Health and equity impacts of alternative air quality management strategies: A quantitative health impact assessment for Detroit, Michigan

Sheena E. Martenies, MPH[1], Angela G. Reyes, MPH[2], and Stuart A. Batterman, PhD[1,3]

[1] University of Michigan School of Public Health

[2] Detroit Hispanic Development Corporation

[3] Corresponding author: stuartb@umich.edu

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Abstract

Purpose: Portions of the Detroit area currently exceed the National Ambient Air Quality Standard (NAAQS) for sulfur dioxide (SO_2). The population in and around the non-attainment area is vulnerable to the adverse health effects of SO_2 exposure due to high rates of asthma and other environmentally-related diseases. We examine alternative strategies for reducing SO_2 concentrations that both meet the NAAQS and that address health inequities experienced by residents. **Study Question**: What are the health and equity impacts of SO_2 emission control alternatives developed for point sources near Detroit, MI? **Methods:** SO_2 emission control strategies are developed using modeling and optimization techniques that meet the NAAQS, maximize health benefits, or minimize the unequal distributions of potential health impacts. Quantitative health impact assessment (HIA) techniques tailored to the intra-urban scale are used to estimate the health burden of exposures based on 2013 emissions at 10 major SO_2 sources in the area. Health benefits are determined as avoided adverse outcomes for each control alternative. Outcomes considered include asthma exacerbations among children and hospitalizations for respiratory disease. Inequality in the distribution of impacts across the study population is measured using the Atkinson index and other measures of inequality. **Results:** At baseline, each year, SO_2 exposures led to an estimated 40 respiratory hospitalizations, 75 emergency department visits for asthma, and more than 5,000 asthma exacerbations among children. The health benefits of control alternatives depend on the tonnage of emissions reduced at the different sources and the proximity of populations to sources. Differences between alternative strategies are demonstrated using the concentration, health, and inequality metrics. **Conclusions:** Quantitative HIAs can identify the health and equity impacts of air quality management alternatives. Health and equity metrics can be used to select alternatives that meet the NAAQS as well as improve public health and help reduce health inequities.

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Community Action to Promote Healthy Environments (CAPHE)

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CAPHE Partner Organizations & Partnerships

Community Action Against Asthma

DEQ

sdev

Healthy Environments Partnership

Detroit Hispanic Development Corporation

Sierra Club Founded 1892

DEC™

Wayne State Law School

greendoor initiative

Celebrating 1995-2015

Detroiters Working for Environmental Justice

Fostering Clean, Healthy and Safe Communities

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CAPHE's Overarching Goals

To develop a multilevel, integrated and scientifically-informed Public Health Action Plan designed to reduce adverse effects of air pollution on health

To promote implementation of components of the plan

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Photo 1: Incinerator, Detroit Renewable Power, Detroiters Working for Environmental Justice, 1-4-16
Photo 2: Truck Traffic, Detroit, Hannah Gordon, 6-18-15

Air Quality in Detroit

- Historic challenges with air quality
- Vulnerable populations in Detroit
- Health disparities in air pollution-related diseases
  - Rates of asthma hospitalizations and deaths are 3.5x and 2.4x the state average
- Non-attainment of the SO_2 National Ambient Air Quality Standard
  - One of 32 areas nationwide
- MDEQ recommended southeast MI be designated as non-attainment of O_3 standard

