Impacts of Adopting Zero-Emission Truck Regulations on Tailpipe and Non-tailpipe Emissions, Air Quality, and Health in Southern California

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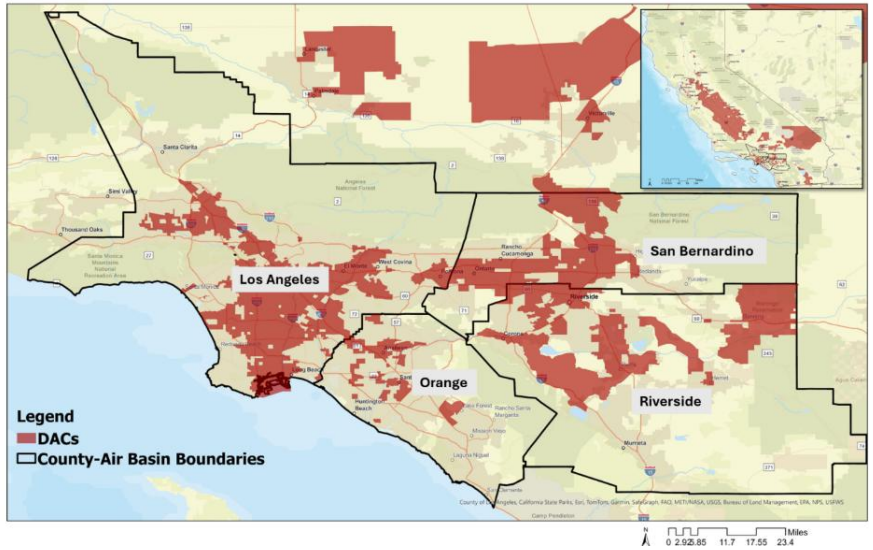
Heavy-Duty Truck (HDT) Emissions

- Major contributor to near-road and urban air pollution
- Diesel particulate matter (tailpipe emissions) is a recognized air toxic
- Non-tailpipe emissions (brake and tire wear) contribute substantially to PM with high oxidative potential
- Disadvantaged communities (DACs) across the South Coast Air Basin (SCAB) experience disproportionately high exposure to truck-related air pollution



Zero-Emission Truck (ZET) Regulations in California

California Air Resources Board's (CARB) zero-emission truck regulations:

1. Advanced Clean Trucks (**ACT**): Requires manufacturers to meet the phased goals for the percentage of zero-emission truck sales in California from 2024 to 2035

2. Advanced Clean Fleets (**ACF**): Requires the transition of government, drayage trucks, high-priority commercial fleets to zero-emission fleets starting 2024; 100% ZET in truck sales starting 2036

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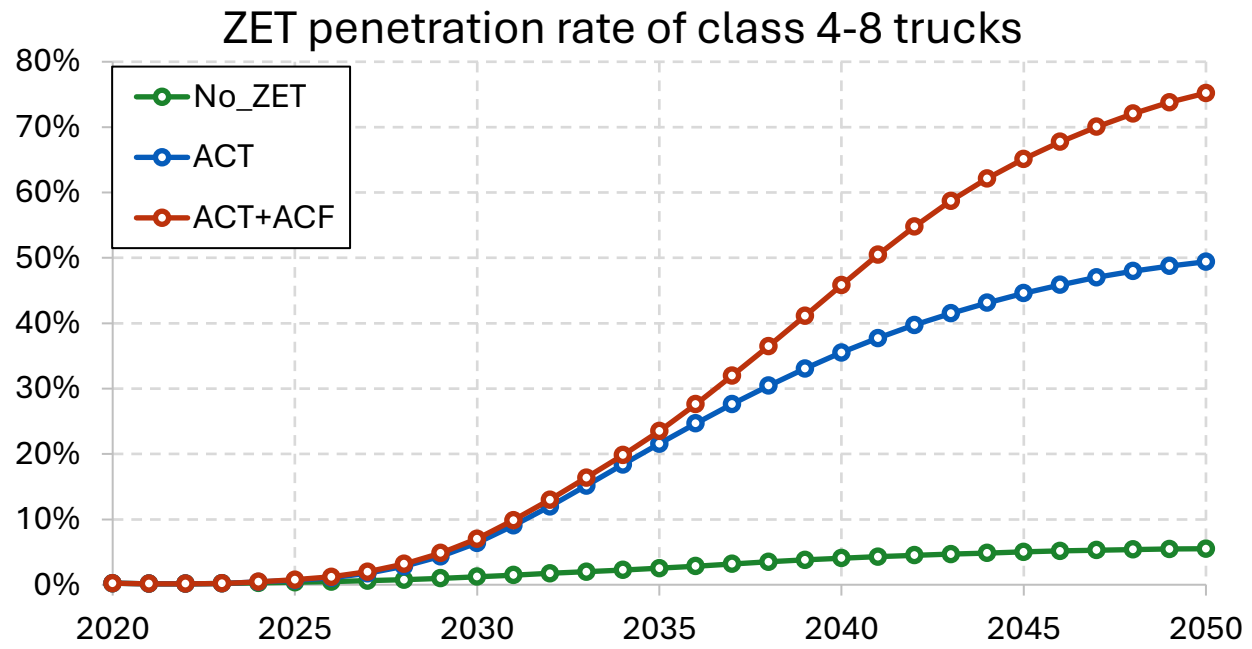
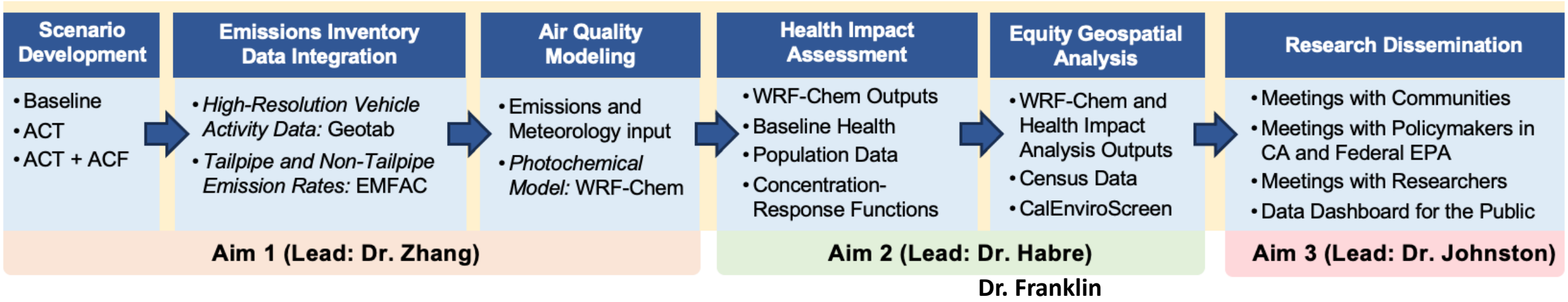


