AIR POLLUTION IMPACTS FROM WAREHOUSING IN THE UNITED STATES UNCOVERED WITH SATELLITE DATA

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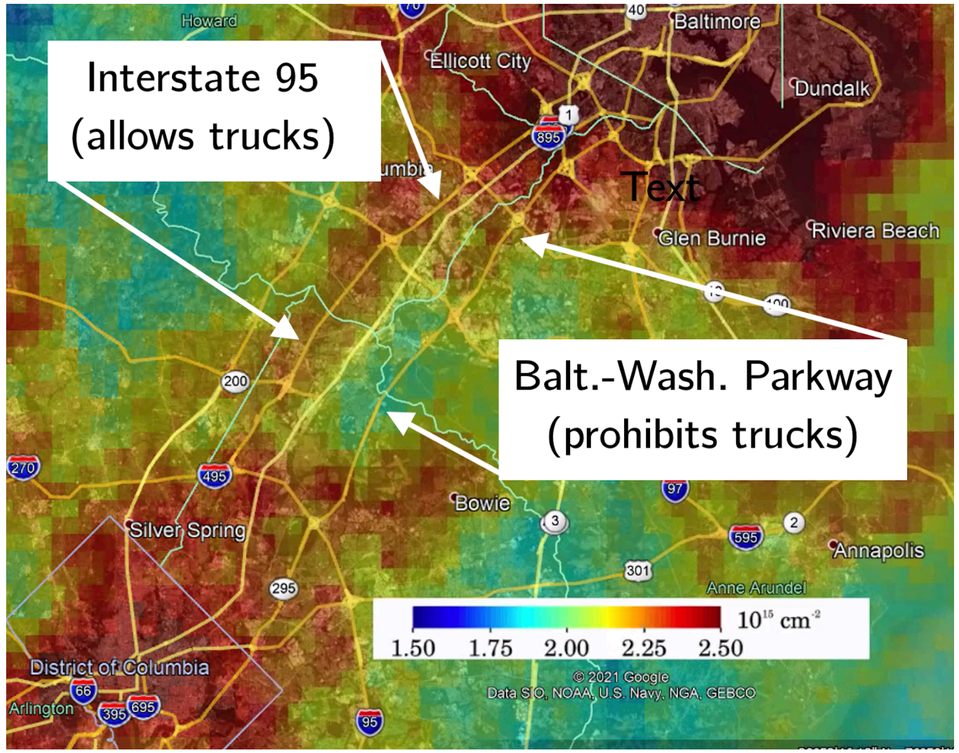
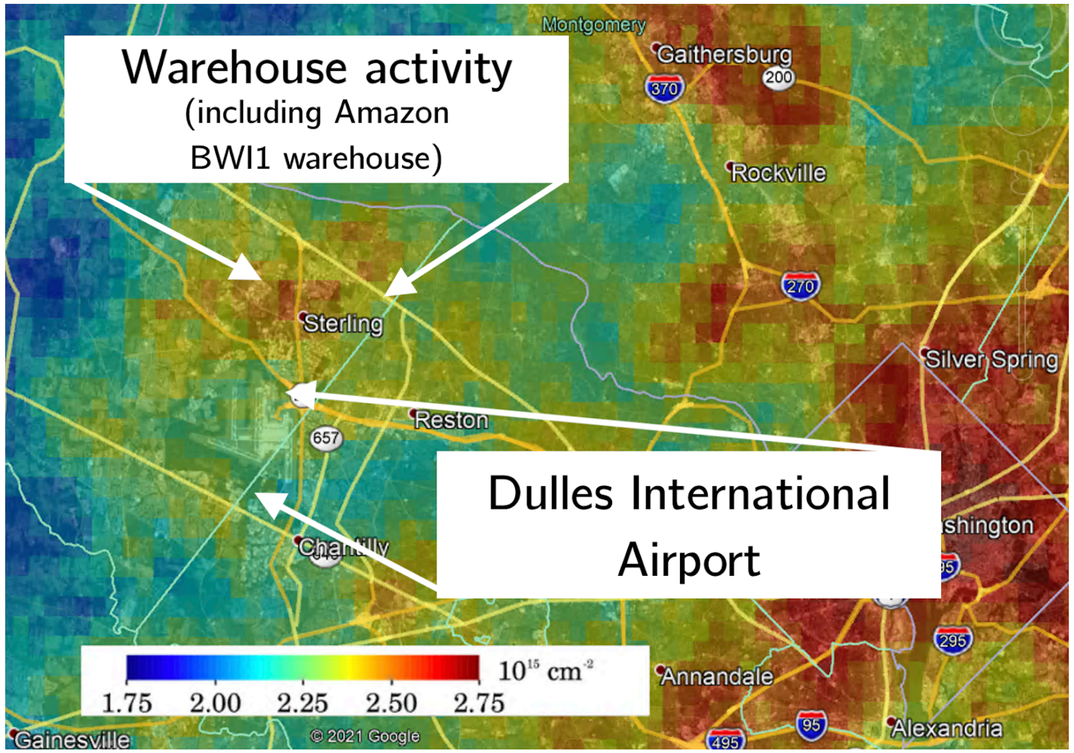
Our previous work has suggested links between heavy-duty vehicles, warehousing, and air pollution