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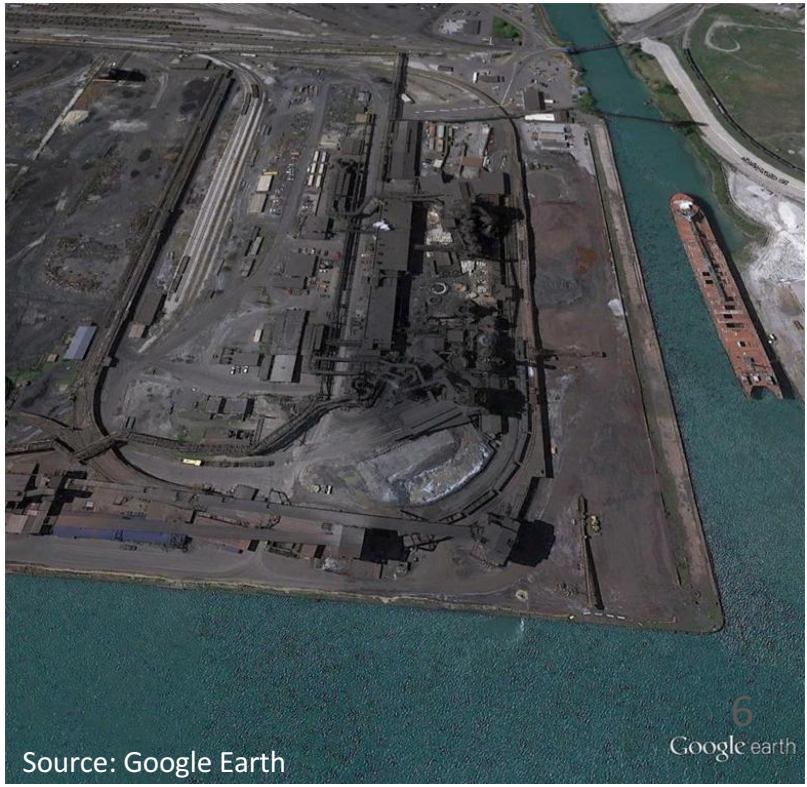
DTE Monroe