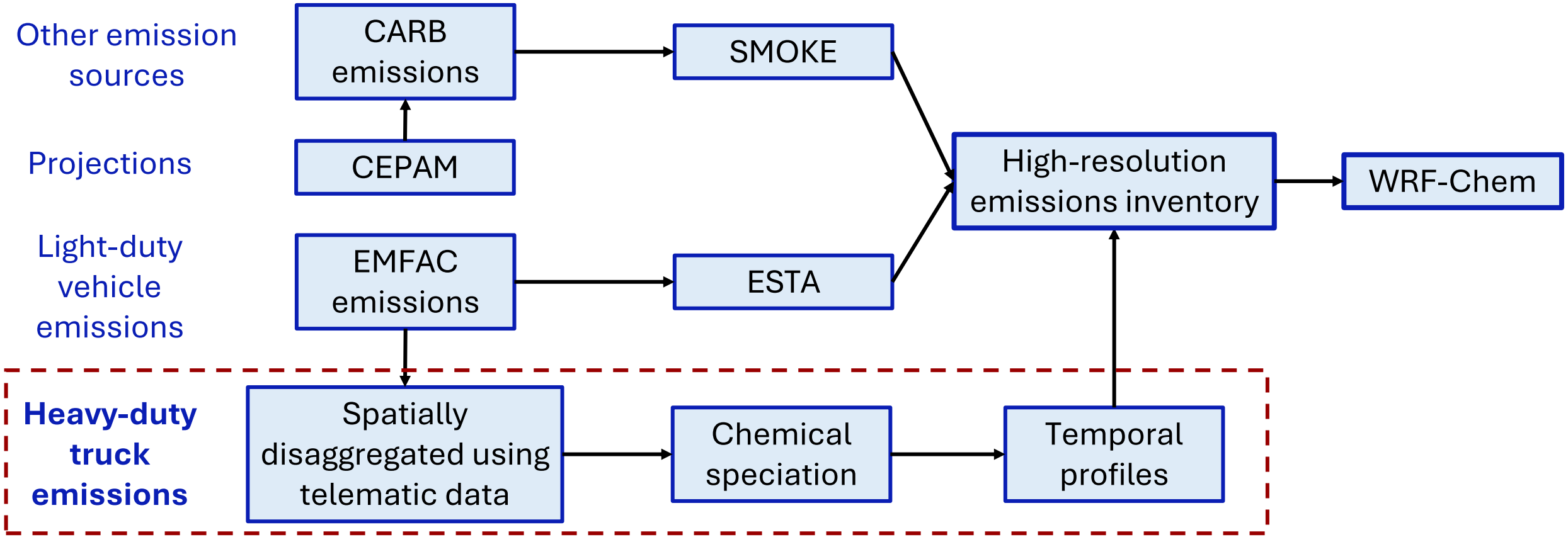
Objectives

- Quantify the air quality and health impacts of California's zero-emission truck regulations (ACT+ACF) on air quality ($PM_{2.5}$, NO_2, and O_3) in the South Coast Air Basin

- Investigate the contribution of non-tailpipe truck emissions to PM concentrations and health impact



