

Assessment of Sociodemographic Disparities in Environmental Exposure Might be Erroneous due to Neighborhood Effect Averaging: Implications for Environmental Inequality Research

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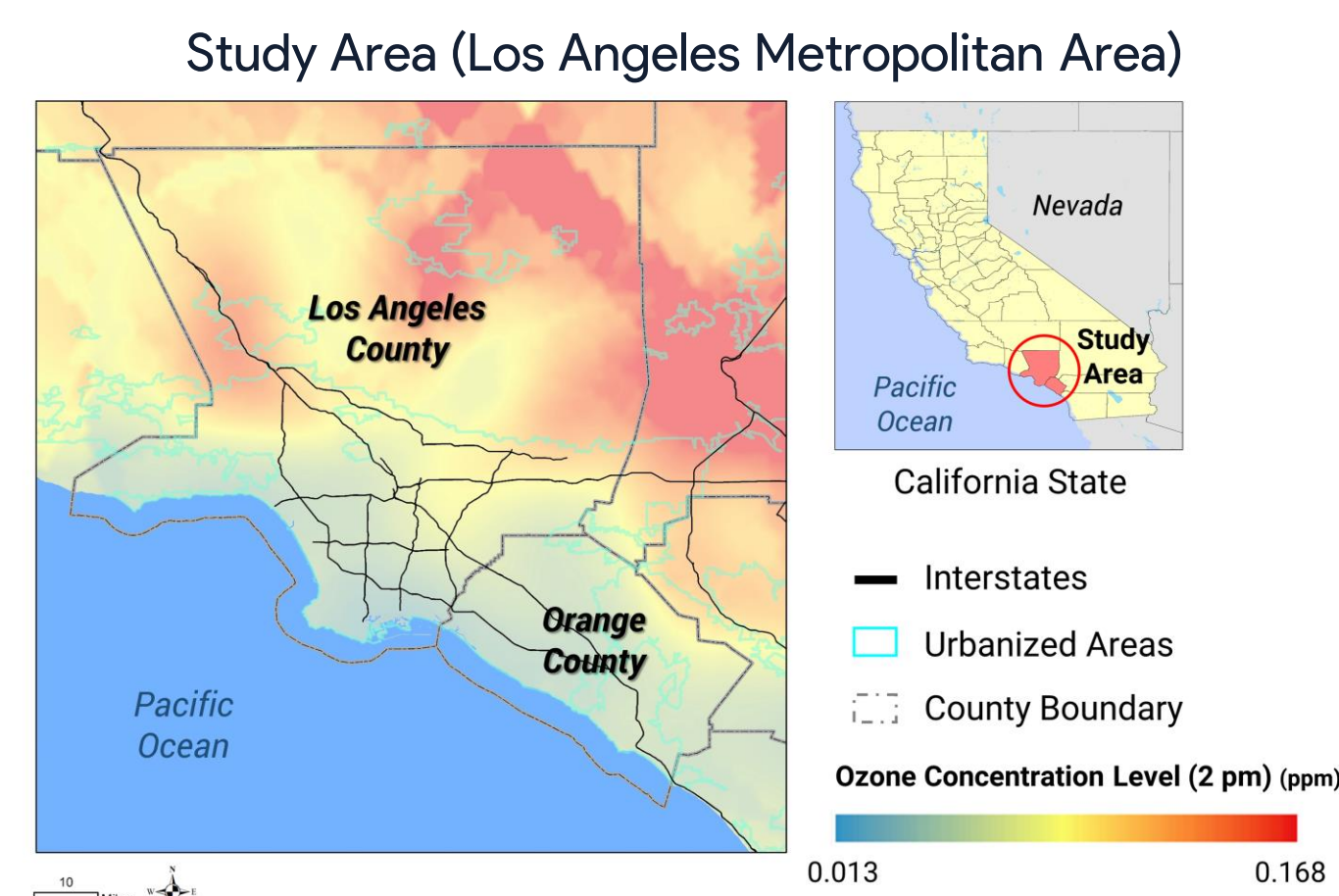


