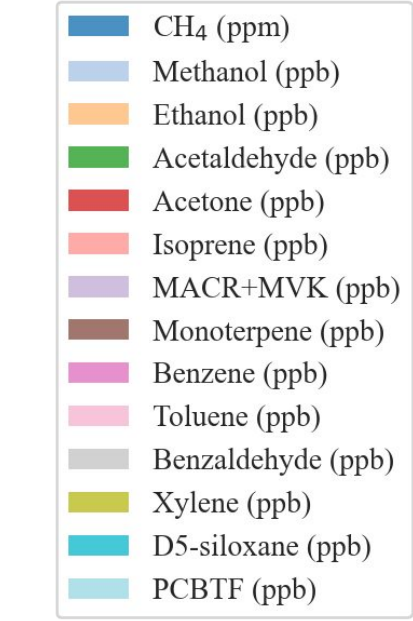
Qindan Zhu
(MIT/CSL)

Becky Schwantes
(NOAA CSL)

Zhu et al. (*Atmos. Chem. Phys.* accepted)

VOC Reactivity Underestimated 20-40% without Cooking





Qindan Zhu
(MIT/CSL)

Becky Schwantes
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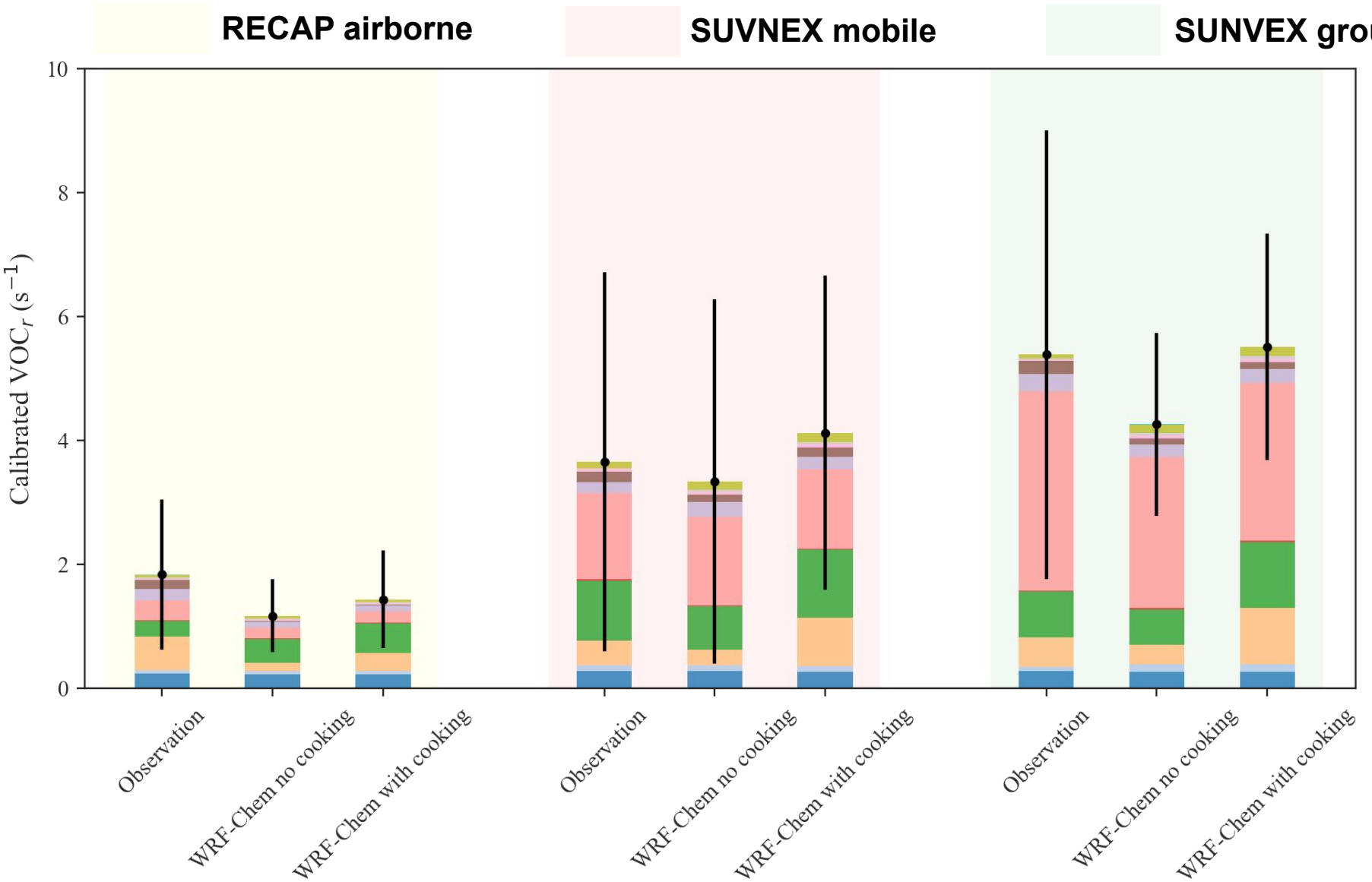
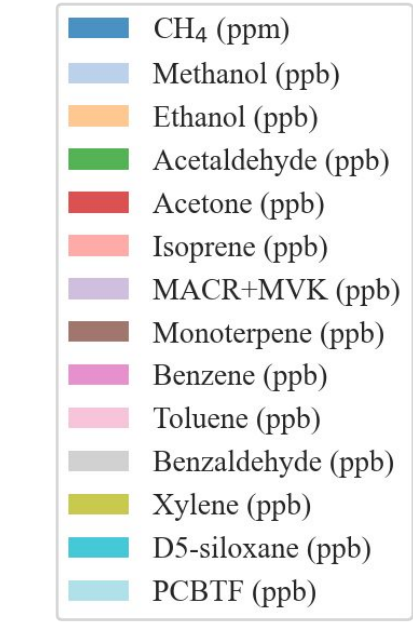
Zhu et al. (*Atmos. Chem. Phys.* accepted)