DTE Trenton Channel

DTE River Rouge



US Steel-Ecorse

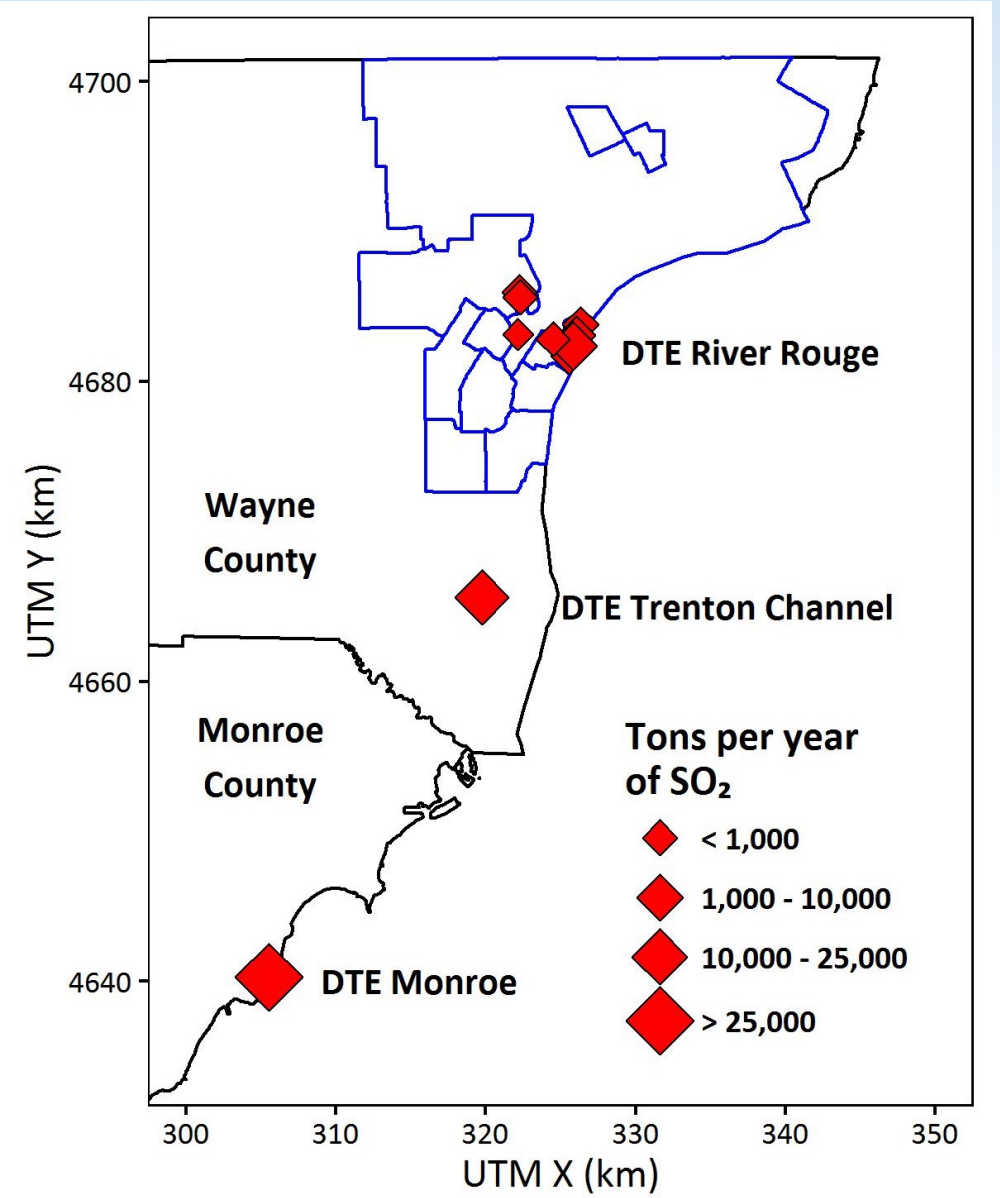
Study Objectives

1. Estimate the burden of disease attributable to specific point sources of SO_2 affecting Detroit, MI area
2. Compare the health and inequality impacts of alternative SO_2 emissions control strategies

Study area includes 21,616 census blocks and a total population of 1,010,956

Study Methods

1. Estimate health impacts for individual point sources of SO_2
   - Combination of dispersion models and health impact functions