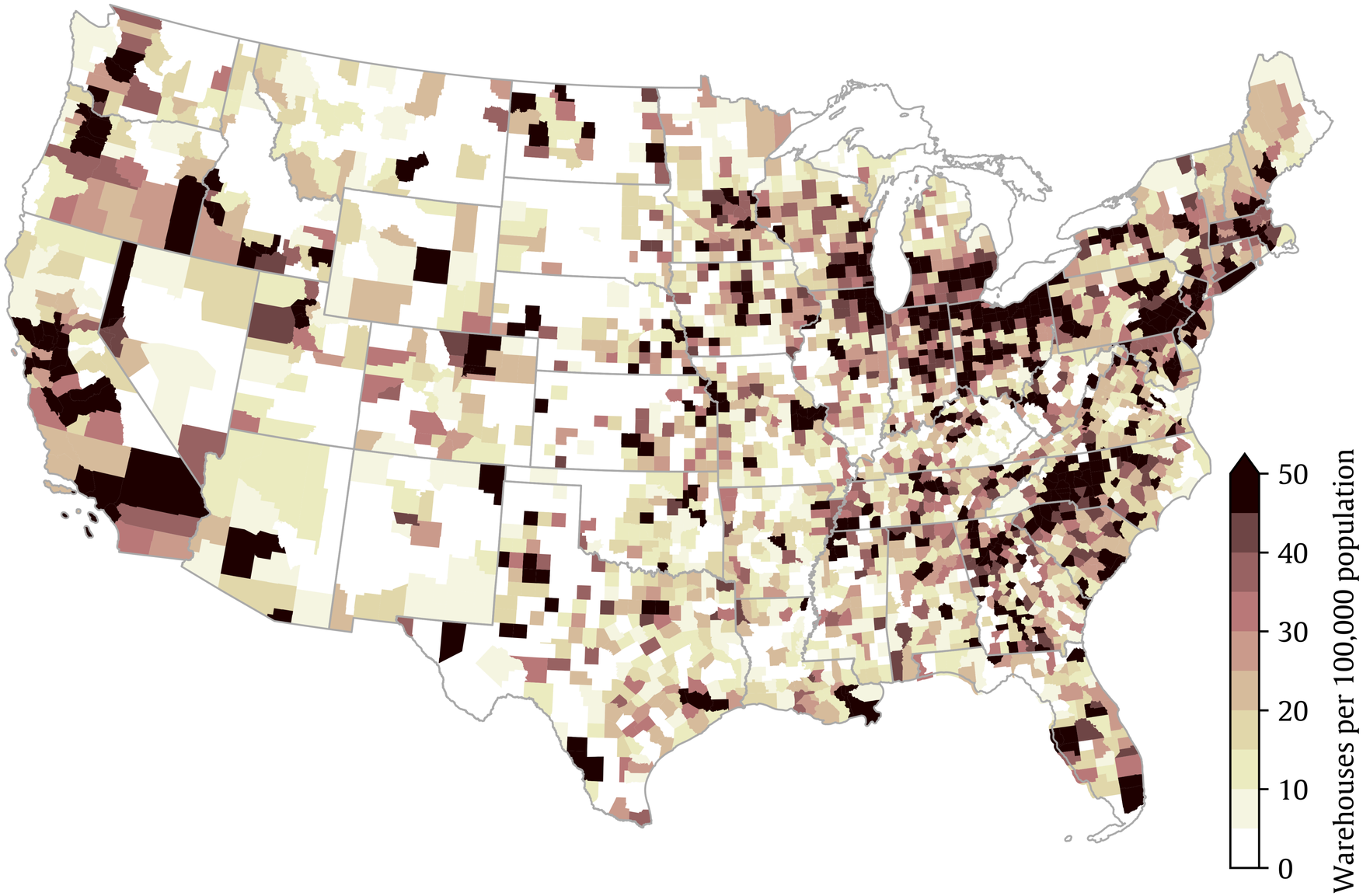
- During the COVID-19 pandemic, nitrogen dioxide (NO_2) pollution was higher on I-95 compared with the Baltimore-Washington Parkway and surrounding a warehousing complex near Dulles International Airport.