Better Agreement with Observations with Cooking





Qindan Zhu
(MIT/CSL)

Becky Schwantes
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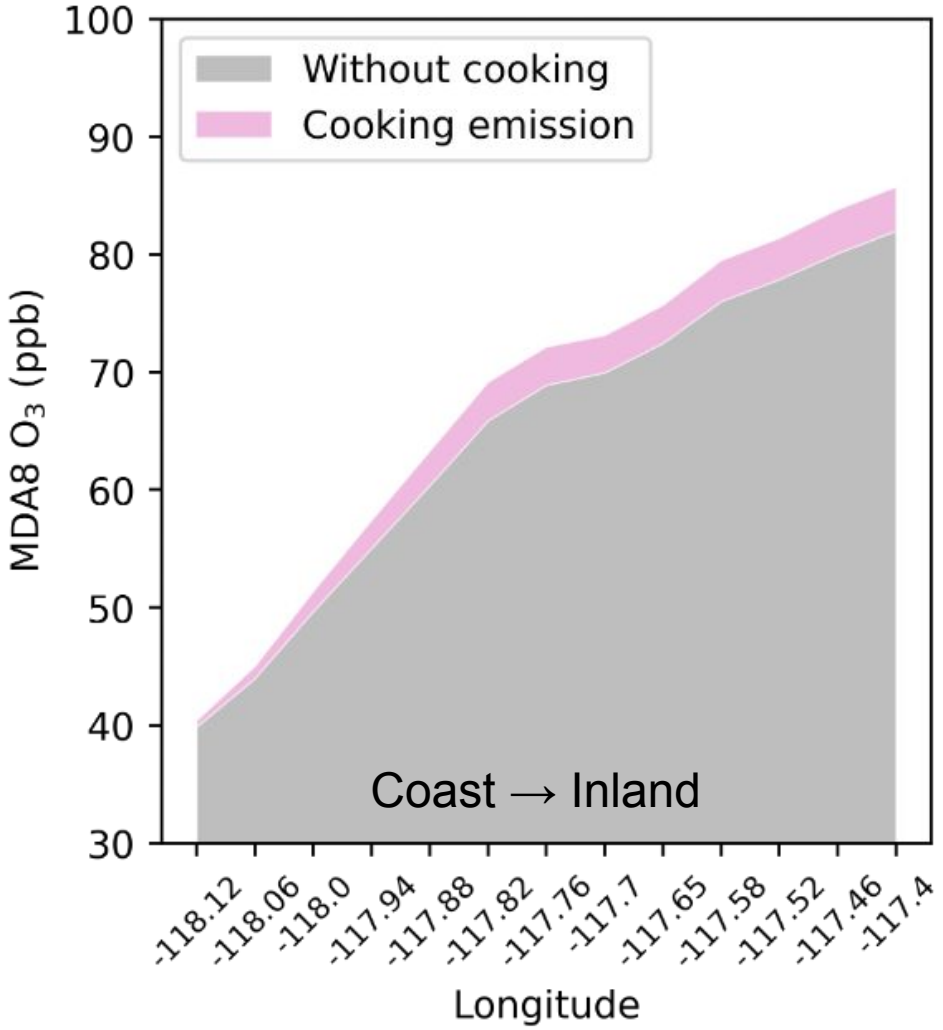
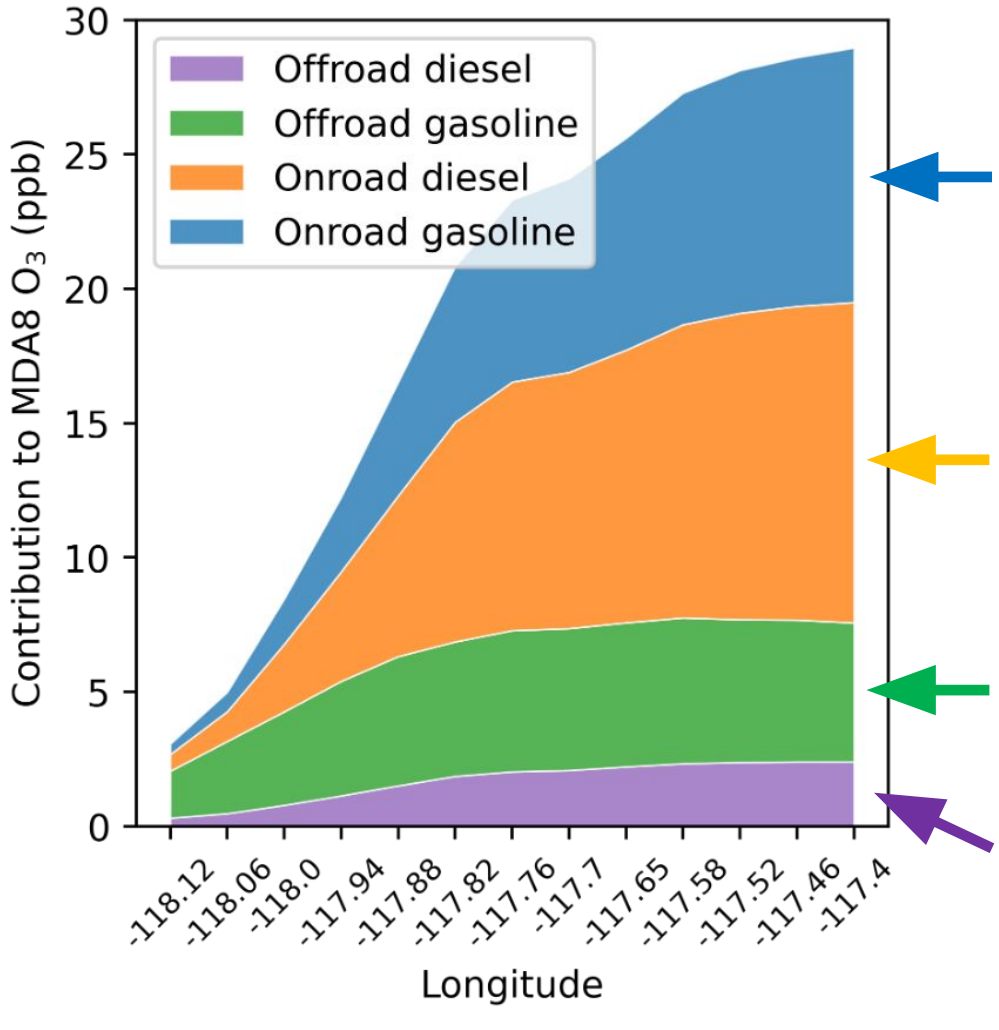
Zhu et al. (*Atmos. Chem. Phys.* accepted)