Highlights

- The neighborhood effect averaging problem (NEAP) is a major methodological problem that might affect the accuracy of assessments of individual exposure to mobility-dependent environmental factors (e.g., air/noise pollution and green/blue exposures).
- Focusing on outdoor ground-level ozone as a major air pollutant, this poster examines the NEAP in the evaluation of sociodemographic disparities in people's air pollution exposures in Los Angeles using GIScience methods and one-day activity-travel diary data of 3,790 individuals.
- The results of our spatial regression models indicate that assessments of sociodemographic disparities in people's air pollution exposures might be erroneous when people's daily mobility is ignored because of the different manifestations of neighborhood effect averaging for different social/racial groups.
- The results of our spatial autologistic regression model reveal that non-workers (e.g., unemployed people) do not experience downward averaging.
- Therefore, to avoid erroneous conclusions in environmental inequality research and ineffective public policies, it would be critical to take the NEAP into account in future studies of sociodemographic disparities related to mobility-dependent environmental factors.

Study Area & Data

- Study area: Los Angeles (LA) Metropolitan Area**
 - LA is chosen because of its severe air pollution.
 - A public survey has revealed that 76% of the respondents living in LA think that air pollution is an important issue.



Activity-travel survey data

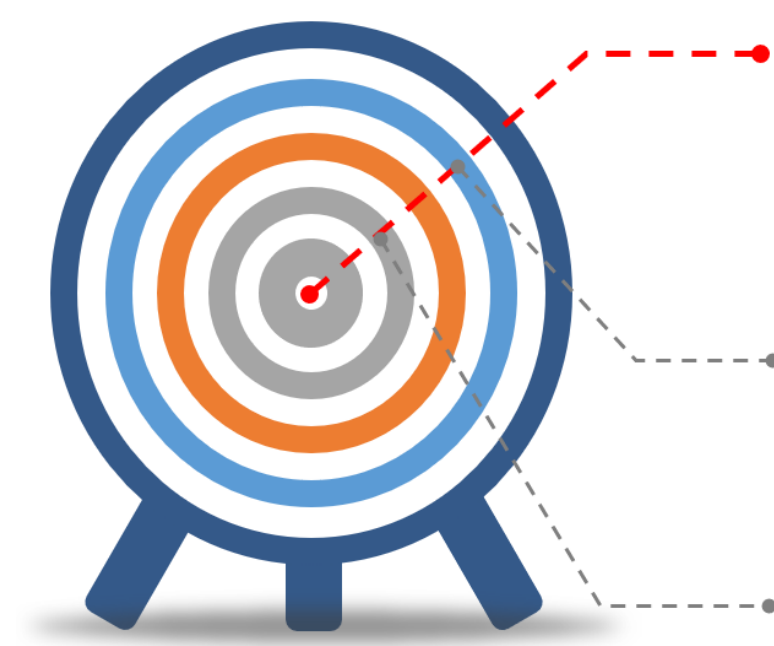
- 3,790 participants (2,640 for weekday and 1,150 for weekend) are extracted from the 2017 National Household Travel Survey.



Hourly air pollution data for co-kriging

- We use ozone, nitrogen oxides, and temperature measurements at 81 monitoring stations at every hour on one randomly selected weekday and weekend day in the summer season.

Research Goal & Questions



Goal. To examine the NEAP in the evaluation of sociodemographic disparities in people's exposure to outdoor ground-level ozone by employing GIScience methods and a one-day activity-travel diary dataset of 3,790 people collected in Los Angeles, California.

