



TRECH PROJECT

TRANSPORTATION, EQUITY, CLIMATE & HEALTH

<https://hsph.me/TRECH>

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HARVARD T.H. CHAN
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What is TRECH?



- Multi-university team researching **T**ransportation, **E**quity, **C**limate & **H**ealth.
- Independent analysis of five policy scenarios related to the Transportation Climate Initiative, or TCI.
- Sharing preliminary results now to foster dialogue and to inform policy choices, such as the TCI memorandum of understanding expected to be finalized later this fall.
- Relied on published peer-reviewed computer models commonly used by EPA, states, and others in regulatory analysis.
- Analysis has been reviewed by our team of 10 experts.
- It is not yet published in scientific journals so it is clearly labeled as “preliminary”.
- Scenarios are illustrative, not predictive. Actual health benefits of a TCI program will depend on state actions (such as cap level, investments, and complementary policies).

What is the Transportation Climate Initiative?

WHAT

- Regional collaboration that aims to reduce carbon dioxide emissions from on-road vehicles
- Proposed cap and investment structure in states from Maine to Virginia, and D.C.

HOW

- Cap would apply to on-road diesel and motor gasoline
- The point of regulation would be liquid fuel wholesale suppliers
- Suppliers would need to hold allowances for the CO₂ content of their fuels
- Allowances would be auctioned off annually and decline over time
- Auctions would generate proceeds that are distributed to states for investment







WHEN

- Proposed program is intended to start in 2022
- The TCI scenario caps reduce CO₂ emissions from on-road vehicles by 20 - 25% from 2022 levels by 2032
- This is equivalent to a 1- 6% reduction between the policy scenarios and reference scenario in 2032
- Final MOU anticipated by end of 2020

Insights from Preliminary Results

1. The estimated health benefits for the five TCI climate mitigation policy scenarios are substantial and are larger than estimated program proceeds, based on this analysis of a subset of total possible benefits.
2. The estimated health benefits of the scenarios analyzed include up to about 1,000 deaths avoided and nearly 5,000 childhood asthma cases avoided under the top-performing policy scenario in 2032.
3. The policy scenario with the largest health benefits is the one with the most ambitious emissions cap (25%) and the largest share of investments dedicated to public transit and active mobility.
4. Under all the policy scenarios examined, health benefits occur in all counties across the region and are concentrated in more populated areas.
5. All the policy scenarios examined modestly reduce inequities in air pollution exposure by race/ethnicity but, even with the reductions estimated under the TCI policy scenarios, people of color would still face higher overall air pollution exposures and more emissions reductions would be needed to address pre-existing inequities.
6. There is nearly a four-fold difference exists in the estimated health benefits across the policy scenarios, underscoring the wide range of possible outcomes and that actual benefits will depend on state actions.

Five *Illustrative* TCI Policy Scenarios Defined by States

		Scenario A	Scenario B	Scenario C
		25% CO2 cap	20, 22, 25% CO2 cap	25% CO2 cap
	Electric cars, light trucks and vans	5%	30%	54%
	Low & zero-emission buses and trucks	21%	23%	27%
	Transit expansion and upkeep	35%	18%	-
	Pedestrian and bike safety, ride sharing	16%	14%	10%
	System efficiency	7%	8%	8%
	Indirect/ Other	17%	8%	-

20%, 22% and 25% cap = 1, 3, and 6% carbon dioxide emission reductions, respectively

TRECH Examines Two Types of Health Benefits

Active Mobility – Biking and Walking



Image by [LaterJay](#) Photography from Pixabay

On-road Emission – Air Quality, Equity, Health



Image by [shilin_wang](#) from Pixabay

Only A Subset of Total Benefits

Summary of Estimated Health Benefits

Five Illustrative TCI Scenarios Compared to No-TCI Scenario in 2032

	Scenario A 25% CO ₂ Reduction Cap	Scenario B 25% CO ₂ Reduction Cap	Scenario C 25% CO ₂ Reduction Cap	Scenario B 22% CO ₂ Reduction Cap	Scenario B 20% CO ₂ Reduction Cap
Estimated deaths avoided (biking, walking, and air quality; central estimate)	1100	950	700	540	280
Estimated benefits for 8 health outcomes (billions 2016\$; based on central estimates)	\$11.1	\$9.6	\$7.1	\$5.5	\$2.7
Estimated total annual TCI proceeds in 2032 (billions 2016\$)	\$8.5	\$6.8	\$5.4	\$3.5	\$1.9

PRELIMINARY RESULTS

Estimated Health Benefits are Larger than TCI Proceeds in 2032

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PRELIMINARY RESULTS

Nearly Four-fold Difference in Benefits, Illustrates Large Impact of Policy Decisions

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PRELIMINARY RESULTS

Investment Scenario A With the 25% CO₂ Reduction Cap Has the Largest Estimated Health Benefits

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PRELIMINARY RESULTS

A Few Caveats

- These scenarios are illustrative, not predictive, and are for the purpose of informing program design. Actual benefits will depend on state actions.
- The scenarios assume that 83% to 92% of proceeds are reinvested in the transportation system.
- The analysis focuses on on-road emissions and does not directly incorporate potential changes in emissions from the electrical grid, but initial screening calculations have been done.
- The air quality analysis was conducted at a 12km by 12km- scale, which is much smaller than a county but larger than a neighborhood. This is very detailed for a regional analysis but is not intended for analyzing changes at the neighborhood scale.
- The analysis does not include climate-related health benefits and potential transportation-related health benefits that could accrue from improving safety, noise pollution, traffic congestion, and access to jobs, healthcare, and education.

