Traffic Particles and Health

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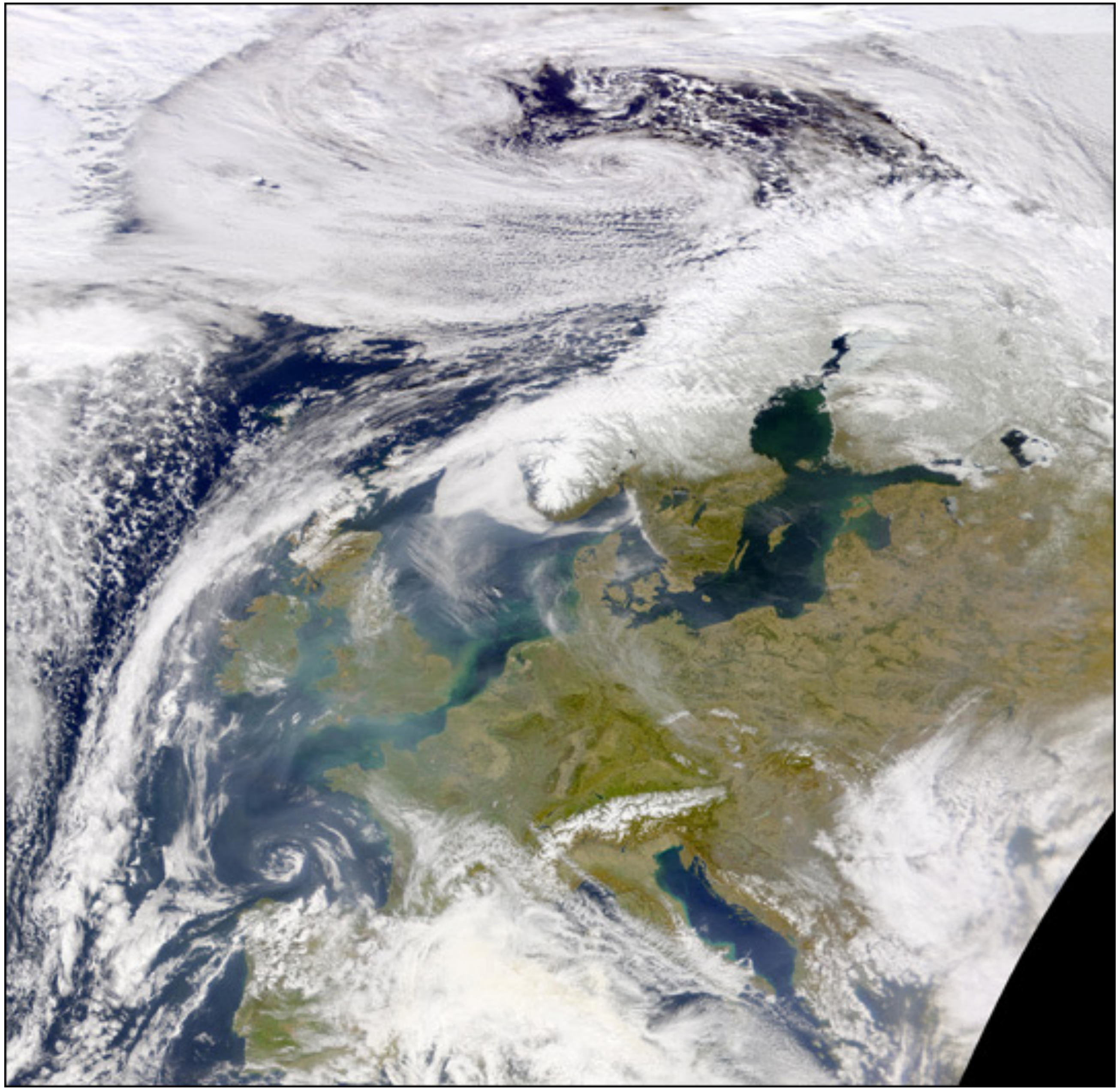
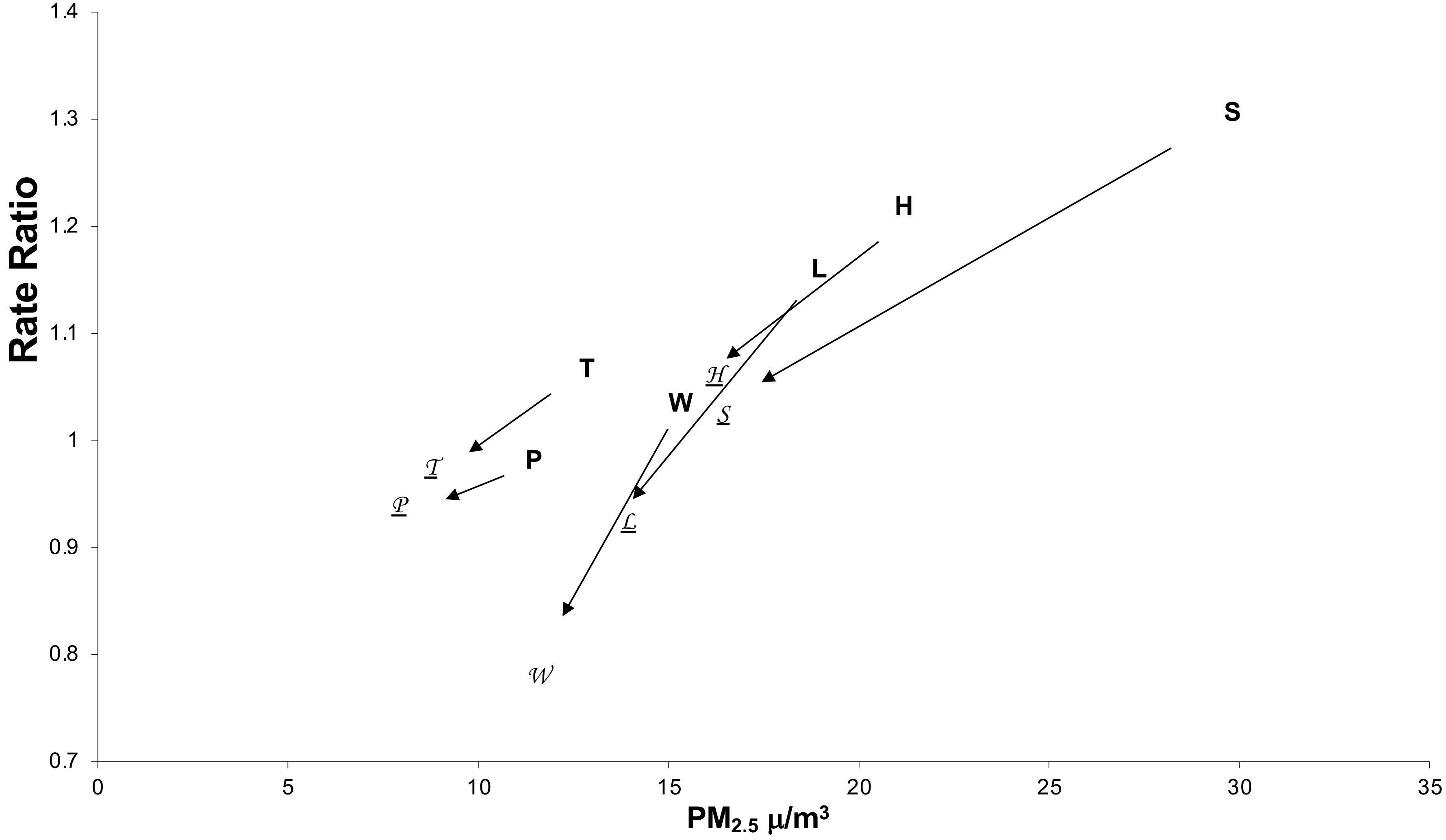
Why do we care about Particles

- They are Everywhere
- They Kill People



Relative Risk of Death in Six US Cities during Two Follow-up Periods



Laden 2006

Yu et al DID in Queensland

- They looked at 449 postcodes in Queensland, Australia
- There were 217,500 deaths during the period
- $PM_{2.5}$ concentrations ranged from 1.6 to 9.0 μg/m^3
- For each 1 μg/m^3 increase in PM2.5 they found a 2.02% increase in total mortality (95% CI 1.41-2.63)

People who Moved

- The sudden change in exposure allows us to assess the impact of change, rather than level of exposure
- This is the causal question: if I change exposure what happens?
- If we stratify on old Zip code we are controlling for previous exposure, and all personal and area level covariates, measured or unmeasured
- If, conditional on the decision to move, and on the original Zip code, the change in pollution is random with respect to predictors of mortality, then we have a causal estimate
- In addition, we fit a propensity score model based on individual covariates and area level covariates at the new zip code, plus year to control for time trends.