Emissions and Air Quality Modeling Framework

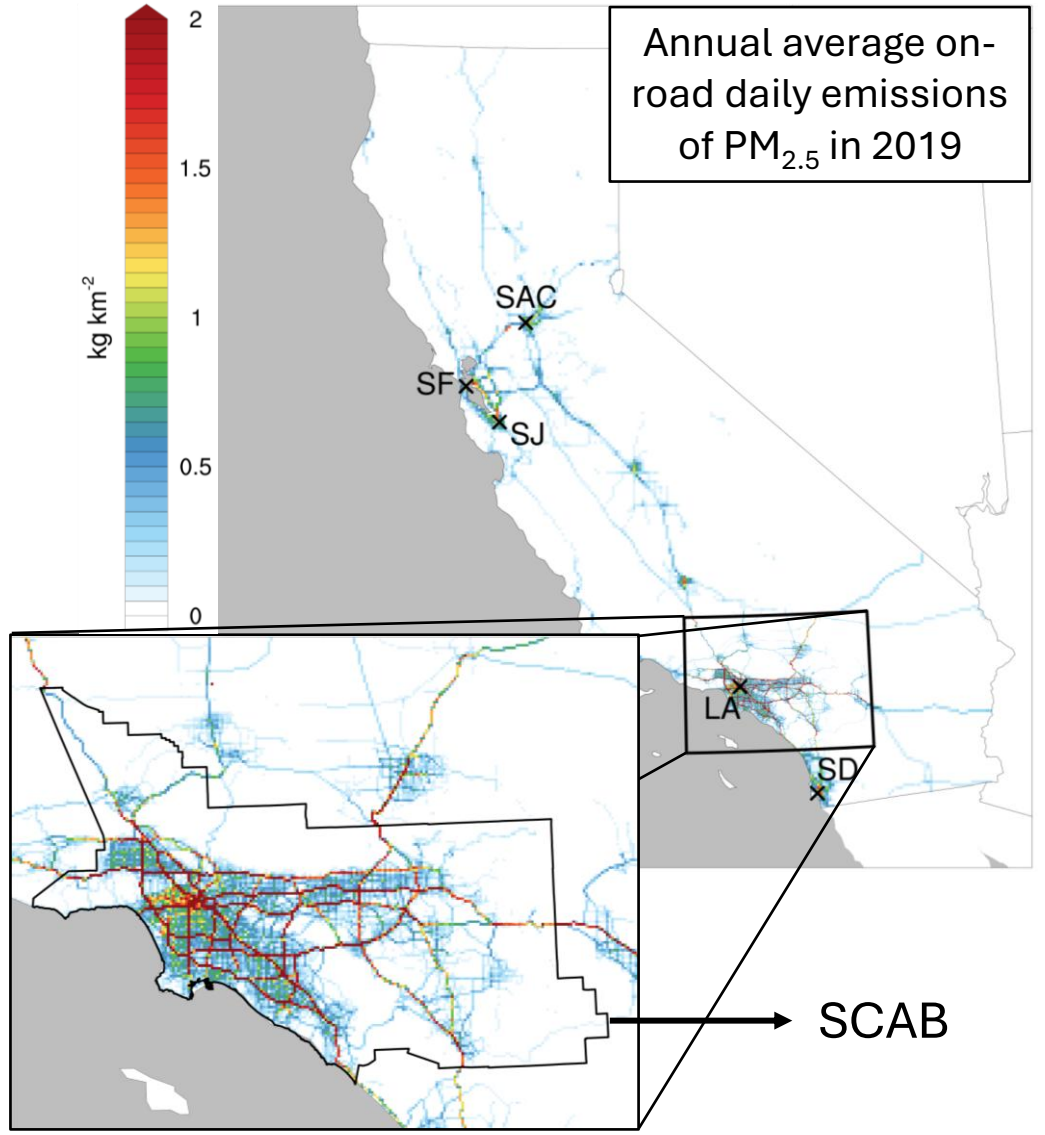


Described in He et al. 2025

WRF-Chem: State-of-the-Science Regional Atmospheric Model

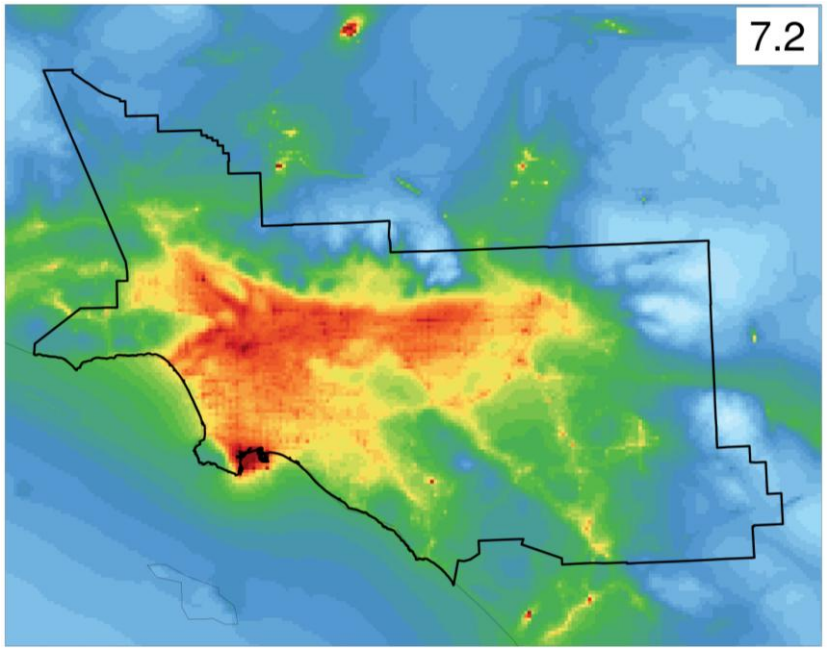
- Study area and grid resolution
  - California | 4×4 km resolution
  - South Coast Air Basin (SCAB) | 1×1 km resolution
- One representative week per month in 2019 and 2045
- MOZART-MOSAIC chemical mechanism
- **We added tracers to track the atmospheric fate of diesel tailpipe, brake wear, and tire wear PM emissions**
- Simulations:

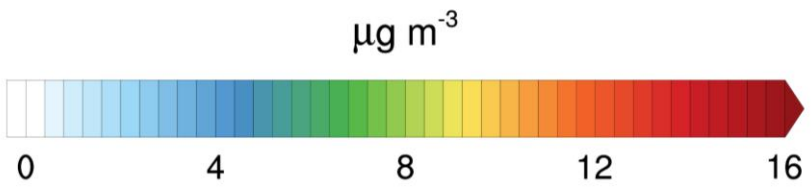
Name	Year	Description
BaseYear	2019	Before the implementation of ACT and ACF rules
No_ZET	2045	No implementation of ACT and ACF rules
ACT	2045	Implementation of ACT rule only
ACT+ACF	2045	With Implementation of both ACT and ACF rules



$PM_{2.5}$ concentrations are projected to decrease from 2019 to 2045

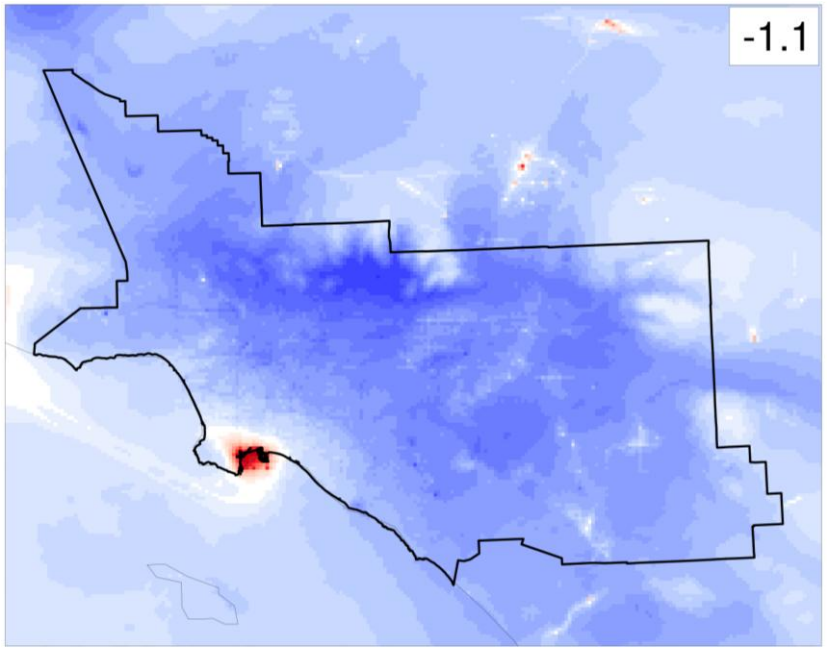
Base Year (2019)

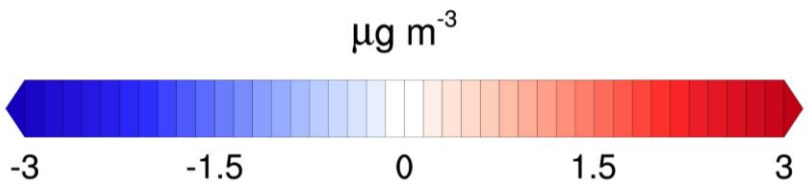




Total $PM_{2.5}$

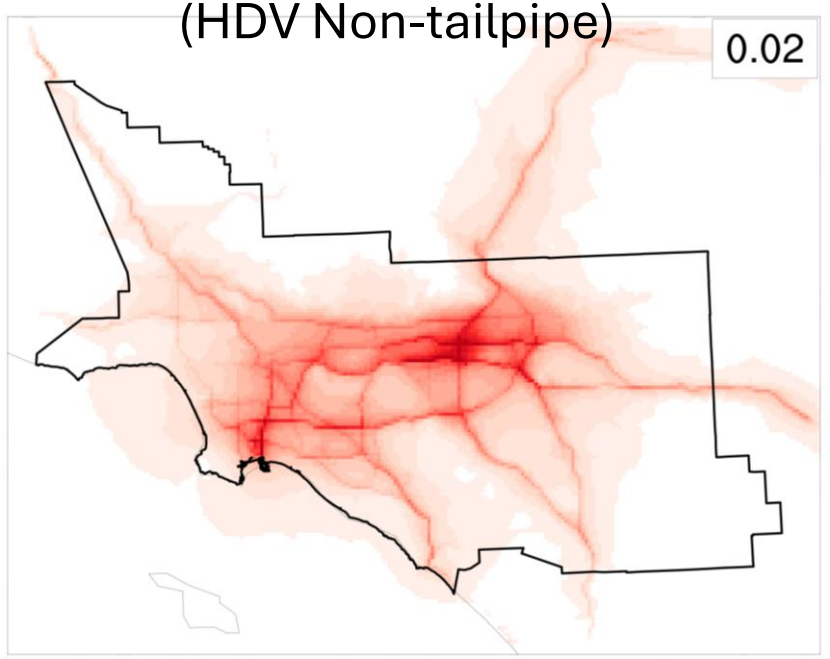
No_ZET (2045) – BaseYear

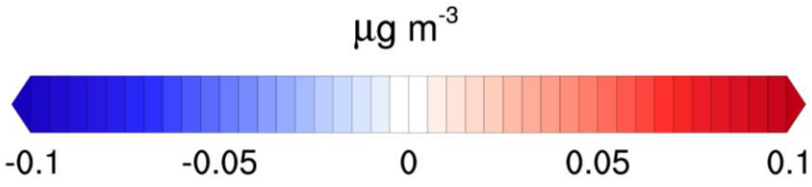




Total $PM_{2.5}$

No_ZET (2045) – BaseYear (HDV Non-tailpipe)