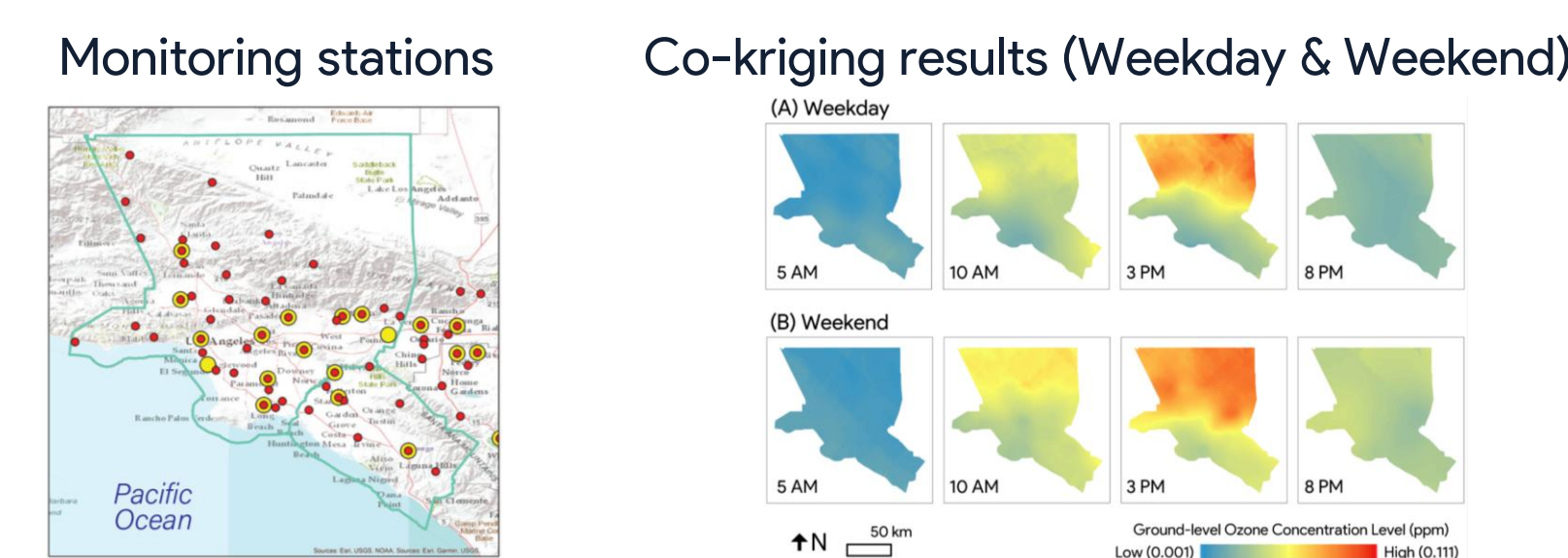
RQ1. How does the NEAP affect the evaluation of sociodemographic disparities in people's air pollution exposures?

RQ2. Which social groups are doubly disadvantaged in exposures? (i.e., Which social groups with high residence-based exposures do not experience downward averaging?)

Methods

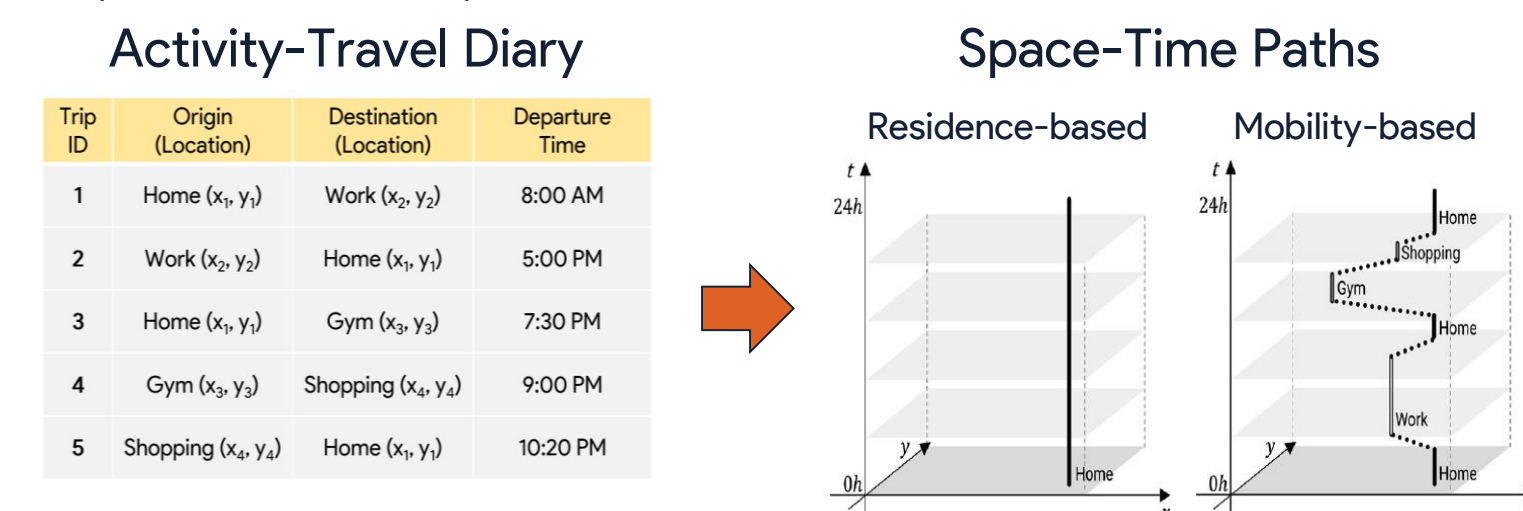
1. Co-kriging estimation for ground-level outdoor ozone concentration surface

- The first figure shows 81 monitoring stations for ozone, nitrogen oxides, and temperature in the study area, and the second figure shows co-kriging estimation results.