Population

- We looked at the Entire US Medicare Population from 2000-2012.
- Of them, 10,679,150 moved during the period, of whom 1,092,109 died.
- Mean PM2.5 was 10.6 $\mu g/m^3$
- Mean Change in Exposure was -0.69 $\mu g/m^3$ for whites (range -25.1,+26.8) and -0.89 $\mu g/m^3$ among blacks (-21.29 $\mu g/m^3$, 24.63 $\mu g/m^3$).

Results

Model	N	Hazard Ratio	95% CI
White movers	9,115,205	1.21	1.20 to 1.22
White movers with exposures ≤ 12 μg/m³	5,697,798	1.25	1.24 to 1.27
Black Movers	914,736	1.12	1.08 to 1.15
Black Movers with exposures ≤ 12 μg/m³	438,386	1.08	1.01 to 1.14

Incidence of Diabetes in SAPALDIA

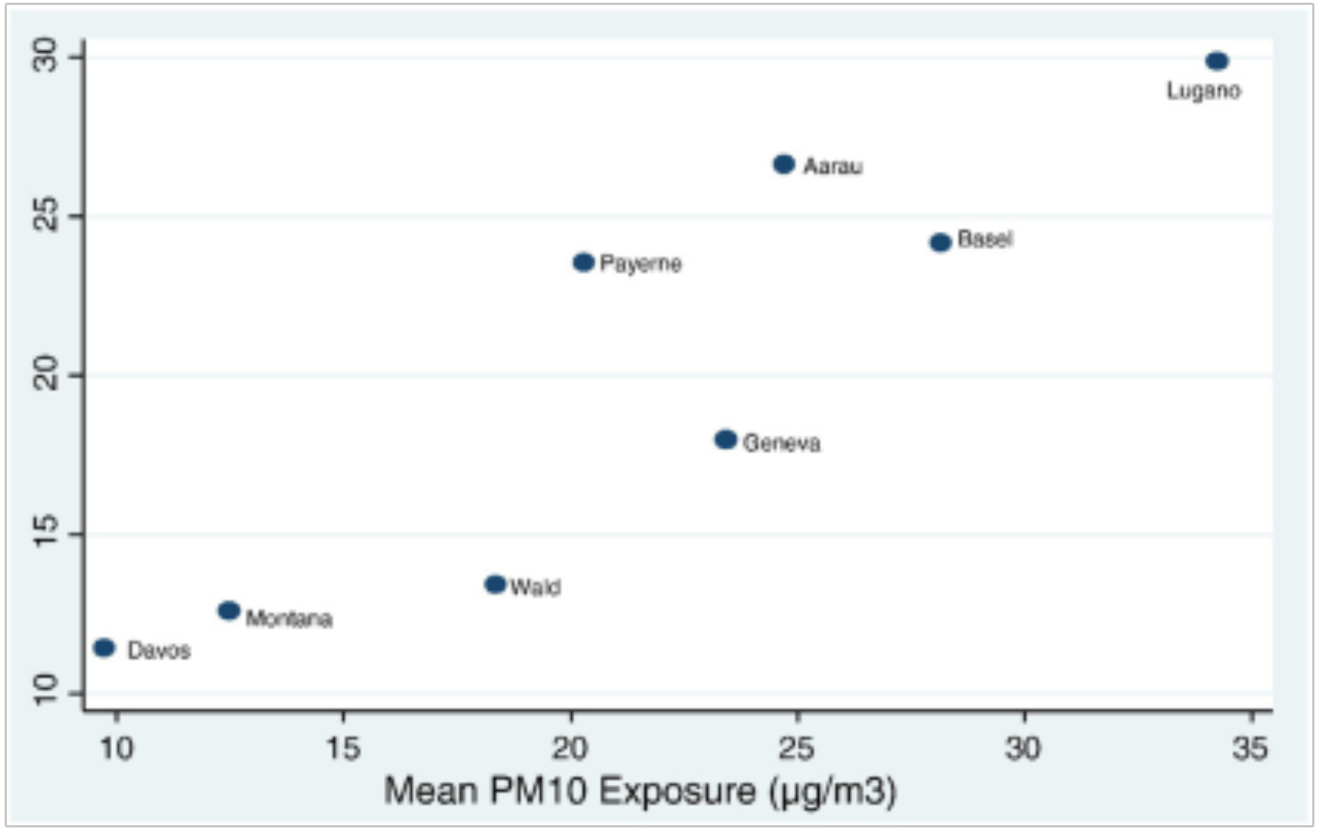


Fig. A2 Correlation between adjusted diabetes prevalence and mean PM_{10} by area.

6392 Adults followed for 10 years

Exposure Modeled at Individual Addresses

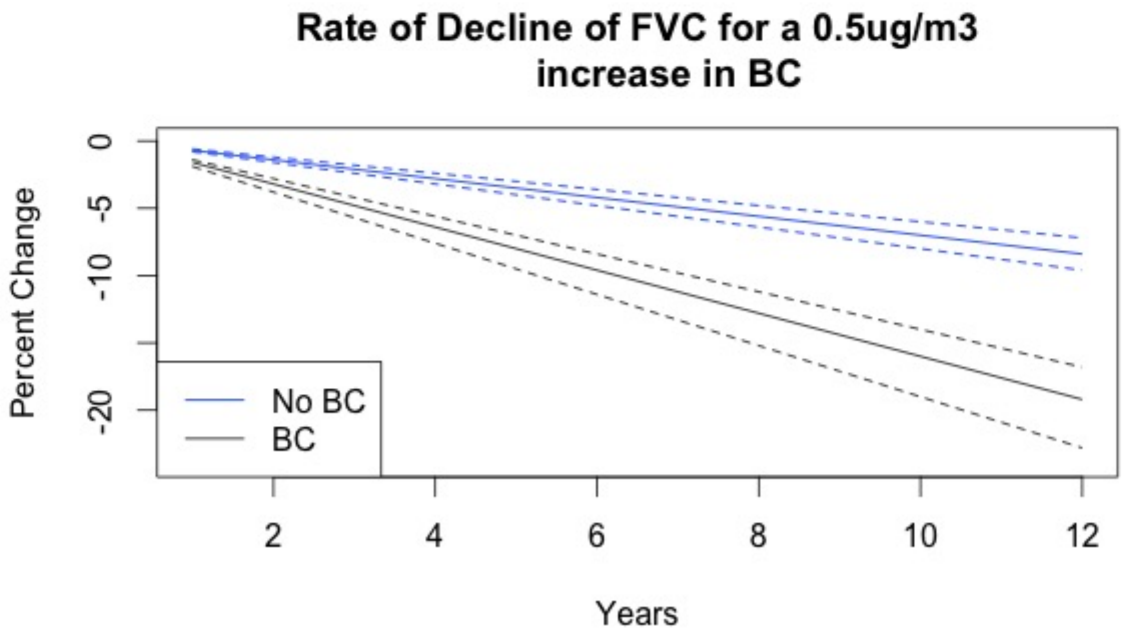
Mixed Effects Logistic model with random intercept for Area

HR=1.40 (95% CI 1.17, 1.67)

What about Traffic Particle Specifically?