Source: Dan Goldberg

Warehouses are omnipresent across the U.S.

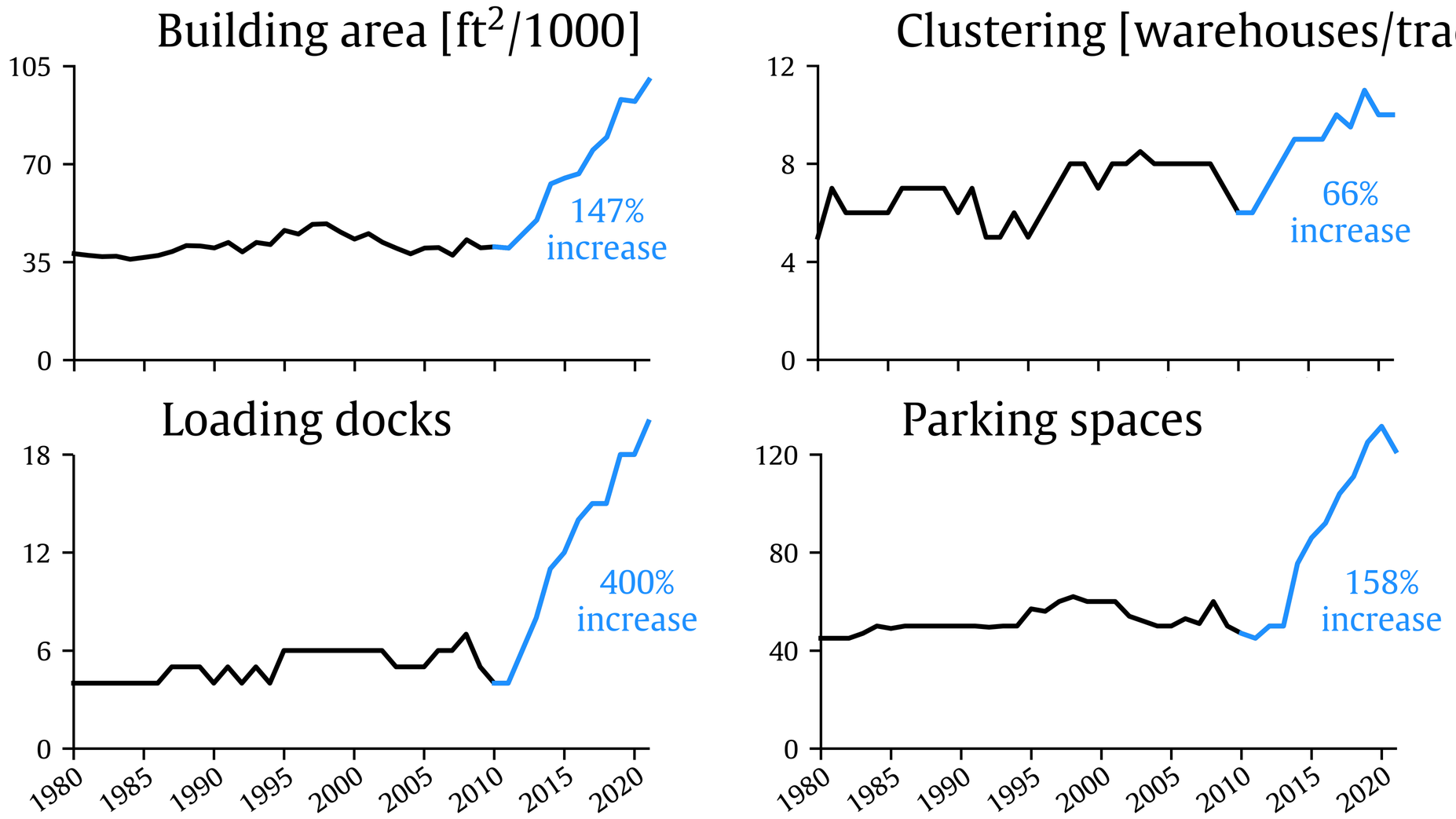
- As of 2021, there were 149,075 warehouses ≥20,000 ft^2 in the contiguous U.S. in the CoStar commercial real estate database.

- Nearly one-fifth of these warehouses are located in just ten (0.3%) counties, including Los Angeles County, CA; Harris County, TX, and Cook County, IL.