Active Mobility Health Benefits: Biking & Walking

A photograph of a paved path in a park-like setting. In the foreground, a person in a grey jacket and dark pants is walking away from the camera. To their right, a person wearing a dark jacket, black pants, and a helmet is riding a bicycle away from the camera. In the background, several other people are walking on the path. The path is flanked by green grass and trees with light green foliage, suggesting a spring or early summer setting. The overall scene is bright and clear.

Estimated Health Benefits from Biking & Walking

Five Illustrative TCI Scenarios Compared to No-TCI Scenario in 2032

	Scenario A 25% CO ₂ Reduction Cap	Scenario B 25% CO ₂ Reduction Cap	Scenario C 25% CO ₂ Reduction Cap	Scenario B 22% CO ₂ Reduction Cap	Scenario B 20% CO ₂ Reduction Cap
Estimated net deaths avoided from biking and walking in 2032	770	640	430	390	200
Estimated monetized health benefits from biking and walking in 2032 (billions 2016\$)	\$7.4	\$6.1	\$4.1	\$3.8	\$1.8
TCI proceeds invested in biking and walking infrastructure in 2032 (billions 2016\$)*	\$0.64	\$0.51	\$0.28	\$0.26	\$0.13

*Public transit investments not included. Transit adds walking benefits.

Central Estimate of Net Deaths Avoided from Biking & Walking by State for Five Illustrative TCI Scenarios Compared to a No-TCI Scenario in 2032