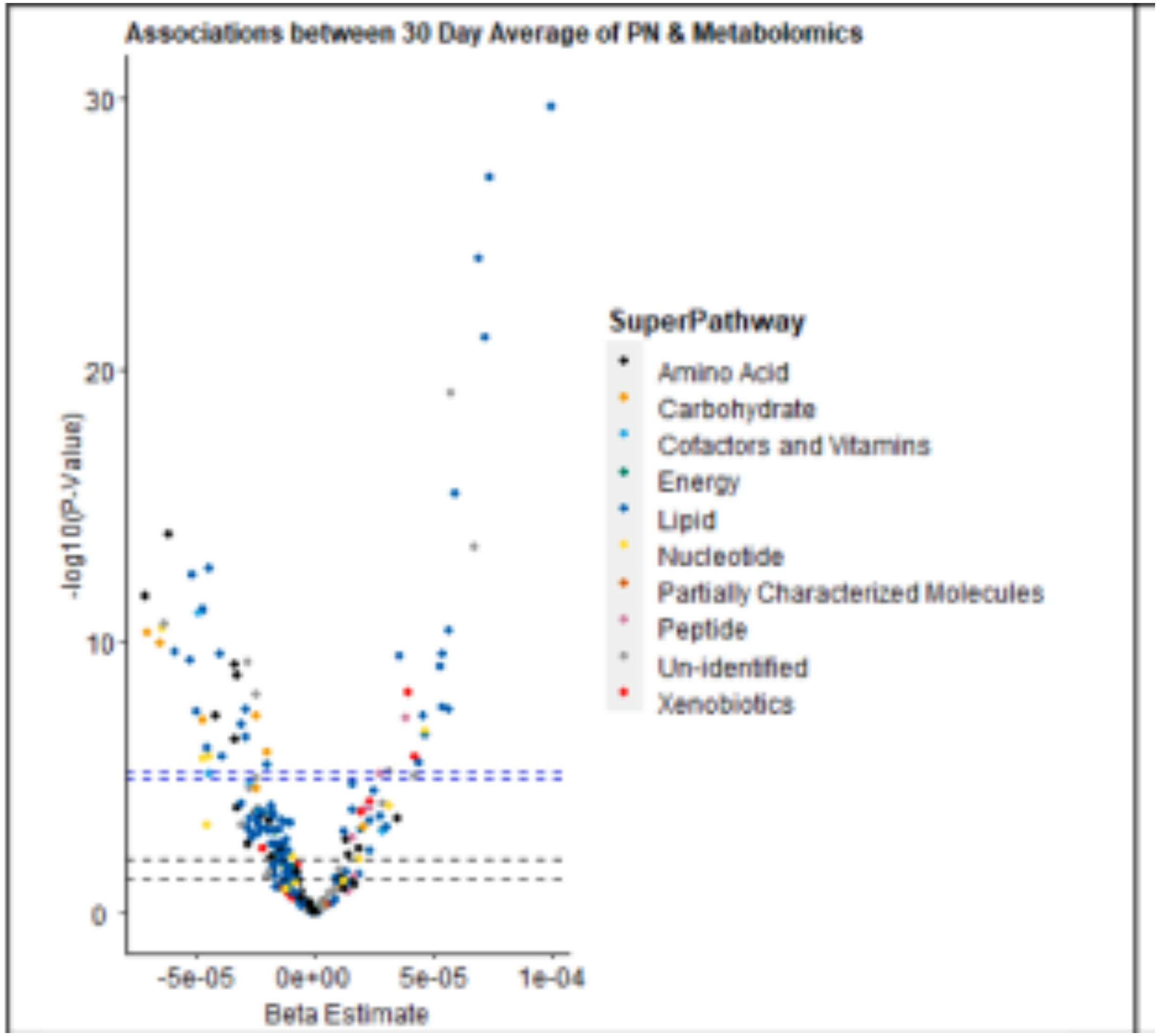
- Traffic particles have the highest intake fraction: a larger fraction of traffic particles in the air get into people's lungs because they are emitted near where people walk and live.
- Ultrafine particles can get into the blood stream and also move up the olfactory nerve from the nose to the brain
- Autopsy studies show them in the brain, and inflamed tissue surrounding them

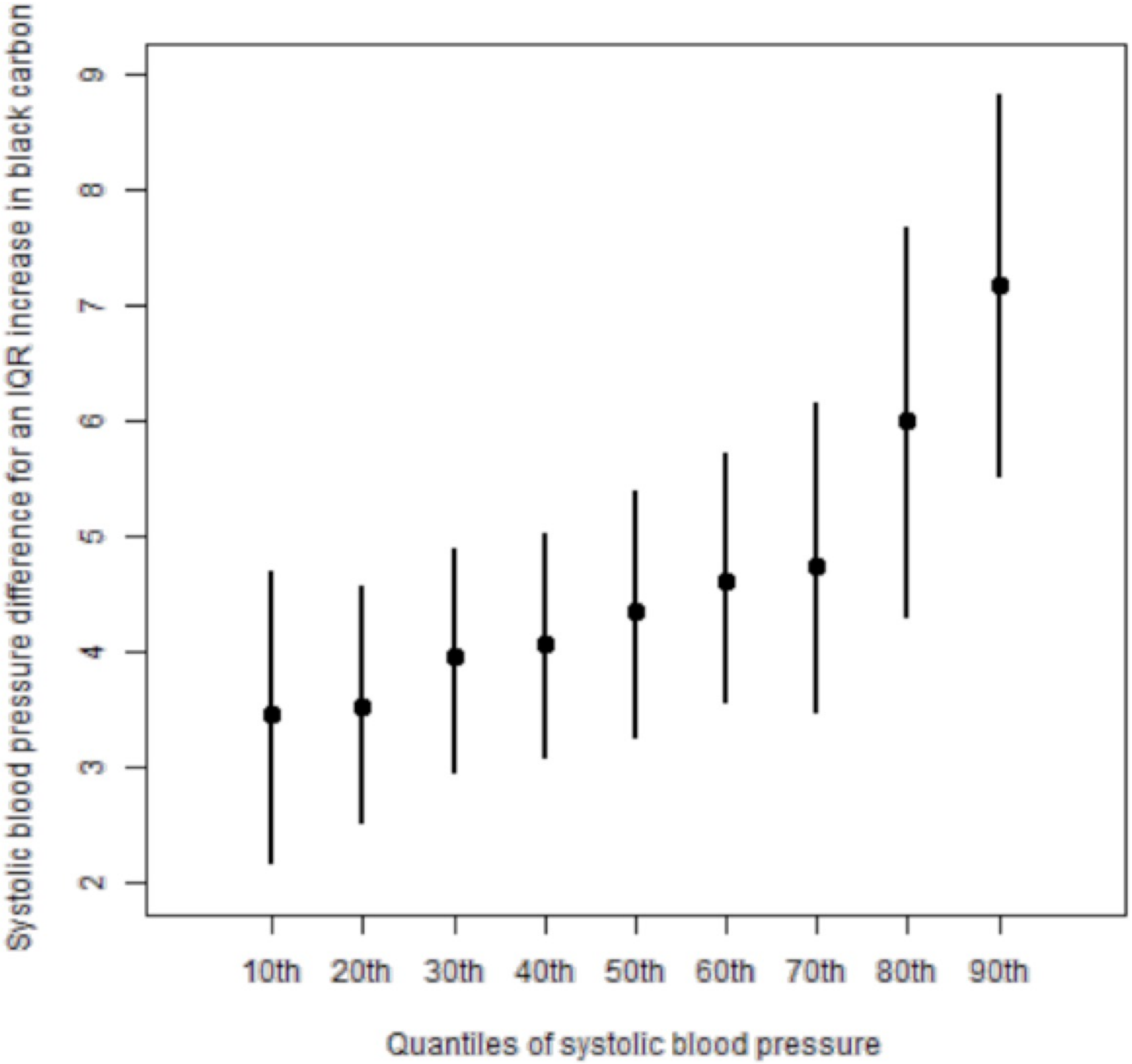
Lung function decline according to black carbon