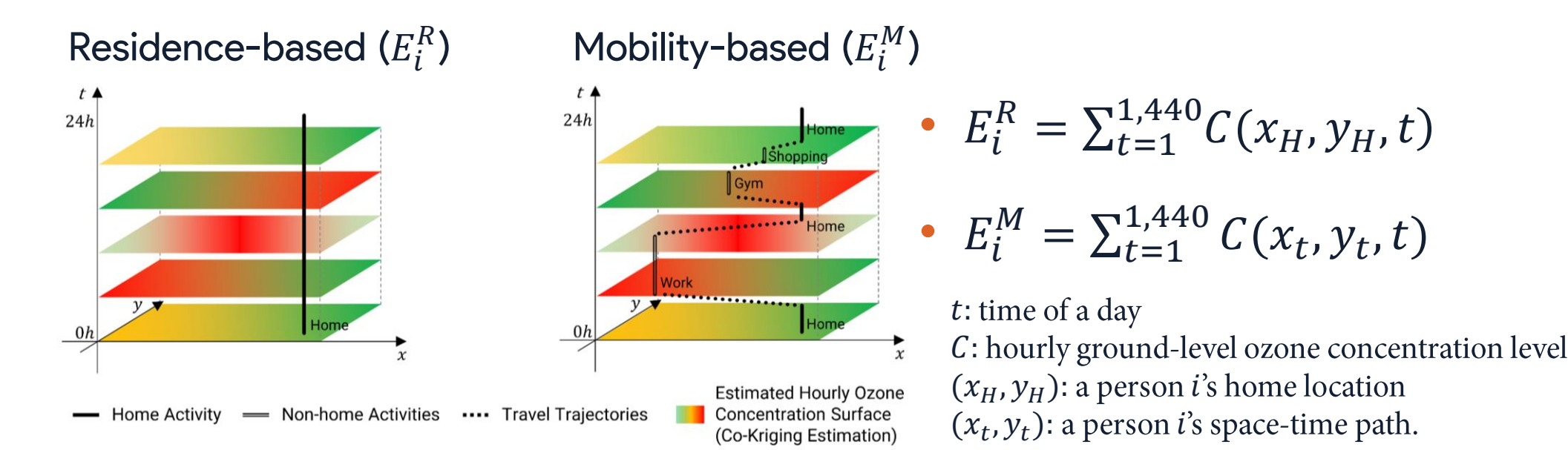


2. Construction of an individual's daily space-time paths

- By using GIScience methods and time geography framework, an individual's daily space-time paths are created based on the activity-travel diary data.



3. Estimating individual ozone exposures in two approaches (i.e., residence-based & mobility-based) by integrating ozone surfaces and space-time paths



4. Examining the effects of the NEAP on the evaluation of the sociodemographic disparities in people's exposures (M1-4)

- Spatial regression models are used for each subsample and dependent variable.

$$E_i^R = \beta_0 + \beta_1 Age_i + \beta_2 Female_i + \beta_3 Black_i + \beta_4 Asian_i + \beta_5 Others_i + \beta_6 Hispanic_i + \beta_7 Immigrant_i + \beta_8 LowIncome_i + \beta_9 HighIncome_i + \beta_{10} Employed_i + \lambda W \epsilon_i + u_i$$