Source: Kerr *et al.* (2024)

New warehouses built during the 2010s were larger and had a greater ability to handle traffic



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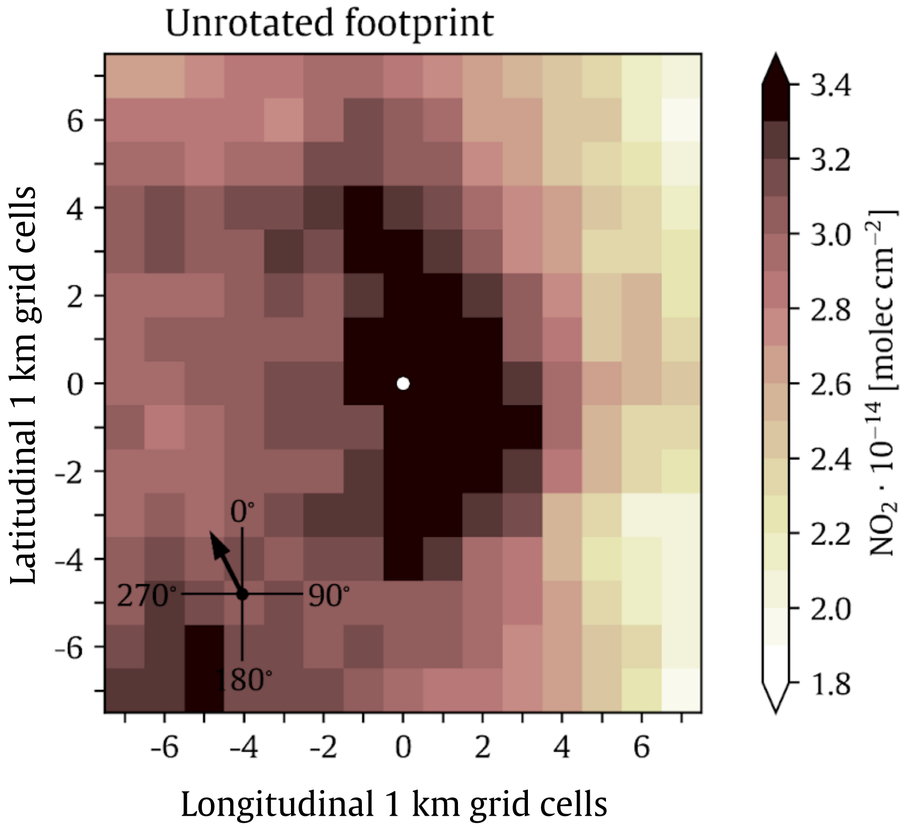
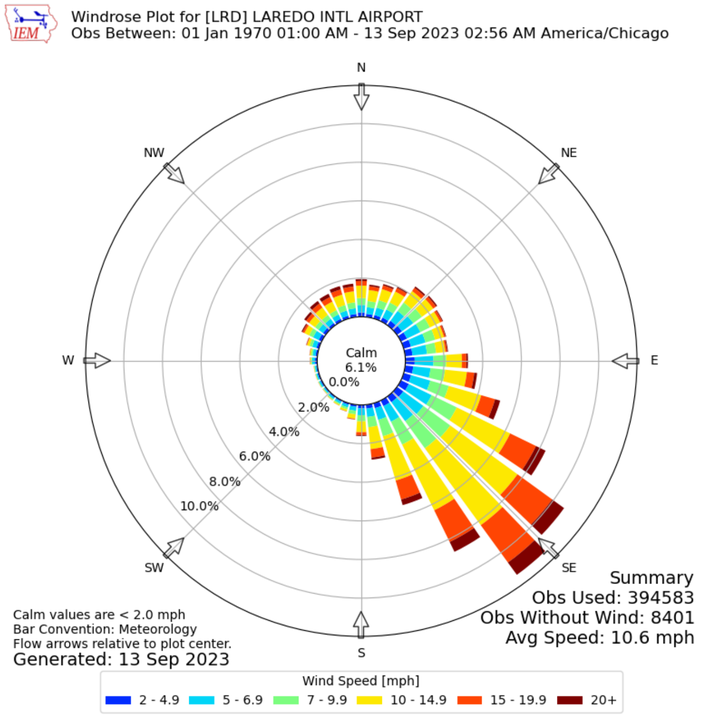
TROPOMI measurements are used to characterize NO_2 enhancements near warehouses





- (Left) We obtain daily TROPOMI NO_2 measurements and 100-meter wind direction estimates near (±7km) each warehouse.
- (Right) NO_2 measurements are artificially rotated in the direction of the prevailing wind such that downwind is to the right of the figure
- Daily wind direction-rotated NO_2 measurements are averaged over all days with valid measurements in 2021.

