WEB MATERIAL

Where Is Air Quality Improving, and Who Benefits? A Study of $PM_{2.5}$ and Ozone Over 15 Years

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Web Appendix 1

Racial isolation calculation. We calculate a previously developed local, spatial measure of RI of self-identifying non-Hispanic Black (NHB) individuals (compared with all other racial/ethnic groups, including Hispanics) in each tract for the continental US.[1,2] The index ranges from 0 to 1. NHB living in a neighborhood environment that is nearly all non-NHB will have a racial isolation value that is close to 0. In contrast, NHB living in a neighborhood environment that is nearly all NHB will have a racial isolation value that is close to 1.

$$RI_{im} = \left(\sum_{j \in \partial_i} w_{ij} T_{jm} \right) / \left(\sum_{j \in \partial_i} w_{ij} T_j \right)$$

In this equation, ∂_i denotes the set of index unit (i) and its neighbors (i.e., tracts which are adjacent to the index tract). Given M mutually exclusive racial subgroups, m indexes the subgroups of M (e.g., NHB). T_i denotes the total population in region i and T_{im} denotes the population of subgroup m in region i. (w_{ij}) denotes a $n \times n$ first order adjacency matrix, where *n* is the number of census tracts in the study area. First order adjacency means that the entries in the matrix, w_{ij}, are set to 1 if a boundary is shared by region i and region j, and 0 otherwise. Entries of the main diagonal (since $i \in \partial_i$, $w_{ij} = w_{ii}$ when $j = i$) of (w_{ij}) are set to 1.5, such that the weight of the index unit, i, is larger than the weights assigned to adjacent tracts. Since we are more interested in the spatial patterns rather than the aspatial patterns, w_{ii} should not be set to too high. For neighbors of any index unit i with 0 population, the corresponding T_{jm} and T_j are 0, so that the value of RI_{im}, the RI index of unit i for subgroup m, would not be affected. We note that, in calculating spatial indices, edge tracts (e.g., tracts along a coastline) may have few neighboring tracts; index values in these tracts may be unstable.

Web Appendix 2

Educational isolation calculation. We develop an analogous local, spatial measure of EI, assessing likelihood of living in the same neighborhood of individuals without a college degree to those with a college degree.[3] We calculate tract-level EI scores by accounting for the population composition in the index tract along with adjacent tracts.

$$EI_{im} = \left(\sum_{j \in \partial_i} w_{ij} T_{jm} \right) / \left(\sum_{j \in \partial_i} w_{ij} T_j \right)$$

In this equation, the value of EI_{im}, educational isolation index of unit i for subgroup m, is calculated in the same way as RI_{im}, except m indexes mutually exclusive subgroups of educational attainment categories (e.g., individuals with a four-year college degree, individuals without a four-year college degree). Note that the right-hand sides of equations for RI and EI are identical. These equations only differ in terms of how subgroup *m* is defined.

The resulting RI and EI indices range from 0 to 1, with values close to 0 indicating the neighborhood environment is almost entirely non-NHB or college educated, respectively. Values close to 1 indicate that the neighborhood is almost entirely NHB or non-college educated. We note that alternative categories for comparison could be chosen; for example, EI could be calculated comparing those without a high school degree to those with a high school degree.

Web Table 1. Mean, standard deviation, minimum, and maximum of social/demographic variables

Variable	Mean (SD)	Minimum, Maximum
Racial isolation (RI)	0.21 (0.17)	0.003, 0.89
Educational isolation (EI)	0.73 (0.15)	0.22, 0.96
Percent urban	67.1 (30.1)	0, 100
Neighborhood deprivation index (NDI)	0 (2.1)	-5.11, 10.35

Web Table 2. Correlations among social/demographic variables

Variable	RI	EI	% urban	NDI
Racial isolation (RI)	1	0.23	0.22	0.50
Educational isolation (EI)	--	1	-0.46	0.58
Percent urban	--		1	-0.050
Neighborhood deprivation index (NDI)	--	--	--	1

Web Table 3. Watanabe-Akaike Information Criterion (WAIC) values for null and adjusted models with and without random slopes[4]

	$PM_{2.5}$	
	Without random slopes	With random slopes
Null model	90,946	90,384
Adjusted model	90,874	90,352
	O_3	
	Without random slopes	With random slopes
Null model	174,447	174,447
Adjusted model	174,301	174,301