5. Identifying the sociodemographic characteristics of the doubly disadvantaged in air pollution exposures (M5)

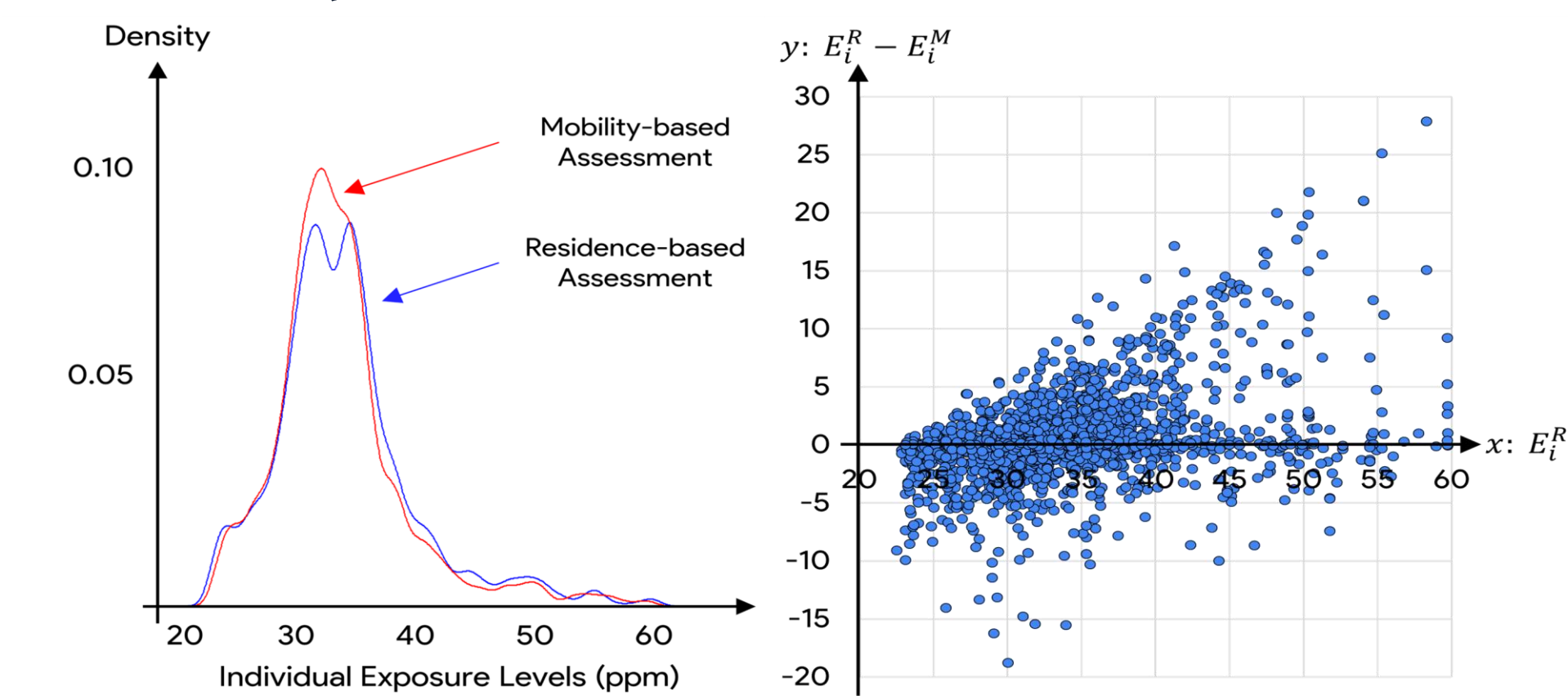
- Spatial autologistic regression model is used.
- Definition of the doubly disadvantaged group (DD_i):

$$DD_i = \begin{cases} 1 & \text{if } Z(E_i^R) \geq 0.5 \text{ and } E_i^M > E_i^R \text{ (Doubly Disadvantaged)} \\ 0 & \text{(otherwise)} \end{cases}$$