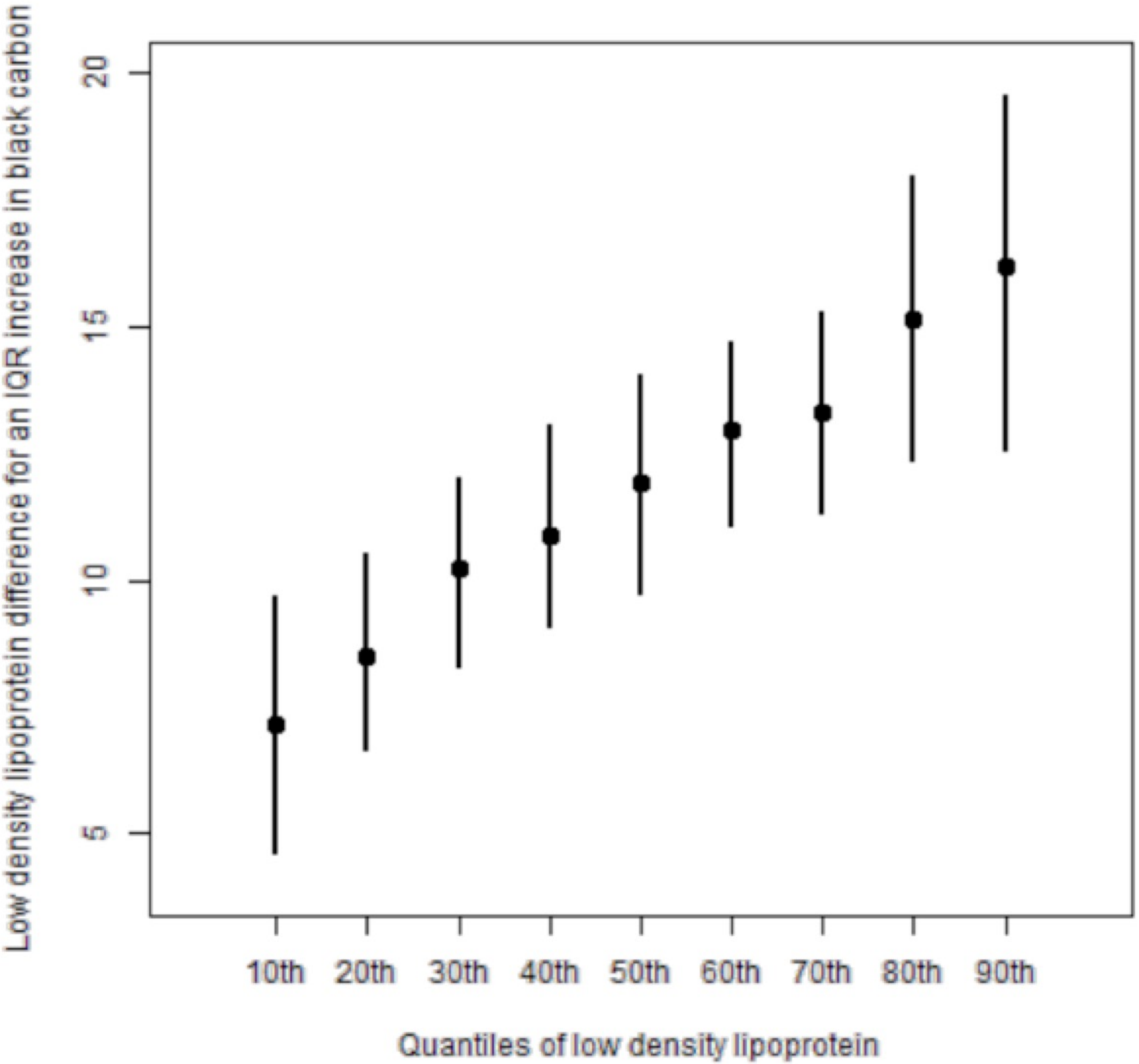
Note: Black Carbon is Diesel Particles

Agnostic Analysis of Particle Number Concentration and Metabolomics

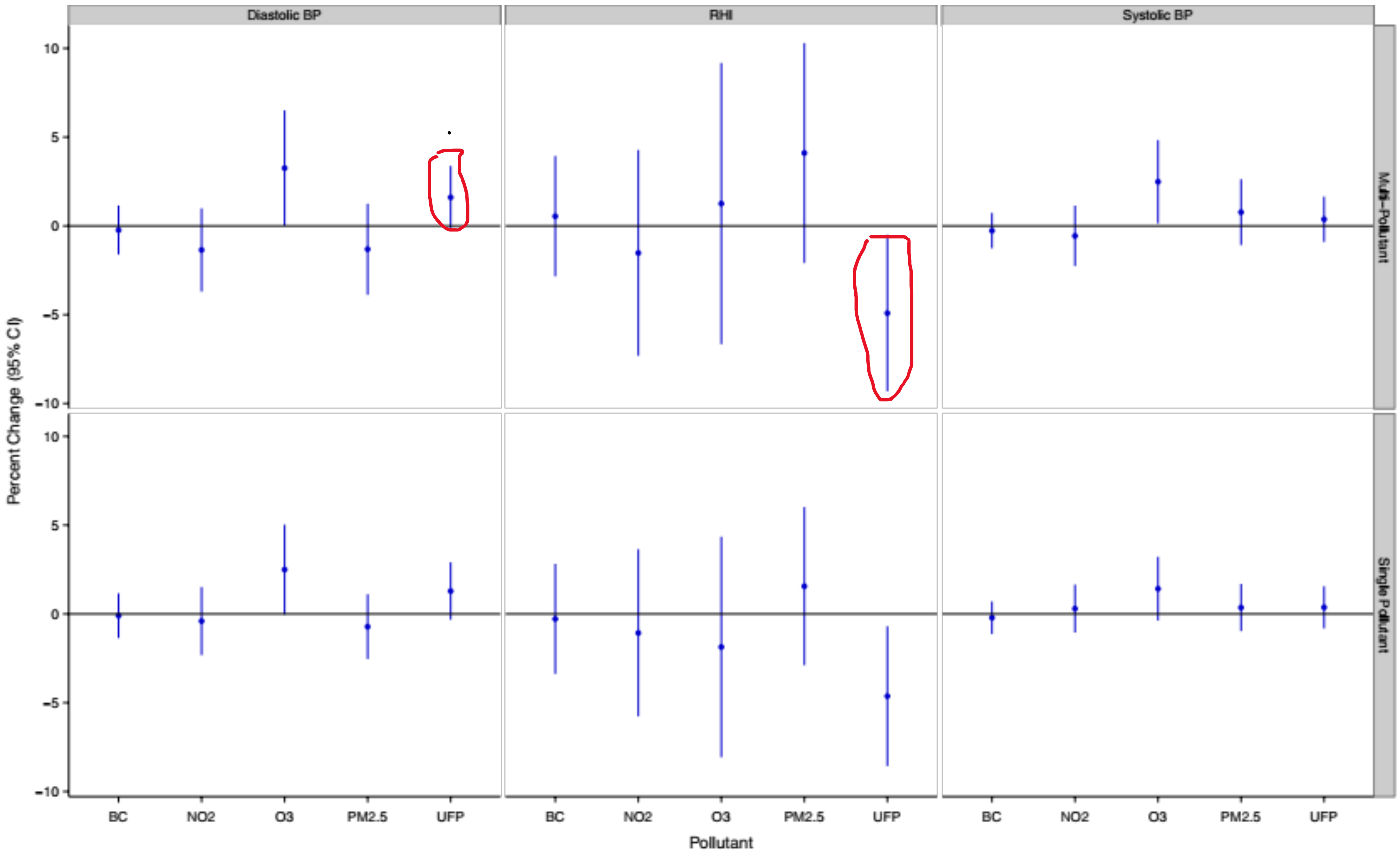




Systolic blood pressure difference for an IQR increase in black carbon
2
3
4
5
6
7
8
9
10th
20th
30th
40th
50th
60th
70th
80th
90th
Quantiles of systolic blood pressure