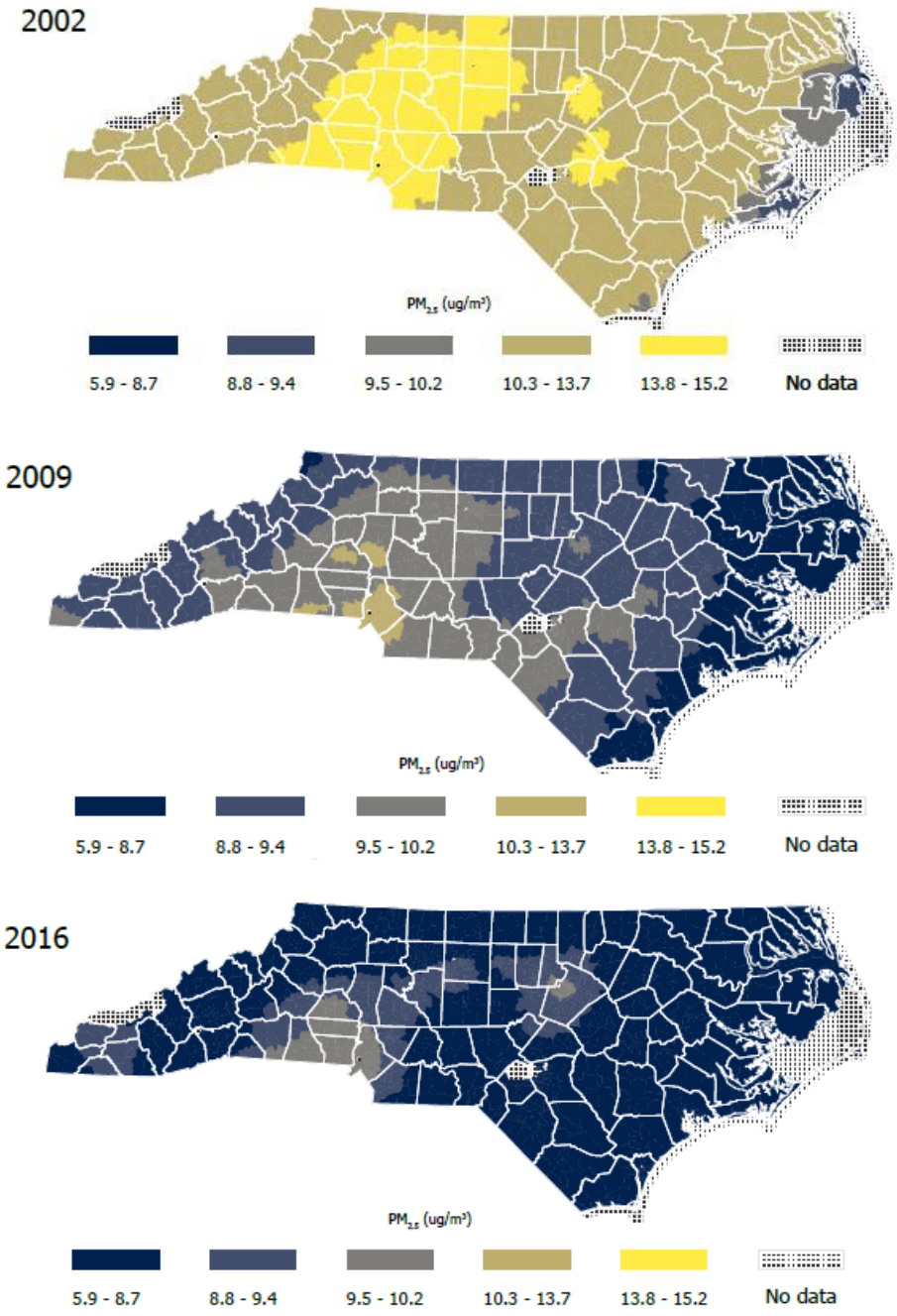
The adjusted models for both $PM_{2.5}$ and O_3 included all community-level characteristics (i.e., RI, EI, percent urban, and NDI); separate models were not fit for each community-level characteristic.