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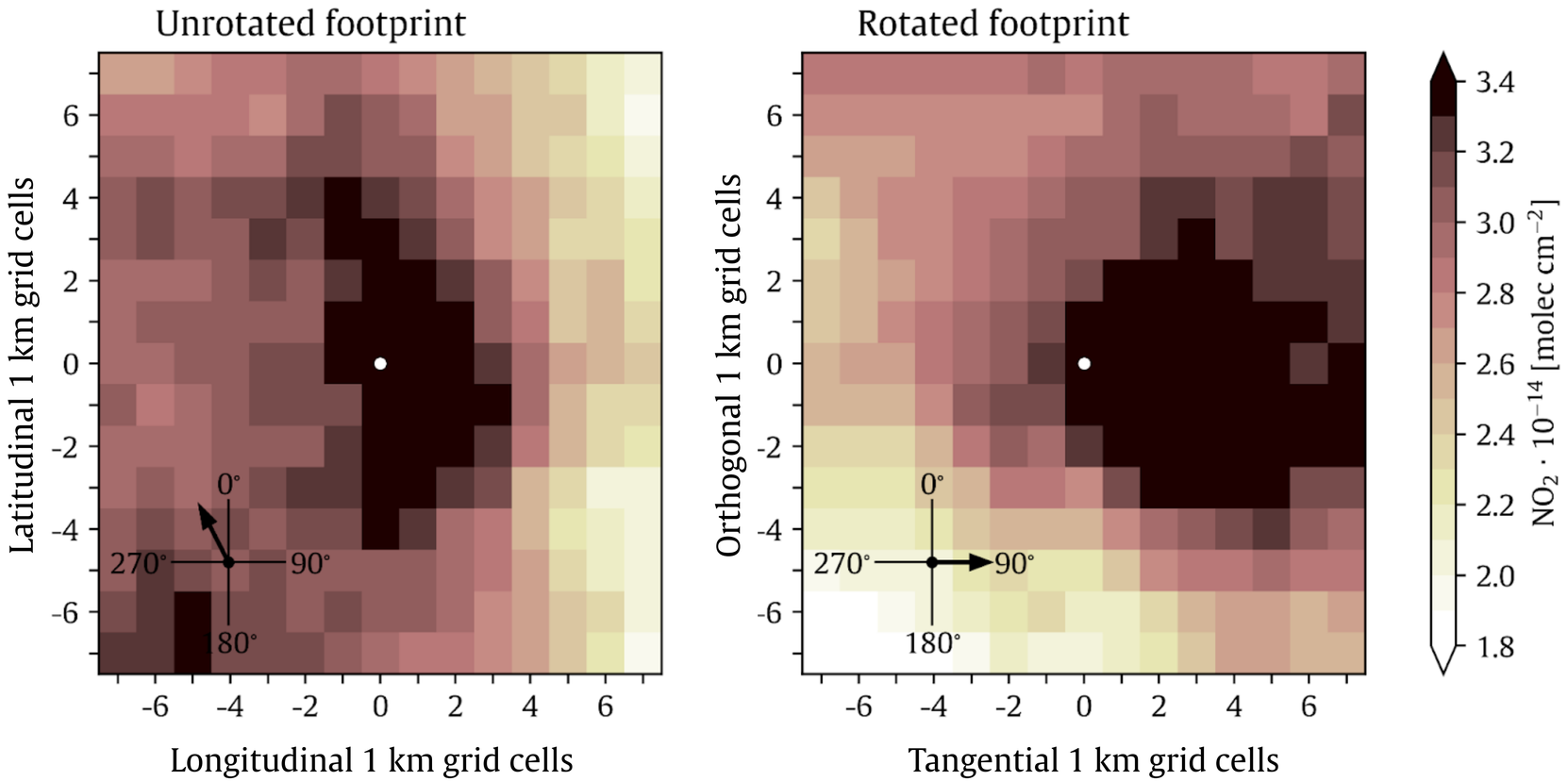