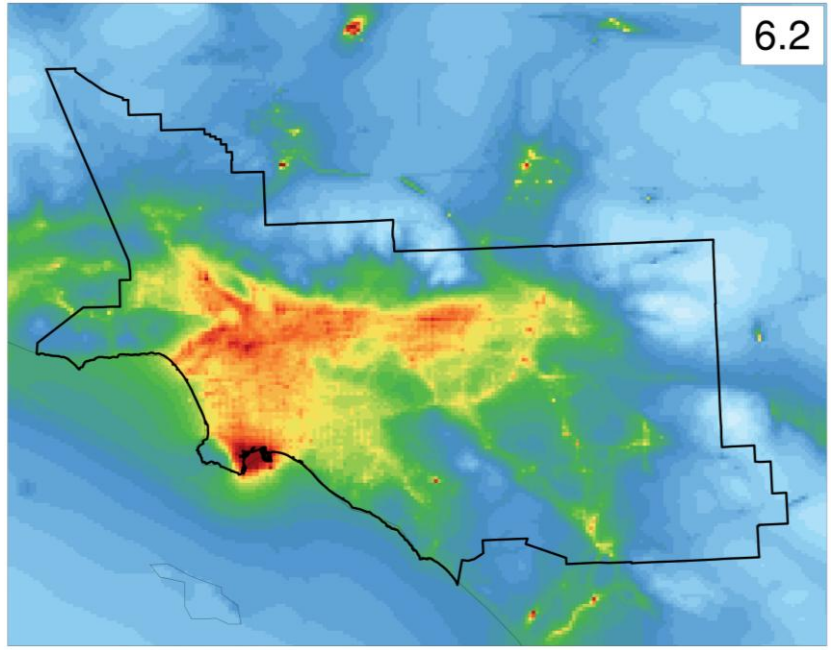




Non-tailpipe HDT $PM_{2.5}$

Zero-emission truck regulations would reduce $PM_{2.5}$ concentrations in 2045

No_ZET

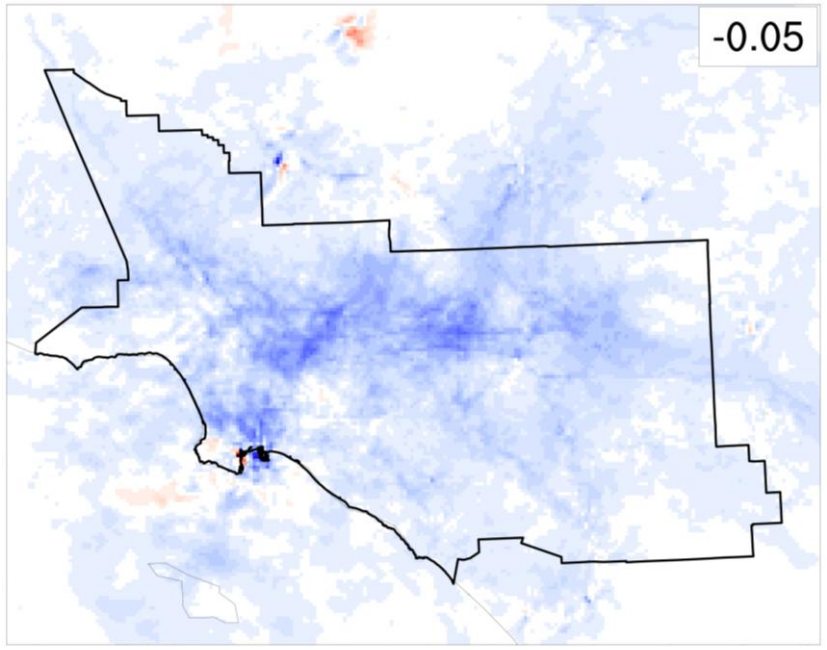


µg m^{-3}

0 4 8 12 16

Total $PM_{2.5}$

ACT+ACF – No_ZET

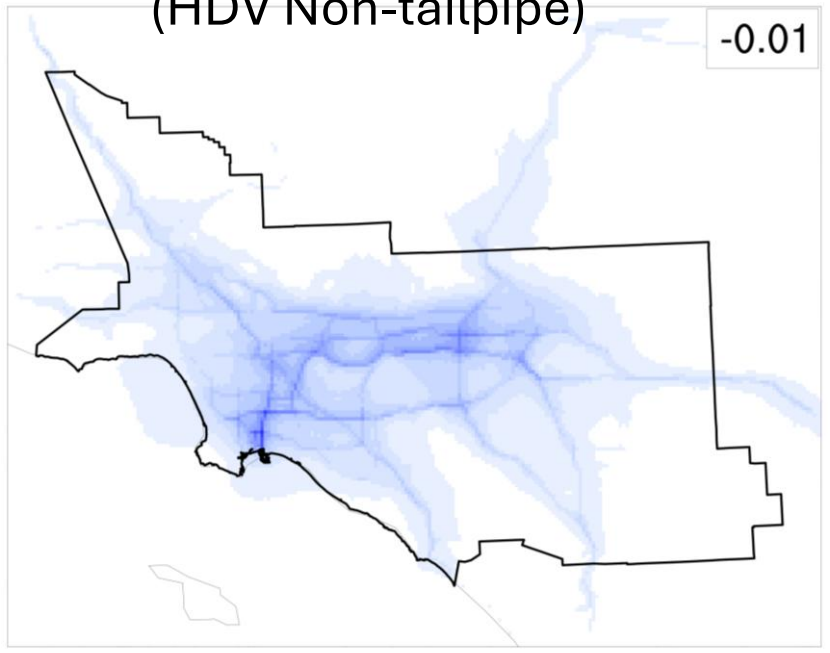


µg m^{-3}

-0.4 -0.2 0 0.2 0.4

Total $PM_{2.5}$

ACT+ACF – No_ZET (HDV Non-tailpipe)