2. Develop alternatives for reducing emissions
   - Uniform reductions at all major sources
   - Reductions at the largest sources first
   - Reductions at the sources with the largest health impacts first
3. Calculate and compare health and inequality metrics
   - Disability-adjusted life years
   - Atkinson Index



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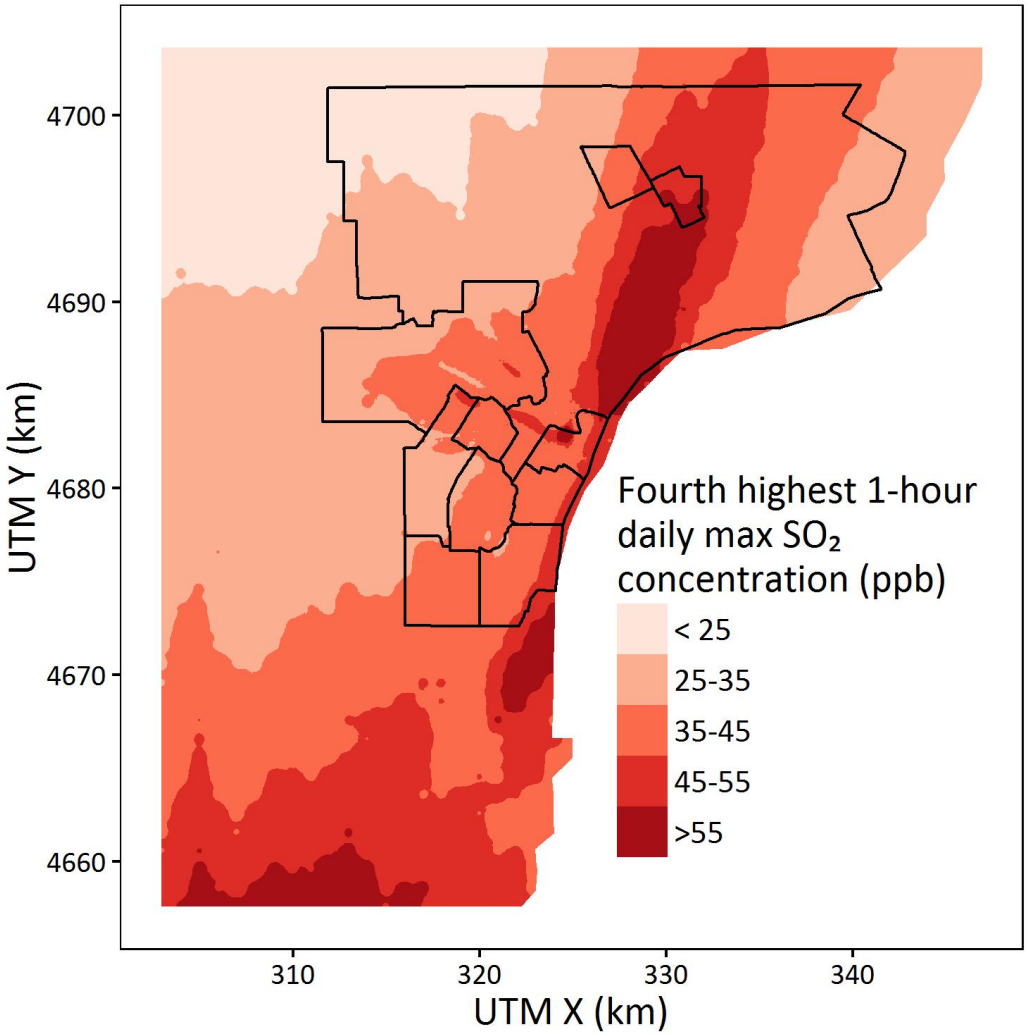
SO_2 exposures contribute to the overall burden of disease experienced by Detroit residents