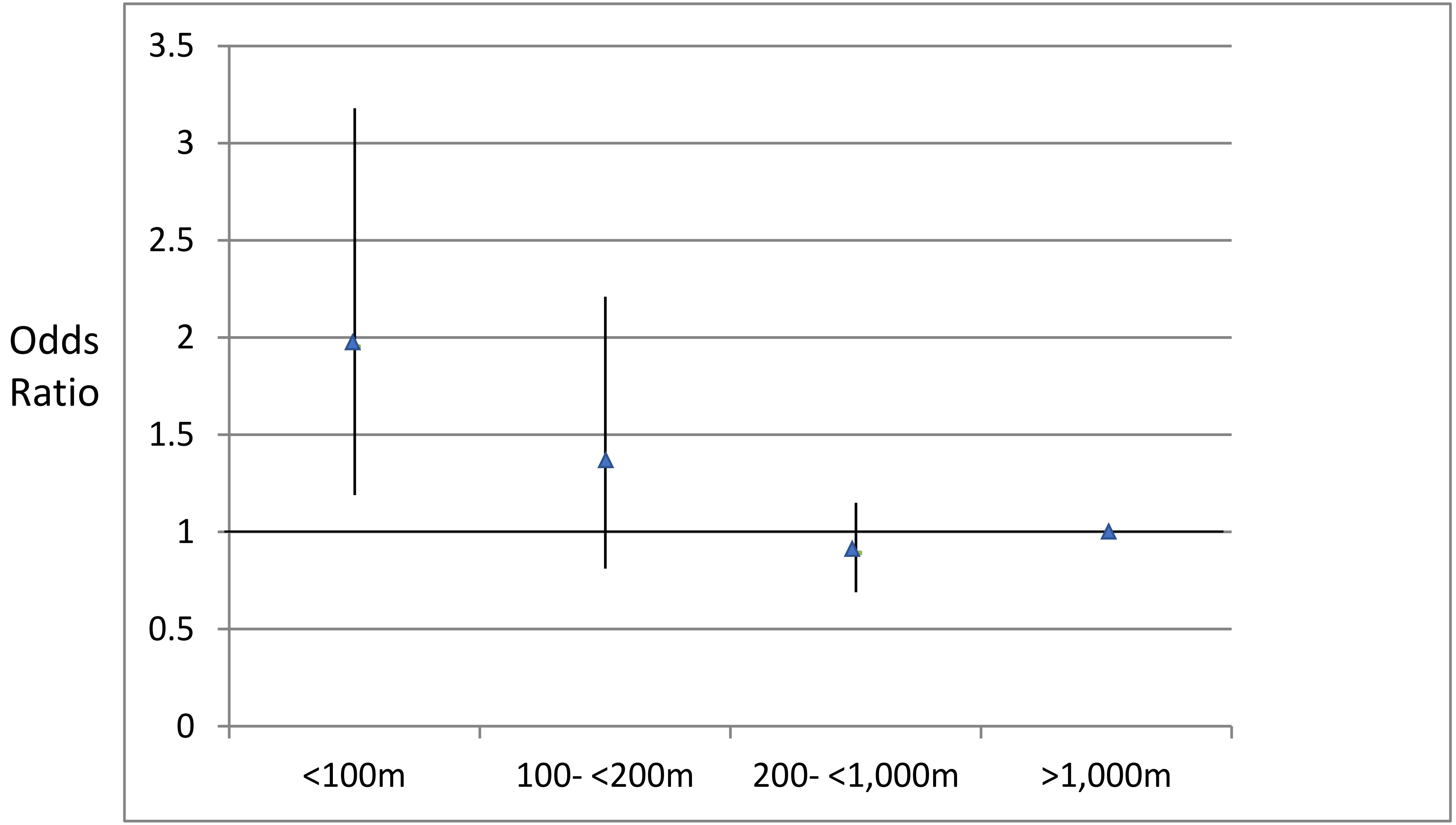


Low density lipoprotein difference for an IQR increase in black carbon
20
15
10
5
10th
20th
30th
40th
50th
60th
70th
80th
90th
Quantiles of low density lipoprotein



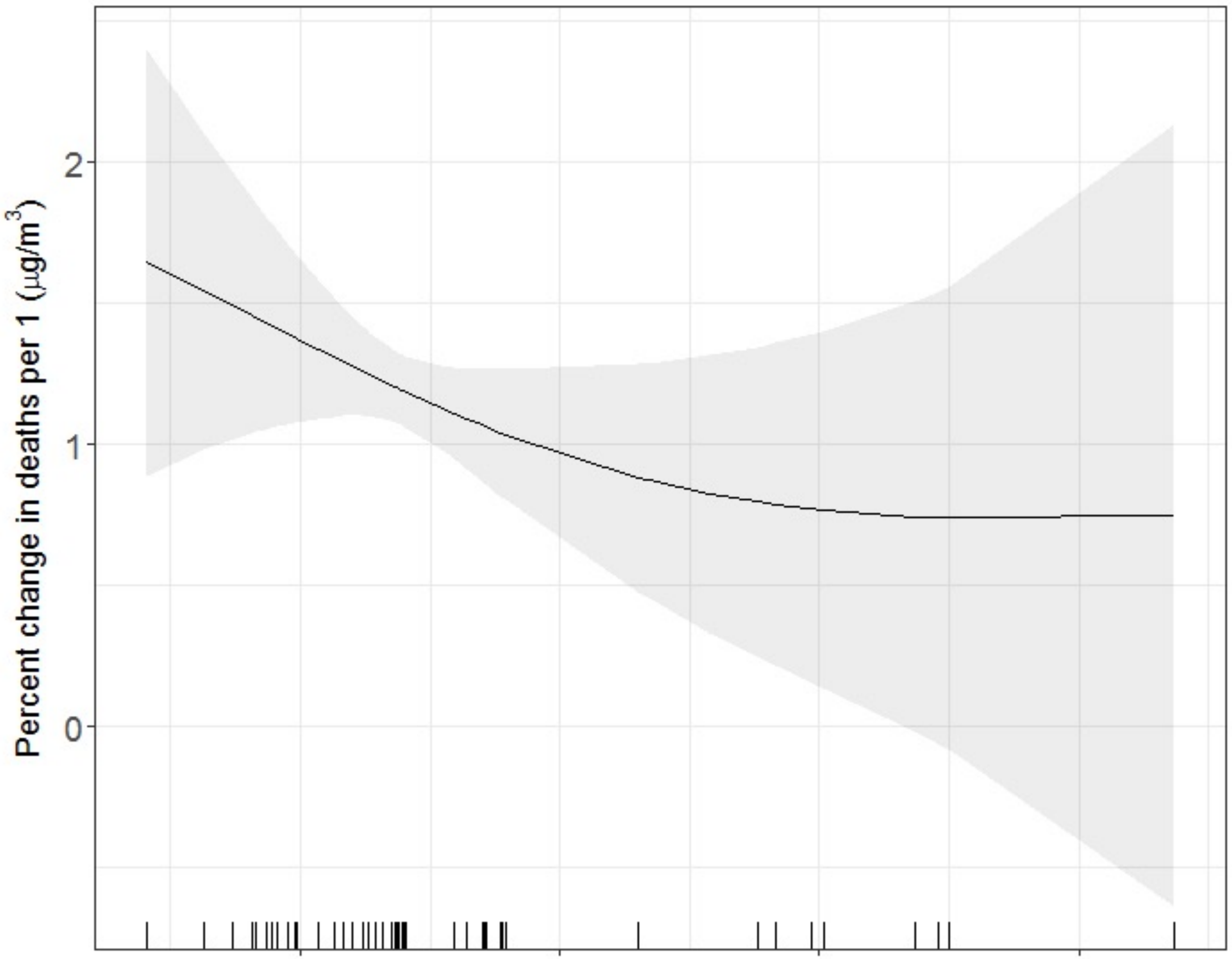
Weichenthal, 2014

Viva Birth Cohort: Distance to Roadway and Odds of Serious Respiratory Infection before age 2



How Bad is It?