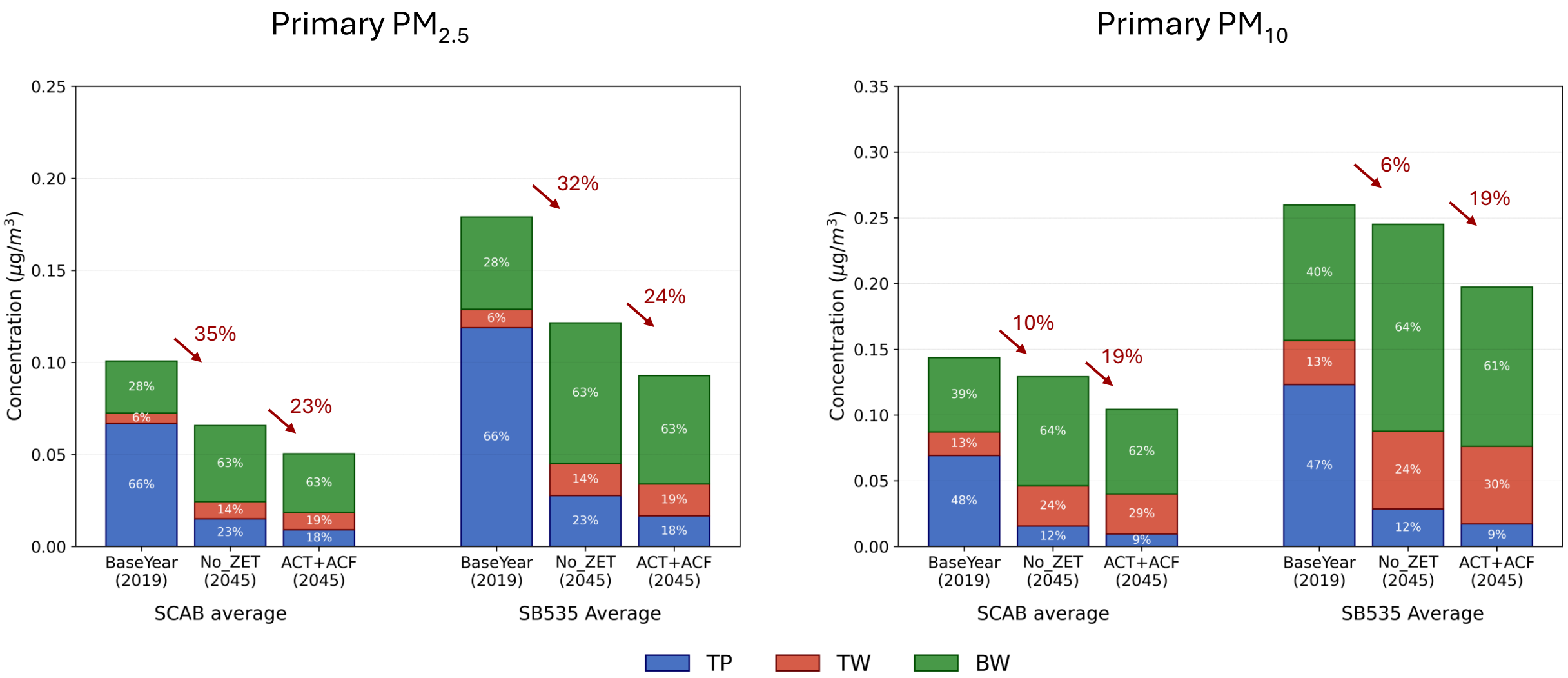


µg m^{-3}

-0.1 -0.05 0 0.05 0.1

Non-tailpipe HDT $PM_{2.5}$

Primary PM concentrations from HDTs are higher in disadvantaged communities in the South Coast Air Basin (SCAB)