Outcome	Impacts per year (95% CI)	
Asthma hospitalization	**7**	(0 – 20)
COPD hospitalization	**39**	(0 – 79)
ED Visits for asthma	**85**	(49 – 125)
Asthma symptoms	**5,540**	(0 – 10,861)
Total health burden **(DALYS)**	**6.55**	(0 – 12.8)
Monetized impact **(million$)**	**1.9**	(0 – 3.9)

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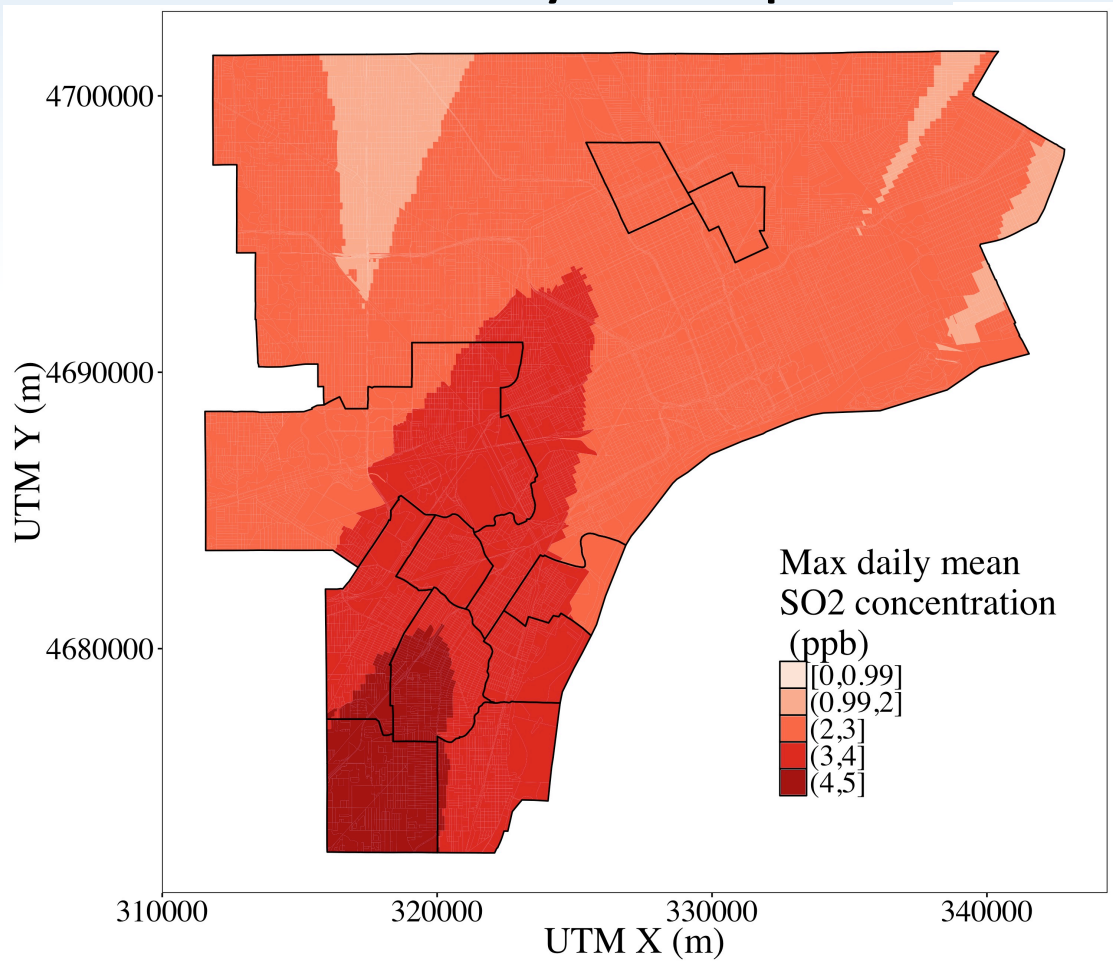
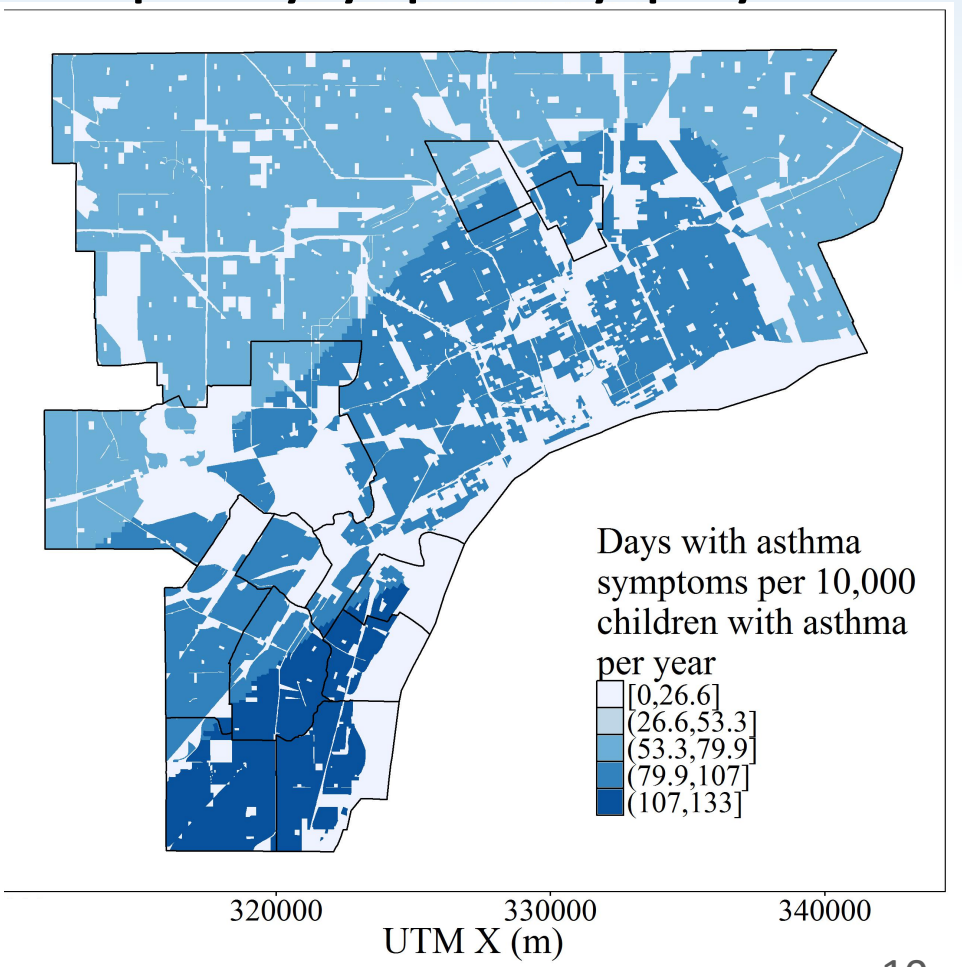
Mapping point source concentration and health impacts