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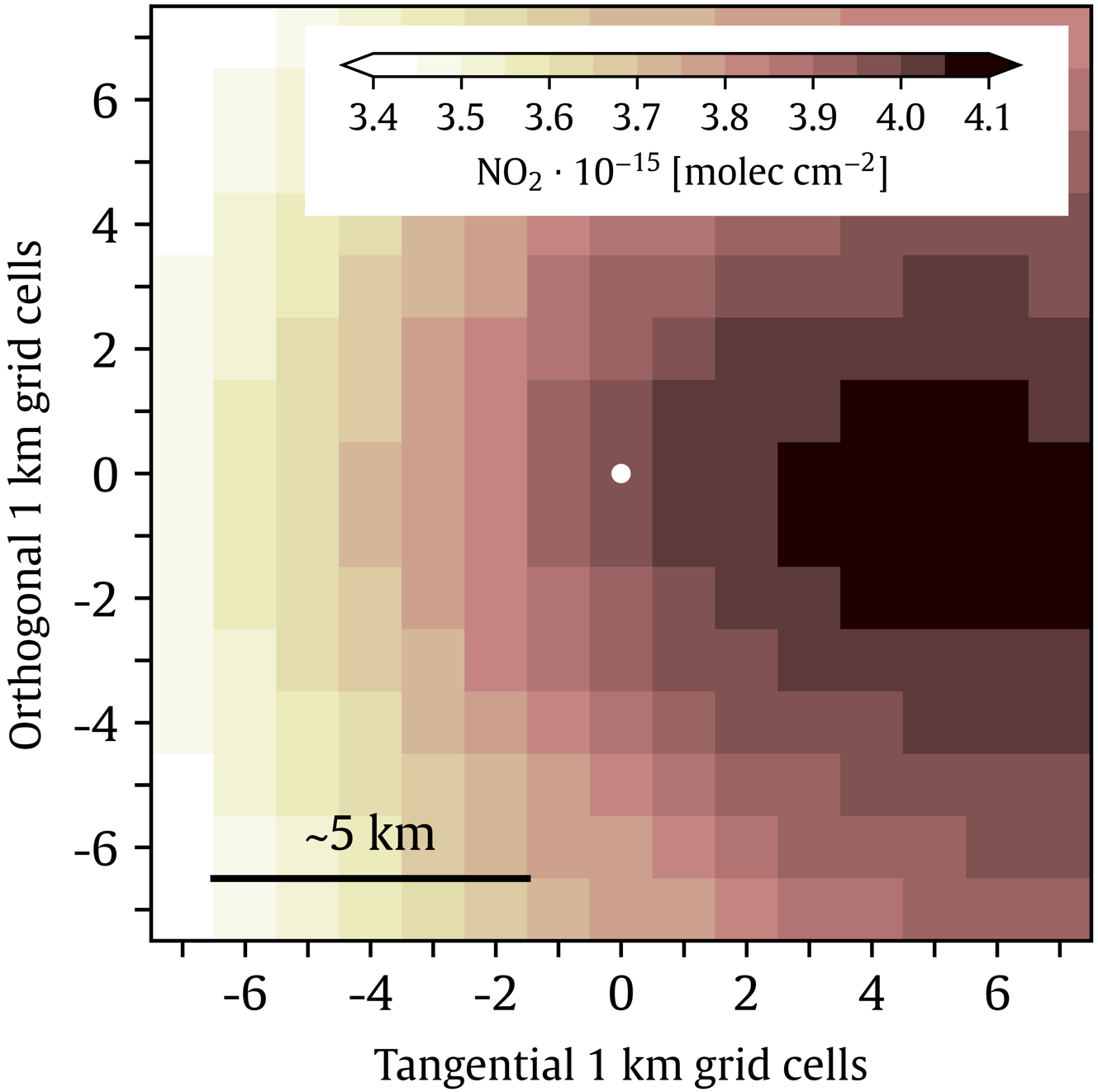
Satellite remote sensing from the TROPOMI instrument reveals a 20% increase in NO_2 near warehouses

- Increase is calculated as the relative difference between maximum NO_2 and NO_2 averaged over the upwind, orthogonal edge of the composite.