Los Angeles Ozone Formation by Emissions Source

Add Cooking VOCs

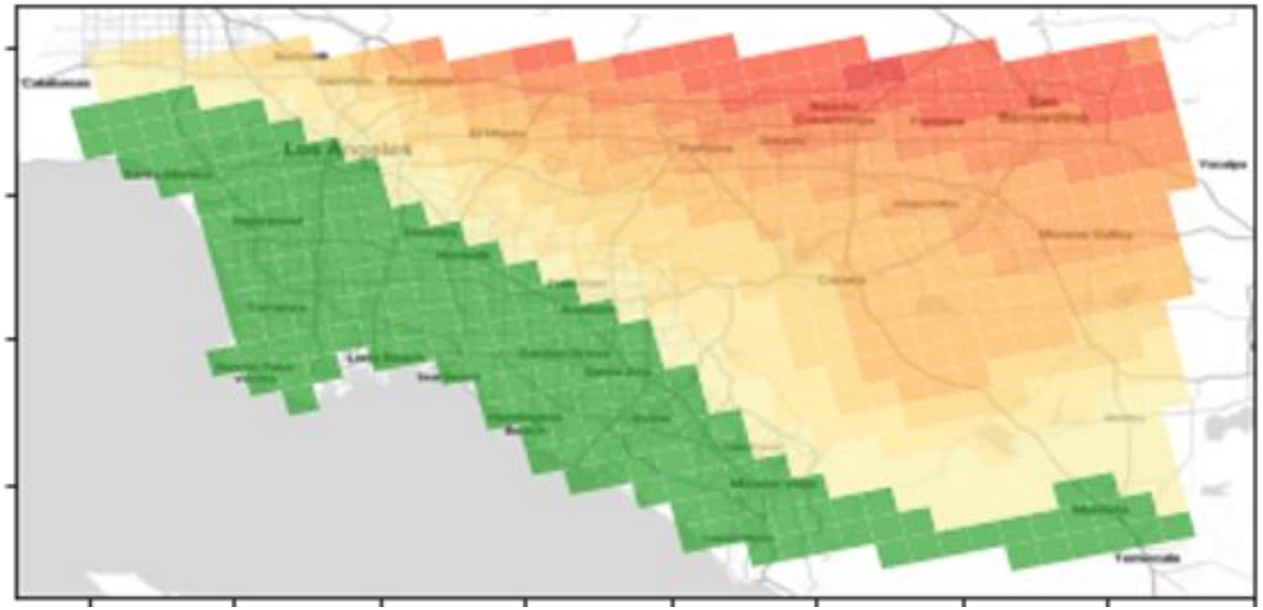


Add Mobile Source NO_x and VOCs

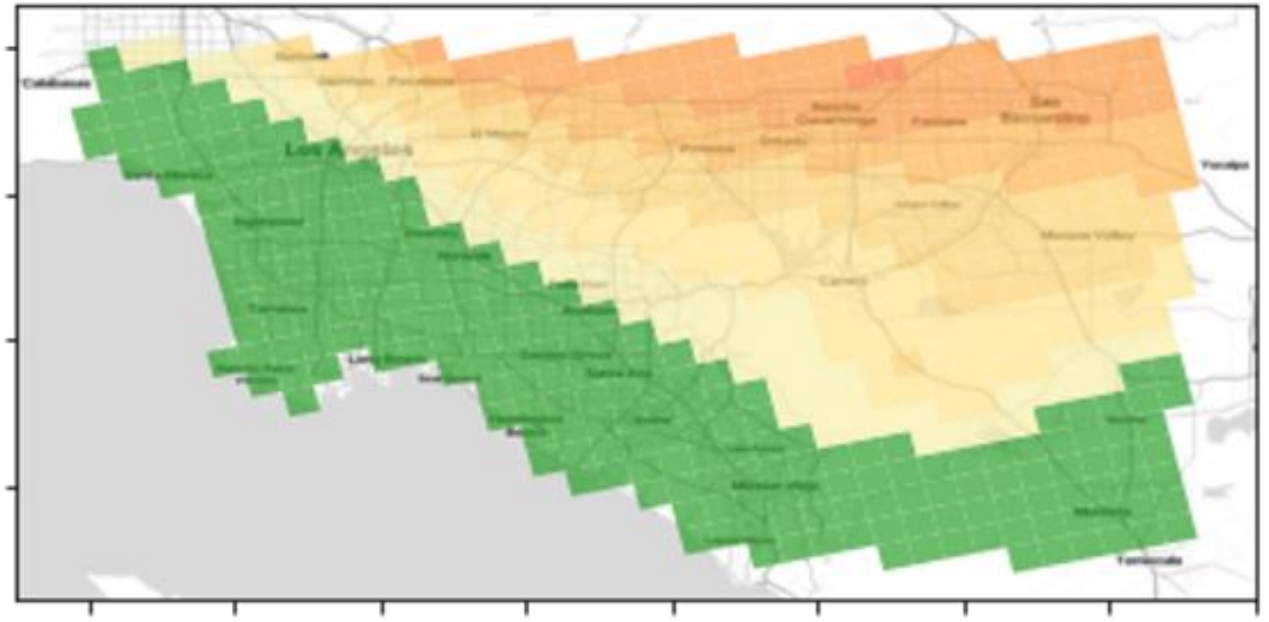


Impact on Los Angeles MDA8 Ozone from Vehicle Electrification