Results

Results of measuring residence-based and mobility-based individual exposures

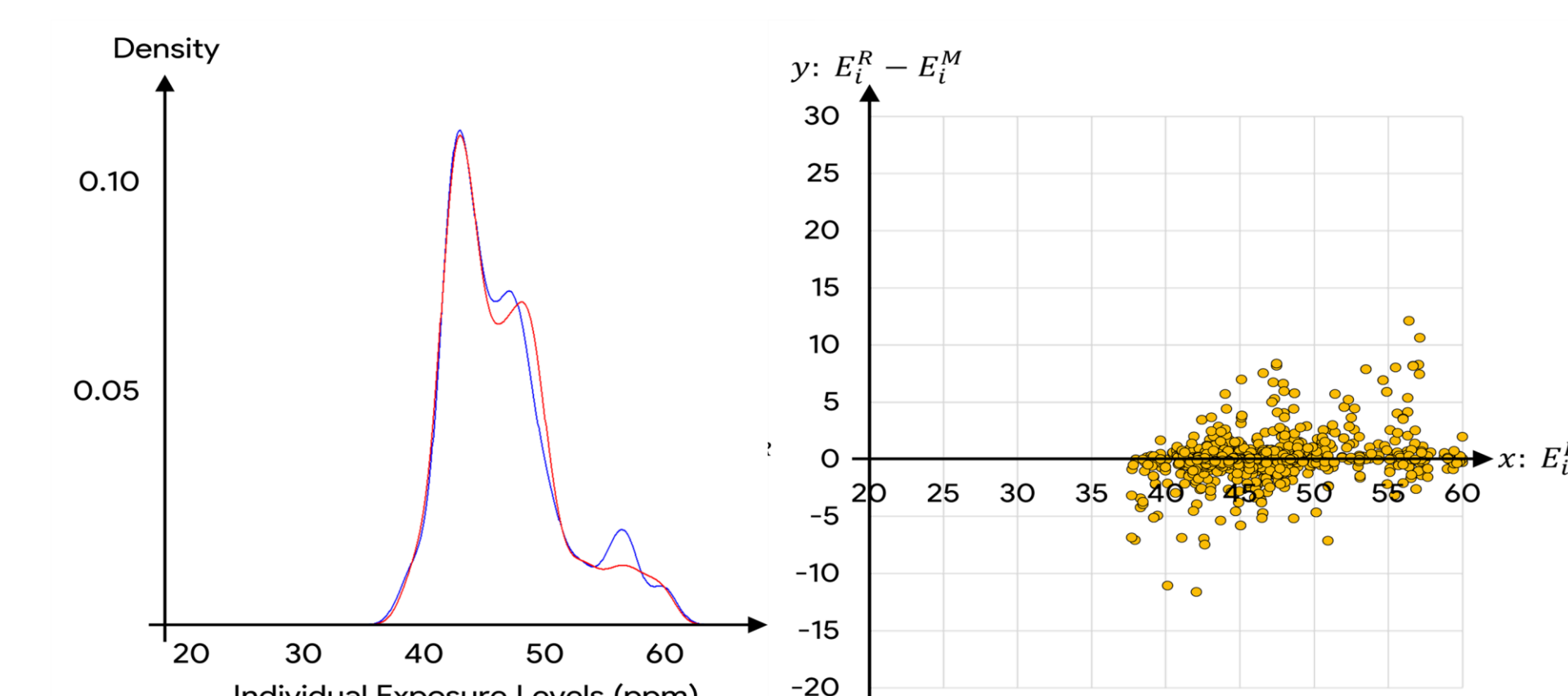
Weekday models



- For weekday participants, the PDF of mobility-based individual exposures is less deviated than that of residence-based individual exposures, indicating that individual exposures tend to converge toward the average exposure level of the participants.
- Also, there is a positive linear relationship between residence-based individual exposures (i.e., x-axis values) and values obtained by subtracting the mobility-based from the residence-based individual exposures (i.e., y-axis values).

✓ The results provide strong evidence for the presence of neighborhood effect averaging in people's air pollution exposures of the weekday.