Web Table 4. Values of random effect variances and spatial dependence parameters in null and adjusted models

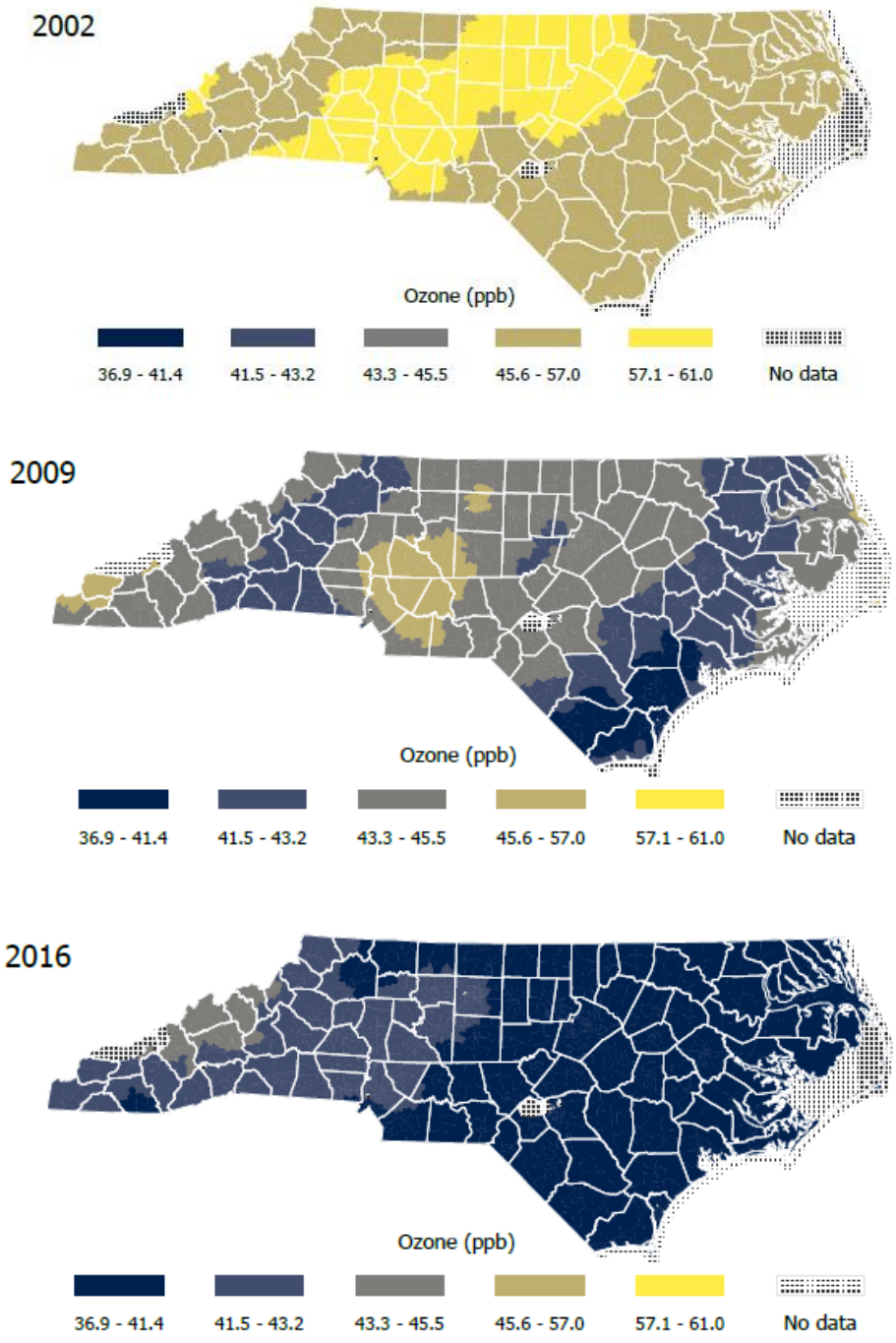
	$PM_{2.5}$			
	Random effect variance		Spatial dependence	
	Intercept (τ_ϕ^2)	Slope (τ_δ^2)	Intercept (ρ_ϕ)	Slope (ρ_δ)
Null model	1.93	0.72	0.30	0.93
Adjusted model	1.58	0.69	0.24	0.93
	O_3			
	Random effect variance		Spatial dependence	
	Intercept (τ_ϕ^2)	Slope (τ_δ^2)	Intercept (ρ_ϕ)	Slope (ρ_δ)
Null model	5.99	–	0.48	–
Adjusted model	5.37	–	0.45	–

The adjusted models for both $PM_{2.5}$ and O_3 included all community-level characteristics (i.e., RI, EI, percent urban, and NDI); separate models were not fit for each community-level characteristic.