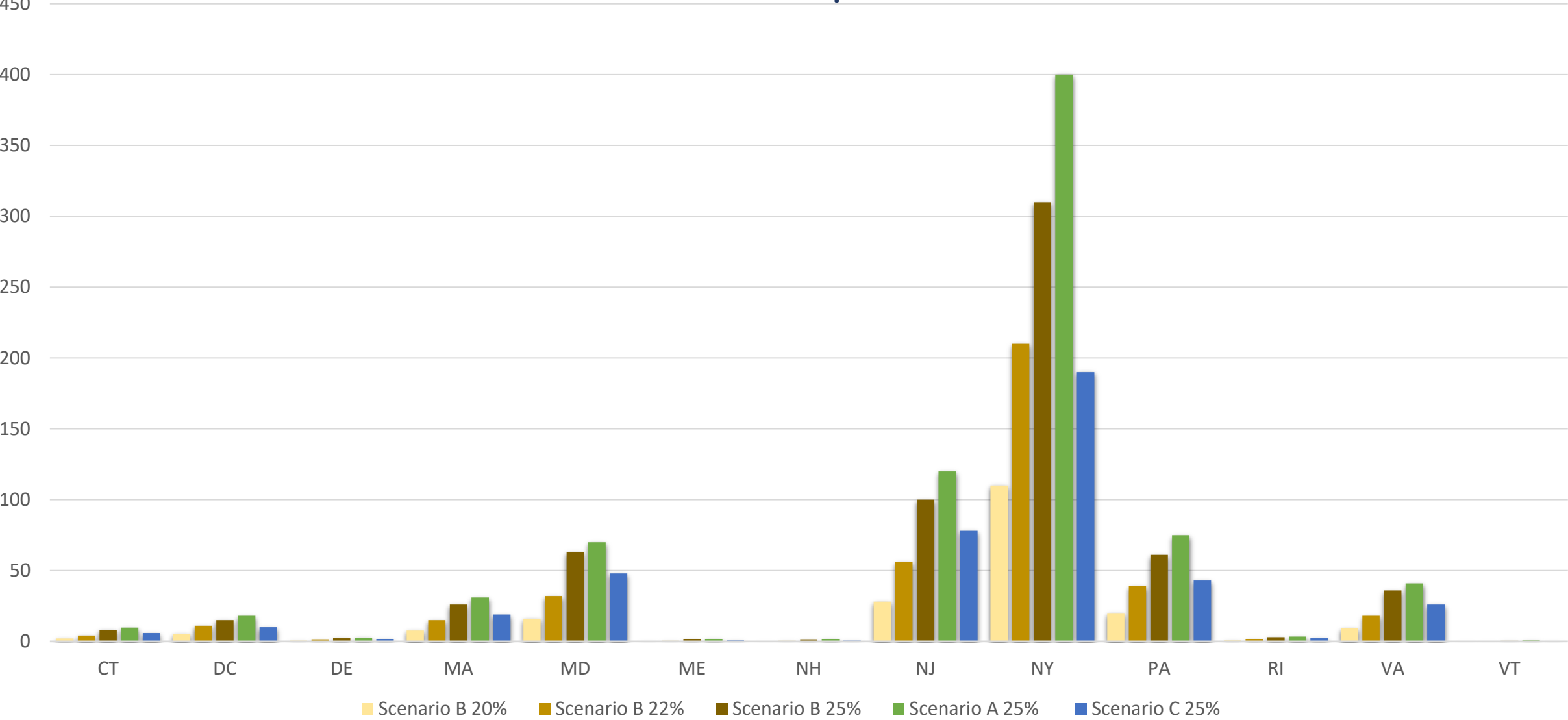


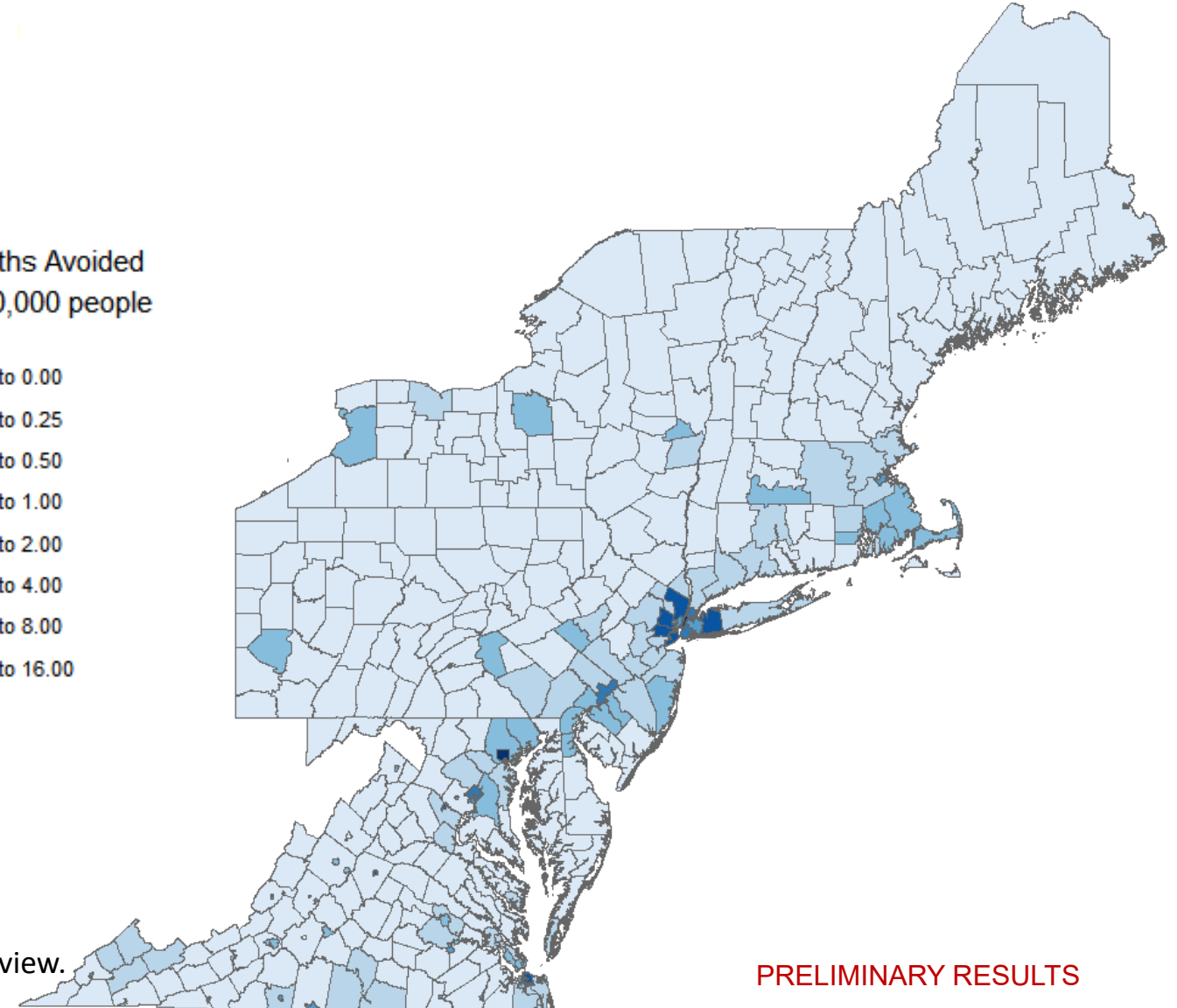
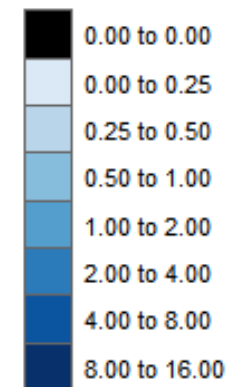
Figure credit: C. Arter. Based on Raifman et al. In review.