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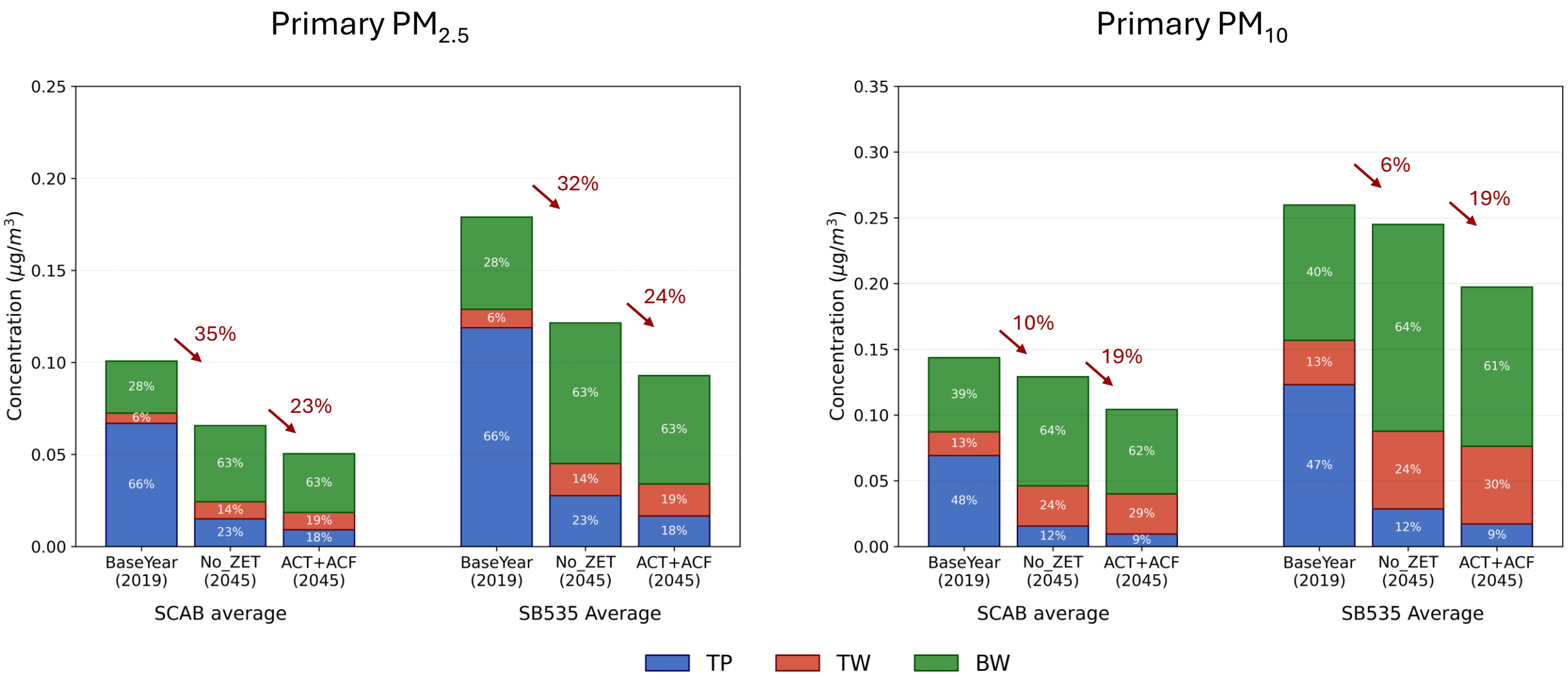
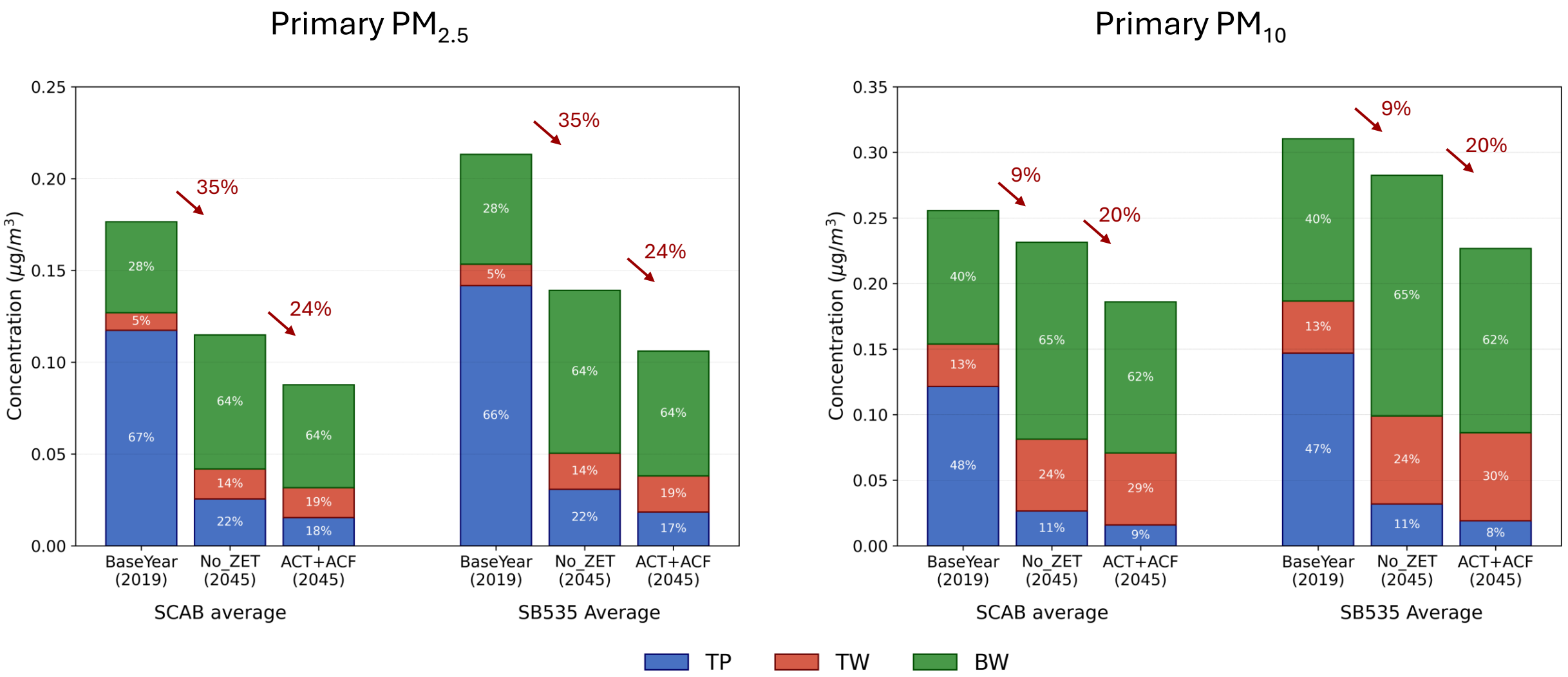
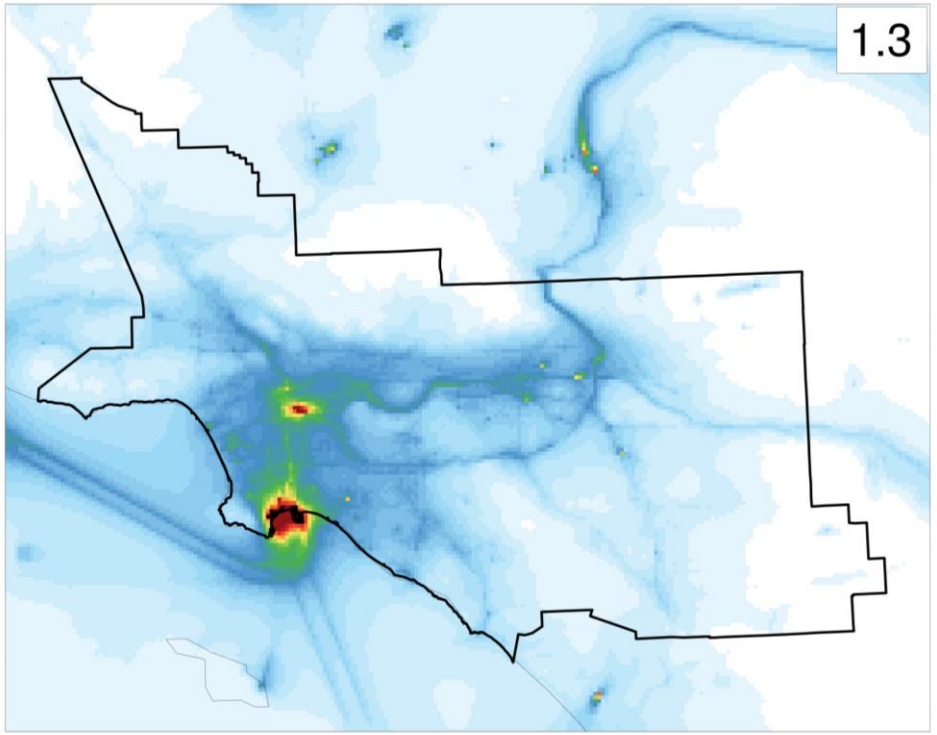