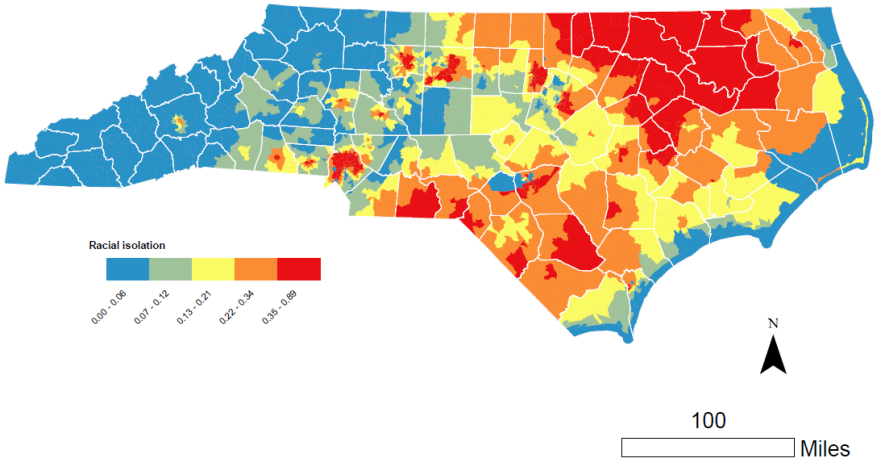
Web Figure 1. Maps of tract-level downscaler-estimated $PM_{2.5}$ concentrations in 2002, 2009, and 2016



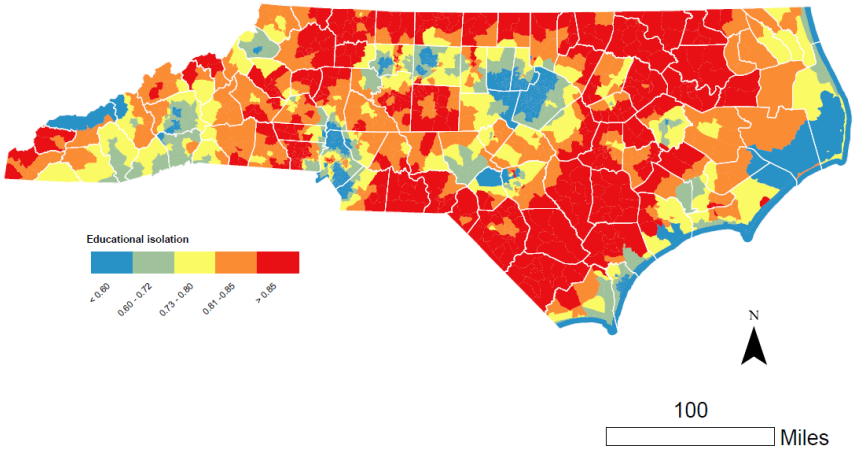
Web Figure 2. Maps of tract-level downscaler-estimated O_3 concentrations in 2002, 2009, and 2016



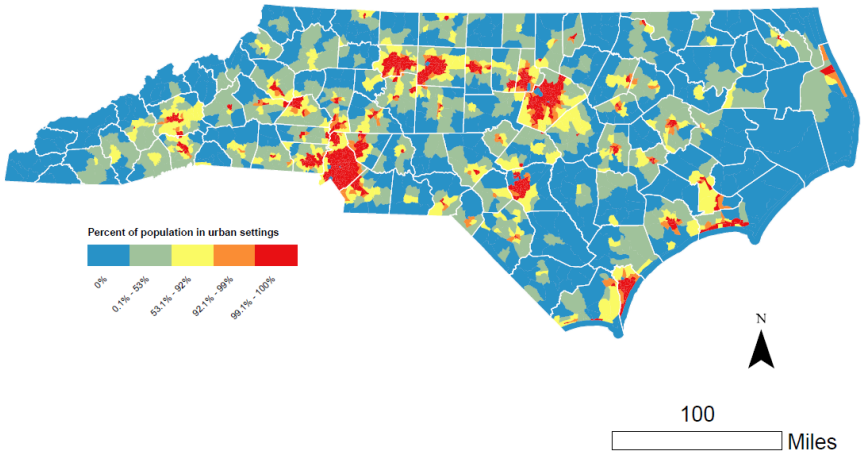
Web Figure 3. Map of racial isolation (RI) of non-Hispanic Blacks (NHB)