PRELIMINARY RESULTS

Net Deaths Avoided Per 100,000 People for Scenario B with the 25% CO₂ Reduction Cap Compared to No-TCI Scenario in 2032

Estimated Active Mobility Benefits Occur in All Counties and are Largest in More Populated Areas

Net Deaths Avoided per 100,000 people




Map credit: M. Raifman, P. Kinney. Based on Raifman et al. In review.

PRELIMINARY RESULTS

Additional Insights

- Activity benefits from biking and walking are larger than air quality benefits, underscoring the value of having more opportunities for physical activity.
- The top scenario has the largest share of investments dedicated to public transit and biking & pedestrian infrastructure. Shifting from vehicles to other modes of travel has double benefits – increased activity and reduced tailpipe emissions.
- The equity of the distribution of physical activity benefits was not analyzed but is an important policy consideration and a focus of future research.



On-Road Emissions: Air Quality

Estimated Premature Deaths from On-road Vehicle Emissions in the TCI Region 2016

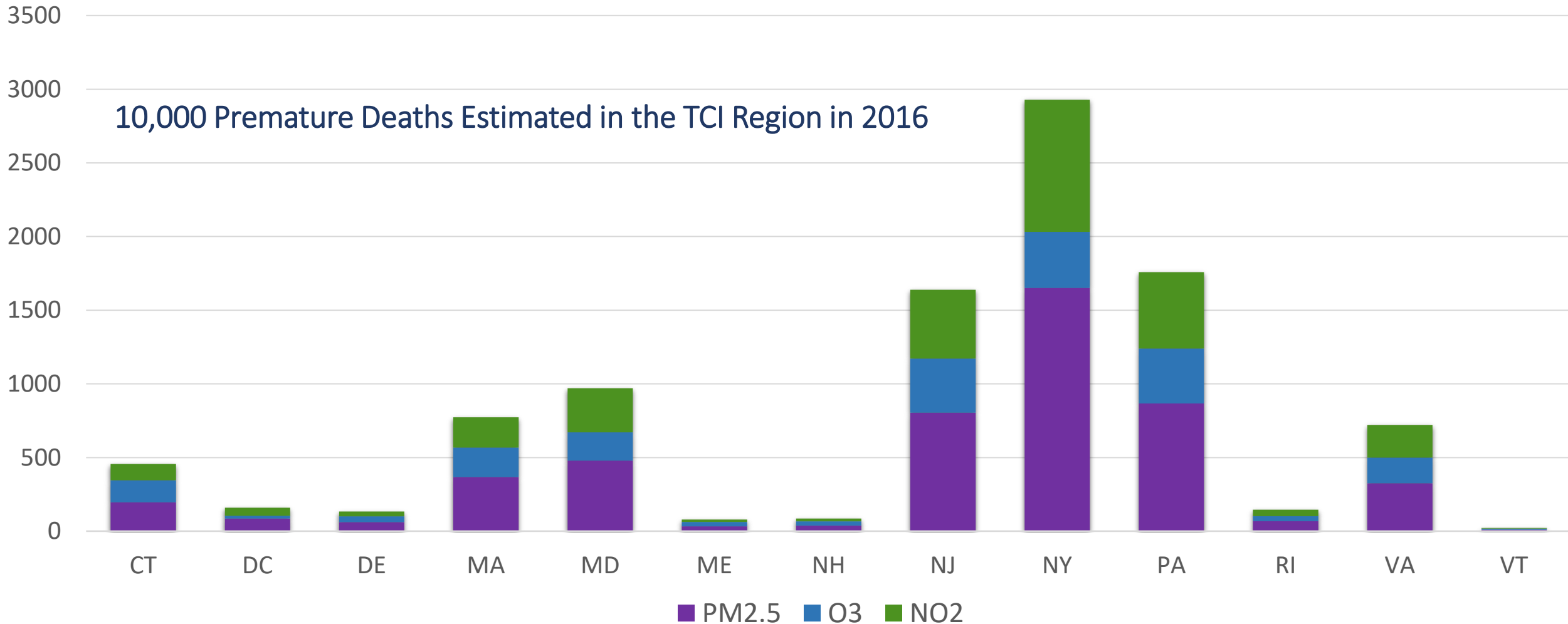
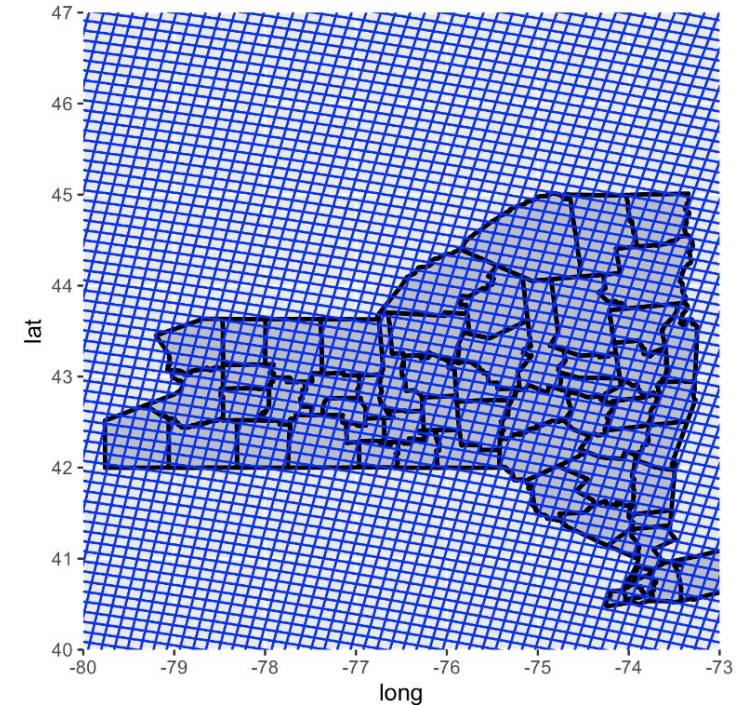