Change in Slope as Mean Concentration Changes



Key Points:

Impact is 25% higher at 10 $\mu g/m^3$ than at 15 $\mu g/m^3$ → impact is larger in U.S.

Impact does not fall off As steeply at high exposure as GBD assumed→ impact is larger in Asia

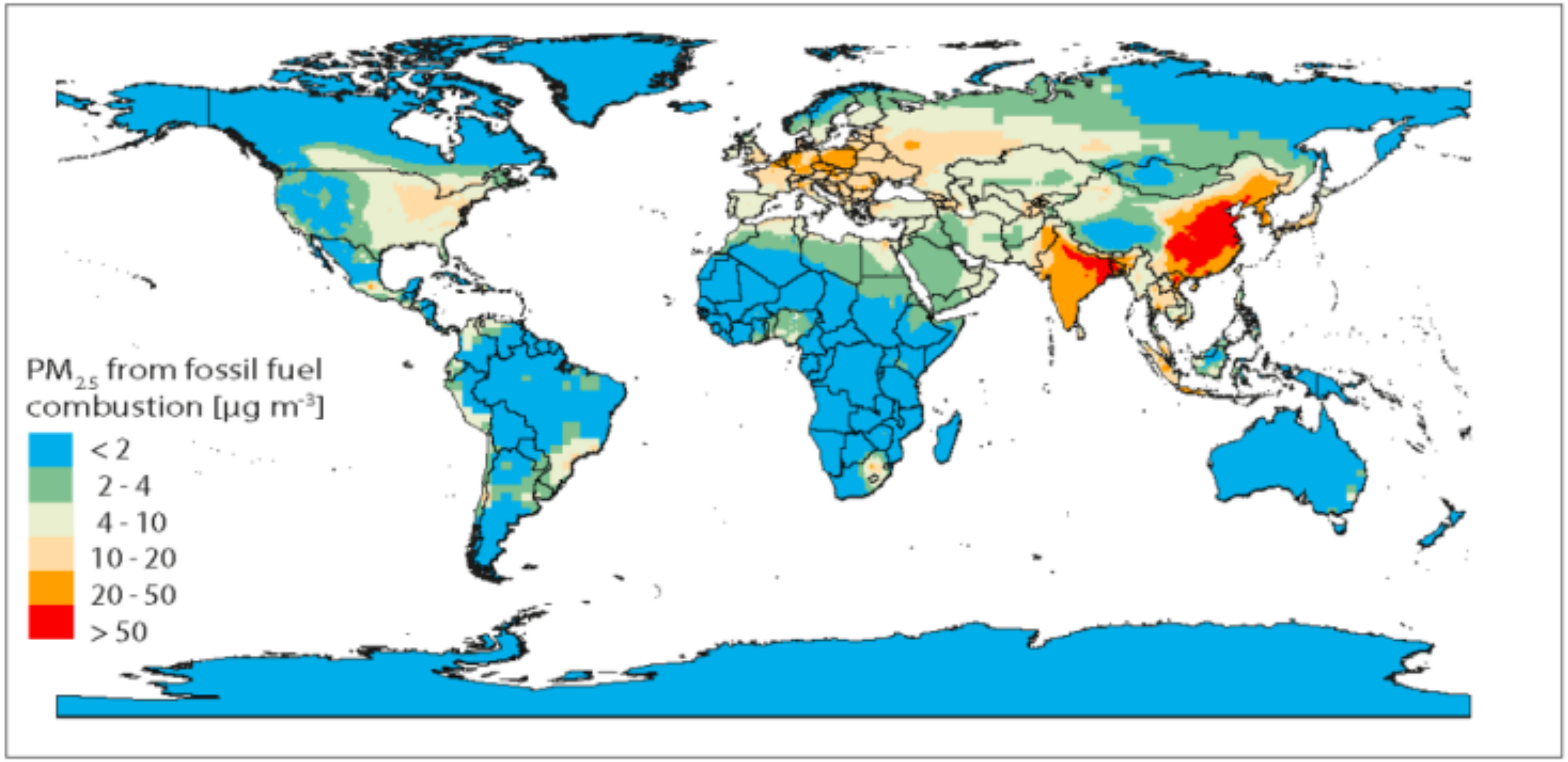


Figure 1: Contribution of fossil fuel combustion to surface $PM_{2.5}$, as calculated by the chemical transport model GEOS-Chem. The plot shows the difference in surface $PM_{2.5}$