DTE Monroe Coal Fired Power Plant

Peak daily mean exposures



Respiratory symptom days per year



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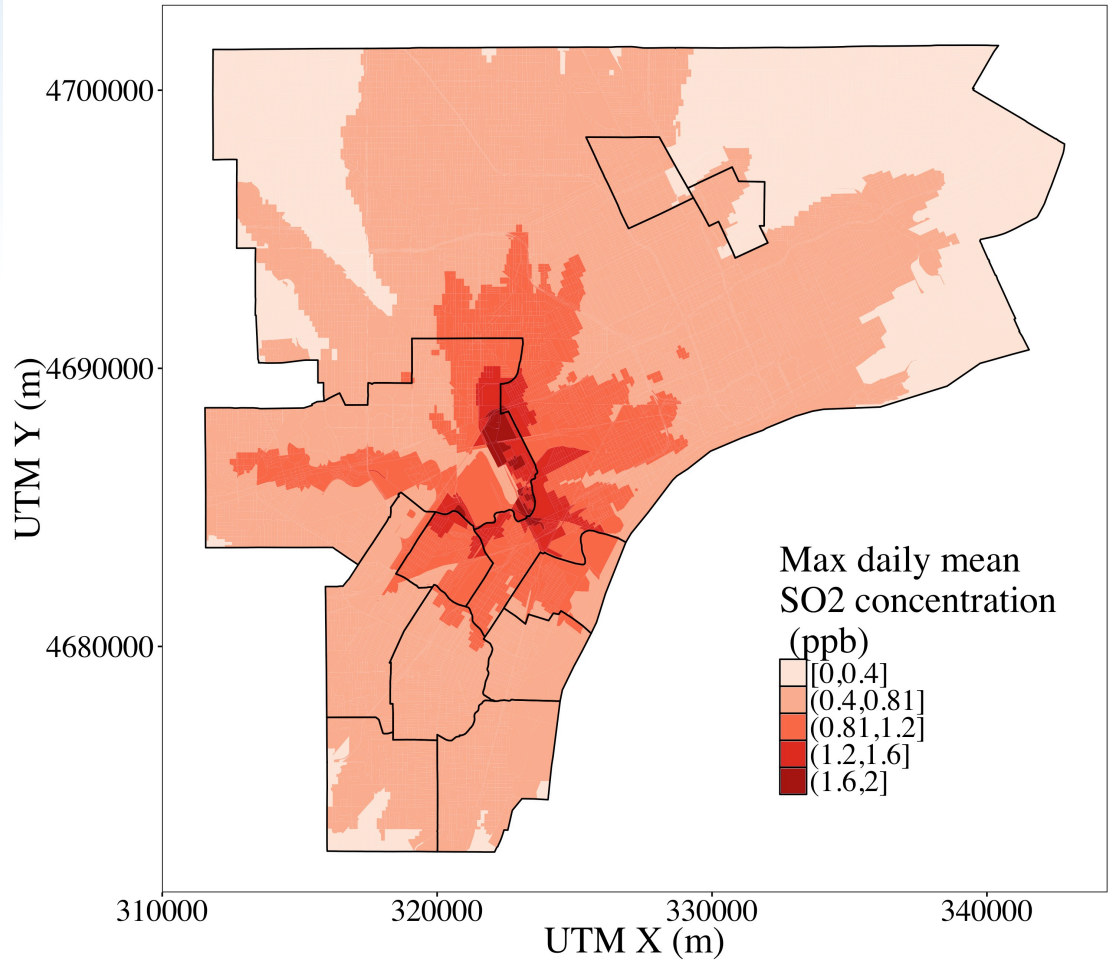
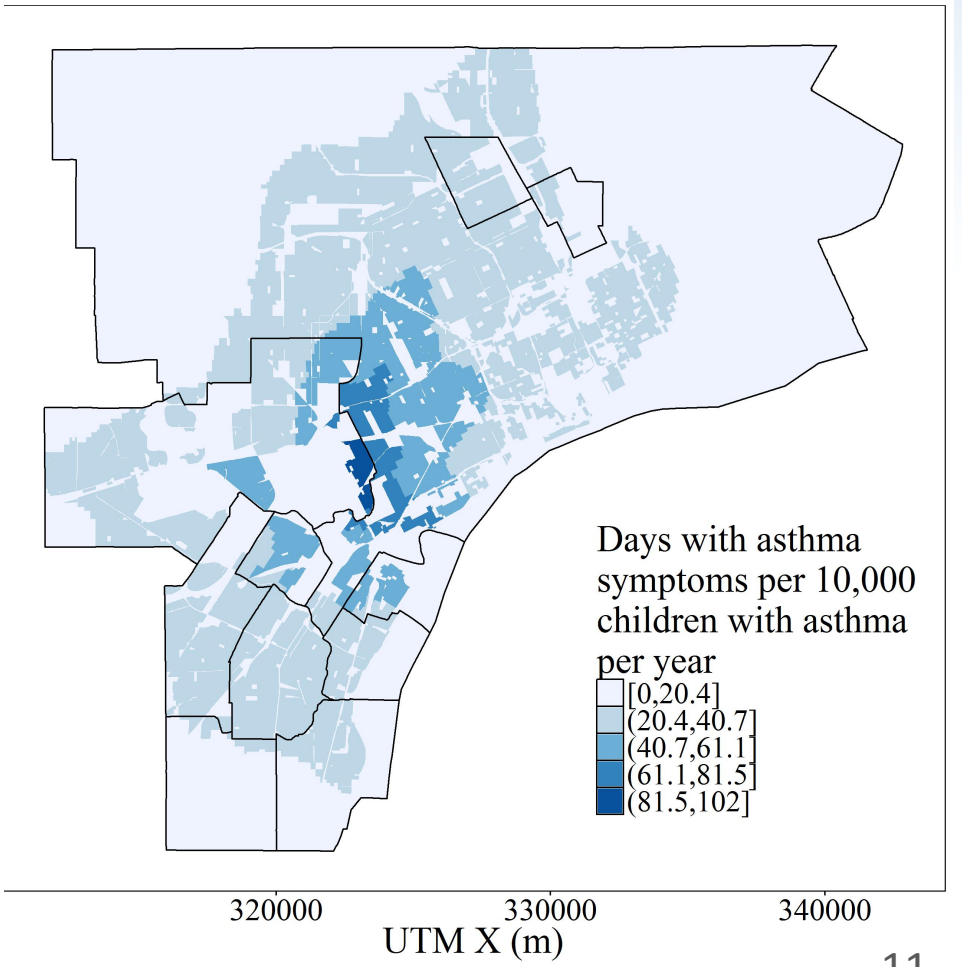
Mapping point source concentration and health impacts