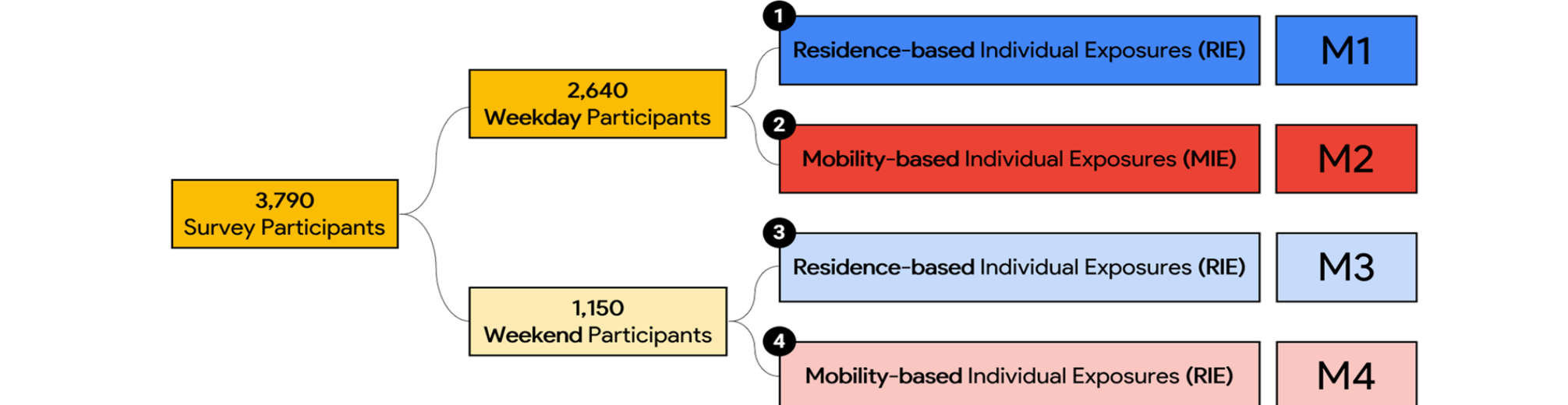
Weekend models



- For weekend participants, the PDF of residence-based individual exposures and that of mobility-based individual exposures are nearly the same, and the pairwise differences between residence-based and mobility-based individual exposures are not significant.
- Also, there is a weak positive linear relationship between x- and y-axis values, indicating a weak operation of neighborhood effect averaging.

Results of the spatial regression models (RQ1)

Model overview



Weekday models (M1-2)

	M1	M2
Age	0.005 (0.204)	0.004 (0.203)
Female	-0.108 (0.128)	0.104 (0.084)
Black	-1.044** (0.310)	-0.169 (0.204)
Asian	0.003 (0.217)	0.016 (0.143)
Others	-0.269 (0.225)	0.116 (0.148)
Hispanic	0.160 (0.192)	-0.102 (0.127)
Immigrant	0.123 (0.168)	-0.062 (0.110)
Low Income	-0.734* (0.293)	-0.239 (0.193)
High Income	-0.087 (0.190)	0.037 (0.125)
Employed	0.143 (0.148)	-0.250* (0.097)
λ	0.851***	0.918***
Intercept	33.523*** (0.531)	33.327*** (0.566)
Log-Likelihood	-7,130.456	-6,090.001