Present Day Los Angeles (Aug 2021)



Electrify Cars



AQI and population impacted

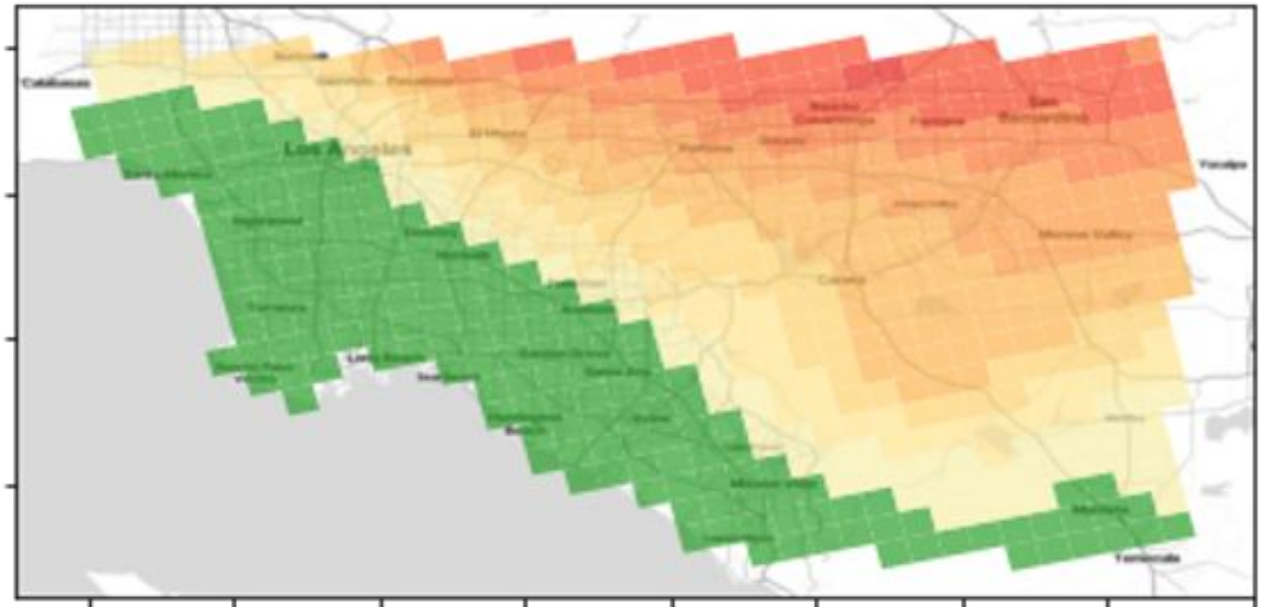
Good | Moderate | Unhealthy for sensitive groups | Unhealthy | Very Unhealthy