AK Steel / Severstal

Peak daily mean exposures



Respiratory symptom days per year



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Smaller sources can have greater health impacts per ton of pollutant emitted

Facility	Total emissions (tons/yr)	Rank	Total health impact (DALYs/yr)	Rank	Impact per unit emitted (DALYs/ 100 tons)	Rank
Carmeuse Lime	640	8	0.383	7	**0.060**	**1**
Dearborn Industrial Generation	768	6	0.420	6	**0.055**	**2**
Severstal/AK Steel	733	7	0.375	8	**0.051**	**3**
Marathon Petroleum	268	9	0.122	9	0.046	4
US Steel Great Lakes Works	2,885	4	1.275	1	0.044	5
EES Coke	2,049	5	0.533	5	0.026	6
DTE River Rouge	**10,442**	**3**	0.772	4	0.007	7
DTE Trenton Channel	**20,824**	**2**	0.781	3	0.004	8
DTE Monroe	**47,409**	**1**	1.201	2	0.003	9

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Lowering ambient concentrations and reducing health impacts

- Reductions in total emissions of SO_2 ranging from 15% to 90%
- Three strategies: uniform reductions, largest sources first, largest health impacts first
- NAAQS concentration: 75 ppb (averaged over three years)

Fourth highest 1-hr daily max SO_2 concentration (ppb)

% Reduction in Total SO_2 Emissions	Uniform Percentage	Largest sources first	Largest health impacts first
Base Case	79.5	79.5	79.5
15%	68.3	76.1	69.3
30%	57.0	72.5	56.3
45%	45.7	68.9	51.5
60%	34.2	64.3	37.2
75%	23.0	62.0	23.9
90%	19.6	19.6	19.6