Population-weighted average primary PM concentrations

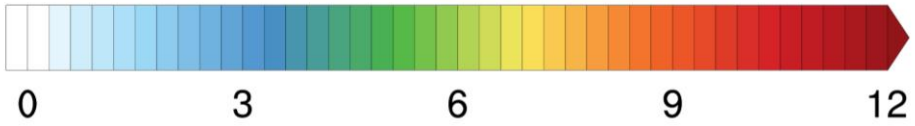


Zero-emission truck regulations reduce NO_2 concentrations in 2045

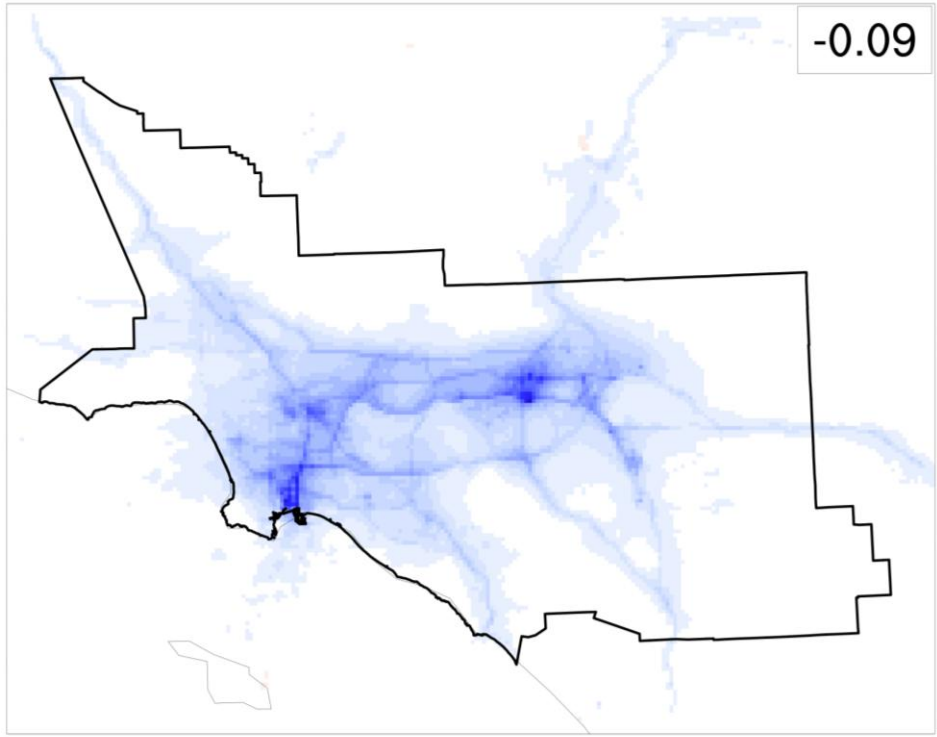
2045 No_ZET



ppb



2045 ACT+ACF – No_ZET



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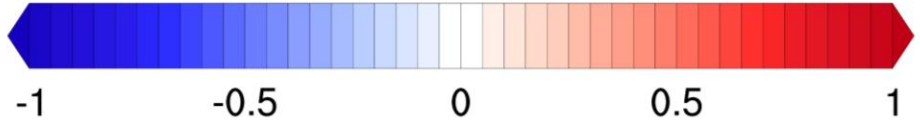
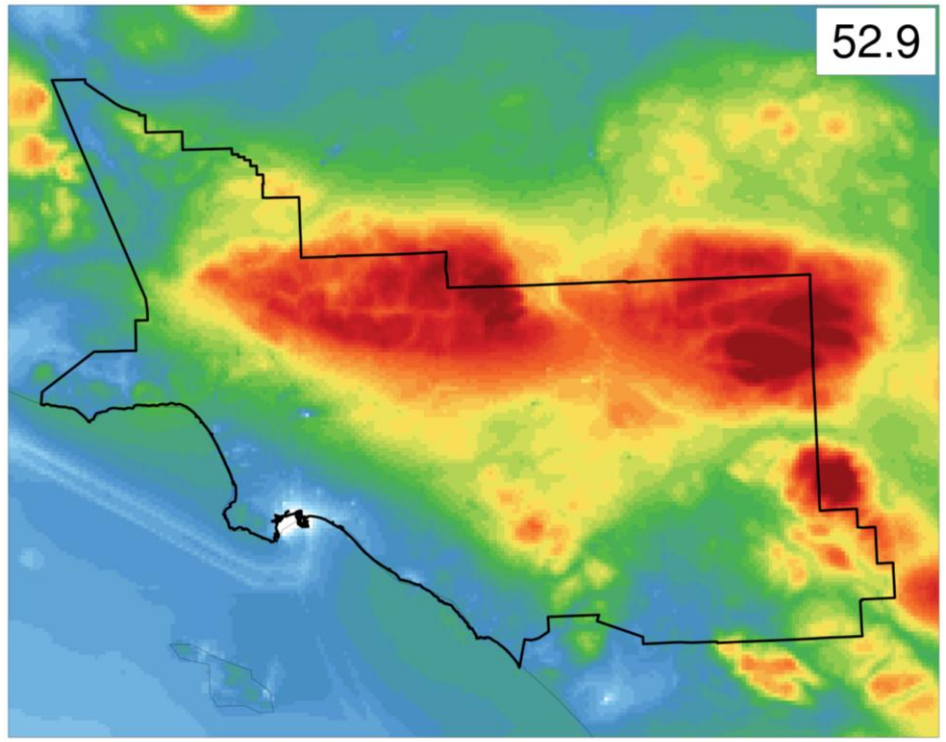


ZET regulations are projected to reduce ozone in most areas, while increase ozone in parts of LA and Orange counties

2045 No_ZET



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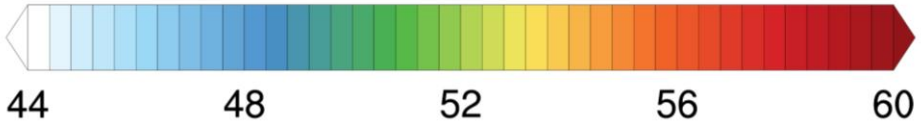
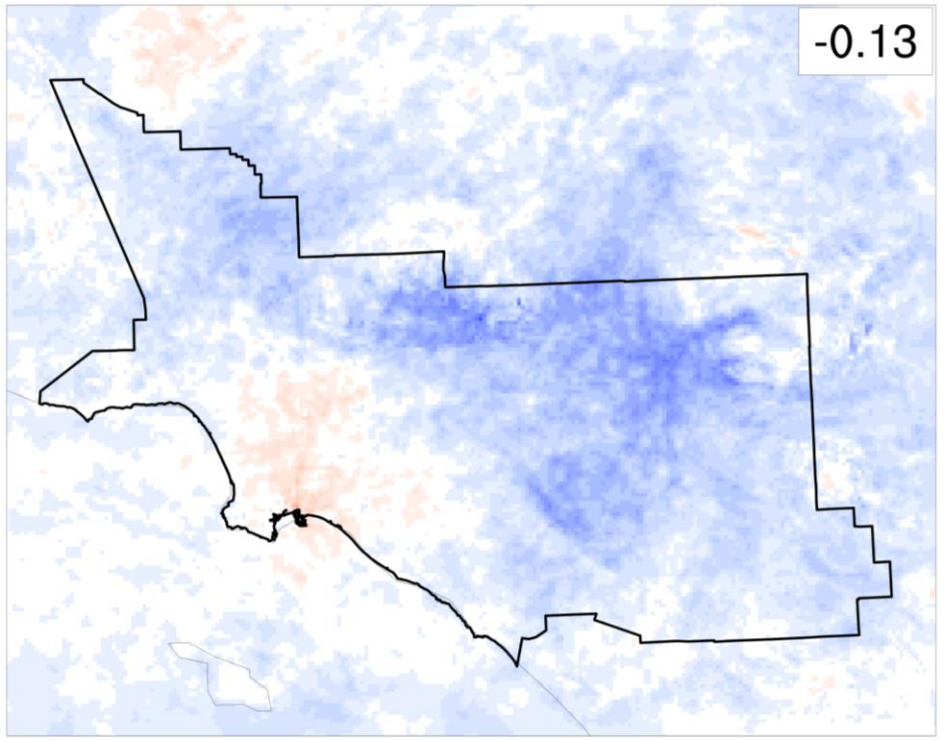


2045 ACT+ACF – No_ZET



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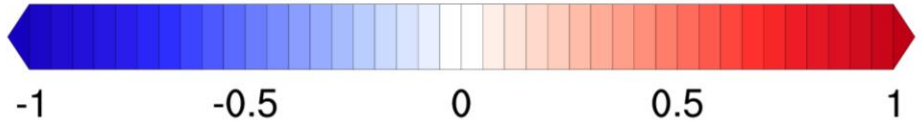
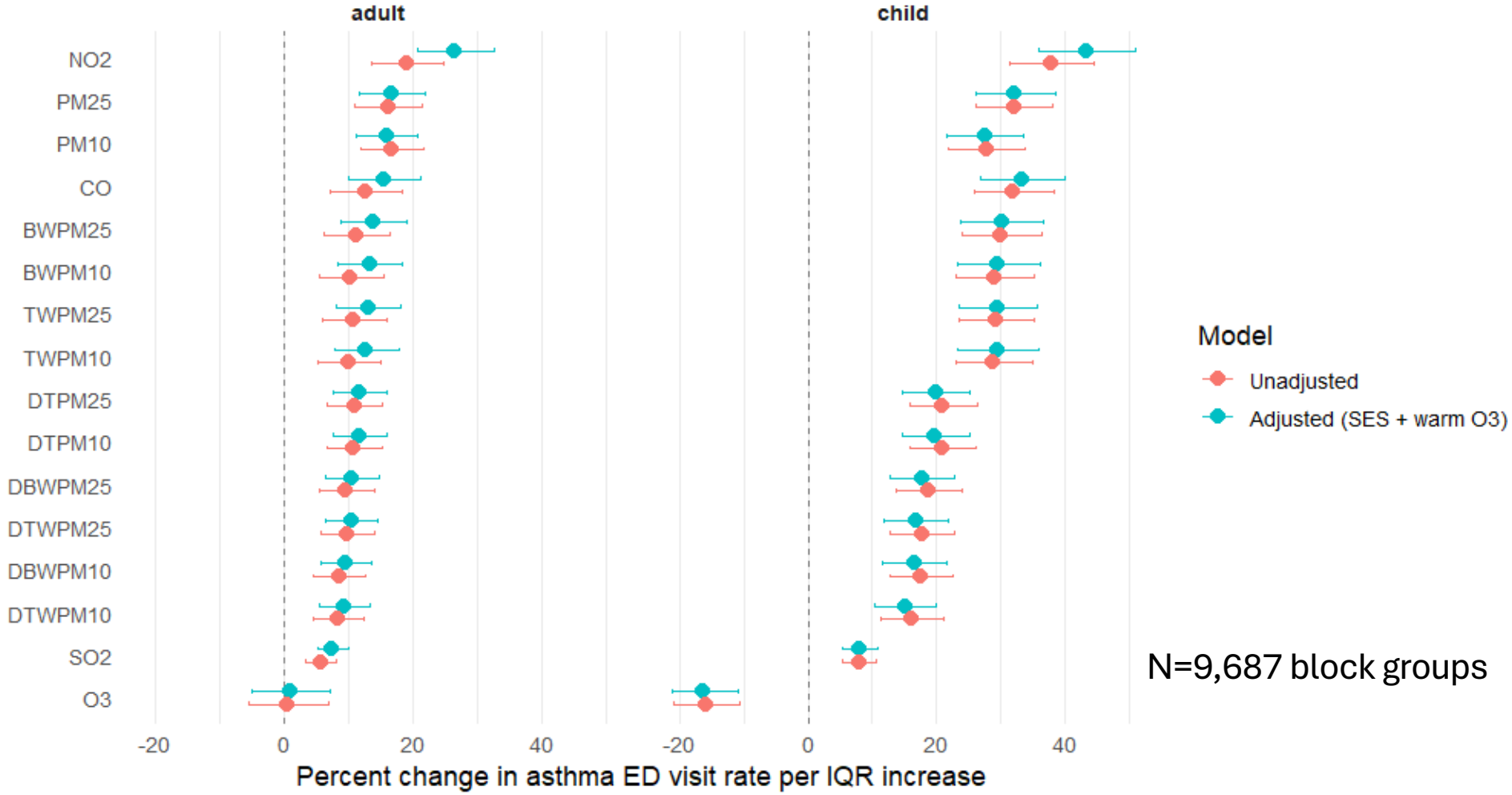