MDA8 Ozone (ppb)

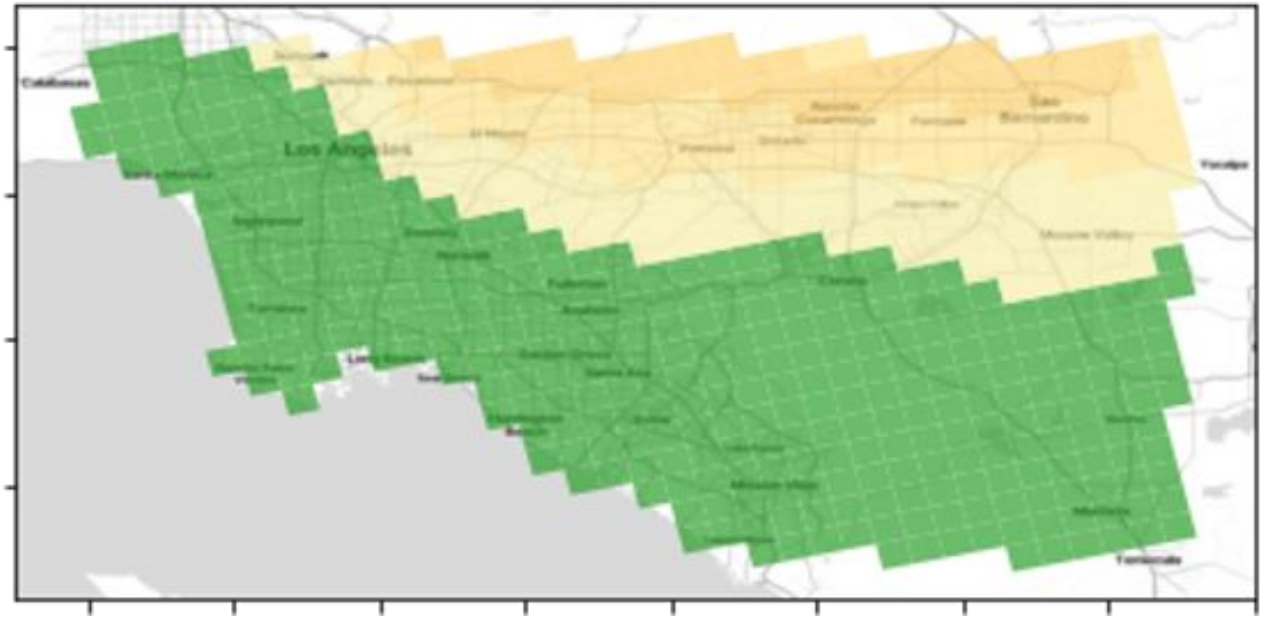
55 60 65 70 75 80 85 90 95 100 105 110 115

Impact on Los Angeles MDA8 Ozone from Vehicle Electrification

Present Day Los Angeles (Aug 2021)