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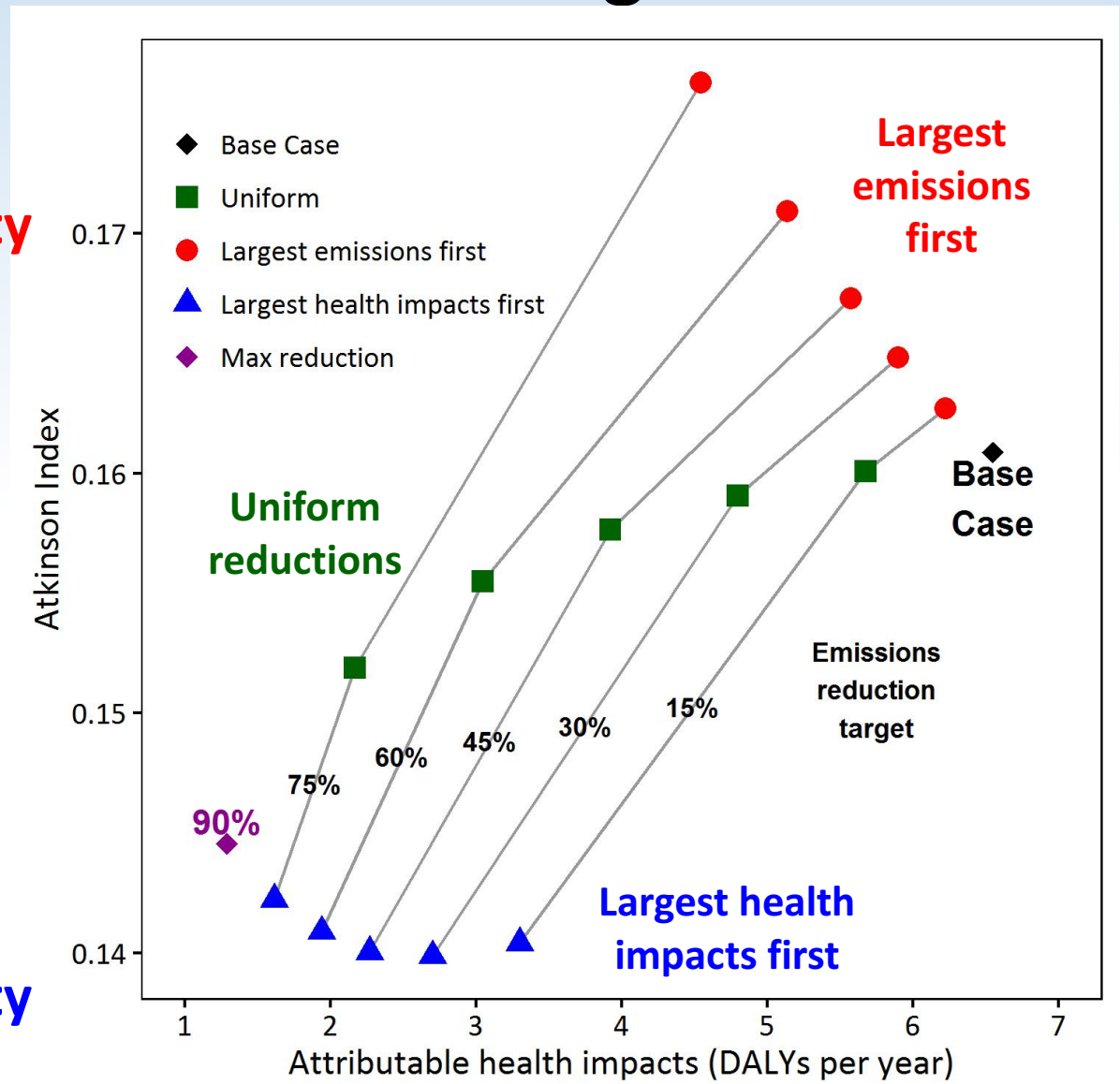
Health & inequality benefits depend on the sources targeted

More inequality

Less inequality



Lower health impacts

Higher health impacts

Limitations

- HIA methods are limited to outcomes for which a reliable CR coefficient is available and causal evidence is sufficient
- Only consider a single pollutant (SO_2)
- Does not include cumulative impacts from other air pollutants or environmental stressors
- No consideration of abatement costs
- Limited uncertainty analysis

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Key Findings

- SO_2 from point sources contributes to environmental inequalities experienced by Detroit residents
- Results depend on source locations, meteorology, and population characteristics
- Targeting the largest sources in the area may increase inequality in health burden
- The greatest reductions in health impacts and inequality come from targeting the sources with larger health impacts per ton emitted first
- Can use a modeled system to optimize strategies and achieve policy goals

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Policy Implications

1) Locations of **sources, exposures, and vulnerable populations should be considered** when developing strategies to reduce air pollutant concentrations and exposures

2) Focusing on ambient concentrations and NAAQS attainment only may **miss opportunities to address environmental inequalities** in air pollution burden

3) Including quantitative HIAs in the air quality management process could help choose alternatives that simultaneously **meet environmental, health, and equity goals**

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