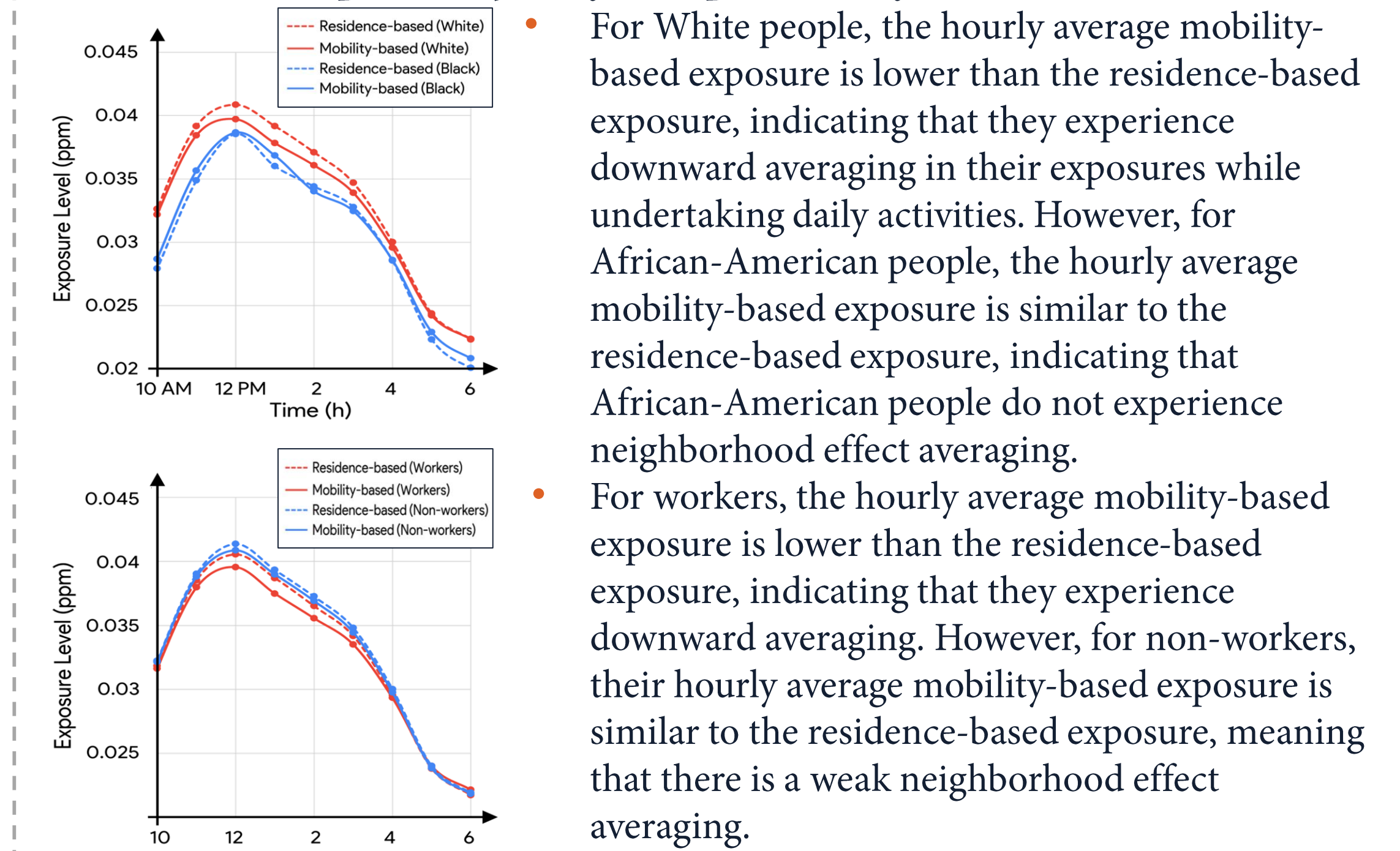
*** p<0.001; ** p<0.05

✓ The results suggest that using residence-based exposure assessments can overestimate the disparity in exposures between African-American and White people and low- and middle-income people and using residence-based exposure assessments can underestimate the disparity in exposures between workers and non-workers.

Results (Cont'd)

Results of the spatial regression models (Cont'd)

An in-depth analysis of the operation of the NEAP



✓ Although the average residence-based ozone exposure of White people is higher than that of African-American people, the difference in exposure between these two groups becomes insignificant when people's daily mobility is considered. This is because White people experience downward averaging in their ozone exposures, while African-American people do not.

Weekend models (M3-4)

	M3	M4
Age	0.001 (0.001)	0.002 (0.003)
Female	-0.025 (0.025)	0.013 (0.105)
Black	0.060 (0.069)	0.377 (0.282)
Asian	0.024 (0.044)	-0.259 (0.180)
Others	0.009 (0.043)	-0.251 (0.176)
Hispanic	0.015 (0.040)	0.024 (0.165)
Immigrant	0.007 (0.033)	-0.007 (0.136)
Low Income	0.046 (0.054)	0.364 (0.221)
High Income	-0.081 (0.044)	-0.083 (0.179)
Employed	-0.026 (0.028)	0.008*** (0.116)
λ	0.985***	0.908***
Intercept	47.725*** (0.898)	46.069*** (0.637)
Log-Likelihood	-862.328	-2,423.875

Results of the spatial autologistic regression models (RQ2)

- The results indicate that, for those who live in high air pollution neighborhoods, non-workers (e.g., unemployed, homemakers, retired, and students) have significantly higher odds of being doubly disadvantaged in ozone exposures than workers.
- This is because non-workers tend to spend most of their time in their residential neighborhoods as the spatial entrapment hypothesis suggests.

Summary

Implications for environmental inequality/injustice research

- First**, researchers and public policymakers should consider human daily mobility to avoid erroneous results in environmental inequality research and policy exacerbated by the neighborhood effect averaging problem (NEAP).
- Second**, policymakers should focus not only on people who live in disadvantaged neighborhoods but also on the immobile social groups, including socially disadvantaged groups because they are doubly disadvantaged because their limited daily mobility makes it difficult for them to "escape" from their polluted residential neighborhoods.

Conclusion

✓ The neighborhood effect averaging problem (NEAP) can be a serious methodological problem that leads to erroneous assessments when assessing sociodemographic disparities in exposures because people's daily mobility could amplify or attenuate (neighborhood effect averaging) the exposures experienced in their home neighborhoods.