Electrify Cars + Trucks



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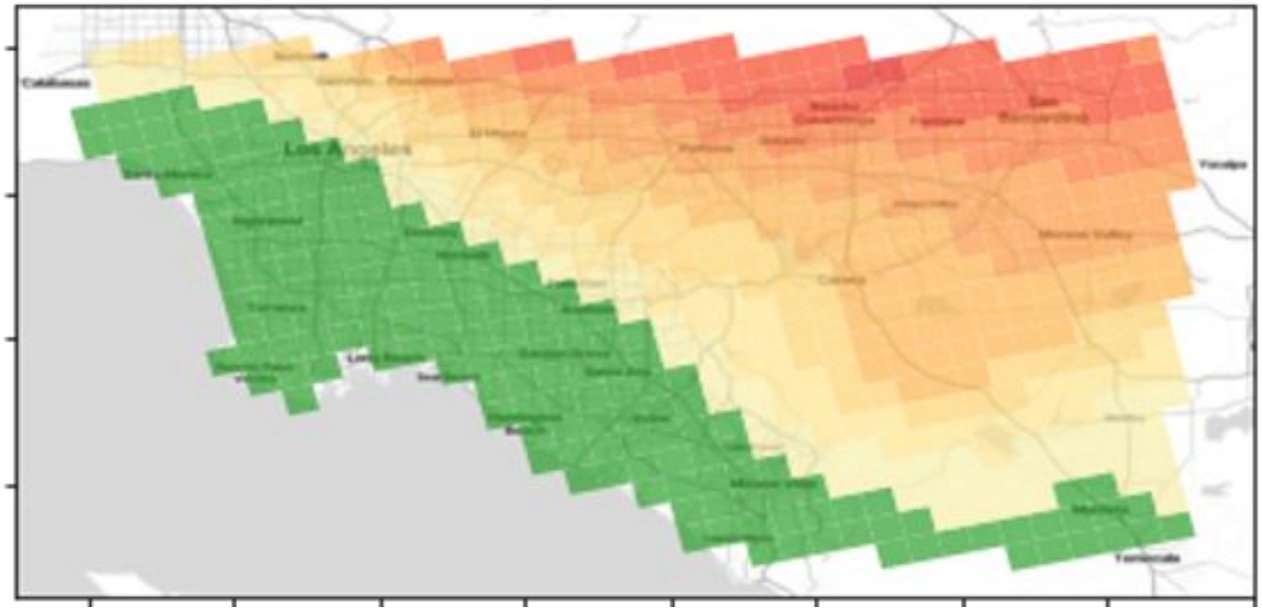
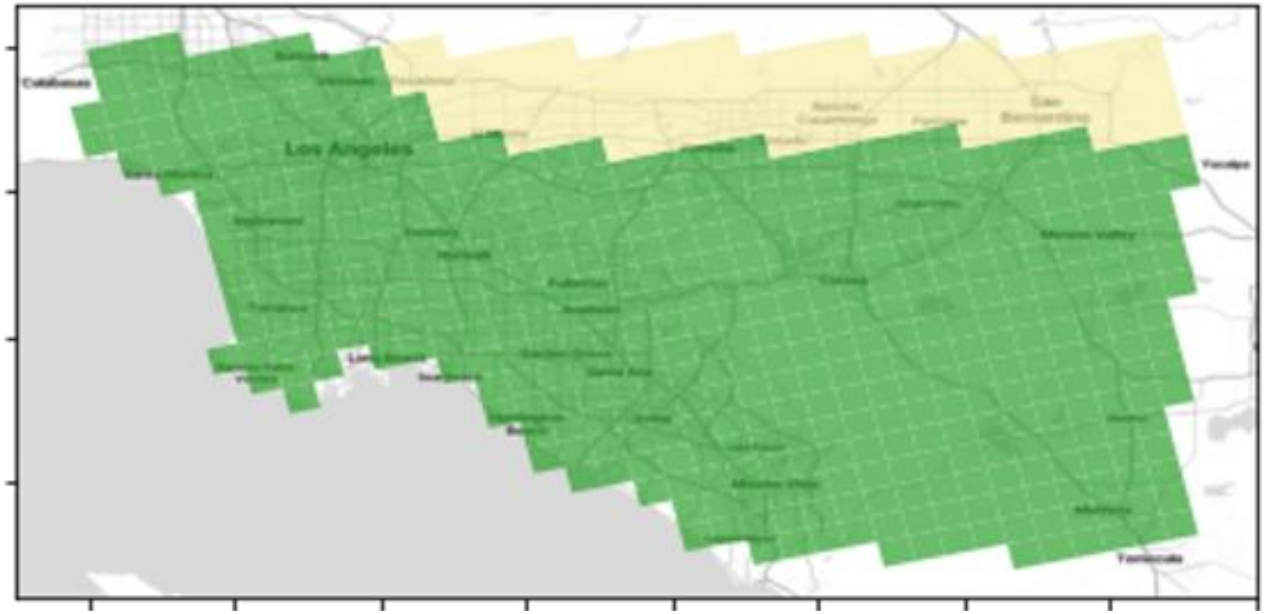


Electrify Cars + Trucks + Offroad Equipment



AQI and population impacted

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MDA8 Ozone (ppb)