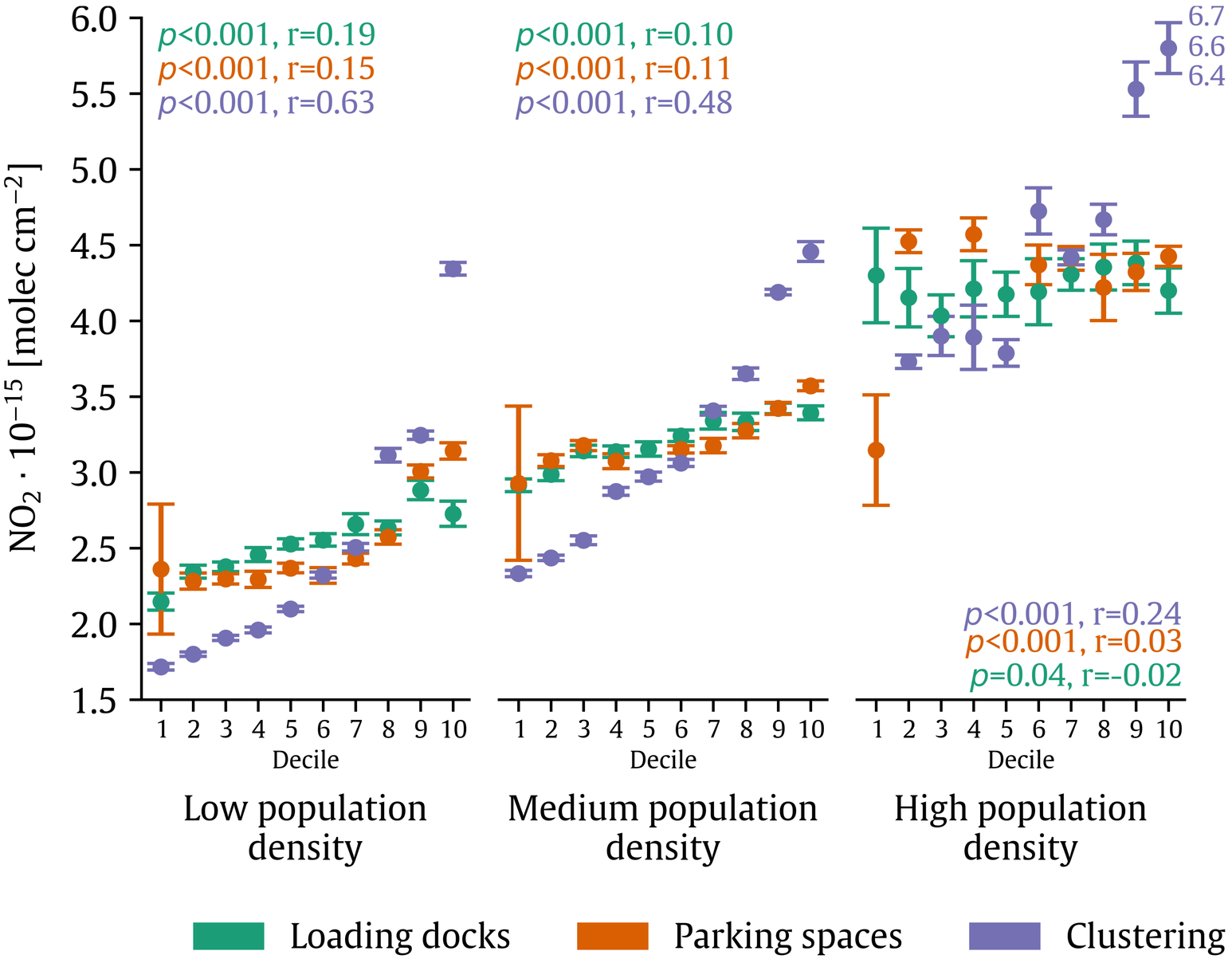
- Spatial displacement warehouse and peak NO_X likely stems from most NO_X (90-95%) being emitted as NO and thereafter oxidizing to form NO_2.



Source: Kerr *et al.* (2024)

Proxies for NO_X emissions are linked with increases in satellite-derived NO_2 near warehouses

- Clustering—the number of warehouses within a given census tract—exhibits the strongest association with NO_2, explaining nearly 40% of the variance near warehouses sited in low population density environments.



Source: Kerr *et al.* (2024)

Larger warehouse clusters and more loading docks are associated with increased truck traffic