Figure credit: C. Arter, S. Arunachalam. Based on Arunachalam et al. In prep.

PRELIMINARY RESULTS

Air Quality Modeling Approach

- Analyzed differences in air pollution from changes in on-road emissions between five illustrative TCI policy scenarios and a no-TCI reference scenario for the year 2032.
- The modeling is at a 12x12-kilometer scale which is much smaller than a county scale but larger than a neighborhood scale.
- Scenarios compare outcomes under different TCI policy scenarios. Actual results will depend on the final policy choices and state actions.



12x12 km air quality modeling grid: Example for New York State

Change in Air Pollution for Scenario B with 25% CO₂ Reduction Cap Compared to No-TCI Scenario in 2032

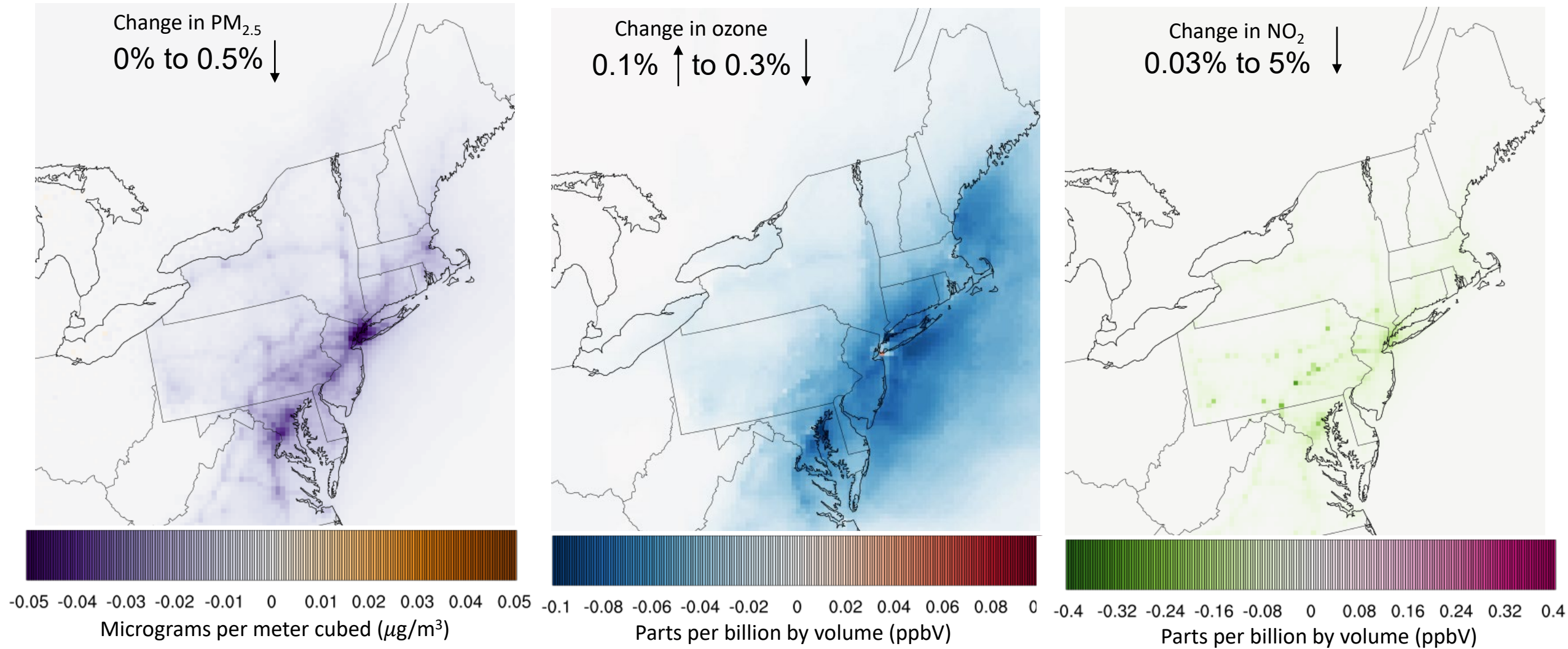


Figure credit: C. Arter, S. Arunachalam. Based on Arunachalam et al. In prep.