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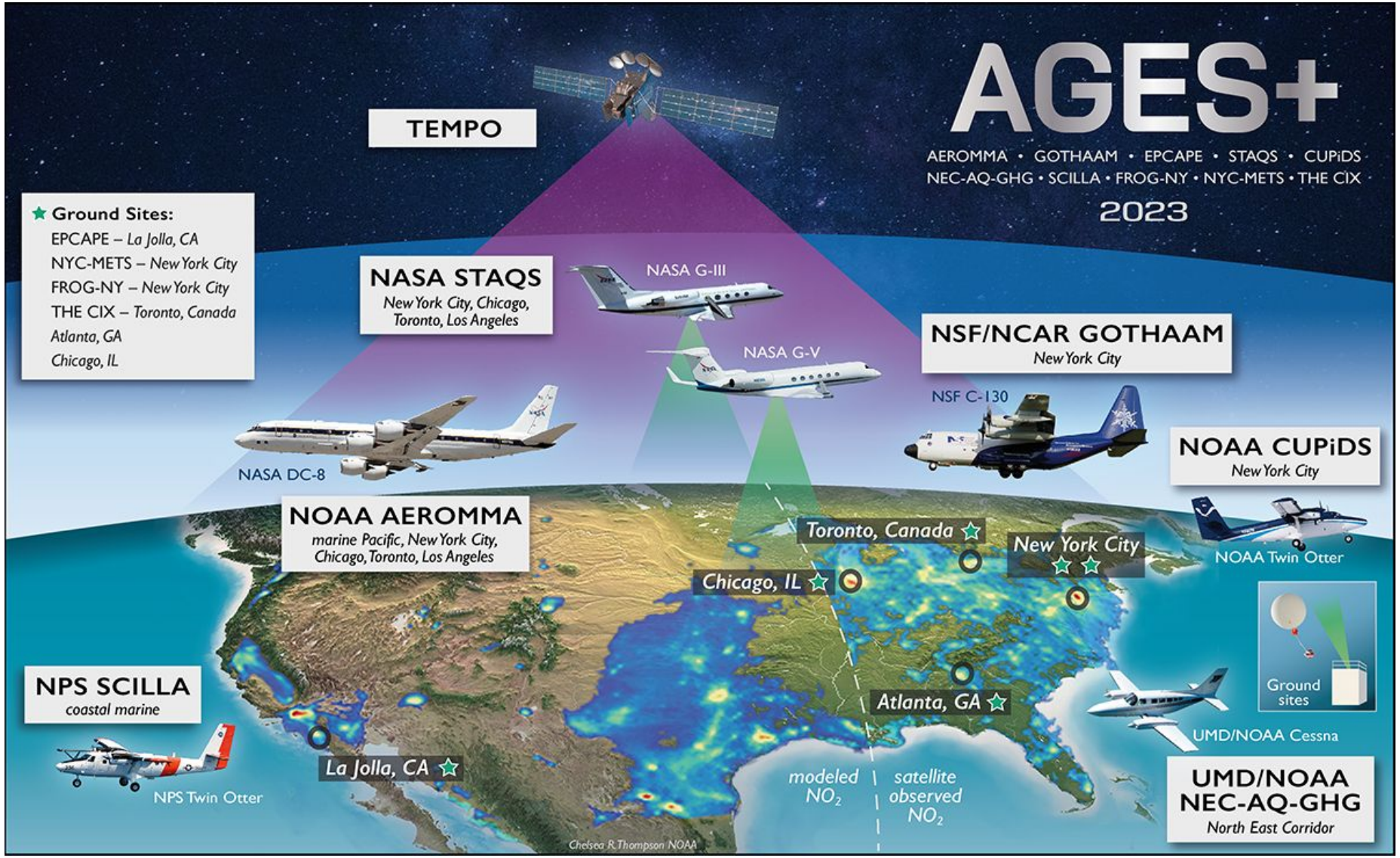
More Field Data in Large Interagency AQ Campaign in 2023



https://csl.noaa.gov/projects/ages/

Summary

- Non-fossil fuels dominate urban anthropogenic VOC emissions, including volatile chemical products (~50%) and cooking emissions (~20%)
- Adding cooking emissions helps close urban VOC budget
- Electrifying mobile source engines (on-road + off-road) potentially effective at moving most areas of Los Angeles into ozone attainment

Future Need: Better linkage between climate models with weather models utilized for predicting air quality