Spatial epidemiologic analysis of asthma emergency department (ED) visit rates

- Cross-sectional, Southern CA, block group level analysis
- Asthma ED visit rates (per 10,000) in 2019
- Spatial error models
- Adjusted for poverty, rent burden, uninsured status and warm-season O_3

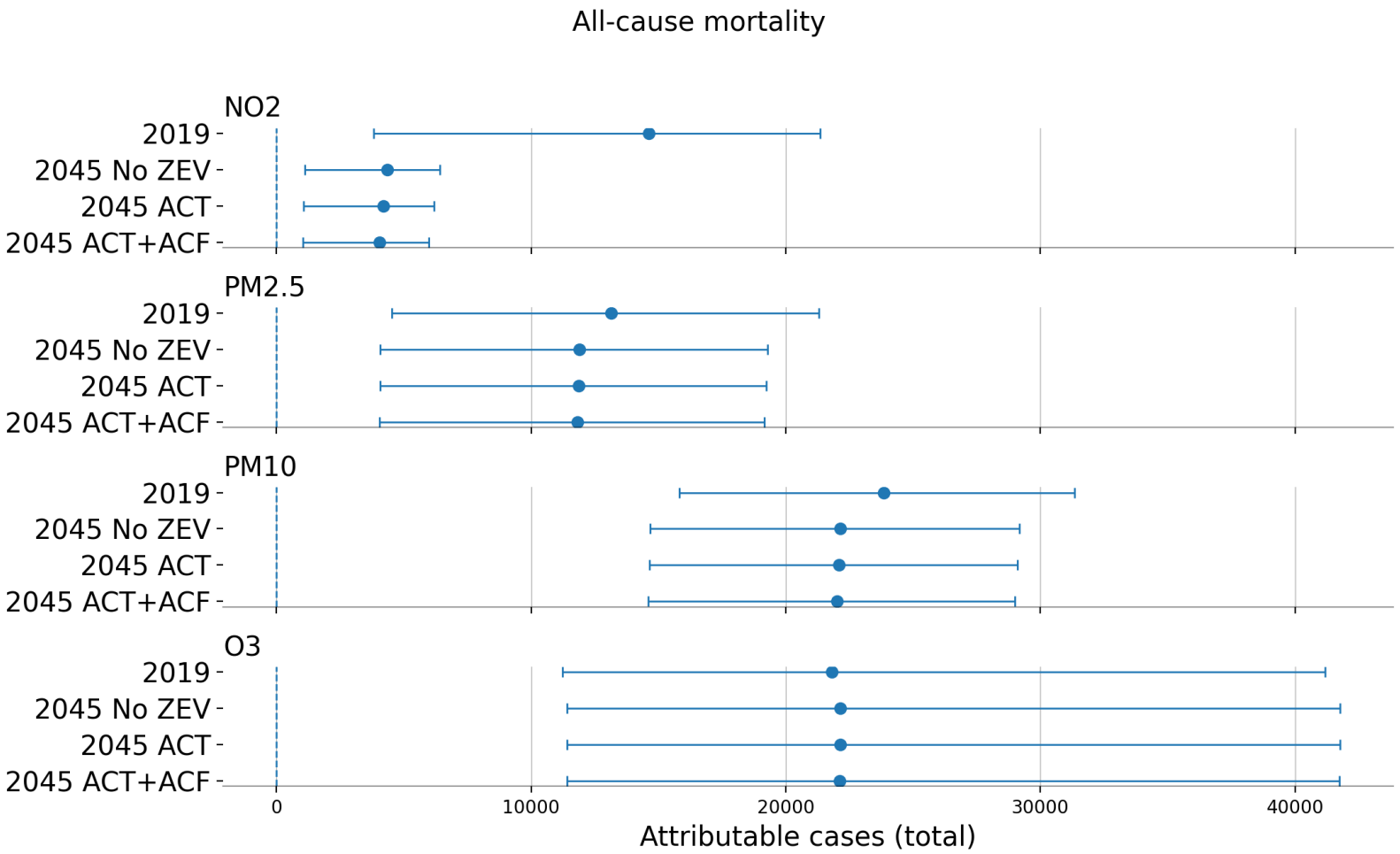


N=9,687 block groups

Health analysis Epi team: Roxana Khalili, Yan Xu, Harshit Gujral, Marisela Rosales, Jill Johnston, Meredith Franklin, Rima Habre

ZET regulations reduce mortality burden in 2045

- Health impact assessment across 9,687 block groups in SCAB; baseline all-cause deaths: 228,660
- ACT+ACF avoids additional all-cause mortality burden relative to No_ZET in 2045 from NO_2 (290 deaths), $PM_{2.5}$ (85), PM_{10} (130), O_3 (24) reductions.



Health analysis HIA team: Harshit Gujral, Yan Xu, Roxana Khalili, Marisela Rosales, Jill Johnston, Rima Habre, Meredith Franklin

Dissemination of findings

- Together with our Community Partners, we are:
  - Co-hosting community meetings to gain feedback and insights from residents living near the I-710 corridor and the Ports of LA and Long Beach
  - Disseminating results from this project in form of an ArcGIS StoryMap (coming soon!) to address community needs and advance community education on freight transportation, electrification, and public health

COMING SOON!

Conclusions

- Advanced Clean Trucks (ACT) and Advanced Clean Fleets (ACF) regulations reduce $PM_{2.5}$ concentrations in SCAB (especially in densely populated areas) by up to 0.4 μg/m^3
- Annual $PM_{2.5}$ concentrations attributable to HDVs are about 70% higher in disadvantaged communities, compared with the SCAB average
- As zero-emission truck (ZET) regulations reduce tailpipe and brake wear emissions, the relative contribution of tire wear to HDV-induced PM concentrations increases
- ACT and ACF are projected to reduce all-cause mortality burden in 2045

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HEI
Health Effects Institute

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