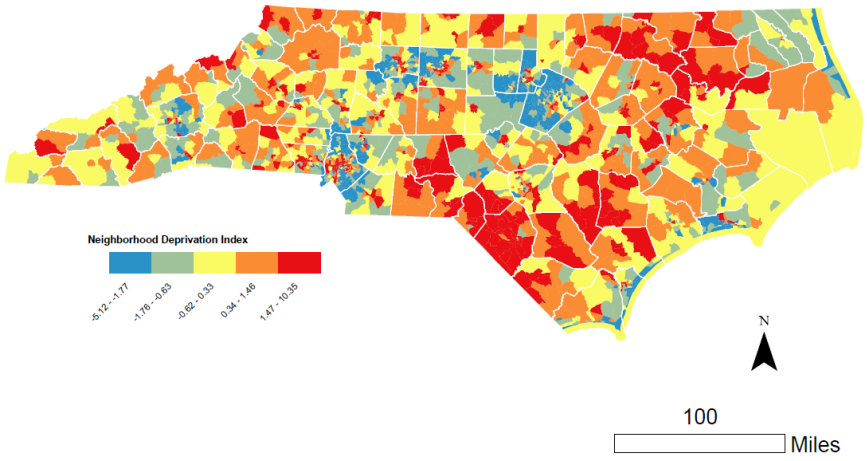
Web Figure 4. Map of educational isolation (EI) of non-college educated individuals



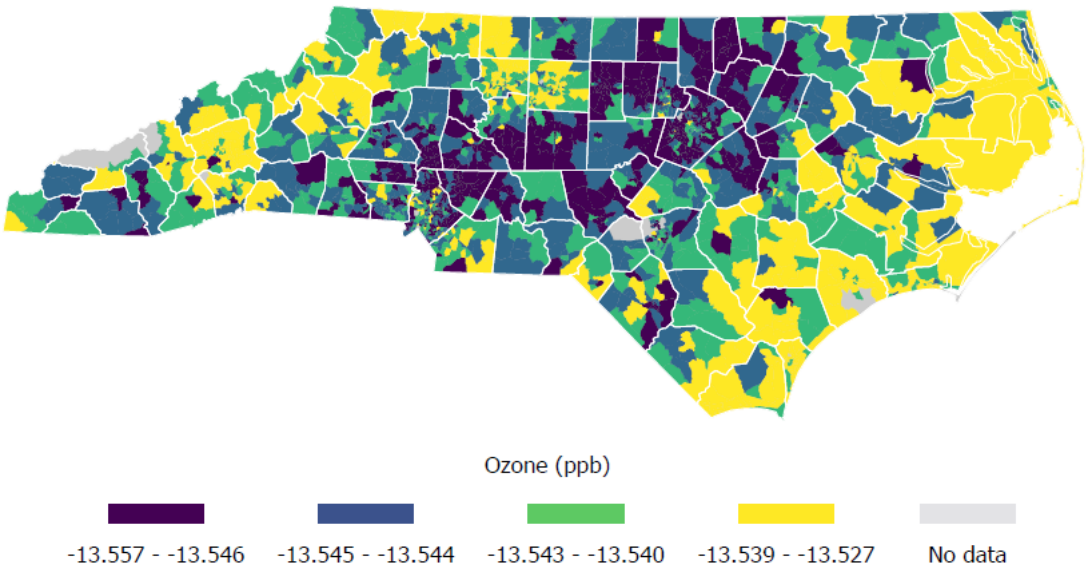
Web Figure 5. Map of percentage of population in urban settings



Web Figure 6. Map of the neighborhood deprivation index (NDI)



Web Figure 7. Adjusted model, O_3: Tract-specific variations in change in O_3 concentration over the study period (2002 to 2016). Note that the range in O_3 concentrations is small.



Web References

1. Anthopolos R, James SA, Gelfand AE, Miranda ML. A spatial measure of neighborhood level racial isolation applied to low birthweight, preterm birth, and birthweight in North Carolina. *Spat Spatiotemporal Epidemiol.* 2011;2(4):235-246.
2. Reardon SF, O'Sullivan D. Measures of spatial segregation. *Sociological methodology.* 2004;34(1):121-162.
3. Bravo MA, Leong MC, Gelfand AE, Miranda ML. Assessing Disparity Using Measures of Racial and Educational Isolation. *International Journal of Environmental and Public Health Research.* 2021;In press.
4. Watanabe S. Asymptotic equivalence of Bayes cross validation and widely applicable information criterion in singular learning theory. *Journal of Machine Learning Research.* 2010;11:3571-3594.