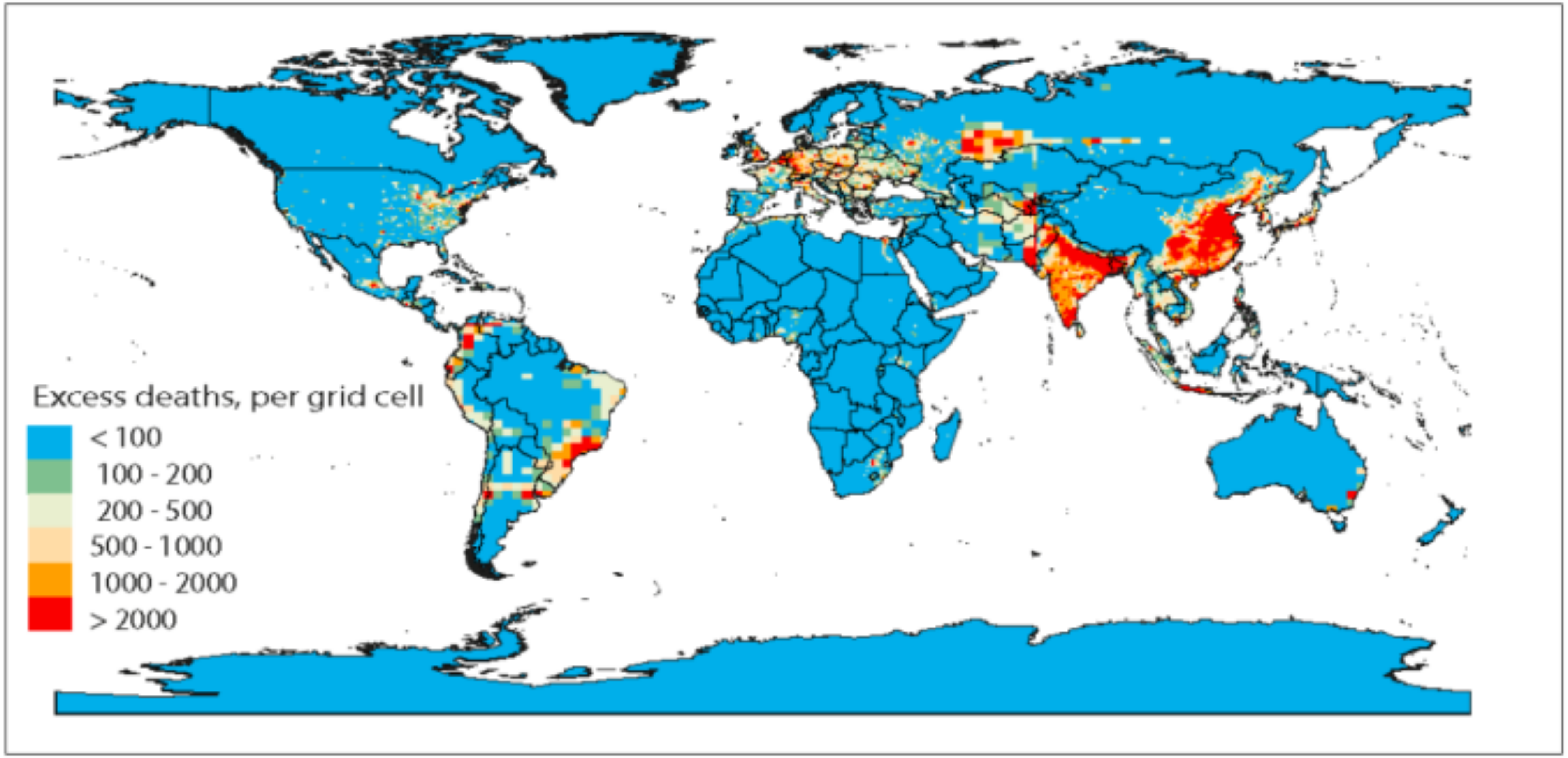


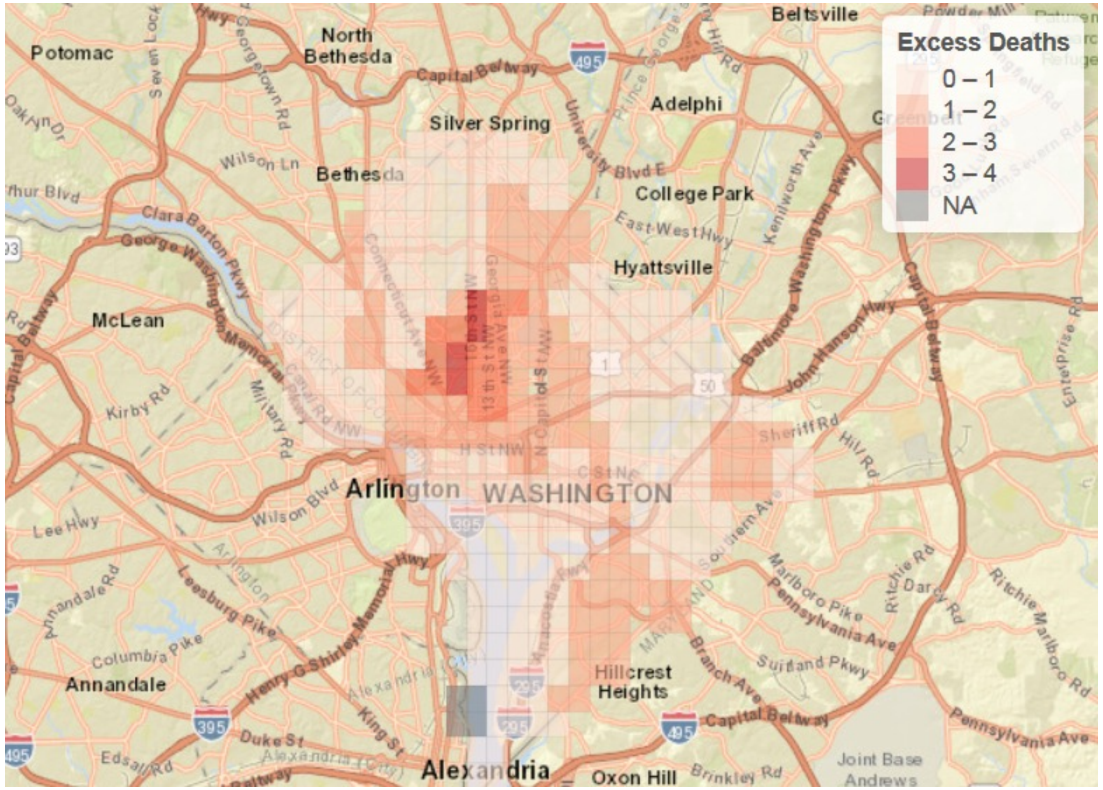
Figure 2. Estimated annual excess deaths due to exposure to ambient $PM_{2.5}$ generated by fossil fuel combustion.