PRELIMINARY RESULTS

Air Pollution Exposure and Health Outcomes

A wide-angle, low-angle shot of a busy city street at dusk. The street is filled with cars, including a black sedan in the foreground and several yellow taxis further down. Pedestrians are crossing the street in the foreground. Tall buildings line both sides of the street, with many windows lit up. A traffic light on the right shows a red light. The sky is a deep twilight blue. The overall atmosphere is one of a bustling urban environment.

Air Pollution Exposure & Health - Preliminary Results

- Under the five illustrative TCI policy scenarios, we estimate a modest reduction in inequality of air pollution exposure by race/ethnicity.
- However, large disparities in air pollution exposures persist by race/ethnicity under the policy scenarios in 2032.
- Equity and health benefits increase as cap stringency increases.
- Equity and health benefits are highest in the scenario with the largest share of investments in public transit, and biking and walking infrastructure.

Estimated Population-Weighted Exposure to PM_{2.5}, NO₂, and Ozone for Scenario B with a 25% CO₂ Emissions Reduction Cap Compared to the No-TCI Reference Scenario in 2032

	PM _{2.5} (µg/m ₃) in 2032			NO ₂ (ppb) in 2032			Ozone (ppb) in 2032		
	No-TCI Reference Scenario	TCI Scenario B 25% GHG Cap	% Decrease	No-TCI Reference Scenario	TCI Scenario B 25% GHG Cap	% Decrease	No-TCI Reference Scenario	TCI Scenario B 25% GHG Cap	% Decrease
Total population	7.94	7.92	0.24	4.48	4.43	1.14	36.34	36.30	0.11
Non-Hispanic White population	7.36	7.34	0.21	3.64	3.60	1.14	36.12	36.08	0.10
Non-Hispanic Black population	9.39	9.37	0.29	6.51	6.44	1.14	37.27	37.23	0.12
Hispanic population	9.90	9.87	0.31	7.42	7.34	1.13	36.75	36.70	0.13
Other populations	9.32	9.29	0.29	6.43	6.35	1.14	36.69	36.64	0.12

Table credit: L. Bucky, J. Levy

PRELIMINARY RESULTS

Modest Estimated Reductions in the Inequality in Air Pollution Exposure

Estimated PM _{2.5} Population-Weighted Exposure (µg/m ₃) in 2032		
	TCI Scenario B 25% CO ₂ Reduction Cap	% Decrease
Total population	7.92	0.24
Non-Hispanic White population	7.34	0.21
Non-Hispanic Black population	9.37	0.29
Hispanic population	9.87	0.31
Other populations	9.29	0.29

Larger numbers signify larger decreases in exposure and reduced inequality

Example: Estimated Population-Weighted Exposure to PM_{2.5} for Scenario B with a 25% CO₂ Emissions Reduction Cap Compared to the No-TCI Reference Scenario in 2032

People of Color Would Still Face Higher Overall Air Pollution Exposures

Estimated PM_{2.5} Population-Weighted Exposure (µg/m₃) in 2032

	TCI Scenario B 25% CO ₂ Reduction Cap	% Decrease
Total population	7.92	0.24
Non-Hispanic White population	7.34	0.21
Non-Hispanic Black population	9.37	0.29
Hispanic population	9.87	0.31
Other populations	9.29	0.29

Larger numbers signify higher exposure into the future

Example: Estimated Population-Weighted Exposure to PM_{2.5} for Scenario B with a 25% CO₂ Emissions Reduction Cap Compared to the No-TCI Reference Scenario in 2032

Air Quality-Related Estimated Health Benefits

Five Illustrative TCI Policy Scenarios Compared to a No-TCI Scenario in 2032

The estimated deaths avoided in this scenario represent about an 8% decrease in estimated deaths from estimated on-road emissions in the TCI region in 2032

	Scenario A 25% CO ₂ Reduction Cap	Scenario B 25% CO ₂ Reduction Cap	Scenario C 25% CO ₂ Reduction Cap	Scenario B 22% CO ₂ Reduction Cap	Scenario B 20% CO ₂ Reduction Cap
Estimated childhood asthma cases avoided in 2032	4700	4100	3300	2000	1000
Estimated deaths avoided in 2032	330	310	270	150	80
Estimated respiratory hospitalizations avoided in 2032	37	33	27	16	8
Total estimated monetized air quality health benefits – all outcomes in 2032 (billions 2016\$)	\$3.7	\$3.5	\$3.0	\$1.7	\$0.8

Table credit: J. Buonocore, F. Perera, A. Berberian et al.