1456 additional truck km traveled per additional warehouse

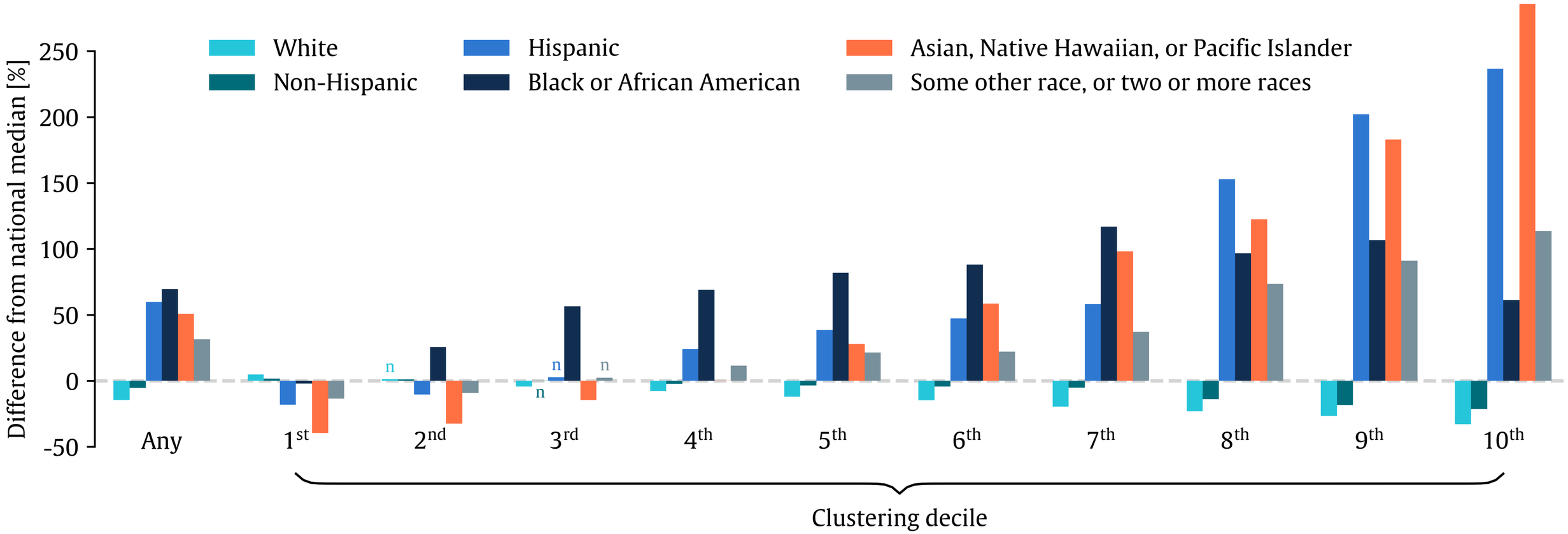
485 additional truck km traveled per additional loading dock

- Traffic impacts were estimated with a regression analysis using road segment-based traffic counts from the Federal Highway Administration.

- We also linked increases in near-warehouse truck traffic with significant increases in satellite-derived NO_2, consistent across different population density environments.

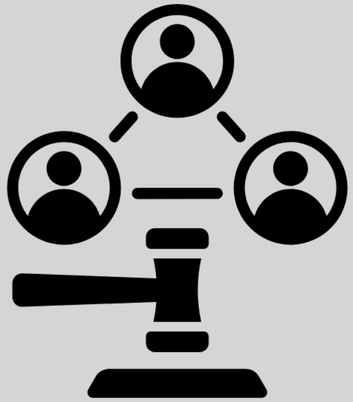
Source: Kerr *et al.* (2024)

Communities with warehousing facilities have more residents identifying as ethnic and racial minorities



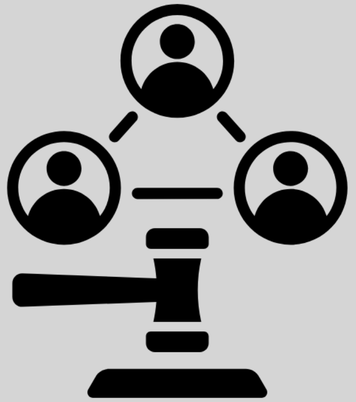
- In the top ten percent of tracts with the most warehouses, the proportion of the Hispanic population was 240% higher and the Asian population nearly 290% higher than U.S. median values.

Source: Kerr *et al.* (2024)



Strengthen engine standards

As has been done through the EPA's latest NO_X emissions and greenhouse gas standards



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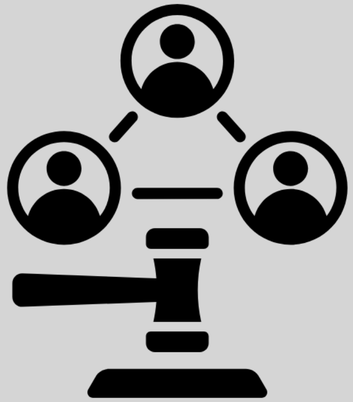
Enact warehouse indirect source rules

As has been done by the South Coast Air Quality Management District



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Phase out oldest, most polluting diesel vehicles or commit to fleet electrification

Summary

- Warehousing worsens local traffic-related air pollution with an average near-warehouse NO_2 enhancement of nearly 20%.

- Facilities with more loading docks and parking spaces—typical of warehouses built during the 2010s—attract the most truck traffic and are associated with the highest NO_2 levels.

- Solutions are within reach! More stringent engine standards, enactment of indirect source rules, and fleet electrification could reduce near-warehouse tailpipe emissions.

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