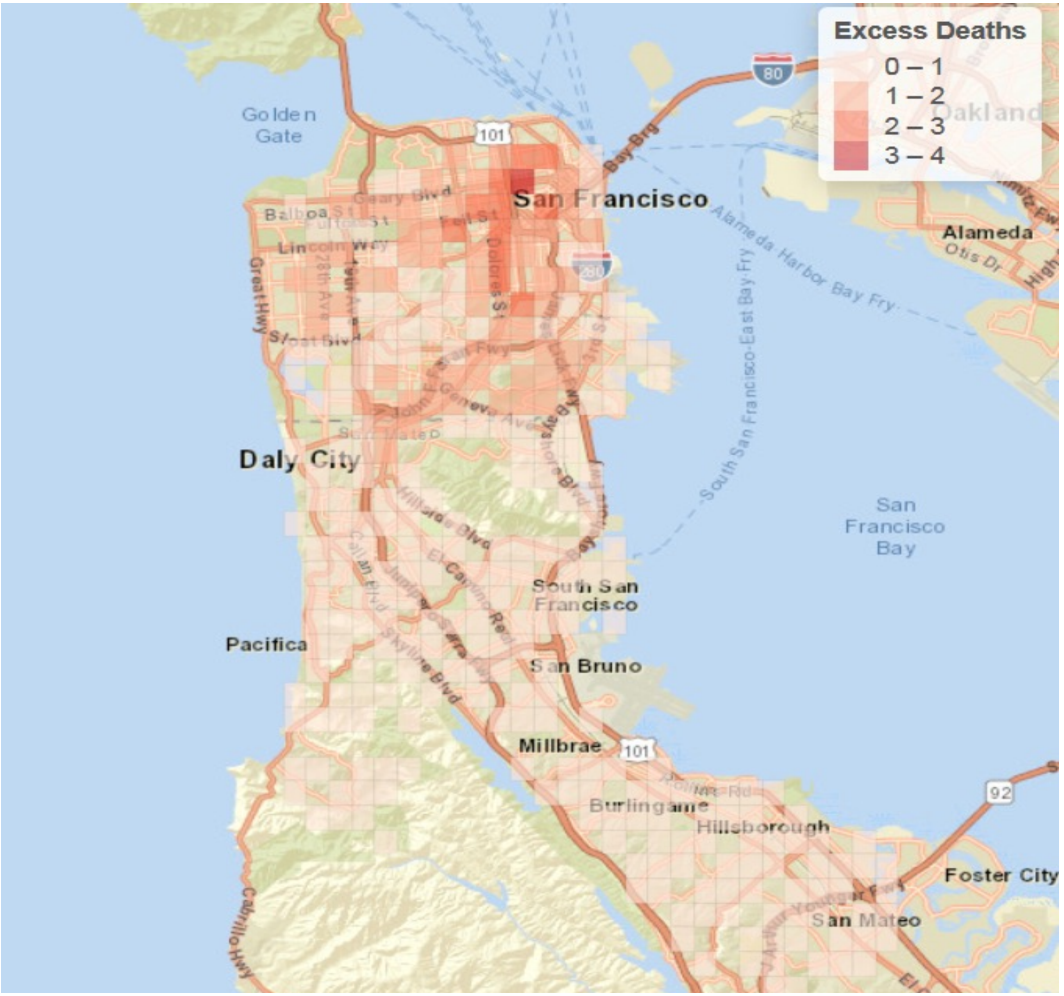
Effects of Fossil Fuel Use on Deaths

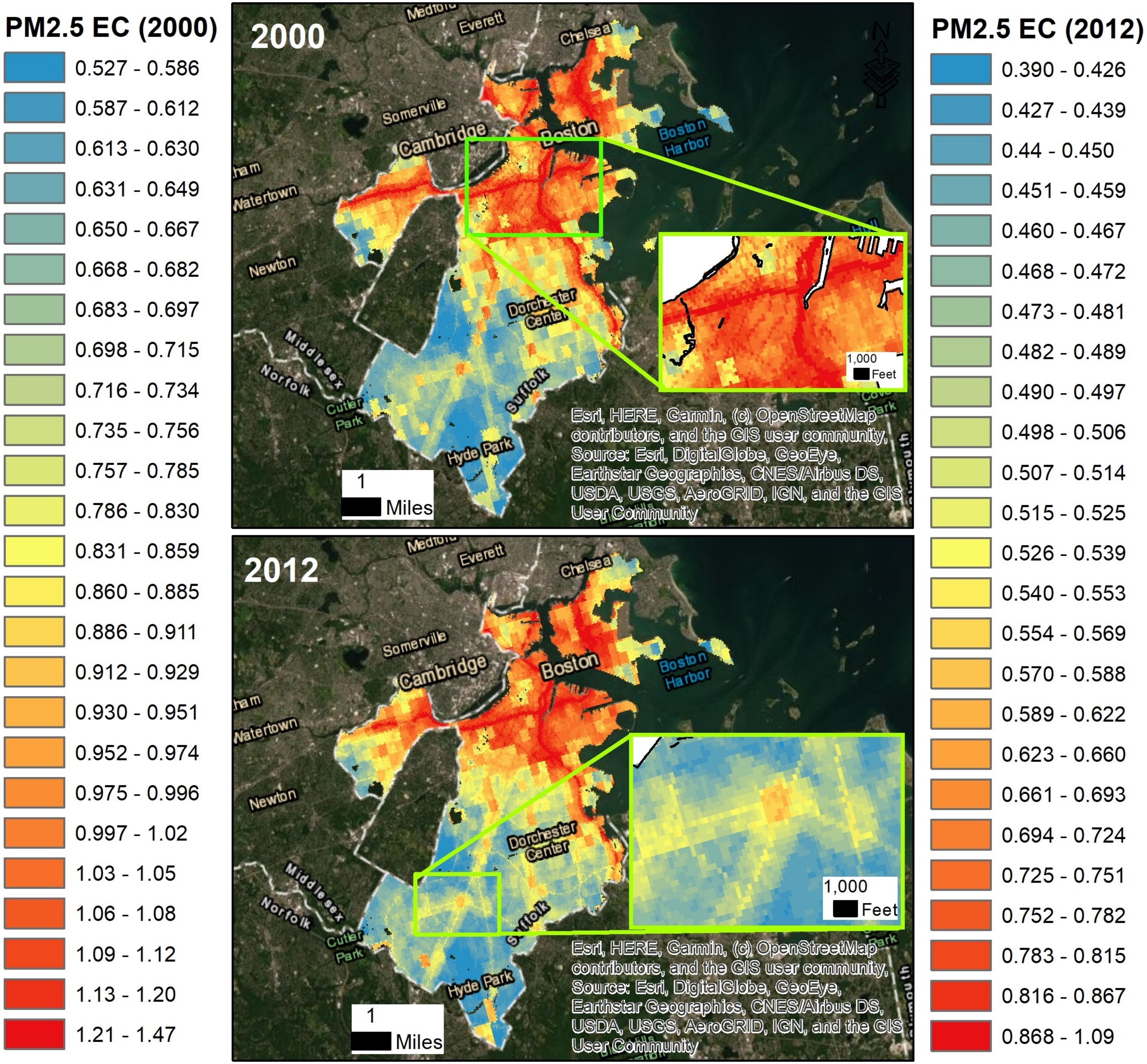
GEOS-Chem spatial grid resolution[a]	Region[b]		Total deaths >14 years old, in thousands	Population-weighted annual mean $PM_{2.5}$ concentration, μg m^{-3}: $PM_{2.5}$ from all emission sources	$PM_{2.5}$ without fossil fuel	Estimated $PM_{2.5}$ from fossil fuel, %	Mean attributable fraction of deaths, % (95% CI)[d]	Deaths attributable to fossil-fuel related $PM_{2.5}$, in thousands (95% CI)[c]	GEMM function deaths attributable to fossil-fuel related $PM_{2.5}$, in thousands (95% CI)[e]
Fine	North America	Central America & the Caribbean	1,148	10.06	3.03	7.03 (69.9)	8.2 (4.5-11.6)	94 (52-133)	80 (62-98)
		USA	2,705	11.81	2.15	9.66 (81.8)	13.1 (7.8-18.1)	355 (212-490)	305 (233-375)
		Canada	250	12.01	1.76	10.25 (85.4)	13.6 (8.0-18.7)	34 (20-47)	28 (22-35)
Coarse	South America		2,389	8.66	3.02	5.65 (65.2)	7.8 (4.5-11.0)	187 (107-263)	159 (121-195)
Fine	Europe		8,626	19.22	4.68	14.54 (75.7)	16.8 (10.4-22.6)	1,447 (896-1,952)	1,033 (798-1,254)
Fine	Asia	Eastern Asia	25,468	51.72	8.68	43.05 (83.2)	30.7 (-189.1-52.9)	7,821 (-48,150-13,478)	4,945 (3,943-5,826)
Coarse		Western Asia & the Middle East	1,456	26.95	20.73	6.22 (23.1)	6.5 (3.0-9.9)	95 (44-144)	54 (43-65)
Fine	Africa		5,274	32.98	28.98	4.00 (12.1)	3.7 (-4.5-8.7)	194 (-237-457)	102 (81-121)
Coarse	Australia & Oceania		189	4.17	2.19	1.98 (47.4)	3.2 (1.6-4.8)	6.0 (2.9-9.0)	6.4 (4.8-7.9)
	Global		47,506	38.01	11.14	26.87 (70.7)	21.5 (-99.0-35.7)	10,235 (-47,054-16,972)	6,713 (5,308-7,976)

We can also do Risk Assessments on a Fine Scale

Number of excess deaths associated with reduction of 40% in $PM_{2.5}$ in selected cities







PM2.5 EC (2000)
0.527 - 0.586
0.587 - 0.612
0.613 - 0.630
0.631 - 0.649
0.650 - 0.667
0.668 - 0.682
0.683 - 0.697
0.698 - 0.715
0.716 - 0.734
0.735 - 0.756
0.757 - 0.785
0.786 - 0.830
0.831 - 0.859
0.860 - 0.885
0.886 - 0.911
0.912 - 0.929
0.930 - 0.951
0.952 - 0.974
0.975 - 0.996
0.997 - 1.02
1.03 - 1.05
1.06 - 1.08
1.09 - 1.12
1.13 - 1.20
1.21 - 1.47
2000
Everett
Chelsea
Somerville
Cambridge
Boston
Boston Harbor
Watertown
Newton
Dorchester Center
Middlesex
Norfolk
Cutler Park
Suffolk
Hyde Park
1,000
Feet
1
Miles
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community, Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
2012
Everett
Chelsea
Somerville
Cambridge
Boston
Boston Harbor
Watertown
Newton
Dorchester Center
Middlesex
Norfolk
Cutler Park
Suffolk
Hyde Park
1,000
Feet
1
Miles
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PM2.5 EC (2012)
0.390 - 0.426
0.427 - 0.439
0.44 - 0.450
0.451 - 0.459
0.460 - 0.467
0.468 - 0.472
0.473 - 0.481
0.482 - 0.489
0.490 - 0.497
0.498 - 0.506
0.507 - 0.514
0.515 - 0.525
0.526 - 0.539
0.540 - 0.553
0.554 - 0.569
0.570 - 0.588
0.589 - 0.622
0.623 - 0.660
0.661 - 0.693
0.694 - 0.724
0.725 - 0.751
0.752 - 0.782
0.783 - 0.815
0.816 - 0.867
0.868 - 1.09