PRELIMINARY RESULTS

Central Estimate of Net Deaths Avoided from Air Quality Changes by State for Five Illustrative TCI Scenarios Compared to a No-TCI Scenario in 2032

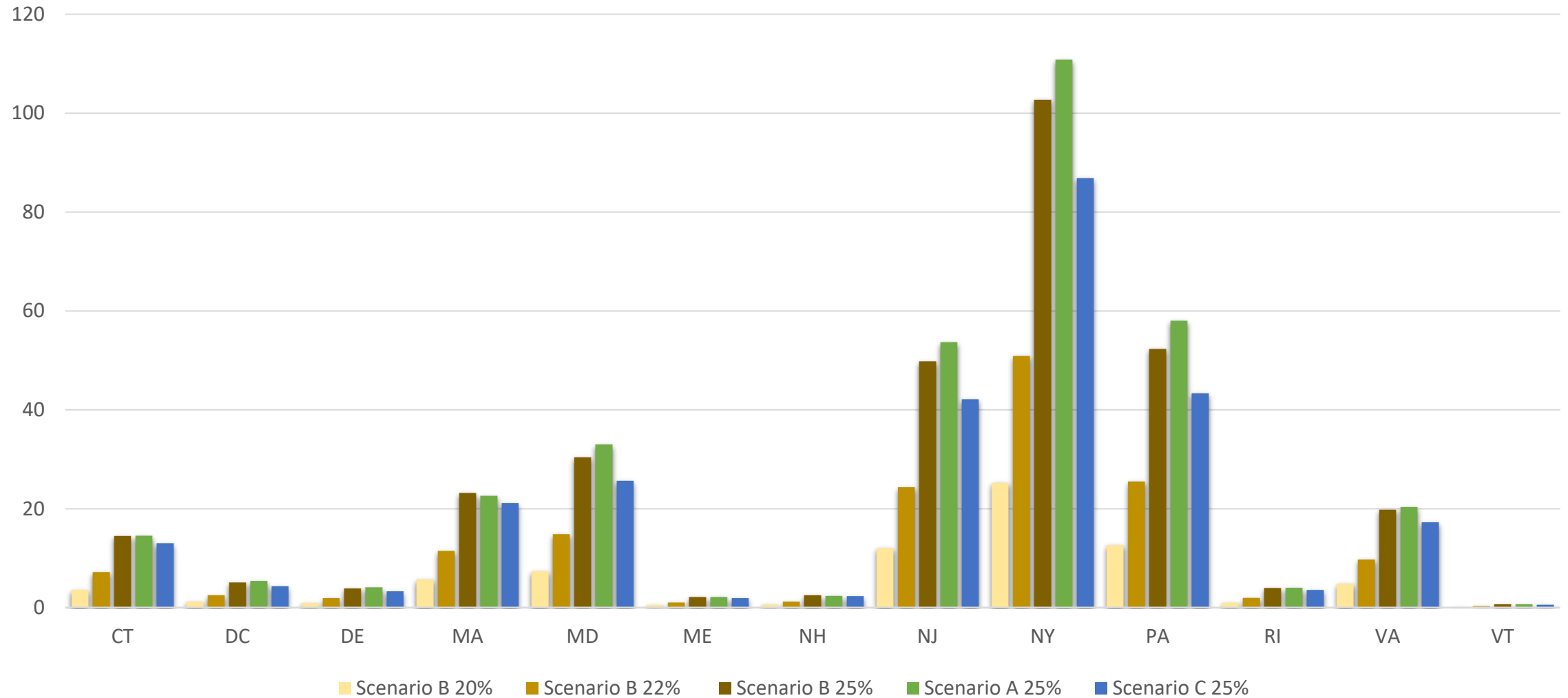
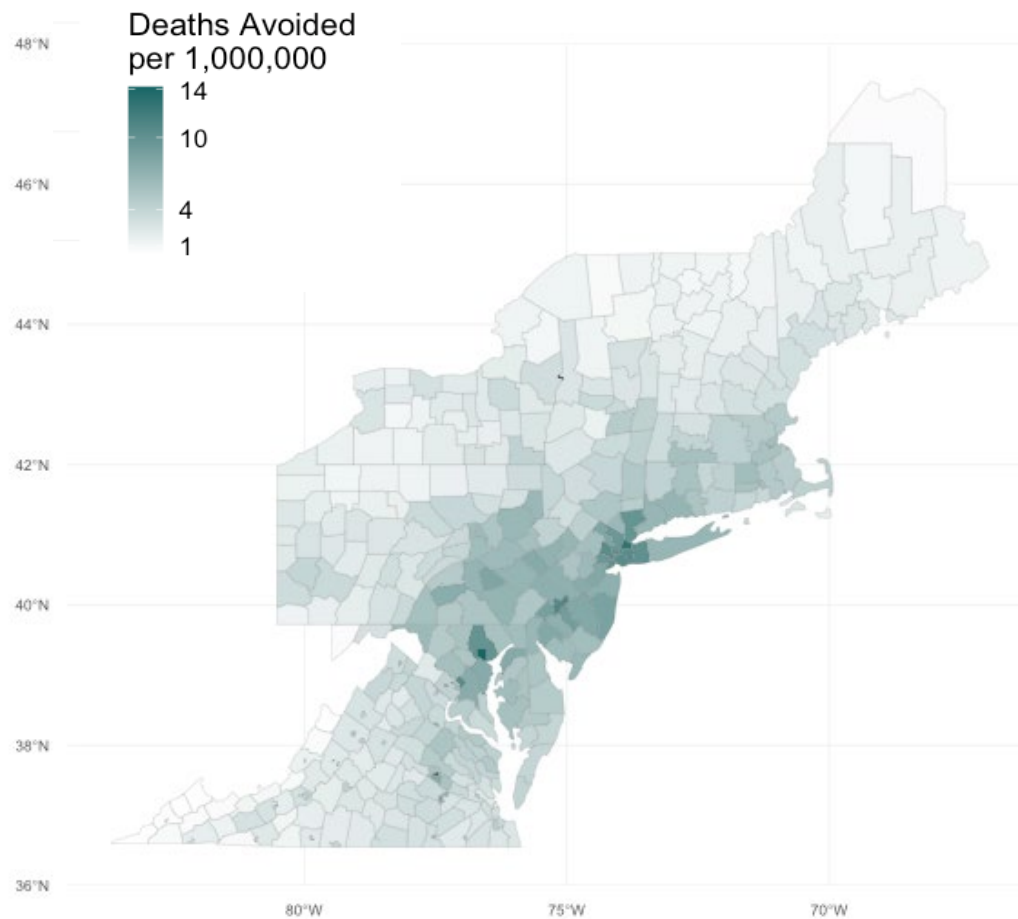
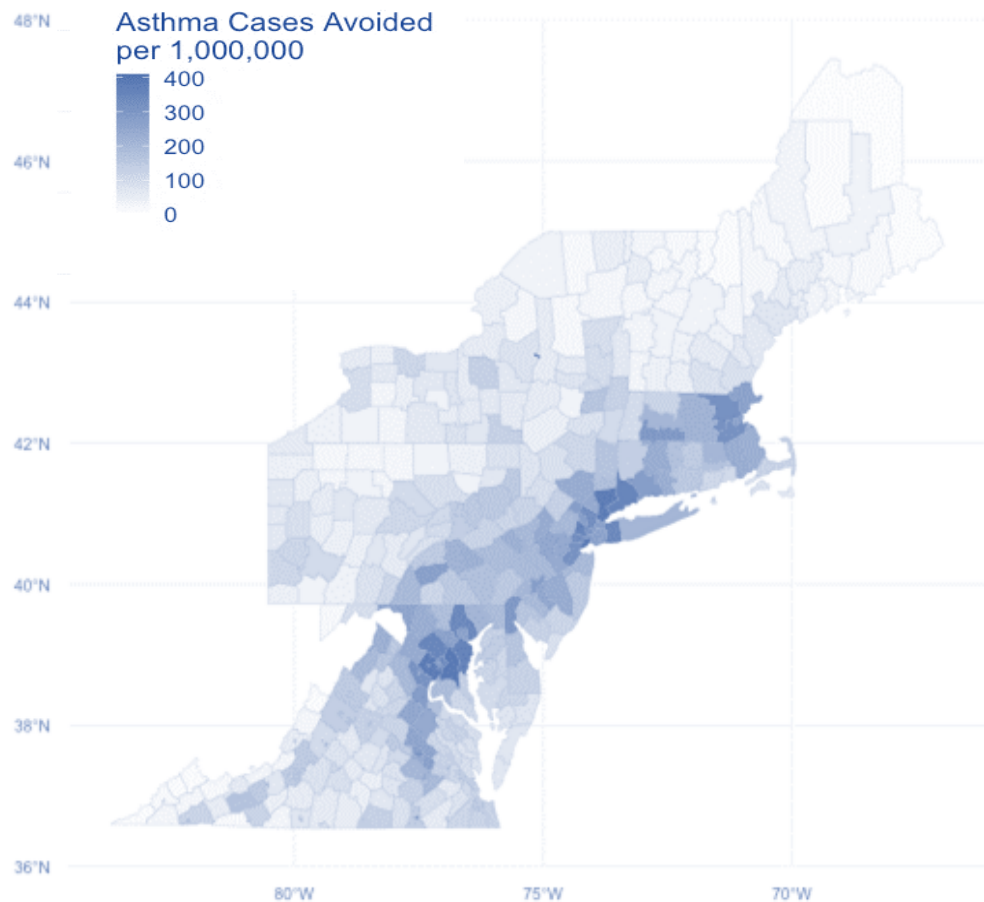


Figure credit: C. Arter. Based on Arunachalam et al. In prep.

PRELIMINARY RESULTS

Estimated Childhood Asthma and Premature Deaths Avoided Per Million People for Scenario B with 25% CO₂ Reduction Cap Compared to No-TCI Scenario in 2032



All Counties See Health Benefits from Air Quality Improvements, Largest in More Populated Areas

Recap: Insights from Preliminary Results

1. The estimated health benefits for the five TCI climate mitigation policy scenarios are substantial and are larger than estimated program proceeds, based on this analysis of a subset of total possible benefits.
2. The estimated health benefits of the scenarios analyzed include up to about 1,000 deaths avoided and nearly 5,000 childhood asthma cases avoided under the top-performing policy scenario